European Journal of Sustainable Development (2024), **13**, 1, 48-72 ISSN: 2239-5938
Doi: 10.14207/ejsd.2024.v13n1p48

Challenges Facing Private Solar Energy Firms in Egypt: A Microeconomic Perspective

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ABSTRACT:
The need for the use of renewable energy sources in general and solar energy in particular is immensely increasing over time. It is true that our planet's future relies to a great extent on the speed of shifting to renewables instead of the use of fossil fuels for energy supply. Accordingly, the Egyptian government has put sustainable development as a priority in its 2030 vision. But to achieve sustainability, various obstacles that impede this process should be carefully identified and addressed. For that, this research work is studying various challenges and barriers that face private solar energy suppliers in Egypt. This is conducted by using an exploratory approach that relies on detailed interviews with private solar energy firms. Results highlight that private solar energy firms are challenged by trade barriers, market barriers, organisational barriers from New and Renewable Energy Authority (NREA), macroeconomic barriers and legal barriers. Furthermore, this study provides policy solutions to partially address the identified barriers and to further speed up the transition to solar energy production and usage.

Keywords: Solar energy market, Egypt, Barriers and challenges, Semi structured interviews, renewables.
JEL: O1, Q2, Q4

1. Introduction

Solar energy is the most abundant renewable energy resource and indeed, Egypt is privileged in this respect. Egypt's Solar Atlas declares that it is regarded as a "sun belt" country with 2,000-3,000 kWh/m2/year of direct solar radiation, making it a prime location for renewable energy projects, (Egypt Solar Atlas, 2018). To capitalize on this potential, Egypt initiated a plan in 2016 to increase its electricity supply that is produced from renewable sources to 42% by 2035. The plan which is still in progress is as follows: wind is to provide 14%, hydropower 1.98%, photovoltaic (PV) 21.3%, concentrated solar power (CSP) 5.52%, and standard energy sources 57.33%. This plan is to be implemented over stages to achieve 33% of energy generated from renewable sources by 2025, 48% by 2030, 55% by 2035, and 61% by 2040. The private sector is encouraged and expected to deliver most of this capacity (Egypt Solar Atlas, 2018); (International Trade

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Administration, 2022); (Fayad et al.,2020).[1] Paradoxically, the private sector is continuing to lag in this respect. Accordingly, this paper follows a pragmatic approach to examine the challenges facing Egypt's private sector solar energy suppliers and to identify the barriers facing the dynamics of this market. This is conducted by using an exploratory approach that relies on detailed interviews with 12 private sector solar energy firms. Furthermore, this study provides policy solutions to partially address the identified barriers.

There are two important rationales underlying the use of face-to-face interviews as the primary method of investigation. First, to unfold the experiences of private sector solar energy firms in Egypt and uncover their explanations on the barriers which impede their performance in the market. Second, semi-structured interviews were undertaken to allow each participant to freely outline his/her specific problems and incentives without constraints. The research findings suggest that incentives for Egypt's solar energy private sector medium and small firms are diminishing.

This paper is organized as follows: section 2 provides an overview of the theoretical framework underlying solar energy followed by the literature on solar energy in Egypt. Section 3 explains the methodology used, the sample and the results of the responses received in the interviews. The responses are categorized to identify trade barriers, market barriers, organisational barriers from NREA, macroeconomic barriers and legal barriers. Finally, policy implications are suggested in the conclusion.

2. Literature Review

This section highlights the theoretical background for the use of solar energy and other renewable sources as substitutes to fossil fuels and as drivers of solar PV production. This will be followed by an empirical review. On the theoretical level, the use of solar energy in specific and renewables in general, can be explained through stressing that the basis of all renewable energy use is the demand for environmentally friendly products as a way of preserving our environmental quality and promoting sustainable development. This is stated in a nutshell in the OECD report entitled "Promoting Sustainable Consumption" "Consumers are key to driving sustainable production and play a central role in sustainable development." (OECD, 2008). For that, lack of consumers' awareness of the importance of shifting to renewables will constitute a challenge faced by the private solar energy firms in Egypt. Not only consumer demand is the main driver behind the shift to solar energy use and thereby PV production, but also ensuring energy efficiency, energy intensity and energy security are key drivers as well, (Hassaballa, 2014). Issues related to diversification in energy use are of relevance to avoid natural resource curse (Muhamad, et al. 2021). This is because energy security is important as it creates a demand pull for PV and renewables within the global, regional and local contexts. Furthermore, the reliance on PV has an effect not only on the diversification of energy resources, but also as an antidote to the

[1] For more information, see https://www.trade.gov/country-commercial-guides/egypt-electricity-and-renewable-energy

resources curse (or Dutch disease). However empirically, Brunet et al. (2022) have proven that this may not be necessarily the case.

Moreover, peak oil theory can help us better understand patterns of oil production which ultimately affect the shift to renewables. The concept of the peak oil is derived from the geophysicist Marion King Hubbert's "peak oil theory" which states that there is a hypothetical point at which the global crude oil production is maximized before going into a decline. Accordingly, oil production is expected to follow a bell-shaped curve, (Hubbert, 1956; Kenton, 2022). From a different perspective, the shift to the use of renewable energy sources in production may be induced by the private firms to skip penalties in the case of strict environmental laws (Atalla et al. 2022).[2] Indeed this may constitute a challenge in Egypt as there are comprehensive environmental laws such as law number 4 of 1994, however, there are problems in specification, enforcement and compliance (Hassaballa, 2013). Moreover, firms can voluntarily adopt these techniques to capture more market shares and gain public acceptance (Brouhle et al. 2004; Hassaballa 2013). Moreover, theories related to sustainable development are also relevant. For instance, the development of the solar energy sector in Egypt can be best categorized as a 'Sustainable Transition(ST)'. STs are unique and differ from most "normal" historical transitions since they are reliant on a "purpose" or a "goal" to solve a persistent problem (Isaksson and Heikkinen, 2018). The ST approach places a lot of responsibility on the public authorities and civil societies to offset resulting negative externalities and to provide incentives to support newly emerging sectors (Munro and Cairney, 2020). The ST literature posits that certain economic frameworks will need to change to incentivize both the end-users and firms (Hansen et al. 2018; Mori, 2018). Those incentives can range from the implementation of a feed-in-tariff, tax cuts, subsidies and finance/credit facilities with low interest rates. Hence, lack of these incentives constitute another challenge in front of solar panels producers. This economic framework will face resistance from vested interests.

Moreover, the ST literature places a lot of emphasis on the "complementary assets" of businesses that will be disrupted by changes in environmental policies. Complementary assets are defined as access to "specialized manufacturing capability, experience with large-scale test trials, access to distribution channels, service networks, and complementary technologies" (Morone and Cottoni, 2016). Those complementary assets belonging to traditional industry leaders (in this case fossil fuel and coal production entities) operate to privilege those sectors vis a vis emerging solar industries. Furthermore, capital intensive industries (in Egypt's case steel, cement, and fertilizers) rely on cheap energy inputs will also represent vested interests. Again, any malfunctioning in complementarities will represent another challenge.

On the empirical level, several initiatives were taken to study the renewable energy market in Egypt. For instance, El Nokaly and EL Seragy (2007) have studied the challenges that hinder the use of renewables in Egypt and concluded that energy end users should be put into consideration and involved to achieve a successful renewable energy transition.

[2] For more information, see https://www.ey.com/en_dk/government-public-sector/six-ways-that-governments-can-drive-the-green-transition

In addition, Khalil et al. (2010) have developed an action plan to promote competitiveness and efficiency of renewable energy systems. From a different perspective, El Kholy and Faried (2011) have studied how to manage energy demand in Egypt with special reference to solar, hydro, biomass and wind energies. Furthermore, Ibrahim (2012) and Obukhov and Ibrahim (2017) have investigated whether there is a potential for solar and wind energy in Egypt. In addition, Aliyu et al. (2018) have provided a review on the development of solar energy as well as other renewables in Africa with special reference to Egypt and Nigeria. Ersoy and Pfaff (2021) applied the MENA phase model to Egypt and concluded that it is true that Egypt has started the energy transition but still substantial efforts are needed to take the outmost of the renewable energy benefits. Trujillo (2021) has studied the obstacles that hinder the use of solar energy in Mexico and Egypt in his dissertation. He has concluded both countries face the same barriers and that unless there is government intervention, these obstacles will not vanish. Finally, Salah et al. (2022) have stepped further through highlighting the possible limitations and challenges that affect realizing sustainable energy in Egypt through analyzing Egypt's current energy policies. They have also proposed recommendations for further development.

Through this brief empirical review, it is apparent that most of these studies have adopted a macroeconomic perspective. Hence, there is a gap in the literature in studying the solar energy market in Egypt on the micro level. This has motivated the researchers of the current study to dig deeper into this matter specifically through analyzing the challenges facing solar energy production at the firm's level.

3. Methodology, Sample & Results:

To detect supply side barriers in the solar energy market in Egypt, semi structured interviews with firms engaged in solar panels production were used. A predetermined questions were prepared in addition to new questions that were developed during the interviews.[3] The advantage of following this approach was that it accounted for variations in background and experience between the firms and it allowed the interviewees to thoroughly explain the main obstacles that they faced on the ground. This facilitated achieving the research objective. According to NREA, there are 140 registered solar energy firms in Egypt.[4] This study has focused on Greater Cairo in which 32 solar energy firms are operating.[5] For that the number of interviewed firms was 12 owing to the fact that the solar energy market is relatively new in Egypt and hence, it has not achieved its full potential yet. According to Hennink and Kaiser (2022), 12 firms is an acceptable sample size given the relatively small number of firms (population is 32) engaged in this type of production in Greater Cairo and hence, resulting in reaching saturation point in qualitative research. Anonymity measures were taken to ensure that interviewees felt comfortable and ready to talk. Most of the interviews lasted for about 30-40 minutes. The sample was

[3] The interview structure is found in the appendix.

[4] For more information see NREA website at http://www.nrea.gov.eg/Investors/FeedInTariffCompanies

[5] For more information see Iqtesaduna website at https://iqtesaduna.com/%D8%AF%D9%84%D9%8A%D9%84-%D8%B4%D8%B1%D9%83%D8%A7%D8%AA-%D8%A7%D9%84%D8%B7%D8%A7%D9%82%D8%A9-%D8%A7%D9%84%D8%B4%D9%85%D8%B3%D9%8A%D8%A9-%D9%81%D9%89-%D9%85%D8%B5%D8%B1-2020/

identified through snowballing approach in which one firm provided the researchers by a list of other firms engaged in the market. An analysis of the respondents' answers to the interview questions are given below followed by the identification of the main barriers that solar firms face in Egypt.

It is clear from the interviews that 83% of the firms in the sample have been working for less than 10 years, whereas only 17% have been in the market for 10 years or more. 100 % of the interviewed firms stated that they are qualified to install grid connected electric power stations. This indicates that firms engaged in solar energy production in Egypt perceive themselves as being qualified. Figure 1 shows years of working in the market for each of the 12 firms.

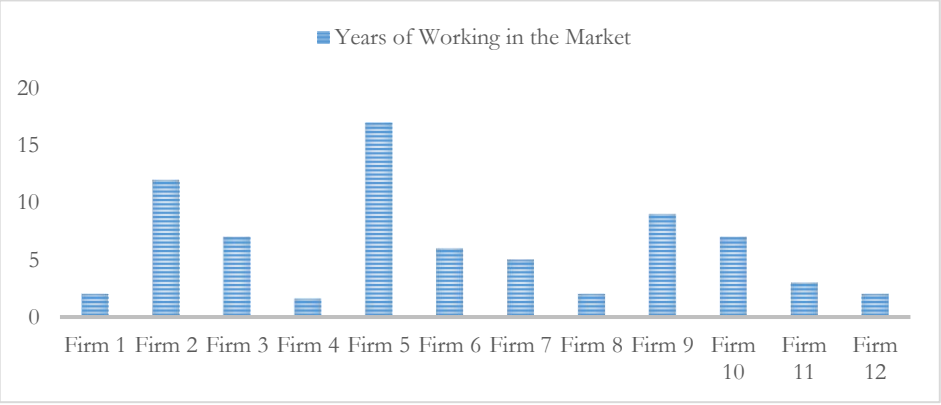

Figure 1: Years of Working in the Market
Source: Authors' results

The objectives for being in the business, as indicated by the firms in the sample, were mainly economic and to a lesser extent social and political in perspective. The firms also added that not only national but also global targets underlie their operations. These objectives include to achieve market domination, to upgrade each company's rank through developing human capital, to provide solar energy with the least cost and the best quality (consumer satisfaction), to provide alternative energy solutions, to follow Egypt's 2030 vision of green energy use, to implement The Sustainable Development Goals (SDGs) and to empower the youth via small and medium enterprises. This indicates that in spite of solar energy firms being more market oriented, sustainable development is also a concern that they aspire to achieve. Figure 2 summarizes firms' objectives.

Figure 2: Firms' Objectives
Source: Authors' result

With respect to questions on whether the solar firms provide training programs to their engineers and technicians, the firms confirmed that capacity building is an ongoing process. Sample quotes are provided as follows:

"Yes, of course, any technician or engineer in the company goes through a long period of training in which he becomes totally aware of the installation and maintenance procedures before he starts leading a project on his own. In addition, technicians and engineers learn the basics of the installation procedures of the electricity station."

"They know the basics of electricity; however, we teach and train them inside the company."

"We qualify and train them as part of the on-the-job training in the firm."

With respect to questions on the firms' target sectors, responses showed that they are targeting various sectors as indicated by figure 3. Firms are not targeting a single sector per se, but they are diversifying their target sectors to include the agricultural, industrial and household sectors. Nevertheless, the agricultural sector is regarded as the most targeted sector which constitutes a priority by 58% of the firms. The industrial and the household sectors are considered a priority by 50% of the firms, and 8.3% of the firms target other sectors as priorities.

One of the firms in the sample (firm 9) responded that "It depends on the market condition" when being asked about the targeted sectors. Firm 11 responded to the same question by linking it to income and grid type as follows: "We operate on grid for those who have bills more than EGP1500 per month. We also rely on off-grid for those who do not have electricity or weak connections to the grid."

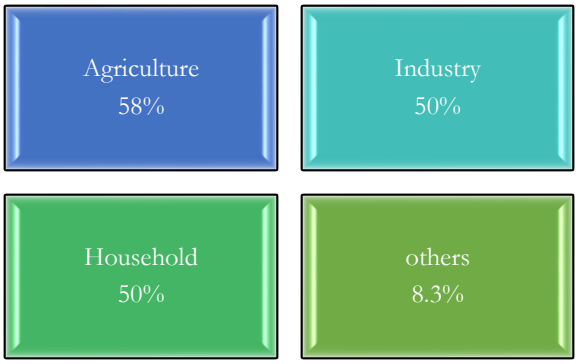

Figure 3: Firms Targeting Priority Sectors
Source: Authors' results

Responses indicate that the sizes of the annual projects conducted by the firms in the sample is between 500-6,000 KWh. Nevertheless, they target up to 10 megawatts per year. This is shown in figure 4 below.

Figure 4: Size of the Projects
Source: Authors' Results

Concerning the market share, the common response was that they are small firms such as the response of firm 6: "Very small share."

Firm 9 replied: "We are a start-up."

Firm 12 added: "Each company can calculate its share based on NREA reports."

Regarding factors considered as important when installing solar stations, 58% of the firms reported that the area is an important factor, followed by 25% considering land type as important, wind speed 16.7% and finally the shade, structure of the buildings, status of electricity network and pollutants, each with 8.3%. This is illustrated in figure 5 as shown below.

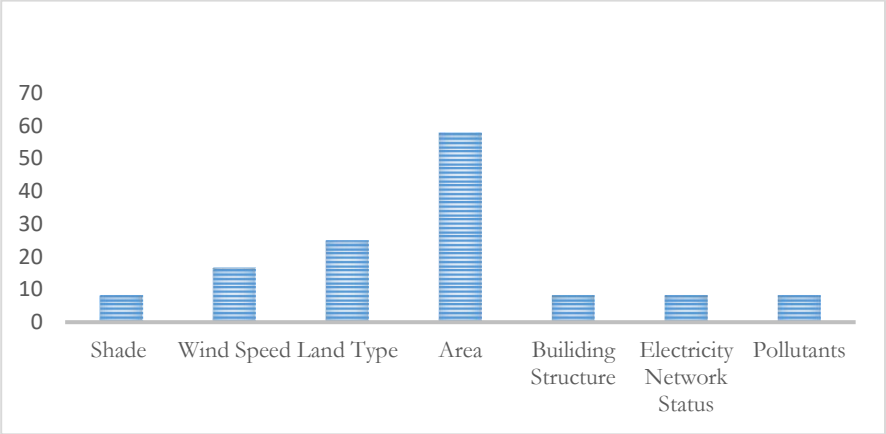

Figure 5: Factors Considered to Install Solar Stations (% of firms)
Source: Authors' Results

In answering whether there is any government/ non-governmental program that supports the solar energy market in Egypt, 75% of the firms agreed that there are governmental and non-governmental programs that support the solar energy market in Egypt, 16.67% of the firms said that there are none and 8.3 % did not answer. They mentioned that the support may be in the form of funds, loans, training, or technical support. Among those who said yes: i) 50% of the firms stated that the main support comes from banks such as the Agricultural Bank of Egypt and the National Bank of Egypt (NBE), through loans/funds to consumers or producers. ii) 25% of the firms stated that the government offers support through the Green Initiative of President Abdel Fattah EL Sisi, New and Renewable Energy Authority (NREA) and the European Bank for Reconstruction and Development (EBRD). iii)16.67% acknowledged having support from PV Egypt in partnership with the United Nations Development Programme (UNDP) and iv) 8.3% reported that the German Agency for International Cooperation (GIZ) offers support to the solar energy market. It is obvious that international and local entities are interested to provide support to the solar energy market in Egypt. Figure 6 shows firm's responses on supporters of the solar energy market in Egypt.

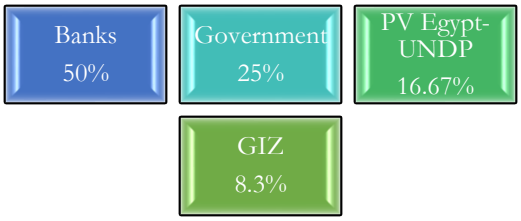

Figure 6: Firms' Responses on Supporters of the Solar Energy Market in Egypt
Source: Authors' Results

In answering whether the solar energy market is growing enough in Egypt and as shown in figure 7, 25 % of the firms indicated that it is expected to grow as stated in Egypt's vision 2030. 16.67% of the firms indicated that the solar energy market is indeed growing since it is cheaper relative to other types of energy. The use of green hydrogen batteries will facilitate further growth as reported by firm 3. However, firm 8 despite

agreeing with firm 3 that the solar energy market is growing in Egypt, warned of the negative impacts of the current rise in the dollar value especially that 80% of the solar panels' components are imported. Furthermore, 16.67 % of the firms stated that the growth will be in the off-grid systems and not the on-grid systems. The reason behind this is that the fees and charges imposed by the government on the solar panel system clients using on-grid systems are high. This is contrary to the off-grid systems where there are no charges accrued. 8.3% of the firms indicated that there is slow growth and that it is not good enough. Actual growth in PV supply is seen to be below Egypt's potential growth given Egypt's exposure to the sunlight all year round. Similarly, another 8.3% of the firms highlighted that solar panel usage will increase in the industrial and the commercial sectors only. However, none of the interviewed firms gave a figure for the expected growth rates of solar energy generated electricity over the coming years.

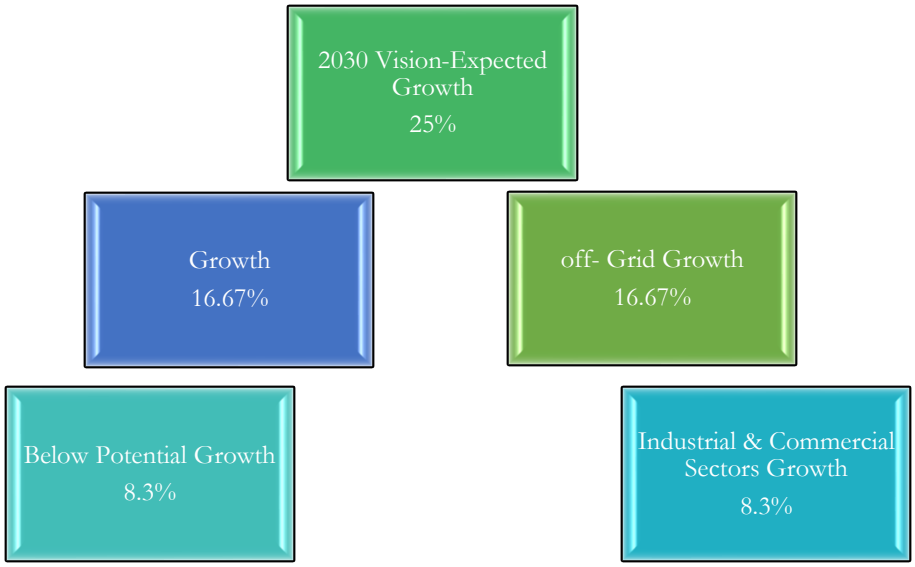

Figure 7: Firms' Responses on the Solar Energy Market Growth
Source: Authors' Results

All firms confirmed that there are entities that oversee the quality of solar power stations. These quality control entities are illustrated in figure 8. For instance, 41.6% of the firms replied that they operate under the supervision of the new and renewable energy authority (NREA) especially the off-grid systems. 16.67% stated that the distribution companies are responsible for quality control especially for on-grid systems. Another 16.67% of the firms stated that the quality control is done through internal supervision especially for the on-grid systems through the protection built in the power plants. These protect both the client and the grid through monitoring systems in invertors. Additionally, online monitoring through the phone is being done. 8.3% of the firms stated that the European Bank and the UNDP are the ones responsible for quality control. 8.3% stated that there is supervision only in the case of on-grid systems but for pumping and off-grid systems, there is no monitoring from a separate or state entity. Firm 9 stated that "This is subject to your conscience." Similarly, firm 11 stated: "We have an issue in the off-grid

systems as a lot of people operate without any paperwork. As a result, this becomes a loophole as these companies ruin the reputation of other companies and NREA receive complaints from clients in this respect." And 8.3% of the firms responded that the ministry of electricity sets standards and tests the productive capacities of stations as well as it checks the components used and their effectiveness. However, the ministry of electricity does not interfere with the installation processes.

Figure 8: Quality Control Entities
Source: Authors' Results

On whether the government provides additional technical support or information about the solar energy sector to the companies, 17% of the firms stated that there is no additional technical support or information provided by the government. Firm 1 stated that NREA has a cadre of highly qualified engineers that can support any company under its supervision. Firm 2 justified this by stating that producing electricity from solar energy by the private sector is considered a strong competitor to the government. 25% of the firms stated that there is no technical support however, there is some information provided. Firm 4 stated that the government provides only guidelines or the minimum quality requirements for the market. Firm 5 added: "The ministry of electricity sets some conditions for the companies to follow." Firm 8 said: "Dr. Mohamed EL Khayat, the executive chairman of NREA is doing an incredible work with reference to the solar energy market in Egypt. Egypt data is provided each year with the shares of the private and the public sectors. It shows the progress of power supply via solar energy." However, 8% of the firms stated that in the past there was no support, but now the NREA is providing support in guiding solar energy companies especially after the construction of Benban solar park. In contrast, 33% of the firms stated that the government provides additional technical support and information to firms about the solar energy sector. This is facilitated through guidelines on solar panels provided by the Ministry of Electricity and Renewable

Energy. Additionally, technical courses are offered by NREA on installation procedures, technical support, summaries of the market condition, as well as annual reports. However, firm 11 added: "As for direct technical support, I did not encounter a situation where I had to ask for help. But NREA is very supportive to companies in this respect." Firm 12 added: "NREA is trying its best, but this may not be enough, but we have to keep in mind that this is a new field for everyone." 17% of the firms did not respond. Responses of firms on technical and information support by the government are demonstrated in figure 9.

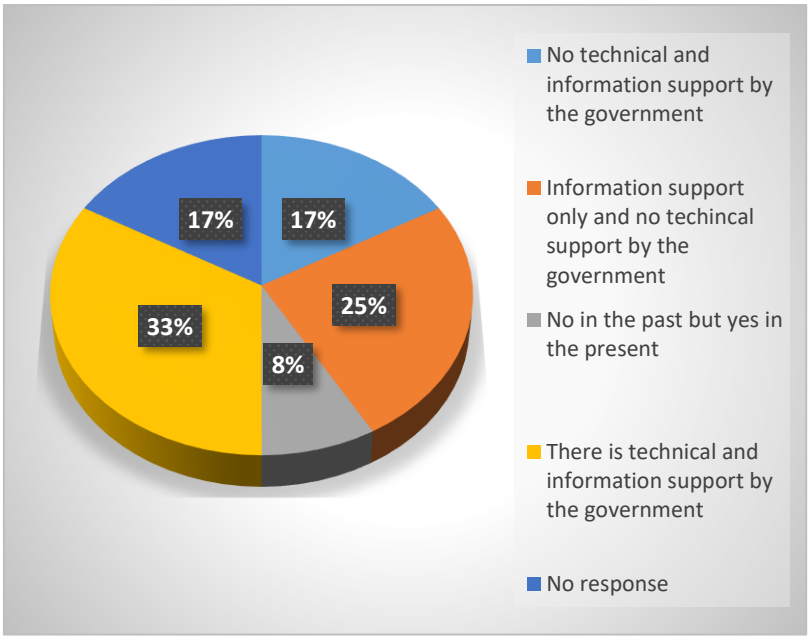

Figure 9 Firms' Responses on Technical & Information Support by the Government
Source: Authors' Results

In addition, types of Information & technical support by the government are identified in figure 10.

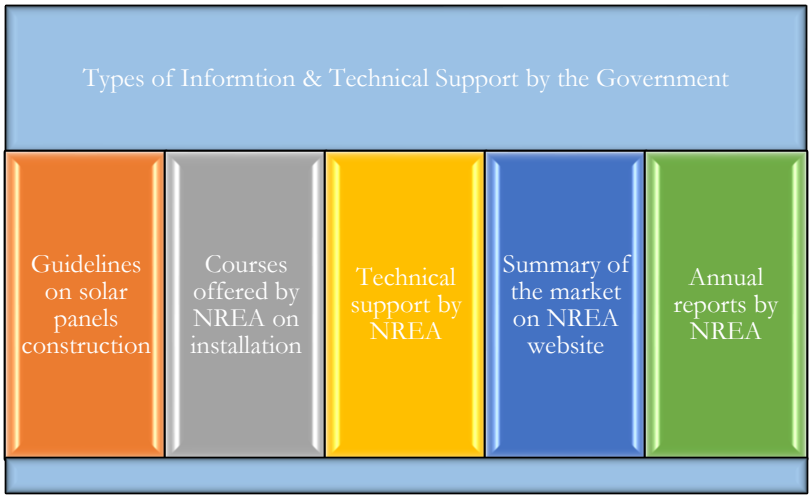

Figure 10: Types of Information & Technical Support by the Government
Source: Authors' Results

Furthermore, from the interview responses, it became evident that there are distinct barriers that hinder the development of solar energy supply in Egypt as shown in the figure 11. These include trade barriers, market barriers, organisational barriers from NREA, macroeconomic barriers and legal barriers.

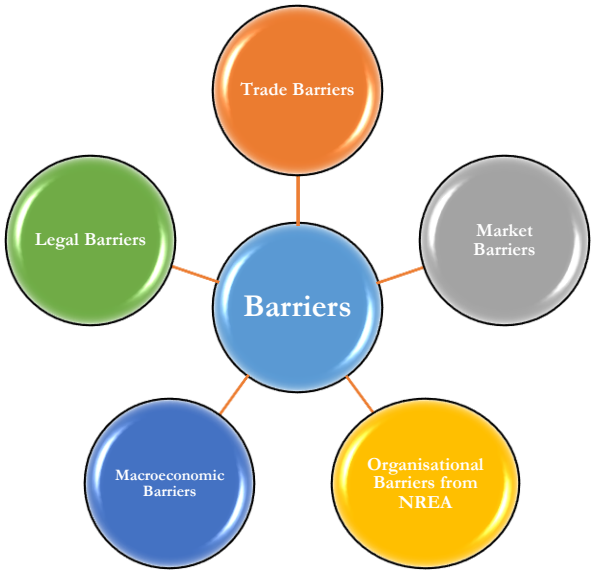

Figure 11: Types of Barriers Faced by the Solar Energy Firms Based on their Responses
Source: Authors' Results

As shown in table 1, trade barriers include tariffs, high import prices owing to exchange rate, shipment costs, as well as the banning of shipments from entry. Following are examples of quotes from different firms illustrating different trade barriers.

"Customs duties and new regulations of the central bank add to trade problems. Although in the beginning there were import reliefs."

"A 5% tariff on imports is inappropriate given the dire economic circumstances Egyptians currently face, and this is magnified in the case of small size customers especially in the agricultural sector."

"Owing to fluctuations in the prices of imported materials, and the variability of the international shipping costs, prices have increased up to five times last year. This greatly added to the costs of production and hence, suppliers cannot settle on a price for the solar power system for up to 60 days. Moreover, there are customs duties regulations constraints."

Table 1

Trade Barriers	Tariffs
	Import Prices
	Costs of Shipments
	Banning Shipments from Entry

Source: Authors' Results

Concerning market barriers and as displayed in table 2, firms' responses highlighted that many market barriers exist, including convincing clients on shifting to solar energy, negative perceptions of the use of the solar system, lack of knowledge of solar PV systems, price volatility, marketing problems, high costs of certification, high installation costs, reliance on used components in certain instances, weak on grid demand, unstable solar market and low demand from governorates. Following are some statements by the firms highlighting these market barriers.

"We also face some market constraints in terms of convincing the clients with our prices and that we offer high quality stations through our extraordinary experts. In addition, past bad feedback on other companies results in some clients generalizing that all solar power companies are underqualified. Another market challenge is the variability of the prices between the high-quality material versus the used and the low-quality materials. The challenge is to convince the client why those price difference of the solar power service appears."

"First, it was unfamiliar among clients, and it was difficult since there were rumors that solar energy is very weak in powering motors."

"Approaching the client is not easy at all and the culture of solar energy is somehow new, so you need to explain to the client why solar power station is beneficial. The main constraint is the financing of the solar power station, especially that the client has to pay the whole capital cost in the beginning and then starts to feel the saving returns during 25 years from the installation of the solar power system."

"We face issues when we associate the system to the grid and those issues are usually with the distribution companies."

"The biggest obstacle I see is the huge volatility and instability in prices. Because there is no supervision on off-grid some could trade in used materials and others try to decrease the price to force the competition out. There is no regulation on prices and products.

"……Besides the on-grid demand is quite weak. People still do not know that they can connect to the grid and not pay electricity for 25 years."

Table 2

Market Barriers	Convincing Clients
	Negative Image from Other Companies
	Lack of Knowledge
	Price Changes, Volatility, Instability and Unregulation.
	Marketing: Issues and Discripency
	Cost of Certification
	High Installation Costs
	Reliance on Used Components sometimes
	Using Imported Components
	Weak On-grid Demand
	Unstable and Unregulated Solar Market
	Low Demand from Governorates

Source: Authors' Results

Firms' responses highlighted organisational barriers from NREA as another barrier that hinders solar energy production. As shown in table 3, organisational barriers from NREA range from recent regulations and periodic adjustments, NREA categorization, reports sent to NREA, NREA follow up with clients and merging return policy. Among the statements said by the firms engaged in solar panels production is the following:

"Regarding qualifying the companies, NREA has changed the requirements for companies to be qualified to filter the qualified companies and organize the solar market."

"NREA has also categorized companies into 3 categories (platinum, gold, silver, and bronzy). Each category has the right to work on a specific scale and each category has its own requirements in terms of engineers and staff the company employs, the size of the projects, the company's capital, and the customers' feedback. Every 6 months each company has to send NREA a report about its projects. NREA follows up with and take feedback from a sample from the clients that company has installed solar power systems for."

"There are now updates to the certification process. It has been divided into categories and each with different price. The new systems along with the new prices have been an issue."

"Off grid system is more loose when it comes to regulations."

"We have an issue in the off grid system as a lot of people operate without the paperwork."

"In large power plants 1+ megawatt, there is a new policy called merging return which adds a fixed fee on your solar production. This is because it is connected to the on grid network which will result in offsetting demand."

Table 3

Organisational Barriers from NREA	Recent Regulations and Periodic Adjustments
	3 categories of NREA: Platenium, Gold, Sliver and Bronze
	Reports Sending to NREA Every 6 months by Firms
	NREA Follow Up Through Getting Feedbacks from a Sample of Clients
	Merging Return Policy in Which Fixed Fee is Added on Large Firm's Production to Be Connected With on The Network for On-grid Systems Which Offsets Demand.

Source: Authors' Results

Concerning macroeconomic barriers, firms' responses showed many macroeconomic barriers present in the solar panels market. As shown in table 4, these macroeconomic barriers include Covid19 crisis effects, not having enough support from the government, depletion of EBRD support and a lot of paper work for bank loans in general, too strict supervision on the on grid systems, little initiatives from the state, civil society or international organisations, no special funds, off grid bad reputation, Integration fees and no tax cuts. Following are some of the statements said by solar panels firms to illustrate various macroeconomic barriers:

"During COVID, the solar power market struggled the most since most companies were expending only on necessities and the installation of solar power systems was not a necessity at that time."

"Not enough support from the government."

"Yes, with EBRD there is a fund with the Egyptian government that support both on-grid and off-grid. For customer per Kw production we could receive up to $250. This fund is now facing depletion."

"To my knowledge we do not receive direct support (no tax cut or technical assistance). The only support I can think of is financing initiatives from government owned banks. However, from my experience, the banks require too much paperwork."

"No, there is no direct support for our market from my experience, there are small initiatives like the financing program of the NBE bank. However, those are concerned with providing credit for our customers to finance projects."

Table 4

Macroeconomic Barriers	COVID Crisis Impact
	Not Enough support from the Government
	EBRD for On-grid and Off-grid Is Facing Depletion
	Too Much Paper Work for Loans from Banks
	Too Strict Supervision on the On-grid Systems
	No Direct Support from The State, Civil Society or the International Organisations but Small Initatives Only.
	No Special Funds
	Off-grid Issues: Unregistered Firms Create a Bad Reputation For Other firms
	Fees on Integrating Solar Plants on Electicity Grid
	No Tax Cuts

Source: Authors' Results

Finally, firms' responses indicated the presence of legal barriers as well. Table 5 shows that legal barriers that face solar panels firms are the strong bargaining power of the electric distribution company, disputes due to some firms' fraud especially in selling used components as new ones for off grid systems, clients escaping full payment, lack of the monitoring of the off grid systems, laws are hindering firms' production, difficult court procedures, absence of special legal court, not monitoring used imported components, NREA lab tests are not obligatory and no laws to govern installation of components. For instance, the following statements highlighted some of the legal barriers:

"Electric distribution companies have a higher bargaining power. They often control the situation and it is rare to have a dispute with the distribution company."

"Firms can "fool" the client with used materials or clients can withhold payments. There is not a specialized entity, but the court system along with the contract can adjudicate. This is often the case in off-grid installations".

"Yes, for on-grid projects. However, for pumping and off-grid there is not monitoring from an independent state entity, it's up to your conscious."

"Yes, there are certain laws that hinder us, but as Egypt is hosting COP27, a lot of those laws are being changed."

"Yes, there is a law in place although it has not been enforced yet."

"In the off-grid it could be hectic and chaotic because of difficult court proceedings specific to the solar energy sector."

"Unfortunately, some companies import very low-quality material (Grade 3 or B). This results in a market challenge to convince the clients who have experienced low quality materials that you are using better quality materials."

"The lab test of NREA is not obligatory at all."

"If the brand is imported for the first time to Egypt, it should be tested by NREA. Quality control is gradually improving over time."

Table 5

Legal Barriers	Strong Bargaining Power of the Electric Distribution Companies
	Disputes Due to Firms Selling Used Components as New Ones
	Disputes Due To Clients Not Paying in Full Especially in Off-grid
	Off-grid is Not Monitored By the Government (Chaotic & Hectic)
	Law Hindrance of Firms Production
	Difficult Court Procedures
	Absence of a Special Legal Court to Resolve Disputes Between Clients and Companies
	Importing Used Compnents without Mointoring
	Lab Tests of NREA Are Not Obilgatory and are Not Backed By Legal Laws
	Absence of Laws on How to Install (Components and Their Effects on the Grid)

Source: Authors' Results

Figure 12 summarizes trade barriers, market barriers, organisational barriers from NREA, macroeconomic barriers and legal barriers that hinder solar energy production in Egypt.

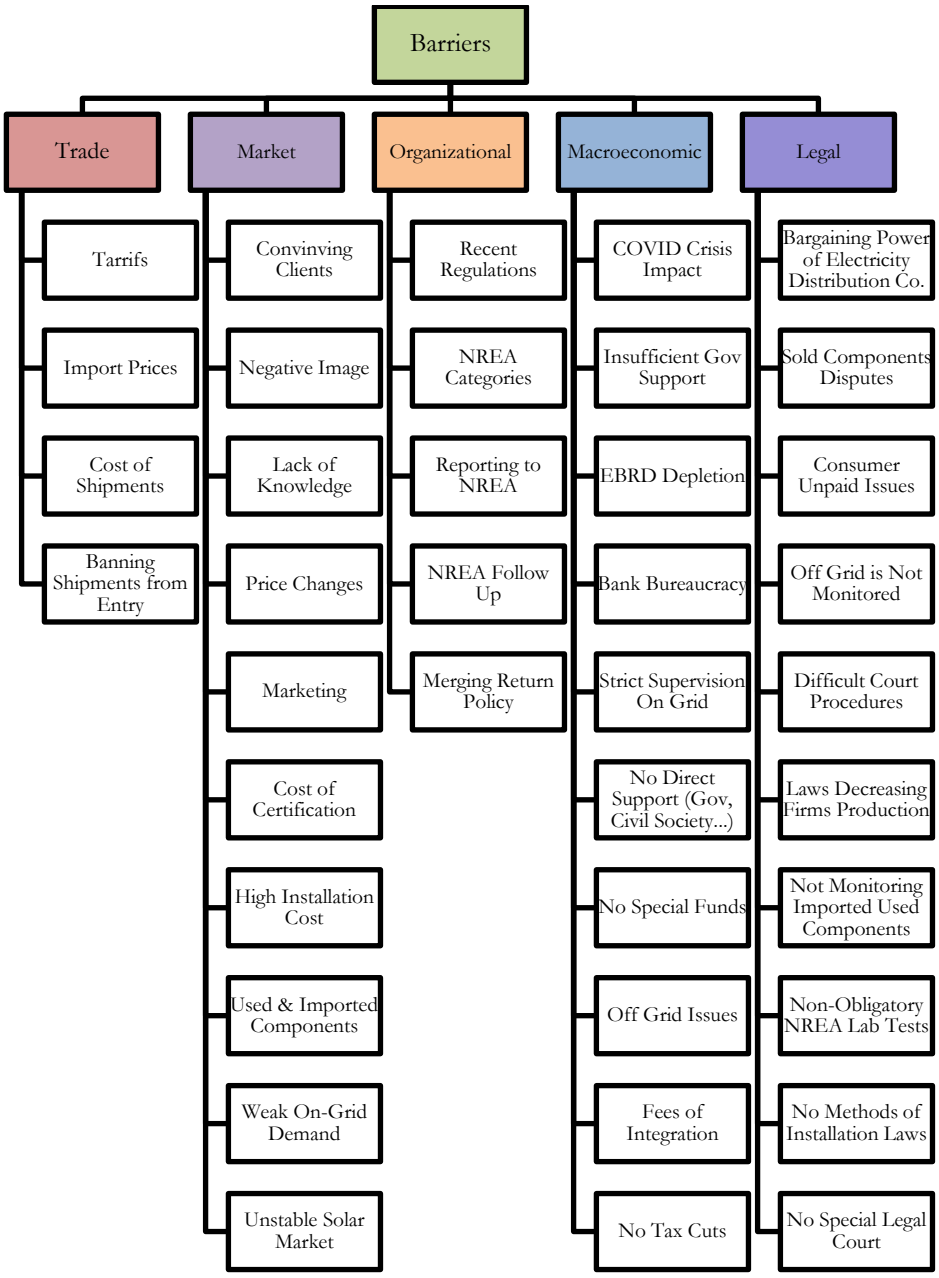

Figure 12: Barriers
Source: Authors' Results

4. Conclusion and Policy Implications

This research work has studied various challenges that face solar energy firms in Egypt. Semi structured interviews were used for 12 firms engaged in this industry. Results highlighted that solar energy is a relatively new market in Egypt, firms' objectives are mainly economic and the agricultural sector is the most targeted sector followed by the industrial and the household sectors. The firms' responses also revealed that they are engaged in relatively small projects and have small market shares. Also, the most important factor that is considered when installing solar stations is area followed by land type, wind speed, shade, building structure and others. Most of the firms indicated that there is governmental and non-governmental support through bank loans, green initiatives, EBRD fund and worldwide organizations. Furthermore, firms stated that there is a potential for growth, however, it varies between sectors and grid systems. They have also indicated that they are supervised by NREA, the distribution company, as well as by internal supervision and highlighted that the supervision varies between on grid and off grid systems. Most importantly, the firms' response regarding governmental informational and technical support provision showed that there is great variation. This is because some stated that there is both technical and information support. Others stated that there is none. Some firms stated that there was none in the past but there is in the present and some stated that information support is provided by the government, but technical support is not.

Finally, various barriers that hinder solar energy production in Egypt were identified based on firms' responses. These include trade barriers, market barriers, organisational barriers from NREA, macroeconomic barriers and legal barriers in which lack of consumers' awareness, absence of stringent laws, weak incentives and complementarities issues as stated in the theoretical review were present in the Egyptian case in addition to other challenges. Having reached this point, it becomes very essential to design suitable policy implications to develop solar energy production in Egypt through tackling the aforementioned barriers. In general, two important points should be considered. First, the development of up-to-date training programs to engineers and technicians to be fully aware of the new techniques used in developed countries and to be capable of applying them in solar energy production in Egypt. Second, tackling obstacles that solar energy firms face in various sectors to promote diversification. This is because the results have shown that the agricultural sector is the most targeted sector by solar energy firms. The reason of this situation should be carefully studied and analysed to derive lessons on how to mimic this in other sectors. One possible explanation is that agricultural farmers usually use solar energy via off grid systems for water pumps purposes or to supply electricity for areas not connected to the grid. Accordingly, the justification for having the agricultural sector is the most targeted sector is simply because it may not entail being linked to the grid system with all its connection and distribution issues.

Concerning trade barriers, the government should revise custom duties and tariffs rates such as those of 5% import tariff on solar panels and PV cells.[6] This is because most

[6] See https://enterprise.press/stories/2022/03/01/egyptera-is-packaging-incentives-for-solar-producers-ahead-of-cop27-66035/

of PV firms in Egypt rely on imported components and this constitute a huge bulk of their costs. In addition, a support fund or a crisis box can be established to offer help to solar panels firms during difficult times such as the current crisis of the great devaluation of the Egyptian currency. Furthermore, be more transparent and specific when it comes to the quality measures of accepting imported components to avoid the condition of banning shipments from entry. A situation that discourages many firms from investing in solar panel due to the possibility of incurring huge losses. Also, this will close the door against any potential corrupt act.

Regarding market barriers, the government should launch a nationwide awareness campaign to increase consumers' and firms' knowledge regarding the importance of relying on solar energy instead of fossil fuels to avoid further environmental degradation. Reduce market uncertainties that arise mostly from instability of prices. This can be done by regulating prices if needed and curbing inflation in general. In addition, reducing costs of certification and bureaucratic registration of firms to encourage investment in the solar energy market is a must. Apply stringent measures on used components is also important as low quality discourages consumers from purchasing the product. Furthermore, solve firms' issues with the distribution company to motivate them to be engaged in production. Study the reasons that discourages consumers from using on grid systems, making information available is one way of doing so. Finally, the government should focus on spreading awareness about solar energy usage in various governorates through regular visits, and not just only in major urban centres.

As for organisational barriers from NREA, it is good that NREA is in control through monitoring, categorizing and organising the solar energy market, however, the following is suggested: First, regulations are essential but they should not be very strict to the extent that discourages firms from joining the market as they are very time consuming especially when considering requirements of both NREA and Egypt Environmental Affairs Agency (EEA). Second, as stated earlier, certification costs should be reduced or even paid in instalments specifically by small firms. Third, formulate regulations for off grid systems as it has proven to be very chaotic and loose due to the absence of registration. Finally, revise the merging return policy to avoid reduced demand.

Macroeconomic barriers also should be addressed through offering soft loans for firms especially those affected by COVID 19 or similar crisis, allowing small firms to access the EBRD fund[7] as their response indicated that it is depleting when it is mainly directed towards mega projects, digitalizing the banking procedures to reduce the hassle of paper work and waiting time, expanding the support provided by NGOs, civil society and international organisation regarding developing solar energy production and use,

[7] EBRD has provided US $5.5 million for TAQA Arabia' solar energy project in Egypt's Minya in 2022. In 2020, it has provided Dina Farms with a loan of $4.2 million to construct and operate 6 MWp solar PV power plant. The bank was also a major player in Benban solar park development with US$ 1.1 billion investments in 16 PV solar plants with 750Mw capacity. For more information, see https://www.ebrd.com/news/2022/how-the-ebrd-became-egypts-leading-partner-for-renewable-energy-.html and https://english.ahram.org.eg/News/479342.aspx and

https://www.sis.gov.eg/Story/172626/EBRD-supports-Egypt%E2%80%99s-private-to-private-renewables-sector-by-%245.5M?lang=en-us

giving incentives through making special funds, providing tax cuts and reducing integration fees. In fact, paying EGP 0.275-0.329 per KWh as integration fees by solar plants over 500KW for both self-consumption and the net metering system is problematic for many firms.[8] This is because it has been imposed at a time of sharp rise of inputs prices and shipping costs. Above all increase the capacity and efficiency of the electricity network to be able to integrate greater electricity production by solar energy firms. Perhaps interconnections with neighbouring countries can be a solution to this.

Finally, for legal barriers, the government should reduce the bargaining power of the distribution company. Strong enforcement of law is essential to reduce firm's fraud. In addition, penalize consumers that escape full payments in a timely manner. Formulate a law to deal with the off-grid systems as it is not regulated. Revise all laws relevant to solar energy production and carry out all the needed amendments to encourage firms to invest in solar energy market. Eliminate difficult court procedures through establishing a special court. Formulate laws to govern the process of importing used components as well as installation methods. Furthermore, NREA lab tests should be obligatory by law to grantee high quality. And above all, take all the necessary measures through inspection and monitoring to ensure law enforcement and compliance. It will be useful for implementation purposes to place these policy recommendations within a specific time frame (short, medium and long run) as shown in table 6. Having a closer look at table 6 shows that the picture is not very bleak as many of the problems can be solved by short and medium run solutions.

Table 6: Time Frame for Policy Recommendations

Policy	Short Run	Medium Run	Long Run
Custom duties and tariff rates revision		/	
Support fund establishment	/		
Set specific imports measures	/		
Raise awareness campaigns	/		
Tackle price instability		/	
Reduce certification costs	/		
Solve distribution companies issues		/	
Ensure transparency	/		
Revise NREA Regulations	/		
Set off grid regulations			/

[8] See https://enterprise.press/stories/2022/02/02/solar-plants-face-new-grid-integration-fees-64029/

Soft loans provision	/		
Digitalizing the banking services		/	
Expand NGOs support	/		
Give incentives	/		
Expand capacity and efficiency of distribution			/
Law enforcement	/		
Laws revision		/	
Establishment of a special court		/	
Obligatory NREA Lab tests	/		

Source: Authors' suggestions

To fully address these issues, the administrative authority should be open minded, flexible and ready to make transitions. Doing this will encourage firms to invest in solar energy markets in Egypt and feel confident to diversify and expand. Over time, this will result in changing the size and number of the solar energy firms in Egypt from small scale to large scale producers resulting in having a wider market share. Hence, gaining the fruits of economies of scale on the micro level and promoting sustainability on the macro level.

Indeed, the Egyptian government is putting sustainable development as a priority in its 2030 vision. This is also evident in the development implemented in the energy sector through deviating from the single energy producer model to a more competitive one. This has been complemented with the new renewable energy law no. 203 of 2014 in which in article 2, the private sector was granted access to supply renewable energy through competitive bids, feed in tariff and the independent power production scheme via a third-party access. Steps have been done towards competition in which local and foreign companies such as Infinity Solar, Orascom, Scatec, Acciona and Masdar have invested billions in solar energy production. However, the independent power production scheme via a third-party access has not been implemented yet.[9] Furthermore, it is apparent from this research that some issues need to be resolved on the micro level to achieve this result. It appears that most of the government support is directed towards giant private or foreign investors in electricity production from renewable energy sources and hence, a lessor attention is given to small producers of solar PV. For that it is essential to examine carefully the suggested policy implications to speed up the transition to solar energy production and usage at all scales. This research work has faced the limitation of the relatively small number of solar firms but as stated earlier this is attributed to the fact that solar energy market has not achieved full potential yet and the focus is on Greater Cairo only but this is due to most solar energy firms are concentrated in this area and also due to budget constraints. For future research work, it will be useful to replicate this study in different developing countries in the Middle East to compare the enabling and challenging

[9] For more information, see https://www.egypt-business.com/paper/details/2330-solar-energy-in-egypt/429062 and https://riad-riad.com/electricity-and-renewable-energy-regulations-egypt-update/#:~:text=Feed%20in%20Tariff%20(%20FiT%20)&text=In%202014%2C%20the%20Egyptian%20Government,1947%20of%202014.

factors that promote/hinder solar energy production in the region. Furthermore, studying the possibility of supplying subsidised off grid systems to lower income groups living in blocks as substitution to the constantly rising electricity prices in Egypt is also interesting to lessen poor income groups burden.

Acknowledgment: The authors would like to state that this work was funded by the DAAD under the collaboration between the British University in Egypt and the University of Cologne-the BaSEF project.

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Appendix

Interview structure

1. How long have you been in the market?
2. What is your objective?
3. Are you authorized and technically capable of constructing solar power station?
4. What are the qualification of the labour working in your firm?
5. Do you provide training to your workers?
6. What is the sector that you focus on the most?
7. What is the size of your projects and/or your market share?
8. What are the factors you consider to install solar stations?
9. Is the solar energy market growing in Egypt?
10. Do you receive any governmental or non-governmental support?
11. Is there any supervision or monitoring when it comes to on grid and off grid systems?
12. Does the government present technical and/or information support?
13. What obstacles do you face?
14. Is there any issue that you face with the distribution company?
15. Is there any specific government entity or court that deals with disputes between you and your clients?
16. Do you face any issue with some of the imported materials used?
17. Is there any entity that examines the quality of imported components or final products?
18. Is there any sort of quality control?