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ESTIMATION OF RENEWABLE ENERGY SOURCES APPLICATION IN THE SYNERGY WITH EUROPEAN UNION POLICY

This paper gives the possibility to analyze the application of renewable energy sources (RES) at different stages of their implementation to energy supply. Through the world experience we research the dynamics of energy consumption by its types; determine, what kinds of alternative sources are demanded most of all. In addition, we assess the efficiency of the application of RES in Ukraine. According to statistical and correlation analysis, it was proved that for Ukraine it is the most profitable to use biomass energy, while solar energy remains relatively expensive for our country. At the same time situation may change if costs for the solar panel will decrease in the future. It is shown that use of alternative energy sources decrease the energy intensity of GDP, while fossil resources increase this parameter. Unfortunately, Ukraine faces difficulties in attracting investments for development of RES as they are not so profitable at this time. It means that government should change its policy, increasing electricity prices to the European level, giving the chance for energy independence. In any case, in Ukraine, it will be necessary to increase the introduction of RES, as our country has only about 2% of RES in energy balance, while European countries in average have 17% and some of them have more than 60%.

Keywords. Energy, renewable energy sources, EU policy, supply.

Introduction. The issue of energy supply is now very vital in the world. Since, taking into account the fact that stocks of energy resources are decreasing, while the population is increasing. Therefore, a global problem appears in the future, which can lead to a possibility of an energy crisis. Such trends have a significant impact on the economies of countries that, with their high production potential, are not able to satisfy energy demand through their own traditional energy sources [1]. It is clear that today all the basic processes of activity and life of people are based on the use of a significant number of different sources of energy, and at last, people are coming to cognize that resources are not eternal and needed to be somehow saved.

Integrated system solutions together with improved management of municipal infrastructure and environments are essential for Ukraine, as any EU state, to address energy challenges. A number of aspects should be examined and developed, including eco-cycle models demonstrating integrated solutions for energy, waste and water, integrated land use and transportation, ecosystems planning, sustainable building design, and strategies to reduce air pollution. It is imperative to apply the principles of sustainable development and support smart solutions today if we are not to compromise the ability of future generations to meet their needs tomorrow.

In this paper, we consider the term "Energy security" as diversification of energy supplies and the way to ensure certainty of supply at an acceptable for society and the economy price but also optimum utilization of domestic energy resources, while applying new technologies and active participation in international initiatives on environment and energy [15]. Unfortunately, the fuel and energy complex in Ukraine is not able to provide economically justified domestic and export demand for the country and of the appropriate quality. The question of energy security for Ukraine is now particularly relevant; we can say that this is a matter of "life" – the main condition for its existence as an independent state (Table 1).

***Table* 1. The main energy threats to the economic and national security of Ukraine**

Internal threats	External threats
1. The inconsistency of reforms in the economy as a whole and the transformations of Fuel and Energy Complex, due to the lack of a clear strategy for economic development, as well as the imperfect legislative framework.	1. High-level monopolization of supply of imported fuel and energy resources.
2. Excessive energy consumption of GDP.	2. The geo-economic and geopolitical pressure of foreign states.
3. High degree of deterioration of power capacities in the absence of the system of renewal and modernization of fixed assets and attractive investment climate.	3. Dependence on the import of a large part of the production equipment, materials, and services for the fuel and energy sectors.
4. Insufficient level of scientific and normative-technical support of the fuel and energy complex, the critical state of branch science.	4. The instability of the global energy prices.
5. Low effectiveness of propaganda and educational measures on the formation of a low-level attitude towards fuel and energy resources in the society, observance of the discipline of paying for them.	5. High level of energy usage may lead to climate changes and therefore to restructure of energy balances in countries [16].

Source: [2].

Fortunately, throughout the whole of the century, various studies have been conducted on the invention of special devices and methods that would replace existing sources of energy or ensure their preservation. Now, most of these technologies are still in development, but there are those that are set into operation and perfectly perform their functions. It would be advisable to consider some of the latest technologies that make up the underlying basis and are used in various energy industries (Table 2).

***Table* 2. Promising newest technologies in power engineering**

New technology	Status	Initial introduction	Potentially supplant	Potential applications
Managed thermonuclear fusion	Theory and experiments over 50 years	Approximately 7–10 years of widespread use (approx. 2027)	Combustible minerals, renewable energy, nuclear power	Generation of electric energy, space flights
Geothermal energy	Distribution of technology	Already used	Combustible minerals, nuclear power	Generation of electricity, heat
Biofuels	Spreading technology	Already used	Flammable minerals	Energy conservation, transportation
Hydrogen power	Technology distribution (hydrogen fuel cells); Theory and experiments for less expensive hydrogen products	Already used for other hydrogen products, their entry into the market is scheduled for the next 5 years (approx.2019)	Other energy-saving technologies (chemical current sources, combustible minerals)	Energy conservation
Nanodel battery	Working patterns	It was firstly designed in 2007 at Stanford University. Now at the stage of perfection. Estimated implementation date 10–15 years (approx.2032)	Other energy conservation technologies: hydrogen power, chemical power supplies and fossil fuels	Portable computers, mobile phones, electric cars. Power saving from the power grid
Ionistor	The spread of technology and the continued development	Wide implementation has not yet gotten, technology upgrades every year (approx. 2025)	Batteries	Recuperative Braking; fast-charging, durable, flexible and environmentally friendly energy sources
Wireless transmission of electricity	Working samples / Distribution and transition into consumer goods category	Slowness. Wide use after 3–5 years (approx. 2020)	Batteries	Wireless power equipment (PCs, smartphones, etc.)
Organic solar cells	Laboratory samples	Widespread use in 5–7 years (approx.2023)	Silicon Solar Battery	Electricity generation

Source: authors based on [3]

First, it should be noted that the time when certain developments will be implemented, is approximate and averaged for the world as a whole. In addition, Table 2 considers the positive scenario of technology development, without taking into account the subjective factors that may arise in the future. For clarity, we mentioned a chronological schedule for the emergence and application of promising technologies in the energy sector (column "Initial introduction"). It is clear that for Ukraine the given schedule will be different. There will be a bias of about 5–10 years, compared with more developed countries. After all, for example, the same alternative energy sources, which include solar and geothermal energy, are only beginning to gain popularity in Ukraine.

One of the main sectors of human life where people use different sources of energy to create their comfortable existence is the public housing. That is why recently a considerable number of devices for energy saving appeared in this area. Table 3 lists the three major newest devices that are already used to save energy in the housing and are more widely available to most users.

***Table* 3. The latest technologies in the public housing**

Technology	Principle of operation
Heat accumulator for residential premises	Electric heater accumulates thermal energy at night time (at low "night" tariff for electricity), and then gives off heat, due to the use of materials of high heat capacity
LED profiles	Profiles are based on LEDs that not only longer lasting, but also more economical than conventional lamps
Smart Lighting	One of the elements of a smart home that provides efficient power consumption and is based on motion sensors

Source: authors on the base [4–6].

As for Ukraine, for the last five years, LED-profiles of various types have begun to be used in the light-fitting premises, and more affluent users have installed intelligent lighting in their homes.

Keeping in mind all the latest technologies that are developed or are already being used in the energy sector the renewable energy sources (RES) are the most available alternative nowadays. The goal of the article is to prove this statement based on statistical data of energy sector.

Literature review: world experience in the application of renewable energy sources. The highest interest in RES was accompanied by the increase of financing in R&D in the energy sector by both state budgets and private companies, including energy companies. That is displayed by the countries that are strongly dependent upon the import of traditional energy resources (the European Union countries, the USA, Japan, later China, etc.). Substantial progress was quickly made in improving energy independence and engineering-and-economic performance indicators of technologies of turning RES into heat and electricity. The technologies of RES energy conversion have become competitive with the traditional technologies. As a result of intensive research, the cost of the energy received from biofuel, produced by wind power stations, photoelectric transformers, sun, heat, geothermal and bioenergy power plants, reduced massively [4].

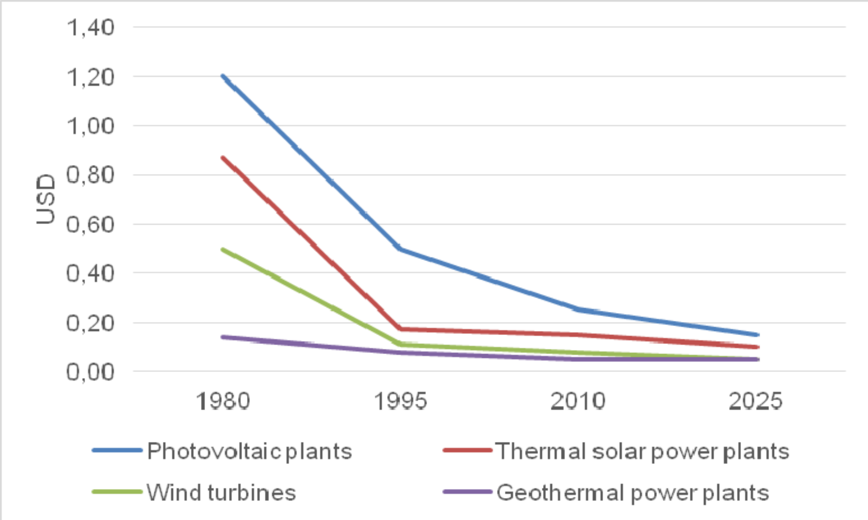

Fig.1. Tendencies of change of energy cost from different RES, USD

Source: author's on the base of data [7].

This gave the reason to consider RES as one of the key trends of the world power industry able to promote solving global energy and ecology problems of the humanity caused by the permanent growth of the population and the growing consumption of energy. By forecasts, that will grow by 2020 up to 18–20 billion tons o.e. per year [7].

Today RES provide a sizable contribution to the world energy consumption that is estimated approximately as 19% [7]. However, there is a backside of the coin. It should be noted that the hydropower potential of big rivers of the world has already been used by one third, at this its unused part is mostly concentrated in developing countries and the further development of the high hydropower industry is limited, among other things, by ecological limitations (flooding of great territories, etc.).

When the traditional power industry based on organic energy resources has been growing since the beginning of the XXI century (on average with the rate of only 1–1,5% per year), the new RES technologies have been developing at the same time with the average rate of tens of percent per year [6]. Such fast pace of RES entering the energy market to which new technologies reach out for decades shows that RES are becoming a more and more serious "player" and is worth great attention. The countries that are leaders in investments in RES include China, the USA, Germany, Italy and India. Integral rates of renewable energy sources development in the world in the period are given in Table 4.

Table **4. Rates of RES development in the world**

Indicator	Measurement	2015	2016
New investment (annual) in renewable power and fuels	billion USD	312.2	241.6
Renewable power capacity (total, not including hydro)	GW	785	921
Renewable power capacity (total, including hydro)	GW	1,856	2,017
Hydropower capacity	GW	1,071	1,096
Bio-power capacity	GW	106	112
Bio-power generation (annual)	TWh	464	504
Geothermal power capacity	GW	13	13.5
Solar PV capacity	GW	228	303
Concentrating solar thermal power capacity	GW	4.7	4.8
Wind power capacity	GW	433	487
Solar hot water capacity	GWth	435	456

Source: [7].

At present 138 countries of the world have formulated the target indicators of the RES development for a longer perspective. Figure 2 illustrates the goal that the countries set themselves up to 2020. In most, it is planned to achieve the RES contribution to the energy balance at the level from 10 to 30%. The most ambitious target indicators are approved in the European Union.

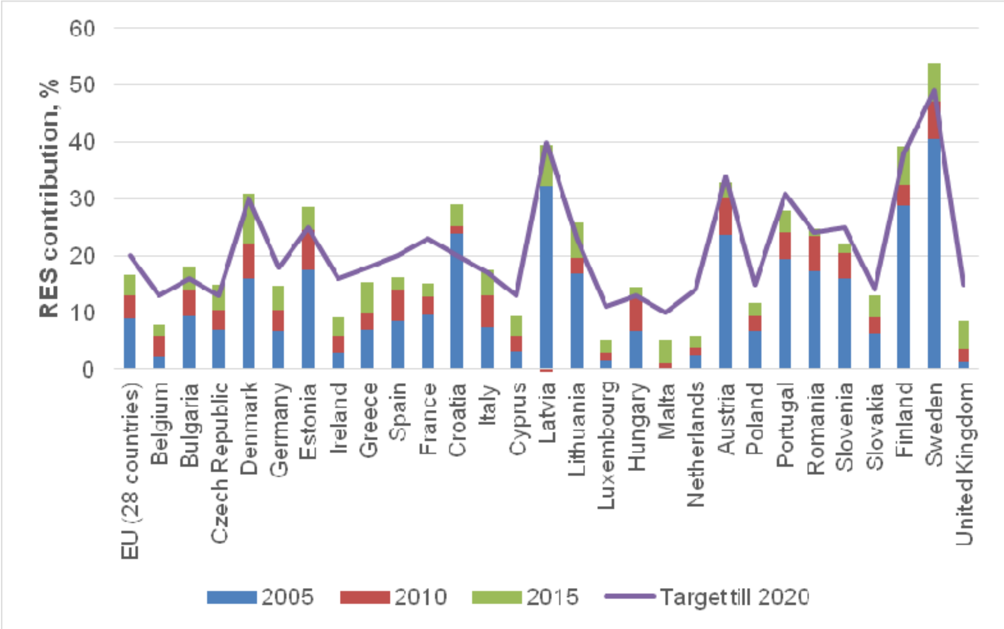

Fig. 2. Rates of the RES contribution to the final consumption of energy in the EU countries and goals for 2020.

Source: Authors' on the base of [7].

Methods of encouragement to use RES in Ukraine. Ukraine has the significant potential to develop RES. All the regions of the country have possibilities to use RES. At the same time, the introduction of RES in the country is too slow. Its contribution to the country's energy balance is not significant, especially, if to consider best practices in the neighbour states (see Annex 1). At present, the rate of RES (biomass) in Ukraine is about 2% only. Nevertheless, the Law of Ukraine "On Alternative Sources of Energy" [8] adopted in 2003 promises that the share of RES is to increase to 6-7% before 2030. There are many reasons for this state of things. The main one is the absence of the system that economically stimulates the transition to RES usage, the declarative nature of normative legal acts that have no concrete mechanisms of its implementation and low-performance discipline. One can not say that nothing is being done in this aspect, but what is being done is not enough to compensate the negative tendencies, such as the global increase of prices for energy carriers, the increase of the country's energy dependence level and the environmental contamination. Ukraine still does not introduce new kinds of RES, not invest in technologies, not develop the production based on new technologies. Thus, it preserves its technological backwardness and can lose its chance to enter the European Community.

Factors favourable to the RES development in Ukraine are as follows:

- the increase of prices for traditional energy carriers;
- ensuring of requirements of ecological norms and standards;
- a growing chance to enter the European Community;
- the necessity to replace the worn-out key assets.

The technically achievable potential of the production of energy carriers from renewable sources of energy and alternative kinds of fuels above 98.0 million tons of reference fuel per year.

***Table* 5. Potential of RES in Ukraine**

№	RES	Yearly technically achievable potential	
		bln. kilowatt-hours/year	million tons o.e./year
1.	Wind energetics	79.8	28
2.	Solar energetics, including:	38.2	6
2.1.	– electrical one	5.7	2
2.2.	– thermal one	32.5	4
3.	Small hydropower	8.6	3
4.	Bioenergetics, including:	178	31
4.1.	– electrical one	27	10.3
4.2.	– thermal one	151	20.7
5.	Geothermal energetics	97.6	12
6.	Environmental energy	146.3	18
Total amounts of replacement of traditional and natural energy resources		**548.5**	**98**

Source: Made up by the authors on the basis of the data of Bloomberg New Energy Finance.

According to Table 5, the total amounts of replacement make up almost half of the total energy balance of the country. Ukraine has favourable conditions for the development of wind energetics, solar energetics, and midget power plants should be renewed – those that require renewal. The technically achievable energy potential of renewable energy sources regarding all the regions of the country is totalled up in Figure 3.

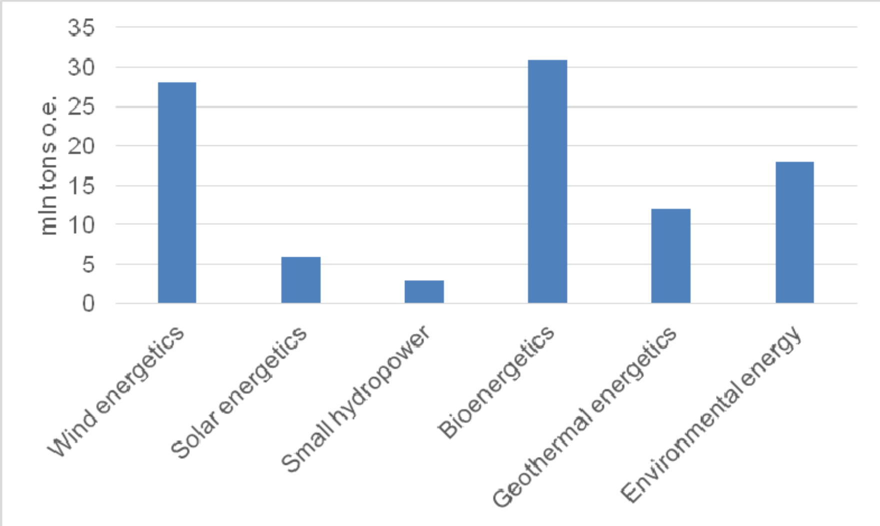

Fig. 3. Potential of different kinds of RES in million tons o.e.

Source: Made up by the authors on the basis of the data of Bloomberg New Energy Finance.

Figure 4 illustrates how many tons of energy sources can be replaced be RES in perspective.

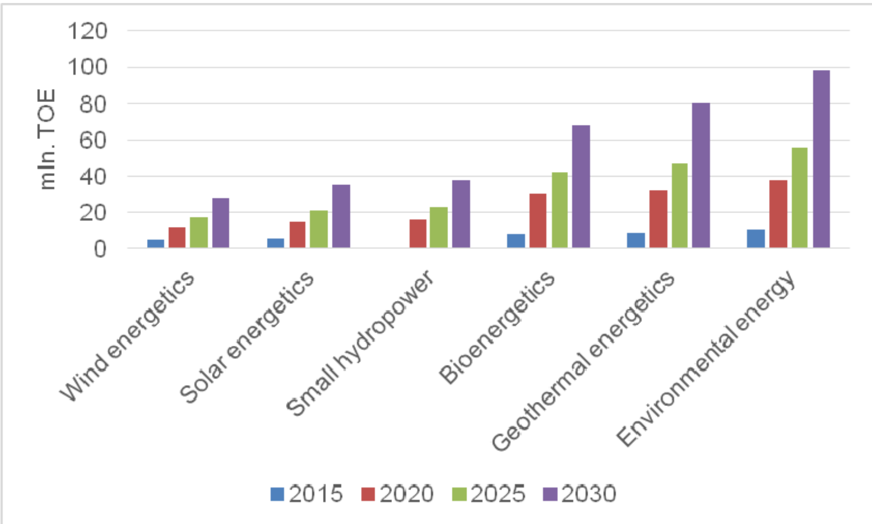

Fig. 4. Achievable yearly amounts of replacement of traditional fuel and energy resources in Ukraine until 2030 in the aspect of RES usage

Source: Made up by the authors on the basis of the data of Bloomberg New Energy Finance.

As seen, the available potential of RES in Ukraine, its scientific and industrial potential allow it in the nearest time substantially accelerate the speed of RES usage in the country. However, for this, it is necessary to create the conditions to stimulate the development of this sphere taking proper measures and using European countries' experience (Annex 1). A number of general political and economic factors will condition the development of the RES sector in Ukraine. Largely, this is the stable legislative authority oriented at the stable development and growing wealth, the effective executive authority that is worth trusting it and judicial authority that provides legal reliability.

In the entire world, some countries invest in RES more than in other kinds of energy production. Net investments in additional production facilities for the extraction of fossil fuel are 132 bln USD whereas in ecologically clear sources 242.5 bln USD were invested [6]. The overwhelming majority of investments is in solar and wind power, their share is more than 90% of all the investments. Anyway, there is the problem of lack of the information about the benefits (financial, social and ecological ones), the profitability of investments in RES usage. There are some factors that stimulate investments in the new forms of energy production and some competition problems. One of the reasons for using renewable resources is lower expenditures on the support of the local energy production and on its possibility which is better for the countries having no developed infrastructure. There are also some other factors that make the investments in renewable energy sources attractive:

- RES industry is an enough "depoliticized" branch of electric power industry;
- RES industry is positively accepted by local communities due to its ecological cleanness;

- the absence of necessity to pay for fuel to other countries motivates the state to support renewable energy sources industry in almost all the countries where it develops;
- relatively stable cost of production. Prices for oil and gas change permanently. At the same time, the cost of solar batteries and their installation come down every year.

To increase the volume of investments in Ukrainian RES it is necessary:

1. To improve the regulatory base, to increase the standards of transparency and accountability.
2. To improve the state of things in the financial sector, i.e. to reduce the cost of loans and in this way to improve credit conditions which are necessary for long-term projects in the industry.
3. To arrange the issue of allocating ground areas for the objects of renewable energy sources industry.
4. To improve the technical specialists' qualification.
5. To solve the problems with connecting to the interconnected network.

Influence of factors on the volume of investments in RES in Ukraine. To determine the degree of the relationship between the following factors: average price for the RES electric energy, electric energy production and the amount of the world investments, amount of investments in RES in Ukraine (as the dependent factor); we use correlation analyses (Table 6).

Table **6. Correlation and determination ratios**

Index	Correlation ratio
Average price for electric energy	-0.91
Electric energy production	0.87
Amount of world investments	0.49

We have the following:

- The correlation ratio is -0.91 and enters the range from 0.9 to 1 that, according to the Chaddock scale, shows a very strong coupling between the "Amount of investments" and "Average price for electric energy" parameters, but it is negative which shows the inverse relation.
- The value of the ratio between the "Amount of investments" and "Production of electric energy" parameters equals 0.87, which enters the range from 0.7 to 0.9 and means a high level of correlation.
- The 0.49<0.5 ratio displays the weak dependence between the "Amount of investments" and "Amount of world investments" parameters. It means that the total amount of investments in the sphere of renewable energy sources in the world has little influence on the volume of investments in Ukraine.

It says that even on the level of slight look the situation with RES in Ukraine is far from the world tendencies.

Determination of the kinds of the alternative power industry in Ukraine that are perspective for investing. The simplest and the most exact way to estimate the potential of different kinds of the alternative power industry is the index method that envisages further calculation of the integrated index. The calculated integral estimation will show the most perspective direction of the alternative power industry. Taking into account that investment attractiveness depends, first, upon the effectivity of investments, the basic factors that we will take to determine the perspectives of investing in the alternative power industry will be as follows:

– modern stage of the RES usage in Ukraine;

– capital investments in the construction of power stations of different kinds;

– yearly technically achievable potential of non-traditional power industry;

– total amounts of traditional organic fuel resources saving;

– the capacity of power stations till 2030 to the potential script of development.

US National RES laboratory calculated expenses for construction of appropriate power plants, which indicated in Figure 5. Relying on calculations of Renewable Energy Institute of NAS of Ukraine, general annual technically achievable potential of RES of Ukraine is almost 98 MTE, or more than 50% of energy consumption of Ukraine to the present day, and 30% of energy consumption in 2030 (Figure 6).

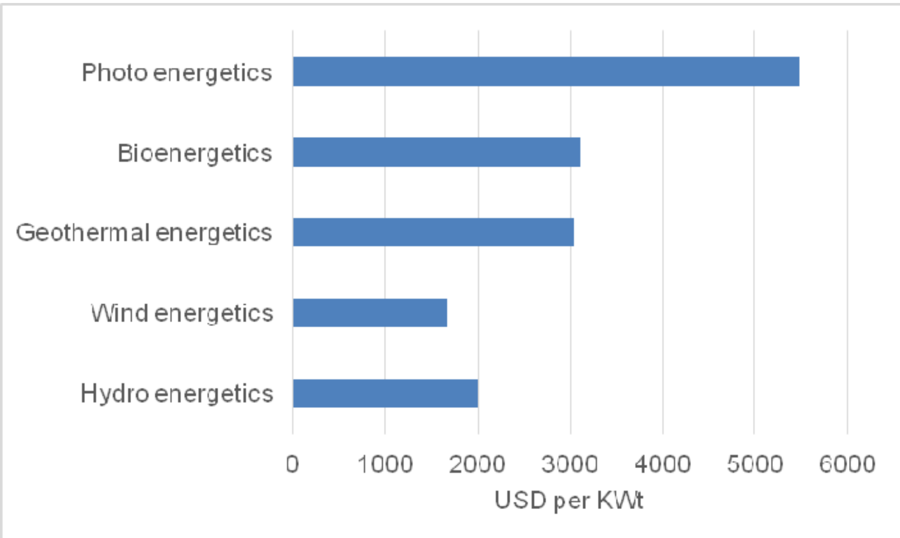

Fig. 5. Expenses for construction of different power plants

Source: Made up by the authors on the basis of the data NRELUSA.

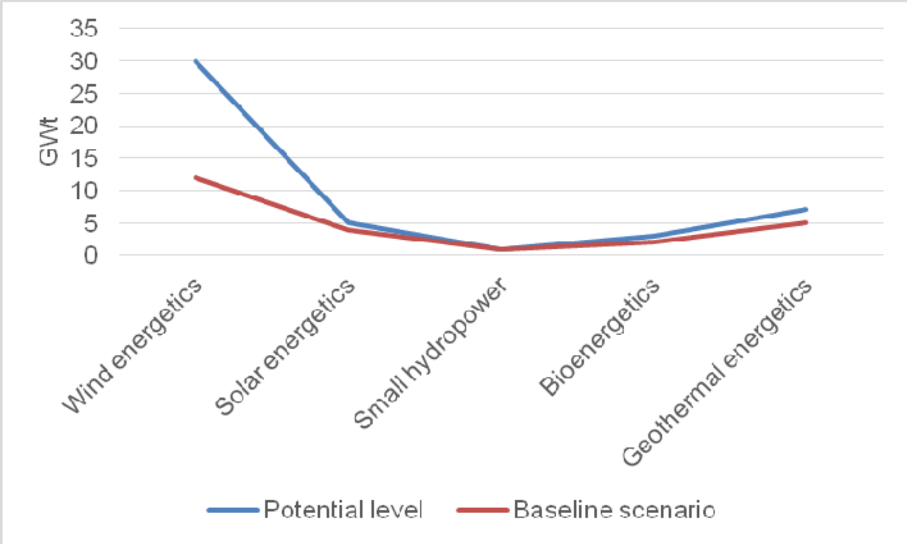

Fig. 6. The capacity of power plants using RES in Ukraine according to potential basic development scenario until 2030

Source: Authors' based on the data of NAS of Ukraine.

Here we are calculating standard values of the most viable type of RES. The formula of standardized values per each value of RES type: $Y_{ij} = \frac{(Z_{ij} - \min_{ij})}{(\max Z_{ij} - \min Z_{ij})}$, where $\min(\max)Z_{ij}$ – minimum/maximum deviation value; Y_{ij} – standardized value X_{ij}. The deviation is calculated by the formula $Z_{ij} = X_{ij} - \overline{X_{ij}}$ – for positive factors of RES development or $Z_{ij} = \overline{X_{ij}} - X_{ij}$ – for negative ones, where X_{ij} is *i*- the value of *j*- a type of unconventional energy; $\overline{X_{ij}}$ – average value; Z_{ij} – deviation from the average value. Thus, we got standardized values for V group of values of RES types (Table 7).

Table **7. Standardized values per RES types**

RES type	Installed capacity	The general amount of renewable energy objects	Annual technically achievable potential	General amounts of savings of conventional fuel resources by usage directions of RES till 2030	The capacity of RES power plants in Ukraine according to potentially achievable development scenario till 2030	Expenses for construction of different power plants
Wind-power	-14,01	-32,20	-0,64	12,00	20,46	1540,00
Solar power	163,79	-29,20	-42,24	-10,00	3,94	-2359,00
Small HEPP	-134,31	-27,20	-71,84	-13,02	-7,14	876,00
Geothermal power	-203,31	-10,20	17,16	-4,00	-4,04	18,00
Bio-power	187,84	98,80	97,56	15,02	-5,34	-75,00

Source: Author's calculation.

Integral rating value of RES equals average weighted partial ratings by type and value group. Calculation formula: $R_j = \sum R_{kj} \times f_k$, where R_j – general rating of *j*-a type of RES, f_k – the weight of *k*-value group. We can determine four ranks of renewable energy (Figure 7), according to corresponding calculations. The most viable type of RES is biomass power, its integral rating value is the biggest one, it is 0.6.

Therefore, the analysis of potential and possibilities of energy-saving technologies usage as well as unconventional RES shows that there is a viable alternative to the nuclear destiny of Ukrainian energy system development with the appropriateness with the EU trends. The agendas of the possible realizations could be considered in Annex 1, as the examples of best EU practices.

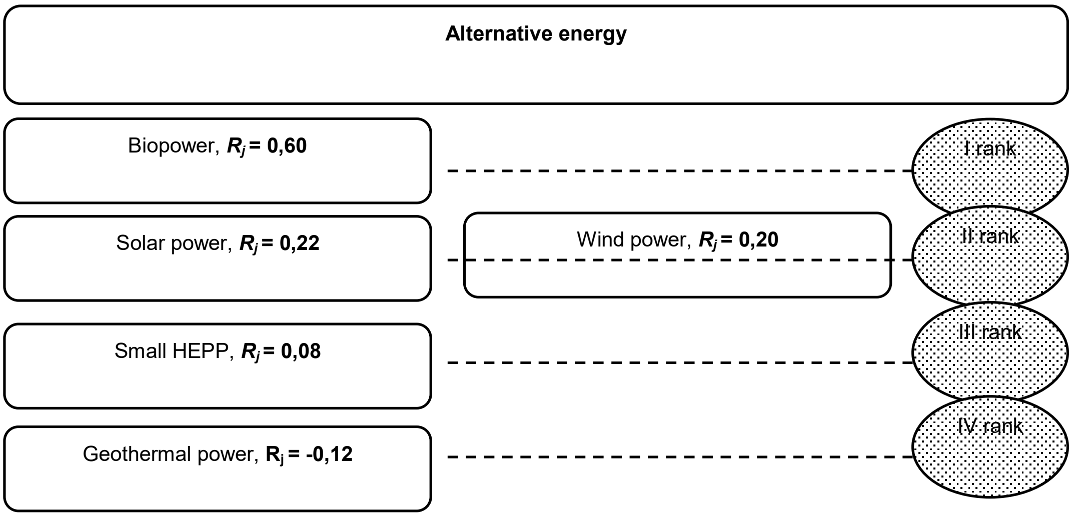

Fig. 7. Integral rating value of Ukrainian RES potential

Source: Authors'.

The impact of RES on the energy intensity of GDP (case of Ukraine). To test the positive correlation between RES and economic performance we decided to use classical approach – to test link "GDP – RES consumption" [9–13]. Next, we introduce the main designations for the studied indicators:

Table **8. The main indicators of the energy intensity of GDP of Ukraine**

Variable	Indicator
Energy intensity of GDP	Energy
Total energy consumption based on RES	Alternative
Total Oil and Petroleum consumption	Oil
Total Gas Consumption	Gas
Total Coal and Peat Consumption	Coal

Source: Created by author.

Just as each of the selected indicators influences the energy intensity of GDP in one way or another, it would be logical as the first step to build a correlation matrix to make sure of this (Table 9).

Table **9. Correlation matrix for the energy intensity model of Ukraine's GDP**

	Energy	Alternative	Oil	Gas	Coal
Energy	**1,00000**				
Alternative	**-0,54803**	1,00000			
Oil	**0,85195**	-0,75091	1,00000		
Gas	**0,96848**	-0,44069	0,78221	1,00000	
Coal	**0,76163**	-0,14317	0,38806	0,75141	1,00000

Source: Authors' with the use of statistics of [8-9, 14].

As can be seen, for this model, the highest positive correlation coefficient is considered between the energy intensity of GDP of Ukraine and the total consumption of natural gas (0.96848), indicating a close relationship between these indicators. Almost all the indicators have high correlation coefficients. It hints that these indicators are correctly selected and the resulting model is correct. In the process of analysis, many different regression variants with selected factors in the software R were constructed, where ENERGY factor is the dependent variable, and the independent variables are selected from Table 8. The level of reliability was chosen – 95%. The step-wise function gave the result that the energy intensity factor depends on the total energy consumption of RES; the total consumption of natural gas, coal and peat. This can be explained by the fact that, in comparison with natural gas and coal, oil is used in a lesser amount, and, moreover, the volume of its use during the investigated period changed its value slowly – it does not have a fairly sharp difference between values over the years. The best significant (adj-R^2 = 0.96, p(F-stat) = 0,000182), stable (Chow test), model, free of multicorellation (VIF), heteroskedasticity (White, Gleiser, Goldfeld-Quandt tests), autocorrelation (Durbin, LM-test) looks like this:

$$Energy = 0{,}6498 \cdot \log(Gas) - 0{,}00001309 \cdot Alternative + 0{,}4657$$

RMSPE prediction error for this model is calculated by the formula::

$$\text{RMSPE} = \sqrt{\left(\frac{0{,}002067}{0{,}161067}\right)^2} = 0{,}01283317 = 1{,}28\%$$

The error rate is not large, which again confirms the fact that the model can be used to predict future values of the energy intensity of GDP of Ukraine.

To summarize, the energy intensity of Ukraine's GDP is highly dependent on the total consumption of natural gas and energy generated by RES. As for natural gas, it is not surprising, because it is used most of all by the fuel and energy complex. The impact of energy consumption of RES can be explained by the fact that in recent years, alternative energy sources have begun to gain popularity in Ukraine, which has led to the expansion of the limits of their use in the country. In general, the value of the coefficient tends to decrease, which means that each year Ukraine is getting closer to world indicators.

Conclusions & discussion. As noted by L. P. Kapitsa: "The future of humanity depends on how it will provide itself with energy", thus, it can be concluded that "political and energy independence are mutually determined". In the modern world, the national security of the state, economic and energy security are interconnected. Forecasts show that in the coming decade energy consumption will not have a tendency to decrease. The unevenness of the supply of energy resources to the countries of the world and the regions of individual countries leads to threats to energy security and, as a consequence, to economic and national security. Especially it has sense in those countries that do not have sufficient reserves of minerals, in particular, coal, oil and natural gas [1].

A good political strategy based will strengthen transmission and distribution efficiency; reduce dependency on single sources; promote decentralized systems.

This paper contains some analysis of the potential of RES. The place of foreign investments has been determined as one of the moving forces of RES development among other factors. With the help of integral rating value calculation of potential of different RES types, the most viable direction for investments in RES has been determined. The given research following conclusions can be made:

- For the present day, the contribution of renewable resources in the worldwide energy generation is nearly 6%, in Ukraine this value is less than 2%.
- The greatest potential for Ukrainian energy operators is bio-power. Assured that implementation of bio-power is reasonable, an important issue appeared – what has specifically influence on the volume of foreign investments in this industry and what things are worth paying attention to.

To increase the volume of capital investments, requirements of transparency and accountability should be increased at the state level; credit conditions for the possibility of the long-term contributions in industry projects should be improved; land plots provision for RES facilities should be started; skills of technical personnel should be increased. In spite of that state has made some steps such as "Energy Strategy of Ukraine for the Period till 2030", inadequacy of regulations and non-performance of made decisions, low budget of research works and engineering developments, insufficient level of information provided to potential developers of RES technologies and consumers are restraining development of RES in Ukraine.

We can assume for the discussion that:

- all the latest technologies that are developed or are already being used in the energy sector are necessary complementary elements that will ensure longer use of non-renewable sources of energy in the future, therefore their further implementation is actual and absolutely necessary, especially in Ukraine;
- the energy intensity of Ukraine's GDP depends on the total consumption of natural gas and energy generated by RES. As for natural gas, it is not surprising, because it is used most of all from the fuel and energy complex. The impact of renewable energy consumption indicators can be explained by the fact that in recent years alternative energy sources have begun to gain popularity in Ukraine, which has led to the expansion of the limits of their use in the country.

Unfortunately, Ukraine faces difficulties in attracting investments for development of RES as they are not so profitable at this time. It means that government should change its policy, increasing electricity prices to the European level, giving the chance for energy independence. In any case in Ukraine, it will be necessary to increase the introduction of RES, as our country has only about 3% of RES in energy balance, while European countries in average have 17% and some of them have more than 60%.

An important role in the RES implementation is to play local authorities because implementation level depends much on local conditions. The rise of prices for traditional energy transporters and ecological payments has become a stimulus for it in the implementation of the RES implementation. However, the state should create the favourable conditions for investing activity in this field, involving both domestic and foreign investments (first of all private ones) and enable it to establish support funds for the most economically viable areas of RES given region.

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ОЦІНКА ЗАСТОСУВАННЯ ВІДНОВЛЮВАНИХ ДЖЕРЕЛ ЕНЕРГІЇ В СИНЕРГІЇ З ПОЛІТИКОЮ ЄС

Аналізується використання відновлюваних джерел енергії ВДЕ на різних етапах їх енергопостачання. Завдяки світовому досвіду, досліджується динаміка споживання енергії за видами; визначається, які види альтернативних джерел країна потребує більше інших. Також оцінюється ефективність застосування ВДЕ в Україні. Згідно зі статистичним та кореляційним аналізом було доведено, що для України найвигіднішою є енергія біомаси, а сонячна енергія залишається відносно дорогою для нашої країни. Проте ситуація може змінитися, якщо витрати на сонячні батареї зменшаться в майбутньому. Показано, що використання альтернативних джерел енергії знижує енергоємність ВВП, а викопні ресурси збільшують цей параметр. На жаль, Україні доводиться стикатися із труднощами в залученні інвестицій для розвитку ВДЕ, оскільки в цей час вони не настільки вигідні. Це означає, що уряд має змінити свою політику, збільшити ціни на електроенергію до європейського рівня, надаючи шанс на енергетичну незалежність. У будь-якому випадку в Україні необхідно буде збільшити впровадження ВДЕ, оскільки в нашій країні є лише близько 2% ВДЕ в енергетичному балансі, тоді як європейські країни в середньому мають 17%, а деякі з них – понад 60%.

Ключові слова. Енергія, відновлювані джерела енергії, політика ЄС, постачання.

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ОЦЕНКА ПРИМЕНЕНИЯ ВОЗОБНОВЛЯЕМЫХ ИСТОЧНИКОВ ЭНЕРГИИ В СИНЕРГИИ С ПОЛИТИКОЙ ЕС

Аанализируется использование возобновляемых источников энергии ВИЭ на разных этапах их энергоснабжения. Благодаря мировому опыту, исследуется динамика потребления энергии по видам; определяется, какие виды альтернативных источников нужны для страны больше других. Также оценивается эффективность применения ВИЭ в Украине. Согласно статистического и корреляционного анализа было доказано, что для Украины выгодной является энергия биомассы, а солнечная энергия остается относительно дорогой для нашей страны. Однако ситуация может измениться, если расходы на солнечные батареи уменьшатся в будущем. Показано, что использование альтернативных источников энергии снижает энергоемкость ВВП, а ископаемые ресурсы увеличивают этот параметр. К сожалению, Украине приходится сталкиваться с трудностями в привлечении инвестиций для развития ВИЭ, поскольку в это время они не столь выгодны. Это означает, что правительство должно изменить свою политику, увеличить цены на электроэнергию до европейского уровня, предоставляя шанс на энергетическую независимость. В любом случае в Украине необходимо будет увеличить внедрение ВИЭ, поскольку в нашей стране есть всего около 2% ВИЭ в энергетическом балансе, тогда как европейские страны в среднем имеют 17%, а некоторые из них – более 60%.

Ключевые слова. Энергетика, возобновляемые источники энергии, политика ЕС, предложение.

Annex 1

GOOD PRACTICES AND CASE STUDIES

PROVINCE OF POTENZA, ITALY	
Background	To implement an integrated energy policy at provincial scale coordinating measures for increasing energy efficiency and the use of renewable energy sources at the local level also promoting a sustainable development process for the municipalities in the Province of Potenza Key issues: • **Implementing RES and EE solutions into the Province high schools and public buildings**; • Spreading the **culture of energy savings** and improving behaviours aiming to increase **environmental protection**; • Promoting of **environmental management systems** on the provincial territory.
Case 1 **The Regional Energy Company foundation**	The Lucana Energy Company promotes interventions for the rationalization and reduction of energy consumption and related costs of public authorities performing the following activities: • **Energy planning** at the regional, provincial and municipal levels, also supporting the Basilicata Region municipalities in **joining, implementing and monitoring the Action Plans for Sustainable Energy** under the Covenant of Mayors (2020); • Analysis, **monitoring and management of energy consumption in on buildings owned by public bodies** on the regional territory; • **Implementation of renewable energy systems on buildings owned by public bodies i**n the region; • **Dissemination on energy issues** in the regional community; • RES behaviour.
Case 2 **ENEPOLIS, the Potenza province Local Agenda 21**	The project ENEPOLIS had been addressed to mountain district characterized by a **high index of woodiness and a high risk of depopulation**. The relevant objective was to realize an **integration of tourist facilities and bio-energy**.
Case 3 **Sustainable Public Housing**	The project is settled in a small neighbourhood of the Municipality of Filiano and it consists of **three in line buildings for a total of 18 houses**. Such buildings **have been built applying the principles, methods and techniques of Green Building and Sustainable architecture with particular reference to energy saving and renewable sources energy production systems**. The project represents a **model of design-oriented to energy saving** promoting the **use of innovative materials with a low environmental impact**, and **RES technologies**.
Case 4 **Safe Ecological Schools**	**Improvement of energy performance in provincial high schools and public buildings** can give a fundamental contribution to the achievement of CO2 abatement targets and to the other targets of EU2020 and **can provide great savings for the Province with regard to energy and heating**. The **GP defines a standard methodology and a wide catalogue of applications which could be extended to a wider scale**. The implementation of **RES plants** and **EE measures on educational buildings raises the awareness among students and teach staff** regarding EE and RES.

MUNICIPALITY OF SLAGELSE, DENMARK	
Background	**EnergyVillage Omø and Flakkebjerg in SlagelseMunicipality** CO_2 emission reduction and identification of **tools a municipality can use to motivate and support towards the installation of RES and EE**. The municipality is not allowed to make any form of financial support for such installations.
Case 1 **GPSmall and Medium Enterprises, SME, working with EE and RES in Slagelse Municipality**	**EE and RES installations in private homes and SME companies**, increased competences of the SME. The municipality organized a **workshop for SME with a brainstorming about how the municipality could help to promote RES and EE**. On that basis, several models were investigated, and **4 companies decided to organize Slagelse Energy-network as a private association**.
Case 2 **Network for energy responsible personal employed in the municipality of Slagelse**	**Network with 15–20** responsible **personal** in different buildings in the municipality. They are each **responsible for the energy consumption in own building**. The network meets 4 times a year. **In Slagelse all municipal buildings have one energy responsible person and are connected to a SCADA** system "Min Energy".
SHEFFIELD CITY COUNCIL, UNITED KINGDOM	
Case 1 **Think Low Carbon Centre, BarnsleyCollege**	The Think Low Carbon Centre, based on BarnsleyCollege's Honeywell site, is packed with working low carbon technology. It has been constructed with the latest energy efficient materials. Amongst the Centre's features are solar panels, a green roof, triple glazing and a building management system which automatically opens windows and vents to regulate temperature. The power generated and used at any moment is publically displayed on-screen.
Case 2 **23 homes, low energy, South Yorkshire Housing Association**	All 23 properties have been constructed to Eco-homes "excellent" standard with super-insulation: timber frames; solar thermal (water heating); photovoltaics (electricity generation); a wind turbine is to be installed which is expected to provide around 800kw of electricity per annum.
DURHAM COUNTY COUNCIL, UNITED KINGDOM	
Case 1 **Solid Biomass Boiler installation in an Off-Gas zone (Weardale, Durham)**	The biomass installation will not only provide the quantified savings in LPG, and a commensurate reduction in CO_2 emissions, but it will have a significant impact on the overall performance of the museum under the Green Tourism Business Scheme.
Case 2 **Solar Photo-Voltaic Scheme, New Business Centre, Derwentside, Durham**	The SPA project (Solar Photo-voltaic Array) sought to reduce the electricity costs and carbon footprint of its larger public facilities by utilizing the roof-space of appropriately sited buildings. In total 35 buildings were selected and over 860kWp of solar panels were installed, ranging from 3,5 kW to 149 kW in size. These sites annually generate over 700,000kWh of renewable electricity along with a CO_2 reduction of 850 tonnes per year.
KAUNAS UNIVERSITY OF TECHNOLOGY, LITHUANIA	
Background	**Carbon reduction project** is still ongoing so are not a clear evaluation of carbon dioxide reducing.KaunascityMunicipality is planning to spend about 6 million Lt (1,7 mln. Euros) for this project. Modernization of Kaunas city street lighting significant reduced installed capacity of illuminators, reduced electricity consumption, ipso facto reduced CO_2, other emissions in electricity production. Local companies performed implementation works of the project and in such a way was increased level of employment.
Case 1 **Renovation of the Kaunas lighting system**	Modernization of Kaunas public lighting system – Lighting has a substantial impact on the expenses for energy also on the environment, accounting for up to 40% of the electricity used in public buildings. Best examples from this field have shown that between 30% and 50% of the electricity used for lighting could be saved by investing in energy efficient lighting systems. In most cases, such investments are not only profitable but they also maintain or improve lighting quality. This activity is very important for KaunascityMunicipality.
CITY OF TULLN, AUSTRIA	
Background	Concerning energy, Tulln is leading the way in the region Lower Austria and will act as a multiplier for suitable and feasible technologies. By the State of Lower Austria, the construction of facilities for the production and use of alternative energy in various fields – and energy saving measures in general – is promoted.
Case 1 **The small hydroelectric power plant**	The municipality of Grafenwörth operates a small hydroelectric power plant to generate electricity. The power station produces since the year 2012 at full capacity (always available) about 19,200 kWh per month. The consumption of the local council is compared to, approximately 1,800 kWh per month.
Case 2 **Wood chip heating plant with heat and electricity use**	The decision to use wood chips as a fuel was made because this is a cheap raw material and comes from the region. The wood chip plant was built to supply the adjacent apartment buildings with electricity and heat. The objective of the investment is, also schools, communities and interested citizens bring closer the processes of electricity generation from renewable energy. *Benefits that arise from this system are:* • Environmental friendly energy 240 MWh electricity and 1,450 MWh of heat per year are produced. Therefore annually about 120,000 litres of heating oil will be replaced. Currently, 45 residential units, 8 large public buildings and households in the catchment area were provided with energy from wood chips. • Emission reduction Through the system, 600.000 kg / an of CO_2 can be avoided. • Jobs
Case 3 **Agricultural College Tulln**	**The Agricultural College Tulln is an educational and advisory establishment of the province of Lower Austria. The school is a training company with about 30 ha of arable land and about an acre of vegetables, wine and fruit growing area. The training and testing are carried out in the individual faculty labs. The school year 2012/2013 started with 56 students. The school lasts 3 years.** The Agricultural College Tulln offers the possibility to choose between the branches General Agriculture, Agriculture and Renewable Energies, Agriculture and Heating, Agriculture and Municipal services, and school for farmers. The Agricultural College Tulln is involved in a variety of projects that are closely linked to the field of renewable energy, such as vegetable oils as fuels, biomass power plants, sustainable development and utilization of cereal plants, combined heat and power and more.
SZCZAWNICA MUNICIPALITY, POLAND	
Background	Szczawnica decided to start using solar energy. The enterprise met with great interest of the Szczawnica community. Over 378 people joined The Association for the Eco-development of Szczawnica "EKOSzczawnica", which has been established in order to organize the project's implementation. Local authorities precisely defined conditions of participation in the enterprise and adopted schedule and timetable of planned activities. The first institution which positively replied to Szczawnica's application for funding was Voivodeship Fund for Environmental Protection and Water Management (WFOŚiGW), which granted the municipality a loan of 2 873 366,79 PLN. The loan has an interest rate of 4% and there was a possibility of its amortization to the amount of 35%. Another institution requested for co-financing the project was National Fund for Environmental Protection and Water Management (NFOŚiGW). Szczawnica had to wait long for the answer but it paid off. Szczawnica received a grant of 3 591 710,00 PLN which covered 50% of the costs of the enterprise. These are significant resources, which – along with funds from WFOŚiGW and interested stakeholders – make it possible to carry out the enterprise.

Case 1 **Solar panels for citizens of Szczawnica**	The authorities of Szczawnica – encouraged by existing programmes for financing environmental projects – decided to undertake unique in Poland enterprise consisting in installation solar collectors at individual consumers. The project entitled "Reduction of low emissions through utilization of renewable energy sources by individual and collective consumers at the area of Szczawnica municipality with special focus to solar installations" included purchase and installation of complete solar systems. Regular meetings for inhabitants of Szczawnica and members of the Association aiming at increasing of environmental awareness of inhabitants were organized. In the near future, awareness-raising activities at schools were planned. *Outcomes:* • improving the quality of residents' life and a state of the environment; • raising environmental awareness in the community and promotion of RES; • diversification of energy sources; • increasing the share of energy from renewable sources; • protection of natural and cultural heritage for future generations with a particular emphasis on areas valuable in terms of nature (Natura 2000) and tourism; • increasing the tourist attractiveness of the area covered by the project. Szczawnica, having about 7,5 thousand inhabitants, focuses on the utilization of solar energy. At present, it has over 5 430 m2 of solar panels in total (also on the roofs of larger buildings with rental apartments for spa guests and tourists), about 3 353,4 kW of energy used comes from this source. Complete solar systems made of approx. 1574 collectors with total absorption surface of about 3 714,64 m^2 and capacity of 3037,82 kW for private owners were co-financed in about 60% by NFOŚiGW and WFOŚiGW. The main success is the reduction of emissions in the Szczawnica region (dust, sulphur dioxide, nitrogen dioxide, carbon monoxide, soot). In addition to ecological benefits, the project has brought significant cost savings. Inhabitants who have installed solar systems use the hot water for free since March till October. It is – in the context of constantly increasing energy prices – is a huge advantage for family budgets
Case 2 **The network of energy saving schools – EURONET 50/50**	To reach less CO_2 emissions schools created a **50/50 NETWORK** around Europe with the aim to save energy. Applying the German 50/50 methodology to 58 educational centres in order to contribute to the fight against climate change. Within the frameworks of the project, a European network of schools was created and energy efficiency measures were implemented in chosen school buildings. The 50/50 concept assumes that thanks to taken up actions 2,5% energy savings will be achieved and money saved will be divided between schools (50%) and municipalities (50%) In Poland: • raining seminars for teachers were organized; • educational materials **(e-pack)** were prepared and sent to all schools participating in the project; • **3 sets of measuring instruments (digital thermometer, luxmeter and energy consumption meter)** were sent to schools for pupils to be used during preparation of the energy characteristics of their schools; • energy audits were conducted in schools to find out the schools' energy baselines and the potential energy savings; • every school has created an Energy Team to coordinate and monitor the implementation; • energy review of the school buildings was organized as well as the measurements of temperature, light intensity and energy consumption; • information and promotion campaigns (full of innovative ideas) were organized to promote the idea of 50/50 and to encourage energy saving whole school community. 58 schools from 9 countries involved in the 50/50 methodology implementation and respective local authorities. In Poland 11 primary schools from 8 municipalities all over Poland. PNEC prepared Polish version of the e-pack, which consists of: a) **Description of the EURONET 50/50 methodology** (*How to set up a successful 50/50 project*) translated into Polish b) **Teachers guide** (with worksheets for pupils) translated into Polish c) **Lesson scenarios** for different school subjects concerning energy saving and climate protection issues d) **Additional materials for teachers and pupils** that were developed within the frameworks of other projects focusing on energy education of children and youths e) **A movie** about the implementation of the 50/50 methodology at German schools (with Polish subtitles) The energy savings achieved in 7 schools (out of 11 participating) in 2010 in Poland amounted to 6,1%, giving a total of 260 571,9 kWh and in 2011 energy savings achieved in 6 schools (out of 11 participating) amounted to 6.9% giving a total of 249 861,4 kWh The most impressive savings was achieved by Primary School No 13 in Bielsko-Biala: in 2010 it saved over 6 600 EUR, in 2011 – as much as over 7 750 EUR! The money saved in the first year let them purchased 2 laptops, 2 projectors and a camera, and organize for the most involved students a trip to Fairy Tales Centre in Pacanow.
Case 3 **Energy Days as a tool of community involvement**	Energy Day is a local event that aims at raising public awareness of issues such as energy efficiency, use of renewable energy sources and the links between energy and climate change. The event can take different forms and should join increasing energy awareness of different groups of stakeholders with good fun. Energy Days included activities such as workshops, exhibitions, study visits, open-door days, forums, competitions for schools (of children drawings, rhymes, songs etc.) and general public etc. Energy Days activate the whole local community: institutions, citizens, local actors and stakeholders, schools: children and youth. As a result of Energy Days, the social awareness was increased – citizens practice saving energy and its efficient use of their houses and workplaces. They seem to be more willing to invest in EE measures. In total, about 4000 people participated in these events, however, due to the wide public campaign and competition organized for schools more than 10 000 people were addressed.
AVRIG MUNICIPALITY, ROMANIA	
Background	Avrig strengthen its leading position in a regional context as a key promoter of sustainable energy development and become a model for other cities in the region and across the country in environmental and social sustainability, as it addressed the use and exploit resources natural abundantly present resources in the area, boosting local professional and entrepreneurial potential through sustainable enterprises.
Case 1 **SC Enev-AVRIG LLC a council-owned investment and electricity distribution company**	**SC Enev-AVRIG LLC** is dedicated to the integration of renewable energy systems in Avrig and surrounding villages. The company, founded by the **City Council** of Avrig assumed an operational role in all projects aiming at the installation of energy distribution, energy transport and thermo-energy rehabilitation of buildings maintained by the Local Council of Avrig. **SC Enev-AVRIG LLC** is also able to acquire new investment funds for future development projects as well as the implementation of existing energy projects and attracting new private and public investors to the city of Avrig. Feasibility study of small hydropower plants on the AvrigRiver and the construction of biogas and biomass power plants have been implemented. In addition, a plan was drawn up for a future centralized heat supply from renewable sources to the residential and commercial areas. Implementation of rooftop solar power to residential and municipality-owned buildings is also on the agenda. There is a possible replicability of the model to other small cities in Romania the other EU countries in using local energy sources to produce decentralized energy for their own uses to bring down local energy costs.
Case 2 **Avrig has jointly implemented, with "The Lucian Blaga" University of Sibiu, a "*Smart community-academic course*"**	Avrig City Hall proposes **"Lucian Blaga" University of Sibiu**, to develop and offer an academic multidisciplinary course based on *Smart community* issues with lecturers that have already demonstrated their knowledge, commitment and involvement to our projects such as Corporate Security Management Research Center, Total Quality Management Scientific Research Center, and other national/international interested lecturers, including Toshiba Group representatives. Establish local RES & EE Education to enhance **"Lucian Blaga" University of Sibiu** in a key role as a player within the community, the City Hall of Avrig proposes starting with basic topics of the academic course to support common growth and development for renewable sustainability in business, academia and local government sectors. Another objective of the Smart community-academic course proposal, to train public servants and public administration professionals in order to understand the impact, needs and responsibilities of the community in sustainable energy. Transferability to other university and colleges as an educational tool to promote the growth of employment in new sustainable energy industries.