Economic and Social Commission for Western Asia

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United Nations Development Account project on promoting renewable energy investments for climate change mitigation and sustainable development

Case Study on Policy Reforms to Promote Renewable Energy in Jordan

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Preface

This case-study report was prepared for the Energy Section of the Economic and Social Commission for Western Asia (UN ESCWA) Sustainable Development Policies Division (SDPD) within the framework of the United Nations Development Account (UNDA) project on Promoting Renewable Energy (RE) Investments for Climate Change Mitigation and Sustainable Development. The project focused on capacity-building for policymakers and project developers in order to promote investments in RE projects. The project was led by UN ESCWA and implemented in partnership with the United Nations Economic Commission for Europe (UNECE).

The UNDA project included case studies on the experience of RE policy reforms in selected countries from each of the two Regional Commissions (RCs). A total of eight countries were targeted (four from each RC): Jordan, Lebanon, Morocco and UAE from UN ESCWA Member States and Georgia, Kazakhstan, Serbia and Ukraine from UNECE Member States.

The report covers the case study for Jordan and was prepared by Ms Fariba Hosseini, Former Director of Planning and International Cooperation at the Jordanian Ministry of Energy and Mineral Resources. It was in part based on an initial draft by Mr Jamal O. Jaber, Professor at the Department of Mechanical Engineering, Al-Balqa' Applied University, Amman, Jordan. The following experts helped review and finalize the document: Radia Sedaoui, Chief, Energy Section, and Mongi Bida, First Economic Affairs Officer (SDPD/UN ESCWA, Beirut).

Executive summary

This report aims to present the case study of renewable energy (RE) policies in Jordan. The report gives an overview of RE status in the country focusing on the impact of Jordanian policies in the encouragement of RE investments by lifting regulatory barriers and business environment to make RE projects more bankable for further development. It covers several related topics including the energy sector characteristics, the energy supply and demand issues, the RE potential, legal frameworks and policy reforms that could contribute to the development and implementation of effective policies that would help Jordan reach its RE targets for 2020 and beyond.

Located in the heart of the Middle East, Jordan is a small upper-middle income county with scarce natural resources, in particular water and energy. Unlike some of its neighbours in the Middle East and North Africa (MENA) region, Jordan has few fossil fuel resources of its own and imports majority of its energy.

Concerns over energy security and fossil fuel imports dependency have intensified in Jordan due to political events in the region, including gas supply interruption since 2011, and more recently, the rapid growth in energy demand caused by a large influx of more than one million refugees and asylum seekers, mostly from Syria and Iraq, which caused the energy invoice to become a heavy burden on the Jordanian.

Jordan currently imports more than 95% of its energy needs. In 2016, these imports included 2,978 kT of crude oil, 2,728 kT of oil products and 4.1 billion cubic meters (bcm) of natural gas. The renewable energy sources contributed for 4.3% of the total primary energy consumption in 2016 with 402 ktoe over a total of 9,614 ktoe.

The Government of Jordan (GoJ) is seeking to address challenges in the energy sector through a combination of medium to long-term solutions. Additionally, the GoJ is seeking to improve its energy security and lower its exposure to external shocks in terms of supply. It is also working on the implementation of measures in line with the objectives to improve fiscal and macro-economic situation and sound and sustainable growth for Jordan.

Key challenges for Jordan include: sustaining economic growth; improving energy security; reducing fossil-fuel consumption and imports; reducing fiscal pressure linked to costly support to fossil-fuel imports; and creating local jobs. Facing these challenges, the GoJ defined its policy in the field of energy through the adaptation of the Updated Master Strategy of Energy Sector in Jordan, originally developed in 2004, for the period 2007-2020, to include renewable energy targets running until 2020, emphasizes private sector development of new energy projects.

In 2015 and under Jordan Vision 2025, the government's ambitious economic plan that pays close attention to the energy sector, the National Energy Strategy (NES) 2015-2025 was formulated for facing the energy sector challenges through increasing local energy portion in total energy mix and raise the proportion of energy consumption met from local supplies from 2% to almost 40% within the next decade with a target of 11% renewable energy input into the energy mix by 2025.

The strategy aims to achieve two broad goals of the enhancement, diversification and development of domestic energy sources and efficiency on one hand, and diversification of supply from external sources on the other hand, and in a way that enhances environmental protection through the development of RE projects, maximizing the utilization of domestic resources and promoting energy conservation and awareness.

Jordan has significant solar and wind energy resources that could be potentially exploited for power generation. The GoJ has underlined its commitment to reach the ambitious targets set in the Energy Strategy and has issued the Renewable Energy and Energy Efficiency Law (REEL) in April 2012. Under the REEL and associated by-laws, Jordan has implemented incentives schemes and procurement methods for awarding long-term power purchase agreements to grid connected RE projects, including the region's first feed-in-tariff system which is designed to reduce energy demand and will allow the sale of surplus energy generated back to the national grid, unsolicited expressions of interest from investors through a "direct submission proposal" procurement scheme where investors have the opportunity to identify and develop renewable grid connected electricity production projects such as wind parks and solar systems, a competitive tender, and public procurement under Engineering, Procurement and Construction (EPC) "turn-key" contracts [1].

As a result of this process, around 2,300MW renewable energy projects are floated and planned up to the year 2021. At present and after the 1st, 2nd and 3rd rounds of direct proposals which consist of: 200MW Photo Voltaic (PV) Round 1, 420MW wind round 1, 200MW PV round 2,100MW wind round 2,200MW PV round 3 and 100MW wind round 3 (which contributes in total to 600MW from PV and 620MW from wind). These projects could substantially reduce Jordan's energy dependency and create significant fiscal benefits: (i) expected to generate about 2,000GWh annually; (ii) create between 2,000 and 3,000 jobs, and avoid 0.9-1.0 tons of Greenhouse Gasses(GHG) emissions depending on the fuel mix used in power generation.

Under REEL, net metering was established, to encourage residential, commercial and small industrial electricity consumers. Wheeling Regulations were designed and issued in 2014, to enable and regulate off-site RE production and on-site consumption by private off takers. At present, Jordan is renegotiating the pricing wheeling methods as there is no structure for high voltage wheeling in Jordan since companies that generate power are Independent Power Producers (IPPs) or state-owned generators delivering to National Electric Power Company (NEPCO). There are no wheeling charges involved as NEPCO is the single-buyer and single-seller of electricity. In addition, the government has set tax exemptions for all systems and equipment for RE projects from custom duties and sales tax.

Jordan has also demonstrated its commitment by establishing the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) to facilitate scaling-up of renewable energy and energy efficiency to meet the energy needs of Jordan, in accordance with the National Energy Strategy and National Energy Efficiency Action Plan (NEEAP). In addition, the by-laws and regulations related to RE projects for electricity generation have been issued, proving the "Reference Price List" which includes the indicative prices for each type of renewable sources.
Jordan has made substantial progress to support investment in RE by developing a comprehensive set of incentives, laws and regulations in the past few years and has become an attractive country for RE investment. Jordan is the only country in the MENA region that has implemented structural separation of generation, transmission and distribution in the electricity sector. It is the first country in the Middle East region to successfully launch and finalize a public-procurement progress for solar energy and is the only country in the MENA region that authorizes unsolicited or direct proposal submission for utility supply by independent power producers. Jordan is also the only country in the MENA region that has established grid codes for distributed and utility scale PV and wind energy system. There are, however, serious grid capacity issues that constrain the deployment of PV and wind power in Jordan.

The RE market in Jordan is growing rapidly, with projects such as Tafila Wind Farm, the first commercial utility scale wind power project in the Middle-East with the capacity of 117MW, increased the power capacity of the country by 3%. In addition to Shams Maan Project, the largest photovoltaic plant in Jordan and among the largest in the Middle-East, for generating electricity from photovoltaic cells with generating capacity of about 52.5MW from 605,400 solar panels installed to produce about 160GWh per year.

This study highlights a few priorities to be considered in order to improve the promotion of RE investment for climate change mitigation and sustainable development. To, summarize, a comprehensive review of existing legislations and guidelines should be conducted with focus on the role, procedure and responsibilities of electricity distribution companies as well as NEPCO. Equally important is the improving planning for grid capacity extension to connect future RE projects to the grid, streamlining licensing and registration process, improving the transparency and enforceability of the direct proposal submission scheme, facilitating net-metering and wheeling procedures for industrial, commercial and residential users, and greening public procurement procedures for public facilities to drive the circular economy.

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List of abbreviations

AADNI	Average Annual Direct Normal Irradiation
AAEPC	Amman Asia Electric Power Company
AAGHI	Average Annual Global Horizontal Irradiation
AES	Amman East Power Plant
AMCE	Arab Ministerial Council for Electricity
ASEZA	Aqaba Special Economic Zone Authority
APICORP	Arab Petroleum Investments Corporation
BAU	Business as usual
bcm	Billion cubic meters
BOO	Build-Own-Operate
BOO(T)	Build-Own-Operate and Transfer
CBS	Competitive Bidding System
CC	Combined Cycle
CCGT	Combined Cycle Gas Turbine
CEGCO	Central Electricity Generation Company
CSP	Concentrated Solar Power
DF	Diesel Fuel
DP	Direct Proposal
EDCO	Electricity Distribution Company
EDISCOs	Electricity Distribution Companies
EDP	Executive Development Program
EE	Energy Efficiency
EIA	Environment Impact Assessment
ELCO	Electrical Equipment Industry
EMRC	Energy and Mineral Regulatory Commission
EPC	Engineering, Procurement and Construction
ESMAP	Energy Sector Management Assistance Program
ETA-max	Energy & Environmental Solutions
EU	European Union
EV	Electric Vehicle
FiT	Feed-in Tariff
GAM	Greater Amman Municipality
GDP	Gross Domestic Product
GHG	Green House Gases
GHI	Global Horizontal Irradiance
GoJ	Government of Jordan
GT	Gas Turbine
GW	Gigawatt
GWh	Gigawatt-hour
HCST	The Higher Council for Science and Technology
HFO	Heavy Fuel Oil
id:rc	Interdisciplinary research consultant
IDECO	Irbid District Electricity Company
IEA	International Energy Agency
IMF	International Monitory Fund
INDC	Intended Nationally Determined Contribution
IPPs	Independent Power Producers
IRENA	International Renewable Energy Agency
JCI	Jordan Chamber of Industry
JCP	Jordan Competitiveness Program
JD	Jordan Dinars (1 USD = 0.7 JD)
JEA	Jordan Engineers Association
JEGP	Jordan Economic Growth Plan
JICA	Japan International Cooperation Agency
JREEEF	Jordan Renewable Energy and Energy Efficiency Fund
JU	Jordan University
Km	Kilometre
kT	Kilo-tone

ktoe	Kilo-tone oil equivalent
kV	Kilovolt
kW	Kilowatt
kWp	kilowattpeak
kWh	Kilowatt-hour
LAS	League of Arab States
LED	Light emitting diode
LNG	Liquefied Natural Gas
MEMR	Ministry of Energy and Mineral Resources
MENA	Middle East and North Africa
MIT	Ministry of Industry and Trade
MoEnv	Ministry of Environment
MSW	Municipal Solid Waste
MVA	Mega Volt Ampere
MW	Megawatt
MWp	Mega Watt peak
MWh	Megawatt hour
MWh/y	Megawatt hour per year
MWI	Ministry of Water and Irrigation
NA	National Agenda
NCC	National Control Centre
NEEAP	National Energy Efficiency Action Plan
NEPCO	National Electric Power Company
NERC	National Energy Research Centre
NES	National Energy Strategy
NG	Natural Gas
NRA	Natural Resources Authority
NREAP	National Renewable Energy Action Plan
NSAP	National Strategy Action Plan
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable Energy
REEL	Renewable Energy & Energy Efficiency Law
REEE II-TA	Renewable Energy & Energy Efficiency Programme-Technical Assistance
REL	Renewable Energy Law
RES	Renewable Energy Scenario
RSDSP	Red Sea–Dead Sea Project
SAM	System Advisory Model
SEPCO	Samra Electricity Power Company
SHP	Small Hydro Power
ST	Steam Turbine
SWH	Solar water-heater
TNC	Third National Communication
toe	ton oil equivalent
UNFCC	United Nation Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollar
WB	World Bank
WTE	Waste-to-Energy

I. Introduction

Jordan is a country with energy supplies challenges. Due to its lack of natural resources in an energy-rich region, the country has long been dependent on energy imports. This reliance in recent years had been the source of growing political, economic and strategic problems for the country. Rapid energy demand growth, limited domestic resources and regional instability, have spurred the need for self-sufficiency in Jordan. Hence, and in order to reduce dependence, energy resource diversification and increased contribution of domestic ones have become key priorities for the government. Natural gas, oil shale and renewable energy (RE) are foreseen to contribute increasingly to the electricity generation mix by 2020.

Jordan has a high RE potential, particularly solar and wind energy. The country has one of the highest solar irradiance levels in the world of 5-7 kilowatt-hour per square meter (KWh/m^2) coupled with more than 300 days of sunshine since it lies in the "global sunbelt" between 29°11` and 33°22` N latitudes. This provides a high potential for the development of solar power in the country. Jordan also possesses high potential of wind energy resources with annual average wind speeds exceeding 7m/s (at 10m height) in some areas of the country, and about 350GWh/yr of municipal waste and biomass. There is also limited potential for small hydropower schemes [2]. These figures establish promising prospects for utilizing RE sources to generate electricity.

Recognizing the potential for RE to achieve energy sector's objectives the GoJ has provided significant support to renewable energy projects and has in place several laws, regulations, targets and incentive schemes to encourage private investment.

This report aims to examine the policy and institutional environments for RE investment in Jordan and provide an analysis of the legal and regulatory frameworks that can contribute to promoting RE, and to identify the barriers and the lessons to be learned and formulate some recommendations to make such investments more bankable.

This document also provides a description of the energy situation for the Hashemite Kingdom of Jordan, including RE potential, and an analysis of the current state of renewable energy policy and policy design.

The remaining of the report consists of the following nine chapters:

- Chapters 2 and 3 provide an overview of the energy situation and cover the characteristics of the energy sector including the supply/demand of energy in Jordan,
- Chapters 4 and 5 focus on renewable energy potential, including a presentation of the methodology used for assessing RE resources in Jordan,
- Chapters 6 and 7 describe the current and previous state of energy policy which has helped to deploy renewable energies in Jordan.
- Chapter 8 discusses the consideration of policy design and analyzes the legal framework and policy reforms that can help transform RE Investment Projects into bankable projects allowing a better access to financing opportunities.
- Chapter 9 assesses the obstacles to the implementation of Renewable Energy projects in Jordan and the lessons learned for the future.
- Finally, Chapter 10 provides recommendations for the challenges, difficulties and obstacles identified in chapter 9 for more bankable RE projects in the Hashemite Kingdom of Jordan.

II. Country Brief

The Hashemite Kingdom of Jordan is an Arab kingdom in Western Asia, on the East Bank of the Jordan River. Jordan sits strategically at the crossroads of the continents of Asia, Africa and Europe. The country is relatively small with the total area of 89,341 square kilometres (km^2) mostly desert land. Since the constitution was put in place in 1952, Jordan has operated as a constitutional monarchy. Under a multiparty parliamentary system, the prime minister is the head of government. As the legislative branch of government, the National Assembly is composed of the Chamber of Deputies and the Assembly of Senators.

Jordan is considered to be among the safest of Arab countries in the Middle East. The country has been historically accustomed to sudden influxes of population fleeing conflict from neighboring countries and seeking safety and security within Jordan's borders. According to the 2015 census, Jordan's population stands at 9.5 million with non-Jordanians accounting for approximately 30% of the total population. Jordan is the largest host of registered refugees in the world (2.8 million refugees registered with UNURWA & UNHCR). In terms of Syrians alone, Jordan hosts 1.3 million refugees, with almost 90% of them residing outside refugee camps, competing for jobs alongside Jordanians [6].

Jordan is faced with rising unemployment that has worsened with the influx of Syrian refugees. Unemployment in 2016 stood at 15.25%, in comparison to 12.5% in 2010, while youth unemployment rate is at 25%. Poverty rates have increased from 14.4% in 2010 to an estimated 20% in 2016. Jordan's top five contributing sectors to Gross Domestic Product (GDP) are Government services, finance, manufacturing, transport, and tourism & hospitality respectively [8].

Jordan is considered as an upper middle-income country and has showcased its ability to remain resilient, maintain internal cohesion, and reinvent itself in the face of adversity. Jordan's GDP growth between 2000 and 2009 averaged 6.5%, but from 2010 until 2016 average growth was a mere 2.5%. Furthermore, Jordan's total public debt has increased at a rate exceeding economic growth. This has resulted in a debt-to-GDP ratio of 90% in 2015, at USD 34.7bn and 95% at the end of 2016, compared to approximately 61% in 2010 [4]. As part of the government's new International Monetary Fund (IMF) extended fund facility program, one key aim is to reduce this ratio to 77% within the next three years [11].

A critical factor in the kingdom's recent debt boom is sovereign debt incurred by the National Electric Power Company (NEPCO), which has risen sharply since 2011. Prior to then, Jordan imported natural gas, which met 87% of its electricity demand from Egypt through a pipeline. Sabotage attacks in Egypt halted Egyptian gas supplies to Jordan, which forced the country to substitute the relatively cheap gas with much more expensive diesel and heavy fuel. Accumulated electricity debt stood at 17.8% of GDP as of January 2016, meaning Jordan debt-to-GDP ratio without NEPCO would be just 72% of GDP – below the government's target of 77% by 2020 [11].

The main obstacles to Jordan's economy are scarce water supplies, complete reliance on oil imports for energy, and regional instability. Jordan's economic resource base are phosphates, potash, and their fertilizer derivatives; tourism; overseas remittances; and foreign aid.

The GoJ is addressing these challenges through its 10-year Executive Development Program (EDP), Jordan 2025, to emphasis private sector participation in economic development, as well as social services and reforms to the public sector. In light of a slowing macroeconomic environment and high unemployment, the Government adopted a Jordan Economic Growth Plan (JEGP) aiming to double economic growth over 2018-2022. The government also launched its Green Growth Plan which identifies a green growth corridor, smart urban transformation and rural resilience as representing the convergence between climate action, sustainable local development and macroeconomic considerations with a focus on the energy, water, waste, transport, tourism and agriculture sectors.

III. Energy Sector Characteristics

Jordan faces major challenges in the field of energy owing to the shortage of domestic commercial energy sources and its reliance on imports, while it requires relatively large amounts of energy to meet its needs for sustainable and comprehensive development. Jordan currently imports about 96 percent of its energy needs, including crude oil, petroleum products and natural gas. The cost of imported energy in 2015 amounted to USD 3.57 billion or about 10 percent of GDP. Due to economic growth and increasing population, energy demand in Jordan is expected to be doubled and continue to grow at an average annual rate of about 5.5% during the next decade [13].

To address the energy challenges, the government represented by the Ministry of Energy and Mineral resources (MEMR) developed the 2004-2020 Energy Sector Strategy and updated it in 2007 to include renewable energy targets, with an aim to enhance local sources of energy towards 2020. Under the strategic plan, by 2020, the energy sector in Jordan is thus to have changed substantially. The strategy aims at decreasing oil usage from almost 60% to 40%, while RE rises to 10%, natural gas to 29%, nuclear to 6%, oil shale to 14% and imported electricity to 1%. A huge amount of investment will be required to achieve these targets estimated at USD 3.4bn for the oil sector, USD 4.8bn-5.8bn for the power sector, USD 1.4bn-3.8bn into oil shale, USD 1.4bn-2.1bn into renewable and USD 2.4bn into natural gas over the plan period. Carrying out such huge investments will be challenging, but there are potential opportunities. This was further enhanced by the adoption of Vision 2025 in May 2015, where energy was a main development area [14].

3.1. Primary Energy Supply

Jordan has two main challenges regarding its energy situation: the growing energy demand on the one hand and the very limited domestic resources to fulfil this demand on the other hand. In 2015, the local production of energy – including crude oil, natural gas and renewable energy – was 305 ktoe (thousand tonnes of oil equivalent) [16], which was enough to cover only about 4% of the energy consumption. The limited domestic resources meant that Jordan had to import 7,656 ktoe (thousand tonnes of oil equivalent) of energy to meet its demands.

This means that the cost of the consumed energy amounts to as much as 17% of the GDP [5].

Table 1 illustrates the increase of primary energy consumption by type of fuel over the period 2000-2015. It demonstrates that Jordan's total primary consumption is entirely focused on fossil fuels, and its installed capacity is also principally fired on oil and gas. It is clear that the country is strongly dependent on imported oil (73%) and gas (21%), while renewable sources contributed by only 2% in 2015.

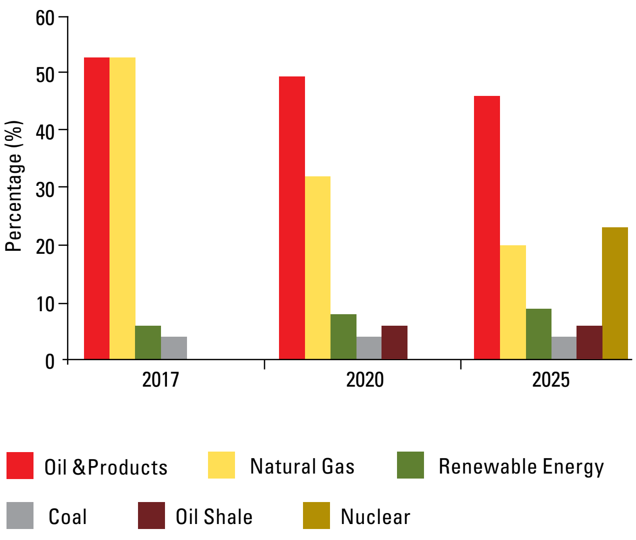
Table 1: Jordan Primary Energy Consumption (000 toe)

Total Primary Energy	Crude Oil & Oil Products	Coal	Pet Coke	Natural Gas	Renewable Energy	Imported Electricity	Total Primary Energy
2000	4,756	0	0	213	75	11	5,055
2001	4,803	0	0	206	76	65	5,150
2002	4,954	0	0	188	79	78	5,299
2003	5,031	0	0	432	77	235	5,774
2004	5,012	0	0	1,196	82	199	6,489
2005	5,325	0	0	1,384	83	238	7,028
2006	4,953	0	0	2,004	110	124	7,187
2007	4,906	0	0	2,406	118	53	7,438
2008	4,426	0	0	2,725	128	137	7,335
2009	4,454	0	0	3,086	137	98	7,739
2010	4,774	0	0	2,289	141	168	7,357
2011	6,141	0	0	873	130	313	7,457
2012	6,992	226	226	659	140	188	8,205
2013	6,689	204	204	907	145	96	8,157
2014	7,479	332	332	301	152	109	8,461
2015	6,331	161	161	1,944	160	183	8,944

Source: Ministry of Energy and Mineral Resources, Annual Report 2015

Demand for primary energy will continue to increase by an expected 5% between 2007 and 2020 [14]. Jordan's top priority is achieving energy supply security and diminishing dependence on imports while meeting the growing demand for primary energy. The current situation presents an ideal environment for development of renewable energy projects whose financial and technical demands are set to be met by the private sector. This will lead to the increase of the energy security for the country. During the last 25 years there were fuel import interruptions, i.e. in 1990, 2003 and 2010 due to several geopolitical issues, this interruption in the energy supply made the country vulnerable economically. The Ministry of Energy and Mineral Resources is planning to reduce dependence on imported energy by introducing nuclear energy and oil shale to replace energy imports. Figure 1 summarizes the forecasted energy mix according to the targets set in 2015.

Figure 1: Forecasted Primary Energy Mix



Source: MEMR, National Energy Strategy 2016-2025.

Source: Spherical tanks and storage tank containing fuel gas oil refineries, by noomcpk, Shutterstock.

3.2. Characteristics of the Electrical Sector

The consumed electrical energy in the kingdom amounted 16,178GWh in 2015 compared with 15,419GWh in 2014, corresponding to an annual growth rate of 4.9%. The total generated and imported electrical energy amounted to 19,616GWh whereas the total production of electrical energy was 19,012GWh in 2015. However, power generated from RE increased in 2015 to reach 185GWh, i.e. about three times what was generated in the previous year. This is due to the completion of two renewable energy projects of 15MW PV and 117 (3x38) MW wind farm, late 2015. These projects were commissioned, operated commercially in the last quarter [7] [9]. Table 2 illustrates significant figures for electricity sector in Jordan.

Table 2: Significant Figures for Electricity Sector in Jordan

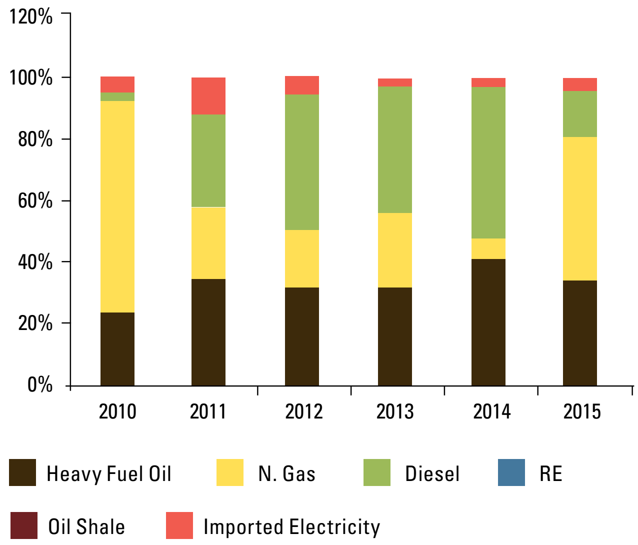
		2014	2015	%
Peak Load (MW)	Generated	3,050	3,470	13.8
	Sent-out	2,930	3,330	13.7
Available Capacity (MW)	Electricity Sector	4,000	4,266	6.7
	Jordan	4,189	4,455	6.3
Generated Energy (GWh)		18,269	19,012	4.1
Consumed Energy (GWh)		15,419	16,178	4.9
Exported Energy (GWh)		64	50	(21.9)
Imported Energy (GWh)		435	604	38.9
Loss Percentage (%)*		14.40	14.89	--
Average (KWh) Consumed Per Capita		2,265	2,320	2.4
Electricity Fuel Consumption (Ttoe)		3,856	3,992	3.5
No. of Consumers (Thousands)		1,862	1,965	5.5
No. of Employees in Electricity Companies		8,016	8,142	1.6

Source: NEPCO, Annual Report 2015.

The total generation capacity of the Jordanian Power System amounted to 4,266MW in 2015 compared with 4,000MW in 2014 with a growth rate of 6.7%. The average annual growth rate of the electrical energy generated in the kingdom for the last five years was about (5.2%), while it was about (4.7%) for the consumed electrical energy for the same period. Figure 2 shows the energy mix for power generation from 2010-2015.

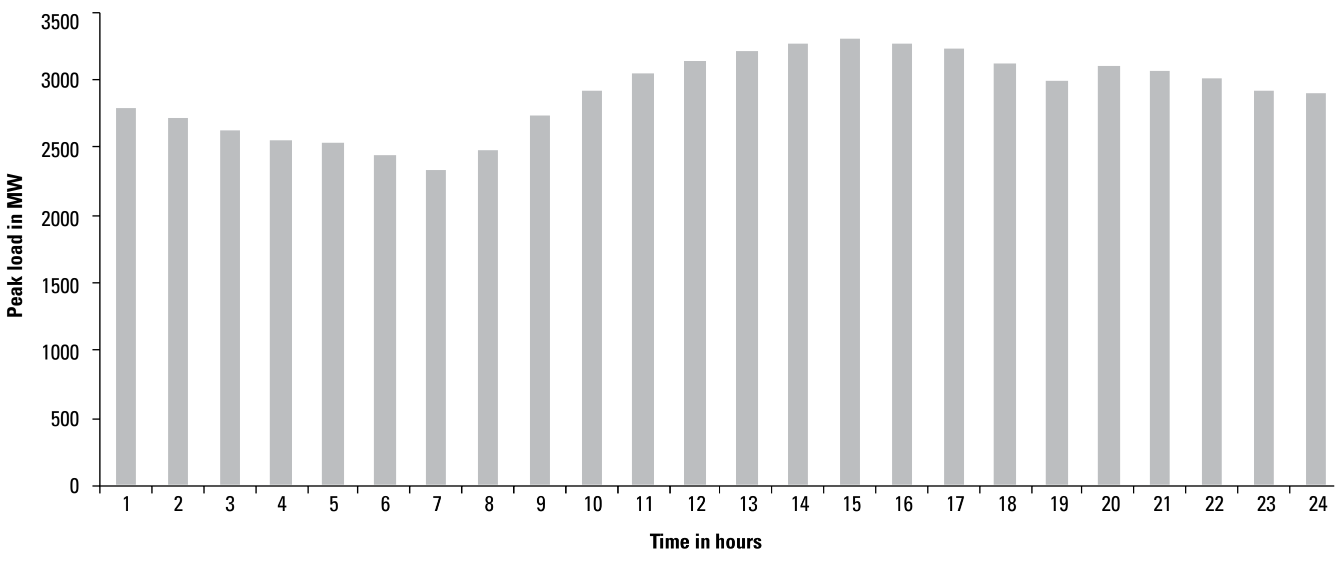
Jordan's total installed power generation capacity was 4,455 MW and the maximum peak demand was 3,300MW in 2015 (4th August, at 15:00 hours, temp. 42, load factor: 0.88) [9]. Figure 3 shows an hourly peak load curve for the mentioned day of maximum peak load demand.

Figure 2: Power Generation Progress according to Type of Fuel



Source: NEPCO, Annual Report 2015.

Figure 3: Hourly load graph for the 4th of August 2015



Source: NEPCO, Planning Department [36]

The mix of power plants is summarized in table 3 It is clear that almost all of the installed capacity in the country, including large industrial plants, is based on firing natural gas, as primary fuel, and diesel oil or heavy fuel oil as secondary fuel, while the renewable energy and corporations contributed by (0.8%), (2.5%) of the total production respectively.

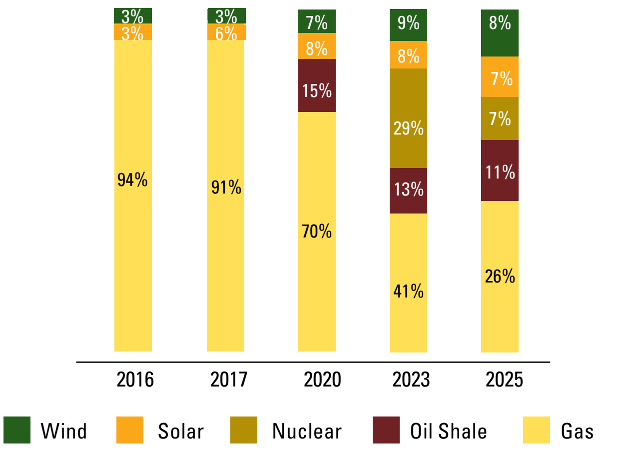
Table 3: Installed Power Generation Capacity (MWe)

Year		2010	2011	2012	2013	2014	2015
Steam Turbines		925	925	925	787	787	787
Gas Turbines	Diesel	149	134	134	27	27	27
	Natural Gas	600	500	500	618	618	332
Combined Cycle		1,317	1,737	1,737	1,737	1,737	2,167
Diesel Engines	HFO & Diesel	-	-	-	-	814	814
Renewables	Wind	1.44	1.44	1.44	1.44	1.44	118.4
	Hydro	12	12	12	12	12	12
	Bio-gas	3.5	3.5	3.5	3.5	3.5	3.5
	Solar	-	-	-	-	-	5
Industrial sector	Steam	85	85	85	85	135	135
	Gas Turbine	7.5	7.5	7.5	7.5	7.5	7.5
	Diesel Engine	46.8	46.8	46.8	46.8	46.8	46.8
Total		**3,147**	**3,451**	**3,452**	**3,325**	**4,189**	**4,455**

Source: NEPCO, Annual report 2010 [35] and Annual Report 2015 [9].
*Does not include power station internal consumption

The Government of Jordan has a target to develop renewable energy as much as 15% of electricity production in a year. Figure 4 shows composition of energy source from 2016 to 2025 in Energy Sector Strategy in Jordan.

Figure 4: Composition of energy source from 2016 to 2025

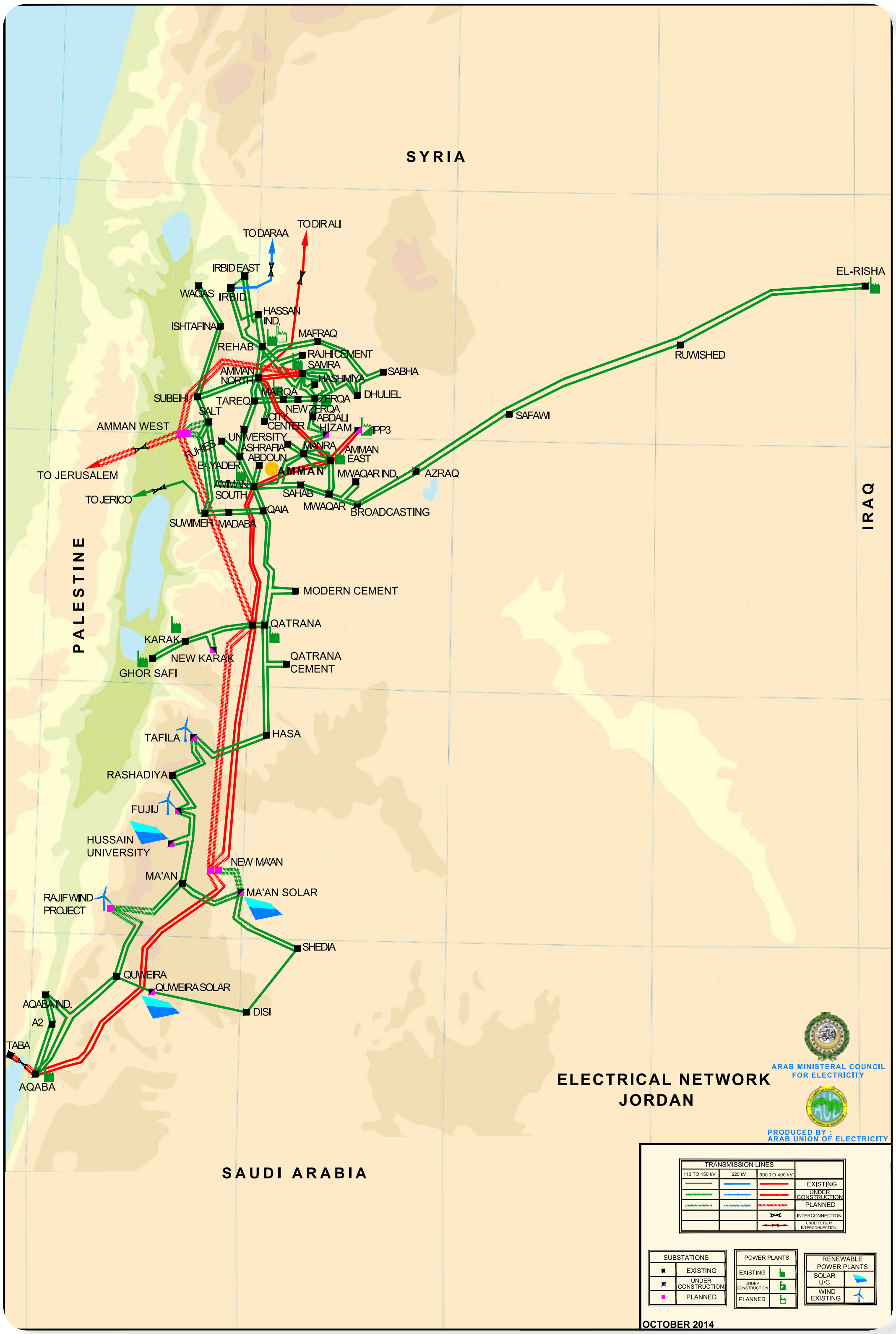


Source: MEMR, National Energy Strategy 2016-2025.

Electrical Grid Characteristics: The power system is composed of mainly 400kV and 132kV as shown in figure 5. The power system is interconnected with that of Syria in the north and Egypt in the south. The voltage of 230kV is partly used in the interconnection line with Syria; however, the interconnection line is separated due to the situations in Syria. The border point between NEPCO and distribution companies is a 132/33kV substation that is called BSP (Bulk Supply Point). The voltage level of the distribution system is 33kV and 11kV.

The power demand is concentrated in Amman, the capital city of Jordan, and located in the north of Jordan. The main power system is the system that supplies power from the power generation plants around Amman and the one that lies in the north and south from Egypt to Amman. The substation total capacity is11,905 MVA. The transmission line lengths of 400kV and 132kV are 924km and 3,579km-circuit respectively.

Figure 5: NEPCO Power System



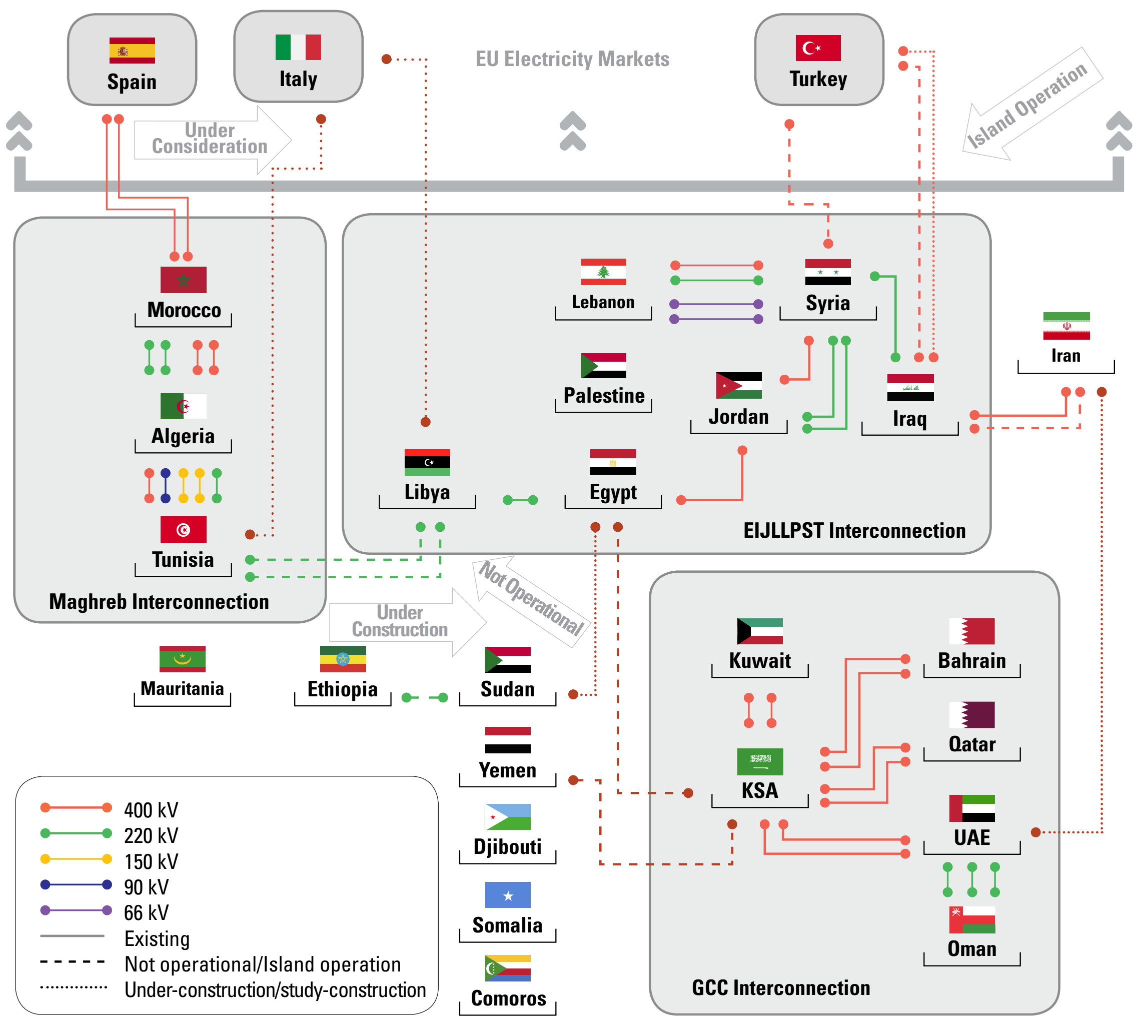
Source: NEPCO, Annual Report, 2014

International Interconnection: The international interconnection with Jordan and surrounding countries is ongoing as the Eight Country Interconnection Project.

The eight countries are Egypt, Iraq, Jordan, Libya, Lebanon, Palestine, Syria and Turkey as shown in figure 6. The electric grids of Libya, Egypt, Jordan and Syria have been interconnected at present.

The transmission line between Jordan and Egypt is interconnected through a 400kV submarine cable at the Gulf of Aqaba and its capacity is 550MW. The Jordan-Syria line is interconnected by 400 kV and 230kV overhead transmissions line and its capacity is 800MW. There are future plans to interconnect with Saudi Arabia and Palestine in 400kV; however, concrete plans have not been decided yet.

Figure 6: International Interconnection with Syria, Egypt and Other Countries



Source: WB, ESMAP, LAS – "MENA Integration of Electricity Networks in the Arab World: Regional Market Structure and Design", Dec. 2013 [45]. Redrawn by Ghazal Lababidi

3.3. Energy Demand Characteristics

Local energy demand is driven mainly by power generation and transport sectors, since these are the main fuel consumers. In 2015, power generation and transportation consumed about 44.7% and 48.0% of the total fuel consumption in the country, respectively. Such figures are considered very high when compared with other countries. The transport sector in Jordan is characterized by being a single mode relying principally on road transport: private cars due to lack of mass transport systems such as railways or urban and intercity buses network as well trucks for different goods.

Table 4 illustrates refined products consumption in Jordan during 2010-2015. In terms of an energy equivalent value, diesel, Heavy Fuel Oil (HFO), gasoline, and natural gas (NG) constitute about 88% of all types of fuel consumed in Jordan. This is because NG and HFO are used in electric-power generation and large industrial plants. Diesel fuel is employed mainly for transportation, industry and, to a lesser extent, for space heating and agriculture as well as to fuel combined cycle power plants when NG is not available. It is obvious that there was a jump in Diesel Fuel (DF) and HFO in 2011 to substitute for the shortage on NG supply from Egypt for power generation. This continued until 2015, when the Liquefied Natural Gas (LNG) terminal was completed and received shipments of LNG, gasified and then pumped in the pipeline to fuel power plants in the country. At present LNG contributes to more than 80% of the total power generation and expected to grow in the future and excess quantities will be supplied to large industries. As for energy efficiency, MEMR has updated the National Energy Efficiency Action Plan (NEEAP) which also included applications of renewable energy [15]. A cabinet decision was made to all public institutions to consider generating 20% of their electricity needs by solar systems and to budget for that as of 2014 within each line Ministry budget.

According to MEMR's annual report the final energy consumption can be distributed between four main sectors, as shown in table 5 and figure 7. It is obvious that the transport sector is the major consumer (48%), followed by residential (22%), industry (17%) and others (13%). The latter includes agriculture, commercial and other minor sectors such as government and military consumptions.

Table 4: Consumption of Petroleum Products (000 ton)

Year	Liquefied Gas	Gasoline	Jet Fuel	Kerosene	Diesel	Fuel Oil	Asphalt	TOTAL
2010	312	1065	351	69	1577	1273	101	4748
2011	378	1083	354	75	2407	1670	109	6076
2012	377	1147	380	81	3103	1578	92	6758
2013	369	1161	357	63	2810	1679	104	6544
2014	371	1187	339	49	3274	2041	159	7420
2015	416	1319	321	91	2235	1705	185	6272
Av. Annual Growth rate % (2010-2015)	**5.9**	**4.4**	**-1.8**	**5.7**	**7.2**	**6.0**	**12.9**	**5.6**

Source: MEMR, Annual Report 2015.

Table 5: Final Energy Consumption

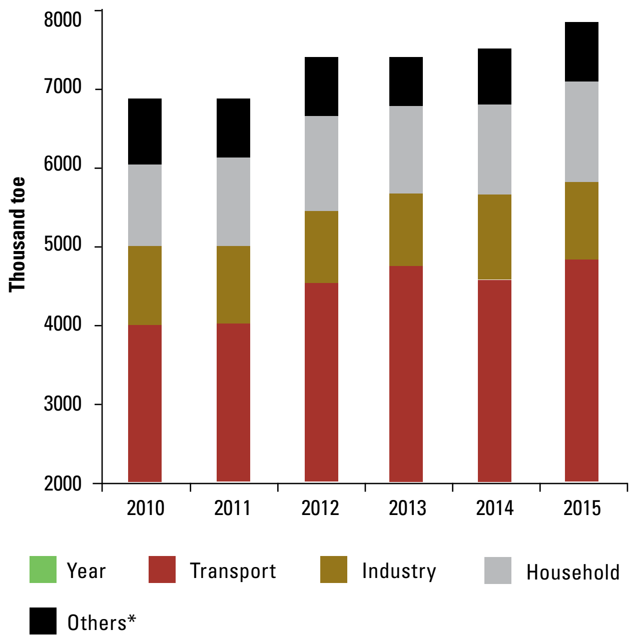
Year	Transport		Industrial		Household		Services & Others		Total (000 toe)
	000 toe	%	000 toe	%	000 toe	%	000 toe	%	
2010	1991	41	1014	21	1019	21	849	17	**4873**
2011	2012	41	961	20	1136	23	779	16	**4888**
2012	2520	47	921	17	1198	22	744	14	**5383**
2013	2734	51	924	17	1109	21	617	11	**5384**
2014	2558	46	1079	20	1152	21	718	13	**5507**
2015	2811	48	991	17	1272	22	754	13	**5828**

Source: MEMR, Annual Report 2015.

The rate of energy consumption, especially electricity, is rising rapidly due to the high growth rate of population and urbanization. Recently, there has been a growing concern about electricity consumption and adverse impacts on the economy and environment. The typical daily loading curve differs seasonally, but the general trend follows two peaks (morning and evening) system, with the evening peak being the highest. This is due to residential and commercial loads, while the morning one is attributed to offices space cooling and heating in addition to official activities.

In 2006, electricity consumption reached nearly 9, 579GWh, of which the residential and industrial sectors had a share equal to 36% and 31%, respectively. Nine years later, 2015, the consumption of residential sector jumped to reach 43%, while consumption of the industrial sector dropped to be around 25% of the total electricity consumption in that year. This could be attributed to unexpected reduction in industrial production from different sub-sectors, and the sudden jump in population because of the refugee influx. Table 6 shows electricity consumption in main sectors during 2010-2015.

Figure 7: Sectorial Distribution of Final Energy Consumption



*commercial, services & agriculture [7]

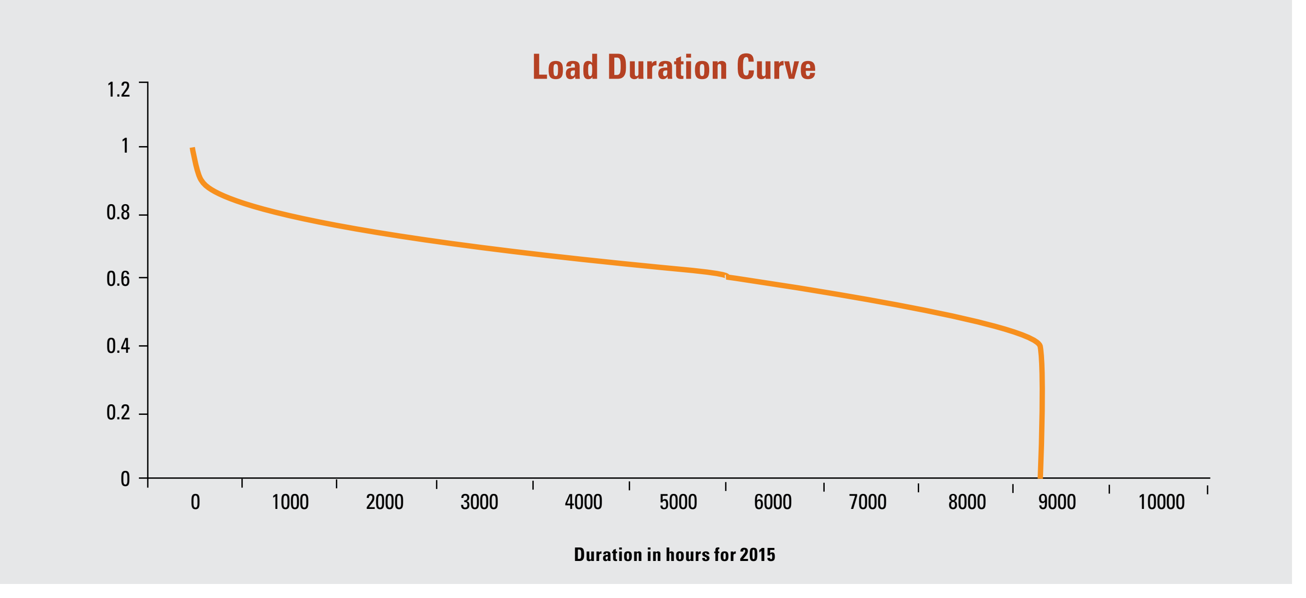
Table 6: Distribution of Electricity Consumption (GWh) and Peak Load (MW)

Year	Residential & Government Buildings*		Industrial		Commercial & Hotels		Agriculture & water pumping		Street Lighting		Total (GWh)	Peak Load (MW)
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%		
2010	5,225	41	3,262	25	2,187	17	1,868	15	315	2	12,857	2,695
2011	5,535	41	3,478	26	2,260	17	1,938	14	324	2	13,535	2,790
2012	6,126	43	3,461	24	2,427	17	1,955	14	305	2	14,274	2,880
2013	6,265	43	3,517	24	2,415	17	2,076	14	291	2	14,564	3,100
2014	6,580	43	3,877	25	2,358	15	2,287	15	316	2	15,418	3,020
2015	6,938	43	4,013	25	2,460	15	2,426	15	336	2	16,173	3,300

Source: NEPCO, Annual Report 2015 [9].
*Include about 6% Governmental + 1.5% Others

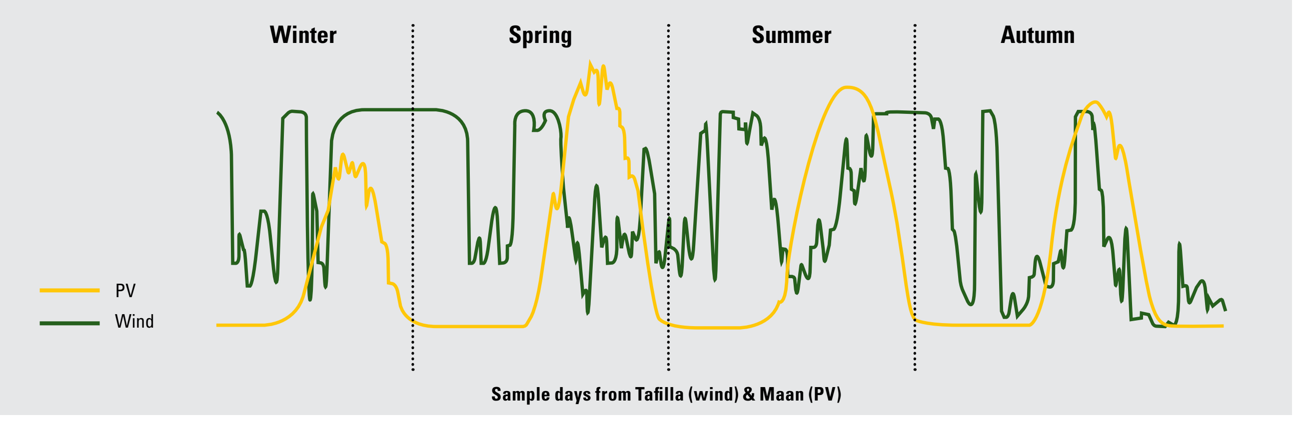
The daily loading curve is characterized with two peaks: relatively moderate peak in the morning (9:30-11:30 am) and high peak demand in the evening (6:00-9:00 pm). The maximum peak demand, 3300 MW in 2015, occurred in the evening during the summer season (July-August) due to high temperatures and dry climate. Equally important is the return of Jordanians working in Arab Gulf countries during the summer holidays and tourists as well as social activities. In winter the peak load still occurs in the evening but less than that in summer. The minimum load always occurred late night and early morning (1:00-5:30 am) before the sun rise. Figure 8 illustrates the load duration curve in terms of hours in 2015 which shows that the load is highest in the beginning and then decreases gradually. Figure 9 represents the renewable energy output profile for two locations using RE as an energy source.

Figure 8: Load Duration Curve



Source: NEPCO, Planning Department [36].

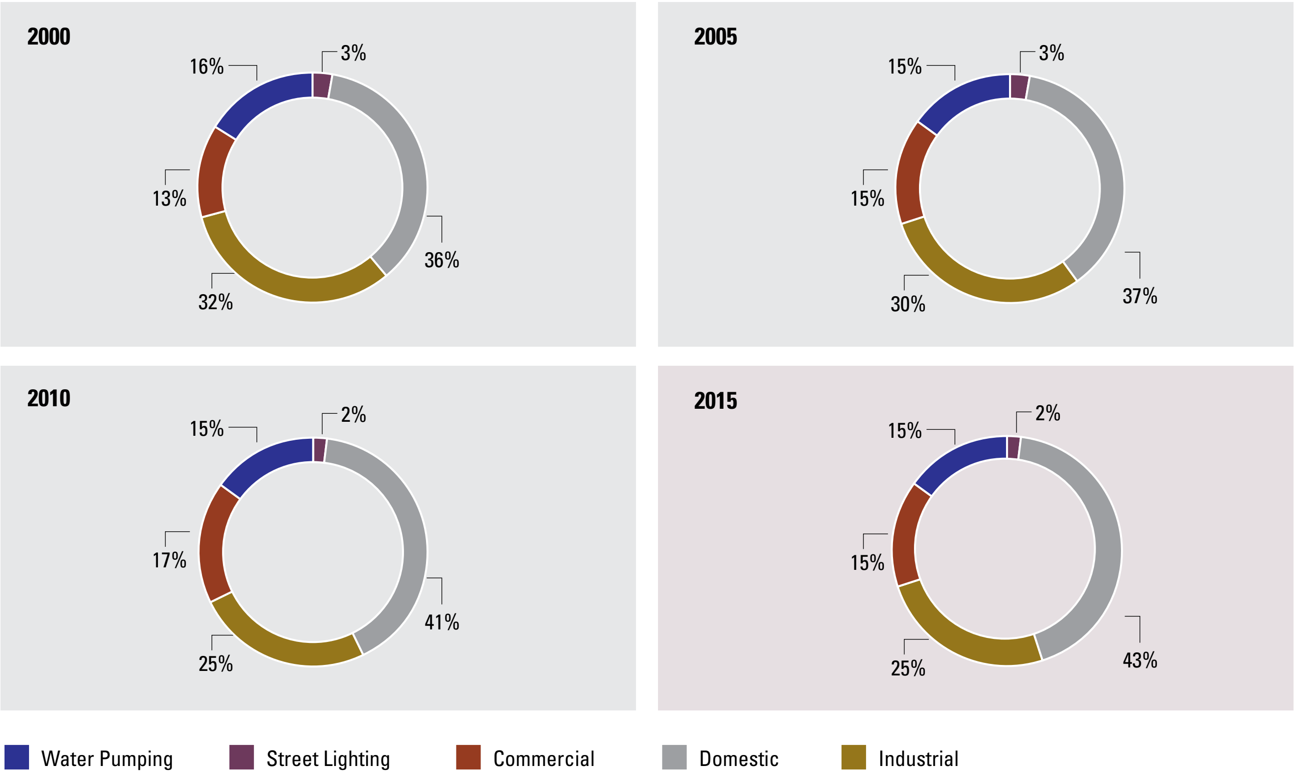
Figure 9: Renewable Output Profile



Source: NEPCO, Planning Department [36].

Figure 10 illustrates electricity consumption by sectors between 2000-2015 (5 years interval). In 2015 Jordan's domestic sector accounts for 43% of the total electricity consumption, followed by the industrial sector at 25%. The overall consumption has been increasing steadily in most recent years. The consumption of the water pumping sector is increasing at high ratio as well; fresh-water is being pumped from underground aquifers from the Jordan valley up to the high land to the western mountain chains that have a big difference in elevation that exceed 1,000 m. Since 2013 water has been extracted and conveyed from the Disi water aquifer, located in the southern desert located at a distance of 350 km from Amman, this change of the location of water resources has led to the increase in the electricity consumption for the water pumping sector.

Figure 10: Electrical Energy Consumption by Sector



Source: NEPCO, Annual Report 2005 [34] and Annual Report 2015 [9].

Table 7: Electricity Demand Forecast in the Interconnected System

Year	Max. Demand*		Electrical Energy Generated	
	MW	Growth (%)	GWH	Growth (%)
2016	**3,485**	5.6	19,559	5.5
2017	**3,677**	5.5	20,654	5.6
2018	**3,879**	5.5	21,852	5.8
2019	**4,092**	5.5	23,097	5.7
2020	**4,317**	5.5	24,368	5.5
2025	**5,643**	5.5	32,303	5.8
2030	**7,375**	5.5	42,419	5.6

Source: NEPCO, Annual Report 2015. *Summer Loads

Forecasted electricity demand is represented in table 7. The demand is expected to grow annually by a percentage of (5.6%) for the period (2016-2030) which is supposed to face the expected increase of the electricity demand in the coming years which is based on various variables such as the expected growth rate of population, and economy as well as consumption patterns of the electrical energy.

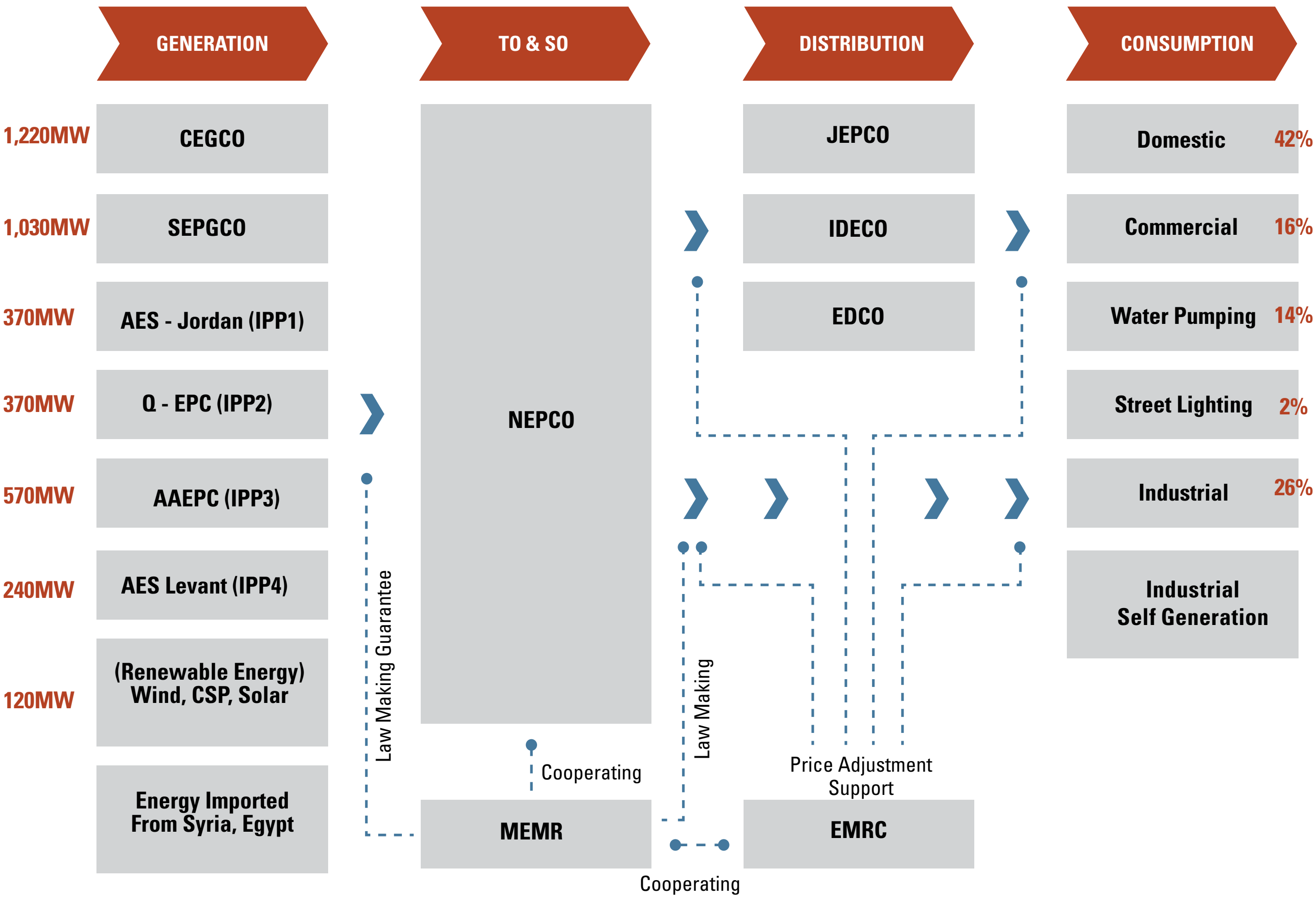
3.4. Structure of Electricity Sub-Sector

System reform in electricity sector in Jordan started in 1996. Power generation, transmission and distribution sectors were privatized in 1999. National Electric Power Company (NEPCO) is operated under the government. As shown in figure 11, NEPCO manages the transmission sector as a single buyer.

Ministry of Energy and Mineral Resources (MEMR) has the responsibility in developing long term strategy etc. Energy and Mineral Regulatory Commission (EMRC) is responsible for electricity law, electricity tariff, issue of business license and general regulation, transmission and distribution/retail sale sectors.

Table 8 shows the main power producers in Jordan. NEPCO purchases electric power generated by all the power producers in the Kingdom. All these companies operate under a 25-year distribution license. The standard license published by the EMRC deals with distribution companies for distributing electricity and retail supply through a single license. Distribution and retail supply holders are prohibited from participating in any activity related to other segments. However, section 28(B)-3 of the General Electricity Law permits anyone to undertake self-generation without the need for a license.

Figure 11: Electricity Sector System in Jordan



Source: NEPCO, JICA study team

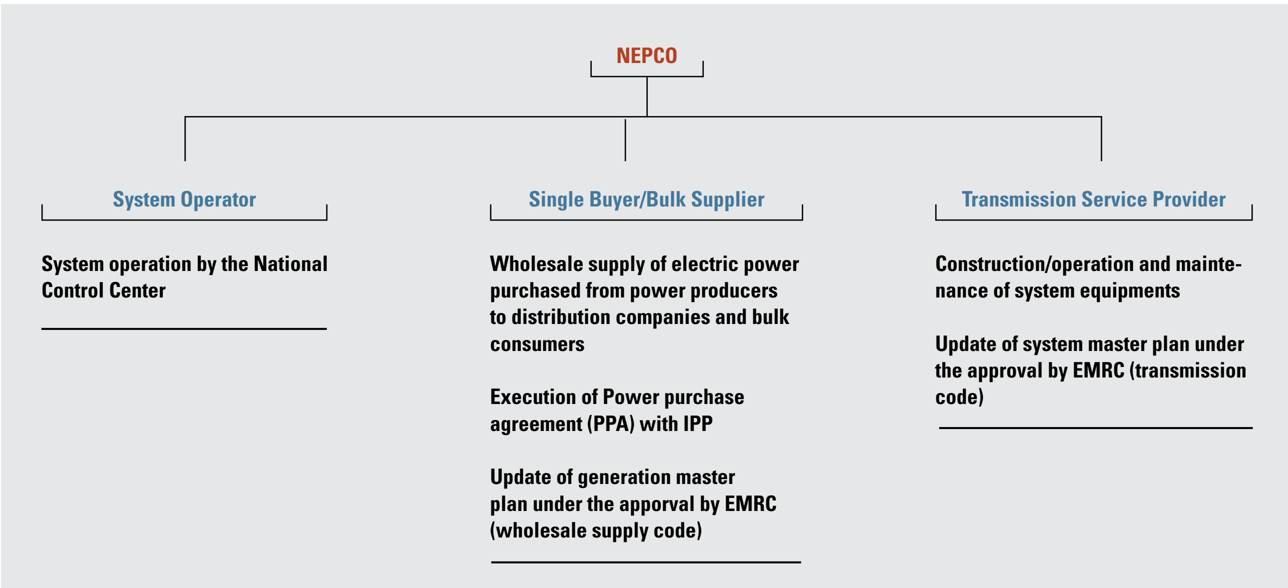
Table 8: Main Power Producers in Jordan

	Company	Capacity	Shareholding	Generation Technology
1	Central Electricity Generation Company (Cegco)	1,687 MW	40% Jordanian Government 60% Private Company	ST, CCGT, GT
2	Samra Electricity Power Company (Sepco)	1,050 MW	100% Jordanian Government	CCGT
3	Amman East Power Company (AES-Jordan, IPP1)	370 MW	AES Mitsui	CCGT
4	Qatrana Electric Power Company (Qatrana, IPP2)	420 MW	KEPCO, XNEL	CCGT
5	Amman Asia Electric Power Company (AAEPC, IPP3)	573 MW	Mitsubishi, WDFS	Diesel Engine
6	Amman East Power Company (AES Levant, IPP4)	240 MW	AES, Mitsui	Diesel Engine

Source: NEPCO, Annual Report 2016.

Figure 12 shows the transmission and distribution sectors in Jordan. NEPCO is the system operator in Jordan and has three main responsibilities: i) single buyer and bulk supplier for electricity; (ii) system operator; and (iii) transmission network operator. The company is 100% state owned and owns the National Control Centre (NCC) and the transmission network which consists of high voltage transmission lines of 132 kV and 400 kV with total length of 4,121 km-circuit and main substation with total capacity of 11,484 MVA.

Figure 12: Transmission and Distribution Sectors in Jordan



Source: JICA Study Team [40].

3.5. Energy Intensity

The expansion in infrastructure and energy intensive industries, such as phosphate and potash mining, fertilizers and cement has played a major role in the Energy Intensity. The Energy intensity level of primary energy (MJ/$2011 PPP GDP) as shown in table 9, has decreased from 5.559 in 2005 to 4.239 in 2011, so a reduction of around -4.4%. The final energy intensity has decreased with higher rate -4.9% in the same period. However, since 2011, both intensities have slightly increased with annual rate of 2.1% and 2.3% respectively showing some kind of degradation of the energy performance of the economy. On the overall period 2005-2014, the primary and final energy intensity has decreased with an annual rate of -2.3% and -2.1% respectively, as the economy witnessed impressive developments in the commercial and service sectors, which do not consume significant amounts of energy but contribute significantly to generating wealth in the country. In addition, the modernization and improvements in energy producing and consuming equipment as well as GoJ efforts in reducing waste and increasing efficiency had contributed to the great reduction in such ratio. Although, such ratio could be improved more since sustainable economic growth should not lead to an increased rate of energy consumption.

Energy efficiency should be promoted on the highest decision-making level in order to meet long-term energy demands. In this regard MEMR has developed the first Jordanian National Energy Efficiency Action Plan (NEEAP) for the period 2012-2014 based on the contents of the Jordan Energy Strategy, aiming to reach the target of 20% improvement in energy efficiency by the year 2020, providing some recommendations related to RE.

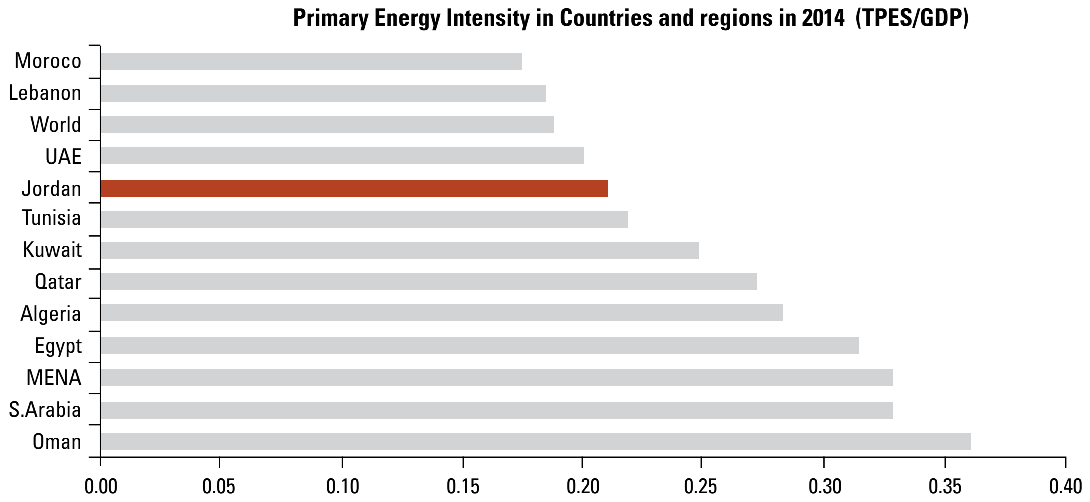
Table 9: Energy intensity level of primary energy (MJ/$2011 PPP GDP)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Energy Intensity	5.559	5.279	5.133	4.694	4.695	4.370	4.239	4.587	4.391	4.509

Source: World Energy Statistics and Balances, IEA (2014); World Development Indicators, WDI (2014)
https://data.worldbank.org/indicator/EG.EGY.PRIM.PP.KD?end=2014&locations=JO&start=2014&view=bar

In compared to other countries as illustrated in figure 13, the primary energy intensity of Jordan can be considered high. It is around 0.21 toe/1000 USD of 2010, 1.2 times the world intensity and 4 times the average EU intensity.

Figure 13: Energy intensity for selected countries and regions



Source: International Energy Agency (IEA) 2016, USD2010

3.6. Energy-Water Nexus

Jordan faces challenges regarding the availability and the utilization of its natural resources. These challenges are generated by the scarcity of both, water and fossil energy resources, and their increasing demand. Jordan's climate is arid to semi-arid with low rainfall and high evaporation rates.

The water sector presents a crucial challenge to Jordan. Jordan has one of the lowest levels of water availability per capita in the world with less than 120 cubic meters and is ranked within the bottom four poorest countries globally in terms of available water resources. Jordan gets its water mainly from water aquifers and basins shared with neighbouring countries which are located at a considerable distance to end users. Jordan's annual budget of water is around one billion cubic meters per annum and the per capita supply is 100-120 cubic meters per year and is estimated to drop down to 90 cubic meters per year within the next eight years.

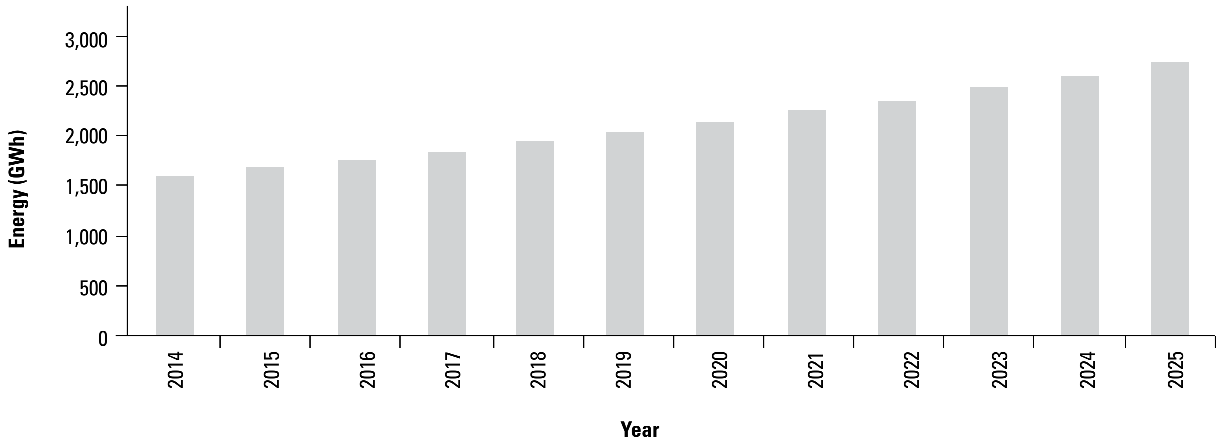
Severe water shortage is a challenge to Jordan's economic growth – the per capita water share is 145 m3 per year, which is 15% of the internationally recognised water poverty level. The government of Jordan already uses a rationing system to decrease personal consumption, households get access to water from the municipalities once or twice a week.

Water Pumping, Treatment and Distribution:
The water sector also involves an energy extensive operation by deploying large water pumping, boosting, and treatment and distribution facilities. The power requirements only for water pumping in 2015 amounted to about 15% of the total power production of Jordan with a total amount of 2485 GWh [7].

The energy demand for water pumping is increasing year after year as the number of residents in Jordan is increasing rapidly due to the political instability of neighbouring countries. In attempts to decrease the energy bill expended on water pumping the Ministry of Water and Irrigation (MWI) is planning to install PV technologies to supply the energy needed to pump water from different parts of Jordan which will save about 1.5-2.0 million USD per year. The water authority's plan is to own and operate PV plants to cover the need of most pumping stations by 2020 which could potentially save 50-60 million Dollars annually [17].

The graph below shows the future expected power demand for the water sector. The Ministry of Water and Irrigation in collaboration with the Water Authority Jordan have released the "Energy Efficiency and Renewable Energy Policy for the Jordanian Water Sector" which serves as a tool for implementing an ambitious national program to promote energy efficiency and renewable energy usage in the water sector.

Figure 14: Energy Consumption in the Water Supply Sector 2014-2025



Source: Water Authority Jordan, Energy Efficiency and Renewable Energy Policy [42].

This policy aims to optimize and improve efficiencies in the water sector, as well as introducing renewable energy technologies to contribute in the reduction of water supply costs, while the energy efficiency aspect aims to avoid unnecessary losses. The energy targets of MWI for the year 2015 are to reduce the overall energy consumption in public water faculties by 15% and to increase the share of renewable energy to 10% of the overall power supply. Taking a step forward in Jordan's sustainable development goals, while reducing financial pressures caused by scarcity of natural resources in Jordan.

Desalination Project: The Kingdom's first water desalination plant is set to work at a capacity of 500 cubic meters per hour. The project aims at desalinating Red Sea water with the support of the Water Ministry and the Aqaba Special Economic Zone Authority (ASEZA). The clean water it will generate, estimated at around 5 million cubic meters annually, will be used for drinking purposes, agricultural and industrial needs.

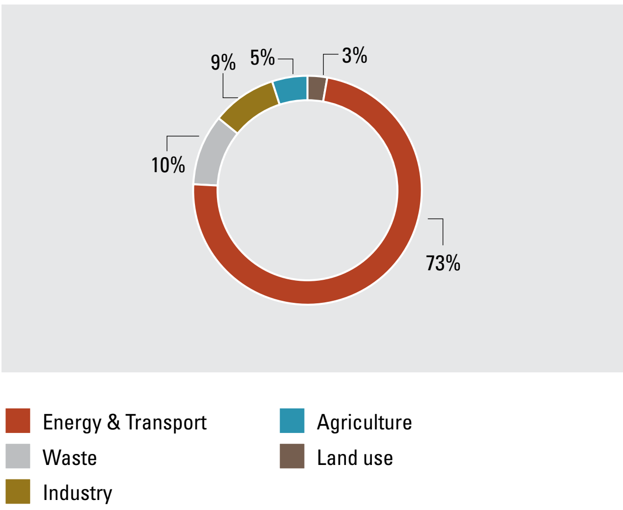
The project, which would meet Aqaba's water needs until the year 2035, is to be fully supplied with renewable energy sources, with the methane gas emitted by the plant and solar energy to generate electricity for the entire project. The biggest portion of water will be pumped into the Aqaba Water Company network to be distributed to consumers. The plant will provide the same amount of water as the Disi project, the main water conveyance project that brings water to Amman from Disi aquifer in the southern desert.

Another major desalination utilities project is the Red Sea-Dead Sea Project (RSDSP) with the aim of connecting the Red Sea to the Dead Sea by pumping seawater up to the high point of the Wadi Araba in the south of Jordan to the East of Aqaba and then allowing it to descend through hydro-electric power stations and desalination plants. The project opens a window of hope in the water sector. The canal aims to meet the urgent need for water through developing a sea intake structure. This project has the ability to establish a secure and affordable water supply for Jordan while saving the Dead Sea from extinction as the sea's water levels is declining by 1 meter annually. The project would be implemented in three phases that would include the private sector for development. Desalination of sea water will produce 30-50 MCM of fresh water as a share for Jordan [17]. Feasibility reports have shown that it is possible to build hydropower stations with a total capacity of 400–800 MW. But the required capital investment is extremely high due to the long canal, i.e. about 200 km, and necessary infrastructure [19].

3.7. CO_2 Emission Footprint

The GoJ in the National Strategy and Action Plan for Sustainable Consumption and Production (NSAP) for (2016 – 2025) which aims to shift to sustainable patterns, the issues of excessive energy consumption and the associated GHG emissions and their potential effects on the global climate change were addressed [20]. Jordan has signed and adopted almost all the international and regional conventions relating to environmental protections, e.g. the Biological Diversity and Climate Change Convention. According to the recent report of the 3rd National Communication on climate change 2014 [18], the annual CO_2 emissions were estimated in 2006 to be 28,717 Gg of CO_2 eq., i.e. 28.72 million ton (Mt) of CO_2 equivalent, and expected to be around 38,151 Gg in 2020. Figure 15 shows that fuels combustion related activities, in both electricity and transport sectors, have the dominant share of GHGs emissions totaling 73%, of about 33 million ton, followed by waste and industrial activities, in 2014.

Figure 15: Distribution of GHG Emissions in Jordan, 2014



Source: Jordan 3rd National Communication on Climate Change [18].

The Country's bulk share of GHGs represents 0.07% of global total with GHG emission of 30.8217 MtCO_2e according to a global GHGs analysis conducted in 2013 [27]. Although this is a small contribution of the world's annual CO_2 emissions, but its intensity is considerably high. According to the World Bank, per capita emission is about 3.465 tons of CO_2 in 2013. Such rate is much higher than that incurred in most European countries, and almost similar to those of oil producing Arab countries.

This implies that there is room for energy efficiency improvement and emissions reduction in all sectors by employing RE systems. The GoJ has developed a targeted program aiming to reduce the national GHGs emissions by 1.5% by 2030 compared to a business as usual scenario levels. It was submitted as Intended Nationally Determined Contribution (INDC) to reduce GHG emissions. The conditional outcome target is aiming at reducing Jordan's GHGs emissions by 12.5% by 2030.

The two targets will be achieved based on implementing at least 70 projects (43 sectorial projects resulted from the mitigation scenario assessment articulated in the 2014 Third National Communication Report to United Nation Framework Convention on Climate Change (UNFCCC) and another around 27 sectorial priority projects proposed concurrently or newly planned and not listed in the Third National Communication (TNC) Report, i.e., proposed after the development of the TNC. The 27 sectorial priority projects proposed were disseminated to INDC document by involved stakeholders, Ministries and organizations in response to INDC formulation process.

These 70 projects represent 14% of INDC of Jordan, of which many projects are now under execution by relevant institutions, and will be implemented under the guidance of the overarching national Climate Change Policy of the Hashemite Kingdom of Jordan 2013-2020 [18].

The climate change policy of Jordan is a holistic nation-wide policy encompassed strategic objectives and measures for mitigation and adaptation. Jordan is one of the few countries in the region to consider all the sectors for climate change mitigation measures, covering the pre-2020 period, which was developed voluntarily as a demonstration of the self-commitment of a small yet ambitious country. The Policy itself as well will be extended at the end of its term to 2030 to concurrently go in line with and serve as an overarching umbrella guiding and monitoring the implementation of the 70 project and 14% GHGs emission reduction pathway of activities until 2030.

IV. Renewable Energy Potential

Jordan is considered one of the best locations world-wide in terms of solar radiation. In particular, the southern part of Jordan has the best solar radiation conditions in Jordan. A site of extraordinary high Average Annual Direct Normal Irradiation (AADNI) of 2798 kWh/m2 is Ma'an in south of Jordan, which is situated at a relatively high altitude of 1012 m above mean sea level. The same station has an Average Annual Global Horizontal Irradiation (AAGHI) of 2327 kWh/m2. The evaluation interval was from June 1, 2011 to May 31, 2015 [28]. Also wind energy is promising in many sites around Jordan. The Highlands in the west hold the best locations for wind. For example, the average annual wind speed at 10m height at Ajloun is 6.1 m/s which is considered very good for wind energy projects.

Recognizing the potential for renewable energy to achieve country's energy security, economic growth and environmental objectives, the GoJ had set the target of 10% renewable energy input into the energy mix by 2020.This chapter will be reviewing different RE resources that are available in Jordan and discussing their potential.

4.1. Renewable Energy Potential for Power Generation

At present and after the 1st, 2nd and 3rd rounds of direct proposals which consist of: 200MW PV Round 1,420MW wind round 1,200MW PV round 2,100MW wind round 2,200MW PV round 3 and 100MW wind round 3 (which contributes in total to 600MW from PV and 620MW from wind). Jordan now has an organized commercial and domestic photovoltaic (PV) program:

the private sector has the technical experience and know-how as well as ability to develop and finance such projects.

Table 10 indicates the committed renewable energy projects of about 2,293MW and the phase they are in, including the 3rd round for direct proposals which was announced by MEMR in 13 December 2016 calling for the installation of 200MW PV and 100MW wind projects in the southern region of Jordan. 64 out of 70 companies and developers have been prequalified based on IPP-BOO scheme, for large blocks of about 50MW on designated sites in the southern part of the country.

PV projects will be constructed in Ma'an area and the wind farms also in the southern region. In the tender documents, MEMR stated clearly that energy storage using batteries will be considered for both types (PV and wind) of RE projects. It is expected that the 3rd round projects will not reach financial closing stage before mid-2018 and may be operational in 2020 for the PV and 2021 for the wind [29].

These projects could substantially reduce Jordan's energy dependency and create significant fiscal benefits: (i) expected to generate about 2,000GWh annually; (ii) create between 2,000 and 3,000 jobs, and avoiding 0.9-1.0 tons of GHG emissions depending on the fuel mix used in power generation.

MEMR is working in close cooperation with the Ministry of Municipalities and the Great Amman Municipality and investors to convert solid waste into energy and the expected installed capacity is estimated at around 60MW.

In addition to these central generation projects, on-grid roof tops PV systems based on net-metering directive witnessed high growth rate during 2013-2016. The estimated installed capacity exceeded 70MW and about 10MW through the wheeling mechanism, as reported by MEMR in December 2016. Such small systems are expected to increase more rapidly due to the fact that the government increased electricity prices by an average of 15% per year for almost all tariff categories except low income households and agriculture sectors [Annex B].

Source: Wind turbine for electricity production on the mountains and beautiful sky, by Etaphop photo , Shutterstock.

Table 10: Committed Renewable Energy Projects

No.	Type	Location	Ownership	Capacity (MW)	Status	Commercial Operation
1	PV	Azraq	Government	5	Commissioned	On-Line May 2015
2	PV	Mafraq	Private	10	Commissioned	On-Line May 2015
3	Wind	Tafila	Private	117	Commissioned	On-Line May 2015
4	Wind	South	Private	245	Under Financial Closure	Expected By 2019
5	Wind	Fujij	Private	90	Under Construction	Expected By 2018
6	Wind	Ma'an	Government	80	Commissioned	On-Line Oct. 2016
7	Wind	Al Rajef	Private	82	Under Construction	Expected By 2018
8	PV	Al Quweirah	Government	103	Under Construction	Expected By The End Of 2017
9	PV*	Ma'an	Private	200	Commissioned	Operational 2016
10	PV**	Mafraq	Private	200	Under Construction	Expected By The End Of 2017-2018
11	PV	Masdar	Private	200	Under Financial Closure	Expected By The End Of 2017-2018
12	PV	Decentralized	Private	132	Commissioned	Operational 2016
13	PV	ACWA+AES	Private	100	Under Financial Closure Under Financial Closure	Expected By 2019
14	PV	Decentralized	Private	179	Ongoing	Ongoing
15	PV***	Prequalified	Private	200	Proposal Submission Stage	Expected By 2019-2020
16	Wind***	Prequalified	Private	100	Proposal Submission Stage	Expected By 2020-2021
17	PV	Jordanian Govern-mental Universities	Government	50	Under Development	TBA
18	PV	Decentralized	Private	200	Ongoing	Ongoing
TOTAL				**~2293MW**		

Source: Renewable Energy Department, Ministry of Energy and Mineral Resources, and Planning Department, National Electric Power Company [29]
*1st round direct proposals to MEMR (2013)
**2nd round direct proposals to MEMR (2015)
***3rd round direct proposals to MEMR (2017)

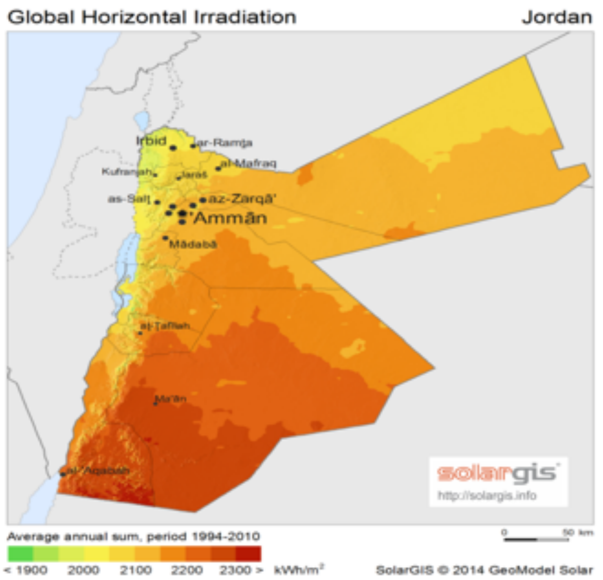
a. Solar Energy

Jordan is blessed with an abundance of solar energy, which is evident from the annual daily average solar irradiance (average insolation intensity on a horizontal surface) which ranges from 5 - 7 kWh/m2/day, which is one of the highest in the world. This corresponds to a total annual of 1,400 - 2,300 kWh/m2/year. The average sunshine duration in Jordan is more than 300 days per year [26].

As shown in figure 16 the country is divided into five regions based upon the solar radiation map as followings:

- The southern region representing Ma'an and Aqaba area, which has the highest solar insolation in the country and has the lowest values of diffuse irradiance. The annual average daily global irradianceis between 6-6.4 kWh/m^2/day.
- The eastern region representing the semi desert and the (badia) remote area with an annual average daily between 4.8-5.2 kWh/m^2/day.
- The middle region with an average global irradiance at 4.5 – 5 kWh/m^2/day, but with the highest annual daily average of diffused irradiance.

Figure 16: Solar radiation intensity



Source: "Direct Normal Irradiation Jordan," SolarGIS, 2015.

- The northern region with the annual daily average global irradiance of about 5.5 kWh/m^2/day.
- The western region representing the Jordan Valley area, situated below sea level and with an average annual daily global irradiance below 4.5 kWh/m^2/day.

In the past 30 years, until the issuance of REEEL, stand-alone PV systems on small or pilot scale were used for electrification of limited number of remote areas, which are located far from the electricity grid-connection supply system. Also, there are some small PV systems that are used to generate power for individual applications such as clinics, lighting, and educational television, for far away locations, and to supply required power for communication towers and police stations in isolated areas. The benefits of renewable energy can be intensified when rural communities are prioritized as key stakeholders in the green economy. This is true for a number of technical and socio-economic reasons.

Decentralized rooftop solar PV market in Jordan has more than doubled between 2013 and 2016 and reached around 100MW. Actual numbers based on applications to connect RE systems to the distribution grids indicate that the market is expected to have a much larger increase in the near future. According to EMRC, the solar PV market is more promising in the next five years.

There is a significant number of PV projects in Jordan, (central power plants, wheeling schemes and net-metering PV systems) as well; some were completed and connected to the grid and others in the pipeline and soon will be commissioned and operating on commercial basis.

This is due to the fact that at current prices, PV systems have the lowest price as compared with other generation systems.

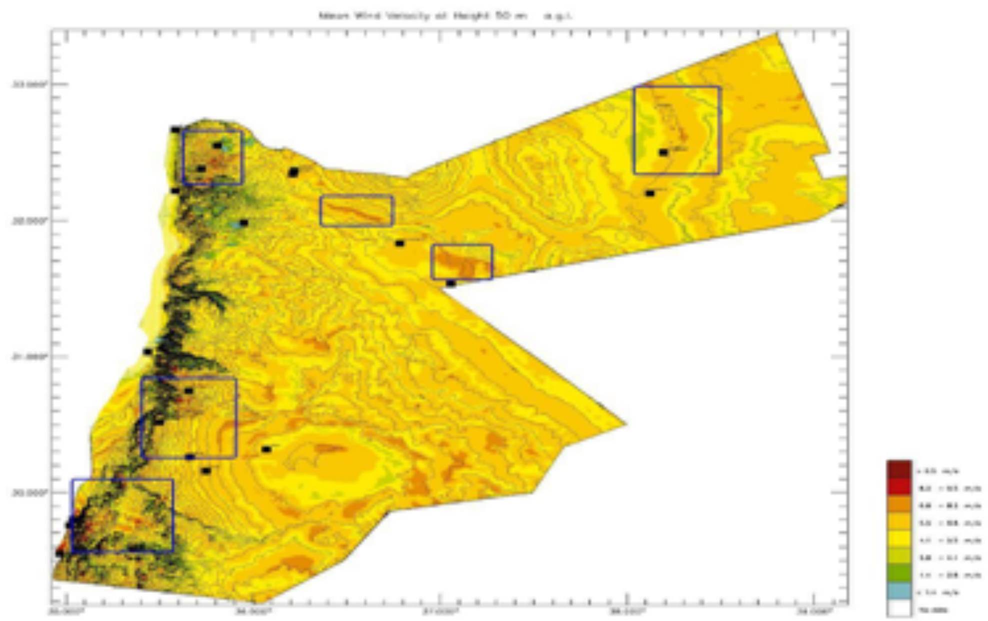
It is expected that after the year 2020, there will be about 1,400-1,600 MWp of PV installed and operating as central plants and about 150-200 MW, or even more depending on the completion of the green corridor, of small PV systems as net-metering and wheeling [Annex B].

b. Wind Energy

There are a number of regions in Jordan with acceptable wind speed to generate electricity, where the great potential areas are the northern, central and southern parts. The country is classified into three wind regions according to prevailing wind speed: less than 4 m/s, between 4 and 6 m/s and more than 6 m/s for low, medium and high regions, respectively, as shown in figure 17.

The high wind regime is limited to certain districts: most attractive sites are Hoffa, in the northwestern corner, Kamsheh nearby Amman-Irbid highway and Fujeij, near Showbak, and Wadi Araba in the south. The potential is promising for wind energy, but more field studies and measurements are still needed due to the fact that wind characteristics are site specific. According to recent reports and meetings with concerned staff, in MEMR and NERC, there is a good potential in the north-eastern corner close to the Syrian border. However, no technical details or field measurements, in the site, are available now nor could be conducted, in the near future, due to the armed conflicts in Syria and the whole border area is closed only for military movement and operations.

Figure 17: Promising Locations of Wind Energy



Source: NERC

Four wind farms have been commissioned in Jordan. The first one is at Al Ibrahimya, located approximately 80 km north of Amman, which consists of 4 wind turbines each one is 80 KW with a rated wind farm power of 320 kW established in 1988 with annual energy production of about 750 MWh.

The second one is at Hofa, located approximately 92 km north of Amman, which consists of 5 wind turbines each one is 225 KW with a rated wind farm power of 1,125 kW established in 1996 with annual energy production of 2.5 GWh. The Tafilaa wind power project in the south is the first of its kind in the Kingdom and the region. The Tafila Wind Farm Project has a power generation capacity of 117 MW. The farm consists of 38 turbines that can create 400 GW/h annually. The fourth operational wind farm is Ma'an Wind Farm in south Jordan, with a capacity of 66MW.

There is good potential in sites where some of the current wind generation power plants already exist and where some pilot projects have been set up, the area in Khamsheh, Fujeij,Tafilah,Wadi Araba and Ibrahimiyya are good in terms of wind speeds according to the wind maps. In Ibrahimiyya for example data is available and has been collected for the past 20 years ever since the establishment of some small wind turbines in that area. Khamsheh has average wind speeds of 8.5m/s which also have potential for future wind projects.

At present, the annual rate of power generation from wind turbines is not much, around 123.1 GWh, thereby avoiding the need for approximately 26,000 toe, i.e. 0.65% of the total annual energy consumption in the power sub-sector [9]. The corresponding savings in fuel cost is about USD 10.0 million annually, based on prevailing prices in 2015 of not less than USD 50.0 per barrel. Equally important is the sustainable and diversified electricity supplies and reduced GHG emissions of about 5,500 ton of CO_2 eq. There are many other wind energy water pumping stations especially in the remote areas using multi blade mechanical wind pumping systems.

To sum up the wind potential in Jordan, is promising and cost-effective in many sites according to preliminary measurements and studies. However, there is a real need to develop a national wind atlas that should cover all promising sites in the country.

c. Geothermal

Jordan is among countries with moderate potential in geothermal energy. However, all surveyed hydro-thermal fields are of low temperature, i.e. less than 100 °C, and located in two main regions: namely the eastern flank of the Jordan Valley, in the west, and the plateau east of Madaba city. Hence, the commercial utilization of these fields will be limited: could not be used for electrical power generation. Nevertheless many of these sources are currently used on a small scale either for hot-water spas or for greenhouse heating. In addition to the lack of discovered high-temperature geothermal resources, Jordan has a shortage of experience and expertise in geothermal developments of all types. has called for an international consultant to express interest for conducting a geothermal target study in Jordan. The scope of work of this new study includes the followings:

- Analyze the latest available studies, statistics, energy policy guidelines in Jordan related to geothermal energy utilization. From a preliminary review of documentation, it is expected that the main potential lies with low and medium enthalpy techniques.
- Financial and technical assessment of the sustainable demand for geothermal energy applications in the Country for heating and cooling and for other applications in different market sectors.
- Identify the most suitable locations across Jordan and the most suitable geothermal technologies.
- Review of all applicable technical solutions by evaluating technical and financial their feasibility.
- Identify a set of stakeholders that could benefit from adoption of geothermal energy to be applied in different sectors.

A better assessment of geothermal potential in Jordan should be made based on the outcomes of this study.

d. Waste-to-Energy and Biomass

Waste-to-energy is getting increasing attention in Jordan because of the cheap and abundant availability of a wide range of biomass feedstock, including municipal solid waste, sewage, industrial waste etc. Municipal solid wastes represent the best feedstock for waste to energy plants in Jordan. In terms of quantity per capita and constituents, the waste generated in Jordan is comparable to most semi-industrialized nations. With a flow of 3000 tons of waste per day, the per capita waste generation in the country is about 0.95 kg/day. The total generation of municipal waste in Jordan is estimated at 2 million tons per year. Another major waste resource in Jordan is in the form of industrial organic waste such as organic wastes from slaughterhouse, vegetable market, hotels and restaurants, organic waste from agro-industries, animal manure mainly from cows and chickens, sewage sludge and septic, olive mills and organic industrial waste.

The Government of Jordan, in collaboration with UNDP, GEF and the Danish Government, established 1MW Biomethanation plant at Rusaifeh landfill near Amman in 1999. The Plant has been successfully operating since its commissioning and its capacity was increased to 5MW by mid-2017. The successful installation of the biogas project has made it a role model in the entire region.

Solid waste management in Jordan, and particular MSW, has been improved for the last decade, with improvement of legal framework and institutional capacity to be the main drivers of sector's development.

With the adoption of Government National Agenda (NA) for Sustainable Development, solid waste management sector is now a priority and will be addressed on par with water and wastewater issues. There are existing projects as of the implementation a project to generate 40-50MW electricity by grate combustion, Direct Incineration/ Municipal Solid Waste (MSW), in Ghabawi landfill, 25 kilometers east of Amman by the Greater Amman Municipality (GAM). The project is of capacity 1500 t/d and there is a thought of increasing the MSW to 2000 t/d after two years from the commissioning day. Recently, MEMR announced for those interested to invest in Waste-to-Energy (WTE) project to submit their proposals and legal documents for pre-qualification, which was closed on 21st of August 2017. The project involves building a WTE facility at the Al Ekaider landfill in the north, close to the border with Syria. The proposal involves the construction of a facility with a capacity of 1000 t/d for the electricity generation on the basis of a BOO(T) scheme with a grate based combustion process as the WTE technology. It is expected that initially the facility will consist of two incineration trains (with an option to add a third train at a later stage depending on the developments in the waste sector, including any changes in the volumes and composition of waste) [30].

The potential of municipal waste to energy could be another 20-30MW from landfill sites of main cities. But this potential can be increased.

e. Hydropower

Hydropower sources are limited due to the fact that the surface water resources, such as rivers and waterfalls, are very scarce in Jordan. However, there are presently two small hydropower installations. The first is the King Talal dam spanning the river Zarqa, with a rated electricity generating capacity of 7 MW. The other installation is at the Aqaba thermal power station, where the hydro-turbine utilizes the available head of returning cooling seawater with a capacity of 5 MW.

The total amount of electricity generated, in 2015, by hydropower units was 52.5 GWh, which is a very small fraction of the total power generation in that year. This represents, at present, the total economically feasible capacity for hydropower in Jordan [7]. However, there is a great possibility to generate electricity, using mini-hydropower stations in selected sites, and by taking advantage of the elevation difference between the Red and Dead Seas, as well. The latter is the lowest region on earth with its water surface located at 400 m below normal sea level. If seawater is allowed to flow from the Gulf of Aqaba into the Dead Sea through a canal system at predetermined rates, it will produce electrical power from hydropower stations and potable water from seawater desalination plants.

While this project is expected to help in establishing new economic activities, such as tourism and agriculture, it will ensure the supply of large amounts of highly needed electricity and water as well as the replenishment of the Dead Sea by replacing the evaporated water. The latter will dictate the amount of electricity generated annually. Preliminary feasibility reports have shown that it is possible to build hydropower stations with a total capacity of 400–800 MW. But the required capital investment, of between7-10 billion JDs is extremely high due to the long canal, i.e. about 200 km, and necessary infrastructure [17]. There is also an opportunity to integrate in this project solar and hydropower in one scheme. In this scheme the required pumps to lift sea water up to an area located near the airport, 200 m above sea level, could be run by electricity generated from a solar PV plant, then water can flow to the dead sea to generate the hydropower.

In the western mountains region, where almost all water sources and/or collection systems are located, many sites are suitable for mini-hydropower schemes. Other important benefits can be induced by such schemes, such as improved agriculture, cultivation, water harvesting and irrigation as well as tourism and recreation further activities in these fields can be developed with increase in generation. At present, all existing dams are being utilized as storage reservoirs to meet water demand during the long dry summer season.

But almost all of the sites can be upgraded as mini-hydro and/or pumped storage schemes since they are located in mountainous terrains in the western part of the country, where annual precipitation exceeds 400 mm and may reach 600 mm with some snow in some areas.

A recent study estimated hydropower potential for the existing small dams and the proposed new ones. These estimates are provided in tables 11 and 12, respectively [21].

The total potential installed capacity for the first group is around 33 MW and the annual electricity production may reach 200 GWh, i.e. approximately 1% of the national electricity generation in the year 2015. While the total potential of the second group is much less and estimated at only about 14 MW with possible annual electricity production of about 90-100 GWh. The annual income due to sales of electrical power would yield USD 20-30 million and approximately USD 9-13 million, for the existing and proposed dams, respectively, based on the agreed upon feed-in-tariff of between USD 0.1-0.15 per kWh generated, however the expected required investment is relatively high.

The latter is considered as the main obstacle for harnessing the potential of Small Hydro Power (SHP) in Jordan. Equally important is the lack of awareness and will to develop such resources among different stakeholders, especially the concerned governmental institutions [22].

Table 11: Estimated Hydropower Generation for Existing Dams

Name / Location	Estimated Hydro-power Potential (kW)	Projected Energy Generation Potential (MWh/yr)
Al Wahdah / Irbid	2,500	15,000
Al Arab / Nothern Shuonah	5,750	34,500
Sharhabiel / Jordan Valley	2,900	17,400
Wadi Shuiaib / Southern Shounah	3,150	18,900
Kafrain / Southern Shounah	5,650	33,900
Karameh / Southern Shounah	250	1,500
Tanoor / Jordan Valley	650	3,900
Waleh / Madaba	4,350	2,6100
Mojeb / Karak	8,000	48,000
Waleh / Madaba	8,000	48,000
Mojeb / Karak	8,000	48,000

Source: Jordan Journal of Mechanical and Industrial Engineering, Prospects and Challenges of Small Hydropower Development in Jordan [43].

The construction of the proposed projects, in Jordan, would reduce fuel consumption by about 75,000-100,000 ton/yr of heavy fuel and/or diesel oil, which costs between USD 50-65 million, based on prevailed prices in the first half of 2016, as well as a reduction of at least 2,000 tons of SO_2 emissions annually.

In addition, it will help prevent the discontinuous water flow and improve the ecosystems as well as reduce floodwater damage in certain locations. Based on the average weighted emission rate from the power sub-sector in Jordan, the avoided GHG emissions would be between 80,000-100,000 tons for the case of the existing dams and between 40,000-50,000 tons for the proposed dams. Such reductions in GHG emissions by using SHP schemes can eventually qualify for carbon financing.

Table 12: Projected Potential of Hydropower Generation for Proposed Dams

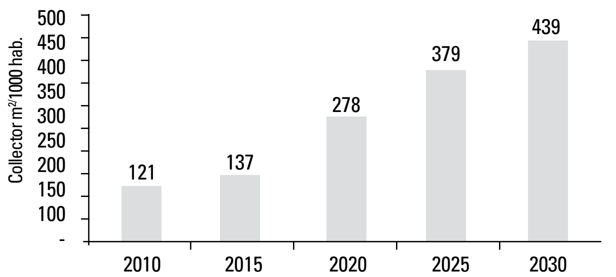
Name / Location	Estimated Hydropower Potential (kW)	Projected Energy Generation Potential (MWh/yr)
Maa'in / Madaba	500	3000
Lajjun / Karak	500	3000
Dalaghah / Tafila	500	3000
Shuthim / Tafila	500	3000
Kufranjah / Ajlun	4500	27000
Bin Hammad	2500	15000
Wahidi / Maa'n	900	5400
Wadi Karak / Karak	1050	6300
Bayer / Eastern desert	2000	12000
Jafer / Southern desert	250	1500
Rukban / North eastern desert	1000	6000
Khanasree / Mafraq	500	3000
Ghadaf / Central desert	250	1500

Source: Jordan Journal of Mechanical and Industrial Engineering, Prospects and Challenges of Small Hydropower Development in Jordan [43].

4.2. Renewable Energy Potential for Direct Use of RE

The annual sunshine duration is around 2900-3200 hours, which can technically be considered sufficient to provide enough energy for solar heating/cooling applications. According to the energy strategy, Jordan Government has to increase the penetration rate of SWH in residential sector to 25% by 2020. If solar water heaters utilized to replace electrical water heaters, it will cut down a significant share of electricity used for water heating in residential sector. On this base, the penetration ratio, expressed as the number of m^2 of collector per 1000 habitant, will reach round 280 m^2 /1000 habitat by 2020 and 440 m^2 by 2030, as presented in figure 18.

Figure 18: SWH penetration ratio (expressed as the number of m^2 of collector per 1000 habitant)



Source: EU, REEE Programme-Technical Assistance [44].

Nevertheless, solar energy technologies are not being extensively used, except for solar-water-heaters (SWH), which are used for heating domestic-water. Another direct application for SWH is space-heating and cooling. Until now solar energy is not being harnessed via solar water-heating systems for space heating as it is still not competing with other RE sources and technologies, and its use is limited to the supply of domestic hot water, and swimming pool heating, for about 10% of the housing stock [7] [10].

The first phase of the let Jordan Shine initiative mentioned in sec.4.1 involves installing Smart Solar systems on roofs of 1000 homes in Tafileh, extending to 20,000 homes across the governorate. Residents taking part in this project will benefit from a reduced electricity bill since each Smart Solar system installed on a rooftop will feed electricity directly into their homes. On the other hand, Mosques initiative aimed to install rooftop PV systems for mosques which is run by the Ministry of Islamic Affairs in close cooperation with MEMR witnessed great progress during the last two years. It is estimated that more than 500 mosques were equipped with adequate PV systems to meet their needs and more mosques will be connected to the grid in the coming years.

Jordan has a long history of R&D in the field of space heating. Since 1980s, a solar house was designed, by the Building Research Center in Royal Scientific Society, to utilize passive and active means to achieve thermal comfort. Flat-plate-collectors and under-floor heating systems are used in space heating, while for this example a desert cooler operated by photovoltaic electric generator was used to drive the fans for space cooling.

Jordan has introduced an incentive scheme for green building known as the green building guide, the Ministry of Public Works and Transportation introduced this guide in 2013 and the incentive scheme was implemented on 3/9/2015. Incentives are based on the grade attained by implementing codes and the incentive scheme works as follows:

80-100 is rated as A and gets 25% more building area
70-80 is rated as B and gets 20% more building area
60-70 is rated as C and gets 15% more building area
50-60 is rated as D and gets 10% more building area.

The rating system is monitored and assessed by the Constructions and Sustainability Center at the Royal Scientific Society as the builder signs a contract and after the requirements are met the Greater Amman Municipality (GAM) gives the approval for the extra building area.

In addition, one of Jordan's main exports is Potash. Jordan extracts 1.8 million tons of Potash per annum from Dead Sea brine at its plant North of Aqaba. It uses solar evaporation to evaporate brine yielding salt and then Carnal-lite is crystalized. This method of solar evaporation is saving large amount of fuel of about $4x10^6$ toe per annum.

Based on estimates by experts in this field (MEMR and NERC) More than half of the lighting stock is installed in Great Amman Municipality. Using PV powered Light-emitting diode (LED) for street lights has a big energy saving potential as street lights use 2% of the electricity consumed according to MEMR. Some pilot projects have been established around the city of Amman.

According to NEPCO water pumping consumes 15% of the total electricity consumed in Jordan, some pilot projects utilize wind energy to empower small water pumping stations in isolated areas aiming to provide clean water for tribes living in the Jordanian desert, monitoring and evaluation is being carried out by NERC.

Geothermal energy sources are currently used on a small scale as hot-water spas and some for greenhouse heating. Recently a few projects were developed to utilize geothermal energy to improve the efficiency of heat pumps for space heating and cooling purposes, for example, the American University of Madaba is using geothermal energy for heating, Abdali Mall in Amman is using geothermal as a measure to increase the building's efficiency for heating and cooling. Other projects are expected to utilize this valuable source of energy.

4.3. Potential for Local Integration and Manufacturing

The industrial sector in Jordan consists of a heterogeneous mixture of manufacturing and conversion activities. These activities range from transforming raw materials into refined products, such as phosphate, cement, plastics and glass and steel to activities involving the production of highly finished end-products, such as food processing and chemical manufacturing. All of these industries if incentivized properly would adopt RE and energy efficiency policies.

Most industries, in Jordan, are working under their rated nominal capacities due to many reasons. The most important factor is that owners of such factories established their business in 1980s and 1990s, based on the fact that they considered exports to Iraq and nearby countries. Thus, the actual production capacity is much higher than the average current working capacity: at present industries are working by 35-45% of the maximum production capacity on one shift basis, i.e. only 8 hours per day, except some cable industries [23] [24]. This means that production capacity could be doubled, or even tripled, easily by increasing the number of workers and working shifts per day. However, some industries should consider the need for renovation or replacement of some of their old and dying machinery/equipment in order to be able to produce high quality products. However, local industries do require and are seeking some kind of help from the GoJ and/or international assistance programs to acquire up-to-date efficient machines and production lines. But it is worth noting that it is a common practice, in Jordan, to import used or written-off machinery, plants and even spare parts from Europe and Southeast Asia.

The SWH industries well developed in Jordan, and the main solar system produced locally is the thermo-siphon-type. 10-15 workshops are manufacturing SWH systems with an acceptable quality. However, only 3-5 factories are producing good quality SWH systems that comply with the specifications outlined by RSS. The remaining operators are small and basic workshops making steel products such as galvanized steel water tanks.

Unfortunately, imported SWHs from China, i.e. vacuum tube type, but with relatively low quality are available at a lower price than locally manufactured flat plate SWHs due to many factors. But the most important is that all imported RE systems are exempted from custom fees and taxes, while locally produced SWHs pay taxes.

According to obtained lists of Jordan Chamber of Industry (JCI), the most involved industries in RE are those immersed in the manufacturing of SWH, various PV components, such as metal drawing and steel fabrication, electrical cables, transformers, PV modules and electrical boards and connection boxes. Other RE technologies, such as wind turbines and Concentrated Solar Power (CSP), still need some expertise to start local production.

Philadelphia Solar, a PV manufacturing company located south of Amman recently introduced a new production line for PV mounting structures. The nominal production capacity of this new factory is sufficient enough to support a generation capacity of 300 MW of PV power plants. In a previous study [26], conducted to assess local industries involved in the manufacture of RE system, in particular, PV system main components, supported by Jordan Competitiveness Program (JCP), a United States Agency for International Development (USAID) funded project, it was found that:

- About 60 industrial establishments were identified that may produce certain parts or items of the electro-mechanical components that will be used in PV power generation systems.

- There are 8 factories that are able to design and produce any metal profile with very high accuracy according to standards and needed specifications set by the client. The same finding applies to industries that manufacture electrical cables. One of the largest industries is currently manufacturing PV cables both for local demand and for export purposes. These are currently manufactured according to the requirements of the German TÜV SÜD, an international service corporation focusing on testing and certification.

- In terms of PV modules and transformers, there is currently one producer of each. Philadelphia Solar is the only solar module manufacturer in the region, and produces Mono and Multi Crystalline modules that are certified according to TUV, CE, ISO, MCS and CUL certifications, and are approved by UL/CUL and CEC. The Electrical Equipment Industry (ELCO), a subsidiary of the three electricity distribution companies, manufactures transformers to meet local and regional demand.

- In addition to the currently capable industries that are manufacturing various components, other industries, such as casings and switch boxes and mounting structures, could enter the RE market provided they receive some financial and technical support to enable them to bring their products up to required standards. In addition there are few small workshops dealing with fiberglass products, mainly large toys for playgrounds for children. Such small industries are keen to find new markets and produce some engineering products, e.g. special tanks, blades for wind turbines, etc.

The GoJ as other governments throughout the globe is focusing more and more on green polices, including industrial policies, to enable them to achieve sustainable economic growth and such conversion towards green economy is becoming a priority. Finally, without incentives for infant industries to grow and develop, given the fact that market oversaturated by low quality products, existing small and medium industries will not be able to develop and produce higher tech components, as those used in RE systems, as well as absorb young Jordanian workers entering the market. Hence, the job market growth could be inhibited.

V. Assessment methodology

In Jordan, different institutions use different methods and methodologies for forecasting and assessing scenarios. In the present report, the assessment methodology of renewable energy potential was completed based on committed renewable energy projects, which represent a fraction of the economic and market potential, and the adopted energy mix in NES [12].

While existing and future renewable energy capacities were considered as reported by MEMR, the potential is much higher. Table 9 summarizes the commissioning plan from NEPCO and the renewable energy roadmap in the business-as-usual (BAU) scenario. This represents a conservative scenario for employing renewable energy in power generation. Moreover, it is expected that more will be installed on rooftops and, after the completion of the green corridor, PV systems will be used on a wheeling basis. CSP technology will still not be deployed, since it is too expensive and the professional expertise is lacking in Jordan. Only one system is used in Jordan for an industrial application: a low-pressure steam (0.6 t steam/h @ 6.5 hPa) is produced by a Liner Fresnel System to supply the pharmaceutical industry, located in King Abdullah II Industrial City east of Amman. The final cost of such a system was incomparable: too high with a very long Special Pharmaceutical Benefits Programme.

Hydropower systems are assumed to remain the same unless the Red Sea–Dead Sea project is approved for financing by international donors. Other small hydro units are not expected to see the light of day within the next few years since the Government's attention is focused on the nuclear power plant which can be considered as a main competitor for future renewable energy projects in Jordan. On the other hand, a WTE project of about 40 MW may become operational in 2020 if the Ministry of Municipalities, the Great Amman Municipality and investors sign the necessary agreements, including a PPA with NEPCO. Other applications are assumed to have a contribution ratio of between 1.5% and 2.0% of the total primary energy consumption, the most important being the attractive economics of PV systems. But it should be recalled that many renewable energy applications were not considered in this study. Such applications include:

- Transport;
- Biomass in agriculture and farming;
- Solar space-heating and cooling;
- Geothermal space-heating and cooling;
- Desalination.

In this case, the accumulated fuel-saving potential during the period from the base year and the year of observation (i.e. 2020) is calculated as following:

$$F = RE_{prod}\,(SFC)$$

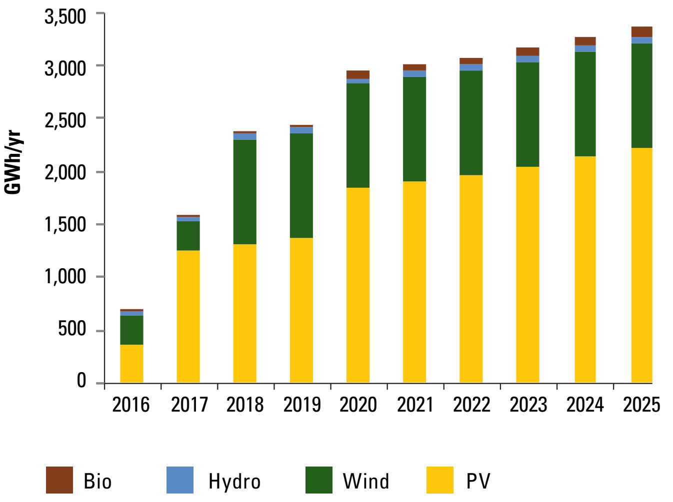
where,
- F = avoided fuel consumption (t/yr)
- REprod = energy produced by renewable energy systems (kWh/yr)
- SFC = Specific Fuel Consumption for conventional power-generation systems (kg/kWh)

Based on the energy mix of the power-generation sector consumption, it is possible to estimate GHG emission reductions by using the emission factor of its energy product.

As can be seen in Figure 19, PV central and small systems contributed slightly more than half the power generated by renewable energy systems in 2016, while wind share was about 40% and the remaining 8.5% was hydro and bio sources.

The long-term energy system is forecast with the use of the TIMES Energy System Model. TIMES is a

Figure 19: Expected power generation by renewable energy sources



bottom-up, partial equilibrium optimization model of an energy system, based on the least-cost approach. Seven scenarios were developed for Jordan with this model [37]: BAU, considered as the reference scenario and various other scenarios such as a renewable energy scenario (RES), or an energy-efficiency scenario (EES), etc.

In each case (except for EES), no additional significant energy-efficient programmes have been implemented and only the improvement of the efficiency of the replaced equipment is considered.

- **Business-as-usual scenario.** BAU is defined by continuing the same current trend for the future in terms of energy demand and energy performances. However, market improvement of the energy performance of appliances and equipment was considered;
- **Renewable energy scenario (NREAP).** The penetration rate of renewable energy sources is considered with high growth;
- **Energy efficiency scenario (NEEAP).** The penetration rate of efficient equipment in residential and commercial sectors (heating, cooling and lighting) was increased. Also, the specific consumption of large industries (cement, fertilizer, etc.) was improved to meet international standards. According to NEEAP, energy-efficiency targets are 10% in 2020 and 20% in 2030, less final energy compared to the reference scenario;
- **Combined RES and EES;**
- **Reference scenario plus coal power plant.**

Historical data: the energy balance for 2014 was taken as a base year. MEMR conducted surveys for the commercial, services, transport, industrial, agricultural and residential sectors. For example, for industries, MEMR surveyed cement and potash plants. For the power sector, the detailed load curve was acquired from NEPCO. The forecasts of GDP and population were obtained from the TNC on Climate Change for the UNFCCC (TNC 2014, Ministry of Environment). The natural gas contract data was taken from MEMR and the imported fuel prices were obtained from the "Project for the Study on the Electricity Sector Master Plan in the Hashemite Kingdom of Jordan" which was formulated by Japan International Cooperation Agency (JICA). Table 13 illustrates the commissioning plan set with NEPCO until 2020.

Factors that affect the development of the energy system were identified, their uncertainties were examined and the most uncertain was used for the definition of alternative scenarios.

In identifying the driving forces for building scenarios, five factors were taken into consideration: social, technological, economic, environmental and political.

Table 13: NEPCO commissioning plan and renewable energy roadmap

Technology type	Input fuel 1	Input fuel 2	Power plant (PP)	Capacity (MW)	Commissioning year
Combined Cycle	Gas	Desulfur Tank	Samra 3	450	2015
Combined Cycle	Gas	Desulfur Tank	Samra 3	230	2015
Combined Cycle	Gas	Desulfur Tank	CCGT1	485	2017
Steam Turbine	Oil Shale		Oil Shale PP	235	2019
Steam Turbine	Oil Shale		Oil Shale PP	235	2020
Nuclear	Nuclear		Nuclear 1	1,000	2023
Nuclear	Nuclear		Nuclear 2	1,000	2025
Wind			Tafilla Wind	117	2015
Wind			King Hussein Wind	80	2016
Wind			First Phase Wind	320	2018
PV			Azraq PV	5	2015
PV			PV	60	2015
PV	Rooftop		PV	38	2015
PV			1st Phase PV	200	2016
PV	Rooftop			20	2016
PV			Quweira PV	103	2017
PV			Second Phase PV	200	2017
PV	Rooftop			25	2017
PV				150	2018
PV				25	2018
PV	Rooftop			25	2019
PV				300	2020

Source: Planning Department, NEPCO

Table 14: Renewable energy scenario (RES) overview

	RES targets	Energy-efficiency (EE) targets	Coal plants	Nuclear Scheduled	Nuclear Delay 1	Nuclear Delay 2
Reference				X		
Reference D1					X	
Reference D2						X
Reference coal			X	X		
Reference coal D1			X		X	
Reference coal D2			X			X
NREAP	X			X		
NREAP D1	X				X	
NREP D2	X					X
Energy efficiency		X		X		
EE D1		X			X	
EE D2		X				X
NREAP + EE	X	X		X		
NREAP + EE D1	X	X			X	
NREAP +EE+D2	X	X				X

Source: Scenario Analysis of the Jordanian Energy System until 2040, MEMR [37]

Figure 20: Primary energy supply

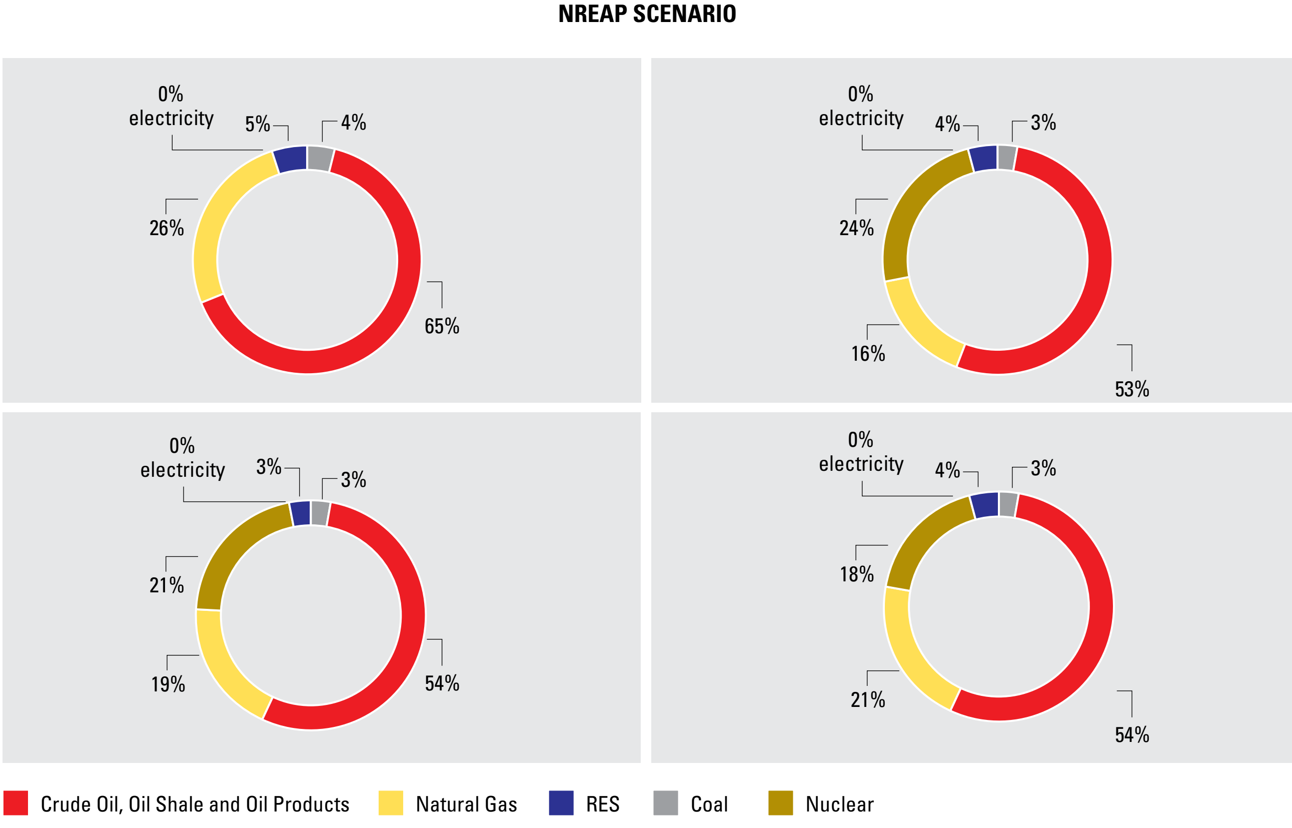
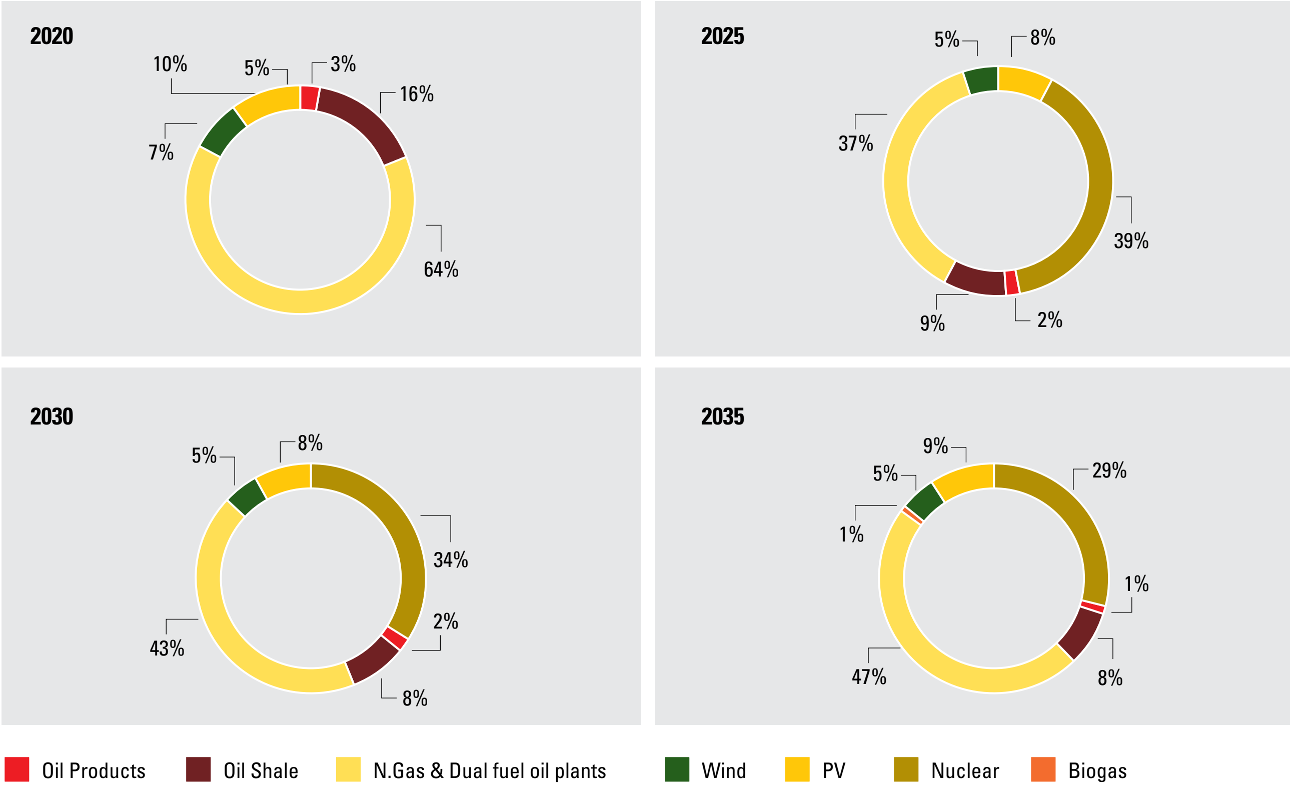


Figure 21: Electricity generation by technology



VI. Current and previous renewable energy policy status

At present, the only available official document related to renewable energy policy is the NES for the period 2015–2025 (MEMR), approved by the Government in August 2016, which is basically a revision of the Master Strategy for the Energy Sector (2007–2020), issued in December 2007. The prime aims of the NES are to: achieve energy security and sustainable supply; increase the share of indigenous sources in the national energy mix; reduce dependence on imported energy; and reduce the energy bill and its burden on the economy.

6.1. Renewable energy strategy and targets

According to MEMR a target of 10% renewable energy input into the energy mix by 2020 was set in the NES. A number of single targets were set for wind power (installation of 1,000 MW), solar energy (600–800 MW) and SWH (30% of water heating) by 2020. This was further enhanced by the adoption of Jordan 2025 in May 2015, in which energy was a main development area and the renewable energy share was set to reach 11% by 2025. According to the new legislation, the Ministry of Energy is responsible for the identification of a list of renewable energy development zones to increase the productivity of future projects. The Ministry will issue tenders to attract competitive proposals for the development of renewable energies at selected sites. As a way to ease the project implementation process, the 2010 legislation allows domestic and international companies to bypass a previously complex bidding process and negotiate directly with the Minister of Energy. Each qualified renewable energy plant proposal shall contain a development plan, including a preliminary design, an initial financing plan and a contribution of local inputs to the facility, supplies, construction and operation. The applicant shall prove sufficient experience – five years – in the field of renewable energy development and implementation. Each project presented shall clearly state its fixed electricity tariff and be part of a PPA with the bulk supply licensee or the retail supply licensee. NEPCO is expected to purchase the entire amount of electricity produced by private producers and will provide grid access to each individual renewable energy project.

Renewable energy projects have been developed and are under development of 1,755 MW capacity (both wind and solar), of which 544 MW are already connected to the grid and under commercial operation (5.6% of generated electricity), 616 MW are currently under construction and another 595 MW are under financial closure to be connected to the grid in 2017–2020.

6.2. Present renewable energy policies and institutional framework

The institutional framework includes the following:

- The responsibilities of the **Ministry of Energy and Mineral Resources** were amended to include the comprehensive planning process, setting general plans and ensuring their implementation in a way that achieves the general objectives of the energy sector, the most important of which is providing energy, in its various forms, for development; organizing its affairs; exchanging electric power with neighbouring countries; and attracting international capital for investment, especially the generation of electric power; the production of oil derivatives; transportation of oil and gas; and utilizing local energy sources;

- **The National Energy Research Centre** is part of the Royal Scientific Society and was established in Amman for the purposes of research, development, training in the fields of new and renewable energy and raising the standards of energy use in the different sectors. One of its main activities is measuring wind and solar data around the country for researchers and investors. NERC has 15 measurement stations for solar radiation in Jordan measuring hourly data of GHI, direct normal irradiation and ambient temperature. Average daily, monthly and annual readings are also available. Wind speed and direction at different heights are available for more than 35 locations, such as Tal Hassan, Jurf ElDaraweesh, Twana, Mudawara, Elaka, Kharana, Aqaba, Wadi Arabah and Shawbak.

- The **Energy and Minerals Regulatory Commission** is a governmental body that possesses a legal identity with financial and administrative independence and is considered the legal successor to the Electricity Regulatory Commission, the Jordan Nuclear Regulatory Commission and the Natural Resources Authority with regard to its regulatory tasks according to Law No. 17 of 2014 regarding the restructuring of institutions and governmental organizations.

The NES mandates a strong emphasis on efficient and clean generation of power. The Government is giving considerable attention to the utilization and implementation of renewable energy resources. It has laid down the necessary regulatory and policy frameworks, as well as commercial tools for renewable energy, and is now ready to attract and receive commercial investments in order to achieve the policy targets in the national energy mix. Some of these tools are described below.

The **Renewable Energy and Energy Efficiency Law** was passed in April 2012 with the aim of encouraging private-sector investment in renewable energy. This was the first law issued to stimulate renewable energy generation in the country and the first of its kind in the region. It contains guidelines on implementation of renewable energies and energy-efficiency measures. It also established the direct proposal regime/ unsolicited submission for private companies to allow investors to identify and develop grid-connected electricity-production projects through unsolicited or direct proposal submission [25]. Moreover, it exempts all systems and equipment for renewable energy projects from customs duties and sales tax. REEL tasks MEMR with identifying suitable locations for renewable energy applications and coordinating this selection with the land-use list.

The **Jordan Renewable Energy and Energy Efficiency Fund** was set up by REEL and was launched in 2013 by MEMR. The Fund provides grants for energy projects and guarantees investors' funding requirements. It is financed by national and international institutions, has a legal identity and is financially and administratively independent. Both national and foreign private companies are allowed to apply for the Fund's support when setting up renewable energy generation projects. It provides renewable energy subsidies to privately operated and owned facilities; interest-rate subsidies on commercial loans; a public equity fund to support the deployment of private investment in the sector; a renewable energy guarantee facility to ease credit access for energy efficiency and renewable energy project developers; research, technical cooperation grants for targeted programmes; and feasibility studies. The Board of Directors of the Fund, comprising the Minister of Energy and Mineral Resources (Chairman), Minister of Planning and International Cooperation, Minister of Finance, the Secretary-General of the Ministry of Environment, and three representatives from the private sector, oversees the activities of the Fund.

The **wheeling regulations**, issued by EMRC, were designed to enable and regulate off-site renewable energy production and on-site consumption by private offtakers. This market, whilst still in its infancy, is particularly active. In December 2012, EMRC announced the introduction of an FIT system for net metering which is designed to reduce energy demand and allow the sale of surplus energy to be generated back to the national grid. This is the first FIT to be implemented in the Middle East.

A **reference price list record** used to calculate a ceiling for electricity purchase prices from renewable energy sources. According to the record, the ceiling tariff for the sale of electric energy generated by renewable energy facilities is set at US$/kWh 0.12, 0.19, 0.17, 0.13 and 0.08 for wind, solar thermal, PV, biomass and biogas.based electricity, respectively. These prices will be applicable to the successful bidders of the direct proposals for renewable energy projects; if a facility of fully Jordanian origin is installed, the tariff can be increased by 15%.

A **net-metering scheme** for small renewable energy systems (rooftops) with fixed purchase prices for excess power. The directive allows the consumers to install, use and connect renewable energy systems (solar, wind, bio-energy, geothermal, small hydro) to the grid if their expected generation does not exceed their average monthly consumption for the previous year (to be estimated by the distribution company in case of new users). The net value of the electricity consumption (or generation) is calculated each month. In the case of net consumption, the user pays the value of electricity to the distributor. In that of net generation, the distributor can roll the surplus over to the next month as long as the balance is cleared by the end of the year, according to the tariffs set by the law (US$/kWh 0.17, 0.13 and 0.12 for solar, hybrid and other forms of renewable energy, respectively). If the systems are of Jordanian origin, the tariff can be increased by 15%, but this increase will be removed once the total grid-connected installed renewable energy capacity reaches 500 MW. The directive also states that the maximum total renewable energy capacity in a geographical location cannot exceed 5 MW and – for each distributor – the capacity of connected systems may not exceed 1% of the maximum recorded load on the low-voltage network and 1.5% on the medium-voltage network.

A **tax incentive regime**: a bylaw, was issued on tax exemptions for renewable energy and energy-efficiency systems and equipment. Article 11 states: "All systems and equipment of renewable energy sources and energy efficiency and its production inputs whether manufactured locally and/or imported, will be exempted from all customs duties and sales tax."

In Article 10, the bylaw made it compulsory to use SWH systems; no permit is granted to connect to services unless a SWH system is installed, since 1 April 2013, as follows:

- Building(s) with an area of 250 m^2 or more;
- Apartment(s) with an area of 150 m^2 or more;
- Office(s) with an area of 100 m^2, or more, in commercial buildings.

The **Bylaw on Exempting Renewable Energy and Systems and Energy Saving Equipment from Custom Fees and Sales Tax** (Bylaw No. 13 of 2015), was issued by virtue of Article 11/B of REEEL. In this bylaw, it is clearly stated that all renewable energy and energy efficiency systems, equipment and devices, imported and locally manufactured (and inputs for local production) are exempted from all custom fees and duties, as well as sales tax. For this purpose, the bylaw established a special committee at MEMR to consider all applications related to tax exemption. Finally, Bylaw No. 49 Jordan Renewable Energy and Energy Efficiency Fund of 2015 enabled MEMR to start activities aiming to support RE and EE projects.

The **General Electricity Law** is the main law for the electricity sector and EMRC is the main implementation body. The Law guarantees non-discriminatory access to transmission lines by NEPCO. Connection to the grid is provided for in the PPA, under standard transmission connection agreements, which were approved by EMRC. Article 47 of the General Electricity Law provides for the EMRC to set tariffs for all sectors, except generation. The tariffs for generation are determined in conformity with any agreements in force between the generation licensee and NEPCO as a bulk supply licensee (General Electricity Law, Article 37 (B) and 47 (A)). According to Article 18 of the General Electricity Law, the Commission, which is EMRC, shall settle disputes that arise between licensees and consumers involving matters of connection and supply of electric power, quality of service and electric tariffs, and the decision of the Council on such disputes shall be subject to appeal to the High Court.

Jordan adopted the **Public-Private Partnership Law** No. 31 (PPP Law) in 2014 to attract appropriate technical and financial partners through a competitive tendering process and implement PPP projects in all sectors of the economy, including renewable energy.

The first Jordan **National Energy Efficiency Action Plan** for the period 2012–2014 included 11 main measures and set the target to deliver a 7.6% reduction in energy consumption by 2014, which equals around 806 GWh of energy-efficiency improvement. The rate of completion of the 11 measures was estimated at 40% (361 GWh of the total of 806 GWh). NEEAP included the following recommendations: to promote SWHs in different sectors; upgrade and update the Solar Energy Code: and enhance capacity-building of engineers and technicians in the fields of solar and wind technologies.

The second Jordan NEEAP was prepared to cover the period 2017–2020 with a target of 2,000 GWh of energy efficiency improvement by 2020.

The first **National Renewable Energy Action Plan** (NREAP) for Jordan was drafted before the end of the year 2017.

6.3. Suitability of present policies and institutional framework to meet announced strategies and targets

Jordan is unique in the Middle East in that it has a policy in place which requires the Government to cover the cost of grid connection for developers. Jordan's almost complete dependence on imported fossil fuels has significantly altered the discourse on renewable energy.

The updated 2007–2020 energy strategy foresees investments in the range of US$ 13–18 billion to cover the diversified sources of energy, of which US$ 2–3 billion will cover RE projects; this is expected to reach a targeted sharing ratio of 10% of the energy produced by 2020. Almost all required investments for such a strategy will be provided by the private sector. Recent progress in strategy, policy and legal implementation for the renewable energy and energy-efficiency parts was made through the adoption of Jordan 2025, in which the targets for renewable energy in the primary energy mix were increased to 4% by 2017, 7% by 2021 and 11% by 2025. The recommendations include:

- Implementation of renewable energy laws to stimulate private-sector investments;
- Implementation of wind-energy projects of at least 600 MW capacity by 2020;
- The continued development of JREEEF.

Under the strategy, developers can submit their proposals for projects directly to the Government. Jordan has witnessed an accelerated growth in the exploitation of renewable energy resources, namely wind and solar, which was embodied by the achievements accomplished during 2016. These achievements were the result of continuous efforts which enabled the resolution of difficulties and challenges through the Government's adoption of policies to encourage investment in renewable energy projects. By adopting the necessary laws and legislation, a successful investment environment with a high return was created, aiming at accelerating the growth of the renewable energy sector to comply with the content of the comprehensive national strategy of the energy sector in Jordan.

In many cases, the relatively high cost of renewable energy is still lower than that for energy from fossil fuels and, as a result, the Government is willing to pay for feasible projects at a price at almost the same cost.

New regulations and the lower inherent risk in solar projects are likely to lead to more investor confidence and raise the bankability of projects. Nonetheless, fossil fuels look likely to remain the baseload energy supplier for the foreseeable future. At a high level, the energy sector's key challenges remain around the resilience of the sector through its exposure to external price fluctuations and the economic consequences of this, which is recognized in Jordan 2025.

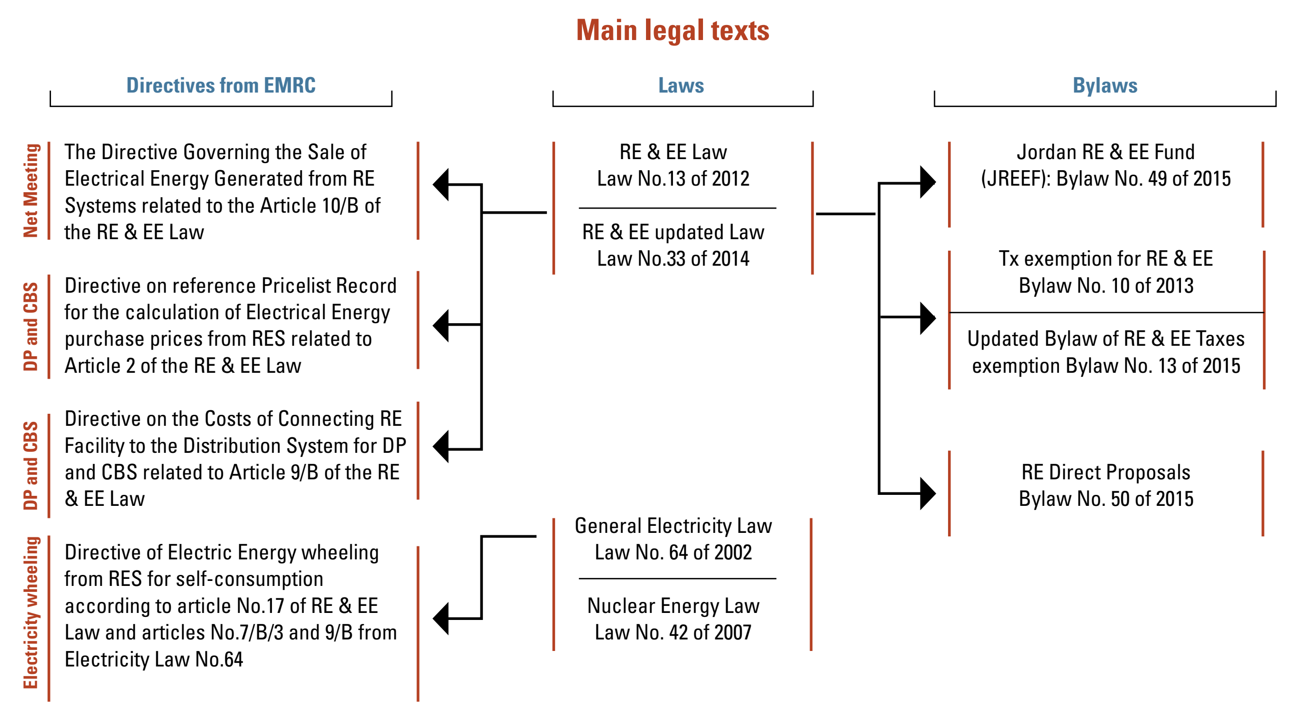
Jordan follows a five-track approach to develop and connect RE systems to transmission or distribution electrical grids as follows (Annex B):

- Direct proposal (DP);
- Competitive bidding system (CBS);
- EPC turnkey (through grants);
- Small-scale RE scheme (net metering);
- Power energy wheeling.

On several occasions, MEMR ensured that the targets could be met much faster, with the implementation of the Green Corridor and when further small and medium-size installations were interconnected both to the national grid and the distribution grids. The grid's current capacity is around 3,200–4,000 MW. The implementation of the Grid Expansion and Reinforcement Plan aims to develop a new high-voltage electricity line connecting the northern to the southern parts of the country, and upgrading existing grid lines, to increase the country's national grid capacity by an additional 1 GW, in order to support the penetration of additional renewable energy. The project should be operational by the end of 2018.

Recognizing the potential for renewable energy to achieve energy security, economic growth and environmental objectives, the Government has developed a comprehensive set of laws, incentives, targets and regulations since 2010 to promote investment in renewable energy, especially in solar PV and wind energy. It has laid down the necessary regulatory and policy frameworks (as shown in Figure 22), as well as commercial tools for renewable energy, and is now ready to attract and receive commercial investments in this field in order to achieve the NES policy targets.

Figure 22: Main features of renewable energy legal framework



Source: MEMR, EU REEE II-TA, Jordan Sustainable Energy Policy

6.4. Renewable energy policy and institutional reforms being introduced

Jordan is currently working under the single buyer model. EMRC plays the major role in determining both bulk and retail tariff under the single buyer model. In order to strengthen transparency with stakeholders in the renewable energy sector and facilitate licensing procedures, EMRC is keen on revising, amending and modifying the terms of the licensing forms for existing renewable energy projects. It has announced a call for tender for the services of an international consultant to study development and implementation of wheeling charges and to review standard transmission-connected generation licenses in addition to standard procedures for license applications, standard distribution-connected renewable energy generation licenses and standard procedures for license applications.

In addition, the licenses are to be amended to comply with current trends in Jordan, after identifying possible gaps or topics not clearly specified in the law, as well as points containing general references and needing a more detailed approach. One of the main objectives of the expert's mission is to encourage renewable energy producers to develop new units in line with the law.

VII. Economy, environmental and policy analysis

7.1. Overall impact of policy measures that were introduced/being considered in the renewable energy market

As an energy importer, Jordan has problems, constraints and difficulties that mandate increasing renewable energy technology utilization. The most effective argument in favour of adopting such technologies is that Jordan's lack of conventional energy sources is compensated by abundant RE resources. The fact that RE technologies are not complex, require fewer operating and maintenance costs and are inherently more environmentally friendly than conventional energy sources has fostered their consideration by policymakers as essential components of the national energy balance.

7.2. Analysis of potential economic and social impacts of the evolution of the renewable energy market

Located in the heart of the Middle East, Jordan is shaped by its geography, history, geopolitics and lack of natural resources. The Government identified poverty and unemployment as two of the most important challenges facing the country. The challenge of meeting the increasing energy demands is another pressing issue.

Promoting energy security. Jordan is increasingly looking inwards to achieve its energy security, by promoting and increasing investments in the renewable energy field. Subsequently, the Government has implemented policies, laws and programmes to diversify the energy sources available. This step will not only reduce Jordan's high energy costs, it will also make affordable energy solutions more readily available to local sectors, allowing them to continue to thrive in line with the recently unveiled Jordan Economic Growth Plan (2018–2022).

With few oil and other resources, Jordan has had to depend on foreign energy sources, primarily oil and natural gas from neighbouring Middle East countries. To bring down its high energy bill, Jordan has invested heavily in local energy sources [32].

Stable energy prices. The costs of renewable energy technologies have declined steadily and are projected to drop even more. While renewable facilities require upfront investments to build, once built they operate at very low cost and, for most technologies, the fuel is free. As a result, renewable energy prices are relatively stable over time. An increased reliance on renewable energy can help protect consumers when fossil-fuel prices spike. Renewable energy could provide affordable electricity across the country as it is resistant to global oil-price changes and can help stabilize energy prices in the future.

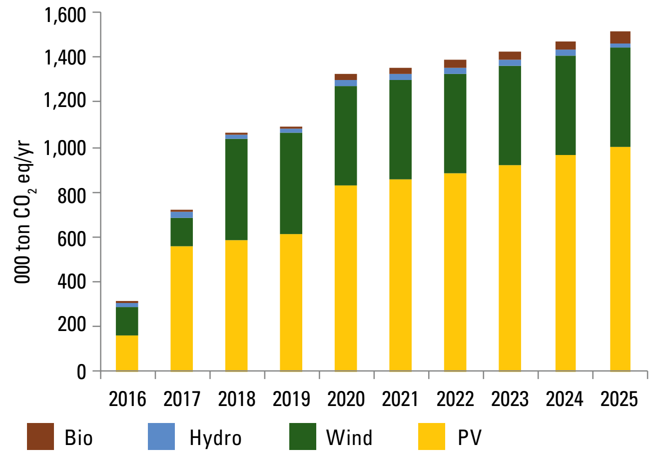
Improved public health and environmental quality. The policies intended to reduce emissions of GHGs will simultaneously affect emissions of local pollutants and, ultimately, human health. The air and water pollution emitted by conventional power plants is linked to breathing problems, neurological damage, heart attacks and cancer. Generating electricity from renewable energy rather than fossil fuels offers significant public health benefits. Reducing CO_2 emissions not only significantly and quickly reduces harmful co-pollutants, saves lives and avoids other adverse health impacts, but also reduces overall healthcare costs.

Jobs and other economic benefits. Compared with fossil-fuel technologies, which are typically mechanized and capital-intensive, the renewable energy industry is more labour-intensive. This means that, on average, more jobs are created for each unit of electricity generated from renewable sources than from fossil fuels. Renewable energy can support thousands of jobs in Jordan. The national strategy estimates jobs created by only installing, maintaining and running renewable energy facilities to be around 3,000 by 2020. In addition to direct job creation, unrelated local entreprises will benefit from increased household and business incomes. Moreover, increasing renewable electricity production would reduce the need to spend money on importing oil and natural gas from other places.

7.3. Environment impacts

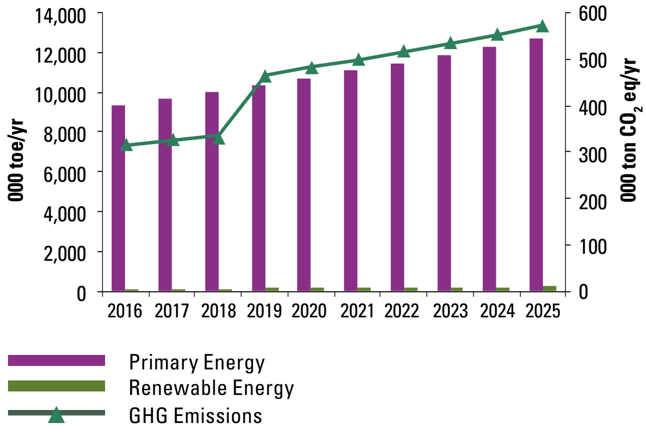
In terms of anticipated reduction in GHG emissions, there is an increasing trend to more power being generated using RE sources, as seen in Figure 23. In 2020, the expected total reduction of GHG emissions as a result of utilizing renewable energy for power generation and direct applications would be about 1.85 million tCO_2eq, which is about 4.5% of the predicted emissions in that year as reported in the Jordan INDC report.

Figure 23: Predicted annual rate of reduction of GHG emissions



Estimated accumulated reduction, as result of power generation, during the study period (2016–2025) would be around 16 million to CO_2eq and approximately 4.5 million tCO_2 eq due to using RE sources in direct applications, such as water- and space-heating, as shown in Figure 24.

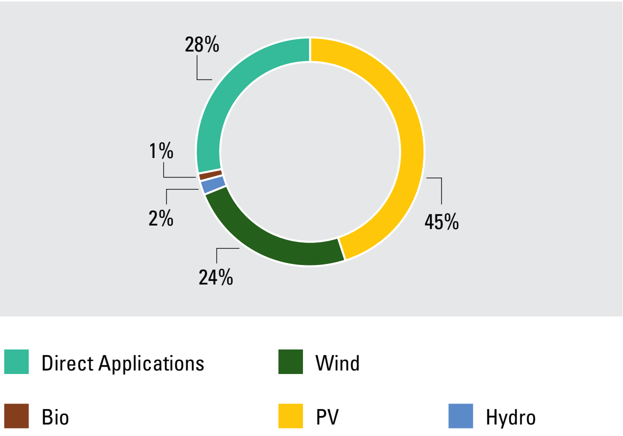
Figure 24: Annual contribution of renewable energy sources in direct applications and associated reduction of GHG emissions



The distribution of the contribution of different sources is illustrated in Figure 25. It is obvious that renewable energy for power generation contributes most of the expected accumulated reduction in GHG emissions during the study period 2016–2025. The solar PV sharing ratio is the highest, i.e. 45% of total accumulated GHG reduction, followed by wind, about 24%, and direct applications of RE by 28%.

The other applications of renewable energy in Jordan will take more time to be implemented. At present, the main application is power generation. The main reasons behind the delay in implementing RE systems for direct applications are related to lack of awareness and know-how about RE technologies, which are still perceived as an uncertain and risky investment, especially by the local banking sector. Equally important is the lack of local financial schemes for RE projects, although JREEEF has announced some initiatives for the industrial and residential sectors. In addition, the lack of transparency in official procedures from application to final approval of projects and the bureaucracy in the implementation of licensing procedures result in delays and the impatience of investors.

Figure 25: Distribution of accumulated reduction of GHG emissions



VIII. Policy design consideration

Jordan has been a pioneer in renewable energy promotion in the Middle East, starting with its first wind-power pilot project as early as 1988, until its first commercial utility-scale wind-power project of 117 MW in 2015.

Jordan has a strong competitive advantage, due to its high renewable energy resource potential. The main driving factors to scale up investment in renewable energy and shape the policy design and institutional framework are the following:

- **Increasing energy demand.** Jordan is facing a high growth rate in energy demand, much higher than its economic growth. Electricity demand has increased rapidly, rising from 8, 712 GWh in 2005 to 16,173 GWh in 2015: an increase of some 6.4% per year. According to NES, the growth in energy demand continues at 5.5% and demand will double by 2025;
- **Energy import dependence.** Despite bordering energy-rich countries, Jordan is resource-poor in terms of conventional energy sources and has long been overwhelmingly reliant on energy imports to meet the bulk of its primary energy needs;
- **International energy price fluctuations.** Since energy plays a primary role in promoting economic growth in Jordan, the impact of oil prices has broad implications for its economic stability. The fluctuation of oil prices and Jordan's dependency on unstable foreign energy resources directly impacts the electricity prices for both the public and private sectors;
- **Increasing greenhouse gas emissions.** Electrical power generation in Jordan relies predominantly on fossil fuels with a significant impact on the environment through harmful GHGs such as CO_2 and NOx. Jordan is determined to reduce its GHG emissions by some 14% by 2030. The conditional and unconditional GHG reduction target aims at reducing Jordan's
- **Geopolitical situation.** Jordan's location at the intersection of multiple conflicts renders it extremely vulnerable as an energy importer. Regional volatility has affected gas supplies from Egypt and scuttled a planned pipeline to Iraq, which forced Jordan to substitute the relatively cheap gas with much more expensive diesel and heavy fuel;
- **Access to energy services.** The PV technology potential for Jordan is high, based on the fact that many remote and isolated sites are located far away from the national electric grid and cannot be connected to it in the near future. The access of low-income, rural consumers to essential electricity has influenced the adoption of renewable energy projects to improve the energy-service security in these areas.

Since the introduction of REEL in 2012, the Government has tendered three rounds of direct proposals, which have led to attracting national and international investors and put Jordan on the map in terms of renewable energy investment.

IX. Challenges facing implementation of renewable energy projects and lessons learned

Jordan has developed a robust policy framework and has proved to be a pioneer in the region in the renewable energy sector.

A few outstanding issues might be addressed to existing policy planning in order to enhance effective implementation of Jordan's legislative and regulatory framework and to create a pipeline of bankable projects.

Jordan wishes to tackle the following barriers and challenges from different angles to keep up with new technologies and remain a role model specifically in the MENA region. After some interviews with the private, public and educational sectors, the main challenges facing Jordan are summarized below.

9.1. Economic and financial barriers

- Land acquisition and leasing process for wheeling projects is one of the main challenges project developers are facing. The land-licensing conversion from agricultural to industrial in wheeling projects is very costly which deters investors and makes investments more tedious. This might be a temporary phase until the release of the planned new wheeling charges by EMRC;

- In accordance with Articles 4A and 4B of REEL No. 13, the Government pinpoints which lands are available for renewable energy projects depending on the grid capacity in different areas. This is currently not the case in Jordan as the grid is saturated in most areas and the Government dedicated pieces of land in the three rounds of direct proposals;

- Electricity is subsidized for low-consuming customers in Jordan and the Government will face a major problem in NEPCO's deficit once high electricity consuming entities go for wheeling. Jordan thus continues to face the challenge of reforming its energy sector.

9.2. Market challenges

- The REEL of 2012 allowed for the direct proposal submission of projects for generating electricity from renewable energy projects which has been the most popular procurement method with IPPs of renewable energy. Jordan has made three rounds of direct proposal submissions so far. This scheme is expected to continue to deliver the majority of the country's RE projects, which is hindering future investments.

9.3. Political, institutional, regulatory and administrative barriers

- Insufficient coordination among different public entities resulted in long delays in completing rounds one and two of the direct proposal process and grid-capacity issues. In addition, there is a lack of coordination between the public and private sectors and efforts to create synergies between the two for more effective and sustainable development have also proved insufficient.

- For investors, researchers, consultants and private home-owners, there is a barrier to easy and clear access to information and data, especially data concerning upcoming policies and what processes are being followed by different administrative and regulatory institutions. A collective database for such data is non-existent, which is affecting progress rates.

- There is not enough support by policy monitoring and evaluation to improve the effectiveness of the SWH obligation. In fact, there are no further regulations or policies enforcing quality standards or system sizes for Jordan's April 2013 bylaw on SWH and the follow-up by the Government agency is not as demanding as investors had expected.

- In the domestic sector, licensing and permits are taking more time than expected and, after the permit is given, the connection point to the transformer on the medium-voltage grid might change, which leads the project to be connected to another transformer, creating additional costs that had not been envisaged.

- Grid-impact studies are taking more time than usual and such studies are a barrier for renewable energy companies working in the domestic market. Inspections and licensing are not consistent and it can take more time to connect to the grid, which creates some frustration for the end user, as well as the companies installing the systems.

- Public facilities such as hospitals, schools and public buildings represent the largest potential single market for off-grid RE projects and the Government should be a more active user of renewable energy in its own facilities and infrastructure.

- There is a limited awareness in Jordan about the concept of green business and a lack of coherent climate policies as the sector has weak carbon pricing and incentives to renewable investment.
- Jordan is also looking for other sources to bring into the mix, which is hindering renewable energy progress, such as the availability of LNG at relatively low prices, even for large consumers, and the emphasis on constructing a 2,000 MW nuclear power plant and employing oil shale for power generation.

9.4. Social, behavioural and educational barriers

- Population growth, paired with unsustainable consumption and production patterns, are the biggest social challenges to achieving the sustainable development of renewable energy.
- The entrenched limited awareness about renewable energy development has impeded progress.
- In the educational sector, there is a lack of innovation-oriented research. This means that there has to be a closer connection between research institutes and the economy, which would also overcome problems concerning the transfer of knowledge to applications in real life.
- Data are not easily accessible to consultants, investors, universities and researchers, which creates a barrier for development and innovation.
- Inadequate interaction between civil society and government.

9.5. Technical challenges

- A grid-capacity constraint has resulted in project delays or the cancellation of expressions of interest for new solar or wind energy projects, hampering renewable deployment. Most investors need to develop their projects in the middle zone, where the majority of the population is located, while the projects in the Irbid District Electricity Company and electricity distribution company (EDISCO) networks, where additional lands can be found, are often cancelled, since the power generated cannot be consumed within the networks' geographic coverage.
- Technological and administrative resources are needed to design and deploy effectively renewable energy projects, while creating domestic jobs and value-added in Jordan, to foster innovation capability and human capacity.

X. Recommendations and conclusions

Recommendations. The investment in renewable energy is well underway, with numerous activities and plans for large-scale deployment of PV and wind technology. In order to improve the enabling conditions for further development of the sector, some key priorities and recommendations are outlined below:

- Jordan has a good legal and financial framework to support renewable energy projects, but needs in particular to prepare the power system to support the high share of intermittent and variable renewable energy sources.
- Different countries have adopted smart grids and smart metering in their strategies; it is recommended that Jordan works on applying such technologies in the future, which would help feed the demand directly, using storage mechanisms. All possibilities of energy storage (battery storage, water-pumping storage) need to be assessed. This can help in solving much of the problems associated with the grid and its capacity and in solving the problem of its frequency/voltage stability.
- Renewable energy will be providing more and more of Jordan's electricity in the future (about

18% by 2020). Grid reinforcement (Green Corridor) is being undertaken by NEPCO in order to install more RE capacities. The more renewable energy feeds into the grid, the more difficult the grid and its electrical properties will be to control and operate efficiently. In order to address the increased variability and uncertainty brought about by integrating higher levels of large-capacity renewable energy, the power system must be made more flexible so as to maintain a balance between generation and load. Improvements in operational technologies and practices should be made at each stage of power-system operation, namely in RE generation forecasting, scheduling, dispatch and control. In addition, EMRC and NEPCO are working on updating and completing the PPAs, including WTE projects. This will help NEPCO to face issues regarding the integration of renewable energy into the national grid, and accordingly, to develop policies with regard to such renewable energy integration.

- The review of the template wind and solar PPAs (available on the EMRC website) indicates that NEPCO has little flexibility in existing PPAs to reduce its exposure to "deemed energy" payments that result in having to curtail wind- and solar-energy generation. The PPA templates are therefore favourable to the seller with regard to deemed dispatch payments that arise from curtailment. As increasingly large penetration levels of renewable energy (wind and solar) generation are forecast on the NEPCO power system, it would be preferable to understand current worldwide practice regarding the curtailment of energy sourced from projects on bulk power systems, and understanding ways in which to mitigate the financial impact of obligations.

- MEMR should concentrate on completing and refining policies and implementation instruments. There is an urgent need for a fine-tuning of existing legislation and for the adoption of additional regulations regarding the renewable energy sector.

- There is a need for a specialized unit or agency to be in charge of the main institutional framework, which would be an effective tool in implementing RE policies and the link between all stakeholders in the RE sector and energy sector in general.

- EDISCOs should be reviewed to ensure they have the right incentives to promote domestic RE systems; EDISCOs' interactions with the EMRC need to be reviewed to ensure that the regulatory arrangements for supporting the RE sector are met.

- A capacity-building plan for the sector, focusing on renewables is essential for the market, and vocational training for different sections of the community should be conducted.

- Greater transparency in the approach to capacity allocation is required. A recommended step for this issue is the development of an overall grid-load flow study, which would identify the critical areas and connection points available on the grid, to promote connections without unduly penalizing any projects.

- To enhance the effectiveness of policy support to renewable projects in the long term, improved coordination between public authorities, donor agencies, development banks and project developers is needed.

- A more consistent application of the tax-incentive regime set for renewable energy equipment is needed. Policy monitoring and evaluation efforts could be strengthened to ensure that developers are achieving their intended objectives. Monitoring efforts should evaluate the fiscal cost in comparison with the benefits arising from lower development costs. If the incentive is not used, or found not to be cost-effective, or is irrelevant in investments and decisions, then it should be eliminated. Additional monitoring and evaluation could help improve the effectiveness of the SWH obligation.

- Mapping the geographical distribution of renewable energy resources to improve coordination between land-use planning and renewable power infrastructure developmen would help identify which areas may require land-use adjustments to allow for deployment of renewable energy projects.

- Considering the potential demand for renewable energy in neighbouring countries linked to Jordan by the grid-interconnection system and encouraging private investors to produce renewable energy for export to other countries in the region.

- The Government must address the financing of investment in renewable energy, as this presents the most important barrier to renewable energy at the moment in the household and commercial sectors. This concerns primarily: the further development of JREEF, so that this organization can become the nodal agency for renewable energy financing; the creation of targeted financing schemes and a credit guarantee fund for renewable energy investment (in particular for small-scale projects in the commercial and residential sectors); and self-sustaining credit facilities focused on the commercial sector.

- There is a need to enhance the effectiveness of policy support to renewable energy projects by improving coordination between public authorities, project developers, development banks and donor agencies.

- The Government needs to ensure that the price of carbon emissions is set in a transparent, credible and predictable manner, and to consider introducing a market mechanism (tax or cap-and-trade systems) to better price carbon and level the playing field with renewable energies.

- As part of a broader effort, the Government is keen to encourage the mass adoption of electric vehicles. To this end, electric vehicles are exempt from taxes and fees, and the Government is committed to build a network of 3,000 solar-powered electric charging stations over the next decade. It is important to note that the appropriate rules and regulations still have to be put in place.

Conclusions. The Government of Jordan is endeavouring to decrease the country's dependence on imported energy, to secure energy supply, and to change the patterns of energy supply and demand into a more sustainable direction. Jordan took serious strides towards developing the renewable energy sector as one of the significant energy alternatives, since investing in renewable energy also bears socioeconomic dimensions. The adoption of REEL and regulations by the Government opened wide opportunities for renewable energy projects and encouraged and stimulated huge potential investments, some of which have already entered the market.

In spite of all the positive improvements on the legislative and institutional levels and good results/ ranking from international institutions' evaluations, the institutional and regulatory framework for renewable energy remains incomplete. Important secondary legislation, rulebooks, financing mechanisms and other critical elements are still not sufficiently developed when compared to European countries and other more advanced countries in the renewable energy field. Jordan still has some major steps to take and obstacles to overcome. Based on the above discussion, some of the recommendations are:

- Policy support is needed to help scale up investment in renewable energy projects;

- The involvement of the private sector is crucial to the development of the renewable energy sector, and to reach the 2020 targets;

- Monitor the net economic and social impact of policy measures (FITs, ceiling price), in order to prevent boom-bust cycles [33];

- Promote technology innovation through pilot projects, competition, research and development and community-based projects;

- Jordan needs to update the policies linking renewable energy generation investors and NEPCO (updating PPAs, for example) and, in parallel, to augment the capacity of its grid in order to absorb new and large energy projects;

- Planning grid-expansion projects for further future renewable energy projects; and

- Mainstream green consideration by greening public procurement procedures for public facilities to drive the circular economy.

If these steps are taken, Jordan could continue its endeavours towards a renewable energy transition and thereby create social benefits.

Annexes

Annex A: List of main stakeholders interviewed during the period 30–10 August 2016

Name	Institution	Position	Subject
Ziad Jibreel	MEMR	Adviser to the Minister	RE policies
Mahmoud Alees	MEMR	Adviser to the Minister	Future energy demand
Yacoub Marrar	MEMR	Head, Solar Section	Solar and wind energy
Muawiah Fayydi	MEMR	Adviser to the Secretary General	Energy efficiency
Hazim Ramini	MEMR	Manager, Oil Shale and Petroleum Dept.	Oil shale
Ibrahim Odeh	JEA	Chairman, Energy Committee	RE market and barriers
Walid Shaheen	NERC	Manager, NERC	RE and EE in Jordan
Muhi Tawalbeh	NERC	Head, Solar and Thermal Section	RE and EE in Jordan
Emil Aliases	NERC	Project Manager, Wind Energy and Concentrating Solar Power	RE barriers
Osama Ayadi	JU	Assistant Prof., Department of Mechanical Engineering	Solar market
Izaat Ahmad	MoEnv	Manager, Environmental Impact Assessment Department	Energy and environmental protection
Abedalkareem Shalabi	MoEnv	Studies and Climate Change Department	Climate change
Mohammad Abu Yousef	MIT	Manager, Engineering and Projects	RE projects and companies
Wijdan Rabadi	EMRC	Commissioner, Renewable Energy	RE regulations and directives
Mohammad Abu Zarour	NEPCO	Manager, Planning and Load Research Department	Large RE projects and connection
Fawwaz Elkarmey	HCST	Assistant for Technical Affairs, Secretary General	RE technologies and capacity building
Raed Shurbajy	JEA	Chief of Mechanical Engineering Division	Regulation and implementation
Ahmad Ghandoor	ETA MAX	Manager, PV Projects Department	Local PV market
Ismail Hinti	ETA MAX	CEO	Local PV market
Ghalib Jallad	Freelancer	Consultant in energy systems	RE market
Ibrahim Alkum	Freelancer	Consultant in water	Water crisis
Tarek Tarawneh	ID:RC	Manager, Interdisciplinary Research Consultant	Local industries
Abedalaziz Zaytoon	SunrRise PV	Project Manager	Obstacles in licensing and construction of PV systems

Annex B

According to REEEL and issued bylaws and regulations, private investors could participate in developing renewable energy projects following one of the following outlined mechanisms.

Net metering

Small RE projects, e.g. residential PV systems, can be connected to the grid on the basis of net metering and the capacity of the RE system is calculated based on an annual average (i.e. average consumption of last 12 consecutive months). This on-site scheme could be a fraction of kWp and up to 5 MWp. The developer or customer should undertake a grid impact study for any system above 10 kWp. In addition, a generation license is required for large systems of 1 MWp or more and up to 5 MWp. After completion of the project, the developer/customer should sign a connection agreement with the EDISCOs for 20 years. Once the system is in operation and, in the case of an electricity surplus production, project developers receive credits, which can be rolled over on a kWh basis and kept for one year. Balancing over a year enables the project to be larger than in the case of other regimes with smaller balancing periods, bearing in mind that EDISCOs provide strict approvals based on previous history of consumption.

Since the implementation of such a scheme, consumers' interest is growing rapidly. As of early 2016, more than 4,000 applications had been submitted to EDISCOs. These were not only residential consumers, but also from industry, commerce and services. According to MEMR and EMRC sources, the installed capacity of solar PV systems exceeded 60 MW, and more are expected to be installed in the coming years, due to the attractive economics of such systems. Equally important is the growing awareness about PV systems and the availability of qualified service companies, dealers and contractors specialized in this field.

Wheeling

Wheeling enables the customer to produce electricity for its own use, but at a location other than that where the electric power is consumed. Here, the offtaker is the same as developer: the scheme operates as virtual net metering, taking into account losses in the grid. The process of this scheme is too long due to lack of information about the load flow and possible connection points to the medium-voltage (MV) network.

More important is the bureaucracy in dealing with wheeling applications by distribution companies.

The first step here is the selection of project land by the developer or customer and obtaining preliminary approval from the distribution company. If successful, the following documents are needed:

- Wheeling application, used to be submitted directly to the distribution company, but now to EMRC (by the developer or customer). EMRC then writes to the EDISCOs requesting the wheeling arrangement, bearing in mind that the developer or customer should comply with the transmission or distribution grid code, whichever is applicable;
- Environmental impact assessment of the proposed renewable energy project and environmental permit issued by the Ministry of Environment;
- Grid impact study, which is considered a bottleneck due to the lack of technical details about the MV grid and low level of cooperation of concerned staff in distribution companies. Unfortunately, EMRC is absent. The cost of this study is fixed by EMRC at JD 15 per kWp, which is considered very high, especially for PV systems, of the capacity of the proposed RE system;
- Connection agreement with EDISCOs or NEPCO or both depending on the connection point to MV or high-voltage (HV) grid.

After the completion of the aforementioned studies, the developer or consumer should obtain a generation license (if above 1 MW) from EMRC. Article 5(A) of the Instruction of Wheeling Charge sets the charge that the owner of the renewable energy generation system should pay to NEPCO as transmission operator and/or to the EDISCOs.

Type of connection	Wheeling charge (fils/kWh)	Losses in grid (%)
Connection to transmission system for a user connected to the transmission system	4.45	2.3
Connection to distribution system for a user connected to the distribution system	7	6
Connection to transmission system for a user connected to the distribution system	11.5	2.3 + 6

Another type of wheeling – wheeling with aggregation – is permitted through Bylaw No. 50 of 2015. This amendment allows customers to aggregate into a larger company, which is legally responsible for supply, and which can share energy between the owners.

Direct proposals

Developer(s) can submit a direct proposal to MEMR for developing a large-scale RE project, as outlined in the Direct Proposals Bylaw No. 50 of 2015. The developer will select a location and propose the technology to be employed. According to Article 6(b) of REEEL, the developer should comply with the following requirements for the direct proposal:

- The proposal shall contain the development plan, including the preliminary design, initial financing plan, and the contribution of local inputs to the facility, supplies, construction and operation;
- The applicant shall possess sufficient experience in the implementation or development of renewable energy facilities similar to the proposal in question;
- Any documents or additional data necessary to fully appraise the proposal shall be submitted;
- The proposed tariff included in the proposal for electricity to be generated and sold by the renewable energy facility shall be a fixed tariff expressed as an amount per kilowatt hour and within an acceptable range according to the reference price list.

MEMR should decide within six months, after submission of proposals, on the most suitable projects subject to any possible financial or technical constraints. If successfully passed through screening and approval stages, the project is entitled to be connected to either NEPCO (HV transmission national grid) or one of the three EDISCO distribution (MV) networks.

The developer should sign connection and power purchase agreements. As mentioned previously, MEMR has launched three rounds (first started in 2011 with 200 MW PV and 200 MW wind; the second started in 2013 with 200 MW PV only) of direct proposals and the third round has pre-qualified investors. Renewable energy projects in this round are envisaged to be connected directly to the MV grid. In the first round, the prices were the same as the published cap price (i.e. flat-rate FIT) but for the second-round, prices were competitive and much lower than those in the first round.

Tendering process

This is simply an EPC contract for public investment projects financed through foreign aid. MEMR is directly promoting the construction of some RE capacity through the issuance of EPC contracts for construction, including maintenance and operation during the first few years of operation. This model is principally applicable to projects financed from donor grants or soft loans. Examples of this form are:

- Solar PV projects financed by Spanish funds in Azraq (2 MW and 3 MW), which have been operational since April 2015;

- The Ma'an 80 MW wind project financed by the Gulf Grant, operational since the end of 2016.
- The Quweira/Aqaba 105 MW solar PV project financed by the Abu Dhabi Development Fund, and expected to be commissioned in March 2018.

The key technical and operating documents, with which developers of RE need to comply, depending on the size of the renewable energy system and where they are to be connected are:

- NEPCO Grid Code
- Intermittent Renewable Resource Transmission nterconnections Code
- Transmission Code
- Distribution Code
- Intermittent Renewable Resources Distribution Connection Code at Medium Voltage
- Use of the grid for self-consumption from renewable energy
- EMRC directives and guidelines for connecting RE systems to the grid
- Instruction and requirements for the preparation and submission of proposals – solar PV/CSP or wind projects connected to the grid.

In addition, various model agreements are available for large RE projects to be connected to the HV network: PPA with NEPCO; support agreement with the Government of Jordan; and transmission connection agreement with NEPCO. In the case of an RE system to be connected directly to MV, i.e. an EDISCO grid, a 20-year connection agreement should be signed with the EDISCO concerned.

The two grid codes, i.e. Transmission and Distribution, are considered as basic requirement to guarantee the integration of the RE system and a stable grid operation. Furthermore, there are two specific RE grid-connection codes, the Intermittent Renewable Resource Transmission Interconnection Code for HV and the Intermittent Renewable Resources Distribution Connection Code at MV. These two codes define specific issues related to wind and PV power plants such as frequency, active power, power factor, harmonics, etc.

As for scheduling and dispatching of electricity produced from RE sources, and according to the General Electricity Law, as for other technologies, green electricity has non-discriminatory access to the grid. While the priority access for RE is not foreseen in the current grid code, NEPCO has the obligation under Article 8 of REEEL to buy all the energy produced, which has a similar effect. NEPCO is responsible for balancing the electrical system, but this activity is not specifically regulated. Costs associated with grid upgrades are fully covered by NEPCO. However, the cost for connecting RE projects to the grid must be paid by developers or owners. Connections to the distribution grid are fully covered by developers and EDISCOs may ask for special arrangements, under any other requirement, in order to connect the wheeling system. Such costs are very high and may exceed JD 0.5–1.0 million, while costs of connecting RE projects to the transmission grid are covered by NEPCO, in its capacity as system operator, and are refunded by project developers.

Annex C

Previous donor support in the energy sector

During the last five years, several agencies and organizations have provided assistance in different forms to enhance energy efficiency and implementation of renewable energy projects in Jordan. These are:

1. Agence française de développement (ADF, French Development Agency) and the World Bank support to JREEF, with a budget of US$ 6.0 million.
2. AFD's € 0.5 million programme to assist the new unit or office responsible for RE and EE activities, to establish this office, organize relationships with other ministries, and develop a centralized database to facilitate strategies for preparation, monitoring and evaluation.

3. KfW (German development bank) agreement with Jordan with a €15.0 million loan to finance energy rehabilitation of government buildings for health and education as a priority.

4. USAID specialized programme: Energy Sector Capacity Building, tackling both public and private sectors and working on demand elements.

5. JICA revision of NEPCO's strategy and future options.

6. Large grid-connected wind and CSP power plants are being supported by several initiatives, involving mainly loans with supporting actions to prepare projects (World Bank, European Investment Bank, European Bank for Reconstruction and Development), AFD, USAID, etc.).

7. Energy efficiency in industry and commerce (and others) benefited from a dedicated credit line of €40.0 million, implemented by AFD via two Jordanian commercial banks. This programme also includes a grant component to assist in the preparation of projects and co-finance energy audits and feasibility studies.

8. To improve the productivity of industries and commercial enterprises, European Commission provides them with technical expertise, equipment subsidies and loan guarantees, through Jordan Enterprise Development Corporation (JEDCO.) In addition, the Chamber of Industry regularly receives some support to develop international business relations.

9. Regarding household appliances, an agreement has been signed between UNDP/GEF and the Ministry of Planning and International Cooperation, for the Energy Efficiency Standards and Labelling in Jordan project, which is implemented by NERC; its objectives include EE appliance policy development, verification and enforcement of EE appliance labels, consumers' and retailers' awareness, and increased capacity of manufacturers.

It is important to mention here that the agreement documents of the REEE-II project was signed in July 2016 between the Government of Jordan, represented by the Minister of Planning and International Cooperation and the EU Ambassador to Jordan, for a total amount of €90 million. This project emerged as a result of lessons learned from the EU Sector Budget Support REEE-I with a budget of €40 million.

It is reported that REEE-I had a positive effect on building local skills and strengthening policies and strategies, as well as on creating a quantity of highly skilled labour within the government institutions capable of dealing with donor agencies and EU rules and regulations. It is expected that REEE-II will add to phase I and continue to address different partners' needs to further enhance the development of the sector, achieve the sector budget-support indicators and further build the capacity of the sector as a whole.

Annex D

List of renewable energy laws and regulations (available in Arabic)*

1. Ministry of Energy and Mineral Resources, 2012: Renewable Energy and Energy Efficiency Law No. 13

2. Ministry of Energy and Mineral Resources, 2012: Bylaw No. 73: Regulating Procedures and Means of Conserving Energy and Improving Its Efficiency

3. Ministry of Energy and Mineral Resources, 2015: Bylaw No. 13: Exemption of Renewable Energy Sources and Systems and Energy Efficiency Devices from Custom Duties and Sales Tax

4. Ministry of Energy and Mineral Resources, Bylaw No. 49, 2015: Jordan Renewable Energy and Energy Efficiency Fund

5. Ministry of Energy and Mineral Resources, 2015: Bylaw No. 50: Direct Proposals of Renewable Energy Projects for Power Generation and Connecting on the Electrical Grid

6. Electricity Regulatory Commission, 2012: Directive for the Costs of Connecting Renewable Energy Facility to the Distribution System for Direct Proposals and Competitive Tenders

7. Electricity Regulatory Commission, 2012: Directive Governing the Sale of Electrical Energy Generated from Renewable Energy Systems

8. Electricity Regulatory Commission, 2012: Reference Pricelist Record for the Calculation of Electrical Energy Purchase Prices from Renewable Energy Sources

9. Electricity Regulatory Commission, 2013: Instruction of Wheeling Charge

10. Electricity Regulatory Commission, 2013: Guidelines for Net Metering

11. Electricity Regulatory Commission, 2014: Revised Wheeling Charge

***Electricity**
http://emrc.gov.jo/index.php/ar/%D8%AA%D9%86%D8%B8%D9%8A%D9%85-%D9%82%D8%B7%D8%A7%D8%B9-D8%A7%D9%84%D9%83%D9%87%D8%B1%D8%A8%D8%A7%D8%A1

Renewable energy
http://emrc.gov.jo/index.php/ar/%D8%AA%D9%86%D8%B8%D9%8A%D9%85-%D9%82%D8%B7%D8%A7%D8%B9-%D8%A7%D9%84%D8%B7%D8%A7%D9%82%D8%A9-%D8%A7%D9%84%D9%85%D8%AA%D8%AC%D8%AF%D8%AF%D8%A9

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