

Volodymyr O. Onyshchenko<sup>1</sup>, Iryna A. Bryzhan<sup>2</sup>, Vira Y. Chevhanova<sup>3</sup>  
**ECOLOGICALLY ORIENTED DEVELOPMENT OF UKRAINE'S  
ECONOMY: PROBLEMS AND PERSPECTIVES**

*The solution of problems in solid waste recycling and low-cost power supply is shown on the example of a special waste products recycling complex. The offered organizational scheme of such complex functioning gives an opportunity to improve the energy efficiency of the economy, reduce the negative impact on the environment and promote ecologically oriented economic development of Ukraine.*

*Keywords: ecologically oriented development; alternative sources of energy; bioenergy; municipal solid waste.*

**Володимир О. Онищенко, Ірина А. Брижань, Віра Я. Чевганова**  
**ЕКОЛОГООРІЄНТОВАНИЙ РОЗВИТОК УКРАЇНИ:  
ПРОБЛЕМИ ТА ПЕРСПЕКТИВИ**

*У статті вирішення проблем утилізації твердих побутових відходів та низьковитратного енергозабезпечення показано на прикладі створення спеціального комплексу з утилізації відходів. Запропоновано організаційну схему роботи такого комплексу, яка сприятиме підвищенню енергоефективності економіки, зниженню негативного впливу на навколишнє середовище і забезпеченню екологоорієнтованого розвитку економіки України.*

*Ключові слова: екологоорієнтований розвиток; альтернативні джерела енергії; біоенергетика; тверді побутові відходи.*

*Табл. 2. Рис. 3. Літ. 18.*

**Владимир А. Онищенко, Ирина А. Брижань, Вера Я. Чевганова**  
**ЭКОЛОГООРИЕНТИРОВАННОЕ РАЗВИТИЕ УКРАИНЫ:  
ПРОБЛЕМЫ И ПЕРСПЕКТИВЫ**

*В статье решение проблем утилизации твердых бытовых отходов и низкокзатратного энергообеспечения показано на примере создания специального комплекса по утилизации отходов. Предложена организационная схема работы такого комплекса, которая даст возможность повысить энергоэффективность экономики, снизить негативное воздействие на окружающую среду и обеспечить эколого-ориентированное развитие экономики Украины.*

*Ключевые слова: экологоориентированное развитие; альтернативные источники энергии; биоэнергетика; твердые бытовые отходы.*

**Introduction.** The current model of Ukraine's economic development is based on short-term gains, without taking into account future development. The negative consequences of using such model are: climate changes, losses in biodiversity, depletion of natural capital, lack of fresh water, food and energy. Gradual public awareness of ecological and economic problems that influence the environment caused the formation of the concept of ecologically oriented development, which aims to replace the traditional concept of economic development based on extensive consumption of natural resources. With ecologically oriented development it becomes possible to

<sup>1</sup> Yuri Kondratyuk Poltava National Technical University, Ukraine.

<sup>2</sup> Yuri Kondratyuk Poltava National Technical University, Ukraine.

<sup>3</sup> Yuri Kondratyuk Poltava National Technical University, Ukraine.

meet the necessary needs of all members of the society by improving the functioning, stability and ability to resist the destructive effects and conditions under which such development does not lead the global civilization beyond the economic capacity of the biosphere and does not cause destructive processes and biosphere degradation, at the same time ensuring its preservation and gradual restoration of the environment integrity, the balance between nature and potential needs of people of all generations.

Economic and ecological development require the achievements of scientific and technological progress providing high efficiency and low natural resource intensity of production to be the basis for economic growth. Therefore, Ukraine should make a gradual transition to a more efficient use of scarce resources and reduce the economic dependence on traditional fossil energy.

The contradiction between economic and ecological development has a double nature. On the one hand, economy should grow, on the other hand, this development gives a rise to adverse environmental effects. One of the most pressing ecological problems in Ukraine is environmental pollution caused by production and consumer waste. Various types of waste cover around 4% of Ukrainian territory: chemical industry waste, household waste etc. Industrial waste, as well as domestic, are removed to unauthorised disposal fields because of lack of waste landfills. In Ukraine the share of solid domestic waste landfills in the total greenhouse gases emission that enter the stratosphere is 2.8%, with the trend of annual increase. Due to continuous increase of the accumulation of solid waste in landfills, gas emissions have been increased by 16% (from 8.4 to 9.7 mln tones CO<sup>2</sup> eq.) during 1990–2009. On the other hand, today for Ukraine one of the most important conditions for eco-oriented development is solving the problems of energy production and increase the share of alternative energy sources. Climate is being changed by current energy systems based on fossil fuel. The part of the energy sector accounts for two-thirds of greenhouse gas emissions. An increase in energy supply from renewable sources reduces harmful effects on the environment. Therefore, the use of ecologically oriented development model is very relevant for Ukraine, and the promotion of such development is possible through the combination of ways to solve the problems of waste management and bioenergy development in Ukraine, including biogas production at solid waste landfills.

**Resent research and publications analysis.** Domestic researchers have noted the high quantitative potential of alternative energy in Ukraine. However, currently the use of this potential is very inefficient. Researchers have developed approaches to the development of alternative energy in general and biomass in particular. But mainly scholars consider the use of logging and wood waste, biomass crops (G. Geletukha and T. Zhelezna, 2010; A. Deyneka, 2009; I. Dubrovin et al. 2009); animal waste (G. Ratushnaik and V. Dzhezdzhula, 2008). The issue of recycling and reuse of wastes was studied by N. Konysheva, N. Kushnyrovych, L. Rozhkov and R. Bezverhova (1992), A. Nevelov (1987) and others. However, in scientific literature little attention is paid to the integrated approach of solving the problems related to wastes, increase in the share of alternative sources and reducing negative environmental impact.

**The aim of the research** is studying the feasibility of complex solving of the problems with solid waste disposal and low-cost energy supply for industries and the residential sector using regional development instruments such as public-private partnership.

**The object of this research** is ecological and economic processes associated with recycling and bioenergy development in Ukraine as a renewable energy source.

**The methods of research** are systemic and comparative analysis of scientific literature and statistical information.

**The global trends in renewable energy.** Renewable energy market and industries are dynamically developing in most European countries. In 1995 in the EU countries 74.3 mln tons of oil equivalent (o.e.) fell to renewed energy sources share that made about 6% of the total energy consumption. In 2011 in the European Union renewable source of energy covered 20.6% of electricity consumption and 13.4% of the gross final energy consumption. Global demand for renewable energy is supplying an estimated 19% of global final energy consumption in 2011. However, some countries have higher electricity demand. For example, in Denmark renewable sources account for 40 % of electricity production, in Spain – 30,5%; in Romania – 28,1%; in Slovenia – 25,1%.

The need for renewable energy can be explained by the following reasons: first, the provision of the world power industry with basic kinds of fuel are: uranium for 30 years, oil – 40 years, natural gas – 60, coal – 200. But the possibility of alternative sources of energy is very significant. So renewable sources of energy can cover a part of the global energy demand (in %): sun – 380%; geothermal – 100%; wind energy – 50%; biomass – 40%; flow hydropower – 15%; ocean energy – 5%. Second, the cost of all kinds of fuel will rise, which is connected with the necessity of the existing fuel complex enterprises renovation, putting into operation the remote deposits with more complicated and expensive ways of extraction. In the long-term, various studies by the International Research Council and the International Energy Agency confirm that oil prices would continue to rise due to the growing oil demand and the increasing cost of developing new oil fields. Third, traditional energy causes vast damage to the environment. Climate changes would be a good reason for moving towards renewable energy.

Energy security is a critical policy issue for all countries. That's why the world public opinion is more supporting renewable energy sources. At least 138 countries had renewable energy targets (Renewables, 2013). The EU directive on renewable energy in 2003 gave guidelines to each of the European countries and set 10% renewable energy use target by 2020 year for Europe overall. Some European countries took even higher percentages for renewable fuel used internally. For example, the national legislation in Finland and the US are targeting 20% of renewable fuel use by 2020, Denmark – 50% by 2020. Germany is on the way to the green energy system and by 2050 its total energy supply will by 50% based on renewable energy.

In Ukraine, government programs set targets to improve the use of alternative energy sources – according to the Ukrainian Energy Strategy in 2010 about 19% of the total energy balance is required to be generated from renewable energy sources. But today, despite the presence of significant technical potential for renewable energy, Ukraine has worse position as compared to other European countries. During 2011 the production of electricity from renewable energy sources accounted for 5,8% of the total production.

**Ukrainian market and industry of renewable energy.** According to the experts of the National Academy of Sciences of Ukraine, the total annual technically feasible

energy potential of renewable energy sources in Ukraine is about 98 mln in standard fuel (Table 1), which is more than 50% of the total energy consumption in Ukraine at present and 30% of energy consumption in 2030 (Kudrya, 2011; Tytko and V. Kalinichenko, 2010). Among all energy sources in Ukraine, wind power and biomass have the greatest economic potential.

*Table 1. The potential of renewable energy in Ukraine (Kudrya, 2011)*

#	Renewables	The annual technically feasible energy potential	
		bln kWh h / year	mln tons coal equivalent / year
1.	Wind power	79.8	28.0
2.	Solar energy	38.2	6.0
3.	Small hydropower	8.6	3.0
4.	Bioenergy, including:	178	31.0
5.	Geothermal heat energy	97.6	12.0
6.	Ambient energy	146.3	18.0
Total amount of substitution of traditional energy resources		548.5	98.0

**The analysis of current status of bioenergy development.** According to previous research, Ukraine has significant potential of biomass suitable for energy production. According to expert estimates and the official statistics, the total potential of biomass is 30 mln tons of coal equivalent, which can meet 18% of Ukraine's primary energy (including biogas from landfill and sewage disposal is more than 0.5 mln tons of standard fuel) (Geletukha and Zhelezna, 2010). Distribution of technically feasible potential of biomass energy by Ukraine's regions is shown in Figure 1.

Currently, the contribution of biomass energy is about 0.7% in Ukraine. Only about 1.3 mln tons of oil equivalent is currently used as wood for domestic purposes as well as for fuel in timber and woodworking industry. In Europe liquid fuels, produced from biomass, provide 3.7% of the total energy. In some countries it is even higher. For example, in Finland it is 20%, in Sweden – 16% (Lakyda et al., 2011).

The landfill gas should be considered as a separate type of biomass. Moreover, the use of landfill gas as an energy source helps to address another very global issue – neutralizing or disposing wastes, which is now an acute problem in Ukraine, as well as throughout the world. The annual amount of municipal solid wastes (MSW) in Ukraine is about 13 mln tons, or 59 mln m<sup>3</sup>. The main part of solid waste (more than 92%) is buried on 6.7 ths landfills, totaling ofr more than 10 ths ha. It is expected that each ton of waste can provide from 300 to 800 m<sup>3</sup> of biogas. Research on domestic biogas potential landfills suggests that about 90 of the existing landfills are the largest and contain 30% of all MSW in Ukraine. The available biogas potential for energy production in these ranges is about 400 mln m<sup>3</sup> per year, the equivalent to 300 ths tons of fuel (Geletukha and Zhelezna, 2010).

The assessment of using the potential of solid waste in Ukraine. In 2012 in Ukraine, according to State Statistics Service 3.9% of all wastes were recycled. Only 2.3% of solid waste is burned at existing waste incineration plants.

These figures show great out-of-use potential that Ukraine has in solid waste management. The lag in effective waste management infrastructure is particularly evident in the comparative context. For comparison, in Belgium, Sweden, Germany, where garbage is treated as a source of energy and an industrial resource, currently



36–48% of wastes are recycled. On average, in European practice (EU-27), only 39.8% of wastes are placed in landfills, and in Ukraine – 92%. Processed and compressing is respectively 35% and 10%. In England and France, the problem of waste disposal is solved mainly by thermal treatment of solid waste in special boilers and furnaces of waste incineration plants in conjunction with heat recovery for heating systems and process systems (hot water and heating, steam production varying degrees of heat and pressure, the production of electric energy).

**Table 2. Processing wastes in the EU, 2009, %** (Blumenthal, 2011)

EU countries	Recycling	Burning	Composting	Disposal
Switzerland	34	49	17	0
Sweden	36	49	14	1
Netherlands	32	39	28	1
Germany	48	34	14	4
Denmark	34	48	14	4
Belgium	36	35	24	5
France	18	34	16	32
Slovenia	34	1	2	63
Ukraine	3.8	4.2	0	92
Romania	1	1	0	98
Bulgaria	0	0	0	100

Any waste contains a certain amount of energy expended in their production, and therefore, the use of waste energy will save this available energy. For example, the energy required to produce one ton of paper is 430–602 kg o.e. The use of recycled paper saves 215 to 387 kg o.e. It is necessary to add the environmental effect as 1100–1200 kg of recycled paper is equivalent to 1700–2400 kg of timber. Furthermore, papermaking pollutes environment by the emissions of mercury and chlorine and requires 100 to 200 m<sup>3</sup> of water per 1 ton of paper. When producing paper from waste paper the flow rate is 2 m<sup>3</sup>/t. Paper can be used 3–5 times in reproduction, while maintaining a certain amount of each cycle and other forest resources. Similar considerations apply to many types of waste, in the first place, to plastic and aluminum as the most energy-intensive products. Reuse of 1 ton of PVC can save 1.5 tons of o.e., and its burning with the heat – only 0.4 tons of o.e. For aluminum, recycling saves energy in 4–5 tons o.e. Currently, there are no technical barriers to recycling paper, glass, metals, some plastics. Reuse of waste can save 210–270 kg of o.e. per ton of waste. Materials recycling facilitates wastes sorting. Ideally, if you use all the wastes in recycling energy savings could reach more than 300 kg o.e. for 1 ton of sorted waste (about a year volume for a family of 3).

In Ukraine a considerable potential remains untapped while environmental threats are growing. In Ukraine, the real value of raw materials represent more than 400 mln tons of accumulated waste. According to experts, the current composition of domestic garbage is: paper and cardboard – 41%; refuse – 17.9%; rubber, leather and wood – 8,1%; food waste – 7.5%; metals – 8.7%; glass – 8.2%, other – 8.6%.

Today Ukraine does not have enough facilities for waste processing and disposal, including the technologies of incineration plants. There are 12 waste sorting plants in 8 cities, in 14 towns they are being built. There are 2 waste incineration plants – in

Kyiv, Dnipropetrovsk and garbage incineration unit in Lyubotin (Kharkiv region); 2 mobile waste incineration plants are operating in Kharkiv. Incinerator "Energy", which is one of the branches of JSC "Kyivenergo", was built in 1987 and currently uses the outdated technology, so the company works with losses – 6 months of 2013 resulted in the losses in the amount of 7.98 mln USD. Unprofitable activities of the company can be explained by the unutilized capacity and non-adjusted cooperation between public utilities in the city and local authorities.

The State Agency for Investment and National Projects has developed the national project "Clean City", which involves forming the system of municipal solid waste treatment by building modern high-tech systems for the processing of MSW in 10 cities: Kyiv, Kharkiv, Dnipropetrovsk, Chernivtsi, Sumy, Vinnytsia, Ternopil, Khmelnytskyi, Kirovograd and Poltava. Feasibility study for the construction of waste treatment plants has been prepared and pre-approved by the Cabinet of Ministers of Ukraine. In addition the talks between Ukrainian government and Japanese international cooperation agency (JICA) on waste recycling factories construction in 13 largest cities of Ukraine are being held. But these measures can only partially solve the problem of solid waste, because despite the fact that waste recycling plants are designed to reduce the negative impact of human activity on environment, yet they also affect the environment.

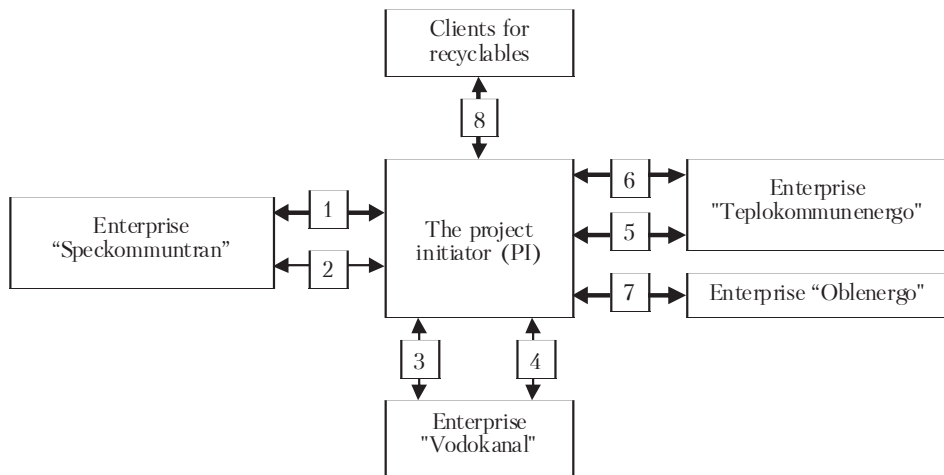
**The organizational scheme for a special waste products recycling complex.** Complex solution of solid waste management and low-cost energy supply of industrial and utility companies, as well as the residential sector are encouraged to implement by creating special facilities for waste disposal. Prospective organizational scheme of this complex involves the use of instruments of public-private partnership and can be implemented in almost any city in Ukraine with the population of 200 ths inhabitants (Figure 2). The project initiator can be a government or consulting firm that has experience in the field of energy efficiency and the use of tools of public-private partnerships in solving municipal problems.

It is assumed that the price of electricity for the enterprises "Vodokanal" and "Teplokommunenergo" as supplied to them by the project initiator will be 10% less than the current rates of enterprise "Oblenergo". For more efficient work under the above organizational scheme it is proposed to add a department of mechanical dewatering of sewage sludge. From 50 to 100 ths of sludge is formed on sludge fields in sewage treatment facilities of "Vodokanal" each year. At burning the dried sludge residue became a source of steam power, and can be used as a recyclable material for concrete batching plants and road businesses. Technological scheme for the disposal of solid waste, sludge and industrial waste, proposed for the implementation in the cities of Ukraine, is shown in Figure 3.

Combined heat and power station will produce energy and heat. "Vodokanal" and "Teplokommunenergo" will sell that to electricity consumers. Heat consumers are city enterprises and institutions, as well as the residential sector. According to calculations, creation of such a complex allows paying back the investments for the construction of CHP within 4–5 years.

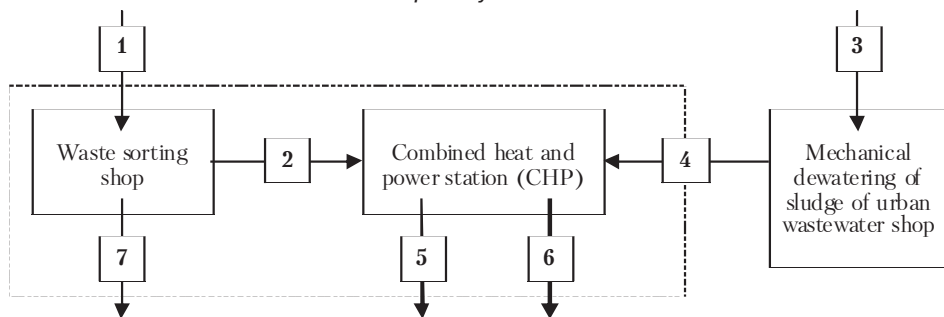
Therefore, using of the organizational scheme of the special complex for recycling thanks to savings and cost efficiency allows finding solutions to critical problems in the industry and the environment, waste management at local and regional levels. It is an innovative approach to a sharp reduction in wastes at a framework when local

authorities face almost intractable economic and environmental problems of waste disposal.



Notation: 1 – The agreement between enterprise "Spetskommuntrans" and project initiator (PI) on leasing of waste transfer station to create waste combined heat and power station (CHP) on its territory and communications; 2 – The agreement between "Spetskommuntrans" and PI to accept solid waste for recycling and disposal; 3 – The agreement between PI and "Vodokanal" on joint activity; 4 – The agreement between PI and "Vodokanal" on buying electricity; 5 – The agreement between PI and "Teplokommunenergo" on buying heat; 6 – The agreement between PI and "Teplokommunenergo" on electricity sale; 7 – The agreement between PI and "Oblenergo" on electricity transit to consumers; 8 – The agreement between PI and consumers on the implementation of the sorted recyclable materials and recycled waste.

Figure 2. **Organizational scheme of the special complex for recycling,**  
*developed by the authors*



Notation: 1 – Delivery solid waste and industrial waste to "Spetskommuntrans"; 2 – The transfer of energy-sorted components to waste CHP as fuel; 3 – Receipt of sludge from "Vodokanal"; 4 – Transfer the pressed sludge at CHP as fuel; 5 – Sale of heat to customers; 6 – Sale of electricity and steam to "Vodokanal" and "Teplokommunenergo"; 7 – Sorted and processed waste products sale for enterprises and households.

Figure 3. **Flow sheet recycling of solid waste, sludge and industrial wastes,**  
*developed by the authors*

The proposed organizational chart provides an efficient mechanism for the application of such a regional development tool as a public-private partnership that allows organizing cooperation of local authorities and businesses to solve common



problems of waste management in the context of the search for clean energy sources. In this case, local authorities, state organizations and business will work on solving the major problems of low-cost energy industry through the use of alternative sources and local wastes disposal. And the introduction of innovative scheme of waste collection and processing, together with the re-use and recycling of waste into energy, will help to achieve high level of diversification without significantly increased costs.

**Conclusions.** Using such a special complex on waste products recycling solves the following local problems which are very actual for the most of Ukrainian cities: waste minimization, collection and recycling of waste, processing waste for reuse, receiving energy from waste, reducing landfills and the effective solution of environmental problems. On the national scale it will help Ukraine to ensure the objective planned in "Energy Strategy" – to increase the share of alternative energy sources. Using biomass would help to reduce emissions caused by electricity production. Investments in renewable energy and waste products recycling present the possibility to develop local economies to, create green jobs. It will contribute to the objectives of climate and energy policy (reducing greenhouse gas emissions and energy conservation through renewable energy sources). Thus, the creation of such special facilities for waste disposal and biogas production contributes to the reorientation of Ukrainian economy to the principles of ecologically oriented development.

However, further development of more effective use of alternative energy sources is hampered by the lack of development and poor infrastructure, low motivation for waste management, passive public authorities at different levels. The following problems hinder the use of special facilities for solid waste disposal and biogas production in Ukraine:

- the creation of an integrated system for collection and disposal of waste. This requires improvement of the regulatory framework. In particular, it is necessary to introduce a ban on the approval of tariffs on waste services below the reasonable level. For a favorable investment climate in the industry it is necessary to revise the tariff system. In Ukraine the average tariff for waste services is 39 UAH/m<sup>3</sup>, including 11,3 UAH/m<sup>3</sup> (30%) for disposal. The waste disposal per person per month is about 5 UAH, it is about 0.1% of the average cost. For the comparison in the European Union is about 1% of the average cost;

- the introduction of preferential tax treatment for certain types of waste;
- the adoption of "green" tariff for electricity produced as a result of waste recycling. It will be a significant incentive for potential investors to start investing in Ukrainian waste processing industry.

Improvements in the area of waste management and a comprehensive approach to solving the problems of solid waste management and low-cost energy supply for industry and the residential sector will help to solve a number of environmental and energy problems. Ukraine will provide substantial energy efficiency of the economy and, consequently, a steady supply for population and economic development using the eco-oriented principles, thereby reducing the human impact on the environment and energy costs to society.

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