



The case for nuclear power in the Middle East and North Africa

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Introduction

Several Middle Eastern and North African (MENA) countries have, over the past decades, declared an interest in nuclear power, although aside from some limited R&D programmes based on research reactors in a few Arab countries (Egypt, Algeria, and Libya, for example) and Iran, until recently no MENA state has committed to a concrete nuclear power programme. This changed in the new millennium, with the UAE's firm nuclear programme that will add 20 MW of nuclear power by 2020, turning it into the first Arab country to produce nuclear power for domestic use. Other regional neighbours, such as Saudi Arabia, Egypt, Jordan, and Kuwait have been announcing plans for similar programmes. This article summarizes the rationale for nuclear power in both the GCC and MENA countries, before reviewing economic competitiveness in the regional context, the requirements for infrastructure and regulation, and the status of regional programmes.

The rationale for nuclear power in the MENA

The GCC countries hold around 40 per cent of world oil and 25 per cent of gas reserves. Government revenues are 80 per cent dependent on hydrocarbons. The demand figures for both electricity and water are growing at close to double digit rates, absorbing increasing amounts of national oil and gas production, having already forced previously gas self-sufficient countries to become importers of natural gas. Demand comes predominantly from residential buildings; this has grown at very high rates, reflecting very low electricity tariffs. Efforts on efficiency

measures are increasing, but the impact has been minimal so far. Tariff increases are politically difficult, but without them average annual electricity demand growth over the next ten years could exceed 6 per cent, draining the region's hydrocarbon resources for use in domestic power generation still further. For many regional oil and gas producers, the use of nuclear power is seen as an important step that could extend the lifetime of reserves, releasing additional domestic oil and/or natural gas production to earn revenues for exporters.

For other MENA countries, in the Levant and North Africa, the nuclear power option provides a secure alternative energy source to meet demand – which rises with population. Almost 50 per cent of Turkey's fuel mix consists of gas imported from Russia and Iran; 70 per cent of Egypt's needs come from its domestic gas resources, which are predicted to be depleted within two decades; Jordan is completely dependent on imported energy. In all these countries, nuclear power could reduce reliance on the import of expensive fossil fuels, thereby saving expenditure over the long term.

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Limited finance is the major challenge; this has resulted in original and innovative funding, initiated by Russian ambition to increase its role as an international nuclear provider. For the first plant in Turkey Russia will fully fund and resource a national company to Build Own and

Operate (BOO), selling a proportion of output to the state at 'preferential rates' with freedom to market the balance. Later, minority private sector participation will be sought. A similar BOO model is reported to have been offered by Russia to Jordan, but this is beset with additional difficulties. Siting is constrained by seismicity and cooling water availability. The presently favoured site relies on treated wastewater. Popular opposition to nuclear power, not least in the wake of Fukushima's recent disaster, is strong and rising.

Regional economics

As 95 per cent of the costs of nuclear power are unrelated to the uranium price, nuclear offers security against price variation and fuel supplies. There have been some security and safety related costs based on lessons learned on preparedness for extreme events as a result of Fukushima, and while these are specific to the physical environment of each site, capital costs are unlikely to exceed \$6500/kW. The BOT funding models, with a high proportion of state equity and favourable credit ratings for residual debt, enable the outsourcing of economic and financial risk. With discount rates of 7 per cent and capital costs of \$6500/kW, the generating cost will then be near \$85/MWh. The \$124/MWh proposed by Russia to Turkey is indicative of costs resulting from BOO and other funding models elsewhere in the region.

In the GCC, competitiveness with the lowest cost alternative technology, CCGT, depends on gas source. Nuclear is uncompetitive with firing domestic gas (including difficult non-associated gas) up to marginal costs of \$8/MMBtu but this source is

limited in many countries. Nuclear is highly competitive with a cost of \$140/MWh for imported LNG, priced at parity with oil at \$100/bbl, and with \$175/MWh cost for steam plants at the same oil price.

The cost-competitiveness of nuclear power depends on the cost of plant, the cost of capital, and the fuel prices of fossil alternatives. To illustrate the point, international oil prices higher than US\$50 per bbl and LNG price higher than about US\$8/MMBtu would be more than sufficient to pay for nuclear power plants costing US\$6500 per kW with an interest rate of 5 per cent. Non-dispatchable generation costs for wind and solar are currently around \$150/MWh and are predicted to approach \$100/MWh within two decades. However, the cost of these resources to a load-serving power purchaser also include the costs of system integration and the combination of back-up fossil plant or the storage necessary to ensure firm capacity, making them significantly higher.

Other drivers of nuclear power in the MENA

Having among the world's highest per capita energy consumption levels, and these being based entirely on fossil fuels, translates to correspondingly high per capita CO₂ emissions and related environmental concerns, with some GCC countries being amongst the highest emitters worldwide. With significantly lower CO₂ emissions than conventional fossil fuels, nuclear power can contribute towards lowering the MENA region's overall carbon footprint, as an important step towards mitigating climate change. Clearly, the Arab countries are also endowed with enormous potential for renewable energy, especially solar energy. Costs of Photovoltaic (PV) and Concentrated Solar Power (CSP) have been declining substantially in recent years – a trend

that is expected to continue. However, intermittency of supply remains a principal issue. Solar energy needs a companion and nuclear power can, in principle, play that role.

There are also geopolitical considerations. Iran's uranium enrichment capability has raised concerns of a potential military dimension. Most of the region's countries that are interested in the adoption of nuclear energy have declared that they are not interested in any domestic fuel cycle activities (except uranium extraction) and that they will be fully compliant with their national safeguards obligations. While all Arab countries are part of the Non-Proliferation of Nuclear Weapons Treaty (NPT) regime and have in place comprehensive safeguards agreements with the International Atomic Energy Agency (IAEA), not all have joined the 'Additional Protocol'. If current negotiations between Iran and the international community produce an agreement that retains Iran's capacity to enrich reactor fuel (up to 5 per cent), other key powers in the region may see this as reason to develop their own nuclear power programmes that would seek similar nuclear fuel cycle (NFC) 'capacity parity'.

Requirements and challenges

Nuclear power has many highly complex technological dimensions. Mastering these to reap its benefits is an even more challenging task. Nuclear power is less forgiving than other energy technologies, requiring persistent discipline in its operation and maintenance, especially with regard to the need for strict adherence to safety standards and regulatory requirements. Competent and effective regulatory oversight is equally important. The Fukushima Daiichi accident is testimony to the fact that that even technologically advanced countries

can have serious weaknesses in their national nuclear programmes.

In technologically less advanced countries without a well-developed safety culture, such as those in the MENA region, the introduction of nuclear power needs to balance the added risk with the benefits. Therefore, the development of a successful, safe, and secure nuclear power programme requires a strong and unwavering long-term national commitment, with strong initial efforts aimed at developing the required infrastructure; this would focus especially on human resources and an effective and disciplined management system for all components of the nuclear fuel cycle and related organizations – a cumbersome and time-intensive process.

The introduction of nuclear power in the MENA requires a permanent national commitment to human resource development, sophisticated institutional infrastructure, international cooperation, transparency and a stringent safety culture (including security of nuclear materials), and adequate waste management and decommissioning plans. Such a move would be unprecedented in the region. Infrastructure requirements include: the devising of laws and enforcement of roles and responsibilities, an empowered independent regulator, and entities regulating and overseeing operating, safety, and radiological protection. Some MENA countries have engaged for decades in nuclear R&D activity, which would provide a basis. However, the UAE has successfully established the region's first nuclear power programme without such a benefit, by outsourcing from the technology provider and international entities. Practically, this approach is an essential fast track, but parallel development of citizens to assume key roles, thereby ensuring national commitment, is essential.



Other aspects of the nuclear power option that need continuous attention are (a) the permanent and safe disposal of high-level waste (HLW) – here, fuel leasing and take back arrangements are potential alternatives for the region; (b) the risks of nuclear weapons proliferation; (c) the physical security of nuclear material and facilities; (d) ensuring the highest level of safety in technology design and facilities operation; (e) lower construction costs; and (f) public acceptance of the technology. Insistence on enrichment or plutonium extraction has been justified as being the development of a national scientific capability for peaceful nuclear power or as maximizing the value of national uranium resources fully within NPT rights and obligations. But such activities may, for some, be related to strengthening a country’s national political position by attaining nuclear fuel cycle (NFC) capacity parity in the absence of an internationally recognized and guaranteed total ban on dual purpose NFC capability and a regional weapon-free zone (including Iran and Israel).

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‘THE COST-COMPETITIVENESS OF NUCLEAR POWER DEPENDS ON THE COST OF PLANT, THE COST OF CAPITAL, AND THE FUEL PRICES OF FOSSIL ALTERNATIVES.’

Electricity grid stability is rendered more difficult by large generating units. Current commercially available reactor technology of 1000 to 1600 MW may not fit the grid capacity of several Arab countries (notwithstanding the fact that these grids are going to be at least twice today’s sizes by the time nuclear power can realistically be introduced in 10 to 15 years), whose electricity grids do not currently exceed a few thousand MW. However, numerous smaller unit sizes are under development and may be commercially available by 2020 to

Plans for nuclear power in the MENA region			
<i>Country</i>	<i>Current and under construction (2020)</i>	<i>Firm and long-term plans (2030–35)</i>	<i>Target (%)</i>
UAE	5 GW	+ 20 GW (25 GW)	12% nuclear 2030
KSA	–	18 GW	15% nuclear 2030
Jordan	–	6 GW	30% nuclear 2030
Egypt	–	4.8 GW	
Morocco	–	2 GW	
Algeria	–	2 GW	14% nuclear 2030
Tunisia	–	0.6–1 GW	
Total	5 GW	(58.8 GW)	
Turkey	–	9.6 GW	10% nuclear 2023
Iran	0.9 GW	(20 GW)	!
Grand total	5.9 GW	(88.4 GW)	Only one-third of long-term plans and targets likely

2025. More intra-regional electricity trade could also help overcome this problem, for instance through the existing GCC Interconnection Grid and North Africa’s interconnected grids.

Status of regional programmes

In one way or another, almost all Arab countries, large and small, have expressed at least some interest in nuclear power. Starting around 2005, smaller countries like Bahrain, Kuwait, Oman, and Qatar, without either nuclear infrastructure or nuclear engineering expertise, became involved in activities such as: carrying out energy studies, signing international nuclear cooperation agreements, gathering information on prerequisite nuclear infrastructure requirements, and adhering to international nuclear treaties, protocols and conventions. After the Fukushima Daiichi accident, however, these countries have dropped or suspended their national nuclear plans. Other countries have continued, or even speeded up, their nuclear plans. As can be seen from the adjacent table, four Arab countries

are currently pursuing plans for nuclear power, with varying levels of certainty.

The UAE is on schedule to commission 4 x 1.4 GW APR-1400 pressurized water reactors (PWRs) at Barakah on the Gulf between 2017 and 2020 on a BOT arrangement with South Korea. The programme has been exemplary from its initiation in 2007 with regard to both establishment of infrastructure by outsourcing and also parallel nationalization and compliance with non-proliferation requirements. A further 20 GW is proposed by 2030. Saudi Arabia has announced plans to build 18 GW of capacity by 2032, naming sites on the Gulf and the Red Sea. Infrastructure is being established. The programme is still to be confirmed but is expected to proceed. Reactor types and funding models have not yet been announced. Jordan established a nuclear commission and regulator in 2007 and has conducted preconstruction evaluations since 2008. The Russian BOO proposal for 2 x 1 GW reactors at the Al Amra desert site has now been selected and is being finalized. A decision to proceed is expected in

2015 with first unit operation in 2021. Egypt has reactivated its programme and is in pre-construction planning of 4 x 1.2 GW reactors at the El-Dabba site. However, the current transitional political environment will further delay the programme.

Fukushima prompted extensive safety reviews and stress tests for nuclear power plants around the world, and has also prompted rigorous reviews of the risks and benefits of nuclear power in interested MENA countries. Nevertheless, the rationale for nuclear – high- and volatile-cost fossil fuel resources, energy security, high electricity demand growth, requirement for low-cost base load generation, low emissions and atmospheric pollution, and technological spinoffs – is unaffected and has continued to drive nuclear plans in those countries that have chosen to move ahead with nuclear programmes.

Conclusions

Is there a solid case for nuclear power in the MENA countries? For the GCC states, the nexus of escalating energy demand and inability to exploit gas resources presents an economic hazard of income loss due to diversion of national resources from export, rising expenditure on imports, limitation of diversification plans, and security of energy supply. Nuclear power could offer the MENA region an important energy alternative to conventional oil and gas, thereby saving revenue for exporters in the long-term while providing resource-poor MENA countries with a cost-effective alternative to imported oil and gas. The strong fiscal positions of the GCC states add to the case for the adoption of nuclear power as part of a future energy mix in the region.

While there are many promising benefits, there are also demanding

challenges and daunting obstacles to overcome on the road to introducing nuclear power. Dismissing one energy option without specifying its replacement on a level playing field is of no avail. There is no perfect technology – without risks and interaction with the environment. Moreover, as much as sustainable development is a dynamic process, technology is also subject to change. Innovation and technology change and improve most aspects of a technology's performance from one generation or investment cycle to the next. The UAE programme is certainly exemplary, but it calls for continued diligence. Saudi Arabia's programme is not yet confirmed or defined in detail, but is considered likely to proceed because of the inevitability of the above rationale. When realized, it offers the rationale for several bilateral programmes and intensified regional cooperation.

