

## **ECONOMIC JUSTIFICATION OF RATIONAL NATURAL USE AS AN EXAMPLE OF NATIONAL ENERGY DEVELOPMENT**



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### **Abstract**

The study presents the economic justification of rational nature use on the example of the development of the national energy industry of Ukraine. To date, it has not been possible to fundamentally rebuild the economic complex of Ukraine on ecologically favorable intensive pro-European principles of nature management activities.

The industries dangerous for the environment of Ukraine include the fuel and energy, metallurgical, heavy engineering, chemical and petrochemical industries; agro-industrial complex; communal economy; transport (especially automobile). The gradual mastering of the experience of nature use and the acquisition of knowledge by mankind about the use of natural resources had both positive and negative consequences. The study presented the level of emissions of the main pollutants into the atmospheric air in Ukraine, the level of discharge of polluted return water into natural surface water bodies by regions of Ukraine, as well as the most polluted settlements in Ukraine by the content of industrial toxicants in the soil. Taking into account the technological level of PEK, the total need for innovative financing (according to experts' estimates) is from UAH 8 to 12 billion annually. Economic entities will not be able to obtain such financial resources by their own efforts without targeted foreign investment. Therefore, the problem of creating an attractive investment climate in the PEK of Ukraine for the activation of innovative processes has acquired special importance.

### **Introduction**

During the years of independence, it has not yet been possible to fundamentally rebuild the economic complex of Ukraine on ecologically favorable intensive pro-European principles of nature management activities.

Among European countries, Ukraine has the highest integrated indicator of negative man-made loads on the natural environment in

almost its entire territory. The international status of our state is officially recognized as an "ecological disaster zone" taking into account more than 10% of the territory of Ukraine, its ecological state, levels of environmental pollution and the state of use of the main natural resources. This status was obtained after the accident at the Chernobyl nuclear power plant, because along with pollution and ecological cataclysms, radioactive contamination of part of the territory was also added. As a result, the cumulative negative impact on people and the natural environment of various chemical pollution and radiation, degradation processes and deterioration of the quality of the environment has significantly increased.

The industries most dangerous for Ukraine's environment include industry (fuel and energy, metallurgy, heavy engineering, chemistry and petrochemicals); agro-industrial complex; communal economy; transport (especially automobile). The study presented the level of emissions of the main pollutants into the atmospheric air in Ukraine, the level of discharge of polluted return water into natural surface water bodies by regions of Ukraine, as well as the most polluted settlements of Ukraine by the content of industrial toxicants (in multiples of MAC) in soils.

Therefore, the gradual mastering of the experience of nature use and the acquisition of knowledge by mankind regarding the use of natural resources, and, in particular, their energy component, had both positive and negative consequences. In particular, with the development of human society, the speed of scientific and technological progress is increasing. There is a violation of the state of equilibrium in the "nature-man" system, there is a threat to the very existence of humanity; all this requires rational and ecologically safe management and highly efficient balanced use of natural resources (fuel and energy in particular), which will create favorable conditions for human health, preservation and reproduction of the natural environment and the natural resource potential of social production [1-5].

### **1. Analysis of the national energy industry as a systemic nature user**

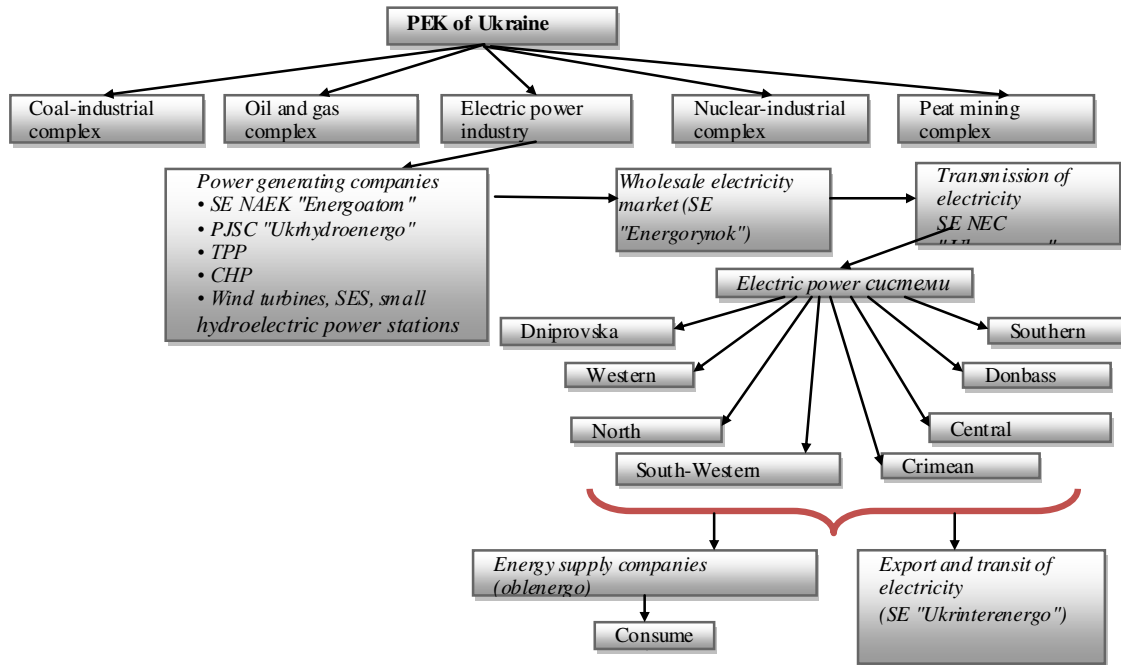
Energy is the main strategic prerequisite for the development of the economy, the basis for ensuring all types of life activities of society. Therefore, the definition and implementation of directions for its development are priority tasks in ensuring national security, political and energy independence, and sustainable development. The fuel and energy complex of Ukraine includes exploration and production,

processing and production, storage and transportation, transmission and distribution, trade and sales (sale) of energy products - fuel, electricity and thermal energy. Formed at one time as a component of the fuel and energy complex of the USSR, it does not fully meet the conditions for the functioning of the energy industry on the basis of sustainable development. Thus, the general structure of the fuel and energy complex of Ukraine consists of several main production industries, such as: oil and gas production and oil refining industry, coal mining, electric power industry (Fig. 1).

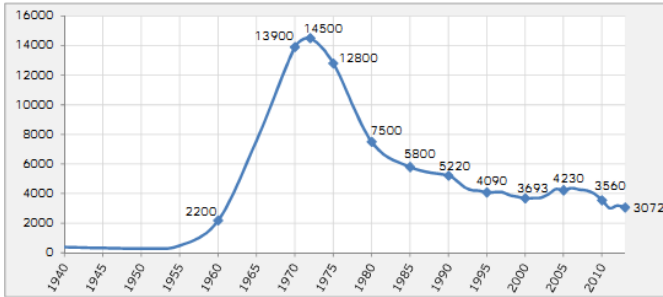
The oil industry of Ukraine is one of the oldest in the world. The total resources of oil and gas condensate amount to 1041 million tons. Since the beginning of industrial exploitation, 375 million tons have been mined, including about 85 million tons in the last 20 years. In three (Eastern, Western and Southern) oil and gas-bearing regions of Ukraine, 41% of the resources have been explored. The eastern region contains about 60% of the country's oil reserves. 205 hydrocarbon deposits have been discovered on its territory, 180 of them have been entered into the state register. The total production reaches 75% of the total in the industry [6-9].

The Western oil and gas-bearing region is located mainly in the Carpathian region, and provides production of up to 20% of oil and gas condensate from the total volume of the industry. It is gradually losing its production value due to the exhaustion of explored reserves. The southern oil and gas-bearing region covers the Western and Northern Black Seas, the Azov Sea, and the Ukrainian zones of the Black and Azov Seas. It is the most promising in Ukraine, it provides crude oil and, especially, gas condensate with high quality indicators, but the development of its deposits (especially marine ones) requires significant capital investments.

The main business entity of the industry is PJSC "Ukrnafta" - a de facto monopolist on the relevant market. 50% + 1 share of this monopolist belongs to Naftogaz of Ukraine. PJSC "Ukrnafta" accounts for up to 85% of annual oil production in Ukraine (and together with gas condensate - up to 70%). There are 296 deposits on the state balance sheet, 236 deposits are in industrial exploitation.

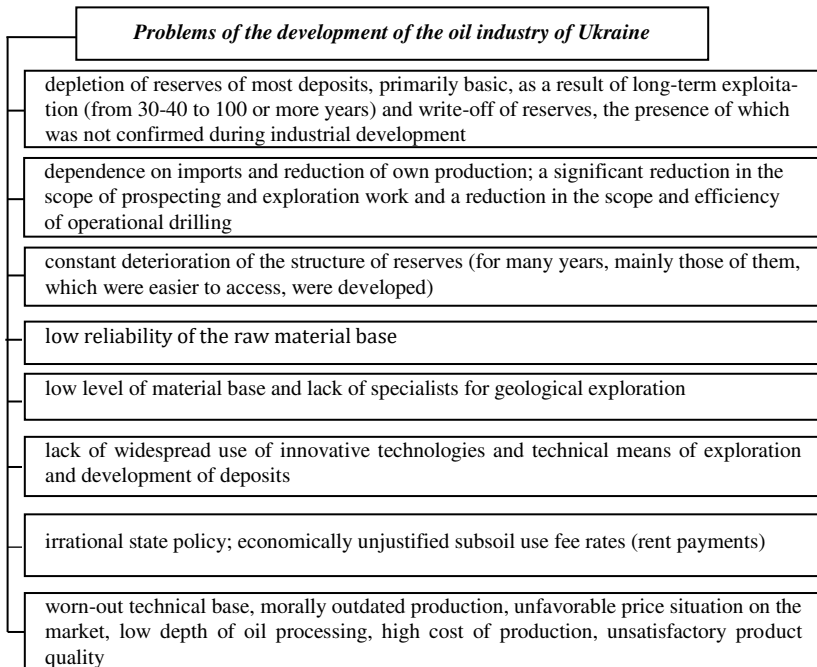


**Fig. 1.** Fuel and energycomplex of Ukraine



**Fig. 2.** Extraction of oil and gas condensate in Ukraine, thousand tons

The reduction in production is associated with a number of systemic problems, the main ones of which are shown in Fig. 3.



**Fig. 3.** Problems of development of the oil industry of Ukraine

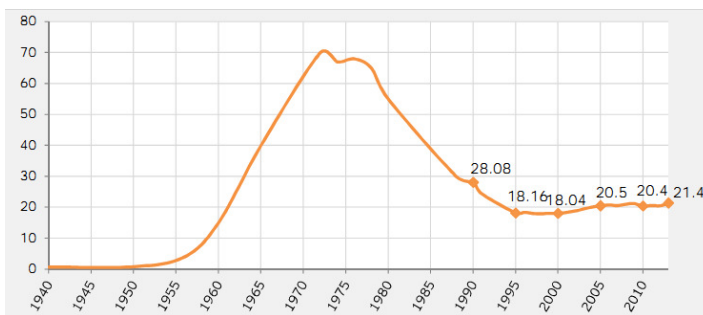
The industry has recently significantly reduced the volumes of oil and condensate production - from 4,5 million tons (2006) to 3,5 million tons (2013) (Fig. 2).

Thus, the reduction in the volume of prospecting works (from 425,000 m in 1991 to 152,000 m in 2010) is significant. In 20 years, only one large oil field was discovered (Subotynskoe, reserves of 65 million tons). The volumes of exploration work carried out in 2006-2011 at the expense of all sources of financing are 5 times smaller than necessary for sustainable reproduction of the raw material base; that is, there is a process of curtailment of industrial production in the near future. The use of innovative oil production technologies is extremely low. For example, investment in fixed capital per 1 ton of oil produced in Ukraine is more than half of the average European level.

As for the development of the gas industry, it operates on a relatively small resource base - proven reserves of natural gas in Ukraine amount to 1193 billion cubic meters, forecast resources - 3491 billion cubic meters. The largest reserves (43 percent of total forecast reserves) are in Eastern Ukraine. The shelf of the Azov and Black seas is also promising - up to 46% of the forecast reserves. The forecast reserves of unconventional gas are potentially promising:

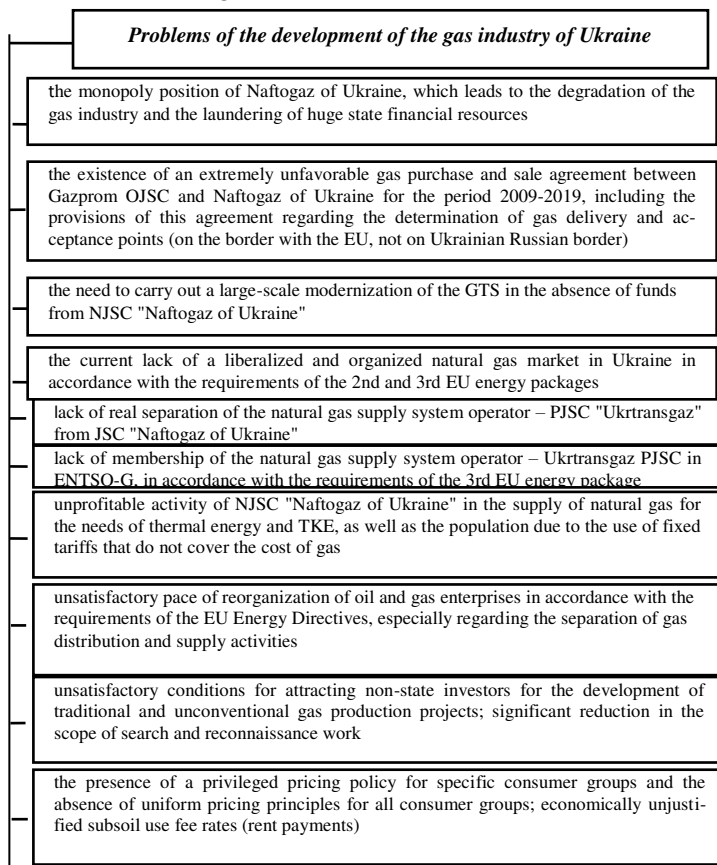
- 1,2 trillion cubic meters of shale gas;
- 8,5 trillion cubic meters of gas from dense collectors;
- more than 12 trillion cubic meters of coal bed methane.

Own gas production in 2014 amounted to 19.8 billion cubic meters (increased by 2,4% compared to 2013), but the overall level of gas production is decreasing (Fig. 4).



**Fig. 4.** Historical trend of natural gas extraction in Ukraine, billion m<sup>3</sup>

The problems of the functioning of the gas production industry are similar to the problems of oil production, but they are specific, taking into account the transit capabilities of the gas transportation system of Ukraine (Fig. 5).



**Fig. 5.** Problems of the development of the gas industry of Ukraine

Thus, the design capacity of the gas transportation system of Ukraine is 178,5 billion cubic meters per year, including 142,1 billion cubic meters in the direction of EU countries and Turkey. In 2013, the transit of natural gas for the CIS countries and Europe amounted to 86,1 billion cubic meters. Due to the political motives of JSC Gazprom, there is an annual reduction in transit volumes. In

addition, Ukraine's gas transportation system is facing the threat of partial conservation not only for political reasons, but also for technical reasons: it has been in need of significant investments for renewal and reconstruction for a long time.

Oil and gas industries have a lot in common in the nature of their impact on the environment. In particular, the main source of pollution in the oil and gas industry is the so-called reservoir water (which comes to the surface during drilling and extraction). According to the chemical composition, reservoir waters are highly mineralized brines with a high content of chloride salts, carbonates, and alkali metals. It is formation waters that make up to 90% of waste water - the main factor of environmental pollution during the exploration and operation of oil and gas wells. Wastewater also contains oil, sulfur, iron oxides, and hydrogen sulfide. This causes oil pollution of reservoirs and aquifers, a critical change in the physical and chemical properties of soils. Main oil and gas pipelines are also a potential source of pollution with a significant negative impact on the environment in case of accidental damage to the network.

The oil refining industry of Ukraine is represented by six oil refineries with a total design annual processing capacity (as of 2014) of 52 million tons of crude oil. However, the actual actual capacity is no more than 15 million tons. Only one Kremenchug oil refinery is actually operating. In addition, 7 more gas processing plants produce petroleum products from gas condensate. In 2014, a total of only 2,6 million tons of raw materials were processed in Ukraine, which made it possible to supply the domestic market with its own petroleum products by only 15%.

The main problems of the oil refining industry of Ukraine include:

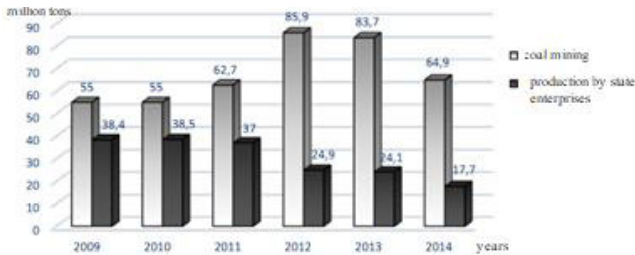
- technological backwardness;
- lack of investment;
- failed privatization of enterprises;
- dependence on the import of raw materials (during the years of independence, oil production in Ukraine decreased by 1,8 times);
- lack of effective sectoral state policy.

The oil refining industry (despite limited production volumes) remains a significant polluter of the environment. In 2012 (together with the coke industry), the total emission of pollutants into the at-



mosphere amounted to 797 thousand tons (about 20 kg per one resident of Ukraine) [10-14].

Analyzing the coal mining industry, it is worth noting that in terms of geological reserves of fossil coal, Ukraine ranks first in Europe and eighth in the world. Explored reserves amount to about 56 billion tons, forecast reserves - about 170 billion tons of coal of all grades - from brown to anthracite and coking coal. In recent years, production has remained at the level of 72-83 million tons of coal per year (Fig. 6).

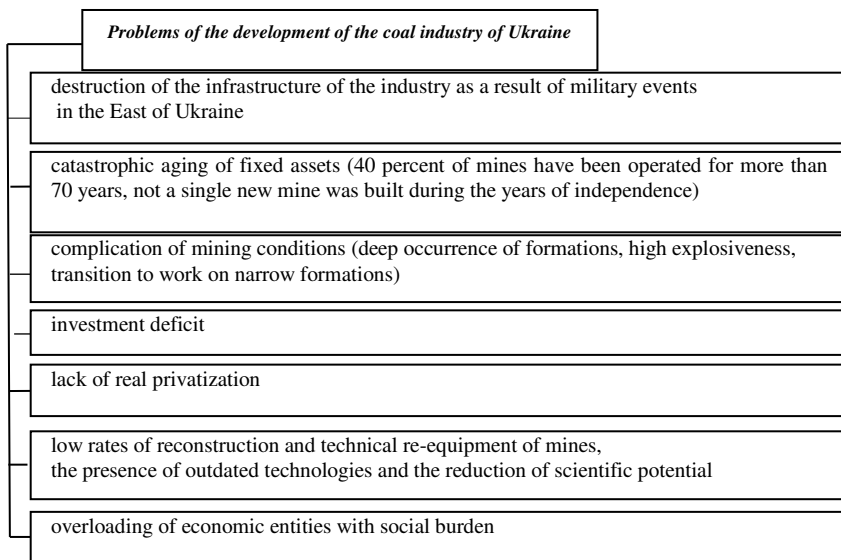


**Fig. 6.** Volumes of coal production in Ukraine for 2009-2014

The coal mining industry is the basis for the fuel and energy complex of Ukraine. At the same time, it is burdened with a whole set of problems (Fig. 7).

The coal mining industry has a complex man-made impact on the environment, namely, changes in natural hydrological regimes; significant areas of land are taken out of the standard ecological regime for landfills and landfills; stationary powerful sources of harmful emissions into the atmosphere and hydrosphere are created.

Thus, from Table 1, we can see that during the years 2010-2015, the volumes of emissions into the atmosphere of pollutants (from 743,3 thousand tons in 2011 to 424,7 thousand tons in 2015) and carbon dioxide (from 2340, 1 thousand tons in 2011 to 384,0 thousand tons in 2015). However, in general, as of 2015, the coal mining industry accounted for about 15% of pollutant emissions from the total emissions by all industries.



**Fig. 7.** Problems of the development of the coal industry of Ukraine

The peat-mining industry in Ukraine is represented by 9 peat-mining enterprises (in the Volyn, Zhytomyr, Kyiv, Khmelnytskyi, Rivne, Sumy, and Chernihiv regions). They are united in the state concern "UkrtoRF". During 2014, they produced 194,6 thousand tons of peat briquettes. The total explored peat deposits (with an area of more than 10 hectares) amount to 1,8 million tons.

Table 1

Emissions of pollutants and carbon dioxide by coal mining enterprises of Ukraine during 2010-2015

	Volumes of emissions			
	pollutants		carbon dioxide	
	thousand tons	in % of the total emissions of industries	thousand tons	in % of the total emissions of industries
2011	743,3	17,0	2340,1	1,16
2012	772,9	17,8	2884,4	1,6
2013	760,1	17,7	1057,6	0,5
2014	424,7	13,3	529,2	0,3
2015	424,7	14,9	384,0	0,3

In the conditions of significant dependence of the economy of Ukraine on imported fuel and energy resources (natural gas, oil) and

the constant increase in their prices, solving the issue of stimulating the development of the peat mining industry as one that provides alternative energy carriers becomes an urgent state necessity. And although peat, geologically the youngest link in the chain of caustobiolites "peat - lignite - hard coal - anthracite", has the lowest level of carbonization and, accordingly, the lowest value of the heat of combustion, the surface location of peat deposits and relatively small costs for the organization and management of mining works make this useful mineral a potentially effective means of energy saving.

Ukraine is the southernmost country in Europe, where peat resources are of industrial importance, which makes peat a real reserve for improving Ukraine's fuel and energy balance. Three Polish regions have the largest peat resources: Volyn, Rivne, and Chernihiv. 1,051 deposits (36% of all deposits in the country) have been discovered and explored on their territory, and geological reserves of peat amount to 1,09 billion tons (50% of Ukraine's reserves).

The amount of peat in the Polish districts of Volyn, Rivne, and Zhytomyr regions reaches 15%. In the western and eastern Polissia, medium-sized deposits (200-1000 hectares) predominate, and in the central Polissia (Kyiv and Zhytomyr regions) small ones - up to 100 hectares.

At this stage of the development of Ukraine's economy, the question of using peat for the development and formation of "small energy" systems and means is relevant, with the aim of obtaining high-quality liquid and gaseous fuel for use in the housing and communal services system, as well as in other economic sectors.

Currently, scientists are working on the technology and equipment of the technological line of biophysical processing of peat, wood and plant waste into liquid and gaseous fuel by the method of "fast pyrolysis" with the output of liquid fuel and gas in volumes of up to 40% of the mass of dry organic matter (sawdust, husk, peat). Energy costs for the implementation of the technology do not exceed 20% of the energy content of the obtained liquid and gaseous fuel. The heat of combustion of the obtained liquid fuel is 42 kJ/kg, corresponding to diesel fuel.

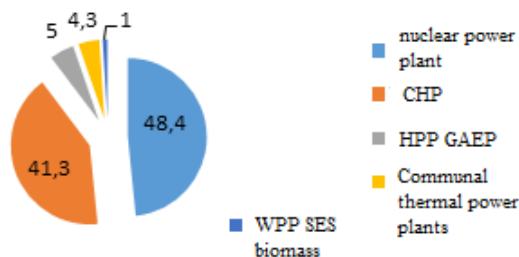
The use of RES energy will save traditional scarce energy resources and improve the ecology of production. However, the state's current lack of incentive measures aimed at supporting the independ-

ent development of peat mining enterprises does not allow it to ensure the proper use of energy potential, which in turn puts obstacles in the way of reducing Ukraine's energy dependence on imported energy carriers (natural gas, oil).

The electric power industry is the last link in the technological chain (from the extraction of energy raw materials to the direct production of energy). According to the sources of electricity generation, it has a branched structure, it includes nuclear power plants (NPP); thermal power plants (TES) and power plants (CHP); hydroelectric power plants (HPP); wind power plants; solar power plants; bioenergy installations.

The United Energy System of Ukraine (UES) has a total installed power plant capacity of 54,5 GW and is one of the largest in Europe. Thus, electricity production in the unified energy system of Ukraine in 2014 amounted to 182,815.4 million kWh. and compared to 2013, it decreased by 5,8%; in 2013, production decreased by 2,3% compared to the same period in 2012 and amounted to 194,377,3 million kWh.

The structure of electricity production in 2014 is shown in Fig. 8.



**Fig. 8.** Structure of electricity production in 2014

As we can see from Fig. 8, thermal power plants and thermal power plants, as well as nuclear power plants, which together provide about 90% of annual electricity production, are dominant in electricity generation. It is worth noting that the so-called thermal power generation (TPP and CHP) is in a pre-crisis state due to the lack of investment and systematic work on the modernization and renovation of power-generating equipment. All TPP and CHP power units were put into operation 40-50 years ago and are characterized by low reliability and efficiency and a high level of emissions of

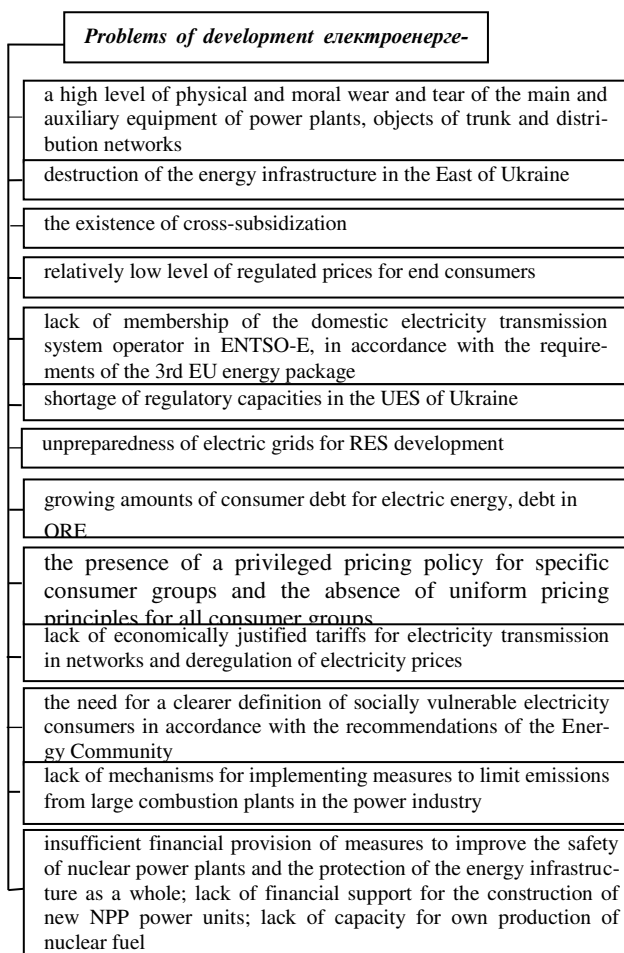
pollutants. Out of 102 power units, 93 (90%) have already exceeded the limits of physical wear, marginal and estimated work resources. Over the past 20 years, no new thermal power generation capacities have been introduced.

The problems in the operation of heat and power generation in Ukraine are typical, as well as for other branches of the state's PEC (presented above). However, since 2014, they have been supplemented by another significant shortage - coal shortage (due to the military conflict in Eastern Ukraine) (Fig. 9).

15 power units with a total installed capacity of 13.9 MW operate at 4 nuclear power plants of Ukraine. On average, they served half of the service life provided by the projects. The existing state program for extending the operating life of each power unit will allow (provided it is timely and fully funded) to preserve the nuclear power industry of Ukraine as a basic branch of the national energy sector for the next 10-15 years. The issue of the completion of 2 power units at the Khmelnytskyi NPP has been postponed for a later period for political reasons.

An additional problem for nuclear power generation in Ukraine is the need to develop its own raw material base and diversify sources of nuclear fuel supply. In terms of discovered uranium reserves, Ukraine ranks first in Europe and sixth in the world. At the same time, own production of uranium raw materials meets the needs of the NPP by only 30%. The construction of the plant for the production of nuclear fuel is suspended. The domestic nuclear power industry mainly uses Russian-made heat-emitting elements to load reactors. The processing of NPP nuclear waste has not yet been fundamentally resolved.

The hydroelectric power industry of Ukraine, despite its relatively small share in the total volume of electricity generation (about 5-6%), plays an important role in ensuring the stability of the combined power system, as it provides it with highly maneuverable capacities in regulating daily load schedules. PJSC "Ukrhydroenergo" includes the combined power plants of the Dnipro and Dniester Cascades, which on average provide annual electricity production of about 11 billion kWh.



**Fig. 9.** Problems of the development of the electric power industry of Ukraine

Ukraine has a sufficient potential of renewable energy sources, which allows to significantly reduce the volume of use of traditional natural resources (experts of the Institute of Renewable Energy of the National Academy of Sciences of Ukraine predict that by 2030, 30% of energy carriers from traditional sources will be replaced by energy carriers from renewable sources).

The "green" tariff operating in Ukraine ensures the attraction of non-state investments and the intensive development of renewable energy. In 2013, the annual volume of electricity produced by renewable electricity generation exceeded 1 billion kWh. As of July 1, 2014, the installed capacity of wind power plants was 497 MW, solar power plants - 819 MW, small hydropower plants - 77 MW, biomass and biogas electricity production facilities - 26 MW.

Electricity is transported by trunk and distribution networks. The length of trunk networks (voltage from 35 kV to 800 kV) is 23.2 thousand km, the length of distribution networks (voltage from 0.4 to 150 kV) is about 1 million km. The power supply system includes 136 main transformer substations and about 200,000 distribution transformer substations. Power grids have the same problem as power generation - they need urgent renewal and reconstruction. Thus, as of January 1, 2013, 42,2% of overhead power transmission lines with a voltage of 220-330 kV in the main power grid had been in operation for more than 40 years, 64.4% of transformer substations had exhausted their estimated technical resource. In the distribution network, up to 40% of lines and transformer substations need to be replaced or overhauled.

In order to fully understand the development of the branches of the fuel and energy complex of Ukraine, we will conduct an analysis of property relations, basic organizational, legal and economic relations and the position of state management bodies regarding the state of affairs in this sector of the national economy.

During the years of independence, PEK of Ukraine went through three stages of privatization. All of them had one common official declared goal - to attract investments for the modernization and revival of the industry. The first stage - 1997-1998 - consisted in the sale by the government of 20-45 percent stakes in 9 of the 27 existing regional energy companies. It was declared that the new owners take on significant investment obligations and have the right to take over state packages of shares of other regional energy companies (so-called external management). The actual result of the first stage of privatization was the practice of mass withdrawal of funds received from electricity consumers to offshore accounts, instead of to the single account of the energy market. The new owners and the so-called management companies of oblenergo grossly violated the

contractual financial relationships between the PEK entities, and put into use barter and promissory note semi-fraudulent settlement schemes. In some months, in Ukraine as a whole, the payment of the energy market for the electricity received by oblenergo amounted to 5-7%. The lack of payments for the generated electricity has put the electricity generating enterprises of PEC on the verge of shutdown, created a threat to the nuclear safety of Ukraine's nuclear power plants. In 1999-2000, the government had to make significant efforts to overcome the catastrophic consequences of the first stage of privatization. A ban on promissory notes and barter schemes of payments for the received electricity was introduced, and the discipline of mutual settlements among energy market participants was increased.

The second stage of privatization began in 2001 and consisted in the sale of shares of another 6 regional energy companies. Unlike the first stage, the sale took place transparently, with the involvement of a strategic investor - the American company AES (acquired Kyivoblenergo and Rivneoblenergo). A categorical requirement was set for the new owners - 100 percent payment for the current (monthly purchased in the energy market) electricity and repayment of the previously accepted electricity debt in accordance with the concluded additional contract. Later, this requirement was extended to the rest of regional energy companies (both privatized at the first stage, and state-owned with external management and simply state-owned). In general, during the next decade, schemes of coexistence of power generation enterprises (state ownership) and almost half (15 out of 27) of privatized power supply companies (oblenergo) were worked out in the energy industry. Practice has shown that there were no significant and the state regulator (the National Energy Regulatory Commission), used the same methodology, which was based on taking into account the amount of useful electricity supply for the corresponding network of subscribers and setting it in electricity tariffs the so-called investment component - a targeted surcharge, which was not paid by the owner of the energy company, but directly by electricity consumers. Additional investment from the owners of energy companies was welcomed, but (despite the provision in the purchase and sale contracts of shares during privatization) was practically differences in investment levels between state-owned and privatized



companies. That is, the main declared goal of privatization (attraction of significant investments) was not achieved. Both state-owned and privatized companies, when developing and approving their annual investment programs at the industry ministry not carried out due to the lack of appropriate control over the implementation of privatization contracts by the State Property Fund of Ukraine and the Cabinet of Ministers.

The third stage of privatization - 2011 - 2013 - was carried out non-transparently, without real competition, with a preliminary limitation of the range of possible participants. For this, a requirement was applied - only the participant who already owns shares of energy enterprises is admitted to the tender for the purchase of shares of state-owned companies. The result was that the owners of energy companies became the same financial groups as at the first stage of privatization. It is impossible to call their activities regarding the modernization of the purchased PEK enterprises positive. There was an excessive concentration of shares of energy companies in the hands of a limited circle of inefficient owners. None of them is a strategic investor, does not have the appropriate financial potential (perhaps, except for R. Akhmetov's DTEK group). All of them, in the conditions of the permanent political struggle going on in Ukraine, are constantly in the zone of changing political influences and, even if desired, cannot form a long-term investment policy due to the threat of property redistribution.

As a result, the capitalization of PEK energy distribution enterprises in 2013 fell catastrophically against the level of 2007 - by 80%. The situation is not better in the electricity generating industry of PEK. If in 2007 their total market value was 6,4 billion US dollars, then in 2009 it was only 1,6 billion US dollars. This is a consequence not only of inflation and the fall of the hryvnia exchange rate, but also of a real lack of systematic and significant investment in PE, regardless of the forms of ownership of economic entities.

The structure of ownership and production capacity is shown below in Table 2.

A considerable list of PEK objects remains in state ownership:

- 7 energy supply companies ("Kharkivoblenergo" - 65% of shares; "Khmelnyskoblenergo" - 70,01% of shares; "Zaporizhzhiaoblenergo" - 60,25% of shares;

- "Mykolaivoblenergo" - 70% of shares; "Cherkasioblenergo" - 46% of shares; " Ternopiloblenergo" - 51% of shares; "Luhansko-blenergo" - 60,06% of shares);

Table 2

Structure of ownership and production capacity of PEK of Ukraine

Financial and industrial group	Name of the energy supply company	Name of the power generating company (thermal power plant, thermal power plant, hydroelectric power plant, gas power plant)
DTEK	1. "DTEK Dniprooblenergo." 2. "DTEK Donetskooblenergo" 3. "Kyivenergo" 4. "DTEK Krimenergo" 5. "DTEK Service-invest" 6. "DTEK PEM-energy coal"	1. "DTEK Dniproen-ergo" 2. "DTEK Zahidenergo" 3. "DTEK Eastern Energy" 4. TPP "Kyivenergo" 5. Myronivska TPP 6. "Kyiv CHP - 5" 7. "Kyiv CHP - 6"
VS Energy International Ukraine	1. "EC Zhytomyroblenergo" 2. "Kyivoblenergo" 3. "Kirovogradoblenergo" 4. "EK Odesaoblenergo" 5. "EK Sevastopolenergo" 6. "EK Chernivtsioblenergo" 7. EC Khersonoblenergo" 8. "Rivneoblenergo"	
Svarog Asset Management	1. "Vinnytsia Oblenergo" 2. "Luhansk Energy Association" 3. "Poltavaoblenergo" 4. "Sumioblenergo" 5. "Chernihivoblenergo"	1. "Kremenchutsk CHP" 2. "Crimea CHP"
"Energy Ukraine", "Ukrizgaz"	1. "Volynoblenergo" 2. Zakarpattiaoblenergo	1. "Kharkiv CHP - 5"
Energoinvest Holding		1. "Donbasenergo" (60.7% of shares)

- packages of 25% + 1 share of 7 energy supply companies ("Vinnytsiaoblenergo", "DTEK Dniprooblenergo", DTEK Donetskooblenergo",

"Zakarpattiaoblenergo", "Kyivenergo", "DTEK Krimenergo", "EK Chernivtsi-oblenergo");

- "Regional Electric Networks" enterprise;

- TPP "Donbasenergo" (25% + 1 share);

- TPP "Centroenergo" (78.29% of shares), "Zakhidenergo" (25%+1 share); "DTEK Dniπροenergo" (25%+1 share); Dniester HPP (84.79% of shares);

- Dniprodzerzhynska, Kryvorizka, Severodonetsk, Zuyevska, Ukrinterenergo Kaluska, Lysychanska, Kharkivska Eskhar, Odessa, Mykolaivska, Khersonska thermal power plants;

- NPP and HPP of the Dnipro Cascade;

- 50%+1 share of PJSC "Ukrnafta" (49% of shares - sold in previous periods under contractual schemes in the interests of the "Privat" group);

- SE NEC "Ukrenergo";

- SE "Ukrgezvydobuvannya";

- 35 coal mines.

The participation of the state in companies of the oil and gas industry of Ukraine in 2013 is given in Appendix B.

Privatization of NPPs and HPPs of the Dnipro Cascade is prohibited by law. SE NEK "Ukrenergo" as the basic national operator of electricity grids needs significant reform and bringing it into line with the 3rd EU energy package. But even without them, the above list of objects likely to be included in the fourth stage of privatization is more than significant. The main thing is which economic strategy will be the basis: selling to anyone under any conditions just to temporarily replenish the state budget or preparing for the sale of PEK objects and selling them to real investors with a real possibility of reprivatization in case of violations of the conditions of the long-term post-privatization period.

The problems of the technical condition of PEK and the shortcomings of its privatization are largely due to the imperfection of the existing system of state management of the industry. During the years of independence, it underwent a number of reorganizations, the declared goal of which was the transition from sectoral to functional management and approximation to EU standards. As of 2015, its key entities are:

- The Cabinet of Ministers of Ukraine (CMU) is the central body of the executive power of Ukraine;

- The Ministry of Energy and Coal Industry of Ukraine (Ministry of Energy and Coal Industry of Ukraine) is the main body in the system of central executive bodies in the formation and implementation of state policy in the electric power, nuclear industry, coal industry, oil and gas and peat mining complexes;

- The National Commission for State Regulation in the Energy and Utilities Sector (NKREKP) is a state regulatory body in the energy and utility sector, subordinate to the President of Ukraine, accountable to the VRU;

- The State Agency for Energy Efficiency and Energy Saving of Ukraine (Derzhenergoefficitnosti Ukraine) is the central body of the executive power to ensure the implementation of state policy in the areas of effective use of fuel and energy resources, energy saving, renewable energy sources and alternative fuels. The agency's activities are directed and coordinated by the CMU through the Minister of Economic Development and Trade of Ukraine.

These four subjects of state management of the PEC determine prospective and current industry policy, form energy balances, implement tariff policy, etc.

The indirect subjects of state management of the PEK include: the Ministry of Ecology and Natural Resources of Ukraine (Ministry of Natural Resources of Ukraine); Ministry of Regional Development, Construction and Housing and Communal Services of Ukraine (Ministry of Regional Development of Ukraine); Ministry of Economic Development and Trade of Ukraine. The mentioned three ministries indirectly influence the activity of the PEK, applying regulatory means of influence within the limits of their powers.

Vertically integrated natural monopolies with specialization in individual sectors of the energy sector, state-owned economic entities subordinated to and belonging to the sphere of management of the Ministry of Energy and Coal of Ukraine are as follows: DK NEC "Ukrenergo"; JSC "Ukrhydroenergo"; SE NAEK "Energoatom"; SE "Coal of Ukraine"; DK "Nuclear fuel"; JSC "Naftogaz of Ukraine"; DK "Ukrtorf".

The key subjects of management are forced to act in the conditions of the parliamentary-presidential political system in Ukraine,

periodically falling under various political influences that do not allow conducting a scientifically and economically sound, purposeful, long-term sectoral policy. Constant (after two or three years) changes of governments, virtually destroyed personnel policy, ambiguous reform of the civil service caused a significant decrease in the level of state branch management in the last 10 years. The same applies to the intermediate subjects of state administration of the PEC.

In such conditions, both vertically integrated natural monopolies and other PEK business entities, on the one hand, are deprived of qualified assistance and coordination, on the other hand, they use the incompetence of industry management and lack of control to allow abuses and violations in financial and economic activity.

In general, the reorganization and reform of the PEK in 2012-2015, despite the relevant declaration by state authorities, have not yet brought the industry closer to the EU requirements, but only partially strengthened the functional capabilities of the state management bodies of the PEK. This is confirmed by the problems in the activity of PEK as a system user of nature, which are not only not resolved, but also worsened in recent years.

To analyze these problems, we will use data from 2012 as the last period for which the Ministry of Natural Resources of Ukraine published the "National report on the state of the natural environment of Ukraine in 2012". For 2013 and 2014, there are no such detailed statistical and analytical reports. In general, in Ukraine, the system of statistical data on the state of the environment is in the stage of formation. Objective control is carried out on a territorial basis, not on a branch basis. System monitoring is established mainly based on the state of atmospheric air. There is no comprehensive monitoring of the ecological impact of the main polluters of the environment (to which PEK enterprises belong) in temporal and spatial dimensions. It is replaced by episodic fragmentary environmental surveys.

An important positive in the activity of the economic complex of Ukraine should be attributed to a significant decrease (by 36% - from 0,98 kg of energy consumption/UAH to 0,621 kg of energy consumption/UAH) for the period from 2000 to 2012 in the energy intensity of domestic gross product (GDP). However, this result is

mainly the result of structural changes in GDP and its positive dynamics, and not technological modernization of the main industries.

PEK of Ukraine is both a producer of energy resources and a significant consumer state.

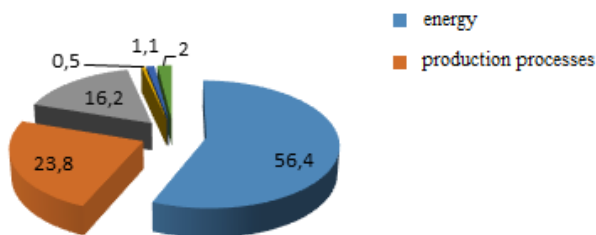
PEK is the biggest polluter of atmospheric air among all sectors of the economy of these energy resources. Its energy consumption is up to 9% of the total in the . In 2012, its enterprises for the production, distribution of electricity and gas accounted for 1,882,7 thousand tons of emissions (excluding carbon dioxide). In 2012, this group of enterprises increased emissions into the atmosphere by 4.2%. Enterprises of the extractive sector of PEK emitted 772.9 thousand tons of pollutants into the atmosphere in 2012 (4% more than in 2011). In total (excluding oil refining), PEK enterprises emitted harmful substances into the atmosphere in 2012 with a total mass of 2,655.6 thousand tons, which is 61,3% of all pollutant emissions by economic entities of Ukraine (for reference: from a total of 8,434 enterprises of all industries, the total emission of polluting substances into the atmosphere amounted to 4335,3 thousand tons).

According to the data of the State Statistics Service of Ukraine, in 2014, in terms of sectors of the economy, the largest share of emissions of pollutants and carbon dioxide falls on the production and distribution of electricity, gas, and water - 43,8% and 54,7%, respectively. The second polluter by volume is the processing industry: it accounts for 30,4% of emissions of pollutants and 39,3% of emissions of carbon dioxide. In particular, the share of metallurgy in the total volume of emissions of polluting substances in the country is 25,1%. In turn, the extractive industry accounts for 17,5% from total emissions of pollutants into the atmosphere (Table 3).

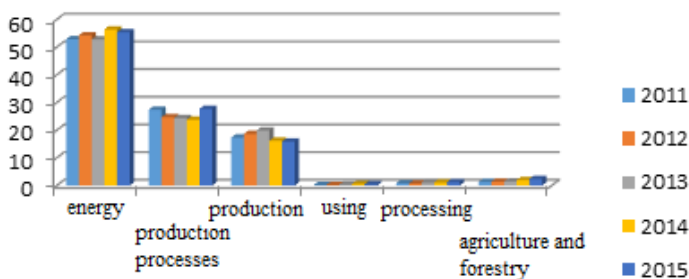
Thus, in terms of production and technological processes, as well as technological equipment, the main polluters of atmospheric air are energy companies (56,4% of all emissions into the atmosphere from stationary sources of pollution in 2014) (Fig. 10, Fig. 11).

The above data confirm the relevance of our research for understanding the real state of affairs and ways of its further improvement. That is, the pursuit of profits by the state and the new owners of privatized PEK enterprises takes place with a complete disregard for ecological reality and environmental prospects. Without a real, rather than declared, reform of the PEC on the basis of its technological modernization, the environment of Ukraine is threatened with sys-

temic destruction, and the population expects an increase in lung, cardiovascular and oncological morbidity.



**Fig. 10.** Emissions of pollutants into the atmosphere from stationary sources of pollution in terms of production and technological processes, technological equipment in Ukraine in 2014



**Fig. 11.** Emissions of pollutants into the atmosphere from stationary sources of pollution in Ukraine in 2011-2015

In this regard, the example of the Carpathian city of Burshtyn (Ivano-Frankivsk region) is illustrative. The thermal power plant located there is part of Zahidenergo PJSC (now privatized by DTEK). Technologically, it consists of 12 power units with a capacity of 200 MW each, commissioned in 1965-1969. The total capacity of the station is 2400 MW. The main technological fuel is coal from domestic coal basins. On July 1, 2002, the industry ministry launched an experiment at the TPP: the so-called "Burshtyn Energy Island". Its essence is the separation of TPP from the unified energy

system of Ukraine and parallel work with the unified energy system of European countries (UCTE) for the export of electricity.

The main consideration here was the favorable geographical location of the station - proximity to the state border, a short length of power grids leading to the EU, which means - small technological losses of electricity during its transportation. At the same time, neither the age of the equipment nor the fact that work in such conditions requires the inclusion of 6 out of 12 available blocks for loading, and not a maximum of 9, as was the case before, was not taken into account. As a result, there is an increase in the number of accidents at power units due to more intensive operating conditions. And in terms of ecology, the consequences for Burshtyn and its surroundings are much more critical.



Table 3

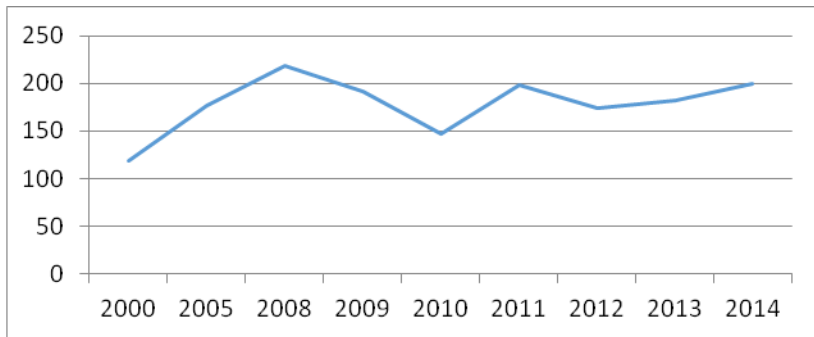
## Volumes of emissions of pollutants from stationary sources of pollution in 2011-2015 by types of economic activity

Types of economic activity	Volumes of emissions in 2011				Volumes of emissions in 2014				Volumes of emissions in 2015			
	<i>pollutants</i>		<i>Carbon dioxide</i>		<i>pollutants</i>		<i>Carbon dioxide</i>		<i>pollutants</i>		<i>Carbon dioxide</i>	
	thousand tons	in % to the total	thousand tons	in % to the total	thousand tons	in % to the total	thousand tons	in % to the total	thousand tons	in % to the total	thousand tons	in % to the total
In total	4374,6	100,0	202222,0	100,0	3190,4	100,0	153119,4	100,0	2857,4	100,0	138932,1	100,0
Agriculture, forestry and fisheries	74,7	1,7	824,6	0,4	77,0	2,4	775,0	0,5	77,7	2,7	1110,4	0,8
Mining and quarrying, including:	856,2	19,6	3795,6	1,9	556,8	17,5	2753,5	1,8	490,9	17,2	2519,4	1,8
extraction of stone and brown coal	743,3	17,0	2340,1	1,2	424,7	13,3	529,2	0,3	424,7	14,9	384,0	0,3
extraction of metal ores	112,9	2,6	1455,5	0,7	96,4	3,0	1374,4	0,9	96,4	3,4	1207,4	0,9
extraction of other minerals and development of quarries	X	X	X	X	7,9	0,2	44,4	0,0	7,9	0,3	74,6	0,1
Processing industry, including:	1387,4	31,7	89501,1	44,3	968,7	30,4	60169,8	39,3	941,4	32,9	57426,6	41,3
production of food products, beverages and tobacco products	31,9	0,7	2674,3	1,3	39,7	1,2	2522,8	1,6	38,3	1,3	2005,4	1,4

Continuation of Table 3

production of coke, oil refining products	93,2	2,1	5749,9	2,8	43,8	1,4	3447,1	2,2	43,8	1,5	3034,1	2,2
chemical production	67,8				17,7	0,6	4245,7	2,8	17,7	0,6	4388,1	3,2
production of other non-metallic mineral products	55,3				33,7	1,0	5406,2	3,5	33,3	1,2	5642,1	4,1
metallurgical production and production of finished metal products	1102,3	25,2	64073,1	1,5	7190,7	3,6	42468,0	27,7	870,7	30,5	40544,5	29,2
Supply of electricity, gas, steam and air conditioning	1805,3	41,3	100537,6	1,2	7035,7	3,5	83782,8	54,7	1174,3	41,1	72250,6	52,0
Construction	20,3	0,5	601,8	0,3	4,6	0,1	614,3	0,4	3,4	0,1	467,7	0,4
Transport, warehousing, postal activities	195,4	4,5	5711,0	2,8	123,3	3,9	3231,9	2,1	76,3	2,7	2419,1	1,8
Other types of economic activity	35,3	0,8	1250,3	0,6	54,1	1,7	1723,0	1,1	55,1	2,0	2377,6	1,7

In particular, emissions of TPP pollutants into the atmosphere increased by almost one and a half times over 12 years (Fig. 12).



**Fig. 12.** Emissions of pollutants into the atmospheric air in the city of Burshtyn, thousand tons

In 2012, Burshtyn accounted for 4% of harmful emissions into the atmosphere from the total number of them in Ukraine as a whole. The town of 16,000 people was second only to Mariupol, Kryvyi Rih and Zelenodolsk in terms of this indicator. By the way, Zelenodolsk (population 15,000) has no less problematic environmental dynamics. DRES-2, located near Kryvorizka, has increased the volume of emissions of pollutants into the atmosphere by 2,8 times (from 79,4 to 219,3 thousand tons) in 12 years. In both cities, it was the powerful PEK enterprises that caused the extremely difficult environmental condition.

PEK enterprises (especially the coal industry) are the biggest polluters of water bodies. In 2012, they discharged 295 million cubic meters of polluted wastewater without treatment, which was a third of the total corresponding indicator of the industry, in 2013 – 307 million cubic meters of polluted wastewater. Unfortunately, in 2014, the State Statistics Service does not provide data on the volume of discharge of polluted return water into surface water bodies by enterprises of economic sectors (including the coal industry), limiting itself to information on the discharge of contaminated, insufficiently purified return water by region.

Specific negative features of the impact on the environment are characteristic of certain branches of PEK. In particular, enterprises

producing fuel and energy minerals are the main "suppliers" of carbon dioxide into the atmosphere - 2884,4 thousand tons in 2012, which is 23,2% more than the level of 2011. Methane emissions also increased by 5,4% and totaled 633,6 thousand tons. Emissions of nitrogen and sulfur compounds practically do not decrease and are accounted for in the total amount of up to 30,000 tons.

The danger of subsidence of the surface above mine workings does not decrease. In Ukraine as a whole (in Volyn, Dnipropetrovsk, Donetsk, Luhansk and Lviv regions), this negative phenomenon covers an area of 2,4 thousand square kilometers. The microdistricts of Donetsk, Makiivka, Horlivka, Yenakievo, Novovolynsk, Sokal, and Chervonograd are in dangerous zones.

In 2012, coal and peat mining enterprises accumulated 44,4 million tons of industrial waste (10% of the total by industry), and the total volume of accumulation is 3,4 billion tons (23,1% of the total by industry) and has a steady growth trend. Half of the liquidated coal enterprises of Ukraine are located on the territory of Donetsk region - 50 mines and 2 beneficiation factories. On the balance sheet of the State Enterprise "Donvuglerestructuring" in the settlement zone of settlements there are 180 rock dumps, 49 of which are burning. Their area is 958,4 hectares. The situation is similar in Luhansk region.

The state of affairs in the nuclear power industry with the management of radioactive waste requires special attention. This issue receives insufficient attention both from relevant ministries and agencies, as well as from environmental activists and the general public. There is no closed technological cycle for the processing of radioactive waste in the PEC of Ukraine. All operating nuclear power plants have their own temporary storage facilities for spent fuel and radioactive waste. Their filling is on average 60%. Repositories of liquid radioactive waste are 20-80% full. These storage facilities are temporary and are not designed for long-term storage and increase in the volume of radioactive waste. For example, about 200 tons of irradiated and fresh nuclear fuel mixed with other components are concentrated at the "Shelter" facility of the decommissioned Chernobyl NPP.

The volume of radioactive waste in Ukraine is predicted to grow due to:

- the return to Ukraine of highly active radioactive waste after the processing in Russia of spent nuclear fuel from Ukrainian nuclear power plants;
- operation of existing nuclear power plants due to the extension of their operating period, commissioning of new nuclear power units;
- accumulation of radioactive waste in temporary storage;
- the absence of a really working modern infrastructure for the processing, storage and disposal of radioactive waste.

In general, during the years of Independence, having a tragic example of previously committed criminal negligence (Chernobyl NPP), all governments of Ukraine postponed solving the problems of handling radioactive waste for an indefinite future. For a country with 15 working nuclear reactors of 4 NPPs and technological dependence on radioactive waste processing from Russia, the absence of an appropriate specific state program may lead to new catastrophic consequences in the near future.

Serious environmental problems are not solved by the production of nuclear fuel. In the city of Zhovti Vody of the Dnipropetrovsk region (the only uranium ore mining center in the country), the population has been living under conditions of technogenic radiation pollution since the 1950s. On the territory of the city, there are more than 400 local areas with a radiation background 5-20 times higher than the natural background. Air, water, and soil are contaminated with radionuclides. In residential premises, the concentration of radon exceeds the permissible standards by several times. The city has accumulated 50 million tons of waste, including 1.4 million tons of toxic I-IV hazard classes. In general, in the region where uranium ore is mined and primary processed, in addition to Zhovty Vody, similar problems occur in the cities of Dniprodzerzhynsk, Kirovohrad and the 7th districts of Kirovohrad and Dnipropetrovsk regions. To reduce the radiological contamination of the mentioned territories, the government should urgently develop and finance a state program to increase the level of radiation safety in the uranium mining industry.

So, as we can see, the fuel and energy complex of Ukraine does not meet the requirements for the energy complex of an independent state: two fundamental principles of energy are significantly violated, namely, reliable, sustainable energy supply and efficient use of energy resources. Due to the inconsistent activity of the state authorities,

not only was the improvement and optimization of the PEC not carried out, but also there was a significant deterioration of its technical condition, technological and raw material external dependence, as well as an increase in the negative man-made impact on the environment, despite a significant reduction in the volume of extraction, production and consumption of energy resources in Ukraine.

## **2. Provision of an innovative model of national energy development by strengthening environmental regulation**

In the previous sections of the work, the state of the PEC of Ukraine as a systemic nature user was considered, the directions of its development from the point of view of ensuring the energy security of Ukraine were assessed, an ecological and economic approach was applied to the analysis and selection of the optimal solution during expert evaluations of new energy technologies. At the same time, the dominant emphasis in our research was on the interaction of the PEK with the environment, on the factors and influences manifested in the process of this interaction, which, in our opinion, meets modern requirements, corresponds to European approaches and the main provisions of the strategy of sustainable development that is relevant for modern civilized society. development

It should be noted that today the innovative direction of development is a basic strategy for business, where knowledge together with social capital create competitive advantages of individual countries and regions to a greater extent than their natural resources. Innovative processes are becoming the main source of economic growth, especially in the context of the modern paradigm of sustainable development and limited natural resources, including energy. Qualitative technological and organizational changes are the basis of innovation.

According to the Law of Ukraine "On Innovative Activity", innovations are newly created (applied) and (or) improved competitive technologies, products or services, as well as organizational and technical solutions of a production, administrative, commercial or other nature that significantly improve the structure and quality of production and (or) the social sphere.

Given that there is a significant share of natural monopolies in the energy industry, one should understand the special role of state authorities in organizing and stimulating the innovative activities of

PEK enterprises. Legislation provides for sufficiently wide application of methods of state regulation of innovative activity, which should be carried out by:

- determination and support of priority areas of innovative activity at the state, branch, regional and local levels;
- formation and implementation of state, branch, regional and local innovation programs;
- creation of a regulatory and legal framework and economic mechanisms to support and stimulate innovative activity;
- protection of the rights and interests of subjects of innovative activity;
- financial support for implementation of innovative projects;
- stimulation of commercial banks and other financial and credit institutions that provide credit for the implementation of innovative projects;
- establishment of preferential taxation of subjects of innovative activity;
- supporting the functioning and development of modern innovative infrastructure.

In accordance with the Law of Ukraine "On priority areas of innovative activity in Ukraine", priority areas are defined as areas of innovative activity aimed at ensuring the economic security of the state, creating high-tech competitive environmentally friendly products, providing high-quality services and increasing the export potential of the state with the effective use of domestic and world scientific and technical achievements.

The priority directions of innovative activity in Ukraine are divided into strategic (intended for the long term - at least 10 years) and medium-term (intended for implementation within the next 3-5 years).

The strategic directions of innovative activity are legally defined for the PEC of Ukraine, the modernization of power plants; new and renewable energy sources; the latest resource-saving technologies; protection and improvement of people and the environment.

Medium-term areas of innovative activity for PEK include:

- new and renewable energy sources;
- the latest resource-saving technologies;
- modernization of power plants and power networks;

- power supply networks of nuclear power plants;
- steam and gas plants and technologies for burning low-grade solid, liquid and gaseous fuels;
- means of labor protection and improvement of safety techniques at coal mining enterprises;
- methods and methods of extraction and utilization of methane from coal deposits;
- oil and gas drilling equipment;
- modernization of gas, oil, ammonia transportation systems;
- energy-efficient light sources and lighting systems;
- energy-efficient, resource-saving, modular equipment for heat supply, water treatment, water supply and drainage.

Therefore, the legislative main task of innovative activity programs in the PEC is defined as the creation of an optimal fuel and energy balance of the state, taking into account energy security; diversification of energy supply sources and energy technologies; an increase in the share of coal and electricity consumption of nuclear power plants due to a decrease in the share of natural gas use; development and implementation of the latest coal burning technologies and TPP modernization; creation of own nuclear fuel cycle; development of the use of renewable energy sources.

It should be noted that the determination of the priority areas of the state innovation policy is only the first step on the path of systemic innovation development. The main task of state regulation of innovative activity is to create appropriate regulatory mechanisms and use their capabilities in the following areas:

- regulatory and legislative framework;
- tax policy;
- tariff and price policy;
- ensuring privatization processes;
- creation of market conditions of competition;
- attraction of investments;
- financial support.

Each of the above-mentioned directions is important and must correspond with the others. Their implementation in the conditions of



PEK can become the subject of a separate study that goes beyond the scope of our work. At the same time, we note the following regarding the financial support of the innovative activity of PEK.

Financing of innovative activities has always been one of the key problems in Ukraine. The main financial sources were supposed to be:

- own funds of business entities (at the expense of part of the profit and depreciation deductions);
- part of the funds received from the privatization of PEK facilities;
- private domestic investments;
- foreign investments;
- funds of the Wholesale electricity market (for the electric power industry);
- state financial support.

Since 2010, government financial support has mainly been provided through the branch ministry as the main fund manager for applied research by branch research institutions. Thus, the total budgetary financing of innovative activity and technology transfer for 2012 in Ukraine amounted to UAH 222,8 million, including UAH 58,5 million for the Ministry of Energy and Coal. (26,2% of the total volume).

Taking into account the technological level of PEK, the total need for innovative financing (according to experts' estimates) is from UAH 8 to 12 billion annually. Economic entities will not be able to obtain such financial resources by their own efforts without targeted foreign investment. Therefore, the problem of creating an attractive investment climate in the PEK of Ukraine for the activation of innovative processes has acquired special importance.

As noted by specialists of the National Institute of Strategic Studies, in order to increase the investment attractiveness of the innovative PEK market of Ukraine, it is necessary to implement a consistent set of measures for rational environmental management.

Achieving the specified levels of basic indicators requires not only intensification of investment activity.

In the end, the environmental regulation of the work of the PEK (as well as other branches of the economic complex) requires the construction of a new system of relationships in the chain: central government - regional government (local self-government) - business entity.

However, the dominant role of the central authorities in the implementation of the system of economic and environmental regulation and control over this process has objectively encountered insurmountable difficulties in the current conditions, namely: lack of effective and objective environmental monitoring; unsatisfactory control over the implementation of state environmental programs and a formal approach to monitoring the implementation of regional environmental programs.

At the same time, regional authorities and local self-governments (in contrast to similar structures of EU member states) do not consider ecological problems of their territories as absolutely priority issues, paying mainly attention to socio-economic issues, the state of housing and communal services, employment of the population.

### **Conclusions**

We believe that in the conditions of reforming local authorities through decentralization and transfer to them of a significant part of powers from the central government, the creation of executive committees at the level of regional and district councils, there are favorable circumstances for strengthening the environmental component at the local level by developing truly relevant target programs adapted to the real state of the environment in each settlement, taking into account environmental monitoring and the activities of the located business entities.

This approach, in our opinion, will best stimulate business entities to a consistent innovation process to reduce harmful emissions and other destructive effects on the environment to regulatory requirements for the purpose of rational environmental management.

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