Sustainable Energy Mix and Policy Framework for Jordan

FRIEDRICH EBERT STIFTUNG

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Royal Scientific Society

Sustainable Energy Mix and Policy Framework for Jordan

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"Meanwhile, we are dealing pro-actively to overcome our limited natural resources. By better managing water resources, and increasing supply through desalination, while providing new solar, wind, and nuclear energy sources, Jordan's future development will be secured".

**** His Majesty King Abdullah II, the Jordan Investment Forum, 2007***

"The sun-belt and the technology belt can become very powerful when they begin to understand themselves as a community: a community of energy, water and climate security; a community for their common future."

**** H.R.H. Prince El Hassan Bin Talal, World Energy Dialogue, Hannover Messe, April 2006***

"The answer for all these crises is the change to renewable energy, a green culture and green economies. And it is about time for the change to take place,"

**** H.R.H. Prince Asem Bin Nayef, Green Techies Forum and Exhibition, 2010***

"Even if we had the best uranium reserves in the world, we would still need to pursue oil shale and other energy sources…"; "However, I think the technology to extract oil from oil shale is still under development, whereas nuclear is a well-proven technology,"

**** H.E. Dr. Khaled Toukan, the Head of Jordan's Atomic Energy Commission (JAEC)***

"We believe more than 3,000 jobs in the coming few years will be created from renewable energy, the GDP will increase 2.5 – 4% because of investment in renewable energy. It will bring foreign direct investments; it will also bring new technologies".

**** H.E. Eng. Khaled Al Irani, Former Minister of Energy and Natural Resources, 5th November 2010***

"Energy Efficiency is an essential feature of energy policy for all countries: both energy importing and exporting countries. Any discussion of energy policy deals with three issues: Energy security, economic development and environmental protection. Energy efficiency as a „triple-win" solution can help to achieve all of these goals.

**** H.E. Eng. Khaldoun Qutishat, Former Minister of Energy and Natural Resources, 9th November 2009***

"Jordan has spotted the international trend where even oil-rich countries have opted to move towards renewable resources, because it makes sense from an environmental, economic, strategic, and security of supply point of view. Jordan has been among the first signers of Desert-Tech Initiative which was initiated as part of the Rome Club. Jordan has been at the forefront of renewable or alternative energy supplies. We have adopted a National Energy Strategy that is driving Jordan to be a net exporter of energy by 2030".

**** Moyad Awad, General Manager, Clean Energy Concepts, 7th November 2010***

"I am very proud of Jordan because it is trying to find energy solutions and has a portfolio that combines different options to meet its future demand. They inherently have different possibilities for success but here is no one simple and complete solution – the options it have to be varied. What we're working on right now is defining the options for success of ICP on Jordanian oil shale".

**** Intisaar Al Kindy, General Manager of Jordan Oil Shale Company, 8th November 2010***

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Glossary

CO_2	Carbon dioxide
CDM	Clean Development Mechanism
EJ	Exajoules (1018 Joules; 1 EJ = 278 TWh; 1 Mtoe = 0.042 EJ)
JD	Jordan dinar
IEA	International Energy Agency
GHG	Greenhouse gas
GJ	Gigajoule (10^9 Joules)
GJe	Gigajoule (electrical output)
GJth	Gigajoule (thermal output)
GW	Gigawatt (10^9 Watts)
IPCC	Intergovernmental Panel on Climate Change
Ktoe	Kilo tone oil equivalent
kW	Kilowatt (10^3 Watts)
kWe	Kilowatt (electrical output)
kWh	Kilowatt hour
kWth	Kilowatt (thermal output)
MSW	Municipal solid waste
MW	Megawatt
PV	Photovoltaic
Tone	Metric tone (1 tone = 1,000 kg)

Organizations engaged in the course of the study

In the course of developing an understanding of the issues and challenges facing Jordan and its energy sector, the Project Team consulted extensively with the following organizations. The Project Team greatly appreciated the extensive and open discussions and comments from the following organizations:

- Ministry of Energy and Mineral Resources (MEMR)
- Ministry of Environment (MoEnvt)
- Ministry of Water and Irrigation
- Ministry of Planning & International Cooperation (MoPIC)
- Ministry of Municipalities and Rural Affairs (MMRA)
- Electricity Sector Regulatory Commission (ESRC)
- Water Authority of Jordan (WAJ)
- Greater Amman Municipality (GAM)
- National Energy Research Center (NERC)
- National Electric Power Company (NEPCO)
- Jordan National Building Council (JNBC)
- Central Electricity Generating Company (CEGCO)
- Jordan Electric Power Company (JEPCO)
- Irbid District Electricity Company (IDECO)
- Electricity Distribution Company (EDCO)
- National Petroleum Company (NPC)
- Jordan Petroleum Refinery Company (JPRCO)
- Jordan Atomic Energy Commission (JAEC)
- Jordan Biogas Company (JBCO)
- Rural Electrification Project (REP)
- Electricity Regulatory Agency
- King Abdullah II for Design and Development Bureau (KADDB)
- Higher Council for Science & Technology (HCST)
- Energy Management Services Int. (EMS)

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This book is the product of a fruitful partnership between the **Royal Scientific Society** and the **Friedrich-Ebert-Stiftung**. It has been built on a foundation of incredible work by countless institutions, organizations, and individuals, all are dedicated to the quest for sustainable energy. Their efforts have affected how we envision our energy situation and future, and many of the products of their work are reflected in this book. Their work is an inspiration not only for our work but also for the future of the world.

Finally, we thank our many colleagues and students who have inspired and pushed us to think through and think about sustainable energy and its many dimensions in science, technology, economics, planning, policy, and society.

Foreword

We in our region have reached an energy crossroads. Beyond the global gaze of those who see us merely as a storehouse for dwindling energy reserves, we have much to discuss amongst ourselves. Ours is a region that has been blessed and cursed with bountiful fossil fuels. Now we must recast ourselves as a collection of nations with a common realization and a shared purpose to do more than merely survive. We must use our intelligence, our initiative and our other, untapped natural gifts to forge a sustainable energy future.

This quest for a sustainable energy policy in our region will not be a difficult one - if we work together and allow our best and brightest to apply themselves to the task. I am therefore delighted to welcome you all to the Dead Sea for a conference that will, I hope, form bonds, set agendas and make the dream of a sustainable energy future more tangible for our people. In this regard, I am delighted that you will discuss the political economy of renewable energy over the course of this conference. I believe that technology will not be the issue in building our renewable future – The challenge will lie in creating a cross-border policy and regulatory infrastructure that allows innovation to thrive. This is most obvious in the case of mooted mega-projects such as Desertec, MASDAR, Trans green and Solar Plan for the Mediterranean.

It is vital that you discuss the social dimension of a coordinated sustainable energy policy, for we must ensure that sources of energy stretch from those mega-projects to local and domestic technology applications. The quest for energy has been the cause of too much social and political instability in recent decades. Let us make sure that we do not allow these fault lines to follow us into the Age of Renewables.

This is also an occasion for me, on behalf of the Royal Scientific Society (RSS), to celebrate the long-standing relationship that exists between Friedrich-Ebert-Foundation and the RSS. This productive partnership dates back to the signing of a cooperation agreement in September 1985. I would mention that the first major energy conference in Jordan was organized jointly by the RSS and FES in May 2006. Today, our two organizations co-operate on a regular basis, especially in the production of research publications. We have recently completed one such study on solar heating in Jordan and we are involved in an ongoing project to prepare the ground for the creation of a Sustainable Energy Mix and Policy for Jordan.

Our foremost aim at this conference is to take stock of the current renewable energy situation in the Middle East and North Africa region. We hope that your discussions will begin a process that strengthens and supports net-working of experts and institutions in the region as well as between the MENA region and Europe. We also hope that by inviting politicians and policymakers, as well as scientists and academicians, we can start a process in which recommendations for energy policies and a sustainable energy mix can be developed and implemented.

With your help, we at the RSS would like to help Jordan in developing a national strategy on renewable energy but we would also like to position the Kingdom as a major hub for foresighted energy policy in the region. We hope to develop capacity within the RSS to drive change in the energy sector, not only with regard to technology, but also in policy development. We believe that there are many voices in Jordan and in the region that should be listened to. Events such as this will help us to present ourselves coherently and convincingly to governments and multilateral organizations.

Energy efficiency is a vital issue for all of us in the region, even those who are blessed with fossil fuel reserves. We are all aware that these gifts are finite and currently the cause of much environmental degradation. Energy commodities such as oil and gas are no longer the fundamental issue in global energy discussions. They have helped to shape the geopolitical world we inhabit and, perhaps more importantly, they have allowed us to create our massively energy-dependent lives. But truly, they are a distraction. Energy is above any commodity. It is a vital force powering business, manufacturing, and the transportation of goods and services to serve the world economies; it is a key element of sustainable development. But we all have cause to be optimistic for our future, as the world's greatest untapped energy source is the naturally released energy that we ignore or waste.

Energy supply and demand plays an increasingly important role in our national security, our national development plans and the future economic output of all our nations. It is hardly surprising that Jordan spends over JD 1 billion annually on its growing energy needs – but that need not be the case. There is an increasing awareness in both the government and the private sectors that new approaches are needed to realize a transformation that will make our economy viable and sustainable into the future. For this reason, the development of new and renewable energy sources and technologies has been given top priority in Jordan. We must take that a vital step further and enshrine such thinking in our core policymaking.

The fact is, the burden of oil importation has led to sporadic forays by policymakers but we must make sure that we all think beyond commodities and adopt a holistic approach to our energy needs. The basis of the present policy of the Jordanian Government is, indeed, solid and aims at achieving the following:

- To seamlessly integrate the planning of new and renewable energy sources and policies into an overall economic framework.
- To improve energy efficiency in the national economy.
- To enhance human resources development through training and education.
- To assess new ways to utilize renewable energy.
- To formulate coherent policies aimed at shifting the present energy dependence structure to a more sustainable and efficient model.
- And to develop awareness of the role of new and renewable energy systems in all sectors of the economy.

In bringing about a regional policy transition, we cannot ignore the fact that the MENA region contains a huge amount of renewable energy resources, as well as the infrastructure to exploit these resources. But in spite of all this wealth accumulated through the extraction of finite fossil fuels, the attention paid to renewable energy resources, our inevitable future, has been sadly lacking. The research and development, and the innovative drafting of vital technology transfer programs are absent from many of our priority lists. Building capable institutions to manage and push this process is a necessary first step to dealing today with our future needs.

We may be known for the fuel that burns through decades of bad policymaking around the world, but today our message must be that we have much to give in terms of renewable energy. Solar thermal power from MENA is of particular value for an EU clean power market. Improved solar heat storage technology allows for power production controlled by demand, and without the risk of fluctuations. Thanks to our almost constant and bountiful solar radiation, MENA countries are perfectly positioned to play a leading role and to establish an enduring economic partnership with Europe. DESRTEC is a model for cooperation between the EU and MENA that guarantees a win-win partnership for all of us, and helps the environment to recover from decades of abuse.

Solar energy in Jordan offers particularly strong potential for positive exploitation. Solar has been historically used to heat water and for cooling applications in Jordanian homes and businesses, for water pumping and for photovoltaic power sources in communications equipment. A resource assessment carried by Lahmeyer International in 2006 estimated that solar power generation in Jordan had a potential of over 6,000 terawatt-hours (TWh) per annum, which compared with domestic the end of use electricity consumption of just 11.5 terawatt-hours (TWh) in 2008.

It is hardly surprising that the Government is keen to expand solar energy usage on a domestic level, not least by increasing household solar heating, photovoltaic technologies and large-scale solar power generation. Vital steps are being taken by the government and private sector alike to make solar energy an important contributor to our overall energy needs.

Similarly, solar desalination has a history of innovation in our country, one that we must strive to build on. A solar heat-pipe system was installed in Aqaba in the late 1970s, consisting of 15 modules with a gross area of 375 square meters. Since that time, the RSS has devised and built several types of solar stills made of available materials such as cement, glass and black paint, to compare the results obtained by these units with heat pipe solar desalination units.

The RSS has also developed a solar water heater that aims to fulfill a set of criteria geared to guarantee low cost, easily installed and maintained units made from local materials. From 1981 on, the RSS has spearheaded a project to assess the potential of solar heating in Jordanian buildings. Both passive and active design criteria are considered to create models for buildings that respond to the challenges and benefits of our environment.

Wind power is also under the microscope in Jordan. As a response to the absence of wind data in Jordan, the National Energy Research Center (NERC) is conducting a wind speed survey of promising sites around the country. More than 35 locations have already been identified and 15 wind measuring systems are up and running.

These are just some examples of what's being done at local and government level to increase our use of renewable energy. There is a great deal more to do but we should be mindful that we begin with the expertise that we require to succeed. I look forward to reading your recommendations for the development of a sustainable energy mix in our region and I sincerely hope that this valuable conference is the first of many in the years to come.

Princess Sumaya Bint El Hassan, 2010, Dead Sea, Jordan

Preface

With this important study, the Friedrich Ebert Foundation (Friedrich-Ebert-Stiftung, FES) aims at supporting the regional search for future strategies and policies in the energy sector which will have to be

- technologically sound
- economically viable
- and ecologically sustainable

On a global level, the Foundation has – for quite some time – been active in enabling an open dialogue and a broad discussion on energy questions. Since the beginning of 2010, activities in the energy sector constitute one of the priorities of our work in the MENA region.

It is, therefore, a great pleasure for me to present to you this study which we have supported in the framework of our longstanding and successful partnership with the Royal Scientific Society.

In fact, this partnership dates back a quarter century: In September 1985, the cooperation agreement was signed between our two institutions. And in April 1986, the first representative of the Friedrich Ebert Foundation in Jordan was sent to Amman.

During the past years, RSS and FES have jointly produced and published a number of important studies on different socio-economic issues.

It is worth mentioning here that the Royal Scientific Society and the Friedrich Ebert Foundation have already organized one important energy conference together in May 2006. This conference which many experts have attended at the time, dealt with Renewable Energies and Energy Efficiency and I think it is fair to say that it did indeed have a considerable impact on the development of the national energy policies in Jordan.

I would like to seize the opportunity today and remember Hermann Scheer who – as a member of the German parliament – was one of the key speakers of that Amman conference of 2006. Many readers will remember him for several reasons:

- Hermann Scheer was an outspoken lobbyist for solar energy,
- As such he was a laureate of the Alternative Nobel Prize – or Right Livelihood Award – in 1999. Among many other honors, he was nominated a "Hero for the Green Century" by Time Magazine in 2002.
- And finally: An outstanding success of Hermann Scheer with relevance for the MENA region was his struggle for the creation of IRENA, the International Renewable Energy Agency which was founded in Bonn in January 2009 and has its secretariat in Abu Dhabi.

We all have felt the great loss when we learned that he passed away so untimely in October 2010.

Following are a few lines from an old report. It said: "A completely new approach is necessary to guide mankind towards goals that bring about a balance rather than further growth. This approach needs an extraordinary level of understanding, creativity and political as well as moral courage". And a few lines further, it continued: "We are of the opinion that social innovation must not lack behind technical innovation. It is time for a radical reform of institutional and political processes."

These lines date from the year 1972. They are part of the famous report "The limits of growth", published then by the Club of Rome – the organization in which Jordan, through the presidency of His Royal Highness, Prince El Hassan bin Talal, between 2000 and 2006 has played an important role. This report and its recommendations were visionary in an era of undoubted economic growth and very few thoughts about the future of the planet.

I am sure that the reader will agree that the report's findings are still as valid today as they were almost forty years ago. In its subtitle, the conference of 2006 also included the Social, Economic and Political dimension of the issue.

Energy and water are two of the key challenges for the foreseeable future on a global level, and even more so in the Middle East and North Africa. More than a dozen conferences in the MENA region during the autumn of 2010 alone were ample proof of the importance of the topic.

This study will hopefully enable, encourage and intensify a broad discussion on suitable approaches to develop sustainable energy policies for Jordan. Ideally, these would then also enrich the debate in the Middle East and North Africa. And it is on purpose that the word "policy framework" is used here since there is no one-size-fits-all-approach, neither for Europe nor for the MENA region.

Certainly we will have to deal with technological developments, but, as the name "Royal Scientific Society" implies – there is a need of exploiting the "science" in it as well as the "society". The study indicates innovative and creative solutions which will utilize the best science has to offer in the service of society.

Therefore, it is necessary to go beyond science and academic research:

- Scientists have to provide creative solutions which will enable the citizens to live a decent life without destroying the very foundations on which their livelihood is built.
- Academics have to provide us with ways to make energy supply for all economically viable.
- And yet: this can only be the basis on which politicians will then have to decide which road forward to take.
- And finally: The best decisions, the most thoroughly prepared laws and regulations will not be a success if we do not convince the population to follow, to adopt those new ways and to change traditional mentalities.
- When one talks about "energy efficiency" it is too often overlooked that "saving energy" could be the easiest and cheapest way to radically reform the energy sector if only the state was able to educate its population and develop a different mentality. But this would need a strong, concerted and dedicated policy of a public outreach on all sides and in all countries.

All these are difficult tasks, they constitute a tremendously complicated endeavor – there is no black and white, no right or wrong. Lessons will have to be learnt and strategies will have to be adjusted to local, national or regional specificities.

The countries of the Middle East and North Africa have achieved a lot with regard to energy policies in recent years. Its decision makers have the advantage that they can exploit the experiences made elsewhere over several decades – but they do have the disadvantage that they most probably will not have the same amount of time which the Industrialized Countries have used.

Let us use the opportunity to build networks of expertise and knowledge in the region, to exchange technical know how and policy concepts across the Mediterranean and to jointly develop the solutions needed for the future.

My sincere thanks go to the Royal Scientific Society and its committed staff which has been essential in compiling this study which will – I am sure – serve as a reference in the energy sector.

Achim Vogt, Country Director, Friedrich-Ebert-Stiftung, August 2011

Executive Summary

This review seeks to examine all components of the energy sector in Jordan, and provide findings and recommendations for each. This Executive Summary suggests areas for priority attention.

Overview

The year of 2011 witnessed two events that have been influencing the energy security, causing energy supply instability and the ever-increasing need for energy self-sufficiency. The first is the earthquake and tsunami that struck Japan on March 11, 2011 and severely damaged the Fukushima nuclear power facility, causing a failure in its power plants' cooling systems and leading to radioactive waste leaking into the surrounding environment. The second is the "Arab Spring", which has seen millions of citizens in the Middle East and North Africa demanding political and economic reforms. As a result of a combination of economic recovery and geopolitical unrest in the Middle East and North Africa, rises in the oil and energy prices have therefore been extremely dynamic and volatile.

At the time of publication the ramifications and consequences of these two events are varying across the world. The consequent implications of the Arab Spring on Jordan have worsened its energy supply and burdened its economy. The several attacks on the Egyptian natural gas pipeline are highlighting the unreliability of natural gas as a short-term solution for energy security and demand in Jordan. Consequently, this has forced Jordan to shift from a clean source of energy to the more expensive diesel and heavy oil fuel to secure its energy demands.

The reliance on oil imports as a substitute to natural gas, combined with the fluctuation of international prices has increased the imported energy bill for 2011 and it is predicted to top $4.8 billion, equal to 20% of the expected gross domestic product (GDP) for 2011, one of the highest rates worldwide. Moreover, the increase in the world energy prices for the whole year (2011) is expected to cost Jordan over JD1.5 billion more than last year.

The Fukushima nuclear accident has played a role in stirring up the debate in Jordan. However, although the Jordanian government is now encountering a growing resistance to nuclear power from public-interest groups and an emerging anti-nuclear campaign taking place amongst a broader context of political demonstrations, Jordan continues to seriously consider nuclear power as part of Jordan's energy mix.

The future of energy supply in Jordan is a high priority on the Government's agenda. The National Agenda recognizes that the energy sector is facing essential challenges, especially the reliance on energy markets for direct imports; the rising cost of crude oil and oil product imports (estimated at 17.6% of GDP in 2008, 11.8% in 2009, and approx. 20% in 2011); the growing demand for oil products which is expected to exceed 3% growth per year, and electricity consumption maintaining an upward trend (expected to exceed 4% growth per year).

Other challenges include the provision of necessary funding for investment in the development of the energy industry and its installations in time to meet energy needs, promoting an efficient use of energy in all sectors and upgrading oil derivatives products specifications in line with international standards in order to ensure safety and environmental protection.

To address these challenges the Government has set certain goals, namely:

- achieving security of oil products supply;
- shifting the energy fuel mix from oil to gas in power generation and energy-intensive industries; and
- achieving security of electricity supply.

The current Energy Strategy charts the best way forward for the sector, with the aim of diversifying the energy mix. To this end, four approaches have been developed:

- utilize oil shale through direct burning by 2015;
- develop Jordan's civil nuclear program with a functioning nuclear reactor by 2020;
- generate 10% of the Kingdom's electricity through renewables by 2020, particularly through wind and solar power; and
- improve energy efficiency to reduce demand.

The Renewable Energy and Energy Efficiency Law adopted in 2010 is a major step forward. The law also sets incentives to promote renewable energy utilization in Jordan as well as establishing the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) but not much has been done so far.

In the years and decades to come, the upheavals that have been seen since the beginning of 2011 are likely to cause a rapid development of renewable energies in both developed and developing countries – and Jordan is among these countries. This is because Jordan, specifically in renewable energy, is ahead of many of its neighbors in creating a legislative framework. It provides investors in the renewable energy sector with a number of incentives, guaranteed network access and some tax and customs exemptions. Nevertheless, having a new regulatory framework in place may not be sufficient for a smooth process of project implementation and substantial work is still needed for putting the regulatory framework into daily life.

Energy needs

The several attacks on the Egyptian natural gas pipeline facilities in the Sinai in 2011 have heightened concern in Jordan, especially since the country has no reserves of its own and no immediate replacement for Egyptian gas. Jordan relies on imports of Egyptian natural gas through the Arab Gas Pipeline for 80% of its electricity generation. However, shifting to oil and diesel during the disruptions of the Egyptian supply has cost Jordan's power company $4 million a day.

Natural gas and crude oil/petroleum products cover approximately 98% of Jordan's total primary energy supply while renewable energy represents less than 1%. As Jordan lacks domestic natural gas and conventional crude oil resources, their high shares in the national energy mix imply a striking dependence on energy imports of more than 90 %. In 2008, the total spending on energy imports was equivalent to around 17.6 % of the GDP. While Jordan is short of conventional crude oil reserves, it accommodates an extremely large affirmed oil shale resource. Geological surveys indicate that the existing shale reserves cover more than 60% of the country and amount to in excess of 40 billion tons.

The Jordanian energy sector is under auspices of the Ministry of Energy and Mineral Resources (MEMR), which was established in 1984. The role of the MEMR is to define policies, fix tariffs and to regulate all activities with an impact on energy. MEMR's responsibilities also include strategies and projects to promote renewable energy technologies, such as solar water heaters or wind energy. In the electricity sector, MEMR aims to increase the share of efficient natural gas-fired power plants and foster the utilization of nuclear power as Jordan possesses significant proven recoverable reserves of uranium. By 2013, the construction of the country's first nuclear power plant is scheduled to begin. The plant is expected to be operational by 2017/2018. At the time being, total installed power generating capacity is 3,098 MW with fossil-fired steam units and combined cycle plants accounting for nearly 92%. Wind turbines, biogas facilities and hydro units cover less than 1% of the national power supply. Almost 55% of Jordan's electricity is supplied by the Central Electricity Generating Company (CEGCO), while the National Electric Power Company (NEPCO) is responsible for the transmission of electricity.

Obstacles to overcome

The first front in the development of the renewable energy projects has been legislative. The lack of a compulsory energy efficiency code and limited incentives for investing in the sector are just some of the obstacles to developing the renewable energy sector in Jordan. Investment and financing of renewable projects is a common problem and government incentives and subsidies have played an important role in many countries. One of the key limitations for a wider project implementation of sustainable energy financing is the lack of financial resources for small-scale projects. The market demand study – once it is prepared – will identify barriers to sustainable energy investments and propose recommendations to overcome the identified barriers on all levels (institutional, financial, legal, etc.). Moreover, it will highlight opportunities to promote market-based financing mechanisms to local financial institutions and Jordanian sectors.

The other front and the most important obstacle to investments in renewable energy is cost. The renewable energy law has created the Renewable Energy and Energy Efficiency Fund, which shall support renewable energy. Combined with ongoing technological advances and lower start-ups expenses, costs should decline to make solar and wind competitive energy sources.

The main challenges in implementing a viable nuclear program are water, size and financing. A 1000 MW nuclear power plant will consume 60 million m3 of water per year, but Jordan has limited access to water. On another note, the same power plant will cost several billion US-dollars, making it a challenge for Jordan to have such nuclear plants financed solely by the private sector.

Parallel to that, the argument has been recently raised by the Jordanian Committee of Anti-nuclear Project that many contradictory statements have been formally announced since 2007 regarding the actual Uranium deposits in Jordan and the viability of the feasibility studies based on the Uranium amount. Quite recently (November, 2011), active criticism of the government has been voiced about Jordan's nuclear program and its "feasibility and the real agenda".

Significant uncertainties remain concerning the exploration and production of oil shale in Jordan, such as how much energy will be required to heat the steam before oil can be produced. Moreover, the in-place volume of oil shale in Jordan is vast but difficult to quantify. Thus, the first 10 years are basically de-risking and then, when the thickest, deepest, and richest oil shale area is reached, it is unsure whether the technology will work commercially.

Looking to the future

In response to the challenges facing Jordan in the field of energy, the government of Jordan developed a comprehensive energy strategy through the Royal Advisory Committee on the Energy Sector in December 2007. According to the new strategy, the total anticipated investment in the energy sector is expected to reach $15 billion by 2020. The current energy mix shows that only 4% is supplied from local sources and the strategy envisages the local content to increase to 39% by 2020 out of which 10% should come from Renewable energy.

In order to achieve such an ambitious target a new Energy and Minerals Law including renewable energy has been drafted and submitted to parliament for ratification and endorsement. The new law offers fiscal incentives and encourages independent power producing projects to generate electricity on BOO & BOT basis (wind park projects to generate a minimum of 600 MW of electricity and solar farms to generate a minimum of 600 MW by 2020).

Furthermore, the strategy recognizes the country's great potential to reduce energy consumption via energy efficiency measures. For example, studies came to the result that the industrial and commercial sector may reduce energy consumption by 20%. In order to meet the target for renewable energy and to improve energy efficiency, legal provisions were established for a fund supporting renewable energy and energy efficiency projects.

It is hard to quantify the overall potential benefits of renewable energy for Jordan. However, by looking at leading renewable energy economies like Germany, it is clear that there is significant potential for job creation, increased investment and environmental benefits.

Private sector leading the way

Jordan has made efforts to incorporate environmentally friendly techniques in different sectors, most notably construction. This includes the introduction of building codes which highlights energy efficiency and green building. However, adoption of the code is currently voluntary and as such its use is not widespread.

In order to ensure the success of the Energy Strategy in 2020, the mix shall depend on more investments from the private sector. Future energy projects shall be led by the private sector, and renewable energy will depend heavily on private sector investment. All oil shale investment currently comes from the private sector investment. Jordan shall continue to develop the right policies, incentives and disincentives to enable the private sector to take control. The first step towards this is in renewable energy share in the 2010 energy mix. The renewable energy law has been designed to allow the private sector to invest directly, with the right framework and tariff structure.

Chapter 1: Introduction

"The struggle for life is not a struggle for basic elements or energy, but a struggle for the availability of energy transferred from the hot Sun to the cold Earth"
Boltzmann, 1886

1.1 Global Energy Sustainability

Energy is the key ingredient in all sectors of modern economies. While there is a growing recognition that (non-renewable) energy production constitutes an increasing risk for the development of civilization on a global level, there is also hope that the production of sustainable energy can be managed through the use of renewable energy sources that are clean, cheap and 'green'. Humanity has been faced with a lack of energy since the dawn of the history. The energy sources in the ancient time were animal traction, wind energy (windmills, sailing ships), low energy hydropower (watermills) and biomass (mainly for home requirements). Changes in energy use provided opportunities for growth of human populations and economic systems and triggered each phase of development of civilization. The essence of this sustainability, as postulated by the World Commission on Environment and Development (WCED) (Brundtland Commission) **[UNC, 1992**], is the need "to satisfy our needs without compromising the ability of future generations to meet their own needs".

However, the year of 2011 witnessed two events that have been influencing the energy security, causing energy supply instability and the ever-increasing need for energy self-sufficiency. The first is the earthquake and tsunami that struck Japan on March 11, 2011 and severely damaged the Fukushima nuclear power facility, causing a failure in its power plants' cooling systems and leading to radioactive waste leaking into the surrounding environment. The second is the "Arab Spring", which has seen millions of citizens in the Middle East and North Africa demanding political and economic reforms.

In the wake of the Fukushima plant disaster in Japan, some European countries have decided to phase-out nuclear power. The nuclear power phase-out opens a whole window of opportunities for renewable technologies. On the other hand, the Arab Spring may provide further support for a critical assessment of civilian nuclear power.

The rising intensity of the Arab Spring has increased the vulnerability of the Middle East countries to their energy needs and also increased energy supply disruptions, forcing these countries to shift from clean sources of energy to the more expensive diesel and heavy oil fuel to secure their energies demand. On the other hand, the Arab spring is perceived as a genuine reform that will ensure both social justice and environmental sustainability, and eventually contribute to a new discourse in sustainable development.

Sustainable energy refers to those patterns of energy production and use that can support society's present and future needs with the least life-cycle economic, environmental, and social costs. However, global population is currently forecast to rise to about 9 billion by 2050 and stabilize by 2100. Hence, without any change in our current practice, the world energy demand in 2020 would be 50–80% higher than 1990s levels **[WBGU, 2003**]. According to estimations done by the International Energy Agency (IEA), a 53% increase in global energy consumption is foreseen by 2030, with 70% of the growth in demand coming from developing countries. Such ever increasing demand could place significant strain on the current energy infrastructure and potentially damage world environmental health by effluent gas emissions and global warming. Achieving solutions to the environmental problems that we face today requires long-term potential actions for sustainable development **[Omer, 2007]**.

Since the dawn of the Industrial Revolution, the population, the economy, and energy use have surged, fueled by oil, natural gas, and coal. Since oil comprises the largest share of world energy consumption, a reduction in availability of oil will cause a major disruption unless other resources can fill the gap. Natural gas and coal production may be increased to fill the gap, with the natural gas supply increasing more rapidly than coal. However, this will hasten the time when natural gas production also peaks. Additionally, any increase in coal consumption will worsen the global climate change situation.

Energy development is increasingly dominated by major global concerns about over-population, air pollution, fresh water pollution, coastal pollution, deforestation, biodiversity loss, and global climate deterioration. To prevent disastrous global consequences, it is increasingly impossible to engage in large-scale energy-related activities without insuring their sustainability, even for developing countries in which there is a perceived priority of energy development and use and power generation over their impact on the environment, society, and indeed on the energy sources themselves **[Moam, 2008]**.

Presently, there is a resurgence of interest in nuclear power. However, it is doubtful that nuclear power alone will be able to fill the gap. Forecasts from International Atomic Energy Agency (IAEA) show that nuclear power around the world will grow only at a rate of 0.5% – 2.2% over the next 25 years (IAEA 2005) **[IAEA, 2005]**.

Based on this information it seems logical that the Renewable Energies (RE) technologies of solar, wind and biomass will not only be essential but will hopefully be able to fill the gap and provide a clean and sustainable energy future. The German Advisory Council on Global Change (WBGU) estimates that as much as 50 % of the world's primary energy in 2050 will come from RE, increasing to 80 % by 2100 **[WBGU, 2003]**.

1.2 Energy, Environment, and Climate Change

Energy production and consumption have environmental impacts. The environmental damages linked to the production, transformation, transport and use of different energy sources are still substantial. The energy sector has also been subject to major catastrophes which have marked its history: oil slicks, rupture of pipelines or well heads, hydro-electric dam failures, nuclear accidents, etc **[Moam, 2008]**. The control of the environmental impact of the various energy systems in terms of emissions, wastes and perturbation of ecosystems, under normal or accident operating conditions is hence a major issue.

In addition, the environmental impacts include air pollution from the combustion of fossil fuels, radioactive materials involved in the nuclear fuel cycle, impacts on lands and waters of fuel extraction, and transport and construction of conversion systems. Moreover, global warming is deemed one of the most difficult environmental problems facing the world.

Thirty years ago, it was a theory that a number of atmospheric gases, principally carbon dioxide (CO_2) and water vapor, transmit most of the short solar wavelengths but absorb most of the longer wavelengths of the Earth's back-radiation, holding in energy and warming the Earth's atmosphere and surface – much like the glass in a greenhouse. Quite recently, global climate change is the major environmental constraint facing fossil energy, triggered by greenhouse gas emissions (GHG), primarily carbon dioxide from fossil fuel combustion.

In 2008, it has been reported by the Intergovernmental Panel on Climate Change (IPCC), that the equivalent carbon emissions from industrial society, primarily caused by the combustion of fossil fuels, have risen to 49GtCO_2- eq/y precipitating a concomitant increase in atmospheric carbon concentration from a pre-anthropogenic level of 280–379 ppmv in 2005 **[IPCC, 2008]**. GHG concentrations at the current level cause a global disequilibrium and even emissions stabilization at these intensities will produce a ~ 2 ˚C temperature rise **[Hansen et.al 2008]**. In order to avoid further disruption to the Earth's thermal equilibrium and negative effects on human society, it has been recommended that greenhouse gas emissions be stabilized at levels below 350 ppmv **[Hansen et.al 2008]**.

The IPCC predicted in 1990, that, on a 'business-as-usual' emissions scenario, global mean temperatures could rise by an average rate of about 0.3˚C per decade (with an uncertainty range of 0.2 – 0.5˚C) during the next century. This could lead to an increase in global mean temperature of about 2˚C above that occurring in pre-industrial times by the year 2025, and about 4˚C by 2100. Such a rate of increase would be expected to lead to increased global average of rainfall by a few per cent by 2030, to diminution of areas of sea ice and snow cover, and to a rise in global mean sea level of 20 cm by 2030 and 65 cm by the end of the next century.

In 2001, the IPCC predicted that anthropogenic warming is likely to lie in the range of 0.1 – 0.2˚C per decade over the next few decades, leading to a likelihood of increased precipitation and a greater risk of extreme weather conditions such as floods and droughts **[IPCC, 2001]**. The environmental, economic and social consequences of such rates of warming are described by the IPCC Working Group on Impacts. Also, according to the USA Department of Energy, world emissions of carbon are expected to increase by 54 % above 1990 levels by 2015 making the earth likely to warm 1.7 – 4.9˚C over the period 1990 – 2100.

According to the IEA, an ever increasing demand in global energy consumption is foreseen in 2030, with 70% of the growth in demand coming from developing countries. Consequently, this could potentially damage world environmental health by effluent gas emissions and global warming. These impacts are part of the "cost of doing business" but to a large extent they are not included in the costs of energy. They are termed externalities. **Energy externalities** are the costs imposed on society and the environment that are not accounted for by the producers and consumers of energy; in other words, they are the costs which are not reflected in the market price. They include physical damage to the natural and built environment. Therefore, to mitigate these environmental impacts, then long term potential actions are required for achieving sustainable development.

In the beginning of the 1990s, the European Commission's Fifth Environmental Action Program 'Towards Sustainability' required the integration of the environmental dimension in other policy areas. Policy decisions should take into account the benefits and costs of action and non-action based on the available scientific and technical information **[Wolfram, 2002]**.

In order to stabilize the GHG concentrations in the atmosphere, at a level that would prevent dangerous anthropogenic interference with the climate system, the United Nations Framework Convention on Climate Change (UNFCC) has adopted Kyoto Protocol in 1997 in Japan. All signatory parties have agreed to reduce their anthropogenic GHG emissions by at least 5% below 1990 levels in the commitment period 2008 to 2012. In 2007, 174 countries covering 61.6 % of global emissions have ratified the protocol.

Problems with energy supply and use are related not only to global warming, but also to acid precipitation, ozone depletion, forest destruction and emission of radioactive substances. These issues must be taken into consideration simultaneously if humanity is to achieve a bright energy future with minimal environmental impacts. Much evidence exists, which suggests that the future will be negatively impacted if humans keep degrading the environment.

The World Summit on Sustainable Development (WSSD) in Johannesburg in 2002 committed itself to "encourage and promote the development of renewable energy sources to accelerate the shift towards sustainable consumption and production". Accordingly, it aimed at breaking the link between resource use and productivity **[Abdeen, 2008]**. This can be achieved through the following:

- Trying to ensure economic growth does not cause environmental pollution.
- Improving resource efficiency.
- Examining the whole life-cycle of a product.
- Enabling consumers to receive more information on products and services.
- Examining how taxes, voluntary agreements, subsidies, regulation and information campaigns, can best stimulate innovation and investment to provide cleaner technology.

1.3 The World and the Energy Dilemma

Since the oil crises in the early 1970s, there has been active worldwide research and development in the field of renewable energy resources and systems. During this time, energy conversion systems that were based on renewable energy technologies appeared to be the most attractive one because of facts such as the projected high cost of oil and the cost effectiveness estimations and easy implementation of renewable energy systems.

Renewable energies and energy efficiencies technologies are considered as potential solutions to the current environmental problems associated with the harmful pollutant emissions. Many countries consider wind, solar, and other renewable energy technologies to be the key to a clean energy future and put efforts to be the world's leader in developing, manufacturing, and using these technologies.

Today the world has an energy dilemma based on the following components:

- 37 % of world energy still comes from petroleum. Oil Reserves are concentrated in the politically volatile Middle East.
- The global climate is already changing due to carbon emissions from fossil fuels, which still provide 86 % of our energy.
- The developing world needs more energy to achieve basic needs. China's energy use is doubling every decade. Global energy usage grew by 2 % per year from 1970 to 2002 and 4.1% per year from 2002 to 2005.
- Progress toward alternatives to oil, carbon, and growth in demand is still slow. The world still depends on fossil fuels now as it was in the 1970s. However, the world energy demand is doubled from 1975 to 2005.
- Transition to sustainable energy faces barriers to change, including uncertainty about supply options and their impacts, economic and political interests, and people resistant to changing their behavior.

With 20 % of the world population consuming 75 % of the world energy and controlling 75 % of the global economy, while the poorest 80 % struggle toward development, the world is far from an equitable energy and economic system.

In more recent times, it has been realized that renewable energy sources and systems can have a beneficial impact on the essential technical, environmental, economic, and political issues of the world. One area which seems to be of considerable importance in many countries is the ability of renewable energy technologies to generate jobs and as a means of economic development to the country-- relative number of jobs created by renewable energy technologies vs. fossil fuel technologies **[Ibrahim, 1999]**.

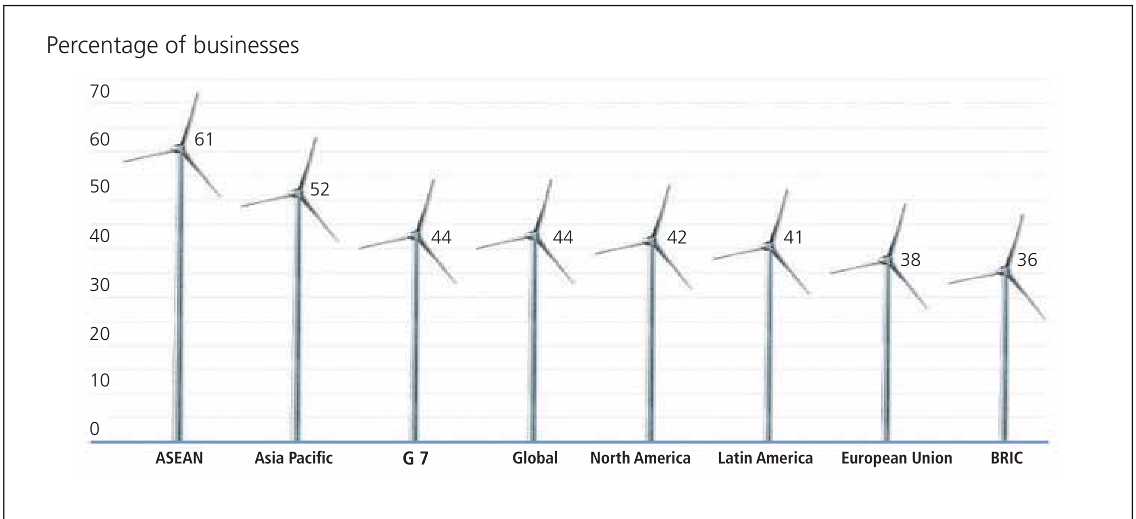
The "Living Planet Index" is estimated to have declined since 1970 by about 30 %, and the "Ecological Footprint" increased by 70 % in the same period: it seems the world is running out of environment much faster than out of resources. For instance, nuclear power produces ~16 % of world electricity; the number of reactors is increasing very slightly; public perception is improving, new government initiatives started, but the same problems remain **[Noam, 2010]**.

Thus, emphasis should be placed on increasing the role of renewable energy in the global energy mix in general, and for developing countries in particular, since they have appropriate resources and development conditions for many renewable energy applications. Many policy instruments are available for developing countries to enhance the utilization of renewable energy **[Gabriele, 2004]**. Governments should use economic instruments, incentives, and privatization schemes to achieve this goal.

In 2011, and due to the intensity of the Arab Spring, the price of oil has increased dramatically. The ongoing natural gas interruptions in the Middle East could move the oil market into considerable volatility, requiring a rebalancing of contracts and a noticeable escalation in prices.

According to the latest research from Grant Thornton's International Business Report (IBR) in 2011, 44% of the global businesses would now support increased government investment in renewable/alternative energy, as shown in Figure 1.1. Consequently, the Arab Spring is believed to be a key issue in global energy security.

Figure 1.1: Business support for increased government investment in renewable/alternative energy



Source: Grant Thornton IBR 2011.

Despite the decision of some European countries to phase-out nuclear power reactors after the Fukushima nuclear accident, a 30 % increase in global nuclear generating capacity by 2020 is predicted, taking Fukushima into account, and 66 % by 2030 **[New York Times, 2011]**. The rising costs of natural gas and coal, together with concerns about energy supply security and environmental constraints, are among the factors contributing to this anticipated nuclear growth.

The immediate alternative source of power will be an accelerated usage of liquefied natural gas (LNG). In recent years, the share of LNG in transport volume has been increasing throughout the world.

Chapter 2: Jordan Profile and Circumstances

"Water and energy are synonyms and it is for this reason that for several years and most recently in the lifespan of the West Asia-North Africa (WANA) region, we tried to focus on the importance of a supra-national water and energy community for the WANA region"
El Hassan Bin Talal, WANA Forum, 2010

"The world is in need of powerful steps towards energy, water and climate security. The DESERTEC Programme could become a key project for a Second Copernican revolution replacing the polluting and limited fossil energies from earth by clean and unlimited energy delivered from the sun"
El Hassan Bin Talal, Berlin, Germany, 2007

2.1 Introduction

Jordan is a non-oil producing country with abundant supplies of renewable energy sources, mainly solar and wind energies, which consumes relatively, more energy per unit of economic output than other countries, of similar social and economic structure. The high energy consumption is driven by the structure of the small economy and its dependence on imported crude oil, which has been the dominant energy source for four decades, for transport and the generation of electricity. There is increasing concern about the excessive rate of fuel consumption in Jordan, in both the commercial and public service sectors; and increasing awareness that Jordan has not effectively used many of the latest developments in energy- efficient technologies.

Jordan has adopted most of the international and regional conventions related to climate change and environmental protection. Jordan is also a signatory to the Kyoto Protocol. Although CO_2 emission in Jordan is under the world average value, the adverse impacts of the excessive greenhouse effect on Jordan are predicted to be severe highlighting the need to identify renewable energy sources and an optimal energy mix strategy for energy and environmental issues.

2.2 Jordan: Government Structure

The Hashemite Kingdom of Jordan is a constitutional monarchy with a representative government. His Majesty King Abdullah II is the Head of State. The king exercises his executive authority through the Prime Minister and the Council of Ministers, or Cabinet. The Cabinet is accountable to a two-house parliament. The Upper House (the Senates) is appointed by the King, while the deputies of the Lower House are elected by popular vote.

Administratively, Jordan is divided into 12 governorates, each headed by a governor appointed by the King through the Ministry of Interior. They are the sole authorities for all government departments and development projects in their respective areas. Each governorate is divided into smaller administrative sub-regions. The district government acts as the executive organ for carrying out cabinet decisions on the local level. These district governments are thus essentially an extension of the central government, and are supervised by the Ministry of Interior.

In contrast to the appointed district governors, mayors are elected. The only exception to this rule is the mayor of Amman, who is appointed directly by the King. Mayors supervise the day-to-day affairs of towns and cities, and grievances against mayors can be appealed to the Ministry of Municipal and Rural Affairs.

Energy Institutional Framework & Regulatory Aspects:

The energy sector in the Jordan is the responsibility of the Ministry of Energy and Mineral Resources (MEMR), which was established in 1984. The role of the MEMR is to define policy, to fix tariffs and to regulate all activities that have impact on energy sector. Moreover, the MEMR is responsible for all activities related to the exploration and development of minerals and hydrocarbons.

In the oil sector, the Jordan Petroleum Refinery Company (JPRC) is responsible for crude oil refining, storage, transportation and distribution. It was established in 1957 as a private company with the exclusive right to invest in and operate petroleum refining and derivative industries; including the right to market, store and distribute all such products. JPRC's operations are regulated by MEMR in accordance with a concession agreement.

The MEMR is also responsible for encouraging the development of renewable energy sources, managing the rural electrification project and has the ultimate authority over the following energy sector entities:

- National Electric Power Company (NEPCO), a company privatized in 1996 and responsible for the planning, development, control, and system management of the national electricity transmission network, and electricity dispatch center.

- Central Electricity Generating Company (CEGCO), a state-owned company responsible for the management and operation of the existing power generation facilities that have been transferred to it after restructuring of NEPCO. This company is subject to privatization.

- Jordan Electric Power Company (JEPCO), a private–owned company responsible for the distribution of electricity in the middle areas of Jordan.

- Irbid District Electricity Company (IDECO), a partially state owned company (55.4%) responsible for distribution of electricity in the north district of the country. This company is subject to privatization.

- Electricity Distribution Company (EDCO), a state owned company responsible for distribution of electricity outside the concession areas of the other two aforementioned distribution companies. This company is subject to privatization.

- National Petroleum Company (NPC), a state-owned company responsible for production of gas and for development of the Risheh gas field resources.

- Jordan Petroleum Refinery Company (JPRCO), a private sector company operating according to a Concession Agreement granting the exclusive right to refine, store, transport, distribute, and market petroleum products.

- Jordan Atomic Energy Commission (JAEC), an independent regulatory body responsible for peaceful uses of nuclear energy, in the fields of industry, agriculture, medicine, water and mineral exploration.

- Jordan Biogas Company (JBCO), a private shareholding company equally owned by the Central Electricity Generating Company and Greater Amman Municipality. It was established in 1997 to follow up and implement a pilot project (round 1MW) to generate electricity by burning the methane gas produced from the municipal wastes, and

- Rural Electrification Project (REP), a separate department under full management and control of the MEMR, established in 1992 to be responsible for the electrification of rural areas and communities in Jordan.

In January 2007, His Majesty King Abdullah II. entrusted HRH Prince Hamzeh to chair a Royal Committee to review Jordan's National Energy Strategy and propose means for meeting Jordanian energy demands for the next 15 years. The committee formed subcommittees on oil, electricity and natural gas, renewable energy and energy conservation.

Other very important partners in the Jordanian energy sector are the following:

- Ministry of Planning (MOP): responsible for securing external technical assistance for RE sources. It is also responsible for preparing Jordan's 5-year plans. All donor activity is channeled through MOP.
  The MEMR works in close collaboration with the MOP, which reviews the energy sector, plans and incorporates it within the natural planning process. The MOP also co-ordinates the foreign borrowing requirements for development projects.
- Ministry of Environment (MOEnv): responsible for estimating greenhouse gas emission from different sectors.
- National Energy Research Center (NERC): a scientific center which was established in 1998 to be responsible for scientific research and development, transfer of technology of new and renewable energy, energy conservation and oil shale. It is managed by a board of directors headed by the Minister of Energy and Mineral Resources and coming under the supervision of the Higher Council for Science and Technology (HCST).

2.3 Jordan: Demographic Profile

In 1961 the first population census was carried out in Jordan. The population then totaled 901,000. A large number of Palestinians moved into the East Bank of Jordan as a result of the Arab-Israeli wars in 1948 and 1967, and the subsequent Israeli occupation of the West Bank and the Gaza Strip. The population of Jordan numbered 2.13 million in 1979; it nearly doubled to 4.14 million by 1994. The population was about 5.35 million in 2004 because of the high rate of natural increase, the return of about 300,000 Jordanians from the Gulf States as a result of the 1990 Gulf Crisis, as well as the return of some tens of thousands of Jordanians and the migration of hundreds of thousands of Iraqis as a result of the 2003 Second Gulf War. The population further rose to 6 million in February 2010. The rapid increases in population have created several problems for the country – namely, shortages in food, water, housing, and employment opportunities, as well as strains on the education system, health services, and urban infrastructure **[Department of Statistics and ICF Macro, 2010]**.

In the second half of the 1990s, the fertility declines in Jordan have contributed to slowing the population growth rate down to 3.2 percent, and to 2.2 percent in 2009. The average size of a private household decreased from 6.7 persons in 1979 to 6.0 persons in 1994 and to 5.4 persons in 2004. In 2009, the average household size is estimated at about 5.2 persons **[Department of Statistics and ICF Macro, 2010]**.

Urbanization is a particularly important topic in Jordan. Historically, internal rural-to-urban migration, as well as immigration, has contributed to rapid urban growth. Recent international crises have also affected flows of migration into Jordan. The population living in urban areas increased by 14 percent between 1980 and 1994 (from 70 to 79 percent), and rose to 83 percent in 2004, which is about a 4 percentage point increase compared with 1994.

Results of the 2004 census indicate that due to the changes in fertility, mortality, and migration; the age structure of the population has changed considerably since 1979. The proportion of the population under age 15 declined from 51 percent in 1979 to 37 percent by 2004 and to 36.5 in 2009, while the proportion of those age 60 and over has been rising, from 4.1 percent in 1979 to 6 percent in 2009 **[Department of Statistics and ICF Macro, 2010]**.

2.4 Jordan: Geopolitical Position

Jordan's strategic position connecting Asia, Africa and Europe has played a major role in shaping its history and development status. Jordan can play a major role in linking North Africa's Eastern part, the Middle East, Iraq and the Gulf area to Europe through the proposed Euro-Med energy networks. With the analysis of different energy sources, plus the feasibility of having networks pass through Jordanian territory; Jordan can become a regional energy hub that is stable from both political and technical perspective, especially when it comes to benefiting from its geopolitical position for both energy generation and energy transmission.

2.5 Jordan: Geographic and Climate Profile

The Kingdom lies at the heart of the Middle East and the Arab world, extending between the latitudes of 29°11'N and 33°22'N, and the longitudes of 34°59'E and 39°12'E. Its area is 88,778 km^2, of which more than three quarters is desert. The port of Aqaba in the far south is Jordan's only outlet to the sea, as Palestine and Israel separate Jordan from the Mediterranean. Saudi Arabia lies to the south and east, Iraq to the northeast, and Syria to the north as shown in Figure 2.1. The area of water bodies is approximately 482 km2 that includes both the Dead Sea and the Gulf of Aqaba. Altitude ranges from about - 415m (below mean sea level) at the surface of the Dead Sea up to 1845m at top of Jabal Um Ad Dani **[Department of Statistics and ICF Macro, 2010, RJGC, 2008]**. The climate varies from dry sub-humid Mediterranean in the northwest of the country with rainfall of about 630 mm to desert conditions with less than 50 mm over distance of only 100 km. There are three main geographic regions:

Jordan-Valley Region (i.e. the Ghor)

This has the distinction of including the lowest region on Earth--the Dead Sea surface is ~400 m below normal sea-level. The climate is sub-tropical: hot and dry in summer and warm during winter, with monthly-average temperatures ranging between 16°C in winter and 35°C in summer. However, temperatures up to 50°C have been reached, in the shade, during summer. The Zarqa, Yarmouk, Wadi Shuib and Jordan rivers are the major sources of the water used for irrigation.

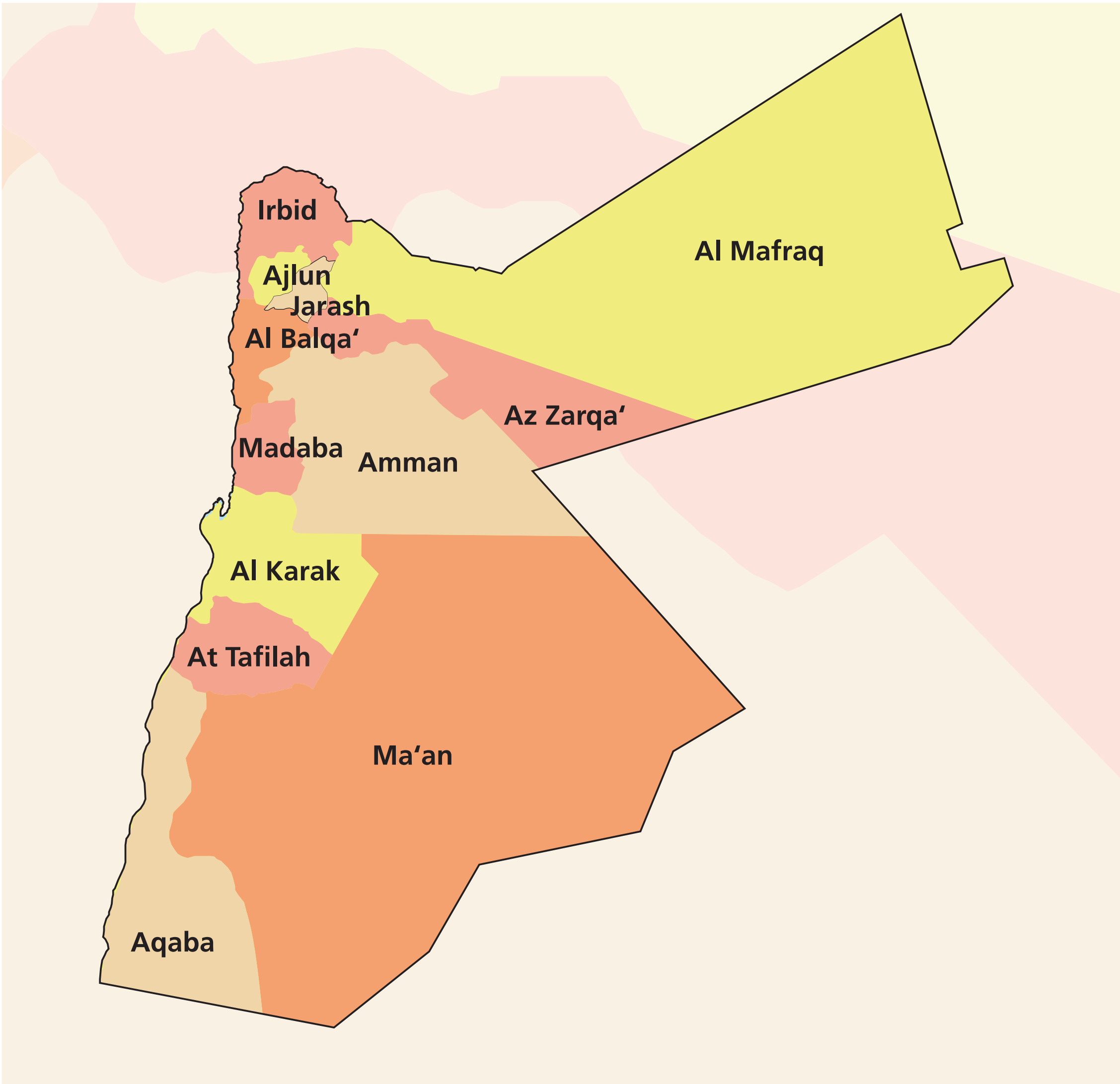
The Highland Region (i.e. the mountainous terrain)

The elevation of this region varies between 1000 and 1500m above normal sea-level. During summer, the climate is moderate and dry, whereas the winters are cold and rainy. The monthly-average temperatures are 10°C in winter and 30°C in summer. The region experiences the highest rainfall in the country; its annual average being approximately between 300 and 550mm with occasional light snowfalls. Most (i.e. 88%) of the country's population lives in this region; the main cities and towns being located there.

The Badia Region (i.e. the desert)

This plateau extends eastwards from the highland region: its elevation varies between 600 and 900m above normal sea-level. It comprises most of the country and is linked with the Arabian Desert. The climate prevailing there is very hot, dry and dusty in summer and cold and dry in winter, with monthly-average temperatures of 5°C in winter and 37°C in summer. The maximum temperature during the summer months usually exceeds 40°C. The average annual rainfall is less than 50 mm, but the amount may vary significantly from year to year.

Figure 2.1: Map of Jordan



Source: worldofmaps.net.

2.6 Jordan: Economic Profile

With regard to the economy, the government of Jordan controls most community services; however, Jordan is moving towards a free market economy. There has been a slight shift in the economic sectoral shares of gross domestic product (GDP). The share of agriculture in GDP at constant prices dropped from 7.3 percent in 1992 to 3.8 percent in 1997, then to 3.3 percent in 2002, and to 3 percent in 2008. The contribution of wholesale and retail trade, restaurants, and hotels to the GDP has not changed significantly; these sectors made up 9.3 percent of the GDP in 1992, 9.9 percent in 2006, and 10 percent in 2008. There was a concomitant rise in the share of the manufacturing sector, rising from 12.4 percent in 1992 to 16.3 percent in 2002 and reaching about 17 percent in 2008. The share of the community and personal services sector also rose slightly during this period, from 2.4 percent in 1992 to 3.9 percent in 2008. The contribution of the transportation, storage, and communication sector to the GDP has changed little over the past 15 years, rising about 2.1 percentage points between 1992 and 2002, and reaching about 15 percent in 2008 **[Department of Statistics and ICF Macro, 2010, RJGC, 2008]**.

The GDP per capita at current prices has demonstrated a steady increase over time, rising from US$ 1,326 in 1992, to US$ 1,610 in 1997, to US$ 1,882 in 2002, to an average of US$ 2,646 in 2008. The cost of living index increased by 20 percent between 1992 and 1997, and increased by 8 percent between 1997 and 2002, and by about 19 percent between 2006 and 2008. The balance of trade deficit rose sharply, by 72 percent between 1990 and 1996, but declined by 14 percent between 1997 and 2001. The deficit rose by 86 percent between 2002 and 2004 and remained stable between 2006 and 2007; it reached about 43 percent between 2006 and 2008. The rate of economic growth at constant prices has increased steadily over time: growth was 3.3 percent for 1997, 5.8 percent for 2002, and 8.8 percent for 2008 **[Department of Statistics and ICF Macro, 2010, RJGC, 2008]**.

Since the late 1980s, with the firm encouragement of the International Monetary Fund and World Bank, Jordan has made sustained efforts to reform its economy. These reform measures included removing public subsidies (including those on fuel), controlling public-sector payrolls, reforming the state pension system, and introducing a general sales tax in the year 2004 **[MoE, 2006]**.

By the year 2000 the economy was growing at an average annual growth rate of 5 percent (compared with less than 3.5 percent on average for the period (1996 – 2000). Remarkably, this growth occurred despite a recession in the year 2003 caused by the Iraq war, which caused the loss of heavily-subsidized oil supplies from Iraq forcing Jordan to purchase crude oil at global market prices **[UN, 2006]**.

2.7 Jordan: Climate Change as a Big Threat

Since Jordan has a semi-arid climate with high dependence on rainfall, almost 90% of the land area of Jordan receives less than 200 mm of rainfall annually, and it is therefore classified as a country with limited water resources. Jordan's Water Strategy for the period of 2008-2022 states that Jordan is one of the four driest countries in the world.

As a result of population growth, the available water resources per capita are falling in Jordan. Annual per capita water availability has declined from 3600 m3/year in the year 1946 to 145 m3/year in the year 2008; this is far below the international water poverty line of 500 m3/year **[MoE, 2006]**.

A comprehensive assessment study was conducted in 1999, through GEF-UNDP supported program, to anticipate the impacts of climate change on water resources in Jordan within the framework of vulnerability and adaptation to climate change. The outputs of this study are as follows **[MoE, 2006]**:

- The mean temperature is expected to increase by 1.7°C in 2040, while another model suggestes this increase by 0.84°C.

- A change in precipitation of 10% led to a change of approximately 5% in irrigation demand, while an increase of evaporation of 10 % (corresponding in an increase of temperature of around +2°C) will increase irrigation demand by about 18 %.

- When the precipitation decreases by 10 % and 20 %, the production of wheat in Jordan will decrease by about 8.5 thousand, and 15 thousand tons respectively.

- If the average of rainfall decreases by 35 mm, the household income would decrease by JD100. If an area receives 350 mm of rainfall and this figure decreased by 20% or 70mm, the income will decrease by JD200.

  The spatial and temporal characteristics of the climatological variables were investigated all over the country in the available longest time series (1961 – 2005). The following findings were addressed:

Temperature:

- Increasing trends in the annual maximum temperature range between 0.3 and 1.8°C.
- Increasing trends in the annual minimum temperature range between 0.4°C and 2.8°C, which are obviously greater than maximum temperature trends.

Precipitation:

- Decreasing trends in the annual precipitation by 5-20 percent during the last 45 years.
- The Ruwaished, in the extreme east, and Ras Muneef, in the northwest, experienced an increase in the annual rainfall amount by 5 – 10 percent.

Global Climate scenarios developed by the IPCC have indicated that Jordan and the Middle East will suffer from reduced agricultural productivity and water availability among other negative impacts. In 2009, the nationally compiled findings of *Jordan's Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC)* further reiterate the scientific evidence that Jordan does contribute a mere 20.14 million tons of Carbon dioxide equivalent **[UNFCCC, 2009]**.

The SNC investigated the impact of different scenarios of climate change on rain-fed agriculture, especially on two main crops, wheat and barley. Results showed that for both crops, however, it has been found that the reduction of rainfall by 10 to 20 percent had a negative impact while the increase in rainfall by 10 to 20 percent had a positive impact on grain yield for both barley and wheat at the different temperature regimes. The maximum predicted losses of yield were 423 Kg/ha and 523 Kg/ha for wheat and barley; respectively **[UNFCCC, 2009]**.

Due to these facts, Jordan is one of the countries to be highly affected by climate change impacts. Although Jordan's emissions of GHG are relatively very low, climate change is a big threat to Jordan since the ecosystem productivity and water resources are highly dependent on the hydrological cycle. Consequently, this shall highlight the need to identify renewable energy sources and the optimal energy mix strategy for achieving energy sustainability and sustainable development in Jordan.

Chapter 3: Jordan Energy Analysis

3.1 Jordan Energy Growth Analysis

Jordan is still in the early stages of industrialization, and has a substantial dependence on foreign energy sources with 96% of its needs served by imports of oil products, natural gas and electricity. The situation has worsened in 2011 as Jordan has been confronted with serious challenges in its energy sector as a result of the Arab Spring and recent attacks on the Egyptian natural gas pipeline highlighting the unreliability of natural gas as a short-term solution for energy security and demand. Moreover, Jordan has seen a rise of popular criticism of its nuclear energy strategy in 2011.

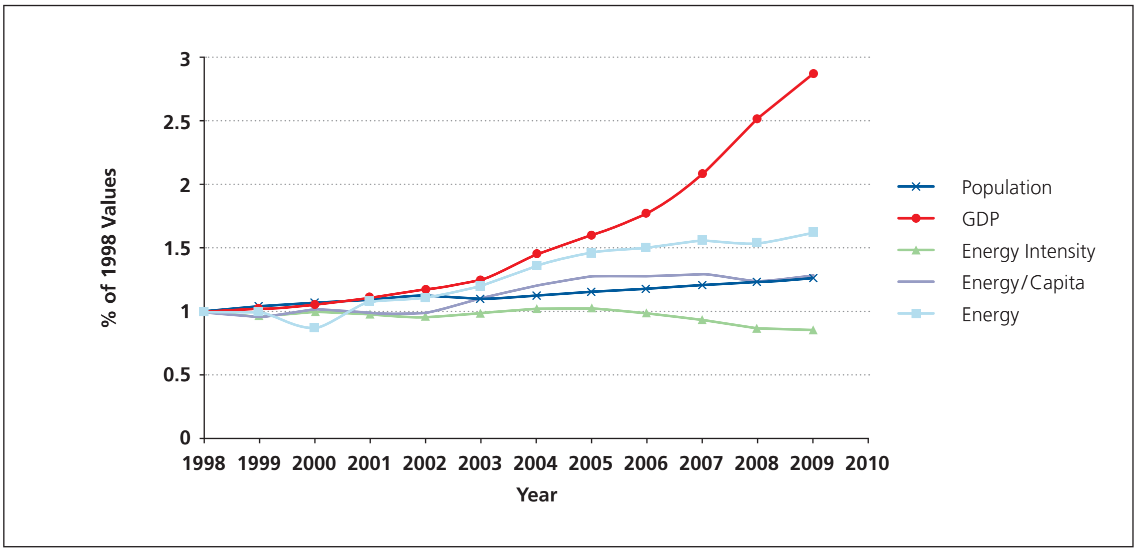
The imported energy bill for 2011 will top $ 4.8 billion, equal to 20% of the expected GDP for 2011, one of the highest rates worldwide, ringing the bell that there is a need for other energy alternatives to replace the imported energies.

In order to investigate the dependence of national economy on energy per unit of economic output, the ***energy intensity*** indicator shall be employed for this purpose. It is measured in energy/$GDP. If energy intensity is low, then energy efficiency is high in that economy.

Figure 3.1 plots indicators of change from 1998 to 2009 on a scale normalized to 1998 values. The graph shows the large increase in the economy, which has outpaced population by 160%. Energy consumption growth has proportionally tracked population growth; however, energy has outpaced population by 36%. Since 1998, Jordan's energy intensity has decreased by 15%. More interestingly, the energy/capita has been relatively constant since 2005.

Energy intensity of the economy has steadily declined while energy use per capita has remained constant. This is good indicator because Jordan gets more economic output from its energy, and there is no increasing in the Jordan average use of energy per person despite driving more, occupying bigger houses, and using more energy gadgets, such as cell phones and computers.

Figure 3.1: Jordan Energy Indicatores of Change, 1998–2009



As shown in Figure 3.2, the sources of energy use in Jordan from 1990 to 2009. Jordan is nearly as dependent on petroleum and its derivatives in 2009 (58.7%) as it was in 1990. Jordan has nearly doubled its use of natural gas in 2009 (38 %) since 2005 (19.5 %).

Other sources are still small compared to the petroleum and natural gas. Figure 3.2 shows also that imported electricity has grown sharply between 2000 and 2005 (nearly 3.4 %), but then declined to only 1.3 % of total energy in 2009. Renewable energy still amounts to only 2% of total energy consumption in 2009. This includes hydroelectric production; wind and solar electricity.

Figure 3.2: Jordan Energy Consumption by Source, 1990–2009

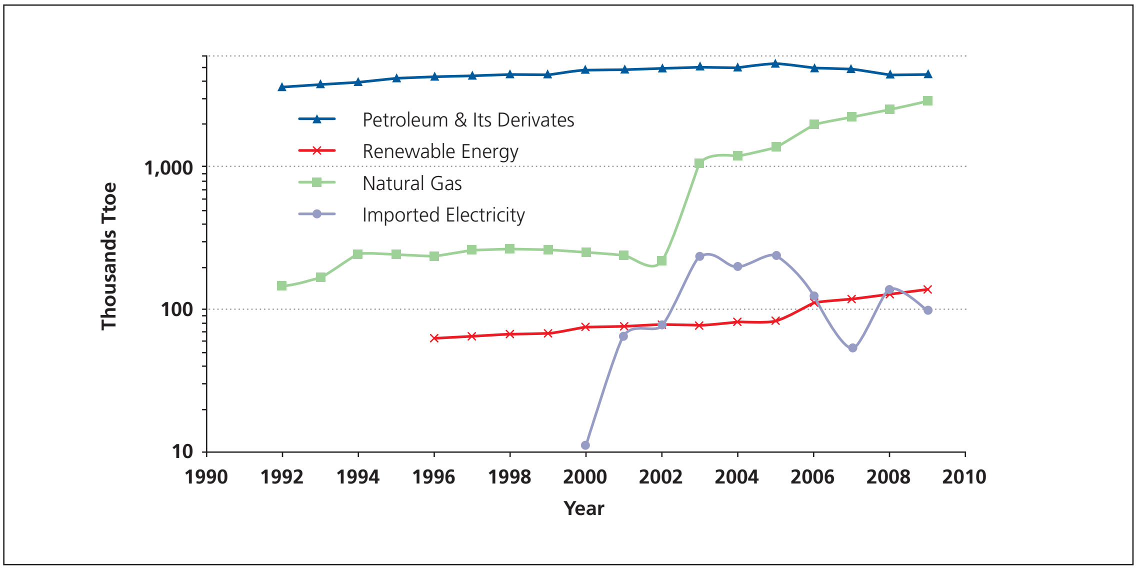


Figure 3.3 indicates the historic growth of energy consumption relative to domestic production (1992–2009). Total consumption doubled from 1992 to 2009. Consumption has outpaced domestic energy production, and the growing gap was met with net imports, almost entirely petroleum and natural gas.

Figure 3.3: Jordan Energy Consumption, Production, and Net Import, 1992–2009

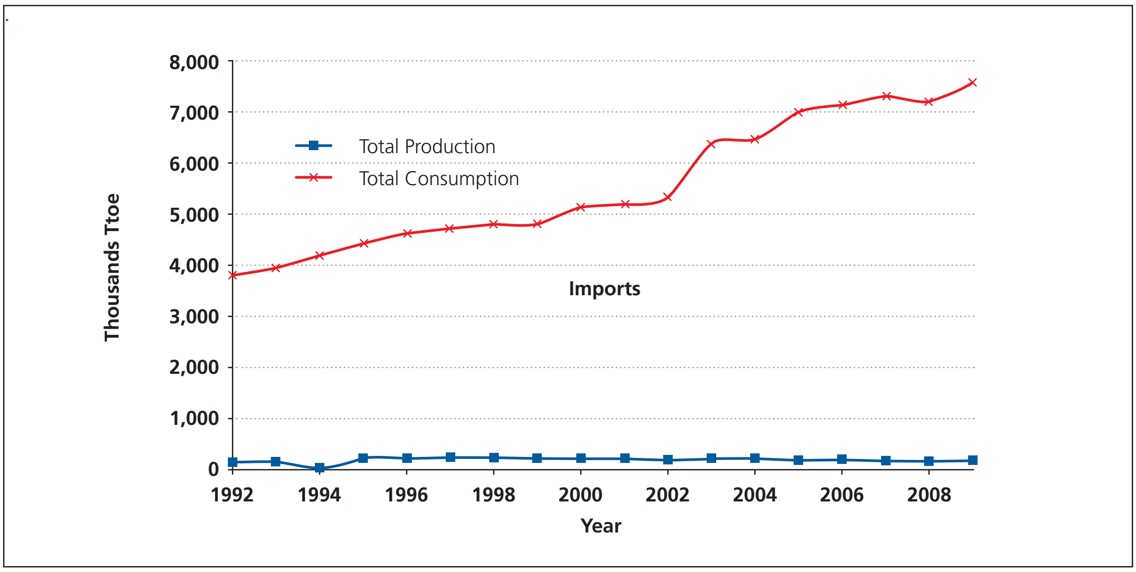


Figure 3.4 and Figure 3.5 shows the distribution of consumed energy to various sectors (2004–2009), and gives the trends and percentage in consumption in each sector. Transportation is still the largest user (39 %), but energy for industrial (22%), residential (21%) and others (18%) are almost with the same rate. The energy consumed in the transportation sector has declined between 2007 and 2008 because of the high prices of petroleum derivatives.

Figure 3.4: Jordan Energy Consumption by Sector, 2004–2009
(*others include the commercial and agricultural sectors along with street lights)

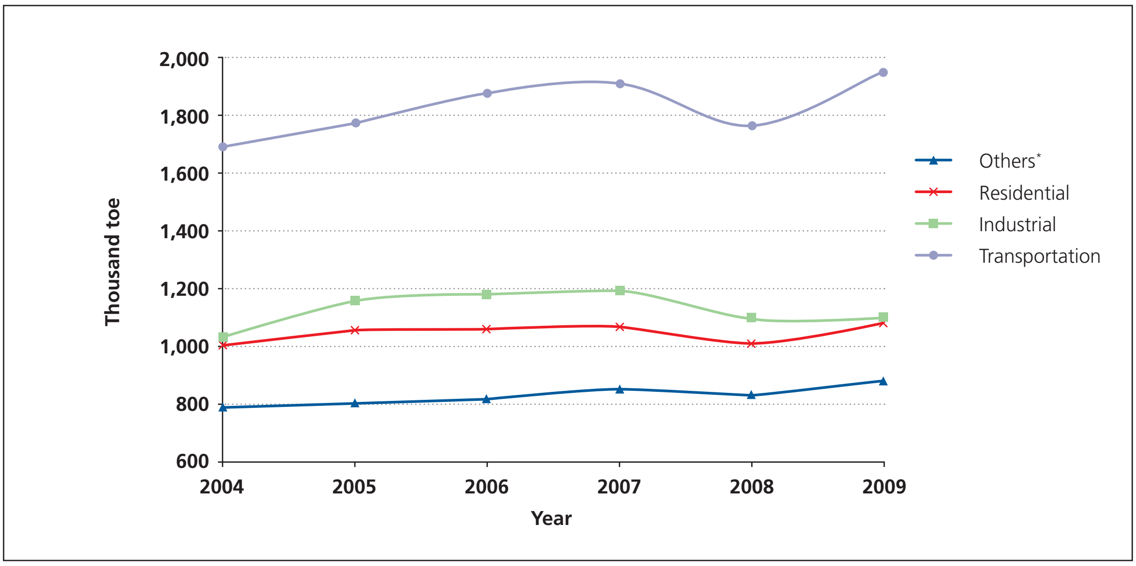
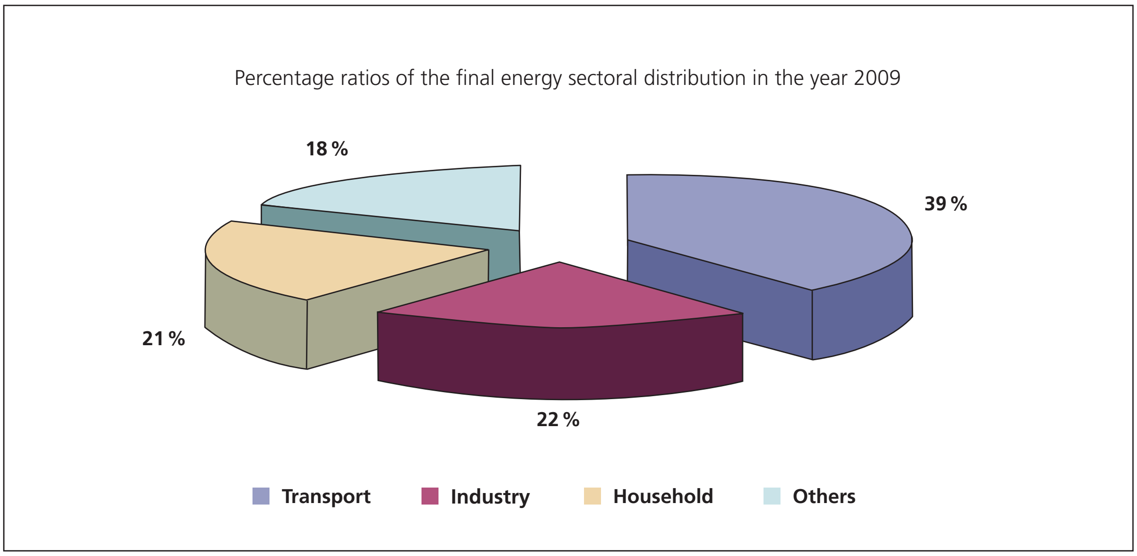


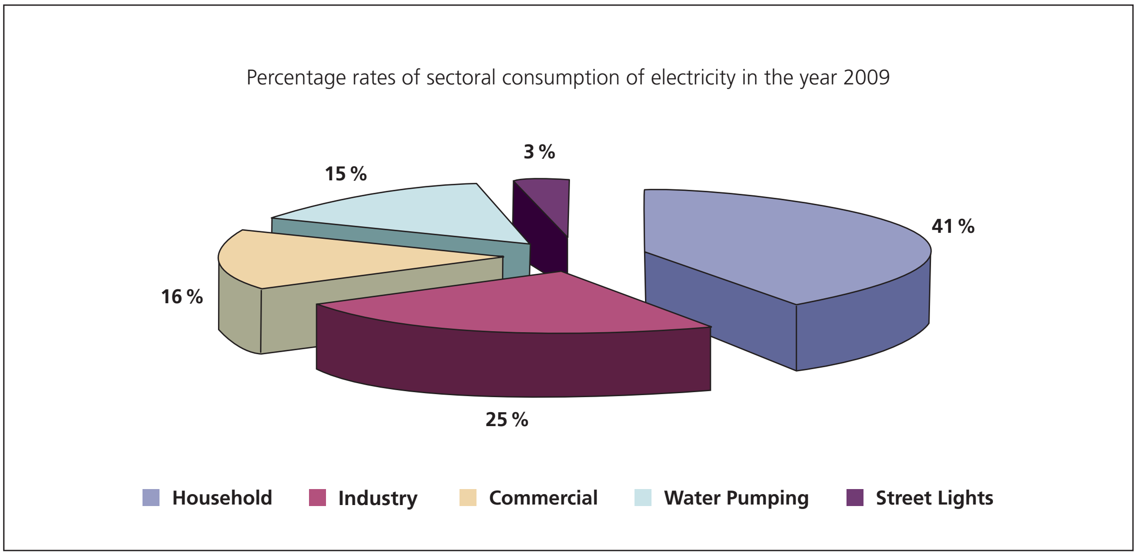
Figure 3.5: **Jordan Energy Consumption Percentage by Sector, 2004–2009, (*Others include the commercial and agricultural sectors along with street lights)**



Source: MEMR, Annual Report 2009.

However, Figure 3.6 shows the percentage of Jordan electricity consumption in each sector (2004–2009). Household is still the largest user (41 %), industrial (22 %), residential (21 %) and others (18 %) are almost with the same rate.

Figure 3.6: **Average Percentage of Jordan Electricity Consumption by Sector, 2004–2009**



Source: MEMR, Annual Report 2009.

3.2 Jordan Patterns of Energy Supply & Consumption

It is important to understand some basic patterns of energy production and use. In order to achieve more sustainable energy use patterns in Jordan, it is useful to know where the energy comes from and how it is used. Moreover, the country's energy data should be analyzed to answer questions about past trends and current uses. To do that, the major characteristics of the Jordan patterns of energy during the past two decades can be summarized as follows:

3.2.1 Growing dependence on fossil fuel imports: 1990–2002

Throughout the period of 1990–2002, the Jordanian energy sector has experienced a growing import dependence on crude oil and oil derivatives for domestic needs. This growing reliance is due to the following reasons:

- Jordan depended on Iraq to meets all of its energy domestic needs and requirements for crude oil and oil refined products. Providing that Jordan benefited from the free transfers of oil, as well as, from a low negotiated price for the rest of the oil imports **[Khresat, 2008]**. Accordingly, Jordan has increased its imports of crude petroleum and its products from 3,471 thousand tons of oil equivalent (Ttoe) in 1990 to 4,954 Ttoe in 2002 **[MEMR, 2003**]. The low price of crude oil in the early 1990s has played a role in increasing the Jordan reliance on imported oil, in addition to the low price of imported energy supplied by Egypt and Syria, namely electrical energy.

- Regardless of the fact that Jordan in the 1980s has witnessed active R&D applications in solar panels used in housings for water heating purposes, but a little governmental awareness-raising or universities education-programs on energy saving, energy efficiency, and renewable energies were during the 1990s. Consequently, growing dependency on oil imports was increased by a deficit of research and development or technology transfer in renewable energy resources.

3.2.2 Jordan energy insecurity: 2003–2008

Starting March 2003, Jordan began to depend on Saudi crude oil and international oil derivatives. Jordan was unable to secure needed oil after the Invasion of Iraq in 2003. More significantly, Jordan was exposed to the rising oil prices in world oil market. For instance the prices of oil arrived to Jordan in 2004 were $37.24 per barrel, and in 2007 it became it became $74.3 per barrel. In 2008 it had almost doubled to $140 per barrel **[JORC, 2008]**.

Throughout this period 2003-2008, the national invoices of energy were increased as a response to the increasing in energy demand in Jordan. For instance, in 2004, the national invoice for energy (including the electric energy from Egypt) was 1,153 million Jordanian Dinars (JD) for 5,236 Ttoe. In 2006, the energy invoice was 1,913 million JD for 5,048 Ttoe, and by 2007 it was 2,280 million JD for 4,910 Ttoe **[JORC, 2008]**.The reasons for this increased demand of primary energy and electricity in Jordan are attributed to the population growth and population influx linked to the 750,000 Iraqis who fled to Jordan in 2003 and 2007. Table 3.1 shows the increases in Jordanian primary energy demand **[NEPCO, 2008]**.

Table 3.1: Increasing demand for primary energy and electricity in Jordan, 2004–2007

Primary energy	2004	2005	2006	2007
Crude oil and its products + natural gas (Ttoe)	6,208	6,706	6,952	7,267
Imported electricity + renewable energy (Ttoe)	281	321	235	171
Total (Ttoe)	6,489	7,028	7,187	7,438
Percentage of increase	12.38	8.31	2.26	3.49
Electric energy				
Peak load (MW)	1,555	1,751	1,901	2,160
Percentage of increase	8.89	12.6	8.57	13.62
Generated electricity in Jordan (GWh)	8,967	9,654	11,120	13,001
Percentage of increase	12.17	7.66	15.19	16.92

Source: NEPCO, 2008.

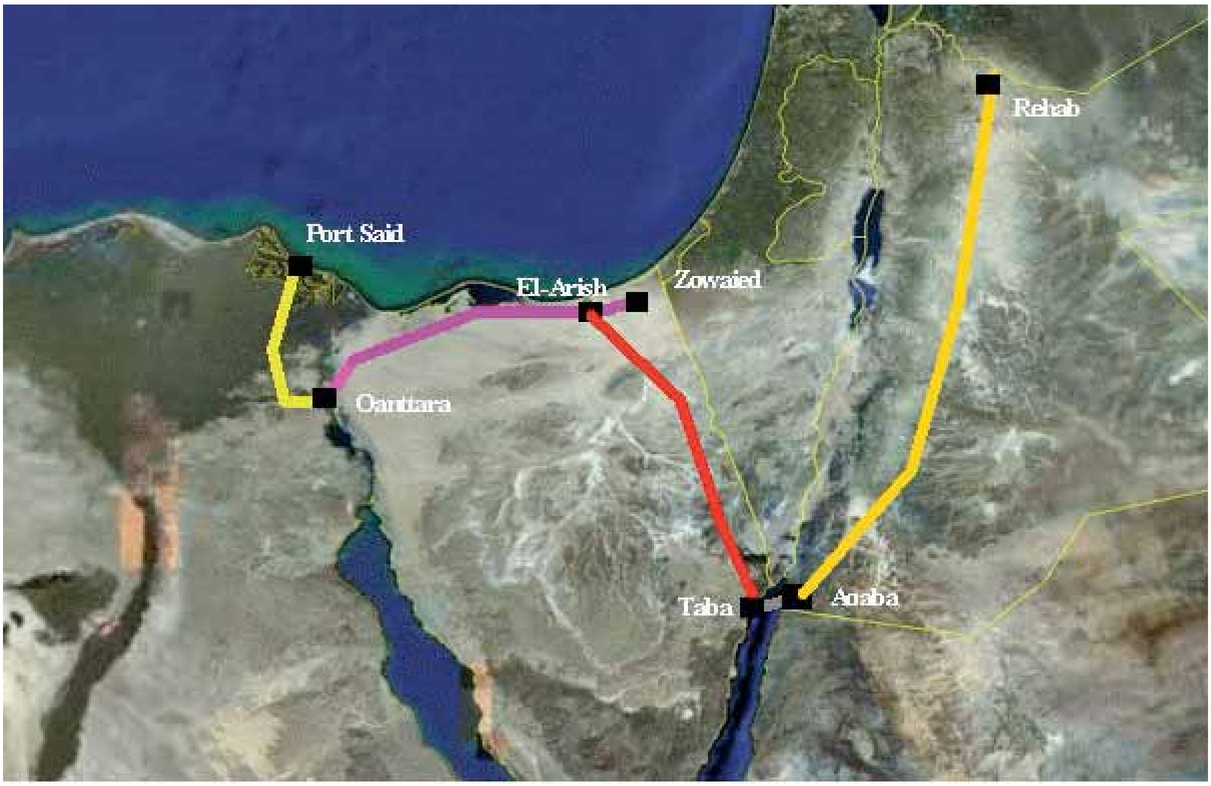
3.2.3 Jordan energy move: natural gas & oil shale

Jordan has exerted efforts, since the 1990s and during the 2003-2008 period, to commercially re-structure the energy sectors to meet the forecasted demand in 2015 by attracting private investment to develop local fossil fuel resources and diversify energy imports.

The combined contribution of domestic oil and gas production in Jordan to the overall energy consumption was 3.8% with 1,200 tons of crude oil was being produced and 8.9 billion cubic feet of natural gas produced in 2006. However, from 2002 until 2006, the production of both was very modest [24]. However, in 2003 Jordan has imported 318 million cubic feet per day of natural gas from Egypt through pipeline constructed in 2002, and stretched from El-Arish in the Egyptian Sinai to Aqaba in southern Jordan, as shown in Figure 3.7, and then extended to the north of the country, supplying the Aqaba, Rehab, and Al-Samra power plants with natural gas. The government has saved substantial energy expenditure by running these plants on natural gas rather than oil.

The several attacks on the Egyptian natural gas pipeline facilities in the Sinai in 2011 have heightened concerns in Jordan, especially since there the country has no reserves of its own and no immediate replacement for Egyptian gas. Jordan relies on imports of Egyptian natural gas through the Arab Gas Pipeline for 80% of its electricity generation. However, shifting to oil and diesel during the disruptions of the Egyptian supply has cost Jordan's power company $4 million a day.

Figure 3.7: Arab Gas Pipeline



Source: NEPCO, 2010.

As Jordan is the third largest and richest country in the world in oil shale reserves, the economic exploitation of these reserves has become more attractive with rising oil prices. It is estimated that the 40 billion tons of oil shale reserves contain about 4 billion tons of oil **[MEMR, 2007]**. However, the technical exploitation process must be chosen in order to avoid any environmental negatives externalities and impacts such as GHG emission or/and large use of water amount **[Jaber et. al, 1999]**.

In 2011, as a result of the multiple attacks on the Arab Gas Pipeline which has caused several disruptions of gas supplies to Jordan, oil shale has become one of the main alternatives that Jordan is currently exploring to meet a five-year "gap" ahead of the development of local energy resources.

3.2.4 Jordan energy recent status: 2009-2010

Energy is one of the most important security issues facing Jordan since it depends extensively on imports. In 2009, 96% of primary energy demand in the country was supplied through energy imports. High growth rate of energy demand (5.5% for primary energy and 4% for electricity during 2009/2008) is witnessed in the past and forecasted for the future, will exacerbate the problem if immediate decisions and actions are not taken **[MEMR, 2010]**. The extensive dependence on energy imports translates into appreciable economic burden. Imported energy cost in previous years ranged between 17.6% of GDP in 2008, 11.8% in 2009, **[MEMR, 2010]**.

The ongoing scenario of energy insecurity in the Jordanian energy sector is due to the following significant challenges:

- Energy Imports – 96% of Jordan energy demand is imported from outside the country.
- Energy Imports Bill – heavy fiscal burden caused by a substantial energy import bill. This was estimated to be 2.28 billion JD (US$3.21 billion) in 2007.
- Energy Demand – Jordan's primary energy requirements are projected to rise 5.5% annually from 7.6 million tons of oil equivalent (Mtoe) in 2007 to 15 Mtoe in 2020.
- Energy Intensity – Jordan's energy consumption density is high. In 2008, the energy consumption density in Jordan was 640 kg oil equivalent oil per $1,000.

These challenges have been investigated by the Jordanian government, and in 2007 His Majesty King Abdullah entrusted HRH Prince Hamzeh to chair a Royal Committee to review Jordan's National Energy Strategy and propose means for meeting Jordanian energy demands for the next 15 years.

3.2.5 Jordan energy in 2011: The impact of the Arab Spring and Fukushima

As stated before, Jordan relies on imports of Egyptian natural gas through the Arab Gas Pipeline for 80% of its electricity generation. However, since the starting of Arab Spring in January 2011, the Egyptian gas pipeline that supplies Jordan has been bombed nine times (December 2011). The Ministry of Finance estimates that gas supply disruptions in the first half of 2011 cost Jordan USD $895 million, and it is expected to cost $1 billion by the end of December. Eventually, Jordan will have spent 20-22% of its GDP on energy imports by the end of the year.

The gas supply agreement calls for Egypt to supply 240 million cubic meters of gas per day over a 12-year period, at prices 30 percent below international market value. At the time of finalizing this study, Egypt is trying to re-negotiate this agreement by providing "some" gas at this original price but pricing the rest at incremental rates **[The Jordan Times, 2011]**.

The Jordanian government has raised electricity rates in response to gas disruptions. Consequently, under the new electricity rate structure, the cost of energy for:

– industrial customers increased 30%,
– agricultural customers 25%,
– hotels 13%, and
– street lighting 23%.

The residential customers who consume more than 750-kilowatt-hours per month will see an increase of 16.7%.

Although the rise in electricity rates does not affect the majority of households since there are only 125,000 high-consumption subscribers out of 1,225,000 total number of residential subscribers, it is expected that this energy price rise will lead to higher prices for goods and services.

Given its worsening energy security situation, and despite of the Fukushima incident in Japan, Jordan is still seriously considering nuclear power as part of Jordan's energy mix. The government announced that uranium had been discovered in central Jordan, and that a further potential for uranium extraction was possible from the country's large phosphate deposits **[Industrial Fuels and Power, 2010]**. Therefore, Jordan plans to generate 30 % of the nation's total energy from nuclear sources by 2030. In the works are plans to build four reactors, the first to be operational as soon as 2020.

Chapter 4: Energy Policy & Analysis in Jordan

4.1 Overview

The transition to more sustainable energy requires a rapid transformation of energy markets from current reliance on oil and carbon-based fuels to greater use of non-carbon sources and greater efficiency. However, this transformation requires technology development, market forces, consumer action, and perhaps most importantly, governmental policy and planning to accelerate emerging technology, use market forces to achieve sustainable outcomes, and encourage consumer choice for sustainable energy.

The biggest challenge facing the sustainable economic growth of the Jordanian economy today is the energy demand and security. Heavy dependence on fuel imports translates into an appreciable economic burden. Imported energy cost in previous years between 19.5 % of GDP (in 2007) to 11.8 % of GDP (in 2009) **[MEMR, 2010]**.

Moreover, in 2011 Jordan has been facing increasingly high and fluctuating energy costs due partly to the popular uprisings in Arab countries and influenced by the Fukushima disaster. As a result of these events, concerns have been revived about the security of the country's energy supplies. Jordan hence has turned its interest into other alternative sources of energy to reduce the import bill. These resources are oil shale, nuclear energy, and renewable energies.

Developing these resources and promoting relevant technologies have always been a major concern to Jordanian policy makers with the aim of minimizing the cost of energy supply to the economy and strategic security of supply.

4.2 International Perspectives on Energy Policy

Energy is a global system. Oil, coal, and natural gas fuels have global markets. Energy technologies such as wind, nuclear, biofuels, and photovoltaics (PVs) are global industries. Moreover, energy production, transport, consumption, and fuel cycles have significant global impacts. International agencies and agreements have been developed to help manage these concerns

For example, the International Energy Agency (IEA) aims to balance energy security, economic development, and environmental protection. IEA provides a review of each member country's energy policy every two years and is the primary source of statistical data on global energy production and consumption.

Among United Nations agencies, the International Atomic Energy Agency (IAEA) has the principal objectives to control the proliferation of nuclear weapons. The UN Development Program (UNDP) and the UN Environment

Program (UNEP) have been instrumental in advancing international dialogue on energy and sustainability issues. They sponsored the 1972 UN Conference on the Human Environment in Stockholm and the subsequent 1992 UN Conference on Environment and Development in Rio de Janeiro. The results of this 1992 Rio Earth Summit included the adoption of Agenda 21 for sustainable development by 178 nations and the establishment of the UN Framework Convention on Climate Change that led to the Kyoto Protocol for control of greenhouse gas (GHG) emissions in 1997.

The European Union has been effective in establishing sustainable energy directives and programs for its member countries. Still, implementation of its directives is dependent on national policies and regulations. Several EU energy directives and policy strategies have emerged since 2000, but the most EU directive is perhaps the **EU CO_2 Emissions Trading Scheme (2003/87/EC)** and its CO_2 emissions trading scheme. In 2005 the EU established a unique "cap-and-trade" emissions trading system (ETS) for CO_2. The scheme is designed so that EU countries will reduce their combined CO_2 emissions to 8% below 1990 levels by the end of the Kyoto Protocol's first commitment period of 2008–2012. In its first phase (2005–2007), the scheme applies only to CO_2 from large emitters in power and heat generation and energy intensive industrial sectors: 11,500 facilities are included that account for 45% of EU's CO_2 emissions.

The **EU Directive on Energy End-Use Efficiency and Energy Services (2006/32/EC)** calls for the reduction of energy use by 9% at 1% per year from 2007 to 2016. It requires each member nation to prepare by June 2007 an initial energy efficiency action plan (EEAP) to achieve this target, a second EEAP by June 2011, and a third by 2014. Each EEAP will be followed by a progress report six months after the plan.

Six months after directive 2006/32/EC was issued, the European Commission (EC) released the **Action Plan on Energy Efficiency: Realizing the Potential (COM(2006)545)** calling for a 20% reduction of primary energy use by 2020. The plan cites considerable potential for savings in all sectors and calls for new policies beyond directive 2006/32/EC.

The **Directive on Promotion of Renewable Electricity (2001/77/EC)** promotes renewable electricity (RES-E) by quantifying national targets (similar to renewable portfolio standards), providing support schemes, simplifying permitting procedures, and guaranteeing transmission access. If 2010 targets are met, EU total renewable electricity would be 22% of total capacity, although a 2004 assessment report indicated current policies will result in an 18%–19% renewable share.

The **Directive on Promotion of Biofuels for Transport (2003/30/EC)** set a minimum replacement by biofuels of marketed diesel or gasoline transport fuels of 2% by the end of 2005 and 5.75% by the end of 2010. If this 2010 target and the 2010 target of 22% for RES-E were met, the EU would achieve a 10% renewable share of total energy; an additional 2% from heating and cooling (RES-H) would give a total share of 12%, the EU goal. But, like the RES-E target, the biofuels displacement is falling short of the target with only 0.6% biofuel replacement in 2005.

The **Directive on Building Energy Performance (2002/91/EC)** requires member states to incorporate into national legislation high-performance building energy standards by 2006 for both new construction and major renovation. European countries, especially Sweden, Denmark, Germany, and France, have developed the building energy standards over the past thirty years.

The **Fukushima** nuclear power station disaster in 2011 and the 25th anniversary of the nuclear meltdown at Chernobyl have raised questions about the share of nuclear power in the world energy mix and marked a watershed that could clear the way for a globally sustainable structure in energy policies. Nuclear energy accounted in 2009 for **5.8%** of global energy consumption and its share was expected to rise to **7.6%** by 2035. In response to the nuclear accident in Fukushima, a number of European countries revised their nuclear policies. The German government agreed, with an overwhelming majority of the federal parliament, on a 10-year phase-out plan by 2022 and to find alternative sources, especially renewable energy sources, for 23 % of the country's energy needs now catered for by nuclear power plants. Similarly, the Swiss government has shelved plans for up to three new nuclear power plants and took a decision to phase out nuclear at the end of the lifetime of the existing reactors by 2035, which would require the closure of its five nuclear reactors that currently provide 40 % of the country's power. In Italy, the government's plans to build four new reactors were rejected in a referendum by 94 % of the population **[Wüstenhagen, 2011]**. In addition, Spain and Portugal have called for the gradual phase-out of nuclear energy. Austria, one of EU's biggest opponents of nuclear power, has called for new stress tests on plants across Europe.

Despite the terrible tragedy that befell Japan, the majority of European countries with a nuclear industry have chosen to continue pushing ahead or even increase investment in nuclear since Fukushima. Several with no history of nuclear power have decided to pursue a domestic industry for the first time. However, it is believed that the coming years are likely to witness more regulation and stringent safety measures in the nuclear industry, making alternative sources of energy cheaper and therefore more appealing than nuclear energy **[Baruah P., 2011]**.

4.3 Jordan's Energy Policy

As has been stated in Chapter 3, Jordan is confronted with serious challenges in its energy sector. Rising energy demand and a lack of domestic resources hinder economic development and growth saddling the country with high energy costs. This dependence on energy imports translates into an appreciable economic burden. As shown in Table 4.1 the extent of this burden is expressed in financial and economic terms.

Table 4.1: Cost of Consumed Energy in Jordan

Year	Cost of consumed energy (mill. JD)	Cost of consumed energy related to		
		Export %	Import %	GDP %
2006	1,913	51.8	23.4	19.1
2007	2,280	56.1	23.5	19.5
2008	2,763	49.0	22.9	18.3
2009	1,916	42.4	19.2	11.8

Source: MEMR, 2010.

This unique situation was exacerbated by the global economic and financial crisis which had a major impact on infrastructure financing, in general, and energy financing, in particular. Moreover, the severity of Jordan's dependence in the energy sector has been plainly illustrated in the first half of 2011, especially due to the disruption of natural gas supply as a result of six separate attacks on the pipeline in Egypt. The natural gas disruption forced Jordan's power plants onto their heavy fuel oil reserves at a cost of some $4 million per day. Consequently, energy officials in Jordan offered a tender for a liquefied natural gas (LNG) terminal, with plans in place to construct an offshore terminal in the Port of Aqaba by 2013 and import liquefied gas. The drive for liquefied gas comes as Jordanian officials attempt to cover a five-year gap period ahead of the development of domestic energy sources including solar, wind and nuclear power. In addition to the switch to liquefied gas, there is an ongoing exploration and drilling project in Risheh, a natural gas field near the Iraqi border, which is carried out with the potential to extract up to one billion cubic feet per day.

Currently the Risheh gas field represents the only commercial indigenous source of energy with a production averaging around 22 million cubic foot per day used entirely to generate some 4% of total electricity generated in the country. The National Petroleum Company (NPC), holder of concession to the Risheh field has recently concluded an agreement with the British Petroleum Company (BP) to develop the field. As for the contribution of RE resources, the predominant contributor is Domestic Solar Water Heaters (SWH). This application has been slowly and stagnating since couple of years but steadily penetrating the local market, other sources of RE contributing to the energy mix are very limited (two grid connected wind farms with total capacity of 1.445 MW).

The electricity sector in Jordan witnessed extensive restructuring over the last decade; the sector was traditionally run by the Jordan Electricity Authority (JEA) and two distributing companies operating under concessions. In 1994 a restructuring plan was initiated where Electricity Sector Regulatory Commission (ESRC) was established, JEA was debundled into three separate companies, namely for generation, distribution and transmission, the generation and distribution companies were privatized and the transmission company kept under government ownership to act as a single buyer for generated electricity. Two other Independent Power Producers (IPP) were licensed and currently operating a total of 743 MW combined cycle plants firing imported natural gas.

The government of Jordan has recently intensified efforts towards exploiting Jordanian oil shale reserves as a primary source of energy. Several agreements were signed with international companies to exploit the oil shale either by in-situ retorting (Shell), surface retorting (memoranda of understanding with 8 different companies) and direct firing to generate electricity (Esty Energy of Estonia). The Energy Strategy (2004) adopted a forecast in which oil shale contribution in primary energy mix shall be 7% in 2015 increasing to 11% in 2020 (medium scenario).

As part of its efforts to exploit domestic resources and improve the security of energy supply, the Government of Jordan initiated the Nuclear Energy Project. The project aims at exploiting uranium ore deposits in the southern part of the country to fuel nuclear power generation stations. The National Energy Strategy set a target of 6 % of primary energy demand in 2020 to be supplied by nuclear energy mainly for electricity generation and water desalination. The Jordanian Atomic Energy Commission was established to conduct and oversee the transfer of nuclear power technology for power generation and peaceful applications. Several cooperation treaties were signed between the Government of Jordan and international institutions for the purpose of providing Jordan with the necessary resources to establish the required infrastructure.

Currently, the institutions concerned are in the process of selecting a vendor and technology option and have shortlisted three contenders. The Fukushima accident seems to have pushed back the schedule for this, though it evidently has not dampened government enthusiasm for the nuclear option. A decision was originally due in March but by September 2011 no selection had been made **[World Nuclear Association, 2011]**.

4.3.1 Energy Policy, Laws, and Strategies

A range of laws, regulations and instructions are currently in force:

Regulation for the Regulation and Administration of the Ministry of Energy and Mineral Resources No. 26 for the year 1985;

- General Electricity Law No. 64 for the year 2002;
- Electricity Companies Licensing Regulations No. 76 for the year 2001;
- Electricity Tariff Instructions;
- Clearance Distance Instructions;
- Meter Certification Instructions;
- Dispute Resolution Instructions;
- Tempering Instructions;
- Natural Resources Law No. (12) for the year 1968;
- Mining Regulation No, (131) for the year 1966;
- Mining and Quarries Fees Regulation No. (8) for the year 1966;

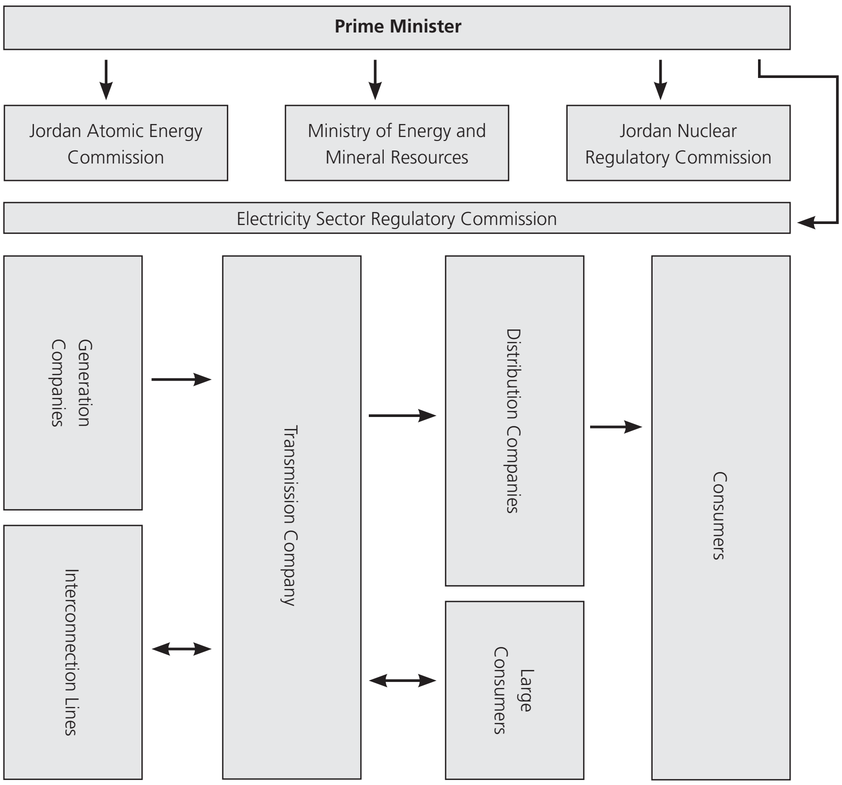
- Conditions and procedures for issues Mining Rights;
- Conditions and procedures for issues Quarry Rights;
- Instruction for the Issuing of Quarry Licenses and Permits;
- Radiation Protection and Nuclear Safety and Security Law No. (43) for the year 2007.
- Nuclear Energy Law No. (42) for the year 2007, and
- By-Law of the National Energy Research Center for the year 1998.

As a general policy, the Government of Jordan adopted an approach to privatize existing public entities in the energy sector and to maximize private sector involvement in future expansion projects. On the institutional level of the energy sector, energy issues have been split among several institutions. The government has been striving to re-organize this sector in order to enhance its efficiency and increase its effectiveness. Figure 4.1 illustrates the structure of the energy and electricity sectors and all stakeholders that are involved in energy policy making process.

Jordan is a signatory to the 1991 Energy Charter and is currently in the process of accession to the Energy Charter Treaty. This demonstrates Jordan's continuing commitment to open and transparent trade and investment in energy, and its desire to work actively with the international community in addressing today's energy challenges. Energy efficiency is an important part of this commitment.

The original National Energy Strategy for Jordan was released in 2004, covering as a planning timeline the decade to 2015. This strategy considers a range of options to address increasing energy demands in Jordan and to reduce the dependence on imported energy. The overarching aim is for local energy resources to supply 28% of primary energy generation by 2010. In its review of the National Energy Strategy in 2007, the Royal Committee decided that this target was too ambitious: it was revised down to 25% in 2010, though with an ambitious target that local energy resources would be supplying 39% of primary energy needs by 2020 **[The Jordan Times, 2007]**.

Figure 4.1: Energy Sector Structure in Jordan



In response to the challenges stated before, the National Energy Strategy, which was developed in 2004 and revised in 2007, includes ambitious targets to increase the contribution of renewable energy resources to the national energy supply. According to the Strategy, the share of renewable energy in the total primary energy mix shall reach 7% by 2015 and 10% by 2020, including 600 MW of wind energy projects and 300–600 MW of solar thermal projects. Furthermore, the Strategy recognizes the country's great potential to reduce energy consumption via energy efficiency measures.

The National Strategy for the energy sector includes clear goals for increasing energy security:

1. Diversifying the supply of energy resources used for electricity generation
2. Developing and intensifying the use of conventional energy and renewable energy resources with additional investment in oil shale exploitation and nuclear power
3. Modernizing and liberalizing energy markets
4. Attracting long-term private sector investment in the energy sector, with a focus on foreign investment sources and privatization of state-owned assets
5. Developing a robust energy audit for promoting energy saving in domestic consumption

In recognition of the importance of supporting legislations, and of overcoming the legislative barrier (such as restrictions on generation and access to transmission and distribution networks) to develop Renewable Energy and Energy Efficiency (RE & EE) activities, the Government of Jordan issued the Renewable Energy and Energy Efficiency Law No. 3 of 2010 as shown in Annex I.

In addition to authorizing the MEMR to facilitate RE & EE projects, the law also made provision for the Renewable Energy and Energy Efficiency Fund (REEEF), the Fund activities will be governed by regulations and by laws to be issued in accordance with the RE & EE Law.

In April 2011, Jordan has taken a series of measures to reduce energy and electricity consumption at government institutions and public facilities, and urged the citizens to cooperate in energy conservation, as Jordan's power plants were forced onto their costly heavy fuel oil and diesel reserves due to natural gas disruption and unreliability of gas supplies from Egypt. The measures include:

- limiting public vehicle use,
- switching off lights at government institutions in the evenings,
- cutting off street lamps in residential neighborhoods after 10:00 p.m.,
- switching off air conditioners at government institutions until further notice,
- reduction the fuel consumption of government cars by 25 liters of consumption of each vehicle per month,
- switching off electric heaters at government institutions,
- allowing the partial use of coal in the industrial sector,

Moreover, the Jordanian government has raised electricity rates in response to gas disruptions. Consequently, under the new electricity rate structure, the cost of energy for industrial customers increased 30%, agricultural customers 25%, hotels 13%, street lighting 23%, and residential customers 16.7% (those who consume more than 750 kWh per month).

4.3.2 Adopted Energy Strategy

The National Energy Strategy initially adopted in 2004 and revised by a Royal committee in 2007, identifies and recommends actions in the following critical themes:

Tariffs and prices:

The previous oil products pricing regime had several disadvantages reflecting on the JPRCO operations and on the sector in general. It was concluded that the prevailing pricing structure does not form an acceptable basis for refinery commercial operations and provides consumers with wrong economic signals. As previously applied electricity tariff, alterations in the structure were required to accommodate the privatization and institutional reforms. As a result, the Government of Jordan decided to adopt a pricing regime reflecting current international oil products and true cost of electricity generation.

Previous complex subsidies in price structures to increase operational efficiencies, were eliminated; the only subsidy permitted in the applicable regime is a life line tariff for the first category of the progressive electricity tariff system for law income electricity consumers (up to 160 KWh/month). More recently, the ESRC has introduced a fuel clause to electricity billing system in order to reflect fuel mix and fuel price fluctuations faced by the electricity generation system.

Oil product prices are currently regulated by the government and changed periodically (on monthly basis) to reflect international parity prices. The Strategy contemplates a pricing regime in the near future (five years) by which regulation is eliminated and prices are set primarily by competition.

These policy reforms represent one important step towards eliminating market distortions and giving the correct signals for investment decisions in renewable energies.

Private sector involvement:

Investment required to implement the action plan envisaged by the Strategy is estimated to reach 14 – 18 billion $ US for the period 2007 – 2020 of which 1.4 – 2.1 billion US$ in renewable energies. Given the scale of the Jordanian economy, it is obvious that (local and international) private sector involvement is imperative. Therefore, private sector involvement shall be maximized. This has been largely accomplished in the electricity sector where all Government shares in existing electricity companies were sold to private investors and new capacity additions to the system were auctioned to Independent Power Producers (IPP). In downstream oil sector (crude oil refining and oil products), a decision was made by the Government not to renew the concession under which the JPRCO operated the sector for 50 years (1958 – 2008).

The sector shall be liberated to competition in the near future where four distributing companies with license to import and distribute products shall be established (of which one to be owned by the JPRCO) alongside one logistic company to handle products storage, handling and transport. Under this scenario, the JPRCO is expected to affiliate with a strategic partner to expand and upgrade the existing refinery in order to be able to compete with oil products imports.

Private participation is also encouraged in other energy sub sectors, for example the agreements signed for oil shale development. In the Renewable Energy field, the government has tendered Al Kamsha Wind Farm 40 MW Power project to be developed under Build Own Operate BOO model. One company was qualified and negotiations are ongoing. The Government of Jordan has also recently issued a Call for Expression of Interest for Fujaij Wind Farm 90 MW Power Project.

Security of Supply

The security of supply is to be enhanced firstly by maximizing indigenous energy resources contribution in the primary energy mix. As shown in Table 4.2, this strategy has particular supply aims for particular energy sources, reflecting a desire by 2020 to cut back substantially the proportion of oil imports (from 66% in 2007 to 40%) and imported electricity (from 7% in 2007 to 1%). While natural gas imports from Egypt and elsewhere are expected to increase, the intent is to allow only a modest increase in the proportion of national energy needs being met by gas.

Table 4.2: Energy Sources for Jordan in 2007, 2015, 2020

Energy sources	Supply of national energy needs (%)		
	2007	2015	2020
Imported electricity	7	2	1
Renewable energy	1	7	10
Oil products	66	51	40
Natural gas	26	29	29
Oil shale	–	11	14
Nuclear energy	–	–	6

Source: Data from Royal Committee on the National Energy Strategy, 2007.

The strategy adopted the following goals for the year 2020 primary energy mix:

- Oil products 39%
- Natural Gas 29%
- Renewable Energy 10%
- Oil shale 14%
- Nuclear energy 6%
- Imported electricity 1%

Renewable energies mix targeted by the strategy:

- 300 – 600 MW Solar
- 600 – 1,000 MW Wind
- 30 – 50 MW Waste to energy

Secondly, Jordan aims at enhancing the interconnection with regional energy networks. The country is interconnected with the ongoing electric network project covering seven regional countries (Syria, Egypt, Lebanon, Iraq, Libya and Turkey). Jordan has used this interconnection to its benefit. On the other hand, the Arab Natural Gas pipeline from Egypt to Syria through Jordan is – apart from the disruptions in 2011 – operational and natural gas supplied by the pipeline is normally used to fuel 80% of the generated electricity.

The security of supply is to be enhanced, thirdly, by modernizing and expanding the capacity of the Aqaba Port to handle crude oil and oil products, and fourthly, by expanding the strategic reserve of fuels in the country.

Legislative and Institutional reforms

Legislative and Institutional reforms have been identified as crucial measures towards achieving the strategic objectives and modernizing the energy sector. As part of the National Strategy, relevant company, commercial, competition, environment, tax and other laws and regulations were analyzed.

Important milestones in the previous decade are as follows:

- The revision of the General Electricity Law allowing for Independent Power Producers (IPP),
- The establishment of ESRC,
- Drafting Energy and Minerals Law (under consideration),
- Non-renewal of JPRCO Concession, and;
- The issuance of the Renewable Energy (RE) & Energy Efficiency (EE) Law No.3/2010.

Energy Efficiency

A new Renewable Energy and Energy Efficiency Law was approved by the Cabinet in 2010. However, the energy efficiency is currently being organized through the preparation of a EE Roadmap to achieve the goals of the government (20% energy savings by 2020).

In 2004, the Government adopted an Energy Efficiency Strategy (2004 EES) (adopted by the Council of Ministers on 7/9/2004). The main goals of the Energy Efficiency Strategy are:

- reducing energy consumption without negatively effecting production or the standard of living, in order to lower the imported oil bill at the national level and reducing the harmful gas emissions into the environment;
- improving the standard of living;
- achieving a balance between imports and exports;
- reducing production cost and improving competitiveness of the local industries and other sectors; and
- reducing investment in the equipment used for the production, conversion, transport and distribution of energy.

The 2004 Energy Efficiency Strategy focused on the following policies to achieve its goals:

- Tariff policy – removing subsidies on petroleum products and electricity and applying a pricing structure based on actual cost.

- Legislation - Strengthening and goal oriented legislations are considered to be the most important tools in improving energy use efficiency and increase the demand for high efficiency equipment and services. Proposed legislation includes taxation and customs policy, and building standards, minimum energy performance standards for energy using equipment.

- Awareness and Training – Implementation of awareness and training programs for improving energy consumption through increasing awareness at the sectorial level, such as investors and energy service suppliers, and at the general public level to improve consumption and savings. This can be achieved through media; education programs; seminars and workshops as well as by involving private sector and nongovernmental organizations. Additionally, establishing an integrated energy database is essential to assist consumers and service suppliers to make informed decisions to optimize consumption and invest. Here the EES also focuses on training and national capacity building to enhance the capacities of targeted groups and provide policy makers and legislators with the needed experience and information to develop and put into place the necessary measures, this is next to ensuring that skilled personal are available to ensure the implementation of such. The establishment of energy information system or energy data base is already included within the mandate of the National Energy Research Center (NERC). But due to the financial constraints, the NERC is not able to conclude this mission. In spite of this situation, the NERC has the data on wind and solar energy. Detailed measurements were begun in 1989 at 10 sites and now reached 20 wind measuring point in different locations in Jordan.

- Financial Policies - Setting proper tools to allow and facilitate the financing of projects and activities aimed at efficient energy consumption through increasing the awareness among local financing institutions of the importance of energy conservation projects and their economic returns; and establishing a special fund to finance energy conservation projects with a shared capital from Government and donor institutions to provide soft loans for such projects.

4.4 RE & EE Regulatory and Policy Framework

4.4.1 Global Perspective

The year 2011 is likely to be a turning point for energy policies especially due to the Fukushima nuclear incident which has severely shaken public confidence in nuclear safety, and the Arab Spring and its impacts on the Middle East natural gas supply. As to the nuclear energy, the public policy responses will have to focus on improved governance and safety standards. Hence, it is likely that this will make nuclear power economically less attractive and will enforce a number of countries to replace nuclear power in the world energy mix by other affordable and viable energy sources.

Natural gas, liquefied natural gas, coal, and oil shale may be favored in the short term, but because of geo-political risks, supply disruptions (gas) and high carbon intensity (coal and oil shale), they become unappealing. Therefore, in the long run, and in order to secure safe and clean sources of energy supply, many countries will probably turn to EE and RE.

International commitment to RE grew over the past few years under the pressure of several factors such as fossil fuel depletion expectations, uncertainty of supply due to political risk, volatility of prices and the continued price escalation trend where world oil prices increased sevenfold between January 2002 and July 2008 .

A major factor influencing the global interest and efforts towards RE, is the environmental threat posed by the prevailing unsustainable mode of development. This risk was first internationally recognized on Head of States level in The United Nations Conference on Environment and Development (UNCED) also known as Earth Summit held during the period 3 – 14 June 1992 in Rio de Janeiro. 172 Heads of States and Governments participated in this event. One of the main issues leading to sustainable development discussed in this summit was the need for alternative sources of energy to replace the use of fossil fuels which are linked to global climate change. The Summit resulted in several treaties of which the most important was the United Nations Framework Convention on Climate Change (UNFCCC). The objective of the treaty is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Obviously, replacing fossil fuels with clean sources of energy became the center of attention in subsequent endeavors to implement the treaty.

The Kyoto Protocol to the UNFCCC, adopted on 11 December 1997 in Kyoto, Japan, and entered into force on 16 February 2005, provided significant financial incentives for developing countries to expand their efforts into maximizing RE&EE resources among other efforts to mitigate so called Green House Gases GHG’s emissions.

Clean Development Mechanism (CDM) is one of three flexible mechanisms adopted in the protocol to reach emission reduction goals. CDM rewards projects in developing countries (Non-annex I countries) leading to GHG emission reductions by issuing Certified Emission Reductions (CER’s) tradable on International Carbon Markets.

Developed countries (Annex I countries) would buy these CERs to offset part of their emissions mandated by the Protocol. It is noteworthy that more than 50% of CER's supplied in 2008 worldwide came from CDM projects in the RE sector.

In 2002 the Earth Summit was held in Johannesburg, South Africa, in which the world leaders reconfirmed their countries commitment to sustainable development and combating global warming.

Commitments made by different countries towards sustainability and Global Warming abatement were translated into national policies. Policy targets for renewable energy were added, supplemented, revised, or clarified in a large number of countries in 2008. European leaders signed up in March 2007 to a binding EU wide target to source 20% of their energy needs from renewables, including biomass, hydro, wind and solar power, by 2020. To meet this objective, EU leaders agreed a new directive on promoting renewable energies, which set individual targets for each member state, countries failing to meet their targets, will be penalized. By early 2009, policy targets for renewable energy existed in at least 73 countries worldwide. Examples are Germany where RE is required to provide 30% of electricity and 14% of heating needs by 2020 and Japan where 14 GW of solar PV to be installed by 2020 and 53 GW by 2030. China also announced ambitious plan to go beyond its existing goal of 30 GW of wind power by 2020 based on new large-scale "wind power bases" in six provinces/regions that could result in 100 GW of new wind power capacity by 2020

To achieve these targets, new trends in RE emerged such as the building-integrated PV (solar panels used as architectural components) and new policies were adopted. Large number of countries enacted solar PV subsidy programs (Japan), these subsidies are usually related to certain applications, capacity and efficiency requirements, new laws mandating utilities to purchase RE electricity at predefined (feed-in tariff) price (Philippine, Mexico) and specialized agencies were created to facilitate RE projects (South Africa).

The majority of countries have adopted mandates for Solar Water Heating (SWH) in residential and commercial sectors mainly in the form of building codes and minimum requirements. Policies also adopt financial incentives to promote the use of RE in water heating and space heating in the form of tax reductions direct subsidies and grants. Several biomass rich countries (Australia, Indonesia, and Vietnam) adopted specific targets and action plans to promote biofuels.

Tax incentives, subsidies and other incentives were adopted and mandatory standards and blending mandates approved. Ethanol production in 2008 reached 67 billion liters/year while biodiesel production reached 12 billion liters in the same year. Worldwide, biomass is the fourth largest energy resource after coal, oil, and natural gas – estimated at about 14% of global primary energy. Installed capacity of biomass power generation worldwide is about 35,000 MW. Law efficiencies is the main obstacle facing biomass existing technologies, new technologies now being evaluated include several types of biomass gasifiers. Gasification offers greater flexibility, both in the range of possible biomass feed stocks and in the the end of use of the energy. For example, as well as driving a gas turbine, the gas from a gasifier can power a fuel cell to generate electricity, or it can be used to generate steam in a gas boiler, sometimes in combination with natural gas.

RE application in rural areas gained momentum in the last decade. Several national and international programs were initiated; several were completed successfully and are being replicated based on experiences gained (Maghreb Countries). Rural electrification programs using RE is considered one of the most straightforward applications for RE technology. Localized small scale RE electricity generation proved advantageous compared to the cost of extending national electric grids to remote scattered consumers. Another advantage of rural RE applications is the direct positive effect on the livelihood of rural population. For example the distribution of efficient biomass stoves to rural households minimized the time required for people (mostly for women) to collect and prepare biofuel (In countries like Burkina Faso, the time women and girls devote to domestic chores was reduced by 2 to 4 hours per day thanks to the access to energy program) It also reduced the likely hood of women being attacked during their search for biofuel. It turned out that Millennium Development Goals MDG and sustainability are best served through rural RE applications.

A significant international event for Jordan was the establishment of the International Renewable Energy Agency (IRENA). By April 2009, 78 countries had signed the statute of IRENA. Members include most countries of the European Union and many developing countries, from Africa to Asia-Pacific to Latin America. Jordan is a co-founder and is expected to benefit largely through bi and multi-lateral collaboration schemes. Another important event on the regional level is the establishment of the Regional Centre for Renewable Energies and Energy Efficiency (RCREEE) on June 25, 2008 through the signing of the „Cairo Declaration of Intentions on Establishment of a Regional Centre for Renewable Energies and Energy Efficiency (RCREEE)" by representatives of its member states: Algeria, Egypt, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia and Yemen. The overall objective of RCREEE is, through its interventions, to achieve:

- Rapid implementation of cost-effective policies and instruments for the increased penetration of renewable energy (RE) and energy efficiency (EE) technologies and practices in member countries;

- Increased market shares of companies and plants located in MENA-countries on the markets for technologies and services related to RE& EE in the MENA and EU regions.

4.4.1.1 Germany: World Leader in Renewable Energy

By the end of 2006, Germany emerged as the global leader in wind energy (with 29% of the world's 74 GW of installed capacity), in photovoltaics (with 38% of the 6.7 GW of installed capacity), and in biodiesel production. It was not due to an abundance of wind and sun, because Germany has poor sun (Berlin is at 52°N latitude, north of Calgary, Canada) and only a small area of class 4 or better winds. Instead, it was due to a combination of political, policy, and technological commitment **[Randolph and Masters, 2008]**.

Germany was struck hard by the energy events of the 1970s and 1980s. The oil crises of the 1970s, the European forest die-off due to acid rain from coal, and the Chernobyl nuclear accident spawned strong anti-nuclear and pro-environmental movements. This led to a first phase of government and private investment, experimentation, and learning in renewable energy and efficiency.

This was further charged by the climate change debate, and around 1990 a series of policy initiatives and demonstration programs began to grow. In the 1990s, Germany's utility deregulation policies led to green power marketing used by 500,000 customers by 2003. In 1999, it passed an "eco-tax" on energy and negotiated a phase out of nuclear power by 2025.

Germany's demonstrations and feed-in rates for renewable power have had the greatest impact on growth of renewable energy. Starting in 1989, the government seeded a 100 MW demonstration of wind power, later increasing it to 250 MW. They also called for 1000 roofs with solar photovoltaic systems, later increased to 100,000 roofs, by initially guaranteeing €0.04/kWh for electricity produced and providing low-interest loans to investors **[Randolph and Masters, 2008]**.

The 1990 Feed-In Law set the stage for considerable expansion of renewable power. It required utilities to connect renewable energy generators and buy power at rates about 90% of average retail rates for wind and PV, based on rationale of added benefits from lower external costs. In 2000, and again in 2004, **the Renewable Energy Sources Act** expanded this program, guaranteeing twenty-year rates for new systems. Those rates vary by source (PV, wind, geothermal, biomass, hydro, landfill methane), capacity, and year of installation.

This one policy is largely responsible for Germany's remarkable growth of PV and wind power, rising to more than 30% of world installed wind and PV capacity by 2006. Three factors facilitated the enactment of renewable energy policies in Germany **[Randolph and Masters, 2008, Wustenhagen and Bilharz, 2006]**:

(1) a strong central government and a political culture open to government intervention,
(2) a critical mass of interest groups in favor of renewables, and,
(3) a critical mass of elected officials with knowledge of and commitment to renewables.

For other countries with these facilitating factors, the following are useful lessons for developing renewable energy policies **[Randolph and Masters, 2008]**:

- The legislature plays a critical role that can transcend industry and ministry interests.
- Interparty coalitions can cut across traditional political camps.
- Careful "burden-sharing" such as feed-in rates can spread costs over a dispersed group through utility rates with minor government budget impact.
- Power market deregulation creates a window of opportunity by establishing new rules that can dissolve traditional political camps and enable new coalitions.
- Customer choice can play a role and complement more direct policy directives and establish a long-term market for green power.
- Germany profited in the political process of policy development from the increasingly professional grass-roots political support.

After the Fukushima nuclear disaster in 2011, Germany has set high targets for renewable energy usage – 35% by 2020 and 80% of all energy from renewables by 2050. The German government plans to phase out its nuclear plants by 2022. The initial decision to phase out nuclear power was endorsed in 2000 by the then Social Democrat/Green Party governing coalition. The decision was accompanied by a new energy plan that has accelerated a phase-in of renewable energy and energy efficiency. The new nuclear phasing-out plan foresees all of Germany's nuclear plants going offline by 2021 – with one possible exception: If the transition to renewable energy does not go as quickly as planned, three of the plants will be allowed to continue operating until 2022, as a kind of safety buffer against electricity shortfalls **[SPIEGEL ONLINE, 2011]**.

According to the German Association of Energy and Water Industries (BDEW) report, renewables accounted for fully 20.8% of production during the first six months of 2011. The wind power, the most important source, rose by 7.5% of total usage. Biomass (5.6%), photovoltaic solar (3.5%), and hydroelectric power (3.3%) were next in line. Waste incineration and other sources covered 0.8% of the total demand.

4.4.1.2 Japan: World Leader in PV Industry

Through 2003 Japan led the world in PV installations until Germany's explosive growth in 2004 and 2005. Japan's PV development followed a more traditional policy model than Germany's. It included "upstream" investment in research, development, and demonstration. Whereas Germany instituted aggressive policies for deployment by setting incentive pricing for PV power, Japan has relied on industrial development policy that has driven down system cost in a competitive market **[Shum and Watanabe, 2007]**.

Post-Fukushima Japan, which previously had aimed to rely on nuclear power for more than 50% of the country's electricity supply by 2030, currently only has 12 of 54 nuclear power plants which are in operation. The rest are either off-line for regular maintenance or shut down for stress-testing (using more stringent tests than previously).

In response to the shift in public opinion away from nuclear, the Japan's government ordered a "review from scratch" of the Basic Energy Plan. This review indicates that the Japan's energy future will result in a commitment to renewable sources with solar and PV at its core. In May 25th 2011, at a ceremony to commemorate the 50th Anniversary of the OECD in Paris, Japanese Former Prime Minister Naoto Kan pledged to generate 20% of the Japan's electricity through renewable forms of energy by the 2020s, ten years sooner than the former Basic Energy Plan had envisaged.

To make renewables more competitive with fossil fuels, a law coming into force in July 2012, which includes a feed-in tariff provision over a set time period, requires utilities to buy power generated by renewable sources, mostly through increased use of wind, solar, geothermal, and mini-hydro and biomass.

4.4.2 Jordan Perspective: RE Initiatives

The increase in the national energy bill in 2011 has placed further stress on a widening budget deficit and highlights the urgent need to develop local energy sources. This is due to the instability in Egyptian gas supplies and the subsequent reliance on heavy fuel and oil imports. The reliance on oil imports combined with the fluctuation of international prices has increased the National Electric Power Company's debt for 2011 to $700 million. Recently, the countries are producing a unit of GDP by using a diminishing amount of energy. Unfortunately, Jordan's consumed energy is growing faster than the GDP growth rate. The economy is growing this year at the moderate rate of 2.3%, while energy consumption is growing at a much higher rate than the economy. This is an unsustainable situation that should not be allowed to continue. Therefore, alternative sources of sustainable energy are encouraged internationally and supported financially as part of the world efforts to reduce GHG emissions and use clean energy in a sustainable way.

Despite abundance of RE resources in Jordan, mainly solar and wind energies, and the unprecedented global efforts to support RE in developing countries, the RE sector in Jordan experienced only modest developments in terms of installed RE capacity as shown in the above discussion. Major impediment proved to be the high cost of produced energy relative to conventional sources and the large investment required to achieve a meaningful contribution of RE resources in the national energy mix. For example, the National Strategy Report of 2004 estimated investment required to achieve 3% of RE of primary energy in 2015 to be $714 million (2004 prices). This is a huge amount in Jordanian standards and raises questions regarding priorities of investment in a country with limited financial resources such as Jordan. To overcome these barriers, a comprehensive policy package should be developed by which other social and environmental added values (other than energy produced) are quantified and accomplished.

The major policy decisions and actions taken by the Government of Jordan towards promoting RE are summarized as follows:

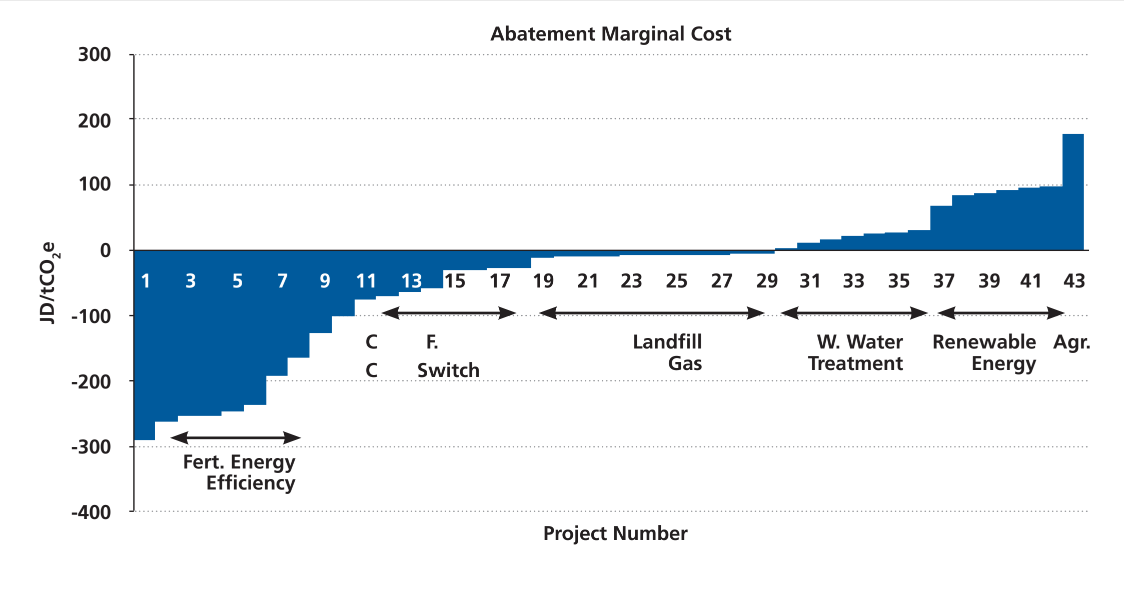
RE & EE Law No.3/2010

Issuance of the Law represents a major step forward in the efforts to exploit RE & EE resources and opportunities. The following observations aim at maximizing the positive effect of the law in future applications and probably future amendments.

The Law reflects the general past attitude of the government towards the RE sector, namely the adoption of KWh price as the main criterion in evaluating projects without provisions for technology transfer and domestic industry creation issues and, almost total reliance on private sector to develop RE & EE sub sector in Jordan. However, the law aims at setting the framework for the accelerated developments of RS & EE in Jordan, For the first time, it allows investors to present unsolicited proposals for grid-connected RE investments such as wind parks or solar parks.

The suggested RE & EE Fund (REEF) may provide the opportunity for the government to reassume its leading role in developing the sub sector. This will depend on the size of the fund and the way assets are allocated to the envisioned activity windows such as equity participation, grants, tariff subsidy, interest rates subsidy and most importantly RE vs. EE projects. The last point is crucial due to the fact that RE projects (except for traditional SWH) are inherently non feasible in comparison to conventional energy sources, while EE projects on the other hand are highly feasible and barriers facing EE could be overcome at lower costs. This fact was reached during GHG Mitigation Options Analysis conducted for the Second National Communication to the UNFCCC. Results of the analysis are shown in Figure 4.2 in terms of cost of GHG mitigation by different technologies.

Figure 4.2: Abatement Marginal Cost of Different Technologies According to Projects Conducted in Jordan



Source: SNC and UNFCCC.

Another critical issue to be considered in operating the Fund is the financing scale required for RE vs. EE, the former generally being more finance (subsidy) intensive than the latter. Therefore, and in order to sustain rolling funding process, as well as, achieving government goals in RE; careful balancing of asset allocation between RE projects and EE projects should be maintained in Fund operations.

Reluctance of the government to introduce feed-in tariff by the Law reflects its attitude discussed above, where RE projects are evaluated mainly on KWh price, while the feed-in tariff reflects a broader approach where the RE is treated as a package that includes other future added values compensating the apparently high feed-in tariff. The Law adopts ambiguous price definition where the developer shall propose a price (acceptable range according to the reference pricelist). This ambiguity in price definition will create a problem of subjective evaluation of future proposals making the price negotiations a political rather than a technical issue.

The General Energy and Minerals Law draft proved to be controversial which made ratification time consuming. This prompted the government to issue RE&EE law separately as a temporary law to facilitate and speed up actions envisioned by the National Strategy. The scope of latter law is to provide the necessary legal framework to develop RE&EE sector through the provision of incentives to and eliminating regulatory risks and hurdles faced by the private sector. It also makes provision for the establishment of the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF). The law precisely identifies the role of each entity involved in the RE&EE sector as follows:

- MEMR (representing the Council of Ministers) shall be responsible for planning and orchestrating all efforts in the sector to achieve its declared goals and objectives regarding security of supply and protecting the environment. MEMR shall set plans and take actions to attract and secure the necessary investment. It shall also survey the country to identify geographic locations and sites suitable for RE applications and establish a registry for identified sites with maps and measurements. MEMR will make these sites available for potential developers through applicable land use related laws (allocation of government owned – treasury – land and acquisition of privately owned lands). MEMR may issue competitive tenders to develop these sites; the law also makes provision for developers to directly submit their offers to the ministry (see articles 3, 4 & 5).

- ESRC shall be responsible for licensing the developer/generator that reaches a successful closure with MEMR (representing the Council of Ministers) and signs necessary agreements (Article 7-b). Licensing authority is given to ESRC by the General Electricity Law. ESRC has the right to waive RE facilities from all or part of the Grid Code or Distribution Code requirements (Article 9-c). The size and nature of such Renewable Energy Facilities and the selling price of the generated electrical power (to the bulk suppliers) shall be specified in accordance with instructions to be issued by the ESRC (Article 10). ESRC shall issue a Reference Price List mechanism for pricing the purchase of electrical power from RE sources (Article 6-b-3).

- Bulk & Retail Suppliers (NEPCO and Licensed Distribution Companies) may not solicit RE generation proposals unless delegated by the Council of Ministers according to special provisions. Said Suppliers are the purchasers of any RE power generated, and are obligated by the Law to purchase all generated energy (Article 8). In case of NEPCO, the Law stipulates that interconnection costs be paid by NEPCO, as for Distribution Companies this cost will be paid according to instructions issued by ESRC (Article 9). The Law also allows for Net Metering for individual (households) producers and sets their selling price at minimum equal to purchase price set by the distributor.

Jordan RE & EE Fund (JREEEF)

RE & EE Law No.3/2010 provides for the establishment of a fund "with the aim of providing the funding necessary for the exploitation of Renewable Energy Sources and the rationalization of energy consumption" (Article 11). The Fund shall have a Board of Directors BOD chaired by the Minister of Energy. Representatives of private sector are also members of the Board (Article 12). BOD shall draw the general policy, approve annual reports, revise budget and financial statements and recommend approval to the Council of Ministers and shall recommend to the Council of Ministers the regulations and by laws needed for proper performance of the Fund (Article 13). Apparently, the main source for Fund's financing is the General Budget of the Government (Article 14), JD 20 million were allocated for the Fund's start up from rural electrification account. MEMR has recently issued a Call for Proposals to interested consulting firms to prepare the Fund's structure, staffing requirements, procedures and by laws. The Fund is expected to be operational by end of 2012.

In 2010, Jordan REEF has been supported and granted Euro 2.3 million amount by the Global Environmental Facility (GEF), implemented by the World Bank, and the French GEF, implemented by the Agence Française de Developpement (AFD). In addition, AFD is in the process of setting up a Euro 40 million credit line in collaboration with local banks which will provide attractive financing to energy efficiency projects in Jordan. Moreover, the World Bank is providing technical assistance and a $3 million subsidy for a 90 MW wind farm project at Al Fujeij, which will be channeled through the Fund.

The government of Jordan aims at making the Fund operational as fast as possible by:

- establishing a REEF governance structure
- designing a financial mode of operation,
- defining priorities and identifying RE & EE projects eligible for financing,
- raising awareness among target groups, and
- by setting up a monitoring and evaluation system.

Several important issues are not addressed directly by the Law and left for future decisions and instructions to be issued by relevant entities. For example the Law directly addresses the cost of interconnection to the National Grid and allocates this cost to the Bulk Supplier (NEPCO) while in case of connecting to retail supplier grid; the issue is left to be handled by instructions to be issued by ESRC. Another example relates to electricity generated by individual generators (households) where (The size and nature of such Renewable Energy Facilities and the selling price of the generated electrical power shall be specified in accordance with instructions to be issued by the Commission (Article 10, RE&EE Law No. 3/2010).

Finally, the Law concentrates on RE almost exclusively while EE is mentioned in general terms and left for the last article in the Law: Article 17 – „The Council of Ministers will issue by-laws necessary for the execution of the provisions of this Law including the procedures and measures for energy conservation and energy efficiency in various sectors". Thus, issues like codes, standards, labels, promotion, and awareness related to EE are not addressed; moreover, the responsibilities of different acting entities are not identified as well.

Regulatory Incentives for Renewable Energy

The recent fiscal and legal moves to encourage investment in renewable energy in Jordan must be seen in this wider regulatory context, and arguably have made more likely the possibility of the country reaching its National Energy Strategy target that renewable sources meet 10% of national energy needs by 2020.

- In April 2008, the Government approved the exemption of imported solar technology both from a 16% national sales tax and 23% customs duties. Combined with high oil prices, this has already boosted renewable energy investment and the shift by some Jordanian businesses to solar energy **[The Jordan Times 2008]**.

- A draft renewable energy law was published in 2007 and submitted for review to relevant energy sector institutions in Jordan, notably the Electricity Regulatory Commission, the National Electric Power Company and the National Energy Research Centre. This draft renewable energy law was based on the input of Lahmeyer International, a German engineering consultancy, and accords MEMR the authority to approve and license Qualified Renewable Energy Plants. Key regulatory incentives in the draft law include the state provision of development sites at favorable rates, 75% income tax exemptions for the first 10 years of profits of Qualified Renewable Energy Plants, and exemptions from other legal revenue charges otherwise due on construction, operation and maintenance contracts.

4.5 Energy Efficiency in Jordan

4.5.1 Overview

The significance of action on energy efficiency arises from the strong annual growth in energy demand and almost entire dependence on imported energy. The RE&EE law allows the MEMR to work with other specialized entities to conserve energy and increase energy efficiency in different sectors (Clause 3c). Moreover, improving the energy efficiency is an integral part of the 2007-2020 Energy Strategy in order to reduce the impact of future increases in energy prices, support security of supply in view of the rapidly growing demand, and create a green economy around energy efficiency services, The strategy called for 20% improvement in energy efficiency. Energy Efficiency facilitate reaching the 10% renewable energy target in total energy mix by 2020 as it reduces the overall demand for energy.

Jordan has conducted many studies regarding energy use rationalization, for instance, the MEMR signed a contract with two companies specialized in energy management, to study 20 commercial and industrial institutes in 2005. The final findings from the study included:

- total savings of 15.9% in the electricity bills.
- total savings of 31.1% in the fuel bills.
- and 21.7% savings in the total energy bill can be achieved if all energy related measures recommended are implemented.

The MoE conducted a study on energy and water consumption in public buildings, in April 2010, with the aim to reduce energy and water bills by 20%. The 20% reduction in energy consumption can save $ 1 billion annually.

Achieving 20% of energy efficiency does not mean that Jordan will reduce its overall energy consumption. The most common indicator to measure progress in energy efficiency is Energy Intensity, which could be reduced by 20% by 2020, compared to the baseline scenario of how energy intensity would have improved – mainly due to technological improvements- in the same period without political action.

In 2011, and due to the natural gas disruptions and the unreliability of gas supplies from Egypt, Jordan has taken a series of measures to use energy rationally at government institutions and public facilities, and urge the citizens to cooperate in energy conservation, as Jordan's power plants were forced onto their costly heavy fuel oil and diesel reserves. The EE measures include:

- limiting public vehicle use,
- switching off lights at government institutions in the evenings,
- cutting off street lamps in residential neighborhoods after 10:00 p.m.

However, in the long term, the main internal instrument for designing and implementing EE projects in line with the National Energy Strategy is the REEF, which is designed to raise awareness for the energy savings potential among industry, commercial and household consumers and provide technical and financial support to overcome existing investment barriers.

4.5.2 Energy Efficiency Challenges in Jordan

The Jordan's National Energy Efficiency Strategy, which was completed in 2004, represented a strong vision for sustainable energy and energy efficiency for economic development but without a policy framework and mandate to affect action. However, the following obstacles are facing the energy efficiency initiative in Jordan:

- No policies to mandate or encourage energy efficiency in certain industries;
- No enforcement of building codes to reduce energy consumption in buildings;
- No enforcement of labeling of machinery, equipment and appliances to facilitate customer choice based on energy efficiency;
- No adopted energy efficiency roadmap (however, it has been drafted lately in 2010).

Nevertheless, this strategy strongly influenced the drafting of the RE&EE law of 2010 and the future action plans regarding energy efficiency and energy saving.

4.5.3 Energy Efficiency and Behavioral Change

To achieve the ambitious goals of the 2007 Energy Strategy target (20% EE by the year 2020), major behavioral changes need to be accomplished, which are summarized as follows:

- Public following EE practices: by following the Energy Conservation (EC) and Energy Efficiency (EE) practices, this delivers reduction in demand and directly contributes to reductions in energy imports. The EC is achieved when energy consumers change their habits and behavior, but not equipment. However, when business looks at its processes to find ways of gaining the same output (for instance, using efficient equipment) from the same input while using less energy, is an example of EE.

- Public using EE products: this delivers reduction in energy demand and directly contributes to reductions in energy imports. Consequently, this will eliminate of energy inefficient products and equipment in the marketplace by replacing then by those that are energy efficient.

Therefore, public knowledge of EE, institutional and organizational framework, will help achieving the behavioral change regarding the EE & EC practices.

4.5.4 Non-Government Role in EE

The private sector has a significant role to play in the EE enabling environment. This can be summarized as follows:

- Manufacturing of EE equipment appropriate for the Jordanian market, educate the customers on energy labeling and quality requirements, and raise the visibility of EE products and participate in campaigns to increase the product uptake.
- Lending money, by banks and funding agencies, to customers for implementing of EE projects, using creative lending and loan repayment schemes.
- Providing technical training, vocational training, and awareness on energy efficiency to all energy sector workers, universities graduates, and students.

4.5.5 Government Role in EE

The government has a key role in creating an enabling policy and regulatory environment for energy efficient future. The policy framework being established through RE&EE law should enable Jordan to benefit from energy efficiency actions. However, this can also be achieved by conducting the following steps:

- The government should commit to energy conservation, saving and efficiency efforts and consider this issue with national priority.
- The government should introduce a comprehensive set of energy efficiency programs for the public sector.
- The government should create financial and/or tax incentives for different stakeholders to promote the energy efficiency projects implementation.
- The government should use ISO standards and similar energy management systems to develop a Jordanian energy management system.
- The government should review, update, and enforce building/energy codes that are related to energy saving and energy efficiency. Also, an incentive programs should be developed to encourage construction over-and-above minimum code performance.
- The government offer incentives and/or tax exemptions to encourage importers and manufacturers promoting for efficient equipment and instruments.

4.5.6 Energy Efficiency Priorities

Most of the energy consuming sectors have somehow the potential for improving energy efficiency. The transport sector has a significant potential for improving energy efficiency since it has the largest portion of energy consumption in Jordan 38% but it is not so easy to realize all this potential. The problem behind is the fact that this sector owned and operated by different operators. The Transportation Regulatory Commission is regulating this sector in terms of defining the routs and issuing permissions and controlling the whole sector operations. In addition, the internal transportation (inside cities) especially small cars (service and taxis) have its own regulations and mostly are controlled by Municipalities.

Building Sector has also big potential for energy efficiency. It consumes around 35% of the total final energy consumption in Jordan which is considered the second largest energy consumer in Jordan. This sector requires the enforcement of the existing and hopefully the adoption of new drafts of building codes, bearing in mind that the enforcement of building codes will be only applied on new constructions and will not lead to realize the whole estimated potential for energy saving in this sector. Therefore, implementing a comprehensive energy efficiency campaign is necessary to address the public specially existing building owners, occupants and operators.

According to studies carried out by NERC, the other sectors such as water pumping, street lighting which considered as public sectors show significant energy saving potential. This saving can be realized through actual actions which can be adopted or directed by the public entities that run these sectors.

4.5.7 Codes of Practice as a Tool for EE

The basis and principles of Jordan National Building Codes are formulated under Law No.7 (1993)-Jordan National Building Law, and the Amended Law for year 2004. Building Codes of Practice and specifications are normally prepared and updated by researchers from the Royal Scientific Society (RSS). Furthermore, preparation & updating can be with the collaboration of researchers from both the private and governmental sectors. After that, the codes are approved by the Jordan National Building Council.

These codes were first enacted by the Jordan Government in 1985. They are prepared to serve all the different disciplines of engineering and scientific sectors, keeping up with new developments and legislations. Currently the procedure for a new code or the amendment of an existing one follows the steps below;

- The MPWH or RSS approaches the JNBC to develop or amend a code.
- The JNBC mandates the development of the code to the RSS.
- The RSS prepares the first draft.
- JNBC forms a committee of experts from public, private sectors and academia to review the code.
- A second draft is prepared according to the committee's deliberations, discussions and notes.
- The second draft is discussed, amended & approved by the JNBC Technical Committee.
- The Technical Committee raises the third draft for the Council and the draft is re amended according to notes and comments by the member organizations and thereafter approved.
- The approved draft is offered for the general public for objections for the period of 60 days & the comments & objections are presented to the Technical Committee within 15 days for its consideration with a maximum period of 3 months, thereafter the JNBC will raise the code to the Jordanian Council of Ministers for approval.
- The council of ministers approves the final draft and its use becomes mandatory.

The Royal Commission on energy initiated the development of the following codes at the end of 2007;

- Updating the existing Thermal Insulation code.
- Drafting a new Energy Efficient Buildings code.
- Drafting a new Gas Piping in Buildings.
- Drafting a new Solar Energy Code.
- Drafting a new Green Building Guideline for Jordan.

Thermal Insulation Code:

Objective: This code aims at defining the building thermal design principles, and the methods for calculating the thermal characteristics of different structural elements. Additionally, furnish the minimum thermal requirements for these elements to facilitate the best selection by the engineers to achieve thermal comfort in buildings. This code was issued in 1985 and updated in 2008.

Scope: This code is updated to reduce the consumption of the fuel through the application of specific requirements and provisions.

Energy Efficient Building Code:

Objectives: This code provides better practices in the construction sector in terms of environmental needs. It intends to lower the heating & cooling bills, to improve the thermal conditions inside buildings, and tp minimize the negative effect of energy consumed in heating & cooling.

Scope: Limit the consumption of energy by utilizing special architectural arrangements, and giving recommendations towards the use of energy consumption electrical and mechanical appliances.

Gas Piping in Buildings Code:

Objective: This code seeks to provide basic information about gas piping system in buildings, and the conditions that must be followed for comfort and public safety, as will as providing means for reducing energy consumption. Additionally, the code gives support in planning, installation, inspection, matching the quality of used materials, maintenance and fulfilling the basic requirements of the system.

Scope: This code is to encourage the public to use LPG and natural gas instead of other petroleum derivatives, where it is possible.

Solar Energy Code:

Objective: This code seeks to define the minimum requirements and standards that must be followed in solar thermal systems, and the solar photovoltaic systems. The provisions of this code shall be applied to the erection, installation, alteration, addition, repair, relocation, and replacement, in addition to the use and the maintenance of solar systems. Furthermore, it encourages the public and investors for the use of solar energy in residential and industrial purposes as an alternative source of energy to reduce fuel consumption.

Scope: This code encourages the public and investors for the use of solar energy in residential and industrial purposes as an alternative source of energy to reduce fuel consumption.

Green Building Guideline for Jordan:

Green design practices include a holistic approach to understanding a building's total impact on the environment: Management, water, energy, site, indoor environment & materials.

The green building guideline and rating system for Jordan is referenced to Jordan's Related Building Codes (as compulsory requirements), and international green rating systems such as LEED from the United States, BREEAM from the United Kingdom, ESTIDAMA from Abu Dhabi , Dubai green building rating system, QSAS from Qatar, and many more.

The Royal Scientific Society (RSS) of Jordan finished the preparation of the Green building guideline with parameters and credits **that are suitable for Jordan's** climate, resources, legislation, policies & policies instrument, building techniques and strategies. This Guideline is attached to a voluntary rating system that is connected to an incentive scheme given by the government.

Since green buildings have a profound impact on our natural environment, economy, health & productivity, the guideline assess building designs in **six** key areas:

- Green Building Management
- Site Sustainability
- Water Efficiency
- Energy Efficiency 33%
- Healthy Indoor Environment
- Materials and Resources

4.6 Nuclear Energy in Jordan

4.6.1 Overview

As stated before, the uncertainty of energy supplies and their increasing costs are severely affecting the growth of Jordan's economy and the security of energy supplies. Hence, the development of secure alternative energy supplies is a top priority. Jordan has limited options to substitute for oil products. The main option is imported natural gas which is a short to mid-term option and cannot be relied upon for the long term. Consequently, natural gas should be used as a peaking source in the future. Renewable energy will be developed to the fullest possible extent. Oil shale is a medium term solution that generates electricity with limited capacity.

The unrest in the Middle East (Arab Spring) has caused a 20% increase in oil prices in the course of 2011. The explosions on the natural gas pipeline from Egypt, which supplies 80% of Jordan's energy, have also caused disruptions that are predicted to cost the government over one billion dollars in 2011. This will likely encourage the Jordanian government to remain committed to the nuclear energy option, as it sees a potential to meet the demand through this option.

The impact of the Fukushima nuclear accident on regional nuclear energy development is unclear. While some European countries, such as Germany and Switzerland, decided soon after the accident to phase out existing nuclear programs, the situation in the Middle East is less straightforward. Although the Jordanian government is now encountering growing resistance to nuclear power from public-interest groups and an emerging anti-nuclear campaign taking place amongst a broader context of political demonstrations, Jordan is still focusing on nuclear energy to meet a part of its energy needs and to achieve the maximum level of energy diversification.

Parallel to that, the Jordanian Committee of Anti-nuclear Project has recently argued that many contradictory statements have been made since 2007 regarding the actual uranium deposits in Jordan and the viability of the feasibility studies based on the uranium amount. Quite recently (November, 2011), active criticism of the government has been voiced by campaigners about Jordan's nuclear program.

4.6.2 Nuclear Power Development Strategy in Jordan

The Jordan Nuclear Energy Commission (JNEC), an agency whose board of directors was chaired by the Minister of Energy and Mineral Resources, was involved in developing a national strategy for the introduction of civilian nuclear power in the energy mix.

In order to prioritize the development of nuclear power, a High Level Ministerial Committee chaired by the Prime Minister was established in November 2006 to explore and marshal national efforts for the introduction of nuclear power in the country. The Committee produced a "roadmap" which outlined the strategic goals and activities to be undertaken to implement a nuclear power program. In essence, the Committee, along with a supporting Technical Group, drawn from various ministries and agencies at the director general or deputy minister level, served the function of the Nuclear Energy Program Implementing Organization (NEPIO).

A Royal Decree to pursue nuclear power was issued in January 2007, taking into account national goals for energy security and diversification, and a desire to reduce dependence on and uncertainty of imports. This was accompanied by the allocation of resources for planning and the enacting of National Laws (42/2007 & 43/2007) to establish guidelines and institutions, specifically the Jordan Atomic Energy Commission and the Jordan Nuclear Regulatory Commission (JNRC).

The High Level Committee was replaced by an inter-ministerial committee in 2009, chaired by the Minister of Planning and included ministers of Energy, Environment, Finance, Water and Irrigation Ministries, in addition to Chairman of JAEC and DG of JNRC. In 2010, a new High Level Committee, chaired by the Prime Minister, has been formed, replacing the previous inter-ministerial committee, and in July 2010, decided to establish a NEPIO Steering Committee.

According to the initial roadmap for the implementation of a nuclear power plant (NPP), in January 2011, JAEC submitted a request for proposals (RFP) soliciting bids from the three shortlisted firms. On June 30, 2011, JAEC accepted the technical bids and the winning firm is foreseen to be announced in December 2011, with the start of construction in 2013, and the start of commercial operation by 2019/20. Jordan in its policy to utilize nuclear power is implementing the International Atomic Energy Agency milestone approach.

Jordan's nuclear strategy aims at ensuring the security of energy supply including fuel; leveraging the national uranium asset; promoting Public/Private Partnerships (PPP); ensuring effective technology transfer and national participation in all phases for electricity production and water desalination and eventually hydrogen production. Additionally, this strategy seeks to develop spin-off industries enhancing electricity export and enabling competitive energy-intensive industries.

In brief, Jordan has a five-point nuclear energy strategy:

- Rely on nuclear power to meet an increasing demand for electricity and drinking water.
- Fuel a nuclear power program with indigenous uranium available in natural deposits and in phosphates.
- Manage steps of the nuclear fuel cycle, including waste management, in accordance with international standards.
- Invest in national human resources development to support the nuclear program.
- Secure funds for nuclear energy development without placing undue financial burden on the treasury.

According to the Jordan Atomic Energy Commission (JAEC), the benefits of a civil nuclear energy program for Jordan include:

- Increased energy independence
- Provision of electricity at a reasonable price
- Revenue and grid stability opportunities through exports
- The opportunity to utilize the country's uranium deposits
- The opportunity to develop nuclear capabilities in project development, design, construction, and plant operation
- Infrastructure upgrades, job creation, provision of services, and education of workforce
- A reduction of carbon-dioxide emissions
- Support for major infrastructure projects, such as the Red Sea-Dead Sea Canal project

The JAEC has defined a set of general criteria for the selection of reactor technologies covering safety and reliability, simplicity, fuel cycle and waste consideration, economics, nuclear desalination, cooling water requirement, and technology transfer for reactors of Generation III/III+ designs in the size range of 700-1,200 MWe.

The JAEC has also established a technology assessment strategy to:

- Evaluate in detail the technologies of interest in accordance with approved procedure and evaluation criteria.
- Select the top three technologies based on technical and financial parameters to carry forward into a competitive dialogue process.
- Implement a competitive dialogue process with the three selected reactor technology providers.

Three nuclear reactor technology providers were selected in May 2010. Currently JAEC is conducting a competitive dialogue with all three vendors and potential operators/investors. In January 2011, JAEC submitted a request for proposals (RFP) soliciting bids from the three shortlisted firms. On June 30, 2011, JAEC accepted the technical bids and the winning firm is to be announced in December 2011, with the start of construction in 2013, and the start of commercial operation by 2019/2020.

In the aftermath of Fukushima, JAEC asked the shortlisted firms to include in their proposals details on their respective reactors' ability to withstand a similar seismic event.

4.6.3 Institutional and Legal Framework of Nuclear Energy in Jordan

The quest to formulate and develop a national strategy for civilian nuclear power has been in progress since 2001. In that year, the law of Nuclear Energy and Radiation Protection (29/2001) substituted law (14/1987), and established the JAEC to undertake both promotion and regulation of nuclear applications in the country.

In July 2007, the law was amended and divided into two laws allowing the creation of two independent entities: JAEC under Nuclear Energy Law (42/2007) and the Radiation and Nuclear Regulatory Commission (RNRC) under Nuclear Safety and Security and Radiation Protection Law (43/2007).

In January 2008, the Parliament amended Law (42/2007) to empower JAEC to lead the national effort, implement the Kingdom's nuclear strategy, and manage the nuclear program. The Parliament, in compliance with IAEA recommendations and with the best of international practices, established the Jordan Nuclear Regulatory Commission (JNRC) as an independent body to promulgate the needed legal, regulatory, and security framework for the introduction of nuclear power.

The JAEC has the direct responsibility for the development and implementation of the nuclear power program. The Jordan Nuclear Regulatory Commission regulates, monitors, controls and issues licenses for applications of nuclear energy to ensure nuclear safety and security. Both JAEC and JNRC report to the Prime Minister (PM).

4.6.3.1 Regulatory authorities

Jordan Nuclear Regulatory Commission (JNRC) was established in 2007 as a successor to the former Jordan Nuclear Energy Commission (JNEC), established in 2001. JNRC is effectively an independent and adequately empowered Regulatory Body. It enjoys administrative and financial independence

The main goals of the JNRC are to work, in coordination with relevant bodies, on achieving the following:

- Regulating and monitoring the use of nuclear energy and ionizing radiation.
- Protecting environment and human health and property from the hazards of radiation and related pollution.
- Ensuring the availability of requirements of general radiation protection, and nuclear safety and security.

The JNRC has the duty of regulating nuclear materials and nuclear installations and facilities, to ensure the reliability and availability of the safety and security conditions and requirements for nuclear materials and nuclear installations and facilities, and the preparation of a system for inventory and accounting of nuclear materials in Jordan under the Safeguards Agreement applied by the International Atomic Energy Agency.

In this regard, JNRC has the duty of preparing the legislative framework of nuclear regulations and safety instructions and guides to control the peaceful use of nuclear energy in Jordan.

In the words of the government's White Paper on Nuclear Energy in Jordan, published in May 2011, the JAEC's mandate is to "to articulate a vision, strategy and roadmap to develop the use of nuclear technology for research, applications and generating electricity."

4.6.3.2 Licensing Process

The licensing processes of nuclear installations and facilities, reactor operators, management of spent fuel, and other related activities are still under preparation.

4.6.3.3 National Laws and Regulations in Nuclear Power

In 2001, the **law of Nuclear Energy and Radiation Protection (29/2001)** substituted law (14/1987), and established the JNEC to undertake both promotion and regulation of nuclear applications in the country.

In July 2007, the law was amended and divided into two laws allowing the creation of two independent entities the Jordan Atomic Energy Commission (JAEC) under **Nuclear Energy Law (42/2007)** and the Jordan Nuclear Regulatory Commission (JNRC) under **Radiation Protection and Nuclear Safety and Security Law (43/2007)**.

In January 2008, the Parliament amended law (42/2007) empowering the Jordan Atomic Energy Commission to lead the national effort, implement Jordan's nuclear strategy, and manage the nuclear program.

The parliament, in compliance with IAEA recommendations and with the best of international practices, empowered JNRC as an independent body to promulgate the needed legal, regulatory and security framework for the introduction of nuclear power.

A number of preliminary drafts of the regulations and instructions as set out in Article (26) of the Radiation Protection and Nuclear Safety and Security Law number (43/2007), and its amendments, are under preparation, namely:

- Regulation for Mining and Milling of Nuclear Materials;
- Regulation for the Safe Use of Nuclear Energy;
- Site Evaluation for Nuclear Installations;
- Tariff on the Fees pursuant to the Regulation on the Safe Use of Nuclear Energy;
- Regulation on the Procedure for Issuing Licenses and Permits for Safe Use of Nuclear Energy;
- Instructions on Insuring the Safety of Nuclear Power Plants;
- Instructions on Insuring the Safety of Research Nuclear Installations.

4.6.3.4 International, Multilateral and Bilateral Agreements

The Government of Jordan, through JAEC, has been active in being signatory in most international and multilateral agreements, which gives Jordan international credibility to pursue utilization of peaceful use of nuclear energy. Furthermore, Jordan during the last 2 years has signed bilateral agreement with countries that have experience with the deployment of peaceful nuclear energy.

Jordan has signed the following agreements with the IAEA:

- Agreement on the Privileges and Immunities of the IAEA; Entry into Force: October 27, 1982
- Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA); Entry into Force: February 5, 1989
- Application of safeguards in connection with the Treaty on Non-Proliferation of Nuclear Weapons (with Protocol); Entry into Force: February 21, 1978
- Protocol Additional to the Agreement between the Hashemite Kingdom of Jordan and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons; Entry into Force: July 28, 1998
- Co-operative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology (ARASIA); Entry into Force: August 20, 2002

Jordan has signed the following main International Treaties:

- Convention on the Physical Protection of Nuclear Material; Entry into Force: October 7, 2009
- Amendment to the Convention on the Physical Protection of Nuclear Material; Signature: October 7, 2009
- Convention on Early Notification of a Nuclear Accident; Entry into Force: January 11 ,1988
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency; Entry into Force: January 11, 1988
- Convention on Nuclear Safety; Entry into Force: September 10, 2009

Jordan Bilateral Agreements (Nuclear Cooperation Agreements) are classified as the following:

• Jordan / France	Signature:	May 30, 2008
• Jordan / China	Signature:	August 19, 2008.
• Jordan /South Korea	Signature:	December 1, 2008.
• Jordan / Canada	Signature:	February 17, 2009.
• Jordan / Russian Federation	Signature:	May 22, 2009.
• Jordan / Argentina	Signature:	September 23, 2009
• Jordan / United Kingdom	Signature:	June 22, 2009
• Jordan / Spain	Signature:	January 27, 2010
• Jordan / Japan	Signature:	September 10, 2010
• Jordan / Romania	Signature:	2011
• Jordan / Spain	Signature:	2011
• Jordan / Turkey	Signature:	2011

4.6.4 Jordanian Nuclear Energy Program

4.6.4.1 Elements

The program consists of two major projects:

1. Nuclear power plant Project established to produce electricity and desalinate seawater.
2. Exploitation of natural nuclear reserves located in Jordan, especially the uranium

The program includes building a Jordanian nuclear research reactor with the capacity of 5 to 10 MW to be an important part of the infrastructure of nuclear technology and the focal point of the Centre for Nuclear Science and Technology. The research reactor will be used to train a new generation of nuclear scientists and engineers, and to provide support for various medical, health, agricultural and industrial services.

JAEC plans to build a second reactor in the next two to three years of commencement of work associated with the establishment of the first reactor, this new reactor will be utilized to provide Red Sea Dead Sea Canal project with energy necessary for the desalination plant and pumping station. The long-term plan of nuclear program includes building four nuclear reactors during the next two decades for peaceful energy uses, these reactors will not only generate the needs of electric power, but will also enable Jordan to export this energy to neighboring countries.

4.6.4.2 Challenges & Risks

JAEC has determined major challenges to be dealt with in order to move forward with the development of its nuclear energy program, namely:

- The exploitation of uranium ores
- Funding
- Nuclear fuel cycle and waste management
- Choice of reactor technology and appropriate application of it
- Human Resource Development
- Readiness of the State and the political environment

Power projects usually involve risk for all parties involved (the power purchaser, project developer and lenders). The parties involved agree on how risks are to be shared, that is often the key to a successful project. Consequently, the successful mitigation of the risks of commercial, political, non-political or force majeure events is critical to the project's financial feasibility.

In the nuclear case, JAEC together with investors and lenders may be exposed to certain adverse events, which could have the effect of impairing the projects ability to service its debt and distribute dividends to shareholders. The main classes of risks are as follows:

- delay the commercial start-up of the project, thus adding cost and deferring receipt of income;
- increase the capital or operating costs of the project, thus diluting returns and ability to service debt;
- disrupt or suspend the project's regular operations, giving rise to income loss and possible contractual penalties;
- affect the quality or volume of key inputs and outputs, leading to underperformance and consequent reduction in income.

Although many specific risks will be under the control of the project company, some risks such as macro-economic events and acts of third parties or of Government will not be so.

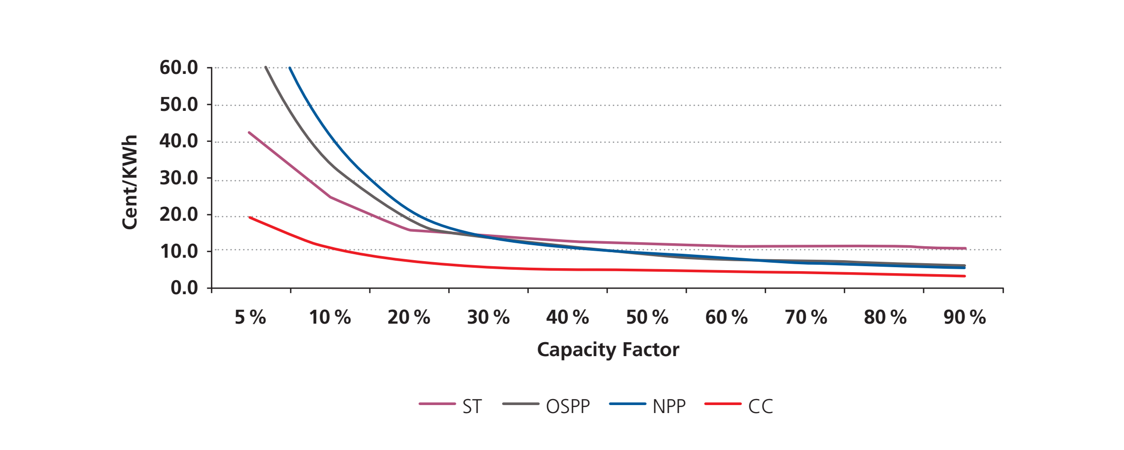
4.6.4.3 Feasibility Study: Screening Curve Analysis

In order to determine the economic feasibility of nuclear energy, a comparability evaluation and analysis has to be performed of the costs of producing electricity through different types of fuel, which includes all future available energy resources. A simplified comparative analysis of the expansion candidates was carried out taking into consideration the construction of new plants to cover the future electricity demand. The analysis was based on a ranking economic criterion of expansion candidates, which was determined by calculating for each plant the total cost per kWh according to the capacity factor of the plant. As for the new candidate plants, the analysis proved that for the values of the load factor adequate for base load operation (70-90%), the nuclear units, oil shale units and combined cycle plants (fuelled by imported natural gas) are the most competitive. Other types of plants based on HFO and diesel oil are less economic.

Figure 4.3 shows the average costs of generated energy from different types of power plants change over a range of plant capacity factor (screening curves), the average generation costs (primary estimation) at high rates of plant capacity factor (base-load operation) as follows:

- Combined Cycle: 38 US$ / MWh
- HFO Steam units: 100 US$ / MWh
- Oil Shale units: 61 US$ / MWh
- Nuclear units: 54 US$ / MWh

Figure 4.3: Screening Curves of Candidate Power Plants (US Cent/KWh)



It is worth mentioning that producing electricity from solar electricity according to calculation from Sams Maan project is around 180 US$ /MWh.

Given the costs in Figure 4.3, electricity generated from nuclear power is considered the cheapest with an advantage of higher availability compared with imported natural gas, which fuel the combined cycle units.

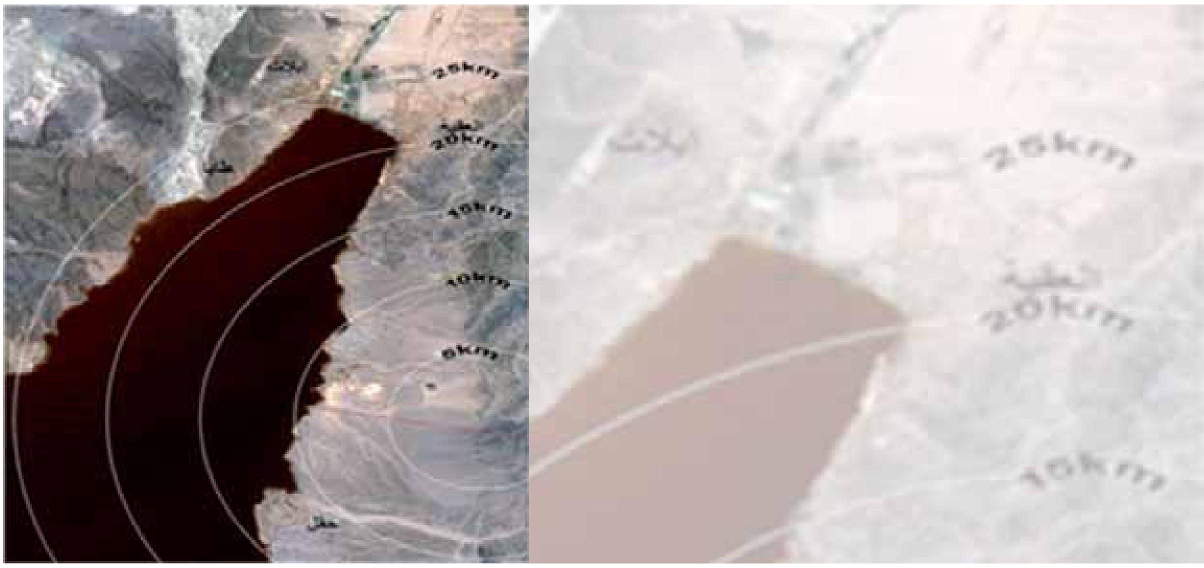
4.6.4.4 Candidate Site

The search for a location for the nuclear power plant was launched with special emphasis on health, safety, and security. Several surveys and studies were conducted in two locations in the Kingdom considering geology, geo-physics, cooling water requirements, risk assessment, grid connections, human induced events and land use, and an environmental impact assessment.

At the end of 2008, JAEC has issued an international bid to solicit the services of international expert house to perform a site evaluation and characterization for the a preliminary location outside the Aqaba Special Economic Zone, as shown in Figure 4.4, which was selected for the nuclear plant mostly because of its proximity to water for cooling requirements.

Currently, JAEC is conducting a site survey and selection activities following the IAEA and JNRC regulations for a new site (Majdal site), which is located in central Jordan at 35 km northeast of Amman. The area lies in the desert near an industrial region which is well connected by roadways to the national highways. The new site will use recycled water from the Khirbet Al Samra water treatment plant, with a similar operational technology to the Palo Verde power plant in Arizona – the only nuclear plant in the world not located near a body of water, where treated wastewater is currently being used to cool three 1,000-megawatt reactors. Jordan’s reactor would become the second in the world to rely on recycled wastewater for cooling, and the first among Generation III models.

Figure 4.4: Earlier Jordanian Nuclear Power Plant Candidate Site (Proposed in 2008, and eventually changed in 2010)



4.6.4.5 Candidate Technologies

The choice of a reactor for the plant is considered as a crucial part of the nuclear program. The Commission is looking solely at Generation III and III+ reactors characterized by the most advanced nuclear technology with the latest active and passive safety features currently available.

JAEC's policy towards available nuclear technologies is neutral. Currently, Light Water and Heavy Water reactors with a maximum generating output of 1000 MW are being scrutinized as candidate technologies for Jordan's program.

Strong emphasis is placed on a number of features and characteristics that include:

- Safety and reliability
- Simplicity, standardization & modularization
- Waste considerations
- Diversion resistance
- Cost
- Fuel cycle considerations
- Desalination compatibility
- Cooling water requirements
- Potential spin-off industry

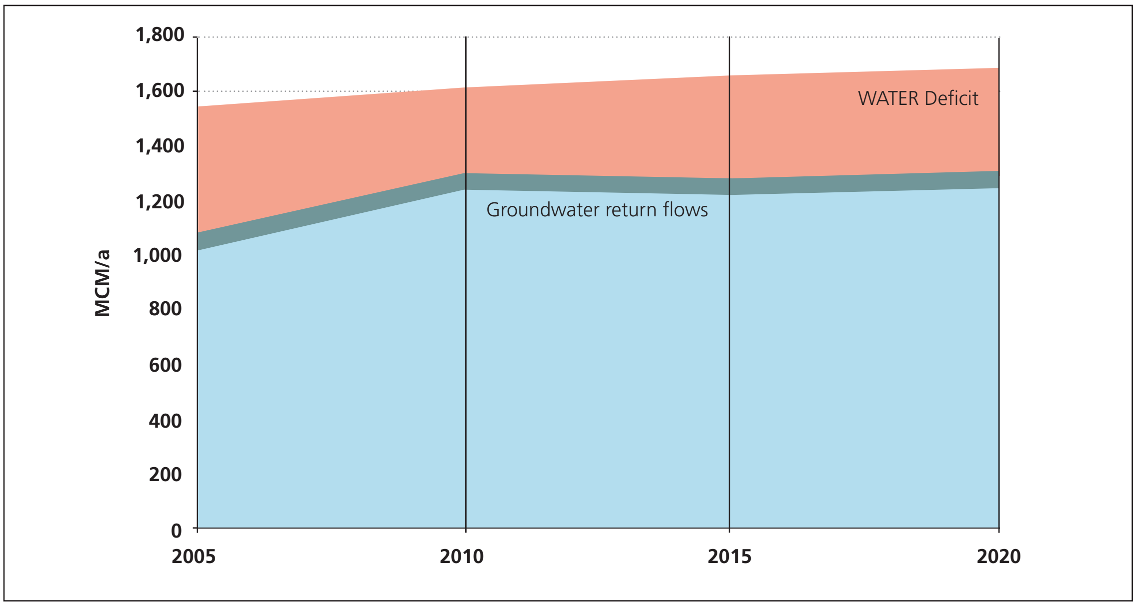
In this context, JAEC has issued an international bid to solicit the services of an international consultant to cover the preparatory phase before start of construction and extend from the award of the contract with the consultant until contact signature with the reactor vendor. The consulting services include feasibility and financial assessment, technology assessment, competitive dialogue and preparation of utility structure options.

4.6.4.6 Water Desalination

Jordan is facing severe shortages of fresh water. Jordan is internationally recognized as one of the ten most water-deprived countries in the world. Individual water consumption stands at 160 cubic meters annually compared to a global average of 7,000 cubic meters and USA average of 9,000 cubic meters.

Therefore, fresh water is a major priority in Jordan's development in general and nuclear power plant project in particular. Where it cannot be obtained from steams and aquifers, desalination of seawater is required. Jordan will need 1.65 billion cubic meters of water in 2020 to meet the needs of its population. This is 500 million cubic meters more than the available resources expected by the Ministry of Water and Irrigation, as shown in Figure 4.5. Since population is concentrated mainly in the northern part as mention in the demography section (Amman, Zarqa and Irbid), the desalinated sea water would require additional generated power in order to be pumped to these areas. The Ministry of Water and Irrigation and incorporation with international consultants estimated the needed capacity to desalinate water (about 600 MCM) and pump it to the consumption centers at about 726 MW per annum.

Figure 4.5: Water Situation and Deficit in 2020



Source: Ministry of Water and Irrigation.

4.6.4.7 Project Funding

JAEC has been exploring various options to fund and finance a nuclear power plant. Jordan expects to exploit the uranium resources to provide part of the funding or financing for NPP. Currently, the Government through JAEC is funding all the pre-construction activities for the NPP program. The Government is also expected to acquire a majority share of the equity of the NPP and to guarantee the electricity long-term power purchase agreement (PPA).

Jordan is inclined to pursue a Public-Private Partnership (PPP) but is also exploring other options, such as a "build-own-operate" (BOO) or a "build-operate-transfer" (BOT) plan.

Moreover, according to Jordanian law the National Electric Power Company will sign a Power Purchase Agreement with the utility for a certain timeframe, which gives confidence to local and foreign investor and lender in the project.

Under either approach, Jordan will contract much of the short-term responsibility (5–10 years) for plant operation to the vendor or international operator but, on the long-term, develop these capabilities indigenously.

4.6.4.8 Fuel Cycle: including waste management

Jordan's experience with the nuclear fuel cycle is limited to exploration of uranium ore. Jordan's uranium resources are estimated at 70,000 tons from surface deposits in addition to potential uranium extraction from the large reserves of phosphates.

Jordan established a national, JAEC-owned company named Jordan Energy Resources Inc. (JERI) in August 2007 to serve as the commercial arm of JAEC, and develop, exploit and market Jordan's natural uranium reserves (as well as vanadium, zirconium and thorium).

With respect to other nuclear-fuel-cycle related activities, Jordan is investigating various proposals for multilateral or international fuel-assurance schemes in addition to commercial deals.

The JAEC also established laboratories for analytical measurements of Uranium, signed exploration agreements to explore central-Jordan Uranium deposits and is negotiating agreements with other international companies to explore Uranium in other areas in Jordan.

Jordan is committed to managing radioactive waste in such a way to avoid the imposition of undue burdens on future generations. JAEC is aware of the issues pertaining to radioactive waste, whether for low and intermediate-level waste (LILW), spent nuclear fuel or high-level waste (HLW). The JAEC has completed in 2009 a 250 m^2 interim storage facility for low level radioactive material and sources.

JAEC is currently developing a National Radioactive Waste Management Strategy in accordance with the national policy. The strategy will investigate and evaluate all options for the long-term management of spent nuclear fuel. Furthermore, JAEC is working on assessing the readiness of the various national institutions to handle the various waste issues and is taking steps to sign and bring into force the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

4.6.5 Project Impacts

4.6.5.1 Environmental Dimension

Those in favor of introducing nuclear energy to Jordan argue that nuclear nuclear power is considered as the most environmentally benign way for producing electricity because of its zero CO_2 emission. The only feasible large scale alternative is total reliance on fossil fuel, which is being consumed so fast that it could be largely exhausted sometime during this century. However, the real problem with fossil fuel is the serious damage it is causing to the climate and the environment as a result of GHG emissions.

The burning of fossil fuel is releasing 25 billion tons of CO_2 every year into the atmosphere, an equivalent of 70 million tons/day, or 800 tons/second. These huge amounts are increasing the greenhouse effect causing the Earth to capture more solar heat and being responsible for many weather changes including higher than normal temperatures and harsh droughts.

While Jordan tries hard to reduce its fuel bill and secure much needed drinking water for its growing population, it is mindful of the need for clean energy as the means to help protect the global environment. It is also mindful of every other possible angle that could have the smallest environmental impact on Jordan's natural resources.

To this end, the planned reactor will use a closed-circuit tower cooling method in which cooling water remains part of the system and is never released into the surrounding environment.

4.6.5.2 Economic Dimension

The nuclear industry could contribute, directly and indirectly, to the Jordanian economy through various activities: in particular, the construction of nuclear reactors (i.e. nuclear power plants), the operation of nuclear electricity plants, and the export of uranium or uranium recovered from phosphoric acid.

However, in order to quantitatively assess the economic impact of nuclear reactor construction, generation, and uranium export of uranium, special models are to be utilized that focus on the domestic component of goods and services to be purchased and labor expenditure, and their likelihood impact on various sectors of the economy.

In this study, some industries and services that could be impacted by the nuclear industry are pinpointed as follows:

- Iron and steel industry
- Air conditioning equipment
- Electrical generators, transformers and converters
- Wire and cable industry
- Cement industry
- Transportation
- Telecommunications
- Bank services
- Insurance
- Architect engineering
- Civil works
- Accounting and legal services
- Computer systems design

Moreover, Government revenue is another important indicator of the economic impact of an activity. Government revenue is generated through various sources such as indirect taxes, corporate income taxes and personal income taxes. Most of these tax revenues are generated indirectly. For example, the nuclear industry creates a job and the job holder pays income tax. Similarly, the nuclear industry causes output of uranium mining to increase, thereby increasing the corporate income tax paid by uranium mining companies.

Furthermore, worker remittances play a significant role in supporting the balance of payments. Jordan as an exporter country of human capital could positively benefit from the possible additional remittances especially to Gulf countries which have currently their own plans to introduce nuclear power into their energy mix during the next 10 to 15 years.

4.6.5.3 Social Dimension

Employment could be positively affected by the nuclear industry, where during the construction peak of a single nuclear unit, 6000 workers (i.e. engineers, welders, technicians, electricians, etc) are needed. Also during operation of the nuclear plant, about 500 to 600 workers are needed. Moreover, human capital development strategy is already developed and in its plan to be implemented as explained in the following section. On the other hand, critical voices argue that far more employment opportunities can be created in other energy-related sectors for the same level of investment needed to build and operate a nuclear plant.

4.6.6 Human Resource Development Strategy

JAEC strategy for human resource development is to develop the knowledge and skills needed for the human resources to support all phases of the Jordanian nuclear power program in a timely manner. In order to achieve the objectives, a plan for both educational and training programs was developed as described in the following sections.

4.6.6.1 Education and Training Programs

The education and training program for the implementation of nuclear power entails the deployment of a multi-pronged training strategy which will include formal education in universities and community colleges; on-the-job training; facility-specific-training provided by reactor vendor organizations; direct participation during project implementation and partnerships with experienced power utility organizations for initial operation of power plants, among others.

Jordan is developing a training plan for capacity building in human resources (engineers, experts and technicians) for its nuclear program. This should be implemented via the education system and additional professional training programs covering the subjects related to:

- Nuclear Power (engineers, experts and technicians and other relevant personnel).
- The specialized subjects in both scientific and technical disciplines.
- On-the-job training (for personnel to experience real-time operation).

In order to achieve this national plan, the following actions are taken:

- **Educational Program:** the mechanism to implement this program will be through:

I. The establishment of nuclear undergraduate program and upgrading of master degrees in nuclear engineering and management in Jordan universities.
II. The provision of scholarships, fellowships in nuclear fields from JAEC, Jordanian universities and other institutions in Jordan and from abroad.
III. The establishment of a center of excellence in collaboration with advanced nuclear power countries.
IV. The collaboration with regional and international agencies such as IAEA in fields related to nuclear power and safety.
V. Postgraduate training in the best international institutes.

A number of educational institutions have established nuclear studies programs to help reach this goal. The Jordan University of Science and Technology (JUST) established a nuclear engineering department in 2007 offering a Bachelor degree to lead Jordan's effort in developing its nuclear energy education infrastructure, and to introduce nuclear power as part of its energy mix. The University of Jordan, Yarmouk University (YU), and al-Balqa Applied University (BAU) have started a Master program in nuclear physics.

JAEC made great efforts to assist JUST in developing its capabilities in its Nuclear Engineering program. A Sub-critical Assembly is being purchased from China to be installed at JUST. A Nuclear Research Reactor (RR) (5 MW) will also be procured to be built at JUST and is expected to be commissioned in 2015. It would serve as an integral part of the nuclear technology infrastructure for education, training, and isotope production. It will also become the focal point for a Nuclear Science and Technology Center (NSTC) and allow for proper training of nuclear engineers & operators and other technicians.

Award of scholarships was started at JAEC in 2009. They cover many fields, including:

- Nuclear Project Management
- Nuclear Reactor Physics
- Nuclear Power System
- Nuclear Safety and Security
- Nuclear Waste Management
- Nuclear Research Reactor Utilization
- Nuclear Fuel Cycle Management
- Nuclear Law

Under either bilateral nuclear cooperation agreements or own funding, Jordan is sending abroad fresh graduates and staff to receive training or complete their post-graduate education. Candidates have been sent so far to France, China, Korea, and US.

With regards to the Center of Excellence, Jordan and France have already agreed and signed a memorandum of understating to establish a specialized Centre of Excellence to prepare qualified manpower for the nuclear program as well as other mega projects. In particular, emphasis will be focused on the near-term needs of personnel needed for the Jordanian NPP program. The Centre may address the needs for training expressed by other interested countries in the region according to the selection procedures mentioned hereunder. The Centre will be a national one and will rely on the faculties and resources of all the academic institutions in Jordan, including those UJ, JUST, Al Balqa Applied University (BAU) and German- Jordan University (GJU).

The main objectives of this Centre of Excellence would be to cover the human resources needs of the Jordanian Megaprojects, from the projects managers to the highly qualified technicians, including the specialized engineers and scientists. The Jordanian nuclear energy program would be its academic priority, with scope to all the other Megaprojects. Also, to focus on "virtual centers" harnessing on strengths of existing faculties and resources of the entire academic and Vocational training (VT) institutions in Jordan.

Three new programs will initially be established in this center as a start, mainly:

- Master Program in Project Management.
- Master Program in Nuclear Safety and Regulation.
- Professional Degree for advanced training for technologists

▶ **Training Program:** the mechanism to implement this plan will be through:

- Every contract that JAEC negotiates includes training component
- Local involvement and technology transfer from design to operation & maintenance
- Close cooperation for training and expert visits with international Laboratories.
- IAEA technical cooperation such as (Specialized training courses & workshops, Fellowships programs and OJT, Scientific Visits, National Consultants, Expert services).
- Arab Atomic Energy Commission (AAEC) projects.

A training plan is under development covering:

- Fundamental: Provide new staff with basic knowledge of NPP(Nuclear Theory, General Plant System, etc.)
- Practical: Provide essential and practical knowledge to improve existing and new staff's expertise (Operation, Mechanical, Electrical, I&C, Core & Fuel, Safety, etc).
- Advanced: Provide advanced specialized training.

4.6.7 The Nuclear Resurgence & Debate

As stated before, Jordan, as other Middle East countries, consider nuclear power to be the best alternative to costly fossil fuel technologies. Jordanian government is attracted to the nuclear power perceived benefits: lower carbon emissions, lower relative start-up costs, freeing up more natural resources for export. However, there is an opposing to this alternative from different NGOs and individuals, who are stating that in the long-run, the costs of nuclear power continue adding up over time, and in the end result, its disadvantages outweigh its benefits.

4.6.7.1 The Nuclear Program Associated Costs

There are numerous costs involved in the up and down-stream stages of nuclear energy production **[Meisen and Hunter, 2007]**:

- **Uranium mining:** Uranium is extracted from mines in Canada, Australia, Russia, and Nigeria and thus must be imported to the Middle East.
- **Uranium enrichment:** Natural uranium contains only 0.7% of fissionable uranium. It must be enriched to 3-5%. 80% ends up as waste product. Presently, this process can only be carried out in sixteen facilities throughout the world. In addition, it has been refused that Jordan carries out the uranium enrichment.
- **Fuel rod production:** Enriched material is converted into uranium dioxide and compressed into pellets in fuel rod production facilities. There are 29 of these globally.
- **Power plant operation:** Uranium nuclei are split in a nuclear reactor, releasing energy which heats up water. This is converted in a turbine generator into electricity. This creates more than100 radioactive products. Of these, plutonium is the most toxic and long-lasting, with a half-life of 25,000 years.
- **Reprocessing:** The contaminated uranium and plutonium must be extracted from used reactor fuel rods. There are currently over 230,000 kilograms of plutonium stockpiled globally. This process requires the transport of radioactive material and nuclear waste around the world.
- **Waste Storage:** Lastly, this waste must be stored. Currently there is not a single final storage facility available anywhere in the world, and this technology is waiting to be developed.

The nuclear waste programs implemented today are extremely long-term and some of the largest construction projects ever undertaken. By observing the large payments associated with the treatment and disposal of nuclear waste from spent nuclear fuel and the requirements connected with decommissioning nuclear power plants decades after they have been taken out of production, researchers in Sweden have concluded that nuclear power has the largest negative salvage value of any other energy system.

The costs of developing permanent nuclear waste storage programs will heavily loom over economies in the future if they are not implemented soon. The US Yucca Mountain project, has already suffered from a very large cost escalation. The cost of site characterization was estimated in 1981 to be $60– 80 million per site. After being postponed for several years, the cost has risen to an estimated $6.3 billion in 2001 **[Meisen and Hunter, 2007]**.

4.6.7.2 Emissions, Downstream Waste

Although the emissions of nuclear power plants are reported as essentially carbon-free, waste is produced both upstream and downstream. Steel, concrete, and other materials are necessary for the construction of nuclear power plants, which will largely use fossil energy. Thus, additional greenhouse-gas emissions occur from chemical reactions during material processing.

During uranium mining, huge quantities of mining debris is generated. In uranium enrichment, 80% of the total volume of uranium ends up as a waste product. Depleted uranium may be used for weapons and thus must be handled carefully. During power plant operation, over 100 products are produced, including plutonium. Workers are exposed to a great deal of radiological hazards. During reprocessing, plutonium must be stockpiled, and the volume of waste increases many tens of times after being reprocessed, discharged daily into the sea and air. The life of plutonium waste is 25000 years **[EREC, 2009]**.

4.6.7.3 Safety Issues

Running a nuclear power facility requires a great deal of safety requirements. However, even when these are in place, a number of things can go wrong. For example, over recent years in the United States, radioactive spent fuel rods have been missing or misplaced from at least 3 nuclear power plants: the Millstone I nuclear reactor in Waterford, CT, the Vermont Yankee reactor in Vernon, VT and the Humboldt Bay Power reactor near Eureka, CA. These missing rods and other radioactive wastes could be seriously misused if they came into the wrong hands.

A nuclear chain reaction must be kept under control, and harmful radiation must, as far as possible, be contained within the reactor, with radioactive products isolated from humans and carefully managed. Nuclear reactions generate high temperatures, and fluids used for cooling are often kept under pressure. Together with the intense radioactivity, these high temperatures and pressures make operating a reactor a difficult and complex task.

The risks from operating reactors are increasing and the likelihood of an accident is now higher than ever. Most of the world's reactors are more than 20 years old and therefore more prone to age related failures. Many utilities are attempting to extend their life from the 40 years or so they were originally designed for to around 60 years, posing new risks **[WNA, 2006]**.

4.6.7.4 Climate Change: nuclear is not the answer

There is a big campaign globally against the use of nuclear energy because it is an unacceptable risk to the environment and to humanity. Moreover, building enough nuclear power stations to make a meaningful reduction in GHG emissions would cost trillions of dollars, create tens of thousands of tons of lethal high-level radioactive waste, contribute to further proliferation of nuclear weapons materials, and result in a Chernobyl-scale accident once every decade. Perhaps most significantly, it will squander the resources necessary to implement meaningful climate change solutions.

Some argue that the key reasons why the self-serving nuclear industry arguments about its role in helping to fight climate change are wrong [Meisen and Hunter, 2007], and this due to the following key reasons:

- Nuclear energy is an expensive diversion from the task of developing and deploying renewable energy, energy efficiency and the more decentralized energy systems required for a low carbon future
- Carbon emissions can be reduced much cheaper and more effectively using renewable energy and energy efficiency measures
- No proven solution exists for dealing with radioactive waste
- Expanding nuclear power internationally would hugely increase the risks from terrorism and nuclear weapons proliferation
- Nuclear power plants cannot be built in time to make even the smallest difference

Chapter 5: Jordan Energy Resources Analysis

5.1 Overview

The availability of energy resources is of significant importance to the society, as they are the backbone of every economy. However, in response to the Kyoto Protocol, as Jordan is a signatory to this protocol, and the era of high fossil energy prices, promoting the utilization of renewable energy has been considered as one of the most environment-friendly strategies for the purpose of getting an equal focus on economic development, energy security, and environmental protection.

Jordan has renewable and non-renewable energy resources which are summarized as follows:

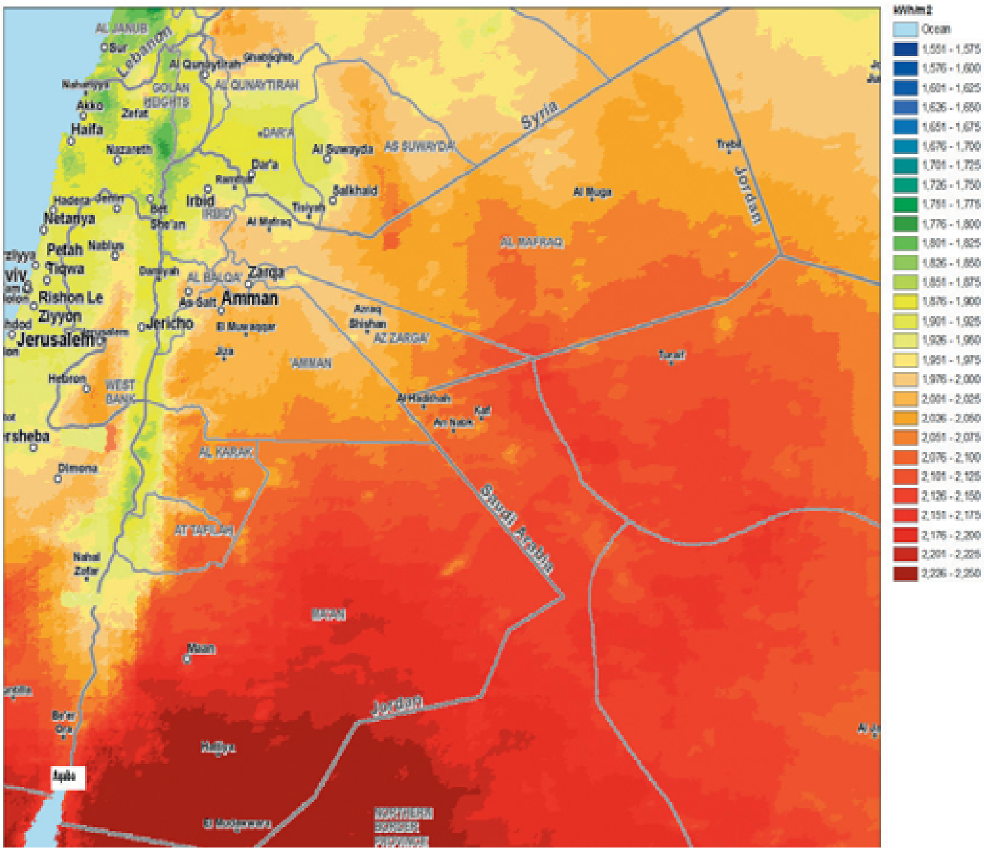
5.2 Solar Energy

Solar energy is the most abundant permanent energy resource on earth and it is available for use in its direct solar radiation. The Sun emits energy at a rate of $3.8x10^{23}$ kW. However, approximately $1.8x10^{14}$ kW is intercepted by the earth, which is located about 150 million km from the sun. About 60% of this amount or $1.08x10^{14}$ reaches the surface of the earth. The rest is reflected back into space and absorbed by the atmosphere. Even if only 0.1% of this energy could be converted at an efficiency of only 10% it would be four times the world's total generating capacity of about 3 000 GW. Moreover, the total annual solar radiation falling on the earth is more than 7500 times the world's total annual primary energy consumption of 450 EJ **[World Energy Council, 2007 Survey of Energy Resources]**.

5.2.1 Potential

As shown in Figure 5.1, Jordan enjoys abundant Solar Radiation. The average over the course of a year ranges between 5 and 7 KWh/m^2/day, which is one of the highest in the world, and annual sunshine duration is 2,900 h [Hrayshat, 2004]. Despite seasonal variation in the radiation intensity, this level of radiation is suitable for all solar applications (PV, CSP).

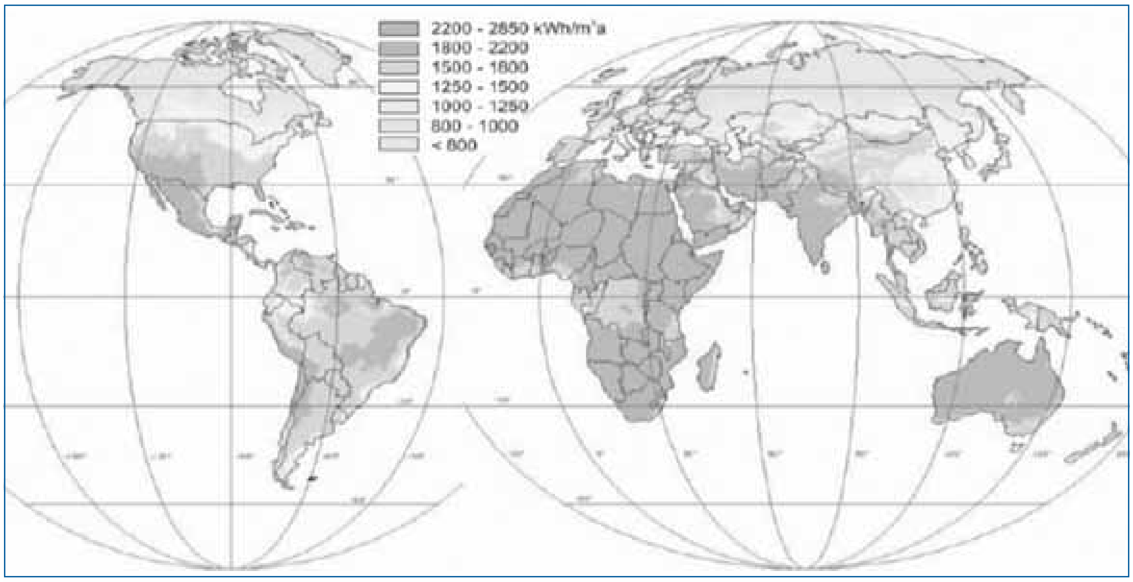
Figure 5.1: Solar Radiation in Jordan



Focus Solar 2009, www.focussolarusa.com

As shown in Figure 5.2, Jordan is classified as one of the Sun Belt countries according to the international classification. The total direct annual solar radiation ranges from 2400 kW h/m² to more than 2700 kW h/m² **[Alsaad, 1990]**.

Figure 5.2: Average Yearly Solar Radiation, Mean Values 1981-2000

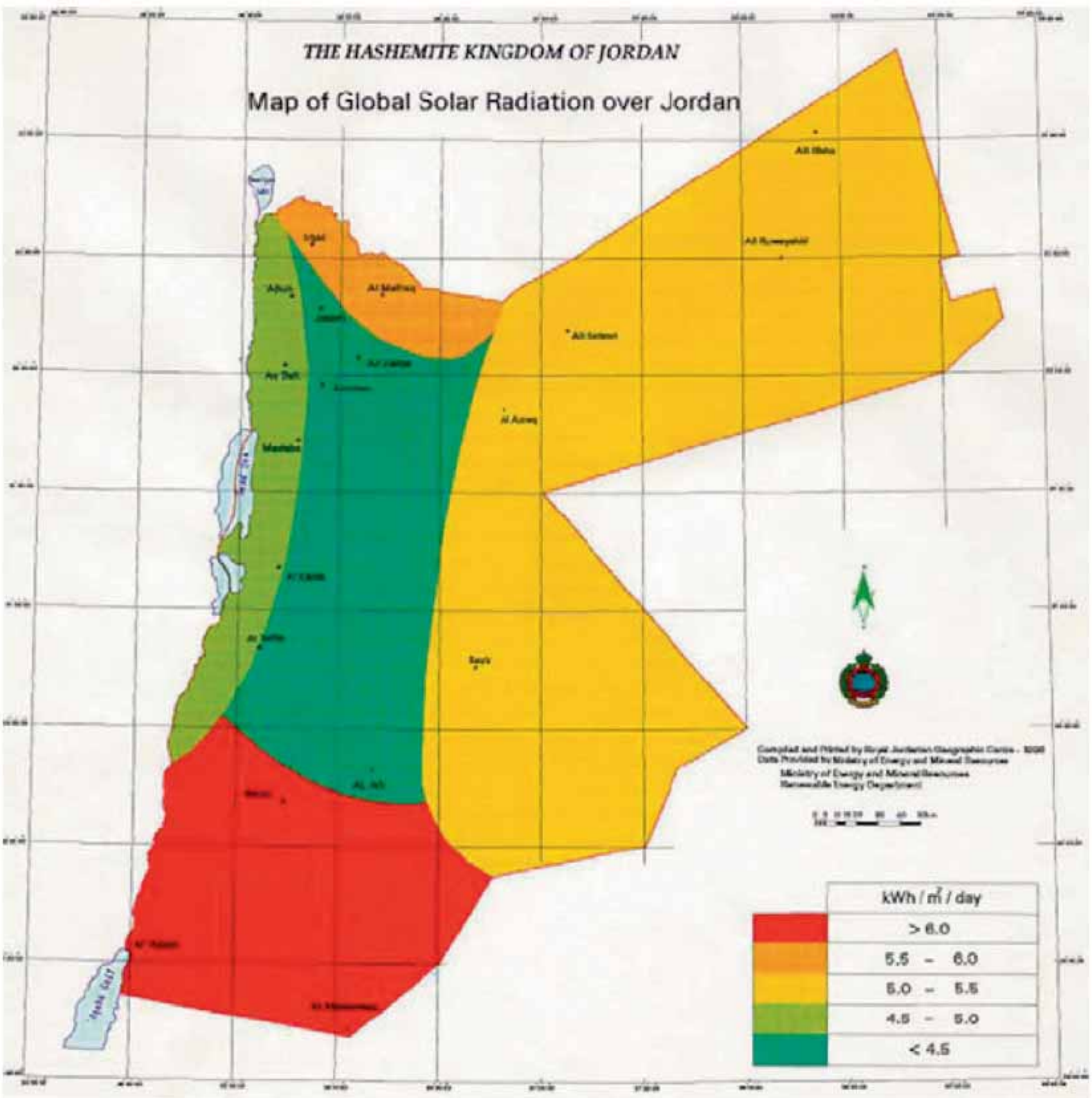


Source: Energie-Atlas GmbH

According to the distribution of the solar regions in Jordan, then Jordan can be divided to five solar divisions according to different regions in Jordan as shown in Figure 5.3, **[NERC, 2004**]:

- The southern region (Aqaba to Ma'an). The highest solar isolation in the country, and has the lowest values of diffuse irradiance. The annual average daily irradiance is 6–7 kW h/m^2.
- The eastern region (semi desert, the badia): annual daily irradiance is 5.5–6 kW h/m^2.
- Middle region: an average irradiance of 4.5–5 kW h/m^2 with the highest annual daily average of diffused radiation.
- Northern region: annual daily average irradiance of about 5.5 kW h/m^2.
- The western region represents the Jordan valley, situated below the sea level with an annual daily average global irradiance of about 4.5 kW h/m^2.

Figure 5.3: The Solar Map of Jordan



Source: NERC, 2004.

5.2.2 Current status

Traditionally, Jordan has employed the solar energy for industrial purposes; mainly a solar pond was built to evaporate 90 million m3/year of Dead Sea water in the process of potash and other salt production, thereby saving approximately 4 million toe of fuel oil annually.

The main application of solar energy in Jordan is in terms of domestic solar water heaters, which are estimated to provide hot water for 11% of households in Jordan **[Jaber et al. 2004]**, with more than 25 manufacturers producing locally-designed solar water heater systems. In 1995, about 25 % of dwellings (i.e. 300,000) had been fitted with solar water heaters, thereby avoiding the need for approximately 2% of total oil imports, with an associated savings of 6 million JD annually **[Hrayshat, 2004]**. The potential for the solar water heating market penetration in Jordan is 100%. For the year 2010, the estimated total potential is 100 ktoe/year **[Hrayshat, 2007]**.

The other application of solar energy is in terms of Photovoltaic (PV) systems which are employed in some remote regions, primarily for water-pumping systems, powering radio–telephone stations, as well as supplying electrical energy for clinics, schools, and a few small villages. Jordan has established a pilot project consisting of the installation of 1036 PV panels in remote villages. Each panel has an average generating capacity of 1050 Wh/day. Therefore, the potential of this technology is 397 MWh/year equivalent to 32 ktoe [Hrayshat, 2007] .

To generate electricity from solar energy in Jordan, there is a number of ambitious projects:

- There has been interest in commissioning a 5 MW pilot solar thermal plant in the Al-Qweira area, as proposed by a German solar energy company, though this is awaiting funding.
- The Aila Oasis Project, which features a Concentrating Solar Power (CSP) plant to provide electricity for an up-market coastal tourist resort on the Gulf of Aqaba, including energy for water desalination.
- The solar powered water desalination research project for desalinization of brackish water in rural areas by small solar energy units. This research project is undertaken with the US National Renewable Energy Laboratory, the German Solar Energy, Hydrogen Centre, and seriously investigated by the Ministry of Water and Irrigation [MEMR, 2007].
- A 30MW thermal power station project is under study, together with a consortium of European companies called “Phoebus”. The study outcome is encouraging and indicates that the utilization of solar energy for remote applications is feasible.

Jordan has several plans for increasing the use of solar energy. For instance, in 2020 it is expected that 30% of all households are to be equipped with solar water heating by the year 2020. The Government is hoping to construct the first Concentrated Solar Power (CSP) demonstration project in Aqaba and the South Eastern region. In summary and according to the national strategy the planned installed capacity will amount to: 300 - 600MW (CSP, PV and hybrid power plants) by 2020.

5.2.3 Problems & barriers

The applications of solar energy in Jordan are faced with the following barriers and challenges:

- Preference for conventional energy remains strong, with prejudice against renewable energies arising from the lack of education and awareness of its benefits.
- There is no information dissemination system to create awareness in terms of knowledge and technological characteristics of solar energy production and use.
- There was no coordination among the different national agencies concerned with solar energy before 2007. Only NERC was leading the renewable energies campaign during 1980s and 1990s, to date.
- The national strategy for priority given to renewable energy development was launched in 2007. Before that, the emphasis of the government was based on fossil fuel, namely oil and gas.

- Since the market for solar water heating in single-family dwellings is essentially saturated, then a technology different than the thermal siphon system used for single-family houses is required. New equipments are currently under testing at the Royal Scientific Society (RSS).
- Due to the high initial costs of photovoltaic (PV) technology, the Jordanian government is reluctant to promote it. In personal communication with NERC technical team, they indicated that technical shortcomings are more relevant, notably the low electricity storage capacity of PV systems and its unreliability for national grid applications.
- Inadequate use of solar energy research projects results. Even though some of these researches are supported by industries, their work has not been aimed at commercialization.
- Lack of technical support services to cater for the three major users of the technology: the domestic sector, the industrial/commercial sector, and developers/ investors. The highest barrier lies in the area of technical consultancy, where potential the end of users can confidently seek advice on the types of equipment to be used to achieve maximum benefits.

5.2.4 Best practices & other experiences

In order to present some good practices and countries experiences of solar energy, various literature have been reviewed including: national, international, governmental reports/websites, and publications **[9, 21, 22, 52]**. The following have been reported:

- **Algeria**

  Algeria receives an average solar radiation of 2000 h/yr, with the high plateaux and the Sahara receiving 3900 h/yr. The average solar energy received is 2400 kWh/m2/yr, ranging from 1700 kWh/m2/yr in the north of the country to 2263 kWh/m2/yr in the south. Whilst the share that solar power contributes to the overall supply of energy is small, it has proved invaluable for the electrification of isolated settlements, especially in the south of the country. Rural PV electrification programs accord priority to regions that are sparsely populated and situated far from the grid. At the end of 2005 approximately 1.4 MWp of photovoltaic capacity had been installed for this purpose. In addition, PV systems provided power for water pumping (0.4 MWp), public lighting (0.2 MWp), telecommunications (0.5 MWp) and other uses (0.2 MWp). Total output from PV devices is reported to have been approximately 3000 MWh in 2005.

- **Egypt (Arab Republic)**

  Egypt is located in the world's solar belt and has an excellent solar availability. The Egyptian WEC Member Committee reports that average solar radiation ranges from about 1950 kWh/m^2/yr on the Mediterranean coast to more than 2600 kWh/m2/yr in Upper Egypt, while about 90% of the Egyptian territory has an average global radiation greater than 2200 kWh/m^2/yr.

  Recognizing the important role renewable energy can play in meeting future energy needs, the New & Renewable Energy Authority (NREA) has set itself the target of providing at least 3 % of the country's electrical energy demand from renewables by the year 2010.

  Photovoltaic (PV) solar systems are presently considered economically advantageous only in remote applications of low power demand, where a grid extension appears non-economic, while conventional stand-alone power sources (e.g. diesel generator sets) show excessive operating costs, in addition to polluting the environment.

  A number of PV systems total is about 4.5 MWp have been installed in Egypt, primarily by NREA, but also by other national and international entities, including some private companies. The main applications are water pumping, desalination, rural clinics, telecommunications, rural village electrification, ice-making, billboards and cathodic protection.

The Egyptian Member Committee has also reported that a protocol has been confirmed between the NREA and the Italian Ministry of Environment and Territory (IMET) in the framework of the Renewable Energy for the Mediterranean Countries Program MEDREP, to use PV systems for lighting applications in two villages located in the Siwa Oasis (Matrouh Governorate), consisting of 100 households, 2 medical centres, 1 school, 3 mosques and 80 street lamps. The implementation of these projects is greatly dependent on the availability of funds (mainly international support), owing to the relatively high investment costs.

- **Australia**

Solar PV is one of the best established renewable technologies in Australia, with over three decades of technology and market development behind it. The overall market expanded by 15.8 % in 2005, bolstered by government grant programs for rooftop applications and off-grid diesel replacement, with the grid-connected segment growing 29 % and off-grid capacity by 14 %. Australia's well established non-domestic off-grid PV market in industrial, agricultural and commercial applications, such as telecommunications, signalling, water pumping, electric fences and cathodic protection, continued to be the largest sector of the PV market, accounting for 41% of capacity additions in 2005 and 55% of cumulative installations. At the end of 2005, installed PV power was 60581 kWp, of which 18 768 kWp was off-grid domestic, 33 073 kWp off-grid nondomestic, 6860 kWp grid-connected distribute and 1880 kWp grid-connected centralized.

The Australian Government provides support for solar energy applications through a number of programs. Two of particular relevance to photovoltaics are summarized below:

The aim of the Photovoltaic Rebate Program (PVRP) is to encourage the installation of PV systems in residential and community buildings. A reported 1042 systems were installed in 2005, amounting to 1.55 MW; 65% of installations, accounting for 73% of installed capacity, were on grid-connected buildings and a total of AUD 4.2 million was allocated in rebates. Since the start of the program in 2000, over 7600 systems, amounting to 9.5 MWp have been installed and grants of more than AUD 34 million have been provided. PVRP is funded by the Australian Government, with administration by the State Governments.

The aims of the Remote Renewable Power Generation Program (RRPGP) are to increase the use of renewable energy for power generation in off-grid areas, to reduce diesel use, to assist the Australian renewable energy industry, to assist in meeting the infrastructure needs of indigenous communities and to reduce greenhouse gas emissions. Each State has established a slightly different program, to meet the specific needs of local off-grid applications. However, in general, the target groups are indigenous and other small communities, commercial operations, including pastoral properties, tourist facilities and mining operations, water pumping and isolated households that operate within diesel grids or use direct diesel generation. Core funding for this program is provided to the States by the Australian Government, on the basis of diesel fuel excise duty collected from public generators not connected to main electricity grids. Grants are available for up to 50% of the capital cost of renewable energy systems replacing the use of diesel. The program is administered by the State Governments, with additional funding provided by some States, and will extend to 2009/2010, although some States may expend their allocations before then.

A specific allocation of AUD 8 million has been made to the Aboriginal and Torres Strait Islander Commission (ATSIC) for the Bushlight Program to assist with the development of industry capability and local understanding of renewable energy systems in indigenous communities.

In 2005, 2.08 MW of PV capacity was installed under RRPGP, bringing the cumulative total under the program to 5.35 MW. Although RRPGP is not PV specific, almost all the small systems installed to date include a PV element. The overall program has funds of some AUD 205 million allocated to it, of which AUD 141 million had been committed by the end of 2005.

- **Germany**

Germany has the highest level of installed PV capacity amongst the European members of the Implementing Agreement on Photovoltaic Power Systems (IEA-PVPS). At the end of 2005 its capacity stood at 1429 MWp, 25 times that of the next biggest country (Spain). Out of the installed PV total, 29 MWp was off-grid and 1400 MWp grid connected.

Recent growth has been nothing short of phenomenal: averaging 58 % per annum from 1999 to 2003 and then accelerating to 80 % or more in 2004 and 2005. Major factors contributing to this rapid rate of expansion were the highly successful 100,000 Rooftops Solar Electricity Program which ran from 1999 to 2003 and the Renewable Energy Sources Act (EEG) which, from April 2000, guaranteed a feed-in tariff for PV.

The Second Amendment of the Renewable Energy Sources Act (EEG) came into force on 1 January 2004, the third on 1 January 2009. It has the aim to increase the percentage of renewable energies in overall energy production to 30 per cent in 2020. There are bonuses for small installations and BIPV.

Solar thermal technology is also expected to benefit from a market incentive program. The total glazed area of solar thermal collectors in operation in 2005 was 6,554,000 sqm; giving an output capacity of about 4588 MWt. Plans were announced in March 2007 for the construction of one of the world's largest PV power plants. The facility will comprise some 400000 m2 of solar panels, with a generating capacity of 40 MWp, and will be erected on a former military airfield near Leipzig.

- **Japan**

As one of the 19 member countries of the Implementing Agreement on Photovoltaic Power Systems (IEA-PVPS) Japan had the highest installed PV capacity (636.8 MWp) at the end of 2002, when it was more than double that of the next highest country, Germany. In three years, however, Germany managed to overtake Japan, and by the end of 2005 was 7MWp higher than Japan.

Of Japan's 1421.9 MWp total capacity, 1.1 MWp was for the off-grid domestic market, 85.9 MWp for off-grid non-domestic, 1332.0 MWp for grid connected distributed and 2.9 MWp for grid connected centralized.

The 1997 New Energy Law led to The Total Primary Energy Supply Outlook in 1998 which specified that the target for installed PV was to be 5000 MW by 2010. In 2001 this target was reduced to 4820 MW. The Ministry of Economy, Trade and Industry (METI) is charged with promoting the measures necessary to achieve this target. The ‚Renewable Portfolio Standard' Law introduced during 2002 requires energy suppliers to use a certain percentage of renewable energy.

It was anticipated in 2006 that some 70000 residential PV systems would be installed during the year and that the total of incremental PV capacity in all applications could reach around 350 MWp. In Japan, most PV installations are on residential property. About 80 % of residential systems have been installed on existing houses and 20% on new properties. One commentator has remarked on the fact that, although fully roof-integrated PV systems are readily available, the number of such installations is quite small, and suggests that purchasers prefer to display their green credentials by opting for panels rather than the less noticeable tiles.

The majority of PV installations are likely to continue to take place in the residential sector, at a rate of between 100000 and 200000 (400–800 MWp) per annum. The number of larger installations on public buildings and industrial property is expected to increase, whilst further applications may be developed in transport and agriculture.

Off-grid non-domestic PV systems are being deployed for use in telecommunications, traffic signs, telemetering, ventilation and lighting.

5.2.5 Policy recommendation for Jordan

In order to maximize utilization potential of solar energy in Jordan, the following are recommended:

- There should be adequate coordination among the solar energy research projects fraternity.
- The evaluation of solar panels' efficiency and design integrity, as well as means to ensure proper maintenance of installed equipment are important aspects to be promoted.
- Investigation is required in the fields of solar water heaters in multi-dwelling buildings, and solar thermal power generation in the scientific and industrial areas for promoting domestic manufacture.
- Building regulation to promote passive solar energy efficiency should also be studied and developed in the short term.
- Solar Water Heating (SWH) should be adopted within the Jordanian Building Code. This will overcome the so called tenant-principal barrier.
- Initiate SWH Fund in cooperation with commercial banks to subsidize consumers. The initial high cost of solar water heating units proved to be one major barrier facing the penetration of the technology.
- Give higher priority in R&D to solar energy based brackish water desalination applications. More synergy and coordination between NERC and water, energy and environment research and studies centers is required.

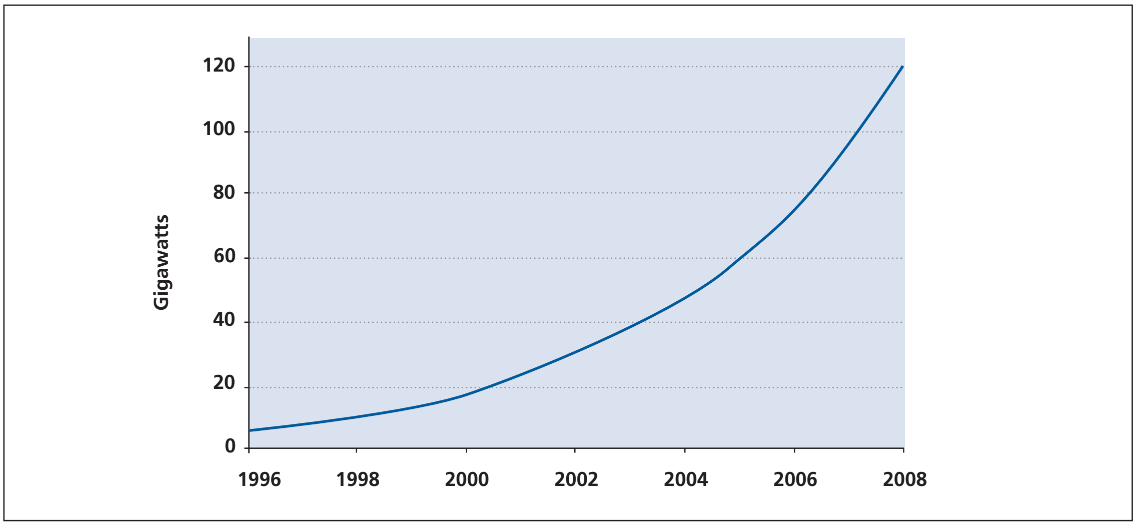
5.3 Wind Energy

Many natural phenomena play a role in winds generation through complex mechanism. These phenomena are the rotation of the earth, heat energy from the sun, the cooling effects of the ocean and polar ice caps, temperature gradient between land and sea, and the physical effect of mountains and other obstacles **[WEC, 2007]**.

The total resource is vast; one estimate suggests around a million gigawatts [13]. If only 1% of the area was utilized, and allowance made for the lower load factors of wind plant (15–40%, compared with 75–85% for thermal plant), the wind-power potential would still correspond, roughly, to the total worldwide capacity of all electricity-generating plant. The offshore wind resource is also huge, with European resources, for example, capable of supplying all the European Union's electricity needs, without going further than 30 km offshore **[WEC, 2007]**.

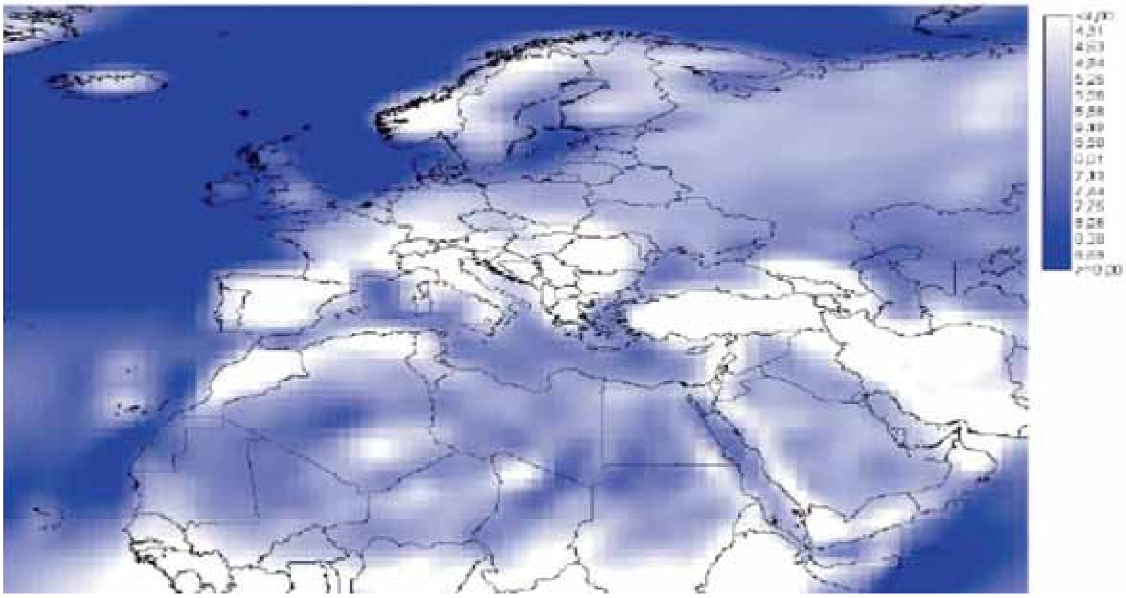
As illustrated by Figure 5.4 above, wind energy harvesting is one of the most rapidly expanding renewable energy applications in the world mainly as Grid Scale Power Wind Farms.

Figure 5.4: Existing World Capacity of Wind Power, 1996-2008



Source: Renewables Global Status Report, 2009.

Figure 5.5: Map Shows the Mean Wind Speed in Different Contents



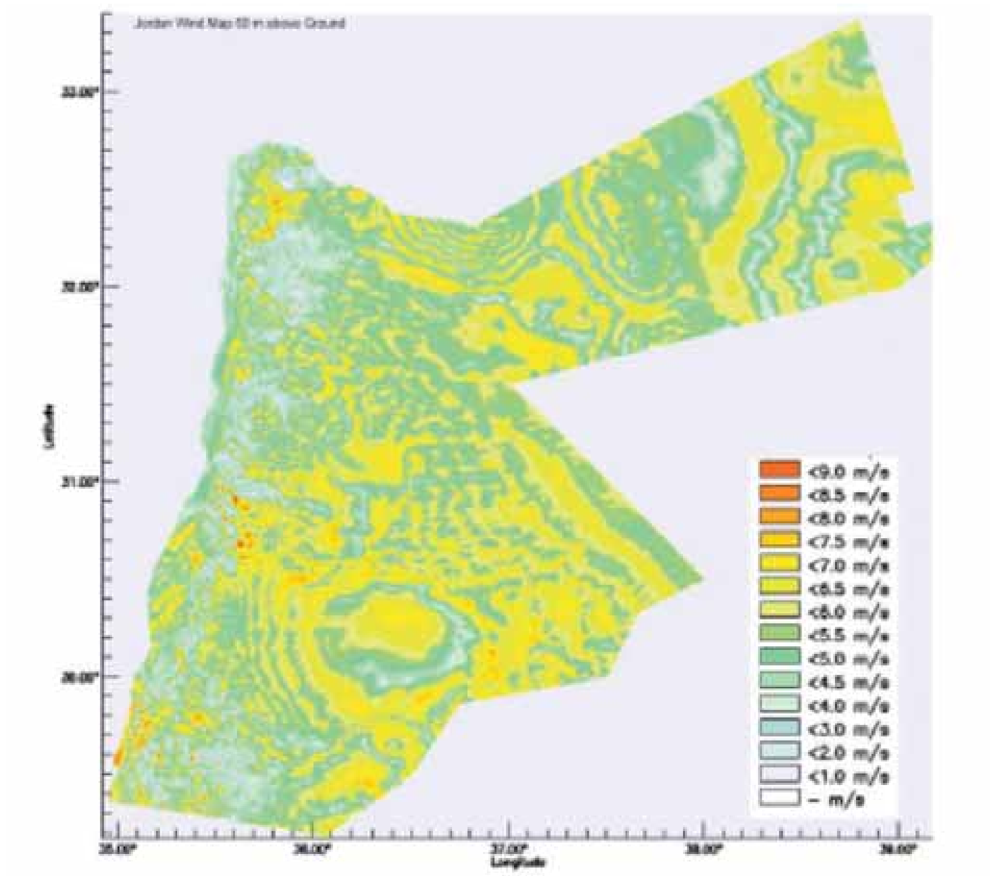
5.3.1 Potential

A wind atlas has been prepared in 1989 based on an assessment of the available resource (36 meteorological stations for a period of 2 years) which demonstrates the existence of a potential for several hundred megawatts of wind-power installations [14]. The potential areas for wind energy exploitation in Jordan, as shown in Figure 5.5, are in the both northern (Al-Ibrahimyya, Ras Munif, and Al-Hoffa) and southern (Al-Fujaja) of the country.

Wind measurement program, initiated by MEMR and NERC in 2001, compiled data from 19 measuring stations, 15 other stations are still under operation. Measurements are made at tower heights of 10, 24, 45, 50 and 60m. The average wind speeds measured ranged between 5 and 8.5 m/s as shown in both Figure 5.5 and Figure 5.6. However, the average annual wind speed exceeds 7 m/s in some areas.

As it is clearly shown in Figure 5.6, wind energy resources are abundant and can cover significant amounts of Jordan's needs if adequately invested. Jordan has an ambitious program in wind energy development, where about 600MW of wind turbines are to be installed by the year 2015, and be doubled by 2020.

Table 5.6: Jordan Wind Map with Mean Wind Speeds (at 50m above ground)



5.3.2 Current Status

There are several wind energy projects that have been established in Jordan since 1980s. They are summarized as follows:

- A small grid-connected wind farm was implemented in northern Jordan in 1987 by MEMR, the Jordan Electricity Authority (JEA), and the Danish firm Tellus. It has a capacity of 320kW (consists of four horizontal axes 80kW wind turbines 24m in height) at Al-Ibrahimyya. Operational experience shows an average annual production of 700MWh equivalent to 60 toe.
- A large wind turbine plant was established in northern Jordan, with German assistance, in 1996 in Al-Hoffa. It contains five wind turbines, 225kW each, with an annual total output of 2.5GWh.
- A hybrid solar-wind power for a remote village in southern Jordan in Jurf El-Darawish in 1987 was set up. It consists of two wind energy converters of 20kW each, a 10kW peak PV field, a storage battery system with a 330kWh capacity, and a backup diesel generator of 65kW.
- There are also numerous small scale mechanical and electrical wind-powered systems used for water pumping in remote areas.
- Six projects have been declared feasible and are in various stages of tendering and commissioning by MEMR [15]:

- Al-Kamshah project in Jarash (anticipated 40 MW capacity),
- Al-Fujaij project in Al-Shobak (70 MW capacity),
- Al Harir project in Al-Tafeleh (capacity ranging from 150–200 MW),
- Wadi Araba project (capacity ranging from 40 to 50 MW),
- Ma'an project (capacity ranging from 100–150 MW), and
- Al-Mafraq project (capacity ranging from 100–150 MW).

5.3.3 Problems & barriers

Jordan would like to see more rapid development of wind sites; however, the available projects with total wind energy potential are limited to 20 ktoe. The development of wind energy in Jordan is faced with the following barriers and challenges:

- Preference for conventional energy remains strong, with prejudice against renewable energies arising from lack of education and lack of awareness of its benefits.
- There is no information dissemination system to create awareness in terms of knowledge and technological characteristics of wind energy production and use.
- High cost of energy generation using small scale wind turbines even though recent studies show that wind energy can be competitive specifically if compared to the cost of heavy fuel and diesel generated energy.
- The national strategy for priority given to renewable energy development was launched in 2007. Before that, the emphasis of the government was based on fossil fuel, namely oil and gas.
- Uncertainties regarding wind potential and wind sites. The existing wind data are not complete for developing commercial wind farm feasibility studies.
- Very few wind energy research projects are running until now.
- Lack of local technical support services and consultancy in the field of wind energy and technology.
- No local industries for the production of wind turbines.

5.3.4 Best practices & other experiences

In order to present some good practices and countries experiences of wind energy, various literature have been reviewed including: national, international, governmental reports/websites, and publications **[9, 21, 22, 52]**. The following have been reported:

- **Egypt (Arab Republic)**

  Egypt is endowed with an excellent wind energy potential, especially in the Red Sea coastal area where a capacity of 20000 MW could be achieved, as the annual average wind speed is around 10 m/s.

  The *Wind Atlas for the Gulf of Suez*, published in March 2003, identified the areas of greatest suitability for wind farm projects. It included data for 13 sites covering the period from 1991 to 2001 and was undertaken with the assistance of the Danish Government.

  Since 1992, 5 MW wind capacity has been in service at Hurghada. At the end of 2006 there was 225 MW of installed capacity at Zafarana on the Red Sea coast, developed in cooperation with Denmark, Germany and Spain. The wind farm has 5 separate operating stations:

  - Zafarana 1 (50 x 600 kW) became operational in April 2001,
  - Zafarana 2 (55 x 600 kW) in May 2001,
  - Zafarana 3 (46 x 660 kW) in November 2003,
  - Zafarana 4 (71 x 660 kW) in June 2004 and
  - Zafarana 5 (100 x 850 kW) in September 2006.

A further 80 MW of capacity planned for Zafarana 6 is due to begin operating in 2008 with German co-operation. Zafarana 7 and 8, each of 120 MW capacity were planned with commissioning dates in 2009. These two latter plants are located in an extension to the west of the originally designated area in Zafarana and are being developed with help from Denmark and Japan.

A new area at the El-Zayt Gulf, some 150 km south of Zafarana, has been identified as being suitable for the installation of wind farms. At the present time feasibility studies are being undertaken for two plants – one of 80 MW with German assistance and another of 220 MW with Japanese assistance.

The *Wind Atlas for the Gulf of Suez* has been expanded to cover the entire country and the data extended to cover the period till 2005. The resulting *Wind Atlas for Egypt* was published in December 2005. It included a study of the migratory bird routes in the Suez Gulf region. This area was found to be a pathway for some 2.5 to 3.5 million birds each year – an essential element to consider when EIAs are undertaken as part of feasibility studies.

- **Tunisia**

Two small experimental wind projects: Aquaria (10 kW) and Jabouza (12 kW) (both now closed) had been commissioned during the 1980s by SEN (Société d'Energies Nouvelles). STEG (Société Tunisienne de l'Electricité et du Gaz) took over the wind turbines when SEN closed in 1994. An early 1990s feasibility study undertaken by STEG led to the 10.56 MW grid-connected wind plant at Sidi Daoud becoming operational in August 2000. An 8.72 MW expansion to Sidi Daoud became operational in 2003 and a further expansion of 34 MW is scheduled.

It has been estimated that the wind potential of Tunisia could support 1000 MW nationwide. Exploratory studies in the north of the country are further advanced than in the remaining territory. Three projects totaling 120 MW (Metline, Kechabta and Ben Aouf in the Bizerte region) are due to be operational there in 2009.

- **Morocco**

A study has shown that the best wind resources in Morocco are found in the north (particularly in the Atlantic coastal regions) and in the south. The former experiences annual average wind speeds of between 8 m/s and 11 m/s and the latter of between 7 m/s and 8.5 m/s. The wind potential can be utilized for both grid-connected electricity production and also water production by desalination.

The Centre for Renewable Energies (CDER) has stated that its objectives by 2012 are that 20% of electricity and 10% of energy consumption should be supplied by renewable energy. The harnessing of Morocco's excellent wind potential began in 2000 with the 50 MW El Koudia El Baida at Tétouan. This was followed in 2001 by a 3.5 MW plant at the same location. During 2005, output from the two wind farms totaled 208 GWh. In September 2005 a 10 MW plant attached to the cement factory in Tétouan became operational. The grid-connected turbines are expected to produce 38 GWh/yr and provide 50% of the factory's consumption.

In the short term two new wind farm projects are planned by the Moroccan Office national de l'électricité (ONE). It is foreseen that a 60 MW system at Cap Sim, 15 km south of Essaouira, will be operational in 2007–2008. Invitations to tender for a 140 MW (165 x 850 kW) project, split between Dhar Saadane, 22 km southeast of Tanger and Beni Mejmel, 12 km east of Tanger were issued in early 2007. It was planned that the project would be operational by 2009–2010.

Many other sites for both large and small projects are currently under development, undergoing feasibility studies or awaiting approval. One desalination project quoted by CDER is a grid-connected wind farm at Tan-Tan city, some 900 km south of Rabat.

- **Germany**

The Electricity Feed-in law (Stromeinspeisungsgesetz) was the progenitor of German wind power development in 1991. But the country's growth in wind capacity from just 110 MW at the end of 1991 to the present day, and its rank as a world leader, is due to further legislation in the subsequent years. In 1997, the Federal Building Code included wind turbines as 'privileged building projects'; April 2000 saw the adoption of the Renewable Energy Sources Act (EEG); March 2001 saw the feed-in tariff model complying with the European State Aid and Competition Law. The Second Amendment of the Renewable Energy Sources Act (EEG) came into force on 1 January 2004, the third on 1 January 2009.

The wind industry has been so successful that the German Wind Energy Association (BWE) estimates that with over 64000 people, it now employs more than the German coal-mining industry.

By the end of 2005 capacity stood at 18,428 MW, representing 17,574 turbines, and provided approximately 6% of Germany's electricity generation. By the end of 2006, capacity reached 20,621 MW, with the federal state of Niedersachsen leading with 5,283 MW. Although all states possess capacity, the northern states of Brandenburg, Bremen, Hamburg, Mecklenburg-Vorpommern, Niedersachsen, Nordrhein-Westfalen, Sachsen-Anhalt and Schleswig-Holstein constitute over 80% of installed wind power.

To date, various constraints - physical (deep water), financial and administrative – have prevented the same growth in offshore projects as has occurred onshore. There is currently one 4.5 MW offshore wind farm operating in the North Sea and two (2 MW and 2.5 MW) operating in the Baltic Sea. However, over 30 projects are either in the first phase of construction, approved or planned. Financial concerns over the repowering of older, lower capacity turbines and finding locations for the sitting of new turbines are among the problems facing the onshore wind sector.

- **Japan**

Although the wind resource of Japan is large, located mostly in the far north and far south of the country, there are impediments to utilizing it to its full extent. The areas of high wind (Tohoku, Hokkaido and Kyushu regions) do not match the areas of high population density and the national, privately-owned grids has each a wind capacity limit, ranging from 3.5% to 5% of the grid capacity. Additionally, to date offshore installations have been precluded owing to the deep waters surrounding the country.

Nevertheless, as a result of the UN Climate Change Conference in Kyoto in 1997, Japan agreed to reduce its output of GHG by 6% by 2010, compared to the 1990 level. In order to meet this target, the Government set an objective of 3,000 MW wind capacity in its latest Primary Energy Supply Plan.

April 2002 saw the Government passing further legislation (the Renewables Portfolio Standard – RPS) so that the renewable energy contribution to total electricity supply (1.35 % by 2010) would be met.

By the end of the fiscal-year 2001, the total installed capacity stood at 139 MW and at the end of the fiscal-year 2005, 1,078 MW. A further 316 MW was added during April-December 2006 to bring the total to 1,394 MW. This high rate of growth has been possible because of Governmental support in the form of field tests, promotional subsidy programs and the RPS.

Following the results of COP3, the Government must set a further target for 2030. The Japanese Wind Power Association has proposed wind capacity of 11,800 MW by 2030 and the NEDO (New Energy and Industrial Technology Development Organization) suggests that 10,000 MW could be in place by 2020 and 20,000 MW by 2030.

- **Canada**

Canada's wind energy capacity has grown significantly during the current decade. By the end of 2005 Canada had 683 MW installed capacity; by the end of 2006 it had grown to 1,460 MW from just 138 MW in 2000. Wind generators produced an estimated 1.8 TWh of electricity in 2005.

The Federal Government's Wind Power Production Incentive (CDN$ 0.01/kWh) has assisted in the development of wind power generation. It aims to increase wind power to 4,000 MW by 2010. By the end of 2005 approximately CDN$ 300 million had been allocated for 22 projects, with a total capacity of 920 MW.

Provincial incentives and Renewable Portfolio Standards have also assisted in the development of wind projects. Each Canadian province is planning to increase its wind power capacity. An example of the ambitious programs for encouraging renewable energy is the Standards Offer Program in Ontario, which provides CDN$ 0.11/kWh for small renewable energy producers. Ontario also has a Renewable Portfolio Standard and aims to generate 5% of its power from renewable energy by 2007 and 10% by 2010. It is expected that up to 80% of this generation will be met through wind power. Saskatchewan has enacted a Green Power Portfolio strategy, stating that all new provincial electricity generation will come from non-GHG emitting sources by 2010. Prince Edward Island (PEI) passed a Renewable Energy Act in 2004 requiring utilities to acquire at least 15% of their electrical power from wind by 2010. Under this Act, there are plans for 59 MW of new wind capacity to be installed in PEI by the end of 2007. By 2015, Quebec is looking to increase its wind capacity by 4,000 MW, while Manitoba, New Brunswick and Nova Scotia are aiming to add 1,000 MW, 400 MW and 380 MW respectively over the same time period.

According to the Canadian Wind Energy Association, there are 33 projects under development, some of which have signed power purchase agreements and are under construction. Should all of these wind farms be developed, Canada's wind power capacity will increase by a further 2,800 MW. Of this, the majority of the development will take place in Quebec (1,245 MW) and Ontario (955 MW), with other significant contributions in British Columbia (325 MW) and Alberta (134 MW).

- **Ireland**

Ireland's prevailing south-westerly winds from the Atlantic Ocean give a feasible wind resource that has been estimated to be as high as 179 GW, or some 40 times the country's current generating capacity.

This abundant wind supply began to be utilized, albeit rather poorly, in the early 1980s with several demonstration schemes. The detailed investigations that followed included the establishment of the Irish Wind Atlas and, in 1996 the Government's Alternative Energy Requirement (AER I) competition. The market support mechanism of AER I in which 15-year power purchase agreements were awarded to renewable electricity generators has been repeated in further programs – AER II to AER VI. In 2005, it was announced that the support mechanism to follow AER VI would be based on a fixed feed-in tariff system over a 15-year period but only applying to new capacity projects.

The Government's Renewable Energy strategy, as contained in the 1999 Green Paper and subsequently the 2000 National Climate Change Strategy, specified a target of an additional 500MW of installed renewable electricity generating capacity to be in place during the years 2000–2005.

The country is also working with the 2001 EU Directive of meeting 13.2% of its electricity generation from renewables by 2010. No target has been specifically set for wind power but it is considered that this resource will make the greatest contribution and the Government has agreed with the relevant parties to work to a figure of 1,100 MW of installed capacity.

By the end of 2005 capacity stood at 496 MW, a total of 676 MW of capacity was already contracted to be grid-connected by 2011 and some 3,000 MW had been applied for and was in the process of being assessed. By the end of 2006 installed capacity had climbed to 745 MW.

At the present time, the majority of installed capacity relates to onshore wind turbines but the first phase of the Arklow Bank offshore plant became operational in June 2004. The 25 MW (7 x 3.6 MW) plant, located off the east coast of Ireland in the Irish Sea was co-developed by GE Energy and Airtricity as a demonstration plant. Testing of this first phase will take place for approximately two years, after which a much larger plant may be developed. In 2003 Airtricity agreed with GE Energy to purchase the plant following the testing phase. A new company, Zeusford (50% Airtricity, 50% EHN of Spain) has proposed the expansion of Arklow Bank to a 200 turbine wind farm with a nominal capacity of 520 MW. Some 10% of national electricity demand could be met if the plan comes to fruition.

5.3.5 Policy recommendations for Jordan

In order to maximize utilization potential of wind energy in Jordan, the following are recommended to be taken:

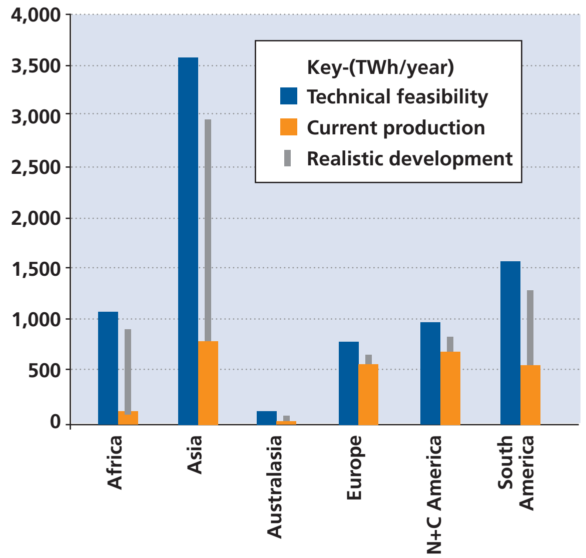
- The development of local industries able to manufacture a high percentage of the wind turbines. Creating of global partnerships to produce wind turbines locally is another option.
- Intensify research and studies to minimize remaining uncertainties regarding wind potential and wind sites.
- The government should take necessary steps to acquire necessary lands in identified locations for Wind Farm development. This should be accomplished prior to floating tenders to minimize Land ownership risks and uncertainties.
- Small scale wind turbines are known to have higher cost of generated energy than conventional and even other RE sources, therefore such applications should only be pursued in specific circumstances making the small scale wind turbine affordable. Nevertheless, recent studies show that in general the production of wind energy is nowadays competitive in Jordan, especially with regard to diesel and heavy fuel.
- Updating of the wind data to the point where reliable commercial wind farm feasibility studies can be developed.

5.4 Hydro Energy

Hydropower is the most advanced and flexible of the renewable energies. As other technologies have been introduced, hydro has tended to evolve into a supporting role – responding to gaps between supply and peak demand. There are 45,000 large dams in the world and the majority does not have a hydro component. Another driver for hydro development is the increasing need for water management. Multipurpose hydro reservoirs can bring security of water supply as well as power. Development of hydro has a long-term economic advantage with annual operating costs being a tiny fraction of the initial capital cost. Additionally, hydro's autonomy from the fuel price is a distinct advantage **[WEC, 2007]**.

As seen in Figure 5.7, hydro provides some level of power generation in 160 countries **[WEC, 2007]**. Five countries make up more than half of the world's hydropower production: Brazil, Canada, China, Russia and the USA. Taking Europe as a benchmark (proportion of production in relation to realistic feasibility), hydro can be expected to see a ten-fold increase in Africa, a three-fold increase in Asia, a doubling in South America, and an increase of about 10% in North America.

Figure 5.7: Estimated Hydropower Development by Region



Source: International Hydropower Association.

5.4.1 Potential

In case the proposed Red Sea-Dead Sea Canal, to transfer seawater 180 km from the Gulf of Aqaba to the Dead Sea, becomes a reality; then there is a potential for major hydropower energy capacity depending on the final configuration of the project. It is estimated that the 400 m drop in height from the Red Sea would facilitate the 400–800 MW hydropower station.

5.4.2 Current status

Conventional hydropower resources are modest in Jordan. The total electricity generated by this renewable source in 2004 was 17.3GWh (1.5 ktoe), i.e. 0.3 % of total national electric generation. Currently, there are two small hydropower systems in Jordan **[Jaber et. al 2007, Hrayshat 2007, JVA 2002]**:

- The King Talal dam, spanning the river Zarqa near Jerash, was constructed in the 1970s with the dam heightened in the 1980s to increase capacity: it has an electricity generating capacity of 5 MW with an average energy production of 13 GWh per year.

- The Aqaba power station (fuelled by natural gas), which has a total electricity generating capacity of 656 MW, two hydroturbines utilize cooling seawater to generate 6 MW.

5.4.3 Problems & barriers

If the hydropower generated by the proposed Red Sea and Mediterranean-Dead Sea Canal would be used to power the large-scale desalination plants planned for this mega-project (producing up to 840–850 million cubic metres/year of fresh water), then the hydropower capacity would save no more than 30 % of the external energy which would otherwise be required to power the reverse osmosis desalination processes and associated water pumping **[Beyth, 2007]**. Therefore, there is an overriding concern regarding the gained net hydro energy.

As to the barriers of hydro power application in Jordan, the main barrier is the fact that there are no plans for the expansion of conventional hydro capacity.

5.4.4 Best practices & other experiences

- **Austria**

The use of hydro-power as a clean and emission-free way of generating electricity has a long tradition in Austria. Hydro-electric power represents about 60 % of the domestic electricity generated and about one-third of the total of energy generated.

In addition to a number of large river power stations along the Danube, storage power stations were built in the western alpine regions which largely serve to cover the power demands in winter. In recent years, assessing the environmental compatibility has been the most important consideration when constructing a plant.

During the summer, practically the entire demand for electricity can be catered for by hydro-electric stations and Austria even exports electricity.

Small hydro up to 10 MW has been granted tariffs of between 3.15 and 6.25 cents per kWh, depending on whether the plant is new or refurbished. There is a new subsidy for middle scale hydro from 10 to 20 MW, with a maximum of € 6 million per plant.

- **Brazil**

Hydroelectric power is one of Brazil's principal energy assets: the republic has by far the largest hydropower resources on the continent. The Brazilian WEC Member Committee reports that gross theoretical capability exceeds 3 000 TWh/yr, with an economically exploitable capability of over 800 TWh/yr, of which over 40% has been harnessed so far. Hydro output in 2005 was 337 TWh, which accounted for 84% of Brazil's electricity generation.

Hydro generating capacity more than doubled between 1980 and 1999, partly through gradual commissioning of the huge Itaipú scheme (total capacity 12 600 MW), which came into operation between 1984 and 1991. Brazil shares Itaipú's output with its neighbour Paraguay, which sells back to Brazil the surplus power remaining after its own electricity needs have been satisfied.

At the end of 2005, Brazil had 5 GW of hydro capacity under construction, including a major (4 125 MW) extension of capacity at Tucuruí and two additional 700 MW units at Itaipú. Nearly 37 GW of further hydro capacity is planned for future development. The 19th 700 MW unit entered commercial operation at Itaipú in September 2006, bringing its total capacity up to 13 300 MW.

Within the overall picture outlined above, small scale hydro (since 1998, defined in Brazil as plants with a capacity of < 30 MW) has an economically exploitable capability of about 17 TWh/yr, 39 % of which had been exploited by capacity installed as at the end of 2005. The 1429 MW of small-scale hydro currently in place will be augmented by 1 800 MW additional capacity which is under construction or planned. The legislation in force anticipates the granting of incentives for small hydro-electric stations (systems under 30 MW), in order to increase competition in the Brazilian electricity market.

- **Canada**

Canada possesses enormous hydropower potential. In 2005, 60 % of its electricity generation was provided by hydroelectric power plants, which generated more than 358 TWh, up from 337 TWh in 2004. Canada is one of the largest hydro producers in the world, and had an installed capacity of 71 978 MW at the end of 2005.

There are many significant hydroelectric projects under way. In total, these projects will increase hydro generation capacity by more than 3 500 MW.

In British Columbia, there are three significant expansions/installations currently being undertaken: the expansion of the Brilliant Dam and power plant on the Kootenay River near Castlegar will increase its capacity by 120 MW when commissioned (Spring 2007); the Forrest Kerr run-of-river hydro facility, with a capacity of 115 MW, is expected to be completed in early 2008; upgrades to the generators at the Mica Dam hydro station will add about 275 MW by 2009. The Waneta Expansion project will commence construction in 2007 pending approvals, and would add a further 435 MW.

In Manitoba, upgrades at the Kelsey generating station will add 84 MW by 2010, the first unit was started in 2006. Construction of the Wuskwatim generating station commenced in August 2006, and will add 200 MW.

In Ontario, upgrades at the Sir Adam Beck II generating station between 1996 and 2005 resulted in an increased capacity of 208 MW, and the Niagara Tunnel Project will increase the capacity factor at Sir Adam Beck II, resulting in an expected 1 600 GWh/yr extra generation by 2009. The recently completed rehabilitation at the R.H. Saunders generating station resulted in a capacity increase of 132 MW.

While plans exist for new hydro capacity in Newfoundland and Labrador, there has been no recent construction.

Quebec is the largest developer of hydroelectricity in Canada. In 2005, the 77 m high Toulnustouc Dam and generating station was completed, adding 526 MW of capacity. The Mercier project is to be completed in late 2007 on the Gatineau River north of Maniwaki, and will add 50 MW. The Eastmain-1 hydro station was fully commissioned in Spring 2007, adding a further 480 MW. The Eastmain-1-A/Rupert diversion project was launched in January 2007; it will add 888 MW when commissioned in 2010/11. Two run-of-river projects are being constructed, at Chute Allard (62 MW) and Rapides-des-Coeurs (76 MW), and should be commissioned by 2008. Refurbishment at Outardes-3 and -4 will increase capacity by 310 MW. Upgrades at the La Tuque power plant will increase capacity by 51 MW.

Installed capacity of small hydro plants of less than 10 MW totalled 978 MW at the end of 2004. These facilities are located throughout the country, particularly in British Columbia, Ontario, Quebec, Nova Scotia, Newfoundland and Labrador.

In Canada, the Income Tax Act defines small hydro as any hydro facility with less than 50 MW, and allows for the accelerated depreciation of those facilities. Under this definition, the installed capacity was 3 400 MW in 2005. An inventory prepared by Natural Resources Canada identified 5 500 technically feasible sites, with a potential of 11 000 MW. However, of these, only about 15% are currently both technically and economically feasible. It is estimated that by 2011, a further 2 000 MW of small hydro capacity, below 50 MW, could be installed.

- **France**

France is one of Western Europe's major producers of hydroelectricity, but its technically feasible capacity has now been very largely exploited. No more medium/large hydro plants are under construction or planned.

The total installed capacity of small-scale (less than 10 MW) plants is around 2 000 MW, which generated 5.8 TWh in 2005. There are, on the other hand, some 280 hydro plants of greater than 10 MW, with an aggregate installed capacity of more than 23 000 MW.

An Arrêté issued on 7 July 2006 in the context of the long-term plan for investments in electricity generation quotes the following targets for total hydropower (including plants of less than 10 MW, but excluding pumped storage): 500 MW additional capacity by 2010; and an additional 2 000 MW (including the aforementioned 500) by 2015. The same quantitative objectives have been set for pumped-storage plants in these years.

A buy-back tariff (Arrêté dated 25 June 2006) is in operation for hydro-electric installations with a capacity of less than 12 MW.

- **Indonesia**

At some 2 150 TWh/yr, Indonesia's gross theoretical hydro potential is the third largest in Asia. Its technically exploitable capability is just over 400 TWh/yr, of which about 10% is considered to be economically exploitable.

Average annual hydro output is about 9 200 TWh, indicating the evident scope for further development within the feasible potential. Hydro presently provides approximately 12% of Indonesia's electricity supply.

Indonesia reported that 135 MW of hydroelectric generating capacity was under construction at the end of 2005 and that 802 MW of additional hydro capacity was at the planning stage.

The installed capacity of small-scale hydro plants is reported as 20.89 MW, with 2005 generation amounting to 55.71 GWh. Additional capacity of 17.31 MW is on order or planned.

- **Turkey**

The Turkish WEC Member Committee reports a gross theoretical hydropower potential of 433 TWh/yr, a technically feasible potential of 216 TWh/yr and an economically feasible potential of almost 130 TWh/yr. Hydro output of 35.1 TWh in 2005 points to a considerable degree of development potential.

At the end of 2005, operational hydro capacity amounted to almost 12.8 MW. A further 3.2 GW of capacity was under construction at that point in time. Some 20 000 MW of additional capacity is planned for development over the longer term.

Small-scale hydropower is reported to have a technically exploitable capability of around 14 500 GWh/yr, of which about 60% is considered to be economic. The total installed capacity of HPPs below 10 MW was 173 MW at the end of 2005, providing an average output of 675 GWh. A considerable amount of small-scale hydro capacity (over 1 000 MW) is planned for installation in the future.

5.4.5 Policy recommendation for Jordan

Very small power plants could be developed in the urban water supply systems, but only for very limited capacities. The only strong potential seems to be in the proposed Red Sea – Dead Sea Canal (600 MW), and in pumping storage into the Al-Wehda Dam (200 MW).

5.5 Bioenergy

The term bioenergy denotes the use of vegetable matter as a source of energy; it covers a variety of fuels such as wood fuel, biomass, and biofules. Biomass is a versatile raw material that can be used for production of heat, power, transport fuels, and bioproducts. Over the past decades, the modern use of biomass has increased rapidly in many parts of the world. In the light of the Kyoto GHG reduction targets, many countries have ambitious targets for further biomass utilization. Oil price increases have also increased the level of interest in bioenergy.

The potential contribution of bioenergy to the world energy demand of some 467 EJ per year (2004) may be increased considerably compared to the current 45-55 EJ. A range from 200-400 EJ per year in biomass harvested for energy production may be expected during this century. Assuming expected average conversion efficiencies, this would result in 130–260 EJ per year of transport fuels or 100-200 EJ per year of electricity **[IEA, 2007]**.

Biofuels, mainly ethanol produced from sugar cane and surpluses of corn and cereals, and to a far lesser extent biodiesel from oilseed crops, represent a modest 1.5 EJ (about 1.5%) of transport fuel use worldwide. Global interest in transport biofuels is growing, particularly in Europe, Brazil, North America, and Asia (most notably Japan, China and India) **[UNDP 2000, UNDP 2004, IEA 2006]**. Biomass combustion (such as waste incineration, and other domestic and industrial uses) is responsible for over 90% of the current production of secondary energy carriers from biomass.

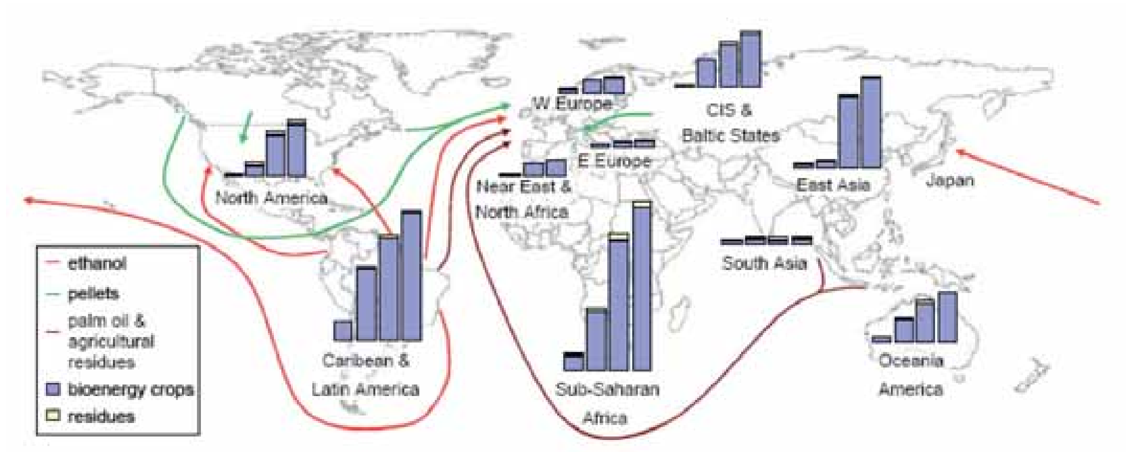
Global ethanol production has more than doubled since 2000, while production of biodiesel, starting from a much smaller base, has expanded nearly threefold. In contrast, crude oil production has increased by only 7% since 2000 **[WWI, 2007]**.

Given the availability of land and relatively low costs of labor in many developing countries, biomass production costs can be low, and thus offer an opportunity to export biomass based energy carriers to developed countries. In the past decade such trade flows have been increasing rapidly. Many trade flows are between neighboring countries, but increasingly, long-distance trade is also occurring. Examples are export of ethanol from Brazil to Japan and the EU, palm kernel shells (a residue of the palm oil production process) from Malaysia to the Netherlands, and wood pellets from Canada, Eastern Europe and Brazil to Sweden, Belgium, the Netherlands and the UK.

The major future exporters include Latin America (Argentina, Brazil) as well as south-east Asia (Indonesia, Thailand), southern Africa (especially Mozambique, Congo) as well as the central and east European states (Bulgaria, Romania, Ukraine, Belarus).

Figure 5.7 shows the future major trade routes as well as the regional bioenergy potentials by different scenarios. As shown in the map, the Middle East and Gulf countries are still free from bioenergy trading activities.

Figure 5.8: Future Bioenergy Trade and Regional Potentials



Source: acc to IEA Bioenergy Task 40.

According to a study of IEA Bioenergy Task 40, the role played by developing countries and transition countries in the export of biofuels will massively increase by the year 2030.

5.5.1 Potential

There is a low potential to achieve energy from biomass in Jordan due to the severe constraints on vegetation growth imposed by the arid climate **[Hrayshat, 2007]**. However, direct combustion of biomass, which is traditionally used by bedouins and in rural areas, can be classified as one of bioenergy sources in Jordan.

However, the governmental interest in bioenergy has focused on the energy potential from burning municipal solid waste and organic waste. It has been estimated that animal and solid wastes in Jordan represent an energy potential of about 100 ktoe/year **[Hrayshat, 2007]**. In 2000 a study on the laboratory analysis of municipal solid waste (MSW) in Jordan has revealed an average energy content of 2747 kcal/kg of waste. This energy is equivalent to about 6% of the total annual fuel imported by Jordan **[Abu-Qudaisa and Abu-Qdais, 2000]**.

The total amount of MSW generated in Jordan in the period of 2002–2015 is projected to grow from 1.56 million tons in 2002 to 2.49 million tons over this period **[MoE, 2004]**. The growth in MSW generation is 3.0%/year, and it is a function of population growth, economic growth and the extent to which people adopt „consumer“ and „disposable“ lifestyles. The data identify that; the amount of waste generated on a per capita basis will grow from around 303 kg/person/year to around 350 kg/person/year over the period of 2002–2015. By far, the majority of the MSW (85+ %) is managed through landfill disposal. Therefore, there is a great potential in direct biomass combustion (waste incineration) of the MSW for industrial uses.

5.5.2 Current status

Currently there are basically two technically developed approaches to exploit the biomass resources, direct firing of the biomass and gasification (producing methane):

- Capturing Landfill Gas has attracted some attention. The Biogas Company, a joint venture between the Greater Amman Municipality GAM and NEPCO is running the Rusaifeh Landfill Gas project with 3.5 MW installed capacity, the project has greatly benefited from the CDM Carbon Credit sale. This success story has encouraged attempts to develop other Landfills under CDM such as Al-Ghabawi landfill which started receiving MSW in 2003 at a rate of 2000 tons per day and has accumulated 2.5 million tons of waste by 2009. The project is expected to operate 1.5 MW Generation capacities. The project is being jointly developed by GAM and International Bank for Reconstruction and Development (IBRD).

- The Common Services Council of Irbid Governorate, which is responsible for operating the Akeeder Landfill (in operation since 1981) in the Northern Jordan, has announced its intention to develop a landfill gas capture and utilization project. The Akeeder Landfill is receiving 650 tons of solid waste per day. The project has faced several barriers mainly lack of awareness regarding CDM and the small scale of the project.
  The Overall MSW received by all landfills in Jordan is estimated to be around 4000 tons/day. Approximately, 2000 tons/day are generated in Greater Amman area, but since quantity is distributed over a large number of Landfills (a total of 22 Landfills where only 16 out of them are operational). However, the actual useful potential is much lower depending on the size of individual landfills. The Ministry of Municipalities and Rural Affairs (MMRA) announced a strategy to minimize the number of landfills by establishing intermediate transfer stations; encouraging investment in recycling and landfill management; and modernizing the equipment and operations at an estimated cost of 10.4 million JD.

5.5.3 Problems & barriers

The development of bioenergy in Jordan is faced with the following barriers and challenges:

- The potential of Biomass from livestock waste and leftovers is not explored. From what is known, the livestock activity is scattered and very few farms if any provide the necessary scale to justify exploiting bioenergy.
- The biomass sub sector in Jordan is not investigated in depth. Municipal solid waste represents the major source of biomass, followed by waste water treatment plants and animal industry.
- Dispersed nature of generated solid waste leading to loss of scale benefits is a major barrier in adopting and implementing management plans.

5.5.4 Best practices & other experiences

- **Lebanon**

  In 2004, it was reported that biogas projects were installed on a small, trial scale. None were designed to generate electricity but rather provide heating fuel. Plant residues are generally burnt in rural homes for space heating.

- **Austria**

  Being well-endowed with forests and therefore wood, Austria opted for energy produced from bioenergy, such as straw and corn, in the early 1980s. This dominance of bioenergy generated power is the result of a targeted research and development policy. Figures from the energy recycling agency show that for the past two decades, investment in this area has been higher than in other renewable energy sources.

  Austria's long years of research and development have led E.V.A. (Austrian Energy Authority) experts to pronounce the country a world leader in biomass firing. Biomass furnaces, particularly when fuelled by new pellets, have successfully shown themselves to be the most environmentally friendly heating system on the market. This technological lead in wood-firing has created a rapidly growing export sector in Austria.

- **Turkey**

  Biodiesel can be produced under the biodiesel processing license, given by the Energy Market Regulatory Body (EMRA). Currently, 52 biodiesel production companies have applied to the EMRA.

  There is only one bioethanol production plant in Turkey, mostly processing wheat. The total production capacity of the plant is 30 000 m3/yr.

The Turkish bioenergy resources are in the form of agricultural crops and residues, including dry manure, but have yet to be properly determined. The results above are taken from the final report of a project founded by European Commission (EC Contract Number: LIFE 03 TCY/TR/000061), *Exploitation of Agricultural Residues in Turkey*.

- **Canada**

Canada has significant advantage in bioenergy, based on the extent of arable land and forested areas. Currently, biofuels, in the form of ethanol and biodiesel, are the most advanced source of bioenergy and the Federal Government has committed to ensuring that fuels sold in Canada have an average 5% renewable fuel content by 2010.

Installed ethanol capacity is 4932 TJ/yr, of which corn-based ethanol accounts for approximately 74 %, wheat-based ethanol contributes 25% and ethanol extracted from wheat straw less than 1%. Installed biodiesel capacity is 406 TJ/yr, of which canola-based biodiesel accounts for about 36% of Canadian production and fish oil for 64 %.

Government support for alternative fuels includes exemption from the excise tax on gasoline, which equates to CDN$ 0.04/liter for biodiesel and CDN$ 0.10/liter for ethanol. The Ethanol Expansion Program provided support (CDN$ 100 million) to ethanol plants. Various research and development programs and public information programs are also supported, including the Canadian Biomass Innovation Network (CBIN) which coordinates R&D activities at the federal level in bioenergy, biofuels, and industrial biotechnology.

The following equipment qualifies for tax incentives with accelerated depreciation treatment: equipment powered by wood waste, municipal waste, biogas from a sewage treatment facility; equipment that recovers biogas from landfill sites; equipment used to convert biomass into bio-oil and biogas production equipment.

In 2005 around 35 million liters of ethanol were exported and 125 million imported. Of the 925000 tons of wood pellets produced in 2005, 825000 tons were exported (approximately 60 % to Europe and 30% to the USA).

5.5.5 Policy recommendations for Jordan

- Ministry of Municipalities should revive its strategy in the field of waste handling in close collaboration with other entities to maximize benefits through comprehensive waste management plans
- Individual efforts should be pooled under one Comprehensive Solid Waste Management Plan where recycling, energy generation, and environmental aspects are all considered in the action plan.
- The ministries strategy should include plans and actions towards minimizing the number of landfills through intermediate waste transfer stations. Accomplishing this step will largely facilitate Comprehensive Solid Waste Management action plans.
- Energy from Solid waste is one of the most benefitting applications within CDM. Waste water treatment which is under the umbrella of the Water Authority of Jordan (WAJ) can also benefit from this mechanism; WAJ should embark on a comprehensive Waste Water Plan including the possibility of energy generation, water recycling and environmental considerations.
- The Ministry of Environment should develop a CDM case based on the preliminary studies that were conducted as part of GHG Mitigation options for the SNC to UNFCCC, these preliminary investigations show that biogas from animal and domestic wastes can save up to 4 % of imported oil (in year 2000) which is equivalent to 130000 TOE per annum. In addition to the 23 Waste Water Treatment Plants existing in Jordan and the livestock farms sub sectors, the waste sector represents 13% of GHG emissions in the country. This fact should attract the attention of the Environmental Fund established recently as a priority area since 15% of CDM revenues belong to the Fund according to Environment Law.

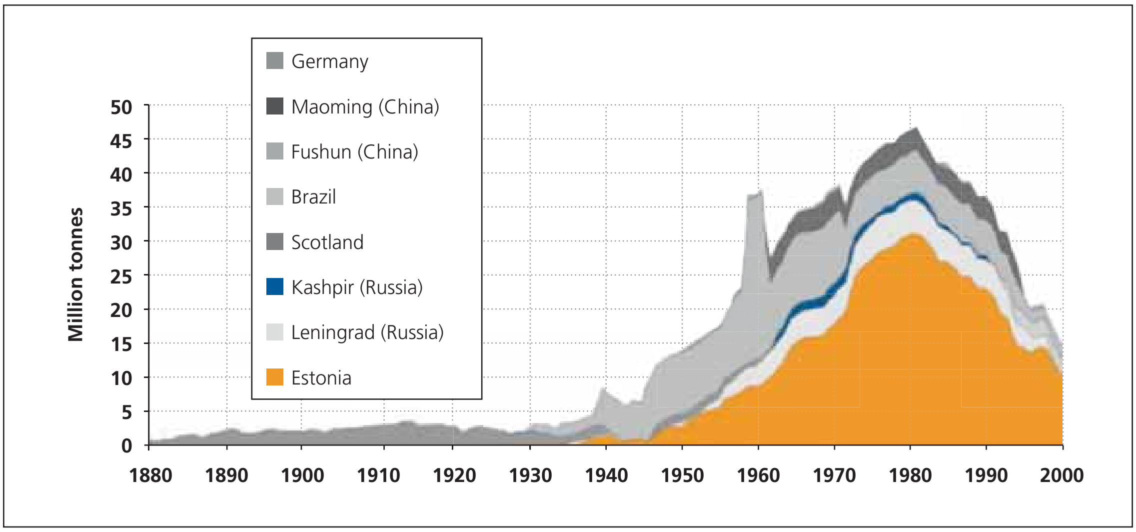
5.6 Oil Shale

Most oil shales are fine-grained sedimentary rocks containing relatively large amounts of organic matter (known as 'kerogen') from which significant amounts of shale oil and combustible gas can be extracted by destructive distillation.

Total world resources of shale oil are conservatively estimated at 2.8 trillion barrels. The petroleum based crude oil is cheaper to produce than shale oil because of the additional costs of mining and extracting the energy from oil shale. However, with the continuing decline of petroleum supplies, accompanied by increasing costs of petroleum-based products, oil shale presents opportunities for supplying some of the fossil energy needs of the world in the years ahead.

During the period 1880 to 2000, only six countries were mining the oil shale as shown in Figure 5.8. From the peak year of 1981, yearly production of oil shale steadily declined to a low of about 15 million tons in 1999. Most of this decline is due to the gradual downsizing of the Estonian oil shale industry. This decline was not due to the diminishing supplies of oil shale but to the fact that oil shale could not compete economically with petroleum as a fossil energy resource. On the contrary, the potential oil shale resources of the world have barely been touched **[WEC, 2007]**.

Figure 5.9: Oil Shale Mined from Deposits in Brazil, China, Estonia, Germany, Russia and Scotland, 1880 – 2000



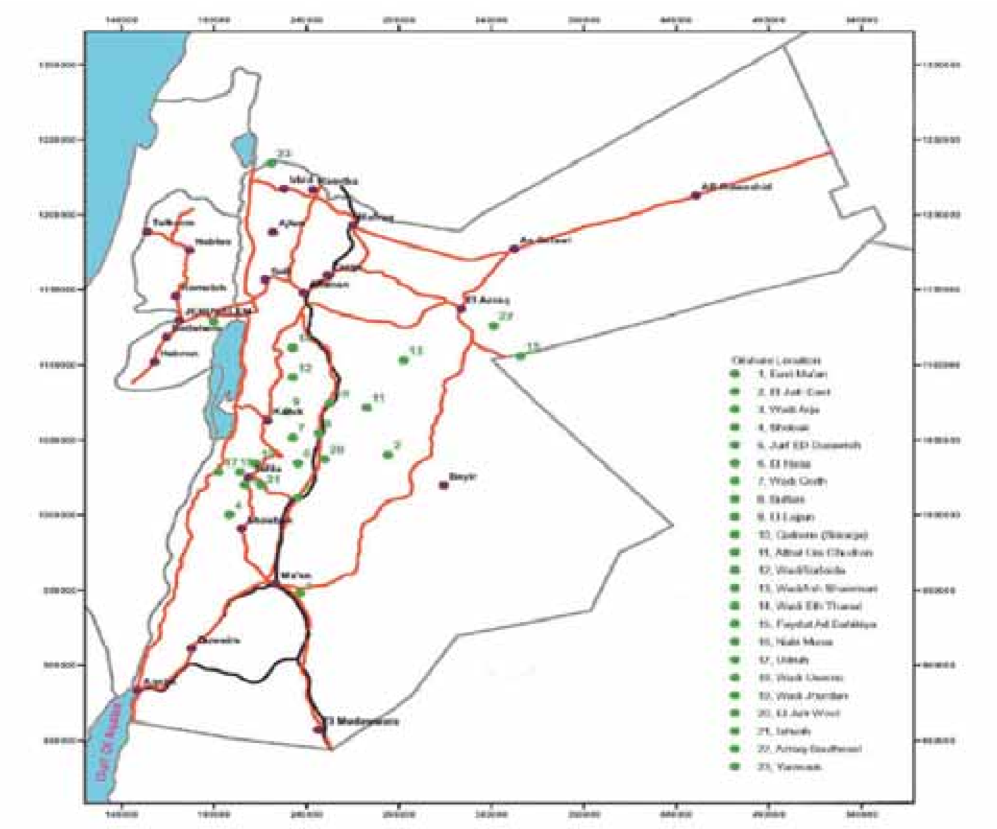
Source: USGS.

„Many oil shale resources have been little explored and much exploratory drilling needs to be done to determine their potential. Some deposits have been fairly well explored by drilling and analyses. These include the Green River oil shale in western United States, the Tertiary deposits in Queensland, Australia, the deposits in Sweden and Estonia, the El-Lajjun deposit in Jordan, perhaps those in France, Germany and Brazil, and possibly several in Russia. It can be assumed that the deposits will yield at least 40 liters of shale oil per ton of shale by Fischer assay". **[WEC, 2007]**.

5.6.1 Potential

Jordan is considered to be the third largest in the world in oil shale reserves. As shown in Figure 5.9, there are about 24 known occurrences, which result in Jordan having an extremely large proven an exploitable oil shale resource. Geological surveys indicate that the existing shale reserves cover more than 60% of the country. Jordan's oil shale reserves are estimated to be 40,000 million ton, containing about 4000 million ton of oil **[MEMR, 2007]**. Four of Jordan's best-known deposits, i.e. El Lajjun, Sultani, Jurf Ed-Darawish, and Attarat Um Ghudran, are located about 100–120 km south of Amman, close to the town of Al Qatrana. These contain more than 22 billion tons of raw oil shale **[NRA, 2007]**. At average oil yield of about 9.0% (roughly 22 gallons per ton (gal/t)) of the potential oil yield, from the previous four deposits only, is approximately 14 billion barrels, which could satisfy Jordan's liquid fuel and electricity needs for centuries **[Jaber et al. 2008]**.

Figure 5.10: Oil Shale Occurrences in Jordan and the Palestinian Territories



Tables 5.1, 5.2 and 5.3 summarize the estimated reserves and characteristics of main oil shale deposits in Jordan **[Hamarnah, 1998]**.

The naturally bituminous marls of Jordan are generally of quite good quality. The oil content and calorific value vary quite widely between deposits but research has shown that 20-30% of the original thermal content remains in the retorted residue, thus providing a source of fuel for the production of heat or electricity.

The eventual exploitation of Jordan's fuel resource to produce liquid fuels and/or electricity, together with chemicals and building materials, would be favored by three factors:

- high organic matter content of Jordanian oil shale,
- suitability of the deposits for surface mining and their location,
- good transport links to potential consumers even though it is away from centers of population

Table 5.1: Estimated Reserves of the Oil Shale Deposits

Eth-Thamad	Jurf Ed Darawish	Wadi Maghar	Attarat Um Ghudran	Sultani	E-Lajjun	
66	90.6	660	348	24.0	20.4	Area (km²)
72–200	63.8	40	45.0	31.6	29.6	Av. Thickness oil shale OS (m)
142–400	47.3	40.5	53.2	69.3	28.8	Av. Thickness of overburden (m)
–	–	1	1.2	1.6	1	Av. Stripping Ratio
11,400	8,000	31,600	24,500	1,130	1,196	Geological reserves (Mt)
–	2,500	21,600	(24,500)*	989	1,170	Calculated & Indicated reserve (Mt)

* NRA current investigation.

Table 5.2: Summary of Chemical and Physical Properties of main Oil Shale Deposits

Eth-Thamad*	Jurf Ed Darawish	Wadi Maghar*	Attarat Um Ghudran	Sultani	E-Lajjun	Wt (%)
10.5	5.7	6.8	8.0	7.5	10.5	Av. Oil content
–	18	20.8	23.16	21.5	22.1	Total organic content
–	864	780-1,270	–	1,210	1,590	Calorific value (kcal/kg)
–	69.1	48	52.2	46.96	54.3	$CaCO_3$
3.2	2.2	2.6	2.6	2.4	3.1	S
1.8	2.1	2.03	1.8	1.96	1.81	Density (g/cm²)
2.5	2.8	2.7	1.71	2.6	2.43	Moisture

* Information is from few boreholes drilled in the area.

5.6.2 Current status

Due to the multiple attacks on the Arab Gas Pipeline which has caused several disruptions of gas supplies to Jordan, the oil shale becomes one of the main alternatives that Jordan is currently exploring in order to meet a five-year "gap" ahead of the development of local energy resources. The abundance of oil shale deposits in Jordan has always inspired energy self-sufficiency aspirations. Since early seventies, MEMR and former Jordan Electricity Authority (JEA) conducted numerous studies and tests to evaluate the potential for shale oil production through retorting technology and Electricity generation through direct burning. Limited technical maturity of existing technologies at that time, in addition to the high cost of such energy in comparison to conventional crude oil and derivates prohibited any actual steps in the mentioned direction. Recently with the technological advances accumulated in the oil shale exploitation technology and the unprecedented increase in oil prices internationally revived the ambitions concerning oil shale resource exploitation.

Most of the feasibility studies and test programs, which have been undertaken by Jordan during the past two decades, have been carried out in cooperation with companies from Germany, China, Russia, Canada and Switzerland. They were all intended to demonstrate utilization through either direct burning or retorting. The Jordanian Government has investigated two main methods of utilizing the oil shale:

(I) Surface ionization of oil shale to produce oil:

Three companies signed memoranda of agreement in November 2006 to prepare feasibility studies of Al-Lajjun region to produce oil from the oil shale. The Companies are:

- The Jordanian Oil Shale company (Estonian Company): the company had been awarded the right to explore 300 million tons of the El Lajjun reserve.
- The Jordanian Company for Mining and Energy, (English Company)
- The International Company for the Natural Resources Investment, (Jordanian Company)

Also, an agreement was signed in July 2007 with the Brasilian company, Petrobras, to study the economic viability of using the company's Petrosix process on the oil shale of the Attarat Umm Ghudran deposit.

The International Company for Crude Oil Shale investments (Saudi Company) has conducted a feasibility study related to Um Al-Ghudran in October 2009.

(II) In-situ conversion process:

The Jordanian government has concluded a commercial agreement with Shell to assess the prospects for producing oil from deep oil shale layers using a thermal injection method, which involves no mining. The full project is expected to last from 13–18 years; the capacity of this project is forecasted to be 350,000 oil barrels per day.

Jordan has sealed an oil shale agreement with Estonian state-owned *Eesti Energia* to extract oil and generate power from one of Jordan's oil shale reserves sites. Under the agreement, the Estonian company is expected to produce 36,000 barrels of oil a day. The firm will reach its full commercial production capacity within ten years. In addition to extracting oil, the Estonian firm will produce electricity from oil shale combustion. The project will generate 600–900 MW of electricity. Eesti Energia had been preparing technical, economic and engineering studies of the project, which are due to be forwarded to the government by the end of 2011. A power plant to generate electricity will launch by 2015.

5.6.3 Problems & barriers

The exploitation of Jordan oil shale reserves is faced with the following barriers and challenges:

The major issue of the oil shale projects development is the significant environmental impacts caused by mining and processing. This includes:

- production of greenhouse gas emissions,
- a large use of water resources (a deficit of 320 million m^3 is forecasted when the first small oil shale plants may appear in the country.)
- the disposal of spent shale (the ash yield is about four times that of a medium grade of bituminous coal with similar sulfur content.)

Oil shale is known to be one of the most polluting energy sources with a very limited international experience in mitigating its environmental impacts. While innovations in mining and processing techniques, like in-situ conversion, can reduce these environmental externalities, oil shale will never be a clean energy source.

The sulfur content in the oil shale is high. The high sulfur content is a very serious defect, because it makes the oil corrosive and unstable, increases the cost of refining, and it is almost impossible for the finished products to meet modern quality standards. Sulfur also inhibits the potential use of the crude shale oil as a fuel for industrial or utility applications **[Jaber et al. 1999, Williams and Chishti 2001]**.

The success of any oil shale project strongly depends on many parameters, such as the investment cost, oil price, capacity factor, or operating costs. Thus, the project could collapse if substantial changes occur in aforementioned parameters; or if the debt is unfavorably structured **[Jaber et al., 2008]**.

5.6.4 Best practices & other experiences

- **Egypt (Arab Republic)**

Oil shale was discovered during the 1940s as a result of oil rocks self-igniting whilst phosphate mining was taking place. The phosphate beds in question lie adjacent to the Red Sea in the Safaga-Quseir area of the Eastern Desert.

Analysis was at first undertaken in the Soviet Union in 1958 and was followed by further research in Berlin in the late 1970s. This latter work concentrated on the phosphate belt in the Eastern Desert, the Nile Valley and the southern Western Desert. The results showed that the Red Sea area was estimated to have about 4.5 billion barrels of in-place shale oil and that in the Western Desert, the Abu Tartour area contained about 1.2 billion barrels.

The studies concluded that the oil shale rocks in the Red Sea area were only accessible by underground mining methods and would be uneconomic for oil and gas extraction. However, the Abu Tartour rocks could be extracted whilst mining for phosphates and then utilised for power production for use in the mines. Additionally, although in both areas power could be generated for the in-place cement industry, the nature of the shale as a raw material would not be conducive to the manufacture of high quality cement.

In view of the depletion of Egyptian fossil fuel reserves, a research project was implemented during 1994–1998 on the 'Availability of Oil Shale in Egypt and its Potential Use in Power Generation'. The project concluded that the burning of oil shale and its use as fuel for power production was feasible, but only became economic when heavy fuel oil and coal prices rose to significantly higher levels. Many recommendations of a technological and environmental nature were made and economic studies continue. A 20 MW oil shale pilot plant for power generation in Quseir was recommended as part of a first step towards the exploitation of Egyptian oil shale.

- **Morocco**

Exploitation of oil shale in Morocco occurred as long ago as 1939, when the Tangier deposit was the source of fuel for an 80 tons/day pilot plant which operated until 1945. A preliminary estimate of this resource has been put at some 2 billion barrels of oil in place.

During the 1960s two important deposits were located: Timahdit in the region of the Middle Atlas range of mountains (north central Morocco) and Tarfaya in the south west, along the Atlantic coast. The total resource has been estimated at 42 billion tons for the former and 80 billion tons for the latter. Oil in place has been estimated at 16.1 billion barrels for Timahdit and 22.7 billion barrels for Tarfaya.

Morocco's total resource is estimated at some 50 billion barrels in place, a level which ranks the country amongst the world leaders in respect of in-place shale oil.

During the 1970s and 1980s, the Office National des Hydrocarbures et des Mines (ONHYM), with the assistance of companies in the USA, Europe, Canada and Japan, undertook research and testing of more than 1 500 tons of Timahdit and 700 tons of Tarfaya oil shale. Within Morocco, some 2500 metric tons of Timahdit oil shale were tested in an 80 tone capacity pilot plant. In 1985–1986 the Moroccan experience led to ONHYM developing its own process called T3, a semi-continuous surface retorting method based on the utilization of two identical retorts operating in tandem according to two modes: retorting mode and cooling mode.

The technical and economic feasibility studies have resulted in Morocco acquiring a large amount of information – a database which can be used for future projects. With the current need to look at developing alternative sources of liquid fuels, the ONHYM has stated that any pilot plant should be followed by a demonstration phase during which the commercial evaluation of by-products should also be undertaken.

- **Estonia**

Oil shale was first scientifically researched in the 18th century. In 1 838 work was undertaken to establish an open-cast pit near the town of Rakvere and an attempt was made to obtain oil by distillation. Although it was concluded that the rock could be used as solid fuel and, after processing, as liquid or gaseous fuel, the 'kukersite' (derived from the name of the locality) was not exploited until the fuel shortages created by World War I began to impact.

Since 1916 oil shale has had an enormous influence on the energy economy, particularly during the period of Soviet rule and then under the re-established Estonian Republic. At a very early stage, an oil shale development program declared that kukersite could be used directly as a fuel in the domestic, industrial or transport sectors. Moreover, it was easily mined and could be even more effective as a combustible fuel in power plants or for oil distillation. Additionally kukersite ash could be used in the cement and brick-making industries.

Permanent mining began in 1918 and has continued until the present day, with capacity (both underground mining and open-cast) increasing as demand rose. By 1955 oil shale output had reached 7 million tons and was mainly used as power station/chemical plant fuel and in the production of cement. The opening of the 1400 MW Balti Power Station in 1965 followed, in 1973, by the 1 600 MW Eesti Power Station again boosted production and by 1980 (the year of maximum output) the figure had risen to 31.35 million tons.

In 1981, the opening of a nuclear power station in the Leningrad district of Russia signalled the beginning of the decline in Estonian oil shale production. No longer were vast quantities required for power generation and the export of electricity. The decline lasted until 1995, since then production levels have varied but generally are less than half of those of the early 1980s.

The total Estonian in-place shale oil resource is currently estimated to be in the region of 16 billion barrels and at the present time continues to play a dominant role in the country's energy balance. However, many factors: economic, political and environmental are all having an effect.

In the years following independence, the oil shale industry was privatized and is now open to the forces of free market competition; production of oil shale has been shown to be economically viable up to a crude oil price of US$ 30 but with prices in excess of this level, new mining projects have become feasible; the country's accession to the European Union has brought compliance with many directives, especially the emissions trading directive. Estonia has ratified the various climate change and pollution control protocols of recent years but must increasingly address the air and water pollution problems that nearly a century of oil shale mining has brought. Many investment programs have been launched in an attempt to reduce the environmental effects of oil shale.

In 2005 14.6 million tons of oil shale were produced, among them the billionth tone. Imports amounted to 0.2 million tons, 10.9 million tons were used for electricity generation, 0.7 for heat generation and 2.8 million tons were processed for shale oil and coke production. Production of shale oil was 345 000 tons, 222 000 tons were exported, 8 000 tons were utilized for electricity generation and 98 000 for heat generation.

The historical ratio of underground mining to open-cast (approximately 50:50) is tending to move away from open-cast production as the bed depths increase – the exhausted open-cast areas are gradually being recultivated and reforested. The Government has decreed that the share of renewables in electricity productionwill increase to 5.1% by 2012. Additionally, both the Long-term Development Plan for the Estonian Fuel and Energy Sector and the Estonia Forestry Development Program for 2001 – 2010 both state that the share of biofuels will increase. However, although the country possesses low-pollution peat and biofuels resources, they are limited and therefore oil shale is likely to remain central to the energy balance in the next decade.

- **Brazil**

The oil shale resource base is one of the largest in the world and was first exploited in 1884 in the State of Bahia. In 1935 shale oil was produced at a small plant in São Mateus do Sul in the State of Paraná and in 1950, following government support, a plant capable of producing 10 000 b/d shale oil was proposed for Tremembé, São Paulo.

Following the formation of Petrobras in 1953, the company developed the Petrosix process for shale transformation. Operations are concentrated on the reservoir of São Mateus do Sul, where the ore is found in two layers: the upper layer of shale (6.4 m thick), with an oil content of 6.4%, and the lower 3.2 m layer with an oil content of 9.1%. The company brought a pilot plant (8 inch internal diameter retort) into operation in 1982, its purpose being for oil shale characterization, retorting tests and developing data for economic evaluation of new commercial plants. A 6 ft (internal diameter) retort demonstration plant followed in 1984 and was used for the optimization of the Petrosix technology.

A 2 200 (nominal) tons per day, 18 ft (internal diameter) semi-works retort (the Iratí Profile Plant), originally brought on line in 1972, began operating on a limited commercial scale in 1981 and a further commercial plant – the 36 ft (internal diameter) Industrial Module retort – was brought into service in December 1991.

Together the two commercial plants have a process capacity of some 7 800 tons of bituminous shale daily. The retort process (Petrosix) where the shale undergoes pyrolysis yields a nominal daily output of 3 870 barrels of shale oil, 120 tons of fuel gas, 45 tons of liquefied shale gas and 75 tons of sulphur. Actual daily output in 2005 was 3 040 barrels of shale oil, 80 tons of fuel gas, 31 tons of liquefied shale gas and 49 tons of sulphur.

The Ministry of Mines and Energy quotes the end of 1999 shale oil reserves as 445.1 million m^3 measured/indicated/inventoried and 9402 million m^3 inferred/estimated, with shale gas reserves as 111 billion m^3 measured/indicated/ inventoried and 2353 billion m^3 inferred/estimated.

- **Germany**

The German oil shale industry was developed in the middle of the 19th century and during the 1930s and 1940s the development of retorted oil contributed to the depleted fuel supplies during World War II.

Today the only active plant is located in Dotternhausen in southern Germany, where Rohrbach Zement began using oil shale in the 1930s. At the beginning of 2004, Holcim, a Swiss cement and aggregates company acquired Rohrbach Zement. The oil shale from this area has a low energy content, low oil yield and high ash content but by using a complex process the complete utilization of both the oil shale energy and all its minerals can be accomplished and incorporated into the manufacture of cement and other hydraulic binding agents. A small part of the oil shale is directly used in a rotary kiln for cement clinker production as fuel and raw material. Most of the oil shale, however, is burnt in fluidized-bed units to produce a hydraulic mineral cement component while the heat of this process is used simultaneously to produce electricity.

A minimal quantity of oil shale is produced for use at Holcim's Dotternhausen cement plant. In 2005 and 2006 production amounted to 284 000 and 320 000 tons respectively.

In 1965 it was estimated that Germany's in place shale oil resources amounted to 2 billion barrels.

5.6.5 Policy recommendations for Jordan

- Jordan should secure proper Environmental Impact Assessment (EIA) Studies for each step of oil shale project. EIA studies should not be undertaken on individual project bases instead, a bubble approach is required to capture the cumulative adverse effects of all planned projects. Concerned parties should coordinate efforts to insure that future oil shale projects will not cause irreversible damages to the environment.

- Jordan should install a robust oil refinery that can process crude shale oil in order to remove much of the market risk from an oil shale project. This shall reduce the capital and operating costs for the project.

- Jordan should take positions in the projects (as done in the phosphate mining and potash industries), thereby providing access to inexpensive multilateral financing, with lower interest rates and longer terms.

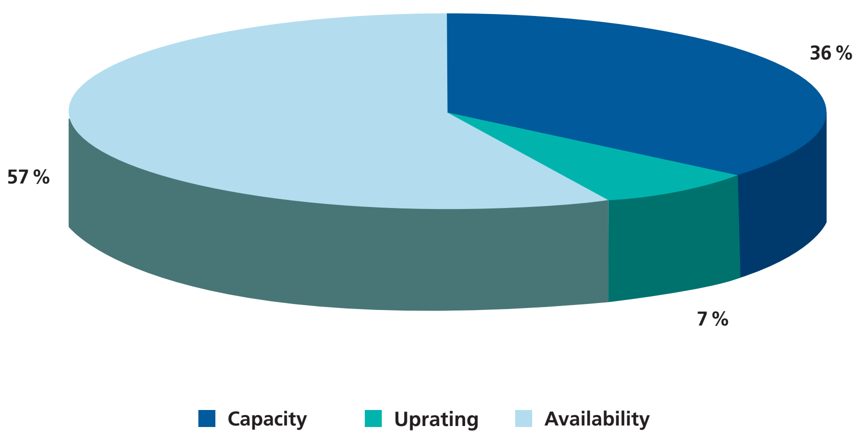
- Water conservation should be emphasized in the Government's negotiations with projects developers. Rates of water use should be considered as one of the critical criteria when evaluating competing proposals.

- Adequate utility services and sufficient public services should be made available, such as public transportation, education, health care, and police and fire protection. This is because normally a rapid development occurs due to the reshaped social, economic, and political life of the communities in the oil shale region, cause by any commercial-scale oil shale project.

5.7 Nuclear Energy

Nuclear power plants are primarily used for electricity production. Currently, 439 reactors are operating in 30 countries and producing over 2700 TWh per year, which is about 16% of the global electricity generation, and about 6% of the primary energy consumption **[OECD/IEA, 2006, IAEA]**. The share of nuclear power in global electricity generation has declined slightly in recent years. However, the total amount of nuclear electricity generation is increasing as plant availability, power uprating, and new plants offset the loss from older plants that are being shut down (Figure 5.10). Due to the economic benefits of continuing operation of a plant after the capital cost has been repaid, and with careful plant life management assessments, a number of reactors have had their operating licenses extended for an additional 20 years. About 58 power reactors are currently being constructed in 14 countries.

Figure 5.11: Factors Contributing to Increase in Nuclear Power Production, 1990 – 2005



The International Atomic Energy Agency (IAEA) in its 2009 report significantly increased its projection of world nuclear generating capacity. It now anticipates at least 73 GWe in net new capacity by 2020, and then 511 to 807 GWe in place in 2030 – very much more than projected previously, and 37% to 116% more than the 327.5 GWe actually operating in 2009. OECD estimates range up to 680 GWe in 2030. The change is based on specific plans and actions in a number of countries, including China, India, Russia, Finland and France, coupled with the changed outlook due to the Kyoto Protocol. The IAEA projections would give nuclear power a 13.5 to 14.6% share in electricity production in 2020, and 12.6 to 15.9 % in 2030. The fastest growth is in Asia.

It is noteworthy that in the 1980s, 218 power reactors started up, an average of one every 17 days. These included 47 in USA, 42 in France and 18 in Japan. These were fairly large – average power was 923.5 MWe. So it is not hard to imagine a similar number being commissioned in a decade after about 2015. But with China and India getting up to speed with nuclear energy and a world energy demand double the 1980 level in 2015, a realistic estimate of what is possible (but not planned at this stage) might be the equivalent of one 1000 MWe unit worldwide every 5 days.

Light water reactors (LWRs) are by far the most prevalent reactors in use today, followed by pressurized heavy water reactors, gas cooled reactors and, currently, two fast reactors. The safety and reliability of nuclear facilities have been steadily improving. Strong networks among countries with operating nuclear power plants have enabled operators to learn from each other and to address common issues. Ongoing efforts have continuously strengthened safety culture and regulatory oversight.

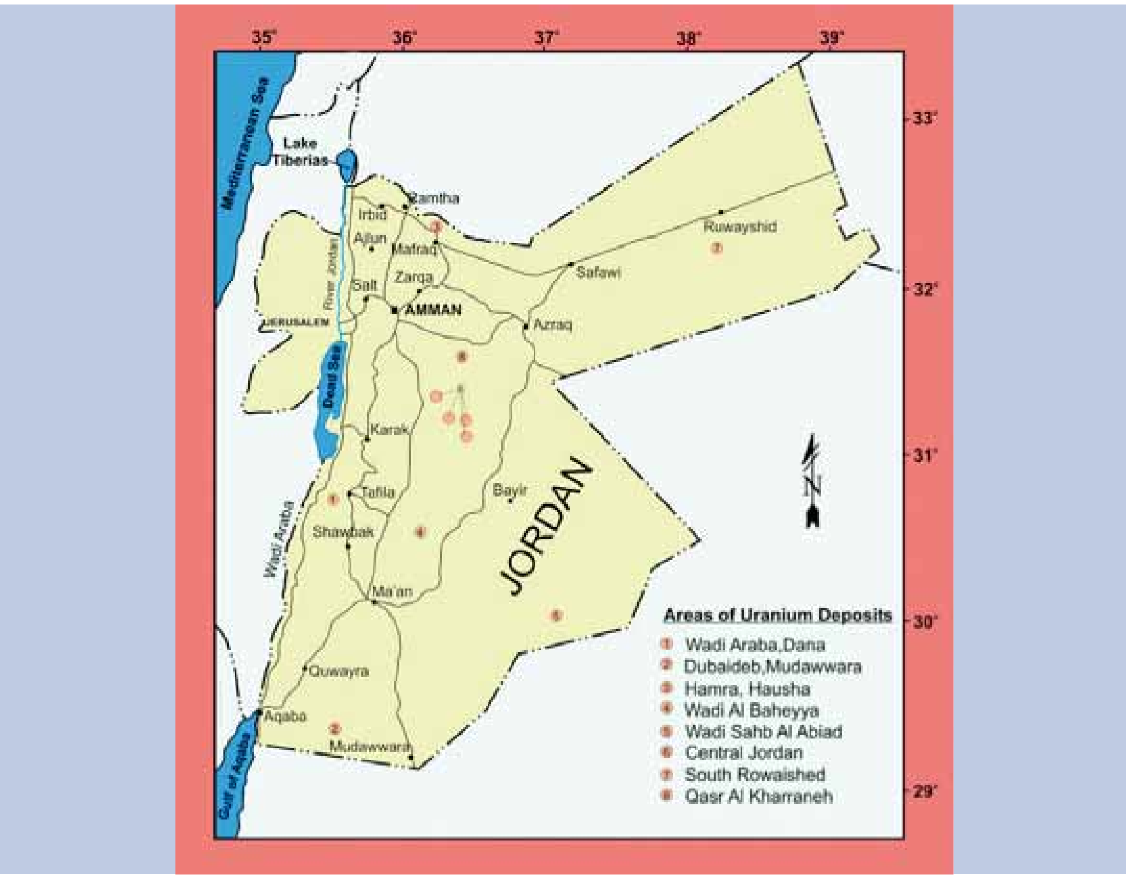
Only a few countries currently use civil nuclear energy for purposes other than electricity production – mainly for seawater desalination and district heating – and even then only to a limited extent. Nevertheless, nuclear power use in non-electricity generation applications may increase in the future for applications such as desalination of seawater, district heating, process heat for industrial applications and coal liquefaction, and hydrogen production. Nuclear power's contribution to the reduction of greenhouse gas emissions may be increased through its indirect contributions in the transportation sector, such as electric powered vehicles and trains

Developing countries with sizable domestic fuel resources have recently begun looking at the feasibility of introducing nuclear power in the 2015–2020 time frame. These include OPEC members Indonesia and Nigeria as well as six member countries of the Gulf Cooperation Council. For them the immediate impact of increased oil prices is not the same as that for oil importers, but the logic may lead in the same direction. Nuclear power can be a vehicle to increase export revenues by substituting domestic demand for natural gas (and to a lesser extent oil) by nuclear power **[WEC, 2007]**.

5.7.1 Potential

Studies have estimated uranium reserves in Jordan be around 60 thousand tons in the central region. in addition to other amounts which are currently being estimated in areas such as Al Baheya Valley, Al Saheb Al Abyad Valley, and Al Ruweished, as shown in Figure 5.11.

Figure 5.12: Areas of Potential Uranium Deposits in Jordan and Palestinian Territories



At the mid of 2011, some 12,300 tons of potential uranium resources have already been identified over an 18 km^2 area in central Jordan. Since 2009, as it has been announced by the Jordanian French Uranium Mining Company (JFUMC), a joint venture of Jordan Energy Resources Inc. and French AREVA, the JFUMC performed intensive exploration activities in the Central Jordan license. Moreover, another ongoing drilling program is currently progressing on secondary adjacent areas, and will be achieved by the end of 2011. However, the overall uranium potential on the license should exceed 20,000 tons according to the preliminary results on this second exploration phase, as announced by JFUMC.

Accordingly, technical and economic studies will be conducted in 2012 to assess the feasibility of an uranium extraction program within the license, taking into account the current and future uranium market outlook.

The Jordan Atomic Energy Commission has taken practical steps to start the extraction of uranium deposits through establishing the Jordan Energy Resources Incorporation (JERI), a Jordanian company with a mandate to explore uranium, thorium and other heavy metals, mining of uranium ore, extraction of uranium from phosphates, milling and processing of yellow cake and other special nuclear heavy metals and provision of nuclear material needed for the civilian nuclear fuel cycle.

It is expected that the rate of production of uranium from mines in the central region will be about 2,000 tons annually, where part of this quantity will be used in Jordanian nuclear reactors and the other part will be exported abroad.

5.7.2 Current Status

In February 2010, Jordan has signed an agreement with AREVA (a French company) to start mining uranium in a designated location in central Jordan. Uranium mines in central Jordan according to preliminary estimates could produce 2000 tons annually, a small part will be used to operate Jordan's nuclear power plant, and another part will be used as a strategic reserve, while the rest will be exported. The Jordan Atomic Energy Commission (JAEC) strategy with international companies is based on a full partnership with no concession. Simultaneously, RIO TINTO (Australian Company) is currently undertaking the task of excavation for Thorium and Zirconium and other metals in the southern part of Jordan, and has already discovered some quantities of zirconium and thorium. Accordingly, Jordan is currently establishing a "uranium atlas" of the country.

5.7.3 Problems & Barriers

- Public and political opposition because of concerns about possible nuclear accidents and the nuclear waste issue (and on proliferation, on another scale): There has been growing opposition to the nuclear power program, especially because of the proposed new site of the nuclear plant northeast of Amman. Opposition has been galvanized further by the Fukushima accident, since which there have been several anti-nuclear protests in Amman.

- Financing difficulties: Nuclear energy has very low costs of fuel and operation, but very high initial investments. Investors are also afraid of the so-called regulatory risks, i.e., changes in the safety standards and evaluations, which can delay the plant construction and therefore increase the financial costs.
  JAEC has determined six major challenges to be dealt with in order to move forward with the development of its nuclear energy program, namely:

  - The exploitation of uranium ores
  - Funding
  - Nuclear fuel cycle and waste management
  - Choice of reactor technology and appropriate application
  - Human resource development
  - Readiness of the State and the political environment

- Critics argue that there is a shortage of local technical experts while proponents of the nuclear option insist that a sufficient number of experts is locally available. According to the critics, there is a lack of local expertise, and the training to be offered as part of pre-construction and to be included in each offer.

- The risk of using treated wastewater from the Khirbet Al Samra water treatment plant for reactor cooling purposes, even though it would be operated by a similar operational technology to the Palo Verde power plant in Arizona; however, a critical debate is ongoing in this regard in Jordan.

5.7.4 Policy Recommendations for Jordan

Jordan has to stress on safety issues related to the nuclear reactor by achieving and maintaining a high level of safety in nuclear installations through the development of safety standards related to site selection and site evaluation, site related aspects of the radiological impact on the environment, and structural engineering and design related aspects and long term operation, including ageing management, periodic safety review and configuration management, as well as external hazards, including all external events that may affect installation safety of natural and human induced origin.

The following systematic steps followed by the international nuclear energy generating countries that can be adapted by Jordan are:

- Conducting safety assessments and safety enhancements at nuclear installations effectively;
- Developing and applying advanced deterministic and probabilistic analytical methods/tools related to events, accidents and severe accidents, to prevent human induced events of malevolent origin, and include the mitigation of their possible consequences, with respect to systems design;
- Assessing the safety aspects of the design of nuclear installations; in integrating deterministic, probabilistic and performance based approaches and applications to the risk informed decision-making process;
- Developing and implementing safety performance indicators to monitor safety performance, better apply safety assessments, and increase their transparency;
- Developing and implementing configuration management and design basis maintenance;
- Establishing and implementing safety assessment education and training programs, and;
- Systematic sharing of lessons learned from safety events. For each safety significant event, its description, cause analysis, lessons learned including the implemented corrective actions provide valuable information to organizations professionally involved in the nuclear fuel cycle industry, such as regulators and their technical support, operating organizations, vendor companies such as design firms, engineering contractors, manufacturers, and research establishments working in the fuel cycle field.

Public involvement is critical to the success of the project, thus Jordan has to disseminate enough information to the public and get stakeholders to support the project.
The nuclear waste solution has to be reached and announced to the stakeholders and to the public as well, to enable local communities to feel safe and secure.
Security of Supply has to be guaranteed by agreements and treaties with partners and suppliers of uranium (if Jordan was not allowed to enrich uranium).

Chapter 6: Conclusions & Key Findings

The following discussion covers our findings and key issues in the Jordanian Energy Sector. First part of discussion relates to all sub sectors, the second part discusses in more detail issues pertaining to RE sub sector.

6.1 General

During the course of the research, two events occurred that have led many countries to re-visit their energy strategies and initiatives. The first is the "Arab Spring", which is defined as a pro-democracy uprising currently (2011) sweeping the Middle East and North Africa, through which millions of citizens are demanding political and economic reforms. The second is the earthquake and tsunami that struck Japan on March 11, 2011 and severely damaged the Fukushima nuclear power facility, causing a failure in its power plants' cooling systems and leading to radioactive waste leaking into the surrounding environment.

At the time of publication the ramifications and consequences of these two events are varying across the world. The consequent implications of the Arab Spring on Jordan have worsened its energy supply and burdened its economy. The several attacks on the Egyptian natural gas pipeline are highlighting the unreliability of natural gas as a short-term solution for energy security and demand in Jordan. Consequently, this has forced Jordan to shift from a clean source of energy to the more expensive diesel and heavy oil fuel to secure its energy demand.

The reliance on oil imports as a substitute to natural gas, combined with the fluctuation of international prices, has increased the imported energy bill for 2011. It is predicted to top $4.8 billion, equal to 20% of the expected GDP for 2011, one of the highest rates worldwide. Moreover, the increase in world energy prices for the whole year 2011 is expected to cost Jordan over JD 1.5 billion more than the previous year.

The Fukushima nuclear accident has played a role in stirring up a lot of debate in Jordan. However, although the Jordanian government is now encountering a growing resistance to nuclear power from public-interest groups and an emerging anti-nuclear campaign taking place amongst a broader context of political demonstrations, Jordan is still seriously considering nuclear power as part of Jordan's energy mix.

Even though it is still too early to make a precise assessment of the future impacts of both the Fukushima disaster and the Arab Spring, the increase in oil prices during 2011 would likely be very different in nature from those of 1973, 1980, 1990 and 2008. Even before the political upheavals in the Middle East and North Africa and the Fukushima nuclear disaster in Japan, oil prices were already high comparatively.

6.1.1 Security of Supply

Limited participation of indigenous energy resources in the overall energy mix is one major concern to the Government of Jordan. The several interruptions in Egyptian gas supplies in 2011, which were disrupted six times due to multiple acts of sabotage on the Arab Gas Pipeline in the Sinai, have widened Jordan's budget deficit and stressed on the urgent need to develop alternative local energy sources.

Serious efforts have been initiated in the last few years to address this issue. On the oil and gas front, the government, through its Natural Resources Authority (NRA), divided the Kingdom into 8 exploration blocks according to geological features. These blocks were auctioned to international oil companies and six blocks were awarded and Production Sharing Agreements PSA signed. In addition NPCO, the holder of concession to Risheh Gas field, signed an agreement with BP Company to develop the field to a larger deposit and production. If these efforts succeed in establishing a presence of commercial crude oil deposits in Jordan, this will lead to a major shift in the energy situation. To date, all exploration efforts yielded disappointing results; most promising ongoing attempt would be the discovery of larger reserves of natural gas in the Risheh field and expanding production.

As a consequent implication of gas instability in Egyptian gas supplies and the subsequent reliance on imported heavy fuel combined with the fluctuation of international prices, NEPCO's debt has during 2011 increased to $700 million. Consequently, this has placed an increased pressure on Jordan to fulfill the National Energy Strategy, which aims to boost reliance on domestic energy sources for electricity generation from 2% to 40% by the end of the decade.

Searching for alternative energy sources, in light of disrupted natural gas supplies from Egypt, Jordan imports heavy oil from Iraq through an agreement inked between Amman and Baghdad in June 2011 under which Jordan is to receive 30,000 tons of heavy oil per day at a $88 per ton discount rate.

In addition to limited indigenous resources, limited import sources magnify the security of supply issue. Crude oil and oil products are totally dependent on road tankers either from Iraq (with its inherent risk factors) or from the Port of Aqaba. Several pipeline options were considered over the years but none materialized due to host of reasons. One crucial barrier was and still is the uncertain future of the JPRCO Refinery (see discussion below) being the beneficiary from the pipeline.

6.1.2 Refining and Oil Products

The present policy of the Government of Jordan aims at liberalizing the refinery sub sector through non-renewal of JPRCO concession and the decision to license three additional companies to import and distribute oil products. This scheme will put the refinery in direct competition with international product sources to produce products at the same new specifications adopted by the government (Euro IV) and at comparable Refinery Gate Prices. Examining the details of the proposed new structure reveals that there are no safe guards against Dumping Prices leading to significant risk for refining. To be able to meet new specifications, the refinery requires extensive investment for expansion and upgrading, recent estimates put the required investment in the range of $ 2 – 2.2 Billion. All attempts to attract a strategic partner failed due to the high risk and uncertainty facing the project without any governmental guarantees. The option to extend the concession to a limited number of years was rejected by the government. This will remain an unsolved issue on the short term. The closure of the refinery proves unavoidable under this policy; major economic social and political repercussions will follow.

6.1.2.1 Natural Gas

Currently, natural gas feeding the Jordanian energy system comes from two sources, the Risheh field with an average production of 7.8 BCF per year used entirely to fire 30x5 MW Gas turbines in the Risheh Power Station generating some 4% of total electricity generated in the country. NPC signed an agreement with BP to develop the field. The second source is the Trans Arab Pipeline from Egypt extending through Jordan into Syria owned and operated under concession by Al-Fajr Company, which supplied power stations with 111 Billion CF of Egyptian natural gas in 2009. The Government of Jordan had ambitious plans to introduce natural gas into the domestic and commercial sectors. Preliminary studies were prepared to supply major cities with natural gas through the development of distribution networks. Prior to the Arab Spring, the developments on the Egyptian Natural Gas front suggested that these projects would be delayed indefinitely due to Egyptian Gas availability and price issues unless other sources were found. The details of the Egyptian Natural Gas Supply Agreement have not been made public yet at the time of writing this study; nonetheless it is obvious that no legal provisions were made to guarantee a future increase in Jordan's share of supplies of Egyptian Natural Gas.

However, the severity of Jordan's dependence on imports of Egyptian natural gas through the Arab Gas Pipeline for 80% of its electricity generation has been clearly illustrated in the first half of 2011. The Ministry of Finance estimated that gas supply disruptions in the first half of 2011 cost Jordan USD $895 million, and it is expected to cost $1 billion by the end of December. Eventually, Jordan will have spent 20–22% of its GDP on energy imports by the end of the year.

The gas supply agreement calls for Egypt to supply 240 million cubic meters of gas per day over a 12-year period, at prices 30% below international market value. Egypt is currently trying to re-negotiate this agreement by providing "some" gas at this original price but pricing the rest at incremental rates.

Jordan attempts to cover a five-year gap period ahead of the development of domestic energy sources including solar, wind and nuclear power. The country offered a tender for a liquefied natural gas (LNG) terminal, with plans in place to construct an offshore terminal in the Port of Aqaba by 2013 and import liquefied gas. However, the current estimates indicate that it would take three years for Jordan to prepare the necessary infrastructure prior to import.

In addition to the switch to liquefied gas, there is an ongoing exploration and drilling project in Risheh, a natural gas field near the Iraqi border, which is carried out with the potential to extract up to one billion cubic feet per day.

6.1.2.2 Oil Shale

The abundance of oil shale deposits in Jordan has always inspired energy self-sufficiency. Since the early seventies, NRA and former Jordan Electricity Authority (JEA) conducted numerous studies and tests to evaluate the potential for shale oil production through retorting technology and electricity generation through direct firing. Limited technical maturity of existing technologies in addition to the high cost of such energy in comparison to conventional crude oil and derivatives prohibited any actual steps in the mentioned direction. Recently with the technological advances accumulated in the oil shale exploitation technology and the unprecedented increase in oil prices internationally revived the ambitions concerning oil shale resource exploitation. Agreements signed with international companies, will reach definitive conclusions within the coming few years. If positive results are achieved, this will lead to dramatic changes in the energy situation in Jordan.

6.1.3 Financing Energy Projects

In the last two decades, Jordan had successfully applied a strict economic reform program; financial reforms and privatization of government owned assets were accomplished, yet the recent international economic crisis brought the Jordanian economy back to square one where debt reached its highest rate allowable by law of 60% of GDP. Traditionally Jordan financed energy projects in general and power generation in particular through loans from the World Bank, international commercial banks, and Arab funds. To minimize the financial burden, the government's policy shifted towards constructing new projects especially for generation, through IPP's by means of competitive beddings based on BOO concept. The First IPP Project was officially running by August 2009 and second IPP reached financial closure by November 2009. The government will continue to apply this approach in the power generation sector regardless of the nature of technology, this is also the model applied for RE generation projects. Whether this experience can be extrapolated successfully to RE generation remains a debatable issue. In the transmission and distribution sub sector, corporate financing is still the model applicable by the concerned companies. It's noteworthy that local financial institutions participation in investments in major energy project is negligible. As for the Refining and oil products sub sector, the interest of the private sector is oriented totally to the commercial part of import and distribution of products where investment requirements on the one hand are very limited compared to refining capacity expansion and upgrading, on the other hand the risk in distribution business is much limited compared to refining.

6.1.4 Environment

Except for few hot spots, Jordan does not have pressing environmental problems. Energy related activities are major source of pollution; current fuel specifications determined by the existing refinery configuration are not acceptable if compared to international specifications. Lead was recently phased out from Gasoline and replaced by MTBE to adjust the Octane number; this represented a major improvement to the environment especially in populated and congested areas in cities. The introduction of Natural Gas in power generation replaced large quantities of Heavy Fuel Oil characterized by high Sulfur and heavy metals content relaxing the environmental stress in power generation stations area. New gas turbines installed in the newly constructed Combined Cycle power stations are equipped with low NOX burners making Natural Gas the most clean source of energy in Jordan. On the other hand, high Sulfur content in Diesel fuel (1.5%) is still a major source of pollution in both stationary and mobile sources. Transport sector being the major energy consumer (39% of final energy demand in 2009) of both Gasoline and Diesel, mobile emission sources (vehicles) represent a priority to any environmental action plan. The National Strategy contemplates the production and use of oil products according to Euro IV specifications, which once applied will reduce pollutants significantly. Ministry of Environment MOE, conducted air quality monitoring study in Al-Hashimya area to evaluate the situation in one of the most environmentally hot spots in Jordan. This is a heavily industrialized area with major sources of pollution (Hussein Thermal Power Station, Jordan Refinery, Samra Waste Water Treatment Plant and several Iron and Steel manufacturers). The monitoring established serious exceeding rates of pollutants relative to applicable Air Quality Standards. As for GHG emissions, energy sector was responsible for 17.5 million tons of CO_2 EQ in the year 2000 out of 23 million tons.

6.1.5 Nuclear Energy

Jordan during the next decade is obligated to move towards indigenous energy resources. The costs of producing energy in the current time are diminishing our economy and impeding the development process.

Nuclear power is one of the options on the table due to the availability of uranium in Jordan. However, adopting the nuclear option to generate electricity and desalinate water entails bringing in enormous efforts on the country level and preparing a risk mitigation plan for anticipated risks. The risks associated with developing a peaceful nuclear power program comprise from a wide spectrum of issues ranging from economics to politics, finance, management and regulatory. Each of which has consequences that lead to increased costs and diluting returns or possible postponement and cancellation of the program.

Although nuclear power produces little carbon dioxide, there are multiple threats to people and the environment from its operations. These include the risks and environmental damage from uranium mining, processing and transport, the risk of nuclear weapons proliferation, the unsolved problem of nuclear waste and the potential hazard of a serious accident.

As has been mentioned several times before in this study, Jordan is still focusing on nuclear energy to meet parts of its energy needs and to achieve a maximum level of energy diversification in spite of the Fukushima nuclear incident which has led to a growing resistance to nuclear power from public-interest groups and an emerging anti-nuclear campaign.

Thus, it is evident that the public policy responses will have to focus on improved governance and safety standards and to search for other affordable and viable energy sources.

6.2 Renewable Energies Specific

6.2.1 General Policy Level

In response to the Fukushima disaster, Jordanian citizens have been calling for an acceleration in the development of clean and renewable energies and to stop the nuclear power project. Globally, such a change of direction would mean a massive transfer of investments towards unconventional oil and gas resources and towards renewable energies.

In the years and decades to come, the upheavals that have been seen since the beginning of 2011 are likely to cause a rapid development of renewable energies in both developed and developing countries. Jordan is among these countries. This is because Jordan, specifically in RE, is ahead of many of its neighbors in creating a legislative framework. It provides investors in the RE sector with a number of incentives, a guaranteed network access and some tax and customs exemptions. Nevertheless having a new regulatory framework in place is not sufficient for a smooth process of project implementation and substantial work is still needed to implement the regulatory framework on the ground, including the necessary by-laws and further assurances for potential investors.

Except for SWH applications, the RE resources in Jordan are extremely under-utilized. Since the creation of MEMR in 1984 and later the establishment of NERC in 1998 side by side with the Royal Scientific Society in 1970, the total installed capacity of RE is a mere 1.445 MW Wind turbines and 103.3 KW of PV. In addition to the fact that RE contribution in primary energy did not exceed 2%, all indicate that RE was never really a priority to decision makers, on the other hand Egypt for example succeeded in becoming the leading country in the region in RE projects and technologies. Egypt is planning to generate 20% of electricity in 2020 from RE sources, 12% of these RE sources are to come from Wind Energy. The Jordanian experience was severely hampered by two factors: first, assuming that RE can provide energy at competitive prices compared to conventional sources, thus evaluating proposed RE projects on the base of KWh cost alone and second factor, the government of Jordan relied on private sector to create and develop the RE sector. In reference to the Egyptian experience, developing a new industry with a host of risk factors proved to depend on government involvement. In the case of RE in particular, governments had more access to financial aid programs than a private sector did. The Government of Egypt succeeded in bringing the price of KWh from Wind Farms into the range of 3 – 5.5 Euro cent by using government financing arranged by the New & Renewable Energy Authority (NREA) of Egypt, and soft loans from European countries. Once success cases are on the ground, private sector may take over and speed the development. The Egyptian Government spearheaded the RE sector through the National Renewable Energy Agency NREA established in 1986. NREA has (122) engineers supported by a cadre of 109 trained technicians, 63 accountants and economists besides the administrative staff. By the end of 2009, NREA had 430 MW of Wind power installed compared to 5 MW in the year 2000. Only recently (May 2009) did Egypt open the door for private power producers through an invitation for a 250 MW Wind Farm on BOO basis.

The rural electrification project in Jordan resulted in connecting 99.9% of the population to the national grid; this achievement eliminated all possible Small Scale RE applications. As mentioned above (section III), only few applications are in place currently. Net metering introduced by the new RE&EE Law is not adequate as it is for Small Scale RE applications in connected households and buildings. These applications will not be feasible due to the inherent higher cost of energy from such applications (cost of electricity from PV is 4 – 5 fold higher than from conventional sources) in addition to the absence of Feed-in Tariff.

Research and Development (R&D) in the RE faces the same inherent barriers faced by R&D sector in Jordan. Lack of adequate financial resources is the major barrier in R&D as shown by allocated budgets in relevant institutions. NERC the main scientific and technological arm of the Government of Jordan in RE had to act within a very limited budget not exceeding 500 thousand JD per year. This budget includes salaries and other overheads faced by the center. The same situation is faced by specialized R&D centers in universities, for example the Water and Environment Research and Study Center at Jordan University internal financing was 99,000 JD plus 101,000 JD as external revenues during 2009, such budgets obviously will not support any serious R&D activities.

Except for SWH, no significant manufacturing base exists in Jordan. Modest manufacturing attempts are made by NERC in (manufacturing and developing some PV- System components) and (mechanical wind pumping system). Creating a manufacturing broad base needs comprehensive policy revision and designing a package where energy generation from RE is coupled with technology transfer and creation of a domestic manufacturing base.

RE becoming a focal issue internationally prompted several local entities (universities, NGO's and private companies) to become active participants in the efforts to promote RE in Jordan, this positive development needs coordination to maximize synergy and avoid harmful competition on limited resources and duplication of efforts.

6.2.1.2 RE & EE Law No. 3/2010

In 2011, and due to natural gas disruption and unreliability of gas supplies from Egypt, Jordan has taken a series of measures to use energy rationally at government institutions and public facilities, and urge the citizens to cooperate in energy conservation, as Jordan's power plants were forced onto their costly heavy fuel oil and diesel reserves.

The issuance of the Law in 2010 represents a major step forward in the efforts to exploit RE&EE resources and opportunities. The following observations aim at maximizing the positive effect of the law in future applications and probably future amendments.

The Law reflects the general past attitude of the government towards RE sector namely the adoption of KWh price as the main criterion in evaluating projects without provisions for technology transfer and domestic industry creation issues and, almost total reliance on private sector to develop RE &EE sub sector in Jordan. The suggested RE&EE Fund may provide the opportunity for the Government to reassume its leading role in developing the sub sector. This will depend on the size of the fund and the way assets are allocated to the envisioned activity windows such as equity participation, grants, tariff subsidy, interest rates subsidy and most importantly RE vs. EE projects. The last point is crucial due to the fact that RE projects (except for traditional SWH) are inherently non feasible in comparison to conventional energy sources, while EE projects on the other hand are highly feasible and barriers facing EE could be overcome at lower costs, this fact was established during GHG Mitigation Options Analysis conducted for the Second National Communication to the UNFCCC.

Another critical issue to be considered in operating the Fund is the financing scale required for RE vs. EE, the former generally being more finance (subsidy) intensive than the latter. Therefore and in order to sustain a rolling funding process and achieve Government goals in RE at the same time, careful balancing of asset allocation between RE projects and EE projects should be maintained in Fund operations.

Reluctance of the Government to introduce feed-in tariff by the Law reflects its attitude discussed above, where RE projects are evaluated mainly on KWh price, while the feed-in tariff reflects a broader approach where the RE is treated as a package that includes other future added values compensating the apparently high feed-in tariff. The Law adopts ambiguous price definition where the developer shall propose a price (acceptable range according to the Reference Pricelist). This ambiguity in price definition will create a problem of subjective evaluation of future proposals making the price negotiations a political rather than a technical issue.

Several important issues are not addressed directly by the Law and left for future decisions and instructions to be issued by relevant entities. For example the Law directly addresses the cost of interconnection to the National Grid and allocates this cost to the Bulk Supplier (NEPCO) while in case of connecting to retail supplier grid; the issue is left to be handled by instructions to be issued by ESRC. Another example relates to electricity generated by individual generators (households) where (The size and nature of such renewable energy facilities and the selling price of the generated electrical power shall be specified in accordance with instructions to be issued by the Commission).

Finally, the Law concentrates on RE almost exclusively while EE is mentioned in general terms and left for the last article in the Law: Article 17 – The Council of Ministers will issue by-laws necessary for the execution of the provisions of this Law including the procedures and measures for energy conservation and energy efficiency in various sectors. Issues like codes, standards, labels, promotion, and awareness relating to EE are not addressed and responsibilities of different acting entities are not identified.

6.2.2 Technology Specific

6.2.2.1 Solar Energy

NERC is conducting a long term project for collecting and evaluating solar insolation intensity on a horizontal surface to have new solar data. For this purpose, 14 measurement stations were installed around the country.

This will enhance investment attraction into the sub sector. As mentioned earlier, SWH technology is the most advanced application in Jordan with 1,135,000 square meters (2002) total collector's area, the National Strategy targets a rate of SWH penetration in households of 25% in 2020.

Other pilot applications in place are:

- Solar desalination using the solar heat pipe principle
- Solar desalination using the solar still method
- Parabolic trough desalination system in the city of Aqaba
- Photovoltaic brackish water reverse-osmosis desalination facility at Aqaba international industrial estate
- Photovoltaic water pumping systems

Large (utility) scale projects proposed earlier all failed due to the high price demanded for produced energy, the government's attitude towards energy from RE resources mentioned earlier, represent a major barrier to RE development in general and Solar in particular since price of electric energy from Solar is higher than other RE sources.

6.2.2.2 Wind Energy

NERC is executing a long term project for wind data (wind speed and wind direction) collection and evaluation to have new wind data that can be evaluated according to the international standards utilizing WASP program.

Kamsha Wind Farm tendered by MEMR faced a dead end due to the high proposed energy price. Despite the fact that negotiations with the Kamsha Farm developer are still not concluded, MEMR floated Al-Fujeij Wind Farm tender and received 16 expressions of interest. The reference price list required by the RE&EE Law was not issued until now. It is not clear whether ESRC will base the list on prices emerging from negotiating Kamsha and Al-Fujeij, or will base it on international references. No progress is expected in wind energy projects or other RE projects for that matter unless the price issue is resolved in a clear and consistent matter.

6.2.2.3 Bioenergy

The biomass sub sector in Jordan is not investigated in depth. The Municipal Solid Waste represents the major source of biomass, followed by waste water treatment and animal industry.

Ministry of Municipalities should revive its strategy in the field of waste handling, in close collaboration with other entities to maximize benefits through comprehensive waste management plans. The individual efforts should be pooled under one Comprehensive Solid Waste Management Plan, where recycling, energy generation, and environmental aspects are all considered in the action plan. The dispersed nature of generated solid waste leads to loss of scale benefits which is a major barrier in adopting and implementing management plans. The ministries strategy included plans and actions towards minimizing the number of landfills through intermediate waste transfer stations. Accomplishing this step will largely facilitate comprehensive solid waste management action plans.

Energy from solid waste is one of the most beneficial applications within CDM. The waste water treatment which is under the umbrella of Water Authority of Jordan (WAJ) can also benefit from this mechanism. WAJ should embark on a comprehensive waste water plan including the possibility of energy generation, water recycling and environmental considerations.

Preliminary studies were conducted as part of GHG Mitigation options for the SNC to UNFCCC. These preliminary investigations show that biogas from animal and domestic wastes can save up to 4% of imported oil (in year 2000) which is equivalent to 130 000 TOE per annum. Adding the 23 Waste Water Treatment Plants existing in Jordan and the livestock farms sub sectors, the waste sector represents 13% of GHG emissions in the country. This fact should attract the attention of the environmental fund established recently as a priority area since 15% of CDM revenues belong to the fund according to the environment law.

6.2.2.4 Geothermal Energy

All resources surveyed in Jordan are of low temperature and located in two regions: the eastern side of the Jordan Valley and a plateau east of the city of Madaba. No geothermal resources allowing a commercially viable electric generation are identified, and best applications for the known resources are therapeutic and tourism. No additional exploration is justified at this stage due to the high cost of drilling exploration wells.

6.2.2.5 Hydro Energy

The lack of water resources in Jordan and the scarcity of rivers and water falls have made the hydropower potential quite modest. The Government of Jordan has been pursuing the Red- Dead Sea Canal for a number of years now, the project will bring a major source of hydro energy (400–800 MW) if implemented.

Chapter 7: Recommendations

The following recommendations are based on the analysis conducted during preparation of this report and findings listed above.

7.1 General

The upheavals caused by the "Arab Spring" and the Fukushima nuclear disaster are leading to major adjustments in energy strategies focused on the development of new energy sources that are fast getting more cost-competitive and ensure a greater protection of the environment as well as its sustainability.

7.1.1 Security of Supply

Security of Supply is a major issue for a country like Jordan totally dependent on imports. Based on the Jordanian context we recommend:

- Strengthen interconnection (electric grid, gas pipeline, future oil pipeline) with regional energy systems, and increase the capacity of interconnections to meet local energy demand.
- Expand the capacity of handling crude oil and oil products at the Port of Aqaba.
- Explore new sources of Natural Gas (KSA, Qatar) since recent experience with the Egyptian supplies suggests limited supply with no possibilities for increase.
- Oil shale and nuclear energy seem to be attractive from security of supply point of view, but pursuing these two options requires extreme attention to the environmental impacts on the short and long term.
- Continue with the reforms in the RE sector to maximize RE sources participation in energy mix.
- Several studies over the years concluded that EE opportunities in Jordan are numerous and highly feasible. Available studies estimate energy savings potential of 20% on average and higher in certain sectors. EE should be given more attention through intensifying efforts towards adopting efficiency standards for all energy consuming appliances, adopting advanced building codes, financial incentives and awareness campaigns. By laws and regulations to be issued soon for the RE&EE Fund should give high priority to EE motivation. This will benefit the fund from generated revenues as an additional source of funding in addition to other sustainability benefits inherent in scattered EE projects.

7.1.2 Refining and Oil Products

The main issue facing this sub-sector is the future of the existing refinery in light of oil product market liberalization and non-renewal of refinery concession. Similar experiences from Lebanon and Cyprus show that domestic refineries are no longer capable of meeting the competition leading to their closures. The Government of Jordan should carefully examine the economic, social and political outcomes of such an event.

7.1.2.1 Natural Gas

Prior to the "Arab Spring" and the multiple attacks on the Egyptian natural gas pipes, the scale of natural gas demand in Jordan was not justifying the construction of a LNG receiving and evaporation terminal at Aqaba. However, recently, such a project should be considered a priority and in a regional context. Depending on the agreement with Al-Fajr Gas Company regarding third party access to the pipeline, the Government of Jordan should initiate a regional effort to introduce LNG imports through a specialized terminal at Aqaba and distribute the gas regionally through a tie-in to the Trans Arab Gas Pipeline.

Other probable new natural gas sources are the ongoing Risheh field development and expansion by NPC and BP, developing Saudi Natural Gas fields near the border (Tabouk region) and developing a Gas field in Iraq near the border. The last two options should be investigated as a long term option.

The unreliability of Egyptian gas supplies has pressured Jordanian authorities to look for alternative energy sources, including the import of liquefied gas from Qatar and natural gas from Iran.

7.1.2.2 Oil Shale

Due to the consequences of both the Fukushima nuclear incident and natural gas disruptions and their impacts on Jordan, the oil shale deserves more attention as a promising source. Significant steps were accomplished towards the commercialization and exploration of Oil shale deposits in Jordan. As discussed above, several agreements and Memoranda of Understanding were signed with international companies. One major issue that should be diligently observed during Oil shale projects development is the environmental effect of such projects. Oil shale is known to be one of the most polluting energy sources with a very limited international experience in mitigating its environmental impacts. This fact should alert the Government of Jordan to secure proper Environmental Impact Assessment EIA Studies for each step of the way. EIA studies should not be undertaken on individual project bases instead, a bubble approach is required to capture the cumulative adverse effects of all planned projects. NRA and MOE should coordinate efforts to insure that future Oil shale projects will not cause irreversible damages to the environment.

7.1.3 Financing

Local financing institutions are not playing their expected role in financing energy projects. In particular, these institutions lack the experience in specialized RE&EE Financing which prompted several governmental efforts to introduce financing agencies to RE&EE market players. One such effort was the Environmental Financing Forum held in Amman during 7–8 March 2010 and organized jointly by MOE and the Jordan Banks Association.

At present the JREEEF and the Environment Fund are both under final stages of their establishment. The French Development Agency is also managing a Sustainable Financing Program in Jordan. Synergy between these efforts and other initiatives must be ensured to prevent duplication of efforts and to maximize benefits. On the other hand, Jordan did not benefit fully from financing opportunities presented by CDM. Only two projects were registered under CDM, the Aqaba Thermal Power Station Fuel Switch to Natural Gas and the Rusaifeh Landfill Gas Capture project. Several small and medium size project opportunities exist in Jordan that could benefit from CDM. The government should intensify efforts to raise awareness and capacity development.

A market demand study, which assesses the sustainable energy investment potential in Jordan, should be prepared. This study will enable the European Bank for Reconstruction and Development (the EBRD) to promote sustainable energy in Jordan as a part of its Sustainable Energy Initiative. In this context, the EBRD is considering the development of market-based financing mechanisms for RE&EE projects in Jordan through the Jordan banking sector including the necessary technical cooperation support. These financing facilities will be targeted to:

- enhance industrial energy efficiency, particularly in small and medium-size enterprises;
- fund small-scale renewable energy projects;
- improve energy efficiency in existing buildings; and
- enhance household energy efficiency using measures such as insulation, installation of energy efficient devices, and use of renewable energy sources.

7.1.4 Nuclear Energy

- Continue to establish regulations and a clear regulation process within the Jordan Nuclear Regulatory Commission.
- Conduct a viable feasibility study of the uranium deposit in Jordan, and announce it formally to the public to finalize the public debate in this regard.
- Impose strict regulations and stringent safety measures in the planned nuclear reactor.
- Continue to develop a skilled technical and administrative labor force.
- Continue with the studies and assessments that are related to the candidate site and reactor technology
- Construct a solid financial package for the whole program.
- Strengthen the cooperation with regional and international countries and institutions.

7.2 Renewable Energy Sub Sector

7.2.1 General Policy level

- Government of Jordan should develop and adopt a package where RE projects are not evaluated based on KWh price alone. The package should require project developers to contribute in creating local RE manufacturing base and know how. The difference between cost of energy from renewable sources and energy from conventional sources will not be otherwise justified. The environmental effect alone cannot justify the high difference in mentioned costs; other added value must be included in the package.

- The government should spearhead the development of RE sub-sector through direct participation in investment and management. Minimum commercial scale RE capacity should be put in place to serve as a model and a success story through government efforts to promote active participation of private sector.

- The government should devise a financial scheme based on innovative financial instruments to support RE development. Government financing and grants may not be sufficient without active participation of the private financing sector. As discussed above, the financial sector is not familiar with RE and Green investment financing. Efforts to promote Green financing mechanisms in the private financial sector are crucial. The government should also encourage the involvement of the private financing sector in the strategic planning process of RE&EE sector.

- Build the understanding and capacity of the financing industry with targeted assistance. Thus, a market demand study to assess sustainable energy investment potential in Jordan should be prepared. One of the key limitations for wider project implementation of sustainable energy financing is the lack of financial resources for small-scale projects. The market demand study would identify barriers to sustainable energy investments and propose recommendations to overcome the identified barriers on all levels (institutional, financial, legal, etc.). Moreover, it would highlight opportunities to promote market-based financing mechanisms to local financial institutions and Jordanian sectors.

- Establish a national company owned by the government, electric companies and other financial institutions. Such a company can benefit from the economies of scale associated with large scale RE projects, instead of the current fragmentation of individual projects. The company should operate under license(s) from a recognized international technology developer and hold concessions to specific areas identified for RE projects in Jordan. This will provide the necessary momentum for RE penetration within the country in the short term and regionally in the medium and long term. Different RE technologies should be evaluated by the said company in light of manufacturing requirements available in the country and scale of expected domestic and foreign markets, based on such evaluation a manufacturing strategy can be adopted. Major regulatory reforms will be needed to secure the successful operation of the proposed company, the adoption of Feed-in tariff; imposing mandatory shares of energy from RE sources on utilities at different points in the electricity supply chain and effective financial incentives are but a few aspects to be addressed by the regulatory reform. Part of the government's contribution will be the land area required for the specific projects.

- R&D activities in the RE field need more attention. Present budgets allocated are not sufficient, the Government should allocate more financial resources for R&D and activities of different research centers should be coordinated under one national program. NERC should not act as an ESCO to generate income through competition with the private sector ESCO's. NERC must be adequately financed to play its essential role as a R&D Center and a Scientific Reference for the energy community in Jordan.

- National RE program overseen by a focal entity is also necessary to coordinate the different activities of the government, private sector and NGOs to control non-productive use of and competition on limited financial resources whether domestic or foreign.

7.2.2 RE&EE Law No.3/2010

- Adopting a feed-in tariff is essential for project developers and financiers. A reference price list as suggested by the RE&EE Law will not provide a clear perspective; on the contrary it may create unnecessary political problems for both the government and developer.

- The proper relative importance of EE vs. RE is not strongly reflected in the law. This shortcoming must be addressed through the expected by-laws and regulations to be issued. As discussed earlier, EE projects are highly feasible providing a new financial source for Fund budget, require lower investments compared to RE and barriers faced by EE are cheaper and easier to mitigate.

- The law directly addresses the cost of interconnection to the National Grid and allocates this cost to the Bulk Supplier (NEPCO) while in the case of connecting to retail supplier grid; the issue is left to be handled by instructions to be issued by ESRC. The Law should specify in a clear manner the source and method of interconnection financing in the latter case.

- The Law should address the issues of standards, labels, codes and specifications for EE, it should also specify more clearly the role of different entities regarding these issues i.e. technical, issuance, enforcing, and testing.

- Consider introducing provisions for mandatory actions such as mandatory labeling of equipment, and mandatory EE actions for large scale industries.

7.2.3 Technology Specific

7.2.3.1 Solar Energy

- Solar Water Heating should be adopted within the Jordanian Building Code. This will overcome the so called tenant-principal barrier.

- Initiate SWH Fund in cooperation with commercial banks to subsidize consumers. The initial high cost of SWH units proved to be one major barrier facing the penetration of the technology.

- Give higher priority in R&D to Solar Energy Based Brackish Water Desalination applications. More synergy and coordination between NERC and Water, Energy and Environment Research and Studies Centers is required.

7.2.3.2 Wind Energy

- Intensify research and studies to minimize remaining uncertainties regarding wind potential and wind sites.

- The government should take necessary steps to acquire necessary lands in identified locations for Wind Farm development. This should be accomplished prior to floating tenders to minimize land ownership risks and uncertainties. As discussed in the General Policy level under VII.2 above, lands acquired by the government will serve as part of its contribution into RE projects.

- Small scale wind turbines are known to have higher cost of generated energy than conventional and even other RE sources, therefore such applications should only be pursued in specific circumstances making the small scale wind turbine affordable.

7.2.3.3 Bioenergy

- Initiate a study to identify the full biomass potential in Jordan. Agriculture and animal industry biomass potential is largely unknown, at the same time limited information exists regarding Landfills and Waste Water Treatment Plants. Since biomass sub sector is a perfect candidate for CDM application and controlled disposing of biomass is a major environmental concern, this area should be of prime interest for the Environment Fund established recently and should rest high on its priority list. The Fund being entitled to 15% of CDM projects revenues is an additional reason why the Fund should spearhead efforts in this sub sector.

- The government of Jordan should adopt blending standards and specifications for biofuels. Several attempts to produce biofuels are being considered but the lack of standards and commercializing and marketing rules are hindering advancements.

7.2.3.4 Geothermal Energy

- All existing information and studies conclude that there is no geothermal potential in Jordan. Existing resources are already being used for recreational and therapeutic purposes which should be expanded as a touristic attraction. Geothermal exploration activities are expensive and not recommended.

7.2.3.5 Hydro Power

- Jordan lacks hydro power resources; the existing limited resources are being exploited. The Red-Dead Sea Canal project is being pursued by the government as a long term option. As discussed above, if successful the project may provide a significant hydro power potential to Jordan in the range of 400–800 MW.

Finally, the Government of Jordan has accomplished significant advances in planning and improving the energy sector. The Energy Strategy adopted was comprehensive and laid the basis for future actions of which the RE&EE Law is the most important due to its effect on enhancing the contribution of local energy resources, improving the environment, increasing security of supply and creating new employment activities. The recommendations above seek to maximize the benefits from the government's commitment to energy sector reforming and its associated efforts.

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Annex I: Renewable Energy & Energy Efficiency Law

Authorized Translation for Law No. (3) of the 2010 Renewable Energy & Energy Efficiency Law

Article 1-

This Law shall be called (the Renewable Energy & Energy Efficiency Law of 2010) and shall enter into force on the date of its publication in the Official Gazette.

Article 2-

a- The following words and phrases wherever they appear in this Law shall have the meanings assigned to them hereunder unless the context provides otherwise:

Ministry	:	Ministry of Energy & Mineral Resources.
Minister	:	Minister of Energy & Mineral Resources.
Electricity Law	:	General electricity law in force.
Commission	:	Electricity Regulatory Commission established in accordance with the provisions of the Electricity Law.
Fund	:	Renewable Energy and Energy Efficiency Fund established in accordance with the provisions of this law.
Board	:	Board of Directors of the Fund.
Chairman	:	Chairman of the Board.
Renewable Energy	:	Energy produced from inexhaustible natural resources.
Renewable Energy Sources	:	Natural resources of energy including solar energy, wind energy, bio-energy, geothermal energy and hydropower
Renewable Energy Systems	:	Systems and equipment based on exploiting Renewable Energy Sources for energy production.
Renewable Energy Facility	:	Facility that works on exploiting renewable energy sources and systems.
Energy Efficiency	:	Series of measures and means carried out with the aim of reducing energy consumption and improving energy efficiency in a way that does not affect the level of performance.
Energy Efficiency Systems	:	Systems and devices that work on rationalizing energy consumption and improving its efficiency including among others: energy saving lamps, thermal insulation materials, thermal and electricity regulators.
Generation License	:	Permission granted by the Commission according to the provisions of the Electricity Law.
Person	:	Natural or legal person.
Licensee	:	Person licensed by the Commission to exploit Renewable Energy Sources to generate electrical power
Distribution Code	:	connection of power production facilities to the Distribution System as well as for Commission to operate Distribution System
Bulk Supply Code	:	Code prepared by the Commission for regulating the purchase of electrical

Project	:	Any project that seeks to exploit
Project Agreements	:	The set of contractual documents entered with the competent bodies to exploit Renewable Energy Sources including, among others, any agreement to among others ,any agreement to implement the project , Power Purchase Agreement or Land Lease Agreement
Land Use List	:	Lands suitable for exploiting available Renewable Energy Sources.
Reference Pricelist	:	Record prepared by the Commission with the relevant bodies for specifying the purchase of the electrical power from Renewable Energy Sources.

b- For the purposes of this law, words and phrases undefined in this law shall bear the meaning specified in the Electricity.

Article 3-

For achieving the objectives of this Law, the Ministry shall work on the following in cooperation and coordination with the competent bodies:

a- Exploiting Renewable Energy Sources for increasing the percentage of their contribution to the total energy mix, achieving safe supply there from and promoting investment thereto.

b- Contributing to environmental protection and achieving sustainable development by promoting the exploitation of Renewable Energy.

c- Rationalizing the exploitation of energy and improving its efficiency in various sectors.

Article 4-

a- The Ministry shall identify, in cooperation with the specialized technical bodies and centers, the geographical locations in the Kingdom of suitable nature, which demonstrate a high potential for exploiting Renewable Energy Sources, and shall establish a priority list for the development of such locations in accordance with the Ministry's energy sector master plan, and any other plans for the development of Renewable Energy Sources adopted by the Ministry.

b- The Ministry shall identify the Land Use List in accordance with the provisions of clause (a) of this Article, including areas and ownership of such lands and submit it to the Council of Ministers for approval.

c- Upon a decision from the Council of Ministers, treasury land that appears in the approved Land Use List shall be allocated for renewable energy projects while listed land owned by individuals shall be acquisitioned according to the provisions of legislations in force and in compliance with the Ministry's plan approved by the Council of Ministers.

Article 5-

Notwithstanding what has been stated in the Electricity Law:

a- The Ministry may, in coordination with the Bulk Supply Licensee, issue tenders or attract proposals on competitive basis for the development of one or more sites included in the Land Use List approved in accordance with the provisions of this Law for the purposes of generating electrical power

b- The Council of Ministers, may issue a decision states that the Bulk Supply Licensee or Retail Supply Licensee is entrusted to issue tenders or attract proposals on competitive basis for the development of one or more sites included in the Land Use List approved in accordance with the provisions of this Law for the purposes of generating electrical power and connecting to the grid, upon recommendation of the Minister based on a report from the Commission illustrates the development of the exploitation of Renewable Energy Sources for generating electrical power exceeds the total of capacity of (500) Mega Watt of such sources,

Article 6-

a- With the exception of sites that are being developed through public tenders and according to the provisions of Article (5) of this Law, any person may submit a direct proposal to the Ministry or to whom entrusted by the Council of Ministers pursuant to clause (b) of that Article in order to develop any site for the purpose of exploiting Renewable Energy Sources, regardless if this site is part of the Land Use List approved in accordance with the provisions of this Law or not.

b- The direct proposal for generating electrical power and connecting to the grid shall meet the following conditions:

1- 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.

2- The applicant shall possess sufficient experience in the implementation or development of Renewable Energy Facilities similar to the proposal in question.

3- 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 Pricelist.

4- Any documents or additional data necessary to fully appraise the proposal shall be submitted.

c- The Ministry or whoever is entrusted by the Council of Ministers pursuant to clause (b) of Article (5) of this Law, in cooperation with the relevant bodies, shall study such direct unsolicited proposals and notify the applicant of its decision within a period of six months from the date of submitting the proposal.

d- In the event of an initial approval on the submitted proposals, the Minister shall submit the recommendations to the Council of Ministers in order to issue the necessary decision thereon.

Article 7-

a- The Ministry or whoever is entrusted by the Council of Ministers pursuant to clause (b) of Article (5) of this Law, in cooperation with the relevant bodies, shall enter into negotiations with the applicants of accepted proposals, in order to proceed to the final Project Agreements.

b- 1- After signing the Project Agreements, the Commission shall issue the Generation License in compliance with their terms.

2- The license must state terms, conditions and obligations due to the licensee, as well as the cases where the license is amended or cancelled.

Article 8-

a- The electrical power generated by the Renewable Energy Facilities which are licensed in pursuance of the provisions of this Law is to be sold to the Bulk Supply Licensee or the Retail Supply Licensee in accordance with the power purchase agreements concluded in pursuance of the provisions of this Law.

b- While taking into consideration the texts of the Bulk Supply Code, the delivery rules which are stated in the Grid Code or the Distribution Code must be adhered to, as the case may be.

c- The Bulk Supply Licensee and the Retail Supply Licensee, as the case may be, shall accept the delivery and the purchase of all electrical power generated by the Renewable Energy Facility which is connected to their respective grid.

Article 9-

Notwithstanding the provisions of the Grid Code or of the Distribution Code, or of any license issued under the Electricity Law:

a- The cost of interconnecting a Renewable Energy Facility to the Grid shall be at the expense of the Bulk Supply Licensee.

b- The cost of interconnecting a Renewable Energy Facility to the Distribution System of any Distribution Licensee shall be paid in accordance with instructions to be issued by the Commission.

c- The Commission may waive Renewable Energy Facilities from any provision of the Grid Code or of the Distribution Code where such waiver is necessary, in coordination with the relevant licensees.

Article 10-

Any person, including small Renewable Energy Facilities and homes that have Renewable Energy Systems for the generation of electrical power, may sell the generated electrical power to the Bulk Supply Licensees and to the Retail Supply Licensees. The size and nature of such Renewable Energy Facilities and the selling price of the generated electrical power shall be specified in accordance with instructions to be issued by the Commission. The selling price of such power should not be lower than the purchase tariff specified by the licensees.

Article 11-

a- A fund to be known as (Renewable Energy and Energy Efficiency Fund) shall be established in the Kingdom with the aim of providing the funding necessary for the exploitation of Renewable Energy Sources and the rationalization of energy consumption.

b- The Fund shall have juridical personality, and it shall be financially and administratively independent. In this capacity, the Fund may perform all legal acts necessary to achieve its objectives including acquiring movable and immovable property, concluding contracts and loans, accepting aids, donations and grants, and shall have the right to litigate and delegate the Civil Attorney General or any attorney to represent the Fund in legal proceedings.

c- The Fund's headquarters shall be in the city of Amman.

Article 12-

a- The Fund shall be overseen by a Board called (Board of Directors of the Fund) under the Chairmanship of the Minister and the membership of:

1- Secretary General of the Ministry, Vice-Chairman.
2- Secretary General of the Ministry of Environment.
3- Secretary General of the Ministry of Planning and International Cooperation.
4- Secretary General of the Ministry of Finance.
5- Commissioner nominated by the Chairman of the Board of Commissioners of the Commission.
6- Three representatives of the private sector with the appropriate expertise and competence appointed by the Council of Ministers upon recommendation of the Minister for a single term of four years.

b- The Board shall meet once every two months and whenever is needed upon an invitation from the Chairman or the Vice-Chairman if the former is absent. The meeting will achieve quorum if the majority of the members are present provided that the Chairman or Vice-Chairman are among them. The decisions are to be taken on the basis of vote majority.

Article 13-

a- In order to achieve the objectives of the Fund, the Board shall have the following duties and powers:

1- Drawing the general policy of the Fund and presenting it to the Council of Ministers for endorsement, and laying down the necessary plans and programs for its execution.
2- Discussing and approving the annual report of the Fund's work.
3- Discussing the Fund's draft annual budget and the year-end financial statements and forwarding them to the Council of Ministers for approval.
4- Preparing the Fund's organizational chart and presenting it to the Council of Ministers for approval.

b- Terms and conditions related to control on the Fund's work and the principles to be followed in providing finance and expenditures therefore shall be determined in accordance with a regulation to be issued for this purpose

Article 14-

a- The Fund shall have a Director appointed by decision from the Board upon a recommendation of the Chairman, and the services of the Director shall be terminated in the same manner thereof.

b- Duties and powers of the Director shall be determined by the Board upon a recommendation of the Chairman.

c- The Director shall represent the Fund before third parties.

Article 15-

a- The financial resources of the Fund shall consist of the following:

1- The amounts allocated in the General Budget.
2- The Fund's revenues and investment proceeds.
3- Aids, gifts, donations and grants subject to the approval of the Council of Ministers if they are from non-Jordanian sources.
4- Any other resources approved by the Council of Ministers.

b- The Fund shall enjoy all exemptions and facilities provided for Ministries and government departments.

c- The Fund's money and rights are deemed public properties that are collected pursuant to the provisions of the State Properties Collection Law in force. To that end, the Chairman is empowered with all the powers vested in the Governor and the State Properties Collection Committee pursuant to the said Law.

d- The Audit Bureau shall audit the accounts of the Fund.

Article 16-

In cases not prescribed in this Law, the provisions of the Electricity Law shall apply.

Article 17-

The Council of Ministers will issue by-laws necessary for the execution of the provisions of this Law including the procedures and measures for energy conservation and energy efficiency in various sectors.

Article 18-

The Prime Minister and the Ministers are charged with the enforcement of the provisions of this Law.

Euro-Jordanian Renewable Energy Conference 2009“ (EJREC)

In response to the challenges facing Jordan in the field of energy, the Jordan Europe Business Association (JEBA) organized a two-day conference in Amman on April 1–2, 2009 entitled "Euro-Jordanian Renewable Energy Conference 2009" (EJREC). The conference was patronized by His Majesty King Abdullah II, deputized by HRH Prince Hamzah bin Al Hussein.

In order to overcome these overwhelming challenges, the government of Jordan developed a comprehensive energy strategy through the Royal Advisory Committee on the Energy Sector in December 2007. According to the new strategy the total anticipated investment in the energy sector is expected to reach $15 billion by 2020. The current energy mix shows that only 4% is supplied from local sources and the strategy envisages the local content to increase to 39% by 2020 out of which 10% should come from Renewable energy.

In order to achieve such an ambitious target a new Energy and Minerals Law including Renewable energy has been drafted and submitted to parliament for ratification and endorsement. The new law offers fiscal incentives and encourages independent power producing projects to generate electricity on BOO & BOT basis (Wind park projects to generate a minimum of 600 MW of electricity and Solar farms to generate a minimum of 600 MW by 2020).

The conference agenda was designed to shed light on renewable energies from various perspectives, to motivate interaction between speakers and participants through a panel format, in which the moderator played the MC role and managed discussions. In addition, academic parallel sessions were organized to cover the technical aspects of renewable energy through academic papers and studies.

The recommendations of the conference include:

On Investment:

1. EJREC urges the government of Jordan to facilitate the inflow of investments into renewable energy projects by creating an attractive renewable energy investment environment through:

- Improving the legal and financial infrastructure.
- Reaching fair electricity tariffs in order to make energy efficiency and renewable energy investments more feasible and attractive.
- Devising financial instruments for the end of users of renewable energy devices in order to increase their market penetration.
- Since the current energy prices are relatively low, and since an increase in the near future is expected. The government should seize the opportunity and add a minimal tax of up to 15% on the prevailing energy prices, to be invested in JREEEF.
- Reconsider the basis upon which concessions are made in order to increase their size and attractiveness to local and international investors.

- Set appropriate mechanisms to increase investments in renewable energy applied R&D and ensure knowledge transfer.
- Taking external costs into account when comparing various energy technologies including the environmental cost and human impact.

On Education and Spreading Awareness:

1. EJREC encourages the Government of Jordan to reduce the time required for spreading the renewable energy concept & culture nationally by studying successful international experiences, choosing the most applicable model and drawing lessons that can be applied in Jordan, while taking into account local characteristics.
2. EJREC calls upon universities to offer training courses in energy efficiency and renewable energy in response to the increasing market demand for more specialized education
3. Mainstreaming cooperation between "Eco-cities of the Mediterranean" initiatives and the outcome of this forum.

On Policy, Laws and Regulations:

1. EJREC urges the Government of Jordan to enhance public private partnership by involving all the relevant stakeholders in the renewable energy policy formulation, and in particular the private sector, through implementing a well structured consultation process, which institutes dialogue and takes into account better international practices in the field.

2. EJREC urge the Jordanian parliament to ratify the energy and natural resources law while insuring that all plausible incentives are included and take into account the recommendations of this conference.

3. EJREC acknowledges that with proper regulations renewable energy initiatives can be self financed.

4. EJREC requests the Government of Jordan to establish a viable and applicable mechanism for enforcing Building Codes. It also encourages the private sector to assume its role in spreading the Green Building Concept.