MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ENVIRONMENTAL SAFETY,
ENGINEERING AND TECHNOLOGIES
DEPARTMENT OF ECOLOGY

APPROVED TO DEFENCE
Head of the Graduate Department
_____________ V.F. Frolov
«_____» ____________ 2020

MASTER THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 “ECOLOGY”,
TRAINING PROFESSIONAL PROGRAM
“ECOLOGY AND ENVIRONMENTAL PROTECTION”

Theme: **«Evaluation of the efficiency of biofuel production from microalgae»**

Done by: student of the EK– 202 ма group, Valeriia V. Onopa
(student, group, surname, name, patronymic)

Supervisor: Ph. D. in Technological Sc., Associate Professor, Lesia I. Pavliukh
(academic degree, academic rank, surname, name, patronymic)

Consultant of the chapter “Labor Precaution”: __________ Olena V. Konovalova
(signature) (S.N.P.)

Standards Inspector: __________ Andrian A. Iavniuk
(signature) (S.N.P.)

KYIV 2020

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

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_____________ В.Ф. Фролов
«_____» ____________ 2020 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

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

Тема: «Оцінка ефективності виробництва біопалив з мікроводоростей»

Виконавець: : студентка групи ЕК- 202 ма, Онопа Валерія Василівна
(студент, група, прізвище, ім'я, по батькові)

Керівник: канд.тех. наук, доцент кафедри екології Павлюх Леся Іванівна
(науковий ступінь, вчене звання, прізвище, ім'я, по батькові)

Консультант розділу «Охорона праці»: _____________ Коновалова О.В
(підпис) (П.І.Б.)

Нормоконтролер: _____________ Явнюк А.А.
(підпис) (П.І.Б.)

КИЇВ 2020

NATIONAL AVIATION UNIVERSITY

Faculty of Environmental Safety, Engineering and Technologies

Department of Ecology

Specialty, training professional program: specialty 101 “Ecology”, Training Professional Program “Ecology and Environmental Protection”

(code, name)

APPROVED
Head of the Department
____________ Frolov V.F.
«____» __________ 2020

MASTER THESIS ASSIGNMENT

Valeriia V. Onopa

1. Theme: «Evaluation of the efficiency of biofuel production from microalgae» approved by the Rector on September 06, 2020, № 1937/ст.

2. Duration of work: from 05.10.2020 to 31.12.2020.

3. Output work: raw material data for biofuel production.

4. Content of explanatory note: to analyze the biofuel market in Ukraine, to analyze the technologies of microalgae cultivation, to assess the potential of microalgae for biofuel production, to analyze the feasibility of growing algae in Ukraine, to make practical recommendations for growing algae in Ukraine.

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

6. Schedule of thesis fulfillment

№ з/п	Task	Term	Advisor's signature
1	Receive themes task, search the literature and legislation	05.09.2020-15.09.2020	
2	Preparing the main part (Chapter I)	16.09.2020-30.09.2020	
3	Preparing the main part (Chapter II)	01.10.2020-15.10.2020	
4	Preparing the main part (Chapter III)	16.10.2020-26.10.2020	
5	Consultation on section IV (Occupational safety)	27.10.2020-04.11.2020	
6	Preparation of the main part (Chapter IV)	05.11.2020	
7	Formulating conclusions and recommendations of the thesis	21.11.2020-25.11.2020	
8	Making an explanatory note to the previous presentation of the department, consultation with the norms controller	26.11.2020-30.11.2020	
9	Presentation of the work at the department	01.12.2020	
10	Taking into account the comments and recommendations and training to protect	01.12.2020-20.12.2020	
11	Thesis defense at the department	21.12.2020	

7. Consultant(s) of certain chapter(s):

Chapter	Consultant (academic rank, S.N.P)	Date, signature	
		Given by	Accepted by
Labor Precaution	Olena V. Konovalova, Associate professor Chair of Civil and Industrial Safety		

8. Date of task issue: «05» September 2020

Qualification Paper Advisor: ________________ Lesia I. Pavliukh
(advisor's signature) (S.N.P.)

Task is taken to perform: ________________ ________________
(graduate's signature) (S.N.P.)

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет екологічної безпеки, інженерії та технологій

Кафедра екології

Спеціальність, освітньо-професійна програма: спеціальність 101 «Екологія», ОПП «Екологія та охорона навколишнього середовища»

(шифр, найменування)

ЗАТВЕРДЖУЮ
Завідувач кафедри
___________Фролов В.Ф.
«____» _________ 2020 р.

ЗАВДАННЯ
на виконання дипломної роботи
Онопи Валерії Василівни

1. Тема роботи «Оцінка ефективності виробництва біопалив з мікроводоростей» затверджена наказом ректора від 06 вересня, 2020, № 1937/ст.

2. Термін виконання роботи: з 05.10.2020 р. по 31.12.2020 р.

3. Вихідні дані роботи:дані про сировинні ресурси для виготовлення біопалива.

4. Зміст пояснювальної записки: проаналізувати ринок біопалива в Україні, проаналізувати технології вирощування мікроводоростей, оцінити потенціал мікроводоростей для видобутку біопалива, провести аналіз доцільності вирощування водоростей на території України, надати практичні рекомендації щодо вирощування водоростей в Україні.

5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, рисунки.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Отримання теми завдання, пошук літературних джерел та законодавчої бази	05.09.2020-15.09.2020	
2	Підготовка основної частини (Розділ I)	16.09.2020-30.09.2020	
3	Підготовка основної частини (Розділ II)	01.10.2020-15.10.2020	
4	Підготовка основної частини (Розділ III)	16.10.2020-26.10.2020	
5	Консультація щодо розділу IV (Охорона праці)	27.10.2020-04.11.2020	
6	Підготовка основної частини (Розділ IV)	05.11.2020	
7	Формулювання висновків та рекомендацій дипломної роботи	21.11.2020-25.11.2020	
8	Оформлення пояснювальної записки до попереднього представлення на кафедрі, консультація з нормоконтролером	26.11.2020-30.11.2020	
9	Представлення роботи на кафедрі	01.12.2020	
10	Урахування зауважень, рекомендацій та підготовка до захисту	01.12.2020-20.12.2020	
11	Захист роботи на кафедрі	21.12.2020	

7. Консультація з окремого(мих) розділу(ів):

Розділ	Консультант (посада, П.І.Б.)	Дата, підпис	
		Завдання видав	Завдання прийняв
Охорона праці	Коновалова Олена Вікторівна, доцент Кафедра цивільної та промислової безпеки		

8. Дата видачі завдання: «05» вересня 2020 р.

Керівник дипломної роботи : ________________ Павлюх Л.І.
(підпис керівника) (П.І.Б.)

Завдання прийняв до виконання: ______________ ______________
(підпис випускника) (П.І.Б.)

ABSTRACT

Explanatory note to thesis «Evaluation of the efficiency of biofuel production from microalgae»: 78 pages, 14 figures, 5 tables, 46 references.

Object of research biofuel production.

Subject – assessment of microalgae application for biofuel production.

Aim of work – To determine the appropriateness of microalgae application for biofuels production.

Methods of research: analysis, data comparison, statistical data processing, mathematical modelling.

BIOFUELS, BIODISEL, BIOETHANOL, MICROALGEA, BIOFUEL OF THIRD GENERATION

CONTENT

INTRODUCTION

Relevance. The transition to the use of alternative energy-saving and environmentally friendly technologies is a complex and time-consuming process that involves the abandonment of mineral fertilizers, plant protection products and other growth stimulants for plants and animals, the use of environmentally friendly biodiesel and more. This process is based on a change in the philosophy of management and leads to a change in the economy and organization of the agricultural production system.

Today, Ukraine meets more than 62% of domestic gasoline and 90% of diesel fuel consumption needs through imports. The biofuel production and use can provide additional tools for the country's energy independence, in particular in the transport sector. However, instead of domestic production, Ukraine annually exports significant volumes of raw materials.

In spite of the declared objectives of the Energy Strategy to increase the share of alternative fuels, the respective Ukraine's potential is practically not used. For example, motor biofuels meet about 4% of transport energy consumption needs in the world and less than 1% in Ukraine.

Scientists believe that with the right policy, Ukraine will be able to provide 50-75% of all alternative fuels consumed by Europe, and the profitability of production will exceed 50%.

Не потрібно порожніх рядків

Aim of work – to evaluate of the efficiency of biofuel production from microalgae.

Tasks of work:

- to analyze the national biofuel market and development of the world energy sphere;
- to investigate the feasibility of microalgae application for biofuel production;

- to compare the advantages and disadvantages of biofuel production from microalgae
- to give practical recommendations for the development of the biofuel industry of Ukraine.

***Object of research* –** biofuel production.

Subject of research – assessment of microalgae application for biofuel production.

Methods of research: analysis, data comparison, statistical data processing, mathematical modelling.

Scientific novelty of the results.

1. The biofuel production from microalgae in the conditions of Ukraine has been further developed.

The practical value of the results obtained. Practical recommendations for growing microalgae in Ukraine are offered.

Personal contribution of the graduate. The analysis of efficiency of production of biofuel from algae is carried out, practical recommendations of annual cultivation of microalgae in the conditions of Ukraine are offered.

Pubications.

1, Pavliukh L., Onopa V., Hussain S. MICROALGAE AS A RAW MATERIAL FOR BIOFUEL PRODUCTION. // Scientific achievements of modern society. Abstracts of the 12th International scientific and practical conference. Cognum Publishing House. Liverpool, United Kingdom. 2020. Pp. 21-27. URL: https://sci-conf.com.ua.

CHAPTER 1
FEATURES OF THE FUELS NATIONAL MARKET FORMATION

In view of Ukraine’s significant dependence on petroleum imports, it is extremely important for us to develop our production and increase the share of replacement of petroleum products with biofuel. The country’s potential for biofuel production allows to replace up to 35% of imported diesel and up to 10% of gasoline due to bioethanol production. But this requires financial and economic incentives along with creating a guaranteed demand for motor biofuels.

1.1. Analysis of the biofuel market in Ukraine

Biofuels are produced in 20 regions of Ukraine. And that just does not serve as a raw material base for its manufacture - from cereals and legumes and ending with livestock and poultry waste.

Polissya and some districts of Western Ukraine are considered to be the leaders and the most suitable regions for the development of this business. These regions have a good raw material base. The main advantage of these places is the availability of raw materials. The basis for biofuel production is rapeseed and wood processing waste. "It is more profitable and easier to produce solid fuel in regions rich in forest plantations, such as Polissya and the massifs around the Carpathians. These regions account for 70% of all biofuels produced in Ukraine.

The most attractive regions for the production of wood briquettes and pellets are Zhytomyr, Chernihiv, Zakarpattia and Ivano-Frankivsk regions. They have the greatest forest potential and, accordingly, a well-developed woodworking industry, provides waste for biofuel production. In addition, in the west of Ukraine there are many companies with foreign investment, and this is a good sign: foreigners are better than our entrepreneurs assess the payback of the business and its prospects, so they place their production near the raw material base.

At the same time, the most favorable conditions for growing winter rape are observed in Lviv, Ivano-Frankivsk, Ternopil, Khmelnytsky, Kyiv regions, and spring - in Kyiv, Cherkasy, Chernihiv. By the way, last year Ukraine became one of the European leaders in the area of rapeseed crops, overtaking France and Germany. Vinnytsia, Kirovohrad and Odesa oblasts took more land for this crop than others. According to Mykhailo Yatskanych, director of the Kirovohrad branch of the Ukrgosfond Farm Support Fund, rapeseed was actively sown last year after several sugar factories were closed and farms stopped sowing beets. The same reason is in Vinnytsia region.

In times of crisis, biofuel production is a sweet business because it requires large investments at once. Accordingly, it is difficult for Ukrainian entrepreneurs to finance it on their own, without attracting foreign investors. Therefore, some try to produce briquettes by hand, for example, make pellets on machines from the Soviet Union.

There are difficulties with the cultivation of rapeseed: when cultivating the soil to create a fine-grained structure, you need modern agricultural machinery, which farmers and small farms do not have. "Rapeseed is a crop worthy of attention, competitive, economically profitable. But it can be considered a panacea for all ills. The fact that it depletes the soil is just the tip of the iceberg.

Ukraine exports 15-20 thousand tons of briquettes and twice as many pellets a year. The quality of export products meets European standards (analyzed for CO_2 content and product hardness).

All domestic biofuel producers work mainly for export. 80% of all produced organic products are sent to foreign markets. Raw materials for the production of biofuels are also exported, for example, more than 90% of domestic rapeseed is sent to overseas plants.

This is due to the fact that the consumption of biofuels has increased so much that Ukraine's production capacity is not enough to meet existing demand. In Europe, both private homes and public institutions are actively switching to the use of biofuels, because the heat transfer of pellets and gas is about the same (a difference of 0.2 kJ), and the price of alternative fuels is 200-250% lower.

"Importing countries indicate a certain amount that they are willing to pay per unit of goods, and the Ukrainian manufacturer is guided by this offer. Demand within the country can be called satisfied: the state is already investing in these programs. The market is growing - so is the production of biofuels. If there are no bans, for example on the woodworking industry, the production of alternative fuels will increase annually.

But so far, alternative energy accounts for no more than 1% of the country's energy balance. Biofuel capacity is used by only 0,8%. Theoretically, within 5-6 years it is possible to increase the share of alternative energy in Ukraine to 10-15%.

1.2. Problems of increasing biofuel production in Ukraine

The world already has technologies for growing and processing special microalgae into biofuels. In Ukraine, this area is known to a wide range of specialists, but no one studies it, does not experiment with it and does not implement it.

There are several problems: misunderstanding and despair, as well as the lack of domestic strains of microalgae themselves. And this is an expensive intellectual product. Not the algae themselves, of course, but information about them. Licenses and seedlings must be purchased. A number of institutes of the National Academy of Sciences of Ukraine are working on this.

For the development of the biofuel market it is necessary to create conditions for growing and selling energy crops as bio raw materials for its production. Biomass grown in agricultural production is considered as primary (used in unchanged form for direct combustion - wood, straw, energy crops, etc.) and secondary energy raw materials (livestock by-products, organic products and sludge from municipal wastewater) [3, 4] .

Biodiesel (rapeseed is considered to be the best raw material for its production), bioethanol (corn is the best raw material) and gaseous biofuel are produced from bio-raw materials. Biodiesel (biodiesel) is a methyl ester obtained by a chemical reaction from any vegetable oils and animal fats. Biodiesel can be used in conventional internal combustion engines either alone or in a mixture with conventional diesel fuel, without making changes to the engine design.

Biodiesel, or biodiesel, is an environmentally friendly type of fuel derived from vegetable oils and animal fats and used to replace (save) conventional diesel fuel [5].

For the full development of the biofuel market, first of all, it is necessary to create a powerful raw material base and appropriate infrastructure to ensure the storage, processing, transportation and sale of finished products. The analytical group Bloomberg New Energy Finance made a report "Towards a new generation ethanol economy", presenting it at the World Economic Forum. The report was commissioned by Novozymes, a world leader in bioinnovation and industrial enzymes. According to the analytical group, 17.5% of agricultural waste today can be used as raw material for processing into biofuels. With this amount of biofuel, more than 50% of the demand for gasoline can be replaced by 2030 [6].

In European countries, there is a plan for the introduction of biofuels, which includes three levels. The first level is the production of biofuels from biomass, the second is the production of elitocellulose fiber, the third level is the production of algae. Most modern scientists note that Europe is on the verge of transition from the first to the second level of the plan [7].

Ukraine not only has a sufficient resource base for the production of alternative fuels. It also has a number of industrial facilities that are able to process the grown biomass on their own. There are about 90 distilleries in Ukraine, but only 11 of them are capable of processing bioethanol. At the same time, the capacity of these plants is sufficient for the production of biodiesel. In addition, it is necessary to take into account the capacity of oil and fat plants, which can process about 7.5 million tons of oilseeds. The above confirms the fact that Ukraine is able to grow and process large enough volumes of biofuels to use it on a large scale in various sectors of the national economy. Scientific institutes have made the necessary calculations, in which it is proposed to build in Ukraine about 3 thousand biogas plants with different volumes [8].

Some changes in the direction of forming an efficient biofuel market in Ukraine have been made at the legislative and legal level. This is evidenced by a number of adopted laws and decrees (Law of Ukraine "On Alternative Liquid and Gaseous Fuels", Law of Ukraine "On Amendments to Certain Legislative Acts of Ukraine on Promotion of Production and Use of Biological Fuels", Decree of the President of Ukraine development of fuel production from biological raw materials ", etc.). Adoption of this legislation allowed to approve programs for the development of diesel biofuel production in the country for a number of previous years; to conduct research on rapeseed cultivation technologies for different climatic zones; to introduce the development of regulatory documentation (state standards harmonized with EU standards) for the production and use of diesel biofuels; manufacture and testing of research lines (low power) for the production of diesel biofuels; use various measures to strengthen the raw material base by expanding the area of rapeseed cultivation, etc. [9,10].

It should be noted that all the above did not create optimal conditions for the effective development of the biofuel market in Ukraine. In recent years, the main national and foreign investments have been directed mainly towards the formation of a strong raw material base, rather than the objects of its processing.

European Union countries are more interested in Ukrainian rapeseed than biofuels. Without state support and investment in the development of infrastructure facilities for the biofuel market and the construction of new national modern biofuel plants, national agricultural producers can only become suppliers of biomass to producers in other countries.

1.3. Analysis of the main trends and prospects for the development of bioenergy in the world

In the European Union, biodiesel production has significant government support. In Germany, biofuels are not subject to mineral and environmental taxes, there is a system of subsidies for rapeseed cultivation. In France, the tax rebate is 0.35 EUR / l of biodiesel. In Spain, motorists who use such fuel are allowed free on-site parking. In Europe as a whole, 1 liter of biodiesel is EUR 0.1 - 0.15 cheaper than diesel fuel.

Also, for example, if a family or business in Germany installs a fuel pellet boiler, the state pays a subsidy of between EUR 500 and EUR 2500, depending on the capacity, equipment and type of boiler. Since the state applied to alternative energy projects, the banking sector has been connected, and incentives to provide long-term loans for 15-20 and even 30 years at low interest rates.

In Ukraine, according to various sources, the cost of 1 liter of biodiesel is 2.2-3 UAH. The cost of such fuel depends on a number of factors, such as the yield of rapeseed, the efficiency of straw and meal, the cost of chemical ingredients (methanol and alkali), the depth of processing of glycerol water, the quality of the technological process of biodiesel.

The defining Paris Agreement on climate change is transforming the global energy system for decades to come. Following the adoption of the Paris Agreement, the world is rethinking the importance of energy security, particularly in the energy sector, which is at the forefront of the fight against climate change.

The country's energy security significantly depends on the degree of diversification and the efficient use of energy consumed for energy purposes. The development of bioenergy is an important part of ensuring the energy security of many countries, as it makes it possible to reduce the consumption of fossil fuels, dependence on imported energy and ensure a quality and reliable energy supply. According to various estimates, the resources of the planet's minerals are limited, their reserves for energy needs will be enough for a maximum of 100 years, so the development of alternative or renewable energy is a relevant, profitable and timely direction of global energy.

The last few years, the annual total world energy consumption is about 11.8 billion tons of oil equivalent . The basis of the world energy balance is hydrocarbon energy - oil, gas and coal. Their share in the world energy supply is about 86%

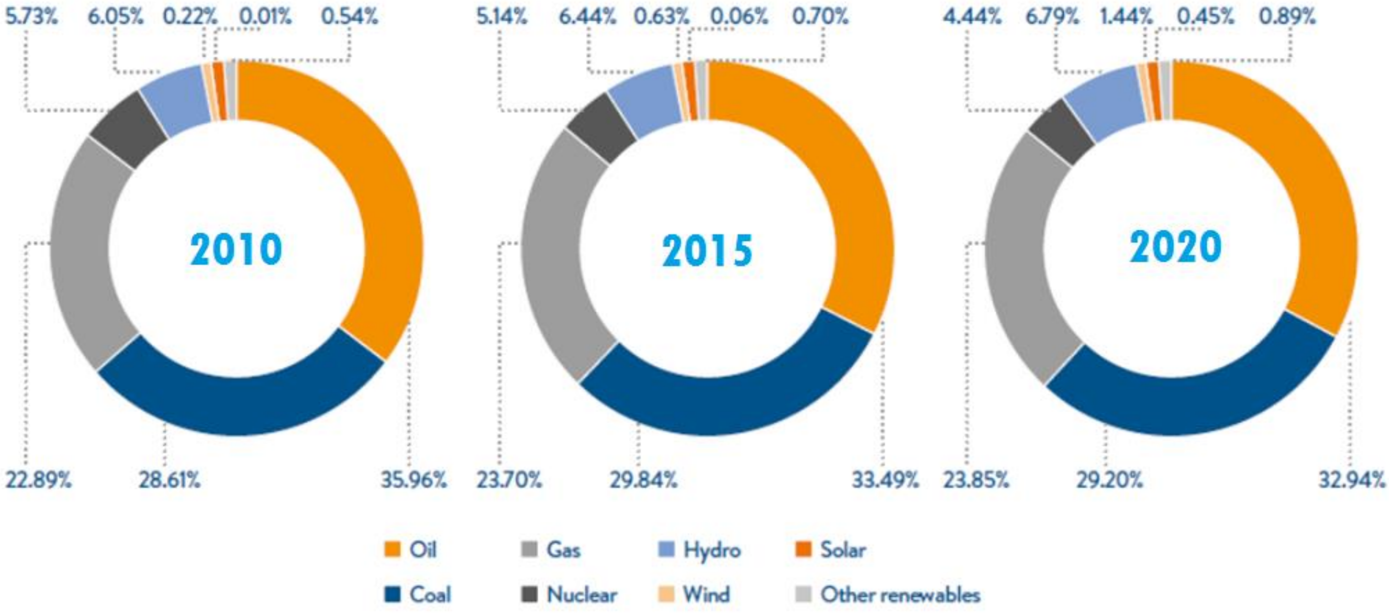

Fig. 1.1. Dynamics of the world energy balance for 2010 – 2020 [37]

From the given diagram, according to WEC, it is visible that the main primary source of the world energy balance is oil, makes 32,9%. Coal accounts for more than 29% of the total energy balance, providing about 40% of global electricity production. However, climate change, mitigation requirements, the transition to cleaner forms of energy have led to a reduction in coal production by 0.6% in 2015 and another 2.8% in 2020. The share of natural gas in the world energy balance is almost 24%, he is the second largest source of electricity generation, provides 22% of the world's energy capacity and the only fossil fuel, the share of which is projected to grow in long-term energy consumption.

The global report REN21 "Renewables 2017 Global Status Report" notes the fact that in 2014 the share of renewable energy sources (RES) in world electricity production was already 22.6%, in 2015 - 23.7 % and in 2016 a total capacity of 161 GW was introduced, which in turn is 9% higher than last year. It is noted that over the past ten years, political and economic circumstances in many parts of the world have contributed to the more active development of various technologies for converting biofuels into electricity and heat, and biomass generation has developed faster than traditional energy sources. Growth was also observed in the production of various types of biofuels. [2]

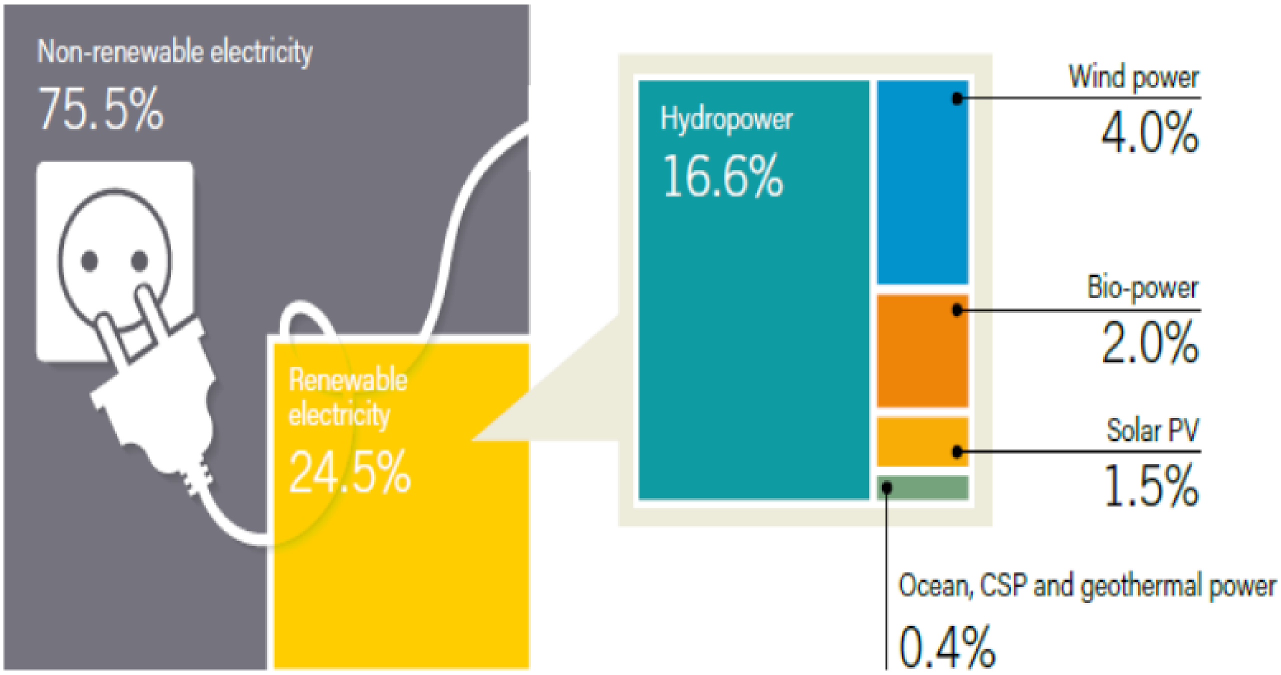

Fig. 1.2. Estimated share of renewable energy sources from the total share of energy consumption [2]

According to the REN21 expert assessment, the most dynamically developing types of RES are: wind energy, bioenergy, solar energy and the use of low-potential energy with the use of heat pumps. At the same time, the use of biomass resources plays a dominant role among other types of renewable energy, forming 46% of the market for renewable energy sources. Gaseous (biogas), liquid (bioethanol, biodiesel) and solid biofuels are produced from various types of biomass. On the basis of biofuels, the volumes of heat and electricity production are growing.[3]

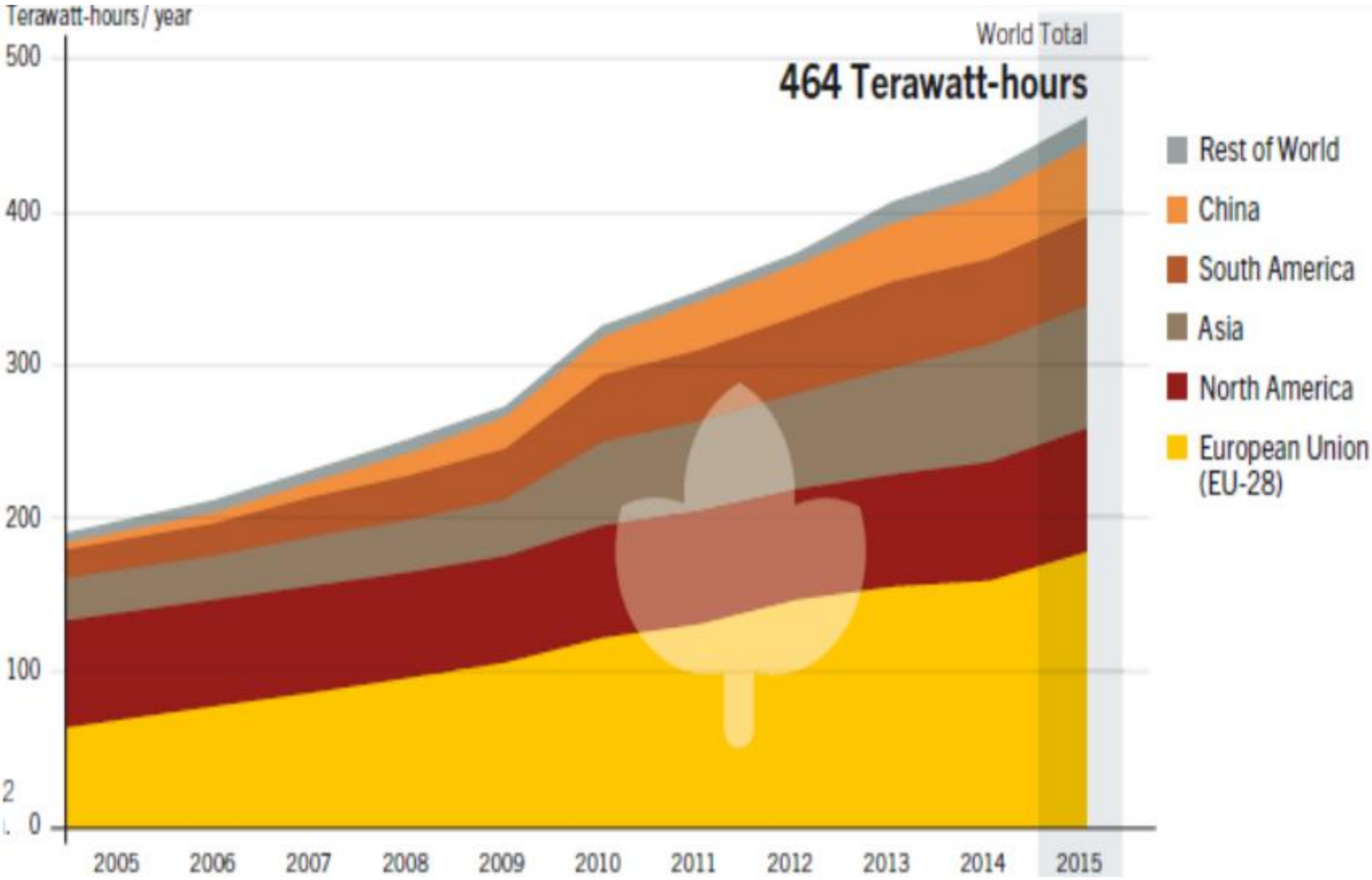

Fig.1.3 Electricity production based on biofuels by regions and countries

According to REN21, in 2015 the installed capacity of biopower plants in the world increased by 5% and amounted to more than 106 GW, electricity generation based on biofuels increased by 8% and amounted to 464 TWh. Leading US countries 5 (wood and agricultural waste), Germany (solid biomass, biogas, biomethane), China (biofuels from agricultural and forestry products and solid household waste), Brazil (sugar cane, cake) and Japan solid biomass, biogas). [3]

According to the IEA, bioenergy is one of the most effective and promising areas of alternative energy. Technologies for obtaining and using bioenergy resources meet the requirements of the Paris Climate Agreement (COP21) on environmental protection.

The rapid and sustainable development of the bioenergy sector in recent decades is due to a number of factors, the key of which is the widespread use of government programs to limit greenhouse gas emissions and protect the environment, reduce traditional energy resources with concomitant rising energy prices, improve technological bioenergy. [4]

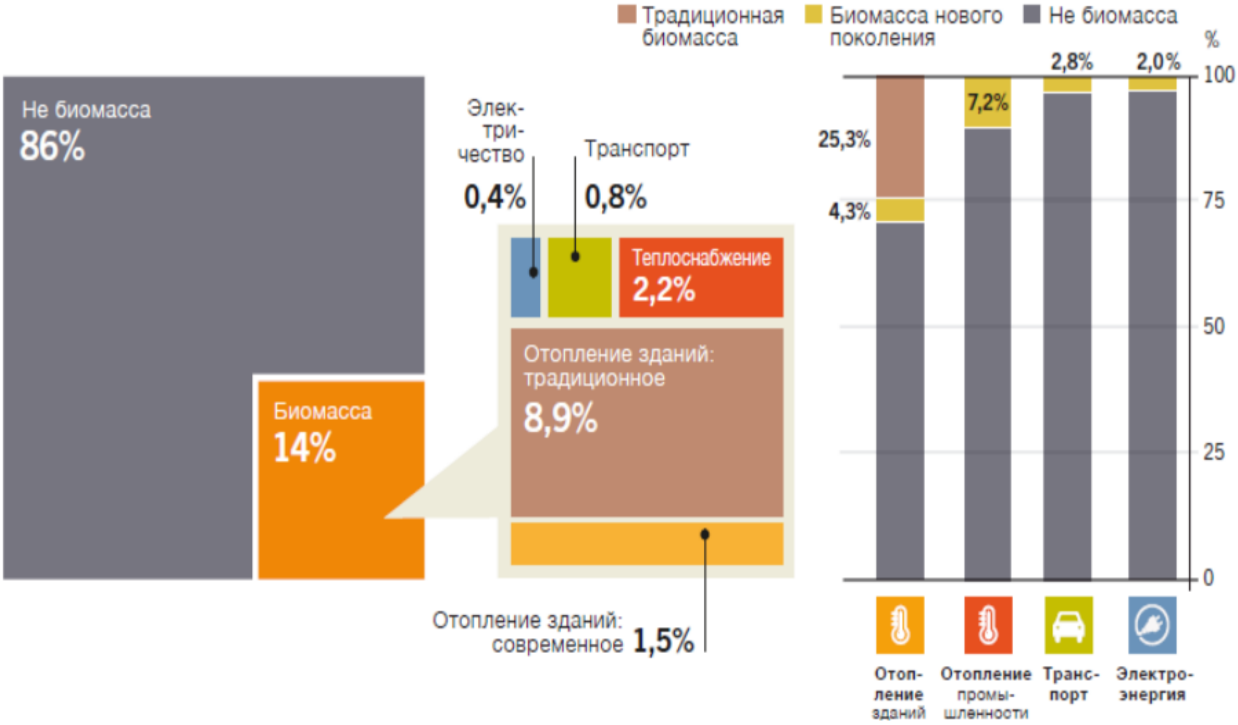

Fig. 1.4 The share of biomass in global energy consumption and in energy consumption by the final consumer.

For the period 2006 - 2015 According to the IRENA International Energy Agency, bioenergy and waste capacity has more than doubled.

IEA forecasts growth until 2030. Demand for primary energy from biomass in 1827 million tons. e., or 12% of total world demand for primary energy, which is twice the volume of 1990 (World Energy Outlook, report on energy and climate change, 2015). According to the IEA, world biofuel production will continue to grow by about 7% annually.

Innovative areas of bioenergy: biofuels, biogas and solid fuel pellets. High world energy prices and the dependence of many countries on their imports, as well as measures to prevent climate change, stimulate the development of technology and the expansion of the use of biofuels, which include primarily biodiesel, bioethanol, biogas and fuel pellets. Biofuels today are an alternative to traditional fuels derived from petroleum. In the long run, the ever-growing demand for biofuels from land, air and sea transport can significantly change the current structure of fuel resources in the global energy market.

According to the IEA, an oil shortage is possible in 2025. It is estimated at 14%, which is significantly higher than in 2015.

Fig.1.5 Global biofuel production, shares by fuel type by country / region

According to the IEA, Brazil and the United States account for 87% of world biofuel production (chart below), primarily due to strong government support. Global biofuel production is projected to grow further, including 6% annual growth in biodiesel and 5% ethanol production in the next decade. Significant increase in production and consumption of biofuels is expected primarily in countries such as the United States, China and India.

The world market for biofuels is growing rapidly. Biofuel production in many countries of the world is stimulated by the provision of significant subsidies, tax benefits and regulation of the mandatory use of biofuels in the proportions set by national regulations.

The global biofuel industry is characterized by a wide range of legislative and regulatory measures for the development of bioenergy, as well as government programs aimed at increasing biofuel production in some countries.

Today, second-generation biofuels (2G) or "improved biofuels" are produced using new technologies from non-food bio-raw materials, which can reduce the conversion of food into fuel, as well as rising food prices in the world.

The raw materials for such biofuel are certain types of specially grown energy plants, wood processing waste and food waste. The main advantages of the 2nd generation biofuel compared to the 1st generation biofuel:

• diversity of biological mass suitable for processing;

• higher production efficiency - on average by 30 - 40%;

• a significant reduction in emissions of some types of greenhouse gases in the process of using biofuels can reach 90% (1st generation biofuels - up to 50%).

Biogas is a product of processing a wide range of wastes (agricultural, municipal, industrial) containing a high proportion of methane. The main directions of development of biogas technologies in the world:

1. Biogas plants for processing of own wastes of the enterprises (farms, the enterprises of the food and processing industry, stations of sewage treatment).

2. Construction of powerful centralized biogas complexes for processing of municipal, industrial and agricultural wastes, wastes of livestock enterprises and food industry enterprises with production of electric and thermal energy.

3. Fermentation of livestock waste and energy crops using the obtained gas for the production of heat and electricity.

4. Construction of large biogas complexes using biomethane as a substitute for natural gas, primarily in the field of electricity (TPPs, CHPs and boilers).

5. Establishment of enterprises for mechanical and biological processing of the organic fraction of municipal solid waste with its subsequent use in boiler houses.

6. Collection and utilization of biogas at municipal solid waste landfills. The highest growth rates of biogas production were observed in the European Union, the United States and China.

Biofuels in the energy sector. In the countries of the European Union, the average use of biofuels for heat production is 15%. However, a number of countries are significantly ahead of European indicators. In particular, in Sweden 61% of heat is obtained on the basis of biofuels, in Austria - 37%, Denmark - 35%, Finland - 32%. At the same time, mainly for thermal energy, solid biofuels are used in European countries: pellets, fuel pellets, etc. For example, in Finland, the total use of solid fuels for solid energy accounts for 94%, in Poland - 93%, in Austria - 89%, in Sweden - 78%.

In general, the situation with the use of different types of biomass in Europe is diverse. If in Finland, Austria and Sweden the predominant share of thermal energy is obtained due to the processing of biomass itself, in France only solid household waste is processed.

Modern biotechnology is a thermal power plant that runs on biofuels, the efficiency of which is comparable to similar indicators of traditional CHP, which uses fossil fuels. IS

Biomass power plants with a capacity of 10 - 50 MW provide an efficiency of 18 - 33%, which is slightly lower than the similar efficiency of fossil power plants.

For example, China is actively re-equipping inefficient existing and building new power plants, the main fuel of which is waste, and primarily - municipal solid waste (TPP on solid waste). In addition to energy production, they solve an important social task - cleaning large cities from waste, and also help reduce greenhouse gas emissions in. Lithuania's experience in the development of bioenergy is also significant. The country is successfully switching to local biofuels for heat production. In 2002, its share in the total fuel balance was 5%, in 2014 - 49%, and in 2020 it is planned to increase to 80 - 90%. At the same time, the consumption of natural gas in the country's energy balance was reduced from 83% to 47%, and oil products - from 27.3% to 2.5%.

Development of new bioenergy technologies. One of the main global strategic objectives is to create organizational and legal bases for the formation of new markets for biotech products, primarily in industrial biotechnology and biofuel production. The world biofuel market has all the characteristics of innovative markets: research is constantly being conducted in the field of improving manufacturing technologies, improving the physical and chemical characteristics of biofuels.

Third generation biofuels are a new technology for the production of biofuels from algae. Algae can be used to produce methane by anaerobic fermentation or ethanol by fermentation. But their greatest potential value is that they can be used as raw materials for biodiesel production. Algae processing produces 3.5 times more fuel than palm oil, 5 times more fuel than sugar cane, 8 times more fuel than corn, and 40 times more fuel than soybeans.

Green Fuel Technologies Corporation (USA) has developed algae cultivation technology that works on CHP emissions. Flue gas or other CO2-enriched gas streams are passed through the bioreactor. The gas optimizes the growth rate of algae, which begin to actively reproduce. The technological process allows to obtain alcohols, biodiesel, high-quality animal feed, while significantly reducing CHP emissions: NO2 - up to 86% and CO2 - up to 40%.

1.4. Type of biofuel

Depending on the physical state, there are three types of biofuels:

- liquid - bioethanol and biodiesel (their production is becoming more and more, they are used as a substitute for mineral fuel - gasoline and diesel fuel - for internal combustion engines), demethyl ether, biomethanol
- solid - firewood, wood pellets (can be made from small branches, sawdust, tree bark, wood chips and other wood waste) and pellets (they are obtained from straw, seed husks, nut shells, etc.)
- gaseous - biogas, methane and biohydrogen, obtained as a result of the process of natural decomposition of various organic substances - methane fermentation.

Depending on the source material used for production, biofuels are divided into several generations:

- <u>first generation biofuel</u> - it is obtained using traditional technologies from vegetable and animal fats, as well as starch and sugar. For the most part, sources of raw materials belong to the product group, which causes a wave of criticism, as the production of biofuels reduces the number of products and causes an increase in their value. Another disadvantage - this type of biofuel is quite expensive, its production requires additional support (subsidies) from the state

- second generation biofuels - for its production biomass is used, consisting of non-food or residual parts of plants: husks, leaves, stems, as well as wood chips, pulp of vegetables and fruits, which remains after squeezing the juice, etc. Modern technologies allow to obtain useful raw materials from fibrous or woody biomass, which contain lignin or sugar, from which further biofuel is obtained.
- third generation biofuel - a promising technology that allows you to get cheap biofuels after processing algae. Algae - highly productive and at the same time - cheap raw materials. One hectare of algae can produce 30 times more energy than a hectare of soybeans. The issue of allocating areas where algae cultivation will be carried out on an industrial scale is problematic.

Table 1.1

Comparison of combustion heat estimation of different types of solid fuels

Type of fuel	Heat of combustion	Sulfur,%	Ash,%	Carbon
Natural gas	35-38 MJ / m^3	0	0	57 kg / GJ
Wood pellets	17,5 MJ / kg	0,1	0,5-0,3	0
Straw pellets	14,5 MJ / kg	0,2	4,0	0
Husk pellets	15,5 MJ / kg	0,1	1,0-2,0	0

1.5. Impact of Biofuels of the environment

One of the promising areas for reducing emissions pollutants in the atmospheric air area are used alternative energy sources, in particular bioenergy based on by-products crop, livestock, forestry and processing products household waste.

The European Union has set ambitious goals - to reduce greenhouse gas emissions by 20% by 2020, increase the share of renewable energy sources to 20% and increase energy efficiency by 20%. To this end, renewable energy action plans have been developed for all 27 EU countries. For example, Sweden should increase the share of renewable energy to 49% by 2020, Latvia - 40%, and Finland - 38%. To date, most EU countries have seen a significant increase in the use of renewable energy sources. For example, Sweden has already "overfulfilled" the plan and exceeded the level planned for 2020.

The latest report on the implementation of renewable energy plans showed that 13 countries are leaving ahead of schedule and only two - with some lag behind the planned goals. In general

The EU has passed the 13% mark with 2% exceeding the planned level. It is assumed that the EU will cross the 20% mark before 2020. [11]

Significant advantages of bioenergy are its cheapness and rather large volumes of bioresources. The disadvantages of bioenergy are their uneven distribution in time and space and lower energy concentration. It is important to take into account the impact of biofuel combustion on air pollution.

The transition to alternative fuels in Ukraine will also help solve environmental problems: biofuels do not pollute the atmosphere, do not contribute to global warming, do not affect public health due to emissions that cause lung disease and allergic diseases, and so on.

Fossil fuel combustion is the most common way of producing energy. However, each of its stages has a negative impact on the environment: it emits,, NO, solid particles and dust. In addition, heavy metal oxides are released into the air. - the main component of greenhouse gases, contributes to global warming, while other acid gases and NO form acid precipitation, degrade air quality. Combustion of fossil fuels, including motor fuels, is a source of approximately 80% of emissions.

The main advantage in the use of biodiesel is associated with the reduction of exhaust gases: carbon monoxide, hydrocarbons and particulate matter. Biodiesel is considered to be neutral in terms of carbon emissions, when carbon dioxide is released into the atmosphere, it is absorbed by plants and does not harm the environment. Nevertheless, the use of biodiesel in engines increases nitric oxide emissions, but they can be controlled by making certain decisions, such as adding methane improver, injection delay, exhaust gas recirculation, etc.

Biodiesel is the most promising alternative fuel compared to others, due to the following reasons [12]:

- biodiesel can be used in existing engines without any design changes;
- biodiesel is made exclusively from plant sources, it does not contain sulfur, aromatic hydrocarbons, metals and petroleum residues;
- biodiesel - is the oxygen of the fuel. Emissions of carbon monoxide and gases are lower compared to conventional diesel fuel;
- Unlike extractive fuels, the use of biodiesel does not affect global warming, CO2 (carbon dioxide) emissions are absorbed by plants.
- biodiesel can be classified as a non-combustible liquid;
- the use of biodiesel can extend the life of diesel engines, because the lubricating properties are greater compared to diesel fuel;
- Biodiesel is made from renewable vegetable oil (animal fats) and, therefore, increases fuel or energy security and economic independence.

Biofuels are still a source of energy that is easily supplied, but it also has its drawbacks. The real question is whether they outweigh the benefits, or at least whether it is possible to put them in balance before fossil fuels? To understand, it is necessary to look at the pros and cons of fossil fuels and compare them with biofuels (Table 1.1). Therefore, along with a number of disadvantages, biofuels have a number of advantages over fossil fuels, however, its integration into the supply chain must be done with great care [14].

Table. 1.2

Comparative characteristics of biofuels with fossil fuel analogues

Biofuels	Fossil fuel	Differences
Ethanol	Gasoline, ethane	About half of the energy of ethanol is accounted for by the mass of gasoline, which means that you need twice as much ethanol to obtain the required energy. Ethanol burns cleaner than gasoline and produces less carbon monoxide. However, ethanol produces more ozone than gasoline and makes a significant contribution. Engines must be modified to run on ethanol.
Biodiesel	Diesel	It has not much less energy than conventional diesel fuel. However, it causes corrosion of engine parts, unlike a standard diesel. This means that the engines must be modified to use biodiesel. It burns cleaner than diesel, producing fewer particles of sulfur compounds.
Methanol	Methane	Methanol has almost a third more energy than methane. It is liquid and easily transported, while methane is a gas that must be compressed for transportation.
Biobutanol	Gasoline, butane	Biobutanol has slightly less energy than gasoline, but can run in any machine that uses gasoline without the need for engine modification.

The use of biomass for energy production already accounts for about half of all renewable energy sources in the world, reaching 70% in Europe, 64% in Sweden, 33% in Denmark and Austria. In 20 years, biomass prices will be as well calculated as coal, oil or gas. Experts expect that investments in the market for growing energy crops will increase to $ 25 billion by 2020, while in 2006 they amounted to $ 2 billion. [13].

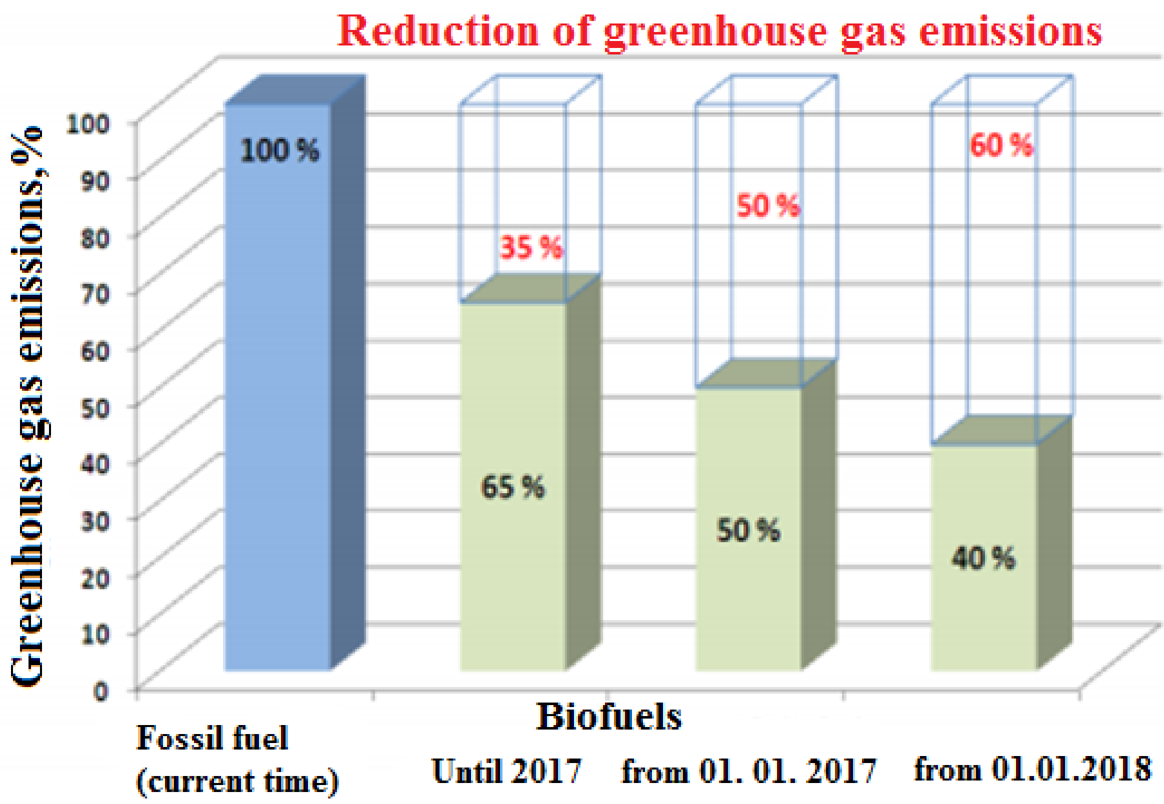

Figure 1.6. - Reduction of greenhouse gas emissions from biofuels according to sustainability criteria

In particular, 1 m3 of crude biogas produces an energy of 23 MJ, and per energy efficiency is equivalent to 0.6 m3 of natural gas. When burning 1 ton of wood briquette, the same amount of energy is released as when burning 1.6 tons of wood, 480 m3 of gas, 500 liters of diesel fuel or 600 liters of fuel oil. 1 kg of pellets is equivalent in heat to burning 0.5 m3 of natural gas, and 1 liter of biodiesel is almost not inferior to 1 liter of diesel fuel.

Table 1.3

Calorific value of different fuels

Type of fuel	Calorific value MJ / kg
Diesel fuel	36
Gasoline	39
Wood	12
Lignite	16
Briquettes from wood waste	18
Coal	20
Natural gas m3	32
Biogas m3	23
Oil fuel	29
Biodiesel	33
Pellets	16

1.6 Conclusion to the chapter

Thus, the biofuel market in Ukraine is in the process of formation, but the raw material supply of this market has very promising areas of development, which significantly depend on importers (mainly European countries), as domestic consumption is insignificant. Global growth in demand for energy crops contributes to rising prices for them, which generates an increase in supply. Therefore, Ukraine's agriculture has every chance to become an industry that can provide not only food but also, to some extent, energy security of the country**.**Ukraine has sufficient resources potential for the production of biocomponents, a number of industrial facilities and can provide raw materials the country's need for liquid biofuels. These opportunities open up prospects for application on transport of bioethanol and biodiesel of own production. It can be argued that the use liquid biofuels, as well as the development and implementation of new technologies for their development - is economical priority today for the economy of our country. At the same time, Ukraine is deprived of an effective one mechanism of bioethanol and biodiesel distribution on its own territory.

In general, it is clear that Ukraine wants to stimulate the use of biofuels as a new impetus will promote the development of the agricultural sector, energy sector, transport etc. It should be noted that, in general, the current legislation of Ukraine has created a proper basis for stable development of the market of alternative fuels in Ukraine. In particular, this applies to tax benefits provided by the state to participants in this market. However, the state budget is limited for biofuels, heated political debate and Ukrainian bureaucracy are still delaying a successful large-scale introduction of biofuels.

It is worth emphasizing that the use of economic incentives and the definition of a stable strategy. The development of the liquid biofuel market will involve an increase in the production of ethanol, biodiesel or others types of liquid or gaseous biofuels from raw materials of agriculture and forestry. It will allow replace the use of fossil fuels as stationary (eg biodiesel for power plants) and for mobile use (motor fuel).

Thus, it should be noted that state regulation for the formation and development of the liquid biofuel market extremely necessary. It should be remembered that the state is unable to introduce or abolish objective economic conditions of development, but it is able to create conditions under which society as a whole, individual industries, markets can develop effectively and predictably.

CHAPTER 2
ALGAE AS AN ALTERNATIVE RAW MATERIAL FOR BIOFUELS

Microalgae are a great biological resource. They are used in various branches of science and technology. Biotechnological investigation of microalgae has been actively developing lately.

Microalgae are unicellular species which exist individually, or in chains or groups. Depending on the species, their sizes can range from a few micrometers (μm) to a few hundred micrometers. Unlike higher plants, microalgae do not have roots, stems, or leaves. They are specially adapted to an environment dominated by viscous forces. Microalgae, capable of performing photosynthesis, are important for life on earth; they produce approximately half of the atmospheric oxygen. Microscopic algae produce half the oxygen we breathe. [15] And use simultaneously the greenhouse gas carbon dioxide to grow photoautotrophically. Microalgae, together with bacteria, form the base of the food web and provide energy for all the trophic levels above them. Microalgae biomass is often measured with chlorophyll a concentrations and can provide a useful index of potential production. The standing stock of microphytes is closely related to that of its predators. Without grazing pressures, the standing stock of microphytes dramatically decreases.

2.1. Biofuel production technology

There are several technologies for biofuel production. Biodiesel production technology is being improved in many countries. It is considered promising to focus on the processing of biomass into a liquid product using catalytic processes. [44]

Table 2.1

Basic technologies for biodiesel production

The name of the technology	**Characteristic**	**Benefits**	**Disadvantages**
Cyclic with the use of catalysts	the reaction temperature is about 65 ° C, atmospheric pressure, reaction time from 20 minutes up to 2 hours, the amount of catalyst - 1.5% by weight of oil, the yield of ether - about 85% of the total weight of biodiesel	- relative simplicity of the technological process - low cost of the technological line - the possibility of using low quality raw materials	- low ether yield - reaction time
Catalyst-free cyclic	reaction temperature 30 ° C, atmospheric pressure, reaction time 5… 10 min., solvent - tetrahydrofuran, ether yield - about 98% of the total mass of biodiesel	- high ether yield - low temperature and high reaction rate - purity of products	- the need for expensive and aggressive solvents - the need to use additional equipment
Multi-reactor continuous	reaction temperature 80… 160 ° C, pressure 2… 3 atm, reaction time - from 6… 10 min., amount of catalyst - up to 1% by weight of oil, ether yield - up to 98% of total weight of biodiesel	- high ether yield - continuity of the process - reaction rate	- the complexity of the technological process - rather high cost of the technological line - high sensitivity to the quality of raw materials

Today, there is a wide variety of technologies for the production of vegetable oil and diesel biofuels, but not all of them are widespread due to problems with the necessary equipment and low efficiency. Conventionally, all technologies can be divided into two groups: industrial (multi-stage technology of vegetable oil and diesel biofuel production using methanol) and agro-industrial (abbreviated version of industrial technologies, specially adapted to meet the own needs of farms in fuel) [45]

Industrial (Fig. 2.1) production technology is traditionally used in large plants with an annual output of diesel biofuel from 20,000 to 100,000 tons / year. It consists of the following processes: esterification; separation into fractions of methyl ether (crude diesel biofuel) and glycerol (by-product of diesel biofuel production); purification of diesel biofuel (distillation of methanol, as well as washing with acidified water, re-washing with water, dehydration and purification from gel sludge by filtration or precipitation of diesel biofuel).

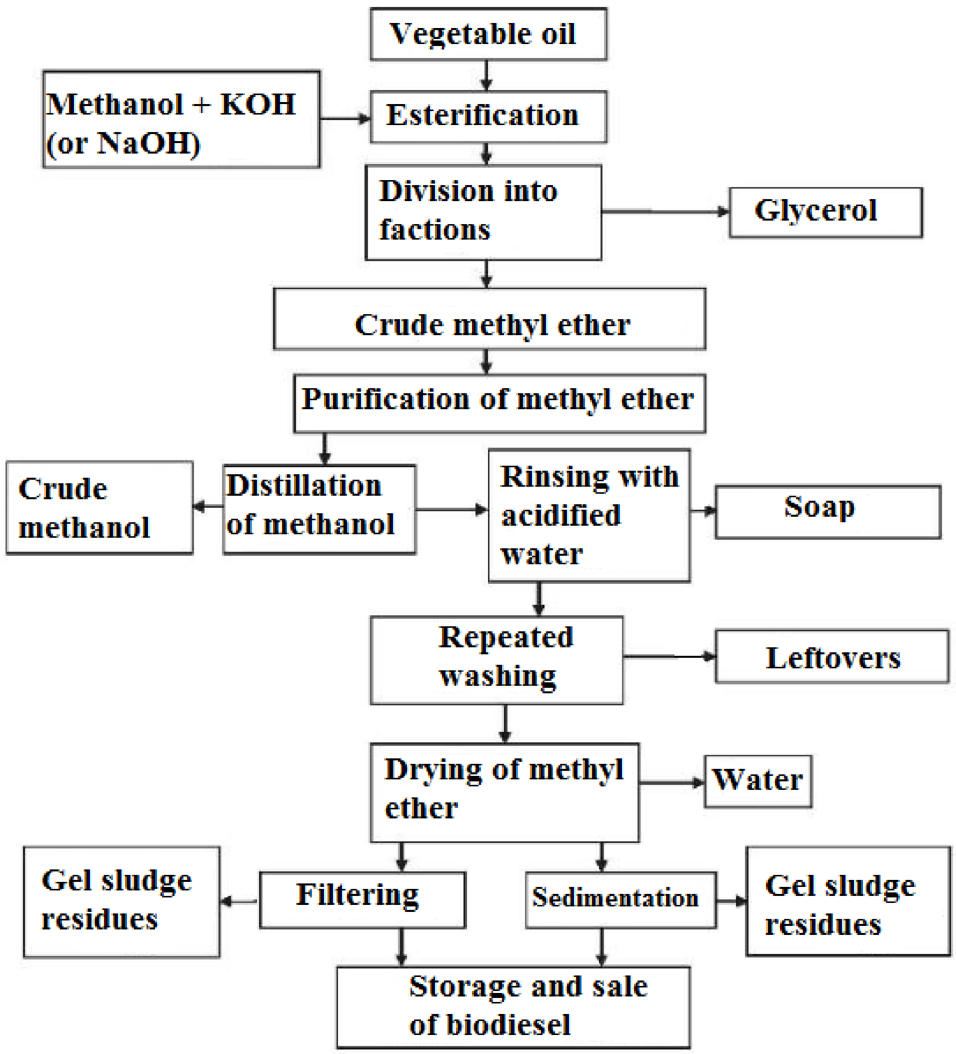

Fig. 2.1. Scheme of industrial production of diesel biofuel

The advantages of industrial technology for the production of diesel biofuels include its high quality, which makes it possible to use diesel biofuel both in mixtures and without the addition of traditional diesel fuel. The main disadvantages: the size of the equipment, low productivity, high energy costs, high cost of production.

Agro-industrial (Fig. 2.2) technology for the production of diesel biofuel is widely used in commercial and small plants with an annual output of diesel biofuel from 100 to 5000 tons / year. [46]

It consists of esterification; separation into fractions of methyl ether (diesel biofuel) and glycerol (by-product of diesel biofuel production); purification of diesel biofuel (distillation of methanol and purification from gel sludge by filtration or precipitation).

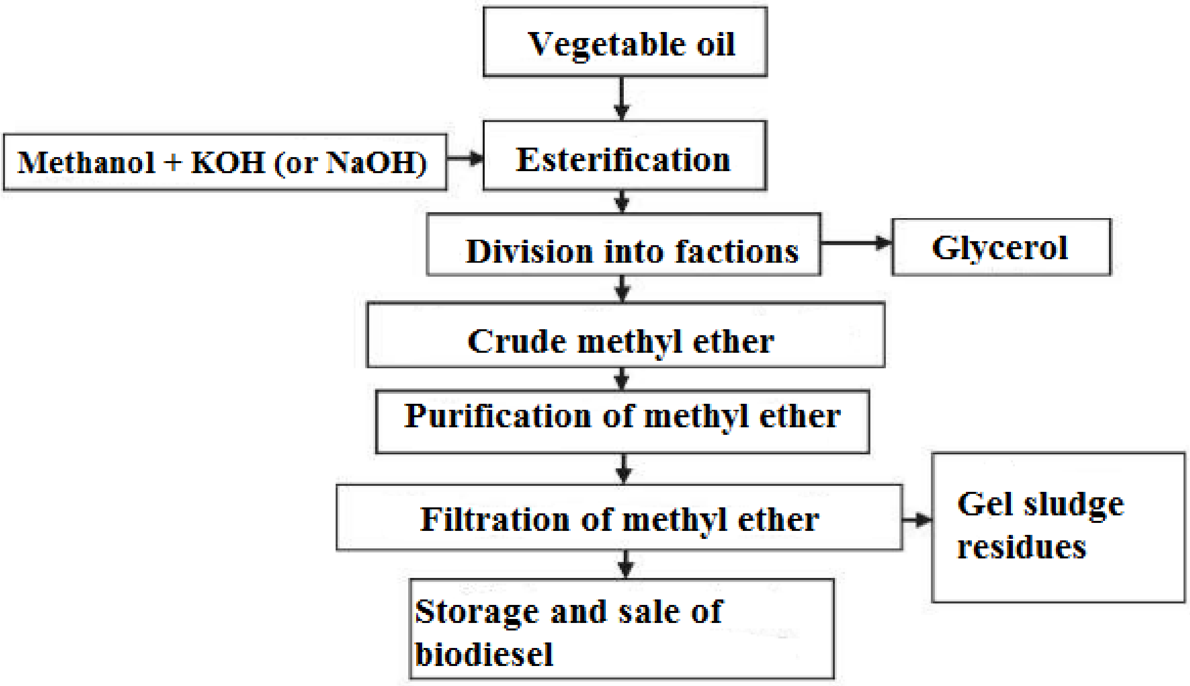

Fig. 2.2. Scheme of agro-industrial production of diesel biofuel

The advantages of this technology include: lower energy consumption compared to industrial technology, availability in use, lower costs for chemical reagents, lower equipment size, low cost of production, no technological operation of washing with subsequent dehydration of biodiesel biofuel, which, in turn , reduces energy consumption and reduces production productivity by increasing the settling time.

Given the needs and fuel prices of the modern market of fuels and lubricants, there is a need to put into operation new technologies for the production of diesel biofuels, the products of which could compete with traditional diesel fuel. Agro-industrial technology for the production of diesel biofuels can meet the needs of economic entities with their own fuel for the operation of machine-tractor units, it is available in material costs and is easy to use.

2.2. Possibilities of biodiesel production from microalgae

The fuel crisis of the 1970s gave impetus to a number of projects, including the production of diesel fuel from blue-green algae. However, the technologies developed at that time turned out to be too expensive, and the costs of producing such fuel were too high. Today, however, unpredictable energy prices and advances in modern biotechnology have breathed new life into forgotten research. Algae (Latin Algae) means various, mainly aquatic organisms that contain chlorophyll and produce organic matter in the process of photosynthesis. From the "fuel" point of view, the most interesting are microalgae, which live almost everywhere where there is moisture, and number more than a hundred thousand species. They need sunlight, carbon dioxide and water to grow.

In the process of photosynthesis, due to which solar energy is converted into chemical, microalgae accumulate lipids and fatty acids in cells. Some species produce 15 times more oil per hectare than traditional crops, such as rapeseed, palm or soybean (Table 2.1). Others grow so fast that they double in size three to four times a day.

Table 2.2

Oil yield from different sources [16]

Source of oil	**Annual oil yield, l / ha**
Corn	160…170
Soy	440…460
Sunflower	950…1000
Rapeseed	1100…1200
Coconut tree	2600…2700
Palm oil	5900…6000
Microalgae (achieved indicators)	17 300
Microalgae (theoretical laboratory parameters)	
up to 30% of the mass. oil in biomass	46 800…58 700
up to 70% of the mass. oil in biomass	140 000…158 000

The search for the most suitable plants for biofuel production continues, as algae with a high oil content tend to grow more slowly than others. For example, algae containing up to 80% lipids divide only once in 10 days, while those containing 30% - three times a day.

On the other hand, species capable of producing large amounts of lipids do so in the absence of nutrients. However, this shortcoming further slows their growth. Some researchers hope to genetically modify algae to produce more oil. Others create yellow algae that allow sunlight to penetrate deeper into the water and promote more even growth.

The next culture can be recomended for cultivating, which have percentage of lipids in them [17-18]**:**

- Botryococcus braunii – 25-85%;
- Neochloris oleoabundans – 35-54%;
- Stichococcussp – 40-59%;
- Nannochloropsissp – 31-68%;
- Dunaliella tertiolecta – 36-42%;
- Dunaliella salina – 16-44%;
- Haematococcus pluvialis – 25-45%;
- Scenedesmus dimorphus – 16-44%;
- Prymnesium parvum – 22-38%;
- Tetraselmis suecica – 20-30%;
- Chlorellasp – 28-32%;
- Chlorella vulgaris – 14-22%;
- Isochrysis galbana – 22-38%;
- Euglena gracilis – 14-20%.

From 1978 to 1996, the US Department of Energy funded research into the high oil content of the Aquatic Species Program. Scientists then concluded that only California, Hawaii, and New Mexico, states with high average temperatures and small fluctuations during the day, were suitable for industrial production of algae in open ponds.

In the proposed areas, algae were grown in ponds with an area of 1000 m^2 for 6 years. The yield was 50 g / m^2 daily. In other words, 200,000 hectares of ponds (less than 0.1% of the land available for this purpose) can supply fuel to 5% of American motorists during the year (one refinery occupies about 500 hectares).

In addition to "open" technology, raw materials were also grown in small bioreactors located near low-potential low-cost heat sources (nuclear or thermal power plants). Thermal emissions from thermal power plants and combined heat and power plants can meet up to 77% of the energy needs of such plants.

In the late 1990s, the algae fuel program was curtailed due to low oil prices (up to $ 15 / barrel), but in 2007 the study resumed. DARPA, in collaboration with Honeywell (UOP LLC), General Electric and the University of North Dakota, sponsored the development of aviation fuel from such raw materials.

In December 2007, Shell and BioPetroleum HR formed a joint venture to build a pilot plant in Hawaii for the production of small volumes of oil and its conversion into biofuel.

The construction of plants for the production of biodiesel from algae was announced:

- Global Green Solutions (Canada) on the technology of Valcent Products (USA) - capacity 4 million bar. for a year;

- Bio Fuel Systems (Spain);

- De Beers Fuel Limited (South Africa) based on Greenfuel Technologies Corporation (USA) - capacity of 900 million gallons of biodiesel per year (algae + oil);

- Aquaflow Bionomic Corporation (New Zealand) - capacity of 1 million liters of biodiesel per year.

Considering microalgae as a fuel raw material, it should be said that they are the only oil crop from which they do not produce food, feed and other agricultural products. Eventually, this fact may become decisive, as the EU already recognizes that by campaigning for biogasoline and biodiesel (in Germany, France, Austria, the Czech

Republic, up to 14% of arable land has already been allocated for rapeseed), they did not guess what this could lead to. The growing popularity of non-traditional fuels has had a significant impact on the price of grain and oil. Redesigning arable land, reducing yields, increasing consumption - all this can provoke a global crisis in the food market. In the report "Bioenergy that does not harm the environment" UN experts emphasize that to increase the share of biofuels in the energy balance, it is necessary to consider a system of growing and restoring food crops. The situation can be changed by using oil derived from microalgae for biodiesel production. It's up to you to learn how to effectively process wet biomass into a product suitable for car fuel tanks.

One of the simplest examples of using algae as an energy resource is a house built in Hamburg, Germany [20]. BIQ house is a joint project of several companies. The building was built by the Austrian company Splitterwerk in collaboration with Arup, Colt International and Strategic Science Consult of Germany. What makes this house special is that its facade on the south-eastern and south-western sides is lined with glass panels-bioreactors two centimeters thick, which contain microalgae - the inhabitants of the nearby river Elbe. Such panels allow not only to produce energy, but also protect the room from direct sunlight in summer, as well as reduce noise.

The concept of BIQ house is based on the fact that microalgae grow and reproduce well in sunlight. The naturally occurring biomass is then sent to a specialized bioreactor with enzymes to produce biogas, which is used for heating and electricity generation.

The developer claims that such technologies can be easily scaled on buildings of any size. Such an approach to the design of houses would allow, among other things, to solve the environmental problem of large cities - to purify the air by converting carbon dioxide into oxygen in the course of their lives [21].

Figure 2.3. The first experimental house BIQ house, which generates energy using microalgae panels located on its facade (Hamburg, Germany)

2.3. Algae production technologies from biofuels

As for biofuel extraction technologies, there are many different options. For example, scientists from the Pacific National Northwest Laboratory of the US Department of Energy propose to convert algae into oil, simulating a natural process using a specialized reactor, which injects hot water at a pressure of 20.7 MPa and a temperature of 350 ° C [22]. The technology developed by them sharply speeds up the process, so in less than an hour the reactor produces oil and a small amount of biogas, from which methane can be produced.

In Japan, Tokyo Gas and NEDO have proposed a technology for fermenting seaweed biomass using microorganisms to produce methane [23]. Methane extracted from algae is sent to a gas engine that rotates an electric generator. The developers claim that such an

installation processes 1 ton of algae per day, with a methane yield of 20,000 liters. The power of the generator of this installation is 10 kW, which is enough to power 20 houses
More traditional technologies for obtaining biofuels from algae (alcohols, methane, biodiesel, hydrogen with synthesis gas, solid biomass briquettes) include extraction (including ultrasonic), transesterification, fermentation, anaerobic processing, gasification and drying.
But, it is clear that in contrast to the house BIQ house, which itself "grows" algae, industrial production of biofuels requires a different organization of raw material preparation. That is, the process of growing algae biomass is very important in such a situation.

What are seaweed oils?
Green algae are metabolically universal and produce important compounds for renewable biomass directly from sunlight. They can synthesize cellulose, a polymer of glucose as part of their own cell walls, accumulate starch as a reserve nutrient and, more importantly, store significant amounts of lipids and fatty acids as energy stores. Fats produced by algae are chemically very similar to the product of oilseeds and are stored in the form of triacylglycerides.

There are also several methods for isolating lipids and processing them to produce biodiesel. The usual methods of obtaining oil from algae are to squeeze it from dried raw materials or add chemicals. In this case, the oil must be treated before it is used as a fuel by standard methods used for raw materials obtained from crops.

2.4. Growing algal biomass

There are 3 ways to grow algal biomass: in outdoor pools, in indoor pools and in photobioreactors [5].

For the first method, a number of sequentially arranged tanks connected by transparent pipes on supports are used. Algae and water are pumped through the pipes, providing maximum exposure to sunlight. The carbon dioxide injected into the installation feeds the algae.

The risk of algae contamination is very small because they live in conditions close to laboratory conditions. Yield is also high, the equipment occupies a small area, but its cost is quite high (for industrial production requires several kilometers of pipes), and significant costs for maintenance of pipes

An alternative method is to pump water through a closed open channel. Approximately as much water circulates in this canal as in the 50-meter swimming pool.

Closed algae biomass cultivation systems are greenhouses with photosynthetic blocks, which are usually located as close as possible to heat and sun. This method of growing biomass is mostly used in countries with cold climates.

Fig. 2.4. Closed algae biomass cultivation systems

Photobioreactors provide high yields in a short time and can be used anywhere, regardless of environmental and climatic conditions. In addition, they can affect the quality of grown biomass, namely the oil content in raw materials. Because, although algae are highly efficient converters of solar energy into renewable biomass, most known algae store solar energy in the form of sugars and not in the form of essential oils (fats or lipids), ie triacylglycerides or phospholipids [24]. In the presence of light, carbon dioxide and some trace elements, most algae store in the form of fats only about 15-20% of their dry weight. Only under certain conditions are algae able to switch to a process known as the "lipid trigger" and store photosynthesis products inside their cells in the form of oils.

In photobioreactors there is an opportunity to create the most favorable conditions for cultivation in biomass of those substances which are necessary in this or that case. They provide algae with the necessary nutrients, carbon dioxide, a stable pH value of the environment, maintaining the osmotic nature of the environment, the homogeneity of the composition of the environment, provide control and regulation of ambient temperature.

Figure 2.5. Photobioreactor for algae biomass cultivation, Algae Extraction and Processing Center (Atlanta, USA)

Open water is cheaper than closed systems, but they have disadvantages: sunlight reaches only the algae near the surface, the water evaporates easily, it is more difficult to control the temperature (if it is much lower at night than during the day).

Figure 2.6 Open algae biomass cultivation system

The risk of contamination is also increasing, as algae-eating organisms are more likely to enter open water. Another problem for both systems is the high water consumption, which should be updated daily, pre-keeping in the dark.

In outdoor pools, algae are grown in areas where it is possible for environmental and climatic indicators (algae require at least +15 ° C). This method is used in Bulgaria, Italy, Israel, Mexico, Chile, Brazil, Thailand, India, China, USA (California), Central Asia and Kazakhstan. It is more economical, but gives less yields. In addition, this method is very difficult to control the purity of strains of microorganisms.

Figure 2.7. Sapphire Energy Algae Farm (New Mexico, USA)

2.5. The use of algae as a feedstock for biofuels

The most relevant at present is the development of approaches to the industrial production of biofuels of the "third" generation, based on the use of algal biomass.

Consider the factors that indicate the feasibility of using algae as a raw material [19]:

1. Algae are a source of oils, proteins, carbohydrates, as well as an excellent raw material for the production of substitutes for natural gas and other energy products.

2. The energy potential of algae is 50-100 times greater than the potential of oilseeds (rapeseed, sunflower), which are known raw materials for biodiesel. It is known that sunflower yields 0.8 tons of oil per hectare, rapeseed - 1 ton, and chlorella microalgae - 79.3 tons.

3. Algae grow 20-30 times faster than terrestrial plants (some species of microalgae can double their biomass several times a day).

The main (and still unresolved) problems are to ensure a stable daily growth of biomass and bring the technology of fuel to a commercially viable level.

The problem with growing algae is their sensitivity to temperature changes. For the normal development of algae, you need to completely eliminate any sharp fluctuations in temperature. Experiments conducted in the United States under the Aquatic Species Program have shown that California, New Mexico, and Hawaii are optimal for growing algae in open water. The yield of the reservoir in New Mexico was 50 grams of algae per square meter. In addition, to date, no effective method has been developed to collect algae grown in large bodies of water. Scientists have calculated that algae need to be grown in a total area of Montana to cover US diesel needs.

Collecting algae and making oil from them is another obstacle. The size of microalgae is too small to collect them by filtering water. Algae-growing plants for the pharmaceutical industry use other methods, such as centrifugation or the introduction of chemicals that promote the bonding of algae. However, both of these methods are expensive in industrial use.

An alternative to growing algae in open water can be the use of special bioreactors, which can be located near thermal or nuclear power plants. The heat they emit can cover up to 75% of the heat required for growing algae. This technology allows you to get biodiesel from algae in almost any part of the planet, not just in hot desert climates.

The main goal of the researchers is to reduce the cost of biofuel production from algae. The result can be considered satisfactory if you can reach the level of $ 0.5 / liter.

2.6. Conclusion to the chapter

Thus, many technologies for obtaining ecological biofuels from algal biomass are known today. Our country should be interested in such developments not only in terms of improving the environmental situation, but also in terms of alternatives to traditional energy sources, given the energy crisis in which we now find ourselves.

Technologies for the use of algae as an energy source occupy one of the central places among the approaches of modern alternative energy. This approach has significant advantages: first, the use of algae will preserve valuable agricultural land to meet the food needs of mankind. Second, algae are more productive sources of vegetable oil compared to traditional oilseeds.

It is known that in Ukraine there are already developments in this area. The first to take such an initiative were the specialists of OJSC BiodieselDnipro (Dnipropetrovsk), who developed their technology and equipment for the production of microalgae and oil for the production of biofuels .

CHAPTER 3

EVALUATION OF EFFICIENCY OF BIOFUEL PRODUCTION FROM MICRALGAE

3.1 Assessment of biomass cultivation in Ukraine

Microalgae cultivation requires significant amount of energy. Taking into account that Ukraine's weather conditions are not among the most favorable in comparison with other regions of the world, the cost of cultivation in Ukraine is expected to be high [27].

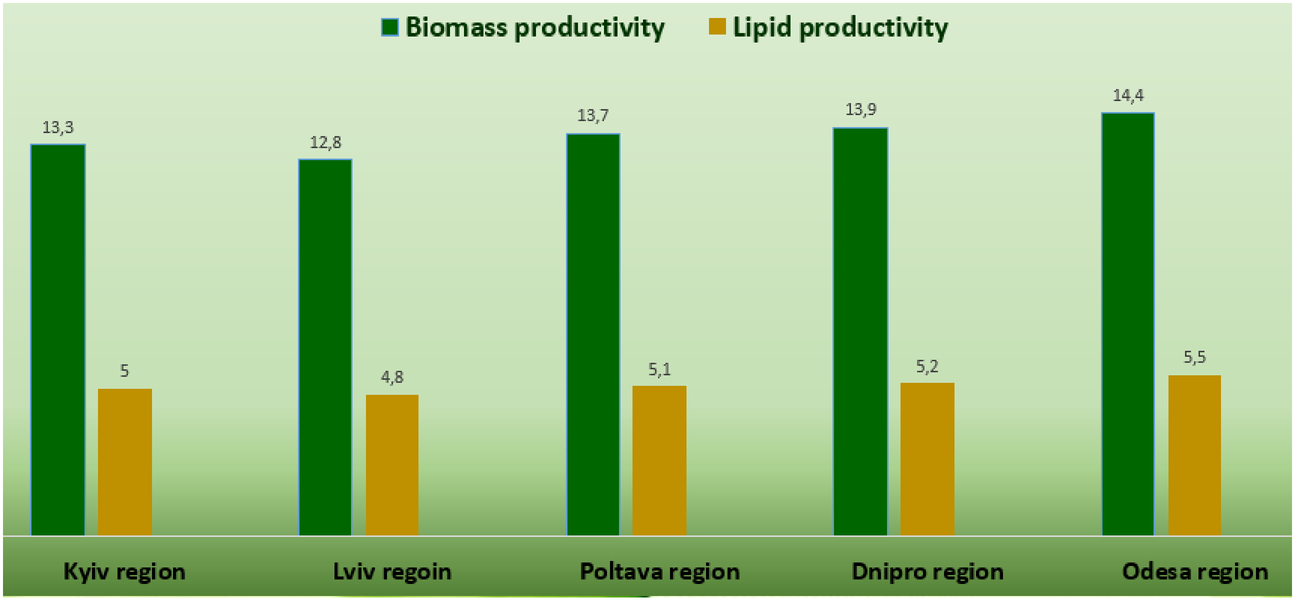

Figure 3.1 Annual biomass and lipid productivity of microalgae cultivation in typical regions of Ukraine, kg/m^2 [36]

To carry out the process of photosynthesis microalgae require biogenic elements. They must be added to the culture medium [28-30]. To reduce the cost of cultivation and provide its higher ecological and economic efficiency, it is proposed to use mechanically purified municipal wastewater as cultural medium [31-33]. The wastewater can contain significant amount of nutrients, especially nitrogen and phosphorus compounds. Household wastewater can contain total phosphorus from 5 to 20 g/m3 [34].

Phosphorus contribution of one inhabitant of residential area to residential sewerage is estimated from 0.65 to 4.80 g/day. The average value is 2.18 g/day. This contribution tends to increase due to constantly increasing usage of detergents. Household wastewater can also contain total nitrogen from 50 to 60 g/m3 [35]. The amount can vary depending on the origin of wastewater. Traditional sewage treatment plants with biological treatment have efficiency of phosphorus removal from wastewater about 20%. When the plants apply technology, which does not use denitrification process, they have efficiency of nitrogen removal from wastewater from 20 to 35%.

That means that residual concentration of nitrogen and phosphorous in purified wastewater is significant even after biological treatment. Discharging this wastewater into open waterbodies is often the cause of their eutrophication (intensive development of phytoplankton, especially on the surface of waterbodies).

This phytoplankton prevents sunlight and oxygen penetration of into the water depth, which leads to death of flora and fauna. It is known that a gram of phosphate compounds in open waterbody, if other conditions are favorable, causes blue-green algae biomas growth from 5 to 10 kg. After treatment of municipal wastewater with microalgae can help to reduce the risks of eutrophication processes development and increase the level of environmental safety.

3.2 The economic benefit from the biomass utilization as biofuel production

The average annual productivity of the growth of microalgae by biomass, when cultivated in a photobioreactor in the weather conditions of Ukraine, can accept 11.5 kg/m2 of the surface of the photobio-reactive zone (culture medium). In this case, the average lipid productivity will be 4.1 kg/m2.

Provided that the waste water is in the working area of the photobioreactor as a medium for an average of 3 days, the total volume of photobioreactor working areas for cleaning the effluent of the urban population of Ukraine will be: 5.8×109 × 3 = 17.4×109 l, or 17,4×106 m3.

If the thickness of the layer of effluents as a culture medium in the photobioractor zone does not exceed 0.2 m, then the total area of all photobioreactors should be:

$$\sum S_{bioreactor} = \frac{17{,}7 \times 10^6}{0{,}2} = 87 \times 10^6 m^2 \quad (3.1)$$

Thus, the annual growth of biomass of algae can be:

$$M_{biomass} = 87 \times 10^6 \times 11.5 = 1000.5 \times 10^6 \text{ kg} \quad (3.2)$$

The annual growth of lipids in this will be:

$$M_{lipid} = 87 \times 10^6 \times 4.1 = 356.7 \times 10^6 \text{ kg (3.3).}$$

Under real conditions, with the effective removal of algae biomass from wastewater 90% (data for centrifugation), the efficiency of separating lipids from biomass of algae by 90%, as well as the energy efficiency of processing lipids in biofuels, 90% of the annual mass of biofuel produced can be:

$$M_{biofuel} = 356.7 \times 10^6 \times 0.9 \times 0.9 \times 0.9 = 260.0 \times 10^6 \text{ kg} \quad (3.4)$$

Given that the density of biodiesel is 0.86 kg/l, the volumetric amount of biodiesel produced will be:

$$W_{biofuel} = \frac{260.0 \times 10^6}{0.86} = 302.4 \times 10^6 \text{ liters.} \quad (3.5)$$

Accepting the price of one liter of biodiesel at the level of UAH 28, the total annual profit from the sale of biodiesel will be:

$$П_{biofuel} = 302.4 \times 10^6 \times 28 = 8466.2 \times 10^6 \quad (3.6)$$

UAH= 282.2 × 106 EUR (3.7)

3.3 Recommendations for the development of the biofuel industry of Ukraine

For the sustainable development of the biofuel industry, Ukraine needs a consistent and systematic action plan for at least ten years. According to the authors, it would be appropriate to take the following comprehensive steps in this direction:

1. Fiscal support:

- introduce a tax that will encourage producers to mix traditional fuels with biofuels. The tax must be levied on each liter of fuel sold. Distributors are not required to pay this tax if they prove the presence of a fixed proportion of bioadditives in the fuel they offer;

- set a reduced rate of excise duty for mixed fuels. The single tax rate and the corresponding corresponding maximum volumes of fuel should be revised annually to compensate for the difference in the cost of conventional and biofuel to avoid overproduction;

- diversify the rate of excise duty depending on the share of bioadditives. Initially, the benefits should apply to mixtures with a biofuel content of 2… 5%, with a gradual transition to mixtures with a share of 5… 10% and above;

- completely exempt biofuel plants from taxes for at least ten years; - make biofuel mandatory by establishing a special system of penalties for violating this requirement;

- provide significant tax benefits to suppliers of high quality biofuels and start its production in large volumes;

- to ensure a gradual reduction of state support with the formation of the market; - to develop a program "Clean City", which will promote the development of the biofuel market.

2. Regulatory support:

- develop bylaws governing the use of biofuels;

- to introduce a system of certification and monitoring of quality standards;

- develop requirements for the quality of blended types of traditional petroleum products with a share of biofuels over 5%, improved regulations for reducing CO_2 emissions, setting levels of minimum biodegradation, ensuring zero water toxicity; - to create an institute of quality control

3. Regional development:

- to develop a system of tenders under which biofuel producers will be able to receive an official long-term certificate (for a period of more than five years) for the supply of biofuels by state order;

- provide investment grants (up to 20% of investment needs) to create jobs in depressed regions;

- subsidize interest-free loans or loans with a minimum interest rate for the development of production facilities in depressed regions;

- develop a plan for each region to obtain optimal (in terms of economic and energy efficiency, the degree of protection of soils and water resources) crops.

4. Infrastructure development:

- support competitive infrastructure and technologies - in particular, the fleet of cars with FFV engines;

- create an infrastructure that ensures the collection of biological raw materials and their transportation;

- to ensure uninterrupted supply of energy raw materials to plants depending on the form of harvest, time of harvest, type of harvested material, stage of maturity, environmental conditions, geography and use in processing;

- integrate the transportation of biofuels into the existing transport infrastructure.

5. Ecological rationality:

- to develop ecologically rational strategies of land resources use, taking into account climatic, ecological, social and economic features of regions;

- use both primary and secondary raw materials of agriculture and forestry;

- develop and adopt clear land laws that clearly define the land for growing crops to prevent soil erosion and facilitate their recovery after use;

- encourage the application of voluntary standards. For example, free parking or additional benefits for the use of environmentally friendly vehicles

6. Information and education:

- to position products in certain segments of the biofuel market, to create a positive attitude to it;

- to prevent underestimation of raw material prices, which negatively affects the main stakeholders - farmers;

- to promote the development of environmentally friendly fuels at the national and regional levels, for example, by creating the image of environmentally friendly regions;

- actively involve market participants in public activities, creating the image of environmentally friendly companies, for example, under the slogan "We care";

- ensure the availability of information on incentives for the use of environmentally friendly fuels for the general public;

- to promote a change in the image of biofuels in society, which perceives it as uncompetitive fuel of low quality;

- provide information to farmers on the benefits of biofuels (energy yields, energy value of food crops, as well as residues and by-products).

3.4 Conclusios to the chapter

Microalgae are one of the most promising third and fourth generation sources for biofuel production. It is possible to achieve a yield of more than 10 kg of biomass per square meter of cultivated area in the weather conditions of Ukraine. The amount of accumulated lipids in this case can reach 6.6 kg / m2. The most promising regions for growing can be considered the eastern regions, in particular, the Odessa region.

The main resource that is needed for cultivation is water. This is the basis of the cultural environment. To improve the environmental and economic efficiency of cultivation, municipal wastewater can be used as a culture medium. It is possible to combine cultivation processes and wastewater treatment processes from biogenic elements (nitrogen and phosphorus compounds). Experience shows that by using wastewater as a breeding ground, the use of fresh water can be reduced by up to 90%. Microalgae treatment of wastewater can help reduce nutrient discharges into surface water bodies, thereby reducing their potential for eutrophication. It also allows for additional renewable energy sources, mainly in the form of biodiesel made from microalgae biomass.

CHAPTER 4.

LABOR PRECAUTION

4.1. Analysis of harmful and dangerous production factors

According to the topic of my diploma project «Evaluation of the efficiency of biofuel production from microalgae» the growth of microalgae is observed in the laboratory. It is necessary to pay attention to the requirements for the workplace area, safe use of equipment and reagents.

In the course of performance of works on the laboratory tester the following dangerous and industrial production factors according to ГОСТ 12.0.003-74 «System of labor safety standards. Dangerous and average production results. Classification "

ГОСТ 12.1.005-88 "Air of the working area. General sanitary and hygienic requirements ". ДСН 3.3.6.042-99 "Sanitary norms of microclimate of industrial premises". "Methodical instructions for measurement aerosol concentrations of predominantly fibrogenic action № 4436-87 ".

Hygienic assessment of noise and vibration was performed according to: ДСН 3.3.6.037-99 State sanitary norms of industrial noise, ultrasound and infrasound. ДСН 3.3.6.039-99 State sanitary norms of general production and local vibration.

Many plant species have allergenic properties, but in the process of processing plant raw materials, workers are exposed to the influence of combined action multicomponent organic dust, where the action various allergens and biologically active substances can be significantly enhanced [39, 40].

It is also known that organic plant dust origin is usually contaminated with a significant number of microorganisms, which include Gram-negative types of producing bacteria endotoxins, and microscopic fungi, producers mycotoxins [42, 43]. Saprophytic bacteria and microscopic fungi, the spores of which are found in air production facilities are large group of pathogens of allergic respiratory diseases, such as toxic dust syndrome, bronchial asthma and allergic alveolitis, conjunctivitis, and can cause allergic skin reactions [41, 44].

1. Factors related to the physical development of the average factor

increased or decreased temperature of surfaces of equipment, materials;

sharp edges, burrs and roughness on the surfaces of workpieces, tools and equipment;

increased noise level;

insufficient education of work areas.

2. Factors related to the chemical evaluation factor

by the nature of the impact on the human body on:

- toxic;
- sensitization;
- skin and mucous membranes.

3. Factors related to psychophysiological dangerous and modern production factor.

- physical overload;
- psychoneurological overload.

4.2. Requirements for the territory and production facilities

Natural lighting should be used as much as possible in production and auxiliary premises. It is forbidden to clutter windows both inside and outside with various objects.

Blinds or other devices should be used to protect workers from direct sunlight. The territory of the enterprise, routes of movement of people and transport, and also places of work with approach of darkness or at bad visibility (fog, rain) have to be provided with artificial lighting according to branch norms. For lighting of shops it is necessary to apply generally the system of the general lighting with a uniform or localized arrangement of fixtures. Incandescent and fluorescent lamps used for general and local lighting must be placed in the fixture. The use of lamps without fittings is not allowed.

Cleaning of lamps should be carried out in the terms specified in branch norms of artificial lighting of the enterprises of the woodworking industry. When cleaning the luminaires, check their condition.

Defective components and parts must be replaced. Production and auxiliary premises must be equipped with natural or forced supply and exhaust ventilation, which provides optimal air parameters of the working area.

The use of a particular ventilation must be justified by the calculation that confirms the provision of air exchange, temperature and condition of the air environment, provided by ГОСТ 12.1.005.

Air curtains or other devices in accordance with the requirements of sanitary norms must be installed at the entrances and entrances to the production premises in order to prevent drafts.

4.2.1. Equipment placement and workplace organization

The location of machinery, equipment, vehicles and other means of mechanization and automation of labor should provide convenient and safe conditions for maintenance and repair, meet the technological process and should not create counter and cross flows in the transportation of raw materials and finished products.

Safety requirements for the location of equipment, workplaces and control bodies of production equipment must comply with ГОСТ 12.2.049, 12.2.061 12.2.064 and. Stationary technological equipment must be mounted on foundations, according to the technical calculation, vibration supports and other devices that do not allow vibration of the equipment. The distance between the machines, elements of buildings and structures must be at least specified in the table.

The floor in the room should be smooth, non-slip, without cracks. Door openings must be without thresholds. Doors in production and auxiliary premises must meet the requirements of current SNiP.

Door 68 openings in production facilities for the transport of goods must be wider than the dimensions of vehicles with a load of at least 0.6 m and higher by 0.2 m. Materials, blanks, finished products and waste must not create obstacles in the workplace.

Their temporary storage is allowed only in a specially designated place with the possibility of mechanized movement and removal from the shop.

All production buildings and structures with jobs in them in accordance with the current regulations must be subject to periodic, general and partial inspections. General inspections are conducted by a specially appointed commission twice a year - in spring and autumn.

The results of all types of inspections must be formalized in acts, which indicate the identified defects, as well as measures and deadlines for their elimination. During operation, production buildings and structures must be under the systematic supervision of those responsible.

4.3. Measures to reduce the impact of harmful and dangerous production factors

One of the most important hygienic indicators of a workplace is room illumination.

The work area or workplace is illuminated to such an extent that it is possible to clearly see the work process without straining the eyes, and it is excluded that the rays of the light source directly enter the eyes. In addition, the level of illumination is determined by the degree of accuracy of visual work. According to the lighting standards and industry standards, the work of an engineer belongs to the fourth category of visual work.

The main task of lighting calculations is to determine the required area of light openings in natural lighting and the power consumption of lighting devices in artificial lighting. The required area of the light opening for lateral natural illumination is determined by the formula:

$$S = \frac{S_n * e_N * K_s * \eta_0 * K_d}{100 * \tau_0 * r_1} \quad (4.1)$$

Where: S_r is the area of the room, m 2 ;

e_N - normalized value of CNI,%;

K_s - safety factor taken from tables;

η_0 - light characteristic of windows (6.5 - 29);

K_d - coefficient taking into account the darkening of windows by opposing buildings (1.0 - 1.7);

r_1 is the coefficient taking into account the increase in CNI due to reflected light from the surface of the room (1.05 - 1.7);

τ_o - general coefficient of light transmission, determined from (0.1 - 0.8). [38]

The area of the room is S_r =6*5=30 m 2 .

The normalized CNI is determined as e N =1.5.

Safety factor coefficient is taken as K_s =1.5.

The value of the remaining coefficients is assumed to be the following:

The ratio of the length of the room to its depth is 1.2, the value of the light characteristic with the ratio of the depth of the room to its height from the level of the conventional working surface to the top of the window is 1.5, so from table hoose value of light characteristic of windows η_0 = 15.

Choose from table value of coefficient taking into account the darkening of windows by opposing buildings K_d = 1,1

Choose from table value of the coefficient taking into account the increase in CNI due to reflected light from the surface of the room r_1 = 1,05.

General coefficient of light transmission is calculated according to formula

$$\tau_0 = \tau_1 * \tau_2 * \tau_3 * \tau_4 * \tau_5 \quad (4.2)$$

Where: τ_1 - the coefficient of light transmission of the material, determined by table. For double sheet glass τ_1 =0.8;

τ_2 -coefficient taking into account the loss of light in the bindings of the aperture, determined from the table. Binders for windows and lamps of industrial buildings, steel, single open τ_2 =0.75;

τ_3 - coefficient that takes into account the loss of light in the bearing structures, determined from the table. With lateral lighting τ_3 = 1;

τ_4 - coefficient taking into account the loss of light in sun protection devices for retractable adjustable blinds and curtains, τ_4 =1;

τ_5 - coefficient taking into account the loss of light in the protective grid, installed under the lantern is taken equal to 0.9.

$$\tau_o = 0.8*0.75*1*1*0.9 = 0.54 \qquad (4.3)$$

So, when calculating we get the following value of the required area

$$S = \frac{30*1.5*1.5*15*1.1}{100*0.54*1.05} = 19.6\ m^2 \qquad (4.4)$$

Considering that the area of the window opening in the room is about S=3.3*6=19.8 m^2, the use of one side lighting is enough for this room.

4.4. Occupational Safety Instruction

4.4.1. General safety requirements

The design engineer informs his immediate supervisor about any situation that threatens the life and health of people, about every accident that occurs at work, about the deterioration of his health, including the manifestation of signs of an acute illness.

While on the territory and in the buildings of the organization, at the work sites and workplaces, the design engineer is obliged to:

- timely and accurately comply with the internal labor regulations, orders of the immediate supervisor, provided that he is trained in the rules for the safe performance of this work;
- comply with the requirements of local regulations on labor protection, fire safety, industrial sanitation, regulating the procedure for organizing work at the facility;
- observe labor discipline, work and rest regime;
- take good care of the employers property.

4.4.2 Safety Requirements before starting work

Inspect the workplace and equipment. Remove all unnecessary items.

Remove dust from the display screen of a personal computer. Adjust the height and angle of the screen.

Adjust the seat height. Check the health of the equipment.

Check approaches to the workplace, escape routes for compliance with labor protection requirements.

Check by visual inspection:

- absence of cracks and chips on the cases of sockets and switches, as well as the absence of bare contacts;
- reliability of closing all current-carrying devices of the equipment;
- presence and reliability of grounding connections (absence of breaks, strength of contact between metal non-current-carrying parts of the equipment and the grounding wire);
- the integrity of the insulation of electrical wires and power cords of electrical appliances, the serviceability of safety devices;
- sufficiency of lighting of the workplace;
- absence of foreign objects around the equipment;
- condition of floors (absence of potholes, irregularities, etc.).

4.4.3 Safety Requirements during operation

Use serviceable equipment, fixtures, lighting devices necessary for safe work, use them only for those works for which they are intended.

Monitor the equipment operation, periodically carry out its visual preventive inspection.

When working with a PC:

- the screen should be 5 degrees below eye level, and be located in a straight plane or tilted towards the operator (15 degrees);
- the distance from the eyes to the screen should be within 60-80 cm;
- the local light source in relation to the workplace should be located so as to exclude direct light from entering the eyes, and should provide uniform illumination on a surface of 40 x 40 cm, not create blinding glare on the keyboard and other parts of the console, as well as on the video terminal screen in direction of the eyes;
- to reduce visual and general fatigue, after each hour of working at the screen, you should use regulated breaks of 5 minutes, during which you take rest.

4.4.4 Safety Requirements after work

Switch off the equipment during a power outage and leaving the workplace after work.

Inspect the workplace and equipment. Remove all unnecessary items.

Check by visual inspection equipment on lack of defects.

4.4.5 Safety Requirements at emergency situations

When eliminating an emergency, it is necessary to act in accordance with the approved emergency response plan.

Upon detection of malfunctions of equipment, instruments and apparatus, as well as in the event of other conditions that threaten the life and health of workers, the design engineer should stop work and report them to his immediate supervisor and the employee responsible for the implementation of production control.

When a fire source appears, you must:

- stop working;
- turn off electrical equipment;
- organize the evacuation of people;
- start extinguishing the fire immediately.

When electrical equipment catches fire, use only carbon dioxide or dry powder fire extinguishers.

If it is impossible to carry out extinguishing on his own, the design engineer should, in accordance with the established procedure, call the fire brigade and inform the immediate supervisor about it.

In the event of injury or deterioration of health, the design engineer must stop work, notify the management and seek medical help.

4.5 Conclusions from the section

Evaluating the work done, we can draw some conclusions. Improving working conditions and safety is becoming one of the most important ways to improve the material and cultural standard of living. Ensuring healthy, safe and highly productive working conditions is an important factor in the existence of the enterprise in conditions of market competition.

The head of the enterprise must create safe working conditions, provide a favorable moral and psychological climate in the workforce, which helps to increase productivity and improve the quality of products and services. In recent years, new methods of improving working conditions in mechanical engineering, metallurgy, light industry, etc. have become widely used.

The main condition for improving working conditions and safety is the creation of integrated technology with the use of new equipment and automation of all processes. Since the introduction of automatic lines and other technical improvements requires high costs, it is best to implement them when designing and building new plants

The main thing in creating a comprehensive technology is the mechanization of labor-intensive operations and automation of process control. As we can see, the production of pellets requires several technological stages and each of them is a danger to the health and life of workers, so it is necessary to strictly follow the recommendations on health and safety in emergencies.

CONCLUSIONS

Thus, we can conclude that the biofuel market in Ukraine is in the process of formation, but the supply of raw materials in this market has very promising areas of development. Therefore, Ukraine has every chance to ensure the country's energy security. Ukraine has sufficient resource potential for the production of biocomponents, a number of industrial facilities and can provide raw materials needed by the country in liquid biofuels. These opportunities open up prospects for the use of bioethanol and biodiesel of own production in transport. It can be argued that the use of liquid biofuels, as well as the development and implementation of new technologies for their development - is today an economic priority for the economy of our country.

It should be noted that, in general, the current legislation of Ukraine has created a proper basis for the stable development of the market of alternative fuels in Ukraine. In particular, this applies to tax benefits provided by the state to participants in this market. However, the state budget is limited for the use of biofuels, heated political debates and the Ukrainian bureaucracy are still delaying the successful large-scale introduction of biofuels.

It should be emphasized that the use of economic incentives and the definition of a stable strategy. The development of the liquid biofuel market will involve an increase in the production of ethanol, biodiesel or other types of liquid or gaseous biofuels from agricultural and forestry raw materials. This will replace the use of fossil fuels as stationary (eg, biodiesel for power plants) and for mobile use (motor fuel).

Thus, it should be noted that government regulation of the formation and development of the liquid biofuel market is essential. It should be remembered that the state is not able to introduce or abolish objective economic conditions of development, but it is able to create conditions under which society as a whole, individual industries, markets can develop effectively and predictably.

Thus, many technologies for obtaining ecological biofuels from algal biomass are known today. Our country should be interested in such developments not only in terms of improving the environmental situation, but also in terms of alternatives to traditional energy sources, given the energy crisis in which we now find ourselves.

Technologies for the use of algae as an energy source occupy one of the central places among the approaches of modern alternative energy. This approach has significant advantages: first, the use of algae will preserve valuable agricultural land to meet the food needs of mankind. Second, algae are more productive sources of vegetable oil than traditional oilseeds.

Microalgae are one of the most promising sources of the third and fourth generation for biofuel production. It is possible to achieve a yield of more than 10 kg of biomass per square meter of cultivated area in the weather conditions of Ukraine. The amount of accumulated lipids in this case can reach 6.6 kg / m2. The most promising regions for cultivation can be considered the eastern regions, in particular, Odessa region.

The main resource needed for cultivation is water. This is the basis of the cultural environment. To improve the ecological and economic efficiency of cultivation, municipal wastewater can be used as a cultural environment. It is possible to combine cultivation processes and wastewater treatment processes from nutrients (nitrogen and phosphorus compounds). Experience shows that by using wastewater as a nutrient medium, the use of fresh water can be reduced by up to 90%.

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