

GUIDANCE MANUAL ON ENERGY EFFICIENCY

SAVING ENERGY –
SAVING FUTURE

2014 - 2015



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This publication has been produced within the project 'Student with Initiative: Vector of Energy Saving' implemented by the Agency for Private Initiative Development in collaboration with the Executive Committee of Ivano-Frankivsk City Council (Ukraine) and the Municipality of Lublin City (Poland). The overall project's goal was to encourage proactive youth of Ivano-Frankivsk region of Ukraine and Lublin Voivodeship of Poland to initiate and implement innovations as well as to launch cross-border cooperation in the energy saving sector.

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The European Union consists of 28 member states, which have decided to gradually link together their know-how, resources and destinies. Together, during a 50-year period of enlargement, they have built a zone of stability, democracy and sustainable development whilst maintaining cultural diversity, tolerance and individual freedoms. The European Union is committed to sharing its achievements and its values with countries and people beyond its borders. The European Commission is the EU's executive body.

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FOREWORD

This Guidance manual is a result of the project 'Student with Initiative: Vector of Energy Saving' implemented in April 2014 - June 2015 in Ivano-Frankivsk Region of Ukraine and Lublin Voivodeship of Poland by the Agency for Private Initiative Development from Ivano-Frankivsk in partnership with the Executive Committee of Ivano-Frankivsk City Council and the Municipality of Lublin. The main goal of the project was to encourage proactive youth of Ivano-Frankivsk Region and Lublin Voivodeship to initiate and implement innovations as well as to establish cross-border cooperation in the field of energy saving.

Therefore, while preparing this publication the authors aimed at promoting energy efficiency tools and informing of renewable energy to a wide array of proactive student youth interested in learning about innovations in the field of energy saving and the use of renewable energy sources in Ukraine and Poland.


The project team is convinced that it is the young generation, who with their fresh thinking, creativity and no fear of the future will manage to solve numerous problems accumulated by their predecessors and related to the loss of natural resources. That is why gaining up to date knowledge, the ability to generate new ideas and the possession of the tools in order to introduce these ideas into the environment and energy saving sectors by the young people are the crucial factors of ensuring the Europe's future energy safety.


Thus, we expect the publication to assist the students of secondary schools and higher educational institutions with learning the principles of energy efficiency and the use of renewable sources. Proactive young people will like practically all chapters of this manual. They will help them to understand the technical features of green energy generators and learn about the legal prerequisites and state incentives to use green energy.

In addition, the Guidance Manual provides the user-friendly resources and tools for the business community, including potential investors, representatives of the state and local authorities, and the citizens, active in applying clean energy for both economic and household needs.


Finally, in front of you - there is a printed book with comprehensive information about energy efficiency and renewable energy, collected, processed and presented in the best interests of a wide range of readers. Though surfing the Web, you would find a great deal of data provided here, but you would not find 100% of this or similar material on a single, even the fullest, web portal. Moreover, this brochure allows you to be energy efficient in the process of acquiring knowledge, turning the pages of global network offline. It is also worth mentioning that the book was published using eco-friendly recycled paper.

The brochure is also available on-line at www.energyouth.org, a web portal of the Youth Cross-Border Cooperation Network for Environmental Safety and Energy Efficiency.

 **The first chapter** of the brochure 'Energy Efficiency' explains the concept of energy efficiency and introduces solutions that will allow optimising energy consumption in different sectors – from a household to municipal infrastructure.

 **The second chapter** 'Renewable Energy Sources' (RES) introduces to the reader the current state of development of renewable energy sources in the world, provides an overview of legislation governing the introduction of RES in Ukraine and Poland and the technical aspects of production of renewable energy and obtaining it by consumers. The chapter highlights the principles of functioning of the green energy market, the potential of renewable energy in Ukraine and Poland and in the target regions of the project, in particular.

 **The third chapter** 'Technological Innovations' introduces the bright results of technical studies aimed at achieving maximum independence from traditional fuels and energy resources in Europe. In particular, the latest smart grids and systems of energy measurement, possibilities of hydrogen energy use and other advanced technological solutions in the power sector are discussed.

 **The fourth chapter** 'Opportunities for Projects Co-Financing in the Field of Renewable Energy and Energy Efficiency' provides an overview of financial aid programmes for the promotion of practices in the field of renewable energy, the peculiarities of financing of the innovative investment projects implemented in the EU and Ukraine and tax preferences for the enterprises that produce green energy in Ukraine and Poland. The chapter draws the reader's attention to the mechanisms and results of the national policies in support of energy efficiency and renewables, introduces the specific examples of implementing environmental initiatives in the local communities of Lublin Voivodeship and Ivano-Frankivsk Region.

 **Definition**

 **Best Practices in Energy Efficiency and Renewable Energy in Communities**

ENERGY EFFICIENCY



What Is Energy Efficiency?

► *Energy efficiency is a complex of measures, actions and conditions in the consumption and use of energy, that leads to the maximum possible use of available energy to obtain the desired effect (lighting, traffic, cold, heat, etc.), but with the minimum expenditure of energy on the things that are not necessary (losses during production, transportation, storage, etc.)*

The issue of energy efficiency is closely related to the concept of 'primary energy', that is the energy contained in fuel (biomass, gas, coal, etc.) or the energy source from which we obtain energy for economic purposes. The more primary energy accumulated or available in fuel or other source we transform into the energy transmitted to consumers, the greater the efficiency of production (or transformation) of energy is. Energy efficiency concerns processes related to electrical energy, the energy of heat and cold, as well as transport. Energy efficiency is the reduction in greenhouse gas emissions by reducing energy production. About 70% of energy consumed in buildings is being spent on heating, so it is worth checking whether our windows and doors are tightly closed and the walls are sufficiently warmed and at the same time provided with the proper ventilation of premises and comfort of living.

Factors Identifying Energy Efficiency

Energy efficiency as a phenomenon is associated with renewable energy sources (RES) in the context of improving the conversion of primary energy contained in fuel (for example, biomass) and the efficiency of interconnection of an energy source with an electrical grid and correlation of power produced by RES with the consumers' needs.

Energy efficiency is greatly dependent on transport, market (prices for energy resources), bodies controlling the market (e.g., Department of Energy Regulation), legislation (e.g., different interpretation concerning businesses and citizens not involved in commercial activity), and trends in fashion concerning the construction and equipping of housing.

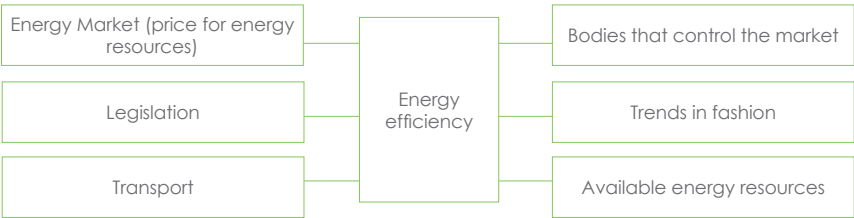


Fig. 1

Energy Saving as a Result of Energy Efficiency

► *Energy saving, connected with improving energy efficiency, is the amount of saved energy as determined by measurements and calculations of the consumption of tools to improve energy efficiency before and after their introduction*

Energy saving is the reduction in energy consumption. Less energy consumption means saving money and less damage to the environment. Energy production requires the use of valuable natural resources such as coal, oil or natural gas. Principles of sustainable development – *the general concept of the necessity to achieve a balance between the satisfaction of modern needs of humanity and the protection of interests of future generations, including their need for a safe and healthy environment* – encourage to use these resources efficiently to save them for future generations. This implies a need to find new, alternative energy sources (diversification of energy sources in the so-called 'energy mix').

The contribution of an individual consumer to energy saving may seem insignificant, but even a group of people, not to mention the entire population of a country or continent, has a huge impact on energy consumption. Each saved kilowatt-hour is a certain amount of saved fuel and less emissions of CO₂ and other pollutants into the atmosphere. Simultaneously the process of saving energy leads to a number of environmental and economic benefits.

Benefits of Energy Efficiency

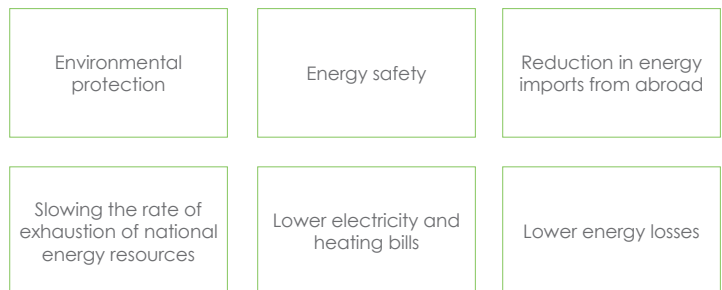


Fig. 2

Everyone should know that!

- ▶ Heating systems equipped with thermostats can reduce energy consumption by 15%;
- ▶ Low-temperature floor heating can reduce energy consumption by 12%;
- ▶ An iron equipped with a thermostat can reduce energy consumption by 5%, and an iron with a steam humidifier provides savings of up to 10% of energy;
- ▶ LCD-monitors can be even twice less energy-consuming than traditional monitors (CRT), plasma TV sets consume the most energy;
- ▶ Desktop computers operate on the average power of 150 W, and laptops – 30-40 W;
- ▶ Equipment with the activated Standby function continually consumes energy from the grid.

Interesting statistics!

Under the Energy Saving Week 2011 in Great Britain there was conducted a study to determine the most common 'sins' of households concerning energy saving, that is the failure to comply with the simple, affordable measures that allow energy saving (i.e. cutting domestic energy bills). The study listed the top 10 most frequent 'sins' as follows:

TOP-10 'sins' of households in energy overconsumption

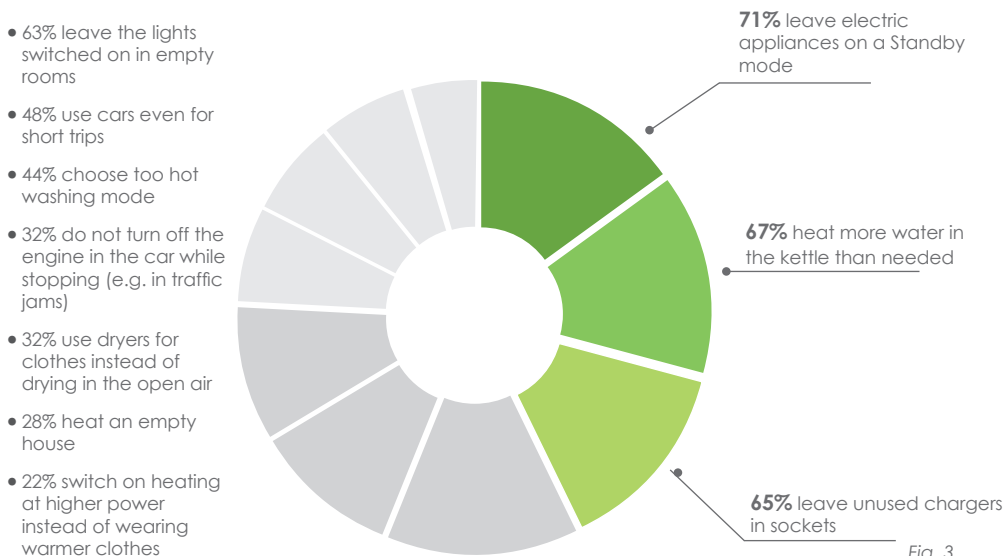


Fig. 3

What can one do by using 1 kWh of electrical energy?

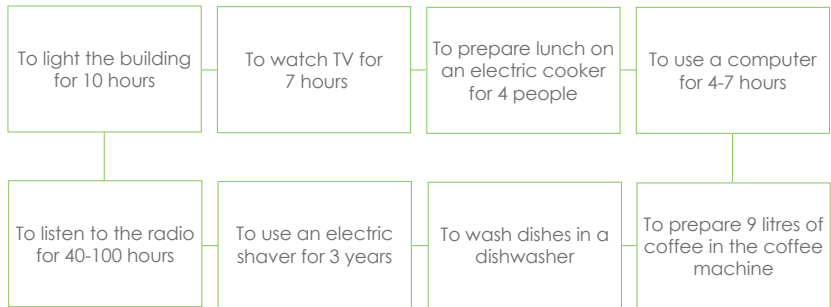


Fig. 4

Ways of Saving Energy

Thermal Modernisation

Thermal modernisation involves introducing changes that will allow to reduce energy demand or to limit heat losses by replacing the heating and hot water supply systems of a building as well as by warming the building.

Thermal modernisation is based on energy audit. Audit allows choosing an appropriate instrument of thermal modernisation that will optimise energy needs of the building and reduce operational costs of apartment building or separate apartment. Due to thermal modernisation, the consumption of heat energy in the building can be reduced. The main purpose and advantage will be the reduction of costs on heating.

Typical measures of the thermal modernisation:

- ▶ Weatherization of walls, roofs and attics;
- ▶ Weatherization of basement supporting structures (overlaps) and floors on the ground;
- ▶ Replacement or repair of windows and exterior doors;
- ▶ Modernisation or replacement of a heat source;
- ▶ Modernisation or replacement of an individual heating system;
- ▶ Modernisation or replacement of a hot water supply system;
- ▶ Improvement of ventilation system;
- ▶ Introduction of RES technologies for heating or warming water.

Motion sensors are considered an interesting solution: light turns on only when needed and automatically turns off.

Modernisation of Lighting

A part of electricity bills we pay covers expenditure on electricity consumption for lighting our apartment or a house. Resulting from the European Union requirements, traditional incandescent light bulbs are disappearing from the shops in Poland being replaced by the energy saving bulbs. In Ukraine in recent years, the population actively exercises the modernisation of lighting using energy efficient methods and devices.

Such replacement ensures the reduction in electrical energy consumption and allows saving up to 80% of energy. The working time of 1 energy efficient bulb equals to 10-15 traditional lighting bulbs: the work cycle of traditional bulb is about 1000 hours, and the best energy saving bulb can work almost for 20000 hours. Though the purchase price of energy saving bulb is higher, it is quickly compensated.

An important element of lighting is its rational use. After leaving the room, it is worth turning off unnecessary lighting, maximally using natural lighting. In its turn when leaving the room for a short time (up to 5 minutes), in which an energy saving lamp is lit, do not turn off the light because too frequent switching on or off the lamps reduces their life cycle.

The bulb capacity should be chosen according to the type of a premise and the brightness of lighting that we strive to receive. In places where very high intensity of lighting is not required, the systems equipped with LED diodes can be used; their power is only a few watts per unit. In addition, LED diodes are characterised by a long work cycle.

The Energy Saving Potential

Saving potential arising from the measures aimed at improving energy efficiency at the local level should be analysed from both economic and environmental perspectives. In order to demonstrate the benefits arising from the functionality of processes and technologies we will use the example of two opposing cases of energy consumption – **energy efficient and energy inefficient ones**.

The examples are symbolic and represent the case with the school required heating energy and the street lighting required the electric energy. Nearby the school and the street, there is a pine forest considered as a local energy source with the unit of measurement – kWh (kilowatt - hour).



Energy Inefficient Case

Initial Data for the Energy Inefficient Case:

- ▶ School with the total area of 1000 m²; heating system not modernized; the building consumes 150 kWh of energy per each 1 m² annually; in addition, there is a boiler for heating the premises and the water, made in the 70s of the XXth century. The boiler energy conversion efficiency constitutes around 40%;
- ▶ Street illuminated with 150 lamps, the capacity of one lamp is 0,25 kW (250 W), luminous efficiency (a ratio of the light flux of a specific light source and the energy consumed by this source per unit time) is 15 lm/W (lumens per watt). The lighting functions without consideration of the real needs in lightning; lightning is on for 2 920 hours per year (on average, 8 hours per day).

In order to produce the amount of energy required for heating the school (150 000 kWh), around 75 tonnes of fuel is required (in our case, fuel is the wood from the pine forest). The source of electricity for the street lighting is a power station, located at a distance of 100 km, and supplied with the fuel in the form of harvested pinewood. Suppose the energy conversion efficiency constitutes 35% (35% of primary energy contained in the fuel is converted into electrical energy) and losses on the transportation account for 20% (20% of the energy transported is wasted in the form of unnecessary heat in power transmission lines and transformers). Energy value of wood used for heating constitutes 5 kWh/kg (about 18 MJ/kg). In order to produce the amount of energy required for street lighting (109 500 kWh) we have to use about 78 tonnes of fuel. Wood from the forest will be transported by the 8 tonnes truck, which has to cover 100 km of distance ten times. Truck fuel consumption constitutes 25% of primary energy contained in the fuel, is being converted to the mechanical (movement) energy, and the rest is being emitted as heat. On average, the truck will require 100 kW of energy. To deliver 78 214,3 kg of wood to the power station it is necessary to provide the truck with about 3,2 tonnes of fuel (wood from the pine forest). Suppose the density of wood of a 75-year-old pine constitutes 500 kg/m³, so from one tree we get 5 m³ or 2 500 kg of biomass.

Summary

150 000 kWh of energy is required for the school heating. Taking into consideration low energy conversion efficiency of the boiler, we will use pinewood with the energy value of about 375 000 kWh of primary energy contained in the fuel. 109 500 kWh is required for the street lightning. Taking into consideration low energy conversion efficiency of the power station, losses on transporting wood and electrical energy, we will use about 407 071 kWh of primary energy contained in the fuel. Summing up this extremely energy inefficient case, taking into account the fuel production, fuel and electricity transportation, the school heating and the street lighting will require annually about 782 000 kWh of primary energy contained in the fuel. This amount of energy is contained in about 63 large 75-year-old pine trees.

Energy intensity of school building		Area of school	Required amount of energy	Energy conversion efficiency of boiler	Primary energy required	Energy contained in wood	Amount of fuel required	
kWh/(m ² *year)		m ²	kWh/year	%	kWh/year	kWh/kg	kg	
150		1 000	150 000	40	375 000	5	75 000	

Scheduled time of work of lamps	One lamp capacity	Number of lamps	Amount of energy required	Energy conversion efficiency of power station	Energy conversion efficiency of power transmission lines	Primary energy required	Energy contained in wood	Amount of fuel required
hr	kW	pcs	kWh/year	%	%	kWh/year	kWh/kg	kg
2 920	0,25	150	109 500	35	80	391 071,4	5	78 214,3

Planned number of trips	Planned distance (in both directions)	Average speed	Average power of engine	Amount of energy required	Energy conversion efficiency of engine	Primary energy required	Energy contained in wood	Amount of fuel required
pcs	km	km/hr	kW	kWh/year	%	kWh/year	kWh/kg	kg
10	200	50	100	4 000	25	16 000	5	3 200

Table 1. Initial data for the energy inefficient option



Energy Efficient Case

Initial Data for the Energy Efficient Case:

- The school is a passive house requiring 15 kWh/(m²/year);
- The street is illuminated by energy saving lamps with a smart control system that regulates the light intensity depending on the existing conditions and needs;
- The electricity is being produced by the local cogeneration source (produces electricity and heating energy and is driven by gas from the wood pyrolysis). The system will operate with the energy conversion efficiency of 85% (i.e. 85% of primary energy contained in the wood will be converted into an electricity and heating energy). In winter, autumn and spring seasons the system will produce 100% of the necessary electrical energy required for lighting the street and 100% of heat energy required for heating premises and water. Taking into consideration the lower need in heating energy during summer season, the system will produce 100% of the required heat energy for heating water and 50% of the required energy for lighting purposes. The rest of the required electrical energy will be produced by solar panels or another renewable energy source, such as wind power station.

In this case the energy balance will constitute 15 000 kWh of heat energy for school heating throughout the year. In order to produce the required energy for school heating it is enough to provide about 3,5 of fuel (pine wood).

For street lightning by smart energy saving lamps, 10 950 kWh of electrical energy is required annually.

Summary

The total fuel mass required to meet the heating and lighting needs, is less than 5% of the primary energy necessary for the previous energy inefficient case: instead of 63 large 75-year-old pine trees we use only 2,5 trees.

Energy intensity of school building	Area		Amount of energy required	Energy conversion efficiency of cogeneration boiler	Primary energy required	Energy contained in wood	Amount of fuel required
kWh/(m ² /year)	m ²		kWh/year	%	kWh/year	kWh/kg	Kg
15	1 000		15 000	85	17 647	5	3 529

Scheduled time of lamps work	One lamp capacity	Number of lamps	Amount of energy required	Energy conversion efficiency of cogeneration boiler	Primary energy required	Energy contained in wood	Amount of fuel required
hr	kW	pcs	kWh/year	%	kWh/year	kWh/kg	Kg
1 460	0,05	150	10 950	85	12 882,4	5	2 576

Tbl. 2. Initial data for the energy efficient option

Conclusions

Thus, the energy consumption in two opposite cases will be as follows:

Option	Energy consumption	Number of trees cut down
inefficient	782 071 kWh	63
efficient	3 529 kWh	2,5

Tbl. 3.

In reality, there are not pure efficient or inefficient systems, and in most cases we deal with the situations in which the method of energy production, transportation and energy use balance somewhere within the above described extremes. It should be noted that it is impossible to reduce fuel consumption in twenty times, but, no doubt, it may be reduced by half.

Such achievable goals allow an ordinary village-type settlement in Poland to receive annual savings of up to PLN 1 million, and a large urban-type settlement can save millions of złotych annually.

► Within the project 'Improving Energy Efficiency in Buildings of Educational Establishments of Ivano-Frankivsk', co-financed by UNDP, a number of measures to improve energy efficiency, reliability and stable functioning of their buildings have been undertaken in five general secondary schools and four pre-schools. In particular, the project implemented the following activities:

- 1) Individual heating units with systems of energy consumption regulation depending on the outside temperature have been installed;
- 2) Windows and doors have been replaced by the reinforced-plastic insulated glazing;
- 3) Heating systems in buildings have been rehabilitated.

As a result, the target schools reduced energy consumption by about 1200 Gcal per year that annually allows savings of more than UAH 1 million of public funds allocated for payment for energy sources consumption. The total cost of the project equalled UAH 5,072,900.

► Thermal modernisation of buildings of the gymnasium №1 and pre-schools № 4 and 6 in the area of Łubieniec can serve as an example of an investment project to improve energy efficiency. The project covered such works as replacing heat sources, modernisation of individual heating systems and hot water supply, weatherization of walls and supporting structures of buildings, and replacement of windows and doors. The project was co-financed by ERDF. For the purposes of the project PLN 1,711,000 were received, and the total cost of the project equaled PLN 2,540,000.

Energy Efficiency of Buildings. Energy Consumption in Various Types of Houses

A low-energy house is the house in which the rate of energy demand for heating does not exceed 50 kWh/m²/year. What does it mean? For each 1 m² of the heated area no more than 50 kWh of energy are required for heating per year. The construction of a low-energy house does not require advanced technologies and systems, and there is no need to hire highly skilled workers. You only need to control the construction phase of individual elements and solutions that have an impact on the energy quality of the house.

A low-energy house is characterised by:

- ▶ well-insulated exterior walls, including good window and door joinery;
- ▶ reduced costs due to minimal thermal bridges that allow cold to 'leak';
- ▶ highly efficient mechanical ventilation;
- ▶ highly efficient heating system.

Low-energy houses consume three times less heat energy than houses with similar space and design. Moreover, the costs of the construction of a low-energy house is only 10% higher.

All low-energy houses are often divided into:

- ▶ passive houses;
- ▶ smart houses;
- ▶ zero-energy buildings;
- ▶ active houses with a positive energy balance (energy-plus houses).

A passive or energy efficient house – is a house with low energy consumption (about 10% of normal energy consumption). According to ISO 7730, a passive house is a building, where the thermal comfort is achieved solely through additional preheating (or cooling) of the mass of fresh air required to maintain the high quality of air in the premises without its additional recycling. In a passive house thermal comfort is achieved mainly by passive means (reinforced outer insulation of walling, heat recuperation, passive use of solar energy and internal heat sources).

A smart house (smart home, digital house) – is a set of different modules, each of which has its own application and is suitable for a particular case. Roughly speaking, they can be divided into 5 subgroups: control devices, operated devices, sensors, communications gateways and logical devices.

Control devices perform the function of transferring your wishes to the smart house. They help you to control the state of appliances and give commands. Operated devices obey the commands of the house and transfer them to your appliances. Sensors receive information from the outside world, communication gateways communicate with your control devices and appliances that need to be managed by not just applying voltage, but through one of the protocols: RS 485, RS 232, LAN, Wi-Fi or through infrared communication.

A zero-energy building – is a building with a very high energy efficiency, able to produce energy from renewable sources on-site and consume it in equal amounts throughout the year. Buildings with zero energy consumption do not use fossil fuels and get all necessary energy from renewable sources. They can be traditional buildings but with a large solar collector, solar panel or wind turbine.

An active house with a positive energy balance (energy-plus building) – is a building, which receives energy for its own needs, with a substantial surplus, from the environment through alternative sources. The idea of creators of an active house was that the house should complement nature and terrain, and do it by both its design and materials.

Passive House

A passive house is considered to be the house, where in both summer and winter there is a comfortable temperature without the use of heating and air conditioning.

A passive house is an intermediary link between a low-energy house and a self-sufficient house with energy consumption at zero level ('zero energy'). Houses of this type are characterised by a very low energy demand for heating. During one heating season, the heating of 1 m² of a passive residential space requires maximum of 15 kWh, corresponding to combustion of 1,5 litres of black oil fuel, 1,7 m³ of natural gas or 2,3 kg of coal. For comparison, the heat energy demand in standard buildings ranges from 100 to 120 kWh for 1 m² per year.

The advantage of passive houses is the use of proven solutions, due to which the high reliability is achieved. In passive houses renewables are used frequently. Houses built according to the passive technology are characterised by over 90% less energy demand than traditional houses. This allows reducing expenditure on electrical and heat energy associated with the use of, among other things, photovoltaic panels, heat pumps and solar collectors. All exterior walls of the house – walls, roofs, windows or floors, are insulated with the special materials due to which heat losses are minimised.

Passive houses use only the heating of ventilated air; the traditional heating systems are not applied. In order to balance the needs for heat, the solar radiation, reuse of heat from ventilation (recuperation) and thermal radiation from inner sources (i.e. from electrical equipment and residents of the house) are applied.

Elements and principles used in the construction of passive houses:

- ▶ bay windows, greenhouses, conservatories
- ▶ energy saving window and door joinery
- ▶ transparent insulation materials
- ▶ buffer zones (garages, wind scoops)
- ▶ concentration of windows on the southern side of the house
- ▶ avoiding cold bridges
- ▶ roof windows
- ▶ recuperators
- ▶ forward-based canopies, which in summer protect windows from excessive solar radiation, while in winter, when the sun is low above the horizon, its rays freely get inside the house
- ▶ use of deciduous trees to shade the house in summer



Photo 1. A passive house
[www.huf-haus.com]

	Low-energy house	Passive house
Attic	0,20 W/m ² K	0,10 W/m ² K
Outer wall	0,30 W/m ² K	0,15 W/m ² K
Basement supporting structures	0,35 W/m ² K	0,15 W/m ² K
Windows	1,1 W/m ² K	< 0,8 W/m ² K
Heating power	45 W/m ²	10 W/m ²
Ventilation	Mechanical or hybrid	Mechanical with heat removal >75%
Need for heat	70 kWh/m ² a	15 kWh/m ² a
Consumption of primary energy (PE)	< 200 kWh/m ² a	< 120 kWh/m ² a

Tbl. 4. Solutions used in the construction of passive houses

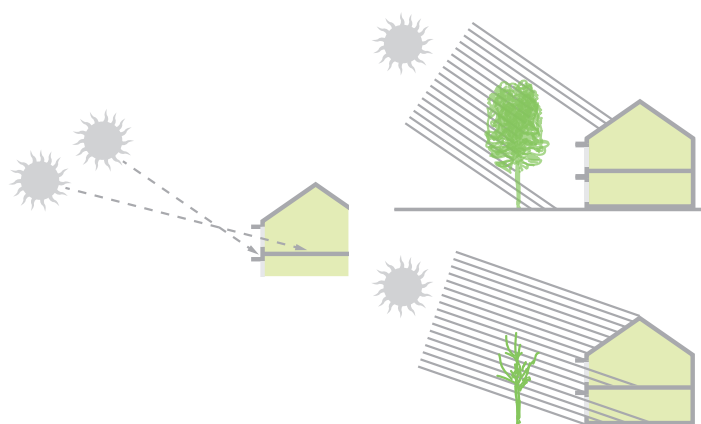


Fig. 5. Solutions used in the construction of passive houses

At present, the cost of constructing a passive house in Poland is higher by 8-35% in comparison with a house constructed in the traditional way. In fact, this is the only one drawback, which actually disproves quite quickly when all above demonstrated benefits of energy efficient homes are activated.

► Nowadays in Ukraine, the owners of households start to care about convenience, comfort and energy saving of their future homes, as well as about their environmental friendliness.

For example, in the village of Drahomyrchany of Ivano-Frankivsk region in 2014-2015 a large family consisting of two adults and three young children built an energy efficient house of 160 m² from recycled (a dismantled adobe house) and natural materials, straw bales. The owners intended to make an environmentally friendly and energy efficient house with a wood-burning stove, which before was very popular in the Precarpathian region rich on forests. In addition, a house made of straw in comparison with the adobe similar ones, remained in the villages from the last century, is a few degrees warmer and much drier. This is especially perceptible in the off-season when rains and humidity dominate in the atmosphere. The total cost of the project in UAH was equivalent to \$80 000.

Smart House

The basis of a smart house (smart home, digital house) is an operational multi-room. With the help of this system all appliances in the building are functionally linked to each other; they can be controlled centrally by remote control. Appliances can be connected to a computer network that allows managing them by using PC and provides remote access to them on-line. Due to the integration of information technologies into the home surrounding, all systems and appliances coordinate their functions by comparing given programmes and external parameters (the surrounding).

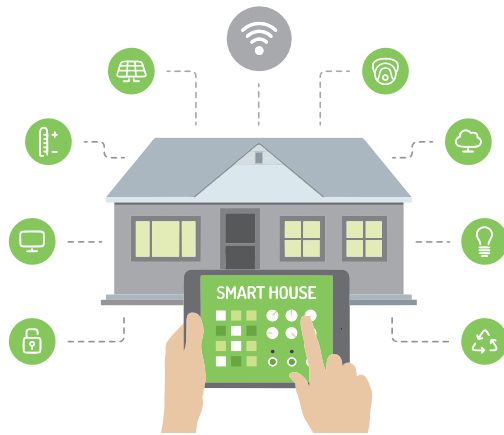


Fig. 6. Smart House

Advantages:

- ▶ convenience and comfort;
- ▶ safety;
- ▶ facilitated supervision over children;
- ▶ energy saving and reduction in utility payments.

Zero-Energy Building

A zero-energy building is a house with a very high energy efficiency, able to produce energy from renewables on-site and consume it in equal amounts throughout the year.

Most of such buildings are being constructed following the principles below:

- ▶ Reduction of required energy;
- ▶ Use of the energy surplus;
- ▶ Reduction of the need of artificial cooling (heating);
- ▶ Provision of highly efficient systems of microclimate control and other systems, including lighting;
- ▶ Use of renewable sources of solar, wind and other types of energy.

Advantages:

- ▶ owners of such buildings do not need to worry about the future rise in the price for energy sources;
- ▶ added comfort due to even distribution of the heat in the building;
- ▶ there is no need for strict energy saving;
- ▶ the total monthly cost of living decreases;
- ▶ the higher resale value of the building: the demand for such buildings is greater than the supply.



Photo 2.Zero-Energy Building

Active House

An active house with a positive energy balance (energy-plus building) applies the best technologies of passive and smart houses to minimise energy losses and save resources.

Design of an active house begins with the study of locality, namely:

- ▶ terrain
- ▶ climate
- ▶ composition of air and presence of chemically aggressive substances in it

An active house is a set of solutions that aims to create the maximum comfort and quality of living through the effective use of natural energy resources and modern technologies. The basic parameter of an active house is the combination of solutions worked out by the Passive House Institute (Germany) and technologies of a 'smart house'. Due to that, it is possible to create the house that not only consumes little energy, but also intelligently manages that minimum of energy that it has to consume. Another important aspect is the creation of favourable microclimate indoors – correct ventilation, maintaining temperature control, etc.

An active house is a house that can generate energy and heat for itself, and in addition for a guesthouse, a sauna and a swimming pool. The world's first active house was built in Denmark. This house consumes less energy than the passive one. Moreover, it produces so much of energy in order to return it back to the central grid and sell it. In this way, the house becomes a source of income rather than expenses. Danish designers claim that an active house is able to recoup itself within 30 years.

Advantages:

- quality
- convenience
- comfort



Photo. 3. Active House

Comparison of Energy Consumption in Various Types of Houses

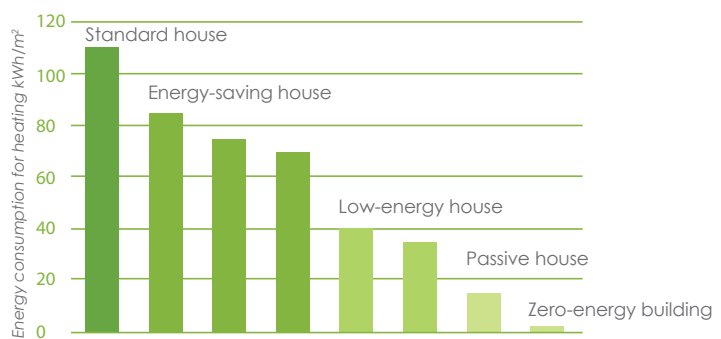


Fig. 7. Comparison of energy consumption for heating in different types of buildings

Thus, nowadays it is very important to construct and use a low-energy house, which provides a number of advantages that significantly improve the quality of life:

- Energy independence gives us the freedom of choice of energy sources.

- ▶ Efficiency enables us to save money.
- ▶ Comfort ensures convenient living.
- ▶ Environmental friendliness – a house practically does not pollute the environment you live.

Energy Audit – What Is It?

▶ *An energy audit is a survey of energy flows in a building to identify opportunities to save energy resources and reduce energy expenses, and to improve the comfort for its residents or staff. The energy audit recommendations concern the reduction of energy consumption and energy expenses with an indication of the value and payback of appropriate measures (definition from the portal of the Association of Energy Auditors of Ukraine – www.aea.org.ua)*

Energy audit is a prerequisite for financing energy efficiency measures and achieving an appropriate environmental effect. The purpose of the audit is to find adequate technical, organisational and legal solutions due to which the audited entity becomes more modern and energy efficient, as well as to calculate the profitability of such solutions. Energy audit determines the scope and economic and technical parameters of appropriate measures.

According to the legislation of Poland, a conclusion of energy audit should include:

- ▶ identification data of the building, local source of heat or local heating supply system, and initial information of the investment company
- ▶ assessment of the technical state of the building, local source of heat or local heating supply system
- ▶ description of potential options for implementing measures of thermal modernisation
- ▶ selection of appropriate measures of thermal modernisation
- ▶ recommendations and consultations concerning the implementation of investment measures aimed at energy efficiency

In Ukraine, according to the Association of Energy Auditors, there are two types of energy audit: express and comprehensive energy audit. It is also possible to carry out energy audit of individual engineering systems.

Express audit means a superficial survey of the building, identification of the most obvious drawbacks and the outline of a work plan for comprehensive energy audit. Usually, the accuracy of recommendations of such audit is estimated at 10-20%.

Comprehensive energy audit means an in-depth study of the building constructions and engineering networks, carrying out instrumental measurements and preparing a detailed plan for implementing energy efficiency measures, including an economic analysis.

Energy audit starts with a detailed study of existing information about the building:

- ▶ building planning and design documentation;
- ▶ data on installed metering stations and sensors (measuring equipment);
- ▶ complains and preferences of habitants / employees concerning the required energy saving actions;
- ▶ statistics of energy consumption over the previous periods;
- ▶ characteristics of the location (they include energy sources, types of fuel, weather conditions, etc.).

If necessary, additional measurements are carried out, such as thermal imaging survey, measurement of internal microclimate, and measuring the level of energy resources consumption. By the way, the latter procedure may help to answer the question: 'Is it beneficial to install a meter (for heat energy or water)?'

After collecting a sufficient amount of materials, an energy auditor builds the balance of energy resources consumption, proposes measures that can be implemented and estimates their efficiency. Usually measures are divided into organisational and short-term recouped (with a payback of 1-2 years), measures with an average payback period (3-6 years), and long-term recouped measures (over 7 years).

Energy audit can be carried out only by accredited auditors.

If audit is carried out by an independent auditor, the advantages are the lack of influence from the designers and impartiality. However, in this case there is a danger of insufficient cooperation with the designers.

If an auditor is associated with the designing company, this usually ensures a fast exchange of information, joint decisions and documents, but the results of this audit are usually standard solutions.

Energy Characteristics of Buildings – Energy Certificate

In EU countries, a system of certification of energy efficiency of buildings has been introduced. The Certificate of House Energy Performance determines the amount of energy consumed within a year and necessary to meet the needs of the building. The certificate aims to encourage the design and construction of low-energy houses and to enhance energy efficiency of already existing houses. Availability of an energy

certificate influences the competitiveness of the building while selling or leasing. The certificate shall be reissued every 10 years and in case of changed energy characteristics of the building, for instance, heating modernisation etc.

The document contains basic data on the amount of energy required for heating, hot water supply, ventilation, air conditioning, and for non-residential premises, it indicates the amount of energy required for lighting and comparative criteria. The certificate also contains instructions and a list of possible improvements to reduce energy needs. It determines the annual needs for non-renewable primary energy (PE) and final energy (FE).

The Certificate was introduced by the EU Directive 2002/91/WE of 16 December 2002 'On the Energy Performance of Buildings'. The Directive obliges the EU countries to introduce compulsory certification of buildings since 01 January 2009. The provisions of the Directive entered into force for Poland with the introduction of amendments to the Law 'On Construction Right' of 19 September 2007 and 27 August 2009.

The Law 'On Construction Right' provides for each house while setting in operation as well as the house leased out or offered for sale must possess the determined amount of energy required to meet different needs associated with the use of this house.

Thus, the Certificate of Energy Performance in Poland is compulsory:

- ▶ For getting permission for setting in operation new buildings;
- ▶ For public buildings with the usable space of over 1000 m², such as schools, airports, museums;
- ▶ For existing buildings prior their sale or lease to a new leaseholder;
- ▶ For buildings thermal characteristics of which were changed due to modernisation.

For houses containing the residential apartments or premises, which are technically and operationally detached and independent, the Certificate of Energy Performance shall be issued for separate apartments or premises. Specifically, the mentioned certificate shall be issued before selling or leasing an apartment or a premise.

In Ukraine energy audit is a voluntary survey carried out on the initiative of a consumer of fuel and energy resources. Such energy audit results are set in a report, allowing the consumer to decide on further modernisation of the building. The main conclusions of energy audit may be specified in the summary of the report on several pages.

RENEWABLE ENERGY SOURCES



Definition and Development of Renewable Energy Sources

► According to Wikipedia, renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, air and water heating/cooling, motor fuels, and rural (off-grid) energy services.

According to the official EU definition, here also belongs the energy from biomass, gas obtained from landfills gas, sewage treatment plant gas, and biogases. In other words, these are the sources that cannot be exhausted, unlike traditional fossil types of electrical energy (gas, oil, coal and even raw materials for nuclear energy), because they are a part of inexhaustible natural phenomena.

The rapid development of alternative energy production is caused by a limited resource of minerals on the Earth, a negative impact of combustion products of various substances on ecology and disposal of radioactive waste.

Such a reliable source as Global Status Report on using renewable energy sources (Global Status Report, Renewables 2014, www.ren21.net/gsr) shows a fresh view of the world's experts on the status of renewable energy sources introduction and the role of some of them in the economic development of the world's countries.

The overview of the situation concerning RES is as follows: renewable energy provided an estimated 19% of global final energy consumption in 2012, and continued to grow strongly in 2013.

Of this total share in 2012, traditional biomass, which is currently used primarily for cooking and heating in remote and rural areas of developing countries, accounted for about 9%, and modern renewables increased their share to approximately 10%.

It cannot go unnoticed that in this context the traditional biomass (we are used to consider it an innovative fuel) refers to a solid biomass that is combusted in inefficient way and as a rule pollutes the environment, and threatens with fire due to the combustion in open fires or furnaces. Energy of solid biomass is used for heating premises and cooking, providing comfort, and for small-scale agricultural and industrial processing, usually in rural areas of developing countries. As experts say, this energy cannot be generated on a sustainable basis.

Thus, traditional biomass currently plays a critical role in meeting rural energy demand in most of the developing world. Modern biomass energy is defined in this report as energy derived efficiently from solid, liquid, and gaseous biomass fuels for modern applications. There is ongoing discussion about the sustainability of traditional

Energy consumption in each country is directly related to both the economy of the state and welfare of its citizens. For example, the development of renewable energy in Germany is ahead of average indices in the world. Here the share of wind energy accounts for 10,1%, solar energy - 7%, biogas - 9,5%, and only the level of hydropower energy is close to the world's one - 4%.

biomass, and experts express doubts whether it should be considered renewable, or only if it comes from a sustainable source – high quality solid, liquid or gaseous biomass types. The Report cites the competent sources for obtaining information about environmental and health impacts of traditional biomass, it also mentions the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (Cambridge, UK: Cambridge University Press, 2011).

Modern renewable energy is being used increasingly in four distinct markets: power generation, heating and cooling, transportation of fuel, and rural/off-grid energy services. The breakdown of modern renewables, as a share of total final energy use in 2012, was as follows: hydropower generated an estimated 3.8%; other renewable power sources comprised 1.2%; heat energy accounted for approximately 4.2%; and transport biofuels provided about 0.8% (see Fig. 8).

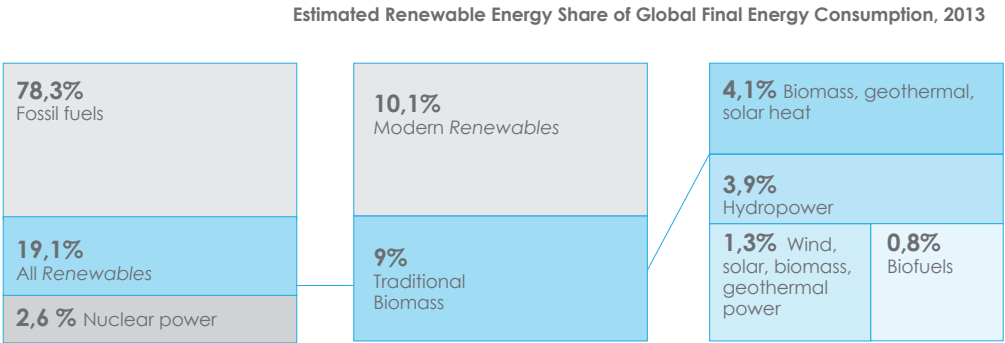


Fig. 8. REN21.
Renewables 2015 Global
Status Report

Almost all nuclear power in the world is used for electrical energy production, however still a significant share of electricity is being generated from combustion of coal or natural gas. Thereby, around 0,5 kg of CO₂ is being emitted in the environment per 1 kWh of electrical energy from the combustion of natural gas and even more from the combustion of oil or coal (0,85 kg per 1 kWh and more than 1 kg per 1 kWh respectively). Every year the focus on increasing requirements for energy purity (from a customer's perspective) and convenience (from a perspective of multiple purposes energy use: lighting, heating, cooling, serving transport, etc.) is strengthened.

Legal Peculiarities of Using Renewable Energy Sources in Poland

In Poland prerequisites of using RES are regulated by both general EU directives and inner legislation. The relevant EU regulations include:

<p>A Strategy for smart, sustainable and inclusive growth</p> <p>'EUROPE 2020'</p>	<p>The Strategy aims at increasing of economic growth, raising of employment rate and solving problems arisen from economic crisis of 2008-2009. Five headline targets have been set for the EU to achieve by the end of 2020. These cover employment; research and development; climate/energy; education; social inclusion and poverty reduction. In addition, it contains seven so-called flagship initiatives in key areas of the strategy, namely: Innovation Union, Youth on the move, the Digital Agenda for Europe, a Resource-efficient Europe, an industrial policy for the globalization era, the agenda for new skills and jobs, and the European Platform against Poverty.</p>
<p>1997 White Paper for a Community Strategy and Action Plan</p> <p>'Energy for the future: renewable sources of energy'</p>	<p>This document specifies the development of renewable sources of energy (RES) as top priority for the EU member states. White Paper presents the objectives of the priority for the promotion of RES pointing out the safety and diversification of energy supply, environmental protection and social and economic unity.</p>
<p>Green Paper</p>	<p>The EU 'Strategy for competitive, sustainable and secure energy 'Energy 2020' represents the intentions and measures which can form the basis of a new comprehensive European energy policy.</p>
<p>'Climate-Energy Package of the EU 3 x 20'</p>	<p>The Climate and Energy Package is a set of measures and legislative adjustments that should enable the transformation of the EU countries to the economy with low indices of emissions and a low level of coal combustion. The Package was introduced by the European Commission on 23 January 2008, and then approved by the Council of Europe in March 2008.</p> <p>On 17 December 2008 the European Parliament adopted a package of six laws, called the Climate and Energy Package. The aim of the Package is actually to force the EU countries to conduct 'green revolution' in the industry and energy development. In the abbreviated form this Package is called '3 x 20': limiting CO₂ emissions by 20%, reducing energy consumption by 20% and increasing the consumption of renewable energy sources in the EU from 8,5% to 20% by 2020.</p>
<p>EU Directive 2009/28/EC (Directive 28)</p>	<p>The so-called Directive 28 'On the Promotion of the Use of Energy from Renewable Sources' was published in the Official Journal of the EU on 05 June 2009, six months after the adoption of the Climate and Energy Package by the European Parliament and the European Council. Among other things, this document actualizes compulsory objectives and measures in the field of using renewable energy sources by 2020 at national levels.</p> <p>The Directive defines strategic aims to reduce emissions and pollution connected with traditional energy sources by 20%, while the share of renewables in the energy balance should be 20% at last, and the share of biofuels – 10%. The Directive came into force on 25 June 2009.</p>

Tbl. 5

The implementation of Directive 28 in Poland:

- ▶ Since 01 January 2014 amendments to the Energy Law and some other laws came into force (the so-called small energy three-package);
- ▶ The Law 'On Energy Efficiency' adopted and came into force on 11 August 2011;
- ▶ Amendments to the Laws 'On Biological Components and Liquid Biofuels' and 'Gas Law' came into force on 25 August 2006, the latest changes were made on 08 April 2014);
- ▶ The Law 'On Renewable Energy Sources' was adopted on 20 February 2015.

Legal Peculiarities of Using Renewable Energy Sources in Ukraine

Name of legislation	
The Association Agreement between Ukraine and the European Union, the European Atomic Energy Community and their Member States, ratified by the Law of Ukraine of 16 September 2014, № 1678-VII	
The Law of Ukraine 'On Energy Saving' of 01 January 1994, №74/ 94-BP.	
The Law of Ukraine 'On Electrical Energy Industry' of 16 October 1997, №575/97-BP	
The Law of Ukraine 'On Alternative Fuels' of 14 January 2000, №1391-XIV	
The Law of Ukraine 'On Alternative Sources of Energy' of 20 February 2003, №555-IV	
The Law of Ukraine 'On the Combined Production of Heat and Electrical Energy (Cogeneration) and Use of Waste Energy Potential' of 05 April 2005, №2509-IV	
The Law of Ukraine 'On Heat Supply' of 02 June 2005, №2633-IV	
The Law of Ukraine 'On the Principles of Ukrainian Electrical Energy Market Functioning' of 24 October 2013, №663-VII	
The Law of Ukraine 'On Licensing Economic Activity' of 02 March 2015, № 222-VIII	

The current legal framework of Ukraine concerning the development of renewable energy consists of the following laws:

Brief description

The Association Agreement provides for mutual cooperation of the parties, in particular in the field of development and support of renewable energy taking into consideration the principles of economic expediency and environmental protection, as well as alternative fuels, including the sustainable production of biofuels and cooperation in the field of legal and regulatory issues, standardisation and certification, and also technological and commercial development and promotion of the mechanism of joint implementation of the Kyoto Protocol to reduce greenhouse gas emissions by implementing projects on energy efficiency and renewable energy (Art. 338). In addition, it provides for assistance and encouragement of trade and direct foreign investment in environmentally friendly goods, services and technologies, the use of balanced renewable energy sources and energy saving products and services, as well as ecological labelling, by removing the related non-tariff barriers (Art. 293).

The Law defines the legal, economic, social and environmental principles of energy saving for all enterprises, associations and organisations located on the territory of Ukraine, as well as for its citizens. It defines measures to encourage energy saving, namely those connected with the development of RES (Art. 16), the main approaches to the formation of energy standards (Art. 19).

The Law defines the legal, economic and organisational principles of activity in the field of electrical energy and regulates relations connected with the production, transmission, supply and use of energy. It lays down licensing principles in the field of electrical energy (Article 13), the principles of setting and application of 'green tariff' (Art. 17-1 and Art. 17-3).

The Law defines the legal, social, economic, environmental and organisational principles of the production (extraction) and use of alternative fuels and the stimulation of increasing the share of their use to 20% of total fuel consumption in Ukraine by 2020. According to the law, a fuel is determined as alternative if it is completely produced (extracted) from alternative / renewable sources and types of energy raw materials (including biomass) or is a mixture of traditional fuels with the alternative ones, the contents of which must meet the technical standards of motor fuel; produced (extracted) from oil, gas, oil, gas and condensate field of nonindustrial importance, from exhausted deposits, of heavy grades of oil, etc. and by its characteristics does not comply with the requirements for traditional fuel (if such fuel by its characteristics complies with the requirements for traditional fuel, this law is applied only to production (extraction) and is not applied to fuel consumers). Simultaneously standards of environmental safety and consequences of using alternative fuels for the environment and human health must meet the requirements established by the legislation for traditional fuels.

The Law was one of the first pieces of legislation aimed at stimulating the industry of RES in Ukraine. It defines the legal, economic, environmental and organisational principles of the use of alternative energy sources and promoting their use in the fuel and energy sector. It provides for measures to stimulate the production and consumption of energy derived from alternative sources (Art. 9), peculiarities of its use (Art. 10) and operating procedures of alternative sources (Art. 11).

The aim of the Law is to lay down legal principles for improving fuel efficiency in the processes of energy production or other industrial processes, development and application of the technologies of combined production of electrical and heat energy, improving the reliability and safety of energy supply at the regional level, attracting investments to create cogeneration plants. The Law regulates relations arising in the field of energy saving between the owners of cogeneration plants and energy supply organisations engaged in the transmission or supply of electrical energy, regardless of their form of ownership.

The Law regulates the basic principles of activities in the field of heat supply. Namely: production, transportation and supply of heat energy. According to the Law, the main growth options of heat supply systems are planning heat supply, development and implementation of schemes for heat supply to cities and other settlements of Ukraine, validity term of which must be at least 5-7 years based on the optimal combination of centralised and autonomous systems of heat supply, implementation of cogeneration plants, on the basis of existing heating plants as well, the use of alternative and renewable energy sources, including solar, wind, biogas, geothermal waters, production waste energy; reducing losses during heat energy transportation in the main and local (distributive) heating systems through the introduction of modern forms of thermal insulation.

The comprehensive Law that lays down the principles of electrical energy market functioning (Art. 3), the components of the market (Art. 4), the rights and obligations of the market participants (Art. 12-20). The Law also defines the peculiarities of participation in the electrical energy market for the electrical energy producers for which a 'green tariff' is applicable (Art. 22).

It defines a list of economic activities that are subject to licensing in Ukraine, in particular, the licensing of activity in the field of electrical energy production, transportation and supply of heat energy (Art. 7), establishes the procedure for issuing licences (Articles 10-13) and related fees.

Legal Acts of the Cabinet of Ministers of Ukraine	
Decree of CMU of 05 February 1997, №148 'On the State Package Programme of Energy Saving in Ukraine'	Analysing the current situation and forecasts for the economic development, the State Package Programme of Energy Saving of Ukraine aims to develop the main sectors of state energy saving policy that provides for the creation of the legal framework of energy saving, the creation of a favourable economic environment, a comprehensive and effective system of state regulation of energy saving. The strategic objective of Ukraine's energy saving policy in prospect is to achieve the level of advanced countries with market economy concerning energy intensity of both gross domestic product and certain types of products, works and services. The programme provides for a wider use of alternative energy sources and alternative fuels.
Decree of CMU of 19 February 2009, №126 'On the Peculiarities of Joining to Electrical Grids of Electrical Energy Facilities That Produce Electrical Energy from Alternative Sources'	The Decree provides the organisational and technical measures aiming at creation of conditions for transmission of electrical energy into local electrical grids from the unit producing electrical energy from alternative sources with the installed capacity of 10 MW, shall be implemented according to the agreement on joining. The licensee that carries out the activity of transmission of electrical energy to local electrical grids using their own networks, in their investment programmes shall take into consideration the connection costs with joining units that produce electrical energy.
Decree of CMU of 01 March 2010, №243 'On the Approval of the State Target Economic Programme for Energy Efficiency and Development of Energy Production from Renewable Energy Sources and Alternative Fuels for 2010-2015'	The aims of the Programme are to create conditions for approaching the energy intensity of gross domestic product of Ukraine to the level of the developed countries and standards of the EU, to reduce the level of energy intensity of gross domestic product over the validity term of the Programme by 20% compared to 2008 (3,3% annually), to increase the efficiency of the use of fuel and energy resources and to strengthen the competitiveness of the national economy, to optimise the structure of energy balance of the state, in which the share of energy derived from renewable energy sources and alternative fuels will amount to no less than 10% in 2015 by reducing the share of imported fossil organic energy resources, namely natural gas, and substituting them by alternative types of energy sources, including the secondary ones.
Decree of CMU of 24 July 2013, № 771 'On the Approval of Procedure for Issuing, Using and Termination of Validity Term of Electrical Energy Origin Guarantee for Market Participants that Produce Electrical Energy from Alternative Energy Sources'	The Decree in accordance with Art. 15 of the Law of Ukraine 'On Electrical Energy Industry' defines the mechanism for issuing, using and termination of the validity term of electrical energy origin guarantee for market participants that produce electrical energy from alternative energy sources (except for blast furnace and coke gases) and with the use of hydropower – only by micro, mini and small hydropower stations.
Order of CMU of 24 July 2013, № 1071-p 'On the Approval of Energy Strategy of Ukraine till 2030'	The objectives of the Energy Strategy are to create the conditions to meet the demand for energy products on a high level and at the lowest total costs, to raise energy safety of the country, to improve energy consumption efficiency and use, to reduce man-caused impact on the environment and ensure civil protection in the sphere of technogenic safety of the energy industry. A separate chapter of the Strategy is dedicated to RES.

Types of Renewable Energy Sources

Classification of Renewable Energy Sources

Directive 2009/28/EU of 23 September 2009 on the promotion of the use of energy from renewable sources defines RES as an energy from renewable non-fossil sources, namely:

- ▶ wind energy
- ▶ solar energy
- ▶ aerothermal energy
- ▶ geothermal energy
- ▶ hydrothermal energy
- ▶ ocean energy
- ▶ hydropower
- ▶ energy from biomass, landfill gas, sewage treatment plant gas and biogases

The given list of renewable energy sources is used in this brochure in relation to RES issues in Ukraine and Poland. Issues related to ocean energy, for obvious reasons, are out of the question.

Wind Energy

The role of wind energy is growing every year. In 2010 power produced by windmills amounted to approximately 0,2 TW, forecasted to reach 1,5 TW by 2020. The price for wind energy today starts to compete with the price for traditional technologies of energy production. However, the use of wind energy relates to a number of difficulties; and the most serious ones are the geographical peculiarities of placing windmills. In many parts of the world, there is limited potential for high-quality transmission of electrical energy produced by wind generators. Furthermore, such generators often lower the aesthetic appeal of certain landscapes and create excessive noise while operating.

One of the largest wind power stations in the world, the Gansu Wind Station in China, produces 5160 MW of power, and by 2020 it will produce 20000 MW. For comparison, the capacities of wind power stations in Ukraine today account only for over 51 MW. Experts say, the total potential capacity of Ukrainian wind energy reaches 5000 MW, including the territory of Crimea. Data on electricity production by wind generators in different countries are presented in the Table 8.

1	Spain	229 865,00
2	UK	124 403,00
3	Germany	39 165,00
4	France	9 285,00
5	Italy	8 662,90
6	Sweden	5 424,80
7	Portugal	4 914,40
8	Denmark	4 845,00
9	Poland	3 833,80
10	Romania	2 953,60
11	Netherlands	2 805,00
12	Ireland	2 271,70
13	Austria	2 095,00
14	Greece	1 979,80
15	Belgium	1 959,00
16	Bulgaria	690,50
17	Finland	627,00
18	Croatia	346,50
19	Hungary	329,20
20	Estonia	302,70

21	Czech Republic	281,50
22	Lithuania	279,30
23	Cyprus	146,70
24	Latvia	61,80
25	Luxembourg	58,30
26	Slovenia	3,20
27	Slovakia	3,10
28	Malta	0,00

Turkey	3762,5
Norway	819,3
Ukraine	497,5
Switzerland	60,3
Russia	15,4
Iceland	3
Europe	133968,2

Tbl. 8 Data on electricity production by wind generators in different countries (MW per year)

Technical Peculiarities of Wind Energy Production

Most wind turbines start generating electricity at wind speed of around 4 metres per second (m/s), and shut down to prevent storm damage at 25 m/s or above. The regularity of such winds at the location of a windmill is also important, as it affects the amount of electrical energy produced throughout the year, and in such a way – the economic recoupment of investment.

The most common type of wind power station is the one with turbine with a horizontal axis of rotation. The diameter of the circle made by its blades reaches more than 100 m. The adjoining smaller wind power plants more often use turbines with a vertical axis of rotation (Fig. 9).

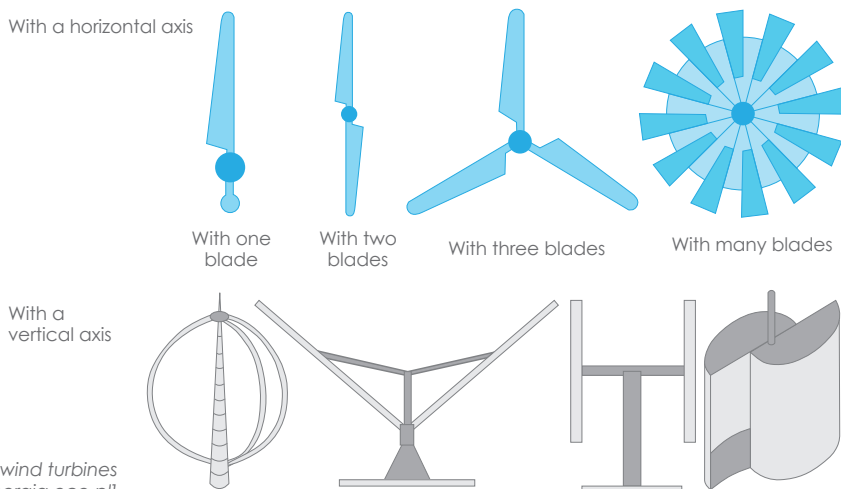


Fig. 9. Types of wind turbines [www.zielonaenergia.eco.pl]

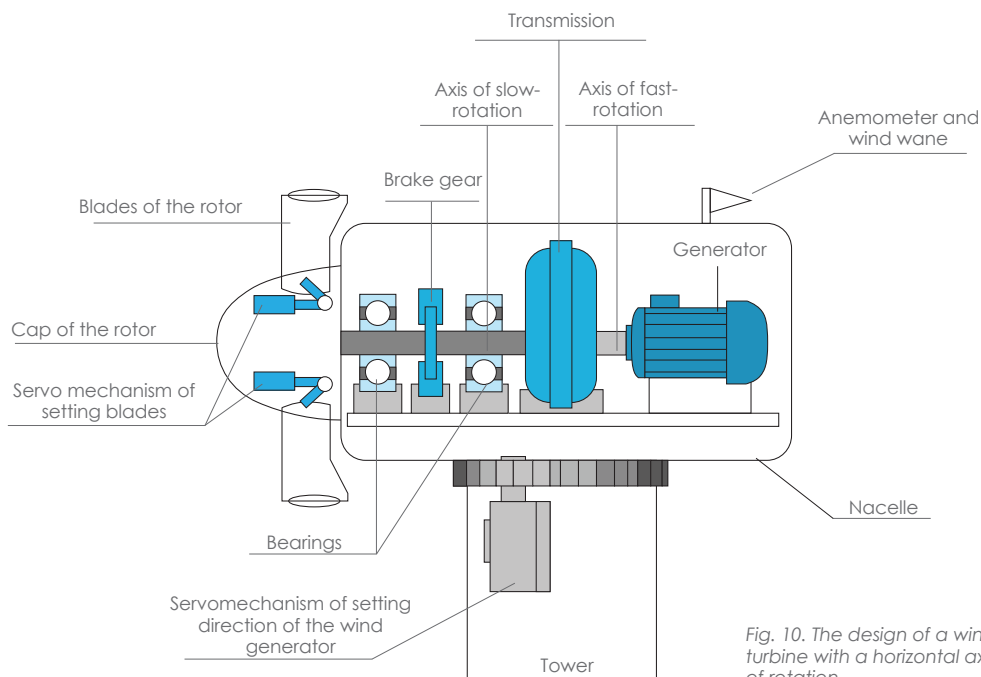


Fig. 10. The design of a wind turbine with a horizontal axis of rotation [www.planetaenergii.pl]

The wind power station consists of a rotor and a nacelle placed on the tower. The most important part of a wind power station is the rotor, where wind energy is converted into mechanical energy. The rotor is installed on the shaft through which the generator is driven and rotates typically at the speed of 15-20 rpm., while a typical asynchronous generator produces electrical energy at the speed of 1500 rpm. In this connection the need for a transmission that regulates the speed of rotation arises.

The most common rotors are those with three blades, built from glass fibre reinforced by polyester. In the rotor head there is a servomechanism that allows to set the angle of pitch of the blades. The nacelle must be able to rotate by 360 degrees so that it can always be offered to wind. Due to that an engine is placed on the top of the tower; it rotates the nacelle through toothed gear. In low-power electrical generators, where the mass of a nacelle is relatively small, it is installed to the wind with the help of a rudder.

The work of the mechanism, positions of blades and the nacelle are managed by the system of microprocessors, acting on the basis of input data (for example, wind speed and direction). In addition, the design of the nacelle provides for a transformer, bearings, lubrication systems and a brake to stop the rotor in emergencies (Fig. 10).

Types of wind power stations:

- ▶ micro wind power stations (less than 100 W) are mainly used for charging accumulators without access to an electrical grid
- ▶ small wind power stations (from 100 W to 50 kW) are used for the needs of individual households or small firms
- ▶ large wind power stations (over 100 kW, up to even 3 MW) are designed mainly to produce electrical energy for sale

1 turbine is able to provide 2222 households with energy

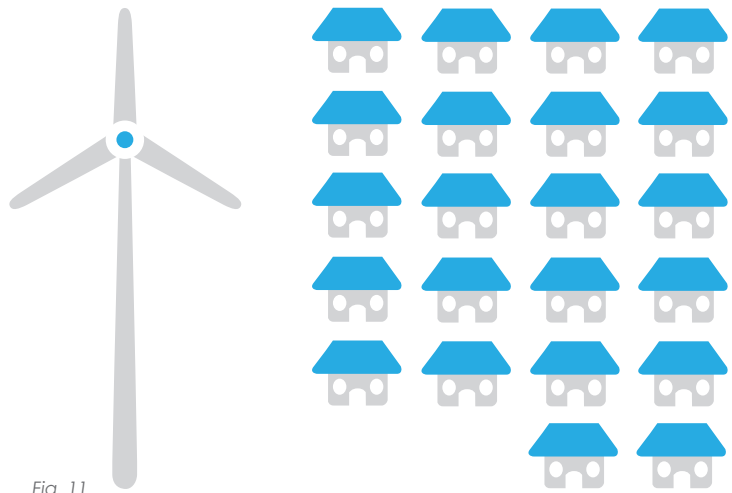


Fig. 11

Wind energy is considered environmentally friendly because energy production does not require the use of any fuel which potentially could have a negative impact on the environment (of course if energy expenditure associated with the construction of power stations is not taken into account).

Solar Energy

- ▶ *Solar radiation is a stream of energy that the sun emits evenly in all directions. A measure of the amount of solar radiation is the so-called solar constant, that is the density rate of a radiation energy stream on the surface of the stratosphere, on average, it is around $1,35 \text{ kW/m}^2$.*

Theoretically, **solar radiation** has unlimited opportunities to meet global energy needs. Sunlight falling on the Earth's surface for one hour could potentially meet the global energy demand for the whole year (which is about 14 TWh).

However, currently solar energy accounts for less than 0,1% of energy production in the world. Unfortunately, the flow of solar radiation is small (less than 1000 W/m^2 at its peak at noon) and intermittent. But according to the popular in Ukraine web-site www.ecotown.com.ua, soon the level of unsubsidized production costs of solar electrical energy will be about USD 0,08–0,13, that is 30-40 % below the retail price for energy on most world markets. In places where electrical energy production depends on coal extraction the correlation between the cost of a 'traditional' kilowatt and the 'sun' one within four years decreased from the level 7:1 to 2:1, and in the next 18 months it will reach parity because the cost of solar panels continues to decline. In the next 5 years solar panels can fall in price by 40%.

Technical peculiarities of solar energy production

There are two ways of using solar energy:

- **photothermal conversion** is the transformation of solar radiation energy into heat energy in solar collectors; it is further used to heat water in the grids, pools or heat supply systems
- **photovoltaic conversion** is the conversion of solar radiation energy into electrical energy in photovoltaic systems

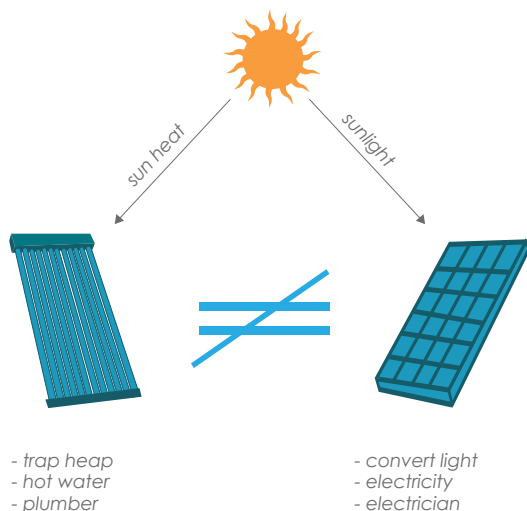


Fig. 12. The main differences between photothermal and photovoltaic conversion

Photothermal conversion

The most popular way to use solar collectors is heating water for domestic needs in households. The carrier of heat energy in the collector can be liquid (water, glycol) or gas (air).

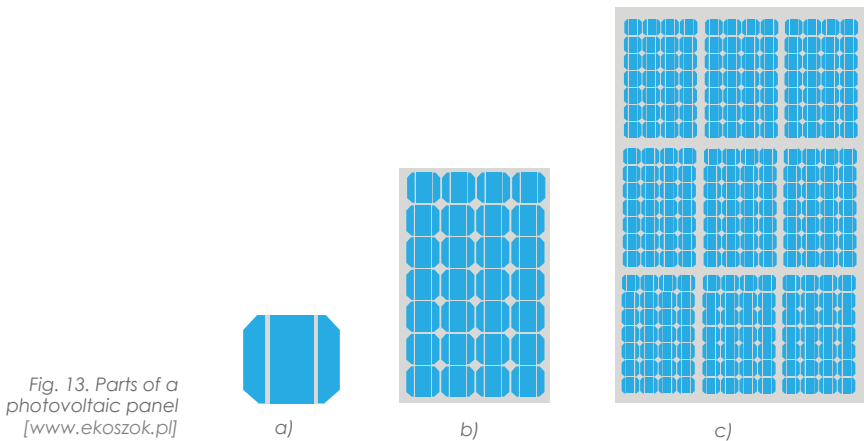
The types of solar collectors are:

- ▶ flat collectors
- ▶ vacuum tube collectors
- ▶ heat-pipe collectors
- ▶ moving parabolic collectors

Photovoltaic conversion

In the photovoltaic devices a photoelectric process takes place, that is the conversion of light energy into the electrical one. Equipment where the photovoltaic conversion process takes place is called solar cells (photovoltaic cells, photocell, and photoelectric converter).

By joining the cells (a), the photovoltaic modules (b) are being produced, and by joining the modules the photovoltaic panels (c) are produced (Fig. 13).



Types of photovoltaic systems:

- ▶ **on-grid** (Fig. 14) is a system that is connected to an electrical grid. It allows to use the current produced by solar cells for own needs and to sell the surplus
- ▶ **off-grid** (Fig. 15) is a system that is not connected to an electrical grid (also called insular). Energy produced by photovoltaic panels is being stored in accumulators, and the current accumulated after passing through the inverter is transmitted to the receivers (home appliances, equipment, etc.), connected to an electrical circuit

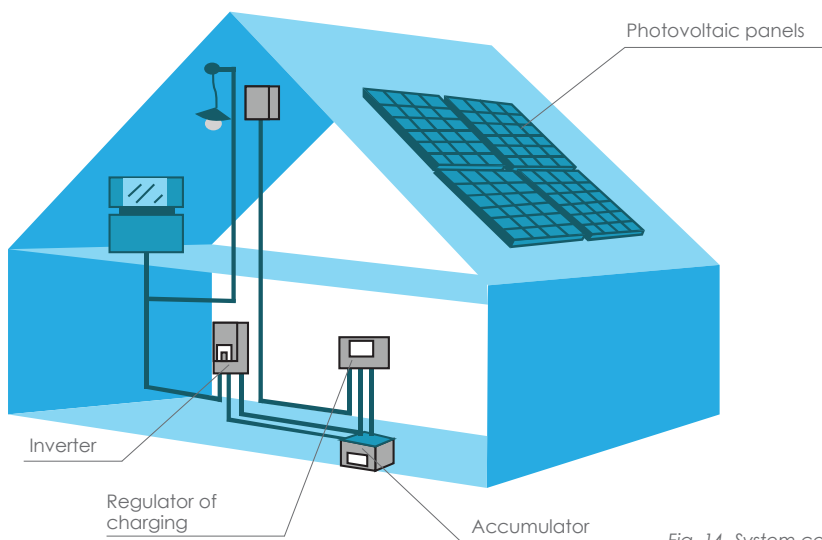


Fig. 14. System connected to the accumulator (off-grid)
[www.ekoszok.pl]

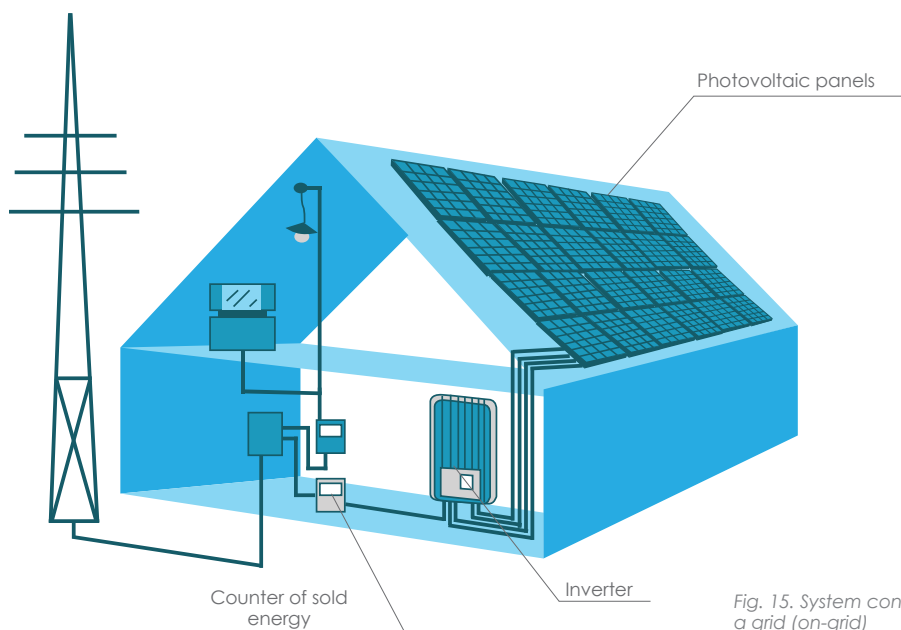


Fig. 15. System connected to a grid (on-grid)
[www.ekoszok.pl]

Hybrid PVT Collector

A PVT collector (Fig. 16) is a combination of a solar liquid flat collector with high energy conversion efficiency that converts solar energy into thermal energy. The collector contains a monocrystalline photovoltaic module that converts solar radiation into electric current.

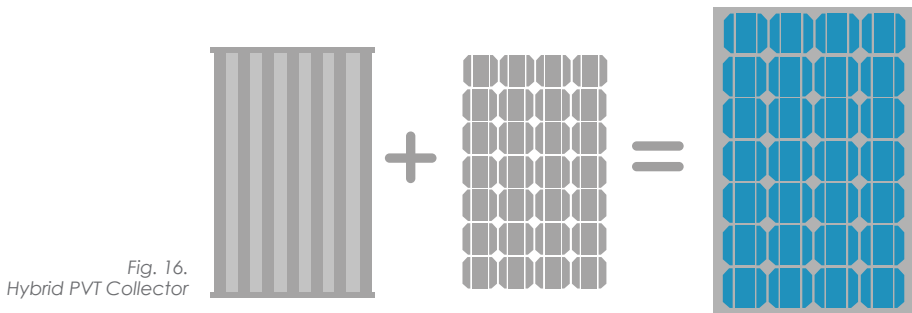


Fig. 16.
Hybrid PVT Collector

► Today in Ukraine you can find more and more examples of the efficient use of solar energy generators for the benefit of local communities. For example, in the village of Rozhniv of Kosiv district of Ivano-Frankivsk region in 2014 with the support of the EU/ UNDP project 'Community Based Approach to Local Development' on the territory of the kindergarten 'Sonechko' (The Sun) a terrestrial solar power station with the capacity of 9,6 kWh was installed. Solar energy produced by the power station is transmitted into the central network of power transmission lines and is separately accounted. Every month the electricity produced by solar power station is being accounted for the kindergarten at a price of 0,2 UAH per 1 kW, which corresponds to the price for transportation through power transmission lines established by the regional energy supply company PJSC 'Prykarpattyaoblenergo'. Thus, in April-September, the kindergarten fully satisfies its energy needs through the solar power station, and in October-March, it generates 1/3 of the required amount of energy. If electricity produced exceeds the required amounts, the surplus may be used for any other public-funded institutions in the rural community. The project costed around €17 000.

► Another project related to the photovoltaic devices is a solar power station 'Stari Bohorodchany-1', located since 2014 in the village of Radcha (Bohorodchany district of Ivano-Frankivsk region). The capacity of the station constitutes 2,8 MW. Annual production of electrical energy is around 3 million kWh, the amount of electrical energy supply to the grid is 2,89 million kWh. By applying solar energy, the local community brought solutions to a number of social problems: new jobs, increased revenues to budgets of all levels and, as such, new funding opportunities for rural infrastructure development. The total project costed around €3 million.



Photo 4. Solar power station 'Stari Bohorodchany-1'

- ▷ Volodymyr Ivanov, an engineer and entrepreneur, installed the heat system on the roof of a five-storey building, where he owns an apartment. The outer part of the equipment is on the ridge of the roof, the inner one – on the attic. The relatively small-sized equipment provides a family of four people with heating energy and hot water in the 60 square metres premises. An equipment includes a solar panel installed on the roof of the building and two water tanks installed on the attic – the collector for 250 litres and the accumulator for 400 litres. Water is being heated in the collector tank and accumulated in the accumulator tank (where it is additionally heated, if necessary), and then enters the heating system in the flat and is used for household needs.

The know-how of the solar station lies in its mobility. Figuratively, a dynamic panel of Volodymyr Ivanov's heat station operates on the principle of a sunflower – during daylight hours it rotates the way the sun moves, reproduces its trajectory from sunrise to sunset. The panel moves and always faces the sun perpendicularly, allowing use of 100% of solar energy continuously. Accordingly, the efficiency of work of the solar station is 1.8-2 times higher than fixed, monolithic solar panels. The project costed approximately €4 000.

- ▷ In 2013 in Ivano-Frankivsk National Technical University of Oil and Gas (IFNTUOG) by sponsors' support, the university administration launched a solar photovoltaic station and the largest in Ukraine solar thermal heliostation used to heat water in the university pool. The developer of this system was the already mentioned Volodymyr Ivanov, who now heads the Department of Energy Saving of IFNTUOG.

The principle of this invention consists in the fact that it uses the sun's energy together with cheap electrical energy at night-time tariffs (almost three times lower), and then at daytime it uses the accumulated energy reserves. Similar systems can be also applied for the centralised installation. In such a way, the entire city can be economically heated, gradually refusing from gas use. In addition, Ivanov's invention does not require imported components – its production can be fully organised in Ukraine. The project costed €5 000.

Geothermal Energy

► *Geothermal energy is a part of geothermic energy (internal heat of the Earth), accumulated in water, water vapour and hot dry rocks.*

In its essence, geothermal energy is the natural heat of the Earth, accumulated in the first ten kilometres of the Earth's crust. Its potential reaches 137 trillion tonnes of reference fuel that 10 times exceeds the potential of geological resources of all fuels combined.

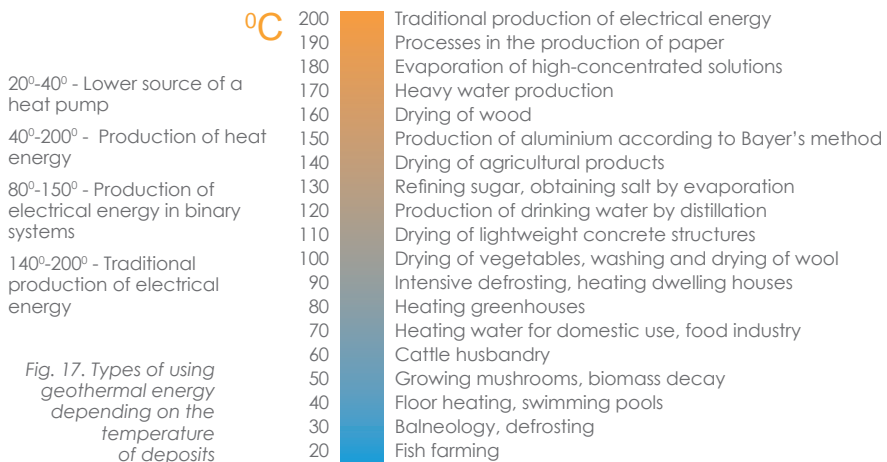
Nowadays up to 1% of geothermal energy of the Earth is being used, and the most common sources of geothermal energy are geysers.

Deposits of geothermal waters result from rainfall penetration into the depths of the Earth, where they are warmed by the heat that comes from the middle of the Earth. Solid rocks that contain no water in their pores but have a high enough temperature ($\geq 150^{\circ}\text{C}$) are called hot dry rocks (HDR). The temperature of the Earth increases in proportion to the depth of penetration of the subsoil. This correlation is called a geothermal step. The geothermal step determines in how many metres deep into the Earth its temperature will rise by the next degree.

Technical peculiarities of geothermal energy production

Ways of using energy accumulated in geothermal waters and vapours are divided into two main groups:

- production of an electric current using geothermal steam as well as binary plants;
- direct application that covers a wide scope of temperatures to achieve different purposes, the most common ones are heating, balneotherapy, and recreation.



There are two types of geothermal power stations:

- ▶ steam power stations, in which an electric current is generated with the use of geothermal water steam;
- ▶ binary (two-phase) power stations (Fig. 18), in which electrical energy is produced with the use of two hydraulic fluids: geothermal water and fluid with a low boiling point.

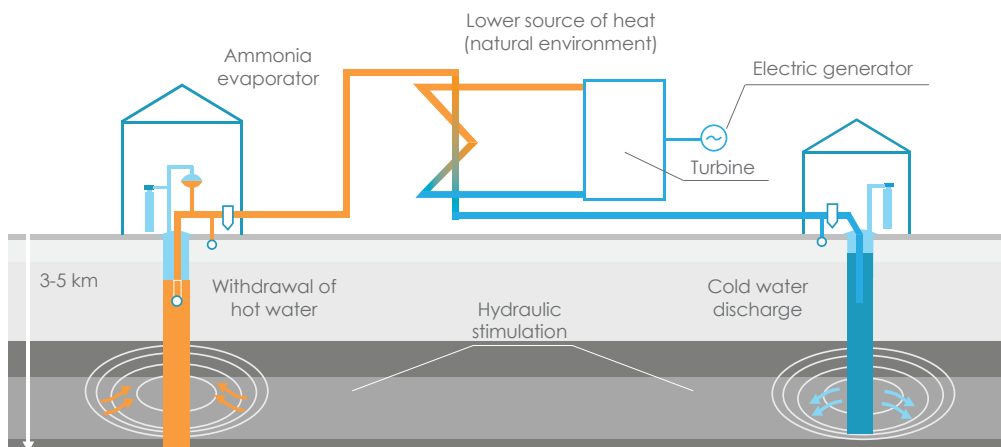


Fig. 18. The scheme for a binary geothermal power station
[www.ekoenergia.pl]

Another type of using the Earth's energy is heating/cooling with the help of heat pumps. In the soil, below the freezing point a relatively constant temperature dominates. It is higher in winter and respectively lower in summer in comparison with the temperature on the Earth's surface. Using this feature, heat pumps deliver heat out of the subsoil inside buildings in winter, and in the opposite direction in summer: from inside the buildings into the subsoil. Surface and subterranean waters, soil or air are used as a heat source.

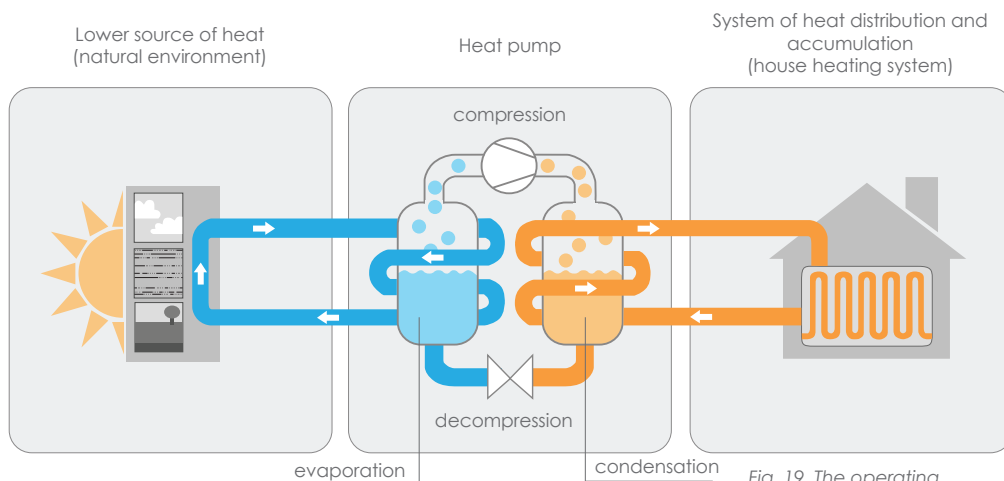


Fig. 19. The operating principle of a heat pump
[www.robmex.com.pl]

Hydropower

In the field of using renewable resources, the share of hydropower remained virtually unchanged between 1973 and 2008. The lack of a substantial growth of energy produced in such a way is caused by social and environmental consequences. The first and most important reason lies in the fact that hydropower stations usually require large plots of land for reservoirs. For example, for the operation of the world's largest hydropower station in China (Three Gorges Dam) about 1,5 million inhabitants were resettled. However, hydropower stations have been and remain an important resource. For example, in Norway, which has low population density, hydropower stations produce more than 90% of electrical energy.

According to 'Renewables 2015. Global Status Report', within a five-year period from end-2008 to 2013 the growth dynamics of hydropower capacity increased more than in the previous 45 years. In 2013 the share of using energy of water among other energy sources accounted for an estimated 3,9% of final energy consumption. Some countries are seeing a trend towards smaller reservoirs and multi-turbine run-of-river projects. There also is increasing recognition of the potential for hydropower to complement other renewable technologies, such as variable wind and solar power.

Technical peculiarities of water energy production

Hydroelectric power plant is a facility that converts water kinetic energy into electrical energy. Large hydropower plants are the main source of energy produced in hydropower sector. They are built on rivers with a high water flow, their energy conversion efficiency can even twice exceed the energy conversion efficiency of thermal coal-fired power plants. The energy they produce is cheap, and the process of its production does not have negative effects in the form of environmental pollution.

The structure of a typical hydropower plant is presented at Fig. 20. Its main elements are: a dam, a channel through which water flows into a turbine, a turbine connected to a generator, a powerhouse with the transformers linked power transmission lines with an electrical grid.

Fig. 21 shows the most common types of hydropower plants.

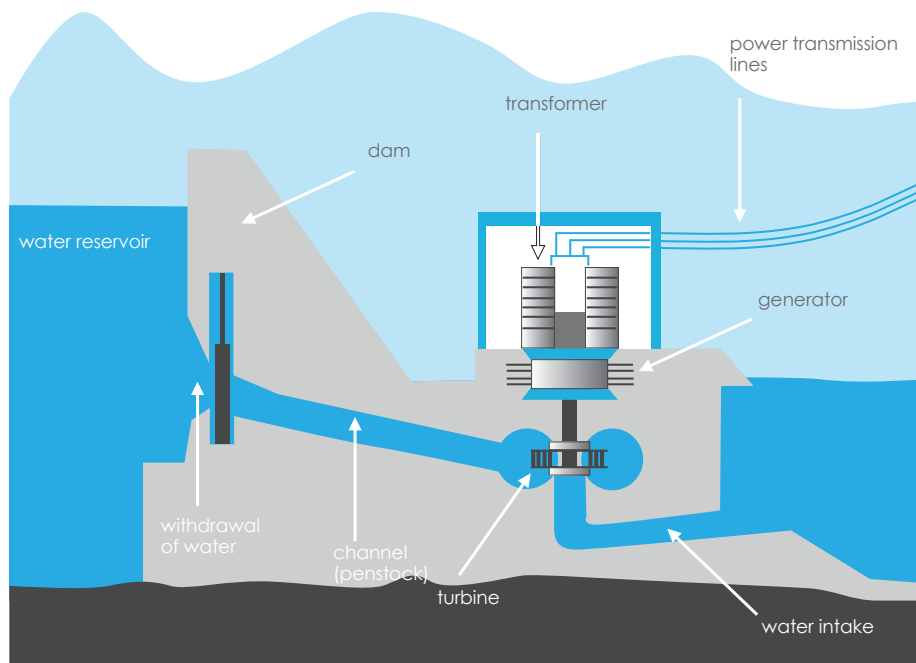


Fig. 20. The structure of a hydropower plant [www.water.usgs.gov/edu]

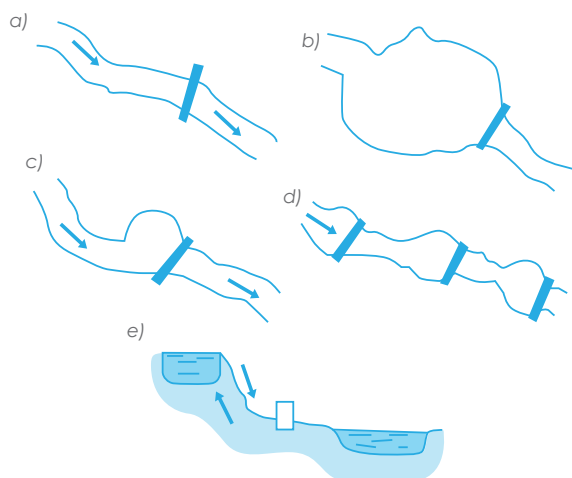


Fig. 21. Types of hydropower plants: a) running water plant without a reservoir; b) regulated plant with a large reservoir of water; c) reservoir plant with a small reservoir of water; d) cascade plant; e) water-storage plant with a reverse hydraulic unit [www.agroenergetyka.pl]

Small hydropower

In the European Union and globally there is no single criterion for the classification of hydroelectric power plants due to their capacity.

Small hydropower plants are divided into:

- ▶ pico power plants with capacity up to 4-8 kW;
- ▶ nano power plants with capacity up to 40 kW;
- ▶ micro power plants with capacity up to 300 kW;
- ▶ mini power plants with capacity from 301 kW to 1 MW;
- ▶ small power plants with capacity from 1001 kW to:
 - o 1,5 MW – Sweden
 - o 3 MW – Italy
 - o 5 MW – Poland
 - o 12 MW – France
 - o 15 MW – India
 - o 25 MW – China
 - o 10 MW – European Union

Data of ESHA (The European Small Hydropower Association www.esha.be).

What are small hydropower plants?

- ▶ small hydropower plants are usually constructed at the facilities built for purposes other than energy industry (anti-flood facilities, reclamation systems);
- ▶ already existing facilities on the water (mills, sawmills, fulling mills) are often used;
- ▶ most often they are running water power plants where electrical energy production is closely dependent on the instant water flow;
- ▶ this is the only way to exploit the potential of small rivers without the necessity to flood large areas.

Table 9 demonstrates interesting statistics of the development, decline and prospects of small hydropower plants in Poland.

Year	Number and description of facilities
1935	8100 facilities (mills, sawmills, power stations, 2500 dams)
1953	7230 facilities, 6330 in operation
1982	2131 facilities, 300 in operation
2006	676 small hydropower plants (up to 10 MW) with the total capacity of 270 MW
2012	717 small hydropower plants
2050	9975 small hydropower plants (forecast)

Tbl. 9.

According to the State Agency of Ukraine on Energy Efficiency (www.sae.gov.ua/ae/hydroenergy), in 2014 in Ukraine operated 105 small hydropower plants with the total capacity of 80 MW, in 2014 they produced 251 million kWh. It is worth mentioning that in the 1960s of the last century there were more than 1000 small hydropower stations in Ukraine and some of them can be restored.

Energy from Biomass

► *Biomass is the total mass of organic matter contained in animals and plants in a given habitat. This concept is also understood as the totality of matter of plant and animal origin in nature, except organic matter contained in the deposits.*

The plant base biomass accumulates energy from the sun through the process of photosynthesis and includes food waste from households, remains of pruning green belts in the cities and waste from wood processing. Biomass is the third largest source of renewable energy among those that are most often used.

The potential of biomass for energy purposes in Poland is the highest among all other renewable sources. Its use in comparison with other sources is also dominant in all energy sectors in Poland:

- In the sector of electrical energy about 60% of energy produced from renewable sources is the energy produced from biomass. The largest part of energy from biomass is generated with the help of co-firing processes in coal condensation boilers of high power;
- In the sector of heating and cooling about 95% of energy produced from renewable sources is heat energy from biomass. Heat energy is generated mainly by scattered objects of low and average power that are not connected to a heating system;
- In the transport sector about 100% of energy from renewable sources is derived from biomass. These are biofuels of the first generation, including bioethanol and biodiesel.

In Ukraine biomass share accounts for 1% in the energy balance, though there is a high potential for growth of this index.

Technical peculiarities of production of biomass energy

Different types of biomass fuels have different properties. Wood and waste from wood processing, plants grown for energy purposes, agricultural products and organic waste from agriculture, some household and industrial waste may be used for energy purposes. The drier and thicker biomass is, the greater is its value as a fuel. The biogas stations, wastewater treatment plants and landfills emit biogas, which is a mixture of methane and carbon dioxide and other gases. It is formed

in result of oxygen-free (anaerobic) fermentation of organic substances. It can be used in various ways, including for production of:

- ▶ electrical energy in spark ignition engines and turbines;
- ▶ heat energy in adapted boilers;
- ▶ electrical energy in combined systems.

Speaking about a liquid form of biomass, the most important elements are alcohols made from plants with a high content of sugar and biodiesel produced from oil-bearing plants. Through fermentation, hydrolysis or pyrolysis of, for example corn or sugar cane, the ethanol and methanol are yielded as biofuels, which then further be added to the traditional fuels.

Solid biofuels	<ul style="list-style-type: none"> • Wood for heating derived from conventional forestry practice and wooden packing waste • Oilseed and leguminous plants residues such as straw or husks • Harvest from plantations of energy plants, such as willow, giant miscanthus, topinambur • Briquettes and pellets
Gaseous biofuels	<ul style="list-style-type: none"> • Biogas from organic waste of agriculture (manure water, dung) and organic waste of industrial plants (sugar factories, breweries, liquor enterprises) • Biogas from municipal landfills and wastewater treatment plants • Biogas from vegetable and grain crops (maize, triticale (a hybrid of wheat and rye), alfalfa, sorghum, fodder beet, sugar beet, potatoes)
Liquid biofuels	<ul style="list-style-type: none"> • Biodiesel, vegetable oils, bioethanol, biomethanol

Tbl. 10. Types of biomass used for energy purposes

The most common thermochemical conversion is direct combustion of biomass in a solid form. Combustion is a process whereby chemical energy contained in fuels is being converted into heat energy during the course of a chemical reaction with oxygen.

Gasification is a process whereby wood gas is produced.

Pyrolysis is a process whereby the bio-oil is being produced at a very rapid heating of the substrate to the temperature of 500-1300°C under high pressure (between 50 and 150 atmospheres).

Another possibility of biofuels production is biochemical conversion:

- ▶ Anaerobic (oxygen-free, methane) fermentation, the product of which is biogas primarily consisting of methane, carbon dioxide and nitrogen. During the fermentation up to 60% of organic matter is converted into biogas. There are wet and dry types of fermentation;

- Alcohol fermentation, the products of which are ethyl alcohol and carbon dioxide. It consists in carbohydrates decomposition under the influence of enzymes, which are formed by yeast. The produced ethyl alcohol after the separation of water is used as an addition or additive to petrol.

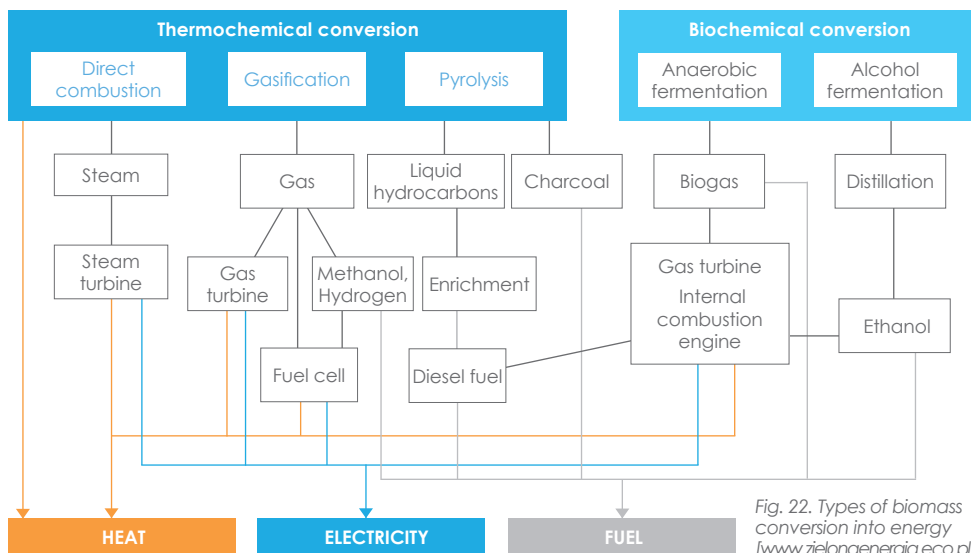


Fig. 22. Types of biomass conversion into energy [www.zielonaenergia.eco.pl]

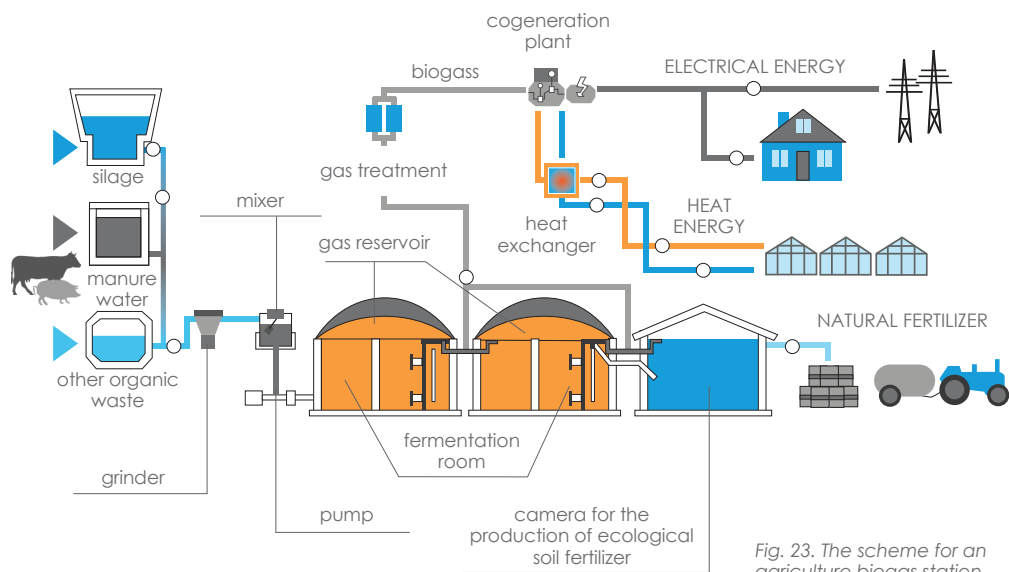


Fig. 23. The scheme for an agriculture biogas station [www.biopowersa.pl]

Biofuel	Plant	Conversion process	Application
Bioethanol	Grain crops, potatoes, topinambur	Hydrolysis and fermentation	Additive and/or addition to petrol
Bioethanol	Sugar beets	Fermentation	Additive and/or addition to petrol
Bioethanol	Energy crops, straw, herbaceous plants	Introductory treatment, hydrolysis and fermentation	Additive and/or addition to petrol
Biomethanol	Energy crops	Gasification or methanol synthesis	Fuel cells
Plant oil	Oil seed rape, sunflower	-	Additive and/or addition to diesel fuel
Biodiesel	Oil seed rape, sunflower	Esterification	Additive and/or addition to diesel fuel
Bio-oil	Energy crops	Pyrolysis	Additive to diesel fuel or petrol

Tbl.11. Types of biofuels and raw materials

Photo 5. Danosha biogas plant



- ▶ In 2013 the pig farm 'Danosha' in Kalush district of Ivano-Frankivsk region launched a biogas plant with the capacity of 1,1 MW. From organic waste of the pig farm, the plant produces biomethane (10980 m³/day), electrical energy (1166 kWh) and heat energy (1200 kWh). The biogas production utilizes the manure, and thus saves the environment for using fossil fuel (the annual savings of natural gas account for more than 1,5 million m³), it also reduces evaporation of green house gases (Methane and CO₂) to the atmosphere. Besides this, the rest product of the manure, after being processed for biogas, is much better utilized by the fields, and the smell of it is almost non-existing. The biogas plants are build with supervision from Danosha's sister company Poldanor S.A in Poland, who has many years of experience in operation of biogas plants. The total project cost equalled €6 million.
- ▶ In September 2011 an agricultural biogas station with the capacity of 1,27 MW was officially opened in the village of Uhnin in Lublin Voivodeship. Annually the power station in Uhnin can produce about 10 thousand MWh, that is enough to meet the annual energy needs of 19 000 inhabitants of the surrounding settlements. The whole investment project cost PLN18 million, of which 10 million were received as co-financing from the European Union within the Operational Programme 'Innovative Economy'.
- ▶ In addition, through the project 'Eco-Energy in gminas Konopnica and Jastków', funded by the European Regional Development Fund and the Regional Operational Programme of Lublin Voivodeship, the gminas received around PLN 6 500 000 as co-financial input for installation of 50 biomass boilers and 864 solar collectors. The project beneficiaries become the households and residential houses who demonstrated their willingness to participate in the project. The project was finalised in mid-2015, and the total project cost was PLN 7 645 000.

Waste-to-Energy

Waste used for energy production is cheap and accessible for everyone. The waste processing decreases the greenhouse effect, allows the recultivation of contaminated landfills and unused lands.

At present, most municipal waste is collected in Poland on the basis of waste sorting. In Ukraine the practice of waste sorting is used in some places for the purpose of instilling the culture of waste treatment.

The technology of waste-to-energy involves separating the fractions to be reused (recycled) from the so-called wet fraction, which is transported to the landfill.

A landfill site is a building objects located and equipped in accordance with the norms used for the organized accumulation of waste disposal with defined characteristics. That is, in theory, waste disposal shall possess the characteristics known and clear to the professionals. If waste characteristics are not studied, such landfills sites cannot be used for recycling and further energy production. Fig. 24 provides the scheme of a modern landfill site.

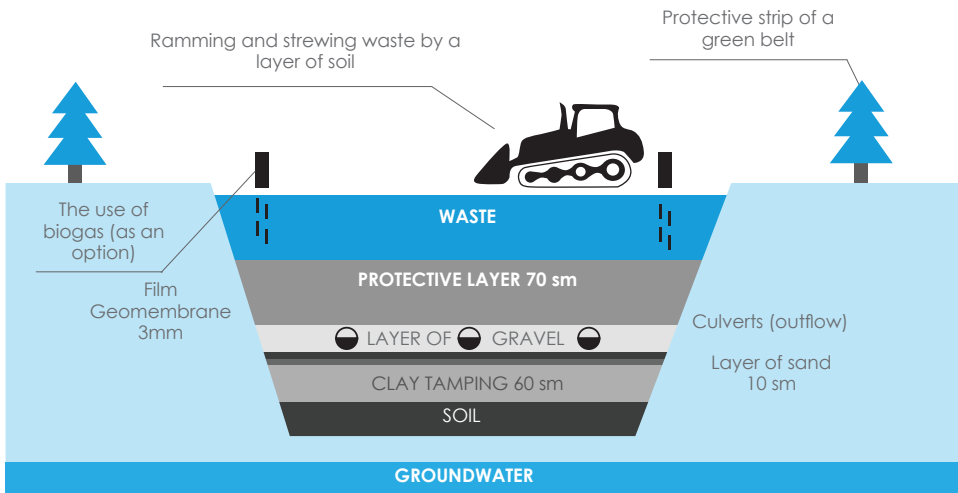


Fig. 24. The scheme of a landfill site with biogas production [www.greenworld.serwus.pl]

Increasing the depth of the landfill and compacting reduces the risk of spontaneous combustion and reduces the amount of windblown litter; furthermore, compaction creates conditions for anaerobic decomposition of the organic matter. Compacted waste also allows the easy movement of vehicles on the surface of the treated landfill.

Landfill gas contains roughly 45-65% methane, 25-40% carbon dioxide and 7-10% nitrogen; trace amounts of other volatile organic compounds comprise the remainder. The further gas use in the energy sector requires the removal of hydrogen sulphide (H_2S), compression (35 bars), and separation of methane (CH_4) and carbon dioxide (CO_2). The hydrogen halides must be removed by absorption of an activated carbon. The landfill gas collection scheme is presented at Fig. 25.

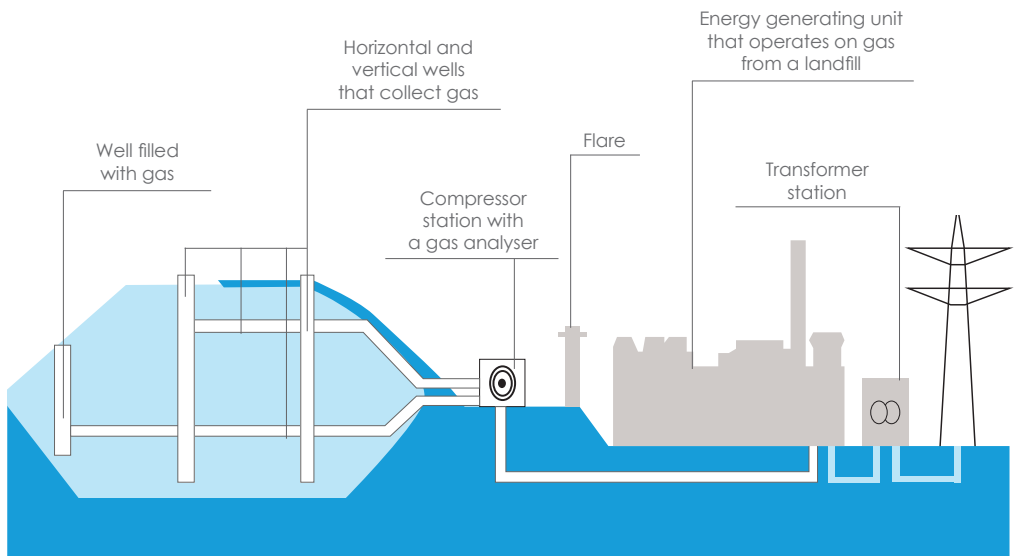


Fig. 25. The landfill gas collection scheme
[www.powermin.nic.in]

Alternative fuel (RDF Refuse Derived Fuel - a fuel produced by shredding and dehydrating solid waste) can be yielded from the domestic, industrial and large-sized waste after the separation of high-calorie waste and its processing. This fuel is an excellent substitute for fuels derived from refining oil, natural gas and coal, it is cheap to produce and has no environment impacts. Depending on fuel value and size, alternative fuel may be suitable for fluid boilers (industrial units) and cement production. Waste processing into a recovered fuel (Fig. 26) undergoes several stages, specifically a preliminary shredding (removal of too large-sized items),

separation of metallic and non metallic components, final shredding (separation of inert fraction – mostly plastics and package elements), final fragmentation and conversion into a fuel. The advantage of RDF is that it provides relative energy independence, as it is yielded from the own raw materials, as well as from agricultural products. Another benefit of this fuel is a lower amount of emissions of toxic substances in the atmosphere in comparison to fuels derived from oil. An additional advantage is low operational costs.

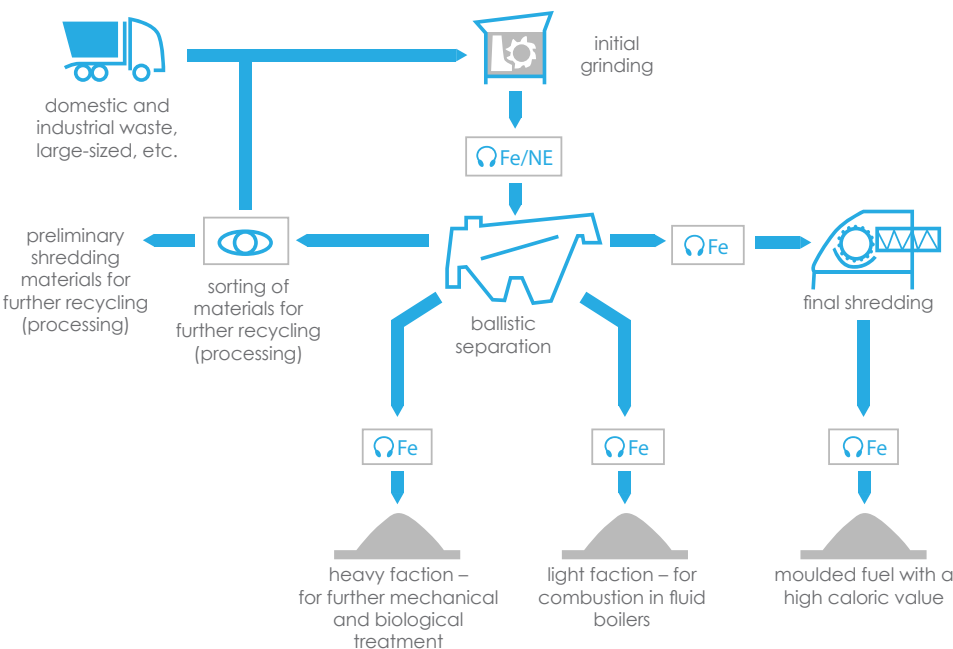


Fig. 26. RDF production scheme

Thermoelectricity

Thermoelectricity is a promising energy development sector. In certain cases, thermoelectric generation is the only accessible way of converting heat energy into electrical one. Generators based on the thermoelectric effect are used not only to convert the sun's heat into electrical energy, but also the heat derived from other sources, such as an exhaust (flue) gas, thermal waters, industrial equipment and even a human body. Thermoelectric modules also can be used for cooling, for example, in refrigerators. Thermoelectric devices are solid, without moving parts. Therefore, taking into consideration their extremely high reliability, they are widely used as coolers of infrared sensors, computer processors, etc.

Energy conversion efficiency of thermoelectric generators is relatively low (industrial indicators are within 3-8%), but it should be noted that generators convert electrical energy from the heat released into the environment from various sources. Thus, by using the heat it does not only provides us with electrical energy, but also reduces impact of the 'greenhouse effect' that is rather important from the ecological prospective.

Nowadays thermoelectric generators are virtually indispensable for energy production in spacecraft industry, they also allow significantly saving motor fuel through heat collection from exhaust gases, as well as perform a number of other functions.

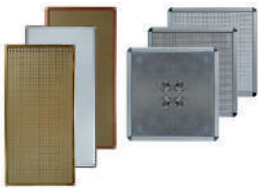


Photo. 6. Example of thermal generator Indigo

► The photo demonstrates an innovative infrared electric film-type heating element 'Indigo' made of electrical isolation materials and fabrics with a built-in infrared transmitter. The operating principle of the infrared heater is similar to the sunlight - the radiation energy is absorbed by the surrounding surfaces, human and animal bodies and given out to the air. 'Indigo' can be used for homes, offices, industrial premises. The advantages of this innovation are significant electrical energy saving up to app. 75% compared to conventional electric heaters and gas heaters; the payback period is 1-1,5 heating seasons due to the low operating costs. Environmental security of the infrared system is primarily due to the absence of combustion products, which eliminates the emission of CO₂ into the atmosphere and moving dust flux and other atmospheric pollutants. The developer of 'Indigo' is the company 'Induktor' (Ivano-Frankivsk).

Prosumption

The term 'prosumer' is a combination of two English words: producer and consumer. In the energy context, this term means any stakeholder who produces energy for his or her own consumption and trade the surplus to an electrical grid. The benefits of converting an ordinary house into the prosuming one consist in the opportunity to produce energy from renewable sources accessible to everyone. Unfortunately, the initial expenses on the installation of power equipment remain relatively high, but most equipment does not require frequent maintenance, so while using it we do not experience additional operating costs and can produce energy practically on a cost-free basis. This is a way to relative energy independence and savings. In addition, generating energy from micro units is environmentally justified, as it reduces greenhouse gas emissions into atmosphere.

Green Energy Market

Green Energy Market in Poland

In the electrical energy supply chain from producer to consumer, which operate on the Polish market, we can distinguish agencies that act as intermediaries (Fig. 27).

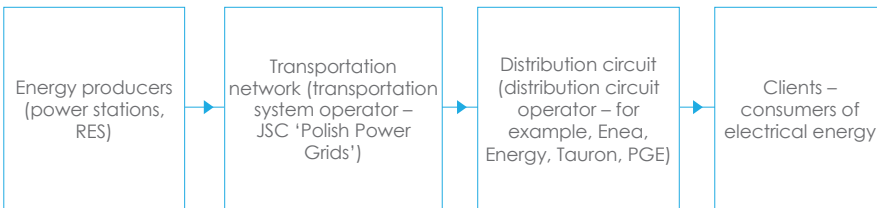


Fig. 27. The chain of electrical energy supply in Poland

An energy producer, using the transportation service, sends physical electrical energy through the grid to the client, who pays both for the energy itself and for its delivery 'to the socket'.

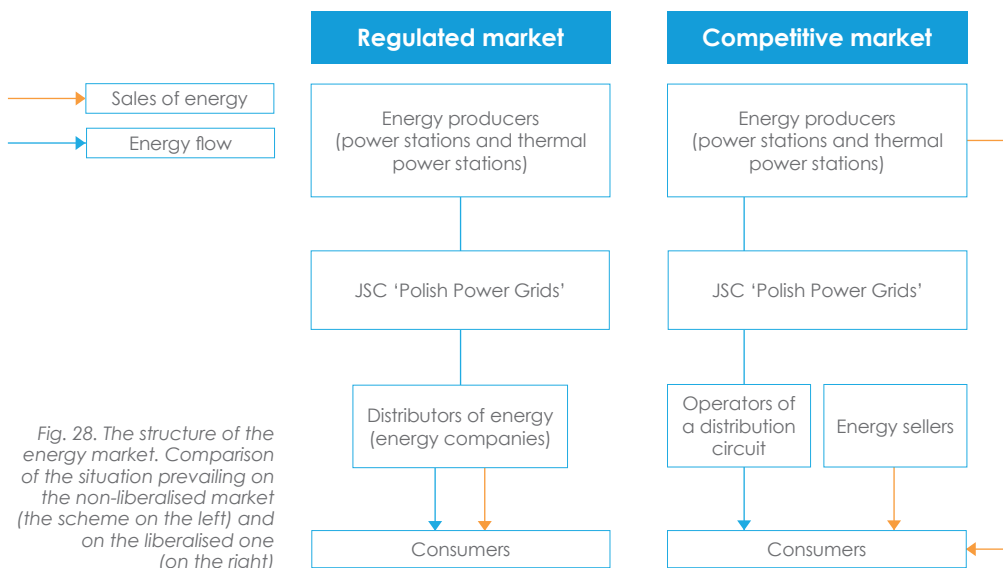


Fig. 28. The structure of the energy market. Comparison of the situation prevailing on the non-liberalised market (the scheme on the left) and on the liberalised one (on the right)

Green Energy Market in Ukraine

According to the national legislation of Ukraine, the activity of Ukrainian market of electrical energy is based on the principles of the national energy security, protection of rights and interests of consumers, energy efficiency and environmental protection, fair competition, equal rights for sale and purchase of electrical energy, non-discriminatory and transparent access to electrical grids and also non-discriminatory access to the market of electrical energy.

Participants of the electrical energy market are:

Energy producers – economic entities that possess generating capacities and produce electrical energy in order to sell it on the market;

Energy suppliers – entities that provide electrical energy supply on the assigned territory and are obliged to conclude an electrical energy supply contract with any consumer located on this territory (guaranteed energy suppliers are mainly regional energy supply companies), as well as entities engaged in the supply of electrical energy to the customers under the contracts, or use electrical energy for their own needs (independent energy suppliers);

Energy transmission enterprises – economic entities that transmit electrical energy in accordance with the licence;

Energy distribution enterprises – economic entities engaged in the distribution of electrical energy in accordance with the licence;

Consumers – economic entities (legal entities and individual persons-entrepreneurs) as well as individual household consumers that use electrical energy for their own needs, as a rule on the basis of electrical energy supply contracts with the energy suppliers;

Guaranteed buyers form a separate group; they are market participants who buy electrical energy from producers using green tariffs.

The wholesale market of electrical energy is presented by State Enterprise 'Energoynok' ('Energy Market'), which performs operations of purchase and sale of electrical energy and National Energy Company 'Ukrenergo', which transmits electrical energy to certain regional suppliers and for export.

The wholesale market regulator is the National Energy and Utilities Regulatory Commission. The functions of the National Commission also include licensing and regulation of the activity of natural monopolies; provision of price and tariff policy, protection of consumers' rights, establishing the rules of using electrical energy.

The Ministry of Energy and Coal Mining of Ukraine is the main body in the system of central executive authority that creates and ensures the implementation of the state policy in the electrical energy sector.

The State Agency on Energy Efficiency and Energy Saving of Ukraine is a specialised central executive authority that implements state policy in the areas of efficient utilization of fuel and energy resources, energy saving, renewable energy sources and alternative fuels. The Agency's activity is governed and coordinated by the Cabinet of Ministers of Ukraine through the Minister of Economic Development and Trade of Ukraine.

The electrical energy market in Ukraine includes the following components:

'Day in advance' market, wherein electricity is purchased by the 'day in advance' market players in organized auctions by entering into respective agreements with operators (the producers, energy suppliers, energy transmitting enterprises, energy distribution enterprises and a guaranteed buyers). Electricity prices and volumes for the 'day in advance' trade are determined in accordance with the 'for a day in advance' market rules. Such prices may be used as an indicator during the electricity prices determination (for purchase and sale) on the bilateral contracts market and the balancing market;

Balancing market, organised by a system operator with the aim of balancing the electricity production outputs and import, consumption and export, and to regulate of system restrictions in the united energy system of Ukraine;

Bilateral agreements market, wherein the buying and selling of electrical energy are carried out upon bilateral agreements (outside 'a day in advance' market, balancing market and retail market of electrical energy). In particular, here the guaranteed buyers buy electrical energy from producers applying green tariff, set by the law. The producers and energy suppliers also have the right to sell and buy electrical energy for further resale;

Retail market, wherein the ultimate customers purchase electrical energy from energy suppliers;

Ancillary services market, wherein a system operator purchase ancillary services from electric generation companies to provide sustainable and reliable operation of Ukraine's united energy system and the quality of electrical energy in accordance with the established standards for the suppliers of such services.

Electrical energy produced by entities from alternative energy sources (except of blast furnace and coke gases, and of hydropower produced only by micro, mini and small hydropower plants) can be sold on the market of bilateral agreements, on 'a day in advance' market and on the balancing market at prices prevailing on the relevant market.

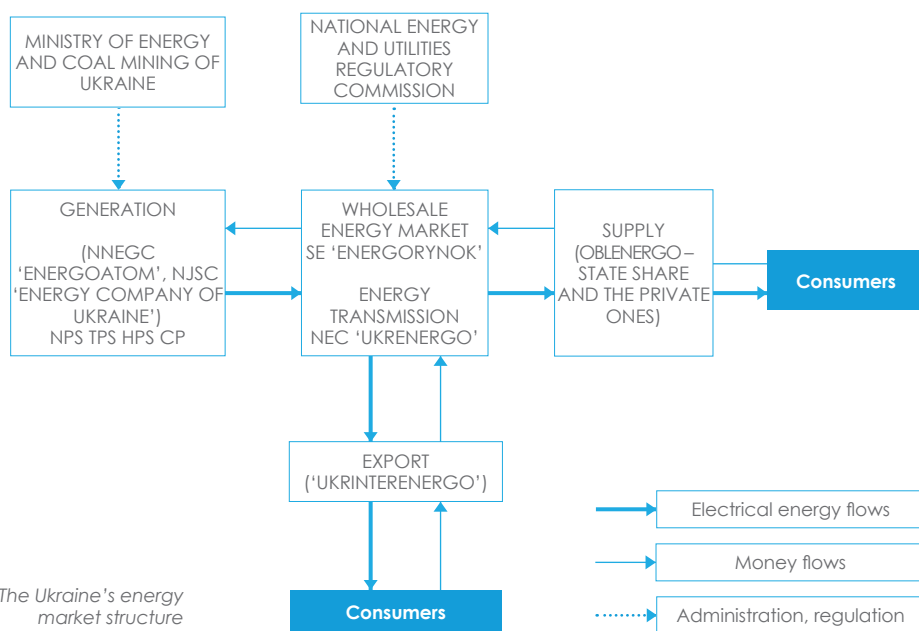


Fig. 29. The Ukraine's energy market structure

Potential for Using Renewable Energy Sources

Potential for Using RES in Poland

While assessing the potential in each energy sector the following aspects should be defined:

- ▶ Theoretical potential, that is the amount of potential energy of a given territory in a given form (for example, every drop of water that flows through a settlement);
- ▶ Technical potential, that is the achievable useful energy generation of a particular technology;
- ▶ Economic potential, that is the energy that could be yielded using economically feasible installations;
- ▶ Sustainable potential, that is the energy that ensures a balance between economic, social and environmental objectives.

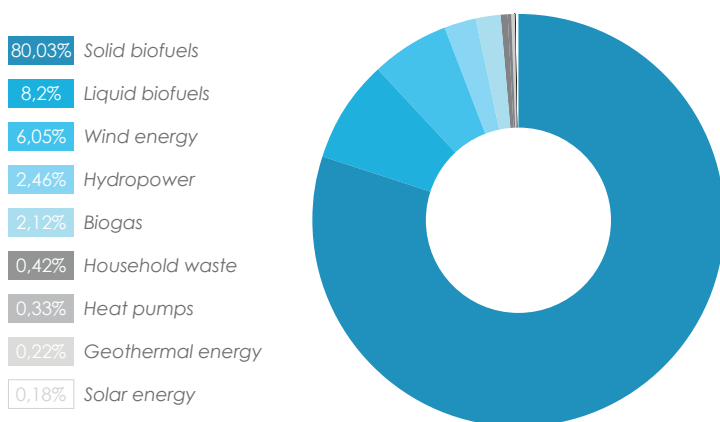
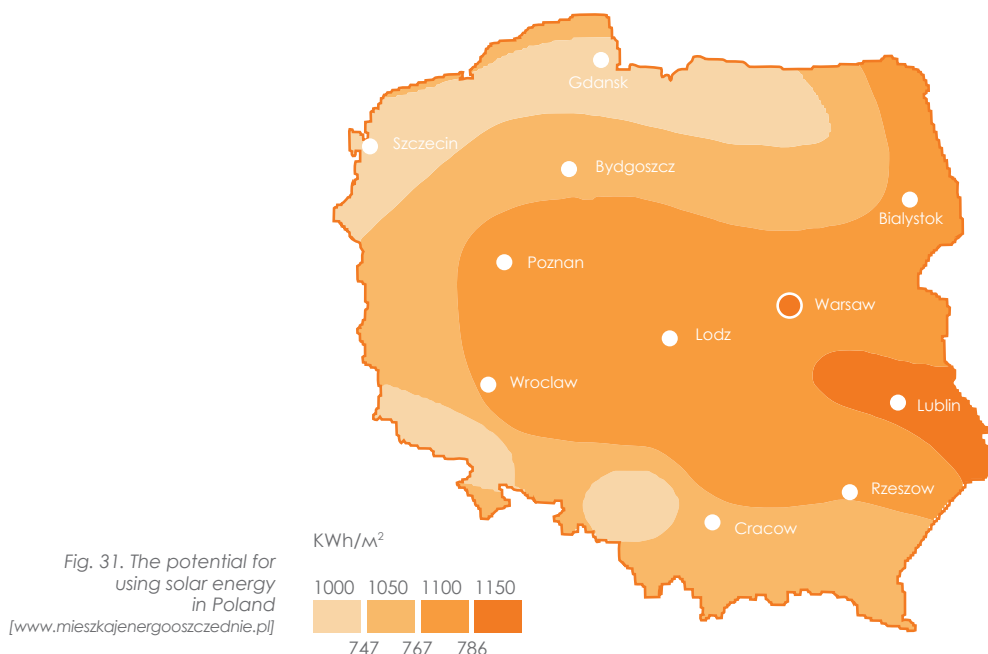


Fig. 30. The share of renewable energy in the total primary energy generated from renewable sources in 2013 [GUS]

Climatic conditions resulting from the geographical location have a significant impact on solar energy resources. In Poland we deal with large fluctuations in the distribution of solar radiation throughout the year, characterised by the decline of solar energy potential in winter. The important and crucial for the development of energy sources using solar energy are the intensity of solar radiation, a solar constant (i.e. the solar energy per unit area over a certain period of time) and insolation (this is the time, expressed in hours, when the sunlight fall directly on the Earth's surface).

The potential of solar energy in Poland is presented by Fig. 31. The most favourable conditions exist in Lublin province. Cloudiness, which in Lublin province generally does not exceed 65%, has a significant impact on the level of insolation. The lowest cloudiness is observed in the belt that stretches from the city of Zamość to the city of Sandomierz, while the highest one is near the city of Puławy. It is estimated that under optimal conditions it is possible to generate around 900-950 MWh of electrical energy from a station with the capacity of 1 MW.



The hydro energy resources depend primarily on the amount of water flow and stream gradient. Other important factors in hydropower are:

- ▶ natural landscape conditions;
- ▶ variability of slopes associated with the management of water reservoirs;
- ▶ efficiency of equipment that is used;
- ▶ technical limitations;
- ▶ obligatory provision of the required water passage;
- ▶ withdrawal of water for non-energy purposes (for household, agricultural needs).

The Vistula with its tributaries has the largest potential of hydropower in Poland. However, there are plenty of available places for small hydropower stations on smaller rivers across the country. The main rivers in Lublin province (with the water flow over 20 m³/s) include the Vistula along the entire length of the

province border, the Wieprz near Lubartów – the mouth to the Vistula and Bug along the entire length of the state border. The great potential is on rivers with lower flows, but they are used to smaller extent. Throughout Poland there are many hydraulic facilities that could be used for the construction of small hydropower stations. In order to upgrade these facilities, appropriate funding is required. In Lublin province there are many remnants of old water objects. Among other things, this is the place for mills on the Bystra river and water mills in Roztocze. As it was mentioned above, at the beginning of the XXth century there were more than 8000 hydropower facilities in Poland that used the energy of water, such as mills, sawmills, power stations. Currently, there are about 700 objects.

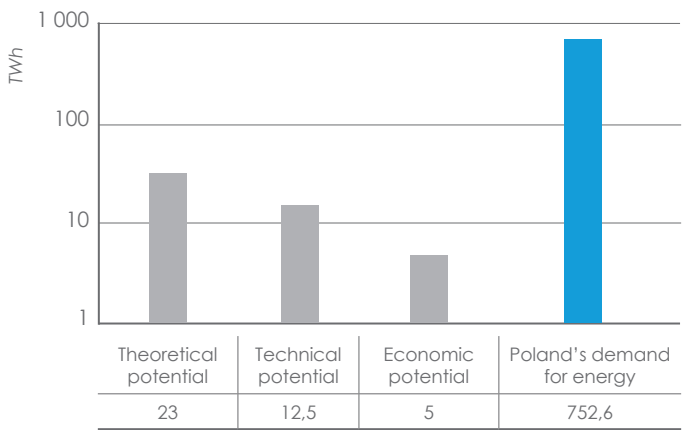


Fig. 32. Resources of energy from falling waters in Poland

Hydropower potential	theoretical	GWh / year
		technical
The Vistula with tributaries	16 457	9 270
The Vistula	9 305	6 177
Left tributaries	892	513
Right tributaries	4 914	2 580
The Odra with tributaries	5 966	2 400
The Odra	2 802	1 273
Left tributaries	1 615	619
Right tributaries	1 540	507
Seaside rivers	582	280
TOTAL	23 005	11 950

Tbl.12. The potential of hydropower sector in Poland

The possibilities of wind energy development in Poland are very promising, as indicated in the research conducted by the Institute of Meteorology and Water Management (IMGW-PIB) on the base of a professional meteorological network of IMGW-PIB by means of long-term observations of wind speed and directions.

In Poland the privileged areas in terms of wind resources are the following:

- ▶ central, the most northern parts of the coast from the city of Koszalin to the city of Hel;
- ▶ area of the Wolin island;
- ▶ Suwałki Region;
- ▶ Central Wielkopolska and Mazowsze;
- ▶ The Silesian and Żywiec Beskids;
- ▶ Bieszczady and Pogórze Dynowski.

The territory of Poland is divided into 5 wind zones (Fig. 33):

- I zone – v average ≥ 5 m/s,
- II zone – v average from 4,5 m/s to 5 m/s,
- III zone – v average from 4 m/s to 4,5 m/s
- IV zone – v average from 3,5 m/s to 4 m/s,
- V zone – v average from 3 m/s to 3,5 m/s.

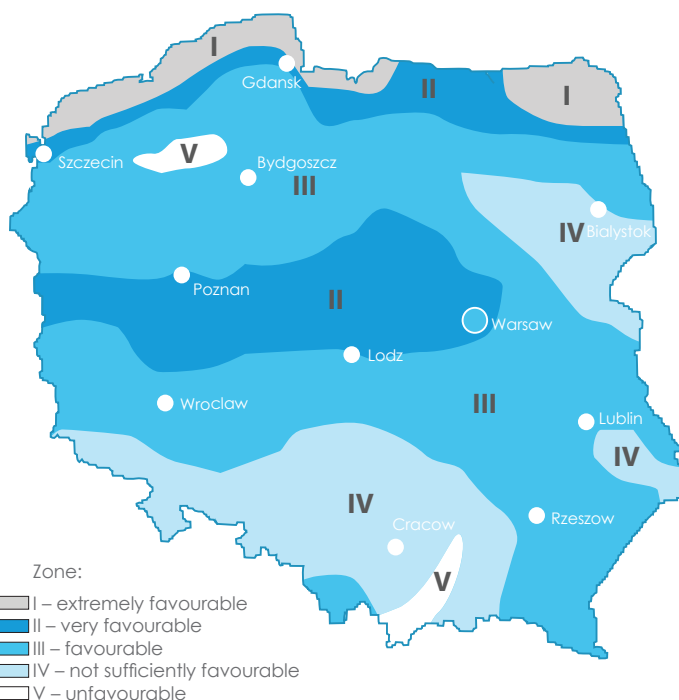


Fig. 33. Wind zones in Poland

The potential of geothermal energy in Poland:

- Poland is one of the richest countries of Europe in terms of geothermal water availability;
- geothermal waters are on about 75% of the country's territory;
- temperature of deposits ranges within 20 - 120°C;
- major resources are available in Grudziądz-Warsaw region;
- a geothermal step in Poland is 30 - 70 m;
- a geothermal gradient in Poland is 15 - 35°C/km;
- the main obstacles are both mining conditions and the economic side of such measures.

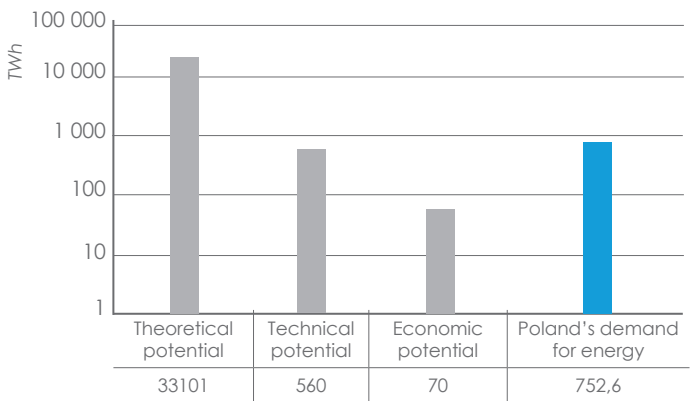


Fig. 34. Geothermal resources in Poland

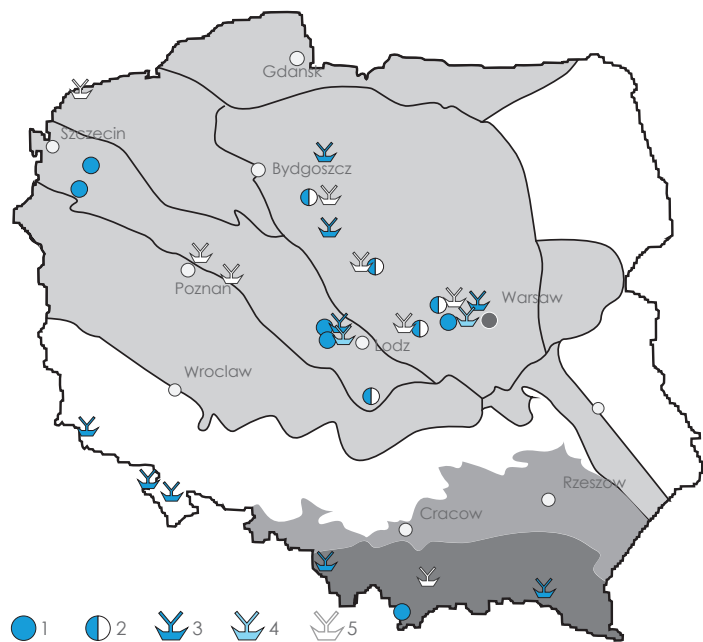


Fig. 35. The use of geothermal energy in Poland: 1. Existing geothermal power stations; 2. Geothermal heating systems under construction; 3. Resorts where geothermal water is used; 4. Geothermal recreational centres; 5. Geothermal recreational centres under construction [Polish Geothermal Society]

Biomass in Lublin Voivodeship is mainly used for heat energy production. The wood from forestry and of industrial origin as well as straw are used with this purpose for the direct combustion. Until now, energy plants were of secondary importance for this process. In Lublin Voivodeship there are few agricultural biogas stations. In Uhnin an enterprise with the capacity of 1,2 MW uses shredded corn plants, rye and grass, as well as waste from liquor industry and potato pulp as substrate for the production of biogas. On the municipal landfill in Rakitno biogas is yielded to produce electrical energy by the generators with the capacity of 0,5 MW, but this is the only one plant of its kind in the province.

Fig. 36 displays the map of biomass potential in Poland. Fig. 37 provides the consumption of liquid biofuels.

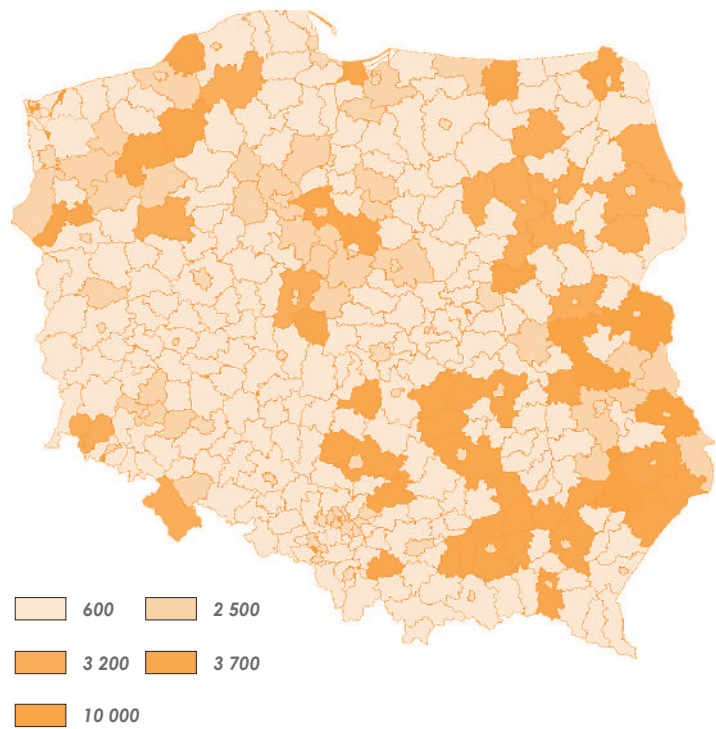


Fig. 36. The area suitable for growing biomass in Poland (in hectares) [GUS]

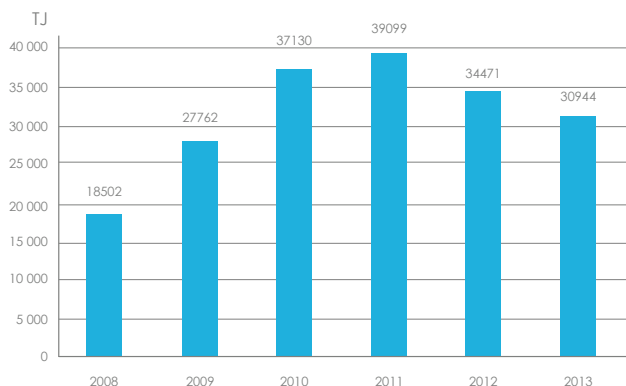


Fig. 37. Consumption of liquid biofuels in 2008-2013 in Poland [GUS]

The development of renewable energy sources is foreseen by the main objectives of energy policy in Poland. Realistic chances of using the potential of RES require significant state involvement and strategic political and economic decisions and cooperation at the local and regional levels. The cooperation in the field of RES should be secured by the adherence to the principles of sustainable development and development of a strategy in a particular region (voivodeship, county, gmina) complying with the European and Polish law.

Potential for Using RES in Ukraine

Ukraine inherited from the USSR a network of large hydropower stations (the Dnieper and Dniester cascades, the Southern Buh). Thus, indices of using the potential of renewable energy in Ukraine are almost commensurate with the indices of Poland. However, in terms of RES development, Ukraine significantly lags behind Germany, Austria and the Scandinavian countries.

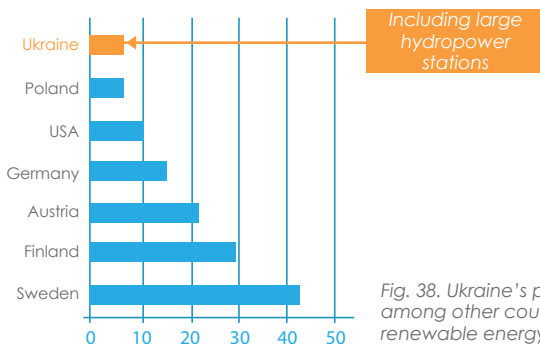
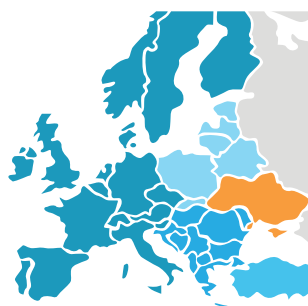


Fig. 38. Ukraine's position among other countries in renewable energy sector

According to the Ministry of Energy and Coal Mining of Ukraine, electrical energy from renewable energy sources (RES) in Ukraine in 2013 has doubled in comparison with the previous year, although it makes a fairly small share of the total amount of produced electrical energy. Specifically, share of electrical energy produced from wind, solar energy, biomass and by small hydropower plants (excluding energy generated by large power stations) in the total amount of electrical energy production increased from 638 million 600 thousand kWh (0,32%) in 2012 to 1 million 247 thousand kWh (0,64%) in 2013.

The National Action Plan of Renewable Energy till 2020, approved by the Cabinet of Ministers of Ukraine on 01 October 2014, indicates the technically feasible annual energy potential of renewable energy sources in Ukraine (according to the Institute of Renewable Energy of the National Academy of Sciences) as 68,6 million tonnes oil equivalent, that makes up about 50 percent of the total energy consumption in Ukraine.

At the end of 2014 the total electrical capacity of renewable energy facilities in Ukraine, operating under the green tariff, amounted to 2008 MW, of which the total capacity of wind power stations constituted 1172 MW, solar power stations – 485 MW, small hydropower stations – 251 MW, biomass and biogas processing facilities – 100 MW. The installed capacity of the facilities that produce heat energy from renewable energy sources exceeded 1462 MW.

The annual technically feasible potential of renewable energy sources in Ukraine is presented in the table 13 (the amount of energy produced by RES within a year is compared with the amount of fuel equivalent within a year).

№	Areas of RES Development	Annual Technically Achievable Energy Potential	
		Billion kWh/year	Million tonnes of fuel equivalent/year
1.	Wind energy	79,8	28,6
2.	Solar energy, of those:	38,2	6,0
2.1	▲ electricity	5,7	6,0
2.2	▲ thermal	32,5	4,0
3.	Small hydro power	8,6	3,0
4.	Bioenergy, of those:	178,0	31,0
4.1	▲ electricity	27,5	10,3
4.2	▲ thermal	151,0	20,7
5	Geothermal energy	97,6	12,0
6.	Energy of environment (thermal pumps)	146,3	12,0
Total volume of replacement of traditional fuel and energy resources		548,5	98,0

Tbl.13. The annual technically achievable potential of renewable energy sources in Ukraine

Solar energy

As mentioned above, the average annual potential of solar energy in Ukraine constitutes 1 235 kWh/m, in the mountainous areas of Ivano-Frankivsk region it is rather high and considerably exceeds the potential in Germany (1 000 kWh/m) or Poland (1 080 kWh/m). This provides good opportunities for the effective use of heat-power equipment in Ukraine.

As stated on the specialised portal www.siriusone.net/index.php, the efficient use of solar plants provides a possibility to rich the efficiency of 50% or higher. In the southern regions of Ukraine this possibility exists within 9 months (from March to November), and in the northern regions – within 7 months (from April to October). In winter the efficiency decreases, but still exists. Thus in the conditions of the Ukrainian climate the solar systems work all year round, though with variable efficiency. In this respect it is worthwhile to consider the total annual potential of solar energy in Ukraine.

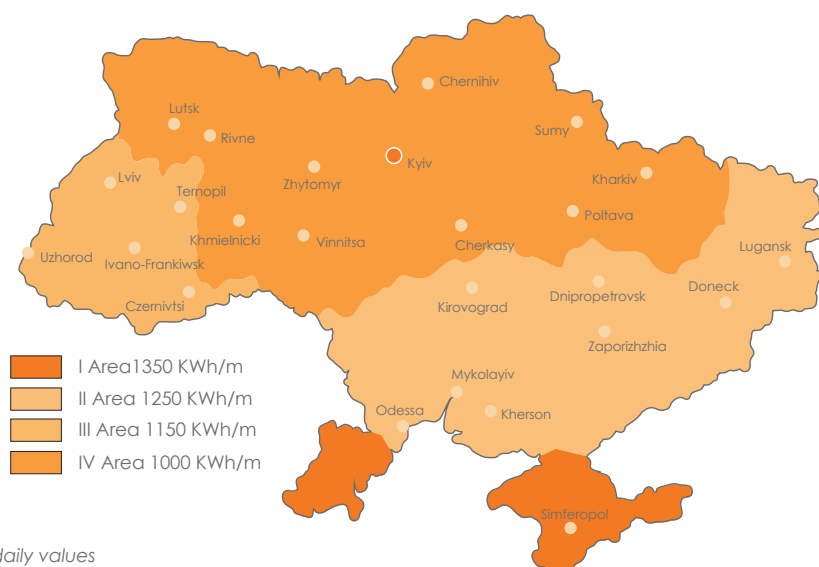


Fig. 39. Average daily values of total radiation in Ukraine

Pilot projects, implemented in recent years, have shown that the annual production of heat energy in Ukrainian conditions accounts for 500-600 kWh/m². Taking the generally accepted potential of solar collectors (1 m² per person) and the energy conversion efficiency of solar plants in the climatic conditions of Ukraine, the annual resources of hot water supply and heating from solar energy constitutes 28 kWh/m² of thermal energy. The fulfilment of this potential would allow saving up to 3,4 million tonnes of reference fuel per year.

The first industrial solar power station in Ukraine and the USSR was built in 1985 in the Crimea near the city of Shcholkine. It had the capacity of 5 MW, the same as the first nuclear reactor. Within 10 years of operation, it generated 2 million kWh of electrical energy. In the middle of the 1990s it was closed. One of the biggest projects implemented in independent Ukraine become the most powerful solar power station in the world launched in 2011 in Perovo in the Crimea.

In Ivano-Frankivsk region, the solar power station 'Stari Bohorodchany-1' operates on photocells. There are solar power stations in city of Kolomyia, in the villages of Rozhniv and Tiudiv of Kosiv district, and in Sniatyn (the latter has the record capacity in the region – 10,5 MW).

The data on the Ukraine's potential from wind, hydro and bioenergy are provided according to the State Agency on Energy Saving and Energy Efficiency (www.sae.gov.ua/uk/ae/windenergy).

Wind energy

The development of Ukrainian wind energy started in 1996 when Novoazovsk wind power station with the planning capacity of 50 MW was constructed in Donetsk region. In 1997 a new wind power station was launched in Lviv region in Truskavets. As of 2000, the total number of turbines operated in Ukraine reached 134, the foundations for another 100 turbines were laid.

The significant growth in the construction of wind power stations has been observed since 2009, after the introduction of green tariffs. As of 01 January 2015 in Ukraine the installed capacity of wind power stations constituted 514 MW (only 0,93% of the total amount of generating capacity of the country) and in 2014 wind power stations produced over 1 171 million kWh of electrical energy.

The Institute of Renewable Energy of the National Academy of Sciences of Ukraine developed a map of wind power potential of the country. Scientists believe that the most attractive regions for the use of wind energy are the seashore of the Black and Azov Seas, mountainous areas of the Crimea, the Carpathian Mountains, Odesa, Mykolayiv and Kherson regions (according to the portal of the State Agency on Energy Saving and Energy Efficiency of Ukraine www.sae.gov.ua/uk/ae/windenergy).

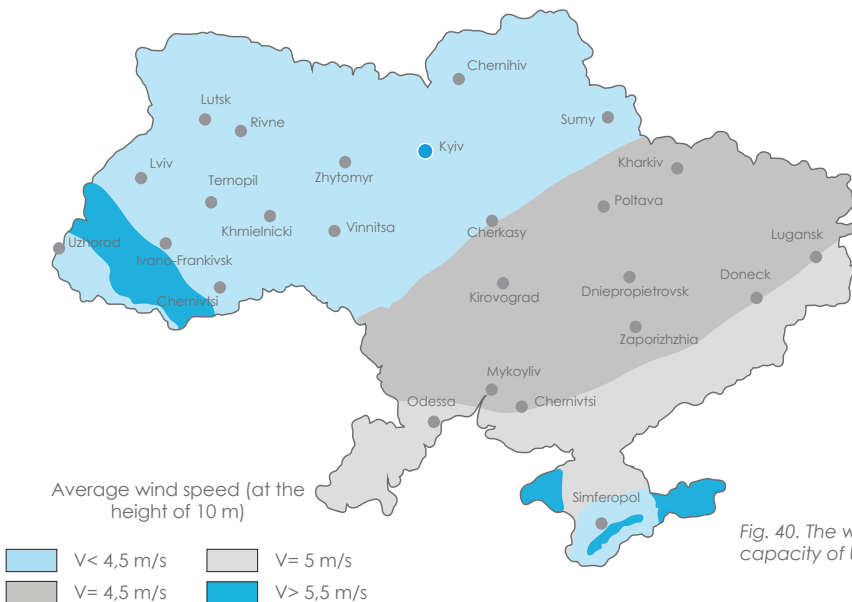


Fig. 40. The wind power capacity of Ukraine

Hydropower

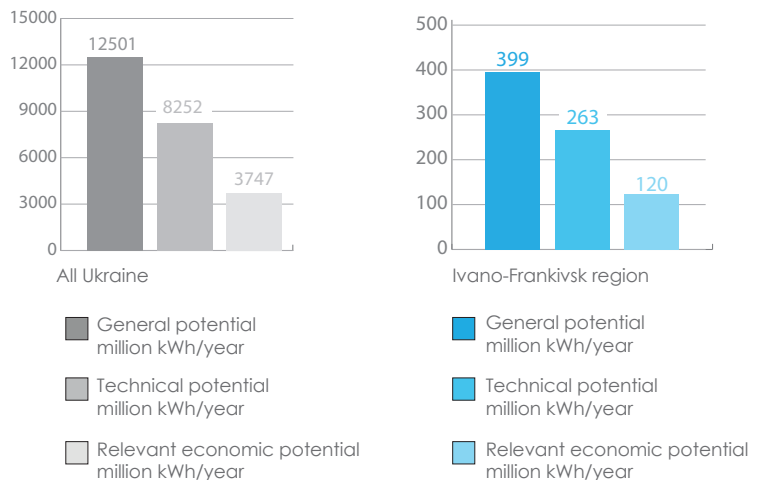
Ukraine in general and the Carpathian region in particular also have considerable hydropower resources of small rivers, the total hydropower potential of which is about 12,5 billion kWh per year, amounting for about 28% of the total hydropower potential of all Ukrainian rivers (according to www.sae.gov.ua/uk/ae/windenergy). The share of hydropower potential of small rivers in Ivano-Frankivsk region equals 10% of the total amount in Ukraine.

The main advantage of small hydropower is the low cost of electrical energy. The lack of a fuel component in the process of obtaining electrical energy at small hydropower stations is a significant economic incentive. Therefore, small, mini and micro hydropower stations can become a powerful basis for energy supply in western regions of Ukraine.

According to the State Agency of Ukraine on Energy Efficiency and Energy Saving (www.sae.gov.ua/ae/hydroenergy), as of 2014 there were 105 small hydropower stations with the total installed capacity of 80 MW in Ukraine, in 2014 they produced 251 million kWh. In Ivano-Frankivsk region there are several hydropower stations: Sniatyn hydropower station on the river Prut, Yablunysia hydropower station (Verkhovyna district) on the river Bilyi Cheremosh (the Prut tributary), and Zolota Lypa hydropower station (Tlumach district) on the river Zolota Lypa (the Dniester tributary). It is worth mentioning that in the 1960s of the last century there were more than 1000 small hydropower stations in Ukraine.

Today 60% of hydropower potential is used, mainly due to the Dnieper cascade and other large hydropower stations. The remaining potential can be realised by installing new and renewing old facilities of small hydropower stations.

Fig. 41. Hydropower capacity of small rivers of Ukraine



Bioenergy

For Ukraine, especially for its western regions, bioenergy is one of the strategic development priority for the renewable energy sector. This is predicated by the need to overcome the critical dependence on imported energy sources, especially natural gas, and the big potential of biomass available for energy production. Unfortunately, the pace of bioenergy development in Ukraine is still significantly behind the EU. Nowadays the share of biomass in gross energy consumption constitutes 1,78%, wherein every year about 2 million tonnes of biomass reference fuel of different types are used for energy production in Ukraine. The highest percentage of economically feasible potential falls on wood – 80%, and the least belongs to grain crops, rape plant and straw (around 1%).

Type of biomass	Theoretical potential, million tonnes	Share available for energy generation, %	Economic potential, million tonnes of fuel equivalent
Straw of grain crops	30,6	30	4,54
Straw of rape	4,2	40	0,84
Waste of corn production (stalks, cobs)	40,2	40	4,39
Waste of sunflower production (stalks, head)	21,0	40	1,72
Secondary waste of agriculture (husk, pulp)	6,9	75	1,13
Wood biomass (firewood, felling residues, wood waste)	4,2	90	1,77
Biodiesel (from rape)	-	-	0,47
Bioethanol (from corn and sugar beet)	-	-	0,99
Biogas from waste and by-products of agro-industrial complex	1,6 billion m^3 of methane (CH_4)	50	0,97
Biogas from landfills of domestic solid waste	0,6 billion $\text{m}^3 \text{CH}_4$	34	0,26
Biogas from wastewater (industrial and municipal)	1,0 billion $\text{m}^3 \text{CH}_4$	23	0,27
Energy crops:			
▲ willow, poplar, miscanthus	11,5 billion $\text{m}^3 \text{CH}_4$	90 ²	6,28
▲ corn (biogas)	3,3 billion $\text{m}^3 \text{CH}_4$	90 ²	3,68
Peat	-		0,40
Total	-		27,71

Tbl. 14. Energy potential of biomass in Ukraine, 2014

Western regions of Ukraine in comparison with other regions have great potential of biomass available for energy use. The basic components of the biomass potential of the region are wood biomass and agricultural waste.

In the short term perspective, the energy from biomass can satisfy approximately 15% of the need of Ivano-Frankivsk region in primary energy (excluding fuel needs of Burshtyn thermal power station) or replace near 50% (300-350 million m³) of natural gas, consumed by the population of the region.

According to the UNDP data, the theoretical and technical energy potential of forest biomass of Ivano-Frankivsk region accounts for 23,59 PJ/year (805 thousand tonnes of fuel equivalent) and 5,16 PJ/year (176 thousand tonnes of fuel equivalent) respectively.

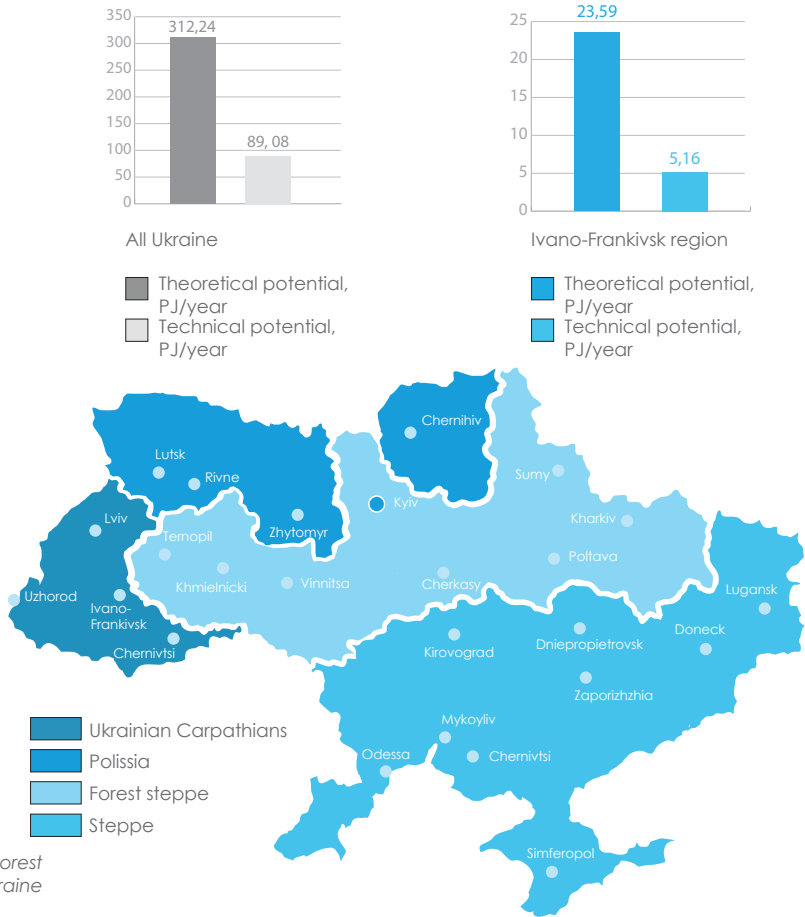


Fig. 42. The potential of forest biomass in Ukraine

Geothermal energy

Ukraine's terrain has specific thermal geological features that create the potential for the development of geothermal energy. However, the current scientific, geological exploration and practical activities in Ukraine focus only on geothermal resources of thermal waters. According to various estimates, an economically feasible energy resource of thermal springs in Ukraine accounts for 8,4 million tonnes oil equivalent/year. The western regions of Ukraine – Zakarpattia, Lviv, and Rivne regions – possess one of the highest potential of geothermal energy.

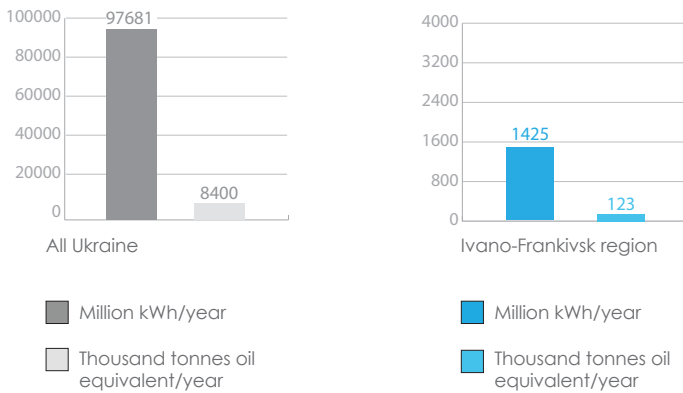


Fig. 43. Potential of geothermal energy in Ukraine

Energy of environment

Energy of environment is the energy produced from natural energy sources of the environment (heat of air, rivers, seas, topsoil and groundwater).

The State Agency on Energy Efficiency and Energy Saving of Ukraine defines an annual technically feasible energy potential of environment energy in Ukraine as 12,6 million tonnes of oil equivalent, which allows saving around 15,6 billion m³ of natural gas.

In the Carpathian region, energy potential of topsoil constitutes 119 thousand tonnes oil equivalent/year, and energy potential of air – 84 thousand tonnes oil equivalent/year.

Procedures for Obtaining Permits for Energy Production from Renewable Sources

Procedure for Obtaining Permits for Energy Production from RES in Poland

Investment in renewable energy is a complex and advanced process both from a technical, logistical, economic, and above all, from a legal point of view. Depending on the source, technology, and the scale of the investment project and the region of its location, administrative and legal procedures may vary significantly from each other. Each investment project requires a number of permits, decisions and agreements, and constantly changing regulations make it necessary to amend the project implementation schedule.

The entire investment process can be divided into several basic steps:

Acquisition of land: the location shall be analysed in terms of logistics (transport facilities), as well as connection to the power grid. The legal status of the land shall be examined, the verification whether the site is not in the area covered by the protection or in close proximity to human settlements performed, which in turn can contribute to not granting a building permit. Significant is also the local land management plan. With preliminary analyses, investor is able to determine the potential of the site and decide on the further implementation of the investment project. It is essential when selecting a location for hydroelectric power plant to analyse the stream gradient and river flow. The most important elements are the topography and environmental issues. Comprehensive knowledge of the location details is essential to avoid problems during the construction of the power plant.

Environmental Decision: for the planned investment, there is an obligation to carry out an environmental impact assessment (EIA) or Natura 2000 environmental impact assessment in case the location of a project is covered by 'NATURE 2000' programme. In Poland, such requirements are regulated by the Council of Ministers' resolution of 25 June 2013 specifying the types of projects that may significantly affect the environment and the specific conditions relating to the eligibility of the project to prepare a report on the environmental impact assessment. In order to undertake the environmental decision, an investor shall submit the application with attachments to the municipal authorities (e.g. to a gmina's prefect, that is a community's mayor). Environmental decision requires opinion, agreed with the Regional Directorate of Environmental Protection (RDOŚ), and the competent authorities of the State Sanitary Inspection (PIS). The mayor/prefect/president of a

city by acting according to the law 'On Access to Information on the Environment and Its Protection and on Environmental Impact Assessments' upon the public hearings, shall issue the environmental decision.

Location decision: the majority of RES related investment projects are carried out based on the change to the local master plan or in the absence thereof - on the basis of its enactment. The request for introduction of relevant changes to the local master plan in relation to the investment project shall be submitted to the municipal authority or to the municipal council, which shall take the appropriate resolution. The procedure for introduction of changes to the local master plan is similar to its adoption, and can last up to several months. If there is no master plan, the determination of ways of land management and its development conditions may be defined by the municipal authorities. An application for such a decision shall be accompanied by, among others, environmental permit, approval of the project, allocation of site boundaries covered by application and characteristics of an investment project.

Connecting to the power grid: an entity applying for connection to the power grid shall submit an application to the local grid operator / network distributor in order to obtain the relevant technical and economic conditions for connection. The format of application shall be set and provided by a power grid operator. The application shall be accompanied by the following documents:

- ▶ document confirming the legal title of the property;
- ▶ development plan or situational plan;
- ▶ the expertise of impact on the electrical energy system (if applicable);
- ▶ an extract from the local master plan confirming the possibility to locate a particular source of energy or in the absence thereof a decision on ways of land management and its development conditions for the property specified in the application, if required pursuant to the provisions of spatial planning and development.

The applicant is also required to pay an advance of a future connection fee of 30 zlotys per kilowatt of installed capacity planned to join the generating unit.

Building permission: an application for a building permission shall be submitted to the district office (department competent for architecture and construction). The most important regulations in this respect are contained in the 'Construction Law'. The application for a building permit must be accompanied in particular by:

- ▶ several copies of a construction planning and design documentation together with conclusions and agreements;
- ▶ a decision on the environmental conditions (environment impact evaluation);
- ▶ a statement that the title to the property for building purposes is held;
- ▶ a decision on ways of land management and its development conditions (if required).

The building permit resolution is issued by a district mayor or a city president.

Depending on the type of renewable energy source, the separate decisions, permits and agreements may be required. For instance, in case of hydro energy, a water permit will be required under the 'Water Law', in case of wind energy, arrangements with the Civil Aviation Office and Air Force Headquarters will be necessary at the initial stage for measuring of wind power.

Putting into service and operation: before commissioning a construction object, investor shall obtain a final permission on putting the object into service and operation. The most important issue at this stage is to obtain concession from the President of the Energy Regulatory Office enabling the business activity on production of energy from renewable sources. The energy produced by the operators of renewable energy sources can be used for their own needs or transmitted into the national grid and sold to enterprises active on energy market.

A small energy three-package introduces a definition of 'a **prosumer**' - an individual who produces electrical energy in micro energy generating systems for their own needs and is able to sell the surplus of the produced **energy**. One of the most important things is that according to the law 'On Economic Activity Freedom' prosumers are not obliged to register their economic activity of this kind and they are not obliged to obtain concessions. The next simplification concerns the connection of the prosumers' micro energy generating systems to the grid, which takes place on the basis of an application requesting

connection to the energy company. According to the law, an electrical energy company is obliged to buy the surplus of the produced electrical energy from the prosumers.

Procedure for Obtaining Permits for Energy Production from RES in Ukraine

The process of launching the activity of the object producing electrical (thermal) energy from RES in Ukraine is logically divided into the following several main stages:

- ▶ Obtaining rights for a land site (immovable property);
- ▶ Object designing and construction;
- ▶ Connection to electrical grids and heating networks;
- ▶ Obtaining licences and permits.

The main procedures for each stage are described below:

Obtaining rights for a land site / immovable property

Obtaining rights for a land site. According to the Land Code of Ukraine, land sites might be leased or purchased by individual persons and legal entities. The procedure includes:

- ▶ Choosing and agreeing on the land site boundary limits;
- ▶ Preparing and agreeing on the land-use planning documentation on the land site allocation in case of changes of land site boundaries or its designated purpose (land sites for energy generating objects are considered to be lands of energy system);
- ▶ Approving of the land-use planning documentation and decision on the land site sale or leasing (decisions in relation to the state owned land sites shall be taken by the local state administrations, while decisions in relation to the communal land sites shall be taken by local councils);
- ▶ Signing and notary's certification of sales agreement or signing of leasing agreement (to be certified by the notary as an option);
- ▶ Registration of ownership rights for a particular land site or leasing rights in the State Register of Rights (the State Registration Service). From the moment of registration, the ownership rights or leasing rights shall become valid.

Obtaining rights for the immovable property

Depending on particular circumstances, a procedure might include the acquisition of either the ownership rights (e.g. through privatization of the state or communal property) or leasing rights (leasing, concession, etc.) for the immovable property located on the land sites. The rights shall be acquired through signing of corresponding agreements, whereat the sales agreements and leasing agreements for a term of three and more years shall be notarized and the corresponding property rights shall be registered in the State Register of Rights.

Planning and designing of an object and its construction.

The Law of Ukraine 'On the Regulation of Town Planning Activity' provides for the following actions:

- ▶ Obtaining of initial data (town planning conditions and limitations, technical conditions, design and planning tasks) by a client or a designer;
- ▶ Developing and approving of the project planning and design documentation (feasibility study/costs estimates, project design, work project design, work documentation);
- ▶ Expertise of the project planning and design documentation (if required by Law);
- ▶ Registration of declaration on the preparatory works launch with the State Architecture and Construction Inspection (if required);
- ▶ Registration of declaration on construction works launch with the State Architecture and Construction Inspection for the objects of the I-III category of complexity, or obtaining permit to carry out the construction works for the objects of the IV-V category of complexity;
- ▶ Commissioning of the constructed object into operation by submitting a declaration about the object readiness to the operation to the State Architecture and Construction Inspection for the objects of the I-III category of complexity, or drawing up of an act on the object readiness for operations and a certificate for the objects of the IV-V category of complexity;
- ▶ Registration of the property ownership rights for the built object at the State Register of Rights. From the moment of registration, the ownership rights shall become valid.

Connection to electrical grids

The rules of connection of electrical units to electrical grids are provided by the Resolution of the National Energy and Utilities Regulatory Commission (NEURC) № 32 of 17 January 2013. According to the mentioned rules, the connection of electrical units designed for electrical energy production from alternative energy sources, presupposes the following actions:

- ▶ Free-of-charge issuing of the technical conditions within the term of 15 working days from the date of submitting the application for electrical unit connection or within the term of 30 working days, if there is a need to coordinate the connection with an owner of the transmission network/ interstate electrical grids;
- ▶ Free-of-charge preparation and issuing by the energy transmission organisation of a signed draft agreement on connection of the electrical unit that produces electrical energy from alternative energy sources;
- ▶ Development of the project planning and design documentation for the electrical units of external electricity provision;
- ▶ Execution of construction, installation and commissioning works and connection of the electrical units to the grid, performed by the energy transmission organisation;
- ▶ Conclusion of corresponding agreements;
- ▶ Connecting of the customer's electrical unit to the electrical grid.

The connection of electrical energy units, which produce electrical energy from alternative energy sources and the construction of which coincides with the development plan of the united energy system of Ukraine, shall be financed by 50% from funds assigned within the electricity transmission tariffs, and by 50% from funds of reimbursable financial assistance given by the customer to the energy transmission organisation.

The fee for connection of other objects of electrical energy sector, which produce electrical energy from alternative energy sources, shall be determined by the planning and design documentation pursuant to the methodology of fee calculating for the connection of electrical units to electrical grids, including expenses on the grids development.

At the same time, the connection to the heat networks shall be regulated by the Rules of Connection to Heat Networks, approved by the National Energy and Utilities Regulatory Commission of 19 October 2012, № 343.

The connection to heat networks shall be performed by the networks' owner upon agreements concluded between the networks' owner and the construction customer and involves the following steps:

- ▶ Submitting an application by the customer to the owner requesting connection to heat networks;
- ▶ Obtaining technical conditions for connection to the owner's heat networks – within 15 days after the submission of application;
- ▶ Concluding an agreement on connection to heat networks;
- ▶ Development of the planning and design documentation by the customer (or a designing organisation on the basis of an agreement with the customer) and its approval by the owner;
- ▶ Fee payment for connection to networks by customer;
- ▶ Technical connection of the facility to heat networks and obtaining of an act on facility readiness for operation.

Licensing and permits obtaining

Obtaining a license. According to the Laws of Ukraine 'On Licensing of Certain Types of Economic Activities' (comes into force on 28 June 2015), and 'On Electrical Energy Industry', licensing is required for an activity in electrical energy sector (i.e. activities of production, transmission, distribution, supply of electrical energy, as well as performing functions of a guaranteed buyer), as well as for the production of heat energy, excluding its production under unregulated tariff. Licences shall be granted by the National Energy and Utilities Regulatory Commission, which secures the state regulation in the electrical energy sector and utilities, pursuant to the procedure determined by the NEURC resolution №1305 of 06 October 1999.

The licence fee shall be charged in amount of one minimal salary, which is valid on the day of license issuing.

The NEURC resolution №540 of 26 April 2006 also approves the licensing conditions for economic activity on heat energy production by combined heat and power plants, heat power plants, nuclear power plants, and RES electrical energy units.

No license is required for the production of electrical energy from solar energy by private households.

Obtaining permit documents

The launch of operations, depending on the facility's specifics, may require obtaining of permit documents (complying with the permit procedures) under the Ukrainian laws, namely:

- ▶ Obtaining a permit to start carrying out of highly dangerous works and start of operation (use) of highly dangerous vehicles, machinery and equipment (Article 21, Law of Ukraine 'On Labour Protection', the Cabinet of Ministers Resolution №1107 of 26 October 2011) from the State Service of Mining Supervision and Industrial Safety of Ukraine;
- ▶ Submission of declaration on conformity of the physical infrastructure of an economic entity to the fire safety requirements to the State Emergency Service of Ukraine (Article 57 of the Civil Protection Code of Ukraine);
- ▶ Obtaining by economic entities with high level of risk a positive conclusion on results of assessment (expertise) of fire-prevention state of an enterprise, object or premise from a licensed expert organization (Article 57 of the Civil Protection Code of Ukraine).

TECHNOLOGICAL INNOVATIONS IN THE FIELD OF RENEWABLE ENERGY SOURCES



Smart Grid and Smart Metering

Having analysed the state of electrical networks in Poland, experts concluded that it is an out-of-date obsolete technology (approximately 40% of generating capacities are more than 40 years old), also characterized by a system based on large central power plants fired with coal. In Ukraine, the electrical networks are in a significantly poorer condition.

In the face of the risk associated with the deficit of primary energy resources and low efficiency of energy generation, transmission, distribution and use, there is a growing need to introduce a new quality to the power grid, which is to create an intelligent energy supply systems commonly known as Smart Grids.

In its most basic meaning, this requires providing electricity consumers or, more broadly – providing energy services – with the use of IT to decrease the costs, increase efficiency and integration of distributed energy resources, including the renewable energy. This concept requires research in various fields of science and solutions in the field of modern technologies. Collaboration is also essential between business, research centres and companies implementing innovations.

'Europe 2020' is the European Union strategy document for 2010-2020. One of its main priorities is a smart economic growth that is economic development based on knowledge and innovations. The general aim is to invest 3 % of GDP (gross domestic product) in research and development during the above-mentioned period. Poland targets to increase investments in this sector up to 1,7% of GDP in 2020.

The further development of Smart Grids aims at:

- ▶ Ensuring energy security by eliminating the interruptions in the electricity supply and by maximizing the efficiency of energy transfer;
- ▶ Minimising the cost of electricity service through the optimal integration of local energy resources;
- ▶ Diversification and individualization levels of quality of the supplied energy;
- ▶ Extend the functionality of the network to the customers' benefit through smart metering and billing services and power management and monitoring conditions of supply;
- ▶ The integration of distributed renewable energy sources, characterized by limited availability of the capacity and energy;
- ▶ Sale of energy surplus from renewable sources and the treatment of energy grids as a source of reserve;
- ▶ Restructuring of existing transmission networks.

The concept of a smart grid also includes a whole range of activities which are primarily related to non-technical analyses of the cost-effectiveness and feasibility of projects undertaken, the search for potential returns on investments and using the appropriate market mechanisms, contracting and financial engineering. Also important are the social, cultural, and behavioural aspects created by new conditions of electrical energy supply.

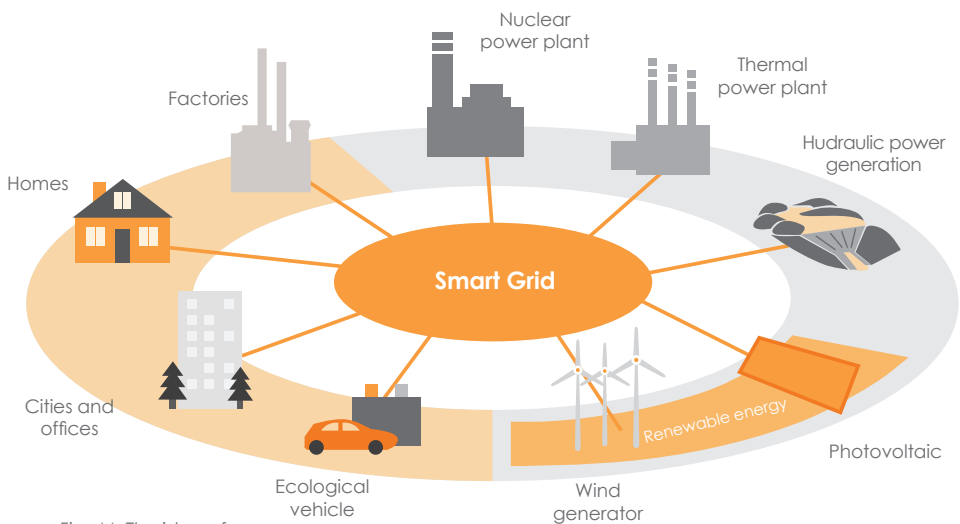


Fig. 44. The idea of Smart Grid

Smart Metering is, in other words, a smart system of metering and measuring.

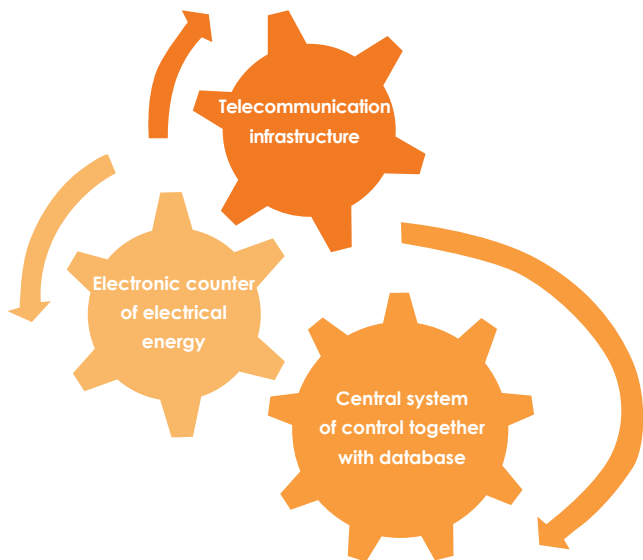


Fig. 45. The idea of Smart Metering

Smart metering (SM) is an integral part of the idea of Smart Grid, which allows reacting to changes in demand for energy and allows more efficient using of distributed and renewable energy sources of prosumers. The system consists of AMI (Advanced Metering Infrastructure), which is a developed measurement infrastructure, and MDM (Meter Data Management), which is computer software for data management. In addition, SM enables two-way real-time communication between the meter and the central computer system.

Smart metering is a solution that primarily serves to increase the energy efficiency (in places where the system has already been used successfully the energy efficiency was increased by 10%). This solution brings an apparent benefit for society, energy providers, the economy and the environment.

Automobiles of the Future

The prospects of depletion of fossil fuel resources and care for the environment tend to look for new environmentally friendly solutions in many areas, including the automobile industry.

The first solution to power vehicles in alternative way was to use a hydrogen fuel for internal combustion engine cars. It can be used as a fuel additive increasing the caloric value or as self-contained fuel. Example of such a solution is shown in Fig. 46.

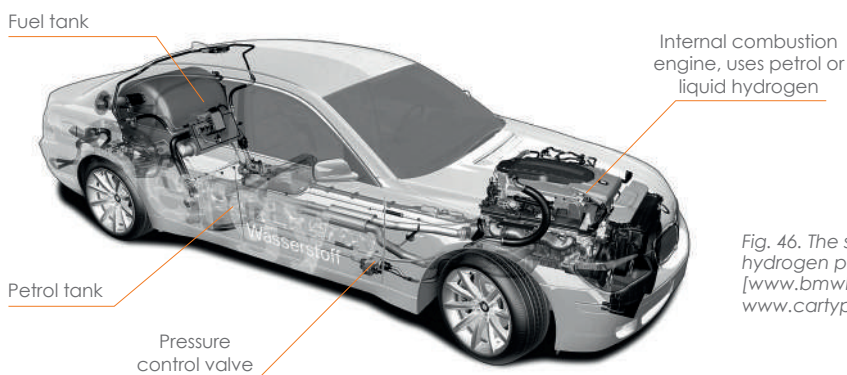


Fig. 46. The scheme of the hydrogen powered vehicle [www.bmwblog.com, www.cartype.com]

Another way to use hydrogen in the automobile industry are more efficient hydrogen fuel cells. The energy coming from the synthesis process of the water at the electrodes is converted into electricity used to power the electric motor. Then the turning torque is being transmitted to the wheels of the vehicle.

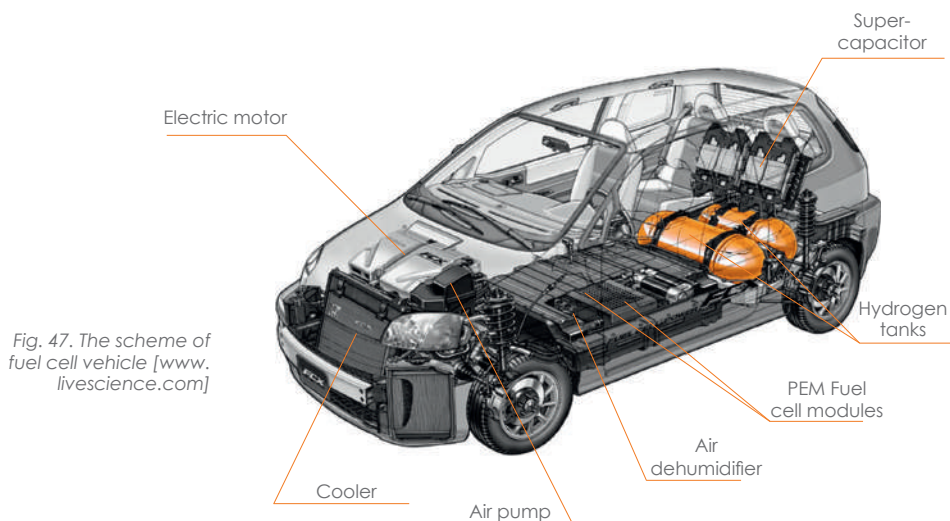
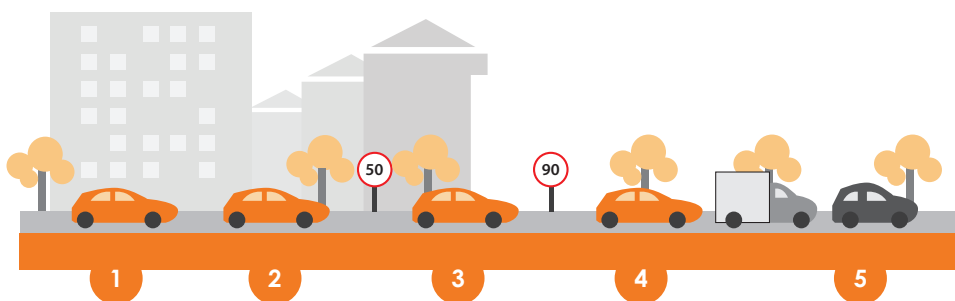


Fig. 47. The scheme of fuel cell vehicle [www.livescience.com]

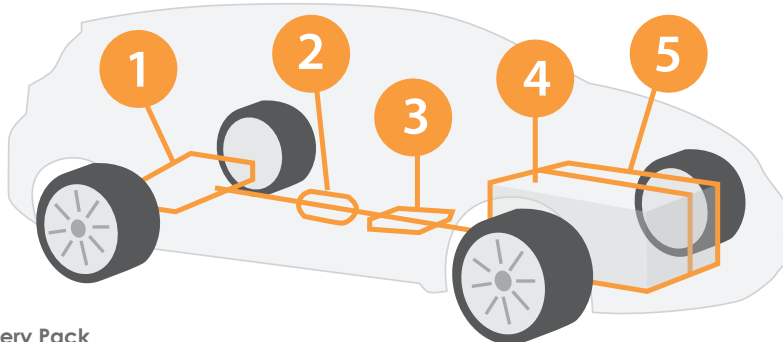


1. Start-up a car with an electric motor
2. An internal combustion engine turns on
3. While speeding up, an electric motor helps an internal combustion engine
4. Batteries are being recharged while braking
5. While waiting in traffic jams the petrol engine stops and an electric motor is on

Fig. 48. How does a hybrid car work? [www.afdc.energy.gov/fueleconomy]

Another solution are vehicles with electric motors powered by pre-charged batteries. The range of these cars between charges varies from approximately 80 km to even more than 300 km, the charging time usually lasts approximately 6 hours. On the market electric cars come with so-called fast charging mode, which allows recharging the batteries for several tens of per cent during several minutes.

Vehicles using both electric motors and traditional internal combustion engines are examples of hybrid electric vehicles. The principle of operation of such cars is shown in Fig. 48 and the structure of a hybrid engine is presented in Fig. 49.



1. Battery Pack

The main purpose of batteries is to supply energy to the working electric motors, as well as on-board electrical systems. Batteries are charged from electric motors (while braking) or, if necessary, from gasoline engines.

2. Power Control Unit

Its purpose is to control the flow of current. The inverter converts the DC current voltage of 288 V flowing out of the battery into AC current voltage to 650 V to power an electric motor.

3. Boost Converter

This element of a hybrid gear increases voltage, and along with the Power Control Unit can also perform this operation in the opposite direction, so while braking it converts AC voltage of 650 V flowing from electric motor to DC voltage of 288 V to charge the battery.

4. The Internal Combustion Engine

It is responsible for:

- Self propelling
- Driving a car with an electric motor
- Driving a car and simultaneous charge the battery

5. The Electric Motor

- Can autonomously put a car in motion
- Complements petrol engine
- While braking operates as a generator processing kinetic energy into electricity

Fig. 49. The structure of a hybrid gear [www.fueleconomy.gov/feg/hybridtech.shtml]

In Germany, Sweden, Austria, Switzerland and the Netherlands, one can see buses powered by biogas. Bio-methane as a fuel in the automobile industry needs to be processed to reach the quality, acceptable for ordinary automobile engines. Carbon dioxide and water vapour have to be removed from the biogas in addition to the substances coursing the corrosion of engines (e.g. hydrogen sulphide).



Photo 7. Bus powered by biogas fuel, the Netherlands [www.finaltech.pl]

Hydrogen Production

Inside the sun there constantly goes on the so-called hydrogen cycle, resulting in the nuclei of hydrogen atoms produce nuclei of helium atoms. During this process, energy is released to which Earth owes its life. For years, scientists are trying to recreate artificially the process, which would allow producing clean energy in a controlled way (at present, we are able to produce energy in a very abrupt way – in a form of a hydrogen bomb). Power plants based on nuclear fusion would solve the problems associated with the production of energy from fossil fuel and could replace today's nuclear power plants, because the end product of the reaction is completely harmless helium, as opposed to radioactive waste, resulting from cleavage of heavy nuclei.

The latest science news report of the tests carried out on two ways of controlled nuclear fusion. The first is to bind and densify the hot plasma with a magnetic field in a donut-shape chamber (international ITER project, which is run in France). The second method invented by American researchers involves calling the synthesis laser beam generated in a powerful installation NIF (National Ignition Facility) (Photo 8). NIF consists of 192 laser beams of ultraviolet light, which meet at one point, to focus its power and release the hydrogen synthesis reaction.

Nevertheless, the construction of a power plant based on synthesis technology of hydrogen is still in a far future, according to scientists, it is possible in the next 30 years.

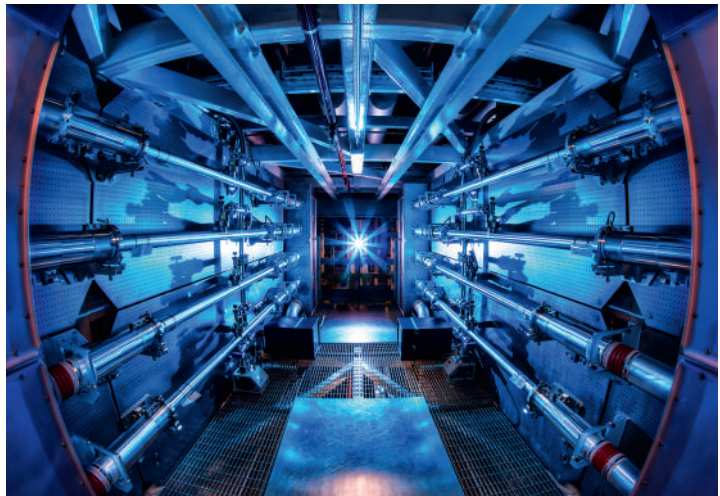


Photo 8. The preamplifiers of the National Ignition Facility allows achieving of a 500 terawatt shot [www.en.wikipedia.org]

Fuel Cells

A fuel cell is a device that directly converts the chemical energy contained in the fuel into electricity. At present, it is only the energy of current. The process of energy production does not change the chemical nature of the electrodes and electrolytes used.

1. Hydrogen fuel is channelled through field flow plates to the anode on one side of the fuel cell, while oxygen from the air is channelled to the cathode on the other side of the cell

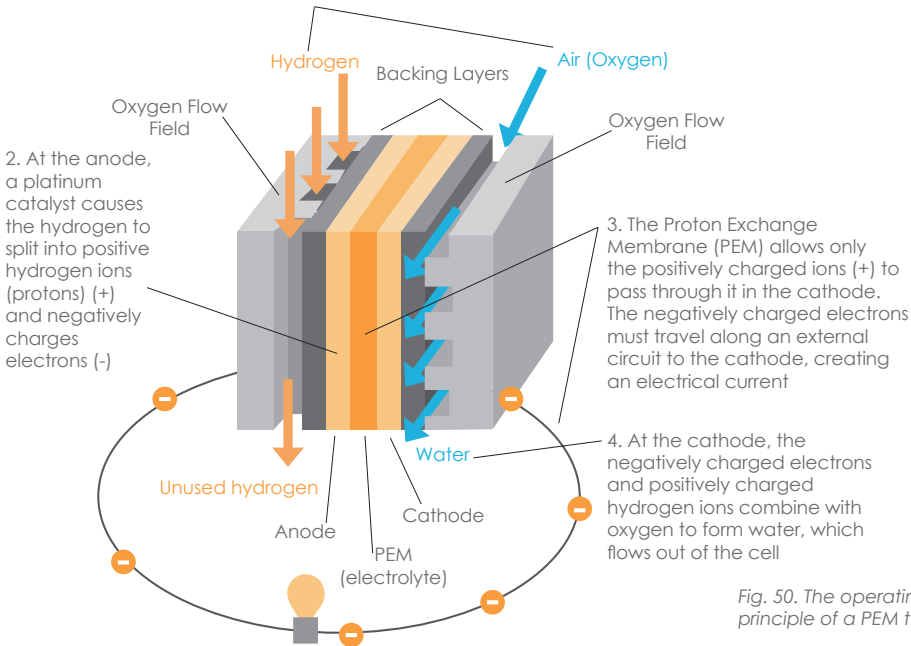


Fig. 50. The operating principle of a PEM type cell

Proton Exchange Membrane or PEM Fuel Cells are considered to be the most versatile type of fuel cells currently in production. They produce the most power for a given weight or volume of fuel cell. PEM cells may be fed with pure hydrogen or hydrocarbon fuel from reforming; the quality of their work is not affected by low temperatures or geometric orientation allowing their flexible use. Another advantage compared with other fuel cells is the lack of aggressive liquids, which could cause corrosion. These cells are compact due to the thin membrane – electrode assembly, which cannot take the enormous shapes and sizes. The principle of operation of the fuel cell is shown in Fig. 50.

The mentioned advantages confirm the possibility of using PEM fuel cells both in the automotive industry, as well as in mobile devices (photo 9). Strong commitment of research teams led to a reduction in costs to the extent that the PEM cells are currently the cheapest and most available on the market for fuel cells.



Photo 9. Application of PEM type fuel cells [www.fueleconomy.gov/feg/fcv_PEM.shtml, www.toshiba.com]

OPPORTUNITIES FOR PROJECTS CO-FINANCING IN THE FIELD OF RENEWABLE ENERGY AND ENERGY EFFICIENCY



Principles of Financing in Poland

In Poland, there is a multi-level and differentiated system of financing of innovative and investment projects in the field of energy efficiency and renewable energy sources. This system includes financing in both a non-repayable form (grants) and a repayable form (loans and credits). Many potential sources of financing use funds from the European Union budget, making it possible for an investor to get rather favourable conditions of financing. The operators of the funds, both state institutions and their separate organisational units (at the national and regional levels), as well as commercial entities, offer investment products related to renewable energy and energy efficiency.

The repayable financing sources in Poland are loans, credits, loans granted by the Regional Funds for Environmental Protection and Water Management.

Regional environment protection funds have the resources to support the implementation of investment projects in the field of environmental protection. Depending on a region, the preferred sectors of the activities financed by the funds may differ from each other, resulting from the nature of basic problems in a particular region.

Non-repayable financing sources of investment projects (grants)

Support at the national level is available under the Operational Programme 'Infrastructure and Environment'. As part of the actions, the programme supports the investments in the construction of units generating electrical energy or heat from renewable sources. This applies to construction projects of power generating units of energy from wind, water at small hydropower plants, biogas and biomass, as well as projects for the construction of heat generation plants using geothermal or solar energy.

Under the programme, economic entities may also seek funding for investment projects in the field of energy production from renewable sources in cogeneration systems, which do not meet the criterion of high-efficiency cogeneration.

The programme specifies the minimum values for the projects that could receive funding:

- ▶ for investment projects in the field of generation of electricity from biomass or biogas, and the construction or extension of small hydropower plants, the minimum value is PLN 10 million;
- ▶ for other types of the projects, the minimum value is PLN 20 million.

The choice of the specific Regional Operational Programme depends on location of a particular investment project (it happens also that it may be necessary for an applicant to locate its main office in a particular region). Each Regional Operational Programme determines its own detailed rules for granting support. All regions apply the competitive procedure for selecting projects for co-financing. An application can only be filed within the period specified in the call for proposals, published on the website of the implementing authority.

The basic principle of applying for EU funding under the national or regional operational programs in the field of renewable energy lies in a proper preparation of a particular investment project to its implementation phase. In other words, submission of the application should be one of the last step prior to the project implementation phase. The first step in the project preparation should be an analysis of the efficiency of a particular investment project in terms of the source of energy for a given location. It is therefore crucial to conduct feasibility studies for different variants of location. The grant application together with the necessary supporting documents (including feasibility studies) should indicate that the project submitted for funding is fully enforceable not only technically, environmentally, but also in terms of formal legal and financial aspects. At this early stage the applicant should obtain required permits in relation to the investment project and indicate the sources of funding (secured by own funds, or a loan), which will allow the implementation of the project before the time of receipt of the grant. Please also note that the actual start of investment project in case of micro, small and medium-sized economic entities can take place after the submission of the application for funding. Earlier start of construction works or placing the first legally binding orders for equipment prior to application submission, with the exception of activities related to preparation of documentation concerning the investment project, automatically disqualifies the project for support.

Taking into consideration the strategic nature and development dynamics of the energy sector in Poland it is eagerly financed by the donor institutions in recent years. The main European Funds are:

European Regional Development Fund (ERDF)

The fund is focused on the development of socioeconomic potential of the Member States of the European Union. ERDF primarily finances projects aimed at the development of entrepreneurship, development of infrastructure, increasing employment, increasing innovation and economic competitiveness, improving environmental protection and activation of cooperation between neighbouring regions of the Member States.

www.ec.europa.eu/regional_policy/en/funding/erdf/

www.funduszeuropejskie.gov.pl

The European Social Fund (ESF)

Ministry of Regional Development

European Social Fund Managing Authority

The main objective of ESF is to solve the problem of unemployment by means of increasing possibilities of education and employment. Support is provided in particular to those at risk of poverty and young people entering the labour market.

www.ec.europa.eu/esf/home.jsp

www.efs.gov.pl

Cohesion Fund (CF)

The fund aims to reduce social and economic disparities and to promote sustainable development mainly by large investments in transport infrastructure and environmental protection. It is designed for Member States whose gross national income (GNI) per capita is less than 90% of the average GNP of the EU.

www.ec.europa.eu/regional_policy/en/funding/cohesion-fund/

www.funduszeuropejskie.gov.pl

Funding Agencies

► **National Fund for Environmental Protection and Water Management in Poland**

The main activities of NFEP&WM is to provide financial support for the protection of the environment and water management. The Fund announces calls for proposals and funds projects with EU and national funds.

www.nfosigw.gov.pl

► **Norwegian Financial Mechanism and Financial Mechanism of the European Economic Area (i.e. so-called Norwegian Grants and EEA Grants)**

It is a form of the financial contributions of Norway, Iceland and Liechtenstein towards the reduction of economic and social disparities in the European Economic Area (EEA) and to strengthen bilateral relations with 16 EU and EEA Member States in Northern, Central and Southern Europe. The national contact institution in Poland is the Ministry Infrastructure and Development, the Department of Aid Programmes.

www.eog.gov.pl

► **National Centre for Research and Development**

The National Centre for Research and Development is the implementing agency of the Minister of Science and Higher Education in Poland as an entity in charge of the performance of the tasks within the area of national science, science and technology and innovation policies. It supports researches dedicated to new technologies and modern solutions by developing innovation support programs.

www.ncbir.pl

► **Foundation of Assistance Programmes for Agriculture**

www.fapa.com.pl

► **Bank Ochrony Środowiska (Bank for Environmental Protection)**

www.bosbank.pl

► **Bank Gospodarstwa Krajowego (BGK)**

www.bgk.com.pl

Operational Programmes to Support Renewable Energy in Poland

An operational program is called one of the most important planning documents, which defines the area of actions that state authorities take or intend to take on the promotion of the country. The main objective is to implement the National Development Plan by financing various projects from the national and the European Union funding sources.

An example would be the Operational Programme **'Infrastructure and Environment 2014-2020' (POLIŚ)**, which is a national program supporting environmental protection, combating and adapting to climate change, low-

carbon economy, transport and energy security. The main beneficiaries of the program are public entities, and large enterprises. The most important source of funding for the operational program will be Cohesion Fund (CF), which for the purpose of programme implementation in 2014-2020 will allocate € 27,41 billion, including € 3 508,2 million will be forwarded to the environment, and € 2 800,2 million to the energy sectors.

The program will be carried throughout 10 priority axes among others: reducing the emissions in industry sector, environmental protection (including adaptation to the climate changes), development of the public transport in cities with a low level of emissions or improving energy security. The first priority axis will cover the funding of the following sectors: improvement of energy efficiency in the public sector and housing; production, distribution and use of renewable energy sources (RES) (e.g. construction, or extension of wind farms, installing of biomass and biogas power units); and the development and implementation of smart grids (e.g. construction of grid networks of medium and low voltage). Expected EU contribution amounts to € 1 828,4 million.

'Horizon 2020' is another example of the operational program. This is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020) – in addition to the private investment that this funds will attract. It promises more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market and is a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation.

Seen as a means to drive economic growth and create jobs, Horizon 2020 has the political backing of Europe's leaders and the Members of the European Parliament. They agreed that research is an investment in the future of EU and so put it at the heart of the EU's blueprint for smart, sustainable and inclusive growth and jobs. It is all about creating a coherent system of financing innovations, from scientific concepts through research stage, to the implementation of new solutions, products, and technologies. To take advantage of the opportunity offered by Horizon 2020 it is needed to mobilize the entire scientific community and joint efforts of government, universities and research institutes and entrepreneurs. Innovations should be used to create new solutions for a low carbon economy, energy efficiency and advanced smart cities and communities. The programme covers not only the EU states. Ukraine is also among the priority target countries for the programme support. 'Horizon 2020' helps to reach certain objectives connected with science improvement, production development and social problems solving, by means of combining scientific research and innovations. By

coupling research and innovation, Horizon 2020 is helping to achieve this with its emphasis on excellent science, industrial leadership and tackling societal challenges.

In 2014-2020 the cross-border cooperation between Poland, Belarus and Ukraine will continue within the **European Neighbourhood Instrument** (ENI) through the Cross-Border Cooperation Programme Poland-Belarus-Ukraine for 2014-2020. The European Commission has decided to allocate €176 million to continue the programme. The programme will focus on improvement of the transport accessibility of the regions through development of long-term and climate-resistant transport and transport networks, promotion of local culture, common challenges in the sphere of safety and protection, as well as promotion of border management and regulation of migration processes, mobility and security.

Another example is the Operational Programme '**Intelligent Development 2014-2020**', which main objective is to support the private sector research and development (R&D), i.e. institutions and people involved in expanding and practical application of knowledge in Poland. The program is a national program funded by operational European Regional Development Fund. The program primarily aims at supporting innovation and competitiveness of the economy. It is about increasing investment in the services sector, scientific and educational institutions, through supporting enterprises in the areas of innovation and R&D activities, raising the level of quality and development of interdisciplinarity, as well as increasing the degree of commercialization and internationalization of research and development work. The programme's priority are the innovative technologies in the field of environmental protection, notably the reduction of greenhouse gas emissions, air and water pollution mitigation and adaptation to climate changes, they are so-called eco-innovation. The programme will be implemented according to the conception of smart specialization, i.e. concentration of the support on the territories with the highest development and growth potential, within the allocated funding in amount of €7,6 billion.

Another important programme for the development of certain Voivodeships is the Regional Operational Programme. The continuation of this programme establishes a system of fulfilment of the National Strategic Frameworks of Correlation. At this particular level Lublin Voivodeship is going to obtain €2228,9 million to be directed, among other projects, at the environmentally friendly energy and energy efficiency with a low emissions level.

Within last several years, the operational programmes contributed greatly to the development of the state in specific spheres, such as culture, entrepreneurship, social aid etc. The time has come to help the environment and the thing, we have valued the least up to now, but the one we are primarily interested in presently, is an economy with a low level of emissions.

Peculiarities of Projects Financing in the Field of Renewable Energy in Ukraine

State Policy of RES Development

In Ukraine, the system of state support policies for renewable energy currently provides for the use of several mechanisms. One of the mechanisms is the system of targeted feed-in tariffs for the energy produced from the alternative sources, the so-called 'green tariff'. This is the way, whereby energy consumers indirectly support RES development. It should be noted, until recently, the Ukrainian 'green tariffs' were the highest in Europe. However, in June 2015 new amendments to the legislation were introduced decreasing tariffs to the average European level.

The other mechanism is the public funding under the government programs such as public soft loans and grants to replace heating systems and insulation of buildings. The government also supports the RES development by providing tax incentives and guarantees for investors. Besides, in case of amending the corresponding legislation the state provides guarantees for the economic entities that produce electrical energy from the alternative sources to apply the particular energy production incentives acting on the date of commissioning of a power generating facility. At the same time, such economic entities may choose new incentives for the production of electricity from alternative sources.

Hereinafter the main support mechanisms for development of renewable energy sources are described. They specifically are the green tariffs, tax incentives and investments.

‘Green Tariff’

‘The Green Tariff’ policy is a feed-in tariff (FIT) scheme for electricity generated from renewable energy sources (excluding blast furnace and coke gases). In the field of hydropower energy, ‘green tariffs’ are imposed only for the energy production by micro, mini and small hydro power plants.

In order to apply ‘green tariffs’, electricity producers must meet the legislative requirements for the so-called ‘local component’.

The term ‘local component’ means a share of components of equipment of Ukrainian origin in energy generating facility. Whereas for the facilities producing electricity from wind, solar and biomass this share should not be lower than 30 % if the construction and setting into operations were commenced after 1 January 2012 and 1 July 2013 respectively; and not lower than 50% if the construction and setting into operations were commenced after 1 January 2012 and 1 July 2014 respectively.

The Ukrainian origin of the components of equipment used in the energy generating facility should be confirmed by a certificate of origin from the Chamber of Industry and Commerce. The requirement to maintain a ‘local component’ share, does not apply to energy generating installations in private households, as well as micro, mini and small hydropower.

Electricity producers can also apply ‘green tariff’ if their facilities are built according to the Development Plan for the United Energy System of Ukraine. In this way, the special tariff cannot be applied to electricity produced in the old obsolete facilities.

‘Green tariff’ shall be applicable for the economic entities, which produce electricity from wind energy, biogas, biomass, geothermal energy, solar energy or in hydroelectric power plants, as well as for private households that generate electricity from solar energy.

The ‘green tariff’ calculations shall be based upon the retail tariff established for January 2009 for the second-class voltage consumers, that is, consumers who receive electricity at the point of sale with a voltage of less than 27.5 kW. The retail tariff shall be multiplied by a coefficient of a ‘green tariff’ for electricity produced from a particular source.

‘Green tariff’ shall be applied based on National Energy and Utilities Regulatory Commission decision following applications from the relevant operators and households.

Legal entities and households that produce electricity using alternative energy sources could apply ‘green tariffs’ by 1 January 2030.

Type of alternative energy source	Capacity of a power facility and other factors that influence 'green tariff' level	Retail price (Euro/kWh)	Coefficient	CPP (Peak Coefficient voltage)	Tariff rate (Euro/kW)
Wind	Up to and including 600 kW	0,05385	1,2	-	0,06462
	Over 600 kW, but less than 2000 kW	0,05385	1,4	-	0,07539
	Over 2000 kW	0,05385	2,1	-	0,113085
Solar energy	Terrestrial power stations	0,05385	3,5	1,8	0,339255
	Power stations on roofs or/ and facades of buildings with the capacity over 100 kW	0,05385	3,6	1,8	0,348948
	Power stations on roofs or/ and facades of buildings with the capacity up to and including 100 kW	0,05385	3,7	1,8	0,358641
	Power stations on roofs or/and facades of private households with the capacity up to and including 100 kW	0,05385	3,7	1,8	0,358641
Biomass and biogas	Waste products	0,05385	2,3	-	0,123855
Hydropower stations	Micro hydropower stations (up to and including 200 kW)	0,05385	2	1,8	0,19386
	Mini hydropower stations (over 200 kW, but less than 1000 kW)	0,05385	1,6	1,8	0,155088
	Small hydropower stations (up to and including 10 thousand kW)	0,05385	1,2	1,8	0,116316

Tbl. 15. Calculation of the minimal 'green tariffs' applicable since 01 April 2013

Type of alternative energy	Date of commissioning a power facility into operation	Minimal percentage of local component required for green tariff (%)
Solar wind and solid biomass energy	Before 01 January 2013	30
	Since 01 January 2013 (the requirement was valid up to 07 July 2013)	15
	Since 02 July 2013 up to and including 01 July 2014	30
Biogas	Up to and including 01 January 2014	absent
	Since 02 January 2014 up to and including 01 January 2015	30
	After 01 January 2015	50
Solar energy (an additional requirement concerning prices for Ukrainian materials in solar modules production)	After 01 January 2013 (the requirement is valid up to 01 April 2013)	30

Tbl. 16. Requirements concerning local (Ukrainian) component

Types of alternative energy sources	Capacity of a power facility and other factors that influence 'green tariff' level	Tariffs (Euro/kW) for facilities commissioned over the particular period				
		Up to and including 31 March 2013	Since 01 April 2013 up to 31 December 2014	Since 01 January 2015 up to 31 December 2019	Since 01 January 2020 up to 31 December 2024	Since 01 January 2025 up to 31 December 2029
Wind	Up to and including 600 kW	0,06462	0,06462	0,058158	0,051696	0,045234
	Over 600, but less than 2000 kW	0,07539	0,07539	0,067851	0,060312	0,052773
	Over 2000 kW	0,113085	0,113085	0,1017765	0,090468	0,0791595
Solar energy	Terrestrial power stations	0,339255	0,339255	0,3053295	0,271404	0,2374785
	Power stations on roofs or/ and facades of buildings with the capacity over 100 kW	0,348948	0,348948	0,3140532	0,2791584	0,2442636
	Power stations on roofs or/ and facades of buildings with the capacity up to and including 100 kW	0,358641	0,358641	0,3227769	0,2869128	0,2510487
	Power stations on roofs or/and facades of private households with the capacity up to and including 10 kW	0,358641	0,358641	0,3227769	0,2869128	0,2510487
Biomass and biogas	Waste products	0,123855	0,123855	0,1114695	0,099084	0,0866985
Hydropower stations	Micro hydropower stations (up to and including 200 kW)	0,19386	0,19386	0,174474	0,155088	0,135702
	Mini hydropower stations (over 200 kW but less than 1000 kW)	0,155088	0,155088	0,1395792	0,1240704	0,1085616
	Small hydropower stations (up to and including 10 thousand kW)	0,116316	0,116316	0,1046844	0,0930528	0,0814212

The energy producers, for whom a 'green tariff' is imposed, shall be entitled to sell the electrical energy applying such a tariff to a guaranteed buyer (public companies, such as regional energy companies). Up to 01 January 2030 a guaranteed buyer shall be obliged to buy from economic entities, for whom a 'green tariff' is imposed, all electrical energy produced from the alternative energy sources. In addition, the economic entities may sell such an electrical energy to other consumers by tariffs agreed by the parties. In the latter case the application of 'green tariffs' is the issue of environmental consciousness and culture.

Tbl. 17. Gradual decrease in green tariffs (Euro/kW)

Tax incentives

According to the Tax Code of Ukraine, some imports into the customs territory of Ukraine are exempt from a value-added tax, in particular:

- ▶ equipment that operates on renewable energy sources, energy saving equipment and materials, measuring means, means of control and regulation over the consumption of fuel and energy resources, equipment and materials for the production of alternative fuels or the production of energy from renewable energy sources;
- ▶ materials, equipment and constituent parts which are used for the production of equipment that operates from renewable energy sources; as well as materials, raw materials, equipment and constituent parts which are going to be used in the production of alternative fuels or the production of energy from renewable energy sources.

Up to 01 January 2019 the following operations are also exempt from a value-added tax:

- ▶ supply of technical means that operate on alternative fuels (the confirmation of suitability of technical means which are designed or re-designed for operating on an alternative fuel is done in accordance with the requirements of the law which regulates technical means that operate on traditional fuels);
- ▶ import of the already mentioned technical means, used for the reconstruction of the existing facilities or the construction of new ones producing biofuel, as well as for the production and reconstruction of technical and transport means operated on biofuel, if such goods are not produced in Ukraine and have no analogues in Ukraine; as well as technical and transport means, including self-propelled agriculture machines, which operate on biofuel, if such goods are not produced in Ukraine.

Operations concerning the sales of electrical energy produced by qualified cogeneration equipment and/or from renewable energy sources are exempt from an excise tax.

It is worth mentioning that the Tax Code of Ukraine defines as renewable the sources of wind, solar and geothermal energy, energy of waves and tidal waves, hydropower, energy of biomass, gas from organic waste, gas of sewerage treatment stations and biogas.

The costs saved by the taxpayers from application of the tax incentives constitute an additional resource for investing into the renewable energy sector.

Legal guarantees for foreign investors

On the territory of Ukraine a national regime of investment activity is applied to foreign investors, it guarantees that foreign investors are under the same legal conditions as national investors. Foreign investments in Ukraine shall not be subject of nationalization.

Shall the guarantees of foreign investments protection determined by the law be changed in the future by the special legislation of Ukraine on foreign investments, a foreign investor would be entitled to request the previous state guarantees of foreign investments protection be applicable for him within 10 years from the date of coming into force of that legislation.

Foreign investors are entitled to compensation of damages, including loss of profit and moral damage caused to them by actions, inactivity or improper performance of obligations with respect to a foreign investor envisaged by the laws by state authorities of Ukraine or their officials. The amount of compensation shall be determined by the decision on compensation of damages.

In case of termination of the investment activity a foreign investor is entitled to compensation of its investments in kind or in the currency of investment without paying any duty, as well as return on such investments in cash or in the form of commodities. Foreign investors are also guaranteed free and immediate transfer of their profit, income and other funds in foreign currency received legally from foreign investments abroad.

In order to increase the foreign investments protection, Ukraine has ratified the Washington Convention 1965 Convention on the Settlement of Investment Disputes between States and Nationals of Other States.

Verkhovna Rada of Ukraine (the Supreme Council of Ukraine) has also ratified international agreements on cooperation and mutual investment protection with more than 70 countries of the world.

The Regional Centres for Investment and Development are the investment promotion units acting as public vehicles for investors on regional level, providing support in interaction with executive and local government authorities through a one-stop-shop format.

Support of Projects on Energy Efficiency and RES in Ukraine

Priority state projects and programmes

The concept of green technologies in the utilities, agricultural and energy sectors dominates in such Ukrainian national projects as **'Clean City'**, **'Energy of Nature'**, **'Grain of Ukraine'**, **'Cattle Husbandry'** and **'High-Quality Water'**. The project **'Energy of Nature'** promotes the energy sources from burnable waste. The national project **'Clean City'** supports the modern technologies connected with sorting and recycling of domestic solid waste. The national projects **'Grain of Ukraine'** and **'Cattle Husbandry'** concern the usage of recycled organic waste (compost, biogas, protein feed additives, etc.) in agriculture. The national project **'High-Quality Water'** aims at establishing and using modern technologies in portable water treatment.

The national project 'Energy of Nature', in particular, supports the construction of wind and solar power stations, small hydropower plants, as well as production of alternative solid fuel. The wind power stations are planned in Luhansk, Donetsk, Mykolayiv and Zaporizhzhia regions, and small hydropower plants are planned in Zakarpattia, Ivano-Frankivsk, Lviv, Chernivtsi, Zhytomyr, Khmelnytskyi and Volyn regions.

The State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) operates a **state assistance programme for population supporting alternative heating projects**. The programme provides for compensation of 20% of the primary loan taken from 'Oshchadbank' for citizens while purchasing solid fuel electric boilers. This programme also encourages citizens, particularly owners of private houses, condominiums and housing cooperatives, to undertake energy saving measures. The programme provides for reimbursement of 30% of the primary loans taken by citizens to purchase energy efficient equipment and materials whereas the sum of reimbursement shall not exceed the UAH 10,000, as well as the reimbursement of 40% of the loans taken by condominiums and housing cooperatives for energy saving measures in apartment blocks. In 2015 the amount of funds available through the programme constitutes UAH 343,5 million.

In December 2014, the company 'Hresa-Group' together with PJSC 'UkrGasbank' worked out a credit programme aimed at supporting the purchases of energy saving and house warming equipment. The credit programme targets the condominiums, legal entities and individual entrepreneurs and offers purchase loans for the period of 3 years with an annual interest rate of 3-11%. The loans are granted on a special terms for purchase of heating, energy generating, water heating, and climate equipment as well as for the heat isolating systems.

International financial assistance

The biggest investors in the sphere of energy efficiency and RES are international financial organisations, which support local projects within different development programmes or work out their own special programmes for Ukraine. The main objective of such investors is to improve energy efficiency in industrial enterprises, small and medium business, and municipal utilities companies in local communities.

The European Bank for Reconstruction and Development (EBRD).

One of the biggest programmes supported by EBRD in the sphere of energy efficiency is the Programme of Energy Efficiency of Ukraine, established in order to grant credits and technical support to small and medium size companies. As of March 2011 approximately \$105 million was allocated to support energy efficiency projects in different sectors within the Programme. EBRD also granted several substantial credits to support energy efficiency projects of big industrial enterprises, electrical energy companies and communal establishments in order to provide modernisation of their out-of-date equipment.

In order to encourage businesses to pursue sustainable energy projects, the European Bank for Reconstruction and Development (EBRD) has launched the Ukraine Sustainable Energy Lending Facility (USELF). To promote projects that are often challenging to finance and implement, the Facility not only provides tailor-made financing, but also assistance by technical consultants for businesses and local authorities. In 2015 EBRD plans to invest €1 billion in Ukraine. The assistance mainly will target the reconstruction of Donbas region and support to reforms.

www.ebrd.com/ukraine

The Eastern Europe Energy Efficiency and Environmental Partnership (E5P) unites the bilateral donors and main international financial institutions to coordinate and accelerate the implementation of important energy efficiency and environmental projects in Ukraine and other Eastern Partnership countries. It is a EUR 170 million multi-donor fund managed by the EBRD. The initiative came from Swedish Government in 2009 during its presidency in the European Union. The E5P grants are allocated through partnership framework, which includes the European Investment Bank, European Commission, EBRD, Nordic Investment Bank, Nordic Environment Finance Corporation and World Bank Group.

E5P grants are allocated in four main priority spheres: district heat supply, energy saving projects, environmental projects in Ukraine and other projects in other Eastern Partnership countries, though Ukraine is considered the main beneficiary of the fund. Environmental projects dealing with, for example, sewage or renewable energy, are also a part of grant financing.

www.e5p.eu

The European Union provides direct support for energy efficiency programmes and RES through the State Agency on Energy Efficiency and Energy Saving of Ukraine. €1,25 million have been allocated for the implementation of the Partnership Project 'Improvement of the Legal Framework in the Sphere of Energy Efficiency and Its Adaptation to the Legislation', which aims at harmonization of national legal acts concerning energy efficiency with the corresponding EU regulations/standards according to the Energy Community requirements. The total amount of assistance from the EU in 2011-2013 constituted €70 million. Financial assistance targets the legal framework reform, public finance management, various energy efficiency actions (energy balance, public awareness, access to financing, etc.), monitoring the implementing policies to reduce energy consumption.

www.sae.gov.ua/en

The World Bank District Heating Energy Efficiency project aims to improve the energy efficiency and quality of service of selected Ukrainian district heating (DH) companies, improve their financial viability and decrease their CO₂ emissions. The global objective is to reduce greenhouse gas emissions through avoided heat generation by improving heat generation efficiency, reducing heat losses in DH transmission and distribution systems, and reducing residential heat consumption. The main project implementing agency is the Ministry of Regional Development, Construction and Municipal Economy of Ukraine. The funds allocated for the project Component 1: Energy Efficiency Investments - \$376,50 million and Component 2: Technical Assistance and Capacity Building - \$5,50 million.

www.worldbank.org/uk/country/ukraine

The United States Agency for International Development (USAID) assists 36 local communities in Ukraine within the Project of Centralised Heat Supply Reforming, investing over the last three years \$16 million.

Another USAID project 'Municipal Energy Reform in Ukraine' aims at strengthening the energy security of Ukraine, particularly through the assistance to the partner cities in planning, preparing and financing projects concerning clean energy and energy efficiency. The main expected results of the project at the all-Ukrainian level are the savings of 266 million cubic metres of natural gas, decrease of CO₂ emission by 500 thousand tonnes, and attracting \$200 million of investments to the projects concerning clean energy and energy efficiency. City of Ivano-Frankivsk is one of 17 partner cities in this initiative.

www.merp.org.ua/index.php?lang=uk

The Community Based Approach to Local Development Project, Phase II (CBA-II) is funded by the European Union and is co-financed and implemented by UNDP, with the support of the Government of Ukraine and in partnership with local executive and elected bodies. Total budget of CBA-II is €17 million with 98.4% contribution from EU and 1.6% cost sharing from UNDP. Project period is 4 years (June 2011 – June 2015). The overall objective of CBA-II Project is to promote sustainable socio-economic development at local level by strengthening participatory governance and encouraging community-based initiatives throughout Ukraine.

Specific objectives of the Project are to promote community-based approach to local governance and sustainable development; to enhance energy efficiency at local level; and to support the creation of the locally owned and managed repository and network of good practices and knowledge on community mobilization and participatory governance.

In the second phase, CBA Project works in all 25 regions of Ukraine, 264 districts and 1108 local councils – all selected through the open competition, based on the criteria of (a) socio-economic hardship; (b) motivation to practice participatory governance.

www.cba.org.ua/ua/about

The UNDP Transforming the Market for Efficient Lighting project aims at introduction of more energy efficient lighting technologies and gradual phase out of inefficient lightning sources and fittings in residential and public buildings and schools. The total amount of financing allocated for the project implementation in 2010-2015 is \$31 million.

www.ua.undp.org/content/ukraine/uk/home.html

German International Cooperation Community (GIZ) has been supporting Ukraine's transition process on behalf of the German Government since 1993. Germany's international cooperation with Ukraine focuses on three priority areas: sustainable economic development, energy efficiency, and the HIV/AIDS response. In the energy efficiency sector in Ukraine GIZ implements the following projects: 'Energy-efficient pilot project', 'Energy efficiency in municipalities' ('Sustainable Infrastructure' program), 'Establishing energy agencies' ('Environment and Climate Change program'), and Programme to support ecological modernisation of the Ukrainian economy ('Green Economy programme').

www.giz.de/en/worldwide/302

The Nordic Environment Finance Corporation (NEFCO) is an international finance institution established in 1990 by the five Nordic countries: Denmark, Finland, Iceland, Norway and Sweden. NEFCO provides loans and makes capital investments in order to generate positive environmental effects of interest to the Nordic region. To date, NEFCO has financed a wide range of environmental projects in Central and Eastern European countries, including Russia, Belarus and Ukraine. NEFCO's activities are focused on projects that achieve cost-effective environmental benefits across the region. NEFCO prioritizes projects that reduce releases of climate gases, improve the ecological status of the Baltic Sea or mitigate release of toxic pollutants. NEFCO's portfolio currently comprises nearly 400 small and medium-sized projects spread across different sectors.
www.nefco.org/introduction/this_is_nefco

DemoUkrainaDH is a funding programme established by NEFCO in cooperation with the Ministry of Regional Development, Construction and Municipal Economy of Ukraine, supported by Sweden and E5P. The objective of the DemoUkrainaDH programme is to demonstrate in Ukrainian cities new District Heating technology and District Heating system solutions in combination with the introduction of international practices for project preparation, design, procurement, implementation and follow up for more energy efficient and sustainable District Heating services. The programme supports the development of sustainable and energy efficient demonstration projects resulting in energy savings of at least 30 % and significant reduction of CO₂ emissions. The total procurement value for the DemoUkrainaDH programme is estimated to about EUR 16 million. The procurement for the first demonstration projects started during 2013. By the end of 2014 procurement has been performed corresponding to a value of about EUR 2.5 million.
www.demo-dh.org.ua

Covenant of Mayors. After the adoption, in 2008, of the EU Climate and Energy Package, the European Commission launched the Covenant of Mayors to endorse and support the efforts deployed by local authorities in the implementation of sustainable energy policies. Indeed, local governments play a crucial role in mitigating the effects of climate change, all the more so when considering that 80% of energy consumption and CO₂ emissions is associated with urban activity. The Covenant of Mayors Office (CoMO), established and funded by the European Commission, is responsible for the coordination and daily management of the initiative. It provides signatories with administrative support and technical guidance, facilitates networking between Covenant stakeholders and ensures the promotion of their activities. The mayor of Ivano-Frankivsk signed Covenant of Mayors at the end of 2011 and committed himself to preparing and implementing the Programme of Sustainable Energy Development of Ivano-Frankivsk till 2020.
www.covenantofmayors.eu

Public and Private Initiatives in Ukraine and Poland

Environmental Education

A necessary condition that must be met in order to achieve sustainable development is environmental education of the whole society. With the help of education, you can disseminate and promote the idea of sustainable development. In schools, classes are held to discuss the problems of the modern world: the devastating impact of humans on the environment and the consequences posed by such activities. The classes aim to raise awareness of the students, as well as to sensitize them on the contents related to ecology and environment. The environmental science is a continuous process already delivered to the youngest children, followed by students of primary, junior high or high schools, at least several class hours of ecological education are obligatory within nature study, biology and geography curricula. Even adults from all sectors are informed about the environment, e.g. through scientific programs on TV, articles on web pages or regulations imposed by the European Union.

In 2001, the Polish Ministry of Environment has published the National Strategy for Environmental Education. The most important objectives of the strategy are to promote the idea of sustainable development, to establish a sense of responsibility for the environment, to raise public awareness about environmental protection, to motivate the public to respect general principles, to involve the public to work actively to protect the environment, to educate public about the catastrophic effects of human activities on the environment.

Over the years, environmental awareness in Poland has changed dramatically, first of all, through accession to the European Union, but also with the many initiatives that have been brought to life to create awareness of society. It is thanks to loud social campaigns such as **'Civil Initiatives for Environment'** the notion of sustainable development has become closer to each citizen. The aim of the priority program **'Ecological Education'** was to improve the environment by solving local problems related to the environment, involving the local community in the promotion of sustainable development, the creation of local partnerships and civil management enhancements for environmentally friendly behaviour. A very important element turned out to be involving the local community in initiatives related to sustainable development - it is easy to see that eco-innovation is nothing terrible and distant. A good practice is to inform about the various forms of financing, and joint decision-making, for example, the disposition of funds in gminas (local communities).

In Ukraine nature study schools work regularly on the basis of regional centres of young naturalists as components of the out-of-school system, where classes are conducted closely to nature. Nature study schools are also an instrument of engaging adults in solving ecological problems, taking into consideration that knowledge about nature and green energy is passed from children to parents.

In Lviv National Museum of Natural History (National Academy of Sciences of Ukraine) operates an interactive exhibition entitled 'Dynamic museum'. According to experts, most parents avoid visiting museums with their children under seven because they find it quite boring. This fact has encouraged the museum staff to organize activities raising questions for children and make their stay in the museum interesting and cognitive.

In Ivano-Frankivsk region, an alternative regular nature study school is to be opened within the Vyhoda Narrow Gauge Railway Heritage Centre in the village of Vyhoda of Dolyna district, established within the projects 'Carpathian Heritage Railways' and 'Nature School and Interpretative Exposition for Vyhoda Narrow Gauge Railway Heritage Centre'. The school will be based on the interactive exposition of the Carpathian nature. The project 'Carpathian Heritage Railways' is implemented by the Tourist Association of Ivano-Frankivsk region in partnership with Ivano-Frankivsk Regional State Administration and Vyhoda Village Council (Ukraine), as well as with the Maramureş Mountain National Park (Romania) and is co-financed by the EU within the Hungary-Slovakia-Romania-Ukraine ENPI Cross-Border Cooperation Programme, 2007-2013. The nature school initiative is supported by the Cooperation Fund of the Embassy of Finland in Ukraine.

Fairs, forums and exhibitions

An Ecological Fair is a good opportunity to exchange experiences and expand knowledge on innovations in the field of environmental protection. The newly established companies at such events can promote their initiatives, find employees or attract investors. Throughout Poland, each year a plenty of environmental fairs are organized.

One of the largest event is the International Trade Fair for Environmental Protection POLEKO in Poznań ('Pol-Eco-System' starting from 2015). International Trade Fair POLEKO is the most prestigious fair in the country devoted to environmental protection, and renewable energy sources, ecological innovations, ecology and municipal economy.

The Fair facilitates the effective promotion of new products, secures platform for meetings, interesting conferences and debates. Participants can directly communicate with the representatives and executives of various companies, state institutions or foundations.

In September 2015 the 5th International Trade Fair and Conferences for Renewable Energy and Energy Efficiency 'RENEXPO' will take place in Warsaw. It is not only one of the biggest and most important energy-related event in the country, but also a platform for exchanging knowledge and technology. This year it will be dedicated to the problems of renewable energy and de-centralised energy production, innovation and energy efficiency, smart distribution and energy networks and energy management.

On 17-19 November 2015 the city of Lublin will welcome the trade fair for energy 'Energetics'. Among other things, it will promote technologies associated with renewable energy sources. The fair will present systems of energy saving resources, and energy producing technologies from renewable sources, and will promote companies, which deal with wind energy, hydropower, solar, geothermal, and biomass energy. The fair also will provide opportunity to exchange the experience and gain knowledge from the professionals in RES sector. 'Energetics' is one of the most important event in Poland for the energy industry, targeted on the representatives of small and medium-sized enterprises as well as large energy companies.

In Ukraine International Trade Fair 'Energy Efficiency. Renewable Energy' has been held for seven years in a row. The VI International Investment Business Forum on Energy Efficiency and Renewable Energy and the VII International Trade Fair 'Energy Efficiency. Renewable Energy – 2014' took place in Kiev. The event was organised by the State Agency on Energy Efficiency and Energy Saving of Ukraine. Its main aim was to familiarize the audience with the best samples of energy saving equipment, materials for production and everyday usage, technologies of alternative fuels and RES, etc. In general, 305 companies (69 from energy efficiency and RES sector) from 19 countries demonstrated their achievements. The event programme covered issues related to energy deficit, prospects for further wind energy development, the European experience in energy efficiency in industry sector, etc.

The VIII International Trade Fair 'Energy Efficiency. Renewable Energy – 2015' will be held in Kiev on 10-13 November 2015 in the biggest International Exhibition Centre of Ukraine.

Useful Resources

Below we provide links to Internet resources concerning the renewable energy sources and energy efficiency well worth visiting. Information from these websites was carefully studied and partially used in the process of preparing of this publication.

Internet resources for users in Poland:

Polish Sejm (Polish Assembly) www.sejm.gov.pl
Ministry of Economy www.mg.gov.pl
Energy Regulatory Office www.ure.gov.pl
Polish Power Exchange www.tge.pl
Polish Power Grids www.pse.pl
Central Statistical Office of Poland www.stat.gov.pl
Lublin Voivodeship www.lubelskie.pl
'Lublin Voivodeship – Profit from Nature' www.oze.lubelskie.pl
Lublin Region Development Fund www.fundacja.lublin.pl
Eastern Cluster of ICT (Information and Communication Technologies) www.ecict.eu
German-Polish Fund 'New Energy' www.nowa-energia.org
IOZE – potential is hidden in nature www.ioze.pl
Institute for Renewable Energy www.ieo.pl
Association for Renewable Energy www.seo.org.pl
European Small Hydropower Association www.esha.be
Association for Small Hydropower Stations Development www.trmew.pl
Polish Association for Wind Energy www.psew.pl
Centre of Information about Energy Market www.cire.pl
Economic portal www.wnp.pl
Information portal 'High Voltage' www.wysokienapiecie.pl
Green energy www.graMBzielone.pl
Energy saving construction www.termodom.pl
Agroenergetyka www.agroenergetyka.pl
GLOBEnergia www.globenergia.pl
Educational portal 'Green Energy' www.zielonaenergia.eco.pl
RESTOR project www.restor-hydro.eu/en
European Commission, Programme 'Horizon 2020' www.ec.europa.eu/programmes/horizon2020
European funds website www.funduszeuropejskie.gov.pl

Internet resources for users in Ukraine:

European Bank for Reconstruction and Development www.ebrd.com/ukraine

World Bank www.worldbank.org/uk/country/ukraine

GLZ (Ukraine) www.giz.de

Convent of Mayors www.uhodameriv.eu, www.covenantofmayors.eu/

UNDP 'Transforming the Market for Efficient Lighting' www.lampochki.org.ua

Cross-Border Cooperation Programme ENPI 'Poland-Belarus-Ukraine 2007-2013' www.pl-by-ua.eu/ua

Cross-Border Cooperation Programme ENPI 'Hungary-Slovakia-Romania-Ukraine' www.huskroua-cbc.net/ua

State Agency on Energy Efficiency and Energy Saving of Ukraine www.sae.gov.ua

National Institute for Strategic Studies of Ukraine www.niss.gov.ua/articles/1440

Ivano-Frankivsk Regional Centre for Investments and Development www.investin.if.ua/uk

Specialised resource about alternative energy in Ukraine and energy efficient construction technologies www.ecotown.com.ua

Specialised portal about solar energy www.siriusone.net/index.php

Ukrainian Association of Renewable Energy, a library of specialised editions in the sphere of energy efficiency and RES www.uare.com.ua

Information about competitions and grants for non-governmental organisations 'Gurt' www.gurt.org.ua

Information about competitions and grants for non-governmental organisations 'Hromadskyi Prostir' ('Public Space') www.civicua.org

Fund 'National Endowment for Democracy' www.ned.org

Energy efficiency in the housing sector 'Warm House' www.teplydim.com.ua/uk/about

Renewable Energy Fostering with Green Tariff in Ukraine. Investors handbook (2013) www.ifc.org/wps/wcm

Research work: Improvement of Energy Efficiency in Ukraine: Reduction in Regulation and Energy Saving Stimulation. Institute for Economic Research and Policy Consulting (Kiev), German Consulting Group (Berlin) www.beratergruppe-ukraine.de/download/Beraterpapiere/2012/PP_01_2012_ukr.pdf

Centre for Alternative and Renewable Energy Sources (project 'Bioenergy of the Carpathians') www.aesd.org.ua

Magazine of blogs for ecological solutions in everyday life and in the housing sector www.rodovid.me

Lviv National Museum of Natural History www.smnh.org/ua







Youth Cross-Border Cooperation Network for Environmental Safety & Energy Efficiency

The Youth Cross-Border Cooperation Network for Environmental Safety & Energy Efficiency united students and young scientists of seven leading higher educational institutions from Ivano-Frankivsk Region of Ukraine and Lublin Voivodeship of Poland: Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk National Medical University, Catholic University of Lublin, Maria Skłodowska-Curie University, University of Life Sciences in Lublin and Lublin University of Technology.

The Network is an informal structure, which unites Ukrainian and Polish students and young scientists under a common umbrella. Being a product of the project 'Student with Initiative: Vector of Energy Saving', the Network was established by the NGO 'Agency for Private Initiative Development', Executive Committee of Ivano-Frankivsk City Council and Department of Non-Investment Projects of Gmina Lublin. After the project completion the Network activities will be administrated in Ukraine by the Agency for Private Initiative Development and in Poland by the German-Polish Foundation 'New Energy' in pursuance of the memorandum between the Gmina Lublin and the Foundation 'New Energy' from Poland and the Department of Economic and Integration Development of Executive Committee of Ivano-Frankivsk City Council and the Agency for Private Initiative Development from Ukraine.

As of June 2015, the Network includes over 50 students from Ukraine and Poland interested in the joint development and implementation of innovative projects in the field of energy efficiency and renewable energy sources. New teams of students are welcome to join the Network and participate in professional debates on energy efficiency and renewable energy sources, partnership projects and other interesting activities as well as use Network's services.

The Network web platform www.energyouth.org, launched by the project, links the active and talented young people with the relevant university study and research programmes in the spheres related to alternative energy, energy saving, and biotechnology. By joining the Network, the young professionals can present themselves through the web platform for potential employers looking for educated staff and thus be able to increase the efficiency of 'selling' their ideas or ready projects to the relevant institutions. In its turn, the platform contains a database of companies from target regions open for cooperation in the field of energy efficient innovations, environment studies and renewable energy. The web platform also serves to generate and accumulate ideas of innovative projects for potential donors or investors.



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