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Master Program
on Bio-Based Circular Economy

Course of Renewable Energy Technologies

Renewable Energy-Solar Report

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Summary

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1 Background

Since the energy crisis and environmental degradation have aroused widespread concern in society, the search for new clean energy has become an eternal topic in the field of energy research. As an important renewable energy, solar energy has the advantages of endless and relatively stable, which naturally becomes a hot research object. After decades of system development, people have studied solar energy deeply and widely, and the future of solar energy is still infinite[1].

Governments of all countries attach great importance to the development of renewable energy and low-carbon economy, and constantly increase the share of renewable energy in the energy consumption structure. Renewable energy plays an important role in the global energy supply in the future. The development and utilization of solar energy mainly includes solar photovoltaic power generation and solar thermal utilization. Solar photovoltaic power generation is a kind of power generation form which uses the photovoltaic effect principle of solar cells to directly convert solar radiation energy into electrical energy. With the rapid development of solar photovoltaic power generation industry and market, it is strongly promoted by continuous technological progress and gradually improved laws and policies. Since the 1980s, the United States, Germany, Japan, Canada, the Netherlands and other countries have formulated medium and long-term development plans to greatly promote the development of photovoltaic technology and industry. In the past 10 years, the annual growth rate of global solar cell production has reached 33%. Photovoltaic power generation has more and more alternative functions in energy, which is mainly reflected in the rapid increase of the application proportion in grid connected power generation. At present, photovoltaic grid connected power generation accounts for more than 80% of the world photovoltaic power generation market share, becoming the leading market of photovoltaic power generation. Photovoltaic grid connected power generation is the inevitable way to develop photovoltaic power on a large scale. Solar focused thermal power generation (CSP) is a kind of solar energy high-temperature heat utilization technology, which began to rise in 2005 and attracted the attention of the international academic community, with frequent academic activities. However, the technology still follows three technical routes: Tower, trough and dish. Solar energy heat utilization technology has been very mature, good economy, has been widely used and completed the commercial operation process[2]. By 2010, the total heat collection area of solar water heaters in the world has exceeded 450 million m^2.

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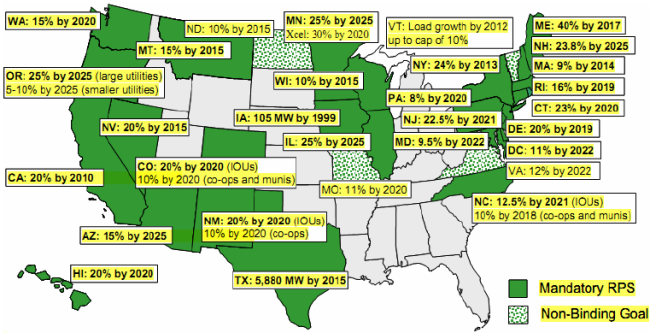

Figure 1. total renewable power generation in U.S. states

The same is true in China. Facing the current energy structure dominated by fossil energy, the state will promote the development and utilization of solar energy to the strategic position of China's energy development, focusing on and giving priority to development. China is rich in solar energy resources. The annual average radiation in the mainland is more than 5000mj / m2, especially in the Qinghai Tibet Plateau, the annual radiation is more than 8800mj / m2. In terms of solar energy utilization, solar water heater is the main form of solar energy heat utilization in China, and its production and retention are also increasing[3].

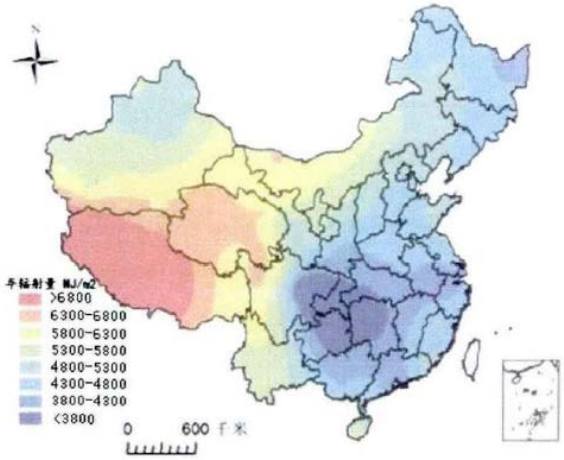

Figure 2. spatial distribution of annual solar radiation in China

At present, the application and research of solar energy in China focus on four aspects: photoelectric conversion, photothermal conversion, photocatalysis and conversion of solar energy to biomass energy. Converting solar energy into electricity is the most common way of using solar energy in our life, and it is also the most rapid development and hot research direction in the field of solar energy utilization in recent years. Solar cells are indispensable for generating electricity by solar. After the first solar cell was made by Bell Laboratories in 1954, the solar cell quickly occupied a place in scientific research, aviation, civil and other fields in the past 60 years. Solar cells can be seen everywhere around us. There are usually solar cells on signal solars, street solars and calculators. In

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the northwest of China, solar cells are also deployed for domestic power generation. In 2018, China's solar power generation capacity has reached 9.2% of the total[4]. The conversion of solar energy into heat energy is the only way to utilize solar energy after photoelectric conversion. When it comes to the conversion of solar and heat, the first thing people think of is solar water heater. It is true that solar water heater is the most common device to convert the energy radiated by the sun into heat energy, but in addition, solar heat is also used in medicine, desalination and other fields. Compared with photoelectric conversion and photothermal conversion, photocatalysis is a relatively unfamiliar vocabulary, but its application prospect is wider than photoelectric conversion and photothermal conversion. The basic principle of photocatalysis is is similar to photoelectric conversion. The main difference is that the excited state electrons generated by semiconductor absorbing solar energy participate in chemical reaction rather than external electric work, thus converting solar energy into chemical energy. Converting solar energy into biomass energy is the earliest way to utilize solar energy. The simplest way to convert solar energy into biomass energy is to plant green trees and crops. These plants use photosynthesis to convert solar energy into biomass energy through their own biochemical reactions, and then people use various means to obtain biomass energy or convert it into other forms of energy for application. In the future, the research on the conversion of solar energy into biomass energy will tend to beautify the environment while solving the problems of air and water and soil pollution, and combine gene technology with photosynthetic microorganisms to produce medical and industrial raw materials needed by human beings[5].

Of course, in addition to solar energy, renewable energy includes wind energy, biomass energy, etc. Compared with solar energy, it has abundant resources and no noise.

2 Use of solar energy

There are basically the following ways to use solar energy: solar-heat conversion and utilization, solar-electricity conversion and utilization, solar-biological conversion and utilization, and solar-chemical conversion and utilization[6]. Among them, the use of solar-heat conversion is the most widely used, the lowest cost, and the best technology; photo-electric conversion has great prospects. The utilization of photo-chemical conversion is still in its infancy, and it is rarely used on a large scale.

2.1 Solar-Heat

"Solar-heat" conversion and utilization means that the solar radiation energy is collected by a heat collector and converted into heat energy, and the heat energy is used to serve human being[7].

"Solar-heat" conversion utilization is divided into low temperature utilization, medium temperature and high temperature utilization. In the "solar-heat" conversion and utilization, today's solar water heaters are the most technical and economical.

Solar water heaters are an important use of "solar-heat" conversion. In the world, solar water heaters are the most well-developed large-scale industries, and their advantages over electric water heaters and gas water heaters. Solar water heaters used abroad are mainly used for heating, followed by hot water supply, while China mainly supplies hot water, heating is still in its infancy[8]. In terms of type of use, solar water heaters in the United States are mainly low-temperature non-glass water heaters and glass water heaters. Low-temperature non-glass water occupies most of the market. Poland, Spain, India and other countries mainly use flat plate collectors; in terms of water heater installation rate, Cyprus, Austria, Israel and other countries have the highest per capita installation rates in the world, while China has a low per capita installation rate; the rooftop water heaters used in China are the most in the world, accounting for 60% of the total consumption; China's water heater production is the most in the world.

"Solar-Heat" Status

Solar water heaters are the most common devices in life that convert the energy of solar radiation into heat energy, but in addition, solar and heat are also used in medicine, seawater desalination and other fields. At present, the most commonly used treatment methods in cancer treatment are chemotherapy (ie, chemotherapy) and radiation treatment (ie, radiotherapy), but in fact research on photothermal treatment is also steadily carried out. Photothermal therapy is to target materials with photothermal properties, such as gold nanoparticles or carbon nanotubes, to tumor tissues, enrich them in tumor tissues, and then irradiate them with near infrared solar. The photothermal materials convert the solar energy into heat energy The local temperature of the tumor is increased, thereby killing the tumor cells. There are also studies on the use of low-cost photothermal materials to use sunsolar to evaporate water in sewage or seawater, and then condensate it into clean fresh water to reduce the cost of seawater desalination and sewage treatment, and reduce environmental pollution during the treatment process.

2.2 Solar-electricity

"Solar-electricity" conversion refers to the conversion of solar energy resources into electrical energy, including solar thermal power generation and solar photovoltaic power generation ; "solar-electricity" conversion has two main ways of utilization, one is solar energy-heat energy- Conversion

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of electrical energy, using the thermal energy generated by solar radiation to generate electricity[9]. Its principle is to use a heat collector to collect solar radiation energy, turn the collected heat into a hot fluid and transmit it to the steam engine, and use the energy to drive the large-scale volt-electric machine to produce usable direct current or alternating current. According to the different ways of collecting solar energy, the solar thermal power generation technology mainly has four technical routes: tower, trough, dish and Fresnel. On this basis, there are some variant technologies, such as tower secondary reflection, Module fixed date and so on. According to different heat collection methods, solar thermal power generation can also be divided into two methods: point focus and line focus. Point focusing is represented by tower and dish technology routes, and line focusing is represented by trough and Fresnel technology routes.

(1)Tower solar thermal power generation system

The tower solar thermal power generation system uses heliostats to reflect solar energy to the heat absorber installed on the high tower, centrally heat the heat transfer medium in the heat absorber, convert and store the solar thermal energy in the heat transfer medium (melt Salt or water), then use high temperature medium to heat water or directly generate steam to drive the steam turbine generator set to generate electricity. Because the concentration ratio of the condenser is more than 1000 times, limited by materials and heat transfer media, the current tower solar thermal power generation system generally works at 565 ℃, and may reach 800 ℃ or more in the future, which belongs to high-temperature solar thermal power generation.

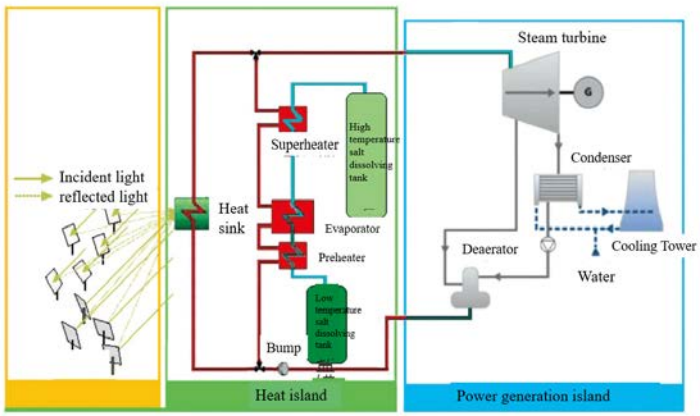

Figure 3. Tower solar thermal power generation system

(2)Trough solar thermal power generation system

The trough solar thermal power generation system focuses and reflects sunsolar on the vacuum tube heat absorber, heats the heat transfer medium in the vacuum tube, and arranges the multi-stage series and parallel to make the heat transfer medium reach the design parameters, and finally generates steam through heat exchange To promote steam turbine power generation. In this technology, the concentration ratio of the condenser is 50 to 100 times, and the medium temperature is usually lower than 400 ℃, which belongs to medium and high temperature solar thermal power generation.

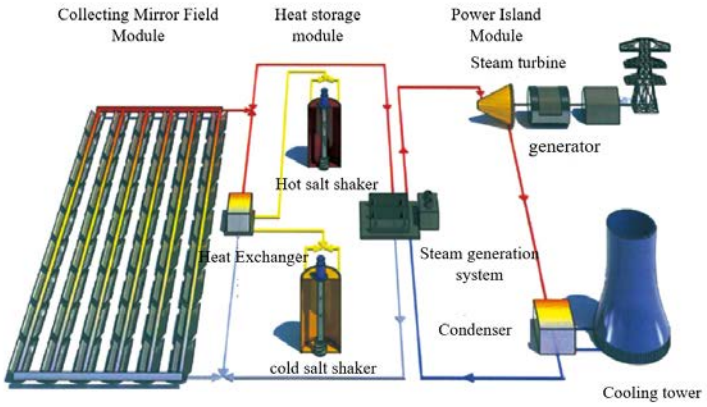

Figure 4. Trough solar thermal power generation system

(3)Dish type solar thermal power generation system[10]

Dish-type solar thermal power generation is a type of solar thermal power generation with the highest photoelectric conversion efficiency. It collects solar energy into a receiver by rotating a parabolic dish-shaped condenser, and the receiver passes the absorbed energy through a thermoelectric conversion system (such as Stirling) (Generator) is eventually converted into electrical energy. In this technology, the concentration ratio of the condenser can reach 1000-4000 times, and the receiving temperature of the receiver can reach 800 ℃. Demonstration projects using this technology have been put into operation abroad. However, due to the difficulty of equipping the disk system with energy storage, the power generation characteristics are similar to photovoltaic power generation, but the price is much higher than photovoltaic power generation. Therefore, it is not recommended to apply this technology at scale until there is no lower-cost energy storage system.

(4)Fresnel solar thermal power generation system

The working principle of the Fresnel type solar thermal power generation system is similar to that of the trough type solar thermal power generation system, except that the technology uses the characteristics of the Fresnel lens and uses many single-axis automatic tracking mirror groups to replace the trough parabolic mirror to replace the sun. The solar is gathered into a linear condenser parallel to the mirror field, heating the working fluid flowing in the condenser steel tube, thereby generating high-temperature and high-pressure steam, and directly driving the turbine generator at the back end to generate electricity. The concentration ratio of the concentrator is 50 to 100 times, and the operating temperature of the system is generally 280 to 400 ℃, which belongs to medium and high temperature solar thermal power generation.

(5)Status of solar power generation

The cost of a solar thermal power generation project has an important relationship with factors such as its scale, technical solutions, heat storage duration and supplementary combustion. But for large-scale solar thermal power generation projects, the concentrating system accounts for about 40% to 50% of the cost of the entire solar thermal power station. The cost of the concentrating system almost completely determines the cost of the solar thermal power station. Therefore, solar cells in the concentrating system are very important. The current research on solar cells is to develop new types of solar cells to obtain higher photoelectric conversion efficiency, and optimize the structure and materials of solar cells to give them more functionality. Such as the study of perovskite solar cells, dye-sensitized solar cells and CIGS thin-film solar cells, etc. new solar cells with higher theoretical efficiency than traditional silicon-based solar cells; study of transparent and flexible solar cells to make them applicable Combine with other flexible devices on irregularly shaped walls and glass.

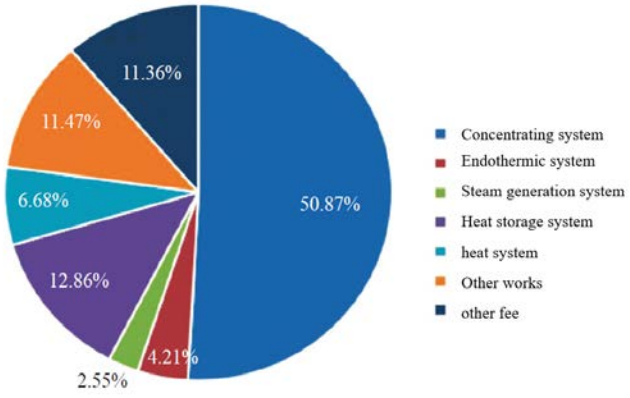

Figure 5. Solar power system cost

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2.3 Solar-Biology

"Solar-biological" conversion and utilization refers to green plants or certain bacteria through a series of complex photosynthetic reactions to convert solar energy into chemical energy stored in the body. It is the largest solar energy conversion and utilization process in nature; existing giant seaweed, Fast growing plants, oil crops, etc.

2.4 Solar-Chemistry

"Solar-chemical" conversion and utilization refers to the process of converting solar radiation energy into chemical energy; for example, the process of photolysis of water to produce hydrogen, because hydrogen is generated after the reaction of hydrogen, has no impact on the environment, so photolysis of water to produce hydrogen is The most ideal process in the "Solar-chemical" conversion utilization can be carried out in the following three ways: one is the photoelectrochemical cell, the other is solar-assisted complex catalysis, and the third is semiconductor catalysis [11].

"Solar-Chemistry" Status

Converting solar energy into biomass energy is the earliest way for humans to use solar energy. The simplest way to convert solar energy into biomass energy is to plant green trees and crops. These plants use photosynthesis to convert solar energy into biomass energy through their own biochemical reactions, and then people use various means to obtain biomass energy or convert it into other forms of energy for application. In addition to this most traditional way of converting solar energy into biomass energy, people have also developed photosynthetic bacteria to use solar energy. Under the irradiation of sunsolar, some photosynthetic bacteria can fix nitrogen, fix carbon, and reduce sulfides, thereby strengthening the carbon, nitrogen, and sulfur cycles in the atmosphere. Metabolites can be used to make fertilizers; some photosynthetic bacteria can synthesize coenzyme Q, chlorophyll Carotene and other natural pigments and pharmaceutical raw materials are used in the fields of medicine, food, and cosmetics; certain photosynthetic bacteria can decompose organic and inorganic pollutants in sewage, effectively reducing the content of ammonia salts, nitrites, etc.; there are also studies on photosynthesis Bacteria and microbial fuel cells combine to generate electricity while decomposing pollutants.

3 Advantages and disadvantages of solar applications

Solar energy is an inexhaustible and green renewable energy, which has received more and more attention. For China, the development and utilization of solar energy has far-reaching practical significance. It can not only solve the problems of inferior energy quality, inferior energy quality and

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long-term coal. At the same time, it can greatly reduce the negative impact of harmful substances produced by fossil fuel combustion on the environment, such as air pollution, acid rain, greenhouse effect, and ecological balance damage. Ensure the implementation of China's sustainable development strategy. In other words, the development and utilization of solar energy is not only an urgent situation facing China, but also a general trend[12].

Compared with other renewable energy sources, solar energy has advantages that other energy sources do not have. The advantages are as follows: First, the energy of solar energy can be said to be inexhaustible and huge. And our planet is only receiving half of the total solar energy emitted from the surface of the sun, which is equivalent to 30,000 to 40,000 times the global energy demand. More specifically, half an hour of solar energy is enough to match the annual energy usage of the world we live in.

The second point is that compared with the underground non-renewable energy coal resources and petroleum resources, solar energy and other renewable energy sources have the greatest advantage in that they produce a large amount of carbon dioxide and sulfur dioxide compared with coal and petroleum combustion[13]. They do not pollute the atmospheric environment; Cause natural disasters, such as: acid rain, greenhouse effect; will not cause ecological imbalance in nature. And as long as there is solar, you can use solar energy. Therefore, we can say that solar energy is green and renewable energy. Today, with the development of industry and the increasingly serious environmental problems, solar energy has a series of advantages such as large reserves, long-term, renewable, pollution-free, and convenient utilization, which makes solar energy have extremely broad application prospects and development prospects[14].

Anything that has advantages has certain disadvantages. The shortcomings of solar energy. The first point: the energy distribution of solar energy changes with the change of wavelength and the conversion efficiency of some solar energy is relatively low, because these energy conversions can only be used for specific frequency bands. Radiation sensitive[15]. For example, when we are in the laboratory, the maximum photoelectric conversion efficiency of solar cells is not greater than 20%, and the conversion efficiency of solar cells is usually between 11% and 15%. Second, although the total solar radiation projected to the entire earth is very large, the energy projected to the surface area per unit time is not very high, that is, the energy per unit area, that is, the energy per unit time. The intensity of solar radiation is very low to us on the surface of the earth, and its intensity rarely exceeds 1 kilowatt/square meter. The third point is that in different seasons, different regions, and different angles, the energy we obtain from the sun will be different. This is because the rotation and revolution

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of the earth will cause the height of the sun to change continuously, so that the angle of height changes continuously. And the energy is also affected by the current weather. The above factors lead to the stability and poorness of solar energy. In summary, solar energy is only a low-grade energy source. For example, the collection, storage, conversion and economic cost of solar energy. The difficulty of overcoming these problems has become a key issue in promoting and using solar energy today[16].

Photovoltaic power generation is a device that converts solar radiation into electrical energy. It uses the photovoltaic effect. The principle is that when solar is irradiated, the physical internal charge changes, the electromotive force changes and the current changes. When performing solar power generation, sunsolar illuminates the semiconductor PN section, at this time, the electromotive force will be generated on both sides, that is, complete solar power generation. Solar power has its unique advantages: ① The solar energy's solar energy comes directly from the solar radiation, it is inexhaustible, and the solar energy is safe and clean, there will be no gas pollution and chemical pollution, and there will be no fossil fuels The danger of burning; ②Solar power generation requires solar panels. For remote areas, there is enough open space and unobstructed solar energy to facilitate power supply in remote areas and reduce the current grid pressure; ③ Solar power generation only needs The battery panel does not require other chemical reactions or other assistance, saving manpower costs; ④The solar panel can be generated by itself after installation, without physical movement, its stability is high, it is not easy to damage, cost savings, and easy maintenance; ⑤Solar power generation is safe and clean, unlike fossil fuels, it produces other substances after combustion, which has a certain impact on the environment and the atmosphere, and solar power generation effectively avoids this problem; ⑥Solar panels can be directly used in remote areas Placed on idle hillsides or other sunny areas will not affect people's normal residence. In densely populated cities or villages, solar panels can be placed on the roof or roof without occupying other space.

Problems of solar photovoltaic power generation in China:

(1) Low power generation efficiency. Although solar energy propagates into space in the form of radiation, the nature of solar cells determines their absorption of the solar spectrum. Generally, single-crystal silicon solar cells only absorb energy in the wavelength range of 3 80-1100 nm for power generation. The energy in the remaining wave bands is absorbed by the solar cell and becomes thermal energy. As the battery temperature increases, the thermal motion of the electrons in the battery increases, the energy band gap decreases, the open circuit voltage decreases with increasing temperature, and the short-circuit current increases with increasing temperature.As a result, the output

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power of the battery increases with temperature. While falling, the temperature rise reduces the photoelectric conversion efficiency of solar cells. The theoretical conversion efficiency of monocrystalline silicon solar cells is about 28.8%, the highest efficiency in the laboratory is 25%, and the efficiency of large-scale production cells is about 17%. At present, the actual average efficiency of monocrystalline silicon cells is about 12% to 16%. The efficiency of photovoltaic cells is about 11% to 15%, and the efficiency of amorphous silicon photovoltaic cells is only 5% to 18%. Due to the low photoelectric conversion efficiency of the battery, to increase the amount of power generation, it is necessary to increase the number of battery plates and build it to a higher level, which restricts its development to a certain extent.

(2) The volatility of the power generation system. Due to the large randomness and volatility of solar radiation affected by day-night alternation, seasonal changes, and geographical location differences, the efficiency of PV is greatly affected by the climate environment and the power output is unstable. In addition, atmospheric transparency, particulate matter in the air, etc. attached to the surface of the battery plate also have a greater impact on the photoelectric conversion.

(3) High energy consumption and pollution in battery production. Solar cells have the characteristics of "no fuel consumption, no noise, and no pollution" in the process of using their power generation, but there are many high energy consumption links in the battery production link, and a lot of pollution occurs. The total power consumption of the whole process from the production of industrial silicon to solar cells in China is about 2.2 million MWh/MW. The average production of 1MW solar cells requires 10kg of polysilicon and the power consumption is 580-6000MWh. The by-product S iCl4 in the battery production process is a colorless or solar yellow fuming liquid with a pungent odor, which will emit toxic and corrosive fumes when heated or decomposed in water. For every 1kg of polysilicon produced abroad, 10 to 15 kg of SiCl4 will be produced. After reduction, the emissions are still as high as 5 to 10 kg; at the same time, HF, HNO3, POCl3, isopropanol and other chemical substances and units are widely used in the production of solar panels. The discharge volume of production capacity wastewater is 500～1500 m3/MW, and the wastewater contains a large amount of F-, COD, TN and other pollutants[17].

Despite the many unique characteristics and advantages of solar energy resources, the development and utilization technology has not yet reached the mature stage, especially the commercial utilization, mainly because the cost of solar energy utilization equipment is higher. Although the emergence of new materials, new materials and new technologies in recent years will inevitably reduce the cost of existing solar energy utilization equipment and increase the utilization

efficiency, but there are still some unsolved problems due to the use of solar energy, such as high cost and power Small, the efficiency of solar energy conversion is relatively low, etc., so that solar energy has not been fully utilized.

4 Solution

4.1 Policy promotion

According to the economic and social functions of the government, as well as the development status and characteristics of China's solar energy industry, the following policies can be implemented: (1) financial support. On the one hand, we should attach importance to the solar energy innovation mechanism, increase the subsidies for the research and development of new products and technologies, and implement regular research and development subsidies, provide demonstration, development and test equipment, etc. On the other hand, subsidies should be provided for production and consumption to encourage enterprises to produce solar energy products, guide consumers to use solar energy products, increase government purchase and expand domestic demand. (2) Tax preference. At the time of energy transformation, increasing tax preferences for new energy such as solar energy is conducive to the rapid rise and growth of new energy industry. First, we need to increase the preferential efforts of value-added tax, income tax and other taxes to effectively promote the continuous growth of enterprises; second, we need to implement the preferential tax policies for investment in solar energy industry to stimulate enterprises to increase investment in solar energy industry[18].

4.2 Reduce technical cost

In the Research Report "solar future" released by MIT not long ago, thin-film solar energy technology can reduce the use of photovoltaic materials and effectively reduce the manufacturing investment. With the further breakthrough of technology, in the future, it will become a reality to apply solar energy at a large price acceptable to the society. The researchers believe that crystalline silicon technology has inherent defects, its production process is very complex, and its solar absorption efficiency is low, which also leads to the need to use thick crystalline silicon for crystalline silicon solar panels. These bulky silicon wafers encapsulated by glass not only lead to the rigidity and fragility of the battery module, but also lead to the high manufacturing cost of the photovoltaic system. Compared with crystalline silicon, thin film technology is to deposit one or more layers of very thin photovoltaic materials on glass, plastic or metal substrates, which can reduce the use of materials in the system and reduce the manufacturing costs. So thin film technology is the most possible way to

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reduce the cost of solar energy. At present, the solar absorption efficiency of commercial thin film material is 10-100 times of that of monocrystalline silicon, so its material is only a few microns thick. Most of the high-purity silicon materials used in China's solar energy industry rely on imports. If we can reduce or avoid the expensive silicon crystal photoelectric conversion process, we can greatly reduce the cost of solar power generation[19].

4.3 Expand solar energy utilization mode and field

(1) Solar and heat utilization. Its basic principle is to collect the solar radiation energy and use it by converting it into heat energy through the interaction with matter. At present, the most commonly used solar energy collection devices are mainly flat plate collector, vacuum tube collector and focusing collector. Generally, according to the different temperature and application, solar energy can be divided into low temperature utilization (< 200 ℃), medium temperature utilization (200-800 ℃) and high temperature utilization (> 800 ℃). At present, the low-temperature utilization mainly includes solar water heater, solar dryer, solar distiller, solar house, solar greenhouse, solar air conditioning and refrigeration system, the medium temperature utilization mainly includes solar stove, solar thermal power concentrating and collecting device, and the high-temperature utilization mainly includes high-temperature solar furnace, etc.

(2) Solar power. In the future, large-scale utilization of solar energy will be used to generate electricity. There are many ways to use solar power. At present, there are two kinds of practical ones. ① Solar heat electricity conversion. That is to use the heat energy generated by solar radiation to generate electricity. Generally, solar collectors are used to convert the absorbed heat energy into steam of working medium, and then the steam drives the gas turbine to drive the generator to generate electricity. The former is solar heat conversion, the latter is heat electricity conversion. ② Optical electric conversion. Its basic principle is to use photovoltaic effect to directly convert solar radiation energy into electrical energy. Its basic device is solar cell[20].

(3) Photochemical utilization. This is a kind of photochemical conversion mode that uses solar radiation energy to decompose water directly to produce hydrogen.

(4) Photobiological utilization. The process of converting solar energy into biomass is realized through the solar cooperation of plants. At present, there are mainly fast-growing plants (such as firewood forest), oil crops and giant algae.

4.4 Improve public awareness of energy conversion and use

Although the extensive use of solar energy has positive significance for national energy security, long-term economic development and other aspects, the government and society have ignored the publicity and education of the general masses, and failed to systematically let them understand the current energy situation in China and the importance of solar energy and other renewable energy for the country and human survival and development, The role of the public in the whole process of renewable energy development is ignored, and the public is not actively and effectively mobilized to participate in the promotion of renewable energy. In fact, this is due to the failure of the mainstream belief in society to improve properly. The change of social mainstream belief affects the smooth progress of institutional change. In the aspect of renewable energy policy, if the government and society neglect the publicity and education for the masses, that is to say, ignore the influence on social mainstream belief, it will hinder the change of new system and its development to a great extent. In addition, all kinds of renewable energy economic incentive policies, including solar energy, are aimed at the energy supply market, and lack of economic incentive policies for renewable energy users or end users to encourage the use of renewable energy in the consumer market.

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References

[1]Xiao Shengze. Research on the current situation and future development of solar energy utilization [J]. Decision exploration (middle), 2019 (02): 70

[2]Zhang Zhi Guo, Wang Ru Yu. Analysis of the present situation and Prospect of solar energy utilization [J]. Shandong industrial technology, 2019 (03): 96

[3]Liu Shihui. Research on the development of China's non hydro renewable energy power generation industry [D]. China University of Geosciences (Beijing), 2011

[4]Shen Yi. Spatial distribution of solar energy and comprehensive potential evaluation of regional development and utilization in China [D]. Lanzhou University, 2014

[5]Ma Weiwei. Current situation and development trend of international solar power industry [J]. Solar energy, 2020 (01): 5-12

[6]Yin Jixin, Zhu Changjun.Utilization of solar energy and its development trend[J].Journal of Xinxiang University (Natural Science Edition), 2009, 26(1):28-29

[7] Ni Mingjiang, Luo Zhongtuo, Shou Chunhui, etc. Comprehensive utilization of solar thermal photoelectricity[J].Shanghai Electric Power,2009,32(1):1-7

[8]Zhang Xinjun. Linked heating technology of solar energy and floor heating[J]. China Electronic Commerce, 2013, 10(19):90-90

[9]Chen Yong. Efficient conversion of thermal energy into electrical energy or reality[J].Neijiang Science and Technology, 2013,34(12):141-141.

[10]Xu Hui, Zhang Hong, Bai Huang, et al. Overview of dish-type solar thermal power generation technology[J]. Thermal Power Generation, 2009, 38(5): 5-9

[11]Mao Wenyi. Feng Xiao.guang The critical solar energy conversion efficiency of catalytic decomposition of water to produce hydrogen[J]. Journal of North China Electric Power University (Natural Science Edition), 2007, 34(2):45-47.

[12]Xu Shengjie, Xi Jing, Wang Jing, Liang Bin. A review of research on solar energy technology[J].Shandong Chemical Industry,2019,48(01):63-64.

[13]Fan Junyi, Wang Haiyang. Development and current status of solar energy[J].Computer Knowledge and Technology,2019,15(10):228-229.

[14]Zhang Zhiguo, Wang Ruyu.Analysis of current situation and prospect of solar energy utilization[J].Shandong Industrial Technology,2019(03):96.

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[15]wang Letian.Analysis of the current status and development prospects of solar photovoltaic power generation in my country[J].Science and Technology Innovation,2018(14):194-195.

[16]Chen Jing,Zheng Weijuan.Development status and prospects of solar photovoltaic power generation in China[J].Times Agricultural Machinery,2018,45(03):48-49.

[17]Wen Jing.On the problems and promotion measures of solar photovoltaic power generation[J].Science and Technology Outlook,2016,26(35):68.

[18]Yilu Gu. Research on the current situation and development path of China's solar energy industry [J]. Development research, 2011 (05): 71-73

[19]Shulin Yang. Problems and Countermeasures in the development of China's solar energy industry [J]. Enterprise Guide, 2011 (21): 104-105

[20]Shiying Wen. Analysis of the application and development prospect of solar energy resources [J]. Science and Technology Economic Guide, 2016 (17): 128 + 143

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Master Program on Bio-Based Circular Economy

Course of Renewable Energy Technologies

Solar

Students: Junjie Wang; Wei Wang; Shihan Wu; ***Yudong Li*** *(Group leader)*

Co-funded by the Erasmus+ Programme of the European Union

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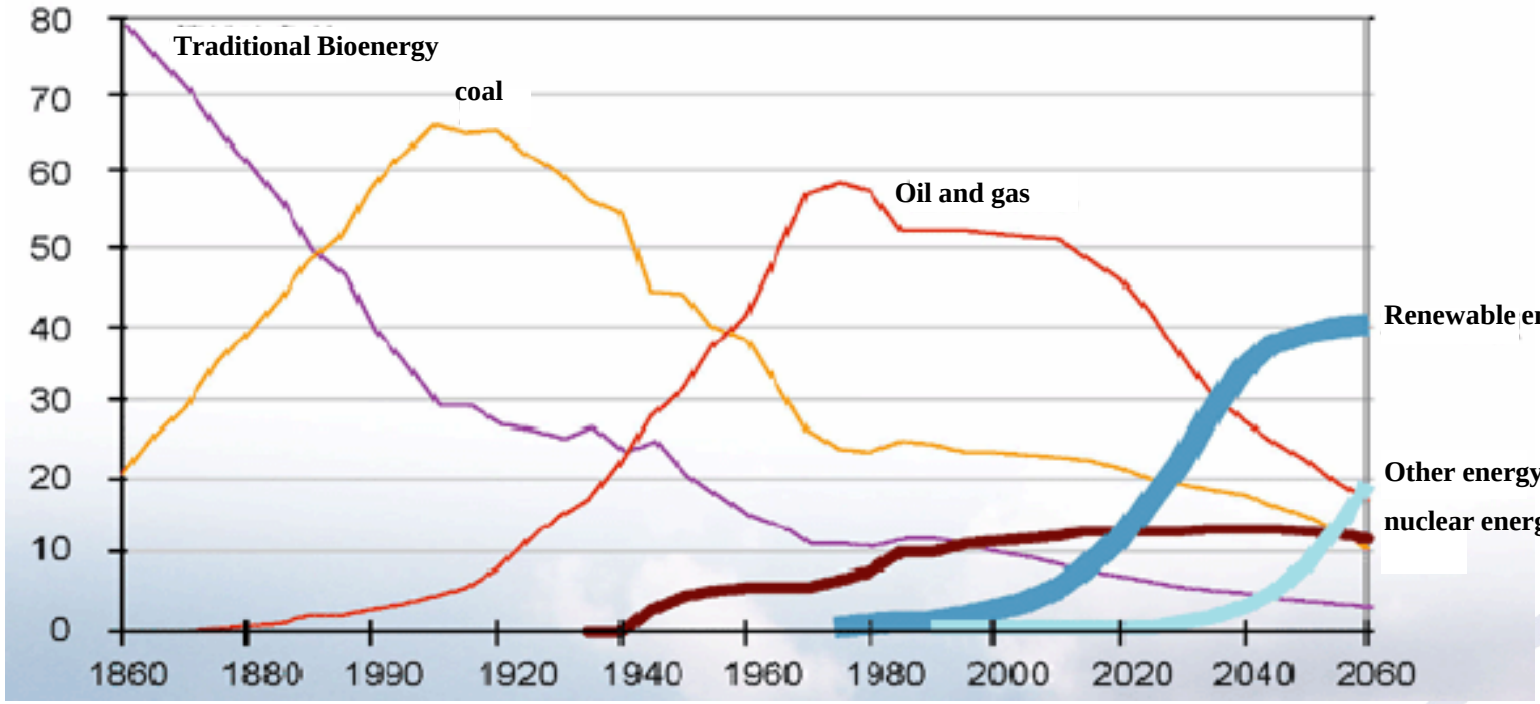
Background

Since the energy crisis and environmental degradation have aroused widespread concern in society, the search for new clean energy has become an eternal topic in the field of energy research.

As an important renewable energy, solar energy has the advantages of endless and relatively stable, which naturally becomes a hot research object. After decades of system development, people have studied solar energy deeply and widely, and the future of solar energy is still infinite.

Background

Governments of all countries attach great importance to the development of renewable energy and low-carbon economy, and constantly increase the share of renewable energy in the energy consumption structure.



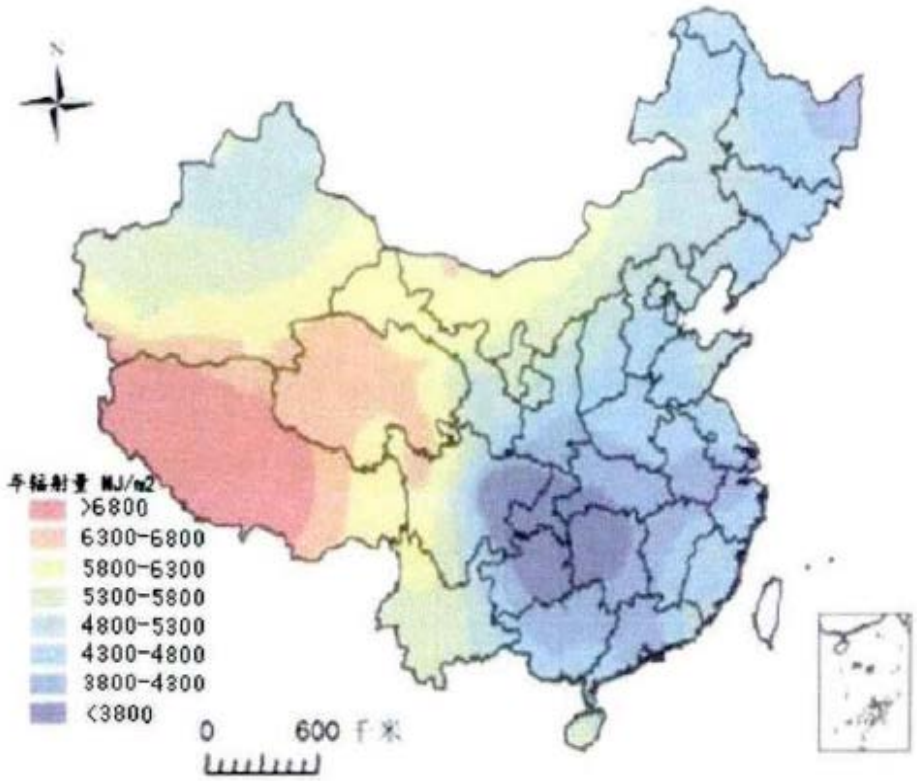
Trend chart of global energy composition

Background

In China, facing the current energy structure dominated by fossil energy, the state will promote the development and utilization of solar energy to the strategic position of China's energy development, focusing on and giving priority to development.

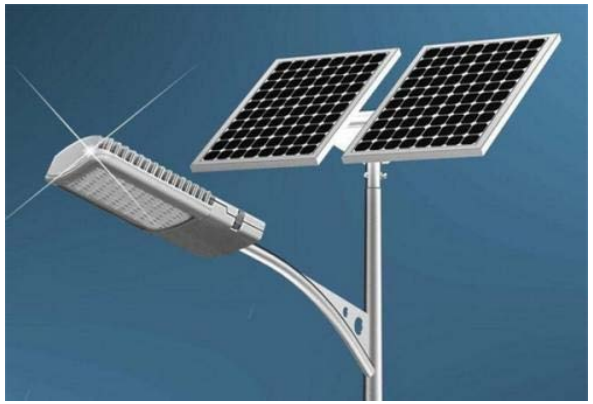
China is rich in solar energy resources. The annual average radiation in the mainland is more than 5000MJ/ m², especially in the Qinghai Tibet Plateau, the annual radiation is more than 5000MJ/m².

In terms of solar energy utilization, solar water heater is the main form of solar energy heat utilization in China, and its production and retention are also increasing.



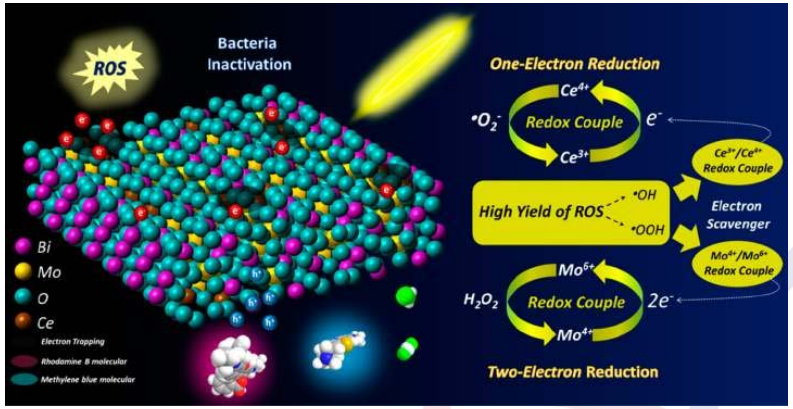
Background

At present, the application and research of solar energy in China focus on four aspects: photoelectric conversion, photothermal conversion, photocatalysis and conversion of light energy to biomass energy.

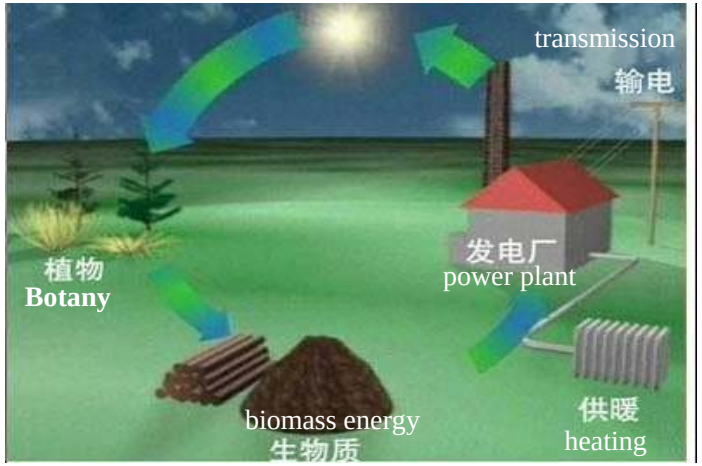


Photoelectric Conversion

photothermal conversion



photocatalysis



Conversion of light energy to biomass energy

Solar energy utilization

Light-electricity

Converting solar energy into electrical energy is the most common way of using solar energy in life. After Bell Laboratories produced the first solar cell in 1954, solar cells have been rapidly used in scientific research, aviation, and civil use for more than sixty years. The field occupies a place.

Light-heat

Converting solar energy into heat energy is the solar energy utilization method second only to photoelectric conversion. When it comes to the conversion of light and heat, people should first think of solar water heaters. Light and heat are also used in medicine, seawater desalination and other fields. At present, the most commonly used treatment methods in cancer treatment are chemotherapy (chemotherapy) and radiation therapy (radiotherapy).

Photocatalytic

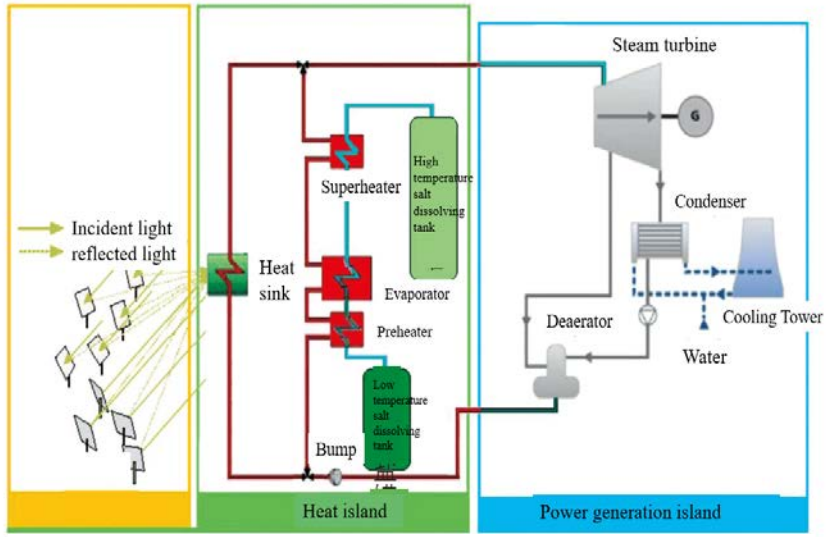
The basic principle of photocatalysis is similar to photoelectric conversion. The main difference is that the excited state electrons generated by semiconductors absorbing solar energy are involved in chemical reactions, rather than doing electrical work externally, which converts solar energy into chemical energy.

Conversion of solar energy to biomass energy

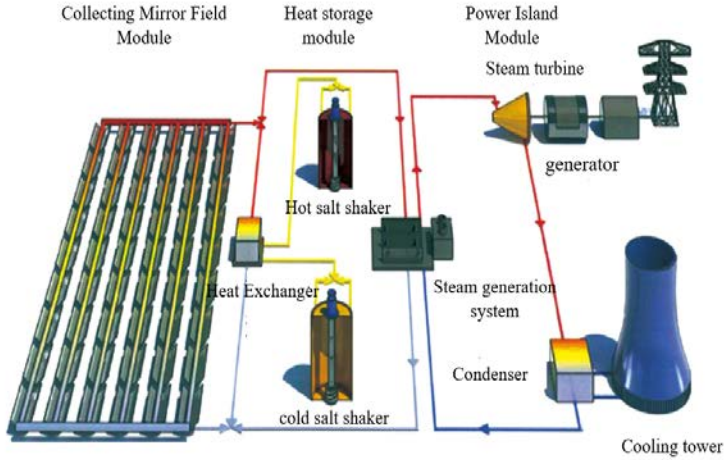
Converting solar energy into biomass energy is the earliest way for humans to use solar energy. The simplest way to convert solar energy into biomass energy is to plant green trees and crops.

Light-electricity

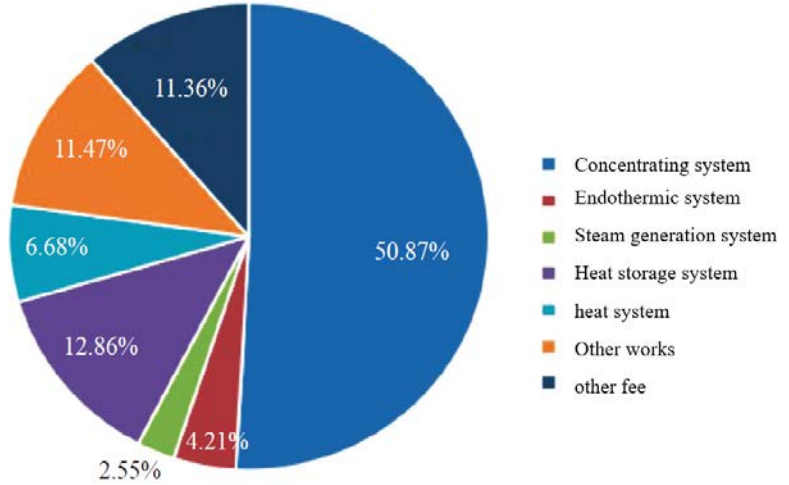
- Tower solar thermal power generation system



- Trough solar thermal power generation system



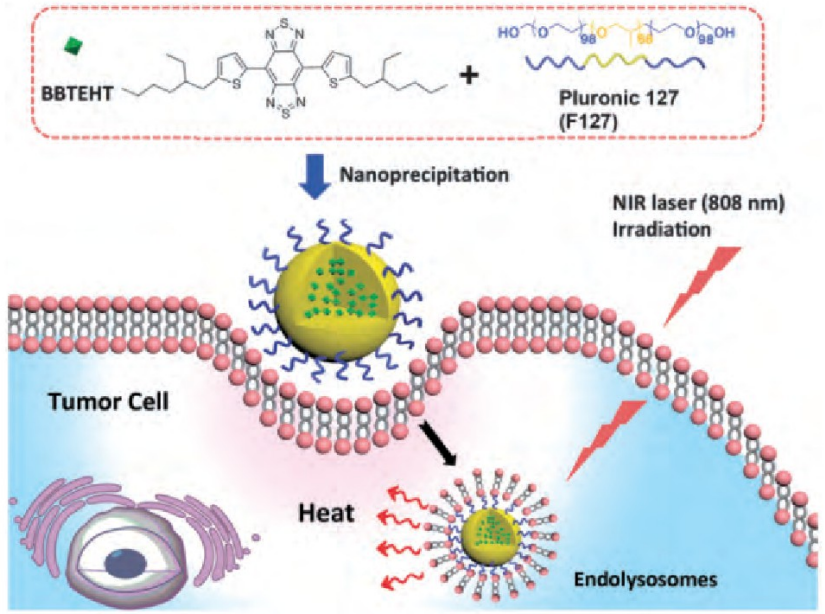
- Dish type solar thermal power generation system
- Fresnel solar thermal power generation system



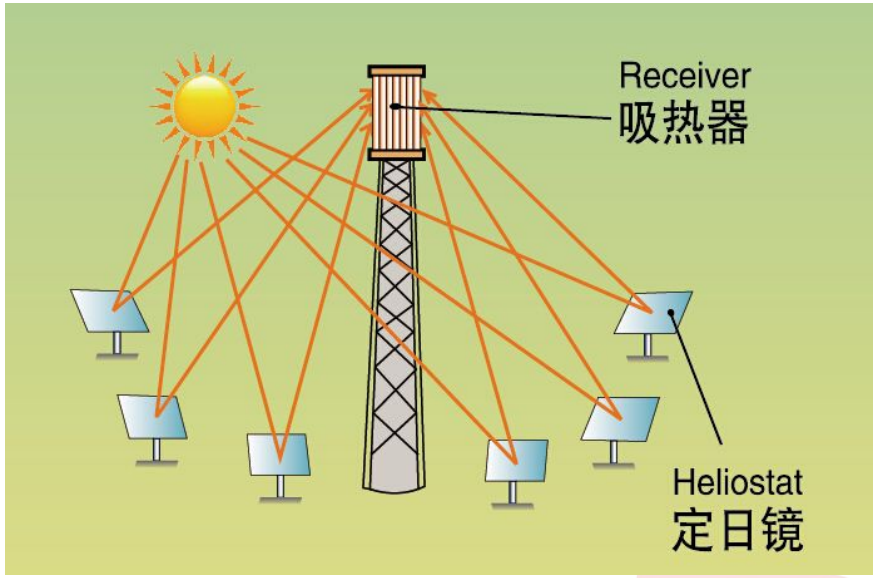
Investment cost structure of a 100 MW solar thermal power generation project

Light-heat

Solar energy → Internal energy



Photothermal therapy



Solar energy- Thermal energy

Photothermal therapy is to target materials with photothermal properties such as gold nanoparticles or carbon nanotubes to tumor tissues to enrich them in tumor tissues, and then irradiate them with near infrared light, and the photothermal materials will convert the solar energy into heat energy The local temperature of the tumor is increased, thereby killing the tumor cells.

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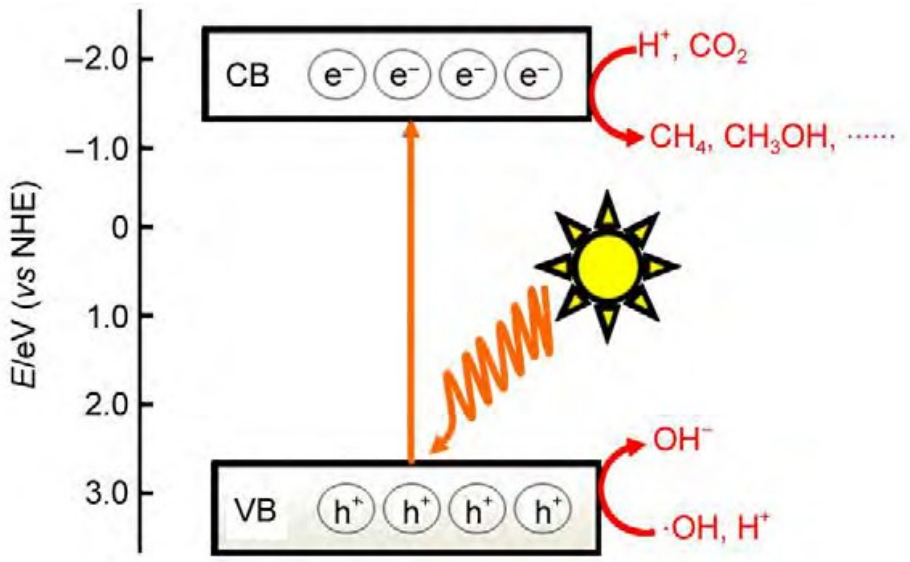
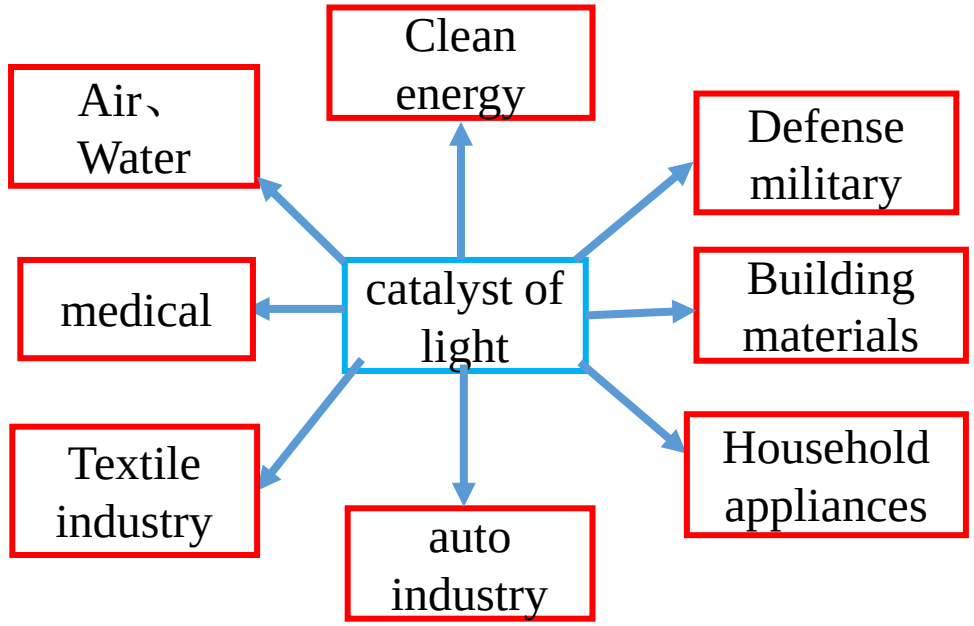
Rui Chen， Organic Photothermal Conversion Materials and Their Application in Photothermal Therapy

Photocatalytic



CO2 reduction by photocatalyst



Photocatalysis applications

The currently found photocatalytic active substances are mainly semiconductor materials, such as TiO2, ZnO, Fe2O3, ZnS, etc. The most useful one is TiO2, which is cheap, easily available, non-toxic and harmless, chemically stable, light-resistant Highly corrosive.

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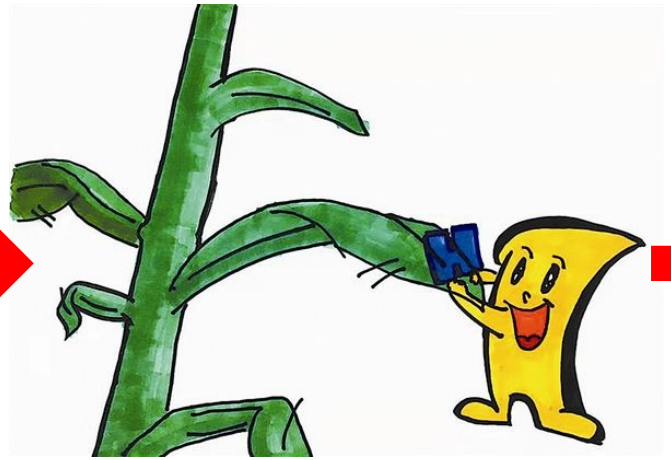
LAN Ben-Yue， Review of Systems for Photocatalytic Conversion of CO2 to Hydrocarbon Fuels

Conversion of solar energy to biomass energy

grow up



process

Plants use photosynthesis to convert solar energy into biomass energy through their own biochemical reactions, and then people use various means to obtain biomass energy or convert it into other forms of energy for application. In addition to this most traditional way of converting solar energy into biomass energy, people have also developed photosynthetic bacteria to use solar energy . Some photosynthetic bacteria can synthesize natural pigments and pharmaceutical raw materials such as coenzyme Q, chlorophyll, carotene, etc., used in medicine, food, cosmetics; some photosynthetic bacteria can decompose organic and inorganic pollutants in sewage, effectively reduce ammonia, Nitrate content.

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strength and weaknesses of solar applications

1.strength

1.Huge solar energy reserves

Our planet is only receiving half of the total solar energy emitted from the surface of the sun, which is equivalent to 30,000 to 40,000 times the global energy demand

2. Solar resources are clean and pollution-free

Compared with the large amount of carbon dioxide and sulfur dioxide produced by the combustion of coal and oil, the biggest advantage of solar energy is that it will not pollute the atmospheric environment; it will not cause natural disasters.

Huge reserves

Green, clean and renewable

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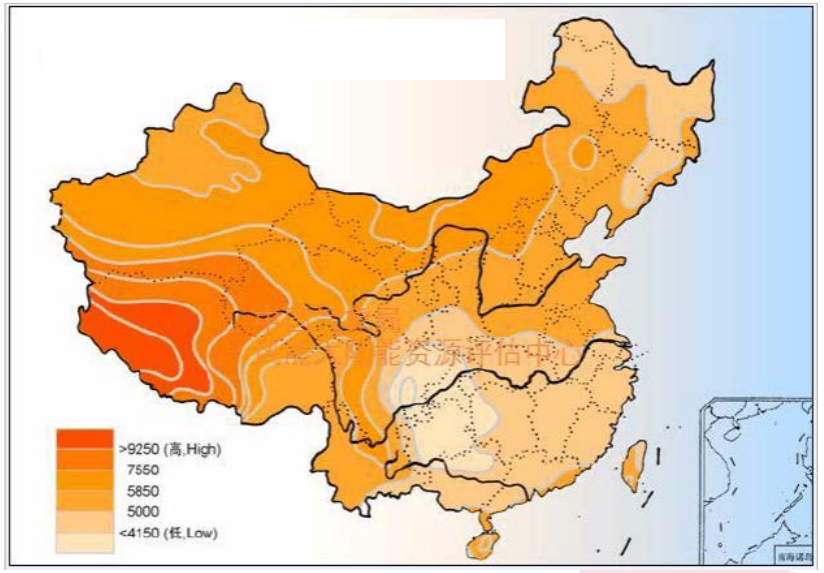
2. weaknesses

1.The conversion efficiency of solar energy is relatively low
The energy distribution of solar energy changes with the change of wavelength, and some conversion of solar energy can only be sensitive to the radiation of a specific frequency band
2. Low energy projected onto the surface area per unit time
The intensity of the solar radiation is very low to the surface of the earth, and its intensity rarely exceeds 1 MW/m2
3. There are many factors that affect solar energy access
In different seasons, different regions, and different angles, the energy we get from the sun will be different, and the energy is also affected by the current weather.

Distribution map of solar energy resources in China



As can be seen from this picture, in Tibet, China, solar energy resources are relatively abundant, while in other regions, solar energy resources are not enough.

The advantages and disadvantages of photovoltaic power generation

advantages

1.The solar energy of solar power generation comes directly from solar radiation， there will be no gas pollution and chemical pollution, and there will be no danger caused by the burning of fossil fuels
2. Solar power generation only requires battery panels, no other chemical reactions or other assistance, saving labor costs
3. After the solar panel is installed, it can generate electricity by itself without physical movement. It has high stability, is not easy to damage, saves costs, and is easy to maintain
4. Flexible installation .Solar panels can be placed directly on free mountain slopes or other sunny areas in remote areas, without affecting people‘s normal residence， In cities or villages, solar panels can be placed on the roof

disadvantages

1.Low power generation efficiency

The nature of the solar cell determines its selectivity for the absorption of the solar spectrum. Generally, single-crystal silicon solar cells only absorb energy in the wavelength range of 380-1100 nm for power generation, and the energy in the remaining wave bands is absorbed by the solar cells and becomes thermal energy.

2.Volatility of power generation system

Solar radiation is subject to day-to-night alternation, seasonal changes, and geographical location. There is a large randomness and volatility, which makes the efficiency of PV greatly affected by the climate environment, resulting in unstable power output.

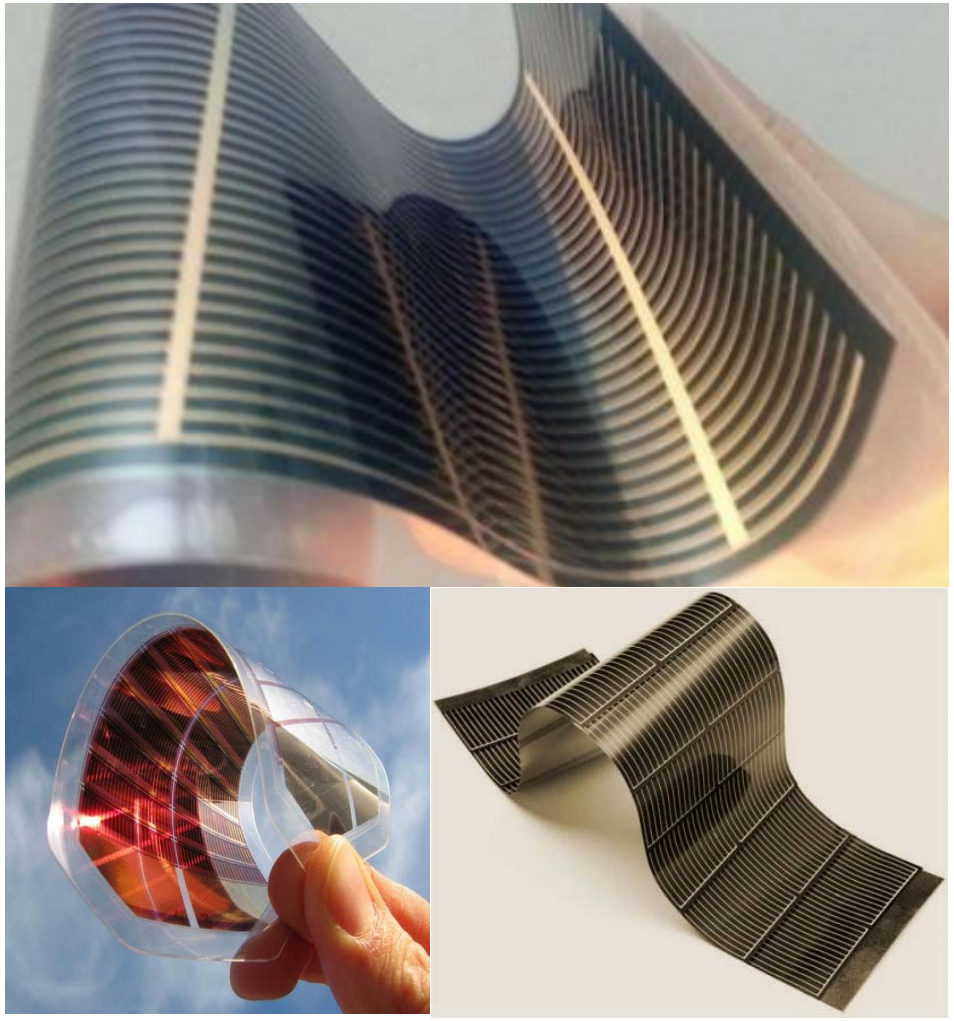
3.High energy consumption and high pollution in battery production

The battery production process will produce toxic corrosive flue gas and a large amount of wastewater, which contains a large amount of pollutants such as fluoride ions and TN

4. Expensive

The materials used in photovoltaic power generation and its processing result in a particularly high cost, which is the most important point limiting its development

1、Reduce technology costs

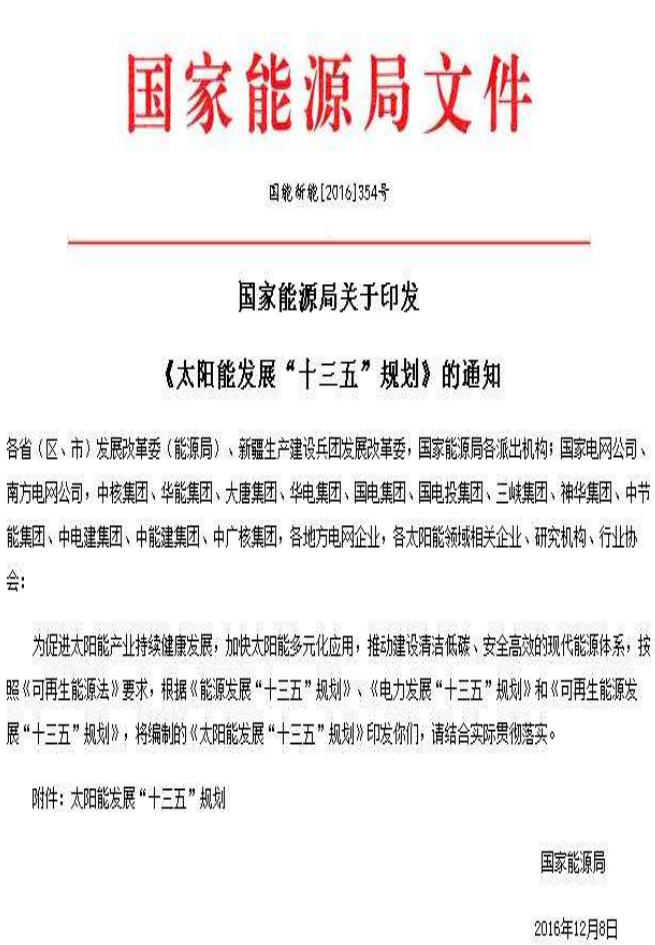


- Crystalline silicon technology has inherent defects, its production process is very complex, and its light absorption efficiency is low, which also leads to the need for thick crystalline silicon for crystalline silicon solar panels, and also causes the high manufacturing cost of photovoltaic system.

- Thin film technology is to deposit one or more thin layers of photovoltaic materials on glass, plastic or metal substrates, which can reduce the material use of the system and the manufacturing cost.

- The light absorption efficiency of commercial thin film material is 10-100 times of that of monocrystalline silicon, so its material is only a few microns thick.

2、Policy promotion



国家能源局文件

国能新能[2016]354号

国家能源局关于印发

《太阳能发展“十三五”规划》的通知

各省（区、市）发展改革委（能源局）、新疆生产建设兵团发展改革委，国家能源局各派出机构；国家电网公司、南方电网公司，中核集团、华能集团、大唐集团、华电集团、国电集团、国电投集团、三峡集团、神华集团、中节能集团、中电建集团、中能建集团、中广核集团，各地方电网企业，各太阳能领域相关企业、研究机构、行业协会：

为促进太阳能产业持续健康发展，加快太阳能多元化应用，推动建设清洁低碳、安全高效的现代能源体系，按照《可再生能源法》要求，根据《能源发展“十三五”规划》、《电力发展“十三五”规划》和《可再生能源发展“十三五”规划》，将编制的《太阳能发展“十三五”规划》印发你们，请结合实际贯彻落实。

附件：太阳能发展“十三五”规划

国家能源局

2016年12月8日

Financial support

On the one hand, we will increase subsidies for research and development of new products and new technologies, and provide subsidies for research and development on a regular basis; on the other hand, we will provide subsidies for production and consumption, encourage enterprises to produce solar energy products, guide consumers to use solar energy products, and increase government purchases to expand domestic demand.

Tax preference

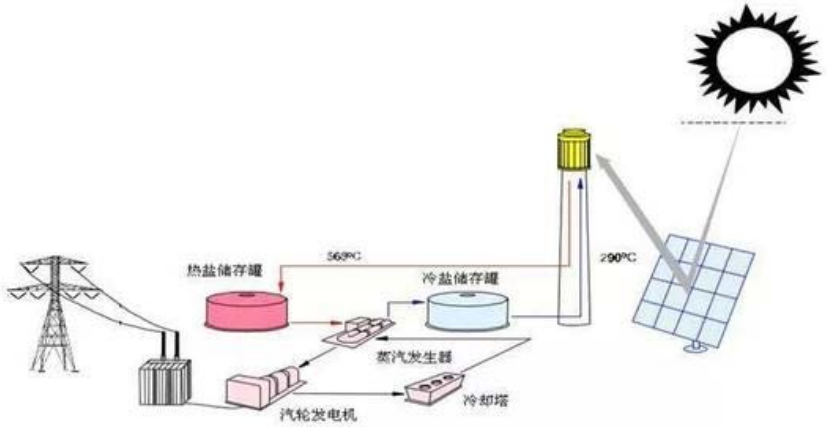
We will give preferential tax treatment to investment in the solar energy industry, and encourage enterprises to increase investment in the solar energy industry.

3.Improve public awareness of energy conversion and use

However, the government and society ignored the publicity and education of the general masses, and failed to systematically understand the current energy situation of our country and the importance of solar energy and other renewable energy for the country and human survival and development.

The change of social mainstream belief affects the smooth progress of institutional change. In renewable energy policy, if the government ignores the impact on social mainstream belief, it will hinder the change of new system and its development to a great extent.

4.Expand solar energy utilization mode and field



Photothermal utilization

Collect the solar radiation energy and convert it into heat energy

Photobiological utilization

The process of converting solar energy into biomass is realized through the light cooperation of plants. At present, there are mainly fast-growing plants (such as firewood forest), oil crops and giant seaweed

Solar power generation

（1）light heat electricity conversion. The solar collector converts the absorbed heat energy into the steam of working medium, and then the steam drives the gas turbine to drive the generator to generate electricity

（2）the solar cell of light electricity conversion

Thank you !