A Study on the Countermeasures and Suggestions of Technology Transfer in the Solar Cells Industry in China

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Abstract. This paper analyzes the development and industrialization of solar cells of three generations: mono-crystalline silicon and polycrystalline silicon solar cell, thin-film solar cell and nanocrystalline solar cell. It is believed that technology transfer and university-industry collaboration play important roles in the solar cells industry; and put forward reasonable suggestions for improvements from the aspects of financial subsidies, intellectual property, risk compensation system, technology transfer intermediary and cultivation of talents.

1. Introduction

New energy technology is one of the most important topics for human's development in the 21st century. The traditional energy sources such as oil and natural gas, have some serious problems like pollution and storage, which cannot satisfy the requirements of human beings and conflict with the sustainable development. As an important component of new energy, solar energy exhibits the advantages of low carbon emission, clean production, flexibility and renewability, which is ideal to be applied as a new alternative energy and has become the focus of the scientific community and industry. Presently, the solar cells have already been used in national defense, communications, computers, transportation and many other fields.

Due to China's unique geographical advantages, to develop the solar energy is the trend of the time. Development of solar cells not only needs the efforts from the industry but also the unremitting contributions from academies and universities which are the driving force of its persistent development. Currently, the technology transfer efficiency of the solar cells industry of the universities and research institute is limited. There are some problems in solar cells industry such as the separation between the industry and academia. To strengthen the technology transfer system and construction of the solar cells industry will benefit the long-term sustainable development of the solar cell industry.

2.Development and Industrialization of the Solar Cells Industry

2.1 Development of the Solar Cells

Through the photovoltaic effect of the semiconductor, the solar cell converts light energy into electrical energy. The principle of photovoltaic effect refers to that electronic in semiconductor move or transit under the sunlight, resulting in a potential difference. The development of solar cell mainly includes three generations[1]:

The first generation of solar cells includes monocrystalline silicon and polycrystalline silicon solar cells. After a long-term development, photoelectric conversion efficiency of the first generation solar cells is high and the technology is relatively mature. Currently, the first-generation of solar cells dominate the photovoltaic market. At present the photoelectric conversion efficiency of monocrystalline silicon cell is about 25%, but the cost is high and the production process is complex. The photoelectric conversion efficiency of the polycrystalline silicon solar cells is about 20% with a relatively simple process.

The second generation of solar cell is the thin film solar cell, including the amorphous silicon thin-film cell, copper indium selenide (CIGS) thin-film cell and cadmium telluride (CdTe) thin film

cell. Among those cells, the CIGS cells have a better performance in low light environment with a photoelectric conversion efficiency of about 19%, containing rare elements. CdTe solar cells have an ideal forbidden band width, the conversion efficiency is around 16%, but it negatively affects the environment.

The third generation of solar cells are nano-crystalline solar cells, including dye-sensitized solar cell (DSSC) and the quantum dot-sensitized solar cell. The advantages of DSSC are low-cost and the simple preparation process. TiO_2 is the mainly electrode material for DSSC at present. The disadvantage of DSSC is that the photoelectric conversion efficiency is not high and the dye is unstable. There are many kinds of quantum dot sensitized solar cells. The cost of quantum dot sensitized solar cells is also low and it has a high theoretical photoelectric conversion efficiency[2].

2.2 Industrialization and Problems of Solar Cells in China

China has successfully developed the first piece of monocrystalline silicon solar cell since 1958 and has gradually developed into one of the strongest country with photovoltaic (PV) power around the world. It is also the world's leading exporter of solar cells. Solar cells production of China reached 8000 mw in 2010, accounting for 50% of the world while domestic demand in China is only 400 mw, accounting for only 5% of the world and the others are all for export[3]. Currently, it has emerged a number of more successful enterprises of solar energy industry in China, such as Wuxi Suntech, Jiangxi SaiWei LDK, JA solar and etc. In terms of production of silicon material, there are also some enterprises like China Silicon Corporation and Jiangsu Zhongneng. These companies will form a perfect solar photovoltaic industry chain and networks in China.

Although China has an important position in the world with a large PV industry, it also meets some problems. Firstly, China's crystalline silicon production occupies a larger share in the world, but the production cost is high. It depends on imports most of the time. The core technology is still in control of the European and American countries[4]. Secondly, China's solar cells capacity grows too fast, but the demand of the domestic market is lacked. Thirdly, Europe and the United States implement anti-dumping and countervailing investigations against China's PV enterprises in recent years. They believe the price of Chinese PV products is much lower than normal market price due to the finance subsidy from Chinese government. This policy seriously influenced the international competitiveness for Chinese solar cell enterprises. Last but not the least, during the production process of polycrystalline silicon, large amounts of waste will be produced. With the increase of polycrystalline silicon production, pollution to the environment will also largely increases, which must arouse people's attention.

Ultimately, all these problems are caused by the lack of independent innovation ability in the solar cell industry. To solve the above problems, strengthening the independent innovation capacity in the industry plays a key role. The source of independent innovation is the university. At present, many colleges and universities have achieved lots of technological achievements in the field of solar cells, for example, the Hong Kong Polytechnic University has conducted a new translucent solar cell with a photoelectric conversion efficiency of 12 %, which is higher than the traditional translucent solar cells with that of 7%. State Key Laboratory of Advanced Technology for Materials Synthesis and Processing of Wuhan University of Technology has invented new generation of Perovskite solar cells, which can be printed like newspaper and is in the advanced level of the world[5]. Strengthening the cooperation between enterprises and universities and establishing technology transfer cooperation alliance will greatly promote the development of the Photovoltaic industry in China.

3. Process and Necessity of the Technology Transfer of the Solar Cells Industry

It can be seen that the development of solar cell industry in China must rely on the independent innovation and the cooperation between college and enterprises. The independent innovation of the initial fundamental research stage are mainly concentrated by universities and research institutions. Due to the differences between the laboratory environment and industrial production environment, how to shift the knowledge and innovation achievements from the universities and institutes to the industry plays an very important role to the PV industry in China.

The process of technology transfer for Solar cells includes three stages: the basic research stage, pilot test stage and the market acceptance stage. The basic research stage can be regarded as the stage in which the new knowledge and technology are created. The basic research team consists of the professors, researchers and students that conduct the research to explore the essence of the law of nature. Basic research is mainly funded by the national or the ministry of education fund support, such as the natural science fund. At present, the country's R&D funds are mainly focus on the first stage. The forms of the output of the basic research in universities are scientific papers and patents.

There is a long distance to transfer the achievement of the basic research into the market. It needs a pilot test phase in between. The purpose of experiments in the lab lies in exploring the laws of nature, while the experimental materials are in small scale and the experimental instruments are precise and the success rate of the experiments is not required. The experiments in the university lab are very different from the industrial massive manufacturing, ending with the fact that the research results from the university laboratory cannot be directly applied to industrial production. For example, in 2014 the photoelectric conversion efficiency of monocrystalline silicon and polycrystalline silicon solar cells in the lab are about 25% and 20% respectively, while that of monocrystalline silicon and polycrystalline silicon solar cells in the industry are only 19% and 17%, which present obvious declines[6]. It is believed that before commercialization, the pilot test stage, which enlarges the scale of the basic research and experiment, is indispensable. The pilot test stage is a transition period between technology supply and demand.

Market acceptance stage is the terminal stage and the demand side of the technology transfer. Even if pilot test stage is successful, technology innovation achievements also need to accept the inspection from the market. At this stage, enterprises which are the demanders of the knowledge and technology, will estimate various aspects for the technology such as the anticipated cost, market prospects and etc. The enterprises will make final decision on whether to apply the product to the market. Whether the knowledge creation and the technology innovation can promote the development of the economy will be decided in this stage. It is worth mentioning that many big companies have their own R&D department and they can create new knowledge and technology internally, so that they can be self-sufficient in most of the time. Due to the limitation of their own conditions, small enterprises cannot conduct the independent research and development, they are more inclined to accept the technology and knowledge from universities.

4.Countermeasures and Suggestions of Technology Transfer in the Solar Cells Industry

4.1 Increasing the Subsidies in Pilot Test Stage

Like other new energies, the solar energy has been taken seriously with a certain degree of financial support by the country at present, but a large percentage of the national funds are mainly concentrated in the basic research stage. For example, there are many projects of the national natural science foundation of China on dye-sensitized solar cells and quantum dots sensitized solar cells these years. It can be seen that China put emphasis on this theme. But there is a big difference between basic research and industrialization and it needs to carry on the pilot test. The funding for the pilot test stage is insufficient in China currently, which hinders the photovoltaic technology transfer from the universities and Institutes to the industry. Therefore, China should set up the fund and financial support for the pilot test stage, which promotes the transfer of photovoltaic technology from colleges and universities to industry.

4.2 Improving the Intellectual Property System

It is obviously that intellectual property plays a significant role in solar cells industry, which is the industry of knowledge intensive. When the firms cooperate with the universities to conduct research, to clarify the property rights of the innovation achievement is very important for the enthusiasm of cooperation. Some western countries judge ownership of the intellectual property by the funding source of the research and development. If the research is funded by the country, the ownership of the intellectual property belongs to the universities and institutes of the nation. If the research is funded by the firms, the ownership of the intellectual property belongs to the firms. If the research is funded by the country and firms, the ownership of the intellectual property belongs

to the universities and institute at the first period of time and the firms that participate in the research have a priority to use this intellectual property, which promote the enthusiasm of the firms to some extent[7]. China can draw lessons from western countries and standardize the intellectual property system of the solar industry.

4.3 Establishing the Risk Compensation Mechanism

The technology innovation and transfer of the solar cells are risky. The risk will reduce the positivity of the researchers in universities and firms to industrialize the relevant technology of solar cells. For example, there is a new photovoltaic technology conducted by researchers in university and it is not sure whether that technology can be successfully industrialized. Due to its technology risk, the firms which have intention to cooperate may hesitate or give up in the end. This will no doubt affect the capacity for independent innovation and technology transfer in photovoltaic industry in China. If the government can set up some financial support for the person or firms which failed in innovation or industrialization of the solar cells and even give secondary innovation subsidies, the risk for the researchers and firms will reduce and their positivity of the innovation and industrialization will increase, which have a positive impact on the development of the whole industry.

4.4 Construction of Professional Technology Transfer Intermediaries

At present, many universities and colleges in China have established technology transfer offices（TTOs）. Compared with the professional TTOs in developed countries, most TTOs in China have very simple functions of contract management and contract transfer. It is still quite lacking of professional technology transfer staff and professional technology transfer model in China, which lead to the situation that the expenditure of R&D is high but the industrialization rate of the achievements is low. It is necessary for China to build professional technology transfer office in universities and institutes to estimate the potential commercial value of the innovation in universities and contact the appropriate industry partners and venture capitalists. TTOs must play a good role of intermediaries.

4.5 Cultivation of Interdisciplinary Talents

Human resources will always be the core competitiveness for high-tech solar cell industry. Most researchers in the solar cells industry are in the major of physics, chemistry and etc, while they have limited commercial knowledge. The staffs with commercial knowledge often don't understand the photovoltaic technology. This will affect the technology transfer of photovoltaic industry to a certain extent. It's better for the scientific researchers to get some commercial skills and know the trend of the development of the industry so that they can adjust the research direction in time to make the output of the research close to the industry.

5.Summary

This paper introduces the three generations of solar cells and analyzes the development and the problems of the solar cell industry in China. It is pointed out that the university-industry collaboration and technology transfer play important roles in the solar cell industry, and the process of the technology transfer is analyzed. Finally, suggestions are given on the technology transfer of the solar cells industry in China.

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Reference:

[1]Zhou R. Photovoltaic Performance of $Ti0_2$ Based Quantum Dot Sensitized Solar Cells[D]. Hefei: University of Science and Technology of China, 2014. (in Chinese)

[2]Green M A, Emery K, Hishikawa Y, et al. Progress in Photovoltaics: Solar cell Efficiency

Tables(Version 39)[J]. Prog. Photovolt: Res. Appl., 2012, 20: 12-20.
[3]Gao S F, Wu R. Present Situation and the Tendency of the Development of Solar Cells in China[J]. Tianjin Chemical Industry, 2012, 26(4):14-16. (in Chinese)
[4]Xie G Y, Li X G. Research on International Competitiveness of China's Solar Energy Photovoltaic Industry[J]. Practice in Foreign Economic Relations and Trade, 2012, (2): 21-24. (in Chinese)
[5]Information on: http://solar.ofweek.com/2016-02/ART-260018-8420-29061398.html
[6]Information on: http://www.chyxx.com/industry/201602/386534.html
[7]Information on:
http://www.iua.ie/wp-content/uploads/2013/02/Intellectual_Property_Protocol_Putting_Public_Research_to_Work_for_Ireland.pdf