THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

The University of Waikato, Corporate & Executive Education

Hamilton, New Zealand

Date: 26.03.2017

Economics (EXPM506-17) - Case Study Report

On

"The Renewable Energy Sector: Solar PV Market"

Submitted to

Dr. Gazi M. Hassan

Submitted by

Madhumita Gogoi Saikia	**1316943**
Molly Fang	**1295459**
Mohd. Yusoff Bin Deraman	**1292837**
Tayla Carson	**1226237**
Wanida Taylor	**1192511**
Yixuan Fang	**1288311**

(Total words: 3477)

EXECUTIVE SUMMARY

The renewable energy industry is the future of power consumption. Green electricity or renewable energy is generated from natural resources which has less environment impact to our Earth compared to fossil fuel energy. Using renewable energy reduces the amount of carbon dioxide into the atmosphere. These will help to reduce climate change or global warming. Renewable energy sources like solar energy will reduce our dependence on fossil fuels and noble gases which are in a current state of depletion (Uswitch, 2017). The solar photovoltaic (PV) systems harness the solar energy from the sun and convert this to usable electricity. These systems have a huge amount of growth potential with exponential growth in population and a constant need for power supplies. There has been a steady increase in the current growth of solar PV systems with no indication of a future decline. It was found that this technology is more viable in Asian countries due to low production and wage costs for labour. The main variables causing growth in this sector is population growth and increased per capita income. There are also continuous environmental public policies being set which favour the use of renewable energy resources including solar PV systems. Crystalline silica is the most common main component used needed to produce these systems and the changing cost of this will affect the future market. Using Porter's competitive model, it was found that the rivalry among competitors is medium to high. There is little threat of substitute products entering the market. Suppliers possess medium to high level of power to bargain. There has been an increasing number of installation of solar PV panels which indicates that in the future the bargaining power of customers could be considerably high. The price elasticity for the solar market was found to be relatively high. Overall there is high potential for growth within this industry and no indication that there would be a decline in the years to come.

Table of Contents

Introduction

Renewable energy is energy produced from natural resources which are easily replenished (Ciolkosz, n.d.). It falls under the utilities sector and utilities industry group, with the sub-industry as renewable electricity (Wikipedia, n.d.). In the past, fossil fuels have been used as easy sources of power such as coal burning or crude oil extraction to be used as gasoline for powering vehicles. These resources are limited and will eventually be fully consumed; making them non-renewable. There are also negative side effects that occur due to burning fossil fuels such as a release in carbon dioxide emissions which is a principal contributor to the greenhouse effect causing the Earth to warm up. There is a necessity to distinguish feasible renewable sources and understand how to use it to convert it into energy that humans can utilise, which is more environmental friendly and viable. There are several types of renewable energy such as solar power, wind power, hydroelectric energy, bioenergy, hydrogen and fuel cells, geothermal power and other forms of energy likes energy from the tides (Wikipedia, 2017). Electricity also can be generated from wind energy which is used to rotate giant turbines and converted into electricity. Hydroelectric dams or water flowing downhill into streams or rivers are used to generate hydroelectric energy by rotating turbines. Other very common renewable energy is bioenergy, which is converted energy from burning of trees or other organic matter for cooking, electricity and heat (Alternative Energy, 2017). Hydrogen which can be found in water also can be converted into electricity when it is burned as a fuel. Earth's internal heat produces geothermal energy, ocean waves produce tidal energy and both can be converted into electricity (Renewable Energy World, 2017). The primary focus for this report will be solar photovoltaic (PV) systems and its industry. PV systems are panel like structures which use solar energy from the sun and convert this into electricity. The market is segmented based on six primary applications of solar PV systems (International Energy Agency, 2015). These are: pico PV system, domestic off-grid system, non-domestic off-grid, hybrid system, distributed grid connected PV and centralised grid connected PV. The following case study investigates the solar PV industry in relation to managerial economics and discusses its potential for future growth[1].

[1] (www.iea-pvps.org/fileadmin/dam/public/report/national/IEA-PVPS_-_Trends_2015_-_MedRes.pdf, pp. 6, 2015)

Current PV market scenario and future potential

China and Taiwan has the highest percentage share of total production of PV modules from 2008 to 2015 (*Figure 1*) (Philipps et al, 2016). There is a steep rise in global annual production in the PV industries situated in China and Taiwan accounting to 43 GWp in 2015 (*Figure 2*). There is a rapid rise in global cumulative installed PV capacity in Asia and Europe between 2008 and 2015 (*Figure 3*) (Philipps et al, 2016).

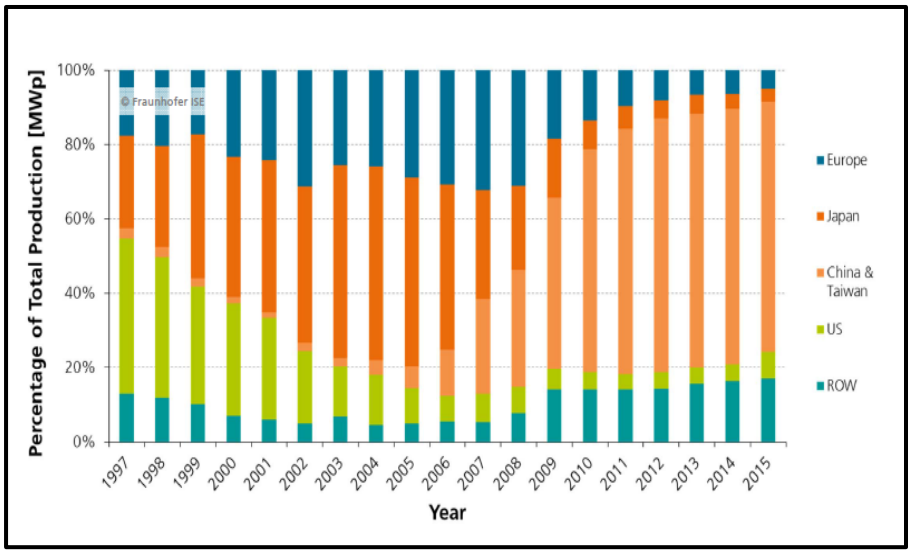

Figure 1: Regional PV module production (Philipps et al, 2016).

From *figure 2*, China and Taiwan are market leaders in the PV industry production, because of cheap industry resources and low wages. This makes it extremely difficult for North America or any other country to compete with.

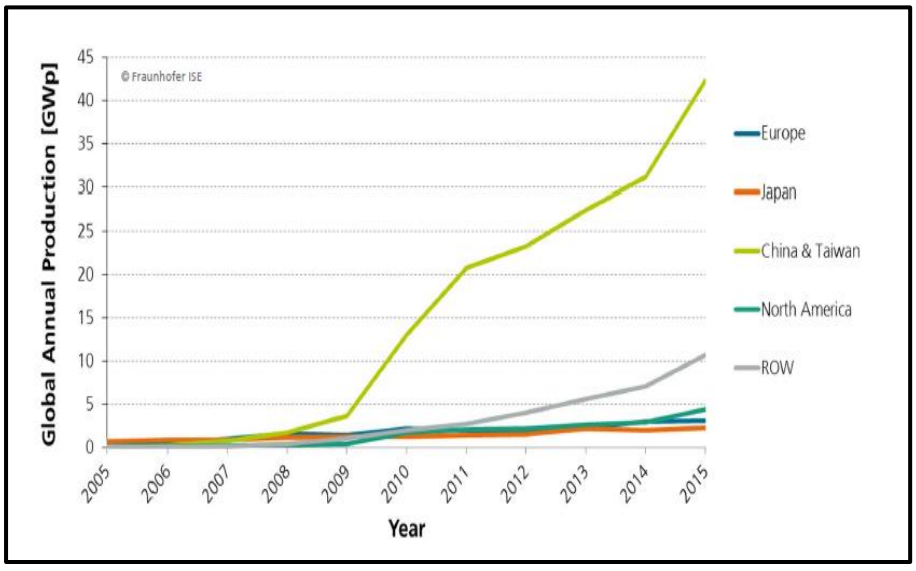

Figure 2: Regional PV industry production (Philipps et al, 2016).

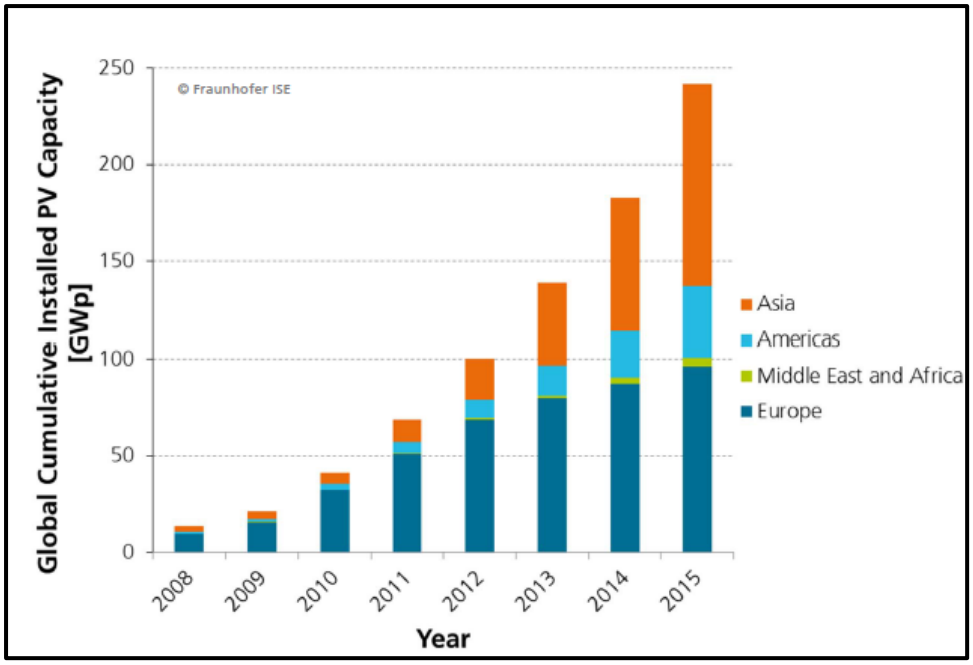

Figure 3: Global PV installation (Philipp et.al, 2016).

Figure 3, shows that the PV installation is increasing around 100%. From this statistic, it is lucrative in the European solar market. Many suppliers are entering this industry which is causing it to be very competitive in Europe.

From *figure 3*, the numbers of PV installation in Asia are almost three times more than in Europe. Due to the high demand in Asian developing countries, and around 512 million people without electricity, this makes the market sector extremely competitive.

Factors affecting demand

Demographics

Population is one of the main factors behind the growing need of electricity. This can be seen from *figures 4 and 5*, which reveals that projected growth in population will reach nearly 9.7 billion in 2050 compared to 7.3 billion at present. It is rising slowly due to an increase in fertility rate and an increase in life expectancy (Khokhar, 2015). The highest proportion of world population will be in Africa and Asia by 2100. It is obvious that with increasing population and life expectancy, the demand of electricity for basic human survival will also increase. This increasing shift tends to boost the consumption patterns of goods and services for the global overall development (Khokhar, 2015).

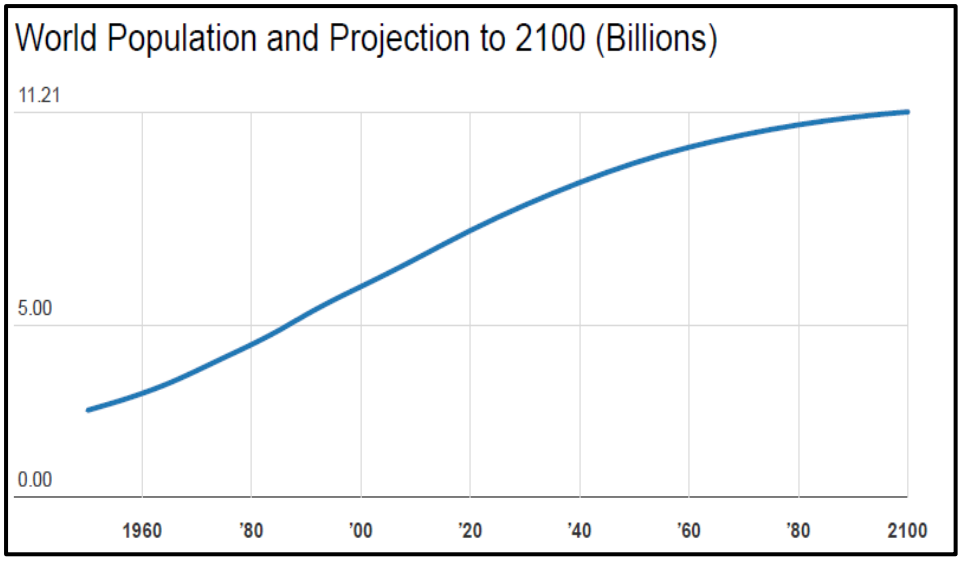

Figure 4: World population projection (Khokhar, 2015).

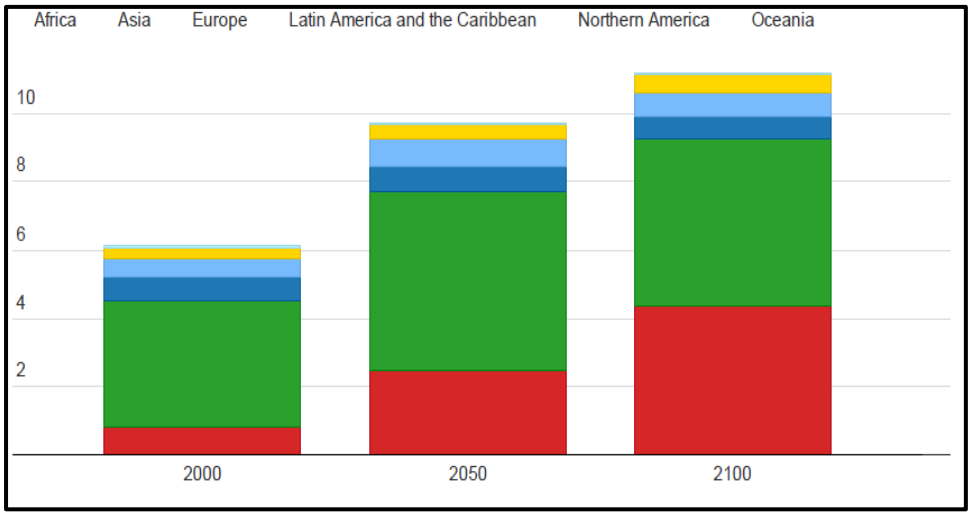

Figure 5: Regional population projection (Khokhar, 2015).

Growth of per capita and income

From the *figure 6*, it shows that between 2013-2035, the average per capita growth will be highest in India (4.8%) followed by East Asia and Pacific (4.5%), China (4.4%) and Sub-Saharan Africa (3.5%) (Hellebrandt & Mauro, 2015). The projected growth in this regard for advanced economies seems to be lower compared to developing countries. For the total gross domestic product (GDP) growth, Sub-Saharan Africa will reach the highest with 6%. There will be a combined increase in GDP, income and population in this region. India, East Asia and Pacific will also have higher GDP growth (Hellebrandt & Mauro, 2015).

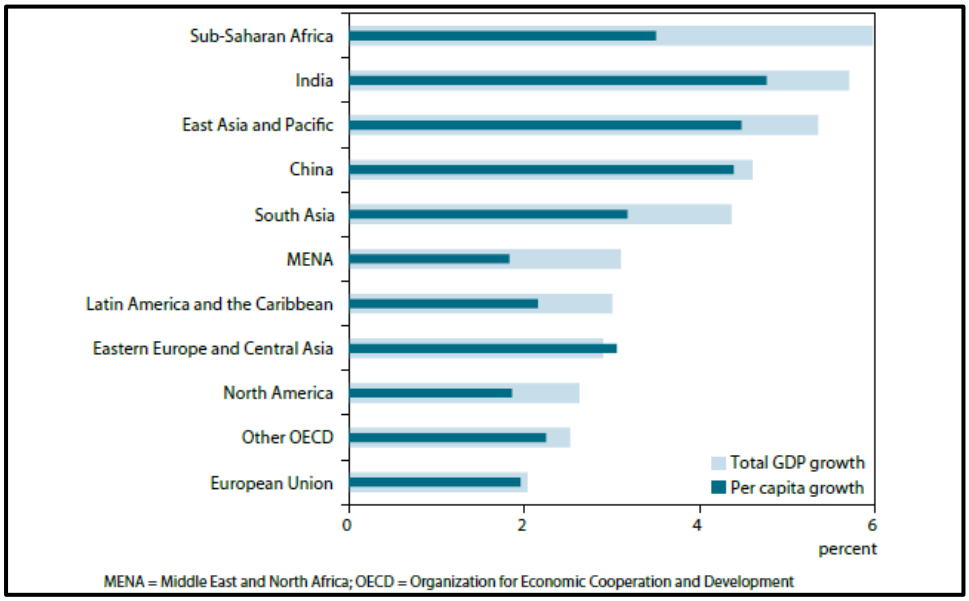

Figure 6: Regional growth rate between 2013 and 2035 (Hellebrandt & Mauro, 2015).

China will have the highest gains in trillions of dollars of total GDP in 2035 *(Figure 7)*. North America, the European Union and India will follow China. This clearly indicates that the developing and emerging countries will have a major share in the total world output (Hellebrandt & Mauro, 2015).

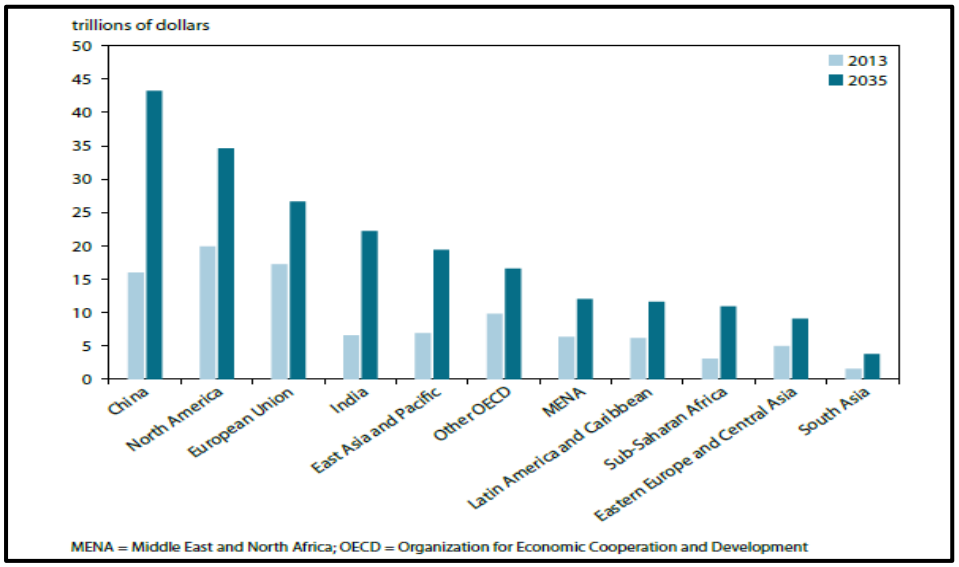

Figure 7: Total Gross Domestic Product (GDP) between 2013 to 2035 (Hellebrandt & Mauro, 2015).

There will also be an increase in GDP as it is estimated that the worldwide median individual income will be more than doubled from $4000 to $9100 (USD) in 2035. The inequality in

world distribution of income is expected to decline as indicated by the Gini coefficient (Hellebrandt & Mauro, 2015).

As indicated by the world bank data, there will be a decrease in poverty with a reduction from 850 million in 2013 to 300 million in 2035 (Central Intelligence Agency, n.d.). Consequently, more people will have purchasing power to avail electricity and there will be better infrastructure available to meet the demand using renewable and non-renewable energy in the future. However, to meet the overall electricity demand, there must be a transition to renewable energy, especially solar due to the supportive environmental policy and faster decrease in cost reduction (BP, 2016).

Market integration

The solar PV industry has had a fast-tracking progress in the social, political, technological and economic integrations in our society due to globalization (Keat et al, 2013). Thus, it has impacted in a greater sense on the management of markets and business in a global scenario. A wide range of products and services are offered at local levels to meet energy demands (Keat et al, 2013).

Currently, solar PV industry is booming and taking major responsibility to satisfy the local needs of electricity in different parts of the world (Mary, 2016). For example, Europe, Germany and the United Kingdom have introduced feed-in premium schemes to compensate for the variation of electricity in the market price. The concept of "prosumers" which is both producer and consumer of energy is growing speedily. There are also net metering policies, which are supported in many countries which include the Netherlands and Germany. Personal consumption is increasing the demand of solar PV systems with access to varied products and capacity of solar panels (Seyboth & Sverrisson, 2016). To enter the new market, merging and acquisitions among manufacturers and installers are continuing. There is currently market consolidation among operations and maintenance providers. Also, more turning into engineering, procurement and the construction of solar PV projects.

Demand from emerging markets

As seen above, it is without a doubt that the emerging markets in the future are China, India, East Asia, Pacific and Sub-Saharan Africa (International Energy Agency, n.d.). These regions are the key future of solar PV projects. In addition, at present 16% of the world population (nearly 1.2 billion as shown below in Table 1) do not have access to electricity and more than

95% of those are living in rural areas of Africa and the developing Asia continent. The percentage of urban electrification has outpaced the rural electrification. Thus, demand for electricity is more in the above regions and are major targets for the solar PV industry in the up-coming years (International Energy Agency, n.d.).

Table 1: Electricity Access of regions (International Energy Agency, n.d.).

Electricity access in 2014 - Regional aggregates				
Region	**Population without electricity, millions**	**Electrification rate** %	**Urban electrification rate** %	**Rural electrification rate** %
Developing countries	**1,185**	**79**	**92%**	**67**
Africa	634	45	71	28
North Africa	1	99	100	99
Sub-Saharan Africa	632	35	63	19
Developing Asia	512	86	96	79
China	0	100	100	100
India	244	81	96	74
Latin America	22	95	98	85
Middle East	18	92	98	78
Transition economies & OECD	**1**	**100**	**100**	**100**
WORLD	**1186**	**84**	**95**	**71**

Factors affecting supply

Public policy

Currently 146 countries in the world are developing renewable energy policies to increase investment, deployment of technology and promote innovation (Seyboth & Sverrisson, n.d.). The greatest attention in 2015 was relevant to power generation. During December 2015, 195 countries agreed set goals to mitigate climate change by reducing emissions and using renewable technology. There is a wide variety of scope in this regard from country to country. For instance, Brazil aim to meet 45% of total energy needs with renewables by 2030 (Seyboth & Sverrisson, n.d.). There was competitive tendering of solar PV projects in Brazil during the same year. China had a tender of 1GW capacity of solar PV. Renewable portfolio standards (RPS) are been developed to stimulate electricity generation by renewables. Thus, national and state level policies are also in favour to increase the number of solar PV manufacturers in the world (Seyboth & Sverrisson, n.d.).

Cost of raw materials

Crystalline Silicon is the raw material that is mostly used to manufacture the solar PV module and used in the PV industry. The wafer based c-Si cells and modules are found with the highest percentage in the present market. In 2010, it has accounted for 87% of the entire global productions (IRENA, 2012).

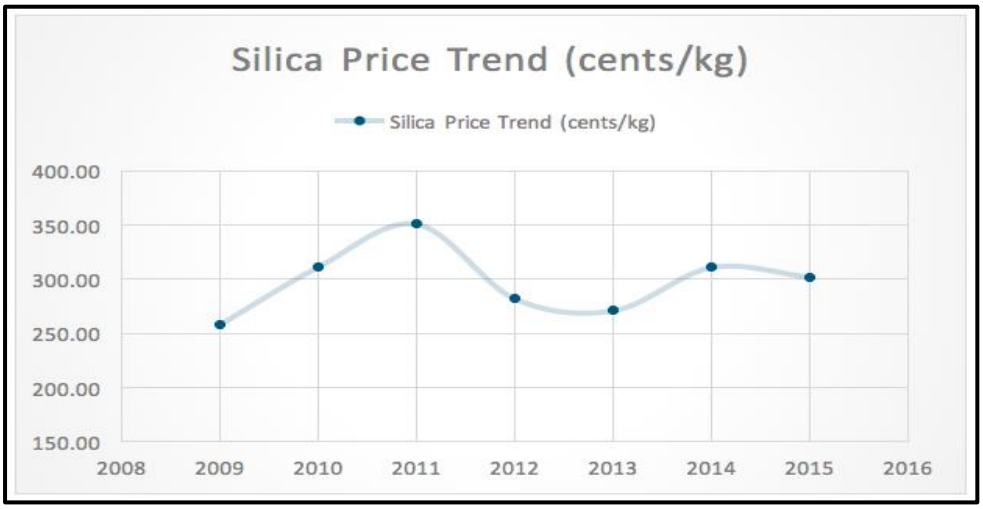

Figure 8: Changing price trend of Silica (Ezysolare, 2016).

Figure 8 shows the changes in cost of silica which trends to fluctuate around 300 cents/kg. Due to variation in price, there is a forecast for a higher demand of silica which would increase the number of installations and demand for solar PV systems. The cost of PV module covers a third to half of the total capital cost of the PV module or PV system (IRENA, 2012).

It is expected that the cost for the PV module will decline in the next two decades with improved technology an increase in demand. This may cause an increase in the numbers of companies entering the market. The PV cell module dropped from US$ 4/W in 2008 to US$ 0.8/W in 2012. The cost of PV investment is projected to narrow down the average cost and could decline further to US$ 0.4/W by 2035. This is indicated by an increased demand and capacity of solar PV installation (International Energy Agency, 2015).

When the cost of raw materials decreases, then the quantities supplied by manufacturer increases for a given price. The manufacturers are always able to supply more with lower cost compared to higher prices. A decrease in any factors of production will increase the supply.

Technology

With rapid market growth in the solar PV sector and price reduction of PV modules after several years, it initiates innovation as a central theme in the solar PV industry. Several producers are turning to profit and introducing innovative equipment in the production lines. Consequently, new factories are being introduced into the market (Rekinger et al, n.d.).

Analysis of findings using Portar's competitive model

The solar PV industry is analysed using the Portar's five forces which determines the competition structure of the industry (Bhasin, 2016).

Intra-market rivalry

With increased installation and government environmental policies, the solar PV market may get competitive with the possibility of many new markets entering this industry. The existing producers in the world could diversify their products and offer operations and maintenance services. It may become highly competitive in the future with lower profitability. The solar PV market is very competitive and fast growing industry. From 2011 to 2012 solar industry in the U.S. grew around 34 percent from $8.6 billion to $11.5 billion (SEIA, n.d.). This made it the fastest growing energy source in the U.S. Many areas using solar PV including homes and businesses.

With an 86% increase in growth and continuing high demand in the solar market, this clean and low-cost energy source is extremely competitive in the United States; across many states. California is one of the largest solar markets in the Unites States and in the world (SEIA, n.d.). Long-term government policies, including a tax credit and state incentives cause a high demand for clean and affordable renewable energy. This industry also employs more than 100,000 workers and many of them are in small businesses (lin et al, 2014).

The growing number of competitors and increasing number of manufacturers leads to high exit barriers and the intensity of rivalry could remain high. Also, the Chinese companies have an advantage because they are supported by their government. They have a trade advantage over European and the United States solar companies. Therefore, the rivalry among competitors is medium to high.

Bargaining power of suppliers

China could be the world's largest solar renewable energy source. Most of the solar panel manufacturing occurs in China. The Unites states cannot keep up with the high demand and rapid growing of this renewable energy. Between 2008 to 2013 China caused the world price of solar-electric industry to drop by 80% (Fialka, 2016). According to Solarbuzz reports in 2009, by increasing the number of the solar manufacturers, the bargaining power of suppliers decreased and the costs of crystalline went down by 55% (Fialka, 2016). This makes the suppliers possess medium to high level of power to bargain (Dastor. n.d.). If the cost of raw materials of PV modules is forecasted to decrease in future, it implies that there will be greater supply and hence, the bargaining power of the solar PV industry with the supplier will be low to medium.

Bargaining power of customers

Customers are increasingly becoming aware of the concept of clean energy, especially solar energy. There has been an increasing number of installation of solar PV panels which indicates that in the future the bargaining power of customers could be considerably high. If the demand exceeds the supply, then the bargaining power of consumers would be low. If there is an increasing trend in the installation of solar PV panels in various applications like previous years, higher consumer demand may make the electricity price generated from it more competitive in the future (Fialka, 2016). An increased customer awareness in renewable energy, governments subsidies, high demand and adopting renewable energy in many

developing countries are the factors contributing to increasing numbers of solar projects. This makes the solar PV industry very lucrative and the ability to attract several companies to make an investment.

Threat of new entrants

Changes of social and economic factors like an increasing rate of population and economic development, as well as in the government regulations in the world in favour of renewable energy, there is a high likelihood of new players entering the market in the future. Thus, the potential threat of new entrants will be high. However, there is a possibility of uncertainty of the financial investment and stable cash flow on solar PV products, but this may change in the future.

Threat of substitute products or services

Solar PV is unique and scarce as a technology, and the costs for replacement are high (Dastor. n.d.). There is better technology and a more lucrative availability in the European market causing more suppliers in this industry and making this business very competitive in Europe. While the numbers of suppliers are limited to keep up with high demand in solar PV worldwide the solar industry depends on the main materials - crystalline silicon to manufacture most solar panels. Hence, the price of crystalline silicon highly related to the price of solar panels. Therefore, many manufacturers signed long term contracts with silicon plants (NC State University, n.d.). If a product had similar properties to crystalline silicon and could be produced easily and cheaper, then the threat to this industry could be substantial.

Electricity produced by solar PV panels can be substituted by produced from different resources coal, natural gas, hydro, biogas and so on. If the price of electricity produced from the substituted resources goes down, then there is a higher threat in this regard. However, with forecasted reduction of price of PV panels in future, it can compete with the price of electricity produced from other sources. Thus, it seems to have lesser threat in future.

Price elasticity

The price elasticity of supply is high at around 2.7 for solar PV power generation (Human Economics, 2015). When there is a slight variation in the price of solar energy, the production amount of solar panels varies widely. It is referred to as the fixed cost, but the consumers can install solar panels based on their required capacity, thus making it behave as a variable cost.

When the price paid for solar power produced from solar PV increases by 1%, there is a 2.7% increase in production of solar panels, thus increasing its supply.

The price elasticity of solar PV may be elastic or inelastic due to a variety of factors. It could depend on the availability of close substitutes, whether the required form of energy is a necessity or a luxury, how much percentage share of income goes into the installation of solar PV panels and time duration (Brownson, 2016). The demand is elastic as there are close substitutes of the form of energy when price of electricity produced from solar panels changes. The electricity produced from solar energy is a necessity and hence inelastic. If there is a high government subsidy for installation of solar PV panels, then the total investment is less and hence the price elasticity of demand is inelastic. For a shorter time duration, it is inelastic and when the evaluation is done for a longer period, where the lifetime period of solar PV is 25-30 years, then the demand becomes elastic.

Conclusion

The demand and supply factors indicate future steady growth in the solar PV industry. Increasing global population especially in the developing countries, rising income because of the improving global economic development and evolving "prosumer" concept may play as critical factors on the demand side of electricity generated from photovoltaic (PV) panels. The production of PV modules may be accelerated in the future for different residential and industrial applications because of all-around concern for climate change and steps taken towards the implementation of varied state, national and global level policy development related to renewable energy. As seen above, the reduction in the cost of raw materials and projected price by 2035, will encourage more suppliers to produce PV modules in the future. The investment by producers in innovative technology used in the entire chain of production line due to positive return can be another reason to allow more suppliers to enter in the future market. It can be anticipated that there will be more demand and supply of PV modules in the emerging countries especially China. Overall, the potential for future growth in the solar PV industry is relatively high. Power is always going to be a basic human need and non-renewable resources are quickly dwindling as we head towards excessive rates of consumption. Renewable energy sources are the future and the most practical and cost effective source is within the solar PV sector. This creates a final product as a utility: "energy" either as heat or electricity. This is not only a necessity but a clean and environmentally friendly way to harness

it and use it in our everyday lives. Solar power will always be around and there is thought for what the future generations will be relying on for many years to come.

References

BP. (2016). *BP Energy Outlook 2016*. Retrieved from: http://biomasspower.gov.in/document/Reports/bp-energy-outlook-2016.pdf

Bhasin, H. (2016). Michael Porter's Five forces model for industry analysis. Retrieved from: http://www.marketing91.com/porters-five-forces-model

Brownson, J. (2016). *Price Elasticity of Demand*. Retrieved from: https://www.e-education.psu.edu/eme810/node/593

Central Intelligence Agency. (n.d.) *Country Comparision: Distribution of family Income – Gini Index.* (n.d.). Retrieved from:

http://www.cia.gov/library/publications/the-world-factbook/rankorder/2172rank.html

Ciolkosz, D. (n.d.). *What is renewable energy?* Retrieved from: http://extension.psu.edu/natural-resources/energy/what

Dastor. (n.d.). Global Solar Industry. Retrieved from: http://www.dastornews.com/2015/10/global-solar-industry/

Ezysolare. (2016). *Trend Analysis on Solar PV Module Prices*. Retrieved from: http://www.ezysolare.com/blog/knowledge-center/trend-analysis-on-solar-pv-module-prices/

Fialka, J. (2016). *Why China is dominating the Solar Industry*. Retrieved from: https://www.scientificamerican.com/article/why-china-is-dominating-the-solar-industry/

Hellebrandt, T., & Mauro, P. (2015). *The Future of Worldwide Income Distribution*. Retrieved from: https://piie.com/sites/default/files/publications/wp/wp15-7.pdf

Human Economics (2015). *Elasticity and the Law of Supply*. Retrieved from: https://patrickjuli.us/2015/09/26/elasticity-and-the-law-of-supply/

International Energy Agency. (2014). *Technology Roadmap Solar Photovoltaic Energy*. Retrieved from: https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapSolarPhotovoltaicEnergy_2014edition.pdf

International Energy Agency. (2015). *Trends 2015 in Photovoltaic Application - Survey Report of Selected IEA Countries between 1992-2014*. Retrieved from: http://www.iea-pvps.org/fileadmin/dam/public/report/national/IEA-PVPS_-_Trends_2015_-_MedRes.pdf

International Energy Agency (n.d.). *Energy access database*. Retrieved from: http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/

IRENA. (2012). *Renewable Energy Technologies: Cost Analysis Series*. Retrieved from:https://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis- SOLAR_PV.pdf

Keat, P. G., Young, P. K., & Erfle, S. E. (2013). *Managerial Economics: Eonomic Tools for Today's Decision Makers* (Seventh ed.). United States of America: Pearson.

Khokhar, T. (2015). *The future of the world's population in 4 charts*. Retrieved from: https://blogs.worldbank.org/opendata/future-world-s-population-4-charts

Lin, Y., Griffiths, S., Tsai, I., & Mezher, T. (2014). Technology Strategy in the Solar and Wind Renewable Energy Industries. *Solar Industry*. (3)57-58. Retrieved from: http://www.seipub.org/emr/papersub/Global/DownloadService.aspx?PARAMS=SUReMTEyNDI_0

Mary, B. (2016). *2015 Snapshot of Global Photovoltaic Markets*. Retrieved from: http://www.iea-pvps.org/fileadmin/dam/public/report/statistics/IEA-PVPS_-__A_Snapshot_of_Global_PV_-_1992-2015_-_Final.pdf

NC State University. (n.d.). *Solar Marketplace*. Retrieved from: https://nccleantech.ncsu.edu/technology/renewable-energy/solar/compare-solar-quotes-online-and-save/

Philipps, S., Preu, S., Warmuth, W. (2016). *Photovoltaics Report*. Retrieved from: https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf

Rekinger, M., Thies, F., Orlandi, S., & Masson, G. (n.d.). *Global Market Outlook for Solar Power /2015-2019.* Retrieved from: https://helapco.gr/pdf/Global_Market_Outlook_2015_-2019_lr_v23.pdf

SEIA. (2012). *U.S. Solar Market Insight: Year-in -Review 2012*. Retrieved from: http://www.seia.org/research-resources/us-solar-market-insight

Seyboth, K., & Sverrisson, F. (n.d.). *Renewables 2016 Global Status Report*. Retrieved from: http://www.ren21.net/wpcontent/uploads/2016/06/GSR_2016_Full_Report.pdf

Uswitch. (2017). *Renewable energy*. Retrieved from: https://www.uswitch.com/energy-saving/guides/renewable-energy/

Wikipedia. (n.d.). *Global Industry Classification Standard*. Retrieved from: https://en.wikipedia.org/wiki/Global_Industry_Classification_Standard

Wikipedia. (2017). *Renewable energy.* Retrieved from: https://en.wikipedia.org/wiki/Renewable_energy