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**JORDAN & THE SOLAR ECONOMY**

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## Introduction

A solar energy industrial revolution is needed to alleviate the Hashemite Kingdom of Jordan's current energy crisis. A global dependence on fossil fuels for electricity generation has weakened Jordanian political, economic, and environmental security. Consequently, a transition to an economy based on solar energy is necessary if the Kingdom is to meet growing energy demand and energy costs amidst a refugee crisis brought about by conflicts in Syria, Iraq, and Israel. This transition is achievable, but it will require leadership from the Jordanian Government and courage from the global private sector.

Jordan imports 96% of its energy. Between 1990-2007, Jordan relied almost entirely on the import of Iraqi crude to meet its energy requirements due to the low price of crude on the international market and the Kingdom's proximity to its oil-rich neighbor. Research and development for alternative energy sources—natural gas, renewables, and nuclear—was negligible. After all, the price for crude petroleum in 1990 was less than US\$37 per barrel. Yet, Jordan's reluctance to diversify energy sources and its increasing reliance upon Iraqi crude to meet energy demand would eventually come back to haunt the Kingdom; for, once the US invaded Iraq in 2003, Jordan would be forced to abandon its special agreement with Iraq and test its luck on the world oil market. By 2008, Jordan was paying US\$140 per barrel, nearly four times what they had paid a decade earlier.<sup>1</sup>

The increase in oil prices after 2003, coupled with an influx of refugees from the Iraq War forced the Jordanian Government to adopt new policies bent on bolstering energy independence. This resulted in a move towards natural gas, oil shale, and renewables to meet growing energy demand. Apprehensions about energy security culminated in the Jordanian

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<sup>1</sup> Michael Mason et al, "The Energy Sector in Jordan—Current Trends and the Potential for

Government publishing the *Master Strategy of Energy* in 2004. Though revised in 2007 (the original plan was deemed too optimistic), the *Master Strategy of Energy* represented a shift in Jordanian energy policy and, more importantly, listed tangible benchmarks for improving energy security. The 2007 review of the *Master Strategy of Energy* also highlighted the development of renewable energy as a key factor in improving energy security. The door to Jordan's solar revolution had been opened, albeit slightly.

With 2,900 hours of sunshine falling on the desert country each year, solar power is the obvious choice for meeting Jordan's energy demand.<sup>2</sup> Jordan's average solar irradiance on a horizontal surface ranges from 5-7 kWh/m<sup>2</sup>, making Jordan one of the sunniest countries on Earth.<sup>3</sup> What is more, solar energy in Jordan is either at, or approaching, *grid parity*. This means that solar energy is producing electricity at the same cost to ratepayers as conventional energies like gas—only solar is produced domestically and with practically zero political risk. Despite the current dip in oil prices, the cost of fossil fuels is projected to increase in the long run, while the price of photovoltaic (PV) and concentrated solar power (CSP) will only decrease with time (see Figures 7 & 8 in Appendix). Globally, “the cost of large utility-scale photovoltaic plants and concentrated solar power plants has dropped sharply. Projects built in 2014 had a lower lifetime cost per kilowatt-hour than projects built in 2010 (see figure 8 in Appendix).”<sup>4</sup> What is more, energy shocks to Jordan's supply of Iraqi crude and Egyptian natural gas in 2003 and 2011, respectively, have forced Jordan to generate nearly all of its electricity from heavy fuels and diesel. Not only is this economically inefficient and environmentally precarious, it is costing

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<sup>2</sup> Ibid, 48-50.

<sup>3</sup> Fareedon Hartoqa, “Jordan: Renewable Energy Market,” *US Department of Commerce, US Commercial Service*, March 2015, Accessed on March 8, 2015.

<sup>4</sup> Brad Plumer, “The cost of wind and solar power keeps dropping all over the world,” *Vox*, February 5, 2015, Accessed on March 8, 2015. <http://bit.ly/1Fam7qV>.

Jordanians and their Government a fortune in subsidies. Figures 6 & 7 in the Appendix illustrate the rise in diesel imports for electricity generation and the subsequent increase in percentage of GDP spent on energy imports. Using solar energy to generate electricity, especially during peak hours, will reduce Jordan's need for diesel fuel and save the country and its energy consumers money in the long run. The economic benefits of solar energy are obvious and they alone merit greater investment. When one considers the additional environmental, political, and social benefits, Jordan's transition to an economy based on solar energy becomes what former Minister of Energy, Khaled Irani, calls "a no-brainer."<sup>5</sup>

Despite the inherent advantage of solar energy, many political, economic, and technical obstacles remain. At times, the Jordanian Government has been reluctant to promote solar, looking instead to diesel, natural gas, liquefied natural gas (LNG), nuclear, and shale oil to generate electricity. To be clear, Jordan is desperate for energy of any kind, but—as this project shows—pursuing any of these options is more time consuming, more expensive, and politically riskier than implementing existing solar energy technologies for electricity generation.

The updated *Master Strategy of Energy* published in 2007 lists having 10 percent of Jordan's energy supply come from renewables by 2020 as one of its goals.<sup>6</sup> This 10 percent benchmark would be admirable for a country with energy options, but Jordan has none. Solar energy is currently the only form of energy that Jordan can produce domestically; it is the only form of energy that can sustain Jordan's growing demand for electricity; the only form of energy with the potential to simultaneously increase economic, political, and environmental security; and the only form of energy that can be implemented in a decentralized manner, reshaping the electric grid and empowering individuals in both urban and rural communities. If solar is truly a

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<sup>5</sup> Khaled Irani, interview by Matthew Calardo, Majlis Ala3yan, Amman, Jordan, March 8, 2015.

<sup>6</sup> Ministry of Energy and Mineral Resources, *Annual Report 2013*. 25.

“no-brainer” then why has there not been a more aggressive push to integrate PV and CSP technologies in a country bereft of conventional energy resources but teeming with sunlight? What are the specific political obstacles, economic concerns, and technical issues that hinder greater solar integration in Jordan? Could it be that the benefits associated with solar are merely overstated and, in practice, PV and CSP technologies are unable to provide for more than 10 percent of Jordan’s energy mix? Or is there a lack of efficacy of governance in Jordan hindering progressive energy reforms?

This project describes Jordan’s current energy crisis, argues that greater solar energy integration is needed to meet the country’s energy demands, identifies the key obstacles to solar energy integration in Jordan, and offers suggestions for how to overcome these obstacles and move the Kingdom towards an economy based on solar. This project also provides a critical analysis of the *Updated Master Strategy of Energy Sector in Jordan*—Jordan’s energy constitution—arguing that the strategy must be amended to give solar energy a greater role if Jordan is to overcome its energy deficit.

## **Methodology**

In order to analyze Jordan’s energy industry and identify the political, economic, and technical obstacles hindering greater solar energy integration in Jordan, this research places Jordan’s present energy crisis within a larger narrative of energy reform in the Hashemite Kingdom. In particular, this research is concerned with the time period between Jordan’s first energy shock in 2003 and the present day (April 2015). This period is significant because it includes two energy shocks and the implementation of a national strategy aimed at strengthening Jordan’s energy security. As previously mentioned, Jordan’s first energy shock was brought

about by the country's dependency on a steady supply of Iraqi crude imports that, when jeopardized by the US invasion of Iraq in 2003, sent Jordan reeling. Consequently, the Master Strategy put forth in 2004 and revised in 2007 sought to mitigate future crises by increasing natural gas imports from Egypt. However, when protests erupted in Egypt in 2011 in an effort to oust then President Hosni Mubarak, natural gas exports to Jordan were disrupted, causing a second energy shock in the Kingdom. Since 2011, the situation in Jordan has only worsened due to regional conflicts and the massive influx of refugees from neighboring states. Still, Jordan has yet to revise a Master Energy Strategy from 2007 that is now woefully outdated. By looking at the period between 2003-2015, this project is able to offer a targeted, contemporary analysis on critical energy issues in Jordan.

Though there is ample literature on both solar energy technologies and the efficacy of governance in Jordan, there is hardly any material that synthesizes these two topics. Ken Butti and John Perlin's famous *A Golden Thread* offers a history of solar energy technologies and has become a touchstone for anyone interested in the subject. Additionally, Perlin's *From Space to Earth: The Story of Solar Electricity* is required reading for any college course interested in the history of solar energy. Likewise, scholars such as Glenn Robinson have written on democratic representative politics in Jordan's political sphere, arguing that the Government will implement enough surface reforms to preserve its hold on power without genuinely changing the status quo. No doubt these historical and political works were useful in understanding solar energy technologies and the pace of political progress in Jordan.<sup>7</sup> However, given the dynamism of the solar energy industry in Jordan, this project relies heavily upon contemporaneous reports from governments, NGOs, and international organizations like the World Bank.

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<sup>7</sup> Glenn E. Robinson, "Defensive Democratization in Jordan," *International Journal of Middle East Studies* 30 (1998): 387-410.



The Master Strategy of Energy Sector is the central document that provides a framework for critically analyzing energy reform in Jordan since 2003. The Master Strategy (also referred to as the “National Strategy” or simply “the strategy”) is the Magna Carta of energy in the Kingdom, and is carefully critiqued and evaluated throughout this project. Data taken from reports published by the Ministry of Energy and Mineral Resources (MEMR), the Jordan Atomic Energy Agency (JAEC), and the National Electric Power Company (NEPCO) among other government entities is used to critique the Master Strategy, as such reports contain information regarding energy supply, energy demand, and the price of energy in Jordan and are published annually. Many European companies have conducted feasibility studies on the potential for solar power in the Middle East (and the eventual export of the electricity generated from these projects to Europe), and these studies by *Deutsche Gesellschaft für Internationale Zusammenarbeit*, Kiel Institute for the World Economy, and the European Academics Science Advisory Council (EASAC), among others, are also used to evaluate the benchmarks set forth by the Master Strategy in 2007.

In addition to the historical literature, updated annual reports, and current media on the subject of solar energy, this project is bolstered by the interviews I conducted throughout my time in Jordan in March 2015. In less than two weeks, I spoke with 12 high-level stakeholders in Jordan’s energy sector, including two former ministers of energy, the Commissioner of the Energy and Minerals Regulatory Commission, the Director of the Renewable Energy Department at the Ministry of Energy and Mineral Resources, and CEOs from some of Jordan’s leading renewable energy businesses. An exhaustive list is featured in the appendix of this project. The access I was granted was remarkable, and the men and women quoted in this project are the individuals driving energy reform in Jordan in both the public and private spheres. They

are the individuals writing the legislation, installing the technologies, and researching future solutions. Their comments are what make this project unique and informative, as I do not believe this information has been synthesized in a single work before now.

As with any project, there are certain realities, or limits to my methods that should be properly recognized. Those who have a vested interest in solar energy are often the authors of current literature on the subject. As a result, some of the literature can view solar energy technologies through rose-colored glasses, often understating the technical shortcomings. To counteract this bias, I incorporated reports from corporations and ministries that promote shale, nuclear, and natural gas. Additionally, while the majority of my interviews were with proponents of solar, I also spoke with several individuals who openly lobby for shale, nuclear and natural gas over solar energy. I must note that all of these individuals were incredibly intelligent and open-minded, and that they unanimously agreed that the best situation for Jordan's future resiliency is a true "energy mix" from a variety of sources. Most of them want to see greater solar energy integration; they simply disagree on the technical capabilities and the percentage of solar needed.

My research and interviews combine to form this project, entitled *Jordan & the Solar Economy*. I borrow the concept of the "solar economy" from Herman Scheer, whose book *The Solar Economy: Renewable Energy for a Sustainable Global Future* inspired me to examine solar energy policy in Jordan. Much like Scheer's work, this project is not meant to be highly technical—I provide neither a comprehensive history of solar energy technologies nor a scientific description of the engineering behind their design. Likewise, this project is not meant to analyze the finer points of climate change. What follows is an economic and political analysis aimed at identifying key problems and putting forth relevant policy recommendations to help

address one of the most critical issues in the Hashemite Kingdom of Jordan. It is my hope that this project fills a gap in the research on solar energy policy in Jordan and—in some small way—increases understanding and support for solar energy technologies in the Hashemite Kingdom.

### **Master Strategy of Energy Sector in Jordan**

In 2007, the Jordanian Government unveiled the *Updated Master Strategy of Energy Sector in Jordan* for the period (2007-2020). The manifesto spelled out a methodology to achieve greater energy independence in Jordan by the year 2020. Specifically, the Strategy sought to “confront the challenges that impede implementation of several projects, which meet the Kingdom’s energy needs during the next stage in a way that would contribute to improving the level availability and openness of the energy market before investments and achieving the energy supply security.”<sup>8</sup> The Strategy also created a Royal Commission to identify key obstacles, update demand forecasts, and construct a sufficient regulatory framework to allow for technical, financial, and legislative progress necessary to diversify Jordan’s energy sector.

The Master Strategy was an important step towards greater energy independence in 2007, but the Middle East has experienced tumultuous changes in the past eight years. Events like the global economic downturn of 2008, the Arab uprisings of 2011, the Syrian crisis, and the rise of violent extremists like the Islamic State in Iraq and Syria have rendered Jordan’s Master Strategy from less than a decade ago obsolete by today’s standards. What is more, volatility in the global oil market (both the price surge of 2008 and the recent drop in December 2014), the falling cost

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<sup>8</sup> Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan*, 2.

of solar PV technology, and the influx of 628,427 additional Syrian refugees since 2011 all mean that the numbers forecasted by the Master Strategy in 2007 are now woefully out of date.<sup>9</sup>

The Master Strategy was and remains a positive and necessary document for energy reform in Jordan, but it must be updated to account for the aforementioned political and economic changes. For example, the 2007 Strategy relies heavily on Egyptian and Iraqi natural gas, the extraction of Jordanian oil shale, and the construction of two nuclear power plants to meet primary energy demands by 2020. If all went according to plan—that is, Egypt and Iraqi imports of natural gas increased and domestic shale and nuclear projects proceeded as scheduled—Jordan would increase the amount of energy generated by local sources from 4 percent in 2007 to 39 percent in 2020.<sup>10</sup> However, the Egyptian uprising in 2011 and the advent of the Islamic State in June 2014 disrupted existing and future natural gas supply to Jordan. In terms of nuclear energy and according to Chairman of the Jordan Atomic Energy Commission, Dr. Khaled Toukan, a contract for the two proposed nuclear power plants (each at 1,000MW) is yet to be signed. Even when the contract is finalized, Dr. Toukan told me in an interview at the Atomic Energy Agency in Jordan, “nuclear plants like these take 7 years to build.”<sup>11</sup>

Natural gas and nuclear will not hit their 2020 targets set forth by the Master Strategy, but what of oil shale? According to Dr. Mousa Ali Al-Zyoud, the Deputy Chairman of Jordan’s Energy & Minerals Regulatory Commission, shale oil projects moved from the exploratory

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<sup>9</sup> “Syria Regional Refugee Response: Jordan,” *UNHCR*, updated April 8, 2015, accessed April 12, 2015. <http://data.unhcr.org/syrianrefugees/country.php?id=107>

<sup>10</sup> Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan*, 15.

<sup>11</sup> Dr. Khaled Toukan, interview by Matthew Calardo, Jordan Atomic Energy Commission, Amman, Jordan, March 9, 2015.

phase to appraisal phase in May of 2013. Dr. Al-Zyoud said that the appraisal phase will go on for roughly 3 years, and that they “expect to have the final decision for investment in 2022.”<sup>12</sup>

My interviews with different leaders of Jordan’s energy sector revealed that the energy goals for 2020 set forth by the Updated Master Strategy in 2007 would not be met. Though underway in research, exploration, and appraising, nearly all of the proposed projects in gas, nuclear, or shale were yet to make substantive contributions to the national energy mix. Given the unique challenges of the Middle East and the difficulty in implementing energy reform in any country (let alone one that borders Syria, Iraq, and Israel), I was not particularly distressed that these projects were behind schedule and would not meet their 2020 targets. More disconcerting was the fact that renewable energy—and solar in particular—was an afterthought at best. Over and over again, from ministry to ministry (including the Renewable Energy Department at the Ministry of Energy and Renewable Resources), I was told that solar energy could not be a base-load now or at any point in the future. Moreover, my interlocutors stressed that to have solar constitute greater than 10 percent of Jordan’s national energy mix would be dangerous, as it has the potential to disrupt the electricity grid and cause blackouts. The irony is that, given the disruptions and delays to other sources of energy, as well as the evolving security situation in the region, solar is now the most reliable form of energy that Jordan can employ. In 2013, for example, Jordan generated 71% of its electricity by burning diesel and heavy fuel imports. Given that the cost of energy consumption made up greater than 25% of all of Jordan’s imports in 2013, Jordan could benefit tremendously by reducing its dependence on diesel and heavy fuels for electricity generation (See figures 6 and 7 in Appendix). In what follows, I analyze the different

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<sup>12</sup> Dr. Mousa Ali AlZyoud, interview by Matthew Calardo, Energy and Minerals Regulatory Commission, Amman, Jordan, March 10, 2015.

sources of energy that Jordan seeks to import and produce in order to meet a growing national demand for electricity. Furthermore, I determine that demand for electricity cannot be met without greater implementation of solar technologies.

## **Oil Shale**

At the end of 2014, Higher Council for Science & Technology Secretary General, Khaled Shraideh, stated that Jordan has the fifth highest quantity of oil shale reserves of any country in the world and that this would be enough to meet the Kingdom's energy needs for nearly 275 years.<sup>13</sup> The Ministry of Energy and Mineral Resources' most recent *Annual Report* from 2013 states, "Jordan is the fourth country in the world in terms of possession of oil shale sources after the United States, China, and Brazil. Where surface oil shale reserves in Jordan underlie over 70 billion tons consisting of more than 7 billion tons of oil [sic]."<sup>14</sup> The United States Energy Information Administration (EIA) agrees that "Oil shale resources have the potential to increase Jordan's reserves significantly, and the country plans to build the first oil shale-fired electricity generation facility in the Middle East after 2017."<sup>15</sup> It is clear that Jordan has substantial oil shale reserves that have tremendous potential to alleviate the Kingdom of its energy woes. However, extracting this oil and turning into fuel is both difficult and costly.

According to the EIA, "Shale is a fine-grained sedimentary rock that forms from the compaction of silt and clay-size mineral particles. Black shale contains organic material that can generate oil and natural gas, and that can also trap the generated oil and natural gas within its

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<sup>13</sup> Mohammad Ghazal, "Planned oil shale project to produce up to 40,000 barrels per day," *The Jordan Times*, November 5, 2014. Accessed April 12, 2015. <http://bit.ly/10XQR02>

<sup>14</sup> Ministry of Energy and Mineral Resources, *Annual Report 2013*. 18.

<sup>15</sup> "Jordan, Country Analysis Note," *United States Energy Information Administration (EIA)*, updated March 2014, Accessed April 12, 2015. <http://1.usa.gov/1IELOPW>.

pores.”<sup>16</sup> Shale formations often contain large amounts of natural gas and/or oil. Oil shale “can be utilized to generate electricity by direct incineration, or produce oil and gas by retort or ICP technology.”<sup>17</sup> ICP, or *in situ* conversion process, refers to a technique developed by Shell oil in the 1980s in which an oil shale field is heated onsite, releasing oil and gas from the shale rock. The oil and gas is then pumped to the surface and converted into fuel.<sup>18</sup> Shale serves as a substitute for crude oil, reduces world oil prices, and has the potential to generate jobs. However, whether through mining or ICP processes, oil shale requires a great deal of energy (and more importantly, water) to extract and convert into fuel, and its impact on the local ecology can be devastating.

Knowledge of shale formations in Jordan is not a new discovery—a 1980 article from *Science News* claims, “The oil-short Arab nation [Jordan] found an estimated 10 billion tons of oil-saturated rock in 1968,” but also that “it proved much more economical at the time simply to forget about the shale and import Saudi oil.”<sup>19</sup> The economics of shale changed when the price of Saudi oil rose and the US invasion of Iraq in 2003 disrupted the supply of Iraqi oil to Jordan. As the Master Strategy indicates, Jordan began laying the groundwork for future shale oil extraction at this time. The need for these plans became apparent when the Egyptian uprising of 2011 disrupted the flow of gas from Egypt to Jordan, and many energy stakeholders in Jordan now claim that shale and nuclear have the potential to make up the bulk of Jordan’s energy supply moving forward. The Master Strategy states, “the alternative of using oil shale for electricity

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<sup>16</sup> “Energy in Brief, Shale in the United States,” *EIA*, updated March 12, 2015. Accessed April 12, 2015. <http://1.usa.gov/1GK8scD>.

<sup>17</sup> Ministry of Energy and Mineral Resources, *Annual Report 2013*. 25

<sup>18</sup> James T. Bartis et al, *Oil Shale Development in the United States: Prospects and Policy Issues* (Santa Monica: RAND, 2005), 40, <http://bit.ly/1ap7fKU>.

<sup>19</sup> “Arabian Shale Oil,” *Science News* 117 (1980): 152, accessed April 12, 2015, stable url: <http://www.jstor.org.proxygw.wrlc.org/stable/3964921>

generation is the most economically feasible for expansion in electricity generation, whether in case of availability of unavailability of additional quantities of natural gas.”<sup>20</sup>

It is no surprise—given the government’s labeling of shale as the “most economically feasible” resource for electricity generation—that Jordan has begun research and development on a number of shale projects, granting franchise rights and signing memoranda of understanding with several domestic and international companies. A Ministry of Energy and Mineral Resources (MEMR) report from 2013 states, “Open zones of oil shale were classified in the Kingdom to work forward and award reliance to interested companies based on criteria approved by the National Resources Authority after having access to all the information and studies to areas under concession.”<sup>21</sup> This same report lists the eleven companies either operating or preparing to operate in Jordan’s shale space. The following table lists each of these eleven companies and shows the current status of their involvement:

<b>Company</b>	<b>Progress Made/ Current Status</b>
Jordan Oil Shale Company (JOSCO)	Completed prospection phase in May 2013; Drilled 30 wells within interest zone of approx. 3000 km <sup>2</sup> ; tested 61 wells for water studies with total spending of \$28.7 million; currently in evaluation phase
Oil Shale Energy Jordan (OSEJ)	Started pre-developed stage in January 2011; currently working on drilling 241 exploratory wells
Karak International Oil Company (KIO)	Began pre-development stage in September 2012; signed MoU in December 2012 to drill in Lajjun and Alna’deyah
PETROBRAS, TOTAL and KAWAR group Coalition	Submitted feasibility study; National Resources Authority urged the company to speed up process; currently studying the

<sup>20</sup> Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan*, 10.

<sup>21</sup> Ministry of Energy and Mineral Resources, *Annual Report 2013*. 43.



	financial regulations
Saudi Arabian Corp for Oil Shale (SACOS)	Signed concession agreement with Government in March 2013; agreement will be submitted to the Parliament for examination and approval
Russian INTER RAOUES Co.	MoU on the verge of being terminated due to company's unwillingness to meet requirements
Aqaba Petroleum for Oil Shale Co. (APCO)	Signed MoU in April 2009; requested extension to December 2014; currently completing feasibility studies
Jordan Oil Shale Energy Company (JOSECO)	MoU signed in April 2010; extended to April 2014
Al-Lajjun Oil Shale Company	MoU signed in September 2010 for surface distillation in Al-Lajjun and Al-Attarat; involved in direct combustion project through agreement with National Electricity Company (NEPCO), China, and UAE; shale ores were allocated to produce electricity
Global Oil Shale Holdings (GOSH)	Signed MoU in August 2012 for surface shale distillation in Sfeer El-Mahatah and Al-Attarat; company began drilling in Sfeer El-Mahattah and prepares to begin drilling in Al-Attarat
Whitehorn Resources, Inc.	Signed MoU in October 2012 for surface shale distillation in Wadi Abu Hamam; company is carrying out the requisite studies and recently began drilling in MoU region <sup>22</sup>

The above table illustrates that the oil shale industry in Jordan is quite nascent. In fact, only four of the eleven enterprises included in the 2013 Ministry report have begun drilling. The majority of these projects is still in the planning and approval phase, or has been canceled altogether. Two additional companies not featured in the 2013 annual report—Al Qamar for Energy & Infrastructure Ltd. and Enefit—signed major agreements with the Jordanian Government in 2014. An MoU states that Al Qamar has two years to conduct feasibility studies and then a contract will be signed for the company to work on extracting shale from an area of 64.3km<sup>2</sup> in the Attarat Um Ghadran region. When describing the MoU, current Minister of

<sup>22</sup> Progress based on information provided by Ministry of Energy and Mineral Resources, *Annual Report 2013*, 42- 43.

Energy in Jordan, Mohammad Hamed, claimed that the company would produce 10,000 barrels per day in 2017, gradually increasing production up to 40,000 barrels per day.<sup>23</sup> The project will not break ground until late 2016 at the earliest, and will likely not generate electricity until 2020.

*The Economist* reported in June 2014 that the Jordanian Government had reached an agreement with an Estonian company, Enefit, and its partners on a \$2.1 billion contract to build a 540MW shale-fuelled power station.<sup>24</sup> This is currently the largest oil shale project on the books in Jordan. According to Enefit’s website:

Enefit is developing two parallel oil shale projects in Jordan. Realization of these projects will help Jordan save hundreds of millions of dollars every year. The power project will substitute more expensive methods of electricity generation and shale oil will replace liquid fuels, which would otherwise be imported. The projects will use the latest and best oil shale processing technologies successfully implemented and operating in Estonia. 3,000 construction jobs and 1,000 permanent jobs will be created.<sup>25</sup>

The table below details the completed and current activities geared towards building an oil shale fired power plant with capacity of 550MW. The following information is based on data from Enefit’s website:

Completed activities	Current activities
Detailed studies regarding Attarat oil shale and groundwater resources; three deep hydrogeological wells drilled	The price of electricity has been agreed upon with the Government of Jordan

<sup>23</sup> Mohammad Ghazal, “Planned oil shale project to produce up to 40,000 barrels per day,” *The Jordan Times*, November 5, 2014, accessed on April 14, 2015, <http://bit.ly/10XQR02>.

<sup>24</sup> “Flaming rocks,” *The Economist*, June 28, 2014, accessed on April 13, 2015, <http://econ.st/1oddToJ>.

<sup>25</sup> “Jordan’s Project,” *Enefit*, accessed on April 14, 2015, <http://bit.ly/118Jv9f>.

Program for determining mine design parameters	Construction can start after the financing contracts have been signed and the due diligence has been carried out <sup>26</sup>
Extraction of large oil shale samples which have been used for pilot testing for oil and power projects	
Environmental impact studies	
Engineering, procurement and construction tender	
Mine tender	

Shale oil has tremendous potential to alleviate Jordan’s energy burden, but there are many economic and environmental risks associated with drilling, extraction, and downstream processes. Extracting oil and gas from shale is also incredibly technical, energy intensive, and time consuming. Consider the fact that Enefit has made more progress than any other company working to tap into Jordan’s shale reserves, and that the power plant project referred to above still will not be constructed until Q4 of 2016. Operation will not begin until the end of 2018 at the earliest. Enefit claims that “There is nothing more important than preserving the environment for future generations” and that the company has “extensive experience in minimizing the environmental impact of shale oil technology.”<sup>27</sup> Admittedly, Enefit has managed to cook shale cheaply and (as far as shale is concerned) “cleanly” in Estonia, but it is irresponsible to label any shale oil project “clean.” As *The Economist* writes, “Although the new methods of exploiting rock are cleaner than old ones, environmentalists still have plenty to worry about. Oil shale varies hugely in quality. Estonia’s is clean, Jordan’s has high sulphur content...digging up oil

<sup>26</sup> Data based on “Jordan’s Project,” *Enefit*, accessed on April 14, 2015, <http://bit.ly/1I8Jv9f>.

<sup>27</sup> “Environment in Jordan,” *Enefit*, accessed on April 14, 2015, <http://bit.ly/1DdtHRz>.

shale scars the landscape.”<sup>28</sup> A report by RAND also details the environmental impacts associated with shale:

“Of all the environmental impacts of oil shale development, the most serious appears to be the extent to which land will be disturbed...Oil shale operations will result in emissions that could impact regional air quality...The production of petroleum products derived from oil shale will entail significantly higher emissions of carbon dioxide, compared with conventional crude oil production...the major water quality issue is the leaching of salts and toxics from spent shale...About three barrels of water are needed per barrel of shale oil produced...”<sup>29</sup>

There are certainly major environmental drawbacks associated with extracting oil and gas from shale and converting it into fuel, but there are also economic and technical concerns that detract from shale’s appeal. In the short term, the issues are mainly with cost of production and the volatility of global crude prices. “The longer-term constraints involve resource access and water availability.”<sup>30</sup> The latter is especially important in Jordan, which according to the World Health Organization is one of the most water-poor countries per capita in the world.<sup>31</sup>

## **Natural Gas & LNG**

Jordan’s natural gas reserves are “very limited despite the exerted efforts spent by the government to develop, search, or prospect for other domestic resources through foreign

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<sup>28</sup> “Flaming rocks,” *The Economist*, June 28, 2014, accessed on April 13, 2015, <http://econ.st/1oddToJ>.

<sup>29</sup> James T. Bartis et al, *Oil Shale Development in the United States: Prospects and Policy Issues* (Santa Monica: RAND, 2005), xii-xiii, <http://bit.ly/1ap7fKU>.

<sup>30</sup> James T. Bartis et al, *Oil Shale Development in the United States: Prospects and Policy Issues* (Santa Monica: RAND, 2005), 44, <http://bit.ly/1ap7fKU>.

<sup>31</sup> “Jordan: Water is life,” The Health and Environment Linkages Initiative, *World Health Organization*, updated 2015, accessed April 14, 2015, <http://bit.ly/1PKavRV>.

companies.”<sup>32</sup> In 2007, Jordan’s Master Strategy laid out essentially three options for procuring natural gas: import natural gas from Egypt via the Arab Gas Pipeline, produce natural gas locally from Jordan’s Risha field, or look to other foreign sources like Iraq or Saudi Arabia. Eight years later, all three of these options seem to have fallen through.

Importing gas from Egypt via the Arab Gas pipeline has proven difficult. At the time that the Master Strategy was published in 2007, obstacles to the Arab Gas Pipeline option included: the high demand for natural gas within Jordan (due to a lack of other resources), the high demand for natural gas within Egypt (to avoid importing other resources at a high market price), and the fact that “the Arab gas pipeline is a regional project that services more than one country and is not earmarked only for meeting the demand for gas in the Jordanian market.”<sup>33</sup>

Making matters worse, the pipeline has historically been a magnet for terrorist attacks. On February 5, 2011, *Reuters* reported that “saboteurs blew up [part of the pipeline] that runs through Egypt’s North Sinai...disrupting flows to Israel and Jordan, after Islamists called on militants to exploit the unrest that has rocked the government.”<sup>34</sup> On April 27, 2011, the *Financial Times* reported an attack on the gas terminal near Egypt’s Israeli border that halted natural gas exports to both Israel and Jordan. the *Financial Times* noted in the same article, “The explosion on Wednesday is the second time in a month that the al-Sabil terminal near the town of el-Arish in northern Sinai has been targeted. On March 27 explosives were planted at the

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<sup>32</sup> Status of projects based on information provided by Ministry of Energy and Mineral Resources, *Annual Report 2013*, 27.

<sup>33</sup> Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan*, 4.

<sup>34</sup> Tom Perry and Edmund Blair, “Egypt gas pipeline attacked; Israel, Jordan flow hit,” *Reuters*, February 5, 2011, accessed on April 14, 2015, <http://reut.rs/1Ozr81f>.

terminal but failed to detonate.”<sup>35</sup> On July 4, 2011, *Al Jazeera* reported another attack on the pipeline at Nagah, in the Bir Abdu region. At the time of these attacks, Jordan was importing 6.8 million cubic meters of Egyptian gas every day, “accounting for 80 per cent of its electricity requirements.”<sup>36</sup> Consequently, each disruption was a significant blow to Jordan’s energy supply. Figure 3 in the appendix demonstrates the estimated revenue lost due to disruptions to Jordan’s natural gas supply from Egypt. The dollar amount in 2012 alone is more than USD 1.5 billion.

Given the insecurities associated with importing natural gas via the Arab Gas Pipeline in Egypt, the Master Strategy mentions producing natural gas locally from Jordan’s Risha field as one alternative. “It is likely to transport quantities of gas to Amman reaching up to (300) million cubic meters daily as of the beginning of 2015 in light of development of Risha gas field and attracting a strategic partner.”<sup>37</sup> Jordan will undoubtedly produce nowhere near 300 million cubic meters daily given that its strategic partner in the project, BP, bailed on the project after sinking \$240 million and drilling two exploration wells. *The Wall Street Journal* reported in January 2014, “BP found the results were too poor to continue in Jordan and will soon hand the drilling results to the country’s National Petroleum Company (NPC).”<sup>38</sup> NPC’s website provides no information on the developments in the Risha gas field after 2005, only that “At present NPC is considering partnership options with competent strategic partners with experience in tight gas

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<sup>35</sup> Heba Saleh and Vita Bekker, “Gunmen attack Egyptian gas terminal,” *The Financial Times*, April 27, 2011, accessed on April 14, 2015, <http://on.ft.com/1IbIAFh>.

<sup>36</sup> “Blast hits Egyptian gas pipeline,” *Al Jazeera*, July 4, 2011, accessed April 13, 2015, <http://bit.ly/1aS3f68>.

<sup>37</sup> Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan*, 13.

<sup>38</sup> Summer Said, “BP’s Risha Exit Means Slim Pickings for Jordan’s Energy Needs,” *The Wall Street Journal*, January 29, 2014, accessed April 15, 2015, <http://on.wsj.com/1egxu4X>.

development.”<sup>39</sup> The upshot is that the Risha field is not an option for generating gas and, consequently, electricity, for the foreseeable future.

Jordan’s third option for natural gas is to import from other foreign sources besides Egypt. The Master Strategy reads, “In view of the limited quantities of natural gas currently imported from Egypt, and in order to meet the future demand for natural gas it is inevitable to look for other foreign sources for supplying gas by importing gas from other countries like Saudi Arabia and Iraq.” The strategy purports that this natural gas could be available as early as 2015.<sup>40</sup> Little progress has been made on gas imports from Saudi Arabia, and the rise of the Islamic State has rendered natural gas imports from Iraq a literal pipedream. Al Hussein Dahya , General Manager of Turkey and Jordan for SunEdison, spoke to me about the project to import natural gas from Iraq via the Aqaba port, describing the difficulty of such a project notwithstanding the threats of terrorism. “Aqaba is really too small, they are trying to fix that but the fix won’t supply all of their need. There is no easy land route to bring it in—Israel on one side is not exactly a cooperative partner despite talk of a pipeline and Iraq and Saudi are simply too remote from where gas is being produced, so while these pipelines are possible they would take a very long time and be at very high expense.”<sup>41</sup>

One additional development in Jordan’s quest to procure natural gas from its neighbors deserves attention: Noble Energy’s discovery of large natural gas reserves in the Eastern Mediterranean. According to Noble Energy’s website, “A string of successful exploration wells offshore Israel and Cyprus has resulted in the discovery of more than 40 Tcf of new gas

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<sup>39</sup> “About NPC,” *National Petroleum Company PLC.*, updated 2005, accessed April 15, 2015. <http://www.npc.com.jo/about.html>.

<sup>40</sup> Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan*, December 2007, 13.

<sup>41</sup> Al Hussein Dahya, phone interview by Matthew Calardo, American College of Oriental Research, Amman, Jordan, March 10, 2015.

resources for this region.”<sup>42</sup> This massive discovery spurred talks between energy-hungry Jordan and Israel regarding importing large quantities of natural gas from Noble’s Leviathan and Tamar fields off the coast of Israel. In September of 2014, Israel and Jordan signed a letter of intent for the export of nearly \$15 billion of gas over a period of 15 years.<sup>43</sup> However, due to complications between Noble and the Israeli government, Jordan suspended talks with Israel, opting instead to import natural gas (albeit in much smaller quantities) from the Gaza Strip.<sup>44</sup> As of April 2015, reports indicate that Israel has approved the shipment of 66 billion cubic feet of natural gas from Tamar, but other parties within Noble and Jordan are yet to approve this deal.<sup>45</sup>

Even if a deal to import natural gas from Israel is approved, it is not without political consequence. While I was in Amman, Jordan in March 2015, a public march was organized to protest the import of Israeli gas. The march began at the Professional Associations complex in Amman and ended at the Prime Ministry at the 4<sup>th</sup> Circle. Over 27 political parties, professional associations and popular movements participated in the demonstration, according to a report by the Jordan Times.<sup>46</sup>

While Jordan will have to import natural gas in some capacity, it can reduce the amount needed by increasing the percentage of solar in the national energy mix. Karim Kavar, former Jordanian Ambassador to the United States and President of the Kavar Group is a proponent of

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<sup>42</sup> “Eastern Mediterranean,” *Noble Energy*, last updated 2015, accessed on March 15, 2015, <http://bit.ly/1DU4Ted>.

<sup>43</sup> Marissa Newmann, “Israel signs \$15 billion gas deal with Jordan,” *Times of Israel*, September 3, 2014, accessed March 15, 2015, <http://bit.ly/1qypWja>.

<sup>44</sup> “Jordan Halts Talks on \$15 Billion Deal for Israeli Gas,” *Bloomberg*, January 4, 2015, accessed March 15, 2015, <http://bloom.bg/1PrknNl>.

<sup>45</sup> Sharon Udasin, “Israel Approves Gas Export Deal with Jordan,” April 2, 2015, accessed April 10, 2015, <http://bit.ly/1Rgt7tp>.

<sup>46</sup> Merza Noghai, “Friday March Planned Against Israel Gas Deal,” *The Jordan Times*, March 4, 2015, accessed on March 5, 2015, <http://bit.ly/1M9ky02>.



solar energy, but states that reality mandates that Jordan import natural gas—from wherever possible—in order to meet energy demand:

Jordan has to diversify its energy sources and it has to look at all options *and* it has to look for lowest cost possible and at energy security. I would pay a premium for renewable energy if it contributes to energy security and reduces my reliance on foreign energy. That being said, you cannot do away with gas. Gas is the most reliable and most efficient fuel for electricity generation and it is cleaner than what Jordan has been relying on in terms of heavy fuel oil and diesel. We do need gas. Liquefied Natural Gas is one source, but what is the cost? If it is four or five times the cost of gas from Israel then, economically, Jordan should look at gas from Israel.<sup>47</sup>

When I bring up the ongoing protests and the Jordanian public's hesitation or, more accurately, indignation at the thought of relying on Israel for any resource, Ambassador Kwar responds: "Here you have the dichotomy in our society. There are people who complain about the cost of energy and want it reduced, but when you say, 'I can get you gas from Israel,' they say 'no we do not want to deal with the Israelis.' Yet, they still want cheaper gas." Ambassador Kwar also highlights the fact that Jordan is already relying on Israel for water coming from the Sea of Galilee and, consequently, importing gas should not be so controversial. According to Amb. Kwar, the Jordanian Government has handled the situation poorly from a public relations perspective. "The government should have started with Palestinian gas—which has to pass through Israel anyway since the Israelis would not let it go through the gas pipeline with Egypt—and that is again where it has been disrupted." When asked about the likelihood of gas reaching Jordan in the near future, Amb. Kwar responds: "Even if there were no legal

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<sup>47</sup> Karim Kwar, interview by Matthew Calardo, Kwar Group Headquarters, Amman, Jordan, March 8, 2015.

challenges and everything went well, it would be four years before gas can flow from Leviathan and Gaza Marine.”<sup>48</sup>

A deal with Israel would bring much-needed energy into Jordan. However, such a deal is incredibly unpopular among Jordanians and is likely to instigate further unrest. Furthermore, it would be more than four years before gas from Israel would reach Jordan. The pros and cons of such a deal must be weighed carefully before a final agreement is reached.

### **Nuclear Energy**

Nuclear energy for electricity generation is not given much attention in the Master Strategy, but since 2007 it has gained momentum among Jordanian policy makers as natural gas options wane. The strategy touches on a “nuclear alternative” in which two units at 400MW each would be in service by 2020 and 2024, respectively.

According to literature from the Jordan Atomic Energy Commission (JAEC), there are six basic forces driving the development of nuclear energy.<sup>49</sup> It is true that nuclear energy can help address many of Jordan’s energy issues, but it is not without obstacles. The following table summarizes the forces driving support for the construction of nuclear power plants and the challenges to and cons of taking on such projects.

<b>Forces Driving Development of Nuclear</b>	<b>Challenges to Development of Nuclear</b>
Increasing demand for energy	Initial conditions like the nuclear infrastructure and the capacity of regulatory body
Desire to reduce foreign dependence on energy	High investment cost, lack of financing, credit rating of Jordan

<sup>48</sup> Ibid

<sup>49</sup> Dr. Khaled Toukan, “Nuclear Energy in the Middle East: Jordan as a Case Study” (document received at Jordan Atomic Energy Commission, Amman, Jordan, March 9, 2015).

Need to diversify energy supply/ enhance the security of supply	Siting—the seismic stability, human induced hazard, and water sources
Need for cost-effective base-load generation	Questions of technology—which is best for Jordan?
Need for long term predictable electricity generation cost	Supply chain limitation
Need to protect the environment by mitigating green house gas emissions	Grid limitation
	Fuel cycle and waste management
	Legal framework
	Human capital and the need to build local capacity
	Regional security concerns

Jordan’s nuclear goals are very ambitious, and many energy stakeholders disagree over nuclear’s role in Jordan’s national energy strategy. Still, nuclear energy would certainly reduce Jordan’s dependency on diesel and heavy-fuel-generated electricity. In an interview with Dr. Khaled Toukan, Chairman of the Jordanian Atomic Energy Commission, I learned that Jordan is planning to add two 1,000MW nuclear power plants over the next two decades: “Today, we are producing almost 3GW of electricity,” Dr. Toukan said, “By the year 2020 it will rise to 6GW, so when we introduce the two new units, [nuclear] will be between 33% and 40% of the total energy mix in Jordan.”<sup>50</sup>

Jordan began construction of its first nuclear reactor in August 2010 thanks to a \$70 million loan agreement from South Korea. The Jordanian Research and Training Reactor (JRTR) was originally scheduled to be completed in March 2015, according to a report by *World Nuclear News* from 2010.<sup>51</sup> However, a document obtained from the Jordan Atomic Energy Commission

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<sup>50</sup> Ibid

<sup>51</sup> “All systems go for Jordan’s first nuclear reactor,” *World Nuclear News*, July 27, 2010, accessed on April 15, 2015, <http://bit.ly/1yqyf7W>.

in March 2015 reveals that the project is currently estimated at 78.02% complete.<sup>52</sup> To be clear, this is the *training* facility that is roughly three-fourths of the way complete. In reality, the construction of two nuclear power plants—and the point in time where those two plants can generate electricity—is unlikely to arrive any time soon.

Though Jordan is desperate for any type of energy source, many experts outside of the JAEC are uncomfortable with the idea of nuclear energy and doubt the completion of any large-scale nuclear projects in Jordan. One major concern is that nuclear power plants represent a centralized form of energy that would be susceptible to attack from hostile parties in a region increasingly besieged by violent extremism and conflict. Realistically, nuclear is too costly and time-consuming to address Jordan’s current demand for electricity. Al Hussein Dahya of SunEdison referred to the JAEC’s proposed power plants as “stuff that will never happen.”<sup>53</sup> Ala Qubain, CEO of Mustakbal Clean Tech, a Jordanian energy startup, expressed doubts as well: “I do not think nuclear energy is a viable option,” he told me during an interview in March 2015 in Amman.<sup>54</sup>

### **Introducing Solar Energy**

Thus far, I have provided an overview of the energy crisis in Jordan and analyzed three energy sources—namely, shale, natural gas, and nuclear power—proposed by the updated Master Strategy in order to shrink Jordan’s energy deficit. As the above information illustrates, projects to extract oil and gas from shale are costly, highly technical, and detrimental to the local

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<sup>52</sup> Dr. Khaled Toukan, “Nuclear Energy in the Middle East: Jordan as a Case Study” (document received at Jordan Atomic Energy Commission, Amman, Jordan, March 9, 2015).

<sup>53</sup> Al Hussein Dahya, phone interview by Matthew Calardo, American College of Oriental Research, Amman, Jordan, March 10, 2015.

<sup>54</sup> Ala Qubain, interview by Matthew Calardo, Mustakbal Headquarters, Amman, Jordan, March 9, 2015.

ecology. Shale oil is also subject to the volatility of the global crude oil market. Plans to import natural gas from Egypt and Iraq have stalled given the security situation in the Levant, and plans to import natural gas from Israel are politically unpopular and unlikely to make an immediate contribution. Nuclear power plants—though still in their earliest stages of development—would be a source of reliable, domestic energy if completed, but issues of cost, regional security, and environmental impact make nuclear a less than desirable option for improving Jordan’s energy security. Conversely, the price of electricity generated from solar energy is falling. Solar technologies are far less technical than those used in the extraction of heavy fuels or nuclear energy and, unlike shale, gas, or nuclear, solar energy is an environmentally conscious form of energy that is also in endless supply. Moreover, electricity from solar energy can be generated domestically, as Jordan has the capacity to manufacture solar technologies locally. Finally, solar can be implemented in centralized or decentralized fashions as well as in urban or rural areas, and the concepts of net metering and wheeling allow for Jordan to export excess energy to neighboring countries. In the sections that follow, I outline the current solar projects underway in Jordan, detail why these projects (and many more like them) are the best option to increase Jordan’s energy security, and explain the political, economic, and technical obstacles to solar energy in Jordan and what must be done to overcome them.

Jordan’s Master Strategy states that renewable energy should contribute to the total energy mix in Jordan “about 7% by the year 2015 and 10% by the year 2020.”<sup>55</sup> The strategy recommends that the government adopt a renewable energy law “to stimulate the private sector to increase its investments” in renewable energy, complete studies to on solar energy, expand the use of solar energy in rural areas, and to create a special fund “to aid renewable energy

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<sup>55</sup> Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan*, December 2007, 20.

projects.”<sup>56</sup> The strategy also recommends exempting from sales tax energy efficient technologies like solar water heaters.

While solar is only mentioned by name 10 times in the 26-page document (nuclear is mentioned 14 times, oil-101, and gas-105), the national strategy does lay the groundwork for Law No. (13) of 2012, or the Renewable Energy & Energy Efficiency Law (REEL)—a massive first step in moving towards greater solar energy integration in Jordan. REEL gave Jordan a regulatory framework for soliciting investment and approving contracts in the field of renewable energy. For the first time, there was a law mandating that the Ministry of Energy and Mineral Resources take tangible steps to implement renewable energy technologies:

The Ministry shall identify, in cooperation with the specialized technical bodies and centers, the geographical locations in the Kingdom of suitable nature, which demonstrate a high potential for exploiting renewable energy sources, and shall establish a priority list for the development of such locations in accordance with the Ministry’s energy sector master plan, and any other plans for the development of renewable energy sources adopted by the Ministry.<sup>57</sup>

REEL was a huge win for the (then virtually nonexistent) commercial renewable energy sector in Jordan. Private companies eager to invest in solar energy projects could now negotiate directly with the Ministry of Energy and Mineral Resources. According to an article from *Green Prophet*, a green energy news outlet that focuses on the Middle East, “Enabling developers to bypass a competitive bidding process will significantly expedite the project start-ups.”<sup>58</sup>

For homeowners and small to medium-sized businesses, REEL provided three key benefits: the establishment of net metering, the requirement of NEPCO to connect utility-scale

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<sup>56</sup>Ibid, 21.

<sup>57</sup> *The Renewable Energy and Energy Efficiency Law*, 2012, Pub. L. No. 13, Article 4, Section a.

<sup>58</sup> Laurie Balbo, “Jordan Gets REEL About Renewables,” *Green Prophet*, June 4<sup>th</sup>, 2012, <http://bit.ly/1CPJVN2>.

renewable energy projects to the grid and purchase the electricity generated from such projects, and the establishment of a REEL fund to improve financing for renewable energy projects in Jordan. Net metering is important for solar energy system owners because it allows citizens to sell excess electricity generated from their solar technologies back to the grid at full retail price. Requiring NEPCO to purchase electricity from utility-scale solar projects assures the companies who build and operate such projects that they will have a return on their investment because they have a guaranteed customer in NEPCO. Lastly, by establishing a formal legal fund for renewable energy, the Jordanian Government streamlines the process for organizations like the French Development Agency, the World Bank, and the Global Environment Fund to aid in financing solar energy projects. If the master strategy laid the foundation for solar energy integration in Jordan, REEL provided tools to attract and, more importantly, protect investments.

### **The Current State of Solar Energy in Jordan**

In order to understand the current state of solar energy in Jordan and its promising market potential, one must first identify the key stakeholders in the Jordanian electricity sector. The Ministry of Energy and Mineral Resources (MEMR), The Energy and Minerals Regulatory Commission (EMRC), and The National Electric Power Company (NEPCO). Figure 4 in the appendix illustrates the structure of Jordan's electricity sector.

The Ministry of Energy and Mineral Resources was created in 1984 and is generally charged with “administering and organizing the energy sector in a way that achieves national objectives.”<sup>59</sup> MEMR is responsible for creating the framework for the production, transmission, and distribution of electricity throughout the country. According to the Ministry's website, “The

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<sup>59</sup> “About the Ministry of Energy and Mineral Resources,” Ministry of Energy and Mineral Resources, accessed on April 21, 2015, <http://bit.ly/1DzRSGK>

most important [duty] is providing energy, in its various forms, for the development process, organizing its affairs, exchanging electric power with neighboring countries, and attracting international capital for investment in this field.”<sup>60</sup> MEMR places particular emphasis on achieving a secure and sustainable supply of energy through local sources, diversifying these sources, and liberalizing the energy market to encourage investment.

The Energy and Minerals Regulatory Commission is “a governmental body that possesses a legal personality with financial and administrative independence and is considered the legal successor of the Electricity Regulatory Commission (ERC), the Jordan Nuclear Regulatory Commission (JNRC), and the Natural Resources Authority (NRA).”<sup>61</sup> The EMRC was formed after the passage of law No. (17) in 2014, which consolidated and restructured a number of governmental institutions. The EMRC is the regulatory body of Jordan’s energy sector.

Lastly, The National Electric Power Company, or NEPCO, is “a public shareholding company owned by the Jordanian Government” that is responsible for “building, operating, and maintaining the Jordanian transmission grid.” NEPCO purchases electricity from the Jordanian generating companies, the four largest of which are: Central Electricity Generating Company (CEGCO), Samra Electric Power Generation Company (SEPGCO), and AES Jordan and Al-Qatraneh Power Generation Company, who are independent power producers (IPPs). After buying electricity from these and other generators, NEPCO transfers it to the three main private distribution operators throughout Jordan: The Jordanian Electric Power Company (JEPCO), the

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<sup>60</sup> Ibid

<sup>61</sup> “Energy and Minerals Regulatory Commission,” Energy and Minerals Regulatory Commission, last updated 2014, accessed on April 21, 2015, <http://bit.ly/1HrTEzo>.



Electricity Distribution Company (EDCO), and the Irbid District Electricity Company (IDECO).

Each distribution company services a different region of Jordan.<sup>62</sup>

The roles and responsibilities of the aforementioned stakeholders are presented in the following tables:<sup>63</sup>

#### Public Stakeholders

Organization	Roles & Responsibilities
Ministry of Energy and Mineral Resources (MEMR)	Set the framework for production, transmission and distribution of electricity
Energy and Minerals Regulatory Commission (EMRC)	Regulator, maintains legal framework for generating energy
National Electric Power Company (NEPCO)	Builds, operates, and maintains Jordan's grid; buys electricity from generators and transfers it to distributors

#### Distribution System Operators

Distributor	Areas Served
Jordanian Electric Power Company (JEPCO)	Distributes to 66% of all customers in Jordan; serves 5,000 km <sup>2</sup> (Amman, Zarqa, Madaba, and Al-Balqaa)
Electricity Distribution Company (EDCO)	Distributes to southern part of Kingdom (Aqaba, Ma'an, Karak, Tafila, Jordan Valley, Azraq, Safawi, Roywashed, and Reshah)
Irbid District Electricity Company (IDECO)	Distributes to northern part of Kingdom (Irbid, Jerash, Mafraq)

#### Electricity Generators

Generator	Operations
Central Electricity Generating Company (CEGCO)	1,669 MW, which produces 52% of the electricity in Jordan
Samra Electric Power Generation Company (SEPGCO)	Responsible for power plant in Al-Risha; has a nominal capacity of about 880 MW

<sup>62</sup> Jack Knaack et al, *Enabling PV in the MENA Region: The Emerging PV Market in Jordan* (Berlin: Deutsche Gesellschaft fur, 2014), 15.

<sup>63</sup> Ibid

AES Jordan	IPP, 380 MW
Al-Qatraneh Power	IPP, 380 MW

Understanding the stakeholders and structure of Jordan’s electricity sector is necessary in order to identify the scope and status of current solar energy projects in Jordan. Current projects take the form of Concentrated Solar Power (CSP) technologies and, more commonly, off-grid and on-grid Photovoltaic (PV) technologies. Projects vary in size from small-scale residential and commercial rooftops to utility-scale solar plants. Since the passage of REEL in 2012, the number of projects in each category has increased every year, though CSP technology is still very costly and difficult to integrate into the Jordanian grid.

The Ministry of Energy and Mineral Resources (MEMR)’s annual report from 2013 states, “In March 2013, (12) tenders were received to generate electricity using photovoltaic systems (PV) with 200MW in total [sic]” and that “An energy purchase agreement is to be approved and signed by the Cabinet of Ministers before the end of the year.”<sup>64</sup> As of March 2015, these tenders for solar energy projects are starting to bear fruit. All twelve of the projects selected signed power-purchasing agreements (PPAs) with NEPCO for 20 years.<sup>65</sup> Additionally, “All round one PV plants have received the \$0.169 per kilowatt hour feed-in tariff, apart from a 52.2 MW project that received \$0.148 per kWh.” The most telling outcome from this first round of tendering is that “The majority of round one projects are now under construction and expected to be electrified by the end of the year.”<sup>66</sup> The second round of tendering is now open and, whereas the first consisted of twelve projects of different sizes culminating in 200 MW, the

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<sup>64</sup> Ministry of Energy and Mineral Resources, *Annual Report 2013*. 43-44.

<sup>65</sup> Ilias Tsagas, “Jordan’s Solar Tender Bears Fruit,” *PV Magazine*, February 2, 2015, accessed on April 21, 2015, <http://bit.ly/1DAakis>.

<sup>66</sup> Ilias Tsagas, “Jordan’s Round Two Tender Applicants announced,” *PV Magazine*, February 25, 2015, accessed on April 21, 2015. <http://bit.ly/1DKTvoc>.

second round will be for four 50 MW PV plants. Thus, “a clear trend regarding the PV sector has emerged: each round has announced bigger but fewer projects, thus attracting large international investors but also presenting fewer market opportunities.”<sup>67</sup>

Jordan’s residential and commercial rooftop sector has exploded since the passage of REEL. As of February 2015, local reports claim that Jordan has installed over 747 residential PV systems that account for 23.4 MW. “Specifically, these systems are installed at 515 private residencies, 80 mosques, 65 businesses, 30 schools, 20 public sector buildings, nine banks, nine hospitals, eight telecommunication stations, four churches, four private universities and two farms.”<sup>68</sup>

The *MENA Solar Outlook 2015*, a report published in January 2015 by the Middle East Solar Industry Association, lists four solar projects—each in different stages of development—that are currently underway in Jordan and expected to be completed in 2015. These are depicted in the following table:

<b>Project</b>	<b>MWp</b>	<b>Project Status</b>	<b>Client</b>
RHC Grid Connected Solar Power Plant	6	In bid stage	Royal Hashemite Court
Round 2 of Direct Proposals for Renewable Energy	200	In bid stage	MEMR
Quweira PV Power Plant	65	PQ Stage	MEMR
Hashemite University Grid-Connected PV	5	In bid stage	Hashemite University <sup>69</sup>

<sup>67</sup> Ilias Tsagas, “Jordan’s Solar PV Spring,” *PV Magazine*, Special Report, January 2015, accessed April 21, 2015, <http://bit.ly/1DL1LVb>

<sup>68</sup> Ilias Tsagas, “Jordan’s Rooftop PV Sector Thriving,” *PV Magazine*, February 11, 2015, accessed April 21, 2015, <http://bit.ly/1HSxruW>

<sup>69</sup> Data compiled from “MENA Solar Outlook 2015,” *Middle East Solar Industry Association*, January 2015, accessed April 13, 2015, 8, <http://bit.ly/1E48r4g>.

## **Jordan's Energy Crisis & The Solar Economy**

Despite positive growth in the solar energy sector, Jordan is still suffering from a worsening energy crisis. The crisis is largely due to Jordan's lack of conventional natural resources, reliance on foreign imports, and the disruptions to these imports due to conflicts in Syria, Iraq and Egypt since 2003. The massive influx of refugees from the Iraq War, the Syrian crisis, and the 2014 war between Israel and Gaza, have increased Jordan's energy demand and exacerbated the already dire energy situation.

Given the lack of alternatives, Jordan has been forced to import heavy fuels from Saudi Arabia at world market prices in order to generate electricity. As a result, NEPCO is running up a huge debt on the books of the Jordanian Government. A report on Jordan's energy sector by German consulting firm *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* notes, "This has increased the costs for the generation and distribution of electricity for NEPCO to more than JD 0.146 per kWh in 2012. High generation costs from conventional power plants in combination with subsidized electricity rates for many small electricity consumers, which are down to JD 0.033 per kWh, have led to a massive deficit for NEPCO."<sup>70</sup> The total cost of crude oil consumed relative to the percentage of Jordanian GDP throughout the years 2008-2013 averages 16.78% according to NEPCO's most recent report (2013). In 2012, with Egyptian gas supply dwindling, Jordan spent greater than 20% of GDP on crude oil consumption.<sup>71</sup> Meanwhile, demand for electricity in Jordan continues to grow at an annual rate of about 2%

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<sup>70</sup> Jack Knaack et al, *Enabling PV in the MENA Region: The Emerging PV Market in Jordan* (Berlin: Deutsche Gesellschaft für, 2014), 11.

<sup>71</sup> National Electric Power Company, *Annual Report 2013*, 13.

with the total number of consumers growing 5.4% between 2012-13.<sup>72</sup> If these rises in demand continue to be met by importing crude oil, NEPCO's debt will either stay the same or increase (depending on the price of oil) as will the percentage of GDP that Jordan spends on crude oil consumption. The oil crash of December 2014 will help lower these numbers for 2014-2015, but the rises in population and electricity demand will offset the positive economic effects of the oil shock. Figures 1 and 2 in the appendix illustrate the falling price of solar compared with fossil fuels. In order to break free of the volatility of the global crude oil market in the long-term, Jordan needs to build off the positive momentum of its booming but still nascent solar industry. As the GIZ GmbH report points out, "From an economic point of view it is important for NEPCO as well as for consumers paying high prices for energy to look for cheaper alternatives of electricity supply."<sup>73</sup>

Solar PV technology is particularly useful in addressing the ongoing refugee crisis in Jordan brought about by conflicts in Syria and Iraq. Because PV technology can be implemented in a decentralized manner and is cleanly generated, it is ideal for electricity generation within large refugee camps in Jordan. Considering Zaatari refugee camp is now Jordan's second largest city, the ability to cheaply and cleanly generate electricity in these growing areas is of the utmost importance. *The National Resilience Plan 2014-2016*, drafted by the Jordanian government in response to the Syrian crisis, cites solar as an integral tool to address Jordan's ballooning refugee population. The plan calls for "Solar energy solutions for growing energy supply needs" at an investment of roughly \$66 million to mitigate the effects of the Syrian crisis.<sup>74</sup>

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<sup>72</sup> Ibid, 16-18.

<sup>73</sup> Jack Knaack et al, *Enabling PV in the MENA Region: The Emerging PV Market in Jordan* (Berlin: Deutsche Gesellschaft fur, 2014), 11.

<sup>74</sup> "Final Draft National Resilience Plan 2014-2016," *Ministry of Planning and International Cooperation*, May 8, 2014, 6.

As has been stated throughout this project, solar energy is the best option to inoculate energy cost and energy demand given its political, economic, and technical advantages. Historically, solar energy has struggled to gain a foothold due to the latter two factors, but today solar energy in Jordan makes economic sense and the technology is becoming increasingly reliable. Consider the fact that, when Abu Dhabi installed the Middle East's first large-scale solar PV plant in 2009, the installation cost was roughly \$7.00/watt. Today, the installation cost of utility-scale solar PV power plants has fallen to less than \$1.50/watt. That is a cost decrease of over 75%, making solar competitive with fossil fuel energy sources. Additionally, while the price of solar continues to fall, the cost of generating electricity from natural gas is rising.<sup>75</sup>

Following the Egyptian uprising in 2011 and the subsequent attacks on the Arab Gas Pipeline, the price of natural gas imported from Egypt skyrocketed to \$0.24/kWh in Jordan. "When solar developers approached the government and offered solar PV energy at a price that was 40% cheaper it's no surprise that Jordan jumped at the opportunity."<sup>76</sup> This opportunity was seized by the tendering of 12 solar projects accounting for nearly 300GWh of clean electricity, or enough to cleanly power 1 million Jordanian homes. The beauty of solar lies in its simplicity—it offers a competitive rate of electricity generation without being subsidized.

There is also the added economic benefit of generating jobs in the manufacturing of PV technologies. In general, electricity demand in the MENA is increasing at annual rates of 6-8%, but "the MENA region has all the right conditions for a transition to renewable energy" and "Renewable energy offers MENA countries the opportunity to create a large domestic market for heavy [renewable energy] infrastructure. This would allow MENA countries to tap their natural

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<sup>75</sup> "MENA Solar Outlook 2015," *Middle East Solar Industry Association*, January 2015, accessed April 13, 2015, 5, <http://bit.ly/1E48r4g>.

<sup>76</sup> Ibid

advantage in this sector and thereby use the investment in RE as a means to develop new industries and create new jobs.”<sup>77</sup> In my conversations with Ala Qubain, I learned that Jordan has the capability to manufacture mounting structures and cables for PV units, but that it will be a long time before Jordan can produce converters or cell modules domestically. Still, the solar energy industry has the potential to create a large number of jobs in Jordan. A report by EUMENA estimates that a €1 billion investment in PV power plant construction generates anywhere between 15,000 and 23,000 jobs in Morocco; 22,000 to 42,000 jobs in Egypt; and 1,000 to 4,000 jobs in Saudi Arabia.<sup>78</sup> Though there is no such estimate for Jordan listed in the report, one can see that the job creation potential of solar energy projects is huge across the entire MENA region.

### **The Obstacles**

As of April 2015, Jordan is behind schedule in meeting the 10% target for renewable energy by 2020. Though some attention has been given to the initial success of the aforementioned projects and their benefits, solar has played a largely insignificant role in Jordan’s total energy mix to date. Given the benefits discussed above and the worsening energy crisis in the Kingdom, it is important to analyze the political, economic, and technical obstacles sidelining solar energy integration in Jordan. This section identifies those key obstacles while the following section offers solutions for overcoming them.

From my conversations with major stakeholders in Jordan’s energy sector, it is apparent that there are many challenges that must be addressed if Jordan is to increase the percentage of

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<sup>77</sup> Philippe Bastien and Giuseppe De Beni, *The Economic Impacts of Desert Power: Socio-economic aspects of an EUMENA renewable energy transition* (Munich: Dii GmbH, 2013), accessed April 15, 2015, <http://bit.ly/1JLMju8>.

<sup>78</sup> Ibid

solar energy in the national energy mix. However, the priority of each challenge and the ability to overcome them varies greatly depending on whom one asks and where they punch the clock. The majority of my interlocutors in the Jordanian Government cited technical issues as the main obstacle, whereas members of the private sector in Jordan emphasized problems with government bureaucracy. “The reason solar hasn’t taken off for private and commercial use is because the government has made the process very cumbersome,” said Al Hussein Dahya, Manager of Business Development in Jordan for SunEdison, a global solar energy company headquartered in the United States.<sup>79</sup> “Globally, the major obstacle is that [solar energy] simply cannot be stored,” said Dr. Khaled Toukan of the Jordan Atomic Energy Commission.<sup>80</sup> “The main obstacle is the oil price,” Ziad Jibril Sabra told me at the Ministry of Energy and Mineral Resources.<sup>81</sup> Walid Shahin offered an additional explanation: “The problem is that PV is not feasible for everybody because of the tariff structure.”<sup>82</sup>

The lack of consensus amongst my informants shows that the obstacles to solar energy are many, and that they vary. Of greater interest is what these discrepancies tell us about prioritizing reforms in Jordan. What is a priority in the mind of the Ministry? What issue is most important for small business owners? For politicians? The obstacles facing greater solar energy integration in Jordan have been categorized in the following three tables (political, economic, and technical). Compiled from my research and interviews with twelve stakeholders in Jordan’s solar energy industry, these obstacles do not represent an exhaustive list. Rather, they are the

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<sup>79</sup> Al Hussein Dahya, phone interview by Matthew Calardo, American College of Oriental Research, Amman, Jordan, March 10, 2015.

<sup>80</sup> Dr. Khaled Toukan, interview by Matthew Calardo, Jordan Atomic Energy Commission, Amman, Jordan, March 9, 2015.

<sup>81</sup> Ziad Jibril Sabra, interview by Matthew Calardo, Ministry of Energy and Mineral Resources, Amman, Jordan, March 9, 2015.

<sup>82</sup> Walid Shahin, interview by Matthew Calardo, Ministry of Energy and Mineral Resources, Amman, Jordan, March 9, 2015.



*main* obstacles that were repeatedly cited in my research and in my interviews with relevant stakeholders as major roadblocks to solar power initiatives in Jordan.

### Political Obstacles

- |   |
|---|
| <ul style="list-style-type: none"><li>• Structural Issues within Government</li></ul>   |
| <ul style="list-style-type: none"><li>○ MEMR structure</li><li>○ The Minister of Energy is responsible for all of the renewable energy projects in Jordan</li><li>○ Lack of continuity—there have been 9 ministers of energy since 2008</li><li>○ Immature political parties</li><li>○ Lack of established programs and precedent</li><li>○ No champion for renewable energy in government</li><li>○ Too many bids were received in the first tendering process indicating the need for more stringent pre-qualification requirements</li></ul> |
| <ul style="list-style-type: none"><li>• Many of the regulations are unclear in practice</li><li>• Distribution companies see solar energy as an existential threat</li><li>• Lack of clarity regarding wheeling of electricity</li><li>• Massive influx of refugees</li></ul>   |

### Economic Obstacles

- |   |
|---|
| <ul style="list-style-type: none"><li>• Lack of government spending/ financial capital</li><li>• Poor performance of Fichtner Consulting Engineers Ltd.</li><li>• Need for cheap energy now</li><li>• Tariff structure for renewables favors wealthy and exacerbates gap between rich and poor</li><li>• No way to provide financeable solution to end users—business conducted on asset purchase basis</li><li>• Lack of private investment</li><li>• Lack of Jordanian investors and companies</li><li>• Lack of systematized credit</li><li>• No space for private investment with NEPCO as only purchaser of energy</li></ul> |
|---|

### Technical Obstacles

- |  |
|--|
| <ul style="list-style-type: none"><li>• Storage capacity and battery technology</li><li>• Fragility of the Jordanian grid</li><li>• Energy loss during distribution</li><li>• Lack of viable rooftop space</li></ul> |
|--|

Politically, many of the obstacles to solar energy integration are obvious. Jordan shares a border with Iraq, Syria, and Israel. Potential investors worry that the volatility of the region may cause the legal and financial framework to shift. In these cases, conflict creates confusion and confusion hurts confidence. Ziad Jibril Sabra, Director of the Renewable Energy Department at MEMR, cites political unrest in neighboring countries as one reason for delaying plans for solar. “No one was anticipating this Arab Spring and other changes in the region...look at Syria and Iraq now! To be frank, this was one of the reasons for delaying renewable development in Jordan.”<sup>83</sup> The irony is that, while violent conflict has the potential to delay any project, it actually strengthens the case for PV electricity generation in Jordan. Solar energy can be deployed in a decentralized manner in order to bring clean electricity to refugee camps. Additionally, it is difficult for adversaries to attack in comparison to large, centralized projects like nuclear power plants or natural gas pipelines. Nonetheless, the ongoing conflicts in Iraq and Syria have hindered private sector investment in Jordan and remain an apparent obstacle to energy reform.

Still, there are less obvious political obstacles—many of them structural in nature—that hinder solar energy integration. In an interview with Karim Kavar, former Ambassador to the US from Jordan and current President of the Kavar Group (one of the largest venture capital firms in Jordan), Amb. Kavar cited the structure of the Ministry of Energy and Mineral Resources as a key hurdle for solar progress:

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<sup>83</sup> Ziad Jibril Sabra, interview by Matthew Calardo, Ministry of Energy and Mineral Resources, Amman, Jordan, March 9, 2015.

Let's start with the Ministry. Having one person responsible for all of the renewable energy projects in Jordan [referring to the Minister of Energy] meant that they did not have the capacity to efficiently process many of the proposals in the first round. The government issued expression of interest, received the 64 proposals and hired a consultant. Usually you would hire a consultant before you even received the proposals. So they bring in a consultant who has not been the best consultant—again adding layers of bureaucracy.<sup>84</sup>

While having one person responsible for all of the renewable energy projects in Jordan may cause bottleneck in the Ministry, Amb. Kawar would most likely welcome any minister who remained in office longer than a year. “We are now dealing with the ninth minister since the first expression of interest was mentioned,” he said. “This means that since 2008 we have had *nine* ministers of energy.” One of these nine former ministers of energy is Khaled Irani, who cited the absence of a champion for solar in government as one potential stumbling block. “Renewable energy is an orphan within the government. If the minister is interested he or she will push, but if you do not have that engine then nothing will get done. You see in nuclear you have the whole agency working on that issue, and you need that engine to drive it and to think outside the box and see what solutions are out there.”<sup>85</sup> This speaks to the value of consistency and stability within the Ministry of Energy and Mineral resources. Impermanence can be a major obstacle to solar energy integration as each new minister brings with him/her a new agenda and a new cabinet. “If energy is truly the biggest challenge that the economy is facing today, then the most important person in government is the Minister of Energy. It is important for them to remain in this position in order to solve these problems and learn.”<sup>86</sup> When speaking with Khaled Irani, he offered that this high turnover rate is not unique to the renewable energy sector. “This is a

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<sup>84</sup> Karim Kawar, interview by Matthew Calardo, Kawar Group Headquarters, Amman, Jordan, March 8, 2015.

<sup>85</sup> Khaled Irani, interview by Matthew Calardo, Majlis Ala3yan, Amman, Jordan, March 8, 2015.

<sup>86</sup> Karim Kawar, interview by Matthew Calardo, Kawar Group Headquarters, Amman, Jordan, March 8, 2015.

frustration in all ministries, not just the energy ministry. This is a political trend in Jordan. There are always debates in Parliament. Another issue is that we do not have mature political parties and programs, so it was based on individual selection of ministers.”<sup>87</sup> Amb. Kawar admitted that it is not entirely on the Minister of Energy to address certain issues and that equally important is to have a good cabinet surrounding the Minister.

Amb. Kawar also mentioned that the consultant brought on to assist in managing the proposals, a German firm by the name of Fichtner Consulting Engineers Ltd. has not done well in helping the Ministry efficiently process the tenders for solar energy projects as dictated by REEL. In my interviews with Jordanian energy stakeholders, I often encountered this problem of cost-versus-quality related to the hiring of consultants or companies to advise, build, or operate PV projects. Amb. Kawar highlighted this issue: “This is a true problem—when the government goes through those competitive bidding processes and you select the cheapest bidder, you are not getting the best quality.”<sup>88</sup>

Another political obstacle, according to Amb. Kawar, is the pre-qualification process for issuing tenders in solar energy. He argues that the pre-qualification process should be more rigid: “If [these companies] weren’t qualified they should have eliminated them, but the government thinks the more bidders I have the more competitive the process and the lower the price gets, but this translates into a lot of time to review those proposals and to evaluate them when you do not have the expertise.”<sup>89</sup> For the first round of proposals, there were 12 different lawyers examining 12 different tenders, creating an administrative burden and a general lack of consistency.

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<sup>87</sup> Khaled Irani, interview by Matthew Calardo, Majlis Ala3yan, Amman, Jordan, March 8, 2015.

<sup>88</sup> Karim Kawar, interview by Matthew Calardo, Kawar Group Headquarters, Amman, Jordan, March 8, 2015.

<sup>89</sup> Ibid

Lastly, Amb. Kwar emphasized the need for stability of legislation. That is, once a law is issued and companies begin building solar power plants, the government should not be able to change that law without fair compensation. For example, Amb. Kwar said that the government once issued a tax exemption for all equipment that went into building renewable power plants. That exemption was removed under one law and re-instituted under another, and in this period they started charging taxes for those projects. “As developers, we always have to deal with these issues. You need to have a consistent legal framework.”<sup>90</sup>

Certain technical challenges must be overcome in order for Jordan to transition to an economy based on solar energy. Two key technical issues regarding solar energy are the current storage capacity of batteries, the state of the Jordanian grid, and the loss of energy during distribution. Speaking to the issue of grid capacity, former Minister of Energy Khaled Irani stated that NEPCO does not consider renewable energy of any kind to be a base-load energy. Hence, Jordan should not exceed the 10% renewable target by 2020 for fear of disrupting the grid. “I believe we should get out of that mentality,” Irani said. “I think there are ways to manage renewable energy. You can develop smart metering and peak tariffs, and you can encourage people to use their electricity in the day when you have cheap energy from renewables. There are many ways to harvest the benefits of renewable energies, especially solar in Jordan.”<sup>91</sup> Yet, Khaled Irani is the only government official I interviewed who expressed optimism when discussing the potential for the increasing the percentage of solar energy in the national mix. Khaled Toukan, Ziad Jibril, Walid Shahin, and Muhiedden Tawalbeg all disagree with Khaled Irani on this point. Walid Shahin is the Director of the National Energy Research Center in Jordan, and in an interview with me at the Ministry of Energy and Mineral resources he

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<sup>90</sup> Ibid

<sup>91</sup> Khaled Irani, interview by Matthew Calardo, Majlis Ala3yan, Amman, Jordan, March 8, 2015.

mentioned, “one of the problems with renewable energy is that it is not a base load. That is why you cannot go 100% renewable.”<sup>92</sup> The narrative that solar is not a base-load energy and cannot make up more than 10% of the national energy mix is deeply entrenched in the minds and rhetoric of many industry officials in government. This argument essentially unfolds as follows: The sun does not shine at night and current battery technology is inadequate for storing the electricity generated from PV during the day.

Ziad Jibril Sabra discussed a number of economic obstacles to greater solar energy integration in Jordan. Quite bluntly, he differed from the political obstacles that Khaled Irani and Karim Kawar focused on. “The main obstacle is the oil price,” Ziad said. “Because of the financial situation of the government and NEPCO, we have to get our energy from the cheapest places. We did not put much research and development into solar and wind energy because the oil prices were so cheap, and we would be getting electricity for below 15 kWh.” For Ziad, the main issue involves bridging the gap between the price of renewables and their generation cost. “The cost is the major issue in our development of renewables. We have to take the price from the cheapest resources.”<sup>93</sup> Jordan is so desperate for every drop of energy that the cheapest option almost always wins. According to Ziad, if oil or natural gas is cheaper than solar energy, then Jordan will invest in oil.

The price of solar may not be right for everybody in Jordan. Walid Shahin cites the tariff structure as a huge obstacle to lower-income Jordanian families implementing PV technologies on their homes:

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<sup>92</sup> Walid Shahin, interview by Matthew Calardo, Ministry of Energy and Mineral Resources, Amman, Jordan, March 9, 2015.

<sup>93</sup> Ziad Jibril Sabra, interview by Matthew Calardo, Ministry of Energy and Mineral Resources, Amman, Jordan, March 9, 2015.

The problem is that PV is not feasible for everybody. Because of the tariff structure in Jordan...it has different trenches. It starts with the low trenches for low-income families where you pay only very low price for the kWh up to 160 kWh. You only pay roughly 4.5 cents per kWh, so for them it doesn't make any sense to go for renewable energy. Only if you consume over 600 kWh per month then renewable energy becomes more feasible...Not everyone can go for renewable energy in Jordan. I wish this were the case because the ones with highest tariff now are the ones going to renewables and this helps support the lowest tariff, and this is going to create some problems for the electricity companies and the government some time down the line. The ones who are paying the high tariffs, they go and start installing PV to keep their costs down, and the low-income families who pay the lowest tariff are not because they cannot afford it. Down the line this will create some problems.<sup>94</sup>

This is a huge issue that must be addressed if Jordan is to reduce its dependency on diesel-generated electricity. The majority of Jordan's population cannot afford to switch to solar energy because, though much cheaper in the long run, PV technology requires a considerable front-end investment. The lack of solar financing options for low-income families makes it difficult to switch from diesel. Conversely, the tariff structure favors the large households, or wealthy families that consume more kWh of electricity per month than low-income families in smaller apartments. The more electricity consumed, the higher the feed-in tariff bracket—this incentivizes PV technology for wealthy consumers and increases their savings over time. On the other hand, there is little incentive for the poor to install PV, forcing low-income households to rely on diesel that will only become costlier over time. The tariff structure effectively drives a wedge between rich and poor, exacerbating the inequality gap over time.

### **Moving towards an Economy Based on Solar – What Must Be Done**

In *The Solar Economy*, German Parliamentarian and President of the European Association for Renewable Energy, Hermann Scheer, famously argues that a global economy

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<sup>94</sup> Walid Shahin, interview by Matthew Calardo, Ministry of Energy and Mineral Resources, Amman, Jordan, March 9, 2015.

based on the exploitation of fossil fuels will result in an environmental and economic collapse and exacerbate resource-based conflicts throughout volatile regions like the Middle East. Scheer maintains that a type of solar industrial revolution is needed if we are to avoid the future perils of an economy based on fossil fuels:

By taking hold of the visible hand of the sun and producing from sustainable resources, the world remains close to the land, and its inhabitants meet in a freer and more just environment. From riches for the few, be they individuals, companies or societies, will increasingly come wealth for all, more justly and more equally distributed. Renewable resources will bring a new era of wealth-creating economic development, initiated not by bureaucratic fiat, but by the free choices of individuals.<sup>95</sup>

For Scheer, solar energy possesses not just an environmental and social edge over fossil fuels, but an economic edge. “Fossil fuel and solar resource use are thus poles apart—not just because of the environmental effects, but also because of the fundamentally different economic logic and the differing political, social, and cultural consequences.”<sup>96</sup> Given that economics, not socio-political or environmental concerns, is often the driver of policy, this section argues for greater solar integration in Jordan based on the inherent economic advantage of solar energy technologies.

People have been developing solar energy technologies since the ancient Greeks “began designing their homes to capture winter sunlight” nearly 2,500 years ago.<sup>97</sup> When speaking with his fellow entrepreneurs Harvey Firestone and Henry Ford in 1931, Thomas Edison said, “We should be using nature’s inexhaustible sources of energy—sun, wind, and tide...I’d put my

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<sup>95</sup> Herman Scheer, *The Solar Economy: Renewable Energy for a Sustainable Global Future*, trans. Andrew Ketley (London: Earthscan, 2005), 325.

<sup>96</sup> *Ibid*, 36.

<sup>97</sup> Ken Butti and Jorn Perlin, *A Golden Thread* (Palo Alto: Chesire Books, 1980), author’s note.



money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that.”<sup>98</sup> Solar has come a long way between 2,500 years ago and now. However, the main difference between 1931 and the present is not as much about technology as it is economics. The solar bandwagon is only now gaining momentum. In 2003, the global solar industry was roughly \$5 billion. In 2013, it was \$93 billion.<sup>99</sup> In Jordan, especially, there is more work to be done.

Keeping in mind the obstacles identified above, the following three tables offer political and economic reforms that can be enacted in order to incentivize solar energy development in Jordan. The last table highlights promising new technologies and contains recommendations that could mitigate many of the technical issues surrounding solar energy:

#### Political Recommendations

- There must be a comprehensive review of the Master Energy Strategy, as it has not been revised since 2007
- The Jordanian Government needs to redefine the national energy mix to incorporate a higher percentage of solar energy—this will bring down the cost of generation, especially during peak load hours
- Encourage net metering—Jordan is one of the few countries in the world with a net metering scheme of up to 5 MW and has the potential to become a global leader in distributive generation in solar
- The Jordanian Government should draft legislation that allows for private power purchasing agreements (PPAs)
- Clarify regulations surrounding the wheeling of electricity
- Increase continuity within office of the Ministry of Energy
- Establish public-private partnerships that allow for private companies to assume the risks associated with large projects

<sup>98</sup> Thomas Edison, conversation with Henry Ford and Harvey Firestone, 1931, quoted in James Newton, *Uncommon Friends: Life with Thomas Edison, Henry Ford, Harvey Firestone, Alexis Carrel & Charles Lindbergh* (New York: Harcourt, Inc., 1987), 31.

<sup>99</sup> Jigar Shah, *Creating Climate Wealth: Unlocking the Impact Economy* (Denver: ICOSA, 2013), Kindle Edition, 32.

## Economic Recommendations

- Prioritize decentralized projects over mega-projects to create more local jobs and increase community resiliency
- Instead of subsidizing diesel for low-income households, redirect this money into a renewable energy fund, build solar projects, and wheel the energy to these homes
- Sell excess electricity generated from PV to neighboring states
- Greater investment in transmission and distribution companies and technologies
- Leverage the private sector—currently all energy projects are on the Government’s books
- Establish grants and soft loans for low-income families to cover their own consumption costs
- Extend tax breaks for renewable energy equipment

## Technical Recommendations

- Make efforts to manufacture mounting structures and cables locally
- If there is not enough space for PV installation in urban areas, produce electricity offsite and wheel it to consumers
- Invest in and employ battery storage technologies like Tesla’s “power wall”
- Move towards digitization of the grid

The most pressing issue—and the single most impactful move that the Jordanian Government can make—is to revise the Master Energy Strategy to reflect the realities of Jordan’s ongoing energy crisis. Along with this revision, there must be a greater percentage of solar energy added to the national mix. Frankly, it is the only solution with the potential for immediate implementation. Without PV technology to offset electricity costs during peak hours of the day, Jordan’s reliance on diesel-generated electricity will bankrupt NEPCO, the Government, and its citizens.

The development of net metering and wheeling technologies and legislation is also a priority. Jordan is one of the rare countries in the world that has a 5 MW cap for net metering. The ability individuals to sell excess energy back to the grid coupled with a regulatory

framework that allows them to generate electricity elsewhere and “wheel” it to their home has the power to revolutionize the grid in Jordan. If necessity is truly the mother of innovation, Jordan has the potential to become a global leader in solar innovation. Still, if this is to happen the tariff structure must be reformed to better represent low-income households. Jordan must double-down on efforts to attract investment in its nascent Renewable Energy Fund and develop additional grants to offset the cost of solar for average consumers.

Considering the main issue cited by solar’s opponents is that it cannot be stored efficiently, the global private sector must innovate on battery technologies. Battery technology like Tesla’s “power wall,” which is a revolutionary lithium ion battery with greater storage capacity for electricity generated from renewables, has the potential to render the grid obsolete in the coming decades. Tesla’s new battery was unveiled in May 2015 and will be available for purchase in Summer 2015. The point is that battery technology is quickly advancing, and it is only a matter of time before the arguments of a lack of storage capacity are obsolete. To forego research, development, and implementation of PV technologies in Jordan because the “technology is not there yet” is foolhardy, as it is only a matter of time before the technology is ready for large-scale implementation.

It is my hope that by prioritizing a revision of the national energy strategy, developing net metering and wheeling legislation, and reforming the tariff structure that Jordan will become an even riper environment for solar energy, especially with recent advances in technology.

This project has illustrated the dire energy situation in Jordan, identified the obstacles preventing greater solar energy integration, and put forth tangible policy recommendations for inoculating some (but not all) of Jordan’s ailments. It is apparent that, at the bare minimum and in its current technological state, solar energy can reduce the need for imported diesel and heavy

fuels. It is also evident that the political, economic, and social benefits of solar energy far exceed those associated with shale oil, natural gas, and nuclear. Admittedly, it is not feasible at this time for Jordan to generate 100% of its electricity from solar. An energy mix—with natural gas as a base load—is needed for increased resiliency in the short to medium-term. Still, the current percentage of solar energy in the national mix is far below where it needs to be and where it can have an optimal impact. If Jordan takes the necessary steps now, there is no reason why it cannot become a global leader in solar energy in the coming decades and one day generate all of its electricity from solar technology.

## Appendix

Figure 1<sup>100</sup>

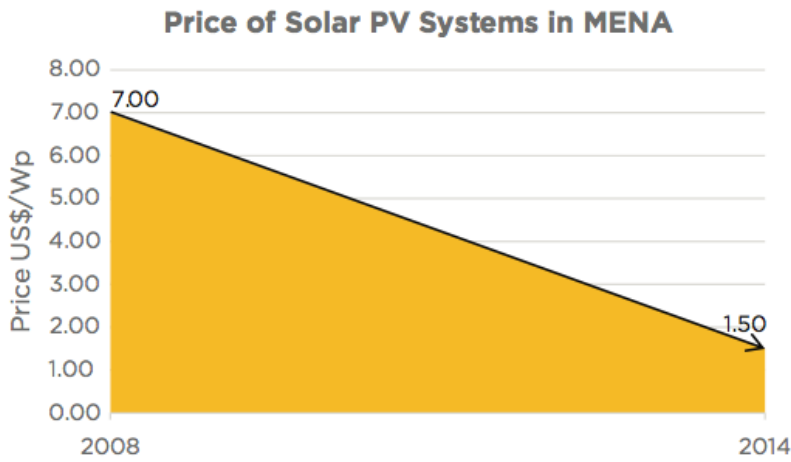


Figure 2<sup>101</sup>

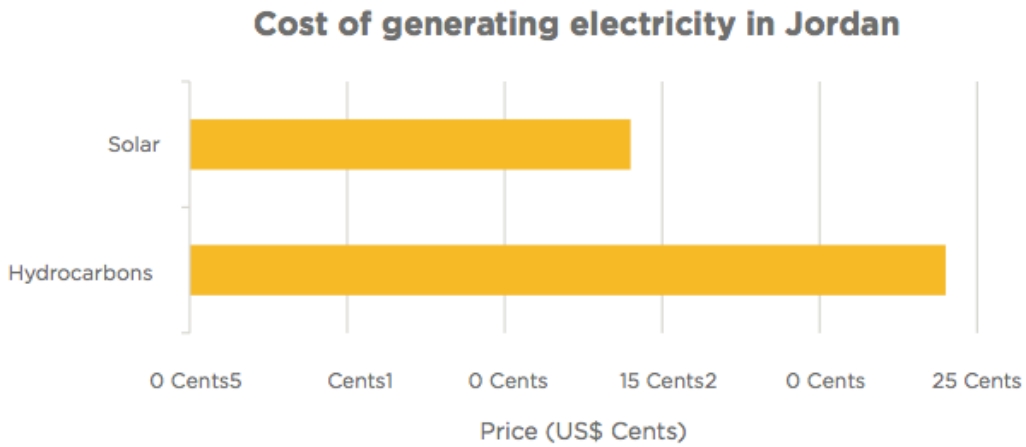
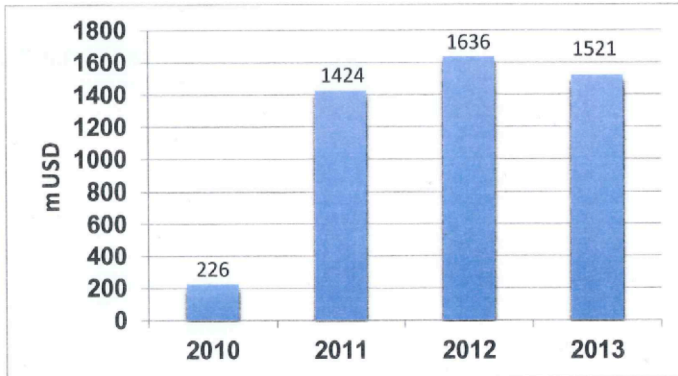


Figure 3<sup>102</sup>

<sup>100</sup> "MENA Solar Outlook 2015," *Middle East Solar Industry Association*, January 2015, accessed April 13, 2015, 5, <http://bit.ly/1E48r4g>

<sup>101</sup> "MENA Solar Outlook 2015," *Middle East Solar Industry Association*, January 2015, accessed April 13, 2015, 6, <http://bit.ly/1E48r4g>

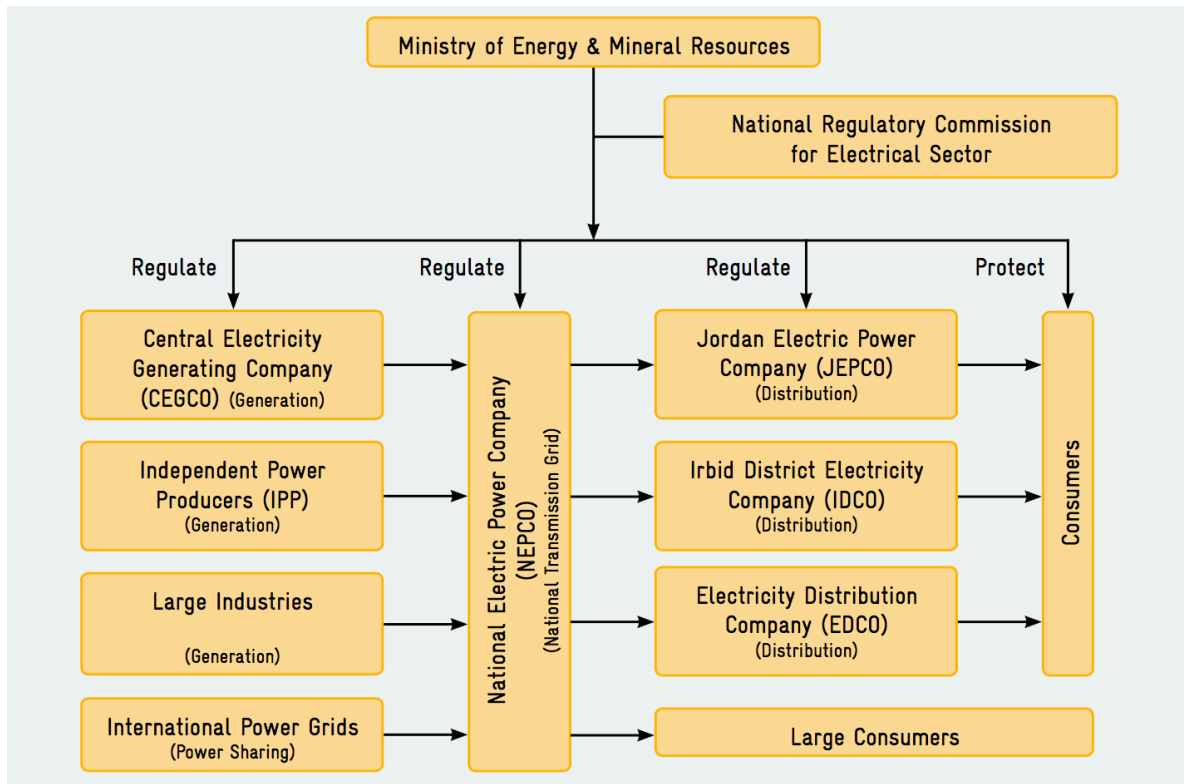
## Direct Losses Due to Natural Gas Interruptions



Jordan Atomic Energy Commission



Figure 4<sup>103</sup>

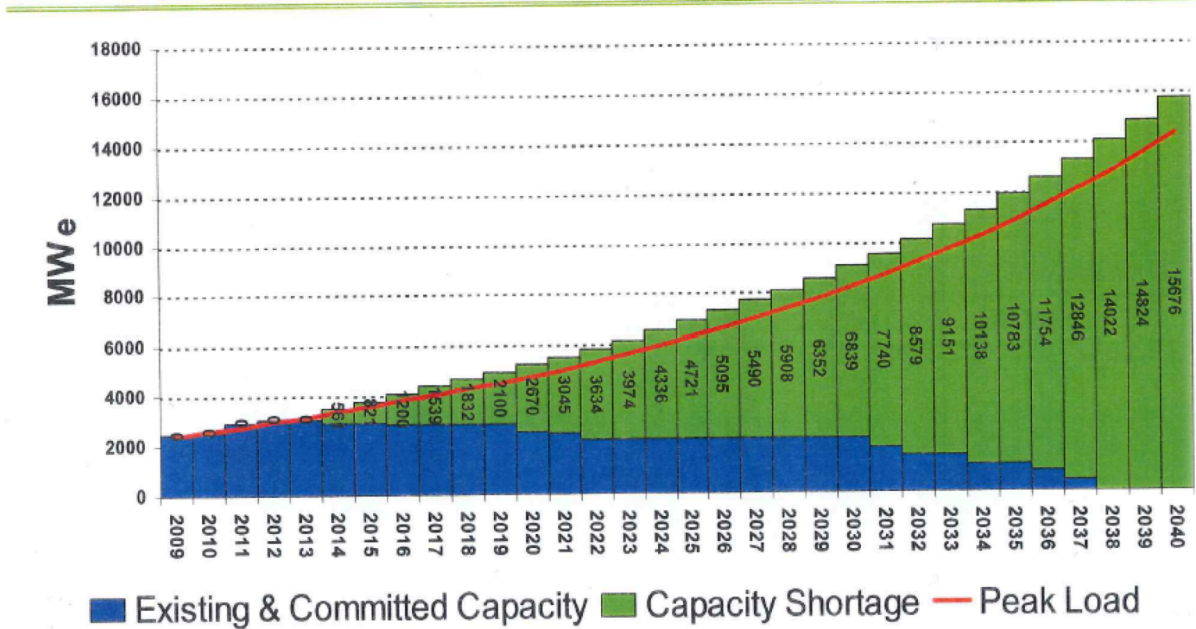


<sup>102</sup> Dr. Khaled Toukan, “Nuclear Energy in the Middle East: Jordan as a Case Study” (document received at Jordan Atomic Energy Commission, Amman, Jordan, March 9, 2015).

<sup>103</sup> Jack Knaack et al, *Enabling PV in the MENA Region: The Emerging PV Market in Jordan* (Berlin: Deutsche Gesellschaft fur, 2014), 16.

Figure 5<sup>104</sup>

## Available and Committed Capacities versus the Electricity Median Load Forecast



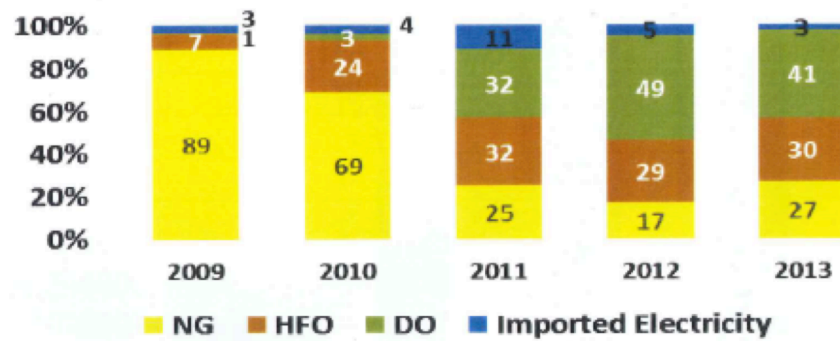
Jordan Atomic Energy Commission



<sup>104</sup> Dr. Khaled Toukan, “Nuclear Energy in the Middle East: Jordan as a Case Study” (document received at Jordan Atomic Energy Commission, Amman, Jordan, March 9, 2015).

Figure 6<sup>105</sup>

## Electricity Generated by Fuel



Jordan Atomic Energy Commission

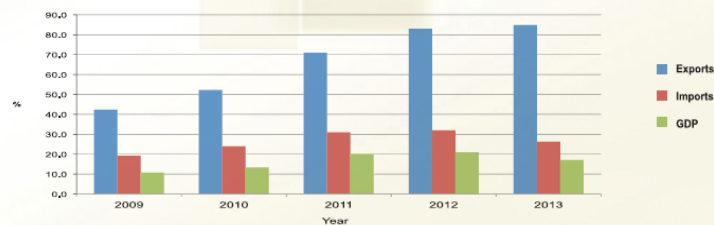


Figure 7<sup>106</sup>

## Cost of Consumed Energy

Year	Cost of Consumed Energy (Million JD)	Cost of Consumed Energy Related to		
		Exports%	Imports%	GDP%
2009	1916	42.4	19.2	10.8
2010	2603	52.2	24	13.3
2011	4019	71.0	31	20
2012	4631	82.7	31.5	21.1
2013	4076	84.8	26.3	17.1

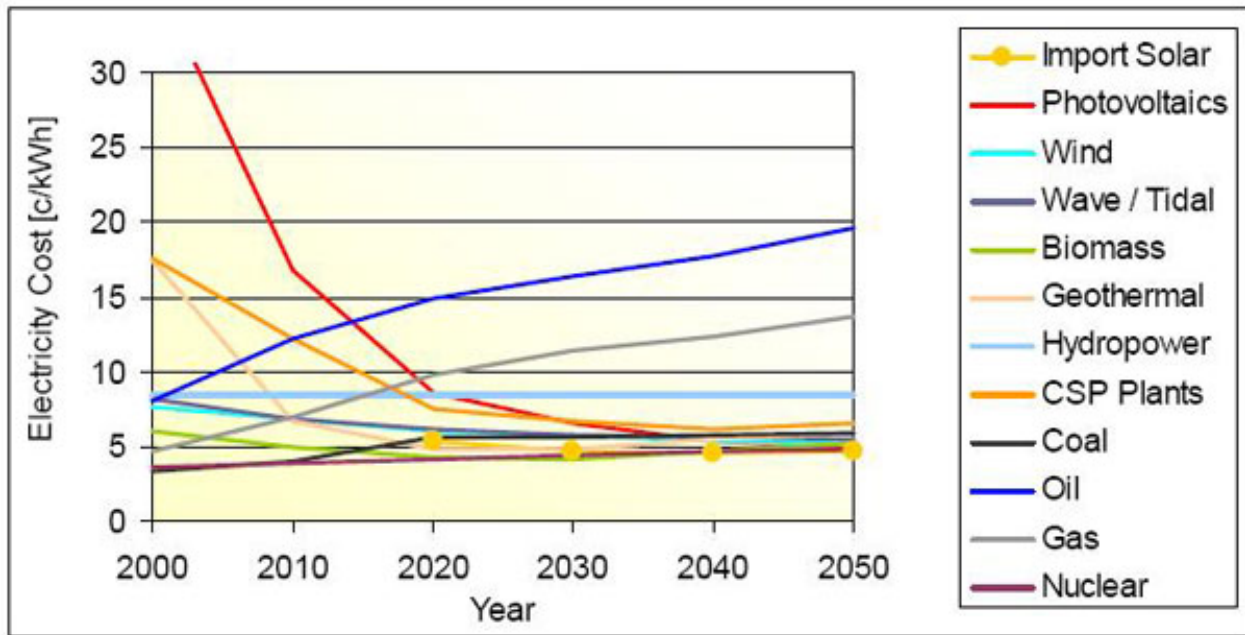
Cost of Consumed Energy as a Percentage of Exports, Imports and GDP (%)



<sup>105</sup> Ibid



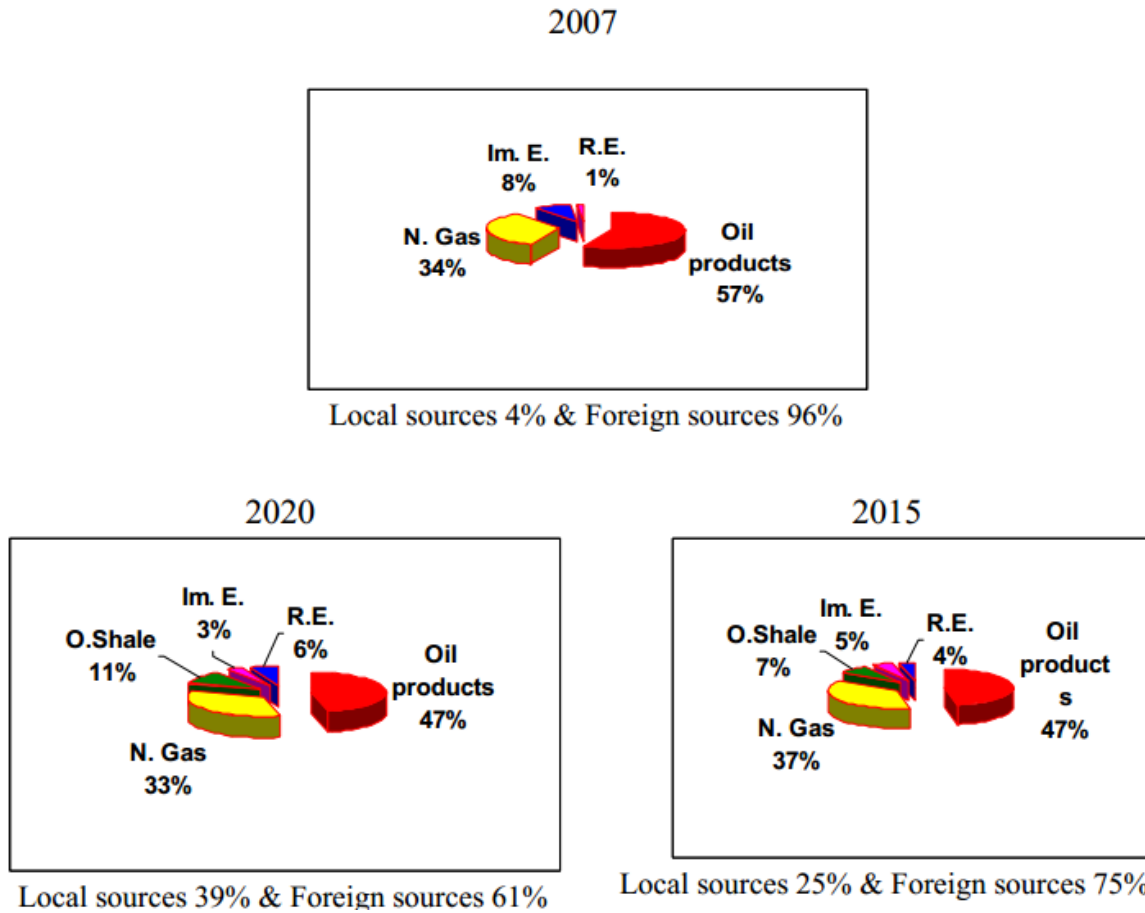
Figure 8<sup>107</sup>



<sup>106</sup> Ministry of Energy and Mineral Resources, *Brochure 2013*.

<sup>107</sup> German Aerospace Center (DLR) Institute of Technical Thermodynamics, "Putting Clean into Practice," accessed March 30, 2015. <http://bit.ly/1Edhlaq>.

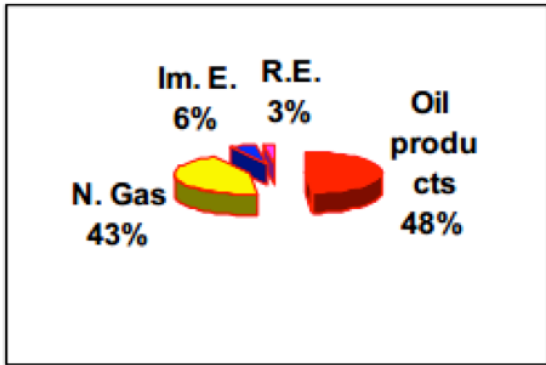
Figure 9 <sup>108</sup>



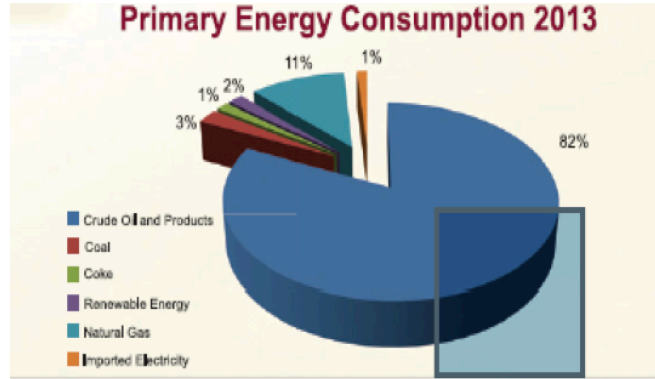
<sup>108</sup> Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan*, December 2007, 15.

Figure 10<sup>109</sup>

2012



Targets for 2012 as per 2007 Master Strategy



Actual Energy Consumption in 2013

<sup>109</sup> Ibid

List of Interviewees

**Wijdan Al Rabadi**, Commissioner, Energy & Minerals Regulatory Commission

**Dr. Mousa Ali Al Zyoud**, Deputy Chairman, Energy & Minerals Regulatory Commission

**Al-Hussein Dahya**, Business Development Manager for MENA Region, SunEdison

**Khaled Irani**, Former Minister of Energy and CEO of E2E

**Karim Kwar**, Former Ambassador to US and President of Kwar Group

**Rudain Kwar**, CEO, Kwar Group

**Johnny Miller**, Founder & CEO, Earthwell Energy Management

**Ala Qubain**, CEO, Mustakbal Clean Tech

**Ziad Jibril Sabra**, Director, Renewable Energy Department, Ministry of Energy and Mineral Resources

**Walid Shahin**, Director, National Energy Research Center

**Muhiedden Tawalbeh**, Head of Energy Efficiency & Solar Thermal Division

**Dr. Khaled Toukan**, Chairman of Commission, Jordan Atomic Energy Commission

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