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FACULTY OF ENVIRONMENTAL SAFETY,
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DEPARTMENT OF ENVIRONMENTAL SCIENCE

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BACHELOR THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 "ECOLOGY",

EDUCATIONAL AND PROFESSIONAL PROGRAM:

"ECOLOGY AND ENVIRONMENT PROTECTION"

Theme: « Estimation of the use of renewable energy sources in Kyiv region »

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KYIV-2022

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_____ Тамара ДУДАР
«_____» _____ 2022 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ «БАКАЛАВР»

ЗА ОСВІТНЬО-ПРОФЕСІЙНОЮ ПРОГРАМОЮ 101 «ЕКОЛОГІЯ, ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА»

Тема: «Оцінка використання відновлюваних джерел енергії у Київській області»

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КИЇВ-2022

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BACHELOR THESIS ASSIGNMENT

Bogdan Kaminskyi

1. Theme: «Estimation of the use of renewable energy sources in Kyiv region» approved by the Rector on April 18, 2022, №388/ст.

2. Duration of work: from 27.05.2022 to 13.06.2022.

3. Output work: open data of renewable energy sources usage; wind speed (2.5 m/s) for calculation wind generator for private house in Kyiv region.

4. Content of explanatory note: the use of renewable energy in the European, American and Asian continents is analyzed; the use of alternative energy in Ukraine is assessed; the state and dynamics of development of renewable energy sources in Kyiv region are analyzed in detail; the expediency of using wind energy for private households has been determined; wind generator parameters are calculated and practical recommendations are given.

5. The list of mandatory graphic (illustrated materials): tables, figures, diagrams.

6. Schedule of thesis fulfillment

№ з/п	Task	Term	Advisor's signature
1	Receive themes task, search the literature and legislation	27.05.2022	
2	Preparing the main part (Chapter I)	29.05.2022	
3	Preparing the main part (Chapter II)	01.06.2022	
4	Preparing the main part (Chapter III)	03.06.2022	
5	Formulating conclusions and recommendations of the thesis	06.06.2022	
6	Making an explanatory note to the previous presentation of the department, consultation with the norms controller	07.06.2022	
7	Presentation of the work at the department	07.06.2022	
8	Taking into account the comments and recommendations and training to protect	13.06.2022	
9	Thesis defense at the department	14.06.2022	

7. Date of task issue: «27» May 2022

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«____» _____ 2022 р.

ЗАВДАННЯ
на виконання дипломної роботи
Камінського Богдана Олеговича

1. Тема роботи «Оцінка використання відновлюваних джерел енергії у Київській області» затверджена наказом ректора від «18» квітня 2022 р. №388/ст.
2. Термін виконання роботи: з 27.05.2022 р. по 13.06.2022 р.
3. Вихідні дані роботи: відкриті дані використання відновлюваних джерел енергії; швидкість вітру (2,5 м/с) для розрахунку вітрогенератора для приватного будинку в Київській області.
4. Зміст пояснювальної записки: проаналізовано використання відновлювальної енергетики у Європейському, Американському та Азіатському континентах; оцінено використання альтернативної енергетики в Україні; детально проаналізовано стан та динаміку розвитку відновлювальних джерел енергії у Київській області; визначено доцільність використання вітрової енергетики для приватних домоволодінь; розраховано параметри вітрогенератора та надано практичні рекомендації.
5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, рисунки, діаграми.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Отримання теми завдання, пошук літературних джерел та законодавчої бази	27.05.2022	
2	Підготовка основної частини (Розділ І)	29.05.2022	
3	Підготовка основної частини (Розділ ІІ)	01.06.2022	
4	Підготовка основної частини (Розділ ІІІ)	03.06.2022	
5	Формулювання висновків та рекомендацій дипломної роботи	06.06.2022	
6	Оформлення пояснювальної записки до попереднього представлення на кафедрі, консультація з нормоконтролером	07.06.2022	
7	Представлення роботи на кафедрі	07.06.2022	
8	Урахування зауважень, рекомендацій та підготовка до захисту	13.06.2022	
9	Захист роботи на кафедрі	14.06.2022	

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ABSTRACT

Explanatory note to thesis: «Estimation of the use of renewable energy sources in Kyiv region»: 48 pages, 8 figures, 5tables, 23references.

Object of research – assessment of renewable energy usage.

Subject – wind generator for private household in Kyiv region.

Aim of work – to assess the renewable energy sources in Kyiv region.

Methods of research: analysis, data comparison, statistical data processing, observation.

We made an assessment of the RES of the Kyiv region, calculated the windmill for a private house.

RENEWABLE ENERGY SOURCES, KYIV REGION, WIND GENERATOR, ENVIRONMENTAL SAFETY

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INTRODUCTION

Relevance of the work. Renewable energy is an important energy sector, whose role all over the world year after year more and more is growing. Traditional energy sources gradually are depleted, and non-traditional - natural sources become relevant and at the expense of modern technology achievements are widely available. In most countries of the world development of renewable energy supported at the level of public policy that aims to reduce production and consumption in traditional economic sectors fuel and energy resources and, in accordance with this, to increase the level of state energy security.

Current challenges, such as the threat of global warming, exhaustion fossil fuels and others are forcing countries around the world to significantly change the structure energy sector. Currently, there are two main trends – replacement of traditional energy sources with renewable energy sources (RES) and reduction of total energy consumption due to implementation energy efficient technologies and measures. More and more countries are developing and implement plans and strategies for significant, within 50-100%, coverage their energy needs through renewable energy sources.

The attractiveness and relevance of the use of renewable energy sources is due not only to large reserves of renewable energy sources, but also to a number of other reasons (inexhaustibility of reserves due to constant renewables, relative ease of conversion and environmental friendliness). This area is becoming especially acute in Ukraine, which is characterized by limited energy reserves.

In such conditions, the use of non-traditional and renewable energy sources (solar energy, biomass, heat of the earth, wind and other species) becomes especially important. They will significantly replenish the energy balance, both of individual regions and the state as a whole. Thus, it is necessary to create a fundamentally new system of energy supply, which allows economic facilities to gain significant energy independence of their development.

Aim and tasks of the diploma work

Aim of the work- Estimation of the use of renewable energy sources in Kyiv region

Tasks of the work:

1. To study the Ukrainian experience of using alternative energy.
2. To analyze the current state and prospects of RES development.
3. Calculate a wind turbine to provide electricity to a small private house in the Kiev region.
4. To give practical recommendations on the use of renewable energy sources by the population.

The purpose to assess the renewable energy sources in Kyiv region.

The object is renewable energy usage.

The subject is to calculate the wind generator for private household in Kyiv region.

Objectives of the study:

1. To analyze the renewable energy sector development in the World.

2. To assess the current state and prospects of renewable energy strategies in Ukraine, in particular in Kyiv region.

3. To calculate wind power turbine to provide electricity for private house.

4. To give practical recommendations of renewable sources usage by population.

Methods of research: analysis, data comparison, statistical data processing, observation.

In our thesis, we assessed the RES of the Kyiv region, and calculated the windmill for a private building.

CHAPTER 1 ANALYSIS OF ENERGY STRATEGIES IN THE WORLD. RENEWABLE ENERGY SECTOR DEVELOPMENT

1.1 Types of renewable energy sources (RES): the future of energy

Renewable energy is energy that has been derived from earth's natural resources that are not finite or exhaustible, such as wind and sunlight. Renewable energy is an alternative to the traditional energy that relies on fossil fuels, and it tends to be much less harmful to the environment. In the table 1.1 types of renewable energy sources are presented [1].

Table 1.1

Types of renewable energy sources

Types	Benefits	Current Limitations
Solar	One of the benefits of solar energy is that sunlight is functionally endless. With the technology to harvest it, there is a limitless supply of solar energy, meaning it could render fossil fuels obsolete. Relying on solar energy rather than fossil fuels also helps us improve public health and environmental conditions. In the long term, solar energy could also eliminate energy costs, and in the short term, reduce your energy bills. Many federal local, state, and federal governments also incentivize the investment in solar energy by providing rebates or tax credits.	Although solar energy will save you money in the long run, it tends to be a significant upfront cost and is an unrealistic expense for most households. For personal homes, homeowners also need to have the ample sunlight and space to arrange their solar panels, which limits who can realistically adopt this technology at the individual level.
Wind	Wind energy is a clean energy source, which means that it doesn't pollute the air like other forms of energy. Wind energy doesn't produce carbon dioxide, or release any harmful products that can cause environmental degradation or negatively affect human health like smog, acid rain, or other heat-trapping gases. Investment in wind energy technology can also open up new avenues for jobs and job training, as the turbines on farms need to be serviced and maintained to	Since wind farms tend to be built in rural or remote areas, they are usually far from bustling cities where the electricity is needed most. Wind energy must be transported via transition lines, leading to higher costs. Although wind turbines produce very little pollution, some cities oppose them since they dominate

	keep running.	skylines and generate noise. Wind turbines also threaten local wildlife like birds, which are sometimes killed by striking the arms of the turbine while flying.
Hydroelectric	Hydroelectric power is very versatile and can be generated using both large scale projects, and small scale projects like underwater turbines and lower dams on small rivers and streams. Hydroelectric power does not generate pollution, and therefore is a much more environmentally-friendly energy option for our environment.	Hydroelectricity facilities use more energy than they are able to produce for consumption. The storage systems may need to use fossil fuel to pump water. Although hydroelectric power does not pollute the air, it disrupts waterways and negatively affects the animals that live in them, changing water levels, currents, and migration paths for many fish and other freshwater ecosystems.
Geothermal	Geothermal energy is not as common as other types of renewable energy sources, but it has a significant potential for energy supply. Since it can be built underground, it leaves very little footprint on land. Geothermal energy is naturally replenished and therefore does not run a risk of depleting (on a human timescale).	Cost plays a major factor when it comes to disadvantages of geothermal energy. Not only is it costly to build the infrastructure, but another major concern is its vulnerability to earthquakes in certain regions of the world.
Ocean	Unlike other forms of renewable energy, wave energy is predictable and it's easy to estimate the amount of energy that will be produced. Instead of relying on varying factors, such as sun and wind, wave energy is much more consistent. This type of renewable energy is also abundant, the most populated cities tend to be near oceans and harbors, making it easier to harness this energy for the local population. The potential of wave energy is an astounding as yet untapped energy resource.	Those who live near the ocean definitely benefit from wave energy, but those who live in landlocked states won't have ready access to this energy. Another disadvantage to ocean energy is that it can disturb the ocean's many delicate ecosystems. Although it is a very clean source of energy, large machinery needs to be built nearby to help capture this form energy, which can cause disruptions to the ocean floor and the sea life that habitats it. Another factor to consider is weather, when rough weather occurs it changes the consistency of the waves, thus producing lower energy output when compared to normal waves without stormy weather.

Hydrogen	Hydrogen can be used as a clean burning fuel, which leads to less pollution and a cleaner environment. It can also be used for fuel cells which are similar to batteries and can be used for powering an electric motor.	Since hydrogen needs energy to be produced, it is inefficient when it comes to preventing pollution.
Biomass	The use of biomass in energy production creates carbon dioxide that is put into the air, but the regeneration of plants consumes the same amount of carbon dioxide, which is said to create a balanced atmosphere. Biomass can be used in a number of different ways in our daily lives, not only for personal use, but businesses as well. This energy came from wood, biofuels like ethanol, and energy generated from methane captured from landfills or by burning municipal waste.	Although new plants need carbon dioxide to grow, plants take time to grow. We also don't yet have widespread technology that can use biomass in lieu of fossil fuels.

So:

– *solar heat energy* – uses a renewable energy source and in the future may become environmentally friendly, ie one that does not produce hazardous waste. Solar heating systems are classified as follows :

- "Active" solar heat supply systems using "active" installations based on solar collectors with coolant circulation, which can be liquid (water, salt solutions) and gas (air);
- "Passive" solar heating systems, in which various structural elements of buildings are used as heat sinks;
- Mixed solar heating systems, which use elements of "passive" and "active" solar heating.

– *wind energy* – the use of wind energy is one of the oldest known ways to use energy from the environment, and has been known since ancient times. To make the best use of wind energy, it is important to have a good understanding of daily and seasonal wind changes, changes in wind speed depending on altitude, the number of gusts of wind in a short period of time, and statistics for at least the last 20 years. Wind energy has been used by mankind for a long time. One of the first inventions of the use of wind was the sail

somewhere in the fifth millennium BC. In the first century BC, the ancient Greek scientist Heron of Alexandria invented the windmill that controlled the organ.

Windmills for grain processing were invented in the Middle Ages. It is believed that the first windmills were built in Sistan, somewhere between modern-day Iran and Afghanistan, between the ninth and seventh centuries BC. They had a vertical axis, from six to twelve wings made of canvas or reed, and were used as mills and water pumps [2].

– *hydropower* – a branch of renewable energy to convert the kinetic energy of water into electricity. The most environmentally friendly source of energy, the use of which can reduce greenhouse gas emissions. Hydropower plants are the most maneuverable capacities, which are able, if necessary, to significantly increase production volumes in minutes, covering the peak part of the load schedule, as well as to ensure the reliability of energy supply in emergency situations.

– *geothermal energy* – a constant flow of heat from the hot bowels, directed to the Earth's surface. There are five main types of geothermal energy:

- normal surface heat of the Earth at a depth of several tens to hundreds of meters;
- hydrothermal systems, ie hot or warm water tanks, in most cases self-draining;
- steam-hydrothermal systems - deposits of steam and self-filling steam-water mixture;
- petrogeothermal zones or heat of dry rocks;
- magma (molten rocks heated to 1300 °C).

– *biofuels, bioenergy* – one of the oldest sources of energy, but its use until recently was reduced to direct combustion over an open fire or in furnaces and furnaces with relatively low efficiency. Biomass means organic substances that are formed in plants as a result of photosynthesis and can be used for energy, including all types of vegetation, vegetable waste from agriculture, woodworking and other industries, household waste.

The most common technologies for the use of biomass in bioenergy are :

- physical method - direct combustion;
- chemical methods - pyrolysis, gasification, production of alcohols and oils for motor fuel;
- microbiological method - anaerobic fermentation with the formation of methane.

A significant resource for renewable energy is the use of chemical energy from biomass. The advantage of biomass is that it can be directly converted into fuel for cars and other vehicles. Biomass can be grown directly for energy production, then it is called third-generation biomass, or biomass waste can be used for other purposes, then it is called second-generation biomass. Biofuels that can be used in vehicles are made from oil, animal fats and fatty wastes. In 2011, it provided 2.7% of fuel consumption by transport [3]. Global indicators of renewable energy in the World for the last 6 years are presented in the Table 1.2.

Table 1.2

Global indicators of renewable energy in the World for the last 6 years [1]

Global indicators of renewable energy	2014	2015	2016	2017	2018	2019	2020
Investment in new capacity (per year), billion US dollars	270	285	241	280	305	302	303.5
Total installed capacity of renewable energy, GW el.	1.712	1.849	2.017	2.195	2.376	2.588	2.839
Total installed capacity of hydropower, GW el.	1.055	1.064	1.096	1.114	1.132	1.150	1.170
Total installed capacity of wind energy, GW el.	370	433	487	539	591	651	743
Total installed capacity of solar power grid facilities (photovoltaics), GW el.	177	227	303	402	505	627	760
Total installed capacity of helioconcentration facilities (CSP), GW							6.2
Total installed capacity of solar water heating facilities, GW heat.	406	435	456	472	480		501
Total installed capacity of geothermal energy facilities, GW							14.1
Ethanol production (per year), billion liters	94	98	98.6	106	112	115	105
FAME + HVO biodiesel production (per year), billion liters	29.7	30	30.8	31	34	47.5	46.5
Number of countries with defined renewable energy targets	164	173	176	179	169	172	165

End of table 1.2

1.2 Evaluation of RES in Europe

In 2003, Stockholm accelerated the transition to renewables by introducing a unique system of quotas and "green certificates". Owners of more than 2,000 hydropower plants in Sweden, as well as wind and solar power plants, receive a certificate for each megawatt-hour of renewable electricity they produce. They can sell these certificates on the open market to suppliers and large consumers of electricity, each of which the state sets a quota - the number of certificates required to be presented. Companies that do not meet the quota are forced to pay fines to the state in the amount of 150% of the average market value of those certificates that are missing.

The Swedish government began converting vehicles from petrol and diesel to biofuels in November 2005 by issuing a "Refueling Decree" requiring each gas station to have at least one biofuel column. All companies that supply, import and produce petroleum products have been subject to energy and environmental taxes. Biofuels were exempted from these taxes. Every year more and more biofuels must be mixed with petroleum products. Now its share should be at least 2.6% in gasoline and at least 19.3% in diesel.

With the mechanisms of quotas and tax pressure, Sweden will soon be able to displace coal and gas from its energy sector. In the long run, Stockholm plans to abandon oil. In 2016, Stockholm announced an ambitious goal: to create 100% renewable energy no later than 2040. And by 2045, Sweden plans to become the first carbon-neutral industrial state to achieve a zero balance of carbon emissions.

The "forest nation" of Finland was unlucky with minerals. The country is forced to import oil, gas and coal for its needs, and soaring prices for these goods are hurting its economy, which needs a lot of energy to supply large-scale industrial production and heat homes during the long cold winters.

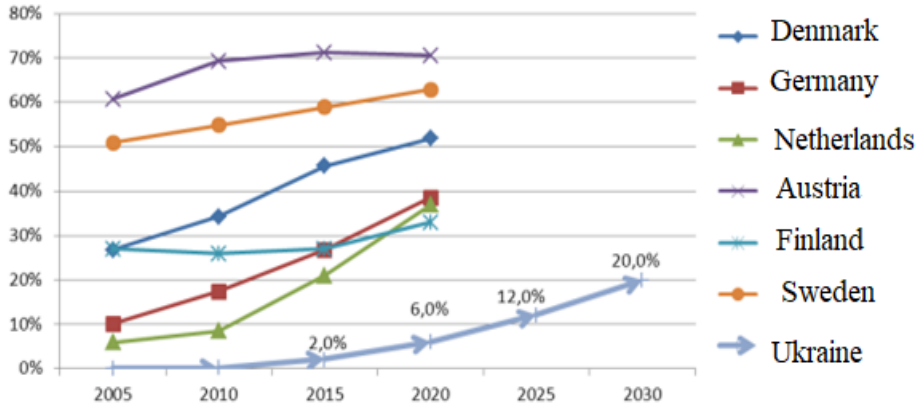


Fig1.1. Renewable energy sources development in Europe, 2005-2030 [4]

Finland supports "green" tariffs and reduced by 50% taxes on greenhouse gas emissions from renewable energy producers of many types, including wind, sun and waves. But for biogas and wood biomass, among other things, there is a particularly powerful incentive - "thermal bonuses". The owners of owners of combined energy systems that

generate both electricity and heat from "forest fuel", the government pays 50 euros for each megawatt-hour of energy produced from biogas and 20 euros for each megawatt-hour of energy from wood fuel. Finland's heat and power systems are steadily increasing wood consumption by 4% per year, not only by obtaining it from Finnish forests, but also by increasing imports from Russia. Currently, the share of "forest fuel" in Finland's total energy consumption is 27%, and the potential for growth in this sector is still great. It is seen in the more intensive cultivation and harvesting of forest raw materials, as well as in the further improvement of energy production technologies from wood. The declared goals of Finland are very ambitious. The country has announced plans to reduce greenhouse gas emissions fivefold by 2050 from 1990 levels, pledged to phase out the use of coal for energy production by 2030, increase the share of renewable energy in total consumption to more than 50% in the 2020s, and increase the share of biofuels in road transport from 18% in 2021 to 30% in 2030, while reducing the consumption of petroleum products by 50%.

Wind energy was chosen as a national priority, for the launch of which in the second half of the 1980s Denmark placed a state order for the purchase of wind turbines, financed research and development, and subsidized construction. At one time, the government reimbursed companies 30% of the cost of wind turbines, later reducing these payments to 20 and 10%.

Since 1992, Denmark has been implementing more progressive support mechanisms. It has imposed a carbon tax on consumers of fossil fuels, which is now $ 31 per tonne of CO_2. And in 1993 it introduced a "green" tariff, which made wind power production competitive. Denmark guarantees windmill owners a surcharge of 0.25 Danish kroner (about UAH 1) for each kilowatt of energy produced over a ten-year period from the start of generation.

The wind energy industry in Denmark has received widespread support. By 1996, tens of thousands of Danish families had joined 2,100 cooperatives to buy large and expensive wind turbines. The main stimulus for further promotion of private wind energy was the clean metering system launched in 1998. It has enabled individual households with

small wind turbines to connect to the general grid and receive payment for the electricity supplied to the grid.

In 2017, Denmark broke its own world record - its wind farms covered 43% of all electricity needs. The government expects to increase this share to 50% by 2020, and over the next 15 years (until 2035) plans to completely switch to renewable sources in electricity and heat production. Denmark intends to ban the burning of coal and petroleum products at power and heating plants no later than 2030, leaving only gas permitted from fossil fuels. In most developed countries, significant progress has been made in the construction and use of wind turbines in recent years in the context of state incentives for the production of electricity based on renewable energy sources.

Wind energy is being actively developed in developing countries - India, China, Brazil, Egypt and others.

Further reduction of the cost and efficiency of wind farms are achieved by increasing the capacity of wind turbines and wind farms, increasing the technical and economic indicators of wind farms in the implementation of new scientific and technical solutions.

In the world, the average annual increase in wind power capacity has approached 30%.

1.3 Estimation of RES in America

The share of renewable energy sources in the structure of electricity production in the United States will grow to 42% by 2050 compared to 21% in 2020, according to the annual energy forecast of the US Department of Energy (EIA). Much of this growth will be provided by the development of wind and solar energy. According to EIA estimates, by 2050 the sun will account for 47% of all renewable energy capacity in the country, 34% - for wind. At the same time, the share of natural gas in the structure of electricity production will remain relatively unchanged at 36%, and the share of coal and nuclear energy will fall by about half. "Stimulating the use of renewable energy sources and reducing the cost of

technology create strong competition for natural gas, while coal and nuclear energy will reduce their share in the energy balance," the EIA report said. The agency notes "increased levels of uncertainty due to the continuing effects of COVID-19." According to the EIA forecast, total energy consumption in the United States will return to the level of 2019 no earlier than 2025. "The energy sector needs time to adjust to the new reality," said Stephen Nellie, acting EIA administrator.

Regional policy to support RES at the state level is key to the development of alternative energy sources in the United States. Much of the electricity generation and supply activities are coordinated at this level. States, counties, and cities develop and implement most renewable energy initiatives. The leaders in this are California and Colorado, where the influence of regional energy commissions is quite significant, and their location provides certain benefits for the development of renewable energy. The United States is among the leaders in the ranking of countries developing renewable energy production (RES).

Fig.1.2. You can see the schedule of renewable energy in the United States. Total investment in this area increased from 6 to 50 billion dollars.

The main instruments for supporting renewable energy in the United States are financial and investment. Total investment in this area increased from $ 6 billion in 2004 to $ 50 billion. $ in 2011. In 2018, this figure was estimated at $ 46.5 billion.

The United States became the first country in the world to acquire almost all the hallmarks of an energy self-sufficient country when new technologies pushed its oil market to world leadership. Over the past 10 years, US import dependence has fallen by 60% to date they are the largest exporter of refined petroleum products, and in 2016-2017 became a net exporter of natural gas25. Research institute Brookings argues that the growth of crude oil exports will have a positive impact on both the US and global markets. Provided that the ban on oil exports will be removed, GDP will grow by almost $ 600 million. USA. However, European partners cannot rely solely on their supplies, because American companies need to negotiate prices with OPEC26.

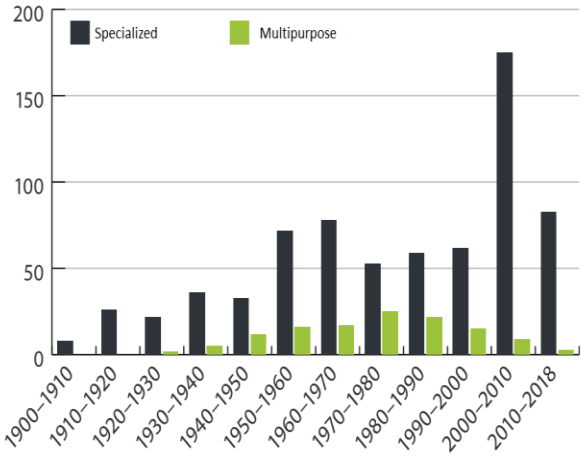
The main goal of increasing energy independence is to reduce the sensitivity to changes in supply and prices, as well as gaining opportunities achieving their geopolitical goals. The decline of the coal industry associated with many factors of economic, social, political and environmental nature. Its main reason is the replacement of relatively cheap shale gas and RES. BNEF analysts say that The changes that took place in 2015 are not accidental, but rather evidence of structural developments in the energy sector. Thus, there is a gradual "decarbonization" of the US energy sector27.

1.4 Estimation of RES use in Asia

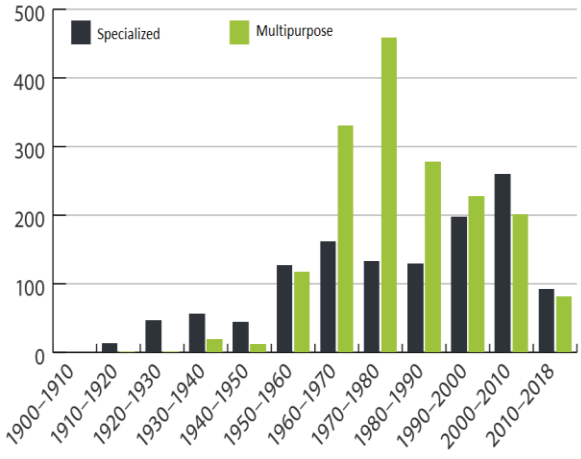
The project in the Malaysian state of Sarawak is a great example of the fact that hydropower not only provides affordable renewable energy. Waterways, including more than 55 navigable rivers with a total length of more than 3,300 km, serve as vital arteries in Sarawak. In some places, these rivers form a single transport route. In addition, these rivers provide Sarawak with renewable energy.

According to the International Hydropower Association's (IHA) Hydropower Report 2019, Richard Taylor, CEO, and President Ken Adams said that governments are increasingly providing advantage of hydropower. Hydropower is developing most actively in the East Asia, the Pacific and South America, increasing its hydropower capacity compared to last year. Overall, Asia alone accounted for 42% (543 GW) of the world's total installed capacity (1,295 GW) last year. Today, Asia is rapidly developing hydropower. China, with 352 GW of installed capacity in 2018, is a world leader in hydropower, well ahead of Brazil and the United States, which have just over 100 GW of installed capacity. Other Asian countries, such as Japan, India and Vietnam, also hold key positions in the world in terms of hydropower capacity. It is in Asia that the world's largest hydroelectric plant, the Three Gorges Dam, spans the middle reaches of the Yangtze River in Yichang, China's Hubei Province. This plant produces from 90 to 100 TWh per year: this energy is enough to power 80 million households. In total, the capacity of this hydroelectric plant exceeds the total capacity of Pakistan and Vietnam, the fourth and fifth largest generators in Asia. Vietnam is the leader in Southeast Asia, increasing its capacity from 16 GW to 44 GW from 2000 to 2016. Poor Laos, neighboring Vietnam, has a theoretical capacity of 18,000 MW and intends to double it by increasing the number of hydropower plants to 46 by next year. Hydropower is a real find for Asia and the Pacific, home to more than 4.4 billion people and accounting for more than half of the world's energy consumption. Although industrialization and urbanization are growing rapidly, more than 10% of the population in this area still does not have access to electricity - a clear obstacle to the region's ability to improve the incomes and quality of life of its inhabitants.

In the regions of East Asia and the Pacific Islands, where 30% of the world's population lives, there has been a significant increase in demand for electricity in recent years. In particular, since 2000, electricity consumption there has been growing by 6% annually, which is twice the world average demand. In this chart you can see the growing number of specialized and multi-purpose hydropower plants in South America and Asia (Fig. 1.3). The scale from 0-500 is the hydraulic units that were put into operation.



Growing number of specialized and multi-purpose hydropower plants in South America (IGA / ICOLD)



Growing number of specialized and multi-purpose hydropower plants in Asia (IGA / ICOLD)

Fig. 1.3. Specialized and multi-purpose hydropower plants in South America and Asia

1.5 Projects to achieve 100% renewable energy consumption

Today, renewable energy sources provide about 19% of final energy consumption in the world, including traditional biomass - 9%, modern RES - more than 10% (heat and electricity production, transport sector). In general, biomass (traditional and modern) covers about 14% of final energy consumption. The term "traditional biomass" means the direct use of biomass for cooking and heating in developing countries. The term "modern RES / biomass" refers to the use of RES / biomass in modern energy production technologies.

The International Renewable Energy Agency has developed the Road map to achieve doubling the share of renewable energy in global energy consumption in the period 2010-2030 (Remap 2030): from 18% of RES in the total final energy consumption (2010) up to 36% (2030). At this modern renewable energy sources should gradually displace use of traditional biomass. Because in 2010 half of the 18% of RES accounted for traditional biomass, in 2030 the share of modern RES has more than triple (up to 30%), leaving the traditional use of biomass only 6%. It is interesting to compare the Roadmap REmap 2030

with the forecast of the World Energy Council, which developed two scenarios for the development of world energy before 2050 Scenario 1 assumes a rather slow development of renewable energy - 20% of total primary energy supply (TPE) in 2050, and quite significant increase in ZPPE compared to 2010 - by 38% (from 546 EJ / year in 2010 to 879 EJ / year in 2050). This scenario seems unrealistic, as its RES target has already been achieved. Scenario 2 is more realistic. It envisages the predominant development of renewable energy and increasing energy efficiency.

Today there are about 150 planned and already in the world implemented projects on full transition to renewable energy. They are divided into several categories: urban, regional, state, projects in housing and business. Among such projects in individual countries and cities and companies can be distinguished as follows:

• Denmark has set a goal of achieving 100% of heat production by 2035 and electricity from renewable sources and 100% of renewable energy in all sectors until 2050

• Iceland has already achieved 100% of electricity production and 85% thermal energy due to RES.

• Scotland: target - 100% of electricity production and supply 30% of total energy demand due to RES by 2020

• Maldives: target - 100% of renewable energy by 2020

• Costa Rica has been providing 100% electricity demand since the beginning of 2015 due to RES. By 2020, the goal is to achieve complete decarbonisation.

• Saudi Arabia has decided to abandon completely by 2040 use fossil fuels and replace them with renewable sources energy.

• The Government of Uruguay has made an official statement that as of December 2015. 94.5% of the country's electricity needs are met renewable sources. By 2017, it is planned to reduce carbon emissions atmosphere by 88% compared to the average of 2009-2013 achieve full decarbonisation by 2030

• Three US cities (Aspen, Burlington, Vermont) have already completely switched to renewable energy. Cities of San Francisco, Palo Alto, San Diego, Ithaca, Greensburg,

Georgetown, San Jose also aimed to move to RES and already have adopted the appropriate programs.

• Vancouver (Canada): In 2015, transition commitments were made 100% of the city with RES.

• Frankfurt (Germany): full decarbonisation of the city is planned account of RES and alternative automotive fuel until 2050

• Copenhagen (Denmark): the goal is to reach 100% of production by 2035 heat and electricity from renewable sources and 100% of energy from RES in all sectors by 2050. Full decarbonization of the city is planned by 2025. Currently, 98% of the population receives heat from solid household appliances waste and biomass.

• Munich (Germany): target - 100% of electricity from RES in residential areas fund until 2015 and for all consumers until 2025

• Malmo (Sweden): target - 100% renewable electricity by 2020

• Sydney (Australia): target - 100% of electricity, heat and cold from RES until 2030 The following joined the action of transition to renewable energy world famous brands like IKEA, Johnson & Johnson, Nike, Procter & Gamble, Starbucks, Voya Financial and Walmart, Google, Apple, Microsoft, Facebook, Virgin Group, RWE, E.ON and others. They aim to use electricity exclusively from renewable sources in all sectors of its own activities.

The EU Roadmap addresses five possible development scenarios energy (so-called decarbonisation scenarios). The basis of each of them one of the following assumptions is made as to what exactly the trend will be prevailing in the future in the energy sector of the European Union:

1. Significant increase in energy efficiency and energy saving ("scenario energy efficiency "). Due to this, the EU needs energy in 2050 to decrease by about 40% compared to the peak of 2005–2006.

2. Significant increase in the share of renewable energy sources in energy balance ("RES scenario"). As a result, the share of RES in the final energy consumption should reach 75%, and in electricity consumption - 97% 2050

3. Diversification of energy sources. In this scenario, the advantage is not provided to no source of energy, they all compete with each other on market principles. Decarbonization in this case will be achieved by implementation of an appropriate tax policy on carbon emissions. Two variations of this scenario are also considered:

4. Diversification of deferred energy sources introduction of carbon capture and storage technologies.

5. Diversification of energy sources, provided that the new nuclear the blocks will not be built, except those that are already under construction. It should be noted that the "RES scenario" is in good agreement with the forecast prospects for the development of EU energy, implemented by the European Council on RES. This forecast shows the real possibility of covering the EU's energy needs 2050 almost 100% from renewable sources, including biomass - 34%, solar energy - 26%, geothermal energy 17%, wind energy - 13%, the rest (6%) - other RES. At the same time, the final energy consumption in 2050 (1050 million tons e.) should decrease by 12% compared to 2020 (1200 million tons AD).

To achieve the goal of 2020 (20% of RES in gross final energy consumption) EU countries should not only increase capacity renewable energy, but also to reduce primary energy consumption - in the EU-28 as a whole, by about 5% by 2020 compared to 2013 (Fig. 2). To meet the 2DS climate change scenario, in 2011 the European Union once again reaffirmed its official goal of reducing greenhouse gas emissions (decarbonization) in 2050 by 80-95% compared to 1990 Because the energy sector is one of the main sources of greenhouse gas emissions gases associated with human activities, and the main reserves for reduction these emissions must be found and implemented in it. Given this, The European Commission has developed a Roadmap for Energy to 2050, which analyzed how exactly you can achieve the goals of reducing emissions greenhouse gases, while ensuring the reliability and competitiveness of energy supply systems.

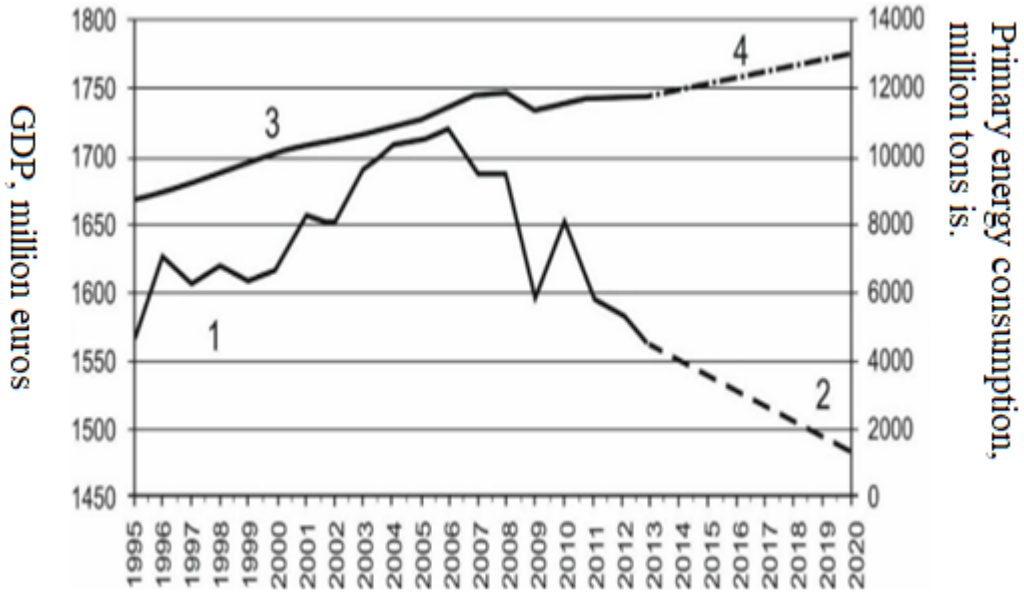


Fig. 1.4. Dynamics of primary energy consumption and GDP in the EU-28 [5]

Every year in many countries around the world the problem of providing different types of energy becomes more acute. The main reasons for this situation are the lack and exhaustion of traditional energy sources (coal, oil and natural gas). The energy problem can be solved either by rational use of available natural energy sources, ie to pursue energy and resource saving policies, or to use new non-traditional and renewable energy sources.

In this chapter we have analyzed the current state and prospects of renewable energy sources usage in the Europe, America and Asian continents. Projects to achieve 100% renewable energy consumption were proposed.

1.6 Conclusion to the chapter 1

In the first chapter, I analyzed the energy strategies in the world and the development of the renewable energy sector. What is renewable energy? This energy is derived from the Earth's natural resources, which are not finite or exhaustible, such as wind and sunlight. Renewable energy is an important energy sector, the role of which is growing every year around the world. Traditional energy sources are gradually depleted, and non-traditional - natural sources become relevant and widely available due to the achievements of modern technologies. I compared the estimates of RES of Europe, America and Asia, you can see it in the tables and graphs.

CHAPTER 2 ESTIMATION OF RENEWABLE ENERGY POTENTIAL IN UKRAINE

In the process of human development, the demand for electricity, which meets the needs of fossil fuels, then hydropower and nuclear energy, increases proportionally, leading to increasing carbon emissions and global warming. As a result, humanity is turning its attention to natural energy sources.

It should be noted that the use and development of alternative types of electricity production in Ukraine, compared to other European countries is only in its infancy and there are many problems with the ideas of practical implementation of such projects.

Given Ukraine's geopolitical position in the world, today it is more important than ever to accelerate the development of alternative energy as one of the aspects for creating conditions for Ukraine's economic development and independence [6].

2.1 Potential of renewable energy sources in Ukraine

The largest is the technical possibility of using wind and solar power plants: 321 GW and 71 GW, respectively. The economically feasible potential for the introduction of RES in Ukraine as of 2030 is estimated at 16-22 GW, compared to 1.1 GW, which is actually set at the end of 2016.

Ukraine has significant potential for renewable energy that can be used to improve trade balance, create jobs and stimulate economic activity in times when the country has overcome important economic challenges, such as increasing dependence on energy imports and the need urgently renew obsolete fixed assets in the energy sector. Development of renewable energy will also be an important contribution to achieving the set policy goals -

reducing dependence on natural gas imports and diversification of energy sources. And this energy supply is also better will ensure energy security.

The International Renewable Energy Agency's (IRENA) REmap program is a roadmap development of renewable energy for individual countries, which show how they can increase the use of renewable energy sources and, thus, will help double the share of these technologies in structure of world energy by 2030. The results show that all countries, including Ukraine, have the necessary potential to increase the share of energy from renewable sources and at the same time can receive significant socio-economic and environmental benefits (IRENA, 2014a).

The REmap 2030 document was the result of a joint effort by IRENA and local experts. In this the summary report provides detailed initial data and analysis results obtained during the work on REmap for Ukraine, as well as proposals on how to maximize the potential of renewable energy sources. In this working document, the National Renewable Energy Action Plan adopted by the Government of Ukraine, used as a basic option for the development of renewable energy for the period up to 2020 and until 2030. and extrapolates the gross final energy consumption planned for 2020 and by 2030.1 report we discuss the realistic potential of renewable energy for 2030 (the so-called Options REmap), the numbers of which are higher than in the baseline scenario. REmap options are based on trends that can be seen in data provided by the Government of Ukraine, as well as from literature sources. Costs of RES and benefits from them applications for the Ukrainian energy system are considered in the context of Ukraine's various political goals. To address the complex energy issue, Ukraine will need to take comprehensive measures, in particular, to ensure environmentally sustainable practices. Such industries are most likely to develop in the country renewable energy such as wind, solar, geothermal energy, biomass use and small hydropower. Proper structure of renewable energy will reduce a significant part of total demand Ukraine on natural gas consumed in electricity. Biogas can also be used in heat energy [7].

Ukraine has great potential to expand the use of biomass for energy purposes, mostly for heat supply. The country has huge resources of agricultural and forestry waste, which are the main raw materials for the plant production of heat and electricity from biomass. In Ukraine to the lands 42.8 million hectares, or 71% of the total territory of the country, belong to agricultural purposes. 32.5 million hectares of agricultural land are arable. Moreover, in Ukraine = one of the most fertile soils in world, the so-called "chernozem". This contributes to maintaining a fairly high productivity of rural areas farms in Ukraine, despite the low use of fertilizers. (ProMarketing Ukraine, 2013). According to the estimates of the State Agency for Energy Efficiency, the economically justified potential of bioenergy exceeds 800 PJ / year - equal to a quarter of the total energy consumption of Ukraine. Half of this potential energy supply is accounted for by the production of energy from agricultural waste and wood biomass. The other half is for energy from energy crops and biogas.

The resource potential of wood biomass in Ukraine is 4 Mt per year. Wood biomass is waste sawmills, logging (branches, tree canopy), firewood and certain technical wood, which is exported today. The composition of biomass will not change significantly in the near future. At the same time as an additional forest potential exists, there are no roads for timber transportation, which is a limiting factor development of heat and electricity production from biomass. Every year more than 10 Mt of straw remains in the fields, it is a difficult task to collect it to use. Most agricultural enterprises are not capable collect, bundle and store straw properly. Remnants of forestry are mostly found in the northern and western regions of Ukraine. For comparison, Primary agricultural waste is found in the central and eastern parts of the country. There are in the east of Ukraine opportunity to grow energy crops (Van der Hilst and co-authors, 2013). And setup on wood biomass, and installations on agricultural residues can replace capacity electricity in the eastern, northern and southern parts of the country, which have already exhausted their resources (Black and Vitek, 2011).

IRENA is preparing a study of biomass potential for the period up to 2030 for each of the countries for which it is REmap plan (IRENA, 2014). Ukraine's potential is estimated

in the range of 1115 - 1780 PJ. Upper border range is a figure that is almost twice the supply potential in 2013. For residues and waste agriculture (biogas) accounts for 53% - 58% of the above potential. On leftovers and waste forestry - about 12%. The share of energy crops and fuel wood is 19% - 31% and 0% - 15%, respectively. Ukraine expects rapid development of energy crops. In 2015 - 2020, the volume production may reach the amount of straw harvested and exceed it after 2020. It is planned cultivate energy crops on non-agricultural lands such as valleys rivers, reclaimed areas of solid waste landfills, quarries, etc. Expect that growing the most available plant resources for energy biomass production will be commercialized by 2020. Processing of organic waste into biogas, which produces heat and Electricity is projected to increase, but there is no significant increase in landfill gas use are waiting.

Table.2.1

Potential of raw biomass supply in Ukraine, 2030

Type of raw material	Supply capacity in 2030 (PJ / year)	Supply costs in 2030 (PJ / year)
Energy crops	345	8,9
Residues after harvest cultures	250 – 400	4,9
Remains of processing	210 – 365	2,7
Biogas	185	2,7
Fuel wood	0-270	7,9
Remains of wood	75-160	11,5
Wood waste	50-55	11,5
TOTAL	1115-1780	6,1-6,3

Ukrainians' interest in technologies using renewable sources is growing, in particular in the use of solar energy. By installing solar power plants (SPP) in their households, families are investing in their own energy independence (Fig. 2.1).

SPP in households are opportunities:

• provide for their own energy needs;

• reduce dependence on imports of traditional energy resources;

• save on electricity bills;

• be autonomous (subject to the installation of battery equipment or a combination of different technologies for the use of renewable energy sources);

• stimulate the local economy.

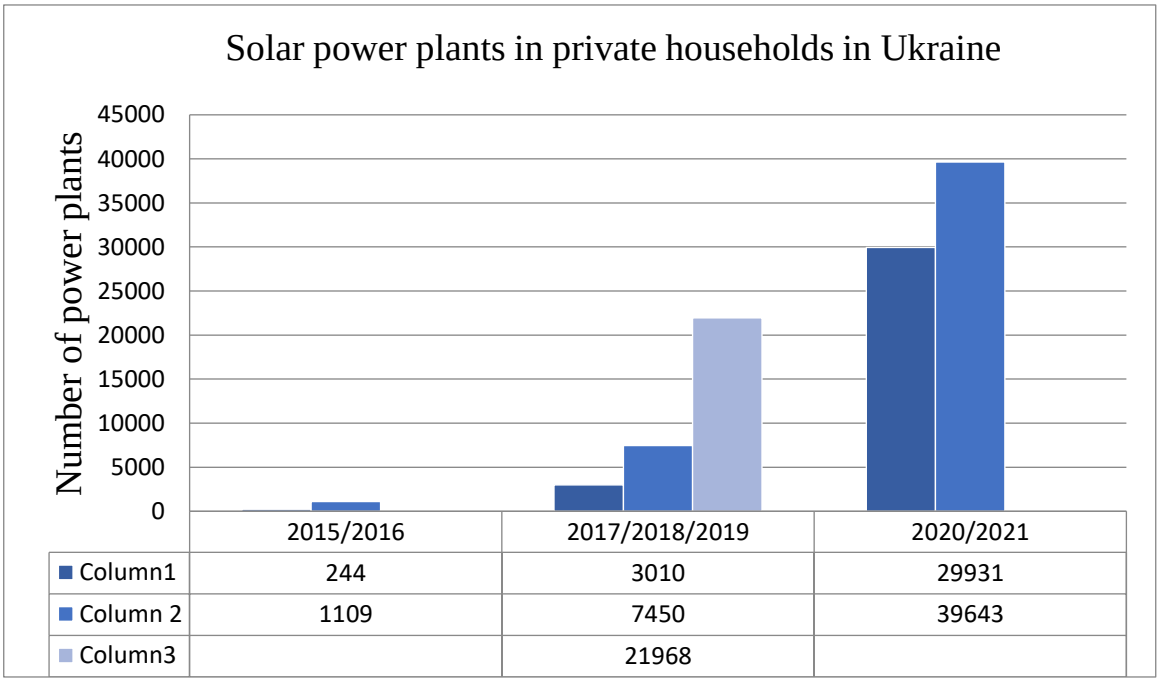


Fig. 2.1 Solar power plants in private households in Ukraine

First of all, it should be noted that increasing the share of renewable energy in Ukraine's energy balance is a goal that needs to be achieved today at all levels, but approaches to its implementation differ. The National Renewable Energy Action Plan for 2020 aims to achieve a share of RES of 11%. One can argue for a long time whether this indicator is too ambitious or, on the contrary, easily achievable for us, but one thing is clear: today Ukraine has a chance to choose a vector of development that will include green energy transformation. Why should we not lose this chance, and what benefits will every

Ukrainian man and woman receive from the development of renewable energy and abandon the usual outdated models of energy production?

With the growth of industrial production in the world, the number of greenhouse gas emissions has increased, which has caused global climate change. To prevent this, the Kyoto Protocol was adopted in 1997 and lasted for 8 years, which in some ways slowed down the implementation of the commitments made by the states. Despite the efforts of many countries, they were still not enough to combat climate change, so in December 2015 at a regular meeting of the Conference of the Parties to the UN Framework Convention on Climate Change in Paris, a new global climate agreement was adopted. This time, the Paris Accords are set to make ambitious commitments to reduce greenhouse gas emissions. Thus, according to the International Energy Agency, energy efficiency (40%) and renewable energy sources (30%) will play a key role in preventing global temperatures from rising by more than 2 ° C and reducing carbon emissions.

Thus, the development and use of RES is one of the tools to combat climate change, which would otherwise affect all scientists in the near future. Ukraine will not miss this phenomenon, as there are already changes in the usual approaches to agricultural production, caused by the instability of weather patterns, which can also pose risks to food security. In addition, an additional argument in favor of RES is the fact that Ukraine's international image is directly related to its fulfillment of its international obligations, including in terms of reducing emissions and environmental pollution. By signing and ratifying the Paris Agreement as one of the first countries, Ukraine has committed itself to meeting high standards and goals for the development of renewable energy sources.

A number of benefits of RES for the environment are more obvious: they are inexhaustible, do not disturb the ecological balance of the planet, pose incomparably lower risks to the environment, do not produce greenhouse gases and other harmful substances, and are therefore safer for human health. But even this list does not limit the benefits of renewable energy. Social gains are less obvious, but no less important. More than 700 million people in the world live in extreme poverty. If this figure is puzzling, we can turn to

another statistic: 1.1 billion people in the world - three times the population of the United States - live without electricity. The development of renewable energy not only reduces the gap of inequality and provides fairer access to energy resources, but also creates opportunities for economic growth and job creation.

According to the International Renewable Energy Agency (IRENA) report 2016, “The Benefits of Renewable Energy: Assessing the Economic Effect”, the economic benefits of RES are still underestimated. Doubling the share of renewable energy in the world energy balance by 2030 will increase global GDP by 1.1% (about $ 1.3 trillion), welfare by 3.7%, and employment in the renewable energy sector by 6% annually. According to IRENA, the renewable energy sector provided about 7.7 million direct and indirect jobs, which is 18% more than in the previous year. Last year 2015 was a record year for investments in "green" energy. Global investment in renewable energy increased by 5% (to $ 286 billion), more than 6 times higher than in 2004. By comparison, global investment in traditional energy sources has been $ 130 billion. than in developed countries. China ranks first in terms of investment - $ 103 billion, which is more than a third of total global investment. Among developing countries, India is not far behind - $ 10.2 billion, which is 22% more than in 2014. A sharp rise in investment can be observed in South Africa, Morocco, Chile and Mexico.

Thus, the benefits of renewable energy range from our environmental commitment to future generations to the socio-economic benefits that give impetus to further innovation without harming the environment. Access to RES is a value for society as a whole, especially for the part where a secure energy supply can significantly improve living standards and economic growth. Thus, stimulating the development of renewable energy is not only a global and national task, but makes sense for each and every one of us when we understand what we can get in return [8].

2.2The largest wind power plants in Ukraine

The first wind power plants in Ukraine were developed by one of the founders of cosmonautics, Yuriy Kondratyuk, in the 1930s. He worked on the project of the Crimean wind power plant with a capacity of 12 MW, with a tower 160 m high and a three-bladed propeller with a diameter of 80 m. In 1937 back in the 1930s. He worked on the project of the Crimean wind power plant with a capacity of 12 MW, with a tower 160 m high and a three-bladed propeller with a diameter of 80 m. "Green" electricity in Ukraine is generated by 34 wind power plants (including those located on the territory of ORDLO). The largest of them are Botievskaya, Primorskaya, Myrnenskaya, Orlovskaya, Overyanovskaya and Novoazovskaya wind farms. All wind farms of the first seven, except Boivska and Pryazovska, were put into operation in 2019 [9].

- Botievskaya WPP is located near the village of Primorsky Posad, Melitopol district, Zaporozhye region. The plant was built in 2012 by DTEK's energy holding company and is the largest wind farm in Ukraine. The station consists of 64 turbines Vestas V-112 3 MW each, total capacity - 200 MW.
- Primorskaya WPP is located in the village of Borysivka, Zaporizhia region. The station started operating in November 2019. The station was built by Wind Power, a subsidiary of DTEK VDE. The wind farm has 52 wind turbines with a capacity of 3.8 MW each. The height of the tower is 110 m and the diameter of the rotor is 137 m. The capacity of the station is 200 MW.
- Myrne wind farm is located on the lands of Myrne united territorial community in Kherson region. There are 35 turbines with a total capacity of 163 MW on an area of 55 hectares. The plant can generate about 574 million kWh of energy annually and reduces emissions by 455 thousand tons of CO_2 annually.

- Orel wind farm in the Primorsky district of Zaporozhye region. In total, the Orel WPP has 26 Vestas V126 wind turbines with a capacity of 3.8 MW. The height of the tower is 112 m and the diameter of the rotor is 126 m.
- Novotroitsk wind farm is located in Novotroitsk district of Kherson region. The wind farm consists of 12 V126 wind turbines with a capacity of 3.65 MW each and 8 V136 wind turbines with a capacity of 3.6 MW from Vestas. The total height of each tower is 117 m, with a blade span of 126 m and 136 m.
- The Overyanivska wind farm is located in the Kherson region within the Genichesk district. The station was put into operation in 2019. WPP capacity is 68.4 MW. This allows to reduce 210 thousand tons of CO_2 emissions per year.
- Novoazovsk wind farm was designed in 1996, it started working 15 years later. It consists of 23 wind turbines with a capacity of 2.5 MW each, manufactured by the German company Fuhrlaender AG. During the design and construction of wind farms took into account all the requirements of botanists, ornithologists, zoologists to reduce harmful effects on the environment [10].

2.3 Potential of renewable energy sources in Kyiv region

Renewable energy in the Kiev region in recent years is gaining popularity. I can say that the construction of solar power plants in private homes and private enterprises is growing every year. After all, the benefits of solar power plants are appreciated every day by more and more residents across the country and in the capital, in particular. To understand whether it is profitable to install a solar station in Kiev, you need to understand the level of insolation in the region. Insolation is the amount of solar radiation that falls on the Earth's surface. In other words, insolation helps determine how much the sun shines and how much radiation a solar panel can receive in different months of the year. Insolation is measured in kW/h/m^2. In Kyiv and Kyiv region there are excellent conditions for the

installation of solar power plants. Here the level of insolation per year is 3.10 kW/h/m^2. Which is much higher than, for example, in Germany, which leads in the amount of solar energy capacity in Europe [11].

A good example is Ukraine's largest rooftop photovoltaic power plant, Studenykivska FES, located in the Pereyaslav-Khmelnytskyi district of the Kyiv region, which will provide clean electricity to 150,000 households in the region. The plant will supply about 15 million kWh per year. According to experts, its work will reduce CO_2 emissions by 15 thousand tons per year. "There are no such large-scale projects even in Europe. Our experts conducted all the necessary research and concluded that solar panels can be placed on the roofs of farm buildings, which further protect animals from high temperatures, thereby improving the welfare of mink on the farm.

It is also a good example Chornobyl Solar Power Plant (Solar Chornobyl-1) is a solar power plant located in the Ivankiv district of Kyiv region on the industrial site of the Chornobyl NPP, right next to its 4th power unit.

Solar Chornobyl-1 is the first solar power plant built as part of the strategy of the consortium of companies RODINA - ENERPARC AG on the development of projects and construction of solar power plants in the areas affected by the Chernobyl nuclear power plant. 3762 solar modules were installed during the construction process. In October 2017, Solar Chornobyl began an active phase of construction and installation work on the construction of the first solar power plant on the site of the Chernobyl NPP.

On October 5, 2018, the Solar Chernobyl solar power plant - 1 MW - was officially opened on the territory of the Chernobyl NPP in Pripyat. In the future, the successfully completed project will be scaled up to 100 MW. The power plant is located on the industrial site of the Chernobyl nuclear power plant, above the 4th nuclear power unit, which exploded on April 26, 1986. The annual capacity of the power plant is 1024 MWh / year [12].

Starting from September 2018, the Spanish company ACCIONA Energia is building a complex of solar power plants with a peak capacity of 57.6 megawatts (nominal capacity

of 44 MW) in the village. Velyka Dymerka, in the north of Ukraine, in which he will invest 55 million euros. The country's first ACCIONA renewable energy facility, when commissioned in 2019, will produce clean energy equal to the consumption of more than 26,000 Ukrainian homes.

The complex is located near the city of Kyiv, 100 kilometers to the north-west, and will consist of three adjacent solar power plants (Dymerskaya SES 2, 3 and 4) on a plot of 92 hectares. The Government of Ukraine promotes the development of renewable energy in order to reduce the country's dependence on imported energy and diversify its energy complex. Under the Association Agreement that Ukraine signed with the European Union in 2014, the country set a goal: 35% of total electricity production should be from renewable energy sources by 2035. [16]

Chernobyl Wind Power Plant is a wind power plant in Ukraine located in the Ivankiv district of the Kyiv region and being built by Furlender Windtechnologies. The planned design capacity is 250 MW [14].

We have created a table of capacities of Kyiv region, which consists of a list of stations in Kyiv region (Tabl.).

Table 2.2

Assessment of renewable energy potential in Kyiv region

Solar power plants	Wind power plants	Biomass power plants
Kyiv City st. Verkhovyna, 17(Sviatoshynskyi district)36 solar panels has been installed on the roof of the capital's preschool № 601 (Sonechko).	Chernobyl Wind Power Plant is a wind power plant in Ukraine located in the Ivankiv district of the Kyiv region and being built by Furlender Windtechnologies. The planned design capacity is 250 MW.	Construction of a biomass power plant with a capacity of 12 MW in the city of Kagarlyk, Kyiv region

UDPR has put into operation the Dymerskaya Solar Power Plant, located in the Kyiv region near the village of Velikaya Dymerka. Thanks to the use of this solar power plant, it will be possible to reduce carbon dioxide emissions into the atmosphere by 6.5 thousand tons per year.	In a private house in the village of Glevakha (Kiev region)	Construction of a cogeneration plant (CHP) on milled peat and wood waste in the city of Yagotin, Kyiv region. The capacity of the CHP is 2.5 MW.
Chornobyl Solar Power Plant (Solar Chornobyl-1)is a solar power plant opened in 2018. It is located in the Ivankiv district of the Kyiv region on the industrial site of the Chornobyl NPP, right next to its 4th power unit.	A feasibility study was developed "Scheme for power distribution of a wind power plant with a capacity of up to 300 MW near the resettled village of Lelev, Ivankovsky district of Kyiv region".	Construction of a biomass power plant in the Vyshgorod district of the Kyiv region. Power plant capacity - 2 MW. The use of wood waste is supposed to be used as biomass.
The network solar station is located in c. Yasnogorodka, Fastiv district, Kyiv region. Power 30 kW under the Green Tariff, project implementation date: April 2021	A feasibility study was developed for the "Scheme for distributing the power of a wind power plant with a capacity of 40.5 MW near the resettled village of Lelev, Ivankovsky district of the Kyiv region";	a business model for the project "Construction of a biomass power plant with an approximate total electrical capacity of 12,500 kW, located in the Borodyansky district of the Kyiv region" was developed.

End of table 2.2

According to the Government portal, the Ministry of Health together with the Ministry of Digital Transformation, the State Service for Special Communications and Information Protection of Ukraine in partnership with representatives of the American company Tesla delivered equipment for alternative energy sources Tesla Powerwall, namely solar panels, to medical institutions of Borodyanka and Irpin.

Hospitals in these districts of Kyiv region have suffered the greatest damage due to Russia's military aggression against Ukraine, so the appearance of the latest equipment here is extremely important to restore their stable operation. “Thanks to state-of-the-art equipment, outpatient clinics will be able to use solar energy as a power source and store electricity. In addition, the installation of solar power plants allows you to significantly save on electricity costs and direct these funds to other needs, such as additional medical equipment, "- said Minister of Health Viktor Lyashko. Medicines were also delivered to the hospitals of Kyiv region together with the equipment.

Ensuring the stable operation of all medical critical infrastructure facilities in an emergency is one of the main tasks of the Ministry of Health today. Therefore, work aimed at meeting the urgent needs of medical institutions in equipment and medicines will continue.

Unfortunately, there are many destroyed objects in Ukraine because of war (Fig. 2.2)

Fig 2.2 Destroyed rooftop solar power plant near the city of Irpin (Kyiv region) [8]

2.4 Conclusion to the chapter 2

In the second section, I conducted an analysis of the assessment of the potential of renewable energy in Ukraine. Ukraine has significant potential for renewable energy that can be used to improve the trade balance, create jobs and stimulate economic activity as the country overcomes important economic challenges such as growing dependence on energy imports and the urgent need to renew obsolete fixed assets in the energy sector. The country has huge resources of agricultural and forest waste, which are the main raw materials for the production of heat and electricity from biomass.

You can see a table of comparative characteristics of recovered sources in Ukraine. Table 2.2 Also in this section I made a table of RES capacities in Ukraine, namely solar, air and biomass power plants.

CHAPTER 3 WIND GENERATOR FOR PRIVATE HOUSE IN THE WEATHER CONDITIONS OF KYIV REGION

Wind turbines for private use are no longer positioned as technical innovations in the alternative energy market. Today, windmills are considered as one of the possible options for savings.

Wind generators are special devices that transform the kinetic energy of wind into electricity. These are independent sources of electricity that are excellent for installation in private homes, small and medium-sized farms, production facilities.

3.1 Design and principle of operation of wind turbines

Wind generators are special devices that transform the kinetic energy of wind into electricity (Fig. 3.1). These are independent sources of electricity that are excellent for installation in private homes, small and medium-sized farms, production facilities. The design of a standard mini-power plant for domestic use includes the following functional elements:

- Aerodynamic blades for wind capture.
- Alternator for AC production.
- Controller for automatic control of the wind station. Allows you to adjust the recharging of batteries, distributes energy flows between devices.
- Drive. Special rechargeable batteries for the accumulation of generated electricity.
- Inverter for bringing the parameters of energy produced to grid standards.
- Mast, raising the blades to a certain height above ground level.

Masts are different: free-standing without extensions, rigidly fixed and swivel on extensions. The latter can be raised and lowered for maintenance, as well as for repair and restoration work.

Fig. 3.1 The simplified scheme of the windmill

Under the influence of wind, the blades mounted on the generator shaft begin to rotate, helping to start the rotor. As a result, the kinetic energy of air flows is converted into mechanical and then into electrical energy. The controller is placed in the circuit after the generator. It converts alternating current to direct current. In this form, electricity is accumulated and stored in batteries, and then from them through the inverter, which converts direct current into alternating current, energy is supplied to the private grid.

The scheme (Fig. 3.2) makes it possible to smooth out voltage instability, as well as to store energy during periods of complete absence of consumption [19].

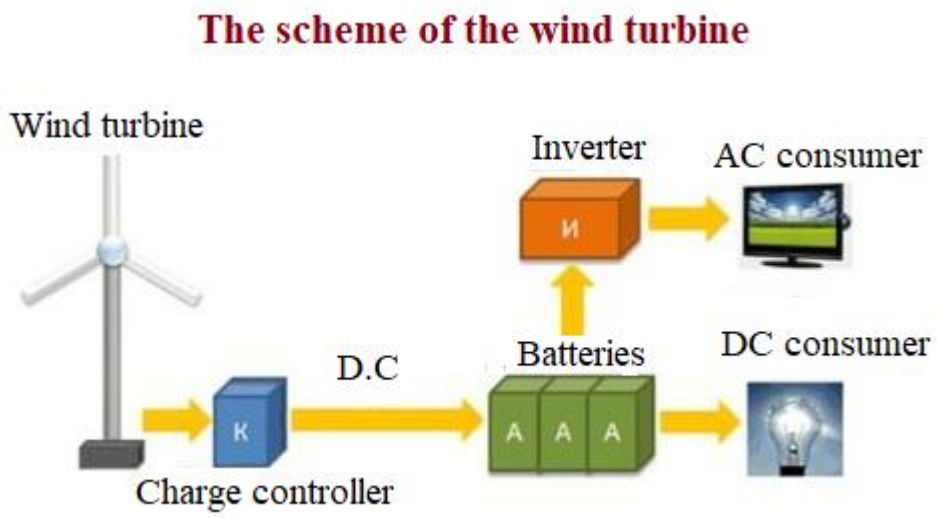


Fig. 3.2 The scheme of wind turbine

During the conversion of electric current according to the scheme of alternating-constant, variable there are certain energy losses, which are approximately 20%. Solar modules and fuel generators can be installed together with an autonomous wind farm.

Types of wind farms

There are autonomous wind turbines and network installations for the type of consumers. The former supply energy to consumers far from the central electricity networks.

Depending on the type of design, there are wind generators:

- with a vertical axis of rotation;
- with horizontal axis of rotation.

These devices are used for different operating conditions, but the most common are models with a horizontal axis. They work like ordinary weather vanes and have a similar structure. The axis of the rotor rotates parallel to the earth's surface.

Such units are characterized by high efficiency (about 40%), simple power adjustment and more affordable price, but are also characterized by high levels of noise and vibration. In addition, they must be oriented in the direction of the wind.

Expediency of installing a wind turbine

Today, small wind farms are widely used as alternative sources of electricity that can achieve real savings.

Such devices are usually installed in suburban areas, in areas remote from the main grid. But this is not the only reason why people increasingly prefer this type of design.

Landowners are successfully using wind turbines to achieve full autonomy and significant energy savings

However, not every area is suitable for wind turbine installation. In order for the mini-power plant to function properly during the period of operation stated by the manufacturer, the climatic conditions of the area must meet the requirements of special equipment.

If you decide to install a wind mini-power plant for the house, you should also consider the availability of free space. It should be borne in mind that the wind should be completely free to "walk" on the shovels, well, without obstacles in its path to reach them from different directions.

That is why the ideal place to install a wind turbine are the tops of the hills, where air masses are compacted with a corresponding increase in pressure and wind speed. Marine regions and the steppe zone are also considered suitable.

3.2 Advantages and disadvantages of wind turbines

The popularity of wind turbines is growing every day. They are advantageous to equip large and expensive cottages, which require a lot of electricity.

It is advisable to install windmills in settlements where there is no centralized electricity supply or electricity supply is produced with constant interruptions.

In such cases wind generators which use has a number of advantages will come to the rescue:

- transformation of energy of air streams into free electricity;

- environmental safety of wind turbines;
- lack of raw materials and waste in electricity generation;
- minimal wear of functional parts;
- long service life - 25-30 years;
- there is no need to constantly monitor the operation of the wind farm.

Disadvantages include variability and unpredictability of wind strength. To minimize losses, you need to duplicate the source or install additional buffer to store energy. Also, a rotating windmill poses a potential threat to flying birds.

Wind power plants create noise that can be compared to the noise of vehicles driving at a speed of about 70 km/h. Increased noise not only scares animals, but also causes discomfort to humans

Another significant disadvantage of wind turbines for domestic use is the high cost. These bulky structures are made of expensive materials, complete with controller, batteries, inverter and mast. The price of wind farms for home use with a capacity of 3 kW to 7 kW is much higher. Such generators with related equipment will cost the buyer $ 5,000-12,000.

It makes sense to install a wind turbine in places where access to centralized energy supply is completely absent. The payback period in this case is 25 years [19].

3.3 Calculation of wind turbine for a private house

Wind turbines for private use are no longer positioned as technical innovations in the alternative energy market. Today, windmills are considered as one of the possible options for savings (in connection with the tariff rise of electricity). Air currents above the earth's surface carry a huge amount of energy, which is currently successfully used in industrial wind turbines and small wind turbines for home use. And because the key indicators for household consumers remain the reliability and stability of electricity supply, many landowners decide to buy and install a wind turbine for a private home.

This part of chapter will give an example of calculating the wind turbine for people living in rural areas and often have power outages.

The calculation is designed for a home with a minimum set of appliances (Table 3.1):

Table 3.1

Electricity consumption by home appliances

lighting	150 W
refrigerator	450 W
washing machine	1700 W
microwave oven	1000 W
vacuum cleaner	1250 W
TV	350 W
computer	600 W
iron	750 W
Totally	6250

In total, these devices will consume 6250 watts, and given these devices together are almost never turned on, the power obtained can be split 3125 watts in half. For the calculation we took the Kyiv region, where the average wind speed is 2.5 m/s. According to the following formula, we calculated the energy of the site:

$$P = V^3 * \rho * S \quad (3.1)$$

For example, an area equal to 20 m^2 blowing air flow density of 1.5 kg/m^3, with the speed 2.5 m/s. Then:

$$P = V^3 \bullet \rho \bullet S = 2{,}5^3 \bullet 1{,}5 \bullet 20 = 3750 \text{ W} \quad (3.2)$$

where V - wind speed, unit of measurement - m/s ; ρ - air density, kg/m^3 ; S - the area to which the blast (pressure) air flow, m^2.

Almost 1.25 kW, if we do not take into account that we will receive 20-50% of the potential energy of the wind turbine, and the other part will be lost to twists, turns and the like. A more accurate calculation can be made according to the formula:

$$P = \xi \bullet \pi \bullet R^2 \bullet 0{,}5 \bullet V^3 \bullet \rho \bullet \eta_{ред} \bullet \eta_{ген} \quad (3.3)$$

where ξ - coefficient of wind power use (in nominal mode for high-speed the windmills reaches a maximum $\xi_{max} = 0{,}4 \div 0{,}5$), an infinite value; R- radius of the rotor, m; V - speed of air flow, m/s; ρ - air density, kg/m^3 ;ηред - efficiency of the gear unit; ηgen - generator efficiency,

For the following data: $\xi = 0.4$; R = 5 m; V = 5.0 m/s; $\rho = 1.5$ kg/m^3; $\eta_{ред} = 0{,}8$; $\eta_{gen} = 0.9$

We expect:

$$P = \xi \bullet \pi \bullet R^2 \bullet 0{,}5 \bullet V^3 \bullet \rho \bullet \eta_{ред} \bullet \eta_{ген} = 0{,}4 \bullet \pi \bullet 5^2 \bullet 0{,}5 \bullet 5{,}0^3 \bullet 1{,}5 \bullet 0{,}8 \bullet 0{,}9 = 1271 * 0{,}4 = 508{,}6 \text{W} \quad (3.4)$$

Results of the calculation: It should be remembered that the amount of electricity generated by the wind turbine increases in cubic ratio with the increase in wind speed. For example, if the wind speed increases 2-fold, then the kinetic energy generated by the rotor will increase by 8 times. Therefore, we can conclude that wind speed is an important factor affecting the power of the plant as a whole. The higher the mast of the windmill, the greater the wind speed (Fig. 3.3).

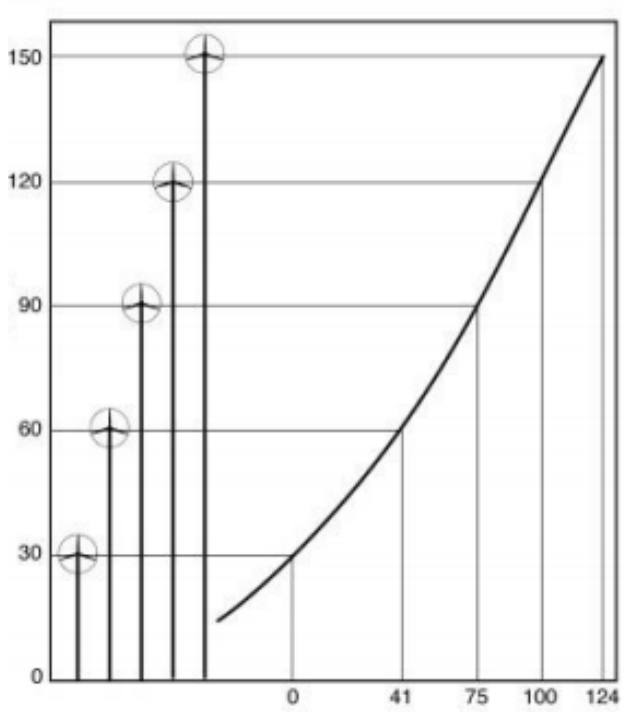


Fig. 3.3 Dependences of wind speed on increasing wind energy

Vertical: mast height (foot) Horizontal: increase energy %

3.4 Practical recommendations for alternative energy usage

Our recommendations for the restoration and improvement of green energy in Ukraine are the following.

To minimize the impact of this situation on the economy and the formation of Ukraine's energy independence, as well as - further development of the industry aimed at abandoning Russian gas, the following low-cost steps are effective:

1. Provide destroyed and damaged green energy facilities with access to the new Fund for the Restoration of Ukraine's War-Destroyed Energy Infrastructure, established by the European Energy Community.

2. Support (in the form of: tax holidays, absence of rent and land tax for 5 years, preferential connection to networks) for the construction of new solar and wind power

plants. New construction should be concentrated in regions where there is a real shortage of electricity.

3. Providing preferential conditions for access of green energy companies in the electricity market "day ahead" in order to reduce the burden on SE "Guaranteed Buyer" for payments under the green tariff.

4. Increasing the level of flexibility and decarbonization of Ukraine's energy system, primarily through the construction of new energy storage and shunting capacities, in particular, with the use of biomethane.

5. Creation of special stimulating conditions for the production of renewable gases by green energy facilities (green hydrogen and synthetic renewable methane).

3.5 Conclusion to the chapter 3

In the third section, I described the operation of a windmill, the types and composition of which you can see in Figure 3.2. This section will provide an example of wind turbine calculation for people who live in rural areas and often have power outages. According to the formula, calculations were performed to determine the energy of the site.

CONCLUSIONS

Renewable energy is developing rapidly around the world, particularly in Ukraine.

The share of renewable energy in total electricity production reaches 25% in developed countries and up to 35% in European countries. The largest volumes of electricity production from renewable sources are provided by hydropower, biomass, solar and wind energy. In the first chapter, I analyzed global energy strategies and the development of the renewable energy sector. Energy comes from the Earth's natural resources, which are not limited or depleted, such as wind and sunlight. Renewable energy is an important branch of energy, the role of which is growing every year around the world. Traditional energy sources are gradually depleted, and non-traditional - natural sources are becoming relevant and widely available through the achievements of modern technology. I compared the RES estimates of Europe, America and Asia, which can be seen in the tables and graphs. In the second section, I analyzed the assessment of the potential of renewable energy in Ukraine. Ukraine has significant potential for renewable energy that can be used to improve trade balance, create jobs and stimulate economic activity as the country overcomes important economic challenges such as growing dependence on energy imports and the general need to renew obsolete fixed assets in the energy sector. The country has huge resources of agricultural and forest waste, which are the main raw materials for the production of heat and electricity from biomass. We also compiled a table of RES capacities in Ukraine, namely solar, air and biomass power plants. In the third section, we described the operation of the windmill, its types and composition. You can see an example of calculating wind turbines for people who live in rural areas and often have power outages. According to the formula, calculations were performed to determine the energy of the site.

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