

RENEWABLES & REFUGEES: A SOLUTION FOR JORDAN

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Abstract

As the Hashemite Kingdom of Jordan continues to host the third largest Syrian refugee population in the world, the state's infrastructure and its people are taking a toll. Before the war in Syria began, Jordan was already suffering from a weak economy, resource scarcity, and an enormous population boom. Since accepting nearly 2.5 million refugees, these issues have compounded year after year—nearly reaching a breaking point.

I propose an unconventional solution to some aspects of the refugee crisis: renewable energy. Renewables are cheaper than fossil fuels, consume less water in electricity generation, emit fewer greenhouse gases, and promote job creation and diversification. Better yet, Jordan has enormous potential for renewable energy, especially in solar photovoltaics (PV) and wind.

In this study, I evaluate Jordan's readiness to implement renewable energy, analyze a case study of the Za'atari refugee camp (which recently transitioned to running entirely on solar energy), and make basic projections on potential job creation and water conservation by switching from coal and natural gas to PV and wind. I find that Jordan has successfully paved the way for jumpstarting its renewable sector, Za'atari has benefitted from solar energy, and the outlook for job creation is good, and water conservation even better. There are also some smaller, indirect positive impacts that renewable energy can have on combating the Syrian refugee crisis in Jordan.

Table of Contents

List of Abbreviations	v
List of Tables & Figures	vi
I. Introduction	1
II. Framework & Literature Review	7
<i>The issues at hand in Jordan today</i>	7
<i>Environmentalism of renewable energy</i>	9
<i>Economics of renewable energy</i>	10
III. Methodology	14
IV. Analysis: RE Progress	16
V. Case Study: Za'atari	23
VI. Analysis: Basic Projections	28
<i>Job creation</i>	28
<i>Water conservation</i>	33
VII. Results	36
<i>Readiness and promotion of the RE sector by the GoJ</i>	36
<i>Za'atari's solar plant</i>	37
<i>Job creation</i>	38
<i>Water conservation</i>	40
<i>Other impacts</i>	42
VIII. Conclusions & Reflections	44
Bibliography	47
Appendix	55

List of Abbreviations

GoJ: Government of Jordan

GW: Gigawatt

GWh: Gigawatt hour

HKJ: The Hashemite Kingdom of Jordan

JC: Jordan Compact

JREEEF: Jordan Renewable Energy and Energy Efficiency Fund

JRP: Jordan Response Plan

JRPSC: Jordan Response Platform for the Syria Crisis

kW: Kilowatt

kWh: Kilowatt hour

MEMR: Ministry of Energy and Mineral Resources

MOPIC: Ministry of Planning and International Cooperation

MW: Megawatt

MWh: Megawatt hour

MWp: Megawatt peak

NEPCO: National Electric Power Company

PV: Photovoltaic

RE: Renewable energy

SRC: Syrian refugee crisis

UN: United Nations

UNHCR: United Nations High Commission for Refugees

UNRWA: United Nations Relief Works Agency

WASH: Water, sanitation, and hygiene

List of Tables & Figures

Table 1: Sustainability Rankings of Four Renewables	10
Table 2: Jordan's Energy Demand Forecast	19
Table 3: Jordan's Energy Demand Forecast (% of total)	20
Table 4: Population of Jordan's Largest Cities and Refugee Camps	24
Table 5: Planned PV and Wind Projects in Jordan, 2017	29
Table 6: Projected wind job creation in Jordan, FES model	31
Table 7: Projected PV job creation in Jordan, both models	32
Table 8: Efficiency of Electricity Generation	33
Table 9: Projected Annual Electricity Production for RE Projects	34
Table 10: Projected Annual Electricity Production for Four Resources	35
Table 11: Estimated Water Consumption for Four Resources at 991.7 MW	35
Table 12: Population and Electricity Consumption in Jordan, 2009-2018	55
Figure 1: Amman, Za'atari, and Azraq	12
Figure 2: Map of PV and Wind Projects in Jordan, 2017	30

I. Introduction

Before the outbreak of the war in neighboring Syria which would soon create one of the worst humanitarian crises in world history, Jordan was already suffering from a multitude of its own domestic issues. A combination of population growth, technological advances, and climate change has made Jordan, a once relatively water-rich state, the third most water-scarce country in the world.¹ In addition to water scarcity, Jordan is very natural resource-poor and must rely on its neighbors to import over 90 percent of its energy.² As in many other Arab countries, a majority of the population is under the age of 30. Some estimates show that the under-20 population in Jordan is as high as 60 percent.³ As youth begin to enter the workforce, the large population boom makes job competition extremely scarce—by 2011, the youth unemployment rate reached 14.5 percent.⁴ Throughout its history, the Hashemite Kingdom of Jordan has been the primary recipient of refugees in the region, hosting Palestinians since the 1940s and receiving several hundred thousand Iraqis during the insurgency in 2003. As a result, the demographics of the Kingdom have shifted substantially: Jordanian citizens are now a minority in their own country.

¹ Keith Proctor, *Tapped Out: Water Scarcity and Refugee Pressures in Jordan*, MercyCorps, 2014, 12.

² "His Majesty Speeches," Ministry of Energy and Mineral Resources, <http://www.memr.gov.jo/Pages/viewpage.aspx?pageID=206>.

³ J.O. Jaber, Fawwaz Elkarmi, Emil Alasis, and Anagnostopoulos Kostas, "Employment of renewable energy in Jordan: Current status, SWOT and problem analysis," *Renewable and Sustainable Energy Reviews* 49 (2015): 491.

⁴ Alexandra Francis, *Jordan's Refugee Crisis*, Carnegie Endowment for International Peace, 2015, 12.

Inevitably, all of these issues have worsened since the massive influx of Syrian refugees began in 2011. As of December 2018, 671,148 Syrian refugees have registered with the UNHCR in Jordan.⁵ At the 2016 Supporting Syria & the Region conference in London, King Abdullah II claimed that one in every five people in Jordan is a Syrian refugee,⁶ bringing the total to about 2 million—though his introduction to the Jordan Response Plan (an international aid agreement discussed in Sections II and IV) cites 2.5 million. Though the exact number of refugees within Jordan’s borders is unclear, it is evident that this population boom has had a tremendous impact on Jordan’s stability by worsening resource scarcity and further straining state infrastructure. The GDP growth rate is stunted, public debt is growing rapidly, and foreign direct investment has plummeted.⁷ Citizens are feeling the effects of these changes, with unemployment reaching a staggering 22 percent in 2014. These economic shortcomings have compounded into increased resentment towards Syrians, as 96 percent of surveyed Jordanians felt that the refugees were to blame for the nation’s lack of job opportunities.⁸

Resource scarcity has also worsened. Before the refugee crisis, Jordan’s natural aquifers were expected to last until 2060; now, they will likely not be functional by 2030.⁹ In the northern municipalities which host the largest numbers of Syrian refugees,

⁵ “Syrian Regional Refugee Response,” UNHCR, 2018, <https://data2.unhcr.org/en/situations/syria/location/36>.

⁶ TRT World, “King Abdullah of Jordan speaks at Syrian donor conference,” YouTube video, 6:57, 4 February 2016, <https://youtu.be/jaxihy0LVYk>.

⁷ H.K.J. Ministry of Planning and International Cooperation, *The Jordan Response Plan for the Syria Crisis 2017-2019*, <https://static1.squarespace.com/static/522c2552e4b0d3c39ccd1e00/t/5956897e78d1714f5b61f5c2/1498843547605/JRP+2017-2019+-+Full+-+%28June+30%29.pdf>, 7.

⁸ Francis, 12.

⁹ Anne Marie Baylouny, “Water Thieves or Political Catalysts? Syrian Refugees in Jordan and Lebanon,” *Middle East Policy* 25, no. 1 (2018): 108-9.

the average per capita water supply is 30 liters a day—50 liters short of the minimum requirement to satisfy basic needs.¹⁰ In Mafraq, water shortages have worsened “fourfold due to pressures from the Syrian influx.”¹¹ According to the Jordan Response Plan, household energy consumption rose 34 percent since the beginning of the conflict, but the per-capita usage actually declined 21 percent. This trend suggests that demand in general is much higher, but on an individual basis the people cannot afford their electricity needs as before. This is because most Syrian refugees live outside of camps and in host communities, squeezing entire families into small garages or other one-room accommodations.¹²

As the Syrian crisis enters its eighth year with no end in sight, the implications of these issues must be considered for Jordan’s—and the region’s—continued stability and security. Continued reliance on immediate humanitarian aid from non-governmental organizations and the United Nations is neither sufficient nor sustainable. In 2017, the UNHCR only secured 57 percent of its \$1.2 billion-dollar appeal for refugee response in Jordan, most of which went towards meeting immediate needs with food vouchers and drinking water and some long-term needs such as education.¹³ While these are important for basic survival of the refugee population, it does little to better their long-term prospects. This is especially important because refugee crises are generally becoming

¹⁰ Glada Lahn, Owen Grafham, and Adel Elsayed Sparr, *Refugees and Energy Resilience in Jordan*, Chatham House, 2016, <https://www.chathamhouse.org/publication/refugees-and-energy-resilience-jordan>, 8.

¹¹ Francis, 10.

¹² H.K.J. Ministry of Planning and International Cooperation, *The Jordan Response Plan for the Syria Crisis 2018-2020*, <https://static1.squarespace.com/static/522c2552e4b0d3c39ccd1e00/t/5ab3565f8a922d5e4a011286/1521702505515/JRP+Final+Copy+21-3.pdf>, 20.

¹³ “Regional Refugee & Resilience Plan 2017 Annual Report,” UNHCR, 2017, <https://data2.unhcr.org/en/documents/download/63530>.

“protracted situations”: 61 percent of refugees have been displaced for five or more years,¹⁴ and the UNHCR estimates that the average refugee (any, not specific to Syria) spends 17 years inside a refugee camp.¹⁵ With natural resources continuing to dwindle and populations continuing to rise, Jordan must look to other means of structural development to combat these issues and provide for both its citizens and guests.

One of the best alternative methods is developing the renewable energy sector. Renewable energy is typically considered a solution for energy cost savings and environmental degradation, not for a humanitarian crisis. However, there are several reasons to look towards renewable energy (RE) to combat this crisis, the first being that Jordan has great potential for renewables. The most common modes of renewable energy generation are solar (photovoltaic or PV), wind, hydroelectric, biomass, and geothermal. This thesis will focus primarily on a solar and wind RE approach given Jordan’s extreme water scarcity, the pollution caused by burning biomass, and the limited geographic locations suitable for geothermal energy usage. Located in the earth’s sunbelt and on hilly terrain, Jordan has the third largest non-hydropower capacity and largest photovoltaic capacity in the Middle East.¹⁶

¹⁴ Rebecca Gunning, *The Current State of Sustainable Energy Provision for Displaced Populations: An Analysis*, Chatham House, 2014, https://www.chathamhouse.org/sites/default/files/field/field_document/2014120EnergyDisplacedPopulationsGunning.pdf, 4.

¹⁵ Brita Nielsen, “Designing for multiple stakeholder interests within the humanitarian market: the case of off-grid energy devices,” *International Journal of Learning and Change* 7 no. 1-2 (2013): 50.

¹⁶ Ana V. Ibáñez Prieto, “Jordan 3rd in region in renewable energy capacity—FES,” *Jordan Times*, 23 January 2018, <http://www.jordantimes.com/news/local/jordan-3rdregion-renewable-energy-capacity-%E2%80%94-fes>; Fayez Abdulla et al., “Status of Jordan Renewable Energy Sector: Problems, Needs, and Challenges,” in *Proceedings of the Regional Collaboration Workshop on Energy Efficiency and Renewable Energy Technology*, 2004.

Renewable energy is also a sustainable alternative to traditional fossil fuels, both economically and environmentally. In fact, one study from Adam Smith International shows that “neglecting the green economy may currently cost Jordan more than 2 per cent of GDP a year in environmental degradation.”¹⁷ Jordan relied on imported heavy fuel oil as its primary energy source until the Egypt-Jordan Arab Gas Pipeline was erected in 2003. At its height in 2009, natural gas imported from Egypt provided for 91 percent of Jordan’s electricity generation; however, due to a combination of high demand, low supply, and targeted attacks during the Arab Spring, the proportion fell to 19 percent in 2012 and now the pipeline is no longer in service.¹⁸ Without domestic resource alternatives to make up for this gap in provision, the cutoff led to immediate energy shortages in the following years until Jordan secured more oil imports from Kuwait and Saudi Arabia.¹⁹ By developing its own renewable energy sector, Jordan can significantly decrease its dependence on others for energy and prevent another mass outage such as this. Developing the RE sector can also diversify the economy and promote job growth, which Jordan desperately needs. The planning, construction, management, and evaluation of solar and wind farms requires a vast array of employees, from engineers to accountants to laborers.

Environmentally speaking, it is well known that burning fossil fuels is not a sustainable option for energy and electricity production. With an exponentially growing demand due to population growth and technological advancements, current non-

¹⁷ *Study of mechanisms to incentivize the financial sector to scale up financing of green investment in Jordan*. Adam Smith International, 2013, 3.

¹⁸ Jaber et al., 495.

¹⁹ *Ibid.*, 492.

renewables are predicted to run out within the century. Burning fossil fuels is also extremely detrimental to the environment, polluting the atmosphere and precious water resources. Renewables, as their name implies, are not finite resources and produce fewer CO₂ emissions than traditional fuels.

The Hashemite Kingdom has begun advocating for renewable energy growth within the country over the past decade. King Abdullah tends to emphasize the environmentally-friendly and sustainability aspects of renewables in his speeches at climate change summits, but in reality, the interest in RE spans much further to political and economic advantages.

In this thesis, I argue that renewable energy—primarily solar and wind—can offset some of the negative effects on Jordanians and Syrians coming from the Syrian refugee crisis (SRC). It could provide more stability and independence in energy provision, create jobs, and conserve water consumption. There is also evidence that RE can indirectly better the livelihoods of both Jordanians and Syrians through improved environments for education and healthcare. If successful, Jordan's renewable energy response to the crisis can revolutionize and set the new standard for worldwide humanitarian refugee response.

II. Framework & Literature Review

The issues at hand in Jordan today

This thesis looks at the potential for renewable energy to mitigate some of the problems caused or exacerbated by the Syrian refugee crisis in Jordan. The effects of this crisis are vast, but I focus primarily on employment and natural resource consumption, because these were already large concerns for Jordan prior to the crisis and have worsened since.

The first chapter of the Jordan Response Plan for the Syria Crisis (JRP), published by the Jordanian Ministry of Planning and International Cooperation (MOPIC) in 2015 and later updated in 2017, highlights many of these issues. Jordan's pre-conflict GDP was growing at a rate of 15.2 percent annually, but now rests at just 6 percent. Public debt has grown exponentially to constitute nearly 93 percent of GDP, and foreign direct investment has decreased 42.6 percent.²⁰ The JRP also mentions increased job competition, strained health and education sectors, poor waste and water management, and large increases in energy demand.

It is important, however, to take publications from Jordanian ministries with a grain of salt—the government “consistently overstates the negative impacts of the Syrian refugee influx,”²¹ likely in attempt to secure more international funding. For example, as

²⁰ *The Jordan Response Plan for the Syria Crisis 2017-2019*, 7.

²¹ Francis, 1.

mentioned earlier, the 2018-2020 JRP states that “the total residential electricity consumption increased by 34% between 2011 and 2016 [...] while per capita consumption of electricity went down by 21% [...] demonstrating that people cannot afford the previous level of consumption.”²² However, using data from the Jordanian Ministry of Energy and Mineral Resources’ 2017 Annual Report and the Department of Statistics’ Jordan in Numbers 2017 yields different results. The total residential electricity consumption *did* increase 34 percent from 2011 to 2016, but per capita usage did *not* decrease 21 percent; in fact, it increased 4.44 percent.²³ It is unclear what data was used in the JRP to find a 21 percent decrease, as the document did not cite any sources. Detailed comparisons between the JRP’s claims and actual numbers calculated using MEMR’s data can be found in the Appendix, Table 11.

Nevertheless, these government publications do describe the increased tensions and strained infrastructure in Jordan, even if exact numbers are sometimes exaggerated. These general findings are backed up by academic publications on the SRC from Chatham House, the UNHCR, the Carnegie Endowment for International Peace, Adam Smith International, Human Rights Watch, and others.

In order to examine how Jordan can begin to solve some of these problems through renewable energy (RE), I divide my focus into two parts: (1) the environmental benefits of RE and (2) the economic benefits of RE.

²² H.K.J. Ministry of Planning and International Cooperation, *The Jordan Response Plan for the Syria Crisis 2018-2020*, <https://static1.squarespace.com/static/522c2552e4b0d3c39ccd1e00/t/5ab3565f8a922d5e4a011286/1521702505515/JRP+Final+Copy+21-3.pdf>, 20.

²³ See Appendix, Table 11.

Environmentalism of renewable energy

While looking at RE as a sustainable solution to combating the aforementioned issues, it is important to consider their environmental footprint. In general, clean renewable energy produces fewer CO₂ emissions and consumes less water than traditional fossil fuel resources. This is especially important in Jordan, which suffers from extreme water scarcity and pollution. Evans, Evans, and Strezov tested several sustainability indicators for four common renewables and two fossil fuels, such as energy efficiency, water consumption, land use, and greenhouse gas emissions. They found that on average coal and gas produced the most CO₂, followed by geothermal, PV, hydropower, and wind.²⁴ However, emissions from hydropower vary greatly depending on the location of energy generation and can be as high as geothermal emissions. As for PV and wind, most of the pollutants are emitted during the manufacturing of panels and mills, and very little while actually generating energy.²⁵ The rate of CO₂ emissions for these two also vary greatly depending on the type of materials used.

Wind and PV by far use the least amount of water. As with CO₂ emissions, most of the water in PV and wind energies is used in the manufacturing of materials, not energy production.²⁶ When it comes to energy efficiency, no other resource can compare to hydropower's 90+ percent efficiency rate. Unfortunately, hydropower is not a feasible energy alternative in Jordan on a large scale. Wind comes in second, with a similar efficiency rating to coal and gas. PV efficiency levels are the lowest, but depend greatly

²⁴ Annette Evans, Vladimir Strezov, and Tim J. Evans, "Assessment of sustainability indicators for renewable energy technologies," *Renewable and Sustainable Energy Reviews* 13 (2009): 1083.

²⁵ *Ibid.*, 1084.

²⁶ *Ibid.*, 1085.

on the type of cells installed—with higher quality products comes more efficient results.²⁷

Considering these three factors, wind and PV energy will be the best options for Jordan, environmentally. They are water-conscious, which is of utmost importance. They also produce very few greenhouse gases while still maintaining ample energy efficiency. The table below summarizes the findings from Evans’ study, ranking the sustainability of different energy sources from one to four, with the lowest score (1) being the most sustainable and the highest score (4) the least sustainable.

Table 1: Sustainability Rankings of Four Renewables²⁸

	Photovoltaics	Wind	Hydro	Geothermal
Price	4	3	1	1
CO ₂ emissions	3	1	2	4
Availability and limitations	4	2	1	3
Efficiency	4	2	1	3
Land use	1	3	4	2
Water consumption	2	1	3	4
Social impacts	2	1	4	3
Total	20	13	16	21

Economics of renewable energy

Perhaps the most immediate—and most important—effect of RE is job production. There is much discussion on exactly how many jobs the renewable sector

²⁷ Ibid.

²⁸ Ibid., 1086.

generates and how the job creation rate should best be measured. Studies show that renewable energy can produce anywhere between 1.7 to 14.7 times more jobs than traditional energy industries.²⁹ This large range is in part due to the varying number of jobs that different RE technologies produce (i.e. PV tends to create more jobs than biomass).³⁰ More importantly, however, studies tend to use two different markers for job growth, further widening the range.

Dalton and Lewis and Llera et al. discuss this in great detail. The two common measurements for RE job creation is jobs/megawatt (MW) installed in one year and jobs/cumulative MW installed.³¹ Llera et al. and Dalton discuss these two modes and both agree that the latter is the most accurate way to depict growth. The former measurement can yield a deceptively high ratio due to the large front-load job creation in manufacturing and installation, and is also “often dictated by economic climate and government policy.”³² The latter is more indicative of the realistic long-term job sustainability. One factor that is not accounted for in either ratio, however, is if the jobs are domestically or internationally-sourced. Countries that are able to manufacture all components themselves will have a higher true job creation rate than those that must import the needed materials. Another thing to consider is that not all jobs related to the RE sector directly correlate with the number of megawatts installed. For example, the number of researchers, designers, and accountants hired to develop a solar or wind farm

²⁹ E. Llera et al., “Forecasting job creation and renewable energy deployment through a value-chain approach,” *Renewable and Sustainable Energy Reviews* 21 (2013): 263.

³⁰ Rosebud Jasmine Lambert and Patricia Pereira Silva, “The challenges of determining the employment effects of renewable energy,” *Renewable and Sustainable Energy Reviews* 16 (2012): 4670, Table 2.

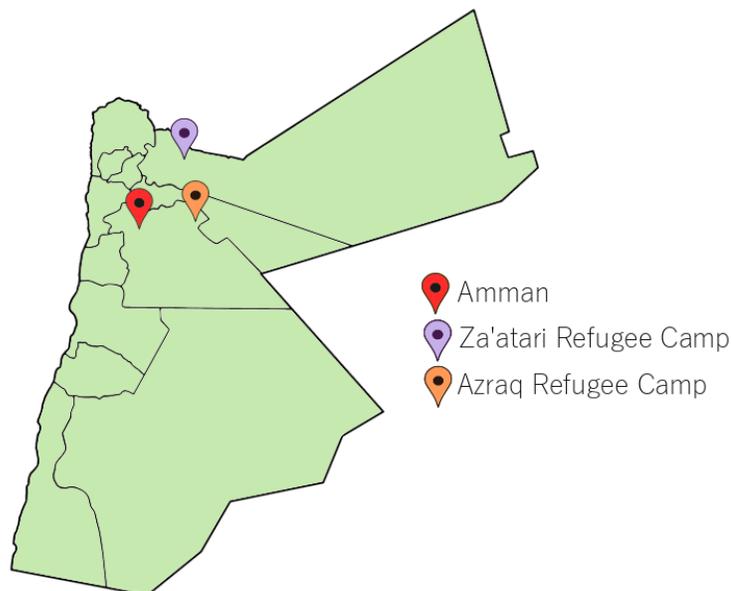
³¹ G. J. Dalton and T. Lewis, “Metrics for measuring job creation by renewable energy technologies, using Ireland as a case study,” *Renewable and Sustainable Energy Reviews* 15, no. 4 (2011): 2124.

³² *Ibid.*, 2131.

are not necessarily dependent on the number of MW installed.³³ Despite this, using jobs/total MW installed is the most accurate and stable indicator currently available. Using this indicator, solar is the largest producer of jobs in the renewable industry.³⁴

In refugee camps, data on RE job creation is limited. There are few refugee camps that have implemented large-scale renewable energy projects—in fact, Jordan was the first to do so in its Azraq and Za’atari Syrian refugee camps in 2017. Despite a lack of statistical data, preliminary findings have shown that the new RE projects have promoted some small boosts in the local camp economy.³⁵ These projects provide refugees with valuable skills that they can utilize when they assimilate into the host communities (granted they obtain a work permit) or return back home.

Figure 1: Amman, Za'atari, and Azraq



³³ Llera et al., 264.

³⁴ *A Guide to Renewable Energy in Egypt and Jordan*, Friedrich Ebert Stiftung, 2016, <https://library.fes.de/pdf-files/bueros/amman/12534.pdf>, 157.

³⁵ Lahn et. al, 23-24.

Developing the RE sector can have other positive direct and indirect effects on the local economy. The UNHCR expects to save upwards of \$5,000,000 a year in electricity costs in Za’atari alone thanks to the solar plant,³⁶ and can delegate these savings to other sectors to better the livelihoods of the residents living in the camp. Because of the increased energy sources at a lower cost, the provision of electricity in the camps has increased from eight to 12 hours a day,³⁷ allowing people to work longer hours. In the same vein, providing electricity to power streetlights can have an indirect effect on education—a number of children do not attend school because they feel unsafe walking long distances throughout the camp in the dark.³⁸

Taking into account both the environmental and economic factors of renewable energy production, PV and wind are the best options for Jordan. They consume the least amount of water, produce few greenhouse gases, are efficient at a sustainable level, promote job growth, diversify the economy, and indirectly affect people’s livelihoods in a positive way.

³⁶ “Jordan-Zaatari Refugee Camp December 2018,” UNHCR, <https://data2.unhcr.org/en/documents/download/67368>, 4.

³⁷ Ibid.

³⁸ Gunning, 2-4.

III. Methodology

To fully answer the proposed question, I conducted three separate analyses. The first questioned the feasibility of a renewable energy sector in Jordan—though there is great physical opportunity for PV and wind, what is the political outlook on this development? I listened to several of King Abdullah II’s speeches at numerous climate change and Syrian crisis response summits to assess the image that Jordan attempts to portray concerning RE. I then inspected the steps the Government of Jordan (GoJ) has taken to promote this change. Important to this analysis were the examination of annual reports and strategic plans from the Ministry of Energy and Mineral Resources (MEMR). I analyzed not only the content of the documents (i.e. the extent of RE’s presence in its future plans and goals), but also their context: is RE the main topic of future developments, or a side project? Are the documents widely available in English and Arabic? Then, I examined how Jordan has reached out on an international scale to achieve the goals it has articulated. Most important of these are the Jordan Compact and the Jordan Response Plan, two corresponding agreements with the European Union that aim to transform the setbacks of the SRC in Jordan into a development opportunity for the state. Both documents stress the need for renewables. Based on these three elements, I determined that the foundational political will for RE in Jordan is significantly developed.

Secondly, I conducted a case study of the Za’atari refugee camp in the northern Mafraq Governorate of Jordan. This was the first Syrian refugee camp established in the

Kingdom, located just 12 km from the southern border of Syria (See Figure 1). Over the years, it has become the largest Syrian refugee camp in the world and as such has been forced to better develop its infrastructure. In November 2017, a solar PV plant opened on the border of the camp that now powers the entire operation. Using UNHCR reports from their open-source online database, I outlined the effects on Za'atari and its residents since the construction and implementation of the on-site renewable energy plant. As stated in the introduction, I am most concerned with impacts on job creation, energy provision, water management, and resident livelihood. Though results are limited due to the recent nature of the plant's launch, I found some links to indirect impacts on Syrian's daily lives, such as increased school enrollment and improved health and WASH (water, sanitation, and hygiene) facilities.

Finally, to put Jordan's renewable sector to the test, I have made some basic projections based on current wind and PV projects in the country. Flanders Investment and Trade published a study in October 2017 that outlined all energy projects under construction in the Kingdom at the time. Using several different models, I estimated the potential job creation and water conservation should Jordan complete all 14 PV and wind projects listed by Flanders. Because unemployment and water sustainability are two big issues exacerbated by the SRC in Jordan, RE's potential to alleviate some of these struggles is imperative to Jordan's stability.

IV. Analysis: RE Progress

In the past decade, even before the onset of the Syrian crisis, the Jordanian government began advocating for the development of renewable energy in the country through compelling speeches at international conferences, implementing laws, and setting statewide goals and initiatives. At the 21st meeting of the UN Climate Change Conference (COP21) in 2015, King Abdullah II emphasized the global responsibility for green alternatives, the Syrian crisis, and Jordan's steps towards the future:

The subject of this conference is also the fight of our generation [...] We must act collectively, with foresight, responsibility and determination [...] Jordan is already the second water-poorest country on earth. We import more than 90 percent of our energy [...] Meantime, we remain a safe haven for refugees fleeing regional violence. Now [...] Jordan has one of the top two refugee populations per capita in the world [...] These harsh realities are why Jordan has been integrating energy and environmental approaches into a sustainable, long-term national development strategy. In 2013, we were the first in our region to produce a comprehensive, forward-looking National Climate Change Policy. In the past year alone, we have made greater strides towards energy independence and enhancing energy efficiency than in the entire life of our country.³⁹

This statement is significant, as it begins to emphasize the link between the refugee crisis and renewables as a potential solution. At the Jordan-U.S. Business Forum, a conference dedicated to facilitating business opportunities between the two states,⁴⁰ the King also said that “problems of cost and reliability mean we must diversify energy resources [...]

³⁹ “His Majesty Speeches,” Ministry of Energy and Mineral Resources.

⁴⁰ “Jordan-US Business Forum,” Embassy of Jordan, <http://jordanembassyus.org/gallery/jordan-us-business-forum>.

the first Jordan-U.S. Business Forum produced new projects in renewable energy, but there are still tremendous opportunities to be explored.”⁴¹

Jordan further projected this progressive image with the passage of Law 13 of 2012 for Renewable Energy and Energy Efficiency (Law 13). This law incentivizes investment in renewable energy in several ways. Regarding the development of a RE project, Article 5a authorizes the MEMR to issue tenders to “attract competitive proposals,”⁴² which allows the Ministry to get a good deal on investments. It also lets both foreign and domestic companies investing in renewable energy projects bypass the typically complex bidding process and instead negotiate directly with the Minister of Energy, allowing for quicker and more streamlined deals.⁴³ Article 11a removes custom duties and sales tax from all equipment and systems purchased for renewable energy projects, further decreasing the previously hefty price of investing in RE. Finally, articles 12-16 establish the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF). Domestic and international organizations with blueprints for renewable energy projects can apply for funding from the JREEEF, which is financed by the state’s general budget, returns on investments, and donations. The JREEEF would provide assistance at every level of development. Law 13 establishes the fund’s hierarchical administration, granting it significant power and independence. The JREEEF only recently became active. In May 2015, the fund had yet to be formed,⁴⁴ but the MEMR’s Annual Report 2017 mentions

⁴¹ RHC JO, “King Abdullah II Remakrs [sic] at the Second Jordan-US Business Forum,” YouTube video, 10:23, 9 March 2013, <https://youtu.be/WcY5KArexmA>.

⁴² “Renewable Energy & Energy Efficiency (Law No. 13),” International Energy Agency, 23 July 2013, <https://www.iea.org/policiesandmeasures/pams/jordan/name-36862-en.php>.

⁴³ Ibid.

⁴⁴ J.O. Jaber et. al, 498.

that the “[JREEEF’s] investment achieved JOD 50 million and created more than 200 permanent jobs.”⁴⁵

Another document published by MEMR, the Updated Master Strategy of Energy Sector in Jordan 2007-2020 (Master Strategy), also displays the government’s commitment to renewable energy. The Ministry originally composed the Master Strategy in 2004 and then updated it in 2007. This document presents the total energy mix goals for 2020, including an increase in renewable energy and oil shale. It also provides the estimated costs of constructing and running new energy projects, obstacles to success in implementing these projects, and recommendations for moving forward.

A thorough analysis exposed major errors in the document, however, revealing the inefficient and inconsistent inner workings of the Jordanian ministries and their attitudes toward meeting commitments compared to the public image of change they have promoted. The Master Strategy is somewhat difficult to follow as it has been translated from Arabic to English. Due to the translation there are some discrepancies in the exact numbers, but in general the Master Strategy calls for the share of RE in the total energy mix to increase from 2007 to 2020.⁴⁶ The table below lists the amounts (in tonnes of oil equivalent, TOE) of five different types of energy needed to achieve the “medium scenario” in 2020, though the meaning or explanation of this scenario is never given.

⁴⁵ H.K.J. Ministry of Energy and Mineral Resources, *Annual Report 2017*, <http://www.memr.gov.jo/echobusv3.0/SystemAssets/469adf39-0f2f-4d01-a72b-d394c3b56332.pdf>, 53.

⁴⁶ H.K.J. Ministry of Energy and Mineral Resources, *Updated Master Strategy of Energy Sector in Jordan for the period (2007-2020)*, <http://www.memr.gov.jo/EchoBusV3.0/SystemAssets/PDFs/EN/energystrategy.pdf>, 6-7.

Table 2: Jordan’s Energy Demand Forecast (quantities in thousand TOE) ⁴⁷

Energy Type	Year			
	2007	2010	2015	2020
Fuel oil	679	637	765	928
Diesel	1889	2174	2652	3203
Gasoline	806	928	1115	1321
LPG	364	418	510	619
Kerosene	163	186	227	274
Aircraft fuel (Avtur)	260	298	356	423
Asphalt	163	175	190	205
Natural gas (imported)	2469	3761	4335	3778
Natural gas (local)	143	65	68	0
Oil shale	0	0	976	2436
Renewable energy	107	122	745	1362
Imported electricity	533	533	533	533
Total [original]	7577	9298	1247	15084
Total [corrected]	7576	9297	12472	15082

The figures following this table in the Master Strategy portray the proportions of the energy mix in pie charts, though the numbers are incorrect. For example, the chart in the Master Strategy labels renewable energy as 6 percent of the total energy mix in 2020 in this scenario, though according to the data provided in Table 3 below it would be 9 percent.

⁴⁷ Ibid., 6.

Table 3: Jordan’s Energy Demand Forecast (% of total)

Energy Type	Year			
	2007	2010	2015	2020
Fuel oil	8.9%	6.8%	6.1%	6.2%
Diesel	24.9%	23.3%	21.3%	21.2%
Gasoline	10.6%	10%	8.9%	8.8%
LPG	4.8%	4.5%	4.1%	4.1%
Kerosene	2.2%	2%	1.8%	1.8%
Aircraft fuel (Avtur)	3.4%	3.2%	2.9%	2.8%
Asphalt	2.2%	1.9%	1.5%	1.4%
Natural gas (imported)	32.6%	40.5%	34.8%	25%
Natural gas (local)	1.9%	0.7%	0.5%	0%
Oil shale	0%	0%	7.8%	16.2%
Renewable energy	1.4%	1.3%	6%	9%
Imported electricity	7%	5.7%	4.3%	3.5%

Later, the Master Strategy provides another table listing eight different scenarios for energy production in 2020. None of the eight scenarios match the data given for the so-called “medium scenario,” and all eight list renewable energy as 10 percent of the mix. Additionally, none of the scenarios in this table add to be 100 percent. These are serious discrepancies that diminish the legitimacy of the Master Strategy. It is unclear whether these miscalculations are due to mathematical or translation errors, as the original document in Arabic is not available on the Arabic MEMR website. However, one can

presume that these errors derived from neglect rather than translation, as both languages use the same set of Arabic numerals.

Despite these flaws in numerical data, the Master Strategy does provide important information regarding the future of RE in Jordan. It reiterates the state's push towards energy alternatives by increasing percentages of renewable energy in the total energy mix every year, although new domestic oil shale projects receive the largest share of increases. It states that high investment costs and a lack of special legislation are significant barriers to the renewable sector,⁴⁸ and suggests that the government issue a law that will “stimulate the private sector to increase its investments in this domain” and create a fund to finance new RE projects.⁴⁹ The government passed Law 13 a few years later in response to these issues.

In 2015, the MOPIC published its first version of the complex Jordan Response Plan (JRP), a “bold and innovative initiative to bring together humanitarian and development programming under a common, nationally-led and resilience-based framework [...] which successfully laid the groundwork for a series of achievements that allowed the Kingdom to withstand the devastating impact of the [refugee] crisis.”⁵⁰ In this document, the ideas of renewable energy solutions and the refugee crisis begin to converge. A year before the JRP was first published, the Jordan Response Platform for the Syria Crisis (JRPSC) was established, a group of representatives from the Jordanian government, donors, international NGOs, and the UN, tasked with implementing and

⁴⁸ Ibid, 4.

⁴⁹ Ibid, 21.

⁵⁰ *The Jordan Response Plan for the Syria Crisis 2017-2019*, v.

monitoring the response plans.⁵¹ Under the authority of the JRPSC are 12 task forces, each charged with research and policy-making responsibilities for Jordan's most critical sectors throughout the Syrian crisis: education, energy, environment, food security, health, justice, livelihood, municipal services, shelter, social protection, transport, and WASH.⁵² The initial JRP struggled to obtain even a third of its annual desired funding, but was helped with the signing of the Jordan Compact (JC) in 2016. This JC was signed between the European Union and Jordan, promising the Kingdom billions of dollars in grants and loans as well as lax trade regulations on the condition that Jordan allow Syrian refugees to obtain work permits.⁵³ The three pillars of the Jordan Compact's goal are to (1) turn the Syrian refugee crisis into a development opportunity, (2) rebuild host communities by financing the JRP, and (3) mobilize grants to support Jordan's macroeconomic framework.⁵⁴ Consequently, the updated Jordan Response Plan for 2016-2018 secured 54 percent of its funding, a substantial increase.⁵⁵

Aside from some setbacks, the Jordanian government has proved overall that it is serious about revolutionizing its energy sector by passing laws, signing international agreements, and advocating for RE at large-scale public forums. In the following two sections, I highlight the changes that have occurred in Syrian refugee camps and host communities due to these pushes for renewable energy in the Kingdom.

⁵¹ Ibid., 10.

⁵² Ibid.

⁵³ "The Jordan Compact: A New Holistic Approach between the Hashemite Kingdom of Jordan and the International Community to deal with the Syrian Refugee Crisis," Ministry of Planning and International Cooperation, <http://www.mop.gov.jo/DetailsPage/NewsDetailsEN.aspx?NewsID=718>.

⁵⁴ Ibid.

⁵⁵ *The Jordan Response Plan for the Syria Crisis 2017-2019*, v.

V. Case Study: Za’atari

Za’atari, the first Syrian refugee camp in Jordan, opened July 2012 in the northeastern municipality of Mafraq. Za’atari is not only the largest refugee camp in Jordan, but is now also the largest Syrian refugee camp in the world.⁵⁶ At its peak in April 2013, Za’atari housed an astonishing 202,993 refugees⁵⁷ in an area slightly larger than 2 square miles; however, since mid-2014 the population has decreased and leveled out to around 80,000, with many refugee families opting to move into Jordanian cities or even return home to Syria.⁵⁸ The camp’s first few years were characterized by dilapidated conditions: little to no infrastructure to manage water, waste, or electricity in combination with a militant, hostile in-camp host governance and post-traumatic stress led to several protests and attacks against international humanitarian aid workers and UNHCR staff.⁵⁹ As the UNHCR struggled to keep up with the thousands of daily new arrivals, Gulf states—primarily Saudi Arabia—increased assistance to purchase semi-permanent caravans to replace the canvas tents that occupied the west side of the camp. With the provision of newer and sturdier living facilities, residents began to wire electricity to their homes, set up small shops and restaurants, and create their own internal economy

⁵⁶ “Syrian Regional Refugee Response,” UNHCR, <https://data2.unhcr.org/en/situations/syria/location/36>.

⁵⁷ Ibid.

⁵⁸ “Zaatari Refugee Camp Factsheet February 2015,” UNHCR, 2015, <https://data2.unhcr.org/en/documents/download/45767>, 1.

⁵⁹ Sakhr Al-Makhadhi, “A city emerges,” *The National*, 12 December 2013, <https://www.thenational.ae/arts-culture/a-city-emerges-1.252218#full>.

financed by vouchers and donated relief items.⁶⁰ At its height in 2013, the Za’atari refugee camp had become Jordan’s fifth largest city.

Table 4: Population of Jordan's Largest Cities and Refugee Camps

City	Population ⁶¹
Amman	1,812,059
Zarqa	635,160
Irbid	502,714
Russeifa	472,604
<i>Al Quwaysimah*</i>	296,763
<i>Tila al-Ali*</i>	251,000
<i>Wadi al-Seer*</i>	241,830
Za’atari Refugee Camp	202,993
<i>Jubeiha*</i>	197,160
<i>Khraiba al-Souq*</i>	186,158

**These were listed as cities in the dataset but are typically regarded as part of the capital city Amman, making the Za’atari refugee camp the fifth, not eighth, largest city.*

Now, the camp has progressed and adapted to become a permanent fixture. A 2017 UNHCR survey revealed that 73 percent of Syrian refugees have “no intention to return [to Syria] in the next 12 months.”⁶² Amidst all the immediate humanitarian needs that the UNHCR must address on a daily basis—providing water, food, and health services—they were also growing increasingly concerned about the makeshift infrastructure of the camp. One of the most pressing issues was electricity: the UN was spending upwards of \$1M USD a month to provide electricity to caravans and tents in

⁶⁰ Alison Ledwith, *Zaatari: The Instant City*, Boston: Affordable Housing Institute, 2014, 10-26.

⁶¹ “Jordan: Governorates, Major Cities & Urban Localities,” <http://www.citypopulation.de/Jordan-Cities.html>.

⁶² “Syrian refugees in Jordan, A protection overview,” Jordan INGO Forum, 2018, <http://testsite.jordaningoforum.org/wp-content/uploads/JIF-ProtectionBrief-2017-Final.pdf>, 16.

Za’atari. In order to alleviate spending, they limited electricity to run only eight hours a day between the hours of 6pm and 2am,⁶³ reducing costs to \$500,000 USD a month during the summer and \$700,000 USD a month during the winter.⁶⁴ The upkeep and monitoring of electricity usage was nearly impossible to manage. By 2013, 73 percent of households had illegally wired a private connection to their homes from the public streetlight grid. Tangled messes of makeshift wiring hookups made maintenance extremely difficult and created a major fire hazard, which proved to be critical in the winter months that brought flooding and electricity outages. Accurate data on per-capita energy usage is limited because each electricity meter was split between seven buildings each.⁶⁵

In response to the growing energy crisis, the construction of a solar PV power plant on the border of the camp began in April 2017. The \$17.5M project funded by the German government⁶⁶ is actually the second refugee camp in the world to be run on renewable energy—the Azraq refugee camp located about 30 miles southeast was the first. With a peak capacity of 12.9 MW an hour under ideal conditions, the 40,000 solar panels can now provide 12 to 14 hours of electricity every day to every single residential building in Za’atari.⁶⁷ With this provision, each household in Za’atari can use

⁶³ Taylor Luck, “World’s biggest solar power plant for a refugee camp opens in Zaatari,” *The National*, 13 November 2017, <https://www.thenational.ae/world/mena/worlds-biggest-solar-power-plant-for-a-refugee-camp-opens-in-zaatari-1.675484>.

⁶⁴ Ledwith, 32.

⁶⁵ *Ibid.*, 30.

⁶⁶ Marwa Hashem, “Jordan’s Za’atari camp goes green with new solar plant,” *UNHCR*, 14 November 2017, <https://www.unhcr.org/news/latest/2017/11/5a0ab9854/jordans-zaatari-campgreen-new-solar-plant.html>.

⁶⁷ “Electrification Factsheet Zaatari Camp - Jordan,” UNHCR, 2018, <https://data2.unhcr.org/en/documents/download/64899>.

approximately 936 kWh annually; in comparison, the average individual living in Jordan outside of the camps will consume 1,244 kWh a year.⁶⁸

For the UNHCR, this means significant savings for a desperately underfunded budget. The organization expects to save \$5M each year in energy costs, resulting in an 80 percent savings.⁶⁹ The plant's production has also provided new job opportunities for both Jordanians and in-camp refugees. 38 percent of the plant was constructed by camp residents,⁷⁰ and the Jordanian National Electric Power Company (NEPCO) and the Japan International Cooperation Agency (JICA) expect to train another 200 refugees to wire new connections, make repairs, and maintain aspects of the solar plant.⁷¹ These are valued skills that trainees can continue to use inside and outside of the camp. Additionally, the plant will also improve Za'atari's carbon footprint by reducing CO₂ emissions by 15,600 tons a year.

Though the solar plant only recently opened, the residents can already expect to see the impact of some of its benefits to the community. With more electricity per day, residents can keep shops and restaurants open longer, increasing their revenues. The ability to keep the lights on for extended amounts of time is particularly important for the 20 percent of women who are head of the household⁷² and for those who depend on creating handmade goods at home as a main source of income. In general, the ability to power the 2,600 streetlights in the camp at all hours of the night will help to increase

⁶⁸ See Appendix, Table 11.

⁶⁹ "Electrification Factsheet Zaatari Camp – Jordan," UNHCR.

⁷⁰ Ibid.

⁷¹ "UNHCR and JICA launch Electricity Training programme for Syrian Refugees in Zaatari Refugee Camp," Japan International Cooperation Agency, 2 August 2016, https://www.jica.go.jp/english/news/press/2016/160802_01.html.

⁷² "Jordan - Zaatari Refugee Camp December 2018," UNHCR.

safety and mitigate crime. A week after the project was completed, the UNHCR conducted a news report in which they interviewed several residents about the solar plant. One mother said it would “keep her children healthy and safe,” citing that because she had to wash clothes at night, they would not dry properly overnight and often made her family sick.⁷³ One child said that with more electricity he will be able to complete his homework and study for school.⁷⁴ Another interviewee who worked on the construction of the solar plant said the technical skills he gained in doing so led to him landing a job in the renewable sector outside of the camp.⁷⁵ In 2012, Practical Action outlined several livelihood standards that are directly linked to energy and electricity consumption, such as light hours per day, cooking and water heating, space heating and cooling, and information and communication technologies.⁷⁶ Electricity can also be directly tied to health, as WASH facilities need water heaters for showering and clinics require adequate technologies to keep vaccines and medications cool.⁷⁷ With an increase in electricity provision in the refugee camps, residents can benefit from improvements in some of these areas.

⁷³ Hashem, “Jordan’s Za’atari camp goes green.”

⁷⁴ Ibid.

⁷⁵ Ibid.

⁷⁶ Gunning, 8.

⁷⁷ Ibid., 5.

VI. Analysis: Basic Projections

Job creation

The previous sections have shown that the Jordanian government has created an environment encouraging RE development and that RE technologies have improved the livelihoods of Syrians living in the Za’atari refugee camp in northern Jordan. This section broadens the scope to a national scale. Here, I have calculated projections on job creation and water conservation based on the construction of the 14 largest wind and solar PV projects under construction or planned for Jordan as of October 2017. The following table outlines the projects’ capacity in megawatts (MW) and Figure 2 shows their locations.

Table 5: Planned PV and Wind Projects in Jordan, 2017⁷⁸

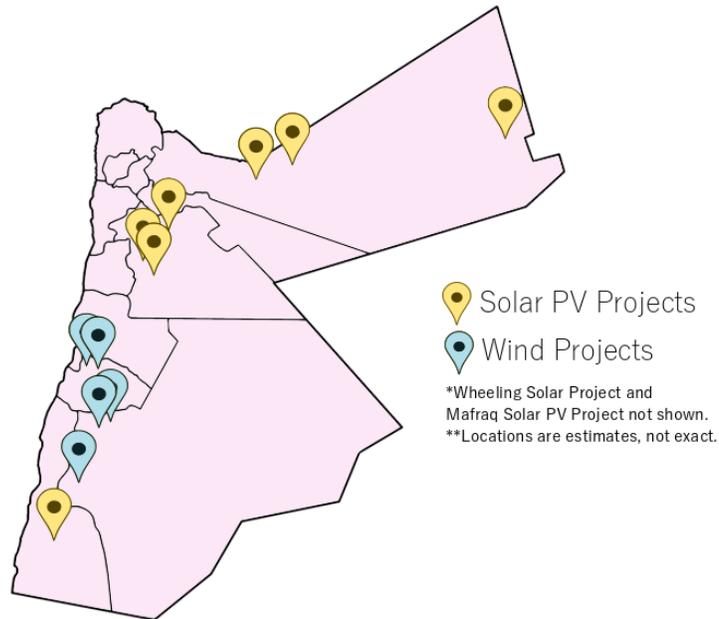
Name	Type	Governorate	Capacity (MW)
Al Quweira Solar Plant	PV	Aqaba	103
Al Safawi Solar PV Project	PV	Mafraq	51
Baynouna Solar Energy Project	PV	Amman	200
FRV Al Mafraq Solar PV Projects (2)	PV	Mafraq	133.4
King's Academy Solar Power Plant	PV	Amman	2.6
Mafraq Solar PV Project	PV	Mafraq	60.3
Risha Solar Energy Project	PV	Mafraq	61.3
South Amman Solar Power Project	PV	Amman	30
Wheeling Solar Project	PV	Unknown	34
Al-Rafej Wind Farm Project	Wind	Ma'an	82
Fujeij Wind Farm	Wind	Ma'an	89.1
New Tafileh Wind Plant	Wind	Tafileh	50
New Tafileh Wind Plant 2	Wind	Tafileh	50
Shobak Wind Project	Wind	Ma'an	45
TOTAL			991.7 MW

Here, capacity is measured in MW installed. For example, the Al Quweira Solar Plant will have an installed capacity of 103 MW upon completion. This means that under perfect conditions and max capacity—that is, no obstruction of sunlight, mounting the panels at a specific angle, air temperature, etc.—the Al Quweira Solar Plant is capable of producing 103 MW/hour. Obtaining perfect conditions outside of a laboratory is rare, so it is highly unlikely that the Al Quweira plant will produce 103 MW/hour, also known as megawatt peak or MWp. However, in this case, the metrics used to estimate job creation

⁷⁸ *Energy Projects in Jordan*, Flanders Investment & Trade, October 2017, https://www.flandersinvestmentandtrade.com/export/sites/trade/files/market_studies/Energy%20projects%20in%20Jordan.pdf, 11-22.

depend solely on MW installed, not energy efficiency. Therefore, efficiency will not be discussed in this section.

Figure 2: Map of PV and Wind Projects in Jordan, 2017



As mentioned in Section II, there are several ways to measure job creation due to renewable sector development. Many academics, such as Dalton and Lewis, argue that measuring jobs/total MW installed is a more accurate depiction than jobs/MW installed per year, while others create their own measurements. In this section, I calculate the potential job creation for these projects using total MW installed based on models from both Friedrich Ebert Stiftung (FES) and Lahn et. al.

Friedrich Ebert Stiftung's special report on renewable energy in Egypt and Jordan claims that 1 MW installed PV power will produce 6.96 to 11.01 jobs, and 1 MW

installed wind power will produce 0.70 to 2.78 jobs.⁷⁹ In a workshop conducted in Amman in 2016, participants reported to Lahn et. al that 2 MW installed PV power will create up to 23 jobs (or 11.5 jobs for 1 MW).⁸⁰ Based on these models, I can estimate that over the total lifetime of all wind projects, 221 to 879 jobs will be created; for all solar projects, 4,702 to 7,539 jobs will be created. Results are shown in the following tables.

Table 6: Projected wind job creation in Jordan, FES model

Name	Capacity (MW)	Job Creation	
		Low Estimate (0.70/1 MW)	High Estimate (2.78/1 MW)
Shobak Wind Project	45	31.5	125.1
New Tafileh Wind Plant	50	35	139
New Tafileh Wind Plant 2	50	35	139
Al-Rajef Wind Farm Project	82	57.4	227.96
Fujeij Wind Farm	89.1	62.37	247.7
Total	316.1 MW	221.27 jobs	878.76 jobs

⁷⁹ *A Guide to Renewable Energy in Egypt and Jordan*, 157.

⁸⁰ Lahn et. al, 23.

Table 7: Projected PV job creation in Jordan, both models

Name	Capacity (MW)	Job Creation		
		FES Low Estimate (6.96/1 MW)	FES High Estimate (11.01/1 MW)	Lahn Estimate
King's Academy Solar Power Plant	2.6	18.1	28.63	29.9
South Amman Solar Power Project	30	208.8	330.3	345
Wheeling Solar Project	34	236.64	374.34	391
Al Safawi Solar PV Project	51	354.96	561.51	586.5
Mafraq Solar PV Project	60.3	419.69	663.9	693.45
Risha Solar Energy Project	61.3	426.65	674.91	704.95
Al Quweira Solar Plant	103	716.88	1134.03	1184.5
FRV Al Mafraq Solar PV Projects (2)	133.4	928.46	1468.73	1304.1
Bayouna Solar Energy Project	200	1392	2202	2300
Total	675.6 MW	4,702.18 jobs	7,438.35 jobs	7,539.4 jobs

It is important to note that these projections are contingent upon all levels of the supply chain being domestic (i.e. all equipment manufacturing, assembly, design, management being done within Jordan's borders). Currently, Jordan does not have the capacity to do so, and many of the investors and manufacturers are international.⁸¹ Therefore, it is extremely unlikely that these projects will produce the calculated number of jobs at this point in time. It is possible, however, that if Jordan continues to develop its renewable energy sector, more of these jobs can be produced domestically.

⁸¹ *Energy Projects in Jordan*, 11-22.

Water conservation

To make basic projections on the potential water savings of renewable energy sources, I used two statistical findings from Evans's study. First, I outlined the efficiency of electricity generation for solar PV and wind as well as natural gas and coal, two common non-renewable resources used in electricity production. Then, I projected the water consumption for PV, wind, natural gas, and coal in their electricity production.

Evans found that of six major energy sources for electricity generation (PV, wind, hydro, geothermal, coal, and natural gas), hydropower was the most energy-efficient and PV the least. Because Jordan uses a negligible amount of hydro and geothermal power in its total energy mix, this section will focus on the other four means of electricity generation. Though one document published by the MEMR provides some numbers on energy and electricity imports, the exact proportion of natural gas, coal, and oil usage in producing electricity in Jordan is unknown. The following table summarizes Evans' findings on efficiency.

Table 8: Efficiency of Electricity Generation⁸²

Type	% Efficiency
Photovoltaic	4-22%
Wind	24-54%
Coal	32-45%
Gas	45-53%

⁸² Evans, 1085.

Here, energy efficiency means generating a high rate of megawatt hours (MWh) in ratio to its max capacity (MW or MWp).⁸³ For example, if a 15 MW wind farm operated at 30 percent efficiency, it would produce 39,420 MWh annually:

$$15 \text{ MW} \cdot 0.30 \cdot 365 \text{ days} \cdot 24 \text{ hours} = 39,430 \text{ MWh/year}$$

If Jordan completely installs all the proposed projects, it will create an aggregate of 675.6 MW solar PV capacity and 316.1 MW wind capacity for a total of 991.7 MW, as seen in Table 5 and below in Table 9. Using the same formula above, I have calculated the highest and lowest potential annual gigawatt hours (GWh) output for both PV and wind, based off Evans' given efficiencies.

Table 9: Projected Annual Electricity Production for RE Projects

	Combined Projects' Capacity	Low Estimate*	High Estimate*
PV	675.6 MW	236.73 GWh	1,302.02 GWh
Wind	316.1 MW	664.59 GWh	1,495.28 GWh
Total	991.7 MW	901.32 GWh	2,797.30 GWh

**1 GWh = 1,000 MWh = 1,000,000 kWh*

Because water consumption during electricity generation is based on efficiency, I have calculated the low and high estimates for coal and natural gas' electricity consumption at 991.7 MW (the equivalent of all combined proposed PV and wind projects) in order to compare them evenly. They have been added to the chart below:

⁸³ "Energy and Power Units," Industrial Wind Energy Opposition, <http://www.aweo.org/windunits.html>.

Table 10: Projected Annual Electricity Production for Four Resources

	Capacity	Low Estimate	High Estimate
PV + Wind	991.7 MW	901.32 GWh	2,797.30 GWh
Coal	991.7 MW	2,779.93 GWh	3,909.28 GWh
Natural Gas	991.7 MW	3,909.28 GWh	4,604.26 GWh

Evans also provides the average water consumption for electricity generation for each resource. Wind uses the least amount of water at 1kg water/1kWh electricity produced, followed by solar PV at 10kg/1kWh and then coal, natural gas, and oil, all reaching 78kg/1kWh.⁸⁴ Using these rates, I have estimated the annual water consumption for PV + wind, coal, and natural gas for both their low estimated efficiencies and high estimated efficiencies at 991.7 MW capacity.

Table 11: Estimated Water Consumption for Four Resources at 991.7 MW

	Low Estimate (tonnes water/year)*	High Estimate (tonnes water/year)*
PV + Wind	3,031,871.04	14,515,442.64
Coal	216,834,808.32	304,923,949.20
Natural Gas	304,923,949.20	359,132,651.28

*1 tonne = 1,000 kg

As seen in the chart above, when these three energy resources generate the same amount of electricity, they consume vastly different amounts of water in the process. At their largest gaps, natural gas consumes up to 118.45 times more water than the RE mix and coal consumes up to 100.57 times more. These are significant differences, especially for the third water-poorest country in the world.

⁸⁴ Herbert Inhaber, "Water Use in Renewable and Conventional Electricity Production," *Energy Sources* 26 (2004): 317.

VII. Results

Readiness and promotion of the RE sector by the GoJ

The Hashemite Kingdom of Jordan has ample, fertile ground to develop its renewable energy sector and in doing so can help alleviate some of the detrimental effects caused by the Syrian refugee crisis, particularly energy and water shortages, unemployment, and diminished livelihoods. The Government of Jordan has taken several steps to implement changes to encourage both foreign and domestic investment in the RE sector. Over the past decade, the Kingdom has emphasized the need for RE, mostly on the basis of its environmental benefits and the need to decrease heavy reliance on imported energy. However, the benefits of RE for Jordan go much further. Renewable energy is a cleaner alternative to traditional fossil fuels, providing much more sustainable and earth-friendly energy that emits far fewer greenhouse gases into the atmosphere. It also promotes job growth among a wide range of fields, especially in STEM. The required specialization of maintaining and constructing renewable energy plants varies from novice to expert, allowing laborers and engineers from all steps in their career to find work in RE. Renewable energy—especially PV and wind, which Jordan is most qualified to run—consumes eight to 80 times less water to generate electricity than coal, oil, or natural gas. This is especially important for Jordan, the third most water scarce country on earth. All of these savings are critical, given that the SRC has driven up unemployment, further diminished limited water resources, and strained state infrastructure.

Jordan understands these benefits and their role in combating the refugee crisis, given the production and signing of the Jordan Compact and Jordan Response Plan. The first goal of the JC explicitly states that it aims to turn the SRC into an investment and development opportunity. The JRP and JC were signed by the European Union on the condition that Jordan would allow Syrian refugees to finally obtain legal work permits, which has begun in small numbers. The complex JRP agreement lists detailed goals in varying sectors of the country to mitigate the effects felt from the crisis, including goals for the environment and the energy sector. With massive amounts of funding from the participating EU countries, Jordan has begun construction on several renewable energy projects around the county: most notably the Za'atari refugee camp.

Za'atari's solar plant

Prior to the installation of a 12.9 MWp solar PV plant in Za'atari, the camp was struggling with numerous issues concerning its infrastructure, namely electricity. With such a large population growth in a short amount of time, the UNHCR was struggling to keep the lights on; to save on running costs, the organization decided to restrict electricity to eight hours a day. As a result, many felt unsafe walking around the camp at night, raced to charge their necessary electronics during the allotted window, and worked fewer hours. After implementation of the PV plant, the residents started to notice changes. The construction of the plant itself hired several hundred local Jordanians and Syrian refugees through the cash transfer program. An initiative between Japan and Jordan trained another 200 Syrians how to upkeep the PV plant and monitor safety hazards, awarding them lifelong skills transferable outside of the camp. Women feel safer walking to WASH facilities in the middle of the night now that the streetlights are guaranteed to be

on, and children say they can complete their schoolwork and study more with longer light hours at home. Ultimately, the UNHCR is saving \$5M USD annually on electricity costs alone, a savings of nearly 80 percent. The solar panels are also self-sufficient and will continue to generate electricity without significant input costs.

The implications of this are very important as the UNHCR may soon have to absorb the responsibilities of UNRWA, a relief agency set up specifically for Palestinian refugees in the Levant. In September of 2018, the United States—UNRWA’s largest donor every year since its inception in 1949—announced it was officially cutting off all of its \$125M funding to the agency.⁸⁵ Without another donor to make up for this deficit, the agency which serves over 5 million refugees in the region (and 2.2 million in Jordan alone)⁸⁶ will have to make extreme cutbacks in its services or shutter its doors entirely. If so, the UNHCR will likely have to pick up what UNRWA left behind. Hopefully this is not the case, and UNHCR can allocate its \$5M savings to address other developmental refugee needs; in the unfortunate event that it does, though, the UNHCR will have some extra funds to allocate to UNRWA’s budget.

Job creation

As the potential for renewable energy generation in Jordan is great, so are the job opportunities. In the previous analysis, I made basic projections for the jobs created in order to completely construct and upkeep 14 PV and wind projects in Jordan using several different indicators. The first came from Friedrich Ebert Stiftung, which

⁸⁵ Clare Foran and Elise Labott, “US ends all funding to UN agency for Palestinian refugees,” *CNN*, 01 September 2018, <https://www.cnn.com/2018/08/31/politics/trump-administration-ending-funding-palestinian-refugees/index.html>.

⁸⁶ “Annual Operational Report 2016,” UNRWA, 2017, 6.

estimated that PV creates 6.96 to 11.91 jobs per MW installed and 0.70 to 2.78 jobs per MW installed of wind energy. Based on their measurements, the combined 991.7 installed MW of the 14 renewable energy projects would produce 4,923.45 to 8,317.11 new jobs. According to Dalton and Lewis and Llera et. al, this estimate is contingent on all levels of operation—manufacturing, construction, installation, operation, and maintenance—being done domestically. Lahn’s fieldwork in Amman gives a more direct ratio of employment: a 2 MW PV plant will employ three Jordanians and up to 20 Syrians (“12 people for the duration of construction and others as needed.”)⁸⁷ Therefore, her high estimate for PV job creation in Jordan’s case is 11.5 jobs per MW.

Lahn’s workshops are very helpful in forming this model because they explicitly state the ratio of Jordanians to Syrians in employment for PV projects, unlike FES’ model which is based on global aggregates. She later quotes a study conducted by EDAMA that found the “clean tech private sector (renewable energy, energy efficiency, water and solid waste management) has the potential to create nearly 19,000 new jobs over the next five years [...] account[ing] for almost 10 per cent of the total number of jobs expected through the Jordan Compact.”⁸⁸ Here, it is evident that the job creation potential reverberates from the initial construction of the plants into the private sector.

In Jordan, the creation of new jobs is vital to both the economic and social wellbeing of the state. The unemployment rate of Jordanians grew from 14.5 percent before the Syrian crisis to 22 percent in 2014.⁸⁹ While generally Jordanians express

⁸⁷ Lahn et. al, 23.

⁸⁸ Ibid., 23-24.

⁸⁹ Francis, 12.

feelings of sympathy and solidarity for Syrians in Jordanian host communities,⁹⁰ animosity and negative feelings towards Syrian refugees is very common. A survey from the International Labor Organization revealed that 96 percent of Jordanians “believed Syrians were taking their jobs.”⁹¹ CARE International’s findings report a lower yet still significant percentage: on average, 62 percent of surveyed Jordanians claimed that Syrian refugees negatively impacted their ability to find or maintain a job, reaching nearly 71 percent of respondents in the Irbid governorate.⁹² In Lahn’s workshops, many participants argued over the ratio of Syrians to Jordanians to be hired for these projects, but all agreed that “the current situation was unsustainable and detrimental to the Jordanian economy,”⁹³ suggesting that this progress was better than nothing at all.

Water conservation

The water savings of the 991.7 MW renewable projects is substantial. At 991.7 MW capacity, the PV + wind combination can generate an estimated 900 to 3000 GWh of electricity a year, consuming nearly 3 to 14.5 million tonnes of water in the process. At the same capacity, coal will generate about 2800 to 3900 GWh of electricity and consume 217 to 315 million tonnes of water; natural gas will generate about 3900 to 4600 GWh of electricity and consume 305 to 359 million tonnes of water.

Immediately, two things become evident: PV and wind consume much less water and are on average less efficient at generating electricity than natural gas or coal.

However, the trade-off is worth it: at their largest gaps (that is, PV + wind operating at

⁹⁰ *7 Years Into Exile: How urban Syrian refugees, vulnerable Jordanians and other refugees in Jordan are being impacted by the Syria crisis*, CARE International, 2017, 74-75.

⁹¹ Francis, 12.

⁹² CARE International, 74-75.

⁹³ Lahn et. al, 23.

their lowest estimated capacity and natural gas and coal operating at their highest estimate capacities), natural gas will consume 118.45 times more water than PV + wind combined, but only produce 5.11 times more electricity. Coal will consume 100.57 times more water than the renewable mix and produce 4.34 times more electricity.

This is a difference that Jordan, which is depleting its water resources at a rapid rate, cannot take lightly. In northern governorates with high numbers of Syrian refugees both in camps and assimilated into host communities, Jordanians and Syrians alike are suffering from extreme water shortages, consuming less than half of the recommended minimum daily water intake to meet basic needs. CARE International's 2017 study found that 57 percent of Jordanian residents in Irbid and 49 percent in Mafraq felt that Syrian refugees hindered their ability to find clean drinking water.⁹⁴ Additionally, only one in three assimilated Syrian refugees had access to water every day of the month,⁹⁵ though this is likely due to their inability to afford it rather than absolute scarcity. Nevertheless, consistent inadequate water consumption can lead to detrimental health effects, such as intestinal diseases and dementia.

Though the two are not necessarily directly linked to each other (i.e. switching from gas to PV will not immediately grant the other two-thirds of refugees water every day), any savings in water is significant for the Hashemite Kingdom. Over time, it can alleviate water shortages and increase supply, making tap and potable water more affordable and available as a whole.

⁹⁴ CARE International, 75.

⁹⁵ Ibid., 17.

Additionally, despite the unbalanced water savings to electricity generation ratio, it is still more financially viable to utilize PV and wind over natural gas and coal. PV and wind are less efficient in generating electricity and therefore require more installed MW. Though PV and wind tend to have much higher up-front costs in manufacturing and planning, generating electricity costs less than half of its non-renewable rivals. According to the Minister of Energy and Mineral Resources Hala Zawati, “a kilowatt of solar energy costs about four cents, which is less than half the cost of oil derivatives, and this is steadily decreasing.”⁹⁶

Other impacts

There are, of course, many other potential positive impacts that renewable energy can have on the Syrian refugee crisis in Jordan that were not analyzed in detail here. Some can make direct impacts on the economy, while others have more intangible, long-term effects. For example, the CARE International study also revealed that rent and electricity constitute 39 percent of the average Jordanian’s monthly expenditure,⁹⁷ and many are struggling to afford electricity at previous rates of consumption⁹⁸ because of higher prices caused by increased demand and population growth. The switch to PV and wind can reduce the costs of generating electricity and thus allow residents to consume more electricity and live more comfortably.

The significant reduction in CO₂ emissions could mean cleaner air for the Kingdom, which suffers from sub-par air quality. The disdain for refugees due to their

⁹⁶ Kamal Taha, “Renewable energy on rise in resource-poor Jordan,” Phys.org, 28 September 2018, <https://phys.org/news/2018-09-renewable-energy-resource-poor-jordan.html>.

⁹⁷ CARE International, 45.

⁹⁸ Ibid., 75.

strain on state infrastructure and daily Jordanian life can be alleviated, improving relationships between the two groups and overall feelings of safety and content. Reduced electricity costs can allow schools to better utilize their resources, streetlights to operate at all hours of the night, and businesses and safe spaces to stay open longer. For example, for many people, the mosque or *masjid* is a safe place to pray, congregate, and briefly alleviate stress. By October 2018, nearly all of the country's 6000+ mosques were operating completely on solar energy.⁹⁹ One particular mosque in Zarqa is completely run on solar energy and provides many services for the estranged and impoverished that the state is now unable to do: it houses prayer halls, medical clinics, a pharmacy, a library, classrooms and computer labs, an emergency room, and even a small operating room.¹⁰⁰ The initial fundraising for the mosque was a grassroots community effort, and now the mosque is undoubtedly saving thousands of dinars in electricity annually and can allocate those savings to providing these resources.

⁹⁹ Adela Suliman, "With green mosques and schools, Amman pushes for zero emissions," Reuters, 30 October 2019, <http://news.trust.org/item/20181030030045-4I5hk/>.

¹⁰⁰ Taylor Luck, "Solar panels? Rooftop prayers? Still, renovated Jordan mosque is a throwback," Christian Science Monitor, 25 September 2018, <https://www.csmonitor.com/World/Middle-East/2018/0925/Solar-panels-Rooftop-prayers-Still-renovated-Jordan-mosque-is-a-throwback>.

VIII. Conclusions & Reflections

The idea of using renewable energy to mitigate the effects of the Syrian refugee crisis in Jordan requires an understanding of the crisis' complexity, Jordan's infrastructure, and renewable energy's potential. Jordan has struggled with a rapid population growth rate, high unemployment, and water scarcity; since the influx of nearly 2.5 million Syrian refugees, these problems have only gotten worse. However, there is hope in using an unexpected resource as a solution: renewable energy.

Though renewable energy is typically considered a solution for energy cost savings and environmental protection, this thesis has evaluated the potential of RE as a crisis and humanitarian response. Located in the global sunbelt and on hilly terrain, the Hashemite Kingdom is a goldmine for wind and solar PV energy. In addition to being physically fit for RE, the Government of Jordan has taken many steps to promote the development of its renewable sector with years' worth of rhetoric, the passage of Law 13 to incentivize renewable investment, and the signing of the Jordan Compact and the Jordan Response Plan to put plans for RE into motion.

Thus far, progress on implementing renewable solutions has been slow. This is largely due to the expensive capital costs of green energy and complicated investment processes. However, Jordan is building its renewable sector little-by-little, and even set a new global benchmark for the use of RE as a crisis response in Za'atari.

In mid-2017, using funds from the German government, Jordan transformed the largest Syrian refugee camp in the world into a sustainable energy model. Za'atari now provides electricity for 14 hours a day, up from just eight. Camp residents have begun to benefit from the extra light hours a day, from feeling safer at night thanks to lit streetlights to the ability to charge their cellphones more frequently and keeping their shops open all day. On the logistics side, the UNHCR is enjoying an immediate savings of \$5M USD annually in electricity generation costs, which can now be delegated to providing other services or camp improvements. This impactful change can serve as a model for other refugee camps worldwide, especially since refugees and IDPs are remaining displaced from their homes for longer lengths of time now more than ever.

Renewable energy, specifically solar PV and wind, has tremendous benefits for both the environment and the economy. Generating electricity from solar and wind energy costs less than half the price of oil derivatives. If Jordan completes 14 of its largest wind and solar plant projects, it can potentially create up to 8,300 new jobs just in building the energy plants. Another 10,700 jobs will arise from the private sector, as they hire experts and laborers to install solar panels and other energy-efficient devices and appliances in their own facilities. Diversifying the economy, lowering household costs, and providing new job opportunities is imperative for Jordan, as unemployment and animosity towards Syrians has only grown since the refugee crisis began.

PV and wind also consume considerably less water in the generation of electricity compared to traditional fossil fuels. The water savings can reverberate over time to help alleviate the extreme water scarcity that again has worsened since the SRC made its way to Jordan. Because renewables emit far fewer CO₂ emissions, they can help the

environment by improving air quality over time, creating a healthier and cleaner atmosphere for citizens. Other potential, less-direct impacts include increased access to education and improved general livelihoods.

As with any study, this thesis has its shortcomings. The projections made on job creation and water conservation were generic, using broad ranges of estimates that were not specific to Jordan's capacity or efficiency. Very little data exists on Jordan's solar PV and wind efficiency rates and actual job production because the energy plants are relatively new and few in number. Had the data been available, I would have liked to compare current water consumption in generating electricity to the potential alternatives (i.e. calculating the water savings should Jordan replace all electricity generated by natural gas to electricity generated by wind power).

Additionally, the analysis of solar's impact on Za'atari is limited because the plant was only recently constructed and implemented. Perhaps in a few years, more in-depth data will become available on the specific changes observed in Za'atari due to RE. Future studies can use this thesis as a foundational beginning for research on the relationship between renewables and refugee camps and their impacts on livelihood and the political rhetoric of the permanent-ization of refugee camps.

Overall, renewable energy can play a positive role in dealing with the Syrian refugee crisis in Jordan. It has the potential to create jobs (combating unemployment), mitigate water waste (combating resource scarcity), reduce household electricity costs (combating inflation due to population growth), and improve some aspects of day-to-day life (combating animosity). Jordan has and should continue to develop its renewable sector and reap the many benefits that come along with it.

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Appendix

Table 12: Population and Electricity Consumption in Jordan, 2009-2018¹⁰¹

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total Population	6,490,000	6,698,000	6,993,000	7,427,000	8,114,000	8,804,000	9,559,000	9,798,000	10,053,000	
Jordanian Pop							6,613,587			
Registered Syrian Pop	0	0	0	116,718	576,354	622,865	633,466	648,836	654,903	671,148
-- in camps					127,796	100,014	114,242	136,879	139,500	126,064
-- in towns					448,558	522,851	519,224	511,957	515,403	545,084
Est. Total Syrian Pop							1,265,514			
Total Electricity Generated					17,261 GWh	18,704 GWh	18,911 GWh	19,390 GWh	20,760 GWh	
Total Electricity Consumed	11,956 GWh	12,843 GWh	13,535 GWh	14,274 GWh	14,588 GWh	15,418 GWh	16,173 GWh	16,669 GWh	17,574 GWh	
Household consumed	4,926 GWh	5,219 GWh	5,548 GWh	6,126 GWh	6,265 GWh	6,580 GWh	6,938 GWh	7,448 GWh	8,076 GWh	
Industry consumed	2,981 GWh	3,258 GWh	3,445 GWh	3,461 GWh	3,541 GWh	3,877 GWh	4,012 GWh	3,939 GWh	3,785 GWh	
Commercial consumed	1,978 GWh	2,184 GWh	2,269 GWh	2,427 GWh	2,415 GWh	2,358 GWh	2,460 GWh	2,447 GWh	2,655 GWh	
Water pump consumed	1,761 GWh	1,867 GWh	1,939 GWh	1,955 GWh	2,076 GWh	2,287 GWh	2,426 GWh	2,485 GWh	2,655 GWh	
Street light consumed	310 GWh	315 GWh	334 GWh	305 GWh	291 GWh	316 GWh	337 GWh	350 GWh	403 GWh	
% Total Pop increase from previous year	3.13%	3.20%	4.40%	6.21%	9.25%	8.50%	8.58%	2.50%	2.60%	
% Reg Syrian Pop increase from previous year					393.80%	8.07%	1.70%	2.43%	0.94%	2.48%
% Electricity Increase from previous year	3.88%	6.91%	5.39%	5.18%	2.20%	5.38%	4.90%	2.98%	5.43%	
Per Capita Res Usage, JRP			2.166 MWh (2116 kwh)					1.719 MWh (1719 kwh)		
Per Capita Res Usage, my calculations			1.26 MWh					1.316 MWh		
% Per capita Res Usage increase from 2011-2016, my calculations	4.44%									

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