

Scaling Up Distributed Solar in Emerging Markets

The Case of the Arab Republic of Egypt

Dalia Sakr
Joern Huenteler
Tyler Matsuo
Ashish Khanna



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Abstract

Like many emerging markets, the Arab Republic of Egypt is keen to promote distributed solar, defined here as systems below 500 kilowatts, but has struggled to create conditions for growth in the sector. The aim of this paper is to identify policy actions to unlock the distributed solar market for on-grid and off-grid applications, using Egypt as a case study. The paper calculates the rate of return on investment for different distributed solar applications, identifies nonfinancial barriers to scaling up distributed solar, and derives policy implications. For on-grid applications, the analysis finds that neither net metering nor the feed-in tariff makes distributed solar financially attractive, despite recent reductions in electricity subsidies and adjustments of feed-in tariff levels in October 2016. For off-grid applications, the profitability of distributed solar depends highly on the local price of diesel: distributed solar

is viable only in areas where diesel is not available at the official (subsidized) price. In addition, several nonfinancial barriers limit the scalability of the distributed solar market. These findings indicate that the distributed solar market in Egypt will remain a niche market in the next few years without strengthened government support. First, for on-grid applications, the net metering scheme should be kept in place until a bankable feed-in tariff has been established. Second, for off-grid applications, the government should explore interventions to unlock opportunities in the agriculture and tourism sectors. Third, the government should strengthen private-sector activity in the sector, including by addressing nonfinancial barriers, such as transaction costs and gaps in the availability of data, and by building capacity among users, suppliers, and financial institutions.

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Scaling Up Distributed Solar in Emerging Markets – The Case of the Arab Republic of Egypt¹

Dalia Sakr^{a*}, Joern Huenteler^b, Tyler Matsuo^c, Ashish Khanna^b

^a Energy & Resource Efficiency Cross Cutting Advisory Solutions, IFC.

^b Energy & Extractives Global Practice, The World Bank.

^c Department of Humanities, Social and Political Sciences, ETH Zurich.

*Corresponding author: dsakr@ifc.org

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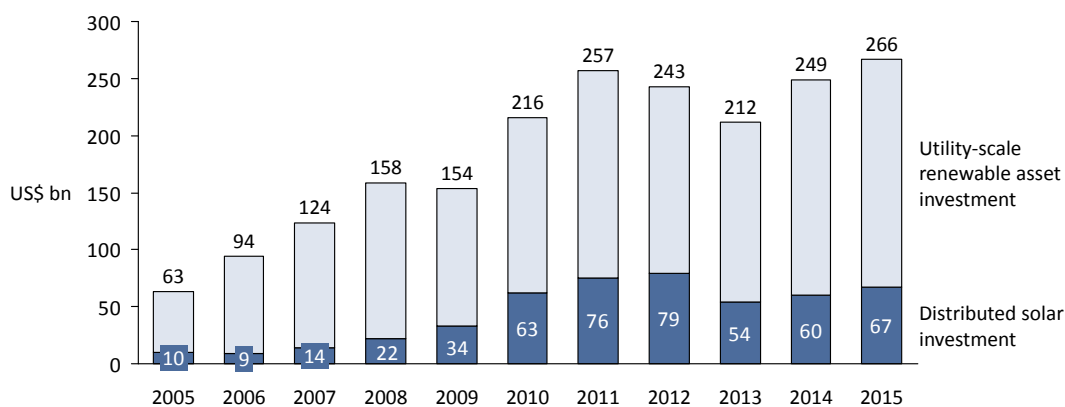
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1. Introduction

Solar PV has grown exponentially over the past decade. Cumulative PV installed capacity worldwide jumped from 39 GW in 2010 to more than 222 GW in 2015, driven by government-led incentives and falling costs (IEA, 2016a; IRENA, 2016).

Distributed solar PV systems, from here on referred to as distributed solar, account for about 42 percent of the global solar PV installations (IEA, 2016b).² Global investment in distributed solar has grown rapidly over the last decade, from US\$9.4bn in 2006 to US\$67.4bn in 2015, as shown in Figure 1 (UNEP & BNEF, 2015). However, distributed solar investments have been concentrated in OECD countries, especially Europe, Australia, Japan and the United States (IEA, 2016a). Emerging markets have struggled to unlock this market; instead, most investment remains focused on large, utility-scale power plants. In recent years, emerging markets such as India and China have set ambitious targets for distributed solar, but have not been able to tap into this market as intended, despite targeted policy incentives (e.g., ADB, 2015; Liang, 2014).

Figure 1: Global renewable asset investment 2005-2015 (REN21, 2013).



Like many emerging markets, the Arab Republic of Egypt is keen to promote distributed solar but has struggled to create conditions for growth in the sector. Egypt has set a target of 20 percent of its electricity generating capacity coming from renewable sources by 2022, which represents more than doubling of the current share of 9.5 percent (including hydro which currently represents about 6% of the total capacity and is expected to decrease to 4% by 2022). In 2013, the country introduced a net metering program to

² The IEA in this statistic uses a definition of systems below 100 kilowatts (kW). This paper uses a definition of up to 500 kW to be consistent with the Government of Egypt's definition.

promote distributed solar. In September 2014, the Government of Egypt (GoE) approved Feed-in Tariffs (FIT) for electricity projects produced from renewable energy resources (solar energy and wind). A total target of 4,300 MW is to be achieved under the FIT program, including 300 MW for distributed PV installations below 500 kW. This program was extended by another two years in 2016, with revised tariffs. However, under the FIT, investors have so far focused almost exclusively on utility-scale systems, and the government is seeking ways to promote growth in the distributed solar segment (NREA, 2016).

Distributed solar systems that are connected to the grid – such as most rooftop installations – generate power where it is consumed and thus reduce transmission and distribution (T&D) losses and avoid additional T&D investments. Off-grid solar systems can displace imported diesel for off-grid users, thereby reducing the fiscal burden of imports on the government budget (where diesel is subsidized), improving the current account deficit, and mitigating the environmental and health hazards faced by local communities when exposed to pollutants from diesel generators. In the case of Egypt, which faces huge income disparities between rural and urban communities, distributed solar projects could further contribute to the government’s plans to reach out to underprivileged regions, such as Upper Egypt, and generate job opportunities for local service providers and installers.

This paper explores in depth the case of distributed solar in Egypt. While generally it aims to provide recommendations to policy makers in Egypt on how to overcome barriers to investment in distributed solar³ through investor-friendly policy frameworks, the conclusions and recommendations may also apply to other emerging markets seeking to scale up their distributed solar market. The methodology for this paper was as follows. First, a literature review was conducted of the global and Egyptian experience with promoting distributed solar PV (section 2). Second, the investment case for distributed solar projects was modeled for different distributed solar applications. The results of this analysis are presented in section 3. Third, a series of stakeholder interviews and consultation workshops were held with government entities, clean tech entrepreneurs and NGOs/associations in Egypt (Annex 1 provides a list of interviewees) between 2016 and 2017 in order to identify additional non-financial barriers to the diffusion of distributed solar. Section 4 summarizes the outcomes of these workshops. The paper concludes with policy recommendations in section 5.

³ For the purposes of this paper, distributed solar is defined as systems up to 500 kW, in line with the government’s definition under the feed-in tariff program.

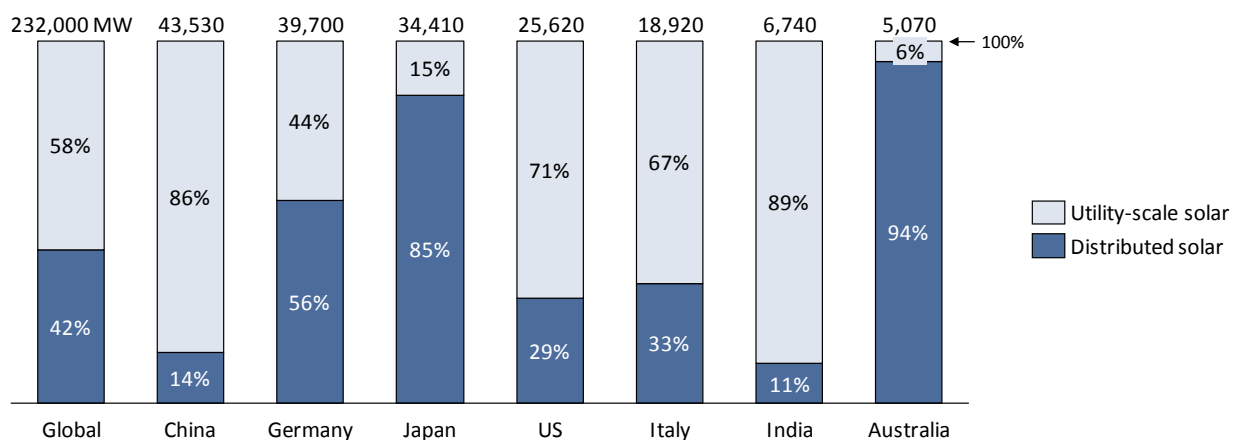
2. Public Policy Experience in Promoting Distributed PV

2.1. Global Experience

Grid-connected distributed solar

Grid-connected distributed solar has outpaced utility scale solar in several OECD countries, especially in Australia, where 94 percent of total PV capacity comes from distributed solar⁴; Japan (85 percent) and Germany (56 percent), as shown in Figure 2.

Figure 2: Share of utility-scale and distributed solar globally and in the seven largest markets (Gupta, Sharda, & Shrimali, 2016), ordered by total market size. India data is for March 2016, other countries' data for 2015.



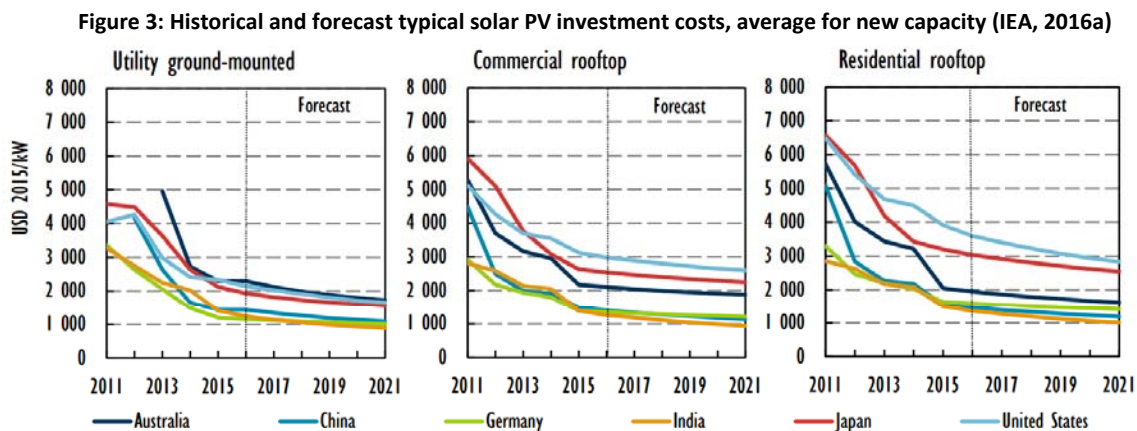
Investment in on-grid distributed solar has in part been driven by market forces, as solar costs have become competitive with retail electricity prices (i.e., they have reached 'grid parity') in many countries. Distributed solar remains more expensive than utility-scale projects⁵ on a per-kW basis (REN21, 2016), but costs have fallen steeply over the past five years (see Figure 3). In Australia, China, Germany, Italy and the United States, the average levelized cost of electricity (LCOE) for residential PV systems fell by 42 to

⁴ Note that the solar PV market in Australia is small in comparison to other OECD countries. Thus, while the share of distributed solar is high, this is partly due to the fact that utility-scale solar PV was not supported with strong policies in Australia and therefore deployment of utility-scale solar has been very limited.

⁵ The capital cost of a PV system has two main components: (i) PV module cost, which includes raw materials for PV cells and manufacturing & assembly and (ii) the balance of system (BoS) costs. The BoS cost includes the structural system (e.g., site preparation), the electrical system costs (e.g., inverter, transformer), storage system if needed (e.g., a battery), and the soft costs of system development (e.g., permitting, labor costs for installation). Modules are traded globally and prices are relatively similar between countries, while the BoS differs from country to country and by end user category. Typically, large utility-scale projects have the lowest BoS costs per kW while the highest is the small residential rooftop systems due to economies of scale.

64 percent between 2008 and 2014 (IRENA, 2015). Wherever retail electricity tariffs are high – be it due to taxes or high system costs – these cost trends have made distributed solar financially attractive for households and commercial electricity consumers. This is particularly the case for Australia which, due to its geography, is characterized by high distribution costs and thus high end-user tariffs. In some remote locations, end-users are even expected to pay for their grid-connection costs, thus making self-consumption of solar PV an attractive alternative.

Notably, as can be seen from Figure 3, the cost of distributed solar differs significantly between countries. These cost differentials have in part been attributed to the cumulative market size in each country, as more installations lead to learning effects that drive down costs. However, costs differ also because of differences in ‘soft costs’, including customer acquisition, installation labor, permitting, interconnection, and inspection procedures (Seel, Barbose, & Wiser, 2014). In Japan, for example, the standardization of solar PV applications helped drive mass market development. Unlike in countries such as the US, which cater to a range of distributed solar users (e.g., industrial, remote residential, or infrastructural applications), the Japanese market is predominantly in the residential sector, with major housing manufacturers even integrating solar PV into their newly built homes. This model not only allowed for the integration of the solar system cost into home mortgages, but also helped drive down local installation and balance-of-system costs as well as customer acquisition costs (Shum & Watanabe, 2007).



Notes: Investment costs are overnight costs and include value-added tax or sales tax where relevant; costs are indicative and may not represent all transactions. National currencies converted to US dollars at average 2015 exchange rates. Historical data points omitted for Australia, where market was not well established.

Sources: Analysis based on IRENA (2016a), *Costing Alliance*, dataset provided to the IEA; IEA-PVPS (2016), *PV Cost Data for IEA*, dataset provided to IEA.

In all major markets, investment in on-grid distributed solar has also benefited from significant policy incentives. Most countries have used a combination of policy instruments, often combining performance-based incentives (i.e., benefits proportional to the amount of electricity produced) with upfront subsidies

to reduce the cost of installing the solar system (e.g., rebates, grants, or low-interest loans). In many countries, the markets for distributed PV only took off when the government allowed for high rates of return on investment (e.g., Grau, 2014). The most common performance-based incentives are FITs (e.g., in Germany, Italy, Japan, and Australia) and net metering (e.g., in the US, Brazil). FIT programs allow system owners to sell all produced electricity at a fixed price to the distribution utility, which is then often reimbursed under a government-administered scheme. Under net metering, system owners consume some of the electricity themselves and receive a credit for all surplus electricity on their electricity bill, thus paying only for their 'net' consumption from the grid. Net metering schemes are attractive where electricity tariffs are high and are relatively easy to administer, especially for users that already have two-way meters installed that can run backwards when surplus electricity is fed back into the grid. In contrast, well-designed FITs can attract renewable energy investors and lenders even when electricity tariffs are low because they generate stable, low-risk cash flow that is not tied to current electricity tariffs. However, FITs require more complex interactions with the distribution utility. Notably, most countries with FITs differentiate tariffs by system size, offering higher rates to owners of distributed solar to account for higher investment cost, as these are often considered justified due to lower T&D losses and other co-benefits of distributed energy installations.

More recently, grid-connected distributed solar systems are also gaining momentum in developing countries, most prominently in China and India. However, in most cases the distributed market segment has been outpaced by utility-scale solar. China set ambitious targets for distributed solar in 2013 and 2014, aiming to install 8.4 GW by 2014, 20 GW by 2015 and 35 GW by 2017 (Liang, 2014). However, at the end of the first quarter of 2016, distributed capacity stood at 7.03 GW (14 percent of the total), even when using a definition that includes all plants below 6 MW (NEA, 2016). India, too, has set an ambitious target, aiming to install 40 GW of rooftop solar power by 2022. However, installed capacity was only 0.7 GW at the end of March 2016 (11 percent of the total), and is growing at a rate too slow than what will be required to achieve the target (Gupta et al., 2016).

Growth of on-grid distributed solar in emerging markets has been subdued, among others, for the following reasons (ADB, 2015; Gupta et al., 2016):

- **High upfront cost and limited access to debt finance:** Consumers are often reluctant – or do not have the means – to invest the high upfront amount required to install distributed solar systems. At the same time, SMEs and households often have limited access to debt because of underdeveloped financial markets.

- **Counterparty risks:** Where net metering schemes exist, utilities are not forthcoming for implementation as these imply negative cash flows. Where solar is reimbursed through FITs or other long-term power purchasing agreements (PPAs), contract enforceability is a concern due to the utilities' weak balance sheets and/or unwillingness to honor agreements.
- **Low electricity tariffs:** In order to incentivize investments, net metering requires that end-user electricity tariffs are high, however electricity tariffs in most emerging markets are still subsidized.
- **Availability of suitable roof space:** In many emerging economies, the built environment has limited physical availability of roof space. A related concern is that of roof rights. For instance, in case of rented accommodation, there is risk of the title of the rooftop. In case of a leased property, the tenure of the lease may not match the duration of the PPA for the lifetime of the solar system. There may also be uncertainty in terms of strength of the building structures and risk of shadowing in the future.

Off-grid distributed solar

Off-grid distributed solar systems are often deployed to improve access to basic energy services either through isolated systems that provide energy at a household level (e.g., solar lanterns or solar home systems) or through community-based micro-grids. Consequently, recent uptakes in investments in off-grid markets have been concentrated in emerging economies where energy access is still a problem: Bangladesh is the world's largest market for solar home systems, and other developing countries (e.g., Kenya, Uganda and Tanzania in Africa; China, India and Nepal in Asia; Brazil and Guyana in Latin America) are seeing rapid expansion of renewables-based mini-grids to provide electricity for people living far from the grid (REN21, 2016). While the market is still asymmetrically developed – with Kenya, Tanzania and Ethiopia dominating the African market and India and Bangladesh the Asian market – about 70 countries worldwide either had some off-grid solar PV capacity installed or had programs in place to support off-grid solar PV applications by the end of 2015 (REN21, 2016).

The market for pico-solar products, or solar products less than 10W, has rapidly expanded in the last five years: about 44 million off-grid pico-solar products had been sold globally by mid-2015, representing an annual market of US\$ 300 million. With this market growth, pico-solar products have experienced large cost reductions due to both technological improvements and increased market competition, and are thus competitive with alternatives such as kerosene (BNEF & Lighting Global, 2016). The lifecycle costs of larger off-grid solar systems are also often cheaper than kerosene or diesel-based alternatives. However, the higher upfront costs of these systems are often prohibitive for rural households with little disposable

income. Pay-as-you-go schemes (PAYG), under which the solar provider assumes the upfront cost and charges the consumer a regular fee to recover its cost, have proven an effective business model for overcoming this barrier. PAYG schemes are now the most common and fastest-growing business model in the off-grid sector: BNEF estimates that a total of about US\$ 276 million was invested in off-grid solar companies (solar lanterns and home systems) in 2015, while PAYG companies received 87% of all such direct investments in 2014 and 2015 (REN21, 2016).

Besides the provision of basic energy services to households or villages, off-grid distributed solar is increasingly used for commercial applications, including irrigation, refrigeration, food drying or mining (International Renewable Energy Agency, 2016b). In these applications, solar often displaces diesel powered generators, which are growing less sustainable in many countries due to diesel scarcity, increasing fiscal pressure to phase out diesel subsidies, and growing environmental concerns. In particular, solar pumps for irrigation are gaining support from national governments. India and Morocco, for example, have set targets to deploy 100,000 solar pumps by 2020 and 2022, respectively (International Renewable Energy Agency, 2016a) .

In addition to specific targets for off-grid applications, national policies promoting distributed solar markets have also played a key role in many countries. In early stages of market development, consumer awareness campaigns that present solar PV as reliable technologies help increase demand and, consequently, attract distributors and suppliers (BNEF & Lighting Global, 2016). Fiscal incentives (e.g., concessional loans, VAT exemptions on solar products or investment subsidies) are often highly effective for technology diffusion given that off-grid customers tend to be highly price sensitive (REN21, 2016).

While the off-grid solar market has grown considerably in the last five years, several bottlenecks are cited as a barrier for further growth (BNEF & Lighting Global, 2016):

- **High up-front cost, long payback times and limited access to finance.** Finance provision is currently dominated by donors and social impact investment funds, with some additional funding coming from crowdfunding schemes. However, impact investors and donors are often unwilling to invest in emerging SMEs with unfamiliar business models or operating in risky markets. Distributors and manufacturers of off-grid solar technologies also lack access to debt finance, and thus have limited working capital to scale-up operations. Finally, consumers living in rural areas often have limited disposable income to pay for solar products and few acceptable assets to use as collateral for loans.

- **Ready access to low-cost fossil fuel alternatives.** In many potential markets, the presence of fossil fuel subsidies (e.g., for diesel) provide little incentive to switch to solar powered technologies.
- **Race to the bottom for solar products.** Recent years have seen a proliferation of generic solar products, some of which are of poor quality. The prevalence of these poor-quality products risks market spoiling, particularly in areas in which the off-grid market is immature.
- **Last-mile distribution of quality products.** While there is often awareness of off-grid solar technologies, many potential users are unaware of where to buy a quality product. Furthermore, in case technologies need to be tailored to specific applications (e.g., for solar irrigation systems), there are often few incentives for suppliers to develop the appropriate technologies for new markets.

2.2. Egypt's Experience

The total installed PV capacity in Egypt was about 32.1 MW in 2015 (NREA, 2016). These are mostly stand-alone applications, including solar powered mobile telephone towers, advertisements along highways, solar pumps for irrigation, as well as 10 MW PV-diesel hybrid system in Siwa financed through a United Arab Emirates grant and operated by El-Behera Distribution Company.⁶ Grid-connected PV capacity is limited, but includes some public and residential buildings, e.g., a 540 kW system at the Egyptian Electricity Holding Company and affiliated companies.

On-grid distributed solar in Egypt

While the GoE has not yet conducted a comprehensive assessment of its distributed solar potential, this potential is likely to be very significant. Space for ground-mounted distributed solar is, by all practical means, unlimited. Rooftop space is more limited because much of Egypt's urban population lives in densely built, multi-level apartment buildings, however suburban and rural areas as well as industrial and commercial rooftops still provide plenty of space. To promote investment in this segment, Egypt is offering net metering and FIT schemes for distributed solar.

⁶ The Middle Egypt Distribution Company has plans to use the same grant funds to install up to 6 MW of solar PV retrofits to hybridize Farafra, Abu Monqar and Qora Al Arbaeen diesel mini-grids.

The net metering scheme, adopted in early 2013 by EgyptERA, allows small-scale renewable energy projects in the residential and industrial/commercial sector to feed electricity into the low voltage grid (EgyptERA, 2013). The net metering scheme does not specify a limit on installed capacity, meaning that customers can connect a system that produces more electricity than they consume, however systems are limited to the low voltage level, typically around 380 volts. Under the scheme, PV generation is credited against the user's bill for consumption from the grid using a slightly unconventional crediting method⁷ (Åberg, 2014). This crediting method, which credits surplus electricity only in the consumers' highest tariff bracket, was adopted to maximize bill savings. However, this crediting scheme also adds complexity to the Egyptian net metering design because it requires relatively complex billing procedures by the distribution companies – especially if the consumer produces more electricity than is used in its highest tariff bracket. This calculation method also requires two installed meters, just like in a FIT system, eliminating one of the advantages of a normal net metering scheme.

The technical potential for net metering is significant. In terms of household consumption alone, the highest two tariff brackets (above 650 kWh) consume 5,866 GWh per year (see Table 1). Despite this potential, however, the net metering scheme has seen only very limited uptake. The main reason is that, even after the tariff increases of 2014 and 2015, Egypt still had relatively low retail tariffs for electricity. Tariffs are highest for household and commercial consumers, but even the top percentile of these groups faced prices no higher than EGP 0.84 per kWh and EGP 0.86 per kWh, respectively, until the summer of 2016 (see Table 6 in Annex 2). The tariff reform announced in August 2016 has raised these categories to EGP 0.95 and EGP 0.96 per kWh, respectively (see Table 1), but it is too early to judge the impact of these tariff reforms on investor interest in net metering.

⁷ Surplus is being credited only against electricity consumed in the consumers' highest tariff bracket for each month. If the consumer manages to produce more electricity than the one consumed in the highest tariff bracket, the excess amount is credited to the next month. A final settlement is done in the end of each year for the residential sector and in the end of each month for certain sectors such as street lighting. Any surplus electricity in the end of the settlement period will be granted to the distribution company (Åberg, 2014).

Table 1: Household consumption by tariff block and tariffs paid in 2014 (EgyptERA, 2014)

Residential tariff blocks		Consumers per block	Total consumption billed per block (GWh)	Tariff (PT/kWh)	Total value of consumption per block (million EGP)
0 – 100 kWh	0 – 50 kWh	4.240 million	2,442	11.0	269
	51 – 100 kWh	2.650 million	2,932	19.0	557
101 – 1,000 kWh	0 – 200 kWh	8.215 million	16,956	21.5	3,646
	201 – 350 kWh	7.685 million	22,271	42.0	9,354
	351 – 650 kWh	3.180 million	17,057	55.0	9,381
	651 – 1,000 kWh	0.265 million	2,353	95.0	2,235
Above 1,000 kWh	0 -> 1,000 kWh	0.265 million	3,513	96.0	3,337
Total		26.500 million	67,524		28,779

^aAssuming 1,700 full load hours per year.

In addition to the net metering scheme, Egypt introduced a FIT scheme in October 2014. Under the scheme, the electricity transmission company and the distribution companies are committed to purchase all power from eligible solar plants through 25-year PPAs. Distributed solar projects are to be handled by the distribution companies. The government set a target of 4,300 MW under the FIT to be achieved by 2016, including 300 MW for distributed PV and 2,000 MW for utility scale solar. The tariff rates are differentiated by system size (see Table 2), with original tariffs for distributed PV (set in 2014) ranging from EGP 0.844 per kWh for systems below 10 kW up to EGP 0.973 per kWh for systems between 200 kW and 500 kW. These tariffs were lower than those for utility scale projects because the government envisioned that distributed solar investors would have access to concessional finance in local currency. Specifically, the Ministry of Finance had proposed a financing program under which investors could receive concessional loans at 4% interest for installations below 10 kW and 8% for installations below 500 kW. However, this financing program was not implemented.

Egypt's FIT program generated considerable investor interest in the utility-scale segment. More than 40 utility scale solar PV projects with a total of 2,000 MW of capacity are under development, and development banks including the IFC, EBRD and AfDB are considering concessional finance in the order of US\$3bn. However, the program ran into a roadblock when projects failed to reach financial closure in the summer of 2016 amid the foreign exchange shortage and unfavorable arbitration arrangements, leading lenders to wait for conditions to improve.

Distributed solar received much less interest. The concessional financing program was not implemented, leaving investors with a FIT that was financially unattractive at market lending conditions. Falling far short of the 300 MW target, Egyptian distribution companies have received about 200 requests for small solar projects implemented on building rooftops as of October 2016 (Egypt O&G, 2016). North Cairo Electricity Distribution Company, one of the nine distribution companies in Egypt, reports that 15 rooftop plants ranging between 6 kW and 20 kW are connected to their network (Egypt O&G, 2016).

On September 6, 2016, the government introduced new FITs effective October 28, 2016. At the time of their introduction, these tariffs, shown in Table 2, were higher for distributed solar (increases between 4.8% and 28.6%) and significantly lower for utility-scale projects (-41.4% and -42.6%) in order to account for changes in the assumptions on lending conditions, technology cost and the exchange rate. The government hopes that these revised tariffs will sustain interest in the utility-scale segment (projects are allowed to transition to phase II) while attracting more investors into the distributed solar segment. Additionally, although the original concessional finance program was never implemented, SMEs in Egypt are eligible for loans at 5% interest rate since January 2016, as Egypt has taken recent steps to expand commercial lending to SMEs. The effect of these changes on the market is not yet clear.

Table 2: Feed-in tariff rates for solar PV in Egypt (EgyptERA, 2014).

	October 2014 to October 27, 2016	October 28, 2016 onwards	Change
Residential ≤ 10 kW	84.4 PT/kWh ^a	108.5 PT/kWh ^a	28.6 %
Installed Capacity ≤ 200 kW	90.1 PT/kWh ^a	108.5 PT/kWh ^a	20.4 %
200 kW ≤ Installed Capacity < 500 kW	97.3 PT/kWh ^a	102.0 PT/kWh ^a	4.8 %
500 kW ≤ Installed Capacity < 20 MW	13.6 US\$ cent/kWh ^b	[7.8 US\$ cent/kWh ^c 6.6 US\$ cent/kWh	-42.6%
20 MW ≤ Installed Capacity ≤ 50 MW	14.34 US\$ cent/kWh ^b	[8.4 US\$ cent/kWh ^c 7.1 US\$ cent/kWh	-41.4%

^aFor installations below 500 kW, the FIT program envisioned that the Ministry of Finance would provide soft loans, at 4 percent interest rate for residential projects and up to 200 kW and 8 percent interest rate for projects ranging between 200 kW and 500 kW. However, these concessional loans were not made available. The new FIT rates are based on market lending rates.

^bThe PV projects' feed-in tariff for installed capacities more than 500 kW was to be paid in Egyptian pounds according to the following equation: FIT (in EGP) = [0.15 X FIT (US\$ cent) X 7.15] + 0.85 X FIT (US\$ cent) X exchange rate on the bill issuance day, as stated in the contract].

^c The FIT for installed capacities more than 500 kW, is being paid in Egyptian pounds according to the following equation: FIT (EGP) = [0.30 X FIT (US\$ cent) X 8.88] + [0.70 X FIT (\$ Cent) X exchange rate on the bill issuance day, as stated in the contract]. The higher numbers cited here represent the FIT rate in EGP assuming an exchange rate of 8.88 EGP per USD, which was the exchange rate as of October 28, 2016. However, since the revision of the FIT in October 2016, the value of the EGP has decreased significantly. As a result of this devaluation and the indexing methodology used for setting FIT rates, the large-scale FITs effectively stand around 6.6 US\$ cent/kWh (500kW – 20MW) and 7.1 US\$ cent/kWh (20MW – 50MW), assuming an exchange rate of 18 EGP per USD.

In sum, during the first three years of support for on-grid distributed solar, neither the net metering nor the FIT program has seen significant uptake as neither made distributed solar financially attractive for a wide set of consumers. The business models pursued thus far have targeted either large commercial consumers or rich households and operate largely under the net metering scheme. Additionally, there are some business models that operate under neither policy mechanism, and instead focus on behind-the-meter solar for self-consumption, targeting users that pay particularly high prices for marginal consumption.⁸ These models are only applicable to a small niche of the Egyptian market. This paper thus analyzes recent upward tariff and FIT revisions in order to understand if these changes can unlock a greater portion of the market.

Off-grid distributed solar in Egypt

Egypt's populated areas are almost fully electrified (over 99 percent), yet, due to growing off-grid energy demand across the sectors of agriculture, tourism, residential, and extractive industries, the off-grid market potential is high. Agricultural farmland in particular is increasingly located in off-grid areas, such as the export-oriented mega-farms in the Western Desert. There is also rapid expansion into new underdeveloped areas under projects announced by the government, such as the 1.5 Million Feddan⁹ desert reclamation project and the Golden Triangle Project.

No policy incentives exist to promote distributed solar for off-grid electricity. At present, the off-grid areas are either partially or entirely dependent on diesel-based technologies, including generator sets, pumping systems and desalination units. The formal price of diesel fuel is EGP 2.35 per liter in 2017. However, many of the off-grid users obtain it at higher prices from the market and frequently face shortages of supply. The agriculture sector is expecting that the diesel cost will increase in 2019 to be around US\$ 0.70 to US\$ 1.00 per liter including transportation costs to the site, which, assuming an exchange rate of 18 EGP per US\$, is more than five times as much as the current subsidized rate (RCREEE, 2016). However, because diesel is still frequently available at prices below market rates and no equivalent financial incentives are available for solar PV, adoption of off-grid solar solutions remains limited.

Based on the existing diesel consumption, the total off-grid PV potential is estimated at 2,097 MW, equivalent to around US\$ 4 billion in investment, as shown in Table 3 (RCREEE, 2016). While a large share

⁸ These users include households that slightly exceed 1,000 kWh/month or commercial consumers whose electricity consumption exceeds license conditions, thus requiring diesel-based self-generation.

⁹ A feddan is a unit of area equivalent to 1.038 acres.

of this potential lies in the agricultural sector, solar systems for the tourism sector are also a potential application.

Table 3: Potential Off-grid PV Market in Egypt (RCREEE, 2016).

Target application	Diesel consumption (ktoe/year)	Potential PV capacity (MW)	Potential investment* (US\$ million)
Utility mini-grids	78	82	\$123
Private mini-grids	60	77.3	\$115
Water pumping in agriculture	3,775	1,938	US\$ 3,876**
Single-activity application	1.87	0.09	US\$ 0.135
Total	3,915	2,097	US\$ 4,114

*Calculated based on PV price of US\$ 1.5 million for 1 MW.

** Calculated based on average solar pumping system of US\$ 2 per W.

Egypt's Solar Industry

A local solar industry has developed in response to the recently introduced policy incentives. Most of the existing local solar companies are project developers and/or distributors for international suppliers. The local manufacturing of PV technologies is very limited, despite the high attractiveness index for manufacturing PV components in Egypt compared to other MENA countries (The World Bank, 2015), due to the availability of materials for solar industries (i.e. glass, steel, stainless steel) and high manufacturing ability. The four existing PV manufacturers in Egypt are the military-owned Arab International Optronics, Benha Electronics Company, government-owned Arab Renewable Energy Company (a subsidiary of the Arab Organization for Industry), and the newly established private company Tiba Solar. However, Egypt is heading to localize the PV manufacturing industry. Additionally, Egypt has a small but vibrant ecosystem of start-ups, SMEs and financiers working on distributed solar, suggesting that significant local value creation and employment can be expected if investment in distributed solar picks up.

3. Economics of Distributed PV in Egypt

In this section, we present the results of a techno-economic model of the profitability of distributed solar in Egypt in three different applications: the net metering scheme, the feed-in tariff and off-grid applications. It has to be noted that these results are based on the official exchange rate of 18 EGP per US\$ as of March 2017, following the devaluation of the Egyptian pound, and are sensitive to changes in input assumptions, as discussed below. The following four findings are derived from the model analysis.

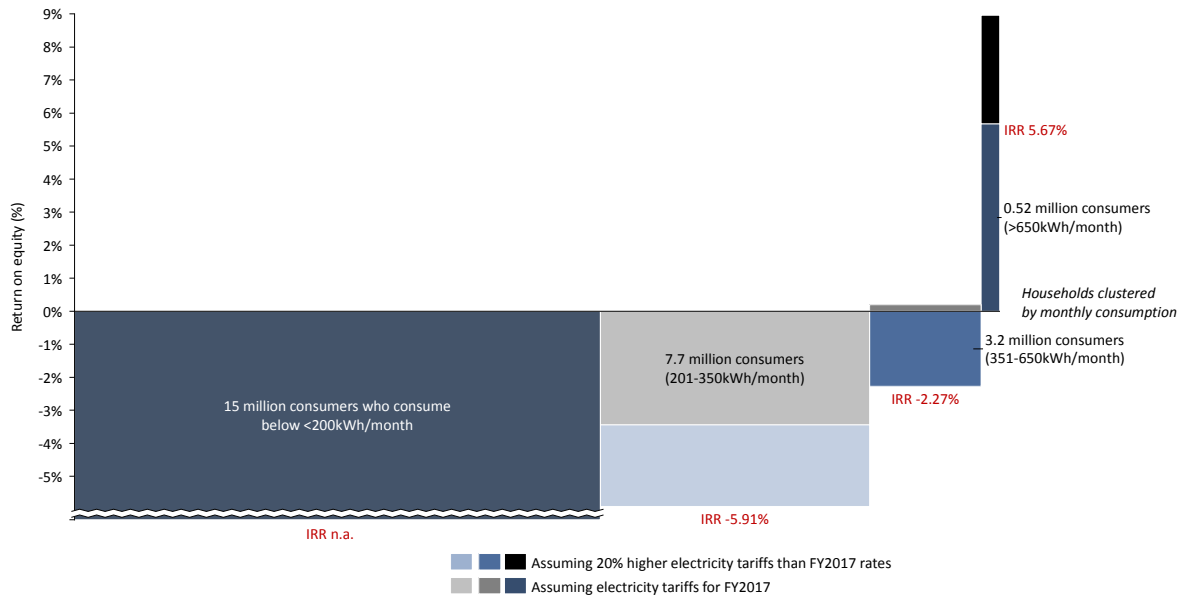
First, net metering remains financially unattractive for all residential and commercial consumers. Under the tariff reforms from August 2016, 98 percent of households would realize a negative return on equity investment (ROEI) assuming an investment cost of US\$ 800 per kW,¹⁰ as shown in Figure 4. The top 2 percent (0.52 million) of household consumers, who now pay EGP 0.95 per kWh on all of their consumption, and the largest commercial consumers, who pay EGP 0.96 per kWh for their consumption, could generate a positive ROEI of 5.67 percent and 5.85 percent from net metering, respectively. However, both of these rates are far below required rates of return on equity investments: the Central Bank of Egypt's benchmark overnight deposit rate, which can be considered a lower-end benchmark rate for capital investments in the economy, stood around 15.75 percent as of January 2017, however more realistically, private investors in Egypt would expect a return closer to 20 percent. Thus, while net metering has become more attractive under the new tariff regime, it is still not an attractive investment for any segment of the population.

Even if all tariffs were increased by 20% as Egypt continues to phase out its electricity subsidies, the net metering scheme still only realizes a positive IRR for the largest energy consumers. This result raises concerns about the social fairness of the net metering scheme as larger energy consumers are also higher income. In Egypt's current tariff structure, richer customers pay higher tariffs than poorer customers in order to keep electricity affordable to all members of the population. If richer households start to defect from this cross-subsidization system, the cost recovery of the utility will worsen, eventually requiring EgyptERA to raise electricity prices for the poor. Other consumer groups in lower tariff brackets may still install solar PV under the net metering to escape power outages in Egypt, for which the net metering scheme is more suitable than the FIT (Åberg, 2014). However, outages have all but disappeared since the winter of 2015, thus reducing the case for solar investment from an energy security perspective. In order for the net metering scheme to work for a wider spectrum of society, the net metering scheme would have to be combined with concessional finance or grants, which could be targeted to smaller consumers. However, since the FIT is more attractive (see below) and government support for the net metering

¹⁰ Rooftop solar costs vary widely worldwide. 2015 estimates for a residential system were around US\$ 2000 per kW in Tunisia and \$3000 per kW in South Africa (International Renewable Energy Agency, 2016b), while current costs in India are as low as US\$ 600 per kW. The US\$ 800 per kW used in this analysis is thus a moderate benchmark, and sensitivities to this assumption are conducted.

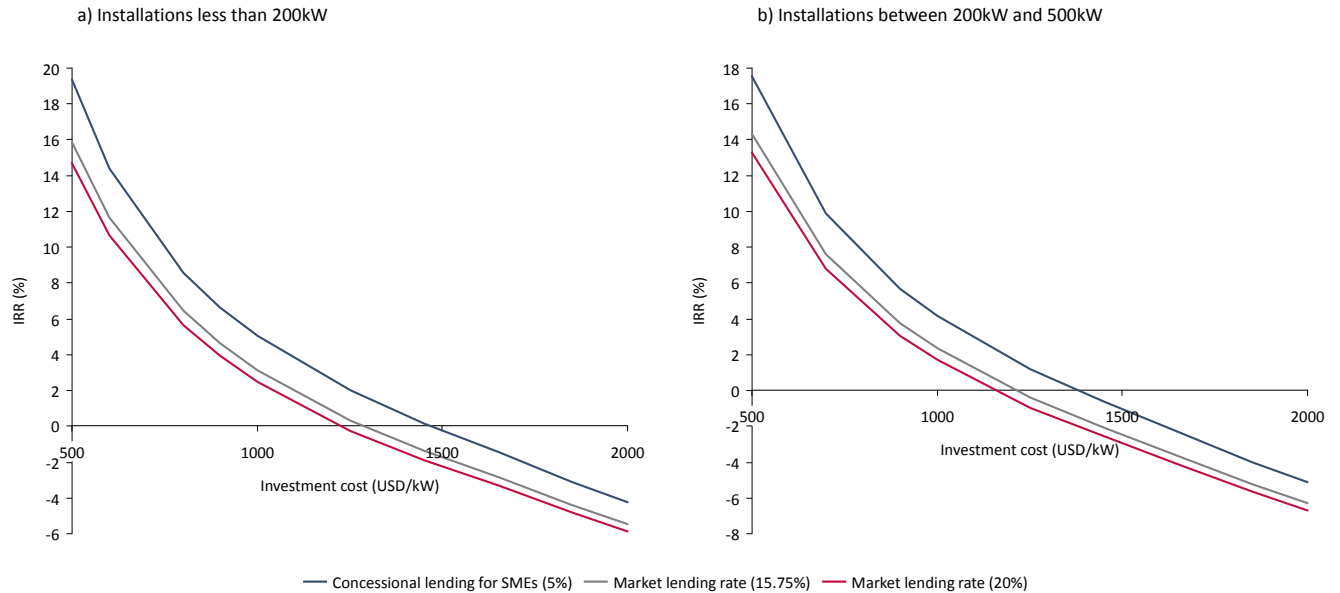
scheme has already waned in practice, further government support to complement the net metering scheme appears unlikely.

Figure 4: Results for profitability analysis for residential users under net metering scheme



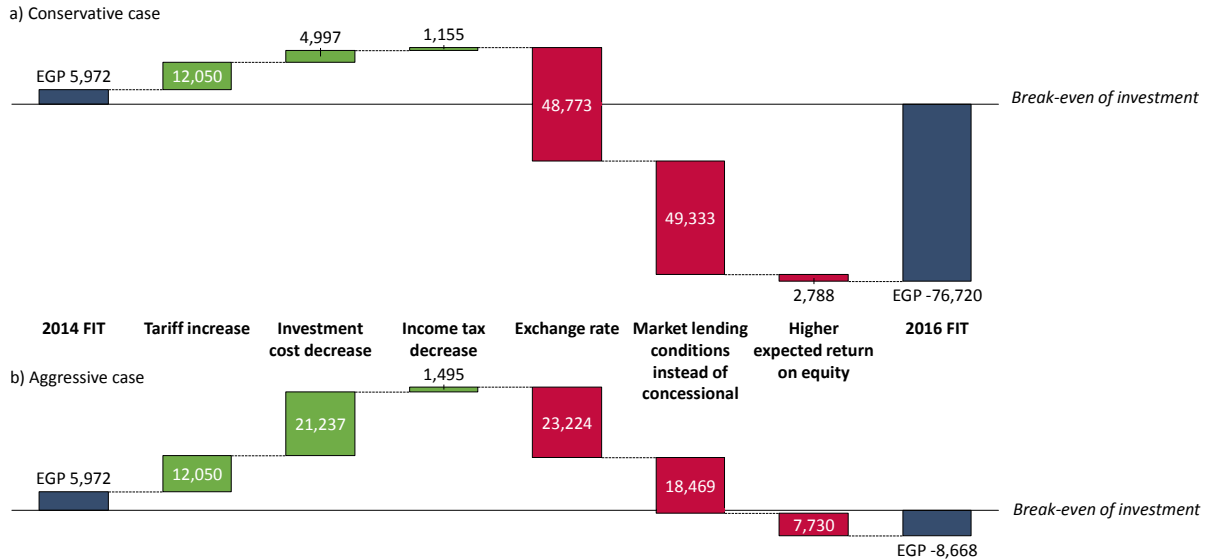
Secondly, although the new feed-in tariffs – which came into force on October 28, 2016 – are higher than current electricity tariffs, these rates are still insufficient to make distributed solar a profitable investment at current lending rates. Under the market lending rate, assumed 15.75 percent based on Egypt’s Central Bank deposit rate, the ROEI ranges between 15.83 percent to -5.46 percent for installations below 200kW (receiving a FIT rate of 108.5PT per kWh) and between 14.31 percent and -6.72 percent for installations between 200kW and 500kW (receiving a FIT rate of 102PT per kWh), depending on the investment cost (see Figure 5). Note that in many emerging markets, investment costs can vary substantially – in Tunisia for example, investment costs between the most expensive and cheapest rooftop solar systems in 2015 varied by a factor of 2.2 (International Renewable Energy Agency, 2016b) – due to underdeveloped markets. Even under the concessional lending conditions of 5% interest rates available for SMEs, the ROEI for distributed solar only achieves a 15.75 percent investment benchmark at very optimistic investment costs of around US\$ 600 per kW.

Figure 5: Results for profitability analysis under FIT scheme



Thirdly, despite the upward revision in FIT rates since 2014, distributed solar is an even less attractive investment than under the conditions assumed by EgyptERA in 2014. As shown in Figure 6, six changes since 2014 have affected the profitability of distributed solar. The tariff increase, the global decline in the cost of solar PV and the decrease in the top rate income tax in Egypt have raised the net present value (NPV) of a typical 5 kW system by between EGP 18,202 and EGP 34,782, depending on whether a “conservative” or “aggressive” investment case is assumed (see Table 4 for details). However, over the same time period, the devaluation of the Egyptian pound, the unavailability of concessional financing (see Section 2.2) and the higher expected return on equity (due to higher inflation) have reduced the NPV by EGP 49,423 to EGP 100,894, again depending on assumed investment conditions. Notably, the devaluation of the Egyptian pound since 2014 has significantly affected the economics of distributed solar, as Egypt lacks a domestic solar manufacturing industry and thus must import solar modules at international prices. In reality, the effect of the devaluation may be less severe than modeled here because, previously, when the FIT was introduced in 2014, it was not possible to buy US\$ from the Central Bank. Instead, US\$ were sourced from the black market at rates that were higher than the official exchange rate.

Figure 6: Net present value of a 5 kW solar rooftop system under the 2014 FIT and the 2016 FIT, and the factors that constitute the difference between the two.

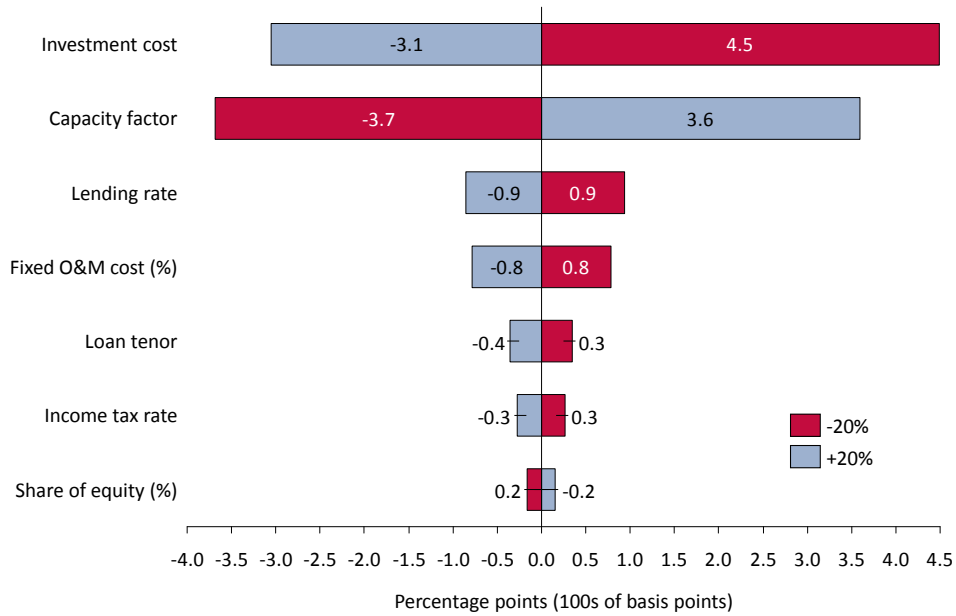


The results are highly sensitive to input assumptions. The baseline assumptions for the 2014 FIT, the 2016 FIT and the net metering in 2016 are listed in Table 4. Figure 7 shows the sensitivity of the ROEI of a 5kW solar rooftop system under the FIT scheme to seven key factors: the investment cost (in EGP), the solar resource (i.e., the capacity factor), the bank lending rate, the O&M cost, the loan tenor, the income tax rate and the share of equity. The ROEI is most sensitive to the investment cost (a 20 percent decrease improves the ROEI by 4.5 percentage points) and the solar resource (a 20 percent increase of the capacity factor improves the ROE by 3.6 percentage points). Note that because it was assumed Egypt must import solar modules – which are denominated in US\$ – the ROEI is highly sensitive to the value of the Egyptian pound as well (i.e., a 20 percent increase in value of the Egyptian pound against the dollar would also improve the ROEI by 4.5 percentage points). Additionally, a change in the tariff would affect the results in the same way as the capacity factor, as both are equivalent to a 20 percent change in operational cash flows.

Table 4: Techno-economic assumptions used for profitability analysis of distributed solar.

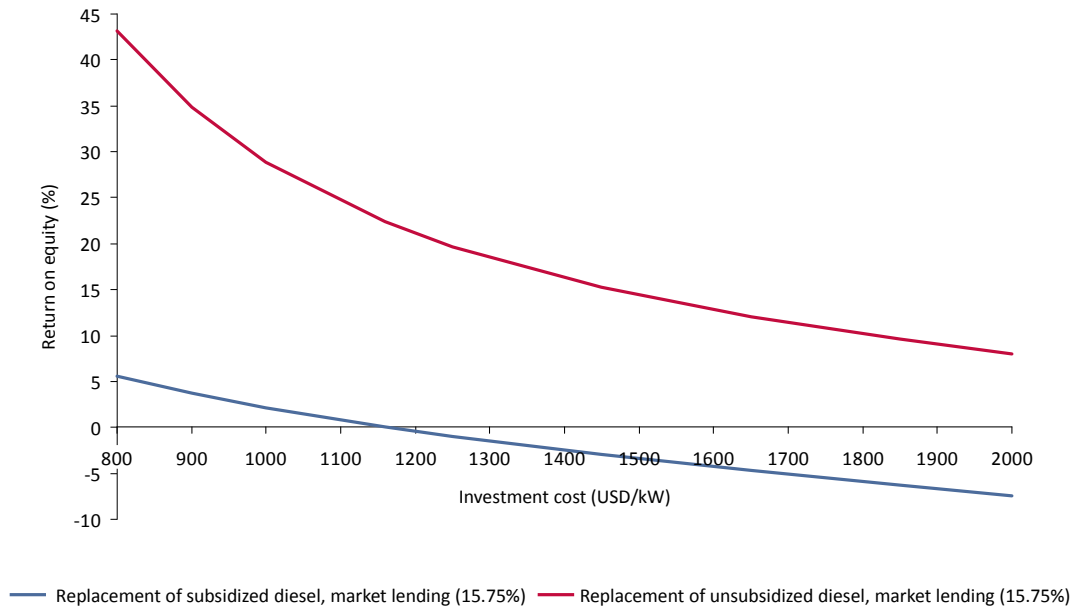
Variable	2014 FIT		2016 FIT (from October 28, 2016) / Net metering (from July 1, 2016)	
	Value	Source/Comment	Value	Source/Comment
Investment cost (overnight)	US\$ 1,450 per kW	(NREA, 2016)	US\$ 600 (aggressive) – 1,250 (conservative) per kW	Assumption based on (IEA, 2016a) data for India
Exchange rate	7.15 EGP/US\$	Central Bank	18.00 EGP/US\$	Central Bank
O&M cost per year (including insurance)	2.5 % of initial investment	(NREA, 2016)		
Depreciable lifetime	25 years	(NREA, 2016)		
Minimum book value	5% of initial investment	Assumption	<i>Unchanged</i>	
Capacity factor	19.4%	EgyptERA		
Share of equity	25%	Assumption		
Expected return on equity	12%	(NREL, 2016)	15.75% (aggressive) 20% (conservative)	Assumption based on higher inflation
Lending rate	4%	Concessional rate assumed in FIT of 2014	15.75% (aggressive) 20% (conservative)	Central Bank overnight deposit rate
Grace period	2 years	Assumption for concessional finance	0 years	Assumption based on market conditions
Loan tenor	12 years	Concessional rate assumed in FIT of 2014	5 years	Assumption based on market conditions
Income tax rate	25%	Ministry of Finance	22.5%	Ministry of Finance
Loss carryforward period	0	Other sources of taxable income assumed	<i>Unchanged</i>	

Figure 7: Return on equity for distributed solar: Sensitivity to input parameters.



The fourth finding is that off-grid distributed solar to replace diesel consumption is highly dependent on the local price of diesel. Figure 8 shows the ROEI for off-grid applications of distributed solar as a function of the investment cost, as these costs can differ significantly between off-grid configurations. When the solar system replaces diesel bought at the subsidized price (currently EGP 2.35 per liter), distributed solar has a positive return on equity for investment costs below around 1150 US\$ per kW, but generally is not a very attractive investment even at very low investment costs. If the solar system replaces unsubsidized diesel (currently estimated at US\$ 450 per ton, or about EGP 6.75 per liter), the ROEI increases to between 8.0 and 43.1 percent, depending on the investment cost. RCREEE found that in practice, when there are no diesel shortages, most consumers pay an average price somewhere between the subsidized and unsubsidized prices, as diesel is sold by third parties at prices above the government rate. Thus, the investment case for off-grid distributed solar is currently fragmented, as it is still unclear exactly how local prices of diesel vary across the country.

Figure 8: Profitability of off-grid distributed solar investments.



However, from the government’s perspective, off-grid solar is extremely economically attractive. Given that solar is cheaper than unsubsidized diesel-powered generation, off-grid solar deployment presents an opportunity for the government to reduce its subsidy bill. At present, off-grid water pumping in agriculture consumes about 3.77 million tons of diesel per year. At the previous subsidized fuel price of EGP 1.8 per liter (prior to the November 4, 2016 increase), displacing this diesel fully with PV systems could have saved the government EGP 5.06 billion per year in diesel subsidies. Despite this, no PV incentive schemes exist by the government for off-grid users. Although the government increased the subsidized price of diesel from EGP 1.8 per liter to EGP 2.35 per liter- effective as of November 4, 2016 – this increase in price was accompanied by a devaluation of the Egyptian pound of over 50%, effectively increasing the value of the fuel subsidy. Thus, the previously estimated numbers are likely lower than the current potential fiscal savings from displacing diesel by distributed solar. Additionally, given the high emissions factor of diesel and low efficiency of many small-scale off-grid diesel applications, a single 2.5kW solar pump could provide CO₂ emissions savings of 145 tons over its lifetime. Thus, if the off-grid market is scaled up, this presents a large opportunity for Egypt to reduce its national emissions.

Table 5: Estimate of fiscally neutral support for PV pump systems in Egypt (RCREEE, 2016).

Target application	Value
Total number of diesel pumps	258,239
Equivalent diesel consumption	3,775,000 ton
Government diesel subsidy for 3,775,000 tons (estimate)	EGP 5.06 billion
Total equivalent solar capacity	1,938 MWp
Average investment needed per pump (average 7.5 kWp)	EGP 77,256
Maximum fiscally neutral subsidy that could be provided by the Government	EGP 21,196 (25.34%)
Total	3,915

4. Non-financial Barriers to Growth in Distributed PV in Egypt

Fixing the economics of distributed solar in Egypt will be important, but non-financial barriers can limit growth in distributed solar even if the financial incentives are in place. As detailed below, interviews and comments from consultation workshops suggest that, in spite of the large potential market and improved economics, a number of barriers remain to growth in the distributed solar market.

First, stakeholders generally note that there is uncertainty in the government’s vision and policies for distributed solar. Although the government set a target of 300 MW of small-scale solar under its FIT program, quantified targets for distributed solar at both a national level and within certain key sectors, such as agriculture or tourism, would provide clearer signals to the private sector of the government’s commitment to supporting distributed solar. Similarly, the government’s policy signals lack clarity. The existence of two parallel schemes, net metering and the FIT, appears to confuse the market. Even among key sector experts, there was disagreement about whether projects were still eligible for the net metering scheme, or if it had been replaced by the FIT. Finally, clarity regarding the schedule of electricity and diesel subsidy reforms would provide greater certainty to the private sector about the opportunities for distributed solar moving forward.

Second, lack of access to data and knowledge is a major barrier to scaling up distributed solar along the value chain. *End users* lack knowledge about the potential benefits of solar, and how to source appropriate and high-quality products. The wide range in quality and technical expertise of suppliers represents a risk. Negative experiences may spoil the nascent market in the eyes of consumers. Stakeholders highlighted the need for technical standards and transparency in PV supply. A training and certification scheme for PV installers and system integrators could help leading to technical

standardization and ensure the quality of the delivered technical service. *Entrepreneurs* lack information about market potential. Current initiatives in Egypt are scattered and lacking the necessary technical and market information needed to scale-up their business. In the off-grid market in particular, technical solutions are often highly customized, leading to high transaction costs for each application. Ecosystem actors in particular highlighted the need to segment the market in order to cluster or aggregate the various initiatives and facilitate customer acquisition and business development. The Access to Knowledge for Development (A2K4D) project at the American University of Cairo is working to provide a platform for data and knowledge exchange. Many stakeholders stressed the value of this initiative and highlighted the need to sustain it going forward. On the off-taker side, the *distribution companies* still lack sufficient technical understanding to integrate distributed solar into their grid planning. If not addressed, this may lead to technical issues once distributed solar takes off, and the benefits of solar for grid operators may not be fully realized. Finally, as to *policy makers*, there is low understanding of the potential economic, social, and environmental benefits of PV solutions for off-grid areas and small-medium end users.

Third, access to debt finance remains a challenge. As systems with a higher debt share have a higher ROEI, this is a barrier to the diffusion of distributed solar. Although concessional finance at 5% lending rates is available to SMEs, smaller actors such as households or small farmers are not bankable due to their low credit worthiness status and limited collateral due to a lack of property/land ownership rights. There is thus a need for targeted concessional microfinance or innovative mechanisms (i.e. pay-as-you-go / mobile payments) for end users. Entrepreneurs, too, reported limited access to finance as a barrier. Entrepreneurs that manage to secure seed financing are often unable to secure follow-up rounds of investment to move their businesses forward. In addition, there is a perception that solar technologies are highly risky and non-reliable compared to traditional systems. The banks do not have the necessary financial models, tools, and technical capacity to evaluate PV projects loan applications for solar projects. Capacity building in banks to help them better understand distributed solar, including the development of standard templates for project appraisals, is needed to unlock greater access to debt finance.

Fourth, the distributed solar industry lacks a voice in the policy debate in Egypt. This is partly due to collective action problems as the industry is currently quite fragmented, with many small players working in silos. Networks that facilitate sharing of knowledge, data, and information on technology suppliers are only beginning to emerge. Examples include Cleantech Arabia, Nahdet El Mahrousa, Governorate Economic and Social Revival (GESR; an initiative by the Misr El-Kheir Foundation) and American University of Cairo's Venture Lab and Technology Transfer office. More formal industry networks may be needed in

order for distributed solar actors to gain a stronger collective voice in steering policy decisions and leveraging on each other's capabilities and resources. Additionally, there is a need for linking government with entrepreneurs through structured public-private dialogue for regulatory and policy advocacy.

Fifth, with a few exceptions, business models tailored to distributed solar have not yet been adopted in Egypt. Although grants and subsidized financing will be needed to kick-off the PV market, the development of an innovative business model for private investment is crucial for the sustainability of distributed solar in Egypt. Most solution providers suffer from insufficient "business development and implementation capacities" to identify and design profitable PV projects, attract clients, develop appropriate business models, and delivery of aftersales operations and maintenance support. Most companies act as equipment dealers rather than PV solutions and service providers.

Sixth, the institutional mechanism for periodic payments under the FIT is unclear to many. The distribution companies should pay the FIT to the project developer (credited to their bank account or by check). However, there is no clarity and adequate communication on the registration process and payment arrangements, which has driven several interviewees to be skeptical. Many private sector actors see the FIT as too risky due to the risk of non-payment or delayed payment by the distribution companies. These payment risks are seen as larger for smaller investors without immediate access to the government than for utility scale-investors.

Lastly, moving forward, there is a need for a better understanding of additional potential barriers not yet raised in the interviews. For on-grid applications, this includes understanding and resolving issues of roof rights and contract enforceability. For off-grid applications – in Egypt's case, the largest potential lies in replacing diesel powered pump sets with solar pumps – further analysis should look into whether agricultural pumps are mobile (i.e., used at multiple locations), whether theft of solar panels poses a threat, and the relevant water depths (pumps greater than 10 kW are difficult and unwieldy for solar pumps).

5. Conclusions and Recommendations

Egypt's growing energy needs, the gradual removal of subsidies, and its ambition to exploit its excellent solar resources create opportunities for investment in distributed solar. However, this paper found that the distributed solar market will remain a niche market in the next few years without government interventions. The distributed solar market could be largely self-sustaining once electricity and diesel subsidies are abolished, but with full subsidy removal still a few years away, growth in the market will remain limited under the current policy framework. In order to unlock the market, this paper suggests three policy priorities for the government.

First, for grid-connected distributed solar, the net metering scheme should be kept in place until a bankable feed-in tariff has been established—i.e., a FIT with regular revisions of the tariff level to account for movements in PV system costs and the exchange rate, and with payment security built into the mechanism. The net metering scheme is currently the most bankable policy for investors and should therefore be kept in place and, if possible, streamlined. Immediately available options to streamline the net metering scheme include developing a bankable standard template for the net metering contract between distribution companies and investors. Furthermore, the complicated method for 'netting out' sold and purchased electricity, which is imposing significant burden on distribution companies, should be revisited. However, in the longer term, net metering is less suitable for scaling up the small-scale on-grid market than a feed-in tariff. This is because (a) net metering does not allow the government to lower incentives once tariffs are above the levelized cost of distributed solar and (b) net metering by design favors richer consumers. However, a bankable FIT is not yet in sight. Therefore, the net metering should be kept in place until significant reforms to the FIT have been implemented and the reformed FIT has proven bankable for investors. These reforms are as follows. First, the feed-in tariff needs to be raised to reflect current cost and financing conditions. Second, the government needs to create a bankable payment mechanism that instills confidence in the market that the distribution companies will pay the tariff in full and in a timely manner. Options for payment securitization include guarantees from an external finance institution such as the IFC or World Bank and/or channeling the payments through a commercial bank rather than the distribution company.

Second, for off-grid solar applications, the government should pursue interventions to unlock market opportunities in the agricultural and tourism sectors. Three priorities for the government emerged from the consultations. First, to evaluate the potential for off-grid solar to replace diesel consumption in different applications. The off-grid market is more fragmented and data on potentials and the investment

case in different applications are patchy. Therefore, more analytical work is needed to underpin any policy intervention to promote off-grid applications. Second, to identify policy options for shifting the diesel subsidy savings towards financial incentives for off-grid users, such as tax incentives or customs exemptions for imported PV technologies. If financial support is to be provided to users directly, this support should take the form of performance-based payments in order to avoid that technologies sit idly or being resold on black markets. Third, to identify options for aggregating users, for example in the 1.5 Million Feddan Project or in poorer areas in Upper Egypt. Because off-grid solar applications are affected by policies of different government ministries, including the Ministry of Finance (for diesel subsidies), the Ministry of Petroleum, the Ministry of Agriculture and the Ministry of Tourism, any intervention should be coordinated between the relevant ministries.

Third, the government should strengthen private-sector activity in the sector, including by addressing non-financial barriers such as transaction costs and gaps in the availability of data, and by building capacity among users, suppliers, and financial institutions. The complexity and administrative procedures of any new policy incentive should be minimized to reduce transaction costs and broaden access to the scheme. The government should make easily accessible any data it has collected that could be useful to estimate the potential for distributed solar in Egypt and should continue doing so for any new analyses conducted in the future. Further, any future financial support by the government for distributed solar should be accompanied an awareness campaign targeted at end-users, distribution companies and other market participants, including banks. Furthermore, capacity building in the form of specialized trainings and certification schemes should be availed.

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Annex 1: Interviewed and consulted stakeholders

Sector institutions

- NREA/ MoERE
- SEDA
- ENCPC /MoTI
- ENCCC
- RCREEE

Clean Tech Entrepreneurs

- Sunergytech
- Solarize Egypt
- Elnour Geh
- IRSC, Cairo - Energy Management
- Jozour
- Dayra, Suez, Cairo, Minya - Waste to Energy
- Namaa Aswan - waste to handicrafts
- Tadweer
- Ashtechs
- Secret of the Earth (Ser el Ard), Qena
- Complete Energy Solutions
- KarmSolar
- Tiba Solar
- Solera

Clean Tech Ecosystems

- A2K4D
- Endeavor
- Clean Tech Arabia
- RiseUp
- CairoAngels
- AUC Vlab

- Nahdet El Mahrousa
- GESR
- RENAC / Oasis
- GIZ Business Innovation
- AUC Technology Transfer Office
- UNIDO
- UNDP

Financial and Legal Institutions

- Commercial International Bank (CIB)
- Social Fund for Development (SFD)
- Egyptian Private Equity Association (EPEA)
- Sharkawy & Sarhan Law Firm

Annex 2: Electricity tariffs in Egypt FY2016 and FY2017

Table 6: Electricity tariffs (variable charges only).

Categories of customers	FY2016			FY2017			Annual increase FY2016 to FY2017			
	Off-peak	Peak hours	Average	Off-peak	Peak hours	Average	Off-peak	Peak hours		
	<i>per kWh</i>									
Residential	0 – 50 kWh	7.5		1		46.7%				
	51 – 100 kWh	14.5		19.0		31.0%				
	0 – 200 kWh	16.0		21.5		34.4%				
	201 – 350 kWh	30.5		42.0		37.7%				
	351 – 650 kWh	40.5		55.0		35.8%				
	651 – 1,000 kWh	71.0		95.0		33.8%				
	> 1,000 kWh	84.0		n.a.		n.a.				
Commercial	0 – >1,000 kWh	n.a.		95.0		n.a.				
	0 – 100 kWh	32.0		35.0		9.4%				
	101 – 250 kWh	50.0		n.a.		n.a.				
	251 – 600 kWh	61.0		n.a.		n.a.				
	0 – 600 kWh	n.a.		69.0		n.a.				
	601 – 1,000 kWh	81.0		96.0		18.5%				
Extra High Voltage (EHV) 220, 132 kV	> 1,000 kWh	86.0		n.a.		11.6%				
	Energy-intensive industries	35.5	53.1	38.4	42.9	64.4	46.5	20.8%	21.3%	
	Other industries	23.7	35.6	25.7	38.7	58.1	41.9	63.3%	63.2%	
	Kima	4.7		n.a.		9.4		n.a.		100%
High Voltage (HV) 66, 33 kV	Metro	18.0		n.a.		30.3		n.a.		68.3%
	Energy-intensive industries	36.7	55	39.7	45.2	67.2	49.0	23.2%	22.2%	
	Other industries	25.6	38.4	27.7	41.1	61.7	44.6	60.1%	60.7%	
Medium Voltage (MV) 22, 11 kV	Metro	20.5		n.a.		32.0		n.a.		56.1%
	All users	37.5	56.2	40.6	48.0	72.0	52.0	28.0%	28.1%	
Low Voltage (LV) – 280, 380 V	Irrigation	22.0		n.a.		27.1		n.a.		23.2%
	Other users	43.5		n.a.		75.0		n.a.		72.4%
	Street lights	58.0		n.a.		64.4		n.a.		11.0%