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Sustainable Development Strategy of Bioenergy and Global Energy Transformation

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Abstract Bioenergy, as a sustainable and clean energy source, plays an important role in sustainable development and global energy transformation. This review explores the role and significance of bioenergy in sustainable development, the challenges and issues facing the current development of bioenergy, and the development strategies of bioenergy in global energy transformation. The review discusses the role and significance of bioenergy in sustainable development, analyzes the challenges and issues facing the current development of bioenergy, proposes development strategies of bioenergy in global energy transformation, and forecasts the future development prospects of bioenergy. In the future, bioenergy will continuously improve production efficiency and reduce production costs; the sources of bioenergy raw materials will become more extensive, thus reducing competition for resources; the application scope of bioenergy will continue to expand, including transportation, construction, and other fields; and bioenergy will be combined with technologies from other fields to achieve diversified utilization of bioenergy.

Keywords Bioenergy; Sustainable development; Global energy transformation; Development strategies

With the continuous growth of global population and economy, energy demand is constantly increasing, and energy supply and sustainable development have become major challenges facing the world. In the context of global energy transformation, bioenergy, as a renewable, low-carbon, and environmentally friendly form of energy, is an important component of today's global sustainable development and a key strategy for achieving global energy transformation. It has received increasing attention and importance. As an important component of renewable energy, bioenergy has high sustainability and environmental friendliness, and has become one of the hot areas of global energy transformation. The sustainable development of bioenergy is considered one of the important directions for future energy development. The production of bioenergy can reduce reliance on traditional fossil fuels, reduce carbon emissions, and promote environmental protection and sustainable development.

Bioenergy mainly includes biomass energy, biofuels, and biogas. Biomass energy refers to the process of energy conversion using biomass as raw materials, such as using wood, straw, etc. for cogeneration and biomass combustion for power generation. Biofuels refer to energy forms that utilize biomass or bio oil for combustion or chemical conversion, such as biodiesel, bioethanol, etc. Biogas refers to the energy form generated by fermentation, gasification, or incineration of organic waste, such as biogas, bio hydrogen, etc.

The advantages of bioenergy lie in its renewability, low carbon emissions, and environmental friendliness. Compared with traditional fossil fuels, bioenergy has lower carbon emissions and relatively less impact on the environment during its production and utilization. The production and utilization of bioenergy can promote the development of agriculture, forestry, and animal husbandry, while also promoting localized production and consumption of energy, helping to alleviate energy scarcity and security issues.

The sustainable development of bioenergy is of great significance, and how to improve its sustainability is an important issue in the current development of bioenergy. To this end, a series of measures need to be taken, such as promoting efficient biomass energy utilization technologies, strengthening the protection and management of biomass resources, exploring new types of bioenergy, and strengthening policy and regulatory construction in the

field of bioenergy. At the same time, scientific evaluation methods such as ecological footprint, carbon footprint, and water footprint need to be adopted to comprehensively evaluate the sustainability of bioenergy.

The review will explore the position and role of bioenergy in the global energy transition from the perspective of sustainable development of bioenergy. We will introduce the types, production methods, and advantages of bioenergy, deeply explore sustainable development strategies and evaluation methods of bioenergy, and propose technologies and management methods to improve the sustainability of bioenergy. We hope that this review can provide readers with a deeper and more comprehensive understanding, as well as valuable references and suggestions for research and practice in the field of bioenergy, which can further promote the development of bioenergy and contribute to the global energy transformation.

1 Bioenergy and Sustainable Development

1.1 Definition and classification of bioenergy

Bioenergy refers to the energy produced from renewable biological resources such as biomass, bio oil, biogas, and bio alcohol. According to the different sources and production methods of bioenergy, it can be divided into some categories:

Biomass energy is the energy produced from biomass sources such as plants, animals, and microorganisms. Biomass energy mainly includes wood and woody biomass, crop residues, energy crops, urban and rural organic waste, biomass waste, as well as biomass feed and feces (Figure 1). Wood is one of the earliest forms of biomass energy to be utilized. It can be directly burned for heating, cooking, and energy production. Crop straw, plant stems and leaves, and other residues can also be used as sources of biomass energy. Specific plants are specifically planted for energy production, and these plants are called energy crops. Organic waste, such as food residue, kitchen waste, and rural waste, can generate methane and other gases through biodegradation or anaerobic digestion for power generation or heating. Biomass waste generated from industrial production and agricultural activities, such as wood processing waste, pulp and paper waste, can also be used for biomass energy production. Animal feces and feed residues can also produce methane through anaerobic digestion (Klein-Marcuschamer et al., 2010; Zabed et al., 2017).

Figure 1 Biomass fuel (Picture by Bing)

Biooil energy is the energy produced from oils extracted from plant seeds, fruits, and other parts. It mainly includes vegetable oil energy and animal oil energy. Vegetable oil mainly comes from oil crops, such as soybean (*Glycine max*), peanut (*Arachis hypogaea*), rape (*Brassica napus*), etc. Animal oil mainly comes from animal fats, such as lard, butter, etc. Biooil can be converted into energy through esterification, hydrocracking, and other methods (Zhuang et al., 2010).

Biogas energy is the energy produced by utilizing the gases produced by microorganisms during biomass fermentation. Biogas energy mainly includes biogas and biogenic gas. Biogas is the gas produced by the decomposition of biomass by microorganisms under anaerobic conditions, mainly composed of methane and carbon dioxide. Biogenic gas refers to the gas produced by the decomposition of biomass by microorganisms

under anaerobic or semi anaerobic conditions, mainly composed of hydrogen, methane, carbon monoxide, etc (Zhuang et al., 2010).

1.2 Sustainability and environmental friendliness of bioenergy

Bioenergy is one of the hot topics in the global energy field today, and has attracted much attention due to its renewable and environmentally friendly characteristics.

Bioenergy has high sustainability. The raw materials for bioenergy mainly come from renewable biological resources such as plants and animals, and are not limited like fossil fuels, so they have high sustainability. In addition, in the production process of bioenergy, resources such as waste and crop straw can be utilized to achieve comprehensive utilization of resources and reduce waste emissions and environmental pollution (Liu et al., 2021). Taking waste utilization as an example, research from the National Center for Bioenergy in the United States shows that utilizing waste can provide the country with over 160 million gallons of biofuel, which is equivalent to reducing greenhouse gas emissions by nearly 3 million tons.

Bioenergy has high environmental friendliness. Compared to traditional fossil fuels, the production and use of bioenergy generate much lower carbon dioxide emissions. The production process of bioenergy will absorb a large amount of carbon dioxide, thereby reducing the content of carbon dioxide in the atmosphere, which is beneficial for environmental protection. In addition, the production process of bioenergy does not produce pollutants such as hydrogen sulfide and nitrogen oxides, and its impact on the environment is relatively small. According to data from the US Department of Energy, a car running on biofuels emits 70% less nitrogen oxides than a car running on traditional fuels. In addition, the production and use of bioenergy generate much lower carbon dioxide emissions than fossil fuels. Taking bioethanol as an example, according to data from the US Department of Energy, the carbon dioxide emissions generated by producing one gallon of bioethanol are 57% lower than those of producing one gallon of traditional gasoline.

Bioenergy is an important component of renewable energy, with high sustainability and environmental friendliness. In the future energy transformation, bioenergy will play an important role, but it also requires our joint efforts to overcome various challenges and problems in production and utilization, and achieve sustainable development of bioenergy.

1.3 The role and significance of bioenergy in sustainable development

Bioenergy is one of the key areas in the global energy industry today, and its role and significance in sustainable development are very important. Through the development and utilization of bioenergy, we can reduce dependence on fossil fuels, promote the development of agriculture and rural economy, reduce energy costs, promote technological innovation and progress, and promote the process of sustainable development (Zhuang et al., 2010).

Bioenergy can help reduce dependence on fossil fuels, thereby reducing its impact on the environment. The use of fossil fuels can lead to significant carbon dioxide emissions and exacerbate global warming. The use of bioenergy can reduce the emission, thereby reducing its impact on the environment. According to data from the US Energy Information Administration, the carbon dioxide emissions required to produce one gallon of biodiesel are 78% lower than those required to produce one gallon of traditional diesel. In Europe, the use of biodiesel has become one of the important means to reduce greenhouse gas emissions, with EU countries using 9.6% of the total diesel sales in 2018.

The production process of bioenergy requires a large amount of land, water resources, and energy, which can promote the development of agriculture and rural economy. And the production of bioenergy requires a large amount of crops, trees, and other raw materials, which will increase the demand for agricultural products and promote agricultural development. Besides, the production process of bioenergy can utilize a large amount of waste and rural resources, thereby promoting the development of rural economy. According to data from the China Electricity Council, as of the end of 2019, there were a total of 1 105 biomass power generation projects in

China, with a total installed capacity of 10.59 GW. Most of these projects are located in rural areas, bringing employment opportunities and economic income to the local area. Similarly, in Europe, the development of biomass power generation projects has also received strong government support, with the EU's installed capacity of biomass power generation reaching approximately 10 GW.

The use of bioenergy can reduce energy costs and promote economic development. The use of bioenergy can reduce the cost of energy, thereby lowering production costs, improving the profitability of enterprises, and promoting economic development.

The development and utilization of bioenergy can promote technological innovation and progress, thereby promoting sustainable development. The development of bioenergy requires a large amount of technological support and innovation, which will promote the development and progress of technology, thereby promoting the process of sustainable development. According to data from National Energy Consulting Company, the efficiency of biofuel cells is 25% higher than that of traditional fuel cells, and they emit fewer pollutants. Therefore, biofuel cells are considered one of the important development directions in the future energy field.

2 Challenges and Problems Faced by the Current Development of Bioenergy

The problems and challenges faced by the development of bioenergy are multifaceted, including high production costs, insufficient production capacity, carbon emissions, and other issues and challenges that require attention. These issues require joint efforts from the government, enterprises, and all sectors of society. It is necessary to promote the sustainable development of bioenergy and achieve the transformation and upgrading of sustainable energy through technological innovation, policy support, resource protection, and international cooperation (Duarah et al., 2022).

2.1 High production costs

High production cost is a major challenge facing the current development of bioenergy. The production of bioenergy requires a large amount of land, water resources, and energy, and the production cost is relatively high. According to data from the International Energy Agency (IEA), the unit production cost of biomass energy is higher than that of fossil energy, with the production cost of liquid biomass energy being more than twice that of solid and gaseous biomass energy. In the EU region, the cost of biodiesel is about 50% higher than traditional diesel, and the cost of bioethanol is about 20%~30% higher than traditional gasoline.

Furthermore, the raw material cost of bioenergy is also relatively high, mainly because the raw materials of bioenergy come from resources such as crops and trees, which require a large amount of agricultural and forestry production inputs. The raw material cost of biomass energy in the United States accounts for over 60% of its total cost, and the increase in raw material cost is often one of the main reasons for the increase in production costs. In addition, the production process of bioenergy requires specific technical support, which also increases production costs.

To solve the problem of high production costs, technological innovation and equipment upgrades can be considered to improve production efficiency and reduce costs. In addition, the government can encourage enterprises to invest in the production and research and development of bioenergy through tax policies and subsidies, in order to reduce production costs. There have been some technological innovations in the field of biomass combustion in biomass energy production, such as biomass gasification technology and biomass combustion waste gas recovery technology, which can improve energy utilization efficiency and reduce production costs. Moreover, the government can encourage enterprises to invest in the production and research and development of bioenergy through subsidies and tax policies to reduce production costs.

2.2 Insufficient production capacity

Insufficient production capacity is also a challenge facing the current development of bioenergy. According to data from the United Nations Environment Programme, only about 5% to 6% of agricultural waste is used for energy production globally each year. It means there is still a large amount of biomass resources that are not utilized.

Additionally, the production of bioenergy requires a large amount of land and water resources, which are limited in some areas. Some bioenergy production processes require special environmental conditions, such as biomass combustion requiring specific temperature and humidity conditions.

To address the issue of insufficient production capacity, it is possible to consider improving production processes and technologies to increase production efficiency and reduce resource consumption. In the production of biomass energy, more efficient production processes and equipment can be adopted, such as biomass fuel cells and biomass gasification technology (Figure 2). In addition, the government can provide more funding and resource support to enterprises by encouraging investment and supporting policies, in order to expand production capacity.

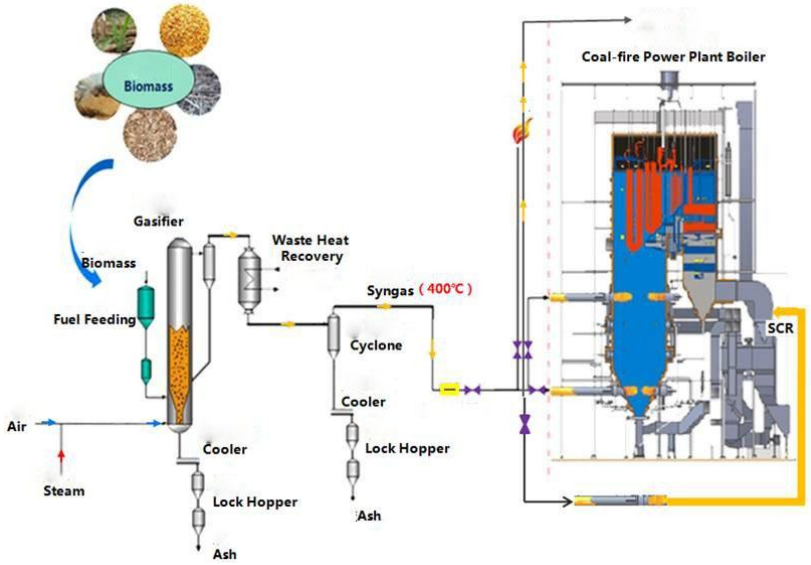

Figure 2 Biomass gasification technology process (Picture by Bing)

2.3 Carbon emission issues

Bioenergy generates certain carbon emissions during its production and use, which is also a major challenge for its sustainable development. According to IEA data, the carbon emissions of biomass energy are about 50% to 90% of fossil fuels. In the process of biomass combustion and biodiesel production, oxidation reactions produce a large amount of harmful gases such as carbon dioxide and carbon monoxide, which can have a certain impact on the environment. Furthermore, the production process of some bioenergy also puts certain pressure on land and water resources, further exacerbating environmental problems (Sagar and Kartha, 2007).

In order to solve the problem of carbon emissions, it is possible to consider improving production processes and technologies, and adopting some technical measures, including biomass combustion waste gas recovery technology and biomass gasification technology, to reduce the emissions of carbon dioxide and carbon monoxide. Besides, the government can promote the sustainable development of bioenergy and reduce its impact on the environment by strengthening regulation and formulating environmental protection policies.

2.4 Problems and measures

In addition to the above-mentioned issues and challenges, the development of bioenergy also faces some other problems and challenges. For example, in some regions, the production and use of bioenergy may have an impact on food security. And in some countries, crops such as soybeans and corn produced from biofuels have led to rising food prices and shortages. Moreover, the development of some bioenergy is also influenced by policies and market environments, which require joint efforts from the government and enterprises to solve.

The problems and challenges faced by the development of bioenergy are multifaceted and require joint efforts from the government, enterprises, and society. Through technological innovation, policy support, resource protection, and international cooperation, the sustainable development of bioenergy can be promoted, and the transformation and upgrading of sustainable energy can be achieved. The reasons for the above problems can be

summarized as insufficient resources, immature technology, and imperfect policies. To address these issues, several approaches can be taken.

Improve production efficiency and reduce costs. The production of bioenergy requires a large amount of biomass resources, which are limited in some regions. For example, according to data from the International Energy Agency (IEA), there is great potential for biomass resources in Africa, but due to a lack of investment and technological support, the utilization rate of bioenergy development is not high. To solve the problem, it is necessary to strengthen resource protection and management, and encourage international cooperation and technological innovation to improve the utilization efficiency of biomass resources.

Need to improve production technology level. Some technologies in bioenergy production are still immature, leading to low production efficiency and high costs. In the field of biomass gasification technology, there are still problems such as low gasification efficiency and unstable gas production. To solve the problem, it is necessary to strengthen technological innovation and research and development investment, and encourage enterprises to invest in the production and research and development of bioenergy (Fang et al., 2022).

We can also strengthen resource protection and environmental regulation, enhance policy support and market promotion. The policy environment plays a crucial role in the development of bioenergy. By strengthening regulation and formulating environmental protection policies, the impact of bioenergy on the environment can be reduced. In some countries, insufficient government support and encouragement for biomass energy have led to slow development of bioenergy. Enterprises can be encouraged to invest in the production and research and development of bioenergy through tax policies and subsidies (Cross et al., 2021).

Moreover, international cooperation can be strengthened to promote the sharing and exchange of technology and experience, in order to promote the sustainable development of bioenergy globally.

3 Development Strategies of Bioenergy in Global Energy Transformation

3.1 The status and role of bioenergy in global energy transformation

With the development of the global economy and population growth, the demand for energy is increasing day by day. However, the limitations of fossil fuels and environmental issues have attracted global attention. Therefore, shifting towards sustainable energy has become an inevitable choice for global energy transformation. Bioenergy is an important component of renewable energy, with advantages such as low carbon emissions and sustainable utilization. Bioenergy, as a renewable energy source, has enormous potential and can play an important role in the global energy transition among sustainable energy.

Bioenergy can replace fossil fuels and reduce dependence on them. Biomass energy includes biomass fuel, biomass electricity, and biomass gas, which can be used to replace traditional fossil fuels such as oil, natural gas, and coal. Bioenergy is a type of renewable energy that can reduce reliance on limited fossil fuels during its production and utilization, providing a new sustainable source of energy for global energy transformation (Yang et al., 2002). According to the International Energy Agency (IEA)'s forecast, by 2030, biomass energy will become the largest source of renewable energy, accounting for over 60%.

Bioenergy can promote the development of agriculture and rural economy. The production of biomass energy requires a large amount of resources such as crops and trees. Therefore, the development of biomass energy can promote the development of agriculture and forestry, and increase the income of farmers. In addition, the production of biomass energy can create employment opportunities in rural areas and promote local economic development.

Bioenergy can also reduce greenhouse gas emissions and reduce its impact on the environment. In the production and utilization of biomass energy, the emission of carbon dioxide is lower than that of fossil fuels. Therefore, the development of biomass energy can reduce greenhouse gas emissions and reduce its impact on the environment.

3.2 The focus and direction of bioenergy development

With the accelerated development of global energy transformation, bioenergy, as an important component of sustainable energy, has gradually become a focus of attention. In the development process of bioenergy, improving production efficiency and reducing costs, strengthening policy support and market promotion, strengthening resource protection and environmental supervision, and promoting multi energy complementarity and comprehensive utilization are the focus and direction of bioenergy development.

The development and application of bioenergy are beneficial for improving production efficiency and reducing costs. Production efficiency and cost are key issues that need to be focused on in the development of bioenergy. In order to improve production efficiency and reduce costs, it can be achieved through technological innovation and research and development investment. A new cellulose hydrolase developed by Shenyang Institute of Applied Ecology, Chinese Academy of Sciences, can efficiently convert cellulose into sugars, and has developed an efficient biodiesel production technology, which has improved production efficiency and reduced costs. At the same time, it is necessary to control costs during the production process, and reduce production costs by reducing raw material costs and improving production efficiency. A study by the US Department of Agriculture has found that using crop waste such as corn straw, wheat straw, and rice straw as biomass energy raw materials to produce biofuels is more than 20% cheaper than petroleum fuel. A study by the US Department of Agriculture has found that using crop waste such as corn straw, wheat straw, and rice straw as biomass energy raw materials to produce biofuels is more than 20% cheaper than petroleum fuel.

Strengthening policy support and market promotion is also an important direction. Policy support and market promotion are essential parts of the development process of bioenergy. The government can encourage enterprises to invest in the research and production of bioenergy by formulating tax policies and subsidies. For example, the US government provides tax incentives to biofuel production enterprises through the "biofuel production tax credit" policy, encouraging them to invest in biofuel production. At the same time, the market-oriented development of biomass energy can also be promoted through the establishment of biomass energy trading markets and other means. The EU has established a biomass energy trading market, which promotes the production and utilization of biomass energy and promotes the market-oriented development of biomass energy through the operation of the trading market.

We can strengthen resource protection and environmental supervision. The production of biomass energy requires a large amount of biomass resources, therefore it needs to strengthen resource protection and environmental supervision. It is necessary to reduce the impact of bioenergy on the environment by strengthening regulation and formulating environmental protection policies, such as controlling the quantity and quality of biomass energy production, preventing excessive exploitation and damage to the ecological environment. The European Union has established the Sustainable Biomass Energy Certification System (SBP), which requires biomass energy production enterprises to comply with environmental requirements and protect the ecological environment during the production process.

In addition, it is also possible to promote multi energy complementarity and comprehensive utilization. The development of bioenergy requires multi energy complementarity and comprehensive utilization. For example, biomass energy can be combined with renewable energy sources such as solar and wind energy to form a multi energy complementary energy system. Meanwhile, biomass energy can also be comprehensively utilized with other forms of energy (Dhanya et al., 2020), such as combining biomass energy with gas power generation technology to improve energy utilization efficiency. The "Zero Emission Ecological Energy System" project jointly developed by China Datang Group and General Electric Company of the United States comprehensively utilizes various forms of renewable energy such as biomass energy, solar energy, and wind energy, achieving efficient energy utilization.

3.3 International cooperation and policy support

As an important component of sustainable energy, bioenergy plays a crucial role in the global energy transition. International cooperation and policy support are crucial for promoting the development of bioenergy. Through

international cooperation, it can promote the sharing of technology and experience, and promote the international development of bioenergy; Through policy support and environmental regulation, sustainable development of biomass energy can be promoted. Through the implementation of these measures, sustainable development of bioenergy can be achieved, contributing to the global energy transformation.

International cooperation is an essential part of the development process of bioenergy. Through international cooperation, it can promote the sharing of technology and experience, and promote the internationalization of bioenergy. For example, the EU and China have engaged in extensive cooperation in the field of biomass energy, jointly developing biomass energy technologies to promote sustainable development of biomass energy. Meanwhile, international cooperation can also promote the trade and circulation of biomass energy. For instance, the EU and Brazil have extensive cooperation in biofuel trade, promoting international trade and circulation of biofuels.

Policy support is an important guarantee in the development process of bioenergy, and the government can encourage enterprises to invest in the research and production of bioenergy by formulating tax policies and subsidies. For example, the US government provides tax incentives to biofuel production enterprises through the "biofuel production tax credit" policy, encouraging them to invest in biofuel production. The government can also promote the development of biomass energy by formulating environmental policies. For instance, the German government has enacted the Renewable Energy Law to encourage businesses to invest in biomass energy and promote its development.

Technological innovation is an important driving force for the development of bioenergy, and the government can promote innovation and development of bioenergy technology through research and development investment and international cooperation. For example, the European Union has conducted extensive research and development in the field of biomass energy, and has developed many new biomass energy production technologies, promoting the sustainable development of biomass energy.

The production of biomass energy requires a large amount of biomass resources, therefore it is necessary to strengthen resource protection and environmental supervision. The government can reduce the impact of bioenergy on the environment by strengthening regulation and formulating environmental protection policies. For example, the European Union has established the Sustainable Biomass Energy Certification System (SBP), which requires biomass energy production enterprises to comply with environmental requirements and protect the ecological environment during the production process.

4 Innovative Technologies for Bioenergy

With the continuous growth of global energy demand and the increasing depletion of traditional fossil fuels, bioenergy as a sustainable clean energy source has received increasing attention. In the field of bioenergy, innovative technologies are constantly emerging, injecting new vitality into the development of bioenergy, which is of great significance for achieving sustainable development of bioenergy.

Gene editing technology is a technique that artificially alters the genome of living organisms, and has made significant progress in its application in the field of bioenergy. Gene editing technology can be used to alter the genome of organisms, making them more suitable for the production of bioenergy (Tan et al., 2003). Researchers have successfully altered the composition of cellulose and lignin in the cell wall of Arabidopsis plants using gene editing technology, making them easier to degrade during biotransformation, thereby improving the production efficiency of biomass energy. Eesearchers have successfully altered the metabolic pathways of brewing yeast through gene editing technology as well, altering the composition of cellulose and lignin in plant cell walls, making them easier to degrade during biotransformation, producing more biofuels, and thus improving the production efficiency of biomass energy.

Telomere modification technology is a technique that changes the length of cell telomeres. In the field of bioenergy, telomere modification technology can be used to extend the lifespan of microorganisms and improve

their ability to produce bioenergy. For instance, researchers have successfully extended the lifespan of brewing yeast using telomere modification technology, thereby improving the production efficiency of biofuels.

Metabolic engineering technology is a technique that changes the metabolic pathways of microorganisms and is widely used in the field of bioenergy. Metabolic engineering technology can be used to optimize the metabolic pathways of microorganisms, making them more suitable for the production of bioenergy (Yang et al., 2002). Researchers have successfully altered the metabolic pathways of certain microorganisms using metabolic engineering techniques, making them more suitable for producing biofuels such as biodiesel. In addition, researchers have also utilized metabolic engineering techniques to successfully alter the metabolic pathways of some microorganisms, enabling them to produce more bio hydrogen.

Bioreactor technology is a technique that improves the efficiency of bioconversion by optimizing reactor design and operating parameters. In the field of bioenergy, bioreactor technology can be used to optimize the production process and improve the production efficiency of bioenergy. Researchers have successfully improved the production efficiency of biomass energy by utilizing efficient reactors and production lines. Researchers have also successfully achieved continuous and large-scale production of biofuels using bioreactor technology.

Biosensor technology is a technology that monitors and controls production processes by utilizing the ability of organisms to perceive and respond to environmental changes, and its application in the field of bioenergy is becoming increasingly widespread. In the field of bioenergy, biosensor technology can be used to monitor key variables in the production process, such as temperature, pH value, etc. Researchers have successfully used biosensor technology to monitor key variables in the production process, thereby achieving real-time monitoring and control of the production process and improving the production efficiency of bioenergy. In addition, researchers have successfully monitored the metabolic status of microorganisms during the production process using biosensor technology, thereby achieving intelligent control and optimization of the production process.

5 Prospect

As a sustainable clean energy, the role and significance of bioenergy in sustainable development cannot be ignored. The development of bioenergy can effectively meet human energy needs without imposing too much burden on the environment. The development of bioenergy can promote sustainable development and environmental protection without sacrificing economic development. Therefore, the role and significance of bioenergy in sustainable development are very important.

Currently, the development of bioenergy faces some challenges and problems. The biggest challenge is the high production cost and low production efficiency of bioenergy. Besides, there are also certain issues with the raw material sources of bioenergy, such as limitations on biomass sources and competition from biofuels for resources such as food. The development of bioenergy also needs to face policy and legal challenges, such as incomplete policies and laws, which limit the development of bioenergy.

To address the aforementioned issues and challenges, we can promote the development of bioenergy in the global energy transition by improving its production efficiency, expanding its raw material sources, providing policy and legal support, and strengthening international cooperation. In the future, bioenergy will play an important role in the global energy transition.

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