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Analysis of Government Responses for the Photovoltaic Industry in China

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Abstract
With the high population, a variety of problems has been emerged like energy scarceness, climate changes, and environmental protection. As a result, currently most of the countries have been turned to find the new energy power to satisfy environmental health, fulfill the energy demand and to reach the sustainable development in the world. At present, China has faced many problems regarding Environmental protection, Climate changes, Employment, Energy sources, and Rural Electrification. The roots of some of the problems here are due to the energy consumption, high population and their distribution throughout the country. As a result, the Chinese government has turned to photovoltaic (PV) industry to fulfill the risen requirements. This study mainly investigated the Chinese government contribution for the improvement of the PV industry in the last several decades. The previous records suggested that, the government has initiated the demonstration uses of PV applications in the 6th (1981-1985) and 7th (1986-1990) Five-Year Plans. In addition to that, they have involved to improve the solar photovoltaic (PV) industry by launching a variety of programs, national development plans, subsidies, policies and government laws. Moreover PV industry data reveal that there is a particular development in the PV industry in China through the positive government responses.
Keywords: Government Responses, Photovoltaic Industry, Renewable Energy

1. Introduction

Solar energy is the widely available, clean energy source in the world. There are mainly two ways of utilizing solar energy as solar heating (Solar Thermal Technology) and solar power generation (Photovoltaic Technology). The solar power generation or Photovoltaic (PV) is a method of converting the solar energy into electricity through the photovoltaic effect by using semiconductors. With the high population, a variety of problems has been emerged like energy scarceness, climate changes, and environmental protection. Due this reason most of the countries have been turned to find the new energy power to satisfy environmental health, to fulfill the energy demand and to reach the sustainable development in the world. As a natural, an abundance and a renewable energy source, many countries have been chosen solar energy as one of the options. Not only that, but also an environmentally friendly resource PV technology has been become very important industry in the world. The outstanding development can be seen in Germany, United States, Japan and China today.

Approximately 1.4 billion people live in China has been ranked as the largest populated country in the world. With this high population, China governors have to prepare for fulfilling mankind's necessities and their development. As well as simultaneously they have to care of local and global necessities. Among these requirements, China has been faced with many problems regarding Environmental protection, Climate changes, Employment, Energy sources, and Rural Electrification. The roots of some of the problems here are due to the combination of energy consumption, high population and their distribution throughout the country. When considering the energy, China plays a main energy consumer as well as an energy producer in the world. To fulfill the mankind's necessities, China is using several energy sources such as Coal, Oil, Natural gases, Hydro and Nuclear power. Among these coal and oil are the highly used energy sources in China. Mass usage of coal is affected by the environment due to emissions of CO2, SO2, and NO which cause to the global warming (Li *et al*. 2007).

Comparing with the world, China's energy consumption is about 10% of the world's total, but SO2 emissions were accounted about 15.1% of the total. It implies that China has been supported to the environmental pollution by exceeding the energy usage in the world. Environmental pollution greatly affects to the social and economic development, as well as the human health. Another main problem due to coal usage is climate changes which have been happening because of emission of CO2, the main gas responsible for global climate change (Li *et al*. 2007). Due to these reasons, the environmental protection has been become a serious problem in China. Unemployment has been arisen as a prominent problem together with high population. Among the several solutions to overcome unemployment, the Government can be implemented some of the programs to reduce it by establishing market oriented mechanisms and through the economic development. According to the distribution

of population in China, huge number of people are living in rural areas. Therefore the rural residents have been faced from unemployment as well as rural electrification problem.

Since the energy consumption has been caused in many directions such as the energy balance problem, climate changes through global warming and appearing environmental pollution, Chinese government has been turned to another direction to reduce these problems by seeking a new natural energy source through research basis. Therefore they started to use solar power as a natural energy source to fulfill the rising requirements through the PV technology. In this process several supporting actions has turned in many directions through government policies and subsidy programs, national development plans, and government laws. Among these rural electrification programs, renewable energy development projects, PV incentive policies, and R & D (Research and Development) support regarding the PV technology have been highly contributed for the improvement of the PV technology in China as well as the reduction of many problems due to the energy consumption and high population.

Government has been involved to launch some programs to support to the PV industry in the period of the 6th (1981-1985) and 7th (1986-1990) Five-Year Plans as a starting point. With the rapid improvement, government has been taken actions to support demonstration uses of PV applications and it was promoted as specialized industries in China. Through the positive government responses such as by making a variety of programs and establishing several policies, PV industry has been become one of the main industries in China and significantly plays major role in the international market. Therefore in this study our objective is to analyze the government responses for the PV industry in China.

The next sections of this study are structured as follows. Section 2 outlines the information about PV Industry and the responses taken by the Chinese government through the literature review. Section 3 explains the China government responses for the improvement of the PV industry. Section 4 explains the progress of the PV industry in China. Section 5 gives the conclusion of this study.

2. Literature Review

Photovoltaic technology plays a key role in the new energy technology throughout the world. As an abundance, renewable and efficient energy source, most of the countries have been involved in the PV technology to accomplish countries' necessities. As well as PV technology has been used to compete with the local and world market. Therefore many people have concerned to search and analyze about the PV technology in a variety of aspects of the past. Among these studies, Li *et al*. (2007) studied about the solar photovoltaic in China. Here they were concentrated in several areas like solar basics and their benefits, global PV development profile and trends, China PV market and production, analysis of the PV power generation cost etc. finally they have reached to discuss the policy and roadmap for solar development in China. Under this section policy framework was discussed through development plans and renewable energy law. Also Government subsidies and R and D supports were pointed out. Finally they have demonstrated a roadmap for PV development in China by using some predictions with numerical data. Sichao (2010) addressed the Chinese photovoltaic market and industry outlook. In his study, he outlined China's PV projects, focusing on the PV market and PV promotion measures. He mentioned some of the PV applications and after that pointed out the government responses through PV promotion policy and new developments. Under this topic he outlined the renewable energy law, feed- in tariff system and their developments. At last he discussed some of the future challenges about PV renewable and other energy sources.

Yixin *et al*. (1999) studied about the technological innovation of the Chinese photovoltaic industry. Under this study he investigated current status and problems of the development and technological innovation of the Chinese PV industry. He achieved this state through literature review, questionnaire survey, and expert interview. After that he proposed some recommendations on the strategy and policy for fostering the development and the technological innovation of the Chinese PV industry.

SEMI PV group, SEMI China PV Advisory Committee, and China PV (2011) involved to study about China's solar future as a collaborative work. They gave an overview about the China PV industry and discussed about the development of China PV market through government incentive programs. Then they explained some policy recommendations according to the solar PV roadmap. Campillo *et al*. (2008) analyzed the global solar PV industry by focusing on the Chinese market. Among this study in one direction, they discussed two policies including subsidies and PV policy and Chinese energy policy.

Grau *et al*. (2011) has done a survey of the PV industry and policy in Germany and China. They provided an overview about the PV industry and described policies such as deployment support, investment support for manufacturing plans and R & D support measures in China and Germany. A Kearny alliance project (2012) has given a support to study about China's solar industry and the U.S. anti-dumping/ anti subsidy trade case through a program called China Global Trade.com. One of the key underlying problems appeared in this program was "why has china's solar industry grown so big and so fast?" Therefore this program was aimed at national and

local subsidy programs in China and the United States, as well as the role of government support in fueling industry development. Apart from that another considered point was the role of foreign direct investment in China in the development of the solar industry.

3. Government Responses for the PV Industry in China

Social and economic developments are the basic phenomena for the improvement of a country. Government is an outstanding party to make fundamental and huge actions to support for the development of any country. Chinese government has been initiated to achieve the country's development through Five-Year Plans. The PV market has been the one of the topics included in these plans to fulfill country's needs. According to the literature, the government has initiated to support the PV market through the time period of 6th (1981-1985) and 7th (1986-1990) Five-Year Plans by starting demonstration uses of PV applications. In these periods PV industry was promoted as special industries in China such as solar power microwave relay stations, military communication systems, and small-scale solar household systems etc. (Li *et al*. 2007).

The time line of the PV industry, the Chinese government responses can be seen through government programs, national development plans, subsidies, policies and government laws. The followings are the information about some of the programs and actions taken by the government to support for the improvement of the PV industry.

3.1 Rural Electrification Initiatives based on Renewable Energies

Rural electrification has been appearing as a main problem due to the low population density, low consumption and the difficulty of terrain. As well as the grid extension was not effective in these areas, the government has made arrangements to supply the electricity through solar power due to easy installation in remote areas. For this approach government has been launched three major programs in Western China such as the Brightness Program, the Township Program, and the China Renewable Energy Development Project (CREDP).

3.1.1 Brightness Program (1996)

The Brightness program was introduced in a world solar peak conference held in Zimbabwe, 1996 as an international effort to bring electricity to rural areas. China has started to implement Brightness project in 1998 with the support of the State Development Planning Commission. The main objective and target of this project was to supply electricity for 23 million people in rural areas by using renewable technology including photovoltaic with an average capacity of 100 W/person. The program was spread across several provinces including Gansu, Qinghai, Inner Mongolia, Tibet and Xinjiang, with the investment of US$50 million for the period 2001-2005 (Long 2007 ; Campillo 2008).

3.1.2 Township Program

The Township program has been launched in 2001 to provide the power requirements of public utilities and residents of un-electrified townships in remote areas initiated by National Development and Reform Commission. One of the main goals of this program was to electrify about 1066 un-electrified townships in western provinces including Xinjiang, Qinghai, Gansu, Inner Mongolia, Shaanxi, Sichuan, Hunan, Yunnan, and Tibet. Other goals were contributing to poverty alleviation and use renewable energy to supply electricity to townships that was unable to use grid extension due to economical problems. The total investment was about US$340 provided by the government (Long 2007).

3.1.3 China Renewable Energy Development Project

This program has been initiated by three institutions including the National Development and Reform Commission, World Bank and Global Environment Facility in 2001. There were several aims to start this program such as to reduce the cost of solar PV systems, to improve the quality of the PV product, to develop the rural PV market, and to improve after-sale services for PV systems in remote rural areas. US$27 million has invested through this program to improve the PV industry across the provinces including Inner Mongolia, Gansu, Qinghai, Xinjiang, Tibet, Sichuan, Ningxia, Shan'xi, and Yunnan (Long 2007).

3.2 China Renewable Energy Scale-up Program (CRESP)

This program has been launched by the Chinese government with the collaboration of the World Bank (WB) and the Global Environment Facility (GEF) in 2005. The program consisted of two phases and the objective of the first phase was to demonstrate the feasibility of scale-up renewable technologies and their economic and environmental advantages. For this the government promotes the implementation of a renewable energy policy development and investment programs. The first phase of CRESP was highly contributed to the renewable energy sector through the Renewable Energy Law which was emerging in this program. It was the major contributor to develop the PV industry in China.

The phase II of CRESP has emerged through the 12th Five-Year Plan to reach sustainable scale-up of commercial renewable energy development through cost reduction, efficiency improvement, and smooth integration. It was consisted of four components including policy and implementation support, development strategy and technology improvement, capacity building and renewable energy investment (Li *et al*. 2007).

3.3 Government PV Incentive Policies

Plans of action adopted by the Chinese government to get positive motivational influence for the PV industry. Therefore several PV market policies have issued by China's central government to boost domestic PV deployment in 2009. The Golden Sun Program was one of the policies issued by the government as a subsidy program to support the installation of solar PV applications. This program was initiated by the Ministry of Finance (MOF), the Ministry of Science and Technology (MOST), and the National Energy Administration (NEA) for the period of 2009-2011. The main objectives of this program were to support demonstration of key technologies in the PV industry and to install more than 500MW PV modules. It was provided installation subsidies about $1.5 billion for large-scale systems.

Apart from this the Solar Roofs program by the Ministry of Finance (MOF), Large-scale on-grid PV projects with feed-in-tariff by the National Energy Administration (NEA) and the Regional deployment support policies can be considered as examples of government PV incentive policies for the improvement of the PV industry. Under the regional investment support policies, the government has issued various refund policies such as refund of loan interest, electricity consumption fees, land transfer fee, corporate income tax, and loan guarantees to promote new plant investment in the PV industry (Grau 2011).

3.4 R & D Support in China

The other way of supporting to the PV industry is Research and Development (R & D) schemes, which are very important to develop the PV technology. Government has been started many programs to support the development of solar PV technology. Those are including Basic R & D support scheme, High-Tech R & D support scheme, Key R & D support scheme, and commercialization support scheme. Basic R & D support scheme, China government was initiated to contribute to the technical and theoretical development of the important parts namely thin-film and dye sensitized solar cells (Ministry of Science and Technology of the People's Republic of China).

High-tech R & D support program is also known as "863 program" which was proposed by the four Chinese Scientists to accelerate China's high-tech development to meet the global challenges of new technology. After implementing through three successive Five-Year plans, progress could be seen in several areas including China's overall high-tech development, R & D capacity, socioeconomic development and national security. Therefore the government has taken action to continue the implementation of the program in 10th Five-Year plan. Boosting innovation capacity in the high-tech sectors and strategic high-tech fields was an objective of this program (Li *et al*. 2007 ; Ministry of Science and Technology of the People's Republic of China).

4. Progress of the PV Industry in China

To analyze the government responses for the PV industry, most of the government programs and policies have been considered as the initial step in China. Many PV industry reports and related documents in China have used secondary data to analyze the government contribution quantitatively. Basically several areas have been used in this study to describe the China government influences on the PV industry. They are annual PV installations, PV market share, PV industry employment, and PV sales revenue.

PV annual and cumulative installation from 2005 to 2007 and PV market share of Five sections are shown in Fig. 1. In the initial state, annual PV installation is quite slow and slowly increment can be seen on the forecasted results. Whn consider the PV market share of five sections including rural electrification, communication and industry, solar PV products, grid PV systems, and large scale (LS) PV power station in years between 2005 and 2010, it depicts a common increment of each market share and significant increments in the share of Grid PV system and LS PV power system from 2005 to 2007.

Fig.2. shows the development of the PV industry employment sector in China from 2005. It shows a strong positive increment in cumulative employment. Based on our predicted results, there is a huge increment of employment in the PV industry with the time. The development of China PV sales revenue also can be seen in the Fig. 2. It also shows the positive increment of both annual sales and cumulative sales from 2005 (Source: Wang 2006 ; Xu 2011).

5. Conclusion

There are various kinds of factors such as activities and responses of the government, available resources in the country, the interest of the general public of the country and their attitudes, and reciprocal relation among the countries are directly affected for the development of the industry. Within all these factors, government responses play the significant role in the development of any industry. Therefore even in the PV industry, government responses can be considered as the root for the development process. It can be explained by analyzing government responses in the PV industry in China. Their responses can be seen through national development plans, subsidies, policies and energy law. They have launched many programs to supply electrification to the public through the brightness program, township program and renewable energy

development program based on PV technology. Moreover, PV incentive policies and renewable energy law were established in China. On the other hand Chinese government has taken many actions to support PV technology through research and development. The evidence for some of areas can be shown by Fig. 1 and Fig. 2 . According to our study and based on numerical data, we can suggest that the government has highly contributed to the improvement of the PV industry. Moreover distinctive development in the PV industry in China has been taken in the past decades, through the positive government responses.

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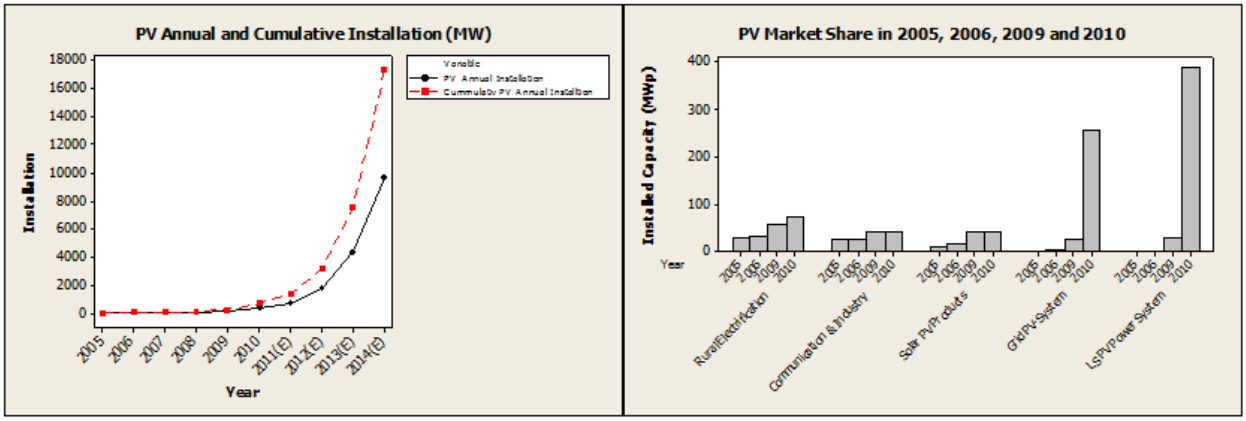

Figure 1. PV Annual and Cumulative Installation (MW) and PV Market Share

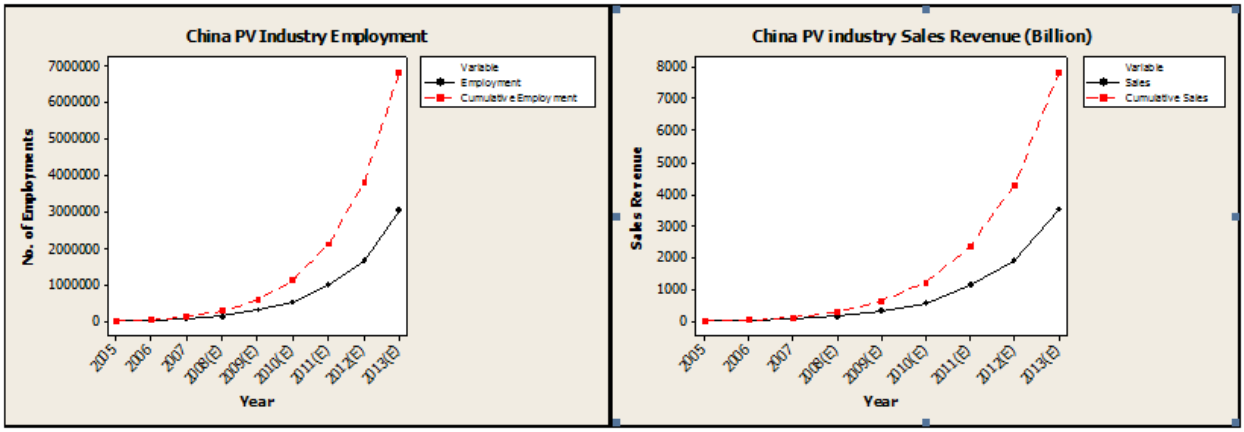

Figure 2. China PV Industry Employment and PV Industry Sales Revenue (Billion)