Japan Solar PV manufacturing in the past and future

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Abstract. Over the past 10 years, the number of solar power generation systems installed around the world has increased rapidly, partly due to the strengthening of measures against global warming. Chinese companies meet most of the demand. While the installation of PV in developed countries is declining, the demand in China, the Middle East, and Southeast Asia are expected to grow continuously. Meanwhile, Chinese exports to the United States declined sharply due to trade friction between the two countries. In this work, the Japan market mechanism of solar PV was investigated to consider how they can survive in the future. Firstly, the historical trend of Japanese solar PV production in the domestic market is reviewed. It is indicated that the Japanese consumer has selected Japanese product even it is expensive. Because they can sell electricity by a reasonable price under the FiT scheme and spend more money on construction to protect from natural disasters. Recently, both Japanese and Chinese companies start to produce solar PV cells outside the country. The production price becomes competitive in the future. The hot production countries in southeast Asia are Malaysia and Vietnam.

1. Introduction
The demand for solar PV has accelerated in the last decade. In Japan, energy security is the most concern in the energy policy, since Japan produces limited fossil energy. Japanese government subsidized PV installation in the household between 1980 and 2006. Japanese solar PV manufacturing had led the world market. From around 2000, the wind power had introduced alternatively, since it is more cost-effective than PV. The Japanese share was top before the Chinese started mass production since 2006. In 2012, the Feed-in Tarif introduced for all kinds of renewable electricity generation. The electricity production by solar PV in Japan has increased five times. However, in 2018, Chinese companies supplied about 58% of world demand, and following Malaysia, Taiwan, Vietnam, Korea. However, when we look at the Japan market, Japanese brand occupies about half. The relation between energy policy and the market of solar PV has investigated by several authors [1, 2]. They report that the domestic policy affects the market and sometimes destroy the domestic firms. The recent trade conflict between China and the US will add another point of view and modify the historical trend of the solar PV market.

In this work, the difference between Japan and the world solar PV market was analyzed. After that, the future Japan market will be discussed, considering the US-China trade conflict.
2. Characteristics of Japan solar PV

2.1. Price of Module
The price of the module made in China is the cheapest in the world, which was about 600USD/kW, closely following made in Germany. It cost about 1,000USD/kW for made in the US and Korea. While it made in Japan was about 1300USD/kW, in 2014 [3]. But the Japanese manufactures have occupied 80% for the house and 50% for non-house in the market share, as shown in Fig.1 [4]. The reason can be identified three; a) high Feed-in Tarif, b) high construction cost, and c) close relation to the housing maker. We will discuss the details in the following section.

![Figure 1. Market share of solar PV by Japanese companies](image)

2.2. The effect of Feed-in Tarif
Japan introduced Feed-in Tarif for renewable energy since 2012 (Fig.2). In the beginning, it was relatively high comparing the selling price in the house, 25JPY/kWh. So, the user does not consider the module price seriously.

2.3. The construction cost
Many house vendors are connecting PV manufactures. One of the reasons is that the holding company, such as Panasonic and Panahome, provides both [5]. They trust each other. Furthermore, the shape of the roof is not simple in Japan because of the small land. So, the PV module should be flexible to fit any shape of the roofs. Japanese PV producer provides a variety of products to fit Japanese houses. The Japanese market share of rooftop PV in Japan is more than 80%.

![Figure 2. FiT price of solar PV in Japan. (unit: JPY/kWh) ](image)

3. Future of solar PV manufacturing
Because of the recent trade conflict between China and the US, Chinese producer starts to make their products outside of China and export from them. Before this movement, Japanese producers have started to produce to reduce labor cost. Notably, in southeast Asian countries, Malaysia and Vietnam
will be the production center of solar PV. Fig. 3 shows the historical trend of solar PV exports from Malaysia and Vietnam. In the case of Malaysia, the major countries are the US, Hongkong, Japan, and Germany. While, in the case of Vietnam, it suddenly increased in 2017, and they export it to the Netherland and the US. Also, Japanese companies produce the module and panel using the imported cells. Fig. 4 shows the shipping of the solar module in Japan. Though market share by Japanese companies is more than 50%, the modules are mainly imported. Because the Japanese company produces solar PV outside Japan. As a result, the quality and module of solar PV become similar. In 2019, the system price is about 2,000 USD/kWh in both cases.

Figure 3. The trend of Solar PV exports (unit: USD) [6].

Figure 4. Solar PV shipping in Japan [4] (unit: kW)
4. Discussion

Thanks to FIT policies, solar PV power generation has increased rapidly in recent years. On the other hand, in 2007, the Japanese solar cell industry occupied 47% of the world market, but despite rising domestic demand, much of it was imported from China. The Japanese producers try to survive, focusing on the rooftop solar market. They believe in avoiding the severe competition by dividing the market between the inexpensive import module for a large solar farm and the high-performance module made in Japan well in terms of the application. Behind this, there is a strong trust between home builders and solar cell producers. The recent trade friction between the US and China forces Chinese manufacturers to actively promoting their products to Japan. However, the complex cost structure in the Japanese solar PV market alienates from international vendors. The reason is that Japanese consumer believes the quality of Japanese products, shows less concern with the module price. There are two reasons. One is the high FIT price. The other is that the ratio of the module is small in the total cost because of high construction costs. Since Japan has many disasters such as typhoons, earthquakes, we need a solid foundation, which raises the cost. Besides, the construction period is more extended than in Germany. German companies succeeded in shortening the period by using a specialized tool while it is impossible to introduce the technology to Japan since the land is tight and the surrounding road is narrow.

Japanese manufactures of solar PV have shifted their production place to outside Japan, seeking low labor and energy cost. On the other hand, the Chinese company also starts to produce PV outside China to avoid the trade conflict. Also, there is less difference in quality manufacturing in the same place and environment. Notably, they will be concentrated in Malaysia and Vietnam in SE Asia. In the future, as the price competition will intensify, for Japanese solar cell manufacturers to survive, it is necessary to provide even higher quality panels at low prices.

5. Summary

In this paper, the historical trend of Japanese solar PV production in the domestic market is reviewed. It is indicated that the Japanese consumer has selected Japanese product even it is expensive. Because they can sell electricity by a reasonable price under the FIT scheme and spend more money on construction to protect from natural disasters. Recently, both Japanese and Chinese companies start to produce solar PV cells outside. The production price becomes competitive in the future. The hot production countries in southeast Asia are Malaysia and Vietnam.

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