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Developing the permanent international competitive advantage of a sector in new industry – case of photovoltaic modules production in Germany

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***Abstract* — This paper is a case study of chosen determinants of the development of photovoltaic (PV) modules production in Germany in the years 2000-2016 in the context of creating a permanent international competitive advantage of new sector. There are analysed causes of failure of German companies, which lost leading position in PV modules manufacturing after emerging cheaper Chinese competitors. German PV modules production sector recorded a very rapid growth in the first decade of the twenty-first century. However, later the demand for its products has been steadily and rapidly declined. This situation arose from a decrease in the demand on the German market, caused by reduction of subsidies and with the emergence of Chinese manufacturers who began mass production of the PV modules at a much lower cost. As a result, German companies, which largely were responsible for the improvement of the refinement of PV technology in the world, have fallen and / or have been taken over, also by Asian manufacturers. In conclusions there is indicated that German firms should implement more long-term strategy, involving analysis of potential competitors which may emerge in the future as an answer to development of new sector. German companies should produce in countries with low-cost labour force and there, through robotisation, gain a cost advantage over local producers. Unfortunately, domestic production turned out a reason of their bankruptcy (however after many years situation changed but it was then too late). They should remember that on B2B market there works different marketing rules than on B2C. Continued technological improvement of German firm could also allow them to gain a technological advantage in Asia. German government whereas should more carefully pay attention on whom to support – if those entities will not be potential competitors of German companies as well as advise German companies in their crucial strategic actions.**

Keywords — photovoltaic modules, Germany, international competitiveness of the sector, China

I. INTRODUCTION

Fast development of renewable energy in recent years became a chance on a development of new export industry for countries that would like to specialise in manufacturing the equipment necessary to build the energy production facilities. One of such sectors that recently multiplied its size inducing demand on the equipment is photovoltaic (PV) industry. Production of the most important device, solar module, became an object of competition between Germany and China. History of German defeat delivers many conclusions how to develop a new sector to not only gain but also maintain its international competitiveness. That is why this paper focuses on determinants that affected loss of leader position in PV modules manufacturing by German companies (for the benefit of Chinese ones) and which could be avoided if different action strategy was implemented by both firm and government. Analysis in this work has a form of case study of the sector and covers a period of 2000-2016 with a focus on the events since 2004.

II. FLOWERING AND FALLING OF PHOTOVOLTAIC INDUSTRY IN GERMANY

A. Beginning of large-scale PV expansion in Germany and in China

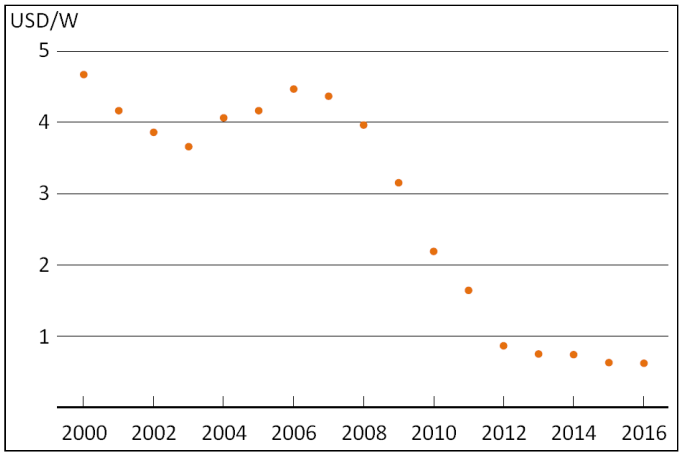
Germany has been promoted renewable energy in law since 1991, when a subsidy police based on feed-in-tariffs (FITs) was established [1]. FITs system assumes that the state pays certain amount for every kWh produced electricity from renewables. In 2000 there was adopted Renewable Energy Sources Act (EEG) [1], later several times amended [2]. Renewable electricity producers were offered to pay them for the electricity an established price, much higher than market rate, regardless of demand [2]. Especially generously there has been supported photovoltaic energy [1]. Broad development of power plants in this technology started after amendment in 2004 [3].

This amendment became not only a factor stimulating this sector in Germany but influenced also other countries, among other China [4]. Massive production of PV modules in China started just as an answer to appeared demand in Germany and other following it countries. In 2004 China accounted for 4% of global cell production, in 2006 it was 14,6%, in 2009 – 37,6% and in 2012 – 71,4%. Most of the production (~90%, depending on the year) was exported [5].

As shown on the figure 1., prices of PV modules has been behaving in accordance with supply and demand laws combined with changes resulted from learning curves and

economies of scale. In 2000-2003 prices were falling due to technological improvement and increasing demand. Since German EEG amendment in 2004 up to 2006 huge German demand significantly influenced PV market on the world causing increase in prices. However it was responded by the supply side, mainly from the Chinese part, which especially since 2007 has been manufacturing more and more PV modules, benefiting economies of scale and learning curve. That resulted in very quick fall in prices on whole the world. In one decade, 2006-2016, average prices of PV modules declined by 85% – from ca. 4,5 USD/W to ca. 0,6 USD/W.

Figure 1. Global average crystalline module selling price (USD/Wp) in 2000-2016.

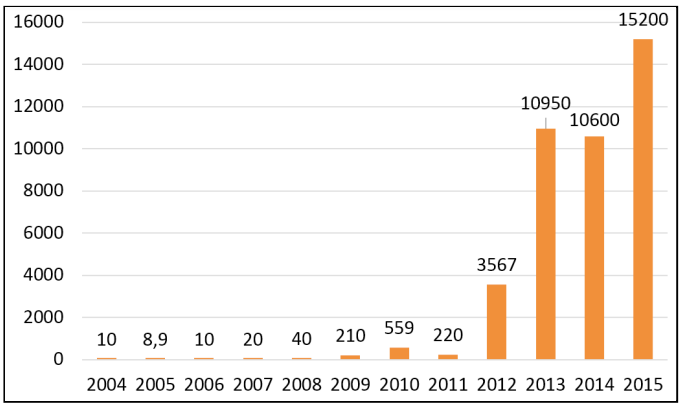


Source: [6, 7].

Price fall influenced demand side also in Germany, significantly increasing new investments in PV power plants. In 2003 in Germany there were installed 140 MW of new PV capacity. Next year it was already 670 MW. Following 3 years added capacities amounted subsequently 950, 840 and 1270 MW. Since 2008 investment boom significantly increased with 1950 MW installed that year and 4450 MW in 2009 [8]. However, it was being covered more and more with Chinese production.

Higher internal demand of PV modules in China whereas started already in 2009 [5], when Chinese government identified solar manufacturing as a strategic industry and started to stimulate it by low cost debts and subsidies. It increased significantly already since 2012 (see figure 2.) [5].

Figure 2. New capacity of PV modules installed in China in 2004-2015 (in MW).

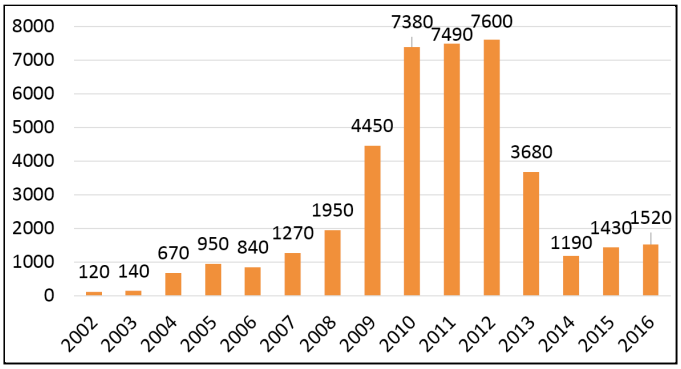


Source: based on [5, 9].

B. Production in Germany declines and loses competition with China

Meanwhile on the global market there appeared huge amount of PV modules decreasing their prices. Huge expansion of PV power industry in Germany started to generate high cost of FITs for the government. Despite these tariffs were decreasing gradually since 2004, in 2012 they were cut much more. As for 2012 average FIT for PV amounted 21,7 ct/kWh, in 2013 it was only 13,8 ct/kWh [10]. Such diminishing of subsidies didn't respond to decline in costs. As a result, demand on PV modules in Germany significantly fell – from 7600 MW of new capacities added in 2012 to 3680 MW in 2013 and 1190 MW in 2014 (see figure 3.).

Figure 3. New capacity of PV modules installed in Germany in 2002-2016 (in MW).



Source: [8].

German companies decided to produce PV modules in Germany. Ex., Q-Cells, the biggest PV modules manufacturer on the world at some time, which at the end of 2007 was worth €8 billion, had its production facilities in Bitterfeld-Wolfen, symbolically in a former lignite mining area [11]. Despite location of production facilities in Germany means different benefits (like proximity to R&D units and to customers) it is also connected with high costs of labour.

Labour costs in Germany are among the highest in the world. However, despite that, this country is also the third

biggest exporter in the world [13]. One of the main reasons, why Germany is able to compete having so high workforce costs, is an automatization of the production. Germany is the 4th most robotised country in the world. So called "robot density" in 2015 amounted there 301 units per 10 000 employees, comparing to world average amounting 69 and Chinese average of 49 [14]. However PV modules manufacturing requires a significant share of human labour. That is why its cost has a big impact on the total cost of the modules [15]. Workforce costs in Asia are much lower and that is why factories operating there can easier achieve lower costs, especially in human labour intensive industries. In addition, there are also cheaper components to production as well as construction and maintenance of the factory also involves much lower costs [11].

German companies, especially those in high-tech industry are used to benefit from so called country of origin (COO) effect. It means that customers seeing label "made in Germany" assume that such product is high quality [16]. Such perception however differs significantly among industries. One of the most important issues is that COO effect doesn't play an important role on business-to-business market. It is whereas a significant factor on business-to-consumer market, especially for luxury goods and high-tech products [17]. German customers have a strong perception that products manufactured in Germany are characterized by significantly higher quality (however higher price as well). Germans show also a strong purchase intention for German products [18]. Photovoltaics modules definitely belong to high-tech industry that is susceptible on COO effect, however it is not a market niche, where label "made in Germany" may be important [15]. Photovoltaics farm are since built by businesses, which are few susceptible on COO effect. Millions of PV modules are also installed on roofs of private houses, however their purchasers generally don't choose the manufacturer of them. Instead they only engage a company that perform a turnkey project, bringing all the equipment. That causes that such companies (i.e. entities less susceptible on COO effect) mostly decides from whom to buy PV modules. Obviously they are also influenced by customers that may prefer local producers and country of origin of PV modules is shown them what is one of the determinants of choosing certain installer. However PV modules producers generally don't profit much from the COO effect.

German PV manufacturers weren't able to win price competition with Chinese rivals. In first half of 2010 average price of Chinese silicone PV modules was ca. 20% lower than the price of German ones. Such situation maintained to the end of 2013 [7]. As a result, German companies massively lost their share in global PV modules. In 2004 they held a 69 percent share of the world's solar modules business. 7 years later, in 2011, it amounted already only 20 percent [19].

Changes on the global market resulted in series of bankruptcies of German PV modules manufacturers. In December 2011, two of the major solar companies, Solon and Solar Millennium, went bankrupt. In March 2012 Scheuten Solar that in 2004 was world's largest solar module producer also declared bankruptcy. The same month the same fate met Solarhybrid and Odersun [11]. In April whereas Q-Cells, once the biggest PV modules manufacturer in the world also filled for insolvency [20]. Whole photovoltaic sector in Germany (production, installation and maintenance services) employed in 2011 over 100 000 people. By 2015 there left only 30 000 of these jobs [21]. Only in since 1.01.2012 to 31.12.2013 the employment in PV modules manufacturing diminished from over 10 000 to 4800 people [22].

Just after enacting generous feed-in-tariffs in Germany in 2004, domestic supply immediately responded to new demand. By 2007 Germany became the global leader in PV modules production [23]. In 2015, however, 67% of market share in PV module production had China and Taiwan; the rest of Asia-Pacific and Central Asia accounted for 14%. Whole Europe contributed with a share of only 5% [24].

Interesting fact is a degree of mutual German-Asian PV modules trade after all mentioned changes. On the one hand around 80 percent of PV modules installed in Germany come from Asia [21]. However, on the other hand, 75% of German PV modules production is sold to Asia and only 9% is directed to the domestic market (Q1 2016) [25].

Very important reason of increase the power of Chinese PV manufacturers was a support from Chinese government, however German one also contributed to their development. Germany spent more than 100 million EUR on development aid to China destined to promotion of "global climate justice" (according to the German environment ministry). Subsidies had different form, however they contributed Chinese PV manufacturers development [11] German government also contributed 9 billion EUR to climate protection program for China, which provides low-interest loans for Chinese industry [12].

C. Mistakes, among other wrongly targeted German marketing result in overtakes by Asians

Many German PV manufacturers went bankrupt after the failure with Chinese rivals. Many other were taken over, like Sunways by LDK [26]. One of the biggest losers, Q-Cells was bought by Korean Hanwha. After taking over Koreans moved Q-Cells production to Asia, however they left its R&D units in Germany. That resulted from the fact that German researches in Germany have better conditions to develop yet better PV modules than it could be achieved in Asia [15].

A worth a notice issue are thin-film modules. It's an advanced type of PV modules based of very thin layer. This technology is one of the alternatives to common crystalline silicon cells. Despite it is known for decades [27], its share in PV technologies use mix has always been in minority (8% in 2015) [24]. One of the reason of such situation has been lower efficiency of energy conversion of this technology through a long time [27]. However many companies decided to invest in it. Ex. Q-Cells in 2006 acquired Solibro, a Swedish solar research company known for researches on thin-film PV modules and holding the world record for efficiency of this type of modules. One of the technical characteristic treat of this technology important from the economical point of view is that such PV modules are cheaper and more environmentally friendly to make [20]. However technological issues caused using them more space-consuming. It is crucial in densely

populated European countries (especially Germany), where land is much less available and more expensive. Such modules are not adjusted to European conditions. However they are suitable for places like China, where PV power plants are mostly located in large, open areas like desserts, where space is less of a concern than in Europe [20]. Shortly after filing for bankruptcy by Q-Cells, Solibro was sold to Hanergy, a Chinese company credited previous year with 4.7 billion USD by China Development Bank [20].

Meanwhile Solibro regularly improves its products, beating records in thin-film modules efficiency [28]. One of the reason of Q-Cells (and not only) defeat can be found in Solibro's official material presenting its products. In one of them we can find: “Solibro supplies products that are sustainable and cost-effective, with extraordinary aesthetics and top quality “Made in Germany“.” [29] Solibro among underlined traits of its modules indicated sustainability and “Made in Germany“ label. They undoubtedly represent idealistic point of view of responsible company that cares about the environment and local economy as well as provides high quality products. Moreover, it is not typical only for Solibro and Q-Cells but for many German companies. However such priorities were unfortunately one of the reasons of their defeat in the clash with Chinese manufacturers. “Made in Germany“ label was insufficient to convince enough high number of buyers on domestic market (vide COO effect on B2B market), as well as especially it wasn't convincing for customers in the country with biggest demand on PV modules, i.e. China. Even the fact that thin-film modules are better adjusted to Chinese conditions (and ecological issues as well) wasn't an enough argument in the clash with the cost and price issues. It resulted from the fact that production in Germany is more expensive than in China and in final score paying much more attention to low price Chinese clients preferred Chinese products.

D. Changes in 2016

PV investments in China experienced a boom after Chinese government interested this sector and decided to support it, especially since ca. 2012. Great investments and connected with them costs started however to be a problem also for China, what led to the decisions of reductions of the subsidies. Due to the withdrawal of governmental support for PV in China since second half of 2016, there significantly declined a demand on them in this country. It resulted in great surplus of the supply. Chinese producers, don’t wanting to lose their market share, decided to lower prices of their products. Dumping and price war resulted in further quick fall of prices on the market, what as an another blow for German PV manufacturers. Ex., in 2016 SolarWorld reduced its employment by 500 temporal workers, justifying it just with a surplus of Chinese PV modules on the market [30].

One of the results of very fast development of Chinese economy in recent decades is also very fast of average wages increase in this country. Only in 5 years 2010-2015 they increased by 67% (from 37 147 CNY to 62 029 CNY yearly) and in a decade 2005-2015 they much more than tripled – average wage increased from by 228% (from 18 364 CNY to 62 029 CNY yearly) [31]. It is still over 5 times less than in Germany (706 EUR monthly in China vs 3611 EUR monthly in Germany in 2015 [32]), however it contributed significantly to lose the Chinese cost advantage that was source of competitive advantage of Chinese manufacturers. German producers with every year has been in comparatively better cost situation (only 23% of average wages in 2005-2015 [32]). Together with the other factors, like among other technological advantage of their products and much higher automatization of the production process (where possible) it resulted in diminishing the cost gap between German and Chinese manufacturers. In half of 2015 prices of crystalline German and Chinese PV modules levelled off [7]. In such situation German manufacturers again started to be able to compete effectively with Chinese rivals. However most of the producers went already bankrupt or were taken over by Asian companies.

III. DISCUSSION

German companies haven't survived a period between expansion of Chinese manufacturers and levelling up the prices (2007-2015). They lost the competition due to the several reasons.

German companies were too much German-oriented and haven't paid enough attention to implication from of the internationalization of the world's economy and its influence on single country's sector. German companies decided to produce PV modules in Germany, being driven by the conviction that “made in Germany” will be a factor of their competitive advantage. However, as it could be it on B2C market, on B2B wasn't and their customers were mainly industrial recipients. They are much less susceptible on COO effect and economic patriotism issues. That is why low prices were very important factor of their purchase decisions what caused that cheaper Chinese manufacturers were preferred. Despite additional costs, like of transport and of distant management, production in low-cost countries (important: countries, where there is no fast wages increase) would allow to offer lower prices of PV modules by German companies. Offshoring would thus allow to prevent loss of their market share in Germany when Chinese low-cost competitors appeared. It would also allow to conquer Chinese market when there appeared huge demand on PV modules.

A factor accelerating emerging the competitors in China was German governmental support for Chinese PV industry. It was driven by a desire of help in mitigation of climate changes, however the same effect could be achieved not only without harm to German manufacturers, but also with a benefit for them just by supporting their expansion to China. If German producers would be supported in establishing foreign direct investments in China, they could not only provide there high-quality and low-price (thanks to cheaper labour) PV modules but also it would give to German companies an opportunity to develop and earn. Moreover such action would also realize mentioned above necessity of offshore production for German market. Yes, it would be deliberate resignation from the jobs creation in own country for the other and moreover it would be justified also by a desire of exploitation the low-paid workers. However, as the reality show, the alternative was a much less favourable solution for German economy and not better for Chinese workers. Supported Chinese companies employed just low-paid employees and the earnings from their production fed

China not Germany. German companies whereas found themselves in conditions without very important in this sector (relatively easy to copy product) cost advantage. The result was the expansion of Chinese manufacturers and defeating the German ones.

Both German companies and government were too idealistic about their attitude to business and aims. However they couldn't get everything at once. They should make a profit and loss account of different solutions combining it with projecting the scenarios, how in the future the situation may change. Fast development of China and connected with it increasing wages was in 2005 not only foreseeable but it was then just a fact and a clear trend. Technological improvement as well – German companies had here an advantage over Asians. Advanced PV technologies that are not so easy to copy like these previous were an opportunity for the future when they will be more elaborated.

Lack of supporting the Chinese companies by German government wouldn't prevent their development, only retard it a little. They were supported much more by Chinese state. However setting up German factories in China and in more low-cost countries in this region would allow German manufacturers to compete with Asians efficiently and deprive them their competitive advantage. Moreover, adoption of automatization level from Germany in German factories in Asia would allow to achieve them higher production efficiency and the cost level that could be even lower than in Chinese factories in China. Then Asian producers couldn't overtake German buyers of PV modules, because they wouldn't offer them anything more than German manufacturers with factories in Asia.

Worth a notice there is also a situation that took place in 2016. After many years prices of German and Chinese PV modules levelled then up. The relative cost situation of production in Germany has significantly ameliorated (due to among other the increase in Chinese wages). In the meanwhile German companies improved more advanced thin-film technologies that are better adjusted to China than to Germany. After several difficult years German PV modules producers found themselves in better competitive situation in relation to the Chinese rivals. Now they would have higher chances on further efficient competition with them even if production would be located in Germany. However nearly 2011-2012 many of major German PV modules manufacturers went bankrupt or were taken over. That is why they cannot do it. They have lost also the technological advantage due to takeovers by Asians.

IV. Conclusions

German PV modules manufacturers lost their leading position on the world due to mistakes made by them and by German government.

1. Workforce in developed countries is very expensive. That is why before deciding where to produce (domestic manufacturing or offshoring), companies should carefully analyse all advantages of both alternatives, taking into consideration among other labour costs, robotisation and marketing factors of competitive advantage (and many other).

2. Robotisation of the production may be a very important factor of the competitive advantage of the factory that may mitigate high labour costs, however if it is enough to justify economically the production in developed country, it depends on the product specifics, especially the share of necessary human work.

3. Marketing factors of competitive advantage (like COO or CSR benefits from domestic production) depends on the country but even with very high customer consciousness, like in Germany, it sometimes they may be not enough, because there is also a difference between B2B and B2C market – this first is much less susceptible on psychological marketing factors, like "made in Germany" label.

4. In order to make competitive advantage permanent, business model should contains long-term perspective taking into consideration not only current competitors but also potential future ones that may emerge soon. Company must analyse potential advantages of such rivals and try to benefit this possible source of their competitive advantage before somebody other do it with a harm to the first firm. It may require involving a significant change of hitherto approach.

5. Not always there can be achieved everything at once. Sometimes company must resign (at least temporarily) from some points of its ideology, because otherwise competitors may defeat it. German case show that in new sector (PV modules are not new product but their broad use is relatively new and that is why such phrase is here justified) situation may undergo significant changes during its period of fast development, among other due to quickly improved technology and achieved scale effect.

6. Government should be very careful about supporting foreign companies in developing countries, because they may be a reason of defeat of domestic firms in supporting country. Government should also advise companies how to create permanent competitive advantage, when the firms make decisions, which in the future may have negative consequences.

7. Government should clearly state its long-term policy in crucial for sector issues. Sudden cuts in FIT for electricity production from PV in Germany significantly diminished domestic demand on PV modules, what was a hit for German PV manufacturers targeting in domestic market.

The experience of German PV modules manufacturers may be useful in many industries. Also in renewable energy sector there may be applied these conclusions – many renewable technologies are either on experimental stage or they could pass large-scale expansion that could completely change the situation in particular industry and which may become a new export sector for developing them countries, ex. different marine technologies or binary geothermal ones.

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