Japan's New Energy Industrial Structure and Development Strategies

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Abstract. This paper analyzes Japan's current industrial structure, mainly explores the current situation and trends of the new energy technology development, introduces the technology research, development and application of the solar energy, wind energy, and hydropower industries, and proposes the strategic developmental goals of Japan's new energy industry, data index and strategic plan in order to ensure the establishment of a real economic energy superpower.

Introduction

Energy is one of the five elements for mankind to live on in the world, and is also the important strategic supplies of the national economic and social development. Japan, as an economically developed country, is extremely short of natural resources. The main energies and resources, such as oil, natural gas and coal, are not sored. The self-sufficiency rate of energy is only around 4%. 99.7% oil, 97.7% coal and 96.6% natural gas of Japan depend on import. Especially the double oil crises have brought severe attack on Japanese economy, which forces the Japanese government to push forward the development and utilization of new energies and make some achievements. The so-called new energies is compared with the traditional energies, which have been used for a long time and are equipped with relatively mature technologies, such as coal, oil, natural gas and hydro energy. New energies are based on new technologies, developed and utilized by the system.

Analysis of Japan's Energy Structure Status

The features of Japan's energy structure are: energy highly depends on the oil, the oil highly depends on import and the import is mainly from the Middle East. Meanwhile, Japan is deeply short of energies and resources and has relatively low self-sufficiency rate of energy. And the situation of energy security is weak. According to Japan's current energy situation, Japan has formulated a series of policies to diversify the energy structure and import ways, save energy and establish a strong strategic petroleum reserve, except for the policies conforming to the situation of Japan. Japan's energy plans are conducted with the support of the government policies, rules and regulations, presenting a top-down characteristic. The SPR is divided into two parts, namely governmental and nongovernmental. The officials and the public take actions together in order to increase efficiency. By the end of 2008, the nongovernmental petroleum reserve amounts to 78d, and the national reserve is 91d, totaling 169d.

Analysis of the current development status and trend of Japan's new energy technology

Japan's new energy development mainly focuses on nuclear energy, solar energy, wind energy, biomass energy, and biofuel cells and so on. It adopts taxing and financial measures to facilitate the development and utilization of new energies and makes many creative technological achievements. In the supply of primary energies, new energies are gradually increasing year by year. Japan takes solar energy and wind energy as new energies, which, together with gas engines and cells, can reduce the production cost, produce energy-saving batteries, energy-saving household appliances and energy-saving cars on a large scale. Especially a great success has been made in fuel-cell-powered vehicles, which accounts for 40% of the applied patents of Toyota and Honda fuel cells and accounts for 62% of Nissan. Currently, the most used fuel cells are four kinds to be applied into distributed generation: PAFC, SOFC, MCFC and PEMFC. They are composed of pretreatment devices, fuel cell stacks and PCU. The direct voltage of one single fuel cell is 0.7V. A certain amount of fuel cells are linked in parallel into fuel cell stacks to produce higher available voltage. PCU changes the outlet voltage of fuel cell stacks V_{FC} into the alternating voltage V_{ac}. The alternating output voltage and the output power of fuel cell stacks can be regarded as the function between modulation factor m and the phase angle δ. The formula is as follows:

$$V_{ac} = mV_{FC} < \delta \quad (1)$$

$$P_{ac} = mV_{FC}V_S \sin\delta / X \quad (2)$$

Suppose that the inverter has no energy consumption. And the phase angle of the alternating output voltage of fuel cell stacks and the hydrogen flow rate present the following relation:

$$\delta = \frac{2FuX}{mV_S N_0} q_{H_2} \quad (3)$$

From the above equation, P_{ac} refers to the output power of the inverter's AC side. V_S refers to the voltage of the electrical load side. X refers to the circuit simplification reactance between the inverter and load. q_{H_2} is the hydrogen flow. N_0 refers to the number of fuel cells parallel in the fuel cell stacks. F is a constant. U is the use ratio of hydrogen. It can be seen in the equation (3) that δ can be controlled by controlling the hydrogen flow. It can be seen in the equation (2) that δ can be controlled by controlling the active power output of fuel cells. PCU can control the voltage amplitude of the AC side through adjusting m. Therefore, fuel cells are taken as the P-V node in the load flow calculation.

Solar Energy Industry

Since 2000, the solar energy generation capacity of Japan ranks the first place in the world. The solar energy output of Japan in 2003 was 859,600 KW, accounting for 49.1% of the world's total solar energy output. In 2004, in the new energy development plan of METI, the target of the solar energy generation was that the installed capacity came to 4,820,000KW by 2010. However, in 2009, the installed capacity of the solar energy generation had been around 4,820,000KW. In 2010, the sale volume of the solar cells of Sharp Corp. amounted to 0.5 trillion yen. 10 electric power companies, including Jingdong Electric Power and Guanxi Electric Power, state that they will make joint efforts to increase 30 solar power systems before 2020, and the generation capacity is 140,000 KW. Guanxi Electric Power and Jiuzhou Electric Power also decide to finish the construction of 40,000 KW solar generation devices by 2010, which can satisfy the electric demands of about 40,000 households for one year and reduce 70,000 tons CO2 emissions.

In order to promote the solar energy application, Japan has enhanced the research on nano crystalline cells to improve the photoelectric conversion efficiency. Iijima, a Japanese scientist, believes that the carbon nano tubes are worth to be promoted with a unique one-dimensional structure, a large specific surface area ($>150 m^2 \cdot g^{-1}$), strong mechanical properties, high heat stability and good conductivity (the work function is 4. 18eV, and it is a good electronic receptor).

"Quantum Dot" Technology

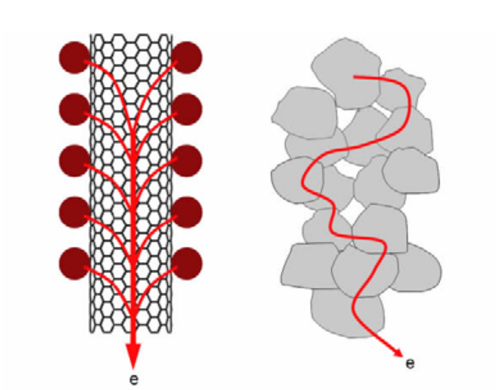
A professor of Tokyo University is ambitiously cooperating with Sharp Corp. He plans to adopt a new "quantum dot" technology in order to increase the conversion efficiency of the new solar cells more than two times than before. According to the computer's calculation, he believes that the photoelectric conversion efficiency of the solar cells can theoretically amount to 75%. To conservatively estimate, the final conversion efficiency can be up to about 60%. At present, this kind of cell has been designed and the following 10-year development plan has also been formulated. That is to say, from 2013, it will take 5 years to increase the conversion efficiency from the current degree to 30% and take another 5 years to 60%. Taiyo Nippon Sanso Corporation, Erjing Electric Corp. and other famous companies will also join in this research and development plan.

At present, the photovoltaic power generation cost of Japan is about 30 yen per kilowatt hour, which is much higher than the 10 yen per kilowatt hour of thermal power and nuclear power. If the development goals can be achieved, then the photovoltaic power generation cost will be the same with that of thermal power and nuclear power. And it will be easier to transfer from the ordinary generation ways to the photovoltaic power generation. However, the “quantum dot” technology only represents one development direction of the next generation Japanese photovoltaic cells.

Carbon Nano crystalline Cells

Carbon nano tubes can be regarded as the seamless hollow cylinders curled by graphitic layers. They are dived into MWCNTs and SWCNTs. Because of their superior physicochemical properties and unique structure, they are regarded as ideal electrode materials and the carriers of many active materials. The compound of carbon nano tubes and semiconductor nanomaterials can achieve the coordination of their material structures and properties. They have been widely applied into emitting devices, polymer materials, super capacitors, biological and chemical sensors, photocatalysis and photoelectronic devices. The functions of carbon nano tubes in photoelectrochemistry are as follows:

(1) To improve the electrical conductivity of the semiconductor electrode materials;
(2) To provide a fast transmission path for the photoelectrons on the semiconductors (seen in Figure 1), and then prevent the recombination of electron-hole, and improve the photoelectric conversion efficiency;
(3) As carrier materials, to effectively disperse semiconductor nanomaterials;
(4) To reduce light reflex, which is in favor of light absorption;
(5) To reduce the photocorrosion of semiconductor materials. Meanwhile, nanocomposite materials, such as the combination of carbon nano tube and $TiO2/ZnO$ (Figure 2) are recently prepared, and their electron transfer and photoelectrochemical properties are also studied.



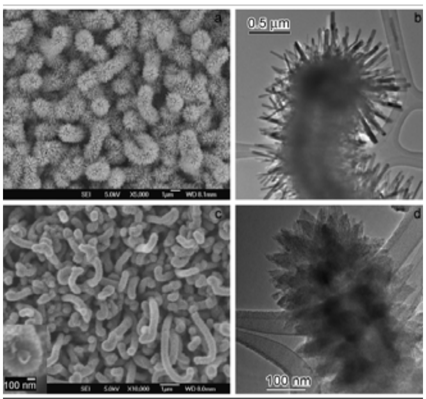


Figure 1 Pictures of Electrons Transmitting Along Carbon Nano Tubes and Among Nano-particles
Figure 2 SEM Picture (a,c) and TEM Picture (b,d) of Carbon Nano Tubes Decorated by ZnO nanowires (a,b) and TiO_2 Nano-particles

Experiments show that carbon nano tubes can improve the photoelectric conversion efficiency of semiconductor materials. This outstanding advantage may make carbon nano tubes/semiconductor nanocomposites applied into solar cells, photoelectron catalysis, photocatalytically splitting of water into hydrogen and photoelectric micro-nano devices, which will greatly push forward the rapid development of the solar energy industry in Japan.

Wind Energy Industry

In the early 1980s, Japan began to do researches and plans on the development and utilization of wind energy, and the development technologies were continuously upgraded. In recent years, the wind energy industry is rapidly developing. The amount in 2002 was 460,000 KW and in 2003 was 730,000 KW. At present, the wind generation capacity of Japan ranks the ninth in the world.

Because of the geographic features, Japan has rich wind energy resources. It has had 576 windmills by 2003, and the generation capacity is 678,000 KW, accounting for 1.72% of the world's wind power generation capacity. By 2004, the generation capacity has been close to 1000,000 KW.

Hydro Energy Industry

Japan, located near the sea, is rich in water resources. The hydroelectric generation industry has achieved rapid development since 1910. In the last century, 95% of the new energy generation was from hydroelectric generation. From 2000, it reached the peak, totaling over 30,000 KW. In the development of new energies, the ocean current power generation was vastly achieved, which mainly depended on the impact force of ocean current to rotate water turbines and then make electric generators generate electricity. Moreover, the cost of establishing ocean current stations just accounts for one in several of the nuclear power through the calculation of generation capacity.

Kuroshio is part of the ocean current of the Western Pacific, flowing through Japan with the flow speed of 1-2m/s. The thickness is about 500-1000m, the width is about 200km, and the quantity of flow is large. The actual measurement of the quantity of flow in Japan reaches 65,000,000m^3/s, which is 360 times of the Amazon River, the largest quantity of flow in the world. It is also a best opportunity of the ocean current generation in Japan.

IHI and Toshiba set about the joint researches on the ocean current generation system by use of Kuroshio's stable energy. The research results of Professor Gao Mujian in Tokyo University guide the design and construction of electric generators' bodies, turbines and anchor stakes. It needs two electric generators' turbine blades with the length of each 40m. And the output power is about 2000KW. The anchor stakes are embedded with the depth of 50~100m. The wire ropes are used to tide down the generators in order to suspend above the sea (seen in Figure 3). The generated electricity is transmitted via submarine cables.

The sample of the generation system will be produced in 2013 at the ratio of 1:40. One trillion yen will be invested in the construction of the first ocean current generation station. According to its running condition, the feasibility in business generation on a large scale will be studied. The final target is to set up 400 such generators and then form a large ocean current generation station with the total output power of 800,000KW.

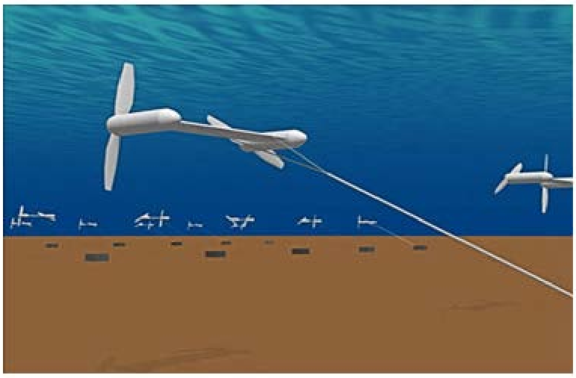


Figure 3 Picture of the Floating Ocean Current Power Generation System

Analysis of Japan's New Energy Development Strategies

New Energy Strategic Targets and Details

In 2006, Japan issued the *National Energy Strategic Plan* of Japan and formulated the national energy strategies for the first time, aiming to establish the dependable energy security, facilitating the sustainable economic development, solving energy and environment problems in an integrated way and making contributions to resolving Asian and the world's energy issues. In order to achieve the new energy development strategic targets, the Japanese government has put forward the following 5 data index:

[1] The efficiency of energy utilization will be increased by 30% by 2030;
[2] The supply of oil in the primary energy supplies will be reduced from 50% to 40% by 2030;
[3] The degree of dependency on oil of transportation departments will be reduced from almost 100% to about 80%;
[4] The nuclear power will account for 30%~40% or even more in the gross generation by 2030;
[5] The ratio of the trading volume of crude oil in the rights of Japanese enterprises in the total overseas crude oil import volume (independent development ratio) will be increased from the current 8% to 40% in 2030.

New Energy Development Strategic Plan

In 2009, the Japanese government put forward the economic stimulus plan to focus on the development of energy conservation, new energies and green economy, which detailed *the National Energy Strategic Plan* in 2006, including measures of increasing the solar energy popularizing rate, developing eco-friendly cars, developing biotechnology and industries. And in the published *New National Energy Strategies*, it also proposes 8 energy development strategic plans: (1) energy conservation plan; (2) new generation transportation energy plan; (3) new energy creation plan; (4) nuclear plan; (5) comprehensive resources guarantee strategy; (6) Asian energy environment cooperation strategy; (7) enhancement of dealing with energy shortage; (8) formulation of energy technology strategies. Under the guidance of the new energy development strategic plan, Japan will push forward diversified new energy industrial structure, ensure its energy security, increase the degree of energy self-sufficiency, enhance the utilization of sustainable energies and reduce environment pollution in order to make itself become an economically strong country.

Conclusion

From the general trend of the world economic development, the advancement of new energy and environment protection technologies is very important for the core competitiveness of a nation and an enterprise. Japan, as a leading country in new energies in the world, should follow the trend and continuously adjust the new energy industrial structure and development strategies to ensure the construction of a real economic and energy nation.

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