Analysis of the Developing States in the MENA Region Seeking Civilian Nuclear Energy, with a Primary Focus on the Kingdom of Saudi Arabia (KSA) and the United Arab Emirates (UAE)

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Abstract
The comprehensive analysis presented here attempts to analyze "newcomer" states in the Middle East and North Africa (MENA), primarily the Kingdom of Saudi Arabia (KSA) and United Arab Emirates (UAE), seeking to implement civilian nuclear energy according to their political and economic situations. By investigating their motivations and funding resources for future nuclear projects, this analysis provides guidance for these states in terms of their nuclear infrastructure and nonproliferation. The overall approach of this analysis relies on the factors for the success of civilian nuclear energy programs identified in experiential studies conducted since the Atoms for Peace speech in 1953. This study also attempts to reduce the gap between developing and developed states by clarifying the major challenges involved in nuclear cooperation and technology transferal.

Since the 1980s, the MENA region has experienced various crises, including the Iraq-Iran War, the Gulf War, terrorist attacks, the Arab Spring, and the Islamic State (IS). However, the two states analyzed here have maintained stable political environments without disturbances to their governmental systems. Moreover, from an economic viewpoint, both states have high revenue from oil and gas production and high oil reserves (more than 20 percent of the world's proven oil reserves). Regarding their motivation for seeking civilian nuclear energy, these states are attempting to address their estimated 8-9 percent annual increase in electricity demand, rapid population growth, and the need for more desalination plants. By implementing nuclear energy programs, these newcomer states will face challenges related to their nuclear strategy, roadmap, infrastructure, and human resources. To address these challenges, the newcomer states will have to secure intense foreign cooperation by signing nuclear agreements with developed states and showing a clear record of compliance with nuclear nonproliferation commitments, such as the Nuclear Nonproliferation Treaty (NPT), the Comprehensive Safeguards Agreements (CSA), and the Additional Protocol (AP), which will raise the transparency of the civilian nuclear program.

Introduction
Rapid population growth and increased electricity demands (for both water desalination and electricity generation) are major energy challenges for governments around the world. Many governments believe that nuclear energy is one of the safest, most reliable, and most cost-effective energy sources that can provide electricity for long periods of time. According to reports by the International Atomic Energy Agency (IAEA),[1] nuclear power demand is expected to increase between a low projection of 17 percent (if the current market remains and few changes in resources and technology occur) and a high projection of 94 percent (if the rate of electricity demand and economies continue to grow) of the world's current total nuclear power capacity by 2030. Thus, many states are seeking to implement civilian nuclear energy programs. Experiential studies conducted since the Atoms for Peace speech in 1953 indicate that the essential factors that determine the success of such programs are as follows: 1) nuclear nonproliferation commitments (Nuclear Nonproliferation Treaty [NPT], Comprehensive Safeguards Agreements [CSA], and the Additional Protocol [AP]), 2) the political situation, and 3) the economic situation (motivations, resources, and gross domestic product [GDP]).[2]

The goal of this paper is to analyze the "newcomer" developing states in the Middle East and North Africa (MENA), primarily the Kingdom of Saudi Arabia (KSA) and United Arab Emirates (UAE), seeking civilian nuclear energy. Additionally, an overview of both states from a nuclear nonproliferation and infrastructure perspective that satisfies the essential requirements for the successful development of civilian nuclear energy is provided. This study attempts to bridge the gap between newcomers and developed states, which can be achieved by clarifying a number of the major and initial difficulties that affect both types of states in the process of cooperation and technology transfer. The presented analysis will investigate the political and economic environments of both states. Politically, this study will analyze the stability of the governmental system as a strong indication of the entire political framework of the targeted state. This study will investigate economic motivations and resources from an energy perspective as well as consider a general GDP-based perspective.

Background

Studies on the development of civilian nuclear power that focus on similar objectives are rare, although two studies by Jewell (2011) were found in literature.[3,4] These studies performed analyses of the motivations and capacities for deploying civilian nuclear energy in fifty-two aspirant states and then in five North Africa states. The evaluations included financial and institutional capacities as well as technical requirements for the electricity grid. The institutional capacity was measured by the World Bank Political Stability Index (PSI) and the World Bank Government Effectiveness Indicator (GEI). The financial capacity was measured by GDP and GDP/capita. Although the use of PSI and GEI are logical and reasonable when evaluating institutional capacities, both indicators are subject to debate. For example, although Pakistan, India, Argentina, Brazil, and Russia have operational nuclear power plants (NPPs), these countries present low PSI or GEI; therefore, these states have overcome the PSI and GEI indicators, met all of the technical requirements, and managed the financial difficulties. The results of the second study showed that Libya and Tunisia had the top two PSI among North Africa states: however, both of these governmental systems have been toppled and the countries are unstable.[5,6] The PSI and GEI were founded on different international efforts, covering a wide range of sources. However, these indicators were highly influenced by Western and European cultures, which are different from the cultures of MENA states.

Historical observations have indicated that under certain circumstances, such as a lack of capability or capacity, strong motivations could make up for the required capabilities or capacities. Therefore, a thorough investigation will not be conducted in this study with regard to the technical requirements, which will eventually be addressed through cooperation with developed states as well as the IAEA.[7,8] In this study, a common ground was defined for evaluating a political situation in which a logical and reasonable indicator reflects the reality of the government systems. Although this indicator may be controversial, it is unique because it is based on logic and reality. The indicator is based on the results of previous crises that the government systems in the MENA region, particularly KSA and UAE, have experienced. These results will be further detailed in the political situation section.

Table 1. Date of NPT Signature or deposit for the states in the MENA region

NPT Agreement			
States	**Signature or Deposit Date**	**States**	**Signature or Deposit Date**
KSA	3 October 1988	Syria *	1 July 1968
UAE	26 September 1995	Lebanon	1 July 1968
Kuwait	15-22 August 1968	Egypt	1 July 1968
Oman	23 January 1997	Libya *	July 1968
Qatar	1989	Algeria	12 January 1995
Bahrain	3 November 1988	Tunis	1 July 1968
Iraq *	1 July 1968	Morocco	1 July 1968
Jordan	10 July 1968		

* Non-compliance status
Source: United Nations Office for Disarmament Affair (UNODA)
Note (light blue): KSA and UAE are the primary focus of this study.

Role of the NPT

The NPT is a very important commitment and considered one of the primary concerns of the international community with regard to nuclear energy. This treaty defines the privileges, responsibilities, and obligations for the 191 state parties and ninety-three signatory states involved.[9,10] The three pillars of the NPT are the promotion of nuclear arms control and disarmament, the prevention of nuclear weapon development, and the encouragement of peaceful cooperation.[10,11] However, the NPT is one of the major factors in the successful development of civilian nuclear energy.[2] Table 1 shows the date of the NPT signature or deposit of ratification for the states in the MENA Region.[9] As parties to the NPT, all MENA states have signed the NPT or deposited their instruments of ratification.

Note that most of MENA states were early signatories to the NPT; in addition, Syria, Iraq, and Libya are currently in non-compliance status.[12-14] The KSA and UAE are two of the later signatories to the NPT. Both states apparently understand that any perception of non-compliance with the NPT may breed distrust from the international community, which will generally affect their future nuclear activities. By maintaining compliance with the obligations and commitments of the NPT agreement, the chances of international cooperation will be much higher, particularly if the political and economic situations in both states help support the need for a civilian nuclear energy program.

Political Situation

Political situation is measured based on the government's stability. An indicator of governmental stability is a combination of logic and the historical conditions, and such indicators for MENA countries are developed by tracing the major changes in the government system according to the various crises in the region. Major changes in the government system have been defined as changes in the entire presidential office, monarchy, or government cabinet. This study used major changes in the governmental system as a strong indicator of the government's stability.

Since September 1980, five major crises have been identified in the MENA region: the Iraq-Iran War, the Gulf War, terrorist attacks,[15] the Arab Spring,[16] and the Islamic State (IS).[17] Three of these crises, the Iraq-Iran War, the Gulf War, and the Islamic State, have not had a significant impact on the government stability of the MENA states that remain in compliance with the NPT. However, terrorist attacks have impacted government stability in Lebanon,[18,19] whereas the Arab Spring impacted the government stability in Egypt, Yemen, and Tunisia.[16] Over the short term, the political environment in certain states in the MENA region will prevent developed states from cooperating towards the development of civilian nuclear energy programs. However, the governmental stability of both the KSA and UAE have not been impacted by these crises. Thus, regional crises should not necessarily preclude the successful implementation of nuclear power technology within the safeguards prescribed by the IAEA. For example, in 2015, Egypt and Russia signed a memorandum of understanding regarding the construction of NPPs.[20] Therefore, these activities are possible if the stability of the government is strengthened post-crisis.

Economic Situation

Motivation for Seeking Civilian Nuclear Energy

The largest countries among the Gulf States in terms of their economies are using approximately one third of their daily production of oil and gas to produce electricity.[21] The estimated increases in the population growth, energy demands, and renewable water requirements per capita by 2030 are shown in Table 2. The increase in electricity demand is estimated to be approximately 8-9 percent per year for KSA and UAE,[22,23] and this increase will be caused by population growth and industrialization. Both states rely on water desalination plants because of the lack of surface and ground water. In the near future, population growth will drive the need for increased desalination plant capacity, which will require greater amounts of electricity. The current solution is to continue building additional plants to burn more oil and gas to meet the demand regardless of the mandates of the climate conference in Paris in 2015, which will place additional pressure on both governments with regard to energy resources.

Table 2. Future population, energy demand, and renewable water in the Gulf States

Gulf States	Population (Million) [A]		Energy Demand [B] (Terawatt/Hours)		Renewable Water Per Capita [C] (Cubic Meters)	
	2015	2030*	2015	2030*	2015	2030*
KSA	28.8	38.8	101.0	317.0	83.0	66.0
UAE	9.3	12.5	99.5	315.0	28.9	23.0
Kuwait	3.4	4.5	66.4	138.0	5.7	5.0
Oman	3.6	4.8	13.9	28.9	836.6	350.0
Qatar	2.2	2.9	18.7	38.9	37.0	29.0
Bahrain	1.3	1.8	14.0	29.0	135.6	109.0

[A.] Source: World Bank Data, which include recent (2015) population estimates and an approximately 2 percent annual population growth rate.

[B, C.] Compiled from Report on the Workshop: Nuclear Dangers Nuclear Realities[21] and updated with recent data. The energy demand is increasing by 8-9 percent for the KSA and UAE and by ~5 percent for the remaining Gulf States. The estimated decreasing percentage of renewable water is ~ (-2 percent) for all Gulf States except Kuwait and Qatar, which is ~ (-1 percent).

* Indicates projected value

Note (light blue): KSA and UAE are the primary focus of this study.

Table 2 shows that KSA will face the largest increase in energy demand and population among the Gulf States, with UAE in second place. Both states are motivated to seek civilian nuclear energy because of 1) the expected growth in population, 2) the yearly increases in demand for electricity, and 3) the need for more desalination plants. To this end, discussions on the implementation of civilian nuclear energy were announced by both governments.[21-23] The UAE has started the construction of four pressurized water reactors,[22] whereas, KSA has merely announced the creation of King Abdullah City for Atomic and Renewable Energy (KACARE), which remains in the planning, study, and evaluation stages.[23] These two civilian nuclear energy programs are collectively estimated to cost more than $100 billion, rendering them among the largest nuclear programs of the century,[22,23] with KSA's program costing $80 billion and UAE's program costing $20 billion. Apparently the huge budgets for these programs raises concerns as to whether the states will be able to fund these long-term investments.

Funding Resources for Civilian Nuclear Energy

In this section, a general overview of the economies of KSA and UAE, which will include oil, natural gas, and GDP, is provided to gain an understanding of both economies. The Gulf region is an area rich in oil, which is among the purest oil worldwide. Additionally, both states have tremendous natural gas production capacities and reserves. These Gulf State governments financially rely on their production and reserves of oil and natural gas. According to the Organization of Petroleum Exporting Countries (OPEC), in which the KSA has a leading role,[24,25] both states are leading countries in oil production. Table 3 presents data on the oil and gas reserves and production for both states.

Table 3. Oil and gas data for the KSA and UAE

Oil and Gas Data	KSA	UAE
Crude oil reserves (million barrels)	265,789	97,800
Natural gas reserves (billion cubic meters)	8,317	6.091
Crude oil production (thousand barrels/day)	9,637	2,797
Natural gas production (million cubic meters)	100,030	54,600
Value of petroleum exports (million dollars)	321,723	126,307

Source: Organization of Petroleum Exporting Countries (OPEC), KSA and UAE Facts and Figures[24,25]

Both states have sizable reserves and a substantial production capacity for gas and oil, which will maintain a stable economic status for several years. Several billion dollars of oil in the form of petroleum exports are added as revenue per day to the budgets of both states. According to the U.S. Central Intelligence Agency (CIA), the KSA is an oil-based economy with a GDP of $927.8 billion and a GDP/capita of $31,200 (2013 estimate), which ranks the KSA first among the Gulf States from a GDP perspective,[26,27] whereas the UAE has an estimated GDP of $269.8 billion and a GDP/capita of $29,900 (2013 estimate), which ranks the UAE second.[26,28] The aforementioned, indicate that both states are wealthy and present a low risk of insufficient funding for the long-term investment of a civilian nuclear energy program.

Status of Newcomer States Seeking Civilian Nuclear Energy

United Arab Emirates (UAE)

UAE's Nuclear Program Specifications

The UAE was the first state in the Gulf region to construct nuclear reactors. As shown in Table 4, the four reactors are named Barakah 1, Barakah 2, Barakah 3, and Barakah 4.[22] Each of these reactors is an Advance Power Reactor APR1400, which is a light water reactor (LWR) that can produce 1,400 megawatts of electricity (MWe). The construction of the four reactors began in July 2012, May 2013, September 2014, and September 2015, and they are scheduled to be complete and operational by 2017, 2018, 2019, and 2020 respectively. The total capacity of the first phase of the UAE's civilian nuclear energy program will be 5,600 (MWe); a second phase has not been announced.

Table 4. UAE's nuclear power reactors

Reactor's Name and Type	Electricity Production (megawatts)	Construction Date	Expected Date of Operation
Barakah 1, APR-1400	1400	July 2012	2017
Barakah 2, APR-1400	1400	May 2013	2018
Barakah 3, APR-1400	1400	Sep 2014	2019
Barakah 4, APR-1400	1400	Sep 2015	2020

Source: World Nuclear Association (2014), *Nuclear Power in United Arab Emirates*.[22]

The four units will be supplied by a consortium that is led by the Korea Electric Power Company (KEPCO) and includes Samsung, Westinghouse, Hyundai Engineering & Construction, Doosan Heavy Industries, and KEPCO Subsidiaries.[22] In addition, a domestic waste repository is an option for the UAE's nuclear program for medium- and low-level waste, and a portion of the waste fuel will be sent to France for reprocessing or to another country with a reprocessing plant. Studies on a domestic geological repository are being conducted with a Swedish company.[22]

UAE's Nuclear Program Strategy and Policy

The UAE government adopted a new model of approaching civilian nuclear energy that non-nuclear weapon states have explored since the Atoms for Peace speech in 1953. This model attempts to ensure the confidence and support of the international community for the peaceful development of UAE's civilian nuclear program.[29] The UAE has shown the international community that it is only interested in peaceful uses of nuclear energy by adopting such models and signing various nonproliferation agreements as shown in Table 5. The UAE's actions aligns with policies in the developed states for transferring civilian nuclear technology as well as with the high standard for nuclear nonproliferation that the international community aims to maintain.

Table 5. UAE's nonproliferation activities

Agreement's Name	Date of Signature or Ratification
Nuclear Nonproliferation Treaty (NPT)	1995
Comprehensive Safeguards Agreements (CSA)	2003
Additional Protocol (AP)	2009
123 Agreement with the USA	2009

The above nonproliferation activities are limited; the list does not include all conventions.

By signing the 123 Agreement, the UAE pledged to import its nuclear fuel and forgo domestic fabrication, enrichment, and reprocessing plants. To this end, the UAE signed various long-term contracts to import nuclear fuel from international firms at a fixed price.[22] The UAE also announced that these reactors would be operated through a joint venture with a foreign firm, with 60 percent ownership by the UAE government and 40 percent by the foreign firm for a period of 60 years.[22] Subsequently, the UAE's civilian nuclear program will rely on the international market for its nuclear fuel.

The other nonproliferation steps considered by the UAE include the selection of LWR and the lack of reprocessing plants in the UAE's territory. Developed states considered this approach to be an effective method for impeding the misuse of nuclear technology. Under normal operations, LWR does not produce high percentages of sensitive nuclear materials such as plutonium (^{239}Pu), in comparison to other types of reactors, such as the fast breeder reactor (FBR).[30] LWRs have another proliferation-resistance feature: when refueling, the entire power plant must shut down, which enables easy monitoring of the NPPs by the IAEA.

Kingdom of Saudi Arabia (KSA)

The KSA realized the need for nuclear technology in 1988 with the creation of the Atomic Energy Research Institute (AERI) in Riyadh.[31,32] The AERI was the first nuclear institute in the Gulf region, and although it was established as a research base, the institute is now involved in many other activities. Initially, the AERI was responsible for researching nuclear technology related to aspects such as agriculture, industry and health. The initial responsibilities of the AERI included the representation of the KSA in the IAEA as well as the creation of the regulatory framework for nuclear energy in the KSA.[33] The new city (KACARE) announced by the King in April 2010 is intended to expand the responsibilities of the AERI. KACARE will be responsible for the KSA's civilian nuclear energy program and projects involving other renewable energy resources, including solar and wind energy projects. KACARE will serve as KSA's representative to the IAEA. Since the inception of KACARE, the importance of achieving cooperation and agreement between KSA and other leading organizations has been acknowledged for the development of KACARE's strategies, roadmaps and plans for civilian nuclear technology and other renewable energy resources.

KSA's Nuclear Program Agreements and Cooperation

KACARE has sought cooperation with many of the developed states, and its achievements in terms of cooperation, which were determined according to newspaper reports and KACARE's website, include agreements with the following: 1) Areva, France; 2) Investigación Aplicada (INVAP), Argentina; 3) Korea Atomic Energy Research Institute (KAERI), South Korea; 4) China Nuclear Engineering Corporation (CNEC), China; 5) Finnish Radiation and Nuclear Safety Authority (STUK), Finland; 6) Rosatom State Nuclear Energy Corporation, Russia; and 6) Hungary.[23] Prior to these cooperation agreements, the KSA had made several nonproliferation agreements, which are listed in Table 6. The KSA signed the NPT in 1988, the CSA in 2009, and the Small Quantities Protocol (SQP) in 2005; thus far, an AP has not been signed (without an AP, the IAEA cannot provide credible assurance of the absence of undeclared nuclear material and activities). The KSA signed a memorandum of understanding for nuclear energy with the United States in 2008, and the Taqnia Company (a Saudi company) set up a joint venture called "Invania" with INVAP (an Argentinian company) in 2015 to develop nuclear technology for the KSA by focusing on small reactors, such as CAREM.[23] The KSA has also engaged in various negotiations regarding nuclear energy technologies with countries such as the United States, Japan, the Czech Republic, and Britain; however, agreements have not been announced.

Table 6. KSA's nonproliferation activities

Agreement's Name	Date of Signature or Ratification
Nuclear Nonproliferation Treaty (NPT)	1988
Small Quantities Protocol (SQP)	2005
Comprehensive Safeguards Agreements (CSA)	2009
Additional Protocol (AP) *	-

* KSA has not yet signed the Additional Protocol (AP).

The above nonproliferation activities are limited; the list does not include all conventions.

KSA's Proposed Nuclear Capacity

KACARE announced that the initial capacity of the KSA's nuclear program would be 17-18 gigawatt-electric (GWe), which should be achieved by 2032.[23] However, this estimate is merely the initial plan, and it is subject to change. In January 2015, KSA officials announced that the targeted nuclear capacity will more likely be achieved by 2040.[23] KACARE plans to construct approximately sixteen reactors by 2032. If this initial plan is followed, the first two reactors will be operating by approximately 2022, and two reactors will subsequently be added each year until the completion of the sixteen reactors.[34,35]

KSA's Proposed Nuclear Reactor Types

The type of nuclear reactor to be used by KSA's nuclear program has not been officially announced, although information has been provided to newspapers and communicated via interviews with the president and the vice president of KACARE. The first reactor type considered by KACARE is the European Power Reactor (EPR), which is capable of producing up to 1,650 MWe. The EPR is a third-generation pressurized water reactor.[36] Other reactor types that have been considered are the AP1000, SMART, and CAREM. The AP1000, which was designed by Westinghouse Company (a U.S. company), is a third-generation-plus pressurized water reactor that is capable of producing between 1000 MWe and approximately 1200 MWe. SMART is a pressurized water reactor designed by KAERI, and it can generate up to 100 MWe, and CAREM is a small pressurized water reactor designed by INVAP (an Argentinean company), and it can generate approximately 25 MWe, which renders this type suitable for use as a research reactor (see Table 7). The choice of LWRs for the KSA's nuclear energy program is a smart option because of its proliferation-resistance features and reduced capacity to produce sensitive nuclear material.

Table 7. The proposed nuclear reactor types in KSA

Reactor Name	Reactor Type	Electricity Production (MWe)
EPR	Pressurized water reactor	Up to 1,650 MWe
AP1000	Pressurized water reactor	Up to 1,200 MWe
SMART	Pressurized water reactor	Up to 100 MWe
CAREM	Pressurized water reactor	Up to 25 MWe

KSA's Proposed Nuclear Fuel Cycle

The president of KACARE has mentioned that KSA wants to be an independent producer of nuclear energy, which implies its involvement in the major stages of the nuclear fuel cycle, including enrichment and fabrication. The KSA has not proposed plans to build a reprocessing plant; however, the sharing of such sensitive technology is limited because of the danger of using the separation technology to obtain "unirradiated direct use material," which could be repurposed for military use. No official announcement or indicators regarding KSA's proposed nuclear fuel cycle have been presented. Therefore, KSA's nuclear fuel cycle may involve one of the following scenarios: 1) the KSA may obtain nuclear fuel from outside sources, which is similar to UAE's nuclear fuel cycle; or 2) the KSA may build fabrication and enrichment plants. The first scenario would save time and increase the transparency of the KSA's proposed nuclear program, whereas the second scenario would include mining, milling, enrichment, and fuel fabrication. If the KSA selects this path, then the Additional Protocol (AP) will have to be signed to provide for higher transparency and enable the IAEA to provide credible assurance of the absence of undeclared nuclear materials and activities. If KSA is going to follow its initial nuclear plan (with its first reactors running by 2022), then nuclear fuel will have to be imported because building and operating fuel plants and manufacturing fuel represent long-term investments. However, implementing these plans will require more time than building the reactor itself. Therefore, a combination of both the first and second scenario is likely.

Different Scenarios for Implementing Civilian Nuclear Energy

The implementation of civilian nuclear energy will initially require the use of highly developed approaches and strategies along with focused cooperation with developed states. From a nuclear technology perspective, developed states are those with advanced capabilities in reactor design and construction (R-D&C) as well as reactor operation and maintenance (R-O&M). Developed states are governed by strict rules regarding the transfer of civilian nuclear energy technology to newcomer states because of the high standard of nuclear nonproliferation that the international community attempts to maintain. Table 8 describes the common scenarios based on current strategies and government agreements for implementing civilian nuclear technology that have been observed since the Atoms for Peace speech in 1953.

Each scenario (see Table 8) involves foreign and local contributions. The advantage of the first scenario is that the country can implement a NPP in a short time to meet its increased electricity demands, although at a limited capability. The disadvantages of the first scenario are that the state will not be able to design or construct its own reactor and it will slowly gain experience in reactor operation and maintenance over the short and medium term (ten to twenty years). In the second scenario, the state will gain reasonable experience in reactor operation and maintenance early in the process and will gain capabilities for implementing most stages involved in reactor design and for performing full operations and maintenance. In the third scenario, the state will be able to contribute to reactor design and construction from the beginning of the implementation process, and with time, the state will be able to design, construct, operate, and maintain its own reactors. The second and third scenarios are viable options for states with an INFCIRC/153-type safeguard agreement as long as an AP is enforced.

Nuclear Proliferation Concerns

Nuclear proliferation is an important global concern that led to the creation of the IAEA in 1957.[37] The initial mission of the IAEA was to control and promote peaceful nuclear technology via the development of the necessary legal frameworks, regulations and legislation.[37] The global concern later resulted also in the NPT and Safeguards Agreements (CSA) to be concluded

Table 8. Different scenarios for implementing civilian nuclear energy

Time	First Scenario A		Second Scenario B		Third Scenario C	
	Foreign Contribution	Local Contribution	Foreign Contribution	Local Contribution	Foreign Contribution	Local Contribution
Short Term (7-10 years) and Involvement Percentage percent	R-D&C 100 percent R-O&M >90 percent	R-D&C 0 percent R-O&M <10 percent	R-D&C 100 percent R-O&M 70-90 percent	R-D&C 0 percent R-O&M 10-30 percent	R-D&C 60-75 percent R-O&M <70 percent	R-D&C 25-40 percent R-O&M >30 percent
Medium Term (10-20 years) and Involvement Percentage percent	R-O&M 70-90 percent	R-O&M ~10-30 percent	R-D&C >70 percent R-O&M <30 percent	R-D&C <30 percent R-O&M >70 percent	R-D&C ~30 percent R-O&M <5 percent	R-D&C ~70 percent R-O&M >95 percent
Long Term (more than 20 years) and Involvement Percentage percent	R-O&M 30-70 percent	R-O&M 30-70 percent	R-D&C <10 percent Special Supplies and Consultant <5 percent	R-D&C >90 percent R-O&M >95 percent	Special Supplies and Consultant <5 percent	R-D&C >95 percent R-O&M >95 percent
Comments: Depends on the states' strategies and legal agreements.	1- State will find it difficult to contribute to R-D&C. 2- State can provide limited contributions to R-O&M.		1- State will find it easy to contribute to R-D&C and may face challenges (in the short-to-medium term) in conducting its own R-D&C. 2- State can fully contribute to R-O&M.		1- State can provide a greater contribution to R-D&C and will be able to conduct its own R-D&C. 2- State can fully contribute to R-O&M.	

A, Adoption of UAE's civilian nuclear model
B, Adoption of China's civilian nuclear model
C, Adoption of South Korea's civilian nuclear model

by non-nuclear-weapon states with the IAEA, which were followed by the AP in 1997.[38-40] The CSA is an agreement that attempts to implement a verification method for assuring that states comply with their obligations at all nuclear facilities within their territory and for preventing diversions of nuclear material from peaceful purposes to military uses.[38,39]

The AP was adopted by the IAEA in 1997 after the commencement of the clandestine Iraqi nuclear weapon program. The AP is an additional agreement for strengthening and improving the CSA by stipulating that states provide additional information on their nuclear programs and clarification as needed to support IAEA inspectors and allow access to their nuclear facilities as well as any location specified by the IAEA.[40]

Sensitive Nuclear Plants and Materials

An NPP is not considered to be sufficient for proliferation; however, the fuel cycle process is considered the primary parameter for proliferation.[31,38] The most important processes in the fuel cycle are enrichment, fuel fabrication and reprocessing plants, and the knowledge required to separate isotopes, enhance specific isotope concentrations, and convert compounds from one phase to another may be employed for military purposes. These plants are central to the proliferation concerns of developed states. The nuclear materials that cause the greatest proliferation concerns are: Pu, ^{233}U and highly enriched uranium (HEU) (^{235}U 20 percent) when applied for direct use; and thorium and U (^{235}U <20 percent) when applied for indirect use.[38] However, the special nuclear materials ^{239}Pu, ^{233}U and HEU ^{235}U have received special attention[31,38] because these nuclear materials (see Table 9) are associated with a quantity that is sufficient to produce a single nuclear bomb.[38]

Table 9. Significant quantities for sensitive nuclear materials

Material	Significant Quantity
Direct Use Material	
Plutonium	8 kg
U-233	8 kg
U-235 in HEU	25 kg of contained U-235
Indirect Use Material	
U-235 in LEU	75 kg of contained U-235, 10 t of natural uranium or 20 t of depleted uranium.
Thorium	20 t

Source: *IAEA Safeguards Glossary 2001 Edition, International Nuclear Verification Series No. 3.*

Double Standard Argument

All of the developed states have formed their own procedures for cooperation when transferring peaceful nuclear technology using official government agreements. One of the best examples of a highly evaluated agreement is the 123 Agreement used by the United States. This agreement entails thorough evaluations of sensitive nuclear materials, equipment, and facilities by isolating sensitive nuclear plants, such as fuel fabrication, enrichment and reprocessing plants.[41] The disadvantages of the 123 Agreement include the variations observed in the agreement from state to state, which could reflect a double standard. The U.S.-UAE 123 Agreement clearly stated that the UAE must forgo the right to implement fuel fabrication, enrichment and reprocessing plants, which was also stated in President Obama's letter to Congress in the context of the U.S.-UAE 123 Agreement.[41] The following statements will provide additional details on the U.S.-UAE 123 Agreement:

First:
"The United States and the UAE are entering into it in the context of a stated intention by the UAE to rely on existing international markets for nuclear fuel services as an alternative to the pursuit of enrichment and reprocessing. Article 7 will transform this UAE policy into a legally binding obligation from the UAE to the United States upon entry into force of the Agreement."

Second:
"In view of these and other nonproliferation features, the Agreement has the potential to serve as a model for other countries in the region that wish to pursue responsible nuclear energy development."

Third:
"Confirmation by the United States that the fields of cooperation, terms, and conditions accorded by the United States to the UAE shall be no less favorable in scope and effect than those that the United States may accord to any other non-nuclear-weapon State in the Middle East in a peaceful nuclear cooperation agreement."

Obviously, the United States, as represented by the Obama administration, has a special model for the MENA region, which is reflected in the new 123 Agreement with the UAE signed in 2009. However, the United States confirmed that other states in the Middle East region will not receive any favorable arrangements in terms of cooperation, conditions, and context in 123 Agreements. In other words, the United States is not willing to share enrichment and fuel fabrication knowledge to any interested nation in the Middle East.[41] However, the U.S.-Vietnam 123 Agreement signed in 2014 did not clearly state that Vietnam must forgo the right to implement these sensitive plants.[42] Thus, the newcomer states in the MENA region must carefully evaluate the available international nuclear cooperation agreements to determine the most suitable agreement for their nuclear program.

Conclusions

This paper attempts to analyze the newcomer states to the MENA region seeking civilian nuclear energy, primarily the KSA and UAE, by investigating their political and economic situations, including their motivations and funding resources. Moreover, this study attempts to clarify a number of the major and initial difficulties that would be faced by both states. Because of the rapid increases in population growth and the increasing needs for desalination plants and demands for electricity, both states have begun to evaluate and implement nuclear energy. Both states are politically and economically stable, which are validated by: 1) the governmental systems maintaining stability throughout the history of crises in the MENA region and 2) the states maintaining economic stability through the high daily revenue resulting from oil and gas production, huge oil reserves and high GDP and GDP/capita.

Newcomer states that seek to implement civilian nuclear energy programs can achieve this objective within a reasonable time frame with the cooperation and support of developed states, which can be secured by official government agreements. The international community takes all activities involving nuclear technology seriously to prevent the proliferation of nuclear technology. Thus, newcomer states must demonstrate that they will use nuclear technology peacefully and convince the international community of their benign intent by following the established high standard of nonproliferation and adopting well-developed approaches, strategies and policies for their civilian nuclear program. For newcomer states, LWRs are the preferred type of reactor because of the following: 1) the production of large quantities of sensitive nuclear materials are not encouraged, 2) the production of sensitive materials can be easily controlled, and 3) the proliferation-resistance features facilitate simple inspections by IAEA inspectors.

Regarding the fuel cycle, developed states prefer newcomer states to import nuclear fuel to eliminate the risk of newcomer states obtaining fuel fabrication and enrichment technology. A double standard is arguably imposed with respect to the fuel cycle for nuclear programs, which is reflected in certain international nuclear agreements, such as the U.S.-UAE 123 Agreement and the U.S.-Vietnam 123 Agreement. The standard imposed in these agreements varies from state to state depending on the political relations and situations between the newcomer states and developed states. The establishment of fabrication, enrichment, and reprocessing plants is associated with the potential use of sensitive nuclear materials and the knowledge required for nuclear military applications. All leading states in the nuclear field are obligated to limit the sharing of their knowledge on sensitive nuclear materials and plants because such knowledge may lead to nuclear military applications unless the materials are subject to IAEA safeguards. Thus, after the general approach and strategy for implementing a civilian nuclear energy program is established, the best standard for the specific newcomer state must be determined.

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Keywords

Nuclear energy, energy policy, nuclear nonproliferation, nuclear materials, nuclear safeguards, IAEA inspections

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