Regulations for Space Based Solar Power as a Key for Innovation

By Ghanim Alotaibi

Abstract

The current climate change crisis requires innovative solutions. The enforcement of renewable energy regulations around the world was an important step in significantly increasing the renewable energy global share. More actions are required to achieve Paris Convention goals. This essay introduces the idea of new regulations that will regulate the deployment and operation of space power satellites as a tool to create a unique ecosystem for innovation disruption in the world.

Introduction

A revolution in terms of scientific basic understanding was realized by Albert Einstein when he explained the Photoelectric Effect.[1] This discovery was a revolution because it led to the invention of the power electronics that are the basis of the digital world today and the invention of solar energy systems.

The basic physical principle of a solar cell is identical to that of a diode. Ohl Russel invented the first single PN Junction in 1940.[2] Ohl's research focused on the study of the electrical properties of purified crystalline silicon. After five years of research, he found that shining light on a cracked piece of pure crystalline silicon increases the voltage across it.

Vanguard 1 was the first application for a solar photovoltaic (PV) system.[3] There were many milestones before the launch of Vanguard 1. For example, a fully functioning PV system with an efficiency of 9% was invented in 1954. In later years, many new concepts of solar cells were invented, and the efficiency of crystalline silicon has increased dramatically, while the cost has decreased. PV solar cells have found their way into many terrestrial applications, and this is the dominant technology for generating power in space.[4]

In September 1990, the West German government announced the Thousand Roofs Program. The idea of the program was to install PV systems in the roofs of 1,000 homes.

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[1] Albert Einstein, "On a Heuristic Point of View Concerning the Production and Transformation of Light," *Annalen den Physik* 17 (1905): 132-48, Science References Services, einsteinpapers.press.princeton.edu/vol2-trans/100.

[2] Lillian Hoddeson, "1940: Discovery of the P-N Junction," Computer History Museum, 1997, www.computerhistory.org/siliconengine/discovery-of-the-p-n-junction/.

[3] NASA, "Vanguard Satellite, 1958," 2015, www.nasa.gov/content/vanguard-satellite-1958.

[4] US Department of Energy, "The History of Solar Energy," 2002, www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf.

When Germany was unified, the number of installed systems increased to 2,250.[5] This long-term research was significant in terms of improving the performance ratio of PV systems, and the results allowed researchers to understand the feasibility of implementing the German Renewable Energy Act (EEG) better.

Discussion

Looking at the history of terrestrial solar PV systems applications, we can learn some lessons for the future to implement space-based solar power (SBSP). Until 1999, the cumulative installed PV capacity around the world was 1 GW.[6] By the end of 2019, the cumulative installed PV capacity had reached more than 580 GW.[7] However, major R&D work and breakthroughs were achieved in the twentieth century. Therefore, it seems that twenty-first century regulations and policy enforcement are behind this massive increase in PV cumulative installations worldwide. The EEG was implemented in 2000. In addition, the enforcement of renewable energy regulations opened the door for a disruptive innovation environment.

There are three major purposes (or drivers) of innovation: technology push, mission pull, and market opportunity and/or risk. Technology push is accomplished by someone interested in advancing a particular technology. Mission pull is accomplished by someone who has a specific mission, and market opportunity arises when there is an identified market demand.

Apparently, the EEG has created an ecosystem for these three innovation purposes. It created a technology push because since the first solar energy system was invented in 1954, many companies and scientific institutes have worked on the technology. The EEG created a clear reason for companies and scientific institutes to request funds to continue their work on PV solar energy systems. Mission pull was created because the policy specified certain quantities of solar modules to be installed within a specific period. Governmental and non-profit institutes do most of the work on the mission of reducing greenhouse gas emissions. Finally, the policy has created market opportunity because the government guarantees that every kWh will be sold in the market. Many countries around the world have adapted the German policy; however, not all countries have been as successful as Germany.

For the implementation of laws that will encourage the use of SBSP, the creation of an international regulatory entity is essential. Because UNOOSA is the organization responsible for promoting international cooperation on the peaceful use of outer space, the proposed entity should be under UNOOSA.

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[5] Gerd Heilscher, *Measurement and Analysis Programme within the Thousand Roofs Program* (Freiburg: Fraunhofer Institute for Solar Energy Systems, 1992).

[6] US Department of Energy, "The History of Solar Energy."

[7] Emiliano Bellini, "World Now has 583.5 GW of operational PV," *PV Magazine*, April 6, 2020, www.pv-magazine.com/2020/04/06/world-now-has-583-5-gw-of-operational-pv/.

It is important for any regulation to start by identifying clear goals. How much do carbon dioxide emissions need to be reduced? When do we need to achieve that goal? Geostationary Earth orbit (GEO) is a limited resource. Carbon emission reduction can be calculated based on the orbital capacity (in GEO) that can be allocated to space power satellites (SPSs). This will indicate how many SPSs can be deployed and the capacity for each SPS.

Regulations should guarantee that the power received on Earth can be sold. This will increase the share of SBSP, just as EEG promoted terrestrial renewables. An SBSP Office could oversee the creation of a global infrastructure for SBSP distribution for the benefit of everyone. This means that a receiver can be in one country, while several countries can benefit from the power it delivers.

Like EEG, SBSP regulations can create a unique ecosystem. An SBSP Office will qualify companies from around the world to build, design, and provide services for the successful deployment of SPSs with low cost and high quality. Since not all countries can access GEO orbit, a centralized SBSP Office under the UN will arrange launch opportunities to GEO and ensure fair access. Qualified companies should provide capacity building programs for less-developed countries.

Therefore, the SBSP Office can create an ecosystem for the three innovation purposes. A start up based in Australia called Space Solar Technologies already exists,[8] and it has produced many publications. Although the SBSP community is small compared with the PV community in 2000, it is highly likely that the terrestrial PV community will get involved in SBSP. The SBSP Office can create a mission pull in the same way the EEG created one in Germany. Finally, market opportunities will be tremendous if the SBSP Office can guarantee that every kWh will be sold.

Conclusion

The history of PV systems is more than a hundred years long. However, the enforcement of regulations was the most impactful step in the increase of installed PV capacity from 1 GW to nearly 580 GW in just twenty years. This has also created a disruptive environment for innovation. SBSP has the potential to drive innovation internationally by implementing SBSP regulations. In fact, SBSP can lead to a significant reduction in greenhouse gas emissions, which may lead to more innovations than terrestrial PV systems.

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[8] Solar Space Technologies, "Home," 2019, www.solarspacetechnologies.com.au/.

Editors' Notes: Regulations are an important part of a well-functioning society, and we must consider what rules will be necessary to optimize our collective efforts as humanity migrates into space. In this article, a follow-up to Alotaibi's contribution to the previous issue of the *Journal*, argues that creation of an international regulatory entity might be critical for facilitating the disruptive adoption of space solar power, and especially for ensuring equitable access to the new infrastructure. Among other reasons, achieving this goal will be important for reducing greenhouse gas emissions here on Earth. ***Gordon Arthur and Mark Wagner.***

About the Author: Ghanim Alotaibi is a mechanical engineer who works in the Physics department at Kuwait University. He is working on the first space mission in Kuwait and is considered the first person in Kuwait to hold a full-time space-related job. Ghanim is also the project manager for the "Moon Village—Participation of Emerging Space Countries" project. The project's aim is to involve developing countries in moon activities to make moon exploration more diverse.

Ghanim worked for the Kuwait Oil Company for six years before he obtained his master's degree from Freiburg University, Germany in solar energy. Since he was an undergraduate student, he has been involved in many space activities. He was the Middle East Regional Coordinator for the Space Generation Advisory Council and he performed two field rotations as an analogue astronaut at the Mars Desert Research Station. Ghanim is also an amateur astronomer with an interest in the photometry of variable stars and he is a graduate of the International Space University.