

Solar Photovoltaic (PV) Fact Sheet – Annotated Bibliography & Methodology

European Photovoltaic Industry Association [EPIA]. (2013). “Global Market Outlook: For Photovoltaics 2013-2017”.

From the European association that specializes in the study of solar photovoltaic energy, this publication gives a thorough and in-depth look at the current state of the global PV industry, and a very educated forecast of how the industry will evolve over the next several years. Even though it focuses much attention on the European market, the main topic of discussion involves the global market as a whole. Each of the three graphs on the right side of the fact sheet come from this report. The report recognizes that even though the market is dominated by Germany and other developed European countries, PV’s chances of successfully competing in the energy sector is heavily dependent on the future development and expansion of the PV industry in developing markets that still offer much potential, such as China, India, and Australia.

European Photovoltaic Industry Association [EPIA]. (2014). “Market Report 2013”.

The EPIA’s 2013 Market Report briefly discusses the key trends and other important data associated with the PV industry performance in 2013. Things of note in this short report include the current state of the global market, as well as the evolution of each region’s major markets. The report also notes that, with the dynamic Asian markets led by China and Japan the Asia-Pacific region took over Europe as the #1 region for new PV installations in 2013.

European Photovoltaic Industry Association [EPIA]. (2011). “Solar Photovoltaics: Competing In The Energy Sector”.

Though grounded in statistical data and evidence, this brief report by the EPIA provides a nearly subjective argument that the levelized cost of energy (LCOE) for PV will steadily decrease to the point that, by 2020, generation costs could decrease by 50%. As a result of this, the report goes on to indicate that within a few years, PV costs will be low enough that the industry will become a heavy cost-competitor in the energy sector, against more traditional natural gas and coal electricity.

Intergovernmental Panel on Climate Change [IPCC]. (2011). “Summary for Policymakers”.
IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation.
Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

This source is a very broad report that covers all the different renewable energy technologies and how they contribute to the sustainable growth of the environment. More specifically, it provides a list of different uses and applications for PV systems, and ways in that PV systems are integrated (or can be integrated) for sustainable development. It also displays tables and charts similar to those from other sources, such as the installed global capacity of the PV industry relative to other technologies, the change in price per peak watt over time, and the industry’s trending growth over the last decade.

Lazard. (2013). *Levelized Cost of Energy Analysis.*

This source provides a comprehensive comparison of LCOE’s for various technologies. By comparing these different LCOE’s together on multiple graphs, we are able to see how costly it is to install and maintain PV systems relative to different energy forms, both renewable and non-renewable. It also further diversifies the cost and use of solar PV technologies by separating it into three different types: crystalline rooftop, crystalline utility-scale, and thin-film utility-scale.

Pearce, Joshua M. "Photovoltaics - a Path to Sustainable Futures". *Futures* 34.7 (2002): 663-74. Web. <http://www.academia.edu/1484565/Photovoltaics_-_a_path_to_sustainable_futures>.

This journal article is twelve years old; however, the purpose of this source is not for recent data (which is compiled enough from other sources), but instead for the theory and concepts behind the solar PV energy technologies. The paper goes on to discuss the environmental, economic, and social benefits that an increased use of PV energy can provide. Even from 2002, when climate change wasn't the significant issue that it is today, Pearce is able to identify the growing climate problems and how PV electrical production and other renewable energies can help establish a sustainable environment.

Photovoltaic Power Systems Programme [PVPS]. (2014). "PVPS Report: Snapshot of Global PV 1992-2013". *International Energy Agency*.

This report from IEA-PVPS (the photovoltaic program that is part of the International Energy Agency) reiterates some of the previously made points from other sources, such as the increasing growth in the market for different regions – especially the surge from the Asia-Pacific region – and the evolution of global installed PV capacity over the last decade. In addition to this, special attention is brought to the top 10 PV markets by country in 2013. From here we can see the Germany's dominance in total installed capacities (almost doubling that of China, which is the 2nd-highest country), and the large-scale installations of new PV systems in China, Japan, and USA in the year of 2013. Like most of the other sources here, the report concludes with an analysis on the global PV industry and the increased role that it should play in the future.

PVNews. (2012). "November 2012 PVNews Newsletter Issue". *PVNews*. Web.
<<http://www.greentechmedia.com/research/pv-news>>.

This source was found for the graph titled "Solar Cell Production, 2001-2010" on the left side of the fact sheet. This was shown to highlight special attention to the fact that even though Europe had been controlling much of the PV market for years, their countries were always a step behind the Asia-Pacific region (primarily China) when it come to solar PV production. The graph indicates that China and other countries in the Asia-Pacific region have a firm control over the global production of PV systems.

Sachs, E., Harvey, D., Janoch, R., Anselmo, A., Miller, D., Hanoka, J. (2004). "Silicon Ribbon via a Mesa Crucible: A New Concept in Ribbon Growth for Low Cost Solar Cells". *Proceedings of the 16th European PV Specialists Conference*. Paris, France.

This source is where the graph at the bottom of the fact sheet was found. This graph shows the relationship between the cumulative production of PV systems, and the correlated PCOE that goes with it. As the text describes to the left of the graph, "over the last 20 years, the price of PV modules has decreased by over 20% every time the cumulative sold volume of PV modules has doubled (learning factor)". As the graph further indicates, the generation costs of install PV energy technologies will be highly competitive with the costs of traditional gas and coal energy to produce electricity. And in certain regions, PV already *is* competitive with these non-renewable resources.

U.S. Energy Information Administration [EIA]. (2012). "Annual Energy Review 2011".

This source was used to show the annual trends of total shipments in the U.S. from 1985 to 2010, and the steady decline in costs to add installed PV capacities over time. While this price does decline over time, the more likely correlation was already implied in the description of Sachs's cost-production graph above. Behind the concept of the learning factor, as greater and greater

volumes of these PV modules were being sold and installed, the cost required to make these gradually declined by a significant margin. So, the increase in total U.S. shipments from 1985-2010 (the above graph) may be a direct cause for the generation costs to decline over this same period.

The annotated bibliographies for each source above explain, in my opinion, most of the reasoning behind why I included the information and data that I did. Overall, I believed that the most important things to discuss about solar photovoltaic energy were: the *significant* increase in use and electrical production over the last 20 years (not just compared to coal and natural gas, but to renewable energies as well); the historical European dominance in the PV market; the rapid globalization of the energy technologies that have allowed China, Japan, USA, etc. to help continue the expansion of the PV market's role in the energy sector; and the increasing cost-effectiveness of installing and developing the technologies, making it more competitive with other energy sources now and in the future. Overall, these factors show that not only is the PV industry looking very strong right now, but it also shows a nearly unlimited potential to become more efficient and more integrated in the sustainable development of our environment, as new developing markets take advantage of its benefits over time. The tables/graphs that I found and created, along with the supplemental text to go along with each one, covered what I thought was the most relevant and important information for solar photovoltaic energy.