



MENA nuclear plans stalled as challenges begin to surface

Rising electricity demand has prompted several MENA states to turn towards nuclear power to diversify their sources of energy and reduce their carbon footprint. The Barakah nuclear plant in the UAE and the Bushehr plant in Iran are currently under execution whilst projects in Egypt, Jordan and Saudi Arabia remain at the planning phase. Licensing and training to operate the plants has been one of the main causes for delays in the UAE, whilst fiscal constraints have prompted the likes of Saudi Arabia and Jordan to consider small modular reactors (SMRs). By 2030, MENA is expected to have added 15.8GW of nuclear capacity. Whilst this would represent less than 5% of today's total capacity, it would be a quantum leap from the 1GW currently generated by Iran and more generally would represent a step change in the region's energy mix.

Rapid annual increases in electricity demand, in tandem with continuing demographic growth, has prompted a number of MENA states to consider alternative sources of energy, including nuclear. For countries in the GCC, nuclear power can free up more oil and gas for exports, while net-importing countries like Egypt and Jordan will be able to diversify their energy sources, enhance energy security and reduce their expensive import bills. Nuclear plants are expensive to build due to high upfront capital costs, but are cheaper to operate over their lifetime because fuel costs are lower and there is no requirement for carbon capture. At present, 2.4GW of nuclear power facilities in MENA are complete - of which only 1GW is operational, 5.4GW are under construction and a further 8GW are planned by 2030.

Nuclear power has been attractive for several reasons. First, cost competitiveness has improved over the past decade, presenting the region with an opportunity to incorporate nuclear energy as a viable baseload alternative within the energy mix, enhance energy security and reduce dependence on a single source of energy. Second, it promotes employment in a new energy sector and can advance human capital. Third, nuclear plants emit less greenhouse gases and help reduce the region's carbon footprint.

But development of the nuclear sector will be both complex and expensive. At a time where government budgets are constrained, countries considering nuclear will need to find funding, attract human capital and put in place appropriate regulatory frameworks. Given heightened geopolitical tensions in the region, governments will need to prove to the global community the peaceful intentions of their nuclear programmes as well as ensure public acceptance.

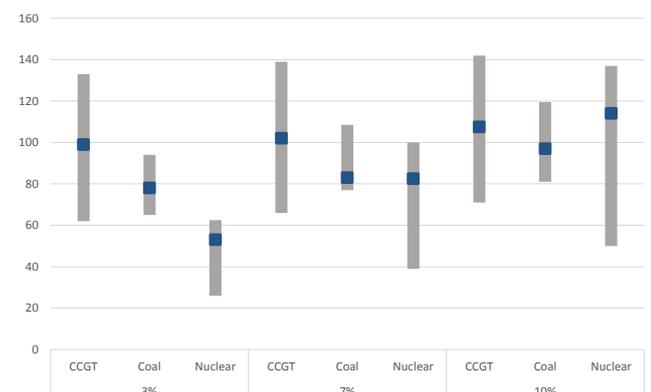
Over the years, the challenges of nuclear power have been increasingly recognised. The region is not fully equipped with the right knowledge and expertise to undertake full operation of nuclear plants - signified by delays in commissioning the Barakah nuclear plant in the UAE. Dependence on Russia to develop and, in certain instances to support the financing of nuclear projects in MENA countries, leaves the region exposed

to a single supplier. Huge capital costs are leading the likes of Jordan and Saudi Arabia to consider small-scale alternatives that are more costly to build per kilowatt of electricity (KWe). Meanwhile renewed sanctions on Iran will overall slow the momentum on nuclear energy deployment within MENA.

Nuclear can be cost competitive

Nuclear projects require substantial upfront capital but exhibit lower operational and fuel costs over their lifetime - typically over 50 years. Upfront capital ranges from \$3-6bn/GW of installed capacity, more than double the cost of equivalent coal or gas-fired plants. Investment decisions are therefore heavily dependent on the availability of finance and government support.

Global average LCOE for baseload technologies (\$/MWh)



Sources: IEA, NEA

Despite the upfront costs, nuclear can be competitive against other sources of baseload technologies. Levelised Cost of Electricity (LCOE) of nuclear increases at higher discount rates, given nuclear is capital intensive. At a discount rate of 3%, nuclear is more competitive than coal and gas. At 7%, nuclear remains competitive and only at 10%, nuclear becomes less attractive. This however is not the case for SMRs, as costs are likely to be 50-100% higher than the typically larger-scale reactors. On the other hand, economies of scale from

manufacturers coupled with lower investment costs and shorter construction times, could reduce capital costs and make them competitive.

While nuclear is often seen as a source of long-term supply, this is contingent on the ability to secure large stocks of uranium. Currently, only four countries in MENA have proven uranium reserves. But, at an average global price of \$68/kg this year, production in the region remains uneconomical. Therefore, countries considering nuclear will have to rely on uranium supplies coming largely from outside the region.

Identified recoverable Uranium reserves – tonnes

\$/kgU	< 40	40 - < 80	80 - < 130	130 - < 260
Algeria	-	-	-	19,500
Egypt	-	-	-	1,900
Iran	-	-	3,900	-
Jordan	-	-	47,700	-
Other Countries				
China	98,900	107,400	66,200	-
Russia	-	47,700	460,100	187,400

Source: NEA, IAEA

UAE caution leading GCC diversification

As the only GCC state with nuclear plants under construction, the UAE nuclear programme has been dubbed a model for nuclear newcomers. Cooperation with the likes of the International Atomic Energy Agency (IAEA) provided the UAE with detailed guidance for developing the infrastructure needed for a nuclear power programme. The Emirates Nuclear Energy Corporation (ENEC) was set up to implement the UAE nuclear energy programme. Abu Dhabi agreed to forgo domestic enrichment, and will instead source its nuclear fuel from South Korea as well as companies from France, Russia and the US. It is also examining different scenarios for dealing with the nuclear waste, including developing its own storage sites or sending waste abroad for processing and bringing back small volumes to the UAE.

Korea Electric Power Corporation is building four 1.4GW nuclear power plants at Barakah at an initial cost of \$20bn with an additional \$20bn for the operation of the plants during their 60-year lifetime. The construction of the first unit began in 2012, and ENEC announced its completion in May 2017. While the expectation was for the plant to begin production immediately, licensing delays and training hold-ups pushed the start-up for mid-2018. The UAE's Federal Authority for Nuclear Regulation (FANR) is reluctant to award the operating license to Nawah energy – the company formed by ENEC and KEPCO to operate the plants - due to the limited experience the intended operators have in observing the operation of such a plant. Nawah has since announced that fuel rods for the first of the plants will not be loaded into the reactor before 2020, with electricity from the plant only reaching the grid later that year. The cost of the project has since increased to \$24.4bn.

The construction of the second reactor is also nearing completion, with ENEC completing pre-operational testing, whilst the third and fourth reactors are more than half way through. The aim was to have a reactor come on line each year until 2020, but this is likely to be pushed back to 2021. Once all four reactors

are operating, they are expected to contribute about 25% of the UAE's non-hydrocarbon energy mix and 6% of total capacity by 2050. Over the coming decades, the UAE hopes to add a further 14.4GW of nuclear capacity, as the government aims for renewables and nuclear to fuel 50% of its power generation by 2050, but no firm plans have yet been announced.

Iran hopeful despite looming sanctions

Iran remains the only country in the Middle East to have a nuclear plant connected to the national grid. Commissioned in 2011, the Bushehr 1 plant reached total capacity of 1GW by August 2012 – nearly 20 years after the initial agreement between Tehran and Moscow was signed. But this still represents only 1% of Iran's total power generation capacity.

Following the lifting of Iranian sanctions in 2016, plans for further nuclear capacity were revived, with the next two phases of the project estimated to cost in excess of \$10bn. The Atomic Energy Organisation of Iran awarded Russia's Atomstroyexport the contracts for both Bushehr 2 and Bushehr 3 in November 2016 under a Build Operate Transfer (BOT) model. Combined the plants will add a further 2.1GW of capacity and are expected to be commissioned in 2024 and 2026 respectively.

Iran and the European Commission launched their first nuclear safety cooperation project worth €2.5m in July 2017. The project will span more than three years; originally set up to enhance the capability of the Iranian Nuclear Regulatory Authority, it will help establish a legal and regulatory framework in line with international standards and set up a Nuclear Safety Centre. It was initially designed to attract European investment, but the recent decision by the US to re-impose sanctions on Iran will likely hinder investments, despite reassurance from the remaining members of the Joint Comprehensive Plan of Action to abide by the signed agreement. Discussions in 2016 with Rosatom for another 4GW and an additional 2GW worth \$10bn with China announced during President Xi's visit to Iran are now less likely to materialise.

Saudi Arabia adopting pragmatic approach

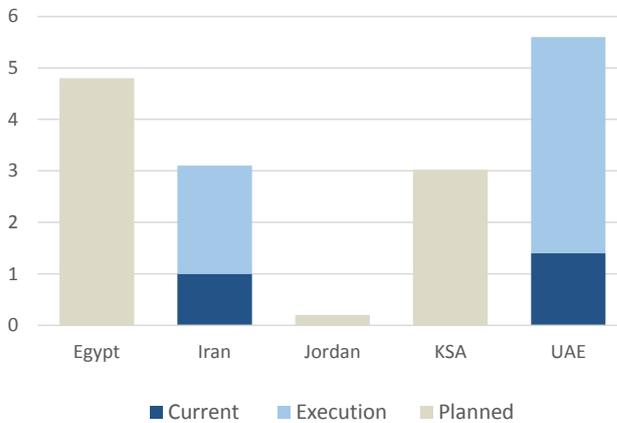
Economic growth, rising populations and sustained periods of low energy prices propelled high power demand growth in Saudi Arabia. The King Abdullah City for Atomic and Renewable Energy Care (KACARE) was established in 2010 to develop renewable and nuclear energy for the country. The kingdom's initial nuclear plan aimed to produce 18GW of power by 2032, but the announcement of the Saudi 2030 Vision revised down these plans. Increases in energy prices at the start of 2018 drove residential electricity prices up by 250%, which according to our estimates will slow annual demand growth to between 1.5-2% over the next five years.

Saudi Arabia plans to award a contract for the construction of its first 2.8GW nuclear facility by the end of 2018, though delays cannot be ruled out. KACARE has announced Russia's Rosatom, France's EDF, China's CNNC, Korea's Kepco and US firm Westinghouse amongst those expected to carry out engineering, procurement and construction work on two nuclear reactors. Initially, the kingdom had identified 17 potential sites, nine of which were along the Red Sea. Since then, they have shortlisted Umm Huwayd and Khor Duweihin, both of which are along the Arabian Gulf near the UAE and Qatari borders. In addition, as part of its 2030 vision to develop the kingdom's

mining sector, Saudi Arabia is seeking to launch a programme to mine uranium needed to fuel the country's nuclear plants.

In addition to large-scale nuclear plants, Saudi Arabia plans to develop SMART (system-integrated Modular Advanced Reactor) facilities that would deliver electricity from smaller scale nuclear reactors throughout the kingdom. KACARE signed a Memorandum of Understanding (MoU) with South Korea back in 2016 to develop the technology, with Saudi Arabia owning a percentage of the intellectual property. KACARE is aiming to award the first two SMART reactors, each boasting a capacity of 100MW in 2020 to be commissioned by 2024. However, these targets seem unrealistic, given problems historically associated with SMRs including the relatively smaller market for the technology, the higher cost of electricity and the need to locate multiple sites suitable for the reactors.

MENA nuclear programmes by 2030 (GW)



Source: APICORP Research

Huge capital costs creating much uncertainty

Jordan's Committee for Nuclear Strategy, established in 2007, envisaged nuclear power providing as much as 30% of the kingdom's electricity needs by 2030. With this in mind, the Jordan Atomic Energy Commission (JAEC) and the Jordan Nuclear Regulatory Commission (JNRC) were also set up. In 2014, JAEC chose Russia's Rosatom to develop the first nuclear project, comprising two 1GW plants in Qusayr Amra located 70km southeast of Amman at a cost of \$10bn. But Jordan's inability to secure the funding, together with an insufficient water supply for cooling has led them to focus instead on building a small modular reactor (SMR). This technology is particularly attractive for Jordan, as the lower power levels of SMRs make it more suitable for the country's smaller electrical grid.

JAEC has signed a project development agreement with Rosatom for a two-unit SMR plant at Amra to be completed by 2022. The expected \$1bn project would supply Jordan with 220MW and can be used as a desalination and heating plant, but will not come without its challenges. The capacity is significantly less than the initially planned 2GW plant, which would only supply 10% of the additional power generation Jordan needs to add to meet electricity demand in 2022. Furthermore, the estimated cost remains highly uncertain, whilst the technology itself is unproven. Nuclear plants are very capital intensive, and with the cost of solar energy already lower than nuclear and continuing to go down, prospects for further SMR remain bleak.

Russian involvement extends to North Africa. In July 2018, Egypt announced that construction of its first nuclear power plant would begin in 2020. In 2015, Russia signed an agreement with Egypt for the construction of four 1.2GW at Dabaa in the Nile Delta. The \$25bn project is slated for 2026, with Russia extending a 35-year soft loan for 85% of the cost and Egypt funding the remaining 15%.

Rosatom is involved to a greater or lesser extent in four of the five MENA nuclear or would-be nuclear power-producing states. Only the UAE is relying exclusively on South Korean companies to construct its nuclear plants. In late 2014, the Russian state firm also agreed to construct a 1GW plant in Algeria, as well as train Algerians and facilitate the activities of the Algerian Nuclear Engineering Institute. In Tunisia, Rosatom also signed a MoU in 2014 to support the development of nuclear energy infrastructure with the possibilities for a 600-1000MW plant. Unfortunately, though, plans in both countries have since been cancelled.

Challenges cloud outlook

Rising domestic demand in the MENA region and pressure to fall into line with global standards to tackle climate change could boost nuclear development. But financial, technical and political problems have begun to surface, causing delays. Despite recovering oil prices, countries looking to incorporate nuclear within the energy mix will continue to face challenges.

Governments considering developing nuclear power must budget for high initial investment costs, potential delays and cost overruns. At a time when governments are rationalising spending, nuclear will trail behind conventional and renewable sources for the near future. Low credit ratings also make it difficult for some MENA governments to access cheap finance. This will mean that countries will look to smaller scale reactors that cannot meet the capacity needs in line with rising electricity demand. In the case of Barakah 1, the project progressed due to the ability of the government to finance the entire programme without relying on local or external debt or equity.

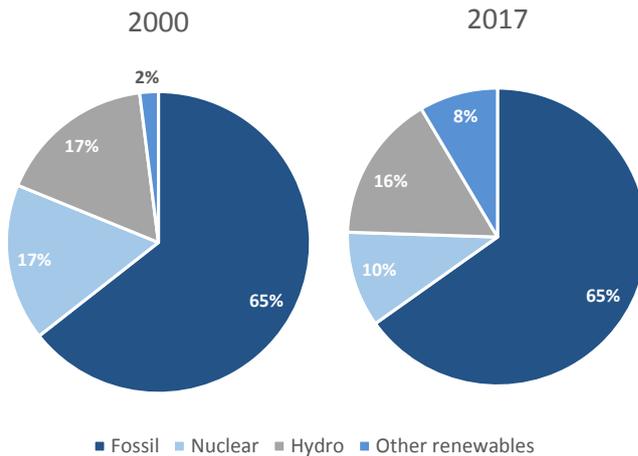
Nuclear plants are typically larger than existing non-nuclear plants and will need sophisticated grid systems to handle the power generated from these plants. Therefore, investments in the grid infrastructure can be substantial. Although this might not be a particular problem for richer nations such as the UAE and Saudi Arabia, it will prove challenging for Egypt – requiring \$18bn of investment in transmission and distribution to support generation capacity in the next five years - and Jordan, which is struggling with inadequate grid infrastructure.

Finding the appropriate sites is also a problem given the risks of terrorism and meltdowns. Aqaba, on the Red Sea, was an obvious choice for Jordan, with seawater on hand for cooling, but was eventually rejected on environmental grounds. In Saudi Arabia, 17 sites were identified, but proximity to the Yemeni border ruled out several sites due to the ongoing conflict, narrowing the options to two sites close to the borders of the UAE and Qatar. In the case of Iran, renewed US sanctions will likely stall their plans for the second phase of the Bushehr plant.

MENA is increasingly favouring renewables and, to a much lesser extent coal, as a source of diversifying their power generation mix. Renewable energy is more attractive, but it cannot be compared on either scale of production or reliability given the intermittency of both wind and sun, and the challenges

of storage. The case for nuclear in MENA is made increasingly difficult at a time when countries such as Germany are implementing strict timelines to phase out nuclear with similar approaches taken in Italy and Spain, though MENA could learn from the experience of countries such as China which is increasing its investment and pushing for more nuclear power to displace coal. Nevertheless, between 2000 and 2017, the share of nuclear in global power generation dropped by 7% from their peak in the late 90's.

Global generation mix



Source: : IEA, BP stats

Countries contemplating nuclear development will need to assure the public that sufficient safeguards are in place to avoid accidents like that at Fukushima in 2011. For this, they will need to establish the appropriate infrastructure such as nuclear law, regulatory bodies and safety measures. Establishments such as ENEC in the UAE and the Jordan Atomic Energy Commission are a step in the right direction but there is still a long way to go. As noted earlier, training operators in accordance with international standards has been a primary cause of the delay in commissioning the Barakah 1 reactor.

MENA states will nevertheless continue to push through with their nuclear plans, driven by growing electricity demand, the need for energy diversification, self-sufficiency in providing domestic power and the need for energy exporters to maximise on hydrocarbon exports. The region expects to invest in total upwards of \$76bn on nuclear capacity by 2030, although the majority of these projects are still at the planning phase. Financing nuclear also remains a major hurdle. The progress of the UAE thus far is no guarantee that other states, particularly those without the benefit of substantial revenue from hydrocarbon exports, will be able to secure investments, prompting them to revise plans or consider small-scale reactors instead.

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