for electricity and water are far less variable and that creates an imbalance between global cyclical shifts and local economic factors.
A decreased reliance on oil and gas means an increased resilience against such shocks, and hence a more stable economic planning environment for sustainable development. While global oil price fluctuations will still have a major impact on the UAE's GDP and government revenues, their impact on the country's domestic energy system is less significant. Since electricity generation and desalination no longer use oil, oil prices only indirectly affect electricity costs, through their link to gas prices (which can be oil-indexed). Nevertheless, the link is not insignificant, and a diversified mix which includes non-fossil sources will further increase the UAE's resilience to global oil and gas price changes.

It is desirable to reduce the exposure of the UAE's power sector to fuel price fluctuations through the use of renewables. Besides the advantage of falling costs for renewables, the absence of cyclical fuel price movements is often overlooked as being a major advantage in long-term energy policy. The certainty of renewable energy costs is a vital advantage over the uncertainty of constantly changing resource prices – for fuels such as gas, oil, and coal.

Given that we know the current technology cost of solar, we can forecast the exact electricity costs from today's power plants up to 2035. Plants have a 20–25 year lifespan over which there is no exposure to fuel costs which could go up or down. The 200 MW solar PV plant awarded in Dubai this year will produce electricity beyond the year 2030 at a rate specified today, without indexed fuel prices that could change over time. And for the power plants the UAE will build in the future, something similarly promising applies. Given that solar technology costs are still changing, we cannot forecast the exact price of new solar power plants, or of the electricity they will produce in 2020 or 2030. But we do know with great certainty that costs:

- will not be higher than today's;
- will very likely be lower by 2020; and
- will likely be much lower still by 2030.

So instead of seeking to foresee the future in the current policy decisions, by 'betting' on a certain gas, oil, or coal price being feasible, a diversified mix using renewables greatly enhances the prospects for smarter more reliable planning.

Conclusion

A shift in mind-set is needed towards seeing energy resources as valuable and limited, however abundant our remaining reserves are. For natural gas specifically the UAE, as a net importing country with growing production costs, can no longer think of natural gas as a cheap resource. Demand for gas is rising much faster than new reserves can be exploited; new reserves are more expensive; and LNG import costs are even higher. So, as we assess new options (such as nuclear, renewables, and energy efficiency) with this new economic reality in mind, many are now highly attractive, as is a shift towards using reverse osmosis desalination, which uses much less energy.

This trend is one that will affect many countries in the region. The UAE is unusual in having spotted this trend early and made major investments early on to develop alternatives. In that sense, it is establishing a model that will inform changes across the region. We are being helped in making this transition by rapid improvements in critical technologies such as solar PV and reverse osmosis desalination, neither of which was attractive in the Gulf region five to ten years ago, but both of which are now technologies of choice. But above all, we have benefited from strategic, long-term thinking at the highest levels, which has allowed us to build the capacities to participate in innovation as well as to make appropriate investments. This strategic thinking has put the UAE in a good position to benefit from the dynamic changes taking place in the energy sector.

**The opinions expressed in this article are those of the author alone and do not necessarily represent the views of the Ministry of Foreign Affairs.*

The new viability of solar power in the Middle East

Robin Mills

As another blazing summer in the Middle East approaches its zenith, the region's solar power industry is hotting up too. As it enters its second age, solar has reached the ignition point where it competes on economic viability alone. The first age of Middle East solar deployment was driven by small-scale pilots and some heavily subsidized larger projects such as Abu Dhabi's 100 MW concentrated solar power (CSP) plant Shams 1. However, the emphasis was more on grand vistas than concrete projects. Saudi Aramco's K.A.CARE

(King Abdullah City for Atomic and Renewable Energy) sketched a grand vision, or mirage, for 54 GW of renewable generation by 2032, including 16 GW of photovoltaics (PV) and 25 GW of solar thermal. From 2009, the Desertec Foundation sought to advance its dream of North African renewables supplying Europe. As reported in the *MENA Renewables Status Report*, every Middle East North Africa (MENA) country has developed a renewable energy target (though many remain aspirational). Having established Masdar, its clean energy vehicle, in 2006, Abu Dhabi successfully secured the headquarters of the International Renewable Energy Agency (IRENA) in June 2009.

But a period of slow progress followed as the economics of solar power were unconvincing in a region of cheap gas and subsidized electricity. The technical performance of concentrated solar thermal power was disappointing in the Gulf's hazy climate; state utilities were conservative in mind-set and governments dithered, or pursued confused and conflicting objectives. The Saudi programme, which had enticed many solar companies to establish a presence in the region, was the biggest disappointment. It became mired in turf wars, with K.A.CARE lacking resources or a mandate to pursue its vision, while the Saudi Electricity Company (SEC) and state oil giant Saudi Aramco later advanced their own renewables plans.

The second age

By contrast, the second age is driven by economics, not by environmental concerns or government fiat. It was foreshadowed in 2012 (see the report *Sunrise in the Desert: Solar becomes commercially viable in MENA*, by the author of this article) when it became clear that the falling cost of solar PV, low financing costs, and high oil and LNG prices would make solar PV economically viable under conditions in the Middle East. Fast-rising domestic power demand raised growing concerns that some countries, particularly Saudi Arabia, would eventually run short of oil for export.

Solar's regional promise became reality when, following the 13 MW first phase, the second (100 MW) phase of Dubai's Sheikh Mohammed Bin Rashid Al Maktoum Solar Park attracted a low bid of US¢5.98 per kilowatt hour (kWh) from Saudi Arabia's ACWA Power in November 2014. The second-placed bid was only slightly higher. Falling panel costs and cheap financing were key in facilitating ACWA's bids. ACWA also offered to build the whole 1,000 MW planned for the park at US¢5.4/kWh, betting on economies of scale and learning. Concerns about desert dust reducing the panels' performance have been eased by operational experience gained at Masdar's 10 MW and Dubai's 13 MW installations, with regular cleaning.

According to the Access Power MEA document 'Dubai Energy Outlook 2020', Dubai subsequently raised its 2030 renewable target from 5 per cent to 15 per cent, with its solar park eventually intended to reach 3 GW capacity, and plans to power half of its Expo 2020 (around 50 MW) with rooftop and building-integrated PV. From 2014, solar water heating has been mandatory on all new buildings. Abu Dhabi and Dubai have both proposed rooftop solar schemes (Abu Dhabi's of 500 MW), with installation standards and net metering.

'DUBAI'S SUCCESS HAS CAPTURED HEADLINES AND SPURRED GREATER INTEREST ACROSS THE REGION.'

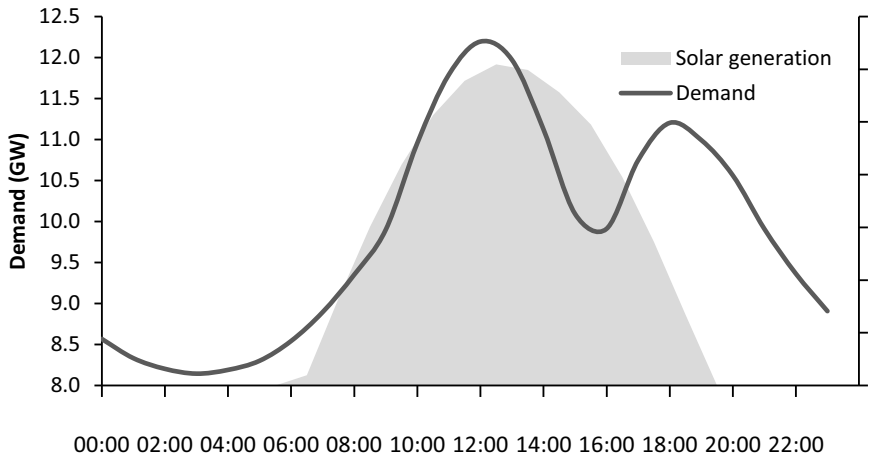
Dubai's success has captured headlines and spurred greater interest across the region. Some of its fuel-importing neighbours have already begun serious investments in solar power and other renewables such as wind.

In November 2014, Egypt announced plans for 2000 MW of utility-scale PV and 300 MW of rooftop PV, supported by a feed-in tariff scheme and concessionary bank financing. (The country has been struggling with gas and power shortages that have turned it into an LNG importer.) The second round of Jordan's solar power tender, totalling 200 MW, saw a low bid of US¢6.13/kWh, with a target of 600 MW by 2020. Morocco has been capitalizing on exceptional conditions for concentrated solar power, with a target of 2000 MW by 2020. Algeria has a feed-in tariff scheme and an 800 MW target by 2020, while Iran plans 5000 MW of solar and wind power by 2018. According to the MESIA (Middle East Solar Industry Association) website, Saudi Arabia is building two integrated combined-cycle gas-fired plants with supplementary solar power, and envisages around 6 GW of PV to 2025, while there are some small PV projects in Qatar, Kuwait, Oman, Lebanon, Mauritania, and Sudan.

Security concerns are also supplementing pure cost considerations, particularly in Jordan, which was plunged into an energy crisis by repeated bombings of the pipeline bringing gas from Egypt, following the 2011 revolution there. Residents and industries in countries plagued by power cuts, such as Egypt, Lebanon, and Iraq, might consider solar power for reliable supply.

New economic viability

This author has calculated that the power purchase price in ACWA's Dubai contract is equivalent to a combined-cycle gas turbine burning gas priced around US$2.7 per million British thermal units (MMBtu) or oil at



Typical summer demand versus solar generation for a Gulf market

around US$16/barrel. Though Dubai has access to low-priced gas from Abu Dhabi and Qatar, it has to supplement this with LNG, costing around US$8/MMBtu, even after recent price falls. Just as a fuel-saver, combined with gas-fired back-up, solar PV is therefore attractive. And at least at moderate penetration levels (up to 10–20 per cent of total capacity), insolation levels in the area match well with regional demand patterns, since air-conditioning represents some 65–70 per cent of total electricity demand during the Gulf summer months, as shown for an illustrative day in the figure above.

In the region, Kuwait, Jordan, and Egypt also import LNG; Bahrain, the UAE emirate of Fujairah, and Morocco may join them. Large quantities of oil are burnt by Kuwait, Saudi Arabia, Iran, and Iraq for power. Even those states which remain sizeable gas exporters – such as Abu Dhabi, Oman, and Algeria – are struggling to keep up with domestic demand, losing them exports at international-parity prices. According to research published by IHS ('Occidental Wins ConocoPhillips's Abandoned Shah Sour Gas Project in Abu Dhabi') on 20 January 2011, new domestic gas resources are more costly: sour gas in Abu Dhabi with production costs estimated at US$5–6/MMBtu; deep offshore and shale gas with top prices of US$5.65–5.88/MMBtu in Egypt; deep, tight, and sour gas in north Kuwait; tight gas in Oman; and tight and shale gas in Saudi Arabia and Algeria. Indeed, in the whole region, only Qatar continues to have access to abundant low-priced domestic gas. And though nuclear ought to provide reliable baseload power, this author concludes that likely generation costs for the UAE's new reactors are above US¢10 cents/kWh.

It may be argued that subsidized energy in the region makes solar power apparently unviable. This is true from the point of view of a residential consumer considering rooftop solar panels. But considered holistically, governments and utilities should seek the lowest-cost generation mix, even if they continue to subsidize the end-consumer.

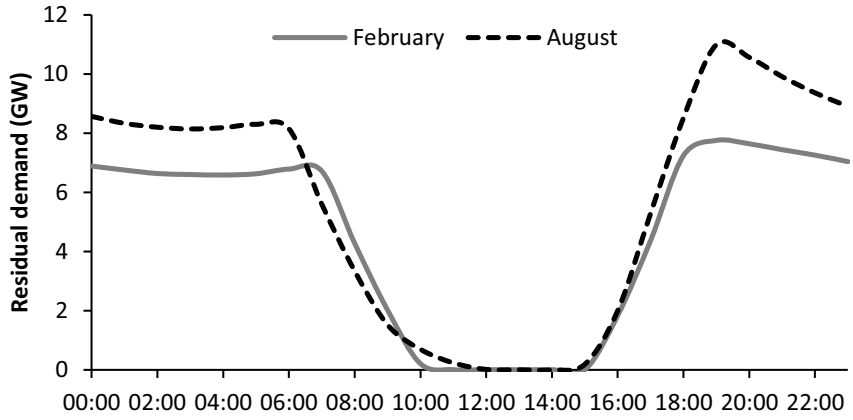
Abu Dhabi's and Dubai's rooftop solar PV schemes do not feature feed-in tariffs or similar support mechanisms. According to a *Gulf News* article ('Abu Dhabi revises water and electricity tariff') from 1 January 2015, Abu Dhabi's electricity prices remain heavily subsidized at around half of cost, while (as will be argued in a forthcoming issue of *Energy Strategy Reviews* by Steve Griffiths and Robin Mills) even in Dubai, rooftop solar PV would only be economically attractive for a heavy consumer such as an industrial site. However, with continuing falls in PV costs, residential rooftop solar in Dubai could be commercial without subsidies by the early 2020s.

Niche solar technologies may also play a role and, as can be seen on its website in an article from January 2013, 'Masdar Launches Renewable Energy Desalination Program', Masdar has a programme investigating solar desalination, with the goal of a commercial-scale plant by 2020. Storage of desalinated water can help match solar generation to demand through the seasons. Reliable and low-cost direct solar-driven cooling could represent a breakthrough for residential customers, given the heavy use of air-conditioning.

On a larger scale, GlassPoint has agreed to construct a 1021 MW equivalent solar thermal plant in Oman to provide steam for enhanced oil recovery (EOR) at the Amal heavy oil field, saving about 15 million cubic feet per day of gas. GlassPoint estimates its break-even at US$5–7/MMBtu, comparable to costs for more expensive Gulf gas fields (see the Rigzone article 'GlassPoint to Build Solar EOR Facility to Boost Oil Output at Oman Field' by Karen Boman dated 14 July 2015).

The falling oil price may have raised some questions as to whether solar power's new competitiveness would endure. Lower hydrocarbon prices are clearly an overall negative for Middle East solar power: less economic growth should calm the rampant advance of electricity demand, reduced oil revenues mean smaller budgets for pet projects, EOR projects are less attractive, while energy importers such as Dubai, Jordan, Egypt, and Morocco are enjoying more moderate bills.

On the other hand, slumping oil earnings are driving governments to look for savings, and to cut energy subsidies. As noted, solar PV is now sufficiently cheap to undercut oil, imported LNG, and higher-cost domestic gas, even at today's distressed prices. And, of course, lower oil prices naturally turn regional governments' attention to a future when their economies can no longer depend on hydrocarbon revenues alone.



Residual demand

Cautions and challenges

At the same time, it is important not to exaggerate the impact of Middle East solar power. The installed capacity today, and over the next few years, is still tiny in comparison to fossil-fuelled capacity, and even to Abu Dhabi's under-construction 5.6 GW of nuclear power.

'THE INSTALLED CAPACITY TODAY, AND OVER THE NEXT FEW YEARS, IS STILL TINY IN COMPARISON TO FOSSIL-FUELLED CAPACITY …'

Abu Dhabi and Dubai both have a target to have renewables, mostly solar, representing 7 per cent of electricity generation capacity by 2020, or around 2250 MW between them. But this would only save around 90 million cubic feet of gas per day, compared to total UAE consumption of 6.7 billion cubic feet daily in 2014. Meanwhile K.A.CARE's vast, and now unlikely, solar ambition for Saudi Arabia (in excess of Germany's entire current installed capacity) would have replaced about 2 Bcf/day of gas or 360,000 barrels/day of oil. This major contribution still has to be seen in the context of about 800,000 barrels/day of oil and 3.8 Bcf/day of gas burnt for power alone in 2012 (according to the International Energy Agency), and a demand for electricity expected to double by 2030 – from about 58 GW today to 120 GW (according to the 2014 annual reports of the Saudi Electricity Company and the Energy and Co-generation Regulatory Authority).

For solar power to take a dominant role in generation into the 2030s and beyond, it would need to address issues of its fit to demand patterns, and of integration with other generation sources. The figure above shows an illustration of residual electricity demand for a city with similar demand patterns and generation patterns to Dubai, with sufficient installed solar PV to cover peak demand in August (the highest-demand month). It can be seen that this would also cover daytime demand in February (the lowest-demand month) as lower insolation is more than compensated by the much lower demand, given reduced use of air-conditioning. But in both February and, particularly, August, there is a pronounced early evening residual peak, as the sun sets but demand rises as people return home from work.

Therefore even this extreme level of solar penetration would only cover about 40 per cent of annual demand. Increases beyond this level would require some combination of flexible generation, probably gas-fired; energy storage, whether by batteries or thermal methods; concentrated solar power with storage; electricity trading with other regions; and demand management.

So, for all the promise of solar power, truly heroic amounts will have to be installed to make an impression on the region's rampant hydrocarbon consumption. Solar will have to be part of a holistic energy policy which would include other renewables (waste, wind in the right locations, and perhaps geothermal), unconventional gas, nuclear power, and major improvements in energy efficiency, driven by the removal of subsidies.

These are questions for the next couple of decades. For now, given the new viability of solar photovoltaics, the laggards should awaken to its potential and make MENA one of the most attractive and fastest-growing markets globally, by driving costs down and building more large-scale projects. The region as a whole needs the white heat of solar technology for its energy and economic future.