

Implementation of Rooftop Solar PV in Qatar through the Roof Rental Business Model

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Abstract: Qatar is an emerging renewable energy market in the MENA region and has a national vision to generate 2% of its electricity from solar energy by 2020. A number of green businesses in Qatar are operating at different segments of the solar value chain. However, deployment of residential and commercial solar PV still remains low. One reason for this is the lack of incentives for the public and businesses to adopt solar energy technologies because of the high capital costs and high tariffs per kWh. This study proposes the use of the roof rental business model by green businesses in Qatar as a method for increasing public support for solar in Qatar and generating income. The current status of solar energy deployment in Qatar is reviewed and the major business players in the solar value chain are presented. The roof rental business model is discussed in detail and recommendations are given on how to implement it. The study also addresses the feed-in-tariff incentive as an essential pillar in the roof rental model. We conclude from this research that the roof rental business model can create massive public support for solar energy in Qatar provided that the feed-in-tariff policy is implemented.

Key words: rooftop solar, roof-rental, feed in tariffs, PV, Qatar

1. Introduction

Qatar, although very rich in natural gas resources, has significant potential for the use of renewables for power generation and for meeting its energy demands. The need to diversify energy sources is a priority for any nation that wants to achieve energy security. Qatar has already set a path for a transition to a knowledge-based and has hence highlighted the need to invest in clean energy resources. The national development strategy of Qatar (QNDS 2011-2016) stated that renewable energies (RE) present many “opportunities for Qatar to enhance its future energy mix, conserve gas and reduce carbon emissions, once technologies become cost-efficient” [1]. The QNDS has also emphasized that the greatest potential in RE is in solar energy. The Emir of Qatar, Sheikh Tamim bin

Hamad, has also announced during the Conference of Parties (COP18) held in Doha in 2012 that by 2020, 2% of Qatar’s electricity will be generated from solar energy [2].

Achieving the vision of 2% electric generation from solar energy by 2020 requires a number of tools. Local support, government policies, and collaboration between government, academia and business are key pillars in accelerating the deployment of solar energy technologies [3]. In the business sector, emerging green businesses have a great role to play. At a global scale, large scale deployment of solar energy has always been powered by the private sector, aided by strong political decisions. In the U.S, as an example, the largest residential solar PV company is SolarCity which nearly owns one third of the market share and has an installed capacity of 650 MW. Successful solar businesses have strong business models allowing them to reach many customers, maximize revenue and maintain high growth rates.

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In the case of Qatar, there are very few green businesses focused on solar energy applications and products. Most of these companies cover a small section of the solar value chain. A number of barriers face these businesses but among them is the poor public support and awareness about the advantages and opportunities that solar energy technologies offer. In this research, we address this barrier by suggesting the use of the roof rental business model which is a win-win situation from the customer's and business's perspectives. The first chapter introduces the potential of solar energy in Qatar and current status. The second chapter reviews major solar businesses in Qatar and their focus in the value chain. The third chapter discusses the roof rental model, its advantages and requirements. Lastly, the research is concluded by policy recommendations to support the roof-rental business model.

2. Solar Energy in Qatar

Qatar has abundant solar energy resources as investigated by a number of research works. Qatar environment and energy research institute (QEERI), Qatar meteorological department (QMD) and the German aerospace center (DLR) all carried solar resource assessment studies in Qatar. QMD has been collecting ground horizontal irradiation (GHI) measurements since 2007 through 12 automated weather stations (AWS) installed throughout the country. These AWSs measure GHI using Kipp and Zonenpyranometers (a device that measures incident solar radiation). Fig. 1 shows the location of the 12 AWSs and the characteristics of GHI in Qatar for the period 2007-2012. This figure was provided by QMD and extracted from a research paper by QEERI.

Fig. 1 shows that the northern and southern regions have generally higher values of GHI (>2200 kWh/m²/year). The central eastern and western coasts both seem to have similar GHI values (approx. 2111 kWh/m²/year). The 4-year average (2009-2012) for GHI was found to be 2113 kWh/m²/year [5].

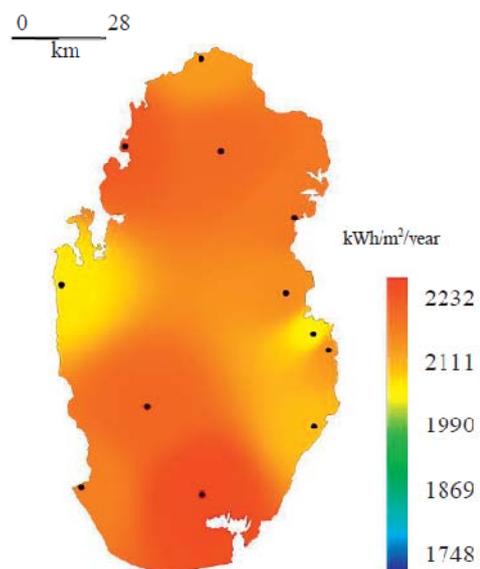


Fig. 1 GHI from ground measurements in Qatar in 2007-2012 [4].

In 2005, the DLR carried a solar resources assessment for the Mediterranean region. This study was commissioned by the German federal ministry for environment, nature conservation and nuclear safety. The purpose of this study was to assess the potential of renewables in general (particularly solar energy) to generate electricity for the Mediterranean region and for export to other countries. This study only estimated the direct normal irradiation (DNI) which is direct radiation received from the Sun without being scattered by the atmosphere or absorbed by clouds. Fig. 2 shows the spatial distribution of DNI in Qatar as reported by the DLR. In a paper written jointly by DLR, University of Bahrain and the Trans-Mediterranean Renewable Energy Corporation, the annual average daily DNI for Qatar was estimated at 5.6 kWh/m²/day [6].

QEERI has highlighted that satellite solar maps of Qatar indicate “decent” values of DNI but this needs to be quantified in a better way [8]. QEERI is currently working on acquiring ground measurements of GHI, DNI and diffuse horizontal radiation (DHI) in order to generate a high resolution map of the available solar resources in Qatar [9]. All of the above studies indicate a good potential for utilization of solar energy for electricity generation in Qatar.

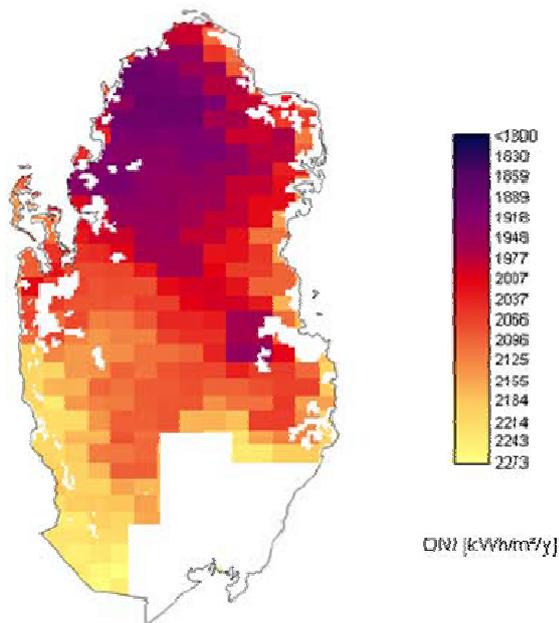


Fig. 2 DNI in Qatar in kWh/m²/year [7].

3. Status of Solar Energy Deployment

The RE market in the gulf cooperation council (GCC) region is in the early stages of development hence RE capacity is very modest and there is very little data to analyze. In fact, the total installed capacity of RE in the power sector is merely 1% [10]. 15% of the total RE capacity of the GCC is in Qatar [10].

Regarding the installed solar PV capacity, by the end of 2014 Qatar had 4 MW of solar PV[11]. 3.4 MW of this capacity is installed at Education City: the campus of Qatar Foundation for education, science and community development. Qatar Foundation (QF) is one of the major investors in clean energy technologies in Qatar in terms of projects and R&D. The Qatar national convention center (QNCC) which is owned by QF has the largest rooftop solar PV array in Qatar with a capacity of 667kW and covering an area of 35.00 m² [12, 13]. This project was jointly developed by UAE based company Enviromena and Green Gulf company in Doha. Fig. 3 shows a photograph of the PV array. This PV array installation is also the first one that was given approval by the general utility company (kahramaa) to connect to the main grid. Green Gulf



Fig. 3 A 667 kW PV array at the rooftop of QNCC [12].

also installed a 26 kW PV array at the National command center for Kharamaa in 2014 [14].

A number of rooftop solar PV projects have been planned recently in Qatar. Among them is the Musherib Downtown Doha project. This project is under Musherib properties which is entirely owned by QF. The planned rooftop PV array will feature 5,200 panels covering an area of 8,400 m² and is expected to meet 75% of the annual electricity and hot water demand of the planned residential complex [15]. In 2013, the first phase of this project was implemented and 463.4 kW_p of the PV array was installed which will be connected directly to the grid of the complex. Other projects also include the 230 MW solar power plant announced by Kharamaa and the 10 MW Duhail solar PV park which is due completion in 2016. As for the rooftop solar PV systems in Qatar, apart from the QNCC installation, no other installation has been reported in the literature.

4. Solar Businesses in Qatar

As mentioned in the above section, Qatar is still a small market for solar energy and hence there are few companies operating in this market. Most of these companies are working in the downstream segment of the solar value chain. The solar value chain is the chain of processes and activities in the solar industry that create value starting from raw materials until installation and maintenance. Value created along the

chain is in the form of products or services. The solar value chain can be viewed in a similar manner to the oil and gas industry value chain. Fig. 4 shows the processes along solar value chain. Processes in the beginning of the chain are called upstream such as extraction of raw materials like silicon. Processes at the lower end of the value chain such as sales and marketing are called downstream.

From the literature, three major commercial companies were identified in the Qatari solar energy market: QStec, Al-Emadi solar and Green Gulf. QStec is a joint venture between QF (70%), SolarWorld (29%) and Qatar Development Bank(1%).QStec operates in the upstream section of the value chain through the manufacturing of polysilicon which is the base material that is later transformed to solar wafers and cells. However, the company announced plans to expand along the solar value chain. Al-Emadi solar is a private Qatari company that operates in the downstream section of the value chain. Al-Emadi solar sells and distributes solar products and also designs and installs solar PV systems for numerous applications such as telecommunications, street lighting, building integrated PV and off grid power. Green Gulf is a private company that focuses in the downstream segment of the value chain by providing services like project development and consultation. The major issue with the Qatari solar energy market is the small number of companies which makes assessing this market and

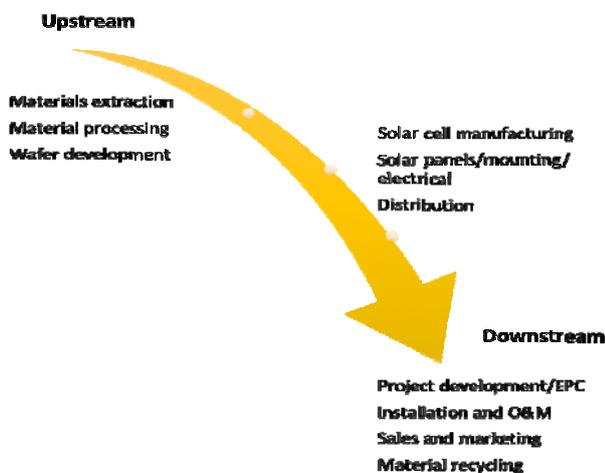


Fig. 4 Solar PV value chain.

its potential difficult. Furthermore, there is lack of diversification in the value chain. Successful companies always aim to be as vertically integrated as possible. Usually the constraints in finance and limited capacity forces companies to work on only a small segment of the value chain. In the United States residential solar PV market as an example, SolarCity and Vivnet solar are the only vertically integrated companies among hundreds of companies. Vertical integration benefits solar companies in two ways; it increases the profit margin and gives them “visibility into the strategies of their competitors” [16].

Regarding the supporting policies and regulations for rooftop solar in general, the implementation of feed-in-tariffs (FiTs) is highly recommended and has been a major driving force in many emerging RE markets such as the UAE. The International Renewable Energy Agency (IRENA) has highlighted that FiTs are among the effective policy tools for deployment of small scale solar energy systems [10]. In Germany as an example, the implementation of FiTs was the major driver for the growth of the PV industry to a capacity of 35 GW by 2013 [17]. Moreover, the International Energy Agency (IEA) has indicated in a survey of support mechanisms for solar PV that FiTs are the most widely used incentive method globally as shown in Fig. 6.

Currently FiTs are not implemented in Qatar nor any GCC country. This makes the business case for private solar companies very weak in the residential sector. In Qatar, electricity is highly subsidized and if no incentives are provided, solar electricity will always

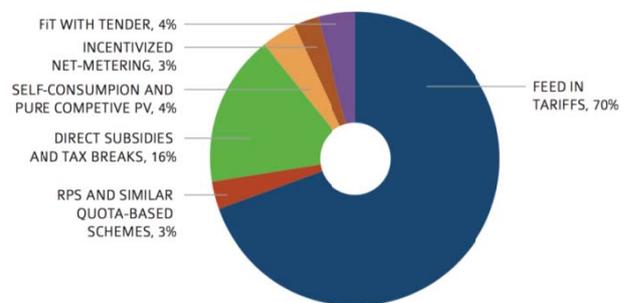


Fig. 5 Historical market incentives and enablers for solar PV [18].

be expensive. There is a need for a thorough investigation to show the economic value created by FiTs for both the utility and the client.

5. The Roof Rental Business Model

A business model (in the context of solar businesses) can be defined as the ownership structure of a solar project at the operation phase [19]. One of the most widely used definitions for solar business models is the framework definition given by Ref. [20]. Table 1 shows the building blocks that comprise the framework of a business model. This framework has been used by a number of research papers such as Refs. [21, 22].

In the context of this paper, we consider a business model as the structure of the contract between the developer and the client (who maybe a resident or a commercial entity). The structure of the contract defines the service provided by the business and the role of all parties involved in the contract. Business models that solar companies operate with are an integral part in the growth of the local solar energy industry. The business model should be attractive from the customer’s perspective and this is an important method in increasing public support for solar PV. The model should also be reliable from the business’

Table 1 Building blocks of a business model framework [20] as cited in Ref. [22].

Business model canvas building blocks	Description
Value propositions	The goods and services offered and their distinguishing advantage
Key activities	The most important activities in executing the value proposition
Key resources	The resources necessary to create value for the customer
Partner network	Relationships considered essential to accomplishing the value proposition
Customer segments	The specific target market(s) intended to be served
Channels	The proposed channels of distribution
Customer relationship	The type of relationship the firm wants with its customers
Cost structure	Characteristics of the cost and expense structure
Revenue streams	The way the firm will make money, how it is paid, and pricing

perspective in terms of generating revenue. Innovation in solar business models is one of the key pillars for increasing growth of the local solar PV market, transforming the electric power industry and overcoming finance barriers [19, 23, 24]. However, solar business models can only effective once supporting policies are put in place, particularly the FiTs for emerging markets.

For this research, we are interested in a business model that increases public support for solar PV and also has a strong investment value for solar companies. Hence, we suggest the roof rental model. In this model, the client (resident or commercial entity) agrees to rent their roof for a designated period (20-25 years) to the solar developer who will install a solar PV system on that roof. The installed solar PV array will be connected to the main grid and all generated electricity will be sold to the utility in return for a feed-in-tariff to the developer. The client benefits through either profit sharing or rental payments and the developer benefits from the FiTs. This model is described as a block diagram in Fig. 6.

The roof rental model has a number of advantages that make it highly suitable for emerging RE markets. In this model, the customer doesn’t bear any costs since all the project expenses (installation, EPC and maintenance) are borne by the developer. Furthermore, clients receive monthly payments for simply allowing their roof (which is usually not utilized) to be used for installing a solar PV system. The use of a RE source may also be utilized by clients like large companies to promote their concern about sustainability and the environment to the general public. Corporations may also integrate the solar roof rental scheme as part of

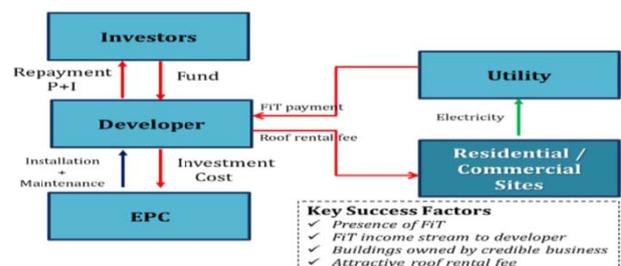


Fig. 6 Structure of the roof rental business mode [22].

their corporate social responsibility (CSR) and hence setting an example for others to follow.

From the developer's point of view, the success of this model relies entirely on the availability of FiTs and support incentives by the government. The developer also needs to get approval by the utility to supply power to the grid through a long term power purchase agreement (PPA). In addition, for this business contract to be financially viable, the developer needs a large roof area (1 MW requires around 7000 m²). Once these conditions are met, this business model will be very attractive for developers.

The risks associated with this model from the clients perspective is the potential damage caused to the roof due to the solar PV array. If such damage were to occur, it is repaired by the developer. The developer on the other hand may be worried about any potential changes in the FiTs or RE incentives which would affect the economics of the project. Moreover, in the case that the building owner wishes to sell the building, complications may occur for the new buyer and the developer to keep the contract valid.

In the case of Qatar, this business model is possibly the least risk model as compared to models like solar lease and PPA which require more policy support and market maturity. For the solar power market in Qatar to gain momentum and compete at a global level, FiTs are a necessity. This is particularly needed to encourage the private sector. We argue that applying the roof

rental model will increase public support for solar PV in Qatar at the "grass-root level" and hence driving the development of the solar energy industry [3].

6. Designing Feed-in-Tariffs for Qatar

Designing the FiTs for any country is a difficult task and requires a thorough economic analysis and an understanding of the RE market. The FiTs rely directly on the RE goals that Qatar aims to achieve in a given time frame. A number of FiTs models exist and have been reviewed extensively in reference [25]. From the literature and drawing from global experiences, most emerging RE market countries use the fixed FiT model shown in Fig. 8a [26]. In this model, the FiT is fixed for the contract period (20-25 years) and sometimes inflation adjustment is also included. Fig. 8b shows the fixed-tariff model with inflation adjustment. We propose that the fixed-tariff model (without inflation adjustment) is the most suitable for Qatar as an emerging solar energy market because of the following reasons:

- Fixing the FiT for a long period provides investor certainty.
- Fixed FiTs facilitate project financing by providing a guaranteed revenue stream for the developer and also attracting more capital for solar PV projects [26].
- Developers will be able to recover costs quickly.

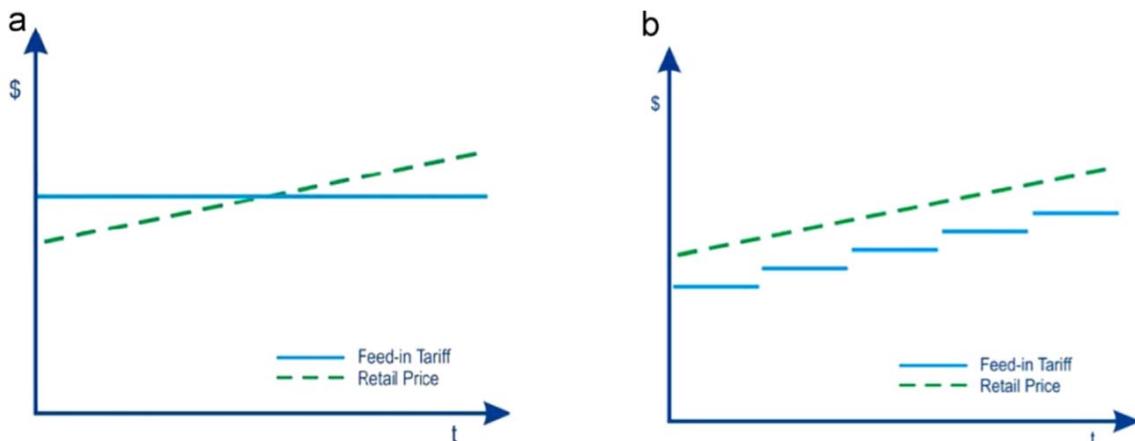


Fig. 8 (a) Fixed FiT model w/o inflation adjustment. (b) Fixed FiT model with inflation adjustment [27].

However, it must be noted that if the FiT set is too high, developers will make too much profit quickly and this may slow market innovation in the technology. On the other hand, if the FiT is too low, there will be slow deployment of solar energy. In the fixed-tariff model, the FiT is decided based in the cost of solar technologies and a profit for developer. Furthermore, the design of the FiT policy must also include some gradual reductions in the tariff to encourage innovation in the PV market. As the Qatari solar PV market evolves and matures, cost of equipment, panels and installation are bound to drop hence reliance on incentives reduces. Table 2 shows the comparison between retail electricity price (in \$/kWh) and FiTs for solar PV electricity in some IEA member countries.

Table 2 Feed-in-tariffs for solar PV in IEA member countries [18].

Country	US	UT	HN	EN	RA	ER	WI	HA	UR	K
Lowest FiT (\$/kWh)	.06	.22	.08	.07	.10	.13	.21	.21	.13	.11
Highest FiT (\$/kWh)	.56	.24	.10	.11	.42	.22	.42	.23	.13	.25
Retail electricity price (\$/kWh)	.23	.27	.08	.39	.19	.38	.27	.12	.19	.23

7. Conclusions and Recommendations

This study reviewed the potential for solar PV in Qatar and the current status of solar technologies deployment. We found from the literature that Qatar has tremendous potential for solar PV applications in the residential and commercial sectors. The major barrier in the Qatari RE market, however, is that only few companies are operating in the solar value chain and the market is very small. Public support for solar PV is limited and few projects have been implemented so far. In this study, we argue that developing the solar PV market requires public support which can be acquired by the adoption of innovative business models. The roof rental model was proposed and explained. The advantages of this model from the client's and

developer's perspectives and its simplicity make it ideal for an emerging RE market like Qatar.

This study recommends the following based on the literature review:

- Success of the roof-rental model requires feed-in-tariffs for solar electricity. These tariffs could be designed based on the cost of solar PV technologies in Qatar and regularly revised.
- The fixed feed-in-tariff model is the best model for Qatar as it provides certainty for investors and facilitates project financing.
- More renewable energy policies need to be formulated that specifically target the private sector.
- Corporations are encouraged to integrate investment in rooftop solar systems as part of their CSR strategies.
- Locals and residents in Qatar should be encouraged to rent their "un-used" roof spaces for PV developers and informed about the reliability of PV panels and their safe operation.

A techno-economic analysis should be carried to evaluate the potential for power generation of rooftop solar in Qatar. This analysis must quantify available roof space and estimated annual kWh production.

References

- [1] Qatar General Secretariat for Development Planning, Qatar National Development Strategy 2011~2016, Doha, Qatar, 2011.
- [2] M. Darwish, *Implementation of Solar Energy for 2% Electric Generation-Qatar 2020* (1st ed.), Lambert Academic Publishing, Germany, 2013.
- [3] G. Vidican, L. Mcelvaney, D. Samulewicz and Y. Al-saleh, An empirical examination of the development of a solar innovation system in the United Arab Emirates, *Energy Sustain. Dev.* 16 (2012) 179-188, doi: 10.1016/j.esd.2011.12.002.
- [4] D. Bachour and D. Perez-Astudillo, Ground-measurement GHI map for Qatar, *Energy Procedia.* 49 (2014) 2297-2302, doi: 10.1016/j.egypro.2014.03.243.
- [5] D. Bachour and D. Perez-Astudillo, Ground-measurement GHI map for Qatar, in: *Solar PACES Conf.*, Las Vegas, USA, 2008, 2013.

- [6] W. E. Alnaser, F. Trieb and G. Knies, The Potential of Concentrated Solar Power (CSP) in the GCC Countries, in: D. Y. Goswami, Y. Zhao (Eds.), *Proc. ISES World Congr. 2007* (Vol. I -- Vol. V) **Sol. Energy Hum. Settl.**, Springer Berlin Heidelberg, Berlin, Heidelberg, 2009, pp. 1843–1846, doi: 10.1007/978-3-540-75997-3_376. German Aerospace Center, Concentrating solar power for the Mediterranean Region, 2005, available online at: <http://www.dlr.de/tt/med-csp>.
- [7] R. H. Mohtar, Qatar foundation vision in energy efficiency and renewable energy overview of QEERI, in: *Beirut Energy Forum*, Beirut, 2012.
- [8] D. Perez-Astudillo and D. Bachour, DNI, GHI and DHI ground measurements in Doha, Qatar, in: *Solar PACES Conf.*, Las Vegas, USA, 2008, 2013.
- [9] R. Ferroukhi, A. Khalid, D. Hawila, D. Nagpal, L. El-Katiri and V. Fthenakis et al., *Renewable Energy Market Analysis: The GCC Region*, Abu Dhabi, 2016.
- [10] Qatar Foundation, Qatar foundation generates solar energy to support Qatar national vision and strengthens sustainability efforts with new energy monitoring centre, 2014, available online at: <http://www.qf.org.qa>.
- [11] Enviromena, Qatar national convention center, accessed July 12, 2016, available online at: <http://enviromena.com/profiles/qatar-national-convention-centre/>.
- [12] Qatar national convention center, About QNCC, accessed July 12, 2016, available online at: <http://qatarconvention.com/media/about-qncc/about-qncc>.
- [13] Green Gulf, Project development, accessed July 12, 2016, available online at: <http://www.green-gulf.com/experience/project-development>.
- [14] Msheireb Properties, No Title, accessed July 12, 2016, available online at: <http://www.msheireb.com/en-us/mediacentre/latestnews/newsdetail.aspx?id=106>.
- [15] Green Tech Media, Is the Solar City model the only way to scale residential solar?, accessed October 16, 2015, available online at: <http://www.greentechmedia.com/articles/read/is-the-solarcity-model-the-only-way-to-scale-residential-solar>.
- [16] K. Mainzer, K. Fath, R. McKenna, J. Stengel, W. Fichtner and F. Schultmann, A high-resolution determination of the technical potential for residential-roof-mounted photovoltaic systems in Germany, *Sol. Energy* 105 (2014) 715-731.
- [17] International Energy Agency (IEA), Trends 2014 in photovoltaic applications — Survey report of selected IEA countries between 1992 and 2013, 2014.
- [18] S. Zhang, Innovative business models and financing mechanisms for distributed solar PV (DSPV) deployment in China, *Energy Policy* (2016) 1-10, doi: 10.1016/j.enpol.2016.01.022.
- [19] A. Osterwalder and Y. Pigneur, *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challenger*, Wiley, NJ, 2009.
- [20] L. Okkonen and N. Suhonen, Business models of heat entrepreneurship in Finland, *Energy Policy* 38 (2010) 3443-3452.
- [21] S. Tongsopit, S. Mounghareon, A. Aksornkij and T. Potisat, Business models and financing options for a rapid scale-up of rooftop solar power systems in Thailand, *Energy Policy* (2016) 1-11, doi: 10.1016/j.enpol.2016.01.023.
- [22] M. Richter, German utilities and distributed PV: How to overcome barriers to business model innovation, *Renew. Energy* 55 (2013) 456-466.
- [23] J. C. C. M. Huijben and G. P. J. Verbong, Breakthrough without subsidies? PV business model experiments in the Netherlands, *Energy Policy* 56 (2013) 362-370.
- [24] M. A. M. Ramli and S. Twaha, Analysis of renewable energy feed-in tariffs in selected regions of the globe: Lessons for Saudi Arabia, *Renew. Sustain. Energy Rev.* 45 (2015) 649-661, doi: 10.1016/j.rser.2015.02.035.
- [25] K. Cory, Renewable energy feed-in tariffs: Lessons learnt from the U.S and abroad, 2009.
- [26] T. Couture G. Y., An analysis of feed-in tariff remuneration models: Implications for renewable energy investment, *Energy Policy* 38 (2010) 955-965.