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ENERGY SECURITY IN JORDAN

by

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December 2015

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This thesis explores if the energy strategy of the Hashemite Kingdom of Jordan, as formulated and executed by the Ministry of Energy and Mineral Resources, will help the country achieve greater energy security. This work qualitatively analyzes the progress in each energy subsector—hydrocarbons, nuclear power, and renewables—on goals presented in the country's strategy and provides further analysis to determine each subsector's potential to play a greater role in future energy development. The primary conclusion is that the goals within Jordan's overarching energy strategy have not been realized and, consequently, the strategy is not on track to provide energy security. This conclusion is based on three main findings. First, Jordan failed in meeting targets to diversify and exploit domestic hydrocarbon resources—being forced to rely on foreign heavy fuels and running a deficit to meet basic energy needs. Second, the kingdom's nuclear program has not kept up with development milestones and further nuclear progress is hampered by significant political and resource constraints. Third, the administration in Amman has been unsuccessful in fully capitalizing on the abundance of renewable energy resources readily available within Jordan's borders.

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ENERGY SECURITY IN JORDAN

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Submitted in partial fulfillment of the
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I. INTRODUCTION

A. RESEARCH QUESTION

Over the years, Jordan has emerged as an important U.S. ally in the Middle East. In contrast to most nations of the region, Jordan has been without the abundance of hydrocarbons synonymous with neighboring countries like Syria, Iraq, and Saudi Arabia. This leaves Jordan without reliable, affordable domestic sources of energy—instead leaving it severely dependent as a net energy importer. Jordan has established an overarching energy plan in the hopes of reducing its dependence on imported energy and improving its energy security. Within the plan, nuclear development, renewable expansion, and hydrocarbon diversification are identified as potential areas for Jordan to expand domestic energy production and create more energy independence. Considering the strengths, weaknesses, opportunities, and threats associated with each energy source, will Jordan's energy strategy meet its future needs and help the country achieve greater energy security?

B. RELEVANCE

Despite being in a region where the abundance of natural resources seems congruent with the focus of U.S. foreign policy interest, Jordan remains important to the United States for its roles as a regional ally, perpetuator of moderate ideology, and status as a bastion of relative stability within the Middle East.[1] While Jordan took up arms against U.S.-allied Israel from the Arab-Israeli War of 1948 to the 1973 Yom Kippur War, Jordan's government has rebounded toward seeking peace as tendered in the 1994 agreement with Israel.[2] In this agreement, Jordan relinquished claims to the West Bank, but continues to play an important role overseeing important Muslim holy sites within Israel—most notably the Al-Aqsa Mosque resting on the Temple Mount.[3] Since taking

[1] Jeremy M. Sharp, "Jordan: Background and U.S. Relations" (Washington, DC: Congressional Research Service, March 17, 2015), 1–3, https://www.fas.org/sgp/crs/mideast/RL33546.pdf.

[2] Ibid.

[3] Ibid.

power in 1999, King Abdullah has continued cooperation with Israel and compliance with U.S. calls for support. Jordan's most apparent demonstration of this support has taken place in its operations combatting the Islamic State of Iraq and al-Sham (ISIS). Since the start of airstrikes in August 2014, Jordan has claimed responsibility for one-fifth of the air attacks conducted by coalition forces in Operation Inherent Resolve.[4] Moreover, U.S. and other coalition military personnel maintain presence in Jordan operating Patriot missile batteries and fighter aircraft.[5]

As conflict continues between Israel and militant groups in Gaza, Syria erupts in Civil War, and Iraq deals with territorial advances by the ISIS, Jordan provides relative safety and security for refugees flooding in from troubled areas of the Middle East. To date, there are approximately two million registered Palestinian refugees in Jordan.[6] Jordanian citizens originally from Palestine also make up between 55 and 70% of the total population.[7] From 2012 to 2015, over 600,000 Syrians sought refuge in Jordan from that nations ongoing civil war—raising the total population by 10%.[8] This rising influx of refugees has dramatically increased economic and political strain on the government in Amman.[9]

Limited supply resulting from chaotic regional events, paired with the increasing domestic demand, leaves Jordan's government struggling to ensure affordable and reliable access to food, water, and energy. At the crux of this problem is a high dependence on foreign hydrocarbons to provide the basic energy needs of the rising population while attempting to develop a more robust domestic economy. Jordan stands as one of the most dependent nations from an energy perspective, regularly importing over 95% of its domestic energy requirements—nearly 20% of its gross domestic

[4] Ibid.

[5] Ibid., 3.

[6] Ibid., 4.

[7] Ibid., 6–7.

[8] Ibid., 3.

[9] Ibid., 3–7.

product.[10] In the last decade, the Middle East's instability has forced Jordan to pivot its hydrocarbon imports from Iraq to Egypt to Saudi Arabia, and now toward Israel for reliable energy supplies. Maintaining an affordable, reliable supply of energy is important for sustaining Jordan's internal stability. After all, the government's power hinges largely on its ability to provide for its swelling population. Without the guiding hand of the U.S.-aligned Hashemite family, Jordan might succumb to growing anti-Western, Islamist ideologies within its population. Such an outcome could strip the U.S. of an important Middle East ally, deny refuge to many displaced persons, and remove the nation's position as a buffer among more adversarial regional actors. Thus, considering Jordan's policies toward energy security is a matter of significant U.S. and regional interest.

C. CONCEPTUAL ORIENTATION

In light of the essential implications of energy security in Jordan, it is important next to consider the energy sustainability trilemma within which energy security exists. On the first axis, energy security focuses on what the World Energy Council defines as "the effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of energy providers to meet current and future demand."[11] Meanwhile, energy equity, defined by the council as "accessibility and affordability of energy supply across the population," is captured on the second axis.[12] Finally, the third axis of the trilemma focuses on environmental sustainability. According to the World Energy Council, environmental sustainability "encompasses the achievement of supply and demand side energy efficiencies and the development of energy supply from renewable and other low-carbon sources."[13] In further considering

[10] Fareedon Hartoqa, "Jordan: Renewable Energy Market," Government (U.S. Commercial Service, Department of Commerce, May 15), http://export.gov/jordan/static/Jordan%20Renewable%20Energy%20Market_Latest_eg_jo_034925.doc.

[11] "Balancing the 'Energy Trilemma,'" *World Energy Council*, 2015, https://www.worldenergy.org/wp-content/uploads/2015/11/Trilemma-what-is-the-energy-trilemma.jpg.

[12] Ibid.

[13] Ibid.

the interaction among these axes, it becomes obvious that progress cannot be made on all three dimensions simultaneously. After all, any action in one dimension is bound to have adverse effects on another. For instance, expanding solar energy might prove useful for enhancing energy security and environmental sustainability axes, but investment in photovoltaic panels and necessary infrastructure would make energy less affordable.[14]

The competing nature of energy security, energy equity, and environmental sustainability are readily observable in the representation of Jordan's energy landscape in Figure 1. On one hand, Jordan's energy equity axis has held fairly strong ratings since World Energy Council scoring began in 2011. This reflects each Jordanians' ample access to reasonably affordable energy supplies when compared to other countries throughout the world. On the other hand, Jordan's energy security and environmental sustainability were rated rather poorly when scoring started. By 2015, Jordan gained ground in environmental sustainability relative to the rest of the world, advancing to ninetieth from one hundred-twelfth in 2011.[15] Yet, the country sacrificed ground in its relative energy security and energy equity. The affordability and access represented in the energy equity measure weakened from the fifty-fifth spot to the sixtieth between 2011 and 2015.[16] Moreover, the kingdom's ranking in the energy security dimension dropped from one hundred-seventh to one hundred-thirteenth from 2011 to 2015.[17] The key takeaway here is that Jordan's energy security, along with its energy equity, suffered at the cost of improving the environment.[18]

[14] Robert Looney, email message to author, December 4, 2015.

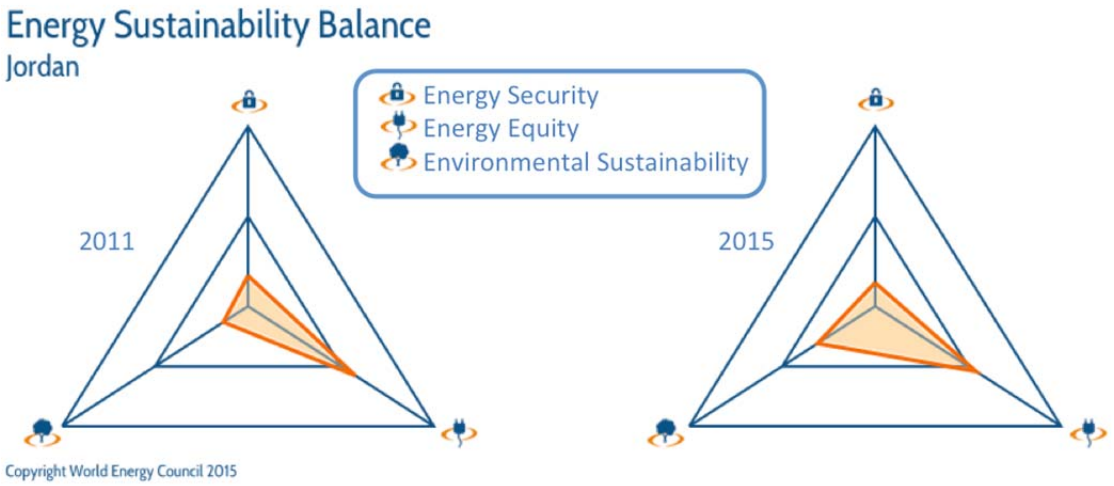
[15] "Energy Trilemma Index: Jordan," *World Energy Council*, 2015, https://www.worldenergy.org/data/trilemma-index/country/jordan/.

[16] Ibid.

[17] Ibid.

[18] Ibid.

Figure 1. Energy Sustainability Balance in Jordan



Adapted from: "Energy Trilemma Index: Jordan," *World Energy Council*, 2015, https://www.worldenergy.org/data/trilemma-index/country/jordan/.

D. LITERATURE REVIEW

Examining Jordan's energy security must, of course, start with the present works covering the crux of the research question: the current policy driving the Jordanian government in its energy pursuits. It seems sensible to start this analysis with the core strategic document outlining Jordan's energy strategy. This document is the Updated Master Strategy of Energy Sector in Jordan for the period 2007–2020, hereafter referred to as the Master Energy Strategy.[19] The completion of this document was undertaken by three subcommittees and overseen by Prince Hamza Ibn Al Hussein to "confront the challenges…which meet the Kingdom's energy needs...in a way that would contribute to improving the level of availability and openness of [the] energy market before investments and achieving…energy supply security."[20] The subcommittees consisted of the following: the oil, electricity, and natural gas sector; the energy conservation and

[19] "Updated Master Strategy of Energy Sector in Jordan for the Period 2007–2020" (Ministry of Energy and Mineral Resources, Hashemite Kingdom of Jordan, December 2007), http://www.memr.gov.jo/Portals/0/energystrategy.pdf.

[20] Ibid., 2.

alternative energy sector—consisting of all non-carbon based energy sources; and the local energy sector.[21]

Throughout the Master Energy Strategy, one can see the relatively high importance placed on hydrocarbons given the obvious dominance of oil and gas recommendation presented by the oil, electricity, and natural gas sector as well as the local energy sector. While such focus seems sensible considering the historical prominence of hydrocarbon fuels, the initial setup of the committees seems to preclude significant consideration of energy sources aside from natural gas or oil. Still, Jordan's strategy seeks limited diversification of its energy as gleaned by its intended shift from its 2007 mix to benchmarks laid out for the years of 2012, 2015, and 2020.[22] Jordan's strategy sought to reduce its oil from 57% in 2007 to 40% in 2020.[23] It seems Jordan intended to use natural gas as a bridge fuel considering it projected a rise in usage from 34% to 43% between 2007 and 2012 before being reduced to 37% in 2015, and 29% in 2020.[24] Jordan foresees the share of imported electricity continuously dropping from 8% in 2007 to only 1% in 2020.[25] To make up for reductions in other areas, Jordan projected shale oil to contribute 7% of total energy by 2015 and 14% by 2020.[26] The Master Energy Strategy also envisaged a continual increase in renewable energy sources from 1% in 2007 to 10% by 2020.[27] In sum, Jordan expected to reduce its foreign dependency from 96% in 2007 to just 75% in 2020. Although, these figures must be considered in the context of the documents further projections that Jordan's energy growth will progress at a modest 6.2% from 2007 to 2020.[28] The document's benchmarks show that Jordan intends to seek greater energy independence from foreign markets, but exploitation of shale oil reserves will create a net increase in the share of carbon-based fuels expected in

[21] Ibid.

[22] Ibid., 7.

[23] Ibid.

[24] Ibid.

[25] Ibid.

[26] Ibid.

[27] Ibid.

[28] Ibid., 8.

the future energy mix. Thus, Jordan seeks a minimal diversification among its types of energies and hopes to experience a greater overarching share of domestic production.

There is support for continuing heavy reliance on oil and natural gas, especially considering the revolution in unconventional extraction methods that has made utilization of shale oil and shale gas a reality. For instance, a 2013 article by David Schenker and Simon Henderson of the Washington Institute for Near East Policy discussed Jordan's plans to build a pipeline from Basra to the Port of Aqaba, revitalizing an oil pipeline from Saudi Arabia, tapping Iraqi and Qatari natural gas, and seeking a natural gas deal with Israel.[29] Sultan Barakat and Andrew Leber of the Brookings Institution see domestic extraction of oil shale as more preferential for the kingdom's internal political stability than foreign gas deals, especially one with Israel.[30] While these examples are proponents of Jordan's policies to continue heavy use of natural gas and petroleum products, there are some who see other options as being more viable.[31]

Adoption of nuclear power is hotly disputed issue both within Jordanian domestic politics and within the international community. The Jordanian Atomic Energy commission sees many boons of atomic energy, including: reduction in dependency on hydrocarbons, more affordable electricity, greater consistency of supply, prevalence of available domestic uranium reserves, potential for export of uranium, and creation of jobs in multiple related industries.[32] Of course, the commission also admits that there are major challenges like financial support, waste management, human resource development, and uranium extraction.[33] Given the high regularity of nuclear power,

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[29] Simon Henderson and David Schenker, "Eastern Mediterranean Natural Gas and Jordan's Energy Options," *The Washington Institute for Near East Policy*, March 11, 2013, http://www.washingtoninstitute.org/policy-analysis/view/eastern-mediterranean-natural-gas-and-jordans-energy-options.

[30] Sultan Barakat and Andrew Leber, "Fortress Jordan: Putting the Money to Work," Policy Briefing (Doha: Brookings Institution, February 2015), http://www.brookings.edu/~/media/Research/Files/Papers/2015/02/03-jordan-barakat-leber/Fortress-Jordan-English.pdf?la=en.

[31] Ibid.

[32] "Benefits for Jordan," *Jordan Atomic Energy Commission*, 2011, http://www.jaec.gov.jo/WhyNuclear/BenefitsForJordan.aspx.

[33] "Challenges," *Jordan Atomic Energy Commission*, 2011, http://www.jaec.gov.jo/JordanNuclearProgram/Challenges.aspx.

Jordan sees it as a means of providing an electricity base load to support greater economic development and desalinization—leveraging energy against the shortage of free enterprise and freshwater. [34]

There are several sources of opposition overlooked by the Jordanian Atomic Energy commission, which have been brought up by in a separate product by David Schenker and Simon Henderson.[35] Internationally, the pair highlights the vocal political opposition from both the United States and Israel. Domestically, its seems the high cost of the two proposed plants, potential for terrorist threats, environmental concerns, and safety concerns are among the major sticking points. Jordanians have conducted planned demonstrations against the proposed nuclear plants and parliament had previously suspended progress on the plants in 2012.[36]

Nicolas Seeley agrees that nuclear energy has the potential to help Jordan overcome some of its water and energy problems, but goes into further detail on the country's domestic political rhetoric.[37] He presents views from the Jordan Friends of the Environment organization, which argue that published budgetary estimates overlook insurance, loan interest, nuclear waste disposal, and the financial burden of mothballing plants in later years. Seeley highlights views from Jordanian parliamentarians, 'Atif Kawwar, Jamal Gammoh, and Hind al-Fayiz, who do not think nuclear power is right for Jordan. Kawwar thinks that oil shale, natural gas, and renewables would provide more immediate, cost-effective answers to Jordan's energy needs, but the nuclear lobby is keeping them from happening. Seeley also presents history of dissent within Jordan Atomic Energy Commission between the current chairman, Khalid Toukan, and former commissioners of the nuclear fuel cycle and site selection. Originally charged with leading examination of the exploitability of domestic uranium reserves for the atomic fuel

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[34] "Benefits for Jordan."

[35] Simon Henderson and David Schenker, "Jordan's Energy Balancing Act," *The Washington Institute for Near East Policy*, March 12, 2014, http://www.washingtoninstitute.org/policy-analysis/view/jordans-energy-balancing-act.

[36] Ibid.

[37] Nicholas Seeley, "The Battle Over Nuclear Jordan," *Middle East Report*, MER 271 - Fuel and Water, 44, no. Summer 2014 (2014), http://www.merip.org/mer/mer271/battle-over-nuclear-jordan?ip_login_no_cache=ff712a360bb8af567f1e32d613050536.

cycle, Nidal Xoubi voiced concern that concentration of the element within core samples was not high enough for economical extraction. This claim was supported when French company Areva abandoned its mining and plant construction agreements after measuring low concentration of uranium within geological samples. The former commissioner of site management, Kamal Khudayr, left in disgust over plans to move the proposed nuclear plants location from the Gulf of ʻAqaba to Qusayr ʻAmr. Seeley also points out the apparent permissiveness between the Jordan Atomic Energy Commission and the Jordan Nuclear Regulatory Commission considering that Majd Hawwari, the newest director of the regulatory commission, is the brother of one of the top five officials in the Jordan Atomic Energy Commission.[38]

One of the most drastic propositions for changing Jordan's energy policies—particularly with regard to shifting toward renewables—is that embodied in Greenpeace's report entitled *Jordan's Future Energy*.[39] Greenpeace argues that Jordan could achieve full energy independence by 2050 through exploiting wind and solar energy alone.[40] Moreover, the report touts Jordan's technical wind and solar potential as being in excess of 60 times projected energy demands through 2050.[41] Greenpeace argues this shift to renewable sources of energy has the potential to save approximately $12 billion and create 30,000 much-needed jobs to help deal with the country's burgeoning youth population and recent influx of refugees.[42] The crux of this vision lies in realization of technical advances and related cost efficiencies that have not yet been realized. To achieve this hypothetical renewable revolution, Greenpeace advocates the gradual transition away from using hydrocarbons as fuel and refutes both the cost efficiency and operational effectiveness touted by nuclear proponents.[43] Greenpeace cites the potential discontinuation of gas supplies from Egypt, increasing cost of hydrocarbon electricity

[38] Seeley, "Battle Over Nuclear."

[39] "Jordan's Future Energy" (Greenpeace Mediterranean, 2013), 1, http://www.greenpeace.org/arabic/PageFiles/481146/Jordan_Report2013.pdf.

[40] Ibid.

[41] Ibid., 2.

[42] Ibid., 1.

[43] Ibid., 2.

production, national debt, uncertainty regarding domestic shale development, renewable grid parity, and likely parity with discounted natural gas-based generation between 2020 and 2050.[44]

A more balanced approach to renewables is embodied within the report titled Sustainable Energy Mix and Policy for Jordan, which was a joint venture between the Jordanian Royal Scientific Society and the German Freidrich-Ebert-Stiftung.[45] The document calls for thinking about energy beyond its simple role as a commodity to integrate planning of renewables, improve economic efficiency, improve human resources, seek new means to apply renewables, recommend policy for transition to renewable energy, and promote public consciousness on the potential for renewables.[46] As a call to shift toward renewables, the report highlights the drastic shifts in energy prices in the wake of the Arab Spring, the economic impact of supply disruption from Egypt, and the associated costs of switching to liquid fuels. Jordan's efforts to use domestic shale oil, develop nuclear power, expand the role of renewables, and improve energy efficiency are all lauded as best practices.[47] The report generally supports Jordan's overarching strategy to bridge toward renewables by diversifying into all areas of energy sources and supplies, but presses renewable energy as an ultimate and necessary end state.

The Royal Scientific Society and Friedrich-Ebert-Stiftung also identify several important challenges that were not identified or addressed within Jordan's Master Energy Strategy.[48] First, is the lack of adequate legislation to encourage renewable energy

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[44] "Jordan's Future Energy," 3–13.

[45] "Vision, Mission and Values," Royal Scientific Society, 2015, http://www.rss.jo/about-us/vision; "About Us," Friedrich Ebert Stiftung, 2015, http://www.fesdc.org/about-us.html. The Royal Scientific Society is headquartered in Amman, Jordan with the mission "to build and strengthen scientific and engineering research in the areas of greatest strategic value to Jordan's long-term competitiveness and development." Headquartered in Bonn, Germany, Friedrich-Ebert-Stiftung is " a non-profit German political foundation committed to the advancement of public policy issues in the spirit of the basic values of social democracy through education, research, and international cooperation.

[46] Mo'tasem Nayef Saeedan, ed., "Sustainable Energy Mix and Policy Framework for Jordan" (Amman: Royal Scientific Society and Friedrich-Ebert-Stiftung, 2011), XVII, http://library.fes.de/pdf-files/bueros/amman/08883.pdf.

[47] Ibid., 2.

[48] Ibid., 2.; "Master Energy Plan."

development, including: lack of energy efficiency laws, lack of adequate private investment incentives, limited availability of finances for small projects within the domestic economy, and the relatively high price of renewable energy production.[49] Financing is also highlighted as a major problem for developing a civil nuclear program—as is Jordan's shortage of water, nuclear waste management, human resources development, speculation on the quantity of domestic uranium reserves, and political opposition.[50] While providing support that Jordanian shale oil reserves are high, the report concedes the difficulty in accurately assessing reserve quantities, high use of scarce water resources, multiple environmental hazards of extraction, byproduct disposal, and high extraction and refinement costs as issues that would need to be overcome. [51]

Several more see a balanced and diversified use of Jordan's domestic energy resources as being the road to great security and energy independence. The Oxford Business Group contends that combining domestic renewable energy, shale reserves, and natural gas in place of vast hydrocarbon imports is the only way to overcome the significant challenges facing Jordan's water and energy shortage.[52] Also acknowledging the importance of mixed resources, analysis by the World Bank concludes that the most important moves for Jordan's energy security are in the areas of energy sector privatization, diversification, and price stability.[53] The International Monetary Fund's Andrea Gamba provides projections suggesting the macroeconomic impact of diversification into varied energy sources—including liquefied natural gas imports through the Gulf of Aqaba, solar, wind, domestic oil shale, and nuclear production—would be a boon for Jordan's economy, but that the attractiveness for switching to these

[49] Saeedan, "Sustainable Energy Mix," 42.

[50] Ibid., 51–60.

[51] Ibid., 87.

[52] "Into the Limelight: Reducing Energy Dependence by Tapping into Oil Shale Reserves," *Oxford Business Group*, accessed June 4, 2015, http://www.oxfordbusinessgroup.com/overview/limelight-reducing-energy-dependence-tapping-oil-shale-reserves.

[53] "Jordan—Strategic Options for Energy Sector Development : A Policy Note" (The World Bank, May 31, 2005), 36, http://documents.worldbank.org/curated/en/2005/05/6644224/jordan-strategic-options-energy-sector-development-policy-note.

sources depends largely on the cost of crude oil.[54] Last, but not least, Daniel Yergin's *The Quest* highlights energy diversification as the simplest means of mitigating energy insecurity.[55] This is because diversification limits the effects of disruption from a given source by offering multiple alternative energy options within the market.[56] It seems the more diverse Jordan's energy portfolio is, the more secure its energy will be.

E. POTENTIAL EXPLANATIONS AND HYPOTHESES

Three essential issues must be considered to address the research question: first, the current energy policy of Jordan; second, determining whether the kingdom's current policy toward energy will adequately address its energy issues; and third, to make suggestions for any changes in Jordanian or U.S. policy that could help the country achieve greater energy security.

It is first important to establish Jordan's collective energy strategy as it stands today. At an overarching level, it seems that Jordan's written policy could be easily ascertained in the Hashemite Kingdom of Jordan's energy strategy document. Since the most recent version of this document was published in 2007, I propose that there are practical deviations from policies as outlined in this document. I further theorize that any deviations were made in reaction to the multiple challenges Jordan has faced both economically and politically. Taking Jordan's core policy document at face value leaves potential for the researcher to overlook the current policies and legislation being enacted to further the nation's energy security. By overlooking policy changes and legislation which has occurred since 2007, one could easily miss any changes made in the wake of political turmoil associated with the Arab Spring movement, rise of the Islamic State, and the related influx of refugees as well as changes made to address related and unrelated economic shifts like the shale revolution in oil and gas production, the fall of petroleum

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[54] Andrea Gamba, "New Energy Sources for Jordan: Macroeconomic Impact and Policy Considerations," IMF Working Paper, Working Paper No. 15/115 (Middle East and Central Asia Department, International Monetary Fund, May 2015), 5–17, http://www.imf.org/external/pubs/ft/wp/2015/wp15115.pdf.

[55] Daniel Yergin, *The Quest: Energy, Security, and the Remaking of the Modern World* (New York: Penguin, 2011), 416.

[56] Ibid., 275.

prices, and technological advances affecting the development of alternative energy sources.

The second issue hinges largely on the first issues ability to correctly identify Jordan's current energy policies. From there, research must objectively determine whether Jordan's current energy policies and practices are meeting the current needs of the population and whether planned provisions provide an appropriate means to address the countries needs going into the future. My hypothesis is that Amman's current measures will not adequately address the challenges facing the kingdom. Of course, this determination will not be binary and must express the degree to which Jordan's policy does or does not meet the challenges to gain greater energy security. I base this thought on the kingdom's heavy historical reliance on energy imports, a heavy dependence on hydrocarbons, and an apparent lack of action to change the status quo. Jordan lacks the capacity to supply enough oil and gas to fuel its economy with the limited domestic hydrocarbon resources on hand. Conventional wisdom dictates that having such a high dependence on gas and oil without large reserves will leave Jordan without the ability to deal with exogenous shocks to energy markets and could leave Jordan in a grave situation. While economic interdependence is generally viewed as a positive characteristic in the liberal school of international relations theory, such outright dependency leaves Jordan in a weakened political and economic state. This dependency opens Jordan up to the use of energy as a weapon, making the regime vulnerable to the whims of its foreign suppliers. Moreover, the inability to provide affordable and reliable domestic energy could create domestic turmoil and political upheaval jeopardizing the legitimacy and control of the Hashemite regime. Each of these outcomes creates a difficult situation for the U.S. and its interests in the region.

The final issue rises out of the context of the second. Whether Jordan is deemed as having taken appropriate measures to address its energy dilemma, I hypothesize that there are a number of areas of improvement that can be taken as points for constructing future Jordanian policies toward energy and U.S. policies toward Jordan. Jordan's extreme dependency on foreign energy imports coupled with its growing population and influx of refugees call the King's government to take action. Long dependent on foreign

aid and assistance from both the United States and neighboring countries, I further propose that Jordan can yet use domestic energy production as a means to further develop its economy. I also hypothesized that there are opportunities for Jordan to diversify its energy portfolio, which have not been adequately explored by the government in Amman. Building a more robust and independent economy is important for dealing with Jordan's high youth population, influx of refugees, and the prevalence of brain drain plaguing its society.

F. RESEARCH DESIGN

To answer the research question, this thesis seeks to accomplish three main goals: first, to identify both the stated and actual energy strategy and policy of the Hashemite Kingdom of Jordan; second, to evaluate whether Jordan's policies are appropriate for achieving energy security; and third, to suggest potential policy and actions for enhancing Jordanian energy security.

First, the thesis will use various means to identify Jordan's energy policy and strategy. The most obvious means of identifying Jordan's energy strategy is through review and synthesis of core strategic documents and legislation like those from the Jordanian Ministry of Energy and Mineral Resources. While written expression of the government's will provides base information on its public intent, it does not necessarily provide the whole picture. Thus, identifying Jordan's unstated policies and willingness to take action must be gleaned through the use of scholarly journals and reports like those offered from the Middle East Journal and the Brookings Institute.

In addressing the second and third goals, the effectiveness of Jordan's stated policies must be determined and any areas for potential improvement should be identified. To this end, the strengths, weaknesses, opportunities, and threats to Jordan's energy security will be examined as a single case study. Each of the major schools of thought regarding Jordan's energy posture and outlook will be considered. In the analysis, these categories will be applied to identify the individual characteristics and relative viability of the three overarching categories of energy currently available to Jordan: hydrocarbons, nuclear, and renewables. In each category, Jordan's explicitly

stated policies and legislation will be brought to light and considered with regard to the economic costs and political implications each type of energy presents for the country. Considering these outcomes can shed light on those policies that will be most beneficial for Jordan and those that will not. Consequently, conclusions may be drawn regarding how U.S. foreign policy toward Jordan and the Middle East should be postured to best support Jordan's energy security and other U.S. interests in the region. The base information for these conclusions will be drawn primarily from scholarly research from groups like the Washington Institute, analysis by organizations like the International Energy Association or private firms like Bloomberg, and information published in news or journals like the New York Times and Foreign Policy.

The study will not include an in-depth discussion of Jordan's energy policies compared to neighboring countries nor will it include a vast amount of detail on other sectors of the Jordanian economy. What will be established within the analysis is that Jordan lacks the natural resources that have been a boon to its neighbors. What will be assumed is that regional unrest combined with adversarial relationships will continue to permeate the politics of the Middle East leaving Jordan in a position where it must seek independent solutions to its domestic issues. While some countries—like the U.S. or Saudi Arabia—might influence Jordan's policies, the assumption is that no benevolent outside actor is going to have the available surplus of resources to solve Jordan's energy problems on its behalf.

G. THESIS OVERVIEW

This chapter provided general background and varying views on aspects of Jordan's energy sector. Chapter II of the thesis analyzes hydrocarbons in Jordan, along with the potential for both domestic and international expansion in the sector. Chapter III discusses the potential of nuclear energy along with the multiple technical and political challenges facing Jordan's Atomic Energy Commission. In Chapter IV, there is dialogue on the potential for renewable resources in Jordan. Chapters II, III, and IV consider the strengths, weaknesses, opportunities, and threats embodied within each potential source of energy. In Chapter V, I link each of the previous chapters to determine the

effectiveness of Jordan's government in seeking energy security while suggesting policy recommendations to further secure Jordan's energy sector.

II. HYDROCARBONS

A. OVERVIEW

Historically, Jordan based a large amount of its energy mix on the employment of carbon-based fuels from abroad. Even in recent years, oil and natural gas made up the majority of the energy mix—accounting for as much as 98% of total energy supply.[57] Still, the overwhelming share of foreign hydrocarbons are imported into the kingdom at a cost of nearly 20% of Jordan's gross domestic product.[58] Most of this recent energy supply was derived from Egyptian natural gas and Saudi Arabian oil.[59] These hydrocarbons kept the Jordanian economy afloat, but with significant internal and external costs. Not having ample or abundant access to domestic energy sources, Jordan's use of hydrocarbon energy sources were often discounted by the graces of fellow Arab foreign nations like Saddam Hussein's Iraq and Hosni Mubarak's Egypt.[60] These discounts created an unhealthy energy market that stifled domestic economic growth both inside and outside the sector. At times, Jordan's heavy reliance on fossil fuel derivatives have left its government indebted from trying to stave off oil market shocks with fuel subsidies meant to keep fuels at prices amenable for private and commercial use by Jordanian citizenry and businesses. To avoid future shocks, Jordan's Master Energy Plan calls for expansion of domestic oil and natural gas production by appealing to foreign investors to undertake exploration and exploitation of the few hydrocarbon resources within the country.[61] Throughout this section, I contend the Hashemite Kingdom of Jordan needs to diversify its sources of fossil fuels and limit their overall contribution to

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[57] "Jordan: Share of Total Primary Energy Supply in 2013," *International Energy Agency*, 2013, http://www.iea.org/stats/WebGraphs/JORDAN4.pdf.

[58] Hartoqa, "Renewable Energy Market," 1.

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

[60] Sofie Cohen, "Jordan's Water and Energy Security Crises," *Jane's Intelligence Review*, December 23, 2014, sec. RESOURCE WATCH, https://janes.ihs.com/CustomPages/Janes/DisplayPage.aspx?ShowProductLink=true&DocType=News&ItemId=+++1732068.

[61] "Master Energy Plan," 23.

its future energy mix. I come to this conclusion based on the lack of progress and limited potential in efforts for domestic expansion. Augmenting this argument is the historical costs of relying on foreign hydrocarbons. These costs are readily apparent when considering the favorable and unfavorable attributes surrounding Jordan's main sources of energy—petroleum and natural gas. Since solid hydrocarbons—like coal and lignite—have not been significant sources of energy within the Jordanian mix they will not be discussed within this thesis.

B. AMBITIONS

First, one must fully consider Jordan's ambitions with regard to hydrocarbons. Jordan expected to reduce the share of its reliance on oil products from 57% in 2007 to 47% in both 2015 and 2020.[62] The Ministry of Energy and Mineral Resources also recommended large investments in downstream oil operations for expanding Jordan's single oil refinery—both increase its capacity and improve product quality. The ministry also called for the refinery company to seek corporate partnership to speed this expansion—which included construction of an oil pipeline from the port at Aqaba to the Zarqa refinery. Other proposed measures included liberalization of oil and fuel markets, improving the competitive environment by ending concessions, implementing anti-trust measures, and increasing storage capacity to expand the national strategic reserve.[63]

With regard to oil shale, the administration hoped domestic shale deposits could be exploited for both oil extraction and electricity generation to crowd out foreign energy sources—with contribution rising from nil in 2007 to cover 7% of the total primary demand for energy by 2015 and 11% by 2020.[64] From a research perspective, Jordan's energy administrators encouraged completion of feasibility studies that were still underway in 2007, accomplishment of further studies to determine the effect of oil shale utilization on the environment, and establishment of a special oil shale unit to carry out these and other related studies. From an operational perspective, the ministry sought to

[62] Ibid., 15.

[63] Ibid., 16–17.

[64] Ibid., 15.

halt concession negotiations with Royal Dutch Shell and focus on agreements for an Estonian entity to build, own, and operate a 600 to 900 megawatt oil shale electricity generation plant by the end of 2015.[65]

On the other hand, Jordan's bureaucrats saw the use of natural gas rising slightly and falling as the country bridged to other energy sources. Natural gas was to rise slightly from 34% in 2007 to 37% in 2015 before dropping to just 33% in 2020.[66] Toward this end, administrators predicted that the country could rely on steady gas supplies from Egypt through the Arab Gas Pipeline and that the Risha Gas field would increase domestic natural gas extraction to some 340 million cubic feet per day. As far as imports were concerned, ministry personnel sought to expand the influx of natural gas from Egypt in the near term and were to seek out alternate sources from other nearby countries. As for domestic natural gas, bureaucrats recommended the administration seek an agreement with a private entity to develop the aforementioned Risha gas field.[67]

C. PETROLEUM

Despite being relatively resource poor, Jordan has long relied on oil to fuel its economy. Since its independence in 1946, this liquid hydrocarbon made up the majority of the nation's energy sources—accounting for over 89% of total primary energy supply as late as 2012.[68] Use of oil-based fuels has persisted for a multitude of reasons. Primarily, the state's geographical placement among oil-rich countries has made petroleum products easily accessible for the Jordanian market. As of the end of 2014, neighboring Saudi Arabia held over 266 billion barrels of crude oil reserves while neighboring Iraq held in excess of 143 billion barrels.[69] Together, these immediate neighbors hold over 27%of the world's proven oil reserves while the Middle East region

[65] Ibid., 20.

[66] Ibid., 15.

[67] Ibid., 19–20.

[68] "Primary Energy Supply."

[69] "OPEC Share of World Crude Oil Reserves, 2014," *Organization of the Petroleum Exporting Countries*, 2015, http://www.opec.org/opec_web/en/data_graphs/330.htm.

as a whole hold's over 48%—the equivalent of 803 billion barrels of crude.[70] As of 2014, Jordan was ranked ninety-eighth in proven oil reserves with an estimated one million barrels.[71]

Jordan, itself, has limited oil production. Discovered in 1984, the Hamzah Oil Field makes up nearly all of the countries petroleum extraction efforts. In recent years, the Hamzah Field produced between 20,000 and 25,000 barrels per day.[72] This figure is only a fraction of the country's daily consumption of petroleum products—estimated to be 122,700 barrels per day.[73] The few petroleum product exports from Jordan are primarily refined by-products of oil extracted in other countries—mainly Saudi Arabia and Iraq. [74] In an effort to enhance its conventional oil extraction, Jordan has enlisted the Transeuro Energy Corporation of Canada to further develop the Hamzah Oil Field.[75] Regrettably, lengthy review and approval process by the Jordanian government has kept the Canadian company from making any notable improvements upon the oil field's existing production levels.

D. SHALE

High world energy prices and a history of energy supply shocks due to regional violence and political strife pressed Jordan to seek more domestic solutions for its petroleum needs. The rise of shale oil extraction raised hopes that Jordan could leverage its underlying shale reserves to help meet future energy demands—spurring notions to build a shale oil power plant. [76] Some even suggested the country might become the next

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[70] "International Energy Statistics," *Energy Information Administration*, 2015, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=57&aid=6&cid=regions&syid=2010&eyid=2014&unit=BB.

[71] "Jordan," *The World Factbook, Central Intelligence Agency*, accessed May 28, 2015, https://www.cia.gov/library/publications/the-world-factbook/geos/print_jo.html.

[72] Mohammad Ghazal, "Canadian Company to Study Developing Hamzah Oil Field," *Jordan Times*, December 8, 2014, http://www.jordantimes.com/news/local/canadian-company-study-developing-hamzah-oil-field.

[73] "Jordan."

[74] Yanal Abul Failat, "The Oil and Gas Sector in Jordan-An Overview," *Oil, Gas & Energy Law Intelligence* 11, no. 3 (2013): 2, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2317168.

[75] Ghazal, "Canadian Company to Study Developing Hamzah Oil Field."

[76] Galbraith, "Jordan Finds Energy Sources in Unlikely Places."

Estonia—a country that generates 90% of its power from oil shale.[77] The high abundance of oil shale deposits within the kingdom attracted interest from companies like Jordan Oil Shale Energy Company—a joint venture between Estonian, Jordanian and Malaysian firms—and Jordan Oil Shale Company—a subsidiary of Shell Global.[78] After all, Jordan possesses upwards of 70 billion tonnes of oil shale.[79] According to its 2007 energy strategy document, Jordan had hoped oil shale would make up 7% of its total energy mix by 2015 through both electricity production and petroleum extraction, but has yet to reap any practical energy from these tight oil deposits.[80] With the high cost of petroleum up to 2014, these oil shale offered many hopes—having enough margin for profit to be commercially viable on the international market. Though, the drop in oil prices in late 2014 and the high likelihood of Iranian oil hitting a larger cross-section of the world market after the lift of economic sanctions do not bode well for shale developments in Jordan. Despite the administrations best hopes and continued endeavors, the sustained drop in international petroleum prices makes development of domestic shale oil resources more troubling and less attractive to foreign companies needed for development and investment.

E. OIL INFRASTRUCTURE

The kingdom's high reliance on the Jordan Petroleum Refinery Company and its refining capacity make it a critical node—and thus another point of weakness—in Jordan's energy security. After all, the remainder of Jordan's petroleum sector remains largely monopolized by this company. This includes producing, refining, and distributing the full spectrum of petroleum products, including fuels, lubricants, hydraulic fluids, and other petroleum derivatives.[81] The Jordan Petroleum Refinery Company owns and

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[77] "Jordan's Oil Shale: Savior or Imposter?," *Jordan Business*, May 2014, http://www.jordanbusinessmagazine.com/cover_story/jordan%E2%80%99s-oil-shale-savior-or-imposter.

[78] "Into the Limelight"; Mohammad Ghazal, "Shale Oil-Fuelled Power Plant to Be Ready Late 2018," *Jordan Times*, October 1, 2014, http://www.jordantimes.com/news/local/shale-oil-fuelled-power-plant-be-ready-late-2018.

[79] Ghazal, "Shale Power Plant 2018."

[80] "Master Energy Plan," 7; "Savior or Imposter."

[81] "Company Overview of Jordan Petroleum Refinery Company Ltd.," *Bloomberg Business*, n.d., http://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=5482316.

operates a single refinery in Al Zarqa, which lies approximately 22 miles northeast of Amman. Through this refinery, Jordan is capable of refining 107,000 barrels of crude per day.[82] To date, the company has the nation's only refining capacity having held a concessionary contract for a 50-year period up to 2008. An empirical analysis conducted by scholars from the University of Jordan and Yarmouk University indicates this refining entity held a natural monopoly from 1961 to 2010—the entire span of available data when the study was conducted in 2012. Given the status as a natural monopoly the market structure could be considered efficient from a cost perspective, but may still be inefficient from the perspective of consumers. Thus, Jordan needs to take action to regulate the market so that both producer and consumer surplus are maximized. Unfortunately, Jordan seems to be forcefully liberalizing the market by making the Jordan petroleum Refinery Company create a subsidiary petroleum products distribution company to allow entrance of competitive distributors.[83]

The lack of operational oil transportation infrastructure is also a weakness. With the prevalence of nearby oil supplies one would think transportation of petroleum products would be easy and cost effective via pipelines, but Jordan had not been able to effectively leverage such infrastructure to tap into supplies from its hydrocarbon-rich neighbors. Rather, much of the transportation infrastructure between Jordan and major oil-exporting countries is dilapidated and in a state of disrepair. Historically, much of Jordan's oil was imported via the Mosul-Haifa Oil Pipeline and the Trans-Arabian Pipeline. The Mosul-Haifa Pipeline begins in Kirkuk extending south and westward across Iraq's Anbar province before entering Jordanian territory where it loosely shadows Jordan's northern border with Syria before crossing into Israeli territory where it concludes at the port city of Haifa. Construction on this pipeline was completed under British supervision in 1934, but operation ceased during the outbreak of the Arab-Israeli

[82] Failat, "The Oil and Gas Sector in Jordan-An Overview," 6.

[83] Taleb M. Awad Warrad and Sameh A. Ajlouni, "Is Jordan Petroleum Refinery Company a Natural Monopoly?," *Journal of Applied Economics & Business Research* 2, no. 4 (2012): 184–185, http://www.researchgate.net/profile/Sameh_Ajlouni/publication/234025182_Is_Jordan_Petroleum_Refinery_Company_a_Natural_Monopoly/links/02bfe50e59ee61a353000000.pdf.

War in 1948.[84] The Trans-Arabian Pipeline, commonly referred to as the Tapline, was initially operational in 1950 with a former capacity of three million barrels per day.[85] Depicted in Figure 2, the Tapline runs from Al-Dammamm, Saudi Arabia on the Persian Gulf crossing Jordan northeast of Amman before crossing Syria and Lebanon where it concludes at the Mediterranean Coast in Sidon. Throughout the Tapline's operation, it was plagued by various conflicts between Arab states and Israel. Often being the subject of sabotage, the pipeline's use was largely ceded throughout these conflicts. Use came to a decisive end in 1990 when the Saudis cut off supplies to the Zarqa oil refinery due to Jordan's failure to impose economic sanctions against Saddam Hussein's Iraqi regime leading up to first Gulf War.[86] Since these pipelines' closure, the lack of regular maintenance has left both lines dilapidated and need of major refurbishments to resume transportation of petroleum products. Yet, there has been some consideration to renew pipeline shipments since these antiquated lines could permit a projected 40% cost savings as an alternative to the current practice of trucking petroleum products overland or transiting tankers around the Arabian Peninsula.[87]

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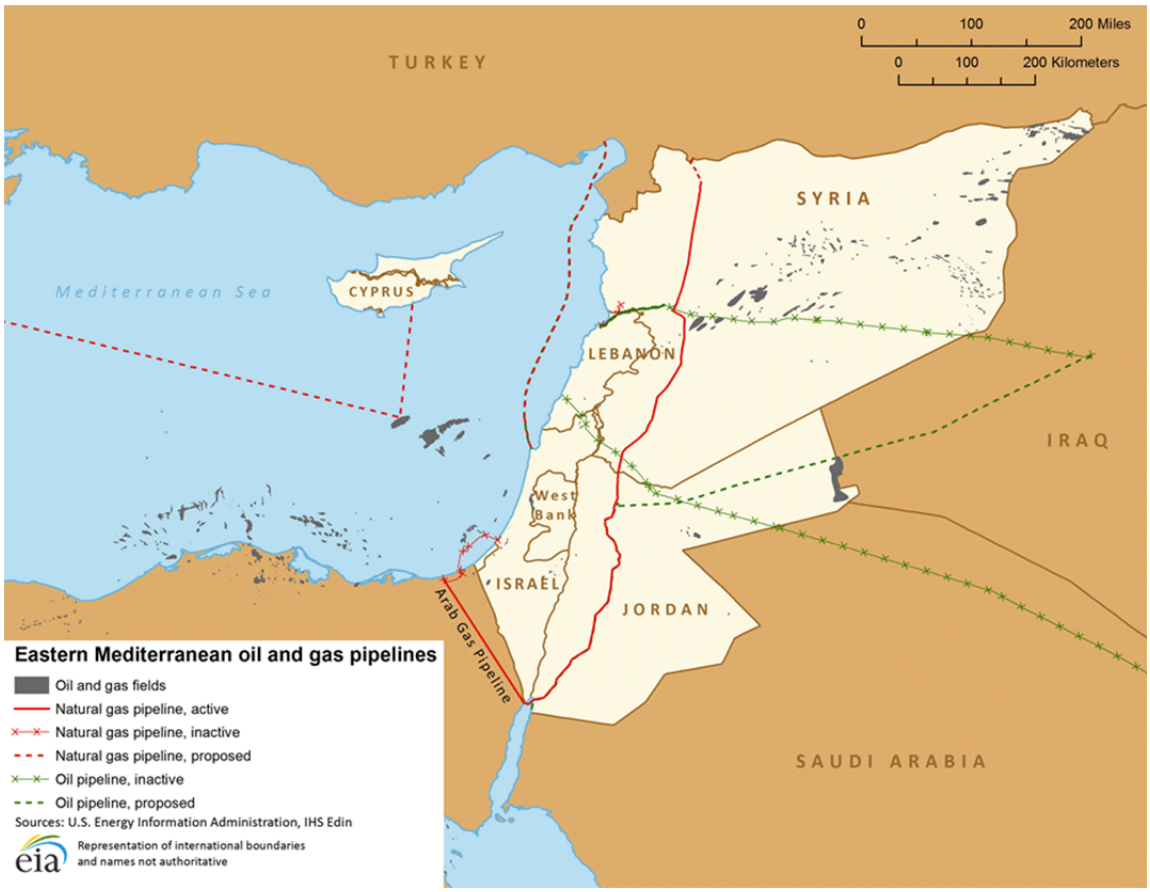
[84] J.H. Bamberg and Ronald W. Ferrier, *The History of the British Petroleum Company*, vol. 2 The Anglo-Iranian Years, 1928–54 (Cambridge, UK: Cambridge University Press, 2010), 164–165; Amiram Cohen, "U.S. Checking Possibility of Pumping Oil From Northern Iraq to Haifa, via Jordan," *Haaretz*, August 25, 2003, http://www.haaretz.com/print-edition/news/u-s-checking-possibility-of-pumping-oil-from-northern-iraq-to-haifa-via-jordan-1.98134.1st-History of the British Petroleum Company p. 164–165

[85] "Trans-Arabian Pipeline | Pipeline, Arabia," *Encyclopedia Britannica*, accessed October 1, 2015, http://www.britannica.com/topic/Trans-Arabian-Pipeline.Encyclopedia Britannica, Trans-Arabian Pipeline

[86] "Economy, Jordan," Regional Surveys of the World, Middle East and North Africa (London: Europa Publications, October 30, 2003), 648, https://books.google.com/books?id=pP315Mw3S9EC&pg=PA648&lpg=PA648&dq=1990+jordan+saudi+arabia+iraq+trans+arabian+pipeline&source=bl&ots=_5enf5huYO&sig=KPUh8q8NiimUWpnL4Qrwfn9H8ME&hl=en&sa=X&ved=0CCkQ6AEwA2oVChMI0IPp8amgyAIVwi-ICh00Rg8i#v=onepage&q=1990%20jordan%20saudi%20arabia%20iraq%20trans%20arabian%20pipeline&f=false.

[87] Anthony H. Cordesman, *Energy Developments in the Middle East* (Westport, CT: Praeger Publishers, 2004), 230, https://books.google.com/books?id=av58rg5oaugC&printsec=frontcover&dq=energy+developments+in+the+middle+east&hl=en&sa=X&ved=0ahUKEwitsqq_27bJAhUIPogKHc4CCHgQ6AEIHTAA#v=onepage&q=energy%20developments%20in%20the%20middle%20east&f=false.

Figure 2. Eastern Mediterranean Energy Infrastructure



The green line with crisscrosses entering Jordan from Saudi Arabia and extending through Syria and Israel to Lebanon depicts the Trans-Arabian Pipeline, commonly known as the Tapline. The proposed Basra-Aqaba oil and natural gas pipeline is depicted as green dashes. The Arab Gas Pipeline is denoted in solid red. Source: "Overview of Oil and Natural Gas in the Eastern Mediterranean Region," *Energy Information Administration*, August 15, 2013, https://www.eia.gov/beta/international/regions-topics.cfm?RegionTopicID=EM.

Other proposed pipeline projects promise to bring new infrastructure to replace the antiquated lines crossing the Kingdom of Jordan. Jordan's latest energy plan suggested building a pipeline from Aqaba to the Zarqa refinery to enhance supply and help offset long-term transportation costs of trucking from the port.[88] This proposed pipeline has since become part of a larger, $18 billion project agreed upon by the governments in Jordan and Iraq to build a pipeline from the Basra oil fields to the port of

[88] "Master Energy Plan," 9.

Aqaba by 2017. The Basra-Aqaba pipeline is partially represented in Figure 1. This greater pipeline project is supposed to be comprised of parallel lines for liquid and gas products extending over 1,000 miles. The line is anticipated to move one million barrels a day—exports via Aqaba are estimated to provide Jordan $3 billion per year and 150,000 barrels of oil will be diverted for use within the Kingdom. The natural gas line is expected to provide Jordan 100 million cubic feet of natural gas per year lending a means to supplant dwindling natural gas supplies that were previously provided by Egypt.[89] Yet, the onslaught of violence stemming from ISIS has already forced Iraq and Jordan to consider a new route avoiding ISIS threatened territory in Iraq's Al-Anbar province.[90] Needless to say, slow progress on important petroleum infrastructure development has exacerbated Jordan's energy problems.

F. NATURAL GAS

Natural gas has also played a significant role in Jordan's energy market. Following oil, natural gas held the second-largest share of Jordan's energy supply accounting for almost 9% of the total share of energy.[91] As of 2014, Jordan was estimated to have just over six billion cubic meters of natural gas reserves—ranking it eighty-seventh internationally.[92] Like petroleum, natural gas in Jordan is far less abundant than other countries in the region considering Middle East holding over 40% of the world's proven natural gas reserves.[93] At roughly 1,193, 885, and 288 trillion cubic feet, respectively, Iran, Qatar and Saudi Arabia make up the majority of the region's holdings toward the Middle East total of 2,813 trillion cubic feet.[94] Jordan's stated strategy called for the country to increase supplies from Egypt and expand its domestic

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[89] Mohammad Ghazal, "Basra-Aqaba Oil Pipeline Still on Agenda — Hamed," *Jordan Times*, August 5, 2014, http://www.jordantimes.com/news/local/basra-aqaba-oil-pipeline-still-agenda-%E2%80%94-hamed.

[90] "Jordan and Iraq Change Route of Oil Pipeline due to ISIS," *Middle East Monitor - The Latest from the Middle East*, accessed September 28, 2015, https://www.middleeastmonitor.com/news/middle-east/19347-jordan-and-iraq-change-route-of-oil-pipeline-due-to-isis.

[91] "Primary Energy Supply."

[92] "Jordan."

[93] "International Statistics."

[94] Ibid.

production efforts so that natural gas would make up 37% of its total energy share by 2015.[95] Though, current calculations reveal only a 15% share of the market has been achieved—showing the vulnerability of foreign supplies and recent disappointments in domestic exploration efforts. [96] These shortcomings also highlight the limited options for this sector going into the future.

As with oil, Jordan has very limited domestic natural gas production. In 2013, Jordan's estimated natural gas production was just over 7.945 billion cubic feet—approximately 32% of the country's annual natural gas consumption.[97] The Risha Gas Field, discovered in 1987, provides the main source of natural gas derived from within the kingdom.[98] This gas field has averaged 30 million cubic feet since its discovery.[99] Under optimistic notions by the Jordanian government that the field could produce upwards of 330 million cubic feet per day, the country had a concessionary agreement with British Petroleum in which the company was supposed to invest $237 million into development of the field over a four-year period.[100] After expending the funds on testing and the drilling of two exploration wells, the British company opted to withdraw in early 2014—finding test results too poor to develop the Risha Gas Field any further.[101]

G. NATURAL GAS INFRASTRUCTURE

The natural gas infrastructure supplying the kingdom is another vulnerability. Since 2003, Jordan sourced nearly 80% of its natural gas from Egypt via the Arab Natural Gas Pipeline.[102] With the annual capability of transporting over 350 billion cubic feet of

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[95] "Master Energy Plan," 7.

[96] "International Statistics."

[97] "Jordan."

[98] Failat, "The Oil and Gas Sector in Jordan-An Overview," 2.

[99] Ibid.

[100] Suleiman Al-Khalidi, "BP Begins Drilling in Jordan's Risha Gas Field," *Reuters*, June 18, 2012, http://www.reuters.com/article/2012/06/18/us-jordan-gas-drilling-idUSBRE85H0JK20120618.

[101] Summer Said, "BP's Risha Exit Means Slim Pickings for Jordan's Energy Needs," *Wall Street Journal*, January 29, 2014, http://blogs.wsj.com/middleeast/2014/01/29/bps-risha-exit-means-slim-pickings-for-jordans-energy-needs/.

[102] Tareq Baconi, "A Pipeline Against Peace," *Foreign Affairs*, January 26, 2015, https://www.foreignaffairs.com/articles/middle-east/2015–01–26/pipeline-against-peace.

natural gas to Jordan, this pipeline extends overland from Arish across the Sinai to Taba, Egypt on the Red Sea and undersea to the port of Aqaba where the pipeline surfaces and extends overland to the north toward Amman before carrying on to Damascus.[103] In recent years, infrastructure failures due to militant attacks against the Arab Natural Gas Pipeline along sections crossing Egypt's Sinai Peninsula have been a major cause of supply disruption—both threatening the kingdom and showing a critical weakness. Since the Arab Spring movement ousted Hosni Mubarak in 2011, pipelines crossing the Sinai were attacked 27 times.[104] It seems militant-borne disruptions are likely to continue given ISIS-affiliated Egyptian jihadist group Ansar Bayt Al-Maqdis continues to attack the pipeline despite a continuing crackdown against Islamists by Egyptian President Abdel Fattah el-Sisi's administration.[105] Despite Egypt's security efforts, the pipeline has reportedly failed to deliver any natural gas to Jordan since July 2013 leaving the kingdom to rely on the aforementioned import of refined heavy fuel oils at nearly six times the cost of natural gas.[106] Moreover, below-market energy exports, state energy subsidies, and slowed investment in exploration and development in the wake of the 2011 revolution left Jordan with a burgeoning state deficit and growing internal energy demand without sufficient domestic resources.[107] The impact of pipeline attacks and Egypt's rising domestic energy concerns have forced Jordan to seek alternatives to its natural gas imports from the Arab republic.

Overcoming reliance on Egypt and misplaced optimism of domestic expansion, Jordan seeks to diversify its resources by looking to other nations. To this end, Jordan has spent $65 million to refit its port at Aqaba with the necessary infrastructure to import

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[103] "Arab Gas Pipeline," *Arab Republic of Egypt Ministry of Petroleum*, 2010, http://www.petroleum.gov.eg/en/ProjectsandActivities/StrategicProjects/Pages/GasPipeline.aspx.

[104] Agence France-Presse, "Egypt Jihadists Claim Attack on Sinai Pipeline to Jordan," *Mail Online*, January 19, 2015, http://www.dailymail.co.uk/wires/afp/article-2917288/Egypt-jihadists-claim-attack-Sinai-pipeline-Jordan.html.

[105] Ibid.

[106] Mohammad Ghazal, "2018 Will Be Turning Point in Jordan's Energy Sector - Minister," *Bilateral U.S.-Arab Chamber of Commerce*, 2014, http://bilateralchamber.org/2018-will-turning-point-jordans-energy-sector-minister/.

[107] "Egypt: International Energy Data and Analysis," *Energy Information Administration*, June 2, 2015, http://www.eia.gov/beta/international/analysis.cfm?iso=EGY.

ship-laden Liquefied Natural Gas (LNG).[108] The LNG terminal opens Jordan's import to LNG exporters across the world. Jordan's Ministry of Energy and Mineral Resource officials claim this measure will help the country cut half-a-billion dollars from its annual energy bill.[109] Nearby Qatar—the world's leading LNG exporter since 2006—offers the best option.[110] Since no pipeline infrastructure currently exists to transport natural gas between Jordan and Qatar, seaborne transfer of LNG is currently the most cost-effective means to transfer natural gas between the two countries. While LNG is typically one of the more expensive forms of energy, Qatar has been known to give price breaks to fellow Arab countries.[111] In May 2015, the first LNG shipment occurred between Jordan's National Electric Power Company and Qatargas—a Qatar Petroleum and Shell Global joint venture—via the Golar Eskimo—a Floating Storage and Regasification Unit.[112] The Golar Eskimo will remain moored at Aqaba to facilitate the daily import of 150 million cubic feet of LNG based on a five-year agreement with Shell Global.[113] Thus, Jordan's efforts to open Aqaba to ship-laden LNG offer the country more flexibility and are a welcomed effort to diversify the countries energy import portfolio to displace reliance on even more expensive refined petroleum products.

Recently discovered natural gas fields beneath Israeli controlled waters offer a practical, if politically contentious, alternative to Egyptian or Qatari natural gas supplies. Once also heavily dependent on foreign supplies from Egypt, the 26 trillion cubic feet of natural gas in the Tamar and Leviathan natural gas fields promise to bring Israel greater energy security with enough surplus for export.[114] In turn, parties signed a deal wherein Israel will export 1.6 trillion cubic feet of natural gas to Jordan over a 15-year period

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[108] "Jordan Looks to LNG to Ease Dependence on Egyptian Gas," *Oxford Business Group*, accessed October 16, 2015, http://www.oxfordbusinessgroup.com/news/jordan-looks-lng-ease-dependence-egyptian-gas.

[109] Baconi, "Pipeline Against Peace."

[110] "Qatar: International Data and Analysis," *Energy Information Administration*, January 30, 2014, http://www.eia.gov/beta/international/analysis_includes/countries_long/Qatar/qatar.pdf.

[111] Baconi, "Pipeline Against Peace."

[112] "King Opens Aqaba Gas Terminal," *Jordan Times*, July 31, 2015, http://www.jordantimes.com/news/local/king-opens-aqaba-gas-terminal.

[113] Ibid.

[114] Baconi, "Pipeline Against Peace."

beginning in 2017. Thus, Israel would supply Jordan with a daily amount of 290 million cubic feet of gas—exceeding the 250 million feet of gas formerly supplied by Egypt and setting Israel up to become Jordan's primary source of energy.[115] Despite promising to save the country around $250 million per year, the contract—signed by private American developer Noble Energy and the Jordanian state-owned National Electric Power Company—has been widely opposed by Jordanian citizens.[116] Palestinians make up a significant portion of Jordan's population and many of them perceive Israel's claims on natural gas as an illegitimate effort to take Palestinian natural resources. Sympathy for those in the Palestinian Territories also leaves many Jordanians feeling as though the energy deal would be providing the financial means for Israel to continue hard-nosed actions against their fellow Arabs. These popular efforts drove Jordan's parliament to pass a decree opposing the agreement to purchase Israeli gas from Noble Energy in late in 2014. Despite this non-binding legislative outcry, King Abdullah II's administration has pressed forward with the deal to import natural gas from Israel.[117]

H. FINDINGS

While Jordan's economy has long been reliant on hydrocarbon imports, the inherent potential for supply disruptions and price shocks call the kingdom to seek further diversification of its energy sources. With the realm of fossil fuels, the Ministry of Energy and Mineral Resources were overly optimistic on the reliability of natural gas supplies from Egypt and the potential to expand and develop domestic energy sources—including conventional oil, oil shale, and natural gas. Moreover, existing oil infrastructure still requires significant expansion and refurbishment to keep up with the kingdom's growing energy demands. Despite the shock of disruptions in natural gas supplies from Egypt, Jordan is slowly—if somewhat unwillingly—adapting to seek new sources of natural gas from Israel while opening itself to the world market through its LNG

[115] Ibid.

[116] Michael Pizzi, "In Jordan, 'pipeline for Peace' with Israel Strikes a Nerve," *Al Jazeera America*, May 29, 2015, http://america.aljazeera.com/articles/2015/5/29/in-jordan-pipeline-for-peace-strikes-a-nerve.html.

[117] Ibid.

terminal. Considering the sustained low price and relatively low emissions of natural gas, this is a move in the right direction. Still, the kingdom must avoid the pitfall of relying on only a couple sources of energy. Diversification is key. In the next chapter, we will consider Jordan's efforts to harness the atom toward that end.

III. NUCLEAR ENERGY

A. OVERVIEW

Understanding that diversification is key to making headway in energy security, the Jordanian Ministry of Energy and Mineral Resources made development of domestic nuclear power a priority in the *Updated Master Strategy of Energy Sector in Jordan for the period (2007–2020)*. Jordan's nascent nuclear program may provide a means for indigenous power production, but multiple unsolved problems facing the drive toward nuclear power threaten to further endanger the kingdom. In this chapter, I contend that while the development of nuclear power could be a boon for addressing Jordan's energy shortage, the current environment is not conducive to development in this area due to operational issues and political contention. Operational issues include a severe water shortage, disputes over the location of proposed nuclear power facilities, the challenge of dealing with atomic waste, allocating financing, and acquiring fissile material. International and domestic political opposition is another major sticking point that the administration cannot afford to overlook.

B. AMBITIONS

The opacity of nuclear energy development was obvious in the administration's energy strategy. After all, the strategy discusses nuclear power only to a limited extent with no clear path forward. First, the strategy calls for further investigation into the development of domestic nuclear energy technology to act as an alternative for meeting the kingdom's expected expansion of electricity demands.[118] Second, the strategy provides a limited cost analysis comparing estimates for nuclear energy with heavy fuel oils and oil shale electricity generation—concluding that oil shale power generation would be the most frugal means of generating electricity in the near term considering the relatively high costs of nuclear fuel development and plant construction.[119] Despite these costs, Jordan's energy strategy called for the country to introduce nuclear power into the

[118] "Master Energy Plan," 4.

[119] Ibid., 9–12.

future energy mix—both to address vulnerabilities in the kingdom's energy security posture through diversification and deal with the related longstanding energy deficit. To this end, the strategy called for establishing a 60-megawatt nuclear power plant by 2020 that would account for an estimated 6% of the national energy demand in that year.[120] In the midst of these studies, Jordan founded the Committee for Nuclear Strategy—a short-term entity that established a separate overarching goal targeted at achieving 30% of the country's electric power generation by 2030 with the additional hope that Jordan can export excess electricity. Accordingly, the longer-term Jordan Atomic Energy Commission and Jordan Nuclear Regulatory Commission were set up to promote and regulate the potentiality of nuclear power going into the future.[121] Jordan's nuclear strategy was oriented toward achieving energy security, building partnerships, promoting technology transfer, utilizing domestic fissionable material, and providing reliable energy for desalination to address water scarcity.[122] Jordan's core energy strategy did not provide a road map or recommendations to direct policy toward this end. We need to consider the challenges facing Jordan's nuclear energy development along with the breadth of proposed solutions arising from outside the framework of Jordan's 2007 energy strategy.

C. WATER SCARCITY

One of the foremost of Jordan's technical challenges is the country's overwhelming water shortage—with an estimated deficit of around 600 million cubic meters per year.[123] Indeed, the Hashemite Kingdom of Jordan proclaims, "the gravest environmental challenge that Jordan faces today is the scarcity of water."[124] In Jordan, renewable freshwater resources are limited to just 106 cubic meters per person, much

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[120] Ibid., 13–14.

[121] "Nuclear Power in Jordan," *World Nuclear Association*, March 2015, http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Jordan/.

[122] "Nuclear Strategy," *Jordan Atomic Energy Commission*, 2011, http://www.jaec.gov.jo/JordanNuclearProgram/NuclearStrategy.aspx.

[123] "Nuclear Power in Jordan."

[124] "Jordan's Water Shortage," *The Hashemite Kingdom of Jordan*, accessed May 5, 2015, http://www.kinghussein.gov.jo/geo_env4.html.

lower than the 8,914 cubic meters per person experienced in the United States or even the 1,053 cubic meters per person in neighboring Iraq.[125] While the application of nuclear power for efforts to expand the prevalence of clean water through desalination is a centrally cited intent of Jordan's Atomic Energy Commission, the country still needs to access a water source with enough capacity to cool the reactors.[126] Due to water theft, leakage, and inefficient agricultural pursuits, Jordan's groundwater is being utilized at an unsustainable rate. This use is estimated to outpace the refresh of aquifers exhausting over a third of these resources over the next 20 years.[127] The Dead Sea is falling at over a meter per year, putting significant risk to the damage and loss of its unique high-salinity ecosystem and Jordan's domestic mineral extraction efforts from that region.[128] The Red Sea surrounding the Port of Aqaba provides the country a viable option to source water, but a parallel desalination plant would have to be built to provide the volume of demand needed without creating a long-term water deficit. Looking ahead, population growth, climate change, and regional conflict are apt to intensify challenge of supplying fresh, clean water for the Jordanian society and economy.[129]

Water shortage is a shared problem among Middle East nations, making it a prime necessity for regional coordination and a potential area for bolstering economic interdependence. In early 2015, Jordan struck a deal with Israel to build a desalination plant at Aqaba. The plant will be funded by the World Bank and is estimated to cost approximately $900 million. Scheduled for completion in three years, the desalination plant is expected to put out approximately 80 million cubic meters of freshwater on an annual basis with Israel buying 40 million cubic meters of water at cost and Jordan retaining the remainder. In exchange, Israel would release an additional 50 million cubic

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[125] "Data: Renewable Internal Freshwater Resources per Capita," *The World Bank*, 2015, http://data.worldbank.org/indicator/ER.H2O.INTR.PC.

[126] "Benefits for Jordan," *Jordan Atomic Energy Commission*, 2011, http://www.jaec.gov.jo/WhyNuclear/BenefitsForJordan.aspx.

[127] "Jordan: Country Development Cooperation Strategy" (Washington, DC: United States Agency for International Development, November 2012), 10–11, https://www.usaid.gov/sites/default/files/documents/1883/CDCSJordan.pdf.

[128] 12/21/2015 5:55:00 PM

[129] "Country Development Cooperation Strategy," 10.

meters of water from the Sea of Galilee to Jordan via pipeline each year. The project also includes the construction of the Red Sea to Dead Sea water conveyor—a pipeline between the two seas depicted in Figure 3—to help recharge the Dead Sea and dispose of brine from the proposed desalination plant at Aqaba. This pipeline will initially pump 300 million cubic meters per year and may be expanded to as much as two billion cubic meters with the addition of future projects. Pursuing partnerships like this with neighboring Egypt, Saudi Arabia, and Iraq could help relieve future conflicts over water and strengthen ties through trade.[130] Though—as we will discuss later—Jordan's efforts toward nuclear energy threaten to unravel the significant progress in addressing water scarcity.

Figure 3. Red Sea to Dead Sea Conveyor

Source: Harriet Sherwood, "Dead Sea Neighbours Agree to Pipeline to Pump Water from Red Sea," *The Guardian*, December 9, 2013, sec. World news, http://www.theguardian.com/world/2013/dec/09/dead-sea-pipeline-water-red-sea.

[130] Suleiman Al-Khalidi, "Jordan, Israel Agree $900 Million Red Sea-Dead Sea Project," *Reuters*, February 26, 2015, http://www.reuters.com/article/2015/02/26/us-mideast-economy-water-idUSKBN0LU23Z20150226.

D. PLANT LOCATION

Given its scarcity, water woes and other environmental factors have forced the Jordan Atomic Energy Commission to shift the proposed location of its plants. Early efforts were focused on building a plant on the southern coastline near Aqaba due to that area's ready access to seawater; however, the port lies over a fault line extending through the Jordan Rift Valley. While the Jordan Atomic Energy Commission initially cited Japan as an example of earthquake safe nuclear technology, the 2011 Fukushima Daiichi nuclear disaster has forced them to reconsider. Jordan has since focused efforts at placing its first and largest proposed plant near the historical site of Qasr Amra using wastewater from the urban area surrounding Amman to cool the reactors.[131]

E. WASTE DISPOSAL AND STORAGE

Nuclear waste storage and disposal is another major issue often overlooked by countries with budding nuclear programs. Jordan recognizes the importance of waste storage and partnered with U.S. Department of Energy to construct a 4000-square-foot low and intermediate level radioactive storage site on the outskirts of Amman to safeguard minimal radioactive waste. Though, this facility would not come close to meeting the demands of a nuclear power program being constructed to address the improper storage of nuclear waste associated with byproducts of healthcare and academic pursuits. [132]

Storage and waste disposal provides another potential area for economic cooperation. With many Middle East nations seeking nuclear power—including Saudi Arabia, United Arab Emirates, and Egypt—it makes sense to create a regional site for securing and storing atomic waste.[133] Israel has pursued both domestic storage of Israeli-enriched materials at Dimona and return of U.S.-provided materials to nuclear storage

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131 "Country Profile: Jordan," Country Profile (Federal Research Division, Library of Congress, September 2006), http://lcweb2.loc.gov/frd/cs/profiles/Jordan.pdf.

132 "Jordan Opens Storage Facility," *World Nuclear News*, March 22, 2010, http://www.world-nuclear-news.org/WR-Jordan_opens_storage_facility-2203105.html.

133 "Emerging Nuclear Energy Countries," *World Nuclear Association*, June 2015, http://www.world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/.

sites in America.[134] The United Arab Emirates is pursuing a "dual track" initiative wherein used nuclear fuels will be stored domestically in reactor ponds or dry storage while exporting certain fuel for reprocessing outside the country. The Emirates is also looking into options for a geological waste depot as part of efforts to find a place for long-term storage of atomic waste in the region.[135] Of course, such an effort would necessitate the rise of a cooperative Middle East security construct to counter local threats and provide a framework for securing stored nuclear waste in the region.

F. FINANCIAL CHALLENGES

Fiscal concerns have been a reoccurring factor causing Jordan to reorient its strategy. Jordan's posture for building nuclear power plants has shifted from four plants at nearly $40 billion to one plant at $10 billion. These numbers are of significant relevance to Jordan considering the country's Gross Domestic Product was only $36.55 billion in 2014.[136] Meanwhile missed deadlines and other contractual issues forced Jordan to shift from deals with Areva to consider deals with companies from South Korea, Russia, Japan, China, and another French company. It seems Jordan might have had a breakthrough in March 2015, signing a deal with Russian state company Rosatom toward constructing a dual reactor 2,000-megawatt plant near Qasr Amra by 2022. Through this deal, the Russians will build and operate the plant while providing 49.9% of the financing. Jordan will be responsible for funding the majority stake of 50.1%.[137] While certainly a financial challenge, the investment seems prudent

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[134] Yossi Melman, "Israel Reveals It Has Returned Dozens of Kilograms of Nuclear Waste to U.S.," *Haaretz.com*, June 21, 2011, http://www.haaretz.com/print-edition/news/israel-reveals-it-has-returned-dozens-of-kilograms-of-nuclear-waste-to-u-s-1.368793.

[135] "Nuclear Power in the United Arab Emirates," *World Nuclear Association*, March 2015, http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/United-Arab-Emirates/.

[136] "Jordan," *The World Factbook, Central Intelligency Agency*, accessed May 28, 2015, https://www.cia.gov/library/publications/the-world-factbook/geos/print_jo.html.

[137] Suleiman Al-Khalidi, "Jordan Signs $10 Billion Nuclear Power Plant Deal with Russia," *Reuters*, March 24, 2015, http://www.reuters.com/article/2015/03/24/us-jordan-nuclear-russia-idUSKBN0MK2QD20150324.

considering Jordan's hydrocarbon dependence was costing approximately $3 billion annually due to disruption of discounted hydrocarbon supplies from Iraq and Egypt.[138]

G. NUCLEAR FUEL

Exploiting Jordan's domestic uranium reserves have been looked at as a means of providing domestic finances. Figure 4 shows the most concentrated areas of Gamma radiation outlining locations of concentrated uranium deposits. Estimates of Jordan's uranium reserves are placed at around 140,000 tons of economically extractable material with another 50,000 tons of material embedded within phosphate deposits, which are more costly and difficult to mine.[139] While uranium traded for $39.4 per pound in March 2014, prices on the rare earth commodity reached a high of $135 per pound at the peak of the 2007 uranium market bubble. By 2008, the Kingdom of Jordan and French energy company Areva Incorporated initiated talks for extraction and processing of Jordan's domestic uranium deposits with the hope that revenue from extraction could independently finance Jordan's nuclear program. This agreement progressed to the establishment of a joint French-Jordanian corporation between Areva and Jordan Energy Resources Incorporated—a state owned company overseen by the Jordanian Atomic Energy Commission—entitled Jordan French Uranium Mining Company. Drilling nearly 10,000 core samples, the company began its efforts within a 100 square kilometer area and found high quality uranium at around 400 parts per million.[140] In total, the joint venture was able to identify 20,000 tons of uranium concentrated within central Jordan and a more focused extraction study was to be completed by 2012 so that mining could start in 2015. Yet, Jordan terminated the contract. Allegedly this was on the grounds that Areva failed to submit a report in a timely manner. Areva maintains that they were only responsible for prospecting and that another contract was needed to carry out feasibility

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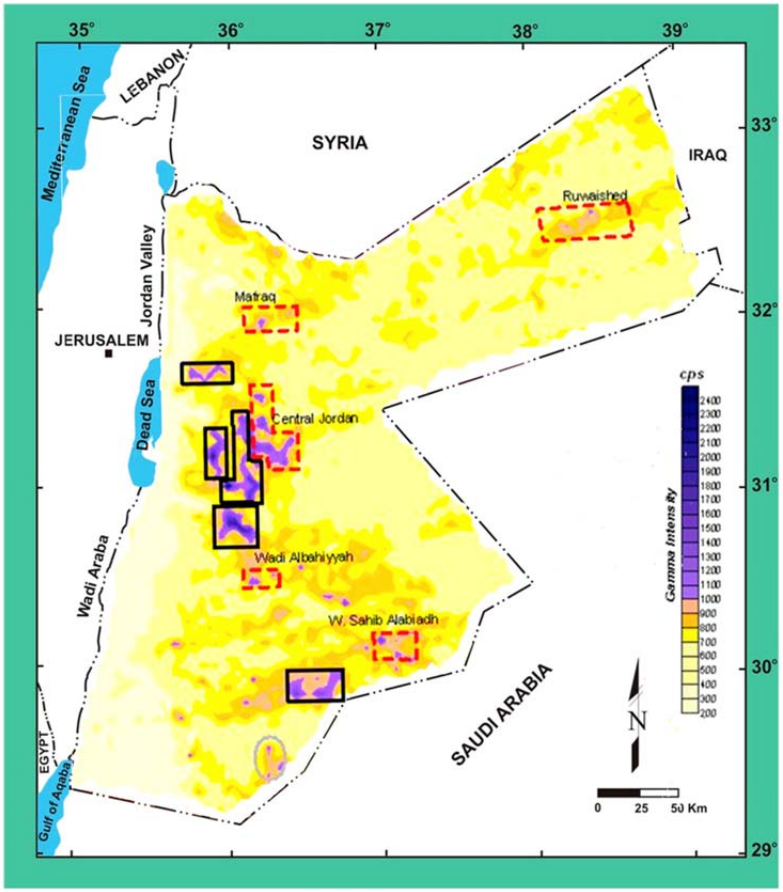
[138] "Russia to Build Jordan's First Nuclear Power Plant," *Al Jazeera*, March 24, 2015, http://www.aljazeera.com/news/middleeast/2015/03/russia-build-jordan-nuclear-power-plant-150324192954416.html.

[139] "Nuclear Power in Jordan."

[140] Charles Ebinger et al., *Models for Aspirant Civil Nuclear Energy Nations in the Middle East* (Brookings Institution, 2011), 20, http://www.brookings.edu/~/media/research/files/papers/2011/9/27%20middle%20east%20nuclear%20ebinger%20banks/0927_middle_east_nuclear_ebinger_banks.pdf.

studies and conduct extraction operations. Regardless, Jordan still needs a means of enriching its domestic uranium and internal enrichment motives are serious points of controversy internationally.[141]

Figure 4. Gamma Radiation Map



"Jordan countrywide Gamma intensity airborne survey, showing areas of high radiation. Known phosphate areas are outlined in black areas with uranium anomalies are outlined in red, and one area with thorium anomalies is outlined in gray." From: Ned Xoubi, "Evaluation of Uranium Concentration in Soil Samples of Central Jordan," Minerals 5, no. 2 (March 25, 2015): 134.

To alleviate concerns over Jordan's pursuit of enrichment and maintain regional stability Jordan needs to forego its enrichment pursuits. While the prospect of enrichment could bring Jordan more energy independence, it places Jordan at odds with Israel,

141 "Nuclear Power in Jordan."

delegitimizes U.S. nuclear negotiations with Tehran, and sets a poor precedent encouraging actions that could lead to proliferation of nuclear weapons. Jordan sees its national uranium reserves as a means to bring jobs and much needed revenue to its people. Uranium extraction efforts can continue, but with the understanding that enrichment will occur exogenously per current 123 agreement standards. The sovereign right to the enrich touted by Jordan must be overcome by encouraging established foreign sources of enrichment—which diminishes potential for weapon grade material and encourages peaceful trade. Progress in the United Arab Emirates nuclear program provides a recent example of how agreeing to discontinue enrichment pursuits can speed the path to nuclear power.[142] Thus, it seems foregoing enrichment can build international support and help Jordan focus more on the core issue of providing power to its struggling domestic economy.

H. POLITICAL CONTENTION

Many operational problems have contributed to political antagonism within the discourse of nuclear discussion. Given the west's current economic sanctions against Russia and the prevalence of conflict in the Middle East, it is no wonder that there is some international reluctance to support the joint Jordanian-Russian bid for a nuclear power plant. From an international perspective, analysts at the Washington Institute highlight the vocal political opposition from both the United States and Israel.[143] Despite their relative peace and cooperation since the 1994 Treaty of Peace Between the State of Israel and the Hashemite Kingdom of Jordan, Israel, King Abdullah made claims that Israel was pressuring Jordan's potential nuclear business partners to stall during their negotiations. Israeli sources maintain that Israel has only supported Jordan's efforts to build a nuclear power plant for peaceful purposes by providing geological data for the area surrounding Aqaba.[144] Members of the U.S. Congress are concerned over the

[142] "Nuclear United Arab Emirates."

[143] Henderson and Schenker, "Energy Balancing Act."

[144] Barak Ravid, "Israel Helped Jordan with Its Nuclear Energy Program, Official Says," *Haaretz.com*, September 23, 2012, http://www.haaretz.com/news/diplomacy-defense/israel-helped-jordan-with-its-nuclear-energy-program-official-says-1.466249.

potential for a nuclear power plant in Jordan to enlarge the regions Sunni-Shia rift and place Iran at greater odds with countries in the region. U.S. officials are also concerned over the region's fragile security situation and abundance of extremist and terrorist organizations in light of expanding Islamic State influence in neighboring Iraq and Syria.[145] Similar to ongoing negotiations with Iran, disagreement over the necessity and right to enrich fissile material has been a sticking point in Jordan's nuclear program.[146]

Domestically, its seems the high cost of nuclear power plants, potential for terrorist threats, environmental apprehensions, and safety concerns are among the major sticking points. Jordanians have conducted planned demonstrations against the proposed nuclear plants and parliament suspended progress on the plants in 2012. While many agree that Nuclear energy has the potential to help Jordan overcome some of its water and energy problems, there is a mass of domestic political rhetoric questioning the viability of a nuclear program in Jordan. For example a Jordanian environmental group argues that published budgetary estimates overlook insurance, loan interest, nuclear waste disposal, and the financial burden of retiring plants in later years. Members of Jordan's parliament, like Atif Kawwar, Jamal Gammoh, and Hind al-Fayiz do not think nuclear power is right for Jordan. Kawwar thinks that oil shale, natural gas, and renewables would provide more immediate, cost-effective answers to Jordan's energy needs, but the nuclear lobby is keeping them from happening. The Jordan Atomic Energy Commission has experienced its own internal points of contention between the current chairman, Khalid Toukan, and former commissioners of the nuclear fuel cycle and site selection. Originally charged with leading examination of the exploitability of domestic uranium reserves for the atomic fuel cycle, Nidal Xoubi voiced concern that concentration of the element within core samples was not high enough for economical extraction. The former commissioner of site management, Kamal Khudayr, left in disgust over plans to move the proposed nuclear plants location from the Gulf of Aqaba to Qusayr Amr. Some are also

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[145] James Jeffrey, "Implications of the Iran Nuclear Agreement for U.S. Policy in the Middle East," *The Washington Institute*, June 3, 2015, http://www.washingtoninstitute.org/policy-analysis/view/implications-of-the-iran-nuclear-agreement-for-u.s.-policy-in-the-middle-ea.

[146] David Schenker, "The Middle East's Next Nuclear Power?," *POLITICO Magazine*, accessed June 13, 2015, http://www.politico.com/magazine/story/2015/01/jordan-nuclear-power-114712.html.

concerned over seeming nepotism between the Jordan Atomic Energy Commission and the Jordan Nuclear Regulatory Commission given the newest director of the regulatory commission is the brother of one of the top five officials in the Jordan Atomic Energy Commission.[147]

I. FINDINGS

The resource constraints and political dynamics surrounding Jordan's nuclear program are unfavorable to development of utility scale nuclear power employment. Without easy access to fissile material and the water necessary for cooling the nuclear reactor, it is unlikely that the country will be able to operationalize a utility scale nuclear project in the near term. Problems of nuclear waste storage and deepening safety concerns associated with the post-Fukushima environment compound the issues facing Jordan's prospects for nuclear energy. Together, these and other issues have cemented political opposition to Jordan's nuclear program at home and abroad. Jordan cannot act unilaterally. The path followed by Jordan's administrators should make them keen to an important awareness—that Jordan does not have the requisite resources to act unilaterally toward obtaining nuclear power. Despite the potential nuclear power has for alleviating Jordan from its energy problems, development of this source will require the country to undertake international coordination and assistance to be seen through to fruition.

[147] Seeley, "Battle Over Nuclear."

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IV. RENEWABLE ENERGY

A. OVERVIEW

While the Kingdom of Jordan might not be experiencing the kind of transformational growth in nuclear energy laid out in the 2007 energy strategy document, the administration has had some success in attracting investment and development of its renewable energy sector. As discussed previously, Jordan was not geographically endowed with amounts of readily extractable oil and natural gas reserves with which to supply its domestic energy market. On the other hand, Jordan was endowed with a wealth of renewable energy that is poised to avail Jordan of some of its energy woes. The purpose of this chapter is to establish Jordan's progress toward meeting its goals in the renewable energy sector and analyze whether its achievements in this area are likely to contribute to energy security. I do not contend that these green energy resources can immediately solve all the country's problems. Rather, I argue that Jordan has significant untapped resources that can augment and diversify Jordan's energy portfolio while reducing the likelihood of adverse environmental risks–particularly the loss or misuse of scarce and precious water resources. Through the course of this section I will present the varied sources of renewable energy and their applicability to Jordan's energy challenges by highlighting the related strengths, weaknesses, opportunities and threats for sources of renewable energy applicable to Jordan. Within the following body of text, I illustrate the characteristics of hydro, wind, solar, geothermal, and biological energies as well as discuss the institutional and infrastructural issues pertaining to renewables in Jordan.

B. AMBITIONS

Before we delve into these sources, however, it is important to provide context by highlighting Jordan's established goals for the renewable energy sector. In the Ministry of Energy and Mineral Resources' *Updated Master Strategy of Energy Sector for the Period (2007–2020*), the administration set progressive goals to increase the amount of domestic renewable power sources within its largely foreign hydrocarbon-based energy sector. At the time this strategy was published, in 2007, domestic renewable sources

accounted for only 1% of the demand for primary energy.[148] Over the course of the development period, the Jordanian administration set goals to expand its employment of renewables in 2015 and 2020 to 7% and 10%, respectively.[149] Thus, Jordan targeted a total of 1,800 megawatts from renewables by 2020. To meet these limited goals for expanding the renewable sector, the Ministry of Energy and Mineral Resources put forth the following recommendations: issue legislation to encourage private investment and growth in the renewable energy sector; complete 600 megawatts of wind energy development by 2020 through proposed projects at Kamsha Fujaij, Harir, Wadi Araba, and other locations to be determined; study potential for employing 300 to 600 MW of solar energy; extend application of solar cells to rural lighting projects as well as multi-use electricity generation; construct a waste-to-energy power plant; consider use of biofuels for displacing use of petroleum-based fuels in transport and industry; and form a renewable energy projects fund to encourage research and investment in renewable energy.[150]

Accounting for the relatively high cost of renewable energy projects, hope for speedy nuclear development, confidence in domestic hydrocarbon development, and the fact that Jordan was receiving discounted natural gas from Egypt at the time the document was published supports a strategy of minimal investment in renewable resources. Jordan formed its strategy on the notion that discounted natural gas supplies from Egypt would continue and perhaps even increase in volume.[151] After all, the kingdom could not foresee the disruptions and shortages associated with the Arab Spring and more recent surge of Islamist violence in the region. Reconsidering Jordan's domestic renewable energy resources in light of these changes offers some means to overcome the country's energy challenges.

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[148] "Master Energy Plan," 15.

[149] Ibid., 20.

[150] Ibid., 21.

[151] Verity Ratcliffe, "Jordan Leads on Energy Tariffs," *The National*, December 15, 2013, http://www.thenational.ae/business/energy/jordan-leads-on-energy-tariffs.

C. WIND

When Jordan's energy strategists planned their way ahead, they envisaged wind-based power accounting for the majority of Jordan's renewable energy and it is easy to see why. Certain parts of the country are endowed with high-rated regular wind speeds from 15 to 25 miles per hour.[152] These areas—concentrated in the northern and western parts of the country as depicted in Figure 5—have been the primary targets for future wind farms. Jordan's pre-existing wind power was developed for research in the mid to late 1980s and summed to just under 1.45 megawatts between the pilot sites at Hofa and Al-Ibrahimiyya north of Amman.[153] Within Jordan's strategy document, six specific sites were recommended for development: a 30–40 megawatt project at Kamsha, a 60–70 megawatt project at Fujaij, a 100–200 megawatt project at Harir, and a 40–50 megawatt project at Wadi Araba. The 2007 strategy called for an additional 300 megawatts of wind energy development at locations that were to be determined by future survey and analysis.[154] By 2012, the Ministry of Energy and Mineral Resources expanded obligations for wind power by increasing goals two-fold in hopes of reaching 1200 megawatts of wind energy capacity by 2020–which would account for two-thirds of that year's projected renewable sector.[155]

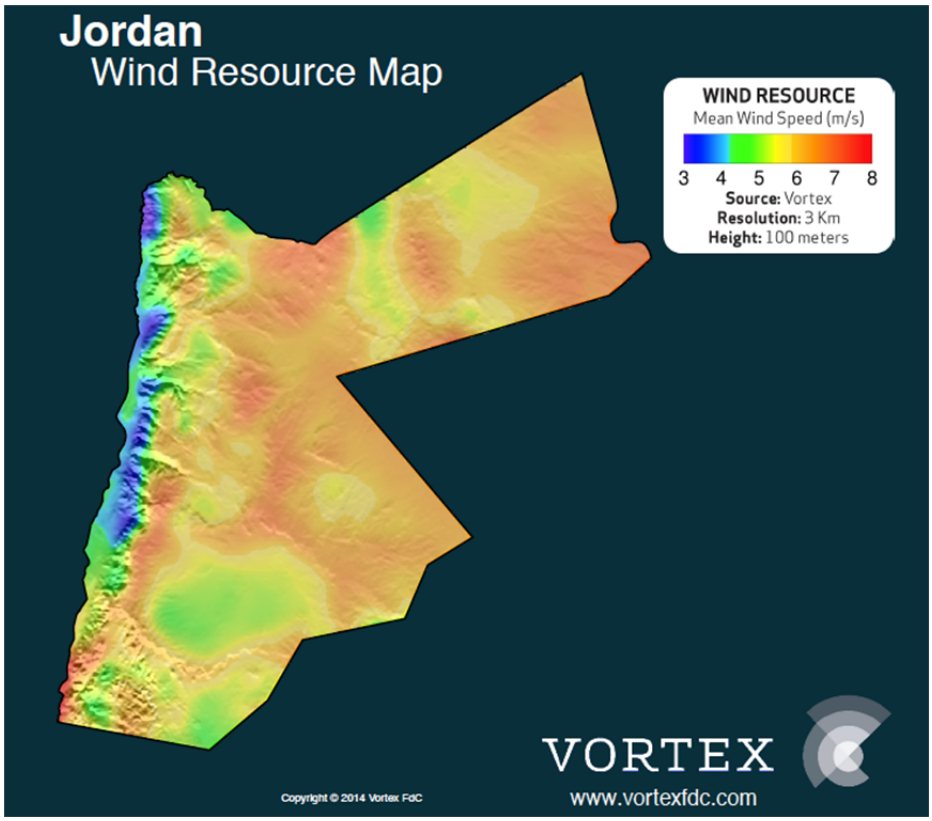
[152] Hartoqa, "Renewable Energy Market," 4.

[153] "Renewable Energy Country Profile" (Regional Center for Renewable Energy and Energy Efficiency, 2012), http://www.rcreee.org/sites/default/files/jordan_fact_sheet_re_print.pdf.

[154] "Master Energy Plan," 21.

[155] "Renewable Energy Profile."

Figure 5. Jordan Wind Resource Map.



Adapted from: "Jordan Wind Resource Map," *Vortex*, accessed November 2, 2015, http://www.vortexfdc.com/jordan-wind-map/.

Progress toward 2020 wind energy goals and recommendations are mixed. Initially due to come online in 2010, development of the Kamsha site was poised to be Jordan's first utility-scale wind farm. Unfortunately, concerns over noise abatement along with extended price negotiations with the Terna Energy-led Greek-Jordanian consortium—which sought to build the wind farm on a buy, own, and operate model—have stalled progress on the site.[156] The Harir site experienced an even worse fate—being cancelled along with other proposed renewable energy production locations due to rejection from the Gulf Cooperation Council for a grant to improve grid infrastructure

[156] Jan DoDd, "Jordan's First Commercial Wind Farm Endangered by Noise Issues and Regulations," *Windpower Monthly*, March 30, 2010, http://www.windpowermonthly.com/article/993625/jordans-first-commercial-wind-farm-endangered-noise-issues-regulations.

needed to integrate the site.[157] On the other hand, the Wadi Araba wind power development site was open for bids as of January 2015.[158] Having the only significant progress among the ministry's original list of locations, the Fujajj site was awarded to Korea Electric Power on buy, own, and operate model through a 2010 tender. In July of 2015, the government approved plans for this South Korean company to break ground on an expanded proposal to bring 90 megawatts of wind turbines online by 2019.[159]

Moving beyond the ministry's original site recommendations, wind energy developments driven by private enterprise have made more significant progress. In July 2015, Jordan approved four projects from companies that made direct proposals through a process enabled by legislation from 2012. Set to come online by 2019, the approved projects include 226 megawatts of capacity spread across plants near Al-Rajef, Tafilah, and Al-Ibrahimiyya. Each company proposed a build, own, and operate model—submitting bids at the government's wind energy price ceiling of 11 cents per kilowatt-hour. Jordan made significant progress toward harnessing the power of its winds, but the administration will need to work quickly if it wants to reach the increased capacity of 1200 megawatts by 2020. Keeping feed-in tariff limits high could attract investors need to reach this goal, but falling costs due to competitiveness of photovoltaic cells discussed in the following section are likely to drive feed-in tariffs downward in future negotiations—perhaps necessitating a greater focus on development of solar farms.[160]

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[157] "Jordan Cancels 400MW Solar and Wind Tender," *PV-Tech*, accessed November 27, 2015, http://www.pv-tech.org/news/jordan_cancels_400mw_wind_and_solar_tender; Michelle Davies et al., "Developing Renewable Energy Projects: A Guide to Achieving Success in the Middle East" (London: Eversheds and Pricewater Coopers, January 2015), 110, https://www.pwc.com/m1/en/publications/documents/eversheds-pwc-developing-renewable-energy-projects.pdf.

[158] Davies et al., "Developing Renewable Energy," 110.

[159] Jan DoDd, "Jordan to Build 315MW Wind Farms," *Windpower Monthly*, July 27, 2015, http://www.windpowermonthly.com/article/1357662.

[160] Ibid.

D. SOLAR

While being largely overlooked in the 2007 energy strategy due to high relative costs, the abundance of solar irradiation in Jordan offers a promising opportunity to meet the kingdom's growing energy needs. After all, the Ministry of Energy and Mineral Resources' 2007 energy strategy simply recommended future studies to consider developing between 300 and 600 megawatts of solar energy before 2020.[161] Completing a countrywide study to consider expansion of solar assets early in the strategy's period of focus, the ministry discovered that areas in the south of the country held the best opportunity for future solar power developments.[162] Having over 300 days of sunny skies per year combined with an average daily solar irradiance of between five and seven kilowatts per hour for every square meter makes Jordan one of the world's most abundant country's in terms of solar potential.[163] Figure 6 shows varying, yet relatively high concentration of solar irradiation throughout the country. This prevalence of solar resources in Jordan could be leveraged to surpass the country's 2020 benchmark of using renewables to fulfill 10% of total energy demand—projected to be 1800 megawatts.[164] Off-grid power applications historically dominated the photovoltaic sector—being targeted toward efforts intended to provide limited electricity, heating, and water pumping in rural areas.[165] As of 2012, Jordan only had 1.6 megawatts of installed photovoltaic capacity in these various applications.[166] Though, falling photovoltaic prices combined with efforts of the Jordan's administration seem to have challenged this precedent.

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[161] "Master Energy Plan," 21.

[162] "Renewable Energy Profile."

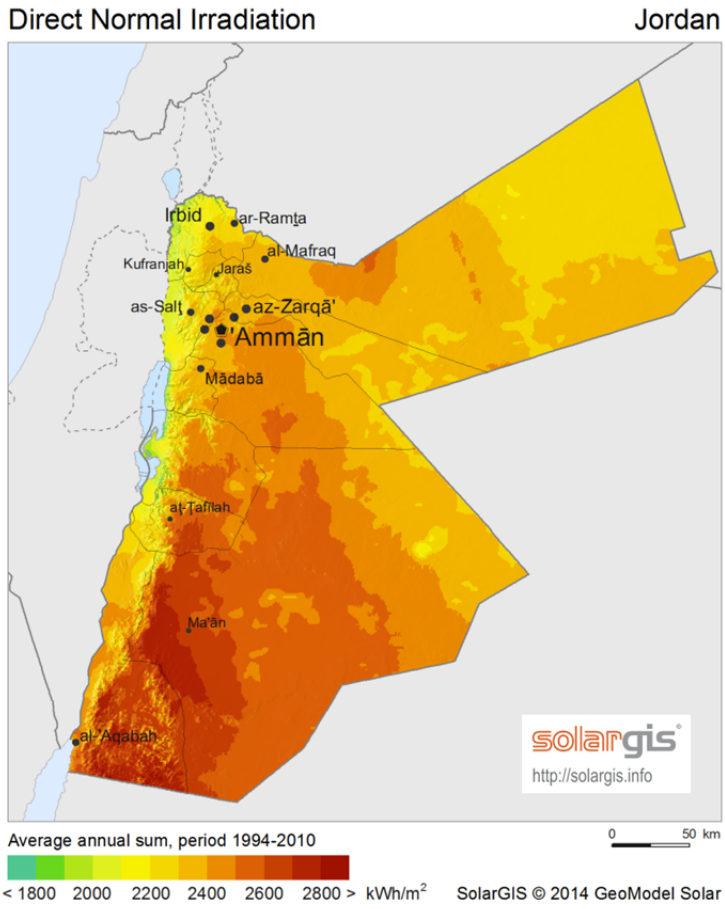
[163] Hartoqa, "Renewable Energy Market," 4.

[164] 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.

[165] Hartoqa, "Renewable Energy Market," 4.

[166] "Renewable Energy Profile."

Figure 6. Solar Irradiation



Source: "Direct Normal Irradiation Jordan," SolarGIS, 2015, http://solargis.info/doc/_pics/freemaps/1000px/dni/SolarGIS-Solar-map-DNI-Jordan-en.png.

The solar budgetary assumptions underlying Jordan's original energy strategy have vastly shifted in the country's favor due to recent advancements in technology that enhance operational efficiency and cost effectiveness of photovoltaic systems. Solar costs in the Middle East are nearly 75% cheaper in 2015 than they were when bureaucrats in the Ministry of Energy and Mineral Resources formulated the strategy in 2007.[167] These falling costs helped encourage investment and construction of 212 megawatts of photovoltaic capacity completed in 2014.[168] In light of these changes, the ministry seems

[167] Hochberg, "Energy Future."

[168] Ibid.

to have shifted its stance toward photovoltaic generation making solar power a greater priority in the energy portfolio by issuing two tender programs for would be developers. In the first round of tenders completed in February 2014, Jordan signed power purchase agreements for a dozen projects summing to 200 megawatts of solar power. In a second round completed in May 2015, Jordan secured power purchase agreements for another 200 megawatts of solar energy capacity with four companies and 20-year fixed feed in tariffs set at record low photovoltaic prices ranging from 6.13 U.S. cents per kilowatt-hour and 7.67 U.S. cents per kilowatt-hour. The record-low prices are no doubt due to recent and projected advancements in the photovoltaic industry. These agreements represent the kind of falling cost burden that could bring solar energy costs into parity with conventional energy sources to transform Jordan's energy mix and surpass the initial strategy's consideration for 600 megawatts of solar photovoltaic capacity by 2020.[169]

E. HYDRO

Jordan's strategy did not provide out specific measures for harnessing hydropower. Considering the environmental and ecological impacts of hydropower, it is debatable whether it should be considered a renewable energy resource. Yet, it provides power without creating direct carbon emissions and upstream water supply is typically replenished in the earth's annual water cycle. Hydropower is considered here because the potential for expanding hydroelectricity it not significant enough to warrant extensive analysis of this energy source in the form of a separate chapter. Considering a relative lack of regularly flowing waterways, Jordan was foregone the opportunity for mass hydropower projects that have helped many countries attain affordable, reliable sources of electricity to power their economies. As one of the four poorest countries in terms of freshwater resources, Jordan does not have a plethora of flowing tributaries to support expanding power production efforts.[170]

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[169] "Jordan's Second PV Tender Leads to Record Low Tariffs," *Pv Magazine*, accessed September 26, 2015, http://www.pv-magazine.com/news/details/beitrag/jordans-second-pv-tender-leads-to-record-low-tariffs-_100019481/.

[170] Steven Gorelick, "Water Security in Jordan: A Key to the Future of the Middle East," *The Brookings Institution*, January 16, 2015, http://www.brookings.edu/blogs/planetpolicy/posts/2015/01/16-water-security-jordan-middle-east-gorelick.

Yet, hydropower comprised the foremost installed form of domestic, non-carbon-emitting energy during Jordan's status as an independent country. Hydropower accounts for just over 60,000 Megawatt hours of annual electricity and accounted for less than one-half of one percent of the country's total energy production in recent years. This power source provided 10 megawatts of renewable capacity in 2012—offering just over 60% of the installed renewable capacity when considered as part of the renewable portfolio.[171] Spanning the Zarqa River in northern Jordan since 1978, the King Talal Dam produces the nation's main source of conventional hydroelectricity—providing approximately 25,000 Megawatt hours of power per year.[172] Other sources of hydroelectricity are limited and can be characterized as efficiency gaining systems from larger existing or planned projects. Examples of projects include turbines installed to generate power from elevation drops in water transport systems. One example is the six megawatt turbines installed on lines transporting seawater used for cooling the fossil-fuel burning Aqaba Power Station. Another is the potential for 400 and 800 megawatts of power to take advantage of the elevation difference between the Red Sea and Dead Sea in the proposed Red Sea to Dead Sea Conveyor depicted in Figure 3.[173] Despite these efficiency-gaining measures hydropower is expected to play a miniscule role in Jordan's future energy mix approaching the end of the strategy's target period in 2020.[174]

F. BIOENERGY

Given Jordan's shortage of readily available water resources and related relatively low share of arable land—which covers only 2% of the small country—leaves Jordan without much potential for conventional biomass utilization.[175] Jordan has neither the sprawling plantations nor the vast forests characteristic of countries that make significant use of biomass. Rather, the little available land has been employed to offset the kingdom's high proportion of food imports. Therefore, the Ministry of Mineral and

[171] "Renewable Energy Profile."

[172] Hartoqa, "Renewable Energy Market," 5.

[173] Ibid.

[174] "Renewable Energy Profile."

[175] "Jordan."

Energy Resources did not consider strict agriculturally based biomass a viable pursuit for expanding the countries energy capacity to meet rising demands.

Yet, there may be a benefit to Jordan's growing population and its rising demands. Jordan's growing population may place strains on the economy, but it also creates municipal waste. This waste along with organic residuals of Jordan's industrial and limited agricultural output can be leveraged in waste-to-energy production to help offset the rising demand for energy. Thus, Jordan made both installation of 20 to 30 megawatts of municipal waste power capacity and exploration of biogas development priorities in its 2007 to 2020 energy plans.[176] Prior to the strategy, a single pilot plant existed outside Amman at Rusaifeh Landfill that was expanded to four megawatts in 2008.[177] By 2012, biomass made up just over 21% of the Hashemite Kingdom's renewable energy capacity at 10 megawatts.[178]

Compared to other renewable sources, the Ministry of Energy and Mineral Resources seems to have received less private interest in expanding bioenergy production. Instead, the central government seems to be relying on decentralized efforts of its major cities and twelve governorates—typified by the proposed Greater Amman Municipality Solid Waste Project at the Al Ghabawi landfill—to fill the bioenergy gap in moving toward the 2020 milestones.[179] Of course, such projects have the added benefit of managing the mounting abundance of waste piling up in the small country's landfills and partially offset hydrocarbon imports.[180] Yet, the lack of substantial development since the implementation of ministry's energy strategy in 2007 suggest that a poor regulatory framework surrounding waste management as well as ceiling tariffs on biomass and biogas—set at 12.7 U.S. cents per kilowatt hour and 8.5 U.S. cents per kilowatt hour,

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176 "Master Energy Plan," 26.

177 Hartoqa, "Renewable Energy Market," 4.

178 "Renewable Energy Profile."

179 Mohammad Ziad Yamin, "Solid Waste Management in Jordan," *EcoMENA*, January 3, 2015, http://www.ecomena.org/swm-jordan/; "GAM Solid Waste Project," *European Bank for Reconstruction and Development*, January 7, 2015, http://www.ebrd.com/work-with-us/projects/psd/gam-solid-waste-project.html.

180 Mohammad Aljaradin and Kenneth Persson, "Current Situation of Municipal Solid Waste Landfill in Jordan," *Waste Management* 31 (2011): 1897–1900.

respectively—are not incentivizing enough action or investment in bioenergy production ventures.[181] To better enable bioenergy extraction, municipalities may need to move away from having several highly dispersed landfill sites to fewer sites that can allow bioenergy developers to take advantage of higher economies of scale.[182]

G. GEOTHERMAL

Jordan possesses an abundance of geothermal resources spread throughout the country. These assets are most abundant in the Jordan Rift Valley in the west and the country's eastern plateau. Unfortunately, known geothermal resources are characterized as low in heat with energy too low to merit exploitation in major power generation.[183] Even if any geothermal electricity were generated, prices would be capped at 12 U.S. cents per kilowatt hour since such electricity would fall under the miscellaneous renewable energy sources category as laid out in Jordan's existing tariff framework.[184] Thus, there is low potential for using geothermal resources outside of limited agricultural and tourist applications.

H. INSTITUTIONAL DEVELOPMENT

The development of new institutions—which the late Douglass North described as "the rules of the game in a society, or…the humanly devised constraints that shape human interaction"—has played a crucial role in enabling development in the renewables sector.[185] Jordan's growing renewable energy sector can largely be attributed to the policy guidance and regulatory framework laid out in the kingdom's 2007 Master Energy Plan and Law Number 13 of 2012 entitled the Renewable Energy and Efficiency Law. On one hand, the Master Energy Plan provided overarching policy guidance driving the diversification of energy sources from its publishing in 2007 through the year 2020—

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[181] "Renewable Energy Profile."

[182] "Sustainable Energy Mix," 102–103.

[183] Ibid., 103.

[184] "Renewable Energy Profile."

[185] Douglass North, *Institutions, Instutional Change and Economic Performance* (Cambridge, UK: Cambridge University Press, 1990), 3.

with the stated intent of reducing the countries heavy dependency on foreign energy sources. On the other hand, the plan set specific milestones for the development of renewable resources at 7% for 2015 and 10% of total energy consumption for 2020.[186] Though, one can note that little progress was made toward these goals leading up to 2012. Extending on the direction of the energy strategy, the Renewable Energy and Efficiency Law provides a specific framework to encourage investment and entrepreneurship in the renewable energy sector by establishing the National Energy Research Center to promote renewable energy and efficiency education, a fund to enhance awareness of savings potential among energy consumers in households and industry while lending technical and financial support to sector development, a means for renewable energy developers to deal directly with the Ministry of Energy, a requirement that the National Electric Power Company cover grid connection costs, and an obligation for this company to purchase any renewably-generated electricity produced by developers based on fixed feed-in tariffs.[187] Seeing the hastened pace of advancement since the Renewable Energy and Efficiency Law was implemented illustrates how development of key institutions may help drive development elsewhere in the energy sector.[188]

I. INFRASTRUCTURE

Despite the hope renewable energy sources bring to dealing with the kingdom's energy dilemma, Jordan needs major investment in grid infrastructure to absorb, transport, and store the output of this budding sector. Building power transmission lines is an acute problem facing Jordan's recent developments. After all, the most lucrative projects in solar energy are located in the county's south, distanced from the major northern population centers that could utilize solar energy to alleviate demands—particularly during periods of peak use.[189] As previously mentioned, the inability to integrate newly proposed projects due to a failure to secure funding for grid expansion

[186] "Master Energy Plan," 7.

[187] "Renewable Energy & Efficiency Law Number 13" (International Energy Agency, July 23, 2013), http://www.iea.org/policiesandmeasures/pams/jordan/name-36862-en.php.

[188] Portions of this paragraph were also used in the author's National Security 4053 Political Economy of Development paper entitled Writing Assignment #3.

[189] Hochberg, "Energy Future."

was advertised by the Ministry of Mineral of Energy and Mineral Resources as the principle reasons for cancelling the third round of renewable energy tenders introduced in February of 2014.[190] Thus, the failure to obtain a grid improvement grant from the Gulf Cooperation Council forced Jordan to forgo some 400 megawatts of potential capacity.[191] Yet, Jordan is making inroads to constructing a grid expansion project referred to as the Green Corridor. In early 2015, Chinese green energy firm Hanergy agreed to grant $310 million to build up Jordan's energy infrastructure and the Kingdom recently released a tender for construction that will allow the corridor to add 1,000 megawatts of grid capacity on top of the Kingdom's current 3,700 megawatt grid.[192] Thus, the administration seems to have learned to ensure capacity is available for renewable expansion and is working to accommodate future green energy projects.

J. FINDINGS

Clearly, renewable sources provide a readily available and sustainable means of fueling Jordan's economy with the energy it needs to propel the country forward. In particular, the countries abundant wind and solar resources promise to enable a major shift in Jordan's economy. After analysis, it is clear that neither hydropower nor geothermal sources are likely to be leveraged toward vast gains in utility scale energy production. Meanwhile, bioenergy delved from waste can help kill two birds with one stone—adding needed energy to the grid and absolving the country of its growing landfills. Overall, the Ministry of Energy and Mineral Resources seemed reluctant to take the drastic measures needed to encourage growth in the renewable sector. Perhaps, the large energy gains from potential megaprojects in other sectors were viewed as being quick kills that could free Jordan from its energy woes in a more rapid and decisive manner. While the gains in individual renewable projects may seem small, they are

[190] Davies et al., "Developing Renewable Energy," 11.

[191] "Jordan Cancels 400MW Solar and Wind Tender."

[192] Mohammad Ghazal, "Gov't Floats Tender to Expand National Power Grid by 1,000MW," *Jordan Times*, October 31, 2015, http://www.jordantimes.com/news/local/gov%E2%80%99t-floats-tender-expand-national-power-grid-1000mw; Mohammad Ghazal, "Jordan to Expand National Grid with $310m Chinese Grant," *Al Bawaba*, May 26, 2015, http://www.albawaba.com/business/jordan-expand-national-grid-310m-chinese-grant-699250.

making real progress where developments in domestic shale and nuclear power have been unsatisfying. Moreover, the scale of the projects allows the administration to incrementally adapt to conditions. This adaptation was evident in both the country's effort to expand infrastructure and its development of key institutions to encourage growth. The growth of renewables in Jordan may have fallen behind the administration's 2007 goals for the year 2020, but these sources are certainly progressing and growing in their share of the overall energy mix. Most importantly, these sources are providing the country with greater energy security—offering more domestic availability, providing greater diversification, and making the country less susceptible to the exogenous shocks of energy markets.

V. CONCLUSION

A. SYNTHESIS

Up to this point, the assorted aspects of Jordan's varying energy sources have been considered. In this final chapter, we synthesize the conclusions of each of the preceding chapters. Synthesizing the findings of the previous chapters lends important evidence supporting the notion that the Jordanian administration has not been effective in seeing its energy strategy through to fruition. Analyzing the implications of Jordan's energy strategy is tenuous for this reason. Despite their efforts, the bureaucracy in Amman has failed to meet all of the milestones set for 2015. What can be said is that in failing to complete these self-imposed objectives, ministerial personnel fell short of tackling what they deemed to be the Kingdom's most important energy challenges. Moreover, the Ministry of Energy and Mineral Resources has not adequately shifted strategy to adapt for ongoing changes in the energy landscape. By reviewing the three main findings presented up to this point, one can better consider the limited effectiveness of Jordan's energy security efforts.

First, Jordan has not been able to fully execute the recommendations provided in the realm of hydrocarbons. After all, the country was unable to fulfill the optimistic domestic oil, oil shale, and natural gas developments called for within the national energy strategy.[193] Conversely, the kingdom succeeded in finding new diversification of natural gas sources by opening an LNG terminal at Aqaba and making a politically contentious deal to buy natural gas from Israeli-controlled gas fields.[194] Thus, the kingdom is likely to continue heavy reliance on hydrocarbons—albeit from more varied sources.

The second main point is that the fits and starts of Jordan's nuclear program have been largely unfruitful and the outlook for future development is poor. Despite heavy administrative investment in atomic energy, the country has yet to see the construction of any utility scale plant. Furthermore, the prospects for such a plant are opposed from

[193] "Master Energy Plan," 13–24.

[194] Galbraith, "Jordan Finds Energy Sources in Unlikely Places"; "King Opens Gas Terminal."

segments of both the national and international community for varying reasons ranging from broad environmental concerns to acute concerns over safety and security.[195]

Third, examination revealed the huge potential for the country's nascent renewable energy development. Despite slow initial progress, the boom of wind and solar development projects in the wake of Jordan's 2012 legislation pertaining to renewables showed the high potential for foreign direct investment in the wake of a supportive institutional framework. Conversely, the Ministry of Energy and Mineral Resources turned investors away, which demonstrated that the ministry did not have the infrastructure or administrative capacity to realize the country's full exploitation of renewable resources. Next, one must consider recommendations for future improvement.

B. RECOMMENDATIONS

There are several proposals that may be imparted from considering the country's ongoing energy problems. First, one must consider the area of hydrocarbons that have long dominated Jordan's energy portfolio. In the face of international energy market austerity, Jordan's energy administrators pragmatically sought to make limited energy independence a priority, but Amman was overly optimistic in the development of domestic hydrocarbon resources. After all, none of the proposed areas for domestic exploitation efforts have translated to significant gains in production. Though, the kingdom's success in establishing a liquefied natural gas terminal at Aqaba and progression on a natural gas deal with Israel provide a way forward. These interconnections offer Jordan a key characteristic to overcome exogenous shocks and disruptions—diversity. In light of the sustained lows in energy price markets, the shale revolution, and reintroduction of Iranian resources to the greater international market, it seems heavy reliance on fossil fuels is likely to persist for the near future.[196] These

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[195] Schenker, "The Middle East's Next Nuclear Power?"

[196] Leslie Hayward, "The Iran Deal and Oil Markets: What to Know," *The Fuse*, July 14, 2015, http://energyfuse.org/the-iran-deal-and-oil-markets-what-to-know/; Angharad Lock, "Yergin: Energy Has Entered 'New Era of Shale' with Big Benefits for Petrochemicals," *Energy Global-Hyrocarbon Engineering*, July 10, 2015, http://www.energyglobal.com/downstream/petrochemicals/07102015/Yergin-Energy-has-entered-new-era-of-shale-with-big-benefits-for-petrochemicals-1552/; Matt Pitrowski, "This Is What a Free Oil Market Looks Like," *The Fuse*, August 25, 2015, http://energyfuse.org/this-is-what-a-free-oil-market-looks-like/.

developments compound with what Daniel Yergin refers to as the "law of long lead times," or the notion that a major shift away from hydrocarbons will take several years due to the deeply embedded nature of existing production capital, infrastructure, and consumer habits.[197] Professor Robert Looney agreed, "The renewable technologies that are currently being deployed are highly unlikely to provide enough reliable and cheap energy to replace fossil fuels."[198] Though considering the Middle East's current state of upheaval and Jordan's history of vulnerability to supply disruption, the kingdom needs to emphasize both the employment of the various types of hydrocarbons and increased variety among the sources of those hydrocarbons. After all, past instances have shown that the threats of supply disruption can come in enumerable ways. Thus diversification will be key to overcoming unforeseen issues with hydrocarbon supplies. To this end, Jordan needs to make oil and natural gas pipeline interconnections with resource-rich neighboring countries a greater priority. The ongoing efforts to connect with Iraq's oil infrastructure are a good, if militarily challenging, first step. Repairing or replacing the inoperable Trans-Arabian Pipeline is an important measure that can connect Jordan to Saudi Arabia's plentiful oil reserves. In doing so, Amman can reduce the high transaction costs associated with shipping supplies into Aqaba and avoid overreliance on the hazardous trucking routes bringing supplies in from Iraq. Another lucrative measure would be seeking a natural gas pipeline across the Saudi kingdom into Qatar to connect to the Qatari's massive offshore North Dome Gas Field. While these measures would surely be beneficial to Jordan, they also bring hydrocarbon supplies from resource extracting countries closer to budding energy transport hub offered in Turkey. Connecting to pipelines in Turkey could enable access to the European market, reduce transaction costs from shipping, make resource allocation more efficient, and enhance energy security for the global market. Moreover, the potentiality of these connections could provide Jordan with further economic input through transit fees and much needed jobs for those residing within the kingdom. Of course, seeing throughput to Turkey and greater Europe will necessitate genuine security cooperation to mitigate threats from the

[197] Yergin, *The Quest*, 722.

[198] Robert Looney, "The Quest: Energy, Security, and the Remaking of the Modern World (review)," *The Middle East Journal* 66, no. 2 (2012): 381–82, doi:10.1353/mej.2012.0069.

region's disparate security threats. Ultimately, the difficulty in stopping these threats underlines the fact that the most important thing Jordan can do from the standpoint of hydrocarbons is avoiding the troublesome reliance on any one source.

Considering the many challenges facing Jordan's nuclear program, it is questionable whether nuclear power is a viable option for the country at this time. Perhaps the best option to pursue nuclear power would be greater cooperation with the United States. A greater degree of U.S. involvement with Jordan's nuclear program can help the beleaguered nation resolve several of its core issues. By agreeing to renounce enrichment and reprocessing of uranium, Jordan could ease international and domestic concern over the country's nuclear intentions. Without the ability to enrich or reprocess fuels, the country would not be able to independently pursue nuclear weapons. The current Jordan-Russia deal threatens to strategically bind Jordan to Russia in the midst of the West's tenuous relations with Russia. Instead of pursuing business with Russia, Jordan needs to follow the standard set with the United States-United Arab Emirates Agreement for Peaceful Civilian Nuclear Energy Cooperation. In doing so, the U.S. could afford Jordan access to technology, training, radiological material, and waste management needed to bring the country's nuclear program to fruition. The high stakes of Jordanian energy security necessitate vast development and diversification into alternative fuel sources. Nuclear power can reduce the reliance on hydrocarbons threatening the economic vitality and political legitimacy of the U.S.-friendly Hashemite regime. Thus, pursuit of a 1-2-3 Agreement for Peaceful Cooperation is a crucial step toward fulfilling Jordan's nuclear energy objective, gaining greater energy security, and reinforcing the stability of a key U.S. ally.[199]

Jordan's solar and wind characteristics offer great potential for future domestic energy development, but the administration needs to solve some important issues to exploit these resources. An updated strategic policy-guidance document could help institute a greater bureaucratic commitment to this end. The institutional development

[199]"123 Agreements for Peaceful Cooperation | National Nuclear Security Administration," *NNSA*, accessed December 1, 2015, http://nnsa.energy.gov/aboutus/ourprograms/nonproliferation/treatiesagreements/123agreementsforpeacefulcooperation.

embodied in Jordan's 2012 Renewable Energy and Efficiency Legislation and the pursuant surge in development projects shows how institutional change can stimulate development in the sector.[200] A lot has changed since the strategy was formulated in 2007, and officially reorienting the strategy through an update could help Jordan's administrators steer the country toward greater employment of wind and solar resources by raising the goals for renewable development and abandoning efforts that have proved less fruitful. Of course, the surge in renewable energy bids also illustrated the limitations of Jordan's electricity grid and the inadequate administrative capacity of the Ministry of Energy and Mineral Resources.[201] Jordan is in the process of updating its grid for projects currently in the pipeline, but the infrastructure will need further expansion to accommodate a greater share of renewable energy.[202] As with hydrocarbons, seeking grid interconnectedness with neighbors in the long-term would provide greater regional energy security and could offer the distant potential to export green energy to high demand markets—which is related in the DESERTEC concept for employing renewable energy from the world's deserts on a massive scale.[203]

Ultimately, there are innumerable paths for Jordan to consider in its energy future. Despite some of the shortcomings highlighted in this text, the aforementioned recommendations illustrate that the country has many potential areas for improvement. Leveraging these opportunities and mitigating threats to the kingdom's energy needs is likely to remain an important issue for the foreseeable future. In doing so, the Hashemite Kingdom of Jordan must remain attuned to the international political and economic environment. As challenging as the continual adaptation to changes in shifting markets and politics may be, the Jordanian people's resilience in the face of austerity shows they are up to the task.

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200 "REEL"; Hochberg, "Energy Future."

201 "Jordan Cancels 400MW Solar and Wind Tender."

202 Ghazal, "Chinese Grant."

203 "DESERTEC Concept," *DESERTEC Foundation*, n.d., http://www.desertec.org/concept/.

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