


Review

Constructing Markets for Solar Energy—A Review of Literature about Market Barriers and Government Responses

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Abstract: A global conversion of energy production and consumption into renewable alternatives is required if climate targets are to be met. Solar photovoltaic systems (PVs), which convert sunlight into electricity, are an energy source that is receiving increasing attention. However, PVs are not competitive on the energy market and have therefore been dependent on governmental support through market interventions since their introduction. The aim of this paper is to find out what overall conclusions may be drawn after 40 years of experience in trying to establish the PV technology on the market through market interventions. In order to answer that aim, a systematic literature review of peer-reviewed studies on PV technology and market interventions from 1979 to 2019 is presented. The review clearly indicates that market barriers and interventions show great similarities over time and the technology is still dependent on government interference. The need for interventions does not look to decrease in the near future. The review also shows that market constructions by governments are short term in character. A conclusion drawn is that governments may sustain market interventions until nondesirable sources of energy are phased out.

Keywords: solar energy (PV) market; market barrier; intervention; institution



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1. Introduction

Currently, it is apparent that prompt and efficient conversion of energy production and consumption is required if climate targets are to be met. According to the United Nations (UN), production and consumption of energy account for an estimated 60 percent of greenhouse emissions and are thus by far the most dominant cause of climate change. A growing population, economic growth, and rising income levels all lie behind the continued increase in global energy demands, which in turn require a rapid increase in renewable energy production [1]. There has long been emphasis on a need to develop markets for renewable energy sources to create growth in new, sustainable technological systems and competencies [2–5].

By the end of 2018, approximately 26 percent of the global electricity market consisted of renewable energy [5]. However, based on current levels of consumption, renewable energy production needs to increase its share of total production if there is to be any chance of achieving the climate goals. To accelerate the conversion, governments play a crucial role in creating market conditions that encourage both new and existing firms to invest in technology that can contribute to a rapid increase in production of and demand for renewable energy.

Solar energy and photovoltaics systems (PVs) is being increasingly noticed as an interesting renewable alternative. PVs, which convert sunlight into electricity [6], are a clean and quiet substitute for fossil fuel [7]. This technology has experienced incredible growth in recent years, making it one of the most promising forms of renewable technology. Although it accounted for only about 2.4 percent of total energy production [5] and 55 percent of renewable capacity additions in 2018 [5], it is currently the fastest growing energy generation source [8]. As much as 54 percent of current capacity was installed between

2016 and 2019, and IEA (2019) forecasts a global increase in distributed solar PV of over 250 percent in the period 2019–2024 [9].

This growth has been dependent on governmental market interventions [10–12]. Packer (1979), and later Berg and Hasset (1984), pointed out already some 40 years ago that PV technology faced financial as well as structural market barriers, concluding that long-term and stable governmental market interventions were required if PV systems would have a chance to be established as an attractive energy alternative [13,14]. According to research, several barriers still hinder PVs from establishing themselves on the market, such as high costs [15–18] and unclear institutional frameworks [15,18,19]. Consequently, governmental market interventions are deemed necessary in order to establish PV technology on the market [4,7,10,20].

In general, the aim of national government involvement in the construction of market institutions is to provide stable and predictable conditions under which firms can operate [21,22]. However, governments sometimes consider it necessary to influence market structures with politically motivated interventions to overcome different barriers and thus promote a certain type of consumption that may be desirable from a societal point of view [23]. In other words, governments may construct market conditions to achieve a specific outcome. This is very much the case when it comes to renewable energy technology such as PV systems, which is not economically competitive but deemed necessary in order to accelerate an energy conversion.

Although interventions may be considered necessary, it is often pointed out that these should not exist longer than necessary because they may disrupt a naturally functioning and thereby efficient market [24]. Obviously, there is a tension between, on the one hand, introducing and maintaining politically desirable market interventions and, on the other hand, the pressure to maintain market conditions which mean that market actors and technologies compete on equal terms. This pressure may mean that measures taken to establish a noncompetitive product on the market do not work long enough to bring about the desired change.

Against this background, the aim of this paper is to find out what overall conclusions may be drawn after 40 years of experience in trying to establish PV technology on the market through market interventions. More precisely, the following research questions are addressed:

- What are the barriers, i.e., obstacles and hindrances that restrict the entry of or hinder the growth of PVs over time and on different continents?
- What interventions have governments taken to overcome barriers over time and on different continents?
- What effects have these interventions had on establishing PV technology in the markets?

To answer these questions, a systematic literature review is conducted. Peer-reviewed studies on PV technology and market interventions from 1979 to 2020 have been included. The next section of this article contains an overview of the markets for solar energy and a review of the literature and some of the more influential studies on the construction of market structure. This is followed by a detailed description of the method used and a presentation and analysis of the collected data. The paper concludes with a discussion and a suggestion for further research.

2. Markets, Barriers, and Institutions

According to economic theory, a perfect market is a market where there are many market actors, where the sellers and buyers can easily enter or leave the market, and where the relationship between supply and demand determines the price [25]. Consequently, there should be no government intervention to disturb the market equilibrium. Such a market may be referred to as a natural market. However, in reality, markets are seldom if ever perfectly efficient. There are often numerous barriers, which may prevent firms from entering or doing business in a specific market.

Mainstream literature about market structure and strategy points out that entering and competing in a market is preceded by multiple considerations and investments on the part of firms since they need to consider several barriers and how to overcome those [26]. Firms already established in a market may have obtained cost and technological advantages as well as important business relationships, which presents barriers for new entrants [26–28]. Consequently, if a firm with a PV-based technology wants to enter the energy market, it may be constrained by different types of barriers. There may be financial barriers, such as high initial or production costs; by market structure barriers, such as markets that are not adapted; by unclear or unsuitable regulations; or by firm-level barriers, such as a lack of reliable value chains or of competence and suitable business models. If the barriers for market entry are high, the outcome may result in an oligopolistic or monopolistic market structure, which restricts the entry of any further actors [26,29].

Markets are, in other words, not always efficient, and they may need to be regulated [22,25,30,31]. Economic sociology [32] has pointed out that the traditional view on market structure and strategy, as presented above, often overlooks the role institutions play in how markets develop. Here, institutions may be seen to be the “... humanly devised constraints that structure political, economic, and social interaction” ([33], p. 97). There are formal institutions, such as codified laws and regulations, as well as informal norms, which affect market structure and behavior [22,33]. Therefore, governments have an especially important role to play since they can regulate and shape market structures through the design of formal institutions [34]. Governments are involved in market construction.

Efficient institutions are regulations that create stable and favorable conditions that encourage exchanges between the market actors, while inefficient institutions are regulations that are perceived to be unfavorable or unstable and that therefore create uncertainty, which leads to actors in the market hesitating ahead of doing business [22,33]. In other words, efficient institutions help to maintain a well-functioning market mechanism, while ineffective ones counteract this. Constructing efficient markets, where the ideal is to get as close to the theoretical model of a perfect natural market as possible, is, in other words, a state-building activity that aims to create stable, long-term, and well-functioning markets [22].

Nevertheless, governments may sometimes want to influence or steer the market for political gain. Markets, no matter how efficient they are, may generate undesirable outcomes from a political and societal perspective, and there may then be interventions for reasons that are not solely economic. If a conversion from traditional to renewable energy sources is desirable, governments may find it necessary to intervene in energy markets where renewable alternatives are constrained. Political market regulations may, in other words, be used as a tool to stimulate desirable consumption of, for instance, renewable energy. Governments then construct markets for certain purposes. A government has several means to influence a market: these are legislation, financial donations, support programs, subsidies, and different kind of taxes. Feed-in tariffs (FIT) and net metering are further measures that are common when it comes to PV technology. Market interventions may stimulate or hinder growth [35,36]. Consequently, government interventions can either favor or create problems for existing market actors or for new entrants as they intervene with fundamental market principles. If, for some reason, governments are not happy with the outcome of a constructed market, they may consider other interventions. They may reconstruct the market.

Government market interventions risk affecting the natural market function, and the market may be inefficient since the interventions may lead to instability and uncertainty. In attempts to achieve a natural market, it is often pointed out that interventions should be gradually decreased when the political objectives of the intervention have been achieved. Shum et al., (2008), for example, argue: “In the promotion of renewable energy, energy experts and policy makers agree that subsidies such as rebate to renewable must continually decrease and that renewable markets must be self-sustaining without reliance on prolonged subsidies” ([24], p. 513). Discontinuing interventions means governmental deconstruction of the market.

As such, it makes sense to distinguish between two types of regulative interventions: economically motivated market interventions and politically motivated market interventions. The first type is used when a market is not functioning in an economically efficient way. It is used to construct (which may include reconstruction or even deconstruction) a market so that it functions more like a natural market. The politically motivated interventions aim to construct or reconstruct an already constructed market in order to achieve some politically motivated aims. Regardless of the type of intervention, they will have an effect on the market and its actors [31].

The degree of change in a market structure and the way “business is done” connect closely to innovation [37]. As indicated in the introduction of this paper, the PV system as a technological innovation is promising and may contribute to a conversion to production and consumption of renewable energy. As such, it should be welcomed as an interesting alternative. However, it is an innovation that does not readily fit into existing market structures for energy supply. Replacing traditional technologies with a new solution is a complicated process. The process of bringing a technological innovation from the laboratory to the customer involves market structures that are suitable for multilevel activities such as research, production, marketing, and installation, which requires activities from different actors in the system [35]. Consequently, governments may support the conversion with politically motivated interventions in order to construct markets in a way that favors PV technology. However, such measures may temporarily distort the way in which a natural market is supposed to function.

3. Solar Photovoltaic (PV)

Solar photovoltaic (PV) systems convert sunlight into electricity [6,38]. Before 2000, the market for solar PV systems centered almost exclusively on off-grid connected PVs (not connected to an electricity network). However, grid-connected systems account for the large and recently rapid increase in installation rate [10]. Companies as well as private households install grid-connected systems where consumers both consume the energy produced and have the opportunity to sell overcapacity back to the system. Financial incentives for self-consumption have been a significant driver for solar PV-technology expansion [5,19] and as such, the role of consumer has developed into the parallel role of producer, i.e., a “prosumer” [39–41].

From being a grassroots technology developed for specific market segments [10,42], PV technology has reached a stage in which increased efficiency in production has led to reduced costs and interest from traditional firms and thereby an increase in demand [5,43]. As a result, the technology has entered energy markets that have been based on centralized systems mainly centered around a few big and powerful actors. The shift has gone from small niche markets to mass production and mass markets. Standardized PV technology, homogenous products, and policy reforms have stimulated entry for new results, and this has resulted in competition [7].

The largest markets for solar PV in 2018 were (based on installed capacity) China, India, the USA, the European Union (with the key market Germany), and Japan. The PV market, consisting of both single households and large companies, is highly concentrated in these countries account for 74 percent of the world’s total rate of installation [9] Figure 1 shows the evolution of annual PV installations in these (and other) markets and by that the installation dominance of leading markets. The figure is based on rates from 2011–2019 since the greatest increase was noticeable during this period.

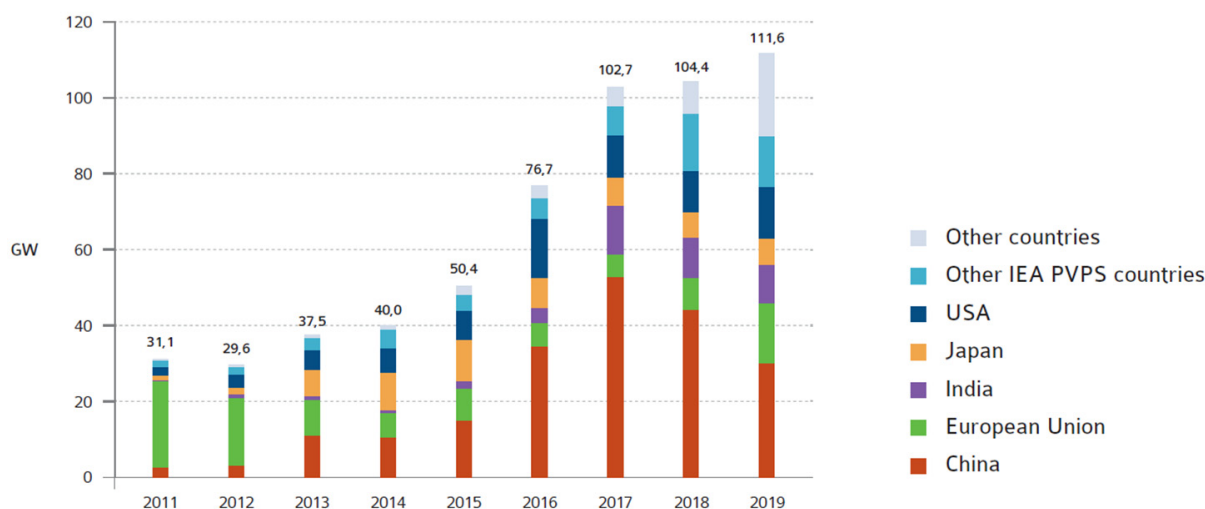


Figure 1. Evolution of annual photovoltaics systems (PV) installations (GW) [44].

4. Research Design

The systematic literature review which was carried out to find studies that suit the purpose of this paper involved mapping the literature in a structured, straightforward, and systematic way [45]. Each step in the process was documented in order to make the research replicable, transparent, and rigorous [45,46]. A research protocol was developed before conducting the first search for relevant literature. In the first stage, the aim of the research and theoretical framing was included in the protocol to guide forthcoming steps. The protocol was then updated throughout the search with search terms, limitations, keywords, categories, and excluding arguments to enhance structure, transparency, and replicability.

To gather articles for our study, two well-known databases, Scopus and Web of Science (WoS), were used. These databases are widespread and cover a wide range of scientific journals and other material in different scientific fields [47]. Scopus and WoS show similarities as sorting parameters (author, citations, and institution). Although there are many similarities between these databases, there are also important differences. Scopus includes a larger number of journals, while WoS has a strong coverage further back in time [47]. The combination of these features gave a wide spread of journals as well as depth to our searches due to the interdisciplinary interest in our framing of the research. The PRISMA flowchart, which is a commonly used practical device in literature reviews, was used during the research process [48] (see adapted Figure 2 below).

Initially, the search terms “market” and “institution” were used in combination with the terms “solar energy” and “PV”. The use of the term “institution” and not “intervention” in our search generated data from the overall market of solar energy. Furthermore, the search was limited to peer-reviewed articles and conference papers to ensure quality, and only literature published in English was included (which almost everything was). The search covered publications until the end of 2019.

The initial search resulted in far too many records, and an overall screening of the content of abstracts clearly showed that many of the records were outside the scope of our study. Since the topic of this research is interdisciplinary, it was decided to limit the search to what was noticed through the screening process to be the most relevant subject areas. Subject areas have somewhat different names in the databases, and those we chose were business administration, energy, environmental sciences, social science, and economics in Scopus, and energy fuels, environmental science, environmental studies, economics, management, and business management in WoS. A renewed search based on search terms and with the restrictions resulted in 170 articles from Scopus and 120 articles from WoS. After we had excluded duplicates (46), the number of records amounted to 244.

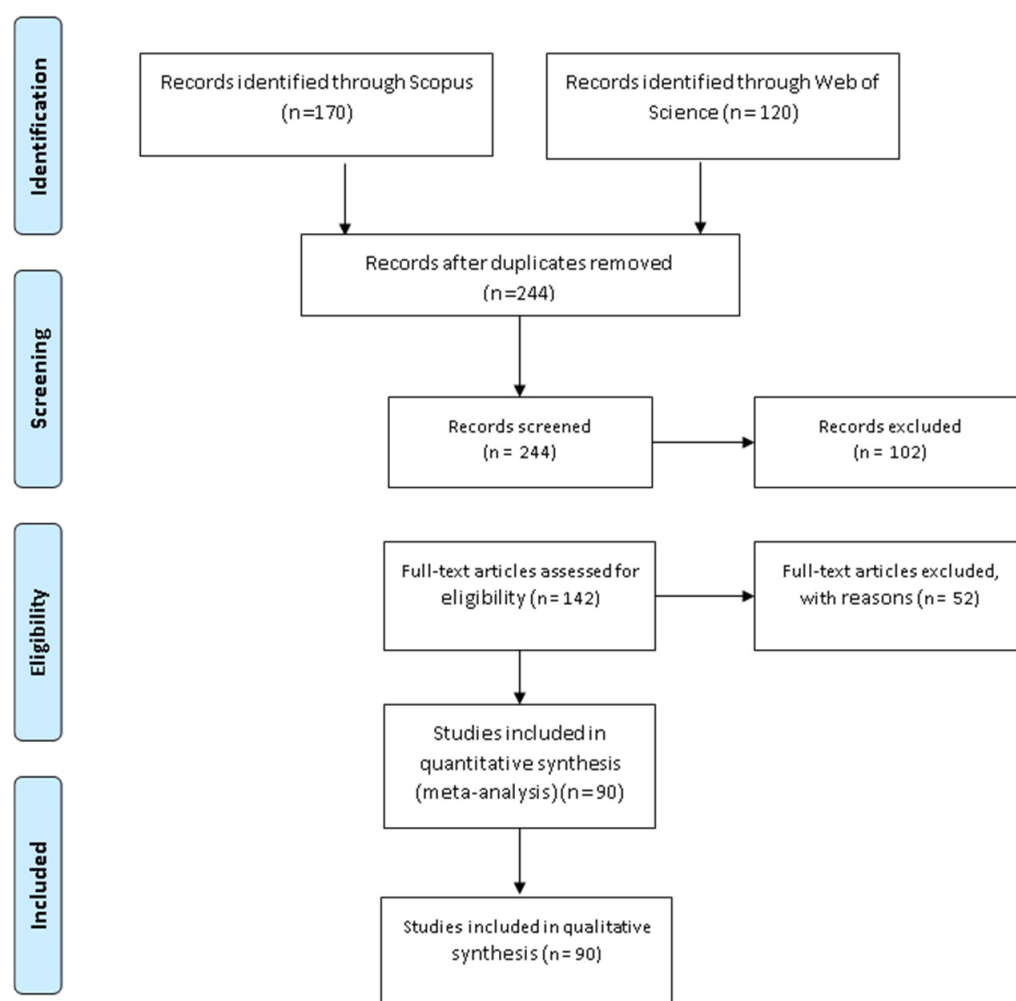


Figure 2. Adapted PRISMA flow diagram [48].

In the next step, a more careful screening (in-depth reading) of all 244 abstracts was conducted. The aim of the screening was to exclude articles that were irrelevant to our study. In this stage, articles with abstracts that focus on the direct technical product development of solar energy were excluded, including storing and power grids. Articles with abstracts focusing on market development and construction of solar energy, for example through governmental initiatives, market barriers, and opportunities were included. In total, 102 articles were excluded, leaving 142 which were assessed for eligibility. To proceed with the systematic selection approach, the included articles were exported to an Excel file where each article had one row in the file and columns for bibliographic information, and other columns for comments and other useful information for future analysis. Then, the in-depth reading of all the 142 remaining articles was started.

In-depth reading is a crucial step in the selection of articles [45]. At this stage, the in-depth reading revealed that even some articles that seemed to have relevant abstracts were not within the scope of our study. Once again, articles were found with a focus on technical characteristics of solar energy and its development, which consequently were excluded. Furthermore, during the reading yet another important criterion for exclusion emerged. Some articles were dealing with renewable energy in general with no specific references to solar energy markets. These articles were also excluded. The in-depth reading resulted in the exclusion of another 52 articles, which gave us 90 eligible articles that we included in the quantitative and qualitative analysis.

During the in-depth reading, the analysis also started by categorizing and commenting on each article [49]. Extracted information was inserted under different categories in the

Excel file for further qualitative and quantitative synthesis. The initial categories derived from theory and included concepts such as institutional support, market factors, and barriers. During the process, the categories were developed in an iterative way. This helped us to develop subcategories through the separation of, for instance, different types of barriers and interventions from each other. This resulted in a structured overview of gathered data, which is crucial for a satisfactory analysis [50].

5. Results and Analysis

5.1. Quantitative Synthesis

The 90 articles selected for the study were published between 1976 and the end of 2019. The distribution (see Figure 3 below) shows an increased academic interest in market creation in relation to solar energy and PV technology. A successive increase occurred in the 2000s and has been strikingly strong in recent years. This trend is not surprising as it largely follows the rapid development of the technology and the increased interest in PV on the market. Please see a detailed presentation of the quantitative analysis in Appendix A.

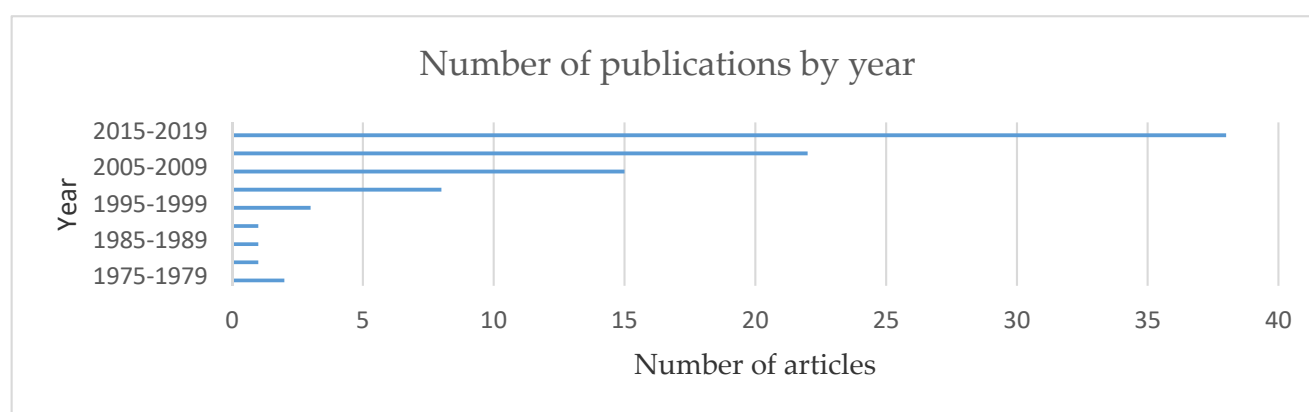


Figure 3. Number of publications by year.

Table 1 below clearly shows the multidisciplinary character of the topic. The 90 articles were published in no fewer than 44 journals from different fields (Table 1). Only two journals had published more than three articles: Energy Policy (23), and Renewable and Sustainable Energy Reviews (12). Based on stated limitations in the search process, the subject areas of energy, environmental science, social science, and management represent most of the selected articles.

The geographical distribution in terms of continents of study is also noticed (Table 2). The categorization of some articles by continent was not possible because of their global/international focus, meaning specific continents could not be isolated. Meanwhile, other articles compared specific countries, meaning they could represent each category. In terms of overall content, many articles were sorted into several categories, while others fell into just one category. This explains why the total number of articles is seldom 90.

Studies conducted on Asian markets focus on China ($n = 14$ (41 percent)), India ($n = 7$ (20 percent)), and Japan ($n = 5$ (14 percent)); studies conducted in Europe had a significant focus on Germany ($n = 10$ (53 percent)); in North America, the USA represents all studies ($n = 8$ (100 percent)); and Brazil stands for 57 percent of the studies conducted in South America. In Africa, no single market stands out. The attention paid to most of these markets is not surprising as they are among the most powerful markets for PV technology [44].

The market barriers reported in the articles are categorized under financial, market structure, and firm-level barriers (see Tables 3 and 4 below). Please observe that there may be more than one barrier identified in some of the articles. It is evident that financial barriers, especially high initial costs, and market structure barriers are the main barriers for

market entry. Firm-level barriers play a less significant role, which probably has to do with the search terms used. This pattern is consistent over time.

Governments have in a number of different ways tried to create the conditions that enable the establishment of PV technology as an interesting option on the energy market (see Tables 5 and 6). There is no clear pattern. However, it seems that direct financial donations have lost some significance in recent years. FIT and net metering are not a dominant measure, even though they are a measure that has been adapted to this type of market. Asian and European markets are highly represented.

Table 1. Journals and Number of Studies.

Journals and Number of Studies		
Energy Policy: 23	Copenhagen Journal of Asian Studies: 1	Water and Energy International: 1
Renewable and Sustainable Energy Reviews: 12	Energy Research and Social Science: 1	Energy Strategy Reviews: 1
Applied Energy: 4	Campus-Wide Information Systems: 1	Energies: 1
Energy for Sustainable Development: 3	Prometheus (United Kingdom): 1	Solar Energy: 1
Journal of Cleaner Production: 3	Mediterranean Journal of Social Sciences: 1	Solar Energy Materials & Solar Cells: 1
Renewable Energy: 3	Administrative Science Quarterly: 1	Business and Politics: 1
Energy: 2	Energy Conversion and Management: 1	Local Environment: 1
Wiley Interdisciplinary Reviews: Energy and Environment: 2	Progress in Photovoltaics: Research and Applications: 1	Mitigation and Adaptation Strategies for Global Change: 1
International Journal of Sustainable Energy: 2	Energy for Sustainable Development: 1	Asia Pacific Business Review: 1
Environmental Innovation and Societal Transitions: 2	Journal of Construction Engineering and Management: 1	International Journal of Environmental Studies: 1
Research Policy: 1	Journal of Business Ethics: 1	Economic and Political Weekly: 1
International Journal of Solar Energy: 1	The Scientific World Journal: 1	Utilities Policy: 1
World Bank Technical Paper: 1	Energy Economics: 1	Futures: 1
Technology Analysis and Strategic Management: 1	Journal of Environmental Management: 1	Global Environmental Change: 1
Journal of Business Venturing: 1	Oxford Review of Economic Policy: 1	

Table 2. Year of publication/continent of study.

Continent of Study	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019	Total
Asia	1	0	8	8	17	34
Europe	2	3	5	3	7	20
North America	1	0	5	0	2	8
South America	0	1	1	1	4	7
Africa	0	0	0	4	5	9
Australia	0	0	3	1	1	5
Total	4	4	22	17	36	83

Table 3. Barriers/year of study.

Barriers	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019	Total
Financial barriers						
High initial costs	4	4	5	10	17	40
Production costs	4	5	5	2	12	28
Market structure barriers						
Non-adapted markets	1	4	3	3	6	17
Unclear regulations	4	4	5	1	7	21
Firm-level barriers						
Lack of reliable value chains	0	1	1	0	5	7
Lack of competence and business models	2	1	2	3	5	13

Table 4. Barriers/year of study.

Barriers	Asia	Europe	North America	South America	Australia	Africa
Financial barriers						
High initial costs	11	7	3	3	0	7
Production costs	12	2	3	2	0	3
Market structure barriers						
Non-adapted markets	4	5	1	3	1	2
Unclear regulations	8	3	4	2	1	0
Firm-level barriers						
Lack of reliable value chains	2	3	0	2	0	0
Lack of competence and business models	5	0	0	2	0	2

Table 5. Governmental interventions/time of study.

Government Interventions	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019	Total
National legislation	4	2	5	2	13	26
FIT, net metering	0	2	3	1	10	16
Direct financial donations	1	0	5	6	8	20
Support programmes	2	2	2	5	15	26
Subsidies, taxes	2	2	7	12	12	35

Table 6. Government interventions/continent of study.

Government Interventions	Asia	Europe	North America	South America	Australia	Africa
National legislation	10	6	3	4	0	1
FIT, Net metering	7	6	1	0	1	2
Direct financial donations	13	5	3	0	0	2
Support programmes	10	4	2	6	1	6
Subsidies, taxes	11	11	6	1	1	1

5.2. Qualitative Synthesis

5.2.1. Early Efforts Created Advantages

At an early stage, PV technology suffered from poor product quality, low customer awareness, and high production costs [13,14,51–53]. Consequently, government financial support through direct donations, subsidies, and contributions to research and development was introduced into many markets in order to lower costs and to increase product quality (see, for example) [19,20,42,54–59]. Countries that today have a well-developed market for PV systems, such as Germany and the USA, received direct donations and subsidies in order to stimulate the development of the technology [3,14,20,55,56]. Later, the Asian market, with China and India at the forefront, received subsidies and tax reductions to improve efficiency in production [19,60–63].

The implemented interventions have yielded positive outputs and the production costs have dropped considerably over time. This has led to the current situation in which product development and research are concentrated to the USA and parts of Europe, while mass production with economy-of-scale advantages can be found in Asia, predominantly China [58].

5.2.2. Others Followed

Over time, a number of interventions have been introduced into other markets (see, for example [1,3,41,54,64–68]). In solar energy markets, worldwide and over time, it is obvious that natural market mechanisms are being replaced by different political interventions as a way to create market institutions that steer the market in a certain (preplanned) direction. Several studies report a pattern of different phases in the technology that have brought it to the level of growth it is at today [3,42,55,62,68–72].

5.2.3. Type of Interventions Changes over Time

As the market has grown and production costs have decreased, focus has shifted to economic barriers on the consumer side [10,16,19,23,24,73–77]. There have been attempts to bridge financial barriers for consumption, FIT, and net metering in many markets. With an aim to increase, the level of self-consumption comes a need to push for efficient interventions.

From early on, the German market benefited from feed-in tariffs, and the idea of using tariff systems spread to many other markets. Jacobsson et al. (2006) stated that the output of FIT is two-fold [55]. On the one hand, FIT stimulated market expansion, and on the other hand, when combined with other interventions (for example, rooftop programs), it opened up for new entrants to the market. However, it was pointed out by Sanden (2004 and Chaurey et al. (2010) that the combination of different interventions needs to be handled with care so that they do not counteract each other [15,20]. Furthermore, another aspect highlighted is that the withdrawal of interventions may call for the implementation of other interventions. As tariffs are to be phased out in Germany, the need to implement other interventions to ensure contingent adoption of the product is emphasized [78].

What is clear is that there is a close interplay between market barriers and state interventions that aim to counteract these barriers in more or less all markets. From time to time, interventions have been shaped and markets reconstructed so as to overcome barriers and meet diverse interests in the promotion of PV technology. Besides regulative interventions, there is a noticeable number of financial incentives to promote solar energy.

5.2.4. The Dependence on Interventions Remain

According to studies, government market interventions may—to a great extent—explain the decrease in production costs as well as the positive stimulation of customer investment [7]. However, the technology is not competitive without government support—at least not yet. Consequently, the continuation of interventions is necessary [63,79–83]. The need to continue interventions is explained by several scholars as being because the technology was introduced into a market that had a structure shaped by and for already mature energy solutions and that was built on a different logic [3,6,10,23].

However, the review of the articles also shows that unlocking these market structures through interventions is difficult. Several studies report that institutional interventions that have been implemented have not generated the intended outcome [3,13–16,18,19,23,74,84–87]. Furthermore, others nevertheless emphasize the problem with market actors depending too heavily on interventions since this may send wrong and uncertain signals to the market [2,20,71,73,84,88].

PV technology is still not competitive without government support. In fact, financial barriers still exist in leading countries such as those mentioned earlier, namely the USA, China, and India [44]. As such, dependency on government interventions in these countries has been constant [2,15,24,61,65,70,89,90].

6. Discussion and Conclusions

Returning to the first research question, it is obvious that PV technology faces, and has faced, substantial market barriers—predominantly financial barriers but also regulative barriers. The review clearly indicates that the technology is dependent on government interference, stipulated formal regulations, and financial incentives for it to be able to overcome these barriers and be competitive in markets (see, for example, [7,55,59,76,80,85,91]. For instance, 17 of the 40 (43 percent) articles report that high initial costs is a barrier, and these studies were published as late as between 2015–2019. Barriers of costs for production and unclear regulations follow the same pattern. Costs for production accounts for 43 percent (12/28) of reported barriers and unclear regulations for 33 percent (7/21).

The answer to the second research question is that it is not possible to see a clear pattern of the type of interventions that are used and have been used in order to construct market conditions that are favorable to PV technology. Depending on context, everything from regulative measures, taxes, and subsidies, FIT and net metering, and donations to different kinds of support programs are used to stimulate production as well as demand. The findings show that all type of interventions have significantly increased over time. According to the studied articles, the need for political intervention to promote a desirable but noncompetitive technology does not look to decrease in the near future. Instead, there will continue to be a need for different interventions, and there is no sign of this changing [12,38,60,62,92]. As many as 77 of the 90 selected articles present interventions that aim to stimulate either demand or supply, with 56 of these (72 percent) being conducted in 2010–2019. The interventions alongside with barriers have made remarks on the market for solar energy over time (see Appendix A where also references [93–117] are included).

In terms of the final research question, it is obvious that governments worldwide appear to have taken action to construct desirable market conditions for solar energy solutions. However, it is also obvious that there is a lack of persistence. The desire or political pressure to return to what is perceived to be a normal market situation is in many cases striking. One conclusion may be that governments must consider that markets can serve as a tool to achieve long-term policy goals. The idea proposed by Shum et al. (2008) and others may be questioned, which is that interventions must be fewer and markets for renewable energy must be self-sustaining. It may very well be the case that governments must sustain constructed and reconstructed markets in order to support renewable energy sources until other sources of energy are completely phased out. It may then be time to deconstruct activities in order to return to a normal and natural market situation.

Based on our study, there are a number of different and relevant avenues for further research. One such avenue is to conduct in-depth studies of different countries' strategies for constructing markets for renewable energy in general and for PV systems in particular. It may be especially interesting to make such studies comparative. Another area that is relevant to delve into is to examine how market interventions affect perceptions and behaviors of both companies and consumers in the short and long run.

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Appendix A

Table A1. Detailed Presentations of Tables 3–6.

Governmental Interventions	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019
National legislation	Berg et al., 1984 [14]	Jacobsson et al., 2004 [3]	Marinova et al., 2009 [94]	Li et al., 2011 [70]	Polzin et al., 2017 [77]
	Cabraal et al., 1998 [53]	Isord et al., 2001 [93]	Kobos et al., 2006 [56]	Chowdhury et al., 2014 [42]	Bradshaw, 2017 [12]
	Packer, 1979 [13]		Hariss-White et al., 2009 [92]		Vaqueuez et al., 2018 [86]
	Martinot, 1998 [16]		McEachern et al., 2008 [95]		Bradshaw et al., 2019 [103]
					Soonoe et al., 2015 [1]
					Christensen, 2015 [104]
					Amars et al., 2017 [76]
					Shubbak, 2019 [105]
					Wu et al., 2019 [23]
					Dewald et al., 2015 [72]
					Hyysalo et al., 2017 [106]
					Curtius, 2018 [107]
					Walters et al., 2018 [18]
					Luo et al., 2016 [85]
FIT, Net metering	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019
		Haas, 2003 [54]	Shum et al., 2009 [65]	Pode, 2013 [98]	Kayser, 2016 [19]
		Jacobsson et al., 2004 [3]	Jacobsson et al., 2006 [55]		Frisari et al., 2015 [60]
			Watson et al., 2008 [17]		Cheung et al., 2019 [108]
					Zhang et al., 2016 [83]
					Soonoe et al., 2015 [1]
					Georgallis et al., 2019 [109]
					Nygaard et al., 2015 [11]
					Korcai et al., 2015 [78]
					Dewald et al., 2015 [72]
					Yenneti, 2016 [61]

Table A1. Cont.

Direct financial donations	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019
	Palz et al., 1994 [52]		Huang et al., 2006 [57]	Lemaire, 2011 [80]	Kayser, 2016 [19]
			Shum et al., 2007 [96]	Ondrazek, 2013 [91]	Polzin et al., 2017 [77]
			Marinova et al., 2009 [94]	Bhutto et al., 2012 [67]	Lacasa et al., 2018 [62]
			Brown et al., 2009 [6]	Chaurey et al., 2010 [15]	Michas et al., 2019 [41]
			Radulovic, 2005 [2]	Mainali et al., 2011 [66]	Goess et al., 2015 [71]
					Yenneti, 2016 [61]
					Curtius, 2018 [107]
					Strupeit, 2017 [7]
Support Program	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019
	Cabraal et al., 1998 [53]	Sanden, 2004 [20]	Watson et al., 2008 [17]	Timilsina et al., 2012 [10]	Bohnsack et al., 2016 [68]
	Packer, 1979 [13]	Haas, 2003 [54]	Watt et al., 2006 [97]	Ölz, 2012 [81]	Kayser, 2016 [19]
				Pode, 2013 [98]	Olzewski et al., 2019 [38]
				Ondrazek, 2013 [91]	Frisari et al., 2015 [60]
				Bhutto et al., 2012 [67]	Nahm, 2017 [58]
					Nygaard et al., 2015 [11]
					Luo et al., 2016 [85]
					Strupeit, 2017 [7]
					Michaud et al., 2019 [59]
					Steel et al., 2016 [82]
					Amars et al., 2017 [76]
					Yenneti, 2016 [61]
					Al Isryad et al., 2019 [63]
					Huang et al., 2016 [57]
					Kolk et al., 2017 [110]

Table A1. Cont.

Subsidies	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019
	Cabraal et al., 1998 [53]	Haas, 2003 [54]	Shum et al., 2009 [65]	Timilsina et al., 2012 [10]	Bohnsack et al., 2016 [68]
	Martinot, 1998 [16]	Jacobsson et al., 2004 [3]	Jacobsson et al., 2006 [55]	Meek et al., 2010 [75]	Polzin et al., 2017 [77]
			Watson et al., 2008 [17]	Zalar, 2014 [99]	Olzewski et al., 2019 [38]
			Kobos et al., 2006 [56]	Chowdhury et al., 2014 [42]	Vaquez et al., 2018 [86]
			Shum et al., 2007 [96]	Pode, 2013 [98]	Nahm, 2017 [58]
			Watt et al., 2006 [97]	Dixon et al., 2011 [79]	Joskow, 2019 [88]
				Mainali et al., 2011 [66]	Gress, 2015 [111]
				Bhutto et al., 2012 [67]	Michaud et al., 2019 [59]
				Xiaohua, 2014 [100]	Goess et al., 2015 [71]
				Harisch et al., 2013 [101]	Dewald et al., 2015 [72]
				Han et al., 2010 [89]	Christensen, 2015 [104]
				Paul et al., 2012 [102]	Shubbak, 2019 [105]
				Ornetzeder et al., 2013 [43]	
Barriers					
Financial barriers	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019
High initial costs	Berg, et al., 1984 [14]	Martinot et al., 2001 [74]	Watson et al., 2008 [17]	Chaurey, 2010 [15]	Curtius, 2018 [107]
	Cabraal et al., 1998 [53]	Jackson et al., 2000 [112]	Radulovic, 2005 [2]	Ölz, 2012 [81]	Mischra et al., 2016 [90]
	Jarach, 1989 [51]	Sanden, 2004 [20]	Baliant, 2006 [115]	Echegaray, 2014 [4]	Nygaard et al., 2015 [11]
	Palz et al., 1994 [52]	Wustenhagen et al., 2003 [69]	Balaguer et al., 2006 [64]	Han et al., 2010 [89]	Olszewski et al., 2019 [38]
			Marinova et al., 2009 [94]	Lemaire, 2011 [80]	Amars et al., 2017 [76]
				Li et al., 2011 [70]	Strupeit, 2017 [7]
				Timilsina et al., 2012 [10]	Kayser, 2016 [19]
				Pode, 2013 [98]	Steel et al., 2016 [82]
				Zalar, 2014 [99]	Polzin, 2017 [77]
				Bhutto et al., 2012 [67]	Walters et al., 2018 [18]

Table A1. Cont.

					Korcaj et al., 2015 [78]
					Luo et al., 2016 [85]
					Muchunku et al., 2018 [116]
					Joskow, 2019 [88]
					Michaud et al., 2019 [59]
					Bradshaw, 2017 [12]
					Scott, 2017 [117]
Production costs	Cabraal et al., 1998 [53]	Jackson et al., 2000 [112]	Baliant, 2006 [115]	Bhutto et al., 2012 [67]	Yenneti, 2016 [61]
	Jarach, 1989 [51]	Muntasser et al., 2000 [73]	Shum et al., 2008 [24]	Mainali et al., 2011 [66]	Mischra et al., 2016 [90]
	Martinot, 1998 [16]	Martinot et al., 2001 [74]	Shum et al., 2007 [96]		Nygaard et al., 2015 [11]
	Packer, 1979 [13]	Sanden, 2004 [20]	Shum et al., 2009 [65]		Olszewski et al., 2019 [38]
		Murthy, 2001 [113]	Marinova et al., 2009 [94]		Amars et al., 2017 [76]
					Strupeit, 2017 [7]
					Kayser, 2016 [19]
					Kolk et al., 2017 [110]
					Bradshaw, 2017 [12]
					Steel et al., 2016 [82]
					Luo et al., 2016 [85]
					Polzin, 2017 [77]
Market structure barriers	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019
Non-adapted markets	Palz et al., 1994 [52]	Sanden, 2004 [20]	Kinrade, 2007 [84]	Zalar, 2014 [99]	Walters et al., 2018 [18]
		Jacobsson et al., 2004 [3]	Baliant, 2006 [115]	Timilsina et al., 2012 [10]	Kayser, 2016 [19]
		Martinot et al., 2001 [74]	Brown et al., 2009 [6]	Chaurey et al., 2010 [15]	Georgallis et al., 2019 [109]
		Faranelli, 2004 [114]			Wu et al., 2016 [23]
					Njoh et al., 2019 [87]
					Steel et al., 2016 [82]

Table A1. Cont.

Unclear regulations	Martinot, 1998 [16]	Muntasser, 2000 [73]	Radolovic, 2005 [2]	Han et al., 2010 [89]	Goess et al., 2015 [71]
	Jarach, 1989 [51]	Jacobsson et al., 2004 [3]	Kinrade, 2007 [84]		Kolk et al., 2017 [110]
	Palz et al., 1994 [52]	Sandén, 2004 [20]	Shum et al., 2007 [96]		Polzin, 2017 [77]
	Berg et al., 1984 [14]	Faranelli, 2004 [114]	Shum et al., 2009 [65]		Vazquez et al., 2018 [86]
			Kobos et al., 2006 [56]		Luo et al., 2016 [85]
					Yenneti, 2016 [61]
					Bradshaw, 2017 [12]
Firm-level barriers	1975–1999	2000–2004	2005–2009	2010–2014	2015–2019
Lack of reliable value-chains		Jacobsson et al., 2004 [3]	Baliant, 2006 [115]		Kayser, 2016 [19]
					Dewald et al., 2015 [72]
					Luo et al., 2019 [85]
Lack of competence, business models	Jarach, 1989 [51]	Martinot et al., 2001 [74]	Radulovic, 2005 [2]	Timilsina et al., 2012 [10]	Polzin, 2017 [77]
	Martinot, 1998 [16]		Balagauer et al., 2006 [64]	Chaurey et al., 2010 [15]	Walters et al., 2018 [18]
					Njoh et al., 2019 [87]
					Mischra et al., 2016 [90]
					Nygaard et al., 2015 [11]
					Nahm, 2017 [58]

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