potential for providing the all-important energy storage on an economic basis than PV (heat storage being much cheaper than electricity storage in batteries). Shouldn't the developed world spend its climate change mitigation subsidies in the region with the best solar resource in the world? That should be the cheapest way of reducing the cost of solar energy for the world.

And Europe could do this because it cares about political stability and economic prosperity in MENA – close to home – and knows that job creation through market access, and the related trade and investment, will be cheapest and most effective for the product in which MENA has the most obvious global comparative advantage – solar energy.

Would solar energy megawatts actually create backward linkages into local manufacturing and employment?

A number of studies have shown positive results on the potential for a solar construction, manufacturing, and services industry in MENA if there is investment in sufficient megawatts to induce it. This is particularly the case for concentrated solar power, given that technology's very low level of intellectual property rights (typically less than ten per cent of the cost base being protected by IPR) and the existing industrial base in MENA (glass, cable, and steel manufacturers being present in some countries, together with engineers and a skilled construction sector, among other factors). It will be largely a question of the scale of megawatts in the region driving economies of scale in manufacturing in the region, possibly supplemented by government incentives or requirements for local content. Exports to Europe could drive those megawatts up fast, and with them substantial jobs in MENA could be created; this can only reinforce stability in the region. A stability that is clearly desirable from the point of view of Europe too.

Diversifying the energy mix in the heart of the oil world

Thani Al Zeyoudi*

The economy of the United Arab Emirates achieved great prominence through decades of economic development driven by hydrocarbon exploration, production, and exports. In the past decade, however, a pathway of diversification – of both its economy and its energy sector – together with the clear recognition of sustainable development goals, have become increasingly significant. This is apparent not only in the physical changes to infrastructure and the numerous policy and regulatory changes, but also in the increased academic attention and use of the UAE as a regional example for renewables, energy efficiency, and active participation in international efforts to tackle climate change.

But why change the fuel mix? Why diversify away from natural gas as the primary energy supplier and crude oil as the primary economic driver? Besides addressing these questions in the context of recent developments, this article will also attempt to go a step further, beyond the seemingly apparent responses relating to '**why**'. It will aim to provide insights into the '**how**' – how the UAE actually needs to be, and to some degree already is, looking at the issue concerned.

What constrains this ambition and how can 'optimization' be approached? The need for a more holistic policy appreciation of 'energy' will be highlighted – covering both demand and supply together with its various uses across electricity, water, heating, and cooling – as opposed to high level 'energy policy' alone.

This article will also point out the flaws inherent in one-off planning, target setting, and execution, due to the constant change being undergone in the UAE. Finally, it will provide a proposal of how optimization of the UAE energy mix can be accomplished, given these inherent constraints. Greatly simplified for the purposes of this article, this argument nevertheless aims to provide both practical guidance to future policy-makers and context for future research and academic engagement with the regional energy agenda.

Why does a gas-rich country seek to diversify the fuel mix?

The United Arab Emirates remains amongst the ten largest oil and natural gas producers in the world. From driving over 90 per cent of Gross Domestic Product (GDP) in the 1970s, crude oil today is providing for just under half of the UAE's economic output, with sectors such as real estate, financial services, and tourism taking larger and larger shares. This economic diversification has often centred on the concept of cheap, plentiful energy. However, for natural gas that is no longer the case. Demand has risen much faster than new reserves can be exploited. Furthermore, new reserves are higher in sulphur ('sour') and therefore more expensive to produce; imports, in the form of liquefied natural gas (LNG), are thus likely to remain high.

This actually contradicts the overall image many international stakeholders have of the UAE as a 'major oil and gas nation'. While it is true that the UAE has plenty of domestic reserves and is also a viable exporter, it actually became a net gas importer in 2009 – meaning that more gas has been imported than exported since then.

This means that we need to assess new options such as nuclear, renewables, and energy efficiency – not against traditional gas production prices in the UAE, but against new domestic production cost and the price of LNG imports. By this metric, a number of gas alternatives are now highly competitive.

The power sector, dependent on gas for nearly 100 per cent of its electricity generation, is hence seeing stark structural change in relation to this trend. A nuclear programme is underway and ambitious solar developments continue to be deployed across the UAE following a first 'wave' of interest in Abu Dhabi through Masdar. By 2018, what was once a single-fuel system will have become a diversified mix with sizeable nuclear and solar components and a far reduced reliance on natural gas. By 2021, 24 per cent of energy will come from clean sources (defined as nuclear and renewables), a goal directly embedded in the highest federal 'Key Performance Indicators' (KPIs) through the UAE Federal Vision 2021, set by the prime minister and endorsed by federal ministries. In some Emirates, plans for renewable energy alone have been increased to as much as 15 per cent by 2030, up from a near-zero base in 2010. (Dubai's Integrated Energy Strategy 2030 was updated in January 2015, raising the targeted renewables share to 7 per cent by 2020 and to 15 per cent by 2030 – up from previous figures of 1 per cent in 2020 and 5 per cent in 2030 – following faster than expected decreases in solar costs.)

How can diversification be managed in a constantly changing world?

Affirming the feasibility of diversification is useful, but not sufficient for policymakers. The 'why' outlined above is reassuring in relation to current policy, and explanatory for those new to the subject – but it is not sufficient to provide an explanation that would enable UAE policymakers and international analysts to understand and address the actual energy policy challenge in the country. In an attempt to add to this understanding, this section seeks to broaden the discussion and to address the 'how' in UAE energy policy.

Firstly, 'energy' policy is, and should be, a broader issue than 'just' electricity. Energy fuels the economy in multiple applications and in many forms. Citizens and consumers don't want 'energy', they want such things as electricity, water, cooling, and transport; policy must hence recognize how such differentiated end uses are linked and the way in which they rely on interdependent policy choices. 'Energy', besides providing amenities such as those just listed, also fuels the economy in another way – it is an economic sector in its own right, generating added value towards the country's GDP, providing employment, requiring investment for infrastructure, and opening opportunities for research and development.

Secondly, the world of 'energy' is in a state of constant flux. Creating and maintaining resilience against adverse shocks and creating the flexibility to adapt and to exploit opportunities as they arise is more important than setting a target for the 'optimal' fuel at any one time. Technologies evolve and as a result prices change; geopolitics and global market dynamics also change constantly, which again affects resource prices, while demand itself continues to grow at an unprecedented pace. Natural gas, for example, was deemed a low-cost resource just five years ago, sometimes below US$2/MMBtu. Today it is being imported as LNG, which costs more than US$15/MMBtu at times.

Global crude oil prices fell 60 per cent between June 2014 and January 2015, recovered 34 per cent in February, and fallen 20 per cent again since then. This has a major link to UAE government revenue, as well as having an impact on transportation fuels and lubricants. Constant change, and often cyclical trends, are common in both oil and gas markets – yet energy policy needs to create a stable, predictable environment for economic planners, businesses, and customers.

'BY 2021, 24 PER CENT OF ENERGY WILL COME FROM CLEAN SOURCES (DEFINED AS NUCLEAR AND RENEWABLES) …'

Renewable energy prices, on the other hand, have only become dramatically cheaper. The cost of solar technology, and that of the resulting renewable electricity, has fallen over 80 per cent in the past few years. In other words, for the investment needed in 2007 for a 100 megawatt (MW) solar photovoltaic power plant, one can now get up to 500 MW, and the resulting cost of electricity is cheaper than gas-fired power in many cases. Energy policymakers observing this trend were delighted, but at the same time troubled, by the thought of how much further it might drop – should their policies target solar at scale now, or wait longer for even lower prices?

To be successful in the long run in light of constant change, UAE energy policy needs to be holistic, bold, and strategic.

'Holistic' energy policy is needed to address the multifaceted use of energy

The recognition that 'energy' is obviously a much broader issue than just electricity (outlined above) introduces a level of complexity sometimes overlooked in energy policy, or conveniently ignored in discussions. But it is critically important to appreciate the complexity of the entire energy system: from primary sources (crude oil, natural gas, coal, renewable resources), through the many transformation methods (such as refining, electricity generation, and storage), to the varied forms of energy consumption (for example: transport, desalination, heating, cooling, and electrical devices). They are all linked – and linked to wider economic and trade policy. A policy that incentivizes cleaner transport, for example, through natural gas vehicles and highly efficient engines, has repercussions on gas export or imports and on refining sector demand. Equally, a policy which introduces new electricity generation sources (such as nuclear or renewables) has repercussions on water production planning as well as on storage, when added to the current system of water and power co-generation from gas. Equally, the question of whether to delay support policy for renewables or invest now can be easily answered – as soon as renewables are cheaper than another given option to be considered (such as LNG imports), scaling up investment already makes good economic sense – even if further cost reductions might be expected.

UAE energy policy hence should be, and is being, pursued in a holistic fashion at a system level – across sectors, use types, and jurisdictions:

- The various *consumer* types (including domestic, commercial, government, and industry segments) need to be addressed, together with their current and future needs. Both the individual demand profiles and growth trends of each group play a major role in holistic energy planning.
- The various *use types* (such as cooling, water generation, industrial heat, transportation, and general electricity), their technological evolution and interrelationships should be considered. In particular, where technology change introduces new requirements (water generation complementing nuclear generation) or presents new opportunities (efficient, electric reverse osmosis desalination), new planning approaches are needed.
- The varied set of *policy-relevant institutions* across the UAE's jurisdictions needs to be taken into account for holistic energy policy. This includes both the relationship between federal UAE-wide policymaking, and emirate-level plans, as well as the difference between each emirate in terms of resource endowments, investment climate, and consumption profiles.

Of course, such an integrated, holistic approach is easy to prescribe on paper or in academic theory, but is far more difficult to put into practice. While much remains to be done, the directional signals for policymaking in the UAE are clear. The need for a holistic approach has been recognized and is apparent in current policy. Examples include the UAE Green Growth Strategy, the 2030 energy policy taskforce from across the UAE's jurisdictions, and Dubai's Integrated Energy Strategy 2030.

'Bold' policy and investment decisions to meet fast-paced demand growth

This is dictated by the simple pace of development, with population (and hence demand) growing at unprecedented levels. 'Wait and see' is not a viable option, as within years the lights would go out, water resources would dwindle, and the economy would suffer – this is clearly recognized in current UAE policy. As is the case with general infrastructure investments in the UAE, the energy sector evolves quickly with bold steps aimed at bringing about change at the necessary scale and pace. Examples range from the UAE Policy on the Peaceful Use of Nuclear Energy, to tariff and subsidy reforms for water, electricity, and transport fuels, to the pioneering, early regional efforts into renewable energy which have triggered the scaling-up of renewables in parallel with expected cost reductions in the UAE (and beyond).

We are unable to shy away from bold infrastructure plans and technology investments; hence we are seeing drastic advances which are moving the energy system towards a holistic and fundamentally transformed outcome by 2030. This will include nuclear, renewables, district cooling, green efficient buildings, and integrated public transport, to name but a few aspects. Few observers, just ten years ago, would have foreseen such a wide-ranging scope of change in such a short period of time.

'Strategic' energy policy to enable flexibility to react to global change

Energy policy in the Middle East today is not about picking the right horse in a race with one winner – it is about picking the right set of choices with the broadest possible set of options in a diversified future. Flexibility and resilience are needed – and current policy choices aim to provide just that.

It is necessary to diversify the system to create resilience against future global oil and gas price fluctuations. The price of oil decreased by 65 per cent in 2014/15, while gas prices increased to US$6–10/MMBtu (at times US$15–18/MMBtu) compared to a price of US$1–3/MMBtu until recently. Prices

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