Spring 2017

Energy Transformation: Examining How Nuclear and Solar Power Could Enhance Stability in the Middle East Region and Implications for U.S. Policy

Brett Matthew Roenigk

ENERGY TRANSFORMATION: EXAMINING HOW NUCLEAR AND SOLAR POWER COULD ENHANCE STABILITY IN THE MIDDLE EAST REGION AND IMPLICATIONS FOR U.S. POLICY

A Masters Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Defense and Strategic Studies

By

Brett Roenigk

May 2017

ENERGY TRANSFORMATION: EXAMINING HOW NUCLEAR AND SOLAR POWER COULD ENHANCE STABILITY IN THE MIDDLE EAST REGION AND IMPLICATIONS FOR U.S. POLICY

Defense and Strategic Studies

Missouri State University, May 2017

Master of Science

Brett Roenigk

ABSTRACT

The U.S. Department of Energy projects that rapid growth in population and access to domestic resources will cause the Middle East's energy consumption to increase by 95% from 2012 to 2040. Currently, Jordan, Saudi Arabia, and the United Arab Emirates do not have enough installed power capacity to handle this increase in consumption. Due to this, these states are looking to solar and nuclear power to diversify their energy sectors. This thesis' focus is to examine the impending energy demand crisis that will affect Saudi Arabia, the United Arab Emirates (UAE), and Jordan. I argue that solar and nuclear power must play a vital role in these states' energy sectors to stave off future power shortages, decrease reliance on domestic hydrocarbons and imported energy, and reduce CO_2 emissions to lessen the effects of climate change. As nuclear energy capabilities for civilian use expand, so does the threat of nuclear terrorism or the possibility for countries to edge closer towards nuclear proliferation. The United States has a vested interest in stemming the proliferation of nuclear weapons and will need to be prepared to address this in the region in the future. Additionally, foreign powers are investing considerable resources and technology in the energy sectors in these states, which could erode U.S. influence in the region going forward.

KEYWORDS: energy security, solar power, nuclear power, Middle East, Jordan, Saudi Arabia, United Arab Emirates, nuclear terrorism, energy demand crisis

This abstract is approved as to form and content

_____

Dr. John Rose
Chairperson, Advisory Committee
Missouri State University

ENERGY TRANSFORMATION: EXAMINING HOW NUCLEAR AND SOLAR POWER COULD ENHANCE STABILITY IN THE MIDDLE EAST REGION AND IMPLICATIONS FOR U.S. POLICY

By

Brett Roenigk

A Masters Thesis
Submitted to the Graduate College
Of Missouri State University
In Partial Fulfillment of the Requirements
For the Degree of Master of Science, Defense and Strategic Studies

May 2017

Approved:

_____
Dr. John Rose

_____
Dr. Robert Joseph

_____
Dr. Andrei Shoumikhin

_____
Dr. Julie Masterson: Dean, Graduate College

ACKNOWLEDGEMENTS

I would like to thank my professors for all the countless hours of education and mentoring that they provided to help me reach this point of my career and academic endeavors. I would also like to especially thank Dr. Rose for his continuous assistance in providing priceless advice and guidance towards my thesis project and studies.

I would like to thank my family for their encouragement and help along every step of the way in helping me achieve my degree.

And last but certainly not least, I would like to thank my wife for her never-ending support of my dreams and her constant encouraging attitude, her relentless pursuit to push me farther to reach my goals, and for her love and understanding during graduate school and all the bumps and struggles along the way that came with it. Thank you for everything—I would not be where I am today without you by my side.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

An often forgotten, yet vital part of national security planning and policy is energy security. The International Energy Agency (IEA) defines energy security as "the uninterrupted availability of energy sources at an affordable price."[1] This is the definition that will be used for energy security throughout this paper. Energy security is taken for granted by the citizens of many states because the assumption is that the state has properly planned where it can acquire sustainable and easily accessible energy fuel sources. Populations within states also assume that energy demands will be met so as to avoid electricity blackouts and energy resource shortages.

Without electricity generated by energy fuel sources, a state cannot function properly in the modern era; without reliable electricity families, businesses, the military, law enforcement, and society as a whole suffer greatly in many ways by losing access to services and products that can improve quality of life such as heating and cooling of homes and quick financial transactions for businesses. In addition, a World Economic Forum (WEF) report detailing the energy sector's effect on economic development found that a reliable and prosperous energy sector within a state will provide economic benefits that spread to other parts of the state's economy, effectively improving economic health of that state as a whole.[2]

---

[1] International Energy Agency, "What Is Energy Security?," *OECD/IEA*, 2016, https://www.iea.org/topics/energysecurity/subtopics/whatisenergysecurity/.

[2] World Economic Forum, and IHS CERA, Energy for Economic Growth Energy Vision Update 2012, Rep. World Economic Forum, 2012, http://www3.weforum.org/docs/WEF_EN_EnergyEconomicGrowth_IndustryAgenda_2012.pdf.

Because of the great importance electricity plays in economies and states' security, states seek reliable, affordable, and sustainable energy fuel sources. In the Middle East, the energy fuel source of choice for consumption to produce electricity has overwhelmingly been hydrocarbons such as oil and natural gas. Oil and natural gas production in this region for electricity accounted for 97.4 percent of electricity production in 2014.[3] This heavy reliance—on a commodity whose price and quantity on the international market can fluctuate greatly—adds additional risk for Middle Eastern states seeking improved energy security postures in the future. Couple this heavy reliance with projected rapid exponential growth in energy demand in the Middle East in the coming decades and these states could experience an unpredictable energy crisis rife with rising energy costs. Access to energy is crucial for states to function sufficiently and grow economically to prosper in the modern era.

The U.S. Energy Information Administration projects a total increase of 95% (30 quadrillion Btu) in the Middle East region's energy consumption from 2012 and 2040.[4] Due to this incredible jump in energy consumption in the Middle East, many regional states will need to greatly expand electricity production capabilities to meet rising demand. Many of these states are not prepared for this forecasted dramatic increase.

---

[3] International Energy Agency, "Middle East: Electricity and Heat for 2014," IEA – Report, *OECD/IEA*, n.d., https://www.iea.org/statistics/statisticssearch/report/?year=2014&country=MIDDLEEAST&product=ElectricityandHeat.

[4] U.S. Energy Information Administration, International Energy Outlook 2016, Rep. no. DOE/EIA-0484(2016), *U.S. Energy Information Administration*, May 2016, http://www.eia.gov/outlooks/ieo/world.cfm.

Figure 1 shows the projected growth in population and energy consumption in the Middle East region as a whole.[5,6]

This paper will focus on Saudi Arabia, the United Arab Emirates (UAE), and Jordan. These three states were chosen because they are key players and U.S. allies in the Middle East that can help bring stability to the region going forward. However, they possess economic weaknesses that could inhibit their potential. Saudi Arabia, which relies heavily on oil export revenues to provide its citizens with widespread social benefits and services, burns about a quarter of the oil it produces. Its domestic energy consumption has been rising three times faster than population growth.[7] The UAE has seen rapid economic growth across the whole state in the past decade, which has ultimately led to dramatically rising demands for electricity.[8] Jordan has typically imported at least 90 percent of its energy needs to satisfy its domestic demand, since it does not have significant petroleum reserves like many of its neighbors.[9] To remedy these problems, the three states are either planning on or just beginning to invest in solar and nuclear power plants to supply themselves with increased power capacity.

---

[5] The World Bank, "Health Nutrition and Population Statistics: Population Estimates and Projections," Health Nutrition and Population Statistics, *World Bank Group*, n.d.

[6] U.S. Energy Information Administration, International Energy Outlook 2016.

[7] Jeffrey Ball, "Why the Saudis Are Going Solar," *The Atlantic*, Atlantic Media Company, July-August 2015, http://www.theatlantic.com/magazine/archive/2015/07/saudis-solar-energy/395315/.

[8] Embassy of the United Arab Emirates, "Energy in the UAE," N.p., n.d., http://www.uae-embassy.org/about-uae/energy-uae.

[9] Michael Hochberg, "Jordan's Energy Future: A Path Forward," *Middle East Institute*, August 19, 2015, http://www.mei.edu/content/article/jordans-energy-future-path-forward.

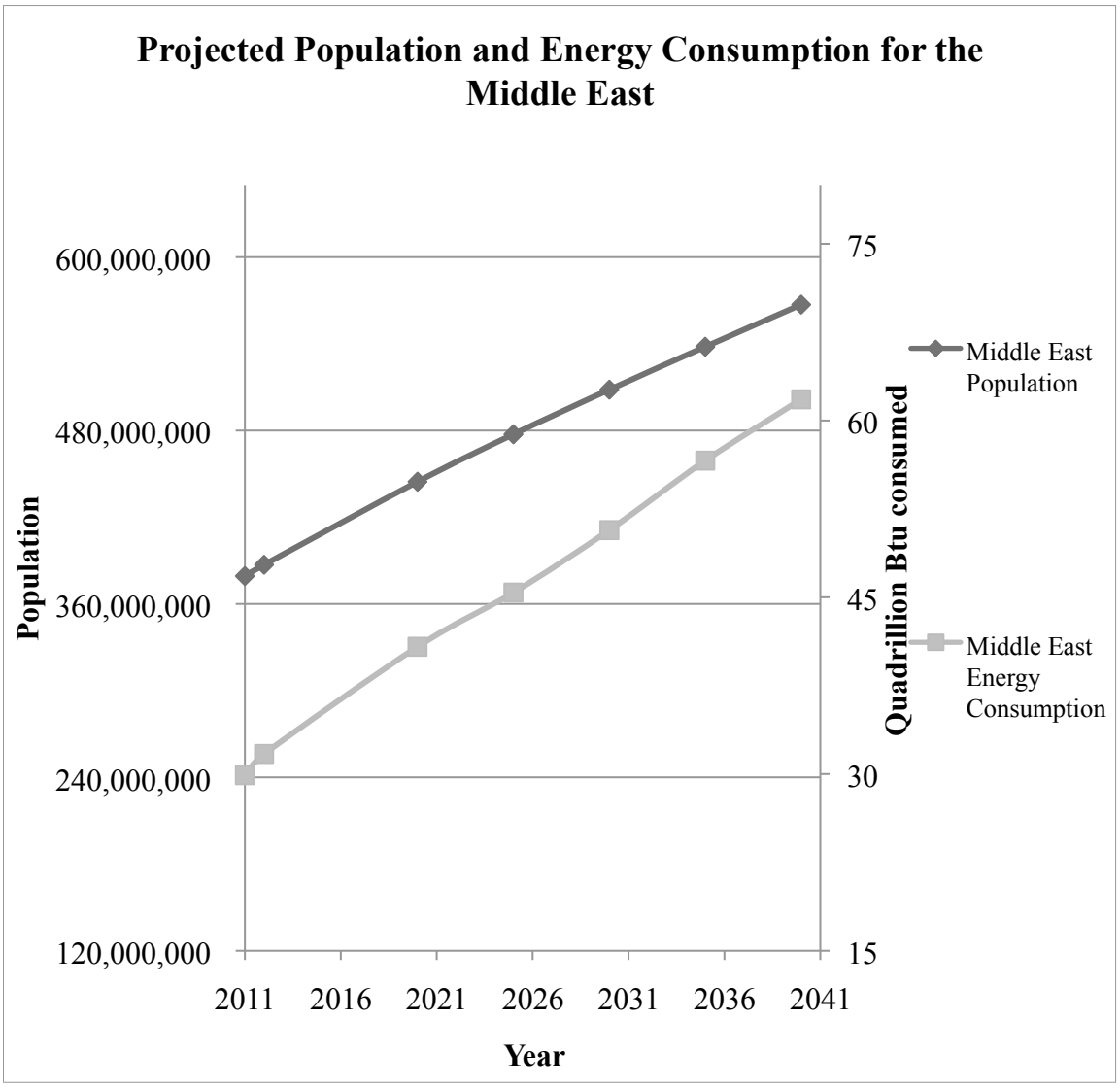


Figure 1. Total population projections and energy consumption projections for the Middle East region (Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, UAE, West Bank and Gaza, and Yemen). Data are divided into two separate axes that are shown by year. Sources: The World Bank, "Health Nutrition and Population Statistics: Population Estimates and Projections," Health Nutrition and Population Statistics, *World Bank Group*, n.d.

The reasons for doing so also range from lowering CO_2 emissions to combat climate change, establishing more reliable domestic energy sources, and consuming less domestic oil and gas so more can be exported to improve trade revenues. Climate change trends such as rising temperatures will dramatically increase the amount of electricity needed for families, individuals, and businesses to sufficiently cool their residences and buildings with air conditioning. These trends will impact energy security in Middle Eastern states. Additionally, the rapidly rising populations in the Middle East will be putting "tremendous stress on countries where climate scientists predict significantly lower rainfall and saltier groundwater from rising sea levels."[10]

This thesis will argue that Jordan, Saudi Arabia, and the UAE must make solar and nuclear power a vital part of their energy sectors to reliably tackle their rising energy demand problem in a sustainable way to ensure greater energy security. This thesis will only look at the specific energy economies and realities of Jordan, Saudi Arabia, and the UAE and not attempt to explain or evaluate the role of energy security across the Middle East region as a whole. This paper's purpose is not to examine the political future and projected importance of oil's role in the region, but it will incorporate the implications of oil's importance in regards to Jordan, Saudi Arabia, and the UAE. These three states were chosen specifically because they are all facing a similar energy demand problem yet, they have varying motivations in regards to why they are all actively exploring the

[10] Hugh Naylor, "An Epic Middle East Heat Wave Could Be Global Warming's Hellish Curtain-raiser," *The Washington Post*, August 10, 2016, https://www.washingtonpost.com/world/middle_east/an-epic-middle-east-heat-wave-could-be-global-warmings-hellish-curtain-raiser/2016/08/09/c8c717d4-5992-11e6-8b48-0cb344221131_story.html?utm_term=.2694145fa3d9.

use of solar and nuclear power plants to be incorporated into their respective energy sectors.

This thesis will also cover the following points and implications that deal with the emergence and growth of solar and nuclear power plants in Jordan, Saudi Arabia, and the UAE:

- Data regarding planned or under-construction solar and nuclear power plants
- The financial costs of nuclear and solar power plants and the planned and estimated timelines for such projects
- Energy consumption data and how rising energy demands will need to be met
- Advantages and disadvantages of solar and nuclear power
- International concerns like nuclear terrorism or nuclear proliferation as they pertain to nuclear power for civilian use
- Impact of energy security in these states and how it affects the United States and its foreign policy concerns and priorities
- How CO_2 reductions could impact these states and the Middle East
- Obstacles towards implementing nuclear and solar powered plants
- The effect of foreign investment in the energy sectors of Jordan, Saudi Arabia, and the UAE

This thesis will begin with a brief background detailing the importance of oil in the region, how it affects energy security for Jordan, Saudi Arabia, and the UAE, and how the prevalence of oil in the region has led many Middle Eastern states to heavily rely on it. Then, an examination of the current energy environment of those three countries will follow that will look at existing and planned solar and nuclear capabilities. Next, a section that will examine the impacts of solar and nuclear power that will look at issues such as nuclear power's role in desalinating water to become potable water, nuclear and solar power's role in reducing CO_2 emissions, and how nuclear and solar power can reduce the amount of imports of energy fuel sources countries may require. Then, this

thesis will look at how the emergence and expansion of nuclear and solar power plants will impact the United States and the three countries' political and economic environments from a global perspective. Finally, this thesis will conclude with an outlook section detailing what we can expect or project might happen in regards to energy security in Jordan, Saudi Arabia, and the UAE. Additionally, this outlook section will present implications and impacts upon security and stability in the Middle East region that can also affect the United States due to energy security transformations.

BACKGROUND OF OIL AND ENERGY'S IMPORTANCE IN THE MIDDLE EAST

An understanding of energy security within parts of the Middle East cannot occur without first understanding the role and importance of oil. Oil has driven many of the economies of the Middle East for decades and is the most traded commodity in the physical trading markets (trades where actual goods are bought, sold, and delivered) in the world.[11] Oil's importance as the global transportation fuel means that it is a commodity that is highly sought after. Because of the economic potential that oil brings to a country, many Middle Eastern states that possess large quantities of oil are heavily reliant on its sales for government revenues. According to the U.S. Energy Information Administration in 2015, five of the top-ten oil producing countries were from the Middle East (Saudi Arabia, Iraq, UAE, Iran, and Kuwait).[12] This large concentration of oil producers in one region of the world is one of the reasons why the Middle East is an incredibly strategic region in international relations. Concurrent with this fact, many countries—including the United States—have a vested interest in promoting security throughout the Middle East to maintain a consistent flow of trade in and out of the region,

[11] Henning Gloystein and Sonali Paul, "Oil Loses Commodity Trade Crown to Unlikely Challenger: Rebar," *Reuters*, April 28, 2016, http://www.reuters.com/article/us-oil-steel-trading-idUSKCN0XP1CT.

[12] U.S. Energy Information Administration, "Total Petroleum and Other Liquids Production – 2015," *U.S. Energy Information Administration*, n.d., http://www.eia.gov/beta/international/index.cfm?topL=exp.

specifically energy products like oil.[13] Due to the combination of oil's global importance as a fuel source and the fact that many of the largest oil producers are in the Middle East, many Middle Eastern regimes' stability rely on the exportation and production of oil.

Oil and Regime Security

Typically, when oil prices are low, high-producing oil states stand to lose revenues and taxes that high-priced oil generates in the economic sector. When oil prices fall, regimes that rely heavily on oil sales for state revenue like Russia and Iran must scale back government budgets and government-funded services or be faced with large-scale budget deficits that could also negatively impact their respective economies. Many high-producing oil states engage in so-called "oil pacts" that hold their societies together—due to high oil revenues, these states can provide their citizens with services and low energy prices in exchange for political support or passivity.[14]

If those governments can no longer carry out these services and discounts to their citizens due to low or volatile oil prices, then those states' societies will ultimately weaken across the board in the form of higher food costs, rising unemployment rates, rising poverty rates, and inflation.[15] These civil problems cannot simply be mended by higher oil prices. By the time oil prices bounce back civil unrest could already be

---

[13] Christopher M. Blanchard et al., *Change in the Middle East: Implications for U.S. Policy*, Rep. no. R42393, Congressional Research Service, March 7, 2012, https://fas.org/sgp/crs/mideast/R42393.pdf.

[14] Politico Magazine, "The Hidden Consequences of the Oil Crash," *POLITICO Magazine*, January 21, 2016, http://www.politico.com/magazine/story/2016/01/oil-crash-hidden-consequences-213550>.

[15] Ibid.

widespread, further weakening governments' control over their populations and damaging the chances of stabilizing the political and economic environment in those states. All of this can cause oil export-reliant states to become unstable and thus, less secure.

Since oil prices can be volatile, it is not always wise for oil-producing countries to heavily rely on high oil prices for revenues. Figure 2 shows how oil prices can vary greatly over the course of even five years.[16] These dramatic, and sometimes unpredictable shifts in the price of crude oil make it very difficult for oil-producing states to consistently rely on oil export revenues to fund government expenditures. This market volatility that surrounds oil could also "help strengthen the long-term prospects of alternative energy."[17] As technological advancements regarding solar energy improve and solar is given the same financial assistance from governments as the fossil fuel industry, then solar power will continue to become cheaper and a wiser investment for states to make to produce clean energy.

The Availability of Energy And Government Intervention

Saudi Arabia. Since oil is so prevalent in many Middle Eastern states, those states that produce and export vast amounts of oil typically use extra government revenue to subsidize electricity and fuel prices in their respective states. Saudi Arabia has one of

[16] Bloomberg, "CL1 Commodity Quote," *Bloomberg Markets*, n.d., https://www.bloomberg.com/quote/CL1:COM.

[17] Politico Magazine, "The Hidden Consequences of the Oil Crash."

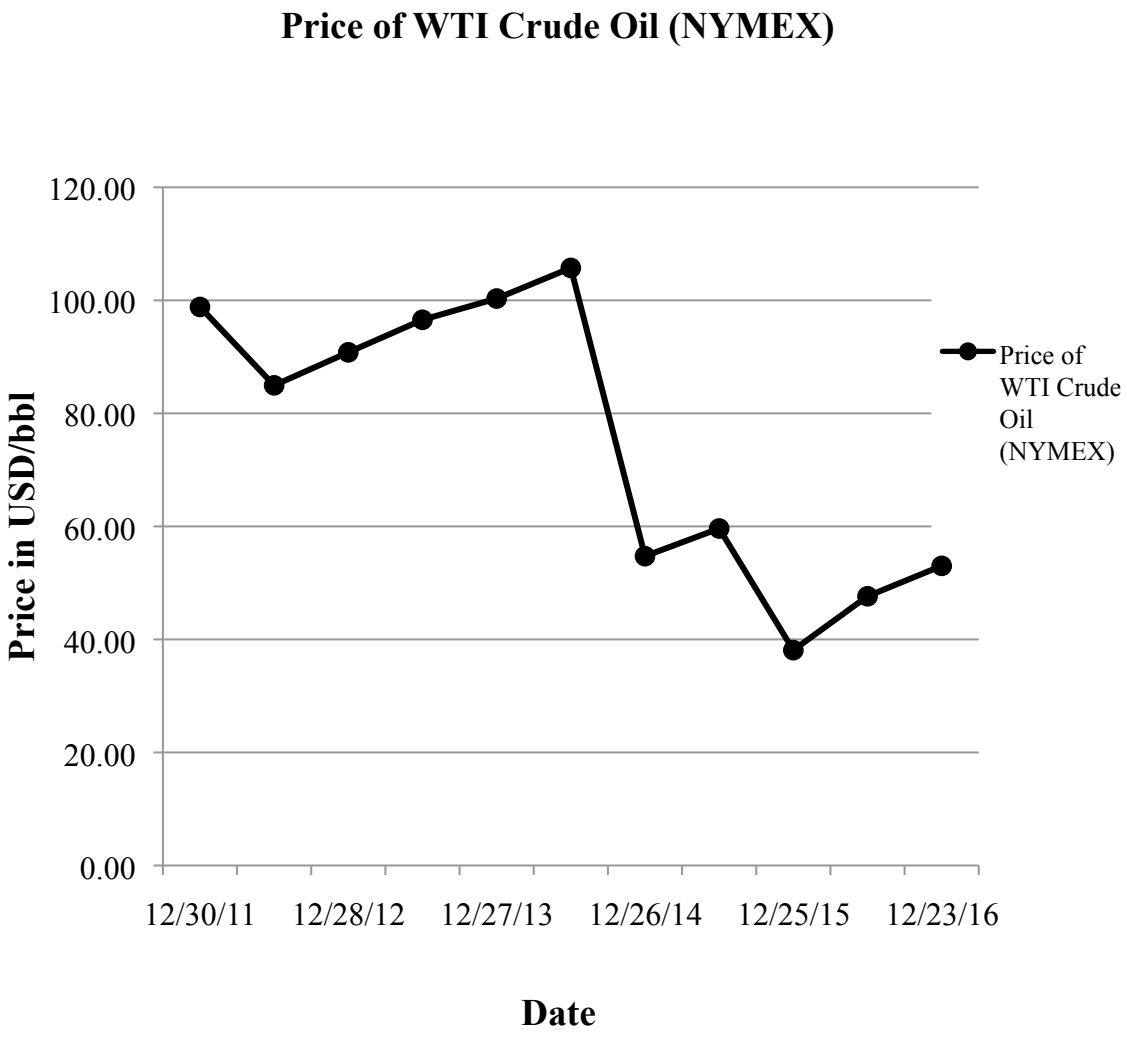


Figure 2. The Price of WTI Crude Oil (NYMEX). Data are from a range of five years and shown in 6 month intervals. Source: Bloomberg, "CL1 Commodity Quote," *Bloomberg Markets*, n.d., https://www.bloomberg.com/quote/CL1:COM.

the largest economies in the Middle East region, even larger than its neighbor Egypt, which is also an economic powerhouse.[18] Saudi Arabia is able to spend "tens of billions a year subsidizing gasoline, electricity, rice and other daily needs…" and additionally in February 2015, gasoline for cars could be bought for only 45 cents per gallon.[19] At the same time, regular gasoline in the United States cost $1.89 on average.[20] This price of gasoline is typical in oil-rich countries in the Middle East like Saudi Arabia, where the government subsidizes energy sources for its citizens. These subsidies encourage more use of the resources, driving up the amount Saudis consume and lowering the amount they export. To combat these problems, the Saudi government has raised fuel prices and is expected to continue this trend of reducing fuel subsidies in attempts to reduce dependence on domestic oil reserves.[21]

Generally across the board, many Middle Eastern states and their citizens have enjoyed considerably low electricity prices when compared against countries not in the region. The following were the prices in cents/kilowatt hour (kWh) in 2010: about 6.25

---

[18] The World Bank, "GDP (current US$)," *World Bank Group*, n.d., http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=EG-SA.

[19] Kevin Sullivan, "If You Think Gas Is Cheap These Days, Look What It Costs in Saudi Arabia," *The Washington Post*, February 8, 2015, https://www.washingtonpost.com/world/middle_east/if-you-think-gas-is-cheap-these-days-look-what-it-costs-in-saudi-arabia/2015/02/07/889536ef-fb15-4453-b99b-eb99622dcf4e_story.html.

[20] U.S. Energy Information Administration, "U.S. Regular Conventional Retail Gasoline Prices (Dollars per Gallon)," *U.S. Energy Information Administration*, December 19, 2016, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epmru_pte_nus_dpg&f=w.

[21] Wael Mahdi, "Saudi Arabia Considers Rise in Retail Fuel Prices in 2017," *Bloomberg.com*, December 20, 2016, https://www.bloomberg.com/news/articles/2016-12-20/saudi-arabia-said-to-consider-rise-in-retail-fuel-prices-in-2017-iwxu7w3z.

cents/kWh for Jordanians, about 5.6 cents/kWh for citizens in the UAE, and about 1.6 cents/kWh for Saudi Arabians.[22] At the same time, US citizens on average paid 11.54 cents/kWh.[23] These low prices are in part due to government subsidies for electricity, often driven by the availability of oil as an energy source and the low cost of extraction in the Middle East for oil compared to other regions.[24] Because of these subsidies, fuel prices in much of the Middle East are extremely deflated by artificial means. The Middle East, unlike much of the world, is a region that still heavily relies on burning oil to generate electricity. Oil is only used to generate three percent of the world's electricity yet in the Middle East, thirty-five percent of the region's electricity comes from oil.[25] The IEA projects that "generating electricity with oil in the Middle East will cost about $60 per MWh in 2020, but without subsidies, it would cost $215."[26]

Reliance on subsidies for oil has encouraged Middle Eastern states and their populations to use ever-increasing amounts of electricity and gasoline, aiding the growing energy demand crisis. Additionally, the prevalent use of subsidies and heavy reliance on

---

[22] Bassam Fattouh, "Energy Subsidies in the Middle East: Issues & Implications," *International Institute for Sustainable Development*, Proc. of Increasing the Momentum of Fossil-Fuel Subsidy Reform, Geneva, Oxford Institute for Energy Studies & Oxford University, October 2010, https://www.iisd.org/gsi/sites/default/files/ffs_gsiunepconf_sess3_bafattouh.pdf.

[23] U.S Energy Information Administration, "Electric Power Monthly," EIA - Electricity Data, *U.S. Energy Information Administration*, December 23, 2016, https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_3.

[24] Jude Clemente, "The Middle East's Growing Oil Demand Problem," *Forbes*, March 29, 2015, http://www.forbes.com/sites/judeclemente/2015/03/29/the-middle-easts-growing-oil-demand-problem/#55955cc24867.

[25] Ibid.

[26] Ibid.

oil export revenues has recently dealt a large blow to Saudi Arabia. Due to enduring low oil prices, Saudi Arabia has burned through its large cash reserves and incurred a staggering budget deficit of $98 billion in 2015, and an expected deficit of $87 billion for 2016.[27]

In late December 2016, Saudi Arabia released an "84-page document outlining how the Arab world's largest economy plans to balance its budget by 2020…" largely due to the shortfall of oil revenues.[28] In the document, proposed changes involving subsidies include "a steady change in energy and water prices from 2017 to 2020. This is expected to help the kingdom save 209 billion riyals [about $55.7 billion as of April 2017] annually by 2020."[29] Additionally, Saudi Arabia is considering raising "prices of local retail fuel by linking them to benchmark oil prices or to the average of gasoline and diesel fuel prices on the international market…"[30] Reductions of fuel and electricity subsidies in 2016 also helped save Saudi Arabia 27 to 29 billion riyals ($7.20 billion to $7.73 billion as of December 27, 2016) and the subsidies reductions "also helped slow

[27] Tim Daiss, "Saudi Arabia Burns Through Cash Subsidies, Economic Crash Possible," *Forbes*, October 14, 2016, http://www.forbes.com/sites/timdaiss/2016/10/14/saudi-arabia-burns-through-cash-subsidies/#5cfe3f9b4855.

[28] Zainab Fattah and Vivian Nereim, "Expat Fee, Subsidy Cuts: What's in Saudi Arabia's Fiscal Balance Plan?," *Bloomberg.com*, December 25, 2016, https://www.bloomberg.com/news/articles/2016-12-25/expat-fee-subsidy-cuts-what-s-in-saudi-fiscal-balance-document.

[29] Ibid.

[30] Ibid.

the growth in energy consumption to 1.7 percent in the first half of 2016 from 3.5 percent in the same period a year earlier."[31]

United Arab Emirates. While the United Arab Emirates does not produce nearly as much oil as Saudi Arabia—3,474,000 bbl/day compared to Saudi Arabia's 11,948,000 bbl/day in 2015[32]--it is still one of the major oil producers in the world. This has afforded the UAE the ability to grant energy subsidies to its population, similar to what Saudi Arabia does. However, the UAE government recently stated in January 2016 at the World Economic Forum summit in Davos that they desire to cut remaining energy subsidies for electricity and gas sold to power generators, but much is unclear on what a proposed timeline for removing the subsidies would look like.[33] The UAE's energy minister Suhail Al Mazrouei said "We saw the opportunity to do the right thing and to get people to pay the right price for energy. We have done it with petrol and diesel, next is electricity."[34] This elimination would help accomplish two things: first, it would save the UAE government money, especially at times when oil revenues could be considerably smaller due to low oil prices, and second, it would help reduce energy consumption growth rates, as higher prices could deter wasteful or excessive energy use when compared against energy usage with lower prices.

---

[31] Zainab Fattah and Vivian Nereim, "Expat Fee, Subsidy Cuts: What's in Saudi Arabia's Fiscal Balance Plan?"

[32] U.S. Energy Information Administration, "Total Petroleum and Other Liquids Production - 2015."

[33] Frank Kane, "UAE to Cut Remaining Energy Subsidies, Minister Says," *The National*, January 24, 2016, http://www.thenational.ae/business/economy/uae-to-cut-remaining-energy-subsidies-minister-says.

[34] Ibid.

A Brookings Institution report published in January 2016 examined the implications and lessons learned from energy subsidy reforms in the UAE. It found that wide spread social backlash did not and has not occurred regarding subsidy reforms; the most substantial subsidy reforms targeted the expat community in the UAE, which could explain why social backlash has been minor.[35] Additionally, the report found that younger generations of UAE citizens "have a better appreciation of the actual costs of resources like water and electricity, and more affinity with conservation and sustainability", which bodes well for the country's future and the government's desire to reduce consumption and cut subsidies.[36] Furthermore, the report advocates that the UAE government must do a better job at educating its citizens why subsidies should be cut, explaining the real costs of resources like energy and water, and a better job of educating citizens on their actual consumption of resources to aid in reducing the dramatic effects of an energy demand/supply crisis in the future.[37]

As a whole, the UAE has been a leader in subsidy reform in the region as it continues to publicly address the growing demand problem and its reliance on oil revenues to provide those subsidies to its citizens. While the UAE has no intentions of dramatically reducing oil exports, it is seeking to diversify its economy to protect it from price volatility of oil in the future. In 2015, the UAE's GDP rose by 3.5 percent and seventy percent of the UAE's GDP came from non-oil sectors; the UAE's key economic

---

[35] Tim Boersma and Steve Griffiths, *Reforming Energy Subsidies Initial Lessons from the United Arab Emirates*, The Brookings Institution, January 2016, https://www.brookings.edu/wp-content/uploads/2016/01/esci_20160119_uae_energy_subsidies.pdf.

[36] Ibid.

[37] Ibid.

sectors include tourism, commercial trade, and financial services.[38] By reducing the reliance on oil revenues, the government can help craft policies that allow businesses to grow. Additionally, growth in the private sector will make the UAE a desirable destination for entrepreneurs to ensure that the UAE can sustain growth that does not rely on oil revenues.

Jordan. The state of Jordan is a unique case in the Middle East because it has an extremely small amount of proven oil reserves when compared to its regional neighbors—Jordan produced 400 bbl/day in 2015 and Saudi Arabia produced 11,948,000 bbl/day in 2015.[39] This lack of oil reserves causes, in part, Jordan to rely on energy imports to meet its energy demands. Jordan has typically imported more than ninety percent of its energy supply to meet its growing needs.[40] In a region that is typically awash with regime change, weak state governments, and violence across borders, Jordan's reliance on energy imports makes it extremely vulnerable to price fluctuations and disrupted supply routes. This played out prominently in Jordan during the Arab Spring uprisings that cut off natural gas imports from Egypt.

After the 2011 ousting of Hosni Mubarak, repeated attacks on gas pipelines "forced Jordan to look for alternatives."[41] Before Mubarak's fall, Jordan received

---

[38] Embassy of the United Arab Emirates, "UAE Economic Diversification Efforts Continue to Thrive," N.p., n.d., http://www.uae-embassy.org/sites/default/files/pdf/uae_economic_development_infographic_v7_1.pdf.

[39] U.S. Energy Information Administration, "Total Petroleum and Other Liquids Production - 2015."

[40] Michael Hochberg, "Jordan's Energy Future: A Path Forward."

[41] Kate Galbraith, "Jordan Finds Energy Sources in Unlikely Places," *New York Times*, September 17, 2014, https://www.nytimes.com/2014/09/18/business/energy-environment/jordan-finds-energy-sources-in-unlikely-places.html?_r=0.

"natural gas at below market rates [from Egypt] in return for political support."[42] When the Arab Spring hit the Middle East, Jordan did not erase its subsidies for electricity, choosing to incur the cost itself to not risk political instability in its own state. Doing so, in part, caused Jordan's national electric power company to accumulate $7 billion in debt during 2011-2016.[43] In 2014, Jordan began increasing electricity tariffs for electricity consumers who consumed the largest amounts of electricity—typically "industries, large companies, mines, hotels and the banking sector."[44] In addition, because Jordan has no significant petroleum oil reserves within its state, it must acquire gasoline on the international market at international prices. Because of this fact, gasoline is not as cheap as in other Middle Eastern countries that possess large amounts of oil reserves like Saudi Arabia and the UAE. In January 2017, a gallon of unleaded 90-octane gasoline cost about $3.29 and a gallon of unleaded 95-octane gasoline cost about $4.32 in Jordan.[45]

A major factor that has affected Jordan's short term and potentially long-term energy security is the ongoing war in Syria. Jordan has one of the largest amounts of Syrian refugees in the Middle East—as of September 2016 there were approximately 650,000 refugees in Jordan registered with the United Nations, with the Jordanian

[42] Taylor Luck, "Jordan's Syrian Refugee Economic Gamble," *Middle East Institute*, May 24, 2016, http://www.mei.edu/content/article/jordan-s-syrian-refugee-economic-gamble.

[43] Ibid.

[44] Ibid.

[45] Jordan Times, "Gov't Raises Fuel Prices by over 6%," *Jordan Times*, December 31, 2016, http://jordantimes.com/news/local/gov%E2%80%99t-raises-fuel-prices-over-6.

government estimating there are about 1 million Syrian refugees actually in Jordan.[46] It is estimated that refugees in Jordan "use around 25 percent less energy than the general population."[47] To help combat the effects of the Syrian refugee crisis upon the state of Jordan and reduce the risk of a massive humanitarian crisis in its own borders, Jordan established the National Resilience Plan (NRP) 2014-2016, which is "a three-year plan that sought to align humanitarian funding with national priorities in addressing the additional pressures on the country…"[48]

The NRP works in conjunction with the Jordan Response Plan (JRP)—established in 2016—which is a national-led plan meant to combat the effects of refugees and development issues and is to be reviewed annually.[49] The JRP contains three energy-specific objectives: 1. Create effective and efficient solutions to offset the incremental energy demand in a sustainable manner, 2. Introduce and promote innovative renewable energy and energy efficient technologies, and 3. Provide refugees and Jordanians with access to an adequate, safe and sustainable supply of energy for every household.[50]

---

[46] Tim Hume, "75,000 Trapped in Refugee Camp on Jordan-Syria Border, Amnesty Warns," *CNN*, September 16, 2016, http://www.cnn.com/2016/09/15/middleeast/jordan-rukban-refugee-camp/.

[47] Glada Lahn, Owen Grafham, and Adel Elsayed Sparr, *Refugees and Energy Resilience in Jordan*, Chatham House, April 20, 2016, https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2016-08-03-refugees-energy-jordan-lahn-grafham-sparr.pdf, 6.

[48] Ibid, 12.

[49] Ibid, 4, 12.

[50] Ibid, 12-13.

In September 2016, Jordan signed an agreement with Israel worth $10 billion that would see Jordan receive 8.5 million cubic meters of gas over a 15-year period.[51] While this pragmatic move would help ensure that Jordan can meet its rising energy demand in the coming decades, it also makes Jordan dependent on Israel. This fact, in combination with strained relations between the two countries, has angered a large number of Jordanians. Some Jordanians view an agreement with Israel as an agreement with the enemy.[52]

However, while the government of Jordan is not extremely close with Israel, it recognizes the need to diversify energy sources and acquire economically favorable and stable agreements to ensure energy security for its state. Energy agreements with other countries can help Jordan provide affordable and reliable energy to its population while looking into other options in the future to rely less on imports. Nevertheless, extremely large imports of energy fuel sources will continue to cost the Jordan state billions every year until it can reduce the role of imports in its energy needs.[53,54]

The United Arab Emirates also possesses a great amount of petroleum reserves, but has insulated itself from oil price volatility much more effectively than Saudi Arabia.

---

[51] Zena Tahhan, "Jordanians Reject 'stolen Gas' in Israel-Jordan Deal," *Al Jazeera*, October 3, 2016, http://www.aljazeera.com/news/2016/10/jordanians-reject-stolen-gas-israel-jordan-deal-161002131442112.html.

[52] Ibid.

[53] Energy imports accounted for 16 percent of Jordan's GDP in 2011 ($4,614,400,000). Mojahed Elsagheer, "Energy Situation in Jordan," *Ministry of Planning and International Cooperation*, July 2013, https://eneken.ieej.or.jp/data/5020.pdf.

[54] The World Bank, "Jordan," *World Bank Group*, 2016, http://data.worldbank.org/country/jordan.

It has done this through diversifying its economy by supporting different industries like tourism, commercial trade, and financial services. Jordan's lack of petroleum reserves makes it highly dependents on energy fuel imports, creating significant amounts of risk to the state's energy security. To help reduce risk, Jordan has established government strategies and trade agreements to secure more stable supplies of energy fuel sources.

SOLAR AND NUCLEAR POWER CAPABILITIES OF JORDAN, SAUDI ARABIA, AND THE UAE

While oil petroleum has been the greatest factor in determining availability, security and price of energy in Jordan, Saudi Arabia, and the United Arab Emirates, all three of these states' leaderships recognize the importance to diversify their energy fuel sources to promote energy security. These states are developing new sources of electricity generation to reduce the risks involved with the imminent energy crisis in the Middle East region, largely caused by rapidly rising demand in energy consumption. To combat this problem Jordan, Saudi Arabia, and the UAE are all either exploring the possibility of using solar/nuclear power for electricity generation or have already begun to build solar/nuclear power plants.[55,56,57,58]

By developing solar and nuclear power plants, states can rely on their own domestically produced power rather than be reliant on imports whose prices and availability are subject to international conflicts and events. Additionally, technology regarding solar power has improved vastly over recent years, making solar powered

---

[55] Anthony DiPaola, "Cheapest Solar on Record Offered as Abu Dhabi Expands Renewables," *Bloomberg*, September 19, 2016, https://www.bloomberg.com/news/articles/2016-09-19/cheapest-solar-on-record-said-to-be-offered-for-abu-dhabi.

[56] Bill Richardson, "Bill Richardson: What Saudi Arabia's Bet on Solar Power Means," *Time*, May 3, 2016, http://time.com/4314182/saudi-arabia-solar-power/.

[57] Oxford Business Group, "Jordan Pushes Ahead on Renewables," *Oxford Business Group*, June 22, 2016, http://www.oxfordbusinessgroup.com/news/jordan-pushes-ahead-renewables.

[58] Karl Vick, "The Middle East Nuclear Race Is Already Under Way," *Time*, March 23, 2015, http://time.com/3751676/iran-talks-nuclear-race-middle-east/.

energy cheaper and more efficient.[59] However, since Jordan, Saudi Arabia, and the UAE are just beginning the initial stages of developing solar and nuclear power, it could take many years for some of them to be fully functional to serve those states' respective needs. Solar power and nuclear power both possess pros and cons that greatly affect the way governments and the public desire them, and the way those plants fit into the respective energy strategies for states. Each energy source has a unique set of advantages and disadvantages that are important to understand if policymakers wish to undertake new energy generation methods to produce electricity and promote energy security.

Pros and Cons of Solar Power

There are two major ways to produce solar-powered electricity that are utilized around the world. One method uses photovoltaics (PV) and the other uses concentrating solar power (CSP). PV technologies generate electricity by taking direct sunlight and using its energy to "excite" electrons in semiconductors on the solar panels to create an electrical circuit that can power electrical devices or send electricity into a power grid.[60] CSP technologies generate electricity using a system of multiple parts, as opposed to PV systems that can create electricity immediately using solar power cells. CSP systems "use mirrors to concentrate the energy from the sun to drive traditional steam turbines or

[59] Chelsea Harvey, "This technology may be the future of solar energy," *The Washington Post*, January 15, 2016, https://www.washingtonpost.com/news/energy-environment/wp/2016/01/15/this-technology-may-be-the-future-of-solar-energy/?utm_term=.fc5023606529.

[60] Solar Energy Industries Association, "Photovoltaic (Solar Electric)," *SEIA*, n.d., http://www.seia.org/policy/solar-technology/photovoltaic-solar-electric.

engines that create electricity.[61] A gas or liquid that resides in tubing is heated using solar energy to propel these turbines that generate electricity in ways identical to how fossil fuels typically generate electricity.

However, since PV systems are hooked directly up to the grid and generate electricity almost instantly, it must be used immediately or stored in short term batteries, as it is not very efficient to attempt to store solar-powered electricity for significantly long-term periods. CSP systems—since they produce electricity like fossil fuel systems—can store the heat that generates electricity through turbines relatively more efficiently than PV systems. CSP systems are generally more practical and efficient when used in larger-scale plants, as they require much more land and equipment to operate; due to their size and relative simplicity, PV systems can be established almost anywhere including on roofs or be used in a power plant system like CSP systems.[62] The installed power capacity of PV systems is nearly forty times greater than the installed power capacity of CSP systems around the world. This is due to many reasons, including the fact CSP relies on direct sunlight (PV systems can work well in any part of the world) and because CSP systems are much more complex and depend on many more pieces of equipment and logistics than PV systems require.[63]

---

[61] Solar Energy Industries Association, "Concentrating Solar Power," *SEIA*, n.d., http://www.seia.org/policy/solar-technology/photovoltaic-solar-electric.

[62] Matt Orosz, "Photovoltaics and concentrating solar power: why hybridization makes sense," *SPIE*, August 26, 2015, http://spie.org/newsroom/6018-photovoltaics-and-concentrating-solar-power-why-hybridization-makes-sense.

[63] International Energy Agency, "Technology Roadmap: Solar Thermal Electricity - 2014 edition," *OECD/IEA*, September 2014, http://www.iea.org/publications/freepublications/publication/technology-roadmap-solar-thermal-electricity---2014-edition.html.

Pros. The following points below are key benefits and advantages of solar power for Jordan, Saudi Arabia, and the UAE:

- *Sustainable energy*—Solar energy's source is the sun, so it will be a sustainable energy source for the foreseeable distant future, unlike other sources such as natural gas or coal, which are non-renewable sources of energy**.** Additionally, sunlight is abundant (especially in the Middle East) so solar power can be produced more often.

- *Energy independence*—Utilization of solar energy is much easier to use for the average citizen, allowing solar panels to be put on individual houses and buildings. Additionally, solar power has the potential to let any state become "a potential energy producer, thus allowing for greater energy independence and security."[64]

- *Low carbon output*—When compared with other forms of electricity generation, solar power generally outperforms natural gas and coal significantly in terms of how much carbon they output (this takes into account carbon produced during manufacturing, installation, operation and maintenance, and dismantling and decommissioning). Solar power tends to emit about .07 to .2 pounds of carbon dioxide equivalent per kilowatt-hour (CO_2E/kWh) and natural gas and coal emit about .6 to 2 pounds CO_2E/kWh and 1.4 to 3.6 pounds CO_2E/kWh respectively.[65]

- *No air pollution*—The use of solar power can contribute to a reduction of pollution, which can create health and financial benefits for a state. China, which is notoriously known for its high air-pollution levels in parts of the country, burns high amounts of coal to generate electricity. The World Health Organization states that air quality that is higher than 25 micrograms per m^3 of PM2.5 particles (PM2.5 are fine particles less than 2.5 micrometers) is considered a health hazard—Beijing has had levels of over 500 micrograms per m^3 PM2.5 particles recently.[66]

---

[64] Matthew Johnston, "Pros And Cons Of Solar Energy," *Investopedia LLC*, May 30, 2015, http://www.investopedia.com/articles/investing/053015/pros-and-cons-solar-energy.asp?lgl=bt1tn-no-widget.

[65] Union of Concerned Scientists, "Benefits of Renewable Energy Use," *Union of Concerned Scientists*, April 8, 2013, http://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#globalwarming.

[66] Kevin Lui, "Shocking Time-Lapse Shows Thick Smog Engulfing Beijing," *Time*, January 4, 2017, http://time.com/4621444/chna-smog-beijing-enivronment-red-alert/.

- *Solar is becoming a more affordable option quickly, as technology improves*—The cost of solar technology and solar powered electricity generation are dropping rapidly. As the cost for solar power drops, more states will be able to afford it and solar power will be able to compete financially with fossil-fueled power generation. A report by the World Economic Forum (WEF) showed that solar power costs have been dropping rapidly in the past decade. Comprised of data from the International Renewable Energy Agency, the WEF report found that "the cost of solar energy has dropped 80% since 2009."[67]

Cons. The following points are key restraints and disadvantages for solar power for Jordan, Saudi Arabia, and the UAE:

- *Storage of solar energy and intermittence*—One of the most restrictive restraints regarding solar power is that solar power is generally—today at least—hard to store efficiently. This means that solar power that generates electricity must be put into the power grid quickly relative to other forms of electricity generation. For instance, nuclear power is generally seen as an "always-on" available power source. Since solar power relies on sunlight and solar energy storage is typically expensive or inefficient, solar powered electricity is intermittent, which can be unreliable.[68]

- *Land Use*—Solar power plants use considerably more land than other forms of power generation when compared to their energy output. Large-scale solar power plants require large tracts of land to be able to employ the many solar panels they require. When compared to nuclear power plants, "the amount of land needed by solar to produce the same generation as 1,000 MW of nuclear capacity in a year is between 45 and 75 square miles" as opposed to about 1.3 square miles for a nuclear power plant.[69] However, Jordan, Saudi Arabia, and the UAE all possess large tracts of desert that could be utilized. Many countries around the world do not have this luxury of large tracts of available land.

---

[67] Tarreq Haddad, "Wind and solar energy to be cheaper than fossil fuels by 2018," *International Business Times UK*, December 27, 2016, http://www.ibtimes.co.uk/wind-solar-energy-be-cheaper-fossil-fuels-by-2018-1598238.

[68] Matthew Johnston, "Pros And Cons Of Solar Energy."

[69] Nuclear Energy Institute, *Land Requirements for Carbon-Free Technologies*, *Nuclear Energy Institute*, June 2015, https://www.nei.org/CorporateSite/media/filefolder/Policy/Papers/Land_Use_Carbon_Free_Technologies.pdf?ext=.pdf.

- *Efficiency rates*—The potential of solar power is limited by the efficiency of solar cells and panels. Solar panels do not achieve anywhere near 100% efficiency—a solar panel that could yield consistent 50% efficiency would be considered extremely efficient. The low efficiency rates of solar power can be considered a prohibitive factor.[70]

Pros and Cons of Nuclear Power

Nuclear power-generated electricity is almost exclusively created through a process called nuclear fission. Nuclear fission involves using neutrons to bombard uranium atoms to split them apart. This causes a chain reaction to expel energy from the atoms, creating heat. The chain reactions are maintained and controlled using control rods that absorb neutrons; the heat that is a product of this reaction is used to heat water to create steam to spin turbines, which generate electricity.[71]

The two most prevalent and well-known types of nuclear reactors that are used to generate electricity around the world are pressurized water reactors (PWR) and boiling water reactors (BWR). Figure 3[72] and Figure 4[73] illustrate visually how a PWR and BWR work respectively. PWRs use the heat from the nuclear reactions to heat water near the core of the reactor and send the water through pipes surrounded by a second

[70] David Rowan, "2017 could be the tipping point for super efficient solar panels," *WIRED UK*, January 3, 2017, http://www.wired.co.uk/article/solar-power-perovskite.

[71] Union of Concerned Scientists, "How Nuclear Power Works," *Union of Concerned Scientists*, n.d., http://www.ucsusa.org/nuclear-power/nuclear-power-technology/how-nuclear-power-works#.WH0lZrYrKRs.

[72] U.S. NRC, "Animated Images of Plants PWR and BWR," NRC: The Student Corner: Multimedia: Animated Images of Plants PWR and BWR, *U.S. Nuclear Regulatory Commission*, September 8, 2015, https://www.nrc.gov/reading-rm/basic-ref/students/multimedia/animated-images-plants-pwr-bwr.html.

[73] Ibid.

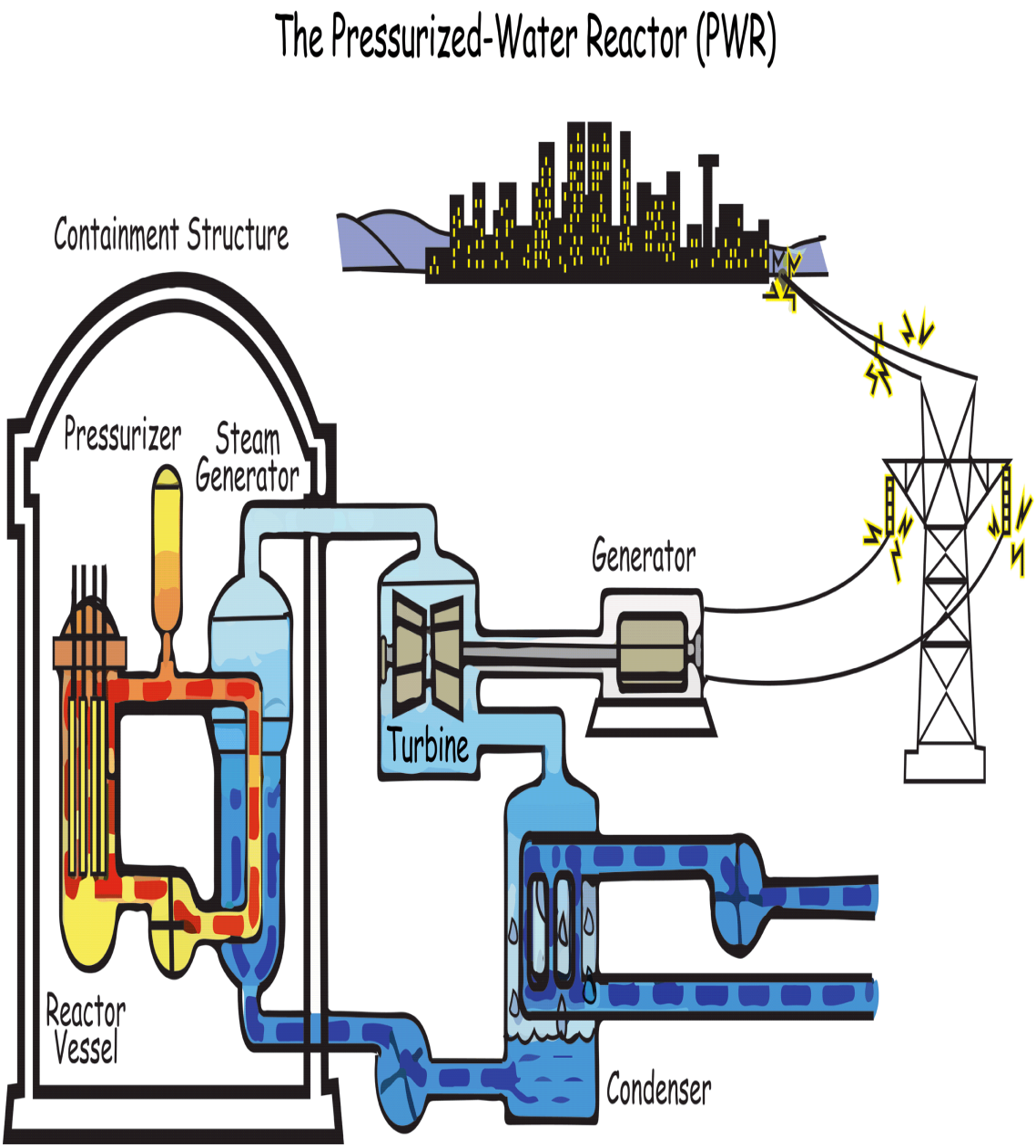


Figure 3. Visual Representation of a Pressurized-Water Reactor (PWR). Source: U.S. NRC, "Animated Images of Plants PWR and BWR," NRC: The Student Corner: Multimedia: Animated Images of Plants PWR and BWR, *U.S. Nuclear Regulatory Commission*, September 8, 2015, https://www.nrc.gov/reading-rm/basic-ref/students/multimedia/animated-images-plants-pwr-bwr.html.

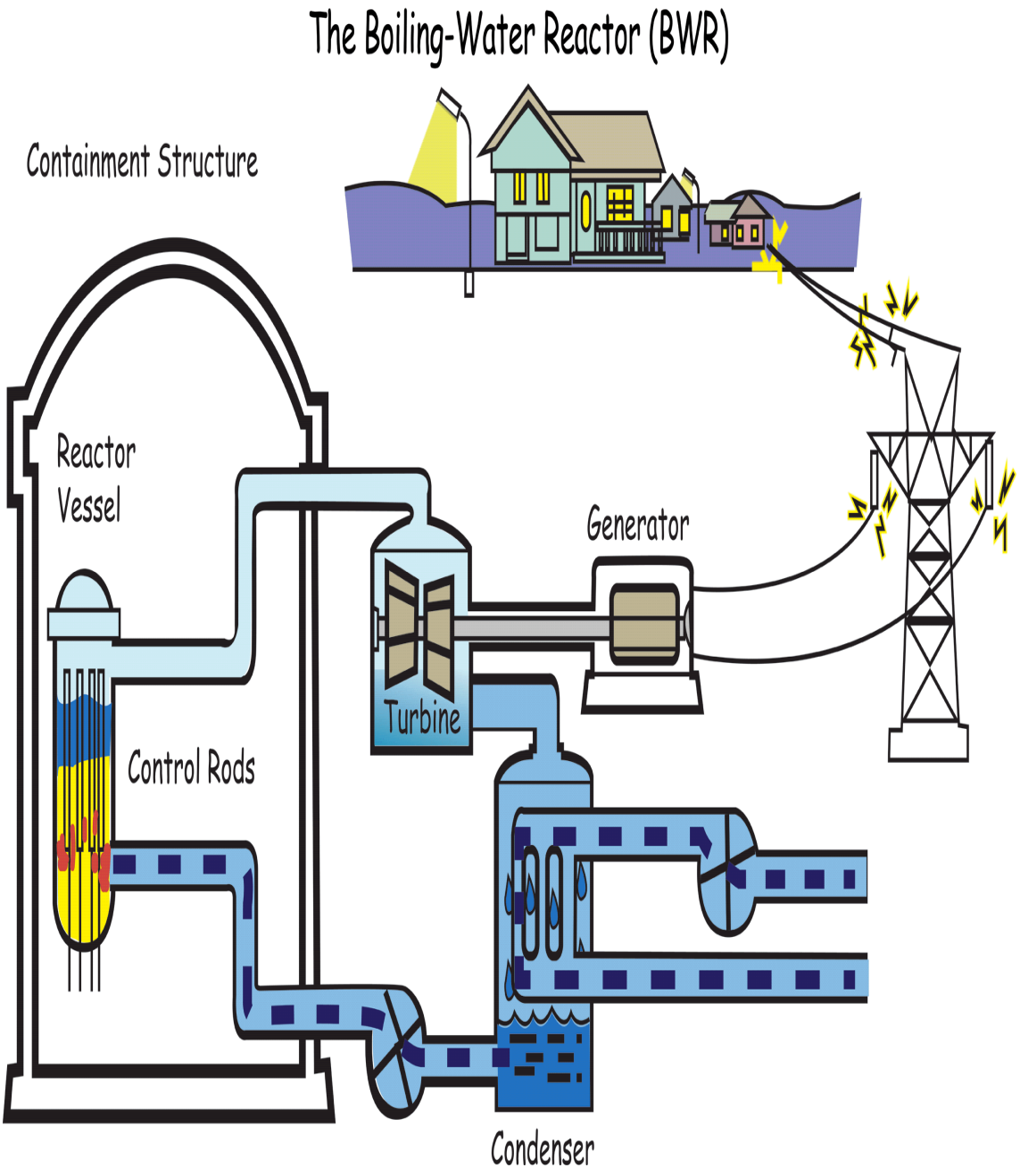


Figure 4. Visual Representation of a Boiling-Water Reactor (BWR). Source: U.S. NRC, "Animated Images of Plants PWR and BWR," NRC: The Student Corner: Multimedia: Animated Images of Plants PWR and BWR, *U.S. Nuclear Regulatory Commission*, September 8, 2015, https://www.nrc.gov/reading-rm/basic-ref/students/multimedia/animated-images-plants-pwr-bwr.html.

water source; however, since the water from the first water source is under great pressure, it does not boil.[74] The water in this second water source is turned into steam caused by the heat emitted from the first water source. The steam from the second water source travels through pipes towards turbines, spinning them to generate electricity. After the steam turns the turbines, the steam is directed towards a reservoir where it is condensed back into a liquid. After this step, this water from the second water source can be brought back to its original location to start the process over again.

BWRs utilize the heat generated from the nuclear reactions to heat and boil water surrounding the core of the reactor, creating steam that is pushed away from the core and directed through pipes.[75] The steam is then carried directly to the turbines to spin them to generate electricity. After the steam spins the turbines, the steam is pushed into a coolant condenser that turns the steam back into a liquid. After the water is condensed it returns to its original location in the reactor to undergo the process all over again.

Pros. The following points below are key benefits and advantages of nuclear power for Jordan, Saudi Arabia, and the UAE:

- *Low carbon output*—Nuclear power, like solar power, produces very minimal amounts of carbon emissions relative to other forms of electricity generation. Nuclear power provides an additional option for states looking to pursue a greener future in regards to energy generation. Four of the top climate scientists in the world argued in an article from the

[74] Duke Energy, "Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR)," *Duke Energy*, March 27, 2012, https://nuclear.duke-energy.com/2012/03/27/pressurized-water-reactors-pwr-and-boiling-water-reactors-bwr.

[75] Ibid.

Guardian that "over the past 50 years, nuclear power stations…have avoided the emission of an estimated 60bn tonnes of carbon dioxide."[76]

- *Land use*—The land needed for a nuclear power plant to produce the same amount of power relative to other forms of energy generation is small. Nuclear power plants use considerably less land than solar or wind energy.[77]

- *Prestige*—Utilization of nuclear power is generally seen as a sign of technological superiority around the world. The science of nuclear power is highly revered around the world, due to the care and intellectual talent required to maintain nuclear power plants. The prestige also undoubtedly comes from the history associated with nuclear energy from the Cold War era.

- *Potential nuclear weapons*—For states looking to develop nuclear weapons, one of the first steps is to develop a nuclear power program. Even if a state has no intention of developing nuclear weapons, a state that possesses a nuclear power facility is much closer to developing nuclear weapons than a state that does not use nuclear energy for electricity generation.

- *Always-on and reliable power*—Nuclear power is part of a core of energy fuel sources that are considered always-on power.[78] Nuclear power plants can run continuously and do not rely on factors that are entirely out of control of humanity like solar and wind power—this makes nuclear power a very attractive option for states that need to make sure baseload electricity demands are always met.[79]

- *Efficient generation capacity*—Nuclear power is one of the most efficient sources of power in terms of generation capacity. The Energy Information Administration reported that in 2012, the world average capacity

---

[76] James Hansen et al., "Nuclear power paves the only viable path forward on climate change," *The Guardian*, December 3, 2015, https://www.theguardian.com/environment/2015/dec/03/nuclear-power-paves-the-only-viable-path-forward-on-climate-change.

[77] Nuclear Energy Institute, Land Requirements for Carbon-Free Technologies.

[78] Elizabeth Landau, "Why (or why not) nuclear energy?" *CNN*, March 26, 2011, http://www.cnn.com/2011/US/03/26/nuclear.energy/index.html?eref=rss_us.

[79] Robert Bryce, "The Conservative Case for Nuclear Energy," Manhattan Institute, *National Review Online*, December 16, 2016, https://www.manhattan-institute.org/html/conservative-case-nuclear-energy-9693.html.

utilization rate for nuclear power plants was 80 percent, much higher than the generation capacity rates for coal, natural gas, or renewable energy.[80]

The following points are key restraints and disadvantages for nuclear power for Jordan, Saudi Arabia, and the UAE:

- *Expensive initial capital costs*—The upfront costs of nuclear power plants can be prohibitive to some, especially when heavy regulations affect the cost of building and planning the construction of a nuclear power plant. The cost to build a nuclear power plant can vary widely from country to country, but nevertheless, it has relatively very expensive up-front costs. These high costs are due to "thousands of workers, huge amounts of steel and concrete, thousands of components, and several systems to provide electricity, cooling, ventilation, information, control and communication."[81]

- *Radioactive waste disposal*—A byproduct of utilizing nuclear energy to produce power is radioactive waste, which requires great care and safety to prevent contamination. Typically, nuclear waste is either stored securely on-site or shipped away to a remote location. Additionally, the waste can be reprocessed for fuel again. However, reprocessed fuel can lead to producing weapons-grade nuclear material, which is a danger within itself.[82]

- *Nuclear accidents*—Another great risk with nuclear power is the chance for an accidental nuclear reactor meltdown caused by weather, earthquakes, or human error. The most infamous examples of incidents include Three Mile Island, Chernobyl, and recently Fukushima. Nuclear accidents risk nuclear material being released into the air and nearby natural environments, potentially damaging and leaving places uninhabitable for decades. Radiation can also travel in the air and spread

[80] U.S. Energy Information Administration, International Energy Outlook 2016, 89.

[81] World Nuclear Association, "The Economics of Nuclear Power," *World Nuclear Association*, December 2016, http://www.world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx.

[82] Robert Rapier, "The Experts: What's the Best Way Forward on Nuclear Power?" *The Wall Street Journal*, April 17, 2013, http://www.wsj.com/articles/SB10001424127887323809304578428570153032936.

to other locations, so nuclear leaks into the atmosphere are not confined to the location the incident occurred.[83]

- *Long wait till plants are operational*—In addition to the amount of time it takes for planning, commissioning, and licensing a nuclear power plant (which all together can take years) it can take approximately 5 to 7 years to build a large nuclear reactor unit. "In comparison, large coal plants can be built in about 4 years, while the construction time for natural gas fired plants is around 3 years."[84] The long timeline that nuclear power plants require can be prohibitive, as states seek quick fixes for energy supply problems or are worried about the risks involved with a lengthy and costly process.

- *Targets of terrorism*—Nuclear power plants have been targets of terrorists in the past. Terrorists could seek out nuclear power plants as targets of attack to cause a nuclear meltdown or damage to reactors to release nuclear material in the air. Additionally, terrorists have sought out nuclear power plants in attempts to acquire nuclear material to either make a dirty bomb or in hopes to eventually develop a functional nuclear weapon.[85]

Jordan

The state of Jordan's heavy reliance on imports is arguably the main driving factor to increase the amount of domestic supplied energy. A heavy reliance on imports forces Jordan to depend on foreign entities and markets to supply it with energy sources to allow the country to function at the most basic level. Figure 5 illustrates the lack of

[83] Simon Rogers, "Nuclear power plant accidents: listed and ranked since 1952," *The Guardian*, March 14, 2011, https://www.theguardian.com/news/datablog/2011/mar/14/nuclear-power-plant-accidents-list-rank.

[84] OECD NEA, "Economics of nuclear power FAQs," N.p., June 8, 2014, https://www.oecd-nea.org/news/press-kits/economics-FAQ.html#2.

[85] Alissa J. Rubin and Milan Schreuer, "Belgium Fears Nuclear Plants Are Vulnerable," *The New York Times*, March 25 2016, http://www.nytimes.com/2016/03/26/world/europe/belgium-fears-nuclear-plants-are-vulnerable.html.

energy production in Jordan compared to energy imports from 1990 to 2014 (the amount of energy exports Jordan conducts are marginal).[86]

In December 2004, the King of Jordan—King Abdullah Ibn Al Hussein II—called upon his cabinet to review and update the energy strategy for the state of Jordan; the Jordanian cabinet endorsed the plan to "…meet the Kingdom's energy needs…improving the level of availability and openness of [the] energy market before investments and achieving the energy supply security."[87] Known as the Jordan National Energy Strategy (NES), the strategy lays out a list of goals and aims to reform the energy sector and promote energy security till 2020. This ambitious strategy plan was established, in part, to help reduce the heavy reliance of imported energy fuel sources for Jordan, which causes great strain on the Jordan economy. Additionally, this heavy reliance on imports creates a high-risk environment that has the potential to cause unfathomable damage in many sectors of Jordan's economy and society if access to energy sources was cut off or threatened.

The NES plans to have renewable energy as a whole cover 10 percent of Jordan's energy demand by the year 2020—solar energy would cover 600MW of the energy

[86] International Energy Agency. "Jordan: Balances for 2014," IEA - Report. *OECD/IEA*, n.d., http://www.iea.org/statistics/statisticssearch/report/?year=2014&country=JORDAN&product=Balances.

[87] Hashemite Kingdom of Jordan, Summary--Updated Master Strategy of Energy Sector in Jordan for the period (2007-2020), *Ministry of Energy and Mineral Resources*, 2007, Print, http://eis.memr.gov.jo/publication/policy/law-policies/283-energy-strategy.

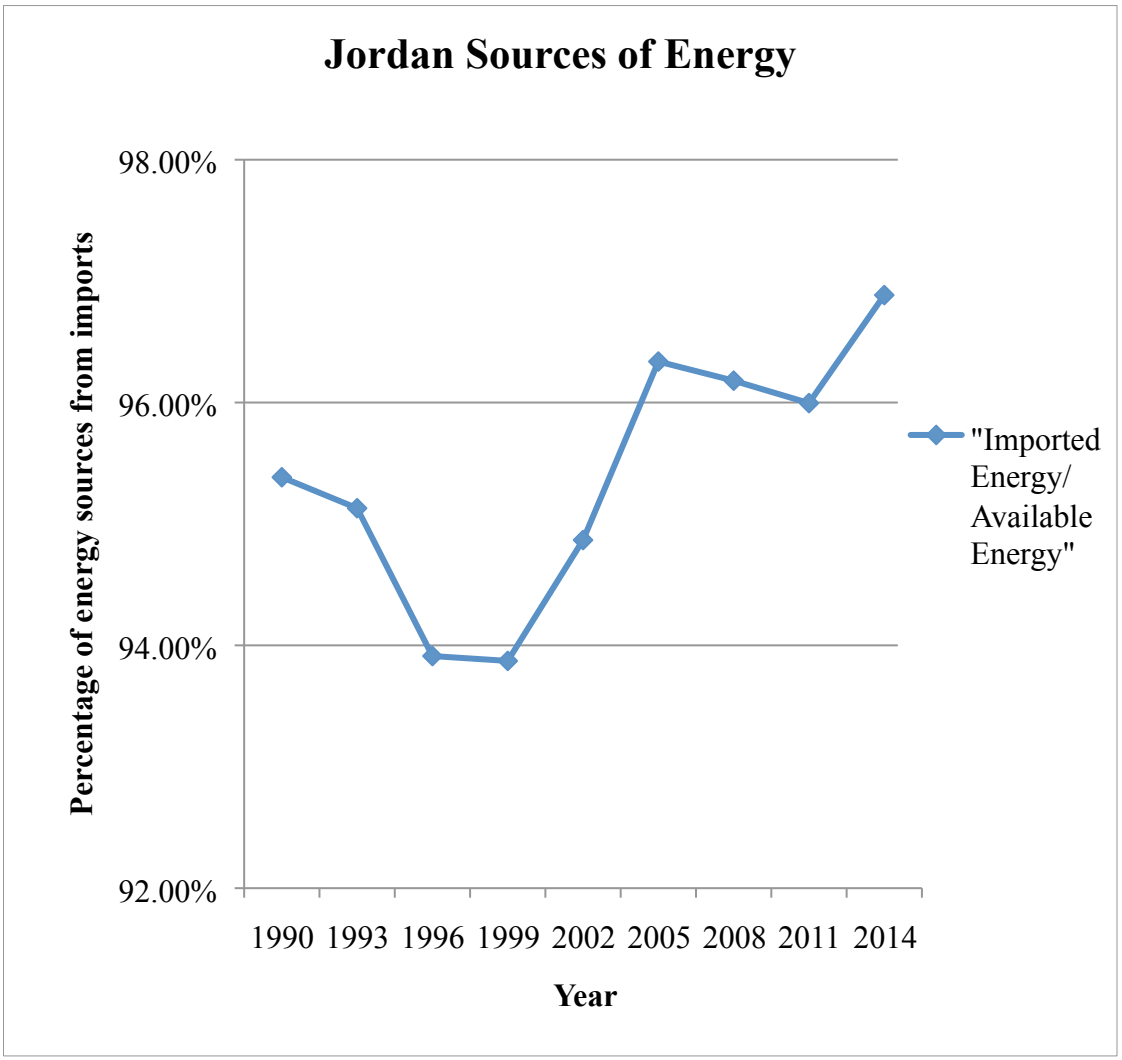


Figure 5. Jordan Energy Sources (Imports/Available energy. Data are presented as percentages. Source: International Energy Agency. "Jordan: Balances for 2014," IEA - Report. *OECD/IEA*, n.d., http://www.iea.org/statistics/statisticssearch/report/?year=2014&country=JORDAN&product=Balances.

demand.[88] One of the most important factors regarding solar power potential for Jordan, and the Middle East as a whole, is that Jordan lies in a geographical region called the "global sunbelt." This part of the world receives the largest amount of sunlight comparative to the rest of the world; because of this, direct solar radiation has the potential to provide up to 5-7 kWh/m^2.[89] This high amount of sunlight potential means that solar power in Jordan could be exponentially more efficient and valuable than states that lie outside of the "global sunbelt." This energy potential has the ability to help Jordan leverage available solar energy to be used essentially forever, while additionally producing more power each year if more solar power plants are created and solar technology improves. Additionally, if Jordan is able to incorporate more solar power plants into its national energy consumption mix, it can reduce the amount of carbon emissions it produces and rely less on risk-filled import fuel sources like natural gas and petroleum.

One important result of utilizing nuclear power plants in Jordan will be the ability to desalinate water to provide potable water to Jordanians. Jordan is one of the most water-poor countries in the world; seeing that nuclear power plants can produce a great amount of power at relatively low operating costs, nuclear power plants are prime sources of electricity for water desalination.[90] Because of Jordan's water predicament, it must

---

[88] Julia Sahawneh, "Energy Policy—Country Report/ Jordan," *Ministry of Energy and Mineral Resources*, June 2, 2015, Japan, PowerPoint Presentation, https://eneken.ieej.or.jp/data/6206.pdf.

[89] Julia Sahawneh, "Energy Policy—Country Report/ Jordan."

[90] Jordan Atomic Energy Commission and Worley Parsons, "White Paper on Nuclear Energy in Jordan--Final Report," *Worley Parsons*, September 2011, http://www.jaec.gov.jo/CMS/UploadedFiles/c18cbcac-92e9-481b-a781-498ca0bf7e9c.pdf, 24.

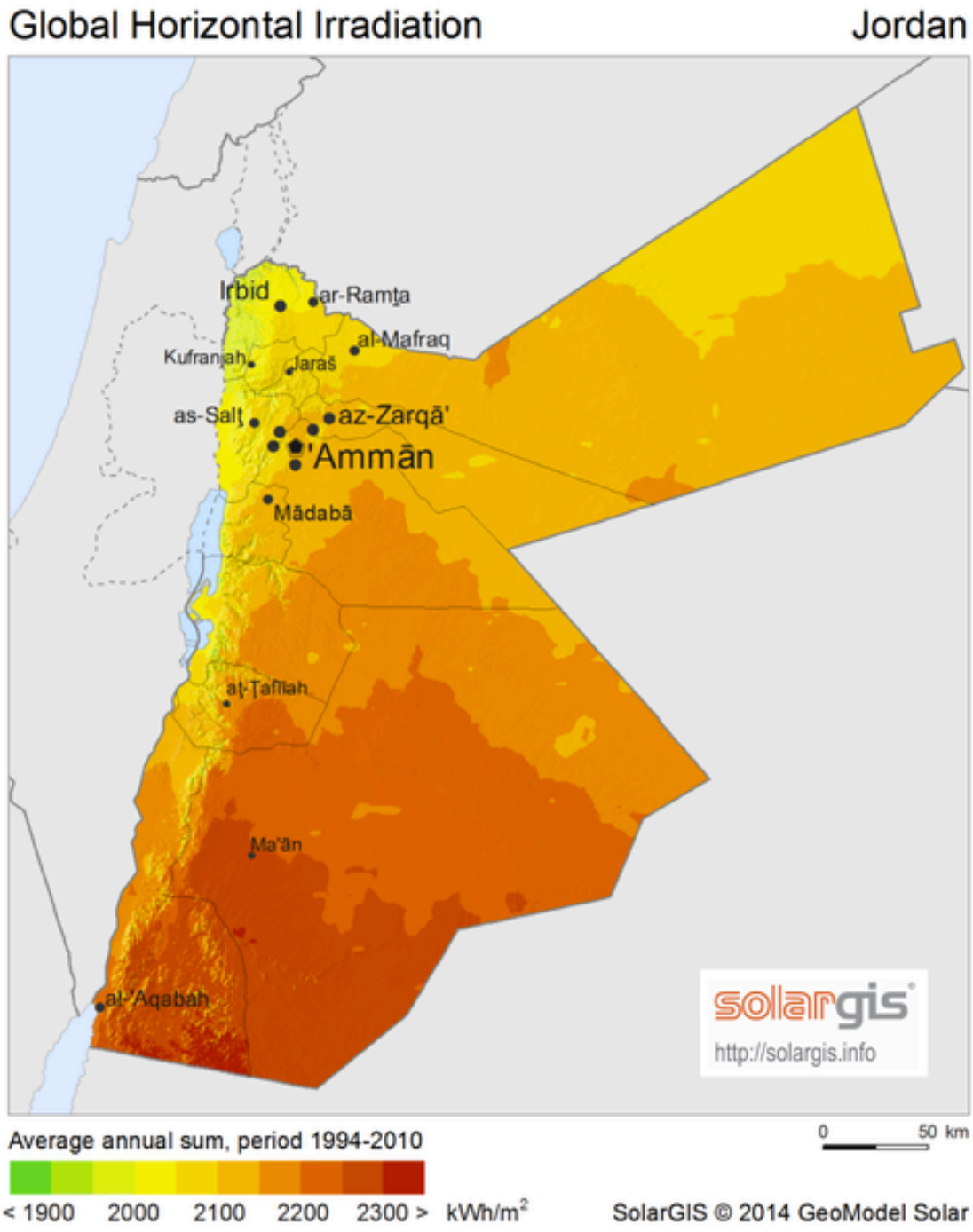
produce potable water in different ways rather than drain its minimal fresh water sources. Desalination is a process that can be done in multiple ways to remove salt from saltwater to produce fresh water.[91] Desalination is a very energy intensive process, which makes it very expensive to run, especially if large amounts of water are desalinated often.

As Jordan's population continues to grow and freshwater sources in Jordan diminish, the importance and need for desalination to provide freshwater will be great. A reliable supply of potable water is needed for a society and state to function properly on a basic level, and needed to grow the economy as well to attract investments foreign and domestic. Additionally, because nuclear power provides reliable energy without producing carbon emissions even close to the levels of fossil fuels, it allows desalination to occur without polluting the nearby environment and air quality of Jordan. This factor can help reduce potential future negative effects of climate change like rising temperatures and further exacerbating droughts that could weaken political and economic security of Middle Eastern states. Practically, the premise of using solar power and nuclear power makes sense for Jordan due to its extremely limited domestic energy sources, its need for potable water, its reliance on energy imports, and the growing demand in electricity consumption.

Planned and Existing Solar Power Capabilities in Jordan. Figure 6 shows how much solar potential measured in kWh/m^2 Jordan possesses in terms of global horizontal irradiation (GHI).[92] GHI "is the total amount of shortwave radiation received from above

[91] Nuclear Energy Institute, "Water Desalination," *NEI*, n.d., https://www.nei.org/Knowledge-Center/Other-Nuclear-Energy-Applications/Water-Desalination.

[92] SolarGIS, "Solar resource maps for Jordan," *SolarGIS*, 2014, http://solargis.com/products/maps-and-gis-data/free/download/jordan.



] kWh/m^2. Map of Jordan showing areas where Jordan receives the most sunlight energy. Source: SolarGIS, "Solar resource maps for Jordan," *SolarGIS*, 2014, http://solargis.com/products/maps-and-gis-data/free/download/jordan. (GHI Solar Map © 2017 Solargis)

by a horizontal surface"—in other words, it is a measurement of how much energy can be derived from photovoltaic solar cells to produce solar energy.[93] Based on the data, Jordan has higher than average GHI levels, which signals that solar power potential could be efficient and significant in producing electricity, raising Jordan's energy capacity and thus increasing domestic capacity and decreasing the need for energy imports. This, in large part, is due to Jordan's relative location to the Equator. Jordan's geographical location causes it to get a large amount of sunlight hours per day, regardless of what time of the year it is.

To attract businesses and foreign investment proposals to build solar power (and wind power) capabilities in Jordan competitively, the government of Jordan temporarily enacted the Renewable Energy & Energy Efficiency (Law No. 13) in 2010, which eventually became permanent in 2012.[94] The law bestowed responsibility upon Jordan's Ministry of Energy to identify a list of renewable energy development zones that would promote renewable energy products with incentives.

Furthermore, the law allowed for "domestic and international companies to bypass a previously complex bidding process and negotiate directly with the Minister of Energy."[95] The law also created the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF), which allows for domestic and international companies to receive financial support for renewable energy projects that are built within Jordan. When the

---

[93] 3TIER, "Glossary of Technical Renewable Energy Terminology," *3TIER Support*, Vaisala, n.d., http://www.3tier.com/en/support/glossary/#ghi.

[94] Jordan Ministry of Energy and Mineral Resources, "Renewable Energy & Energy Efficiency (Law No. 13)," *OECD/IEA*, July 23, 2013, https://www.iea.org/policiesandmeasures/pams/jordan/name-36862-en.php

[95] Ibid.

law was made permanent in 2012, it was amended to establish that "all renewable energy sources and energy conservation systems and equipment and its production inputs, whether manufactured locally or imported, will be exempted from all customs duties and sales tax."[96]

This law has helped attract solar power companies to invest in Jordan to compete for contracts to produce solar-powered electricity, like in the Ma'an Development Area. The Ma'an Development Area provides financial and administrative benefits including allowing companies to be 100 percent foreign owned and tax benefits on income generated from investment projects.[97] By October 2016, the largest solar PV plant in Jordan and one of the largest in the region went online, with an installed capacity of 52.5MW.[98] The Shams Ma'an plant—which occupies around 2 million square meters and cost around $170 million—can produce around 160GWh per year, supplying about 1 percent of Jordan's electricity needs. Additionally, the plant will prevent thousands of tons of carbon emissions by using solar power to produce electricity instead of fossil fuels.

Plans and negotiations are also underway between a Masdar subsidiary called Baynouna Solar Energy Company and the National Electric Power Company of Jordan to construct a large solar power plant near Amman. The new plant will have an installed

---

[96] Jordan Ministry of Energy and Mineral Resources, "Renewable Energy & Energy Efficiency (Law No. 13)."

[97] Ma'an Development Area, "FAQ," *Ma'an Development Area*, n.d., http://www.mda.jo/faq.aspx.

[98] Shams Ma'an, "Shams Ma'an Launches Production Phase of the largest Electricity Generation Project Using Photovoltaic Cells in Jordan," *Shams Ma'an*, December 21, 2016, http://www.shamsmaan.com/page/shams-ma%E2%80%99-launches-production-phase-largest-electricity-generation-project-using-photovoltaic.

capacity of 200MW using PV technology and could prevent the carbon emissions of up to 360,000 tons annually.[99] In January 2017, it was also announced that a Saudi Arabian company, Acwa Power, will construct a 61.3MW solar PV project that will produce "electricity for 5.88 US cents per kilowatt-hour – the lowest solar tariff ever for a project in the country."[100]

One of the ways to help supplement the energy sector and satisfy growing energy demand is to use solar panels on roofs and smaller-scale settings. The government of Jordan is aiming to utilize solar PV panels on rooftops of around 2,000 of the country's 6,300 mosques.[101] Additionally, many universities in Jordan are seeking installation of solar panels to provide themselves with clean energy and to potentially produce surplus electricity to "sell the generated power to the grid."[102] On January 17, 2017, Jordan announced that it had met its goal of having renewable energy sources comprising at least 10 percent of its energy mix by 2020.[103]

---

[99] Masdar, "Masdar appoints IFC to oversee funding of Jordan's largest solar power project," *Masdar*, January 18, 2017, http://www.masdar.ae/en/media/detail/masdar-appoints-ifc-to-oversee-funding-of-jordans-largest-solar-power-proje>.

[100] LeAnne Graves, "Acwa plans low-cost solar project in Jordan," *The National*, January 16, 2017, http://www.thenational.ae/business/energy/acwa-plans-low-cost-solar-project-in-jordan.

[101] Ilias Tsagas, "Jordan: mosques and universities embrace solar," *Pv magazine International*, April 12, 2016, https://www.pv-magazine.com/2016/04/12/jordan-mosques-and-universities-embrace-solar_100024107/.

[102] Ibid.

[103] Petra News Agency, "Jordan Achieves 2020 Renewable Energy Strategy 2020 Objective, Minister," *Embassy of the Hashemite Kingdom of Jordan*, January 17, 2017, http://www.jordanembassyus.org/blog/jordan-achieves-2020-renewable-energy-strategy-2020-objective-minister-1.

Planned and Existing Nuclear Power Capabilities in Jordan. The concept for Jordan utilizing nuclear power was briefly touched on in its NES but was not mentioned at length to the extent renewable energy was. The first major step towards realistically exploring the option to utilize nuclear power plants in Jordan occurred in 2007, when National Laws 42/2007 and 43/2007 were enacted to create the Jordan Atomic Energy Commission (JAEC) and the Jordan Nuclear Regulatory Commission (JNRC) respectively.[104] The JNRC was later merged with other similar agencies into the Energy and Minerals Regulatory Commission (EMRC). Both the EMRC and the JAEC report directly to the Prime Minister.

Since those commissions have been created, the government of Jordan has made substantial progress in terms of planning and beginning to phase estimates for nuclear power into Jordan's energy mix; this planning buildup culminated into a $10bn deal between the Jordanian government and Rosatom, a nuclear power based corporation owned by the Russian government.[105] The agreement entails building two 1,000MW reactors in the northern part of Jordan to form one nuclear power plant. Additionally, the state of Jordan will own slightly above 50 percent of the plant while Rosatom will own about 49 percent. The original Jordan NES projected that nuclear power would comprise

[104] International Atomic Energy Agency, "Jordan," Country Nuclear Power Profiles, *IAEA*, 2016, https://cnpp.iaea.org/countryprofiles/Jordan/Jordan.htm.

[105] AP, "Russia to build Jordan's first nuclear power plant," *Al Jazeera English*, March 24, 2015, http://www.aljazeera.com/news/middleeast/2015/03/russia-build-jordan-nuclear-power-plant-150324192954416.html.

about 6 percent of Jordan's primary energy by 2020; however, Jordan's first nuclear power plant is not expected to be in full operation until 2023.[106]

Saudi Arabia

Saudi Arabia is a state with expansive potential for utilizing solar energy to produce electricity. Since Saudi Arabia burns a significant amount of its own oil for electricity generation, it can stand to benefit greatly by implementing solar and nuclear power plant projects to reduce domestic consumption of oil. Due to this demand, the capital that Saudi Arabia possesses, and the quickly rising population of Saudi Arabia, Saudi Arabia stands to become potentially the largest solar power market in the world. For those reasons, Sami Khoreibi—CEO of Enviromena Power Systems, a solar power firm in the UAE—expects that "Saudi Arabia will be the largest market in the region in the medium- to long-term."[107] Figure 7 shows how much solar potential measured in kWh/m^2 Saudi Arabia possesses in terms of global horizontal irradiation (GHI).[108] Most of the country possesses high potential yield amounts that would ensure that solar power could be highly effective and efficient to produce reliable electricity.

---

[106] World Nuclear Association, "Nuclear Power in Jordan," *World Nuclear Association*, December 2016, http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/jordan.aspx.

[107] Anna Hirtenstein, "Saudi Arabia begins shift from oil to solar power to fuel electricity generation," *The Independent*, December 21, 2016, http://www.independent.co.uk/news/business/news/saudi-arabia-oil-revenue-production-solar-power-shift-electricity-energy-opec-a7488626.html>.

[108] SolarGIS, "Solar resource maps for Saudi Arabia," *SolarGIS*, 2013, http://solargis.com/products/maps-and-gis-data/free/download/saudi-arabia.

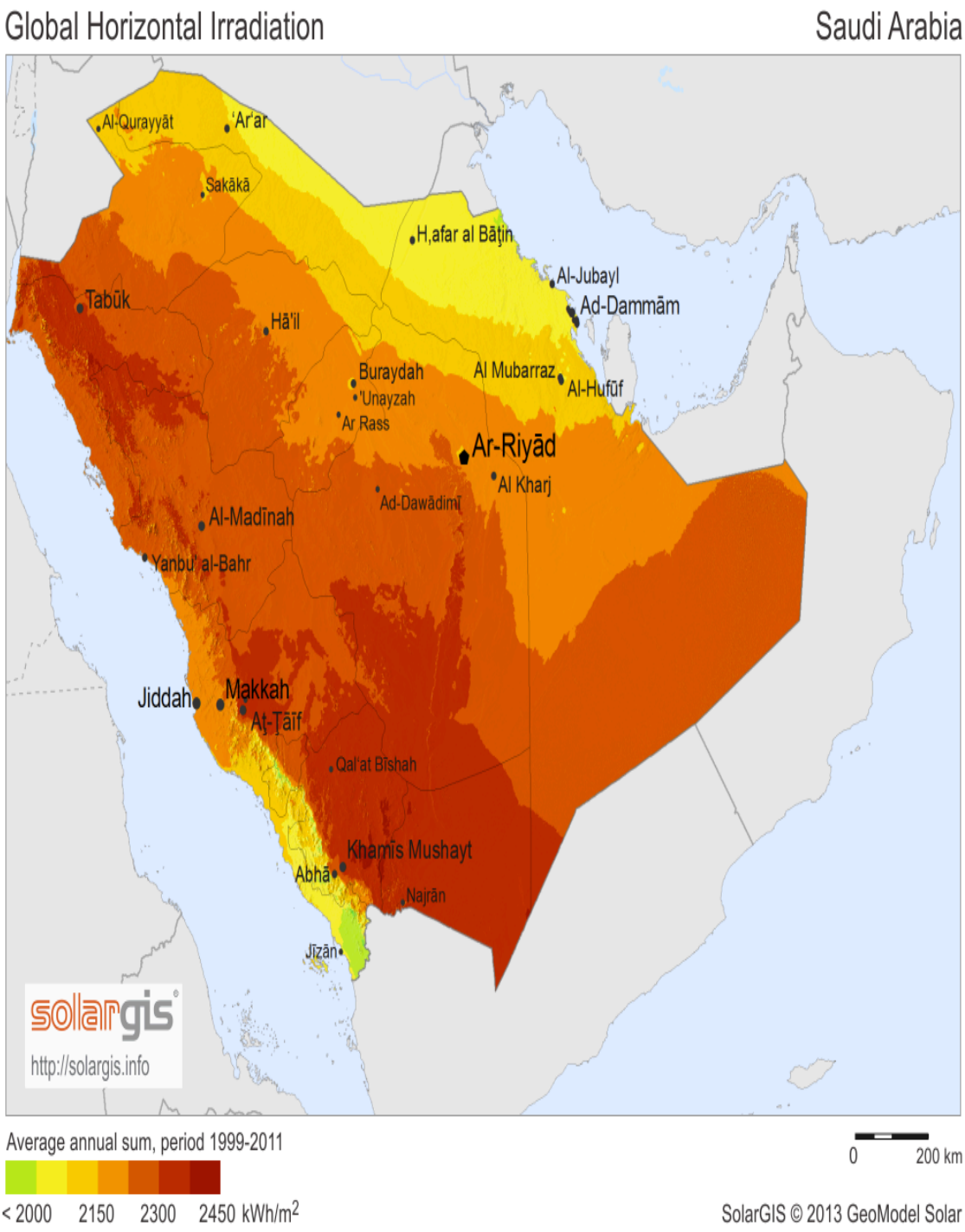


Figure 7. Saudi Arabia Solar Potential Yields (Global Horizontal Irradiation) in Terms of kWh/m2. Map of Saudi Arabia showing areas where Saudi Arabia receives the most sunlight energy. Source: SolarGIS, "Solar resource maps for Saudi Arabia," *SolarGIS*, 2013, http://solargis.com/products/maps-and-gis-data/free/download/saudi-arabia. (GHI Solar Map © 2017 Solargis)

In January 2017, Saudi Arabia announced it would start accepting proposals for a vast new renewable energy program. The program could cost between $30-50 billion to produce power plants to provide Saudi Arabia with about 10GW of electricity capacity from primarily solar and wind power by 2023.[109] However, solar-powered electricity only makes up a fraction of the share of electricity produced for Saudi Arabia currently.[110] Saudi Arabia has had bold plans regarding renewable energy in recent years but its actual planning and implementation of renewable energy power plants has been spotty, in part due to unpredictable revenue profits from oil exports and unwillingness by Saudi leadership at times to diversify its economy away from heavy reliance on energy exports.

Planned and Existing Solar Power Capabilities in Saudi Arabia. Saudi Arabia's King Abdullah bin Abdulaziz Al Saud established the King Abdullah City for Atomic and Renewable Energy (K.A. CARE) on April 17th, 2010, which has the responsibility to develop a sustainable system to produce alternative forms of energy like solar and nuclear to help meet Saudi Arabia's growing energy needs.[111] K.A. CARE is the principle organization that rolls out energy strategies and announcements regarding alternative energy power plants and projects. K.A. CARE established goals to install solar power plants that would add 41GW of power by 2032—16GW from PV systems

[109] Anthony Dipaola, "Saudis Seek Up to $50 Billion in Renewable-Energy Expansion," *Bloomberg*, January 16, 2017, https://www.bloomberg.com/news/articles/2017-01-16/saudis-seek-up-to-50-billion-for-first-phase-of-renewables-plan.

[110] Jeffrey Ball, "Why the Saudis Are Going Solar."

[111] King Abdullah City for Atomic and Renewable Energy, "The Establishing Order," *King Abdullah City for Atomic and Renewable Energy*, n.d., https://www.kacare.gov.sa/en/about/Pages/royalorder.aspx.

and 25GW from CSP systems.[112] Additionally, Saudi Arabia has aims to eventually sell and export surplus solar power-produced electricity to Europe.

Saudi Arabia has two major CSP plants that are under construction or planned to be built in the near future. One is ISCC Duba 1, and it will have an installed capacity of 43MW.[113] The other is the Waad Al Shamal ISCC Plant, and it will have an installed capacity of 50MW.[114] Saudi Arabia is also currently seeking international investments to construct two planned solar power plants that would be built in the northern part of the state, with both plants possessing installed capacity levels of up to 50MW of power.[115] Beyond the very small amount of solar power plants that already exist and the limited amount of announcements Saudi Arabia has made regarding planned power plants, Saudi Arabia has not made much concrete progress towards meeting its solar power goals yet. However, this could change in the coming months or years if the Saudi government becomes more determined to advance renewable energy to wean itself off of its heavy reliance on domestic hydrocarbons for electricity.

Planned and Existing Nuclear Power Capabilities in Saudi Arabia. While Saudi Arabia does not possess any functioning nuclear power plants yet, it is actively

---

[112] King Abdullah City for Atomic and Renewable Energy, "Solar," *King Abdullah City for Atomic and Renewable Energy*, n.d., https://www.kacare.gov.sa/en/FutureEnergy/RenewableEnergy/pages/solarenergy.aspx.

[113] National Renewable Energy Laboratory, "ISCC Duba 1," *U.S. Department of Energy*, January 31, 2017, https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=4300.

[114] National Renewable Energy Laboratory, "Waad Al Shamal ISCC Plant," *U.S. Department of Energy*, February 7, 2017, https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=4300.

[115] Reuters, "Saudi Seeks International Investors for Two Solar Plants," *Fortune*, June 12, 2016, http://fortune.com/2016/06/12/saudis-seek-solar-investors/.

exploring options to implement nuclear power to produce electricity. K.A. CARE has stated that it plans to have nuclear power plants in Saudi Arabia produce up to 17.6GW of power by 2032.[116] In October 2016, the Saudi government announced that it would have "concrete plans" regarding the immediate future of nuclear power within a year.[117] Saudi Arabia has taken regulatory steps in preparation for a nuclear power program and wants to choose sites within the next year for its first nuclear power plant.

Saudi Arabia has announced in the past that it wants to have a vast network of nuclear power plants to provide the country with power. In 2011, Saudi Arabia announced that it planned on building sixteen nuclear reactors by the year 2030 to keep up with the rising demand of electricity in the country.[118] However, when Saudi Arabia announced those plans the price of oil was trading at or near $100 a barrel—the price of oil recently has been near $50.[119] This steep drop in the price of oil will dramatically affect government budgets and revenues, likely hampering Saudi Arabia's ambitious energy security measures including building solar and nuclear power plants according to previously stated goals and strategies.

---

[116] King Abdullah City for Atomic and Renewable Energy, "Atomic," *King Abdullah City for Atomic and Renewable Energy*, n.d., https://www.kacare.gov.sa/en/FutureEnergy/Pages/nucularpower.aspx.

[117] Angelina Rascouet and Wael Mahdi, "Saudi Arabia to Select Nuclear Power-Plant Site 'Very Soon'," *Bloomberg*, October 20, 2016, https://www.bloomberg.com/news/articles/2016-10-20/saudi-arabia-to-select-nuclear-power-plant-site-very-soon.

[118] Reuters, "Saudi plans to build 16 nuclear reactors by 2030," *Reuters*, June 1, 2011, http://www.reuters.com/article/saudi-nuclear-idAFLDE75004Q20110601.

[119] U.S. Energy Information Administration, "Spot Prices for Crude Oil and Petroleum Products," *U.S. Department of Energy*, February 8, 2017, http://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm.

UAE

Out of the three states that are specifically examined in this thesis, the UAE is arguably the most prepared and organized to weather rapidly rising energy demands in the future. The UAE is expected to have one reactor in operation by the summer of 2017 and all four of their reactors that compose the Barakah nuclear power plant in operation by 2020.[120] Additionally, the UAE has been establishing many solar power projects and utilizing a wide array of international investors and businesses to grow their energy sector. In September 2016, the UAE received a bid from joint partners JinkoSolar Holding Co. of China and Marubeni Corp. of Japan to produce electricity for a record-low price for solar power for 2.42 cents per kWh.[121] These events accurately describe the "energy revolution" occurring in the UAE to sustainably produce electricity at affordable prices that will help the state weather possible financial or geopolitical problems in the future.

The government of the UAE recently released an energy strategy document called the UAE Energy Plan 2050 which "aims to cut carbon dioxide emissions by 70 percent, increase clean energy use by 50 percent and improve energy efficiency by 40 percent…"[122] The plan seeks to dramatically expand renewable energy generation capabilities and continue to maintain nuclear power as a source of reliable energy. The goals laid out in the document are very ambitious, such as the aim to have forty-four

[120] World Nuclear Association, "Nuclear Power in the United Arab Emirates."

[121] Anthony DiPaola, "Cheapest Solar on Record Offered as Abu Dhabi Expands Renewables."

[122] LeAnne Graves and Thamer Al Subaihi, "UAE turns green with new power plan 2050," *The National*, January 11, 2017, http://www.thenational.ae/uae/uae-turns-green-with-new-power-plan-2050.

percent of local energy consumption to come from renewable sources of energy.[123] However, if there were one Arab-Middle Eastern state that would likely achieve ambitious clean energy goals, it would be the UAE due to its investment organization, its expanding markets, and political and civil willingness to diversify its economy.

In 2008, the government of the UAE published a report—the Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy—where it determined that "nuclear power-generation emerged as a proven, environmentally promising and commercially competitive option" that would contribute greatly to the UAE economy and provide energy security assurance.[124] Since then, the government has established the Emirates Nuclear Energy Corporation (ENEC), which is the UAE's public entity entrusted with "evaluat[ing] and implement[ing] nuclear power plans within UAE."[125]

This entity is the principal organization that handles the operations and ownership of the UAE's nuclear power plants, specifically the Barakah program that is ongoing. The UAE has also collaborated extensively with the IAEA. In November 2016, the IAEA completed a two-week mission requested by the UAE government to examine "the physical protection of nuclear material and nuclear facilities, and the security of

---

[123] LeAnne Graves and Thamer Al Subaihi, "UAE turns green with new power plan 2050,"

[124] Government of the UAE, "Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy," *Embassy of the United Arab Emirates*, April 2008, http://www.uae-embassy.org/sites/default/files/UAE_Policy_Peaceful_Nuclear_Energy_English.pdf.

[125] World Nuclear Association, "Nuclear Power in the United Arab Emirates."

radioactive material, associated facilities and associated activities."[126] The IAEA concluded that the UAE has taken considerable steps to ensure nuclear security involving its nuclear program.

The UAE is a focal point for solar power technology growth and investment in the Middle East region. Figure 8 shows how much solar potential measured in kWh/m^2 the UAE possesses in terms of global horizontal irradiation (GHI).[127] The UAE has a very solid foundation for solar power growth: it is the home to the International Renewable Energy Agency (IRENA), Masdar City (a planned city focused on sustainable living and renewable energy), and the Mohammed bin Rashid Al Maktoum Solar Park (when completed, will be one of the largest solar power projects in the world).[128] The UAE looks to continue growth in its solar power sector by attracting foreign investment and pursuing large-scale solar power plants to support a growing economy.

Planned and Existing Solar Power Capabilities in the UAE. While the UAE is extremely ambitious in its pursuit to grow solar power capacity and make solar a vital part of its energy sector strategy, the UAE did not start producing electricity through

[126] IAEA Press Office, "IAEA Completes Nuclear Security Review Mission in United Arab Emirates," *IAEA*, November 10, 2016, https://www.iaea.org/newscenter/pressreleases/iaea-completes-nuclear-security-review-mission-in-united-arab-emirates.

[127] SolarGIS, "Solar resource maps for United Arab Emirates," *SolarGIS*, 2014, http://solargis.com/products/maps-and-gis-data/free/download/united-arab-emirates.

[128] Andrew Korn, "Challenges to UAE solar power remain, but it still makes sense," *The National*, May 5, 2016, http://www.thenational.ae/business/energy/challenges-to-uae-solar-power-remain-but-it-still-makes-sense.

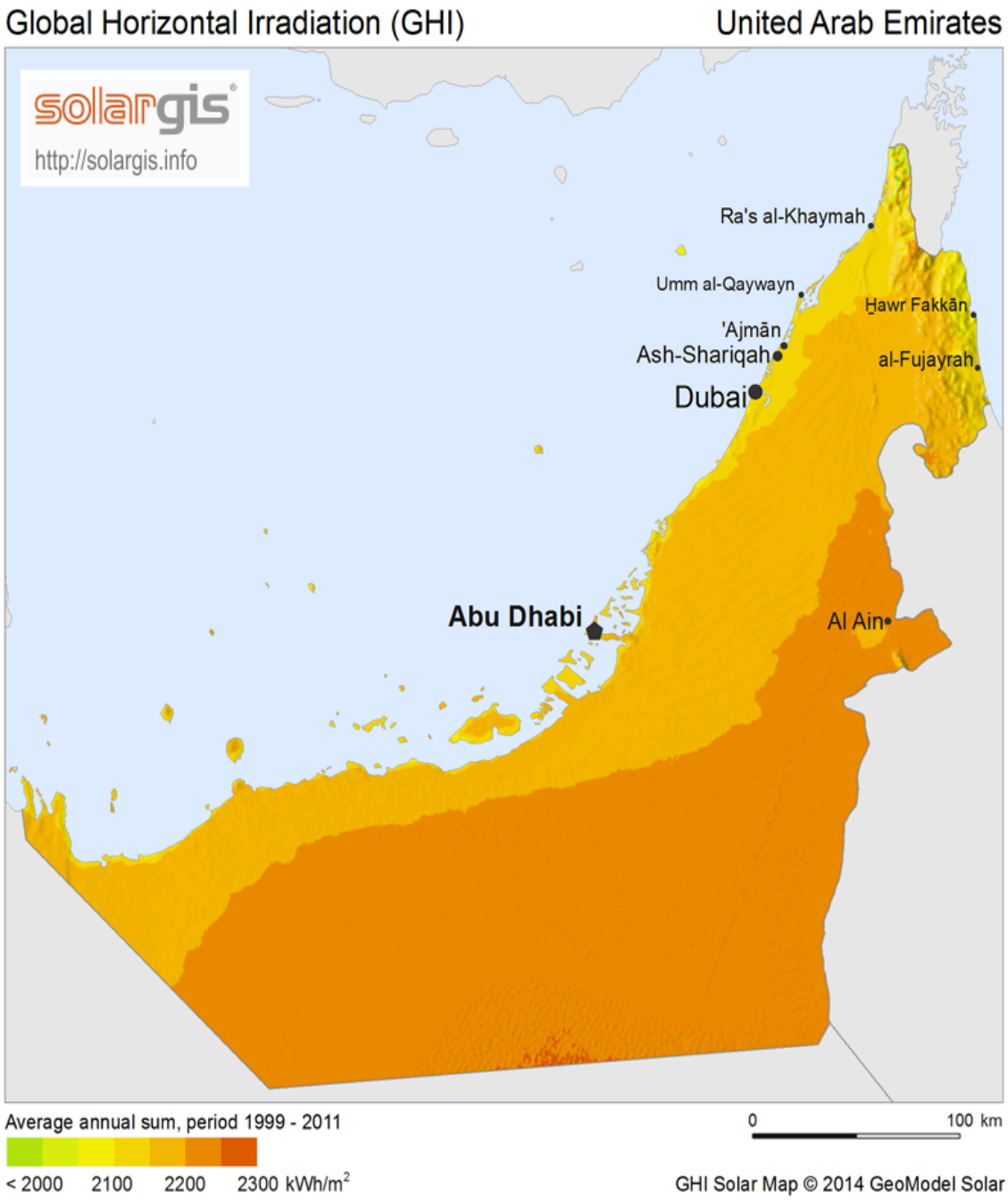


Figure 8. United Arab Emirates Solar Potential Yields (Global Horizontal Irradiation) in Terms of kWh/m2. Map of the UAE showing areas where the UAE receives the most sunlight energy. Source: SolarGIS, "Solar resource maps for United Arab Emirates," *SolarGIS*, 2014, http://solargis.com/products/maps-and-gis-data/free/download/united-arab-emirates. (GHI Solar Map © 2017 Solargis.)

solar-powered means until 2013.[129] Since then, the UAE has constructed or is constructing some major solar power plants. One is the Shams Solar Power Station, located in the Abu Dhabi region.

The Shams plant in Abu Dhabi has an installed power capacity of 100MW, cost about $600 million, and took about three years to build until it was completed in 2013.[130] The plant is a solar thermal power plant, using parabolic trough technology. Parabolic troughs generate solar power by using solar panels to direct heat and light onto a tube that is filled with a liquid, to turn it into steam that is then directed to turbines to spin them to generate electricity. The CEO of Masdar, one of the principal companies that helped build the power plant, stated, "Shams 1 is a significant milestone, as large-scale renewable energy is proving it can deliver electricity that is sustainable, affordable and secure." This theme is commonly echoed from officials all over the region looking to solar power to wean their states off hydrocarbons for producing electricity.

Another extensive solar project in the UAE is the Mohammed bin Rashid Al Maktoum Solar Park, located in the Dubai region. The solar park project launched in 2012 when the first phase of the project was implemented, adding 13MW of installed

---

[129] International Energy Agency, "United Arab Emirates: Electricity and Heat for 2013," *OECD/IEA*, n.d., http://www.iea.org/statistics/statisticssearch/report/?country=UAE&product=ElectricityandHeat&year=2013.

[130] Damien Gayle, "Who needs oil? World's largest solar power plant with 258,000 mirrors opens in Abu Dhabi," *Daily Mail Online*, March 19, 2013, http://www.dailymail.co.uk/sciencetech/article-2295717/Who-needs-oil-Worlds-largest-concentrated-solar-power-plant-258-000-mirrors-opens-Abu-Dhabi.html.

capacity to the UAE's electrical grid.[131] The project will expand using a phased approach with goals to implement 1,000MW by 2020 and 5,000MW by 2030 of installed capacity. Total investment of the solar park is estimated to be around $13.6 billion by the time the project is completed.[132]

In 2015, the vice president and prime minister of the United Arab Emirates and emir of Dubai, Sheikh Mohammed bin Rashid Al Maktoum—for whom the solar park is named—announced his plans for a clean energy strategy with aims to put solar panels on every roof within Dubai by 2030.[133] The plan also seeks to dramatically cut Dubai's carbon footprint, aiming to make Dubai "the city with the smallest carbon footprint in the world by 2050."[134] To help fund these measures and promote sustainable financial assistance, Dubai is planning to open the Dubai Green Fund, a program that will provide investors with loans at low interest rates for clean energy projects. The fund will have about $27 billion allocated for these projects.

Planned and Existing Nuclear Power Capabilities in the UAE. The UAE is making significant progress in regards to nuclear power. Its first nuclear power plant under construction—the Barakah plant located in the Abu Dhabi region—will have four

---

[131] Dubai Electricity and Water Authority, "Our History," *Dubai Electricity & Water Authority (DEWA)*, n.d., https://www.dewa.gov.ae/en/about-dewa/about-us/about-us/our-history.

[132] Ibid.

[133] Alexandra Ma, "Oil-Rich Dubai Pledges To Put Solar Panels On Every Roof By 2030," *The Huffington Post*, December 12, 2015, http://www.huffingtonpost.com/entry/dubai-solar-panels_us_565f1699e4b072e9d1c43a67.

[134] Ibid.

APR-1400 nuclear reactors that will each be able to produce 1,400MW of energy.[135] The first reactor should be completed by May 2017, with a new reactor completed every year until the last one is finished in 2020. The construction of the nuclear power plant and its four reactors, contracted to the South Korean firm Korea Electric Power (KEPCO), will cost $20 billion.[136] Compared to many other nuclear power plants that have been built recently, the Barakah plant looks to be completed in a relatively short time frame and within the proposed budget estimates.

There have not been any other announced plans for any additional nuclear power plants after the Barakah plant is completed. While cost could definitely be a factor, the Barakah plant is expected to potentially produce twenty-five percent of the UAE's electricity by 2020.[137] Once the Barakah plant is completed there may be new nuclear plants developed, but for now the UAE seems content with the four reactors the Barakah plant will be composed of, and instead, push for greater integration of renewable power generation like solar power projects since those can be built more quickly and handle rising demand over the short term.

Power and electricity can be produced in a number of different fashions but Jordan, Saudi Arabia, and the UAE are primarily looking to solar-powered and nuclear-powered means to supplement existing capabilities to address rapidly rising demands. Solar and nuclear power both possesses varying and unique factors that shape their

---

[135] World Nuclear Association, "Nuclear Power in the United Arab Emirates."

[136] The Economist, "How to build a nuclear-power plant," *The Economist*, January 28, 2017, http://www.economist.com/news/business/21715685-new-crop-developers-challenging-industry-leaders-how-build-nuclear-power-plant.

[137] World Nuclear Association, "Nuclear Power in the United Arab Emirates."

attractiveness and utility as options for power generation. Solar power is a very environmentally clean option and it has potential to be a very stable financial option going forward. However, solar power is still largely inhibited by the amount of land required for large-scale solar power plants and by a lack of affordable and efficient methods to store power for long periods of time. Nuclear power provides states with international prestige as well as relatively environmentally clean energy. Additionally, nuclear power is considered to be a source of reliable, always-on power. Nuclear power can be viewed as an unattractive option, though, due to its long construction and planning timelines. Nuclear power is also an extremely capital intensive investment and can present great environmental risks if the plant experiences a nuclear meltdown or significant attack, factors that can cause some states to be deterred from utilizing or expanding nuclear power operations.

Jordan's heavy reliance on energy fuel imports has give rise to increased attention to expand domestic energy production sources, namely nuclear and solar power. The state of Jordan has passed a series of legislative initiatives aimed at improving efficiency and expanding water desalination capacities, as Jordan is one of the most vulnerable states regarding security of potable water. To expand solar power capacity, Jordan is attracting foreign investment and businesses to invest in solar power plants in places like Jordan's Ma'an Development Area. While Jordan has not started construction of nuclear power plants, it has established agreements with Russia's Rosatom to construct two 1,000MW nuclear reactors in Jordan in the future, expected to not come online until 2023.

Saudi Arabia is primed to be one of the largest potential markets for solar power due to its size in terms of land and population. While Saudi Arabia currently possesses a small and limited capacity of solar power systems, it has announced a series of strategies and goals to accept proposals from companies to build a number of CSP and PV power plants. This is in part, to wean the country off its heavy reliance of using domestically produced oil to produce electricity, a practice largely uncommon in developed countries. Furthermore, Saudi Arabia currently possesses no functioning commercial nuclear reactors. It has, however, announced to build and utilize sixteen nuclear reactors by the year 2030. Saudi Arabia's solar and nuclear initiatives will largely depend, however, on the price of oil, which significantly affects how much revenue the Saudi government generates each fiscal year.

The UAE's energy transformation is the most developed between it, Jordan, and Saudi Arabia. It has successfully negotiated multiple contracts to produce solar power plants and nuclear power reactors. Jordan's most ambitious solar project is the Mohammed bin Rashid Al Maktoum Solar Park, which is planned to possess 5,000MW of installed capacity by 2030. Jordan's Barakah nuclear power plant, slated to be completely finished by 2020, will possess four-1,400MW nuclear reactors. The plant's production was contracted to South Korea's KEPCO utility corporation.

POLITICAL AND ECONOMIC IMPACTS OF NUCLEAR AND SOLAR POWER

The prospect of more countries in the Middle East region utilizing nuclear power and solar power is growing every year as technologies improve and the need for energy grows. The imminent energy demand crisis brewing in the Middle East has led countries like Jordan, Saudi Arabia, and the UAE to make strides to close the gap between energy consumption and energy demand by expanding production capacities for non-hydrocarbon forms of producing power. With these pushes for nuclear and solar power, Jordan, Saudi Arabia, and the UAE will experience a set of consequences that will impact them politically and economically and which have the potential to modify the geopolitics of the region and security challenges in general.

Some of the important consequences and impacts to consider regarding this expansion of non-hydrocarbon energy production in these countries include the following: using nuclear power to help desalinate water to provide increased quantities of potable water, utilizing nuclear and solar power to reduce carbon emissions, the presence of nuclear reactors and the possible security threats that could arise in specific regards to terrorism, the expansion of nuclear and solar power to allow Saudi Arabia and the UAE to use less domestic oil and natural gas for electricity generation and instead export more of it to generate higher government revenues, and the impact nuclear and solar power plants being built will have on economic output and job creation. All of the above considerations have the potential to greatly impact the political and economic futures of Jordan, Saudi Arabia, and the UAE and their state relations in the region and the world.

Desalination

The issue of securing enough potable water for regional populations in the Middle East is pressing. Historically, Saudi Arabia, Jordan, and the UAE all have struggled with securing sufficient amounts of potable water and the trend appears to continue in the future. An analysis report published by the World Resources Institute (WRI) in 2015 revealed that Saudi Arabia, Jordan, and the UAE are all projected to be in the top 15 of the most water-stressed countries by 2040—using climate models and socioeconomic scenarios, the WRI defines water-stressed as "a measure of competition and depletion of surface water."[138]

Saudi Arabia. Due to the fact that desalination requires a large amount of energy to function, it is important that desalination plants can utilize reliable and large amounts of electricity to ensure that water can be purified for the general population. Because of this, many countries are looking to produce desalinated water using electricity generated from "green" forms of energy, which include solar and nuclear. In 2015, Saudi Arabia announced plans to establish the "world's first utility scale, solar powered desalination plant".[139] The plans called for the plant to be commissioned by 2017 and the expected cost to be $130 million. The plant is expected to produce up to 60,000 cubic meters of water a day, on top of the 24 million Saudi Arabia produces already every day. While the additional 60,000 cubic meters of potable water that will be produced is a "drop in the

[138] Andrew Maddocks, Robert Samuel Young, and Paul Reig, "Ranking the World's Most Water-Stressed Countries in 2040," *World Resources Institute*, August 26, 2015, http://www.wri.org/blog/2015/08/ranking-world%E2%80%99s-most-water-stressed-countries-2040.

[139] Kent Harrington, "Saudi Arabia Creates New Solar-Powered Desalination Technology," *AIChE*, October 16, 2015, http://www.aiche.org/chenected/2015/10/saudi-arabia-creates-new-solar-powered-desalination-technology.

bucket" towards expanding additional desalination capacity for a state in desperate need as demand for water grows over time, it is a step in the right direction meant to stave off water shortages and disruptions in potable water reaching Saudis. The desalination plant will be supplied power from a nearby solar power plant that is expected to provide "all [of] the plant's energy needs during peak output, which in Saudi Arabia will be for much of the daylight hours."[140]

Jordan. Jordan seeks to use electricity from its future nuclear power plants to power desalination plants to keep up with rising demand and costs of desalinating water. Since desalinating water is a costly process financially and in terms of electricity demand, nuclear power plants can serve as a strong option to power desalination plants. This is because nuclear power plants can generate constant, consistent energy throughout the day. Desalination plants can use surplus energy produced during low-demand times to provide relatively cheap electricity as to not waste electricity produced by the nuclear power plants.[141] For Jordan, this will be a very promising option, as it recently signed a $900 million water-sharing deal with Israel that would create a desalination plant in the southern Jordanian city of Aqaba that will produce at least 80 million cubic meters of water a year.[142]

---

[140] Kent Harrington, "Saudi Arabia Creates New Solar-Powered Desalination Technology."

[141] World Nuclear Association, "Nuclear Desalination," *World Nuclear Association*, January 2017, http://www.world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-desalination.aspx.

[142] Conor Gaffey, "Israel and Jordan Sign 'Historic' $900 Million Deal to Save the Dead Sea," *Newsweek*, March 18, 2016, http://www.newsweek.com/israel-and-jordan-sign-historic-900-million-deal-save-dead-sea-310084.

The deal will see Israel purchase 40 million cubic meters of the 80 million cubic meters with the rest of the water to be left for the state of Jordan.[143] Nuclear power has the potential to create low relative costs of electricity that can supply desalination plant projects like this one to sustainably provide water to water-poor states like Jordan, to reduce carbon emissions in the region, and to help reduce reliance on imported energy fuel sources. Solar power will be used in similar fashion in Jordan as well, with investors from the private sector working towards establishing CSP plants in the Ma'an Development Area.[144]

UAE. The United Arab Emirates has been a regional leader in terms of innovation and progress in terms of using clean energy to desalinate water in recent years. In 2013, a renewable energy company, Masdar, with ties to the UAE's government "launched a renewable energy desalination pilot programme to research and develop energy-efficient, cost-competitive desalination technologies that are suitable to be powered by renewable energy."[145] The pilot program consisted of building four small-scale desalination plants built by private companies—the plants were built by Abengoa, Suez Environnement, Sidem/Veolia, and Trevi Systems (an American company). Additionally, Utico—a private energy company that works directly with the UAE government—is currently

[143] Conor Gaffey, "Israel and Jordan Sign 'Historic' $900 Million Deal to Save the Dead Sea."

[144] Salman Zafar, "Solar Energy in Jordan," *EcoMENA*, March 30, 2016, http://www.ecomena.org/solar-energy-jordan/.

[145] Masdar, "Renewable Energy Desalination Pilot Programme," *Masdar*, n.d., http://www.masdar.ae/en/energy/detail/renewable-energy-water-desalination-in-uae.

building a 20MW solar power facility to generate power for a reverse-osmosis desalination plant.[146]

The UAE's approach to seek foreign investment and technologies to create a competitive environment to produce efficient and sustainable desalination plants appears promising. As energy costs may be between sixty to seventy percent of the overall cost of desalination, Mohammad El Ramahi (Masdar's director of asset management and technical services) stated, "If you dramatically reduce the energy intensity, you dramatically reduce cost."[147] Additionally, the UAE's current ongoing construction project to build four nuclear reactors will add an additional 5.6GW of additional power capacity to the power grid; this massive increase will be able to help support increased demand of desalination plants as time goes on.[148]

Reduction in Carbon Emissions

Climate change, as a whole, is a controversial topic around the world. However, statistical data accumulated over the past decades have shown a legitimate trend of rising levels of carbon emissions in the air (produced "through human activities such as deforestation and burning fossil fuels, as well as natural processes such as respiration and

[146] International Trade Administration, "United Arab Emirates - Renewable EnergyUAE - Renewable Energy," *U.S. Department of Commerce*, September 1, 2016, https://www.export.gov/article?id=United-Arab-Emirates-Renewable-Energy.

[147] Mahmoud Habboush, "Abu Dhabi's Masdar Seeks Partners for Clean-Energy Desalination," *Bloomberg*, September 8, 2016, https://www.bloomberg.com/news/articles/2016-09-08/abu-dhabi-s-masdar-seeks-partners-for-clean-energy-desalination.

[148] World Nuclear Association, "Nuclear Power in the United Arab Emirates," *World Nuclear Association*, October 2016, http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/united-arab-emirates.aspx.

volcanic eruptions"[149]) and a rise in global temperature that has continued its trend for many decades. According to data compiled by NASA, "the 10 warmest years in the 136-year record all have occurred since 2000, with the exception of 1998."[150] These two variables play a massive role in how climates across the globe as a whole are affected.

High amounts of carbon in the air can increase the risk of health hazards associated with breathing and quality of life. As mentioned in a previous section, high levels of carbon emissions can create smog and a toxic environment for populations, especially in urban areas where high carbon levels are most likely. Rising temperatures in the Middle East can make the region uninhabitable, as average temperatures there could become dangerously high. Furthermore, rising temperatures in the Middle East will speed up the pace of water resources drying up, reduce the amount of arable land, and increase the need for air conditioning for buildings and homes in the region, increasing the cost of electricity and increasing electricity demand in general.[151] To offset these current trends, one of the most effective solutions could be to reduce carbon emissions.

All of the above issues—if allowed to continue to worsen—pose the potential of upsetting political order in Jordan, Saudi Arabia, and the UAE. If the air continues to become more polluted, there is the possibility that life expectancy rates could decrease in the region due to increased health and general respiratory hazards. Additionally, rising temperatures and depleting water resources could drive populations to move and migrate

---

[149] NASA, Holly Shaftel, and Laura Tenenbaum, "Carbon Dioxide," *NASA*, January 19, 2017, http://climate.nasa.gov/vital-signs/carbon-dioxide/.

[150] NASA, Holly Shaftel, and Laura Tenenbaum, "Global Temperature," *NASA*, January 19, 2017, http://climate.nasa.gov/vital-signs/global-temperature/.

[151] The World Bank, "Climate Change in the Middle East & North Africa," *The World Bank Group*, n.d., http://www.worldbank.org/en/programs/mena-climate-change.

to different states or regions that have been impacted less harshly due to environmental climate changes.[152] These actions would likely cause great harm to regional and local economies that are tied to agriculture and services dependent on current environment conditions. The effects would be widespread and would ripple out across the region, ultimately spreading the effects across the world in this globalized era.

To an extent, this has already been occurring in the Middle East; climate change's effects have been augmented due to the ongoing civil war in Syria. Migrants and refugees have been leaving the Middle East and have been immigrating into Europe in large numbers in the past few years. Michael Werz from the Center for American Progress—a progressive public policy research organization—believes that for the Middle East region "all the indicators seem to fairly solidly convey that climate change — desertification and lack of water, or floods, are massively contributing to human mobility."[153] These factors and effects have led many countries in the Middle East to seriously look at how the effects of climate change can be reduced—or even negated—to preserve the foundational integrity holding their respective economies and governments together.

Saudi Arabia is arguably one of the most vulnerable states in the Middle East in terms of the negative effects of climate change and rising energy consumption. The Saudi government created the "King Abdullah City for Atomic and Renewable Energy (KACARE), a body set up by the government to spearhead development of renewable

[152] Aryn Baker, "How Climate Change is Behind the Surge of Migrants to Europe," *Time*, September 7, 2015, http://time.com/4024210/climate-change-migrants/.

[153] Ibid.

and nuclear energy" in 2012.[154] The measures Saudi Arabia has introduced and is planning for the purposes of meeting rapidly rising energy demand levels are also largely intended to tackle carbon emissions.

Saudi Arabia and the UAE are both among the highest producers of carbon dioxide per capita—17.9 metric tons and 18.7 metric tons in 2013, respectively.[155] The UAE has invested millions of dollars into commercial projects and in the form of grants and soft loans to proliferate and improve renewable energy projects.[156] Within the UAE is a planned city project devoted to renewable energy and energy efficiency called Masdar City. Masdar City is meant to serve as an area that can become a model for what an eco-friendly city should look like by employing energy saving techniques and design features into architecture and city landscapes.

Additionally, the UAE is a firm believer and proponent of utilizing nuclear power for electricity in the Middle East and recognizes the role it can play in reducing carbon emissions. The Atlantic Council—a think tank in Washington D.C.—collaborated with the Energy Ministry of the UAE to create an event focused on bringing together international partners, leaders, and businesses for a forum event to focus on energy issues of the future. The event, called the Atlantic Council Global Energy Forum, was held for

---

[154] Reuters, "Saudi Arabia Says It's About to Launch a $30-$50 Billion Renewable Energy Program," *Fortune*, January 16, 2017, http://fortune.com/2017/01/16/saudi-arabia-renewable-energy-program/.

[155] Carbon Dioxide Information Analysis Center, "CO2 emissions (metric tons per capita)," *The World Bank Group*, n.d., http://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2013&start=2013&year_high_desc=true.

[156] Grantham Research Institute on Climate Change and the Environment, "United Arab Emirates," *London School of Economics and Political Science*, January 13, 2017, http://www.lse.ac.uk/GranthamInstitute/legislation/countries/united-arab-emirates/.

the first time in Abu Dhabi in January 2017. One of the speakers was Dr. Cho Hwan-eik, president and chief executive of the Korea Electric Power Corporation, the primary contractor for the UAE's ongoing nuclear power plant project.[157] At the forum Dr. Cho stated, "Nations cannot afford to make the mistake of underestimating nuclear energy's place in beating climate change..."[158] This mindset is also conveyed in the UAE's aggressive plan to make nuclear power a prime pillar in its energy policy and electricity production.

Since Jordan relies almost entirely on fuel imports to produce electricity, it faces a tougher challenge in reducing carbon emissions for the time being. In 2013, Jordan introduced a new seven-year plan titled The National Climate Change Policy of the Hashemite Kingdom of Jordan 2013-2020 intending to pursue climate-friendly energy policies, examine social implications of energy and water policies, and adapting to climate change as a whole.[159]

Since seventy-four percent of greenhouse gas emissions from Jordan come from its energy sector, the way to make the largest impact in terms of reducing these gases is to

---

[157] Caline Malek, "Nuclear energy key to confronting climate change, Abu Dhabi forum hears," *The National*, January 12, 2017, http://www.thenational.ae/uae/environment/nuclear-energy-key-to-confronting-climate-change-abu-dhabi-forum-hears.

[158] Ibid.

[159] Grantham Research Institute on Climate Change and the Environment. "The National Climate Change Policy of the Hashemite Kingdom of Jordan 2013-2020." *London School of Economics and Political Science*, May 2013. http://www.lse.ac.uk/GranthamInstitute/law/the-national-climate-change-policy-of-the-hashemite-kingdom-of-jordan-2013-2020/.

help reform the energy sector.[160] This is one of the most important reasons why Jordan seeks to reduce its reliance on imported hydrocarbons to produce energy and replace them with domestic sources of energy like renewable and nuclear energy. As this shift occurs, a correlating decrease of CO_2 emissions and greenhouse gases from Jordan are likely to occur, reflecting the increased production levels of clean energy.

Threat of Nuclear Terrorism

In recent years, terrorists have been able to expand their field of operations and use new sources of social media and technology to spread their message and further their causes. As terrorist groups become stronger and more determined, some may embark upon a mission to obtain weapons of mass destruction (WMD) or employ tactics of nuclear terrorism. Just as recently as early 2016, law enforcement officials in Belgium had uncovered evidence that seemed to link the terrorist group ISIS with possible plans "to attack, infiltrate or sabotage nuclear installations or obtain nuclear or radioactive material."[161] In regards to nuclear terrorism, groups could aim to seek out—regardless of probability of success—nuclear material to make a nuclear bomb or a dirty bomb, attack a nuclear power plant to destroy or damage nuclear reactors, or even damage infrastructure that supports the nuclear power plants safety features to cause a nuclear power plant to fail.

---

[160] Jordan Ministry of Environment, "The National Climate Change Policy of the Hashemite Kingdom of Jordan 2013-2020," *Ministry of Planning and International Cooperation*, 2013, http://inform.gov.jo/en-us/By-Date/Report-Details/ArticleId/67/The-National-Climate-Change-Policy-of-the-Hashemite-Kingdom-of-Jordan-2013-2020.

[161] Alissa J. Rubin and Milan Schreuer, "Belgium Fears Nuclear Plants Are Vulnerable."

At a nuclear power plant in the city of Doel, Belgium, an unidentified individual walked into one of the plants reactors and turned a valve, draining "65,000 liters of oil used to lubricate the turbines," causing the plant to be shut down and out of commission for a duration of five months.[162] So while terrorist groups may have primary desires to acquire WMD, including nuclear material, there are many other effective ways to cause panic and strike terror into civilian populations involving nuclear terrorism. Some of the most prominent groups to actively seek nuclear material are ISIS and al-Qaeda.

The Belfer Center for Science and International Affairs with the Harvard Kennedy School released a report in March 2016 titled *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline*. In it, the writers note that ISIS' capabilities and resources are significantly larger than al-Qaeda ever had at its own strongest point.[163] Due to ISIS' prominent presence in the region, it can pose a significant security risk for states and their energy security and cause continuing stress for regional governments and economies. For this reason, nuclear power plants in the Middle East can be seen as prime targets for terrorists and security threats in general, not only because of nuclear material, but also because of countries needs for the electricity nuclear power plants produce.

Due to the grave consequences of nuclear terrorism and lasting implications if a nuclear-terrorist related act occurred, international leaders have agreed at the Nuclear

---

[162] Alissa J. Rubin and Milan Schreuer, "Belgium Fears Nuclear Plants Are Vulnerable."

[163] Matthew Bunn et al., *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline,* Harvard Kennedy School--Belfer Center for Science and International Affairs, March 2016, http://www.belfercenter.org/sites/default/files/legacy/files/PreventingNuclearTerrorism-Web.pdf.

Security Summit in 2010 that "nuclear terrorism is one of the most challenging threats to international security."[164] The Nuclear Security Summits were intended to allow international leaders from delegations all across the world to meet to discuss pressing and long-term issues regarding nuclear security. There were fifty-six delegations represented at the 2016 Summit, which included delegations representing Jordan, Saudi Arabia, and the UAE.[165]

The UAE is on course to be the first Arab country to possess functioning nuclear reactors for electricity production. As such, great care will need to be exacted to ensure the safety and stability of the nuclear power plant. Since the nuclear reactors will be the first of their kind in the region, terrorists may set a priority on attempting to acquire nuclear material or cause great damage to the reactors. Either of these actions would create a grave security threat and would damage local economies in the UAE by harming the energy security the UAE seeks. If the UAE can safely secure its reactors and prevent major safety malfunctions at their upcoming reactors, it will help set a precedent that other countries in the Middle East can follow in terms of regulations and safety, as well as promoting further security and stability in the often volatile region.

Exports of Hydrocarbon Fuels

One simple reason why Saudi Arabia and the UAE are also seeking to utilize nuclear and solar power to produce electricity is to reduce the amount of domestic

---

[164] Matthew Bunn et al., *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline.*

[165] Nuclear Security Summit, "Attending Delegations," The 2016 Nuclear Security Summit, N.p., n.d., http://www.nss2016.org/attending-delegations/.

hydrocarbons that are consumed to produce electricity. This is because Saudi Arabia and the UAE either burn large quantities of their own domestic hydrocarbon fuel sources to produce electricity or import hydrocarbons to assist in meeting demand for electricity.[166,167] By increasing the share that renewable and nuclear power occupy in terms of electricity generation in a state's energy infrastructure, that state can export more domestic-based hydrocarbons to be sold in the international market for profit.

While Saudi Arabia stands to be one of the largest potential victims in terms of negative climate change effects, the Saudi Arabian government recognizes that its regional posture depends heavily on its petroleum sector—namely its export market. In mid-2015, Saudi Arabia was paying about $4 for a barrel of domestic oil (to be used domestically for electricity production or other purposes); at the same time, Saudi Arabia could have sold that same barrel of oil on the international market for around $60.[168] While the Saudi government may have some fears about climate change and what its effects could bring about upon its state, the stability of the leadership and the monarchical regime rest on the country's expansive oil sector revenues which provide many services and social benefits for its citizens, often called the "ruling bargain."[169] This current political-social structure requires that the Saudi government maintain petroleum exports to support state-sponsored services to maintain political and social stability. If this

---

[166] Jeffrey Ball, "Why the Saudis Are Going Solar."

[167] U.S. Energy Information Administration, "United Arab Emirates plans to increase crude oil and natural gas production," *U.S. Energy Information Administration*, October 23, 2015, https://www.eia.gov/todayinenergy/detail.php?id=23472.

[168] Jeffrey Ball, "Why the Saudis Are Going Solar."

[169] Ibid.

balance is upset, the Saudi government runs the risk of economic erosion and social unrest, which may in turn become catalysts that create internal and external security threats that could spread throughout the Middle East.

While the UAE relies heavily on oil export revenues like Saudi Arabia, it is in a better position financially, due to other thriving and blossoming business sectors in the state, such as financial services and tourism.[170] While the UAE has decades' worth of natural gas reserves within its borders, it has been experiencing a dramatic rise in energy demand. Couple this fact with subsidized energy prices, the UAE cannot keep up production levels with demand levels, requiring imports from countries including the United States.[171] By increasing its domestic fuel supply, the UAE can decrease the cost of electricity generation in whole by reducing fuel imports. As a consequence of reducing fuel imports, the UAE can afford the possibility of exporting more petroleum products to increase revenue and reinvest those revenues into energy production ventures like natural gas, solar, and nuclear power. A continued reliance on petroleum revenues and exports for government budgets and GDP growth will only harm Saudi Arabia and the UAE in the future by not encouraging and promoting economic diversification.

---

[170] Embassy of the United Arab Emirates, "UAE Economic Diversification Efforts Continue to Thrive."

[171] Jim Krane, "Reversing Middle East Dependence: U.S. Begins Exports Of Shale Gas To Oil-Rich UAE And Kuwait," *Forbes*, November 17, 2016, http://www.forbes.com/sites/thebakersinstitute/2016/11/17/reversing-middle-east-dependence-us-begins-exports-of-shale-gas-to-oil-rich-uae-and-kuwait/#5c9b57347cdb.

Effect on Economic Growth

Reliable electricity can often be a good indicator that reflects standard of living in a state. Many basic necessities and simple luxuries rely on electricity. This can include running water, air conditioning, traffic lights, electronics, internet access, refrigerators and kitchen appliances. Typically, the wealthiest countries in the world with high standards of living have reliable access to electricity. In Africa, this correlation holds true as Nigeria and South Africa—two of Africa's wealthiest countries—have high access to electrical grids.[172]

Modern economies within states require constant communication between producers and consumers, investors and firms—those entities depend upon reliable electricity. As the standard of living improves across the globe—specifically in Jordan, Saudi Arabia, and the UAE—states will increasingly demand more electricity to support this improvement. Private investors and entrepreneurs will typically seek the most profitable and stable environment to conduct business in. If a state or locality wishes to grow in terms of population and economic activity, then there must be reliable sources of electricity to support this growth.

Additionally, the creation of nuclear and solar power plants will help create new jobs for construction, maintenance, consulting, and other areas focused around the plants. While not all of the jobs would be permanent, there would be a core of jobs that would be focused around ensuring the safety and management of the plants. There would also be a contingent of extra revenue and jobs that would benefit as an indirect effect of the creation of the nuclear and solar power plants.

[172] The World Bank, "GDP (current US$)," *World Bank Group*, n.d., http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?name_desc=false.

Another added benefit that is extremely difficult to calculate but can be measured qualitatively and seen directly is the health benefits created through increased use of clean energy sources like solar and a correlating decrease in fossil fuels for electricity generation. As mentioned previously, burning fossil fuels for electricity generation reduces the air quality in the nearby environment of fossil fuel-based power plants. Low air-quality can cause illness in individuals and create financial costs associated with the health problems caused by polluted air. Researchers at Harvard's T.H. Chan School of Public Health discovered that renewable electricity projects and energy efficiency measures could create health benefits by improving air quality, saving localities and governments millions of dollars per year.[173] While the study and research was conducted based upon factors and projects in the United States, the research can be extended to create forecasted health and financial models in other countries, due to the fact that carbon emissions and pollution from burning fossil fuels can create health hazards regardless of what country fossil-fueled electricity generation occurs in.[174]

As mentioned previously, Jordan, Saudi Arabia, and the UAE are all in desperate need of continued desalination to produce potable water. As their respective populations grow, so will the demand for water. To meet this demand, desalination processes must increase to keep up with demand if the population is to be served sufficiently. Since desalination is an extremely energy intensive process, abundant electricity must be

---

[173] Monica Heger, "Renewable Energy is Good for Your Health," IEEE Spectrum: Technology, Engineering, and Science News, *IEEE*, August 31, 2015, http://spectrum.ieee.org/energywise/energy/environment/renewable-energy-is-good-for-your-health.

[174] Union of Concerned Scientists, "The Hidden Costs of Fossil Fuels," *Union of Concerned Scientists*, August 30, 2016, http://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/hidden-cost-of-fossils#bf-toc-2.

available for it to occur consistently. Therefore, if water-scarce states that require desalination to produce potable water wish to grow and essentially survive in the future, then electricity generation capacity must be greatly expanded in the coming decades. To be able to keep up with this ever-rising demand for power, the reliability of nuclear power and the ever-decreasing cost of solar power can serve vital roles to meet this demand.

There are numerous political and economic impacts involving solar and nuclear power. The Middle East is one of the most water-deprived regions in the world however, nuclear power can be used as a source of power to desalinate water due to its reliability to be able to desalinate water at all hours of the day, regardless of peak times of demand for electricity. Solar and nuclear power are also the leading technologies in attempts to dramatically reduce carbon emissions. A broad consensus among many leading climate scientists believe that climate change is the result, in part, to dramatically rising carbon emissions that pervade Earth's atmosphere. Climate change stands to disproportionately affect the Middle East, potentially cascading its social effects to spread to multiple regions in the world. To dampen the negative effects of climate change, Jordan, Saudi Arabia, and the UAE are examining ways to reduce carbon emissions, most of which come from the states' energy sectors.

The threat of nuclear terrorism will be elevated once Jordan's Barakah power plants comes online and more states in the Middle East look to nuclear power to provide energy security. Terrorists groups such as ISIS and al-Qaeda have openly stated their intentions to secure WMD. Additionally, to cause irreparable damage to societies and states, terrorists do not necessarily even have to acquire WMD. Terrorist groups could

still create significant damage and potentially casualties if they were able to cause a nuclear meltdown by damaging nuclear reactors and their respective safety infrastructures. International governments have also engaged in nuclear security summits to address the growing and extremely dangerous threat of nuclear terrorism.

As the production of solar and nuclear power capabilities expand in the future in Saudi Arabia and the UAE, an opportunity is created for those states to be able to export more hydrocarbons fuel sources like petroleum and natural gas. Furthermore, increased export revenues can reduce the political risk both the Saudi Arabian and UAE governments face. Since Saudi Arabia and the UAE rely heavily on export revenue to supplement their respective governmental budgets, a collapse in oil prices or oil sales would significantly damage economic growth and stability. These damages could promote civil unrest and political instability, which could spread throughout the region.

Promotion of energy security by expanding electricity production through solar and nuclear power can help improve the standard of living in Jordan, Saudi Arabia, and the UAE. By providing reliable electricity aimed at affordable prices, states can attract entrepreneurs and investment opportunities to help promote economic growth by creating more jobs. Additionally, the increased utilization of clean energy power sources like solar and nuclear power can crate numerous health benefits for populations. Poor air quality produced by carbon-intensive power plants can create health hazards and illnesses, costing governments millions of dollars per year.

IMPACT ON THE UNITED STATES AND THE MIDDLE EAST

Being a global power with global interests causes the United States to be affected by even the smallest of changes around the world affecting international relations or international economics. The ongoing and planned changes to Jordan's, Saudi Arabia's, and the UAE's energy infrastructures set forth a fundamental shift in the way Middle Eastern countries utilize available alternatives to produce electricity. As those three countries explore the possibilities and potential benefits of utilizing nuclear and solar power to increase capacity, volatile market forces regarding the sale of petroleum and climate changes, the United States must be ready to face the challenges and new political environment that will be created as a byproduct of this shift in energy sources. In addition, the United States needs to help shape the discussions, negotiations, and actions involving Middle Eastern security going forward to strengthen regional security and secure its own national interests in the region. The United States can do this through continual engagement with Middle Eastern leaders and policymakers and by leveraging its relationships to help drive policy forward to avoid stagnation.

To maintain its global position in the world as a superpower and maintain its influence and interests around the world, the United States must recognize and strategically react with great care to some of the following implications and impacts that come with nuclear and solar power's emergences in the Middle East. The United States must be able to effectively react to the following possible implications: 1. The possibility of increased nuclear terrorism threats and possible nuclear proliferation in the Middle East, 2. The effects of Section 123 Agreements and U.S. nuclear-related trade involving

Jordan, Saudi Arabia, and the UAE, and 3. The increase of foreign influence in the Middle East due to expansion of energy technology and infrastructure that requires international expertise and assistance. Those possible implications could all dramatically affect the way U.S. foreign policy is conducted in the Middle East and around the world and transform how the United States projects both soft and hard power.

Nuclear Proliferation and Nuclear Terrorism

As mentioned in the previous section of this paper, one of the most prominent worries involving the growth of civilian nuclear power plants in the Middle East is the possibility of nuclear proliferation and nuclear terrorism in many different forms. The United States has often been an ardent supporter of states utilizing nuclear energy peacefully an in a civilian manner to produce electricity. Paralleling this policy, the United States was one of the founding members of the International Atomic Energy Agency (IAEA). The IAEA was established in 1957 based on the ideas mentioned in President Eisenhower's Atoms for Peace address he gave to the General Assembly of the United Nations on December 8th, 1953.[175]

At the outset of its creation, the IAEA set out "to work with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies."[176] Most of the states in the world are members of the IAEA, as the body has grown from 56 members in 1957 when it was founded to a total of 168 member states

[175] International Atomic Energy Agency, "History," *IAEA*, n.d., https://www.iaea.org/about/overview/history.

[176] Ibid.

as of 2016.[177] The United States, also in conjunction with the IAEA, has made a strong effort in promoting nuclear energy usage as long as it is for peaceful purposes. One way it has done this is through security agreements and through collective security alliances like NATO. As of 2017, there are only nine countries in the world that likely possess nuclear weapons: the United States, the United Kingdom, France, Israel, Pakistan, India, Russia, China, and North Korea.[178] While some of those countries listed pose concerns for U.S. policymakers, the list has remained small but is growing, as mistrust among states in the international community grows. If it were not for the United States' alliances and security guarantees that assist in deterring states from acquiring nuclear weapons capabilities, the number would likely be much higher among U.S. allies.

Iran's path towards utilizing nuclear energy for civilian and military purposes has ignited a debate amongst leaders in the Middle East about whether or not some states should also seek nuclear weapons to counter Iran. If Iran acquires nuclear weapons and delivery capabilities, it will trigger other Middle Eastern countries, including Saudi Arabia, to develop nuclear weapons for strategic defensive purposes. Due to Saudi Arabia's regional rivalry with Iran and Iran's influence in the region, many suspect that if and when Iran were to acquire a fully functional nuclear weapon and delivery system, Saudi Arabia must do the same.[179] If Saudi Arabia were to then produce nuclear

---

[177] International Atomic Energy Agency, "List of Member States," *IAEA*, February 2016, https://www.iaea.org/about/governance/list-of-member-states.

[178] Arms Control Association, "Fact Sheets & Briefs," *Arms Control Association*, August 10, 2016, https://www.armscontrol.org/factsheets/Nuclearweaponswhohaswhat.

[179] Angus McDowall, "Saudi Arabia considers its own nuclear options after Iran deal," *Reuters*, July 21, 2015, http://www.reuters.com/article/us-iran-nuclear-saudi-nuclear-idUSKCN0PV1GC20150721.

weapons, this could set a chain reaction off throughout the Middle East causing other states in the region to proliferate as well.

If nuclear proliferation were to occur in the Middle East, this would bring about incredible amounts of risk not only to the region but the international community and U.S. interests as well. Since countries like Jordan, Saudi Arabia, and the UAE are or will be building nuclear power plants, those moves help those countries be one step closer to nuclear weapons proliferation. While nuclear power plants can be major security risks, nuclear weapons proliferation in the Middle East would pose an exponentially monumental security risk for a couple main reasons.

First, the Middle East is one of the most conflict-ridden regions in the world. The political environment and rivalries involved in the region based upon history, competition, and religious and ethnic differences create a tense security environment. Since the Middle East is a high-risk region, the existence of nuclear weapons and the proliferation of such could escalate tensions bringing about wars and conflict that would fundamentally affect the region and the world in a significantly negative manner. Additionally, radical terrorist groups that operate in the region have voiced strong interest in acquiring nuclear material and nuclear weapons. Nuclear proliferation in the Middle East would be favorable for terrorists groups that would seek to exploit lax security measures or use espionage to infiltrate nuclear reactors or disrupt and damage the reactors.

Second, the United States' has been able to leverage its position on the international stage through security agreements and alliances to convince states not to acquire nuclear weapons. If states begin to acquire nuclear weapons, lack of confidence

in the United States would likely grow, leading more states to then acquire nuclear weapons for their own national and security interests as well, setting off a domino effect. This security environment would likely bring about chaos into the region as mistrust amongst states would grow which could lead to minor conflicts and events becoming large-scale conflicts. The United States has a vested interest in stopping the spread of nuclear weapons—the Department of State regards it as one of its highest priorities.[180] By maintaining the current international order, the United States can more easily shape outcomes in regions like the Middle East. However, if the nuclear proliferation threat grows, this would begin to threaten the United States' posture in a significant way.

Section 123 Agreements

One of the primary tools of state power that the United States utilizes to convince foreign states to only use nuclear energy and nuclear power for peaceful purposes is through diplomatically constructed agreements commonly called Section 123 agreements. Section 123 agreements are agreements deriving from the principles laid out in Section 123 of the U.S. Atomic Energy Act, which "requires the conclusion of a specific agreement for significant transfers of nuclear material, equipment, or components from the United States to another nation."[181]

---

[180] U.S. Department of State, "Bureau of International Security and Nonproliferation (ISN)," *U.S. Department of State, The Office of Website Management, Bureau of Public Affairs*, n.d., https://www.state.gov/t/isn/.

[181] National Nuclear Security Administration, "123 Agreements for Peaceful Cooperation," *U.S. Department of Energy*, n.d., https://nnsa.energy.gov/aboutus/ourprograms/nonproliferation/treatiesagreements/123agreementsforpeacefulcooperation.

These agreements are used to form a cooperative and legal framework between states for the premises of nuclear cooperation to ensure peaceful growth of nuclear programs and to quell nuclear weapon proliferation ambitions that some states may seek. Section 123 agreements—which allow for technical exchanges, scientific research, and safeguard discussions—require that the states that sign them with the United States "must commit [themselves] to adhering to U.S.- mandated nuclear nonproliferation norms."[182]

The nine nonproliferation criteria that must be met by any state that signs a Section 123 agreement are as follows (as explained by the Arms Control Association):[183]

- Nuclear material and equipment transferred to the country must remain under safeguards in perpetuity.
- Non-nuclear-weapon states partners must have full-scope IAEA safeguards, essentially covering all major nuclear facilities.
- A guarantee that transferred nuclear material, equipment, and technology will not have any role in nuclear weapons development or any other military purpose, except in the case of cooperation with nuclear-weapon states.
- In the event that a non-nuclear-weapon state partner detonates a nuclear device using nuclear material produced or violates an IAEA safeguards agreement, the United States has the right to demand the return of any transfers.
- U.S. consent is required for any re-transfer of material or classified data.
- Nuclear material transferred or produced as a result of the agreement is subject to adequate physical security.
- U.S. prior consent rights to the enrichment or reprocessing of nuclear material obtained or produced as a result of the agreement.

[182] National Nuclear Security Administration, "123 Agreements for Peaceful Cooperation."

[183] Arms Control Association, "The U.S. Atomic Energy Act Section 123 At a Glance," *Arms Control Association*, March 14, 2013, https://www.armscontrol.org/factsheets/AEASection123.

- Prior U.S. approval is required for highly-enriched uranium (HEU) and plutonium obtained or produced as a result of the agreement. An agreement permitting enrichment and reprocessing (ENR) using U.S. provided material requires separate negotiation.

- The above nonproliferation criteria apply to all nuclear material or nuclear facilities produced or constructed as a result of the agreement.

These criteria form the crucial framework that deters nuclear weapons proliferation and sets a standard for other countries to follow if they wish to engage in exchanges and nuclear cooperation with the United States. The United States has signed over twenty agreements with states including but not limited to Canada, China, and South Korea and also with organizations such as the European Atomic Energy Community (Euratom) and the IAEA; while the United States has not established a Section 123 agreement with either Saudi Arabia or Jordan, it did establish an agreement with the UAE that entered into force on December 17, 2009 that will last thirty years, which can be renewed.[184]

As codified in Section 123 of the U.S. Atomic Energy Act, a state that signs a Section 123 agreement with the U.S. is not banned from reprocessing or enriching nuclear material directly tied to the agreement. However, if the state signatory to a Section 123 agreement with the U.S. wants to enrich or reprocess nuclear material, it must also sign a separate agreement allowing such activity. The agreement between the United States and the UAE was monumental in that it produced language in the Section 123 agreement where the UAE "voluntarily renounced pursuing enrichment and

[184] Paul K. Kerr and Mary Beth D. Nikitin, *Nuclear Cooperation with Other Countries: A Primer*, Rep. no. RS22937, Congressional Research Service, December 27, 2016, https://fas.org/sgp/crs/nuke/RS22937.pdf.

reprocessing (ENR) technologies and capabilities."[185] This declaration of renouncing future enrichment and reprocessing has been called the "gold standard". The "gold standard" is cited to be the most favorable benchmark agreement the United States can negotiate with a state to further its interests of nuclear nonproliferation.

The idea of the Gold Standard and similar principles of reducing the risk of global nuclear proliferation, while promoting the peaceful use of nuclear energy can be traced back to George W. Bush's administration. In July of 2007, President Bush and Russian President Vladimir Putin released a joint statement expressing their views that the spread of the peaceful use of nuclear energy could be accomplished simultaneously with strengthening nonproliferation efforts.[186] One way Bush and Putin proposed to do this was by having states sign the IAEA Additional Protocol, which would allow the IAEA to verify nuclear safeguard measures within states that sign it. The most important aspect of the statement involves the commitment from the United States and Russia to "enter into discussions jointly and bilaterally to develop mutually beneficial approaches with states considering nuclear energy or considering expansion of existing nuclear energy programs in conformity with their rights and obligations under the NPT."[187] Additionally, in exchange for forgoing enrichment and reprocessing of nuclear material, the countries that sign agreements with the United States and or Russia would receive benefits including

---

[185] Arms Control Association, "The U.S. Atomic Energy Act Section 123 At a Glance,"

[186] The White House--Office of the Press Secretary, "Declaration on Nuclear Energy and Nonproliferation: Joint Actions," *National Archives and Records Administration*, 2007, https://georgewbush-whitehouse.archives.gov/news/releases/2007/07/20070703.html.

[187] Ibid.

but not limited to economic support for nuclear programs, assistance in constructing and facilitating nuclear reactors, and providing nuclear fuel services. All of this was meant to ensure that states would be incentivized to adhere to existing international norms of using nuclear energy for peaceful purposes and to be deterred from nuclear proliferation activities.

Today, there is an ongoing conversation among U.S. security professionals and government officials about the best way to promote non-proliferation in states seeking nuclear power capabilities. Some groups and individuals like Henry Sokolski, the current Executive Director for the Nonproliferation Policy Education Center and former U.S. Deputy for Nonproliferation Policy in the Office of the Secretary of Defense, are worried about the national security implications of the United States' increasingly diluted role in supplying nuclear-based infrastructure and supplies to countries. Sokolski argues that "it's pretty clear that leading and leaning on key nuclear suppliers to adopt the Gold Standard is our only option" to ensure that steps to promote nonproliferation are effective.[188] Others have expressed a hopeful outlook by arguing that there will "be strong demand for 123 agreements—primarily because of countries' desire for positive relations with the United States and the value associated with a U.S. stamp of approval."[189]

The United States policymaking community has undergone rigorous debate about whether the "gold standard" should be applied and required of all future Section 123

[188] Jessica C. Varnum, "U.S. Nuclear Cooperation as Nonproliferation: Reforms, or the Devil You Know?" *Nuclear Threat Initiative*, November 27, 2012, http://www.nti.org/analysis/articles/us-nuclear-cooperation-nonproliferation-reforms-or-devil-you-know/.

[189] Ibid.

agreements or if a case-by-case approach should be applied to individual states.[190] While it may be desirable for every Section 123 agreement the United States negotiates with to possess the "gold standard" it may not be realistic, as many states are concerned about restricting potential enrichment in the future if one of their enemies or regional rivals pursues nuclear weapons—this is the case with Saudi Arabia in regards to concerns about Iran.[191] Additionally, the United States has not been able to successfully negotiate a Section 123 agreement with Jordan, due to the fact that Jordan seeks to maintain its right of nuclear enrichment.[192]

American businesses dealing with nuclear technology and infrastructure can legally engage in business, trade, and entrepreneurship in states that posses Section 123 agreements with the United States. These business engagements can help improve U.S. relations with many countries and foster closer peaceful nuclear ties. Until Section 123 agreements are signed with Jordan and Saudi Arabia, American nuclear-related businesses lose out on the opportunity to engage with those states, allowing other foreign countries like Japan, Russia, and South Korea to fill the void.

---

[190] Arms Control Association, "U.S. Nuclear Cooperation as Nonproliferation: Reforms, or the Devil You Know? | NTI," *Arms Control Association*, November 27, 2012, http://www.nti.org/analysis/articles/us-nuclear-cooperation-nonproliferation-reforms-or-devil-you-know/.

[191] Sigurd Neubauer, "Will President Obama Prioritize Nuclear Cooperation with Saudi Arabia?" *Atlantic Council*, March 19, 2014, http://www.atlanticcouncil.org/blogs/menasource/will-president-obama-prioritize-nuclear-cooperation-with-saudi-arabia.

[192] David Schenker, "The Middle East's Next Nuclear Power?" *POLITICO Magazine*, January 28, 2015, http://www.politico.com/magazine/story/2015/01/jordan-nuclear-power-114712.

Going forward, the lack of Section 123 agreements within the Middle East due to U.S. insistence on the "gold standard" may weaken U.S. influence in the region. However, it is not yet known how the Trump administration may negotiate future Section 123 agreements with these states. President Trump has given a wide range of conflicting remarks regarding nuclear proliferation in the past before he became President of the United States. Once, he stated "Wouldn't you rather, in a certain sense, have Japan have nuclear weapons when North Korea has nuclear weapons?" but he has also stated "No, no, not proliferation. I hate nuclear more than any...I don't want more nuclear weapons."[193] A shift away from promoting nuclear non-proliferation would be a massive departure from long-held U.S. security policy.

Foreign Influence in the Middle East

As new electrical power plants are built and planned in Jordan, Saudi Arabia, and the UAE, economic progress and growth is likely to follow. This economic growth invites businesses—foreign and domestic—to invest in new infrastructure, investment projects, and companies. These opportunities provide windows of opportunity for U.S. businesses to be able to inject capital into Jordan, Saudi Arabia, and the UAE and to also establish business relations with these states. Since nuclear power is just beginning to take shape across the Middle East and solar power capabilities are growing rapidly, expertise and technology must either be imported or built from scratch. To supplement

[193] Brendan Thomas-Noone, "Trump and nuclear proliferation: 'The importance of this issue to our security is clear'," *Guardian News and Media*, November 17, 2016, https://www.theguardian.com/commentisfree/2016/nov/18/trump-and-nuclear-proliferation-the-importance-of-this-issue-to-our-security-is-clear.

gaps in technologies, these countries often look to foreign investments and businesses to provide great-quality products and service at competitive costs.

Jordan's Ma'an Development Area contains a solar park that is dedicated for foreign investors and companies to build and implement new technologies that Jordan can use for its own energy sector. The Shams Ma'an power plant was constructed from investments and products from many different companies in different countries including Japan, Qatar, the United States, and Jordan.[194] Jordan's primary foreign partner for its two planned reactors—totaling 2000MW of installed capacity—is Russia's Rosatom nuclear vendor company. To fund its portion of the nuclear construction agreement, Jordan is seeking financial assistance and investors regionally and internationally. Future solar and nuclear projects in Jordan will undoubtedly require more foreign assistance in the form of technological expertise and financial investments to ensure that Jordan can receive quality power plants that can be financially sustainable.

Saudi Arabia is actively planning on building nuclear power plants and expanding solar power plant capabilities over the next few decades. Currently, Saudi Arabia has no active or under-construction nuclear power plants. However, they have begun seeking foreign investors and companies to pursue building sixteen nuclear power plants over the next couple decades.[195] Saudi Arabia has signed an array of international agreements regarding nuclear cooperation with many states, including France, Argentina, South

[194] Shams Ma'an, "Shams Ma'an Launches Production Phase of the largest Electricity Generation Project Using Photovoltaic Cells in Jordan."

[195] Reuters, "Saudi plans to build 16 nuclear reactors by 2030."

Korea, China, Russia, and Hungary.[196] While Saudi Arabia is still planning on the exact locations of where its nuclear power plants will be built, international companies have begun to make their case as to why they should be contracted to build and or operate nuclear power plants in Saudi Arabia—GE Hitachi Nuclear Energy and Toshiba/Westinghouse have made pitches to Saudi Arabia to construct nuclear reactors.[197] Saudi Arabia has also signed agreements with South Korea, Argentina, and China to produce and conduct research regarding small-scale nuclear reactors, some of which could be used for water desalination.[198]

Saudi Arabia has also begun seeking out foreign and domestic companies for more solar power plants to be built in Saudi Arabia. It is currently looking for international investors to be involved with two 50MW solar power plants that would be built in the northern part of the country.[199] Countries and companies from all over the world will be extremely interested in business opportunities in Saudi Arabia, as it stands to be arguably the greatest potential market for solar power due to the size of the country and its rapidly growing energy consumption levels. Saudi Arabia signed a contract with Taqnia—a Saudi state-owned company—to finalize "a deal to provide solar energy for 5 cents a kilowatt-hour..."[200] Over the next couple years, however, it is likely more final

---

[196] World Nuclear Association, "Nuclear Power in Saudi Arabia," *World Nuclear Association*, October 2016, http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/saudi-arabia.aspx.

[197] Ibid.

[198] Ibid.

[199] Anna Hirtenstein, "Saudi Arabia begins shift from oil to solar power to fuel electricity generation."

[200] Jeffrey Ball, "Why the Saudis Are Going Solar."

decisions will surface from the Saudi government about which companies—foreign and domestic—will be involved with expanding Saudi Arabia's solar power sector.

The United Arab Emirates has been an active player in seeking out international investment and assistance to construct nuclear and solar power projects. The UAE's inaugural nuclear power plant project to build four nuclear reactors totaling 5,600MW in installed capacity will be conducted with assistance from KEPCO. In December 2009, the UAE announced that KEPCO won the bid to construct reactors at the Barakah site in the western part of the UAE.[201] While KEPCO will be the primary foreign contractor and partner for the UAE's current construction and operation of its nuclear power plants, the UAE still requires international assistance elsewhere. In September 2012, the Export-Import Bank of the United States "authorized a $2 billion direct loan to the Barakah One Company of the United Arab Emirates (U.A.E.) to underwrite the export of American equipment and service-expertise" for nuclear-related technologies and operations.[202] The transaction will see U.S. companies like Westinghouse Electric Company LLC provide the UAE "reactor coolant pumps, reactor components, controls, engineering services, and training."[203]

In regards to solar power, the UAE is aggressively pursuing growth by seeking out investments to help diversify the UAE's energy sector. The UAE is embarking upon creating what would be the "largest single-site solar project in the world with a planned

---

[201] World Nuclear Association, "Nuclear Power in the United Arab Emirates."

[202] Export-Import Bank of the United States, "Ex-Im Approves $2 Billion in Financing for Nuclear Power Plant in U.A.E," N.p., September 7, 2012, http://www.exim.gov/news/ex-im-approves-2-billion-financing-for-nuclear-power-plant-uae.

[203] Ibid.

capacity of 5,000MW by 2030."[204] Called the Mohammed bin Rashid Al Maktoum Solar Park in Dubai, the solar park will be completed using a phased-approach by having companies and consortiums constructing solar plants to be integrated into the UAE's electrical grid. In June 2016, companies recently competed for a large 800MW phase of the solar park. A Masdar-led consortium won the contract by pitching a "bid of 2.99 US cents per kilowatt hour."[205] Announced in January 2017, the Dubai Electricity and Water Authority of the UAE is now accepting bids from other companies and groups to construct another phase of the solar park for a 200MW CSP power plant.[206] As the rest of the phases of the solar park are enacted, more foreign and domestic companies will continue to bid in attempts to win contracts to construct more solar power plants in the UAE.

While foreign private companies that provide infrastructure, technology, products, service, and labor to Jordan, Saudi Arabia, and the UAE do not necessarily represent their respective home government's views or policies, it does create a foreign trade link between the states involved. Over time, these trade and business influences will spillover into the political realm where we are likely to see favorable trade policies between involved countries to ensure that more business ventures and international investments

---

[204] LeAnne Graves, "Dubai's Mohammed bin Rashid Al Maktoum Solar Park shatters world record again," *The National*, June 28, 2016, http://www.thenational.ae/business/energy/dubais-mohammed-bin-rashid-al-maktoum-solar-park-shatters-world-record-again.

[205] Ibid.

[206] Dubai Electricity and Water Authority, "DEWA releases RFP for 200MW Solar CSP Power Plant, the fourth phase of the Mohammed bin Rashid Al Maktoum Solar Park," *Dubai Electricity and Water Authority*, January 20, 2017, https://www.dewa.gov.ae/en/about-dewa/news-and-media/press-and-news/latest-news/2017/01/dewa-releases-rfp-for-200mw-solar-csp.

can occur, as the energy sector globally will only continue to rapidly grow as technology is improved. States will likely support businesses in their own energy sectors that are involved with international trade as a way to help establish friendlier government relations and promote foreign relations that can produce favorable outcomes that create win-win scenarios for states.

Growth in solar and nuclear power sectors in the Middle East can help bring economic benefits to the United States. Companies like First Solar—who has constructed a small solar power plant in the UAE—can compete for contracts with other foreign companies in the Middle East.[207] The United States has been a prime market for solar power in the past and has also been an innovator in the solar power market. As states expand solar power capacity in the Middle East, U.S. companies can begin to develop more targeted marketing and development strategies focused on the Middle East region as a whole. Additionally, solar power can be an attractive investment for both energy exporters and energy importers, argues Matthew Merfert, the senior director of business development in Europe for First Solar.[208]

The United States has a vested interest in maintaining stability in the Middle East due to its global commitments and interests. One way to enhance stability and security is by ensuring that states in the region have access to sustainable energy sources. Since energy security can be closely linked to political stability and security, the United States must continue to monitor shifting forces and trends in energy markets in the Middle East.

---

[207] Elsiefu, ed., "First Solar to Build 13MW Solar Power Plant for Dubai Electricity & Water Authority," *EnergyTrend PV*, Ed. Elsiefu, October 18, 2012, http://pv.energytrend.com/news/F_S_Solar_20121018.html.

[208] Jeffrey Marlow, "Is the Middle East the Next Big Market for Solar Energy?" *Wired*, May 17, 2013, https://www.wired.com/2013/05/dubai-goes-solar/.

Additionally, the US has an interest in encouraging states to reduce energy security risks by adopting low-risk and sustainable energy fuel sources like solar power. If states like Saudi Arabia continue to rely too heavily on oil exports for government revenues, price volatility or unpredictable international security incidents could trigger a troubling scenario where conflict and unrest could grow in the Middle East, similar to the Arab Spring.

The Arab Spring showed that not all Middle Eastern and North African regimes are insulated from unrest and political instability. A wave of protests and conflicts like the ones that arose from the Arab Spring that would be tied to energy security and uncertainty about access to electricity and services would create a fundamental crisis in the region, ultimately affecting US security. A massive amount of trading and commercial activity occurs in the Middle East connected to energy resources that impact politics and economic activity all over the world. Additionally, the United States has a military posture covering a broad position in the Middle East, with soldiers stationed in allied states including but not limited to Kuwait, the UAE, Oman, Bahrain, Saudi Arabia, Qatar, Jordan, and Iraq.[209] If mass conflict involving unrest and potentially war originating from energy insecurity events erupted in the Middle East, US forces would be affected, possibly requiring their withdrawal from the affected area.

[209] The Heritage Foundation, "Middle East," 2017 Index of U.S. Military Strength, *The Heritage Foundation*, 2017, http://index.heritage.org/military/2017/assessments/operating-environment/middle-east/.

OUTLOOK OF IMPACT TO U.S. AND MIDDLE EASTERN SECURITY AND STABILITY

Energy security will continue to play a large role in international relations and regional politics in the future. For states like Jordan, Saudi Arabia, and the UAE, their respective populations will continue to grow at increasing rates. Additionally, these states are modernizing and increasing the standard of living, driving up not only prices but also expectations. To handle these changes, those states will need to be more determined in securing sufficient energy fuel sources to produce electricity.

There will come a time where Saudi Arabia and the UAE will not be able to rely so heavily on exporting hydrocarbon fuels for government revenues. This may already be occurring in a minor fashion, as oil prices have been significantly lower than in years past. Additionally, Jordan cannot sustain the path it is on to continue to be at the behest of international markets for imported energy fuel sources. Energy markets can be volatile and transportation of energy sources can be risky as well, as evidenced by attacks on pipelines or regional conflicts. For these reasons, it makes reasonable sense for Jordan, Saudi Arabia, and the UAE to pursue alternative methods for energy production and electricity generation—the ways of old will not continue to work forever.

Fortunately, those states have incredible potential in terms of yielding electricity through solar-powered means, with the possibility of even being able to export electricity to other states and regions. This potential will highly likely continue to make the Middle East a hotbed for foreign investment going forward for decades. In the Middle East, foreign investors and companies have a massive market to sell solar power technology

and infrastructure. These transactions will be able to occur for decades as technology continually improves, allowing for growth in the energy sector of Jordan, Saudi Arabia, and the UAE, which will also likely drive down prices over time.

Investment in solar power technology and infrastructure will also yield many benefits for both states and their respective populations. As states begin to reduce reliance on hydrocarbons for electricity production and shift to replace hydrocarbon power plants with solar power plants, states will be increasing energy security by effectively dampening the negative impacts of volatile energy markets that could make the price of oil fluctuate greatly. Furthermore, increased investment and usage of solar power systems will mean that states will emit less carbon and greenhouse gases into the atmosphere. Doing so will help improve the health of populations and the environment, helping to dampen the negative effects of climate change like rising temperatures, desertification, and increasing water scarcity.

While using solar power domestically to produce electricity, this doesn't mean states like Jordan and Saudi Arabia will stop selling hydrocarbons, but quite the opposite. Since those states will increasingly use less of their own oil and natural gas for electricity over time, they will be able to sell increasingly more amounts of hydrocarbons on the international market to export. While environmentalists may be disappointed in this possible trend, it would just be a reaction to the forces of trading and market economics. For the near future, it is highly unlikely most states in the world will adopt and utilize solar power on a massive scale. Large-scale solar power—and even nuclear power—is still largely a product for developed nations. This means that there will still be states that seek cheap and reliable energy fuel sources, i.e., oil and natural gas. However, since

states like Saudi Arabia and the UAE will be adopting solar power plants in the future, they will ultimately be emitting less greenhouses gases looking forward. This would be a major achievement, since Saudi Arabia and the UAE are one of the highest emitters of carbon emissions per capita in the world.[210]

Nuclear power's global future is more unpredictable. Nuclear power plant incidents like Fukushima and even more distant events like Three Mile Island and Chernobyl tend to decrease interest in nuclear power as a source of electricity immediately after they occur, even though all three of those incidents were caused by human error. Currently however, nuclear power is continuing to grow in slim margins globally. The IAEA also projects that nuclear power will continue to grow as states will seek reliable sources of power to help reduce carbon emissions.[211] The projected rise of nuclear power could suffer based upon unforeseen nuclear accidents, the decreasing costs of renewable energies, the low cost of natural gas, and sluggish economies.

Nuclear power's features such as high reliability to provide "always-on" power and its ability to produce electricity with minimal carbon emissions will likely continue to make it an attractive source of electricity for states, even with its risks. However, the capital and regulatory costs and the amount of time required to get a nuclear reactor functioning are very prohibitive factors that may hinder the growth of nuclear power. In an age where renewable energy is expanding and improving quickly and with low prices

---

[210] The World Bank, "CO2 emissions (metric tons per capita)," *The World Bank Group*, n.d., http://data.worldbank.org/indicator/EN.ATM.CO2E.PC?year_high_desc=true.

[211] IAEA Press Office, "IAEA Sees Global Nuclear Power Capacity Growing Through 2030," *IAEA*, September 23, 2016, https://www.iaea.org/newscenter/pressreleases/iaea-sees-global-nuclear-power-capacity-growing-through-2030.

of oil and natural gas, states may look only towards short term projections and determine that building a nuclear power plant right now does not help them in the near future. Expanding nuclear power in a state requires great amounts of capital and political will.

While the UAE is soon to have a functioning nuclear reactor, Saudi Arabia is still in the planning phase. If Saudi Arabia were to successfully build nuclear reactors it could always potentially seek a nuclear weapons program eventually down the road. Saudi Arabia is extremely concerned with Iran acquiring a nuclear weapon and does not want to be seen as weaker than Iran in the eyes of the world or its own people if it does not acquire a nuclear weapon as well.[212] If Iran acquires a nuclear weapon and Saudi Arabia possesses working nuclear power plants, Saudi Arabia may wish to seek a nuclear weapon as well, prompting an arms race in the region and potentially causing other nearby states to acquire WMD as well to hedge their bets.

The prospect of nuclear proliferation is frightening to U.S. policymakers. As countries begin to explore and utilize nuclear power in the Middle East, the United States must make firm commitments and strongly negotiate with states to promote nonproliferation measures like it did with the UAE. This challenge will not be easy, but the risks are too great for the United States and other great powers to sit back and watch and hope that these states seeking nuclear energy for peaceful means do not shift their intentions or capabilities.

To help bolster this, the United States should continue to aggressively negotiate Section 123 agreements with states like Saudi Arabia and Jordan to help promote good relations and to promote nonproliferation. The United States 123 agreement with the

[212] Angus McDowall, "Saudi Arabia considers its own nuclear options after Iran deal."

UAE will help foster stronger relations between the two states and encourage cooperation not only in trading, but hopefully also security policy matters. The United States can benefit greatly by continuing to negotiate 123 agreements with states to ensure that the United States does not get left behind in the nonproliferation and foreign investment arena. If the United States cannot cooperate and trade nuclear related technologies with states that stand to be a potential proliferation risk, then states like Russia and China will fill the US' void, setting different standards and establishing greater relations with these states. If so, Russia and China's interests may not necessarily be the same as the United States' interests.

If Jordan, Saudi Arabia, and the UAE cannot reasonably provide their respective populations with reliable and affordable power, civil unrest and conflict would likely arise due to many reasons. The lack of reliable electricity could weaken local and regional economies, causing governments to cut back on public services such as waste management, water treatment, health services, and public safety. These factors could spillover into instilling an environment that could promote a lack of political and civil order. In turn, this could allow factions and organizations to fracture governments' control over their respective regions, creating great security concerns.

Since the United States is a global power with global interests, these effects and incidents would directly affect it. An increase of disorder and political governing weakness could allow terrorist groups like ISIS and al-Qaeda to improve their relative power in the Middle East and to exploit nearby populations and regions. This scenario would be highly unfavorable to the United States and U.S. allies in the region, as it would promote insecurity, conflict with the possibility for war, and economic regression. The

United States has a vested interest in weakening and eliminating terrorists groups that seek the subversion of the U.S. government and the destruction of the American society. If Jordan's, Saudi Arabia's, and the UAE's governments are hampered by the limitations of their energy sectors and suffer from significant energy insecurity threats, however, then those governments cannot effectively ensure stability and security against terrorist factions and organizations that seek to subvert Middle Eastern governments.

The future of energy politics and energy security may be unpredictable as a whole. However, it is certain that the energy and demographic situation in Jordan, Saudi Arabia, and the UAE is shifting dramatically towards a direction that may create instability and conflict. If Jordan, Saudi Arabia, and the UAE adopt solar and nuclear power safely and efficiently into their energy production sectors, they will be able to help dampen the effects of quickly rising population growth and increasing levels of standard of living. Those states will also be more prepared to handle potential economic recessions and unforeseeable political events that could threaten social stability in the region such as war. Additionally, by incorporating solar and nuclear power into their respective energy sectors, Jordan, Saudi Arabia, and the UAE can set precedents for other states in the region to follow, allowing for easier facilitation and adaption of solar and nuclear power in other Middle Eastern states. Furthermore, these states would also likely find themselves in a position to receive economic benefits from increased economic and investment activity from foreign markets. Investors will be much more likely to invest in states that have diversified energy markets that present less risk and to invest in states that do not experience power shortages that could create political and economic uncertainty, loss of revenue, and damaged business reputations.

If Jordan, Saudi Arabia, and the UAE do not adopt solar and nuclear power in a substantial way, then risk driven by energy insecurity will pervade these states' political, social, and economic sectors. Jordan, Saudi Arabia, the UAE, and the Middle East as a whole will experience a sharp increase in population growth and continual increases in standard of living due to more segments of their respective populations gaining access to fundamental societal resources. A continued reliance on imports in the case for Jordan or a continued reliance on domestically produced oil for electricity production and government revenues for the cases of Saudi Arabia and the UAE are not sustainable in the long-term. These courses of action would make those states susceptible to economic volatility due to many factors that are largely outside their control, leaving their prospects of economic and political success up to uncertainty and uncontrollable actors. Furthermore, if Jordan, Saudi Arabia, and the UAE do not diversify their energy sectors, they run the risk of failing to keep up with rising demand for energy resources and electricity. In doing so, this would likely cause foreign investment and businesses to reduce commercial activity in these states, creating economic hardships that cannot be easily reversed. It can take years, even decades, to go through the whole planning/development/construction process for solar and nuclear power plants. Energy sector diversification cannot happen overnight, meaning that states must prepare and act based on the long-term projections and realities of tomorrow, rather than the needs of today, if they are to properly gather the resources, expertise, and infrastructure to tackle rising energy demands that will ultimately occur.

To stave off insecurity and instability, Jordan, Saudi Arabia, and the UAE must make solar and nuclear power a vital part of their energy sectors to reliably tackle the

rising energy demand problem in a sustainable way to avoid heavily relying on energy imports or excessive oil/gas consumption from domestic sources. While the threats of energy shortages and financial insecurity are not currently knocking on those states' doors, they ultimately will be, and may come with a vengeance if not addressed immediately.

REFERENCES CITED

3TIER. "Glossary of Technical Renewable Energy Terminology." *3TIER Support*, Vaisala, n.d., http://www.3tier.com/en/support/glossary/#ghi.

AP. "Russia to build Jordan's first nuclear power plant." *Al Jazeera English*, March 24, 2015. http://www.aljazeera.com/news/middleeast/2015/03/russia-build-jordan-nuclear-power-plant-150324192954416.html.

Arms Control Association. "Nuclear Weapons: Who Has What at a Glance." *Arms Control Association*, August 10, 2016. https://www.armscontrol.org/factsheets/Nuclearweaponswhohaswhat.

Arms Control Association. "The U.S. Atomic Energy Act Section 123 At a Glance." *Arms Control Association*, March 14, 2013. https://www.armscontrol.org/factsheets/AEASection123.

Arms Control Association. "U.S. Nuclear Cooperation as Nonproliferation: Reforms, or the Devil You Know? | NTI." *Arms Control Association*, November 27, 2012. http://www.nti.org/analysis/articles/us-nuclear-cooperation-nonproliferation-reforms-or-devil-you-know/.

Ball, Jeffrey. "Why the Saudis Are Going Solar." *The Atlantic*, Atlantic Media Company, July-August 2015. http://www.theatlantic.com/magazine/archive/2015/07/saudis-solar-energy/395315/.

Baker, Aryn. "How Climate Change is Behind the Surge of Migrants to Europe." *Time*, September 7, 2015. http://time.com/4024210/climate-change-migrants/.

Blanchard, Christopher M., Alexis Arieff, Zoe Danon, Kenneth Katzman, Jeremy M. Sharp, and Jim Zanotti. *Change in the Middle East: Implications for U.S. Policy*. Rep. no. R42393. Congressional Research Service, March 7, 2012. https://fas.org/sgp/crs/mideast/R42393.pdf.

Bloomberg. CL1 Commodity Quote." *Bloomberg Markets*, n.d. https://www.bloomberg.com/quote/CL1:COM.

Boersma, Tim, and Steve Griffiths. Reforming Energy Subsidies Initial Lessons from the United Arab Emirates. *The Brookings Institution*, January 2016. https://www.brookings.edu/wp-content/uploads/2016/01/esci_20160119_uae_energy_subsidies.pdf.

Bryce, Robert. "The Conservative Case for Nuclear Energy." *Manhattan Institute*, National Review Online, December 16, 2016. https://www.manhattan-institute.org/html/conservative-case-nuclear-energy-9693.html.

Bunn, Matthew, Martin B. Malin, Nickolas Roth, and William H. Tobey. *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline*. Harvard Kennedy School--Belfer Center for Science and International Affairs, March 2016. http://www.belfercenter.org/sites/default/files/legacy/files/PreventingNuclearTerrorism-Web.pdf.

Carbon Dioxide Information Analysis Center. "CO2 emissions (metric tons per capita)." *The World Bank Group*, n.d. http://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2013&start=2013&year_high_desc=true.

Clemente, Jude. "The Middle East's Growing Oil Demand Problem." *Forbes*, March 29, 2015. http://www.forbes.com/sites/judeclemente/2015/03/29/the-middle-easts-growing-oil-demand-problem/#55955cc24867.

Daiss, Tim. "Saudi Arabia Burns Through Cash Subsidies, Economic Crash Possible." *Forbes*, October 14, 2016. http://www.forbes.com/sites/timdaiss/2016/10/14/saudi-arabia-burns-through-cash-subsidies/#5cfe3f9b4855.

DiPaola, Anthony. "Cheapest Solar on Record Offered as Abu Dhabi Expands Renewables." *Bloomberg*, September 19, 2016. https://www.bloomberg.com/news/articles/2016-09-19/cheapest-solar-on-record-said-to-be-offered-for-abu-dhabi.

Dipaola, Anthony. "Saudis Seek Up to $50 Billion in Renewable-Energy Expansion." *Bloomberg*, January 16, 2017. https://www.bloomberg.com/news/articles/2017-01-16/saudis-seek-up-to-50-billion-for-first-phase-of-renewables-plan.

Dubai Electricity and Water Authority. "DEWA releases RFP for 200MW Solar CSP Power Plant, the fourth phase of the Mohammed bin Rashid Al Maktoum Solar Park." *Dubai Electricity and Water Authority*, January 20, 2017. https://www.dewa.gov.ae/en/about-dewa/news-and-media/press-and-news/latest-news/2017/01/dewa-releases-rfp-for-200mw-solar-csp.

Dubai Electricity and Water Authority. "Our History." *Dubai Electricity & Water Authority (DEWA)*, n.d. https://www.dewa.gov.ae/en/about-dewa/about-us/about-us/our-history.

Duke Energy. "Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR)." *Duke Energy*, March 27, 2012. https://nuclear.duke-energy.com/2012/03/27/pressurized-water-reactors-pwr-and-boiling-water-reactors-bwr.

Elsagheer, Mojahed. "Energy Situation in Jordan." *Ministry of Planning and International Cooperation*, July 2013. https://eneken.ieej.or.jp/data/5020.pdf.

Elsiefu, ed. "First Solar to Build 13MW Solar Power Plant for Dubai Electricity & Water Authority." *EnergyTrend PV*, October 18, 2012. http://pv.energytrend.com/news/F_S_Solar_20121018.html.

Embassy of the United Arab Emirates. "Energy in the UAE." N.p., n.d. http://www.uae-embassy.org/about-uae/energy-uae.

Embassy of the United Arab Emirates. "UAE Economic Diversification Efforts Continue to Thrive." N.p., n.d. http://www.uae-embassy.org/sites/default/files/pdf/uae_economic_development_infographic_v7_1.pdf.

Export-Import Bank of the United States. "Ex-Im Approves $2 Billion in Financing for Nuclear Power Plant in U.A.E." N.p., September 7, 2012. http://www.exim.gov/news/ex-im-approves-2-billion-financing-for-nuclear-power-plant-uae.

Fattah, Zainab, and Vivian Nereim. "Expat Fee, Subsidy Cuts: What's in Saudi Arabia's Fiscal Balance Plan?" *Bloomberg.com*, December 25, 2016. https://www.bloomberg.com/news/articles/2016-12-25/expat-fee-subsidy-cuts-what-s-in-saudi-fiscal-balance-document.

Fattouh, Bassam. "Energy Subsidies in the Middle East: Issues & Implications," *International Institute for Sustainable Development*. Proc. of Increasing the Momentum of Fossil-Fuel Subsidy Reform, Geneva. Oxford Institute for Energy Studies & Oxford University, October 2010. https://www.iisd.org/gsi/sites/default/files/ffs_gsiunepconf_sess3_bafattouh.pdf.

Gaffey, Conor. "Israel and Jordan Sign 'Historic' $900 Million Deal to Save the Dead Sea." *Newsweek*, March 18, 2016. http://www.newsweek.com/israel-and-jordan-sign-historic-900-million-deal-save-dead-sea-310084.

Galbraith, Kate. "Jordan Finds Energy Sources in Unlikely Places." *New York Times*, September 17, 2014. https://www.nytimes.com/2014/09/18/business/energy-environment/jordan-finds-energy-sources-in-unlikely-places.html?_r=0.

Gayle, Damien. "Who needs oil? World's largest solar power plant with 258,000 mirrors opens in Abu Dhabi." *Daily Mail Online*, March 19, 2013. http://www.dailymail.co.uk/sciencetech/article-2295717/Who-needs-oil-Worlds-largest-concentrated-solar-power-plant-258-000-mirrors-opens-Abu-Dhabi.html.

Gloystein, Henning, and Sonali Paul. "Oil Loses Commodity Trade Crown to Unlikely Challenger: Rebar." *Reuters*, April 28, 2016. http://www.reuters.com/article/us-oil-steel-trading-idUSKCN0XP1CT.

Government of the UAE. "Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy." *Embassy of the United Arab Emirates*, April 2008. http://www.uae-embassy.org/sites/default/files/UAE_Policy_Peaceful_Nuclear_Energy_English.pdf.

Grantham Research Institute on Climate Change and the Environment. "The National Climate Change Policy of the Hashemite Kingdom of Jordan 2013-2020." *London School of Economics and Political Science*, May 2013. http://www.lse.ac.uk/GranthamInstitute/law/the-national-climate-change-policy-of-the-hashemite-kingdom-of-jordan-2013-2020/.

Grantham Research Institute on Climate Change and the Environment. "United Arab Emirates." *London School of Economics and Political Science*, January 13, 2017. http://www.lse.ac.uk/GranthamInstitute/legislation/countries/united-arab-emirates/.

Graves, LeAnne. "Acwa plans low-cost solar project in Jordan." *The National*, January 16, 2017. http://www.thenational.ae/business/energy/acwa-plans-low-cost-solar-project-in-jordan.

Graves, LeAnne. "Dubai's Mohammed bin Rashid Al Maktoum Solar Park shatters world record again." *The National*, June 28, 2016. http://www.thenational.ae/business/energy/dubais-mohammed-bin-rashid-al-maktoum-solar-park-shatters-world-record-again.

Graves, LeAnne, and Thamer Al Subaihi. "UAE turns green with new power plan 2050." *The National*, January 11, 2017. http://www.thenational.ae/uae/uae-turns-green-with-new-power-plan-2050.

Habboush, Mahmoud. "Abu Dhabi's Masdar Seeks Partners for Clean-Energy Desalination." *Bloomberg*, September 8, 2016. https://www.bloomberg.com/news/articles/2016-09-08/abu-dhabi-s-masdar-seeks-partners-for-clean-energy-desalination.

Haddad, Tarreq. "Wind and solar energy to be cheaper than fossil fuels by 2018." *International Business Times UK*, December 27, 2016. http://www.ibtimes.co.uk/wind-solar-energy-be-cheaper-fossil-fuels-by-2018-1598238.

Hansen, James, Kerry Emanuel, Ken Caldeira, and Tom Wigley. "Nuclear power paves the only viable path forward on climate change." *The Guardian*, December 3, 2015. https://www.theguardian.com/environment/2015/dec/03/nuclear-power-paves-the-only-viable-path-forward-on-climate-change.

Harrington, Kent. "Saudi Arabia Creates New Solar-Powered Desalination Technology." *AIChE*, October 16, 2015. http://www.aiche.org/chenected/2015/10/saudi-arabia-creates-new-solar-powered-desalination-technology.

Harvey, Chelsea. "This technology may be the future of solar energy." *The Washington Post*, January 15, 2016. https://www.washingtonpost.com/news/energy-environment/wp/2016/01/15/this-technology-may-be-the-future-of-solar-energy/?utm_term=.fc5023606529.

Hashemite Kingdom of Jordan. Summary--Updated Master Strategy of Energy Sector in Jordan for the period (2007-2020). *Ministry of Energy and Mineral Resources*, 2007. Print. http://eis.memr.gov.jo/publication/policy/law-policies/283-energy-strategy.

Heger, Monica. "Renewable Energy is Good for Your Health." IEEE Spectrum: Technology, Engineering, and Science News, *IEEE*, August 31, 2015. http://spectrum.ieee.org/energywise/energy/environment/renewable-energy-is-good-for-your-health.

Hirtenstein, Anna. "Saudi Arabia begins shift from oil to solar power to fuel electricity generation." *The Independent*, December 21, 2016. http://www.independent.co.uk/news/business/news/saudi-arabia-oil-revenue-production-solar-power-shift-electricity-energy-opec-a7488626.html>.

Hochberg, Michael. "Jordan's Energy Future: A Path Forward." *Middle East Institute*, August 19, 2015. http://www.mei.edu/content/article/jordans-energy-future-path-forward.

Hume, Tim. "75,000 Trapped in Refugee Camp on Jordan-Syria Border, Amnesty Warns." *CNN*, September 16, 2016. http://www.cnn.com/2016/09/15/middleeast/jordan-rukban-refugee-camp/.

IAEA Press Office. "IAEA Completes Nuclear Security Review Mission in United Arab Emirates." *IAEA*, November 10, 2016. https://www.iaea.org/newscenter/pressreleases/iaea-completes-nuclear-security-review-mission-in-united-arab-emirates.

IAEA Press Office. "IAEA Sees Global Nuclear Power Capacity Growing Through 2030." *IAEA*, September 23, 2016. https://www.iaea.org/newscenter/pressreleases/iaea-sees-global-nuclear-power-capacity-growing-through-2030.

International Atomic Energy Agency. "History." *IAEA*, n.d., https://www.iaea.org/about/overview/history.

International Atomic Energy Agency. "Jordan." Country Nuclear Power Profiles, *IAEA*, 2016. https://cnpp.iaea.org/countryprofiles/Jordan/Jordan.htm.

International Atomic Energy Agency. "List of Member States." *IAEA*, February 2016. https://www.iaea.org/about/governance/list-of-member-states.

International Energy Agency. "Jordan: Balances for 2014." IEA - Report. *OECD/IEA*, n.d. http://www.iea.org/statistics/statisticssearch/report/?year=2014&country=JORDAN&product=Balances.

International Energy Agency. "Middle East: Electricity and Heat for 2014." IEA – Report, *OECD/IEA*, n.d. https://www.iea.org/statistics/statisticssearch/report/?year=2014&country=MIDDLEEAST&product=ElectricityandHeat.

International Energy Agency. "Technology Roadmap: Solar Thermal Electricity - 2014 edition." *OECD/IEA*, September 2014. http://www.iea.org/publications/freepublications/publication/technology-roadmap-solar-thermal-electricity---2014-edition.html.

International Energy Agency. "United Arab Emirates: Electricity and Heat for 2013." *OECD/IEA*, n.d. http://www.iea.org/statistics/statisticssearch/report/?country=UAE&product=ElectricityandHeat&year=2013.

International Energy Agency. "What Is Energy Security?." *OECD/IEA*, 2016. https://www.iea.org/topics/energysecurity/subtopics/whatisenergysecurity/.

International Trade Administration. "United Arab Emirates - Renewable EnergyUAE - Renewable Energy." *U.S. Department of Commerce*, September 1, 2016. https://www.export.gov/article?id=United-Arab-Emirates-Renewable-Energy.

Johnston, Matthew. "Pros And Cons Of Solar Energy." *Investopedia LLC*, May 30, 2015. http://www.investopedia.com/articles/investing/053015/pros-and-cons-solar-energy.asp?lgl=bt1tn-no-widget.

Jordan Atomic Energy Commission and Worley Parsons. "White Paper on Nuclear Energy in Jordan--Final Report." *Worley Parsons*, September 2011. http://www.jaec.gov.jo/CMS/UploadedFiles/c18cbcac-92e9-481b-a781-498ca0bf7e9c.pdf, 24.

Jordan Ministry of Energy and Mineral Resources. "Renewable Energy & Energy Efficiency (Law No. 13)." *OECD/IEA*, July 23, 2013. https://www.iea.org/policiesandmeasures/pams/jordan/name-36862-en.php

Jordan Ministry of Environment. "The National Climate Change Policy of the Hashemite Kingdom of Jordan 2013-2020." *Ministry of Planning and International Cooperation*, 2013. http://inform.gov.jo/en-us/By-Date/Report-Details/ArticleId/67/The-National-Climate-Change-Policy-of-the-Hashemite-Kingdom-of-Jordan-2013-2020.

Jordan Times. "Gov't Raises Fuel Prices by over 6%." *Jordan Times*, December 31, 2016. http://jordantimes.com/news/local/gov%E2%80%99t-raises-fuel-prices-over-6.

Kane, Frank. "UAE to Cut Remaining Energy Subsidies, Minister Says." *The National*, January 24, 2016. http://www.thenational.ae/business/economy/uae-to-cut-remaining-energy-subsidies-minister-says.

Kerr, Paul K., Mary Beth D. Nikitin. *Nuclear Cooperation with Other Countries: A Primer*. Rep. no. RS22937, Congressional Research Service, December 27, 2016. https://fas.org/sgp/crs/nuke/RS22937.pdf.

King Abdullah City for Atomic and Renewable Energy. "Atomic." *King Abdullah City for Atomic and Renewable Energy*, n.d. https://www.kacare.gov.sa/en/FutureEnergy/Pages/nucularpower.aspx.

King Abdullah City for Atomic and Renewable Energy. "Solar." *King Abdullah City for Atomic and Renewable Energy*, n.d. https://www.kacare.gov.sa/en/FutureEnergy/RenewableEnergy/pages/solarenergy.aspx.

King Abdullah City for Atomic and Renewable Energy. "The Establishing Order." *King Abdullah City for Atomic and Renewable Energy*, n.d. https://www.kacare.gov.sa/en/about/Pages/royalorder.aspx.

Korn, Andrew. "Challenges to UAE solar power remain, but it still makes sense." *The National*, May 5, 2016. http://www.thenational.ae/business/energy/challenges-to-uae-solar-power-remain-but-it-still-makes-sense.

Krane, Jim. "Reversing Middle East Dependence: U.S. Begins Exports Of Shale Gas To Oil-Rich UAE And Kuwait." *Forbes*, November 17, 2016. http://www.forbes.com/sites/thebakersinstitute/2016/11/17/reversing-middle-east-dependence-us-begins-exports-of-shale-gas-to-oil-rich-uae-and-kuwait/#5c9b57347cdb.

Lahn, Glada, Owen Grafham, and Adel Elsayed Sparr. *Refugees and Energy Resilience in Jordan*. Chatham House, April 20, 2016.

https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2016-08-03-refugees-energy-jordan-lahn-grafham-sparr.pdf

Landau, Elizabeth. "Why (or why not) nuclear energy?" *CNN*, March 26, 2011. http://www.cnn.com/2011/US/03/26/nuclear.energy/index.html?eref=rss_us.

Luck, Taylor. "Jordan's Syrian Refugee Economic Gamble." *Middle East Institute*, May 24, 2016. http://www.mei.edu/content/article/jordan-s-syrian-refugee-economic-gamble.

Lui, Kevin. "Shocking Time-Lapse Shows Thick Smog Engulfing Beijing." *Time*, January 4, 2017. http://time.com/4621444/chna-smog-beijing-enivronment-red-alert/.

Ma, Alexandra. "Oil-Rich Dubai Pledges To Put Solar Panels On Every Roof By 2030." *The Huffington Post*, December 12, 2015. http://www.huffingtonpost.com/entry/dubai-solar-panels_us_565f1699e4b072e9d1c43a67.

Ma'an Development Area. "FAQ." *Ma'an Development Area*, n.d. http://www.mda.jo/faq.aspx.

Maddocks, Andrew, Robert Samuel Young, and Paul Reig. "Ranking the World's Most Water-Stressed Countries in 2040." *World Resources Institute*, August 26, 2015. http://www.wri.org/blog/2015/08/ranking-world%E2%80%99s-most-water-stressed-countries-2040.

Mahdi, Wael. "Saudi Arabia Considers Rise in Retail Fuel Prices in 2017." *Bloomberg.com*, December 20, 2016. https://www.bloomberg.com/news/articles/2016-12-20/saudi-arabia-said-to-consider-rise-in-retail-fuel-prices-in-2017-iwxu7w3z>.

Malek, Caline. "Nuclear energy key to confronting climate change, Abu Dhabi forum hears." *The National*, January 12, 2017. http://www.thenational.ae/uae/environment/nuclear-energy-key-to-confronting-climate-change-abu-dhabi-forum-hears.

Marlow, Jeffrey. "Is the Middle East the Next Big Market for Solar Energy?" *Wired*, May 17, 2013. https://www.wired.com/2013/05/dubai-goes-solar/.

Masdar. "Masdar appoints IFC to oversee funding of Jordan's largest solar power project." *Masdar*, January 18, 2017. http://www.masdar.ae/en/media/detail/masdar-appoints-ifc-to-oversee-funding-of-jordans-largest-solar-power-proje>.

Masdar. "Renewable Energy Desalination Pilot Programme." *Masdar*, n.d. http://www.masdar.ae/en/energy/detail/renewable-energy-water-desalination-in-uae.

McDowall, Angus. "Saudi Arabia considers its own nuclear options after Iran deal." *Reuters*, July 21, 2015. http://www.reuters.com/article/us-iran-nuclear-saudi-nuclear-idUSKCN0PV1GC20150721.

NASA, Holly Shaftel, and Laura Tenenbaum. "Carbon Dioxide." *NASA*, January 19, 2017. http://climate.nasa.gov/vital-signs/carbon-dioxide/.

NASA, Holly Shaftel, and Laura Tenenbaum."Global Temperature." *NASA*, January 19, 2017. http://climate.nasa.gov/vital-signs/global-temperature/.

National Nuclear Security Administration. "123 Agreements for Peaceful Cooperation." *U.S. Department of Energy*, n.d. https://nnsa.energy.gov/aboutus/ourprograms/nonproliferation/treatiesagreements/123agreementsforpeacefulcooperation.

National Renewable Energy Laboratory. "ISCC Duba 1." *U.S. Department of Energy*, January 31, 2017. https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=4300.

National Renewable Energy Laboratory. "Waad Al Shamal ISCC Plant." *U.S. Department of Energy*, February 7, 2017. https://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=4300.

Naylor, Hugh. "An Epic Middle East Heat Wave Could Be Global Warming's Hellish Curtain-raiser." *The Washington Post*, August 10, 2016. https://www.washingtonpost.com/world/middle_east/an-epic-middle-east-heat-wave-could-be-global-warmings-hellish-curtain-raiser/2016/08/09/c8c717d4-5992-11e6-8b48-0cb344221131_story.html?utm_term=.2694145fa3d9.

Neubauer, Sigurd. "Will President Obama Prioritize Nuclear Cooperation with Saudi Arabia?" *Atlantic Council*, March 19, 2014, http://www.atlanticcouncil.org/blogs/menasource/will-president-obama-prioritize-nuclear-cooperation-with-saudi-arabia.

Nuclear Energy Institute. *Land Requirements for Carbon-Free Technologies*. *Nuclear Energy Institute*, June 2015. https://www.nei.org/CorporateSite/media/filefolder/Policy/Papers/Land_Use_Carbon_Free_Technologies.pdf?ext=.pdf.

Nuclear Energy Institute. "Water Desalination." *NEI*, n.d. https://www.nei.org/Knowledge-Center/Other-Nuclear-Energy-Applications/Water-Desalination.

Nuclear Security Summit. "Attending Delegations." The 2016 Nuclear Security Summit, N.p., n.d. http://www.nss2016.org/attending-delegations/.

OECD NEA. "Economics of nuclear power FAQs." N.p., June 8, 2014. https://www.oecd-nea.org/news/press-kits/economics-FAQ.html#2.

Orosz, Matt. Photovoltaics and concentrating solar power: why hybridization makes sense." *SPIE*, August 26, 2015. http://spie.org/newsroom/6018-photovoltaics-and-concentrating-solar-power-why-hybridization-makes-sense.

Oxford Business Group. "Jordan Pushes Ahead on Renewables." *Oxford Business Group*, June 22, 2016. http://www.oxfordbusinessgroup.com/news/jordan-pushes-ahead-renewables.

Petra News Agency. "Jordan Achieves 2020 Renewable Energy Strategy 2020 Objective, Minister." *Embassy of the Hashemite Kingdom of Jordan*, January 17, 2017. http://www.jordanembassyus.org/blog/jordan-achieves-2020-renewable-energy-strategy-2020-objective-minister-1.

Politico Magazine. "The Hidden Consequences of the Oil Crash." *POLITICO Magazine*, January 21, 2016. http://www.politico.com/magazine/story/2016/01/oil-crash-hidden-consequences-213550>.

Rapier, Robert. "The Experts: What's the Best Way Forward on Nuclear Power?" *The Wall Street Journal*, April 17, 2013. http://www.wsj.com/articles/SB10001424127887323809304578428570153032936.

Rascouet, Angelina, and Wael Mahdi. "Saudi Arabia to Select Nuclear Power-Plant Site 'Very Soon'." *Bloomberg*, October 20, 2016. https://www.bloomberg.com/news/articles/2016-10-20/saudi-arabia-to-select-nuclear-power-plant-site-very-soon.

Reuters. "Saudi Arabia Says It's About to Launch a $30-$50 Billion Renewable Energy Program." *Fortune*, January 16, 2017. http://fortune.com/2017/01/16/saudi-arabia-renewable-energy-program/.

Reuters. "Saudi plans to build 16 nuclear reactors by 2030." *Reuters*, June 1, 2011. http://www.reuters.com/article/saudi-nuclear-idAFLDE75004Q20110601.

Reuters. "Saudi Seeks International Investors for Two Solar Plants." *Fortune*, June 12, 2016. http://fortune.com/2016/06/12/saudis-seek-solar-investors/.

Richardson, Bill. "Bill Richardson: What Saudi Arabia's Bet on Solar Power Means." *Time*, May 3, 2016. http://time.com/4314182/saudi-arabia-solar-power/.

Rogers, Simon. "Nuclear power plant accidents: listed and ranked since 1952." *The Guardian*, March 14, 2011. https://www.theguardian.com/news/datablog/2011/mar/14/nuclear-power-plant-accidents-list-rank.

Rowan, David. "2017 could be the tipping point for super efficient solar panels." *WIRED UK*, January 3, 2017. http://www.wired.co.uk/article/solar-power-perovskite.

Rubin, Alissa J., and Milan Schreuer. "Belgium Fears Nuclear Plants Are Vulnerable." *The New York Times*, March 25 2016. http://www.nytimes.com/2016/03/26/world/europe/belgium-fears-nuclear-plants-are-vulnerable.html.

Sahawneh, Julia. "Energy Policy—Country Report/ Jordan." *Ministry of Energy and Mineral Resources*, June 2, 2015. Japan, PowerPoint Presentation. https://eneken.ieej.or.jp/data/6206.pdf.

Schenker, David. "The Middle East's Next Nuclear Power?" *POLITICO Magazine*, January 28, 2015. http://www.politico.com/magazine/story/2015/01/jordan-nuclear-power-114712.

Shams Ma'an. "Shams Ma'an Launches Production Phase of the largest Electricity Generation Project Using Photovoltaic Cells in Jordan." *Shams Ma'an*, December 21, 2016. http://www.shamsmaan.com/page/shams-ma%E2%80%99-launches-production-phase-largest-electricity-generation-project-using-photovoltaic.

Solar Energy Industries Association. "Concentrating Solar Power." *SEIA*, n.d. http://www.seia.org/policy/solar-technology/photovoltaic-solar-electric.

Solar Energy Industries Association. "Photovoltaic (Solar Electric)." *SEIA*, n.d. http://www.seia.org/policy/solar-technology/photovoltaic-solar-electric.

SolarGIS. "Solar resource maps for Jordan." *SolarGIS*, 2014. http://solargis.com/products/maps-and-gis-data/free/download/jordan.

SolarGIS. "Solar resource maps for Saudi Arabia." *SolarGIS*, 2013. http://solargis.com/products/maps-and-gis-data/free/download/saudi-arabia.

SolarGIS. , "Solar resource maps for United Arab Emirates." *SolarGIS*, 2014. http://solargis.com/products/maps-and-gis-data/free/download/united-arab-emirates.

Sullivan, Kevin. "If You Think Gas Is Cheap These Days, Look What It Costs in Saudi Arabia." *The Washington Post*, February 8, 2015. https://www.washingtonpost.com/world/middle_east/if-you-think-gas-is-cheap-

these-days-look-what-it-costs-in-saudi-arabia/2015/02/07/889536ef-fb15-4453-b99b-eb99622dcf4e_story.html.

Tahhan, Zena. "Jordanians Reject 'stolen Gas' in Israel-Jordan Deal." *Al Jazeera*, October 3, 2016. http://www.aljazeera.com/news/2016/10/jordanians-reject-stolen-gas-israel-jordan-deal-161002131442112.html.

The Economist. "How to build a nuclear-power plant." *The Economist*, January 28, 2017. http://www.economist.com/news/business/21715685-new-crop-developers-challenging-industry-leaders-how-build-nuclear-power-plant.

The Heritage Foundation. "Middle East." 2017 Index of U.S. Military Strength, *The Heritage Foundation*, 2017. http://index.heritage.org/military/2017/assessments/operating-environment/middle-east/.

The White House--Office of the Press Secretary. "Declaration on Nuclear Energy and Nonproliferation: Joint Actions." *National Archives and Records Administration*, 2007. https://georgewbush-whitehouse.archives.gov/news/releases/2007/07/20070703.html.

The World Bank. "Climate Change in the Middle East & North Africa." *The World Bank Group*, n.d. http://www.worldbank.org/en/programs/mena-climate-change.

The World Bank. "CO2 emissions (metric tons per capita)." *The World Bank Group*, n.d. http://data.worldbank.org/indicator/EN.ATM.CO2E.PC?year_high_desc=true.

The World Bank. "GDP (current US$)." *World Bank Group*. n.d. http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=EG-SA.

The World Bank. The World Bank, "GDP (current US$)." *World Bank Group*, n.d. http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?name_desc=false.

The World Bank, "Health Nutrition and Population Statistics: Population Estimates and Projections," Health Nutrition and Population Statistics, *World Bank Group*, n.d.

The World Bank. "Jordan." *World Bank Group*, 2016. http://data.worldbank.org/country/jordan.

Thomas-Noone, Brendan. "Trump and nuclear proliferation: 'The importance of this issue to our security is clear'." *Guardian News and Media*, November 17, 2016. https://www.theguardian.com/commentisfree/2016/nov/18/trump-and-nuclear-proliferation-the-importance-of-this-issue-to-our-security-is-clear.

Tsagas, Ilias. "Jordan: mosques and universities embrace solar." *Pv magazine International*, April 12, 2016. https://www.pv-magazine.com/2016/04/12/jordan-mosques-and-universities-embrace-solar_100024107/.

Union of Concerned Scientists. "Benefits of Renewable Energy Use." *Union of Concerned Scientists*, April 8, 2013. http://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#globalwarming.

Union of Concerned Scientists. "How Nuclear Power Works." *Union of Concerned Scientists*, n.d. http://www.ucsusa.org/nuclear-power/nuclear-power-technology/how-nuclear-power-works#.WH0lZrYrKRs.

Union of Concerned Scientists. "The Hidden Costs of Fossil Fuels." *Union of Concerned Scientists*, August 30, 2016. http://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/hidden-cost-of-fossils#bf-toc-2.

U.S. Department of State. "Bureau of International Security and Nonproliferation (ISN)." *U.S. Department of State, The Office of Website Management, Bureau of Public Affairs*, n.d. https://www.state.gov/t/isn/.

U.S Energy Information Administration. "Electric Power Monthly." EIA - Electricity Data, *U.S. Energy Information Administration*, December 23, 2016. https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_3.

U.S. Energy Information Administration. International Energy Outlook 2016. Rep. no. DOE/EIA-0484(2016), *U.S. Energy Information Administration*, May 2016. http://www.eia.gov/outlooks/ieo/world.cfm.

U.S. Energy Information Administration. "Spot Prices for Crude Oil and Petroleum Products." *U.S. Department of Energy*, February 8, 2017. http://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm.

U.S. Energy Information Administration. "Total Petroleum and Other Liquids Production - 2015." *U.S. Energy Information Administration*, n.d. http://www.eia.gov/beta/international/index.cfm?topL=exp.

U.S. Energy Information Administration. "United Arab Emirates plans to increase crude oil and natural gas production." *U.S. Energy Information Administration*, October 23, 2015. https://www.eia.gov/todayinenergy/detail.php?id=23472.

U.S. Energy Information Administration. "U.S. Regular Conventional Retail Gasoline Prices (Dollars per Gallon)." *U.S. Energy Information Administration*, December 19, 2016. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epmru_pte_nus_dpg&f=w.

U.S. NRC. "Animated Images of Plants PWR and BWR." NRC: The Student Corner: Multimedia: Animated Images of Plants PWR and BWR, *U.S. Nuclear Regulatory Commission*, September 8, 2015. https://www.nrc.gov/reading-rm/basic-ref/students/multimedia/animated-images-plants-pwr-bwr.html.

Varnum, Jessica C. "U.S. Nuclear Cooperation as Nonproliferation: Reforms, or the Devil You Know?" *Nuclear Threat Initiative*, November 27, 2012. http://www.nti.org/analysis/articles/us-nuclear-cooperation-nonproliferation-reforms-or-devil-you-know/.

Vick, Karl. "The Middle East Nuclear Race Is Already Under Way." *Time*, March 23, 2015. http://time.com/3751676/iran-talks-nuclear-race-middle-east/.

World Economic Forum, and IHS CERA. Energy for Economic Growth Energy Vision Update 2012. Rep. World Economic Forum, 2012. http://www3.weforum.org/docs/WEF_EN_EnergyEconomicGrowth_IndustryAgenda_2012.pdf.

World Nuclear Association. "Nuclear Desalination." *World Nuclear Association*, January 2017. http://www.world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-desalination.aspx.

World Nuclear Association. "Nuclear Power in Jordan." *World Nuclear Association*, December 2016. http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/jordan.aspx.

World Nuclear Association. "Nuclear Power in Saudi Arabia." *World Nuclear Association*, October 2016. http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/saudi-arabia.aspx.

World Nuclear Association. "Nuclear Power in the United Arab Emirates." *World Nuclear Association*, October 2016. http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/united-arab-emirates.aspx.

World Nuclear Association. "The Economics of Nuclear Power." *World Nuclear Association*, December 2016. http://www.world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx.

Zafar, Salman. "Solar Energy in Jordan." *EcoMENA*, March 30, 2016. http://www.ecomena.org/solar-energy-jordan/.