Present Solar Energy Potential and Strategies in China

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***Abstract*—Facing great pressure of economic growth and energy crisis, China pays much attention to the renewable energy. Renewable energy development is one of the main targets of the Chinese government on the way to the sustainable development and climate change mitigation. China's energy policy target is to reach 15.4% renewable energy share by 2020 and 27.5% by 2050. China's total installed electrical power capacity reached 700 GW by the end of 2007 and is predicted to surpass 900 GW in 2010. A similar goal exists for the solar photovoltaic power sector which China intends to increase generating capacity from 0.14 GW as of 2009 to over 1.8 GW by 2020. In order to achieve this target, the Government has implemented many instruments from laws and policies and financial incentives. The paper gives introduction to the present situation of the solar energy development in China and overviews the main policies that China uses to promote and develop the solar energy. Also, the suggestions for the further development of solar energy technologies in China are given.**

***Index Terms*—China, renewable energy, solar energy.**

I. Introduction

China is the world's most populous country with over 1.3 billion people. It has experienced tremendous economic growth over the last three decades with an annual average increase in gross domestic product of 9.8% during that period. This growth has had huge implications for energy consumption and environmental impact [1]. This has led to an increasing demand for energy, spurring China to add an average of 53 GW (gigawatts) of electric capacity each year over the last ten years to its power generation capabilities. It is obvious that most of the Chinese electricity generating capacity is based on coal fired power stations [2]. China's carbon emissions are low on a per capita basis; China is already ranked the world's second largest producer of carbon emission, behind only America [3], [4]. At the same time, approaching 50% of China's oil consumption comes from the overseas market, causing a significant energy supply security concerns [5].

China has set ambitious targets for developing its non-hydropower renewable energy resources with a major push of laws, policies, and incentives in the last few years [6]. Among the technologies referring to utilization of solar energy, concentrating solar power (CSP) is a promising option, which has a profound significance for China, but in comparison, Solar photovoltaic (SPV) technologies are more mature than solar thermal power generation technologies. Therefore, solar power is definitely an important CO_2 mitigation option at the present and in the long-term [7]. China's solar cell has experienced rapidly growth inspirited the booming of German PV market. The total output of China's solar cell in 2007 was 1088 MW, ranking it first in the world [8]. Although China is a top manufacturer of solar panels, the high cost of the most efficient technologies hinders their deployment. By the end of 2007, the total installed capacity of photovoltaic power generation was about 105 MW, and the new PV capacity 25 MW. Namely, more than 90% of China's solar cell exports to overseas [9]. The PV market in China is currently quite small; it is expected to grow drastically within the next 5 years in order to meet its targets to supply 15% of total primary energy in 2020 from renewable energy sources [10].

With the rapid rise of the energy price, the application of solar energy is accelerating, and the great environmental and economic benefits have been brought by using the PV [11]. It is estimated that in 2050, the renewable energy will have a share of 25% in the whole energy supply, and the PV generation will have a share of 5%. The capacity of PV generation is 100 GW in 2050. Some policies were formulated in China by the central government and operated in the whole nation. Hundreds of manufactures have produced millions of PV equipment's in the last 5 years [12].

II. Photovoltaic Development

The potential of solar energy in china is very high. Recently, it has been found that the special considerations on solar power have effectively decreased the cost of photovoltaic (PV) power generation. For instance, in 2007, electricity tariff from PV generation was 4 Yuan (US Cent 58.9)/kWh. In 2008, Sun tech Power Co., Ltd, the biggest Chinese solar cell producers, declared that it can reduce the PV power price to 1 Yuan (US$ 0.15)/kWh by 2012. Moreover, in 2009 the PV concession demonstration project has propelled the PV generation to reduce to 0.69 Yuan (US$ Cent 0.1)/kWh. The continuous pressure for carbon reduction has tempted China to determine its future energy policies. The market share of Chinese PV has increased from 1% to 35% in the last 8 years, and the quality has step up at the same time. According to the data of Germany web news, the total yield of Chinese solar cell in 2007 is more than 1200 MW, which have a share of 35% in whole world, which ranks the first in the world. Based on the news of economy daily, the total yield is more than 2000 MW in 2008 [8], [13]. A similar goal exists (china has set a goal) for the solar photovoltaic (PV) power sector which China intends to increase capacity from 140 MW as of 2009 to over 1.8 GW by 2020 [14]. At present, the PV market in China is mostly

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used to the electric energy supply of remote villages and communication and solar energy manufacture and PV generating electric power (PGEP). Some productions are used to improve the daily life of common people, such as solar energy street lamp, solar energy lawn lamp, solar energy traffic signal lamp and solar energy sight lighting. The grid-connect energy production is located in demonstration moment due to the costly price of PV generating electric power. According to the present plan, total PV power installations will reach 300 MWp by 2010, 1.8 GWp by 2020 and 1000 GWp by 2050. According to forecasts made by the Chinese Electric Power Research Institute, renewable energy installations will account for 30% of total electric power capacity in China by 2050, of which PV installations will account for 5%. At present, the biggest photovoltaic plant is established in Shilin of Yunnan province. The capacity and the investment are 66 MW and 0.6 billion dollars, respectively. Consequently, the market and development potential of solar energy are startling in the future China [15]. At present, more and more Chinese enterprisers begin to invest the PV industry. Certainly, the PV industry of China faces some difficulties at present, such as the technology of production, raw and processed materials and environmental pollution. The PV is produced in some factories, and the number is more than one hundred. But most of them are nothing more than assembling the subassembly of PV. There is no little technology, and the benefit of economy is bad. The essential reason is no pivotal technology, such as silicon material, incision, forging and polish, etc. It is well known that the production of PV products has a lot of contamination, such as acidic and alkaline waste water, heavy metal waste residue, which have big effect to local environment.

III. Solar Energy Policies

In 2005, the National People's Congress has passed The Renewable Energy Law (REL) [16]. This law has marked a new stage of renewable energy development program in China. Since the introduction of REL, a number of supporting regulations and guide-lines have been put into place to implement it. The law was designed to "promote the development and utilization of renewable energy, improve the energy structure, diversify energy supplies, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society." China's initial goal for solar power was established in 2007 at a modest 1.8 GW, but this target is in the process of being revised upward to perhaps 20 GW. A "Golden Roofs" initiative announced in March 2009 provides a subsidy of $2.93 per watt for roof-mounted PV systems over 50 kilowatts (kW) which could cover over half of a system's installation cost. A feed-in tariff of $0.16 per kilowatt-hour (kWh) was also established for PV power projects at the same time. Encouragement for larger utility scale solar projects was announced in July 2009 under the "Golden Sun" program, which provides for up to 50% of project costs (including transmission or distribution lines to connect to the grid), and up to 70% of such costs for projects in more remote areas (such as the Western Region). The Golden Sun program is for projects of 300 MW capacities and above, which are in service for a minimum of 20 years.

Although the history of renewable energy development in China is short, the Chinese government has formulated and executed a series of policies and specific policy measures for the purpose of renewable energy development [17]. These policies include: (I) all PV electric power should be purchased by Power Company, and which should provide enough grid-connect service. (II) The electrovalence is established more than conventional price in order to encourage the development of solar energy, the benefits of investor should be ensured. (III) The central government gives some allowances to the renewable resources industry. (IV) The central government encourages the renewable resources DG (distributed generation) in order to improve the electric power serves of no electric power supply region, and the early investment and medium-term maintenance are afforded by central government. (V) Although the end user uses the electric power from PV generation, but the electrovalence of end user is same compared with the end user who uses the conventional electric power? As mentioned above, the central government of China regards the development of PV in order to improve the unreasonable energy structure.

Policies for encouraging renewable energy in China are largely driven by the central government, and enacted through national and provincial and local government programs. China led the world in 2009 in renewable energy investment, spending $34.6 billion, with the United States second in clean energy spending, investing $18.6 billion [18]. Financial support for renewable energy in China involves subsidies, tax policies, pricing mechanisms, and a reward scheme for green production. Subsidy support is extended to overhead costs of programs (i.e., administrative, operational, and other expenses for government renewable energy agencies), renewable energy technology research and development, and provincial or local electrification projects. Tax incentives can come from the central or local governments, and can be technology specific. Pricing for renewable energy is not standardized, and is set by contracts negotiated between projects and utilities.

Despite these programs the renewable energy economy is not yet cost-competitive with the fossil energy economy. Hence the continued development of the renewable energy economy is dependent upon government support. Examples of such support include economic encouragement policy (e.g., financial subsidy, favorable taxation policy, and favorable price policy), industrialized support policy, technical research and development policy, and government renewable resources model projects. However, As Chen [19] noted that much more could be done to support policies for renewable energy development in China. As Zhang [20] conclude, for example, there is lack of coordination and consistency in policy, weak and incomplete encouragement system, no innovation in regional policy, incomplete financing system for renewable energy projects, and inadequate investment in the technical research and development for renewable energy [21]. In order to improve the inopportune energy structure and sustainable development the Chinese central government has established some policies and laws, in this regard the following measures were especially recommended:

A. Government Policies to Promote PV and Grid Connected System

The applications of solar energy are promoted by the policy of central government and local governments, the allowance of government is important to increase the competitive power of PV production. And the Chinese central and local government should increase the research fund of PV to grasp the pivotal technology, such as circuit topology and MPPT (maximum power point tracking) control method and grid-connect. Moreover, the tax should be reduction or exemption by government, which will motivate the enthusiasm of entrepreneurs, and which will increase the PV market through government policy initiatives. The advantage of investors should be ensured by government policies. Certainly, the government fund should be launched in the vast power supply project in order to improve the energy structure in the foreseeable future. For example the large desert grid-connected power plant must be established. The ordinary investor and corporation cannot supply the vast fund in the desert grid-connected power plant domain. The devotion of government is obligatory.

B. Research on Solar Energy in the Universities and International Cooperation

Abundant fund and personnel should be launched into the interrelated research of PV, and the universities and graduate schools should be encouraged to research in solar energy. The cooperation between corporations and universities should be enhanced in order to improve the research level. The students are trained by universities in order to supply enough persons with ability to cooperation. Certainly, international cooperation should be encouraged to improve the domestic technology by central government and local governments.

C. Technology Improvements

The PV industry chain should be established in order to enhance the economy benefit of Chinese PV industry. Especially, the lack of silicon material and pivotal technology should be settled in future. The PV market should be enlarged in order to digest large numbers of PV product. The attestation and detect organization lacks the contact with the international organization, and the criterion of whole industry should be established.

IV. Conclusion

Solar energy is one of the most promising renewable and environmental friendly. It is very consistent and is not significantly vulnerable to changes in seasonal weather patterns. To achieve a measurable impact on market growth and to reach a diverse cross-section of users, retail financing terms need to be flexible. In order to promote and ensure the rapid, effective and smooth development of renewable energy, the Chinese government has formulated a series of policies on renewable energy development, including laws, regulations, economic encouragement, technical research and development, industrialized support and solar energy model projects, etc. These policies provide significant motivation and interest for the development and use of renewable energy technologies. It is obvious that china that utilizes solar energy for power generation have policies specific to solar energy. The existence of solar energy policies managed to increase solar power generation significantly. In general, their policy analyses have increasingly focused on the effects of negative externalities on environmental quality, human health, economic development, or institutional objectives such as emissions growth management. Regarding the particular solar energy policy China's initial goal for solar power was established in 2007 at a modest 1.8 GW. Encouragement for larger utility scale solar projects was announced in July 2009 under the "Golden Sun" program, which provides for up to 50% of project costs (including transmission or distribution lines to connect to the grid), and up to 70% of such costs for projects in more remote areas (such as the Western Region) and their projects capacity is of 300 MW and above. It is forecasted that solar energy in china will take fundamental role in the years to come as country prepares to substitute fossil fuel towards novel fuel sources which are truly clean, renewable and safe.

V. Suggestions

To better understand China's solar energy economy, it is crucial for researchers to undertake rigorous and extensive research into for example, the substitution possibilities between renewable energies and fossil energies; the effects of solar energies on the environment, energy markets, agricultural markets, and rural income growth. Such extensive research is required because China's solar energy economy is still in its infancy and there are many issues that need to be investigated and applied. In the future, central government of china should recognize the pertinence of solar energy utilization, prioritize it accordingly and increase investment [22]. At the time, the local government should develop a medium and long-term plan of solar energy utilization, especially focused on systems operation and maintenance.

1) The applications of solar energy are promoted by the hortative policy of central government and local governments, the allowance of government is important to increase the competitive power of PV production. And the Chinese central and local government should increase the research fund of PV to grasp the pivotal technology, such as circuit topology and MPPT (maximum power point tracking) control method and grid-connect. Moreover, the tax should be reduced or exempted by government, which will motivate the enthusiasm of entrepreneurs, and which will increase the PV market through government policy initiatives. The advantage of investors should be ensured by government policies. Certainly, the government fund should be launched in the vast power supply project in order to improve the energy structure in the foreseeable future. For example the large desert grid-connected power plant must be established. The ordinary investor and corporation cannot supply the vast fund in the desert grid-connected power plant domain. The devotion of government is obligatory.

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