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CASE STUDY

Potential of rooftop solar photovoltaics in the energy system evolution of the United Arab Emirates

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ABSTRACT

Solar power, and in particular solar photovoltaics (solar PV), is a rapidly growing source of energy in many regions of the world. However, the contribution of solar power in Middle East and North Africa (MENA) countries has been minor even though these countries possess some of the best levels of solar insolation globally. Recently, though, this has been changing. Changing hydrocarbon markets in the region, technology advances in solar PV and rapidly falling costs make solar power increasingly attractive to MENA countries that are actively diversifying their energy systems away from dependence on hydrocarbon fuel sources. Although utility-scale CSP and PV plants have been the focus through 2014, rooftop solar PV is being positioned to play potentially an important role in the United Arab Emirates (UAE)'s future energy mix. In this paper, rooftop solar PV in the UAE is taken as a case study for the evolution of a MENA energy system toward an increasingly sustainable power generation mix. The results show that rooftop solar PV can be an economically viable technology choice and hence will increasingly become part of regional energy strategies as technology costs continue to fall and tariff reforms continue to gain traction.

1. Introduction

In 2014, global investment in new renewable energy capacity reached USD 270 billion, representing 59% of net additions to global power capacity [1]. Solar power was the leading sector for investment, accounting for 55% of total new investment in non-hydro renewable energy. The majority of investment in the solar sector went to solar photovoltaics (solar PV), resulting in a cumulative global solar PV installed capacity of 177 GW [1]. Technology advances in solar PV and rapidly falling costs now make unsubsidized solar power economically viable in certain regions of the world. For example, solar power is now cost-effective in countries where electricity prices are high and for island nations where off-grid diesel engine generators are heavily utilized [2]. Solar PV is also increasingly attractive to Middle East and North Africa (MENA[2]) countries actively diversifying their energy systems away from dependence on fossil fuel sources for power generation and utility-scale solar PV has become cost competitive against conventional power generation in several MENA countries [3–5]. As a result, all MENA countries now having renewable energy targets for 2020 or later [6] and these targets place a priority on solar power. Utility-scale solar power supported by Power Purchase Agreements (PPAs) has been a primary focus throughout much of the region. Now, however, several MENA countries, including the United Arab Emirates (UAE), are additionally pursuing residential and commercial solar PV projects supported by policy frameworks such as feed-in-tariffs (FiTs) and net-metering [7].

In 2015, the United Arab Emirates made international headlines when Dubai Electricity and Water Authority (DEWA) and a consortium led by Saudi Arabia's ACWA Power signed a 25-year, utility-scale solar PV power purchase agreement to deliver electricity at a record low unsubsidized[3] tariff of USD 0.0584/kWh. In light of this very low price for

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2 MENA in this paper refers to Gulf Cooperation Council (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates), Levant countries (Iraq, Jordan, Lebanon, Palestinian Territories, and Syria) and North African countries (Algeria, Libya, Morocco, Egypt, and Tunisia).

3 An implicit subsidy may be part of the agreement if land and grid connection costs are borne by the Dubai government, as appears to be the case.

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solar power achieved in Dubai, the emirates of Abu Dhabi and Dubai plan to deploy more solar capacity, including distributed rooftop solar power as a significant component of their increasingly diversified future energy systems [8]. In this paper, the UAE's rooftop solar ambitions are considered from policy and cost perspectives. The analysis suggests that although utility-scale PV will likely be the dominant mode of solar deployment in the UAE, rooftop solar PV is becoming economically attractive in Dubai where the price of electricity is relatively high compared to most GCC countries. Furthermore, distributed rooftop solar PV is an increasingly attractive option for electricity and water authorities in the UAE and the region as it helps reduce peak electricity demand as well as transmission and distribution requirements while providing environmental, social, educational, energy security and broader economic benefits.

In the following sections, background on the UAE energy system is provided and followed by an assessment of policy frameworks and costs for rooftop solar PV in the UAE context.

2. Background

2.1. UAE electricity sector overview

2.1.1. Supply and demand

In 2014, the UAE generated approximately 117.6 TWh of electricity, which was less than the generation of Iran, Egypt and Saudi Arabia but sufficient for the UAE to rank fourth in electricity generation out of all MENA countries [9]. The UAE's electricity and energy system has been summarized elsewhere in detail [8,10–12]. In short, the UAE's rapid economic growth has strained the country's electricity supply capacity in recent years. Approximately 98% of UAE's electricity production capacity relies on natural gas as a feedstock and rapid growth in electricity production has been partly responsible for the UAE's current status as a net importer of natural gas. Although the UAE can presently meet most of its natural gas demand from low cost domestic gas production and imported gas from Qatar via the Dolphin Energy pipeline, there is an expected shortage of these inexpensive gas supply sources in the coming years [13]. The expected shortage is largely based on the UAE's projected electricity demand growth of more than 5% annually through 2020 [12,14].

The electricity grid in the UAE is serviced by four separate organizations that serve as both utilities and electricity authorities. The two largest, the Abu Dhabi Water and Electricity Authority (ADWEA) and the Dubai Electricity and Water Authority (DEWA), serve primarily Abu Dhabi and Dubai although ADWEA also supplies some amounts of electricity and water to the country's Northern Emirates. The UAE had a total installed generating capacity of 26 GW in 2011, of which 13.8 GW belonged to ADWEA, 8.7 GW to DEWA, 2.6 GW to Sharjah Electricity & Water Authority (SEWA) and the balance with the Federal Electricity and Water Authority (FEWA) [15]. The combined ADWEA and DEWA capacity has been projected to approach 40 GW by 2020 to meet increases in electricity demand in these rapidly growing emirates [12]. By 2020, nuclear power is expected to meet approximately 25% of Abu Dhabi's electricity demand [16] and the remainder of demand is expected to be met primarily by a mix of natural gas plants as well as smaller amounts of clean coal in Dubai, waste-to-energy, and renewable energy, mainly in the form of solar PV and solar CSP.

2.1.2. Electricity tariffs

Retail electricity tariffs in the UAE vary depending upon emirate, electricity consumption and customer type. The tariffs are set independently by each of the four electricity authorities and the tariffs in Abu Dhabi and Dubai are provided in Table 1 and Table 2. In general, tariffs in the UAE are low compared to the true cost of electricity production, transmission and distribution [17], although increases in Dubai have brought tariffs to cost-reflective levels for expatriates, and Abu Dhabi has increased its tariffs in 2015 to about half of cost. Low electricity tariffs have led to unsustainable levels of electricity demand that has put the UAE, as well as many other MENA countries, in a position where demand side management and new sources of power production, such as nuclear and renewables, are increasingly important [18].

2.1.3. Renewable energy

The UAE has taken a measured pace in the deployment of renewable energy technologies and several studies have been aimed at assessing the opportunities and required policy frameworks [8,11,19–23]. In 2013 the UAE had installed approximately 124 MW of solar capacity, the most significant of which is Shams 1, a 100 MW concentrated solar power plant in Abu Dhabi, and the first utility-scale solar power facility in the GCC. Table 3 provides a summary of the major solar deployments in the UAE as of 2013 and a summary of the UAE's smaller solar projects is provided by Mokri et al. [10].

Table 1
ADWEA standard electricity tariffs.

Customer type	Tariff rate ($/kWh)
UAE national residential	$0.014
Expat residential	$0.057
Commercial	$0.044
Industrial	$0.044
Farms	$0.044

Table 2
DEWA slab electricity tariffs, including fuel surcharges.

Electricity consumption (kWh/month)	Tariff rate ($/kWh)
Residential and commercial	
0–2000	$0.080
2001–4000	$0.094
4001–6000	$0.105
6001+	$0.121
Industrial	
0–10,000	$0.080
10,001+	$0.121

Abu Dhabi has set a renewable energy target of 7% of electricity generation capacity to be met by renewable energy sources by the year 2020 and the majority of this capacity is expected to come from solar technologies. Projections for Abu Dhabi's 2020 peak electricity demand tend to shift based on demand outlook updates. However, recent reports have suggest that the 7% target implies 460 MW of renewable power capacity in Abu Dhabi by 2020 [7]. The amount of capacity that is allocated to either PV or CSP depends on evolving costs of each technology and the need for dispatchable power, which only CSP with storage can currently provide.

Dubai's renewable energy targets were established in 2011 with the launch of Dubai's Integrated Energy Strategy 2030. By 2020 Dubai had planned to supply only 1% of electricity from renewable sources and 5% by 2030. However, the targets were increased in early 2015 to 7% and 15%, respectively, due in large part to the exceptionally low utility-scale solar PV tariff established in the emirate. The total expected renewable energy deployment in Dubai is now 3 GW by 2030 with the majority coming from solar energy [7].

3. Opportunities for rooftop solar in the UAE

Abu Dhabi has been exploring policy and deployment schemes for solar rooftop PV since 2008. Likewise, Dubai has indicated that rooftop solar PV is one of the pillars of its plans for meeting its renewable energy targets for 2020 and 2030. The UAE's push for rooftop solar PV is perhaps surprising given that the very low retail electricity prices in Abu Dhabi and, to a lesser extent, in Dubai (Tables 1 and 2) make electricity produced from solar power seemingly uncompetitive with electricity purchased directly from the grid. Regardless of electricity subsidization, however, the true cost of power generation in