Climate change, greenhouse gases and the bioeconomy

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Abstract. According to existing estimates, by the middle of the twentieth century, due to intensive deforestation and large losses of wood, as well as as a result of qualitative changes in the economy and nature management, hydrocarbon reserves (gas, oil) and coal became the basis of energy supply. Intensively developing industrial production, construction, transport, agriculture, as well as the intensification of land use and forestry, combined with the growing population of the planet, began to have a significant impact on the planet's climate, in particular, in the form of warming due to the "greenhouse" effect.

1 Introduction

Already in the last decade of the 20th century, the main cause of the "greenhouse" effect began to be considered emissions into the atmosphere of the so-called greenhouse gases (greenhouse gases), consisting of CO2, methane, nitrous oxide and some other compounds that are formed from natural gas, oil and coal at different types of anthropogenic activity. The roles of many other factors that can influence the "greenhouse" effect and lead to other impacts on climate continue to be actively studied in the 21st century. In 1992, the accumulated knowledge about the role of the greenhouse effect became the subject of analysis by the Intergovernmental Panel on Climate Change [1]. As a result, predictive models were presented that suggested that if fossil fuel consumption continues at current levels, global temperatures will increase by 0.3 C per decade and this will lead to droughts, floods, and storms will become more frequent and strong. Moreover, sea level rise was to be expected, with serious consequences for states located in coastal zones. At the same time, measures were also proposed that could stabilize the greenhouse effect: energy conservation, energy efficiency, switching to hydrogen instead of carbon as a fuel source, and reforestation.

2 Research Methodology

A number of authors noted the need for appropriate, purposeful scientific activity to form new areas of research, models of individual sectors of the economy and technologies that can slow down climate change [4]. Moreover, Mattiasson B. (2016) directly pointed to the

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vital role of industrial biotechnologies in achieving the key goals of the Paris Agreement. In particular, it was emphasized that, in addition to biofuel production, a number of other areas of industrial biotechnology deserve special attention in this regard:

- deriving biochemicals and other materials from renewable resources;
- water treatment - both for consumption and for waste water;
- conducting agricultural activities;
- solid waste management;
- environmental biotechnology to reduce environmental pollution.

This chapter has already cited various materials that testify to the ongoing efforts to achieve the listed goals of the Paris Agreement. At the same time, Mattiasson B. (2016) paid special attention to countries located in the tropics, where biomass is abundant, and noted that there the use of new technologies for the efficient management of these resources can play an important role in reducing greenhouse gas emissions. In order to fulfill the entire set of obligations under the Paris Agreement, shortly after its signing, the question was raised of the creation and widespread use of so-called technologies with zero ("net-zero emissions") or even "negative" greenhouse gas emissions [5]. Many authors have pointed out that in order to achieve the stated goals, energy services that support both industrial production and agriculture must be modernized so that greenhouse gas emissions into the atmosphere could approach zero. At the same time, for some activities, such as light-duty transport, heating, cooling and lighting, electrification with the generation of electricity from renewable energy sources (RES), such as wind energy, solar energy, was proposed as a solution.

3 Results and Discussions

In fact, traditionally, hydropower is recognized as the most widely used environmentally friendly energy resource, which fully complies with the requirements of "net-zero emissions". However, it is noted that the decision to build hydropower facilities and manage dams often requires complex trade-offs between environmental, economic and social factors at different geographic scales and taking into account different attitudes of stakeholders. Nuclear energy, which (despite known risks) received some attention in connection with the Paris Agreements, can also be classified as "net-zero emissions". Compared to hydropower and nuclear power, wind and solar power are still used much less, and the latter are largely dependent on external circumstances. For example, calm weather or reduced insolation can limit the use of wind and solar energy. At present, many countries already have significant quantities of both hydroelectric and nuclear power plants, as well as wind and solar power plants. When the latter generate electricity as separate sources of electricity, they face certain limitations, in particular due to the above circumstances, which affect the working conditions and consumer characteristics. Accordingly, so-called multi-energy complementary power generation systems are proposed, taking into account various factors (cost, efficiency, environmental protection, etc.). Chinese authors consider it possible to reduce costs and/or improve production efficiency with the help of such systems for the production of electricity through the integrated use of several energy sources. It should be noted that in our country this problem has been solved in a general way for quite a long time, since hydroelectric power plants and many other electricity generating enterprises are combined into large power networks that ensure uninterrupted supply of consumers located in large areas. In addition, the Federal Law of March 26, 2003 No. 35-F3 "On the Electric Power Industry" provided for mechanisms to support the stimulation of electricity production by generating facilities with a capacity of not more than 25 MW using renewable energy sources in the form of compensation for the cost of technological connection to power grids [6]. The main conditions for state regulation of the processes of production of "green" energy and the use of renewable energy sources have been in force since 2009 and are determined by the Energy Strategy for the Development of Russia for the period up to 2030 [Decree No. 1715-r dated November 13, 2009]. It should be noted that in the second decade of the 21st century, many countries of the world at the state level formed and began to implement energy production programs based on renewable energy sources. The progress made is clearly evidenced by the dynamics of electricity production from renewable sources (A) and installed RES capacity (B). Moreover, there is evidence that the growth in installed capacity (electricity capacity) from 2011 to 2020. in the world bioenergy amounted to 45%.

At the same time, special attention was paid to the so-called technologies for the production of solid, liquid and gaseous biofuels of the third and fourth generations in combination with the production of biodegradable biopolymers. It is believed that third generation biofuels made from cyanobacteria and microalgae can overcome some of the greenhouse gas disadvantages associated with first and second generation biofuels. It is known that cyanobacteria and microalgae are able to absorb CO2 during photosynthesis, which ultimately leads to the formation of the necessary biomasses. This CO2 is then released back into the atmosphere when algal biofuels are burned [7]. In other words, the production of biofuels from cyanobacteria and microalgae can be considered as a promising way to “net-zero emissions”. Significant interest in cyanobacteria and microalgae is also determined by the fact that they are considered as potential raw materials for the production of biodegradable biopolymers. In addition, it is believed that biomasses from these organisms can be used as sources for the production of products with antioxidant, anticancer and antiviral properties. General schemes for the production of different types of third-generation biofuels are presented in Fig. 1.

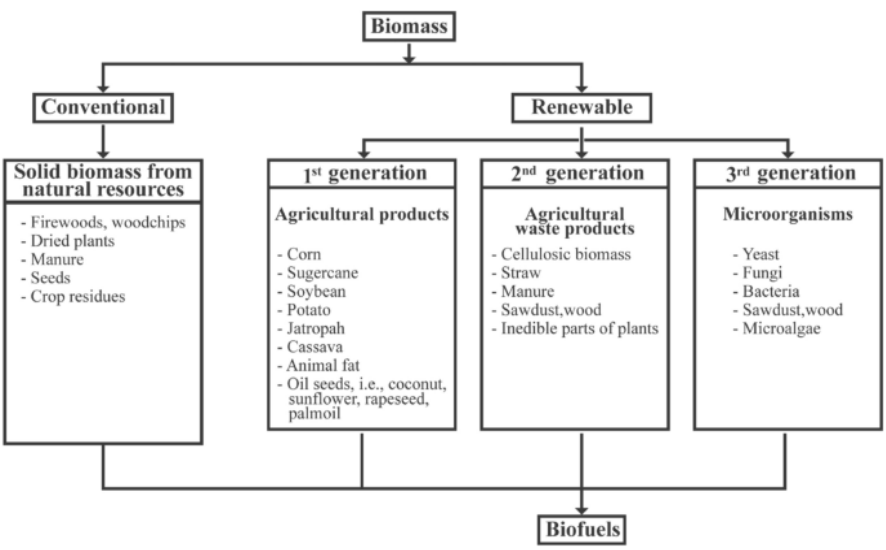

Fig. 1. Classification of biomass into generations

By the end of the second decade of the 21st century, it was convincingly shown that cyanobacteria and microalgae, as raw materials for the third generation of biofuels, have clear advantages over lignocellulosic biomass. In particular, it was emphasized that the high content of carbohydrates allows the production of both higher alcohols and bioethanol, and the lipids present are used for the production of biodiesel, isoprenoids and other hydrophobic compounds. At the same time, it was noted that the commercial introduction of third-generation raw materials (biomass from cyanobacteria and microalgae) is limited due to high energy costs. Accordingly, it is necessary to analyze the relationship between the formation and consumption of CO2 during the production of biofuels from cyanobacteria and algae [8]. A qualitatively new step is the emergence of the fourth generation of biofuels, for the production of which they began to use strains of microorganisms obtained using targeted genetic modification. It is believed that industrial implementation of such technologies can be achieved using microbial cell factories. Microbial cell factories were characterized as reliable and sustainable sources of bioproducts, capable of minimizing environmental impacts while enabling the commercial production of biopolymers and industrially important enzymes. Moreover, according to some authors, it is precisely such cell factories that open the way to the transition to the bioeconomy from the modern economy focused on fossil energy sources. More recent research has emerged on how to achieve zero net CO2 emissions by mid-century, particularly from energy and industry in the US. Thus, according to the data presented, it was concluded that such a goal could in principle be technically feasible and economically feasible, but would require a large-scale transformation of the entire infrastructure. However, it was noted that various risks and uncertainties remain. According to Williams J.H. et al. (2021) wind and solar power will become the main sources of primary energy for the organization of a system that does not have harmful emissions, although the scale and pace of deployment of these types of energy can create serious problems for nature management and some other areas of activity. It was also noted that maintaining the current level of gas thermal generating capacity until 2030 is necessary to ensure reliability and may remain so until the middle of the century [9]. In addition, all the proposed paths to "net-zero emissions" included certain compromise solutions. Obviously, some activities (long-distance road transport, air transport, steel and cement production, etc.) are particularly difficult to operate without emitting CO2 into the atmosphere. Accordingly, a number of authors have suggested focusing on approaches that can reduce the content of greenhouse gases in the atmosphere using technologies with so-called “negative” greenhouse gas emissions (“negative emissions technologies, NET”). It is planned that the implementation of NET will require large-scale costs and the creation of new innovative technologies.

At the same time, NET strategies are also being developed, which can play a key role in preventing catastrophic climate change in the near future. However, while many of the proposed engineering solutions remain uncompetitive in terms of cost [10]. So, Ozkan M. et al. (2022) recently reported the emergence of direct air capture (DAC) CO2 technologies with at least 19 installations capturing more than 0.01 million tons of CO2 per year. However, the authors emphasize that active DAC installations are still in their infancy and costly, and DAC technologies themselves also need to be improved. However, according to Ozkan M. et al. (2022) DAC can already partially help reduce annual emissions from concrete production (8%), transport (24%), steel industry (11%) and forest fires (0.8%). As an intermediate result, it seems important to note that work on the transformation of the industry to "net-zero emissions" and "negative emissions technologies" continues, and this allows us to hope for the achievement of the required goals in the short term. The ongoing work in the Russian Federation to reduce CO2 emissions can be illustrated by the example of the share of organizations that reduce the corresponding emissions (Fig. 3.).

Fig. 2. CO2 Emissions by Country 2023

4 Conclusions

Summing up the intermediate results of the analysis of the materials presented in this article, it seems important to emphasize that the observed trends in the development of the bioeconomy give reason to hope that the goals stated in the relevant strategic documents, under favorable conditions, can be achieved by 2030 or in the next decade.

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