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Nuclear Energy's Future in the Middle East and North Africa

Several countries in the Middle East and North Africa (MENA) have announced plans to embrace nuclear power as part of their future energy mix. The United Arab Emirates (UAE) is ahead of its peers in building the first Arab nuclear power plant and becoming the first country in twenty-seven years to start constructing its first reactor. As these countries seek to meet their growing energy needs, they are forced to weigh the highly contested costs and benefits of nuclear power.

Over the next decade, new nuclear power plants are scheduled to be operational throughout the MENA region. The UAE's Barakah flagship project will have a total installed capacity of 5.6 gigawatts (GW); the first unit is expected to start generating electricity in 2017, and the final unit is scheduled for operation in 2020, providing in total nearly one-quarter of the nation's electricity needs. Saudi Arabia will follow with the most ambitious nuclear plan, involving sixteen nuclear reactors to be built by 2032 with a total capacity of more than 17 GW (expected to meet 15 percent of the country's electricity needs). The first reactor is expected to be operating in 2022. Jordansigned a deal with Russia's Rosatom, the state nuclear corporation, to build Jordan's first nuclear

power plant, with a capacity of 2,000 megawatts (MW), projected to be operational in 2023. Egyptalso signed a deal with Rosatom to build four reactors, each with a capacity of 1,200 MW, over the next twelve years. Morocco, Tunisia, and Algeria, which has run two research reactors since the early 1990s at Draria and Ain Oussera, are also assessing their options. Kuwait, Oman, and Qatar, however, have cancelled their nuclear plans following the Fukushima Daiichi Nuclear Power Station accident in Japan in 2011.

Carole Nakhle

The jury is still out with respect to nuclear energy. Globally, nuclear energy has been struggling to maintain its growth momentum for more than fifty years. Its popularity has been often dampened—and for a long time—by major accidents. Despite advances in technology since the first use of nuclear power for peaceful ends in the 1950s, several challenges—from costs to safety—remain. For each argument put forward in favor of nuclear power, there is perhaps an equally convincing argument against. The nuclear debate has, therefore, been going

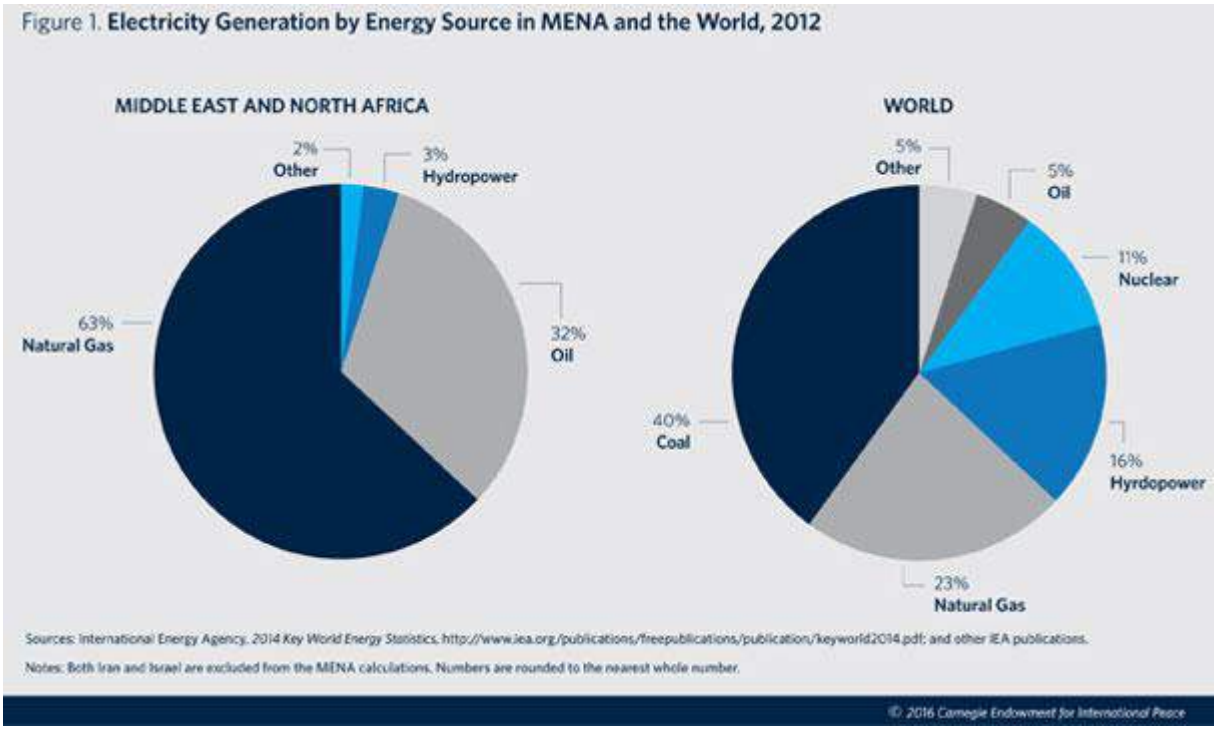
through cycles: from proponents of nuclear power gaining ground to opponents of nuclear power regaining it and back again, restricting the contribution of nuclear power to world energy.

The MENA region faces unique challenges and opportunities when it comes to nuclear power. The tense geopolitical environment makes nuclear power an even more controversial issue in the region than elsewhere: states are suspicious that neighbors might use their civilian nuclear programs for military ends. Iran's nuclear plan, for example, led to the imposition of sanctions by the international community followed by years of negotiations. Given the already highly subsidized economies in the region, there are also concerns about MENA governments making such massive investments in nuclear power. Unlike most of the other nuclear energy users around the world, some Middle Eastern countries have the advantages of being oil and gas rich, which gives them more time to consider the role nuclear power should play in meeting their energy needs.

Nuclear power will make its way into the energy mix of the MENA region, but without much-needed economic reforms, it will not solve the region's long-standing energy problems. Quite bluntly, civil nuclear power is not an escape route. It may help, but the reality the MENA states have to face is that they have to build modern, competitive

economies. Without this necessary transformation, nuclear power could well turn out to be more of a burden than a benefit.

Governments in the region have made a number of arguments to justify their pursuit of nuclear energy, including the desire to meet a rapidly rising demand for electricity; safeguard oil exports; support economic growth; achieve greater security of supply; and reduce their carbon footprint. Nuclear energy can also help the MENA countries diversify their rather straightforward primary energy mix, which is currently heavily reliant on oil and gas (see figure 1).



Some MENA governments are full of praise for nuclear power. As put by Emirates Nuclear Energy Corporation, nuclear energy is “the right choice for the UAE because it is a safe, clean and proven technology, it’s commercially viable, and it delivers significant volumes of base-load electricity.” A white paper commissioned by the Jordan Atomic Energy Commission concluded that “taking into account the social, health and environmental costs of fossil fuels relative to those same costs for nuclear, the economics of nuclear power are outstandingly attractive.”

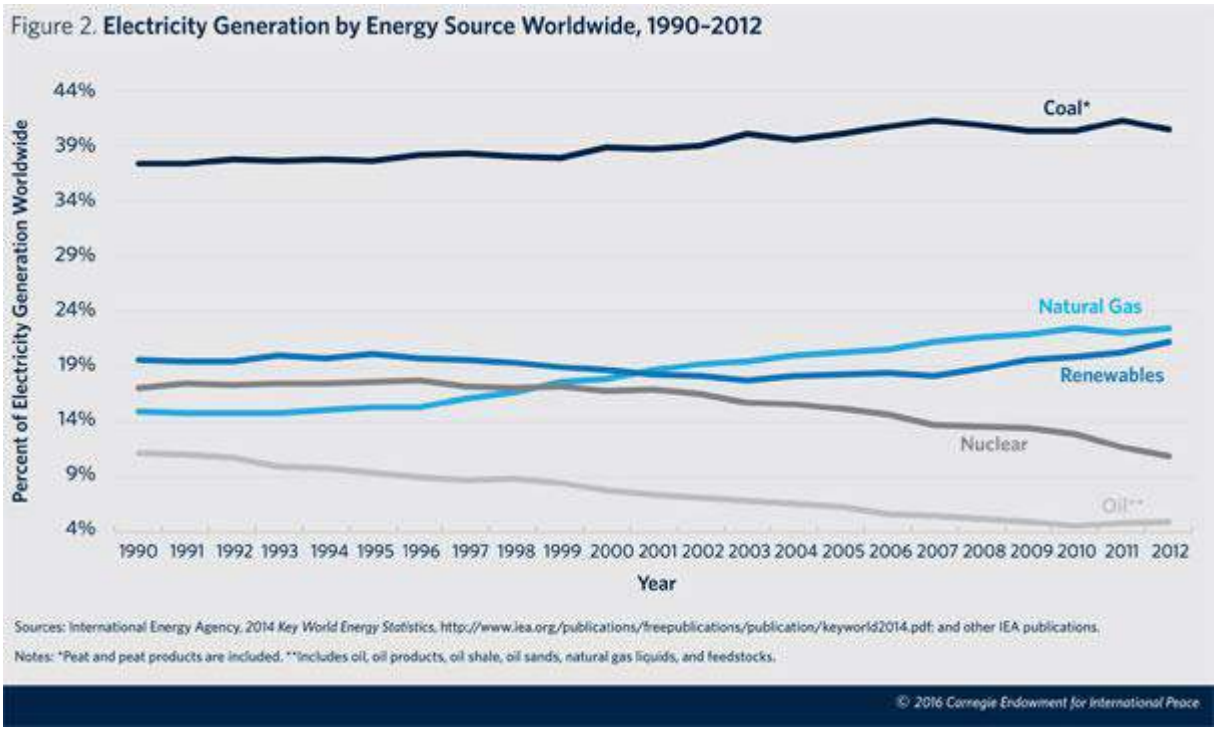
Some commentators see the nuclear initiative among the Gulf countries in particular as a contingency plan—a nuclear defense doctrine—against Iran’s nuclear program and uranium enrichment capability. As put by one expert, “prestige and competition are also intertwined in this issue. The Saudis do not want to be ‘one-upped’ by Tehran.” The transition from civil nuclear power to nuclear weapons, however, is not that straightforward, although it can be argued that the technology required for peaceful purposes makes militarization easier.

It is true that nuclear energy is a superior source of electricity generation compared to fossil fuels in terms of climate impact. Nuclear power plants emit very low levels of carbon dioxide. Compared to renewable, nuclear energy’s superiority stems from the fact that it does not

depend on the availability of sun or wind—which are intermittent—or water, which is constrained.

Scale is another advantage; one power plant can produce enough electricity to light half of a country; in this sense it is less intrusive from an environmental standpoint. In Slovenia, for instance, only one operating nuclear reactor supplies approximately 40 percent of the country's total electricity needs. The cost of electricity generation, once the initial investment cost has been amortized, is very competitive with other sources of energy.

Despite these advantages, and after more than sixty years since the first nuclear power plant started its operations at Obninsk, Russia, nuclear power accounted for only 11 percent of global electricity generation in 2012, down from a peak of nearly 18 percent in 1996, according to the International Energy Agency (IEA) (see figure 2). Like nuclear, oil's share has been declining, as oil has been increasingly crowded out of the power sector by natural gas and renewable, which have been expanding rapidly.



Nuclear power plants run on uranium fuel. Just four countries—Australia, Canada, Kazakhstan, and Russia—hold more than half of the world's uranium. In sharp contrast, the MENA region is uranium-resource poor. Only Jordan (0.5 percent), Algeria (0.3 percent), and Egypt (less than 0.1 percent) have uranium resources, albeit of the more expensive categories. The MENA countries will, therefore, have to rely on uranium supplies coming largely from outside the region.

According to a joint report by the Organization for Economic Cooperation and Development (OECD) Nuclear Energy Agency and the International Atomic Energy

Agency (IAEA), the currently identified uranium resources are “more than adequate to meet high case uranium demand through 2035.” However, the report adds that this “will depend upon timely investments given the typically long lead times required to turn resources into refined uranium ready for nuclear fuel production. Other concerns in mine development include geopolitical factors, technical challenges, increasing expectations of governments hosting uranium mining and other issues facing producers in specific cases.” In this sense, if the nuclear motivation for some countries is to strengthen their energy security by reducing exposure to energy imports, that worry will remain, albeit in a new form.

The majority of the 30 countries that have nuclear power plants are hydrocarbon resource poor and/or net oil and gas importers (see figure 3). In sharp contrast, MENA’s oil and gas producers are not short of these conventional resources. The Gulf Cooperation Council (GCC) countries, in particular, are among the world’s largest producers and exporters of oil and gas, holding almost 30 percent of the world’s proven oil reserves and 23 percent of the world’s proven gas reserves.

Figure 3. **Nuclear Reactors by Country, December 2014**

Country	Operating Units	Under Construction	Share of Electricity From Nuclear Energy	Share of Worldwide Nuclear Generation of Electricity	Nuclear as Share of Total Primary Energy
United States	99	5	19.5%	33.1%	8.3%
France	58	1	76.9%	17.2%	41.5%
Russia	34	9	18.6%	7.1%	6.0%
South Korea	23	5	30.4%	6.2%	13.0%
Germany	9	-	15.9%	3.8%	7.1%
China	23	26	2.4%	5.0%	1.0%
Canada	19	-	16.8%	4.2%	7.2%
Ukraine	15	2	49.4%	3.5%	20.0%
United Kingdom	16	-	17.2%	2.5%	7.7%
Sweden	10	-	41.5%	2.6%	28.7%
Spain	7	-	20.4%	2.3%	9.7%
Belgium	7	-	47.5%	1.3%	13.2%
India	21	6	3.5%	1.4%	1.2%
Czech Republic	6	-	35.8%	1.2%	16.8%
Switzerland	5	-	37.9%	1.1%	21.9%
Finland	4	1	34.7%	0.9%	20.6%
Japan*	48	2	-	-	-
Brazil	2	1	2.9%	0.6%	1.2%
Bulgaria	2	-	31.8%	0.6%	20.1%
Hungary	4	-	53.6%	0.6%	17.7%
Slovakia	4	2	56.8%	0.6%	23.4%
South Africa	2	-	6.2%	0.6%	2.9%
Romania	2	-	18.5%	0.5%	7.8%
Mexico	2	-	5.6%	0.4%	1.1%
Argentina	3	1	4.1%	0.2%	1.5%
Iran	1	-	1.5%	0.2%	0.4%
Netherlands	1	-	4.0%	0.2%	1.1%
Pakistan	3	2	4.3%	0.2%	1.5%
Slovenia	1	-	37.3%	-	21.1%
Armenia	1	-	30.7%	-	20.3%
United Arab Emirates	-	3	-	-	-
Belarus	-	2	-	-	-
World	432	68			

Sources: International Atomic Energy Agency, Nuclear Power Reactors in the World, Reference Data Series No. 2 (Vienna: IAEA, 2015), http://www-pub.iaea.org/MTCD/Publications/PDF/rds2-35web-85937611.pdf; and BP Statistical Review of World Energy 2015, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Notes: *Japan shut down all its nuclear reactors following the Fukushima accident. It has since worked to gradually restore operations, beginning with the restart of one of the nuclear reactors at the Sendai plant in August 2015.

The capacity and quality of a country's grid system is an important consideration when making a decision about building a nuclear power plant. According to the World Nuclear Association, "many nuclear power plants are larger than the fossil fuel plants they supplement or replace, and it does not make sense to have any generating unit more than about one tenth the capacity of the grid (maybe 15% if there is high reserve capacity). This is so that the plant can be taken offline for refueling or maintenance, or due to unforeseen events." This is why countries like Oman, which have small grids, are more in favor of pursuing nuclear power as part of a regional effort.
There is much debate about the real costs of building, maintaining, and decommissioning nuclear power plants.

Proponents of nuclear power point to the low feedstock fuel costs of electricity generation, which represent a very small proportion of the overall cost (around 2 percent). In this sense, the effects of changes in the uranium price on the cost of nuclear-generated electricity are relatively modest compared to other forms of electricity generation.
This is, however, offset by the long construction periods and high investment costs involved in building the nuclear power plants, especially the new generation of reactors that are larger and more complex than the older ones. The life cycle of the new generation of nuclear reactors is

exceedingly long and can span two or three decades. As explained in a joint OECD and Nuclear Energy Agency (NEA) study, any judgements about their economic success are, therefore, probably best withheld for another decade.

To assess the viability of any investment, the future value of its expected earnings and spending is calculated in present terms—a financial process called discounting, which accounts for the time and risk related to an investment. For example, investors have to take into account that technological breakthroughs or the emergence of cheaper energy alternatives will reduce the present value of their investment in nuclear power. Thus, the longer the period of investment or the higher the perception of risk is, the higher the discount rate will be.

As a joint report by the IEA and the NEA points out, since "nuclear technologies are capital intensive relative to natural gas or coal, the cost of nuclear rises relatively quickly as the discount rate is raised." For instance, "at a 3% discount rate, nuclear is the lowest cost option." At a 7 percent discount rate, the average value of nuclear is close to that of coal, but at a more realistic 10 percent discount rate, the present value of nuclear is lower that that of either gas or coal. These calculations are based on a carbon cost of $30 per ton, which puts nuclear at an

advantage over fossil fuels. In the absence of carbon pricing, the cost of nuclear will be even higher.

One study on nuclear energy in Saudi Arabia concludes that the economics of nuclear power are not favorable when compared to natural gas, even if the currently low domestic natural gas prices in Saudi Arabia were to rise substantially. Solar power also has the potential to be cheaper than nuclear power within the next decade if the rapid decline in solar energy costs continues.

Nuclear power development requires large, long-term investments in complex technologies. This makes purely commercial financing difficult to obtain. The nuclear industry, therefore, relies heavily on government support, through both an enabling, supportive public policy framework and appropriate financing. Saudi Arabia**'s planned nuclear power reactors come at an estimated cost of** $80 billion. The UAE's Barakah plant has an estimated price tag of **more than** $20 billion**.** These projects will require massive government subsidies, which is especially problematic in a region with already highly subsidized economies. As the IAEA points out, "the UAE's experience with developing a national nuclear infrastructure and its establishment of a regulatory framework and system has been impressive," but this has been made possible in no small part because of substantial government investment, including in hiring highly qualified (and mostly foreign) personnel.

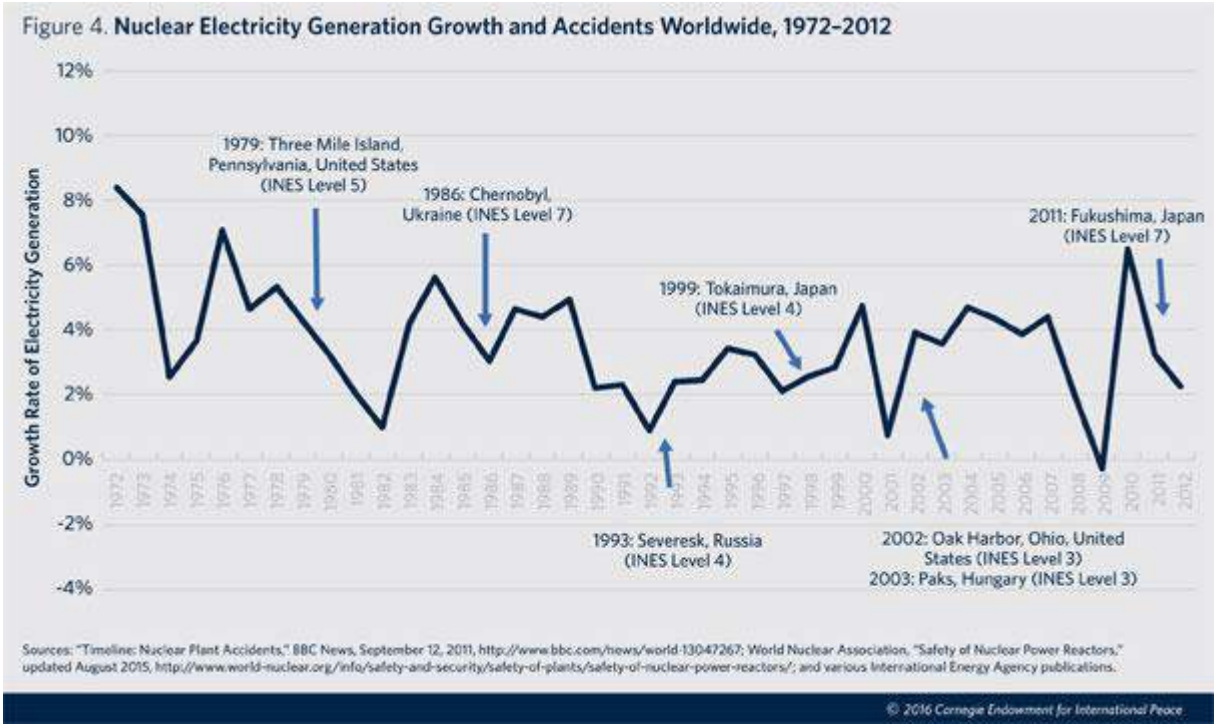
Such a privilege is not readily available in non-oil-rich states like Egypt, Jordan, and Morocco, where government funding is severely constrained. But even in the oil-rich states, an oil price of less than $50 per barrel is putting significant pressure on public finances, further exacerbating the financial burden of investing in nuclear plants.

Additionally, all these cost estimates are likely to be revised upward. According to the UK Energy Research Center, “It is evident from the disparity between future projections and actual outcomes that . . . appraisal optimism has been a fairly consistent feature of nuclear costs analysis. The reasons appears [sic] to be a combination of both industrial/technological enthusiasm and commercial/political pressure to lowball cost estimates.”
Nuclear energy is not only highly subsidized, it is also associated with higher social costs than other energy technologies. The potential costs of nuclear accidents are so high that nuclear power plants are virtually uninsurable privately. If something goes wrong, the government carries the burden. These costs are then passed on to society.

Major nuclear accidents, such as Three Mile Island in 1979 in the United States (in which there were no casualties), Chernobyl in 1986 (in which at least 30 people

were killed), and Fukushima (in which there were no casualties), are a rarity, but they are not easily forgotten (see figure 4). Their impact, such as the effects of radiation, is not swiftly contained; it can spread over decades and affect more than one generation. It is, therefore, not surprising that public acceptance has been one of the main handicaps to the expansion of nuclear energy. Although the antinuclear movement is not as robust in the MENA region as it in Western Europe and North America, there are some nongovernmental organizations, such as the Jordanian Friends of Environment, that fiercely oppose nuclear power.

Nuclear energy accidents are not limited to those major events; no less than 99 nuclear accidentshave occurred worldwide from 1952 to 2009, with many ranking above 4 on the International Nuclear and Radiological Event Scale (levels 1–3 are rated as “incidents” and levels 4–7 are rated as “accidents,” with each level increase reflecting an event approximately ten times more severe).



There are also serious security concerns regarding nuclear power plant construction in a politically unstable region like MENA. Nuclear power plants are vulnerable to hostile actions. The Bushehr nuclear site in Iran was repeatedly bombed by Iraqi forces during the Iraq-Iran war in the 1980s. There are fears that nuclear power plants may become terrorist targets.

With the advancement in technology and tighter safety regulations, nuclear power plants are bound to become safer. The downside, however, is a further increase in cost and delay in construction permit approval, meaning that it could take much longer to obtain a license to build a nuclear plant than to actually build it.

Another major challenge facing nuclear energy and its economics is the decommissioning cost. The IEA estimates that almost 200 reactors operating at the end of 2013 will be retired by 2040, at a cost exceeding $100 billion. Furthermore, considerable uncertainties remain about the decommissioning costs because of the relatively limited experience to date in dismantling and decontaminating reactors and restoring sites for other uses. The industry will need to manage this unprecedented rate of decommissioning while also building substantial new capacity for those reactors that are replaced, which will be costly.

The permanent disposal of nuclear waste remains a problem with no solution. Nuclear energy supporters argue that nuclear energy is very clean, as it produces little waste compared to other industries. However, a part of that nuclear waste—the high-level radioactive waste, which is 99 percent radioactive—requires permanent isolation from humankind's environment, as it takes about ten thousand years for the radioactivity of such waste to decay. According to the IEA, "no country has yet established permanent facilities for the disposal of high-level radioactive wastefrom commercial reactors, which continues to build up in temporary storage." Until such a solution is devised, nuclear power is unlikely to be on par with other sources of energy.

The three stages of the nuclear fuel cycle—uranium mining, plant operation, and nuclear waste storage—consume a significant amount of water. This is particularly true for light-water reactors, which Saudi Arabia is planning to build and which use fresh water as a coolant. Because MENA lacks an abundance of water resources, this is potentially problematic for the spread of nuclear power in the region.

There are conflicting views on whether nuclear power requires more water than other sources of electricity generation. The Nuclear Energy Institute, which represents the nuclear industry's interests in the United States, writes that "compared to other energy sources used for electricity production, nuclear power plants use moderate amounts of water and minimal land per amount of electricity produced." According to the Union of Concerned Scientists, "in 2008, nuclear power plants withdrew 8 times as much freshwater as natural gas plants per unit of energy produced, and up to 11 percent more than the average coal plant."

The MENA countries' institutional challenges also hinder their nuclear ambitions. The problem is not unique to the MENA region. One study, using the World Bank's Government Effectiveness Indicators—which measure everything from perceptions of the quality of public services to the quality of policy formulation and implementation—concludes that the institutional

capacity of “newcomer countries” tends to be lower than that of the established nuclear power countries.

Developing domestic expertise is crucial. As put by the IAEA, “the responsibility for safety cannot be delegated to another country or organization.” The development of the local workforce can easily take more than a decade, while the operational phase of a successful nuclear power program is likely to span at least two generations of the workforce, so ongoing, integrated workforce planning is essential for the safe management of the sector. The UAE’s nuclear program, for example, relies on a large amount of expatriate expertise, responsible for key aspects of the nuclear program and related institutions. However, expats can only fill the gap to a certain extent. According to the Nuclear Energy Institute, “about half the nuclear industry’s work force will be eligible to retire during the next 10 years” globally, which means that the competition for talent throughout the industry will be fierce for the foreseeable future.

DOMESTIC REFORMS AND RENEWABLES

In the coming decades, MENA countries will continue to grapple with how to meet the rapidly growing demand for electricity. Demand in the region is expected to continue to grow by around 6 percent over the next ten years, which is

double the expected world average rate. Some MENA countries fear that domestic energy production will struggle to keep up with the demand and hence new sources like nuclear energy must be considered.

But perhaps a more effective way to solve this problem is to identify what is driving demand growth and to work to curb it. Population growth has surely been a factor, but low energy prices have played a far bigger role. The MENA region accounts for 48 percent of global energy subsidiesand cheap energy prices relative to income, which tends to fuel wasteful consumption and inefficiencies. According to the BP Energy Outlook 2030, “energy intensity [in the Middle East] in 1970 was less than half the level of other non-OECD; by 2010, it was 50% higher. With the trend in other countries pointing toward continuous improvement, the Middle East region by 2030 is likely to be more than twice as energy intensive as the rest of the non-OECD.”

Reforming domestic energy prices is, therefore, essential to slow the growth in domestic demand and improve energy efficiency. This strategy has been advocated for some time by international organizations and experts alike. But MENA governments have been reluctant to undertake such policy reforms due to fears of provoking social discontent and unrest.

Even on the supply side, the MENA countries have not run out of options. Renewables are increasingly considered, but costs and intermittency hinder a rapid expansion. Natural gas is widely available across the region, although it is not effectively or efficiently exploited. Algeria, Egypt, Iraq, Libya, Oman, Qatar, and Saudi Arabia are among the world's twenty largest gas flaring nations. Flaring is not only a waste of a valuable resource, but it is also an important contributor to carbon emissions. Reducing gas flaring will help preserve this natural resource and will reduce the region's carbon footprint.

Such steps are more easily and cheaply adopted than building nuclear power plants. These steps also don't exclude a role for nuclear power in meeting the region's growing energy needs. Nuclear energy's contribution to the energy mix in some of the MENA countries will become an irreversible reality, but the region must tackle its long-standing structural, economic, and institutional problems to find a comprehensive solution to its energy needs.

The author would like to thank Alain Kfoury for his research assistance.

Correction: This article originally stated that at a 10 percent discount rate, the value of nuclear is higher than that of either gas or coal. The author meant to state that

the present value of nuclear is lower than that of either gas or coal. This has been corrected.