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White Paper on Nuclear Energy in Jordan

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**Jordan Atomic Energy
Commission**

White Paper on Nuclear Energy in
Jordan



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I. Nuclear Power – A Global Perspective

1. Introduction

Global population growth and industrial development are projected to double electricity consumption by 2030. Rapidly increasing electricity demand, together with the need to renew a large amount of old generating capacity in developed countries, strengthens the requirement for new power plants.

After years of neglect, the interest for nuclear power has been revived. Worldwide, 64 units are under construction, with most construction taking place in China, the Russian Federation, India and South Korea. Out of 29 countries currently using nuclear power, 13 have new plants under construction and 14 have supported the construction of new units by including nuclear as a potential option for the future energy generation mix.

Around 65 countries across the world are expressing interest in, considering or actively planning for nuclear power. Of these, 21 are in the Asia-Pacific region, 21 in Africa, 12 in Europe and 11 in Latin America.

Nuclear energy is seen as the technology of choice for satisfying future electricity demand since it ensures safe and stable electricity production at a reasonable and competitive price, while providing independence from fossil fuel and associated price fluctuations.

At the same time, the development of nuclear programmes facilitates the expansion of an entire high-tech nuclear sector, which in turn increases the country's technical and scientific development.

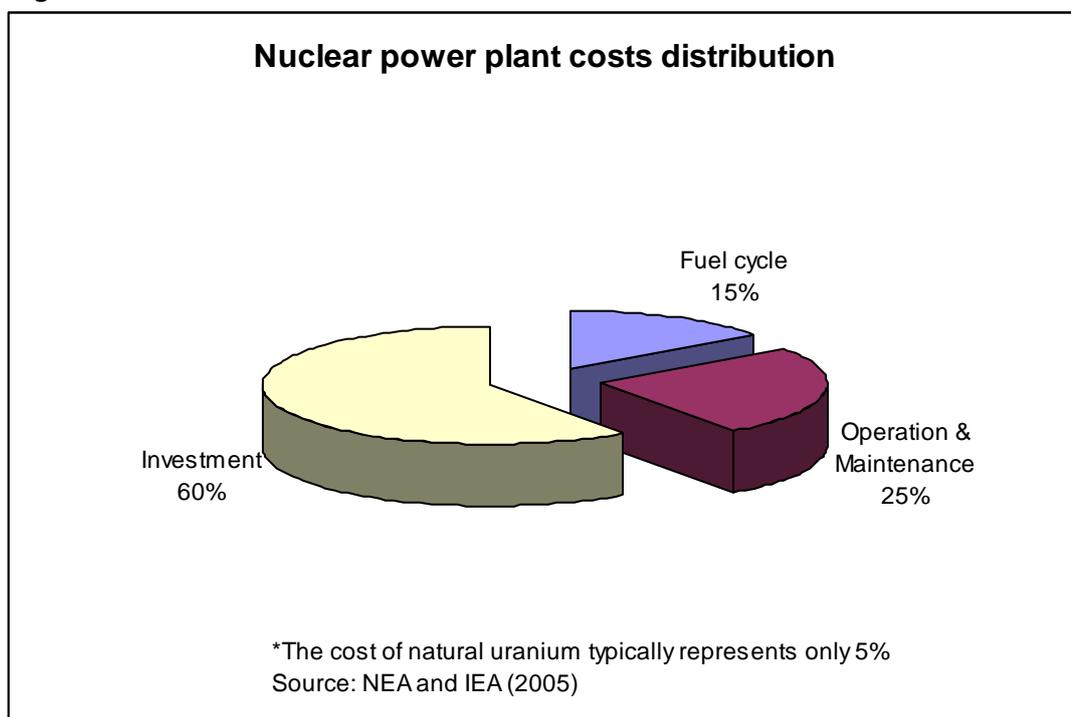


2. Advantages of nuclear power

2.1. Stability of Electricity Price and Fuel Availability

Electricity production costs at nuclear power plants are not as volatile as for fossil fuel-based plants, because uranium fuel represents a relatively small fraction of the total cost of nuclear plants' electricity production.

Figure 1 Nuclear Power Plant Costs Distribution



The use of nuclear fuel for electricity generation provides greater fuel independence compared to other energy resources, even for countries with limited local resources for nuclear fuel manufacturing.

Generally, nuclear fuel is loaded, at most, only once a year at a plant and there is ample time to make arrangements for the supply of new fuel. Nuclear fuel suppliers are dispersed globally, and are generally based in politically stable countries. Although each nuclear technology is connected to a specific fuel design, suppliers are generally independent of the technology vendor. The fuel supplier could therefore be changed, providing the necessary technical and licensing requirements are met.

2.2. Reasonable/Competitive Price

When generating electricity, nuclear energy is generally cost-competitive compared with fossil fuel-based generation, even though it involves relatively high capital costs and the requirement to manage all waste disposal and decommissioning costs.



On a comprehensive basis, taking into account the social, health and environmental costs of fossil fuels relative to those same costs for nuclear, the economics of nuclear power are outstandingly attractive.

Compare the cost of electricity from various sources for different countries, as calculated by the Organisation for Economic Cooperation and Development (OECD), below.

At a 5% discount rate, nuclear is noticeably cheaper than coal and gas in all countries. Although capital costs are greater than those for coal-fired plants and much greater than those for gas-fired plants, nuclear fuel costs are very low. As a result, total generating costs for nuclear are quite favourable.

Table 1 OECD Electricity Generating Cost Projections for 2010 (cents/kWh) at 5% Discount Rate

Country	Nuclear	Coal	Coal with CCS	Gas CCGT	Onshore wind
Belgium	6.1	8.2	-	9.0	9.6
Czech R	7.0	8.5-9.4	8.8-9.3	9.2	14.6
France	5.6	-	-	-	9.0
Germany	5.0	7.0-7.9	6.8-8.5	8.5	10.6
Hungary	8.2	-	-	-	-
Japan	5.0	8.8	-	10.5	-
Korea	2.9-3.3	6.6-6.8	-	9.1	-
Netherlands	6.3	8.2	-	7.8	8.6
Slovakia	6.3	12.0	-	-	-
Switzerland	5.5-7.8	-	-	9.4	16.3
USA	4.9	7.2-7.5	6.8	7.7	4.8
China	3.0-3.6	5.5	-	4.9	5.1-8.9
Russia	4.3	7.5	8.7	7.1	6.3
EPRI (USA)	4.8	7.2	-	7.9	6.2
Eurelectric	6.0	6.3-7.4	7.5	8.6	11.3

Source: OECD/IEA NEA 2010, table 4.1.a.

In comparative analysis such as this, assuming a higher discount rate would give preference to projects with lower upfront/capital costs and higher operational costs. Even at a 10% discount rate, the cost of generating nuclear power would still be competitive.

**Table 2 OECD Electricity Generating Cost Projections for 2010 (c/kWh)
at 10% Discount Rate**

Country	Nuclear	Coal	Coal with CCS	Gas CCGT	Onshore wind
Belgium	10.9	10.0	-	9.3-9.9	13.6
Czech R	11.5	11.4-13.3	13.6-14.1	10.4	21.9
France	9.2	-	-	-	12.2
Germany	8.3	8.7-9.4	9.5-11.0	9.3	14.3
Hungary	12.2	-	-	-	-
Japan	7.6	10.7	-	12.0	-
Korea	4.2-4.8	7.1-7.4	-	9.5	-
Netherlands	10.5	10.0	-	8.2	12.2
Slovakia	9.8	14.2	-	-	-
Switzerland	9.0-13.6	-	-	10.5	23.4
USA	7.7	8.8-9.3	9.4	8.3	7.0
China	4.4-5.5	5.8	-	5.2	7.2-12.6
Russia	6.8	9.0	11.8	7.8	9.0
EPRI (USA)	7.3	8.8	-	8.3	9.1
Eurelectric	10.6	8.0-9.0	10.2	9.4	15.5

Source: OECD/IEA NEA 2010, table 4.1.b.

2.3. Safety

Nuclear power has been demonstrated to be safe during several thousand reactor-years of operation worldwide.

The key objective of nuclear safety is to protect individuals, society and the environment from harm by establishing and maintaining effective defences against radiological hazards in nuclear installations. This is achieved by taking reasonably practicable measures to:

- Prevent accidents in nuclear installations and mitigate their consequences should they occur.
- Ensure that any potential radiological consequences are minor and below prescribed limits.
- Ensure that the likelihood of accidents with serious radiological consequences is extremely low.

These measures are defined based on comprehensive safety analyses of plant performance when operating normally, and if there are deviations from normal operations or accidents. These safety objectives are achieved by robust engineering design including secure containment and safety systems, and methodical attention to emergency response requirements. Once the nuclear installation is commissioned, its safe performance becomes subject to the strictest control during its entire lifetime.



2.4. Climate Change

Electricity production from nuclear power generates zero carbon emissions. There are alternative methods of electricity production which generate no carbon emissions, but most of these technologies are either not reliable for baseload power needs (solar and wind), geographically constrained (hydroelectric power, which requires massive dams), or not commercially proven (thermal power plants with carbon capture and storage technologies).

Meeting the increasing demand for electricity in the coming decades will require a mix of energy resources which emit low levels of CO₂ or none at all, including nuclear power in an increasingly predominant role.

Existing nuclear energy already has a very substantial positive effect on the environment. Today, nuclear power plants operating in 29 countries produce 15% of the world's electricity, avoiding the emission of over two billion tonnes of carbon dioxide (CO₂) each year. This saving is equivalent to more than 20% of global CO₂ emissions from power generation.

The Intergovernmental Panel on Climate Change (IPCC) has recommended that all countries should give serious consideration to nuclear power as a means of reducing greenhouse gas emissions.

Although Jordan is not an Annex 1 country (Annex 1 countries are those that have committed themselves under the Kyoto Protocol to reduce the level of greenhouse gas emissions), CO₂ emission reduction is still a strategic goal of the country.

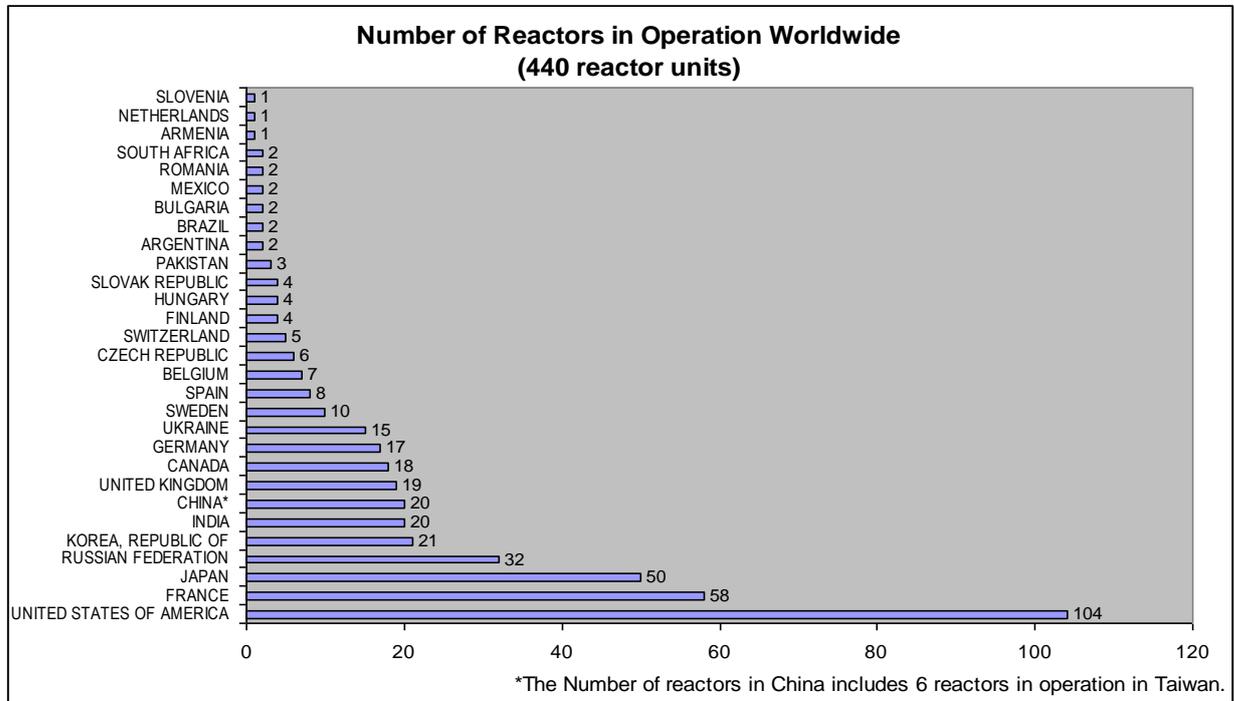
3. History and Operating Performance of Nuclear Plants

3.1. Electricity Production from Nuclear Power Plants

Nuclear energy's share of world electricity production has remained largely unchanged since the mid-1980s at approximately 15%. As of May 2011, there were 29 countries operating 440 units, while a further 64 units were under construction.

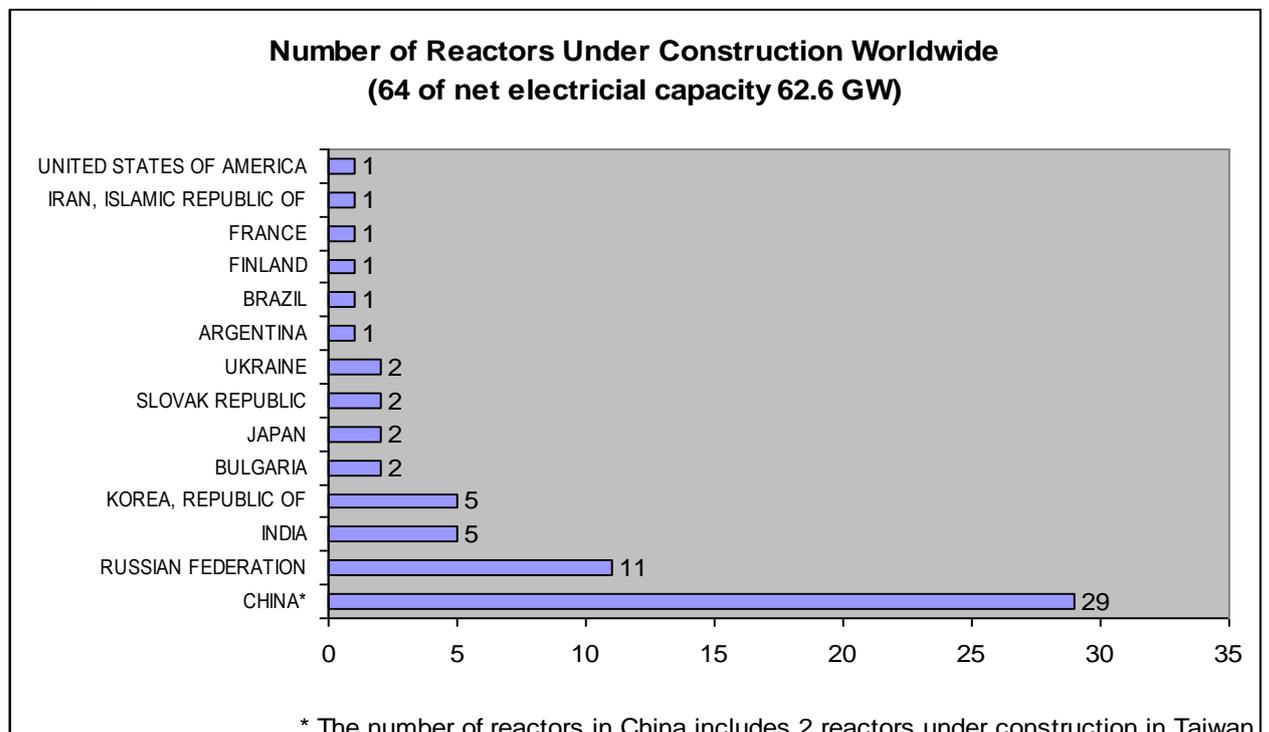


Figure 2 Number of Reactors in Operation Worldwide



Source: IAEA website (accessed 26 May 2011)

Figure 3 Number of Reactors Under Construction Worldwide



Source: IAEA website (accessed 26 May 2011)



3.2. Safety Record

Performance and safety records have improved significantly over the years. Well-operated nuclear power plants have proven to be safe. Good safety and performance records over the past two decades, the resulting increased profitability, and the expectation of further improvements all contribute to rising expectations for nuclear power safety.

Recent events in Japan have necessitated continued assessment and refinement of nuclear safety. From the early stages of the Fukushima plant problems, it was clear that the problems were directly caused, and the response complicated, by seismic and tsunami intensity well beyond what the plants had been designed to withstand. In the case of Jordan, the site conditions are vastly different compared to Fukushima, and any potential hazards caused by the location can and will be readily addressed.

3.3. New Reactor Designs

Generation III and III+ designs are Advanced Reactors that have evolved in line with 21st century safety standards. The most significant improvements compared to the second-generation designs are:

- The implementation at design stage of provisions to cope with severe accidents involving core melt, including in the long term. These provisions would prevent the occurrence of significant or early radiological releases to the environment. Any subsequent need for off-site protection of the public would be limited in time and space.
- Better prevention of accidents by consideration of all types of internal and external hazards and failures, and credible combinations thereof.
- The reinforcement of defence in depth with greater independence between the different levels of defence depth, in particular through diversity provisions, thus reducing the risk of accidents.
- Protection against large commercial aircraft.
- The existence of passive safety systems that do not require active controls or operational intervention to mitigate accidents in the case of failure, and may rely on gravity, natural convection and high-temperature resistance.

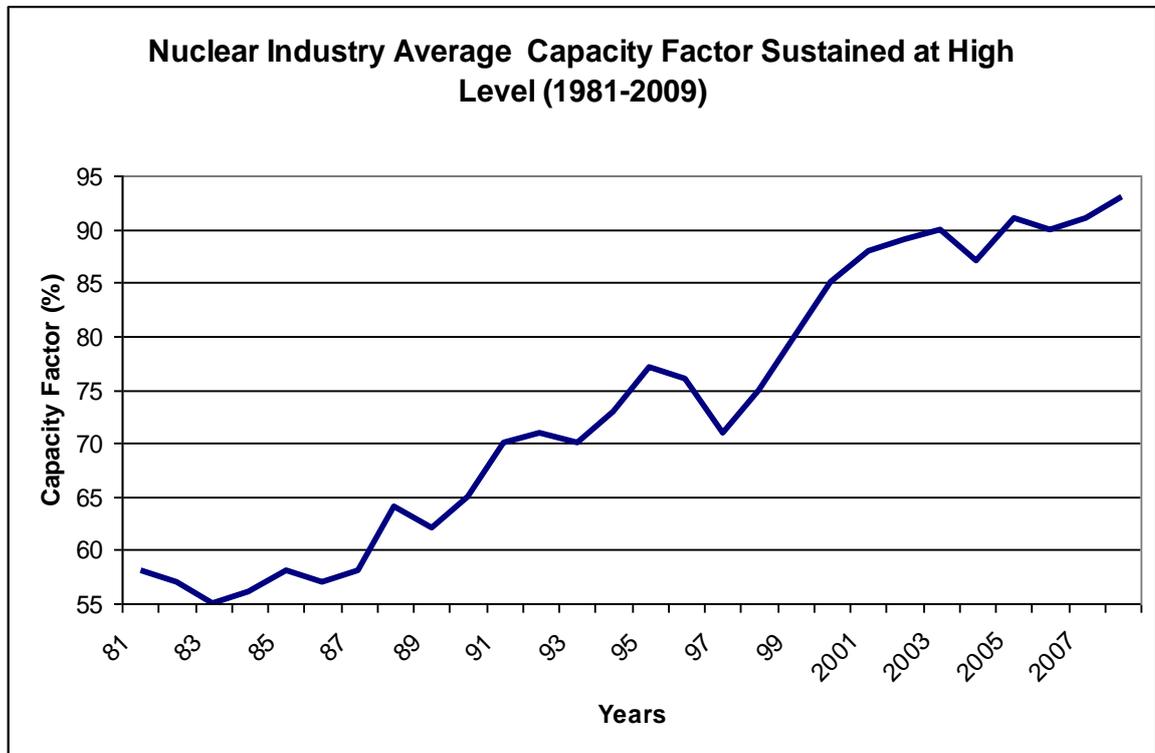
The safety features of Generation III and III+ reactor designs demonstrate that they will be able to cope with accidents such as the recent one in Fukushima. In order to prove resilience to external hazards such as the accident mentioned above, the selected design will undergo a stress test during the technical design review according to internationally agreed requirements.

3.4. Plant Performance

Nuclear reactors worldwide experience very few unplanned and forced outages and have relatively short planned outages. Consequently they have a high capacity factor. Figure 4 demonstrates the increase in performance of nuclear energy from 1981 up to 2009.



Figure 4 Nuclear Industry Average Capacity Factor Sustained at High Level (1981–2009)



Source: Estimates of Energy Information Administration, Nuclear Energy Institute



II. The Major Challenges Facing Jordan

1. Need for Electricity

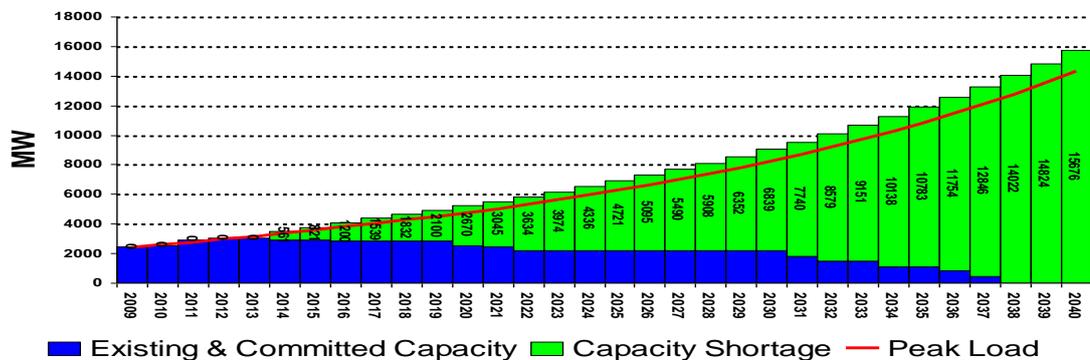
Jordan is completely dependent on imports to cover its primary energy needs. About 96% of Jordan’s electricity generation is fuelled by imports, of which 80% is from Egyptian imported natural gas.

Jordan’s electricity generation fleet is relatively old, with most existing power plants scheduled for decommissioning by 2020. In this same timeframe, the anticipated substantial increase in electricity consumption will widen the gap between available capacity and electricity demand.

Projected electricity demand translates into a total electricity generation capacity need of more than 15,000 MW by 2040 (up from 2,662 MW in 2007), with an annual average growth rate of approximately 6%.

Figure 5 demonstrates the available and committed capacities versus electricity peak load forecast.

Figure 5 Electricity Generation Capacities



To address the shortage of capacity, new build projects are already planned or underway, all using natural gas as fuel. They are:

- ▶ Qatrana Power Station – Qatrana will be a 373 MW power station some 100 km south of Amman. The first phase of the project includes two gas turbine units with 127 MW per unit. The later phase includes converting the gas turbines to a combined cycle by adding a Heat Recovery Steam Generator (HRSG) which will bring the combined-cycle power station to its full capacity of 373 MW by August 2011.
- ▶ Samra Power Station Phase II – In order to convert two existing gas turbines to a 300 MW combined cycle unit, a 100 MW HRSG will be added at Samra power station.
- ▶ Samra Power Station Phase III – The generation capacity added in this phase will be 420 MW and will consist of two gas turbine units with a capacity of 140 MW per unit, which were added in early 2011. During 2013, the gas turbines will be converted to combined cycle by adding an HRSG with a capacity of 140 MW. After completion of the third phase, the installed capacity will be 1,050 MW.



As can be seen, the planned power plants will only provide temporary relief from the widening generation gap; a longer-term solution is necessary to address the issue of insufficient generating capacity and fuel.

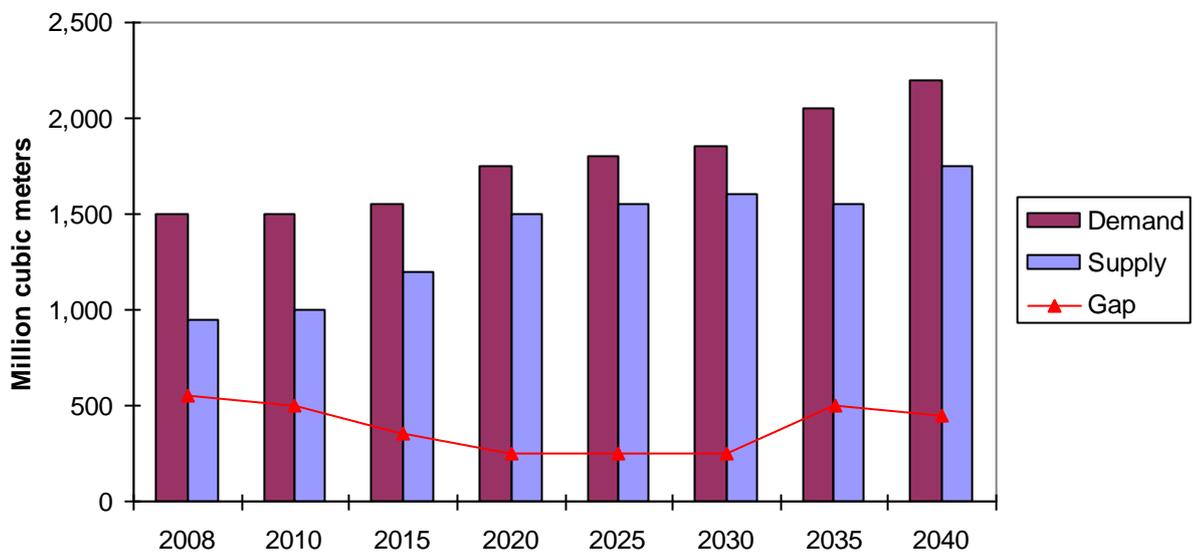
2. Need for Water

Jordan’s severe water deficit illuminates the true urgency of establishing a secure, sustainable source of inexpensive energy. The Kingdom is internationally recognised as one of the five most water-deprived countries in the world.

Internationally, a water-scarce country is defined as one that has less than 1,000 cubic metres of fresh water available per person per year. In Jordan, individual water consumption stands at 160 cubic metres annually, compared to a global average of 7,000 cubic metres and the US average of 9,000 cubic metres. The limited sources available are being rapidly depleted, and demand outpaces supply at an increasingly alarming rate each year.

Figure 6 presents a forecast of total demand and supply of water, along with the supply gap expected up to 2040 if this issue is not addressed in the very near future.

Figure 6 Water Demand and Supply



Source: Ministry of Water and Irrigation of Jordan

As can be seen from Figure 6, the supply gap is quite severe even today. It amounted to 500 million cubic metres (mcm) in 2010, and the situation will only worsen if no new water supply capacity is added. Meanwhile, the existing options to do so are few, costly, energy intensive and insecure from a geopolitical perspective. The figure includes the future supply of water from the Disi project and from the Red-Dead water project (both of which are still not online).

Presently, all of Jordan’s drinking water comes from surface water, treated brackish water (pumped from the Jordan Valley to urban areas at a distance of 50 km and an inclination of 1500 m) and groundwater extracted at a depth of 700 m.



The Government of Jordan is working to increase the supply with the implementation of the Disi Water Conveyance System (DWCS), which is scheduled to come online in 2013. The DWCS will draw 100 mcm of water per year from the Disi aquifer that lies beneath the desert in southern Jordan and northwestern Saudi Arabia, and will pipe it 325 km to Amman. The additional 100 mcm per year of water provided from the Disi project will enable measures to be taken that will help correct the imbalances in the groundwater basins of northern Jordan.

The supply from Disi is approximately equal to the current deficit in the Amman-Zarqa and Azraq basins. However, the amount of water from existing water resources, including the Disi aquifer, is only sufficient to cover domestic and commercial use until 2020, after which Jordan will have to resort to desalination to close the gap between supply and demand.

The Government of Jordan is also pursuing a project to supply Jordan with 930 mcm of desalinated freshwater a year by 2045 through the Jordan Red Sea Project (JRSP).

This project entails construction of a 180 km pipeline to transport water from the Red Sea to the Dead Sea and use the 400 metre elevation difference between the two seas to generate power in the Jordan Valley area and to desalinate some of the pumped water. Planners envision the project coming online in 2018 to supply 200 mcm of water annually in the project's first phase.

In addition to the power required to construct and install the infrastructure for such a massive project, upon completion the JRSP will require a massive amount of electrical power to power pumps in the facility's booster pump stations and desalination facilities. Eventually between 20 and 25% of this power will be supplied by the JRSP itself through the generation and utilisation of hydropower, but the remainder will have to be supplied through another means. The desalination of water drawn from the Hesban wells and other wells in the fertile Jordan Valley could add another 25 mcm per annum to the water supply.

Table 3 presents an overview of current projects under consideration, according to the Ministry of Water and Irrigation.

Table 3 Water Supply Projects Currently Under Consideration

Project	Water supply capacity (mcm per year)	Year of commissioning	Projected investment cost (US\$ million)	Power consumption (thousand MWh per year)
Disi	100	2013	944	590
Red-Dead phase I	200	2018	4,200	2,213
Red-Dead phase II	950	2045	n/a	n/a
Hisban wells	25	n/a	30	n/a

Clearly, there is currently no alternative source of water which could address the water supply deficit shown in Figure 6, as all the major water supply projects (Disi and Red-



Dead phase I) are already included in the anticipated future supply sources. Water desalination will have to be a part of the future water supply mix.

The combined effect of bringing new water sources online from the Disi water project and Red-Dead phase I, and the need for desalination to address the remaining water supply gap, will put a tremendous strain on the power system overall, particularly on generation and transmission.

The generation system will have to deliver an additional 2.8 million MWh of electricity for the Disi and Red-Dead phase I projects, which roughly corresponds to 380 MW of installed power-plant power (assuming baseload source and 85% utilisation).

If we consider that desalination needs roughly 1 MW of installed power to deliver 1 mcm of desalinated water per year, and the supply deficit illustrated above is roughly 250-300 mcm, water desalination needs at least an extra 250 MW to cover the supply gap.

Thus, the total need for new electricity generation capacity to cover future water demand is roughly 630 MW. The Water Authority of Jordan, which manages the Jordanian water supply system, currently only consumes around 1.3 million MWh of electrical energy per year, which corresponds to approximately 180 MW of installed power generation capacity (assuming baseload source and 85% utilisation).

The necessary scale of increase of electricity consumption for the supply of water is clearly immense, three and a half times what is consumed today for the same purpose. Even compared to the total Jordanian installed capacity of almost 3,000 MW, this is an increase of approximately 20% – an important indicator of the scale of the challenge facing the Jordanian power system in the near future.

Continued reliance on imported fuel to power Jordan's water sector will also expose water prices to volatilities in the oil and gas markets. This will have impacts across the board on Jordan's economy and the country's overall development. It is likely to stifle the growth of the industrial sector and is very likely to have ramifications for Jordan's food security.

At a more basic level, it is also possible that many Jordanian households would be unable to bear the cost of potable water. The threat this poses to most Jordanians' already modest standard of living, to basic health and sanitation standards and to overall social stability is clear.

3. Need to Support Major Infrastructure Projects

Major infrastructure projects, which are necessary to support Jordan's transition from developing to developed country, require stable and secure sources of electrical energy.

Mega-projects currently planned or underway are listed in Table 4.



Table 4 Mega-projects in Jordan

Sector	Project
Water	Jordan Red Sea Project
	Disi Water Conveyance System
Transport	Jordan National Rail Network
	Amman Zarqa Light Rail
Mining	Jordanian French Uranium Mining Co.
	Developing Risha Gas Field (first three years)
Resources and energy	Oil Shale: Deep Shale Extraction
	Oil Shale: Surface Mining
	Kamshah Wind Power Projects (30 MW)
	Fujaij Wind Power Projects

All these projects will require reliable sources of electricity at stable prices and in a sufficient quantity to support operations.

4. Agricultural Production

Jordan currently imports 87% of its food, due to limited natural resources for agricultural production (only about 5% of Jordan’s land mass is considered arable). Because of strong upstream and downstream linkages, a large percentage of gross domestic product (GDP) is considered as agriculture-dependent.

Jordan is therefore pursuing a water-efficient agriculture, and is focusing on more value-added crops and utilisation of new technologies in order to increase crop yields on available land. There is a limited quantity of water available for irrigating farms, once the basic needs of the population are met. This in turn limits the amounts of food domestically available to support livestock farming.

In order to secure a reliable supply of food, it will be necessary to increase the supply of water for food production, which will in turn further increase demand for electricity.



III. Jordan's Need for Nuclear Energy

From the above, the growing need for electrical power in Jordan is very clear. The case for nuclear power, as a way to meet that need, is detailed below.

1. Pre-feasibility Study for Construction of a Nuclear Power Plant

To test the feasibility of constructing a nuclear power plant, and compare it to other available options, a pre-feasibility study was produced in early 2010 (since updated).

A sound recommendation of the best option for expansion of a generation system requires a careful review of the available resources, both internationally and domestically. Jordan has limited access to energy resources – an important consideration when planning the expansion of an electrical system. Table 5 outlines the resources that are available to Jordan.

Table 5 Energy Resources Available to Jordan



Resource	Description
Local Natural Gas	<ul style="list-style-type: none"> Local natural gas is produced at Al Risha field in the eastern part of Jordan. Daily production is about 18 million cubic feet (MCF), only enough to operate generation capacity of 60 MW. BP has been selected through a competitive bidding process to participate in the Risha's Concession for exploration and development of the Risha gas field. This Concession was issued as a temporary Law No. 1 on January 3, 2010. BP started phase 1 of its programme in 2010.
Imported Natural Gas	<ul style="list-style-type: none"> In 2001, the Governments of Egypt, Jordan, Syria and Lebanon signed a Memorandum of Understanding (MOU) to establish the Arab Gas Pipeline network, which would use natural gas from Egypt. On June 5, 2001, Jordan and Egypt signed a Framework Agreement under which Egypt will sell Jordan a defined quantity of Egyptian gas and will implement the first and second stages of the Arab Gas Pipeline project. The first stage from Al Arish in Egypt to Aqaba in Jordan was completed in 2003 and is now supplying Aqaba Thermal Power Plant with natural gas. The second stage included extending the pipeline from Aqaba to the north of Jordan and was completed in 2006, after which it started supplying Rehab and Samra with gas. Natural gas is imported from Egypt to Jordan under a 30-year Gas Sales Agreement (GSA), extendable to up to 40 years subject to the mutual agreement of the two countries; currently Aqaba, Rehab, Samra and Amman East power stations are using this imported natural gas as a primary fuel. Under the GSA, the available gas for Jordan is 2.3 billion cubic metres (bcm) from 2011 onwards, but the GSA allows the buyer to increase the annual contract quantities by 15%; furthermore, at the beginning of 2008, an additional 1 bcm of gas was allocated to Jordan by a principle agreement signed in 2008. This agreement was considered cancelled by the Egyptian side and replaced with new arrangements to supply Jordan with additional quantity. The imported natural gas average price is indexed to oil prices, with a floor and a ceiling. The price formula will be revised at intervals as per the agreement. Contracted volume under the base GSA is insufficient for future expansion of the power generation system in Jordan after 2011. The needs of the existing combined-cycle power



	plants must be satisfied through adding volume.
Heavy Fuel Oil (HFO)	<ul style="list-style-type: none"> All crude oil needed to produce HFO is imported to Jordan through the Aqaba port, and transported by truck to the Jordan Petroleum Refinery, which produces the HFO and then disseminates it for power generation.
Light Oil (Diesel Oil)	<ul style="list-style-type: none"> Jordan's needs for light oil are mainly satisfied from imports, along with some local production.
Local Oil Shale	<ul style="list-style-type: none"> The existing oil shale reserves in different areas of Jordan, from Ma'an in the south up to the Yarmouk River in the north, are estimated at about 40 billion tonnes. An agreement was signed with EESTI ENERGIA to build an oil shale power plant using direct burning technology, with a proposed capacity of between 600 MW and 900 MW. The first phase of this project (if proven feasible) is expected to come online by 2016.
Local Uranium	<ul style="list-style-type: none"> The Jordan Atomic Energy Commission has taken practical steps to start extracting uranium deposits by establishing Jordan Energy Resources Incorporated (JERI). JERI is a Jordanian company with a mandate to explore for uranium, thorium and other heavy metals, to mine uranium ore, extract uranium from phosphates, mill and process yellow cake and other special nuclear heavy metals, and provide nuclear material needed for the civilian nuclear fuel cycle.
Renewables	<ul style="list-style-type: none"> Jordan has large solar power potential, as it has long hours of sunshine and high solar levels; nevertheless, Jordan does not currently use solar energy for electricity generation. There is further potential to be explored in wind and biogas, and Jordan plans to increase the share of renewable energy in the total energy mix to 1800 MW by 2020.

Based on the availability of resources described above, several scenarios were considered, as follows:

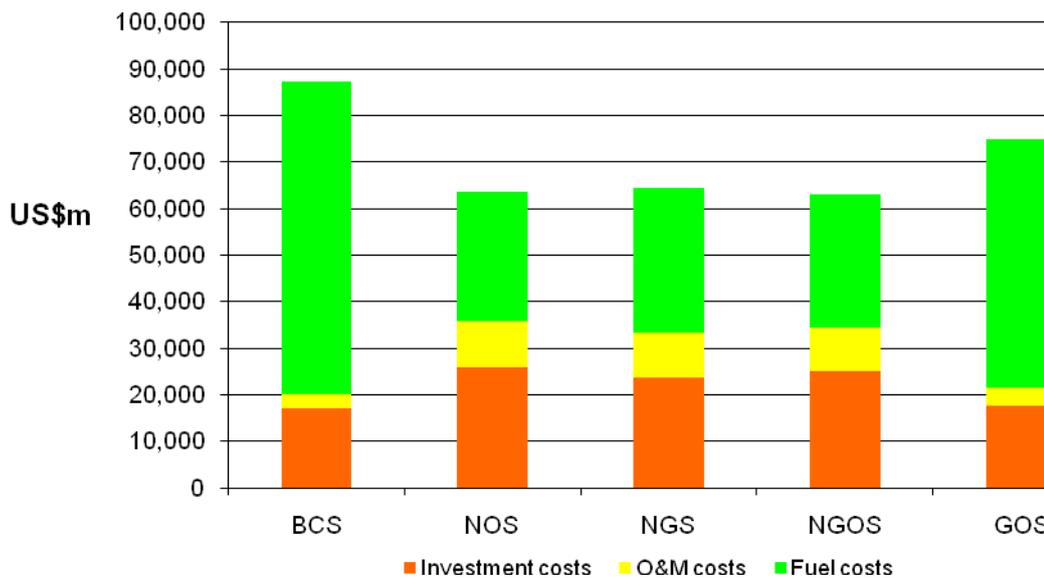
- The Base Case Scenario (BCS) (business as usual) continues to rely on current types of fuel imports (heavy fuel oil and diesel oil), because of the limited gas quantities defined by the GSA with Egypt and its amendment.
- The Nuclear and Oil Shale Scenario (NOS) considers the utilisation of oil shale for power generation, starting from 2015 and limited to an installed capacity of 900 MW. Nuclear power is available for Jordan's future power system expansion with a ceiling of 5,000 MW from 2020. The nuclear units are introduced in a way that achieves economies of scale in 2020, 2023, 2028, 2031 and 2036. In addition, the assumptions listed under the BCS are applied.



- The Nuclear and Gas Scenario (NGS) considers the availability of nuclear power for the expansion of Jordan’s power system from 2020, with the same assumptions as those mentioned in the NOS. Additional quantities of imported natural gas (2 bcm) are available to Jordan at international prices (US\$8/MMBTU). The assumptions listed under the BCS are also applied.
- The Nuclear, Gas and Oil Shale Scenario (NGOS) includes all assumptions listed in the previous scenarios.
- The Gas and Oil Shale Scenario (GOS) includes all assumptions listed in the scenarios above, excluding the nuclear option for power generation expansion.

The scenarios were entered into the MESSAGE and WASP IV modelling environments that are used by the International Atomic Energy Agency (IAEA) for similar analyses. The output from the model, in the form of total system generation with undiscounted costs over the study period 2010-2037, is shown graphically in Figure 7.

Figure 7 Generation With Undiscounted Costs Model



Source: Nuclear Power Plant Pre-feasibility Study for the Hashemite Kingdom of Jordan, 2010

Leaving aside the BCS and GOS scenarios, at face value the total cost differences between the other scenarios appear relatively insignificant.

However, it is important to recognise that the system costs do not account for the fact that new generating plants and equipment have operational lifetimes several decades beyond the 30-year period that was considered in the simulation. While their full investment costs are included in the system costs, most of their benefits are not, as these continue to accrue after the end of the study period.



In general, scenarios with high infrastructure investment and low fuel costs provide long-term economic benefit, while scenarios with low investment but potentially high fuel costs focus on maximising short-term returns and lack long-term attractiveness.

The investment requirements for the BCS (US\$17 billion) are the lowest of all the scenarios, as the BCS is built on steam unit technology, which has a relatively low investment cost. Still, the BCS is the most expensive scenario overall due to the high fuel cost of HFO. The fuel cost is US\$67 billion and the total generation cost is around US\$87 billion over the study period.

The total NOS investment costs are higher than for the BCS. However, the contribution of nuclear fuel cost to total generation costs and the low oil shale fuel price reduce the total NOS costs over a 30-year period. The lower nuclear and oil shale fuel prices result in fuel costs that are 58% lower than for the BCS.

The NGS's investment requirement is around US\$24 billion, which is 39% higher than for the BCS.

The total NGOS investment requirement is US\$25 billion, 47% higher than for the BCS. However, the contribution of nuclear fuel cost to total generating costs and the low shale oil fuel price reduce the total NGOS costs over a 30-year period.

The GOS is the second worst option when considering the total cost. While investment requirements are around US\$17.6 billion, the GOS fuel cost is about US\$53.5 billion.

The above economic comparisons demonstrate that the nuclear option is the cheapest in terms of cost of production. These figures will be confirmed by the financial feasibility study currently in progress.

It needs to be pointed out that nuclear energy is not the only option that will be pursued, but rather a part of a future energy mix. Future generation plant builds will depend on technology trends, oil/gas prices, the characteristics of the Jordanian economy and the purchasing power of its citizens.

Jordan will pursue a diversified strategy of deliberate choice in terms of an energy mix that will maximise energy efficiency and utilisation of renewable energy sources, and perhaps introduce oil shale and more gas to the mix. Jordan cannot but pursue a diversified energy strategy with a continuously evolving energy mix that gets optimised along the way, given the major challenges it is currently facing and taking into account that it currently does not have the luxury of the high purchasing power necessary for high water and electricity tariffs that more developed western countries can afford.

2. Benefits from Implementation of Nuclear Power

2.1. Strategic Energy Independence and Reduction in Volatility of Electricity Production Cost

Nearly 96% of Jordan's energy consumption is met by imported fossil fuels. This poses two significant challenges: firstly, Jordan depends on oil and gas exporting countries to fulfil its energy needs and secondly, Jordan's economy is exposed to fossil fuel price volatility, which can create an immense strain at times of high prices.



Coal and gas prices more than doubled from 2003 to mid-2008 across almost every part of the world. The price of coal later decreased by 70% in the second half of 2008 and gas prices declined as well, albeit not as much. In 2007 Jordan spent the equivalent of 20% of GDP, or 24% of its total import costs, on importing energy resources.

Before the Gulf wars, Jordan met almost all of its petroleum needs with Iraqi oil, which was imported at below-market prices. This flow has been disrupted, and Jordan now pays market rates. Furthermore, Jordan has limited options to substitute for oil products. The chief option is natural gas, which can displace oil, but this is a short- to mid-term option and cannot be relied upon for the long term. Most of Jordan's natural gas comes from Egypt; presently Egypt caps the below-market price it offers and in the future it is likely to place a cap on volume.

The recent attack on the Egyptian pipeline in Al Arish resulted in a complete suspension of the flow of US\$3.5m a day of natural gas from Egypt, forcing Jordan to revert to heavy fuel reserves such as diesel. Even in normal circumstances, the supply of natural gas from Egypt can drop; at one point during the summer of 2010, it dropped to 70% of its usual level. This caused blackouts and affected water distribution.

Jordan's vision is to move away from fossil fuels and lessen its dependence on energy imports. A nuclear power plant is the ideal way to achieve independence and at the same time serve as a natural hedge against the cyclical nature of oil prices and the new normal of higher oil prices. This is because the cost of producing electricity from nuclear power is much less volatile than that from a natural gas or an HFO power plant, which are presently used for most of the generation. This will allow the Government of Jordan to better manage disruptions to the current account as well as support the capability to fight inflation and sustain a stable currency exchange rate.

2.2. Utilisation of National Natural Resources

Jordan is estimated to have 65,000 tonnes of uranium oxide resources in the central part of the country, and an additional 100,000 tonnes found in phosphates. Recently, new uranium deposits were discovered in the Al Hasa area, with a preliminary estimate of 20,000 tonnes of uranium oxide.

JERI (Jordan Energy Resources Incorporated) was established as a Jordanian company with a mandate to explore for uranium, thorium and other heavy metals, mine uranium ore, extract uranium from phosphates, mill and process yellow cake and other special nuclear heavy metals, and provide nuclear material needed for the civilian nuclear fuel cycle.

In 2008, an Exploration Agreement was signed with AREVA to begin extracting uranium in central Jordan. In 2010, this developed into a Mining Agreement between AREVA NC and JERI. It has been operating within a 1,400 km² area in central Jordan, for which it obtained mining rights in February 2010.

In 2009, an MOU was signed with the Anglo-Australian mining conglomerate Rio Tinto to establish a general framework for the exploration of uranium, thorium, zinc and other metals. The MOU also foresees the creation of future consortia for further exploration and mining in the south and east of Jordan.

Jordan's vast resources of natural uranium, the source of the raw material for nuclear fuel, serve as a natural hedge against fluctuations in uranium fuel prices. It is important to



affirm that Jordan does not plan to enrich its own fuel in the near term, but will use one of the global nuclear fuel suppliers to satisfy its fuel needs for the foreseeable future.

2.3. Water Desalination

Jordan is among the most water-deprived countries in the world, and the scarcity of water will only increase in the future.

Most of Jordan's existing water resources have already been tapped, but water desalination is one new option for water production that will become available once a large source of electricity is online.

In spite of the high construction cost of nuclear power plants, water desalination powered by nuclear electricity might be the only new source of water available in the future. A nuclear power plant is ideally suited to provide electricity for water desalination, given its low operating cost and suitability for baseload operation.

2.4. Reduction of Pollution and CO₂ Emissions

Nuclear power does not produce any emissions that cause air quality to deteriorate at the point of electricity generation.

The complete nuclear power chain, from resource extraction to waste disposal including reactor and facility construction, emits the same carbon equivalent per kilowatt-hour as wind and hydropower.

Among the nine electricity generation mitigation technologies assessed by the Intergovernmental Panel on Climate Change (IPCC), nuclear power has the largest mitigation potential by a large margin and is considered to have the second lowest mitigation costs after hydropower.

Nuclear power is also the way to attract industrial investment thanks to the sustainability of the electricity prices in the long term.

Jordan's objective is sustainable, environmentally friendly long-term economic growth, and nuclear power will help achieve this by providing a reliable energy source with very low CO₂ and other greenhouse gas (GHG) emissions. The current generation fleet is very CO₂-intensive, since it is largely composed of older, inefficient units or newer Combined Cycle Gas Turbine (CCGT) units, which are among the most intensive generators of CO₂ emissions among all modern production technologies.

The introduction of nuclear power into the mix will effect a substantial and necessary shift in the environmental impact of electricity generation in Jordan.



IV. Socioeconomic Impact on Jordan

Energy projects are normally evaluated on narrow energy-sector objectives such as securing sufficient energy supply in combination with reasonable energy prices. However, nuclear energy projects encompass a much broader array of important national objectives besides those relating directly to the energy sector.

These include reducing imports of conventional fuel sources, creating a better employment environment, the development of new products for export and improving economic competitiveness.

The primary benefit to the region of nuclear power plants will be the availability of a new, reliable and zero-emission energy source at a reasonable and stable cost. In addition, there will be major secondary impacts from the large investment in the Jordanian economy to support plant construction and operation.

The total impact on the economy is the sum of the direct, indirect and induced effects. The direct effects are listed below. These are the local expenditures made by the project and the direct employment of local people by the plant.

The secondary (indirect and induced) effects reflect the inter-industry transactions taking place as a result of the project and the related changes in household incomes. To estimate the secondary effects in the economy, an Input-Output model was used. An additional benefit from the project is the increase in tax revenues from both the primary and secondary effects.

It should be stressed that all the effects of nuclear power plant construction quantified in this chapter are based on a set of assumptions, which might change as a result of adjustments in market conditions. The forecast figures are an output from a mathematical model, and should therefore be read as indicative, signifying the order of magnitude of impact, rather than as an exact forecast of the future effects of the project.

1. The Current and Future Economic Profile of Jordan

Jordan is a small, open economy with limited natural resources and high energy import dependency. In fact, Jordan could be considered as one of the most open economies in the Middle East, and as such its economic growth is dependent significantly on world oil price fluctuations and the availability of external grants.

Large industrial projects, such as the construction of nuclear power plants, will increase GDP, reduce unemployment, limit Jordan's exposure to high oil prices, and reduce both inflation and the current account deficit.

1.1. Gross Domestic Product and Economic Growth

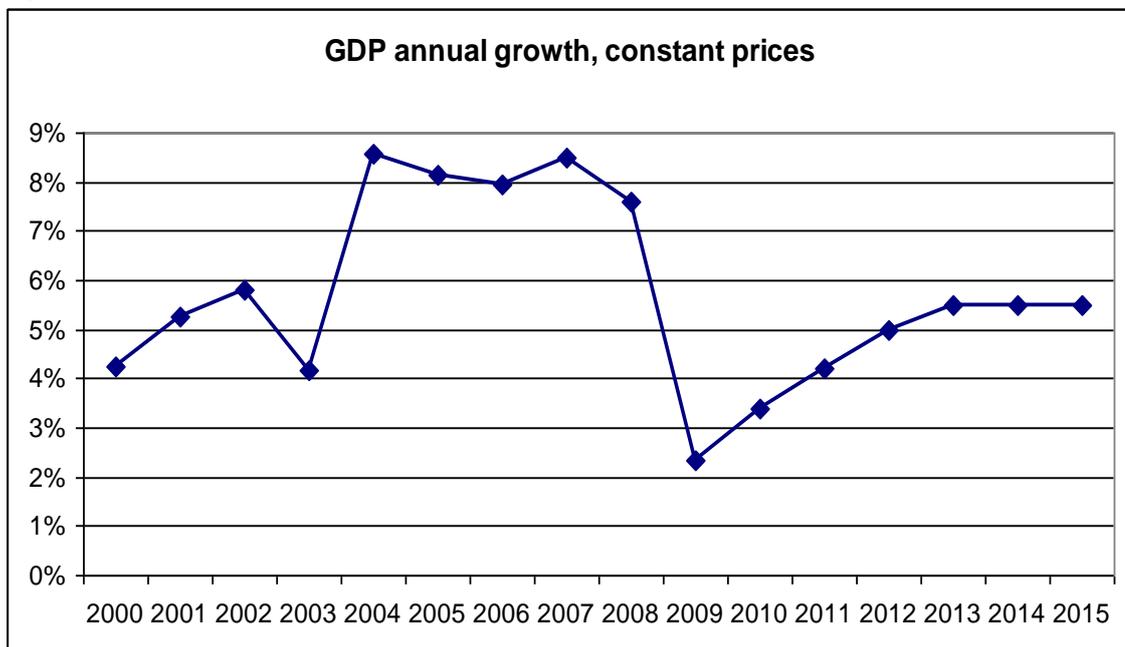
Jordan had high and relatively stable GDP growth between 2003 and 2009. The major factors influencing Jordan's growth are fluctuations in world oil prices, flows of foreign



direct investment (in 2006, FDI accounted for nearly 22% of GDP) and the availability of grants from abroad.

In 2008, external shocks such as high oil prices and a decrease in grants from foreign countries contributed to a higher budget deficit, higher inflation and lower GDP growth. In 2009, when the world financial crisis hit the markets, Jordanian GDP growth fell sharply to only 2.3%. Although a recovery has started and is expected to continue, GDP growth is likely to remain below its highs of 2004-05 based on current forecasts.

Figure 8 GDP Annual Growth



Source: World Development Indicators, The World Bank, Jordanian government data and International Monetary Fund forecast from World Economic Outlook Database, October 2010

The impact of a large industrial project such as the construction of a nuclear power plant is likely to change the dynamics of GDP growth significantly, due to large project-related investments in the local economy. These investments, directly linked to plant construction, create secondary but important additional economic benefits for the Jordanian economy.

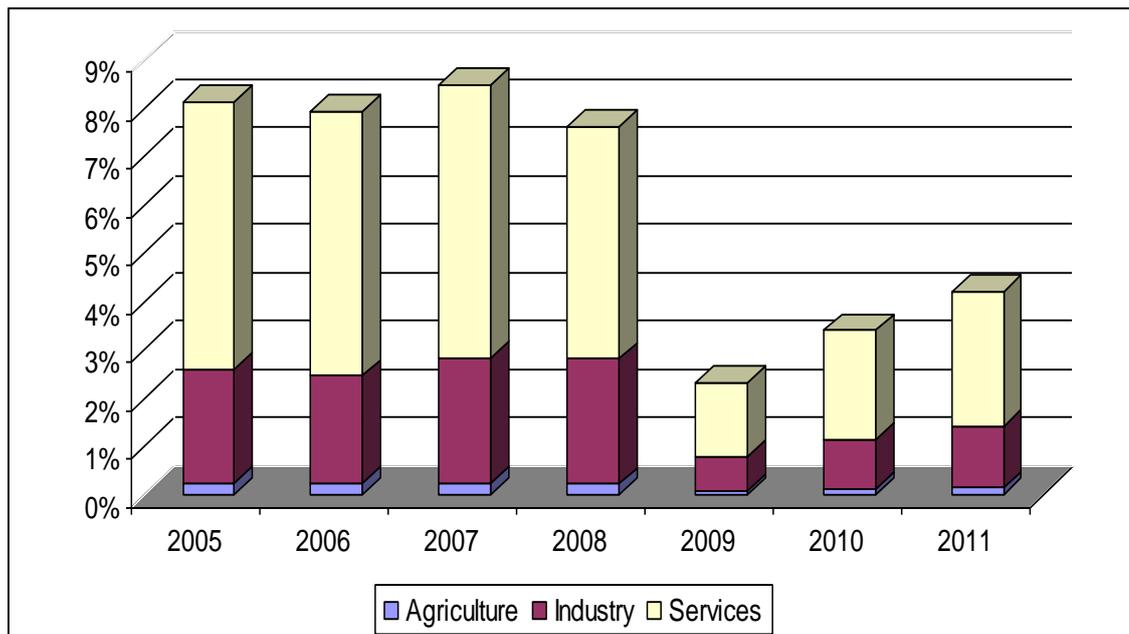
1.2. Components of GDP

Jordan is a very strongly service-oriented economy. The service sector accounts for 65-70% of GDP. Agriculture accounts for nearly 3% and the remaining 27-32% is provided by industry. The agricultural and industry sectors account for around 25% of total employment. The main manufacturing industries are textiles, mining (potash and phosphates), fertilisers, pharmaceuticals, oil refining and cement.



The latest statistical data available for Jordan from 2009 shows that, since services are contributing the largest share to GDP, the growth rates in this sector have a great impact on total annual GDP growth. The sector by sector value-added as a percentage of GDP can be seen in Figure 9.

Figure 9 Economic Sectors' Value-Added as % of GDP Growth



Source: EIU Country Report – Jordan 2009-2010; World Development Indicators, The World Bank, Jordanian government data and International Monetary Fund forecast, World Economic Outlook Database, October 2010

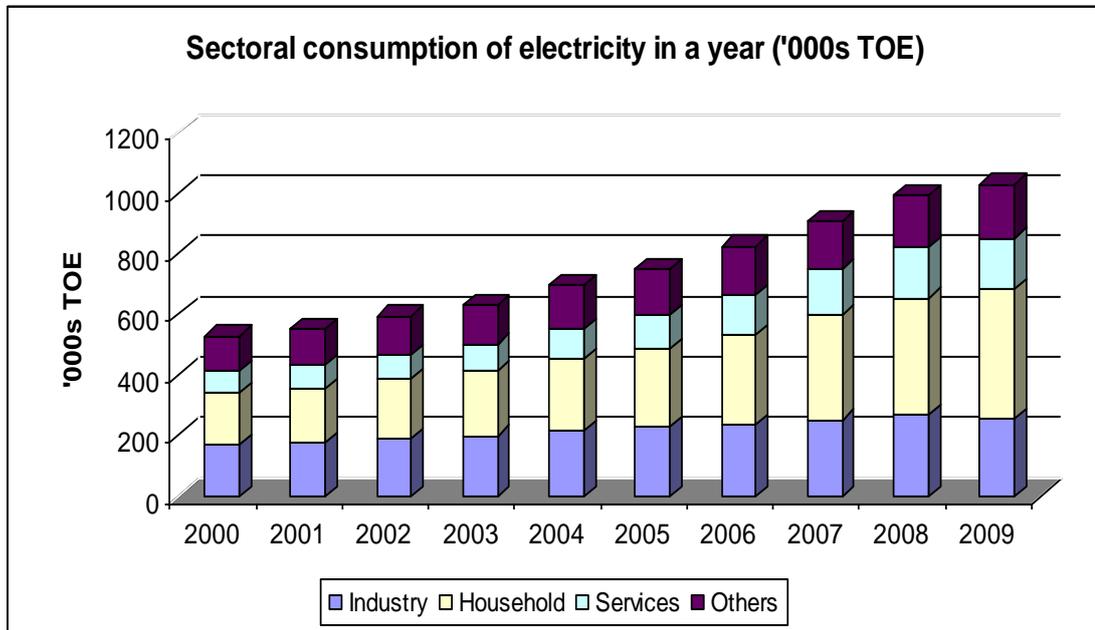
Electricity consumption is an important characteristic of each economic sector and historical data on consumption shape expectations for future electricity demand.

Figure 10 displays how the main sectors have grown over the years in terms of electricity consumption. Households and industry had equal shares of electricity consumption in 2000, but this ratio has changed significantly. In 2009 households consumed 41% of the electricity supplied in Jordan, compared with 25% for industry, as shown in Figure 11.

One reason for this steadily increasing residential consumption of electricity could be high oil prices, which prompted an increase in electrical heating in Jordan. Consumers' behavioural change in electricity use emphasises the importance of secure and affordable domestic electricity sources, which will decrease exposure to increasing oil prices.

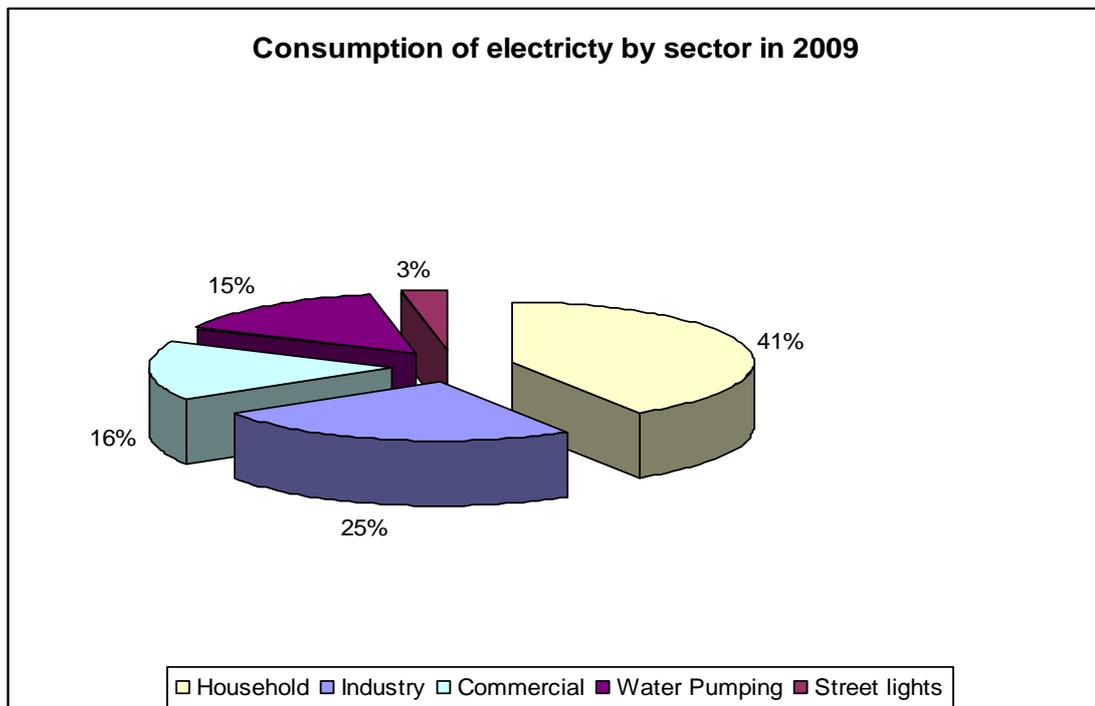


Figure 10 Sectoral Consumption of Electricity in a Year



Source: Energy balance for Jordan 1994-2009, Department of Statistics, Ministry of Energy and Mineral Resources

Figure 11 Consumption of Electricity by Sector in 2009



Source: Energy balance for Jordan 1994-2009, Department of Statistics, Ministry of Energy and Mineral Resources, Annual Report 2009

**Table 6 Electricity Consumption by Industry Sector**

Electricity consumption in a year (%)	Household	Industry	Commercial	Water pumping	Street lights	Others
2005	34	31	15	15	3	2
2006	36	29	16	15	2	2
2007	38	28	17	15	2	-
2008	39	27	17	15	2	-
2009	41	25	16	15	3	-

Source: Ministry of Energy and Mineral Resources, Annual Report 2009

Other factors contributing to increased residential electricity consumption are population growth and GDP growth. Jordan's annual population growth was approximately 2.3% between 2000 and 2007, rising to 3.2% in the following two years.¹ The growing population will contribute to a further increase in electricity consumption by households.

1.3. Inflation Levels, Contributions to Inflation

The level of inflation is influenced mainly by commodity prices and food prices.

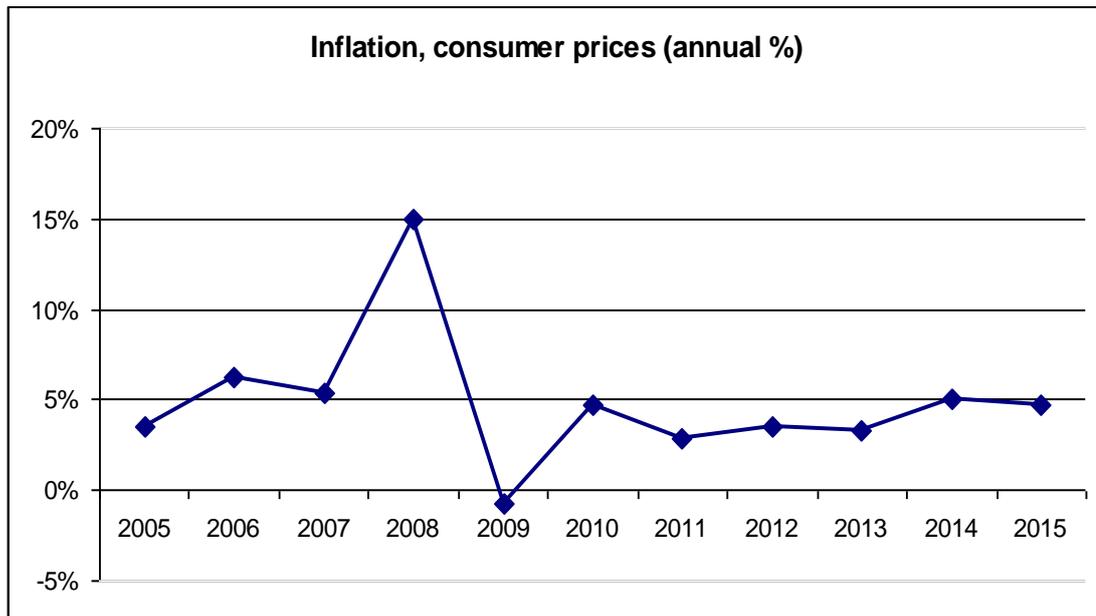
The removal of fuel subsidies in 2008 and their replacement with a fuel price adjustment mechanism exposed Jordanian consumers to increasing oil and food prices.

¹ World Bank, World Development Indicators: Jordan profile



The weakness of the dollar pushed up inflation in Jordan due to the Jordanian dinar's peg to the US dollar. The Jordanian dinar has been pegged to the US dollar since 1995, and the Central Bank of Jordan is committed to maintaining this. Although this leads to a lack of monetary flexibility, the pegged currency rate increases monetary confidence towards the country without harming its competitiveness, as the largest single export market for Jordan is the United States.

Figure 12 Inflation Rate



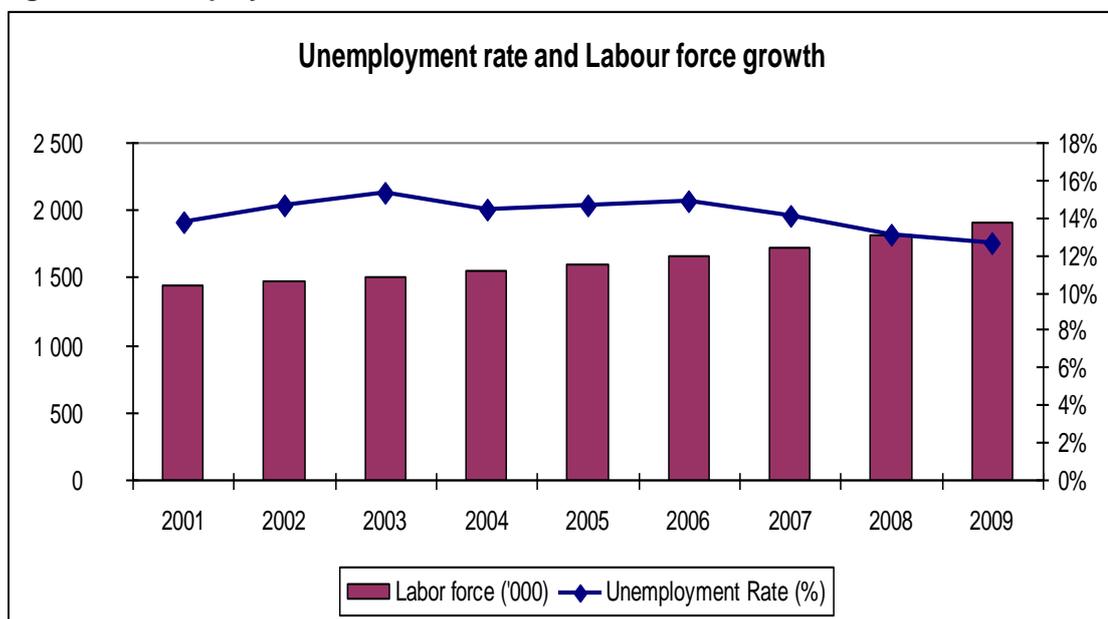
Source: World Development Indicators from the World Bank, Jordanian government data and Economist Intelligence Unit (EIU) forecast



1.4. Unemployment Rate

The unemployment rate has been significantly higher over the years, compared to other countries, but with a decreasing trend. The unemployment rate in 2005 averaged about 15%, falling to 13.1% in 2007. Forecasts from the Economist Intelligence Unit show that the rate of unemployment is expected to remain around 13% in the near term. The impact of a nuclear power plant construction project on the Jordanian unemployment rate is addressed below.

Figure 13 Unemployment Rate



Source: World Development Indicators from the World Bank, Jordanian government data

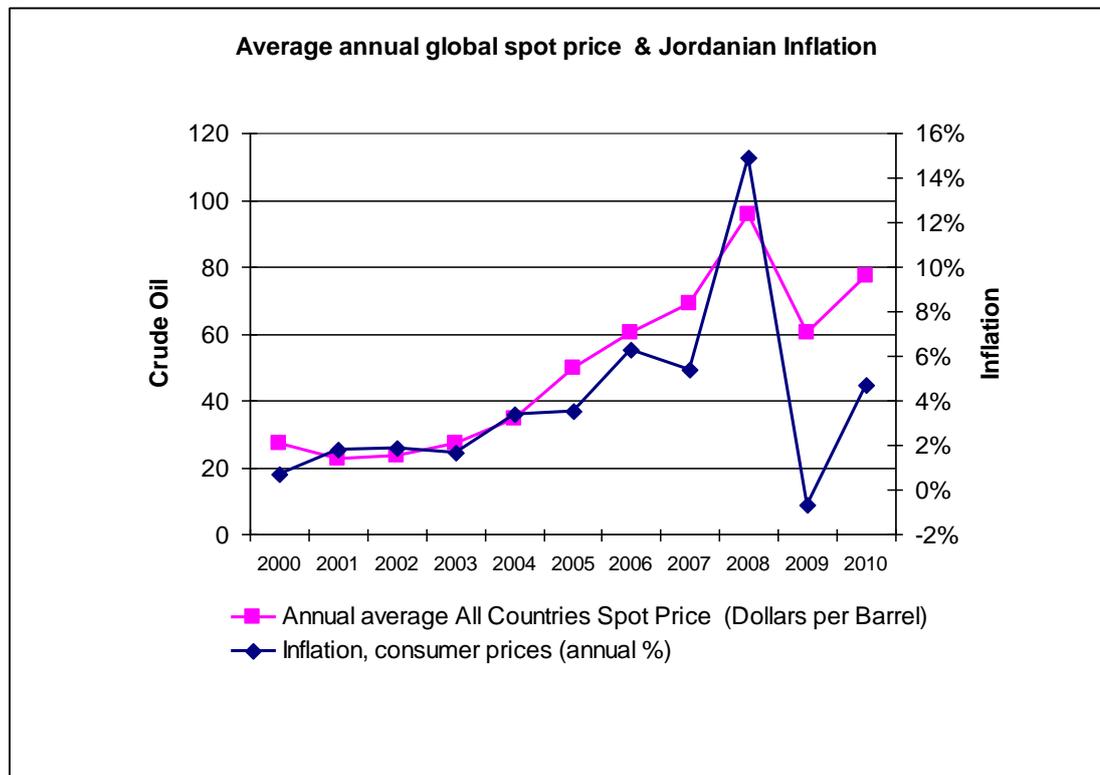
1.5. Current Account Deficit and the Level of Imports

The current account deficit in 2009 narrowed to 6% of GDP from 11% in 2008. Contributing factors include revenues from tourism, remittances and lower oil import spending due to low oil prices. These factors offset the decline in exports compared with 2008.

World oil prices have been volatile over the last three years. The surge in oil prices is linked with Jordan's inflation. Figure 14 shows the correlation between Jordanian inflation and spot oil prices, but it has to be kept in mind that there are other distortions that impact Jordanian inflation to a much greater extent and the figure presented illustrates only one of the external factors impacting Jordanian inflation through the years. When the price of fuel resources used for electricity generation and heating increases, prices of other consumable goods rise too, so it will be very beneficial for Jordan to limit exposure to oil price increases.



Figure 14 World Oil Prices and Jordanian Inflation



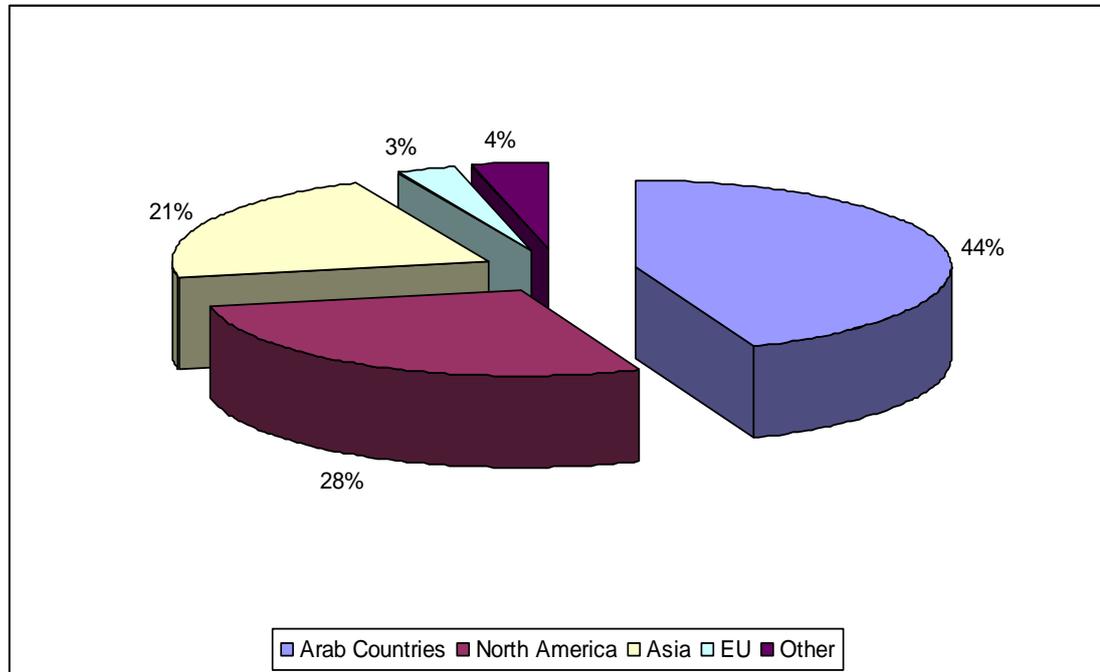
Source: US Energy Information Administration; World Development Indicators from the World Bank, Jordanian government data and Economist Intelligence Unit (EIU) forecast

Exports

Jordan's main exports are garments and textiles, pharmaceutical products, jewellery, electrical appliances, machinery and equipment, furniture, chemicals and allied products, minerals and plastic products.



Figure 15 Export Markets for Jordan: Share of Total by Region



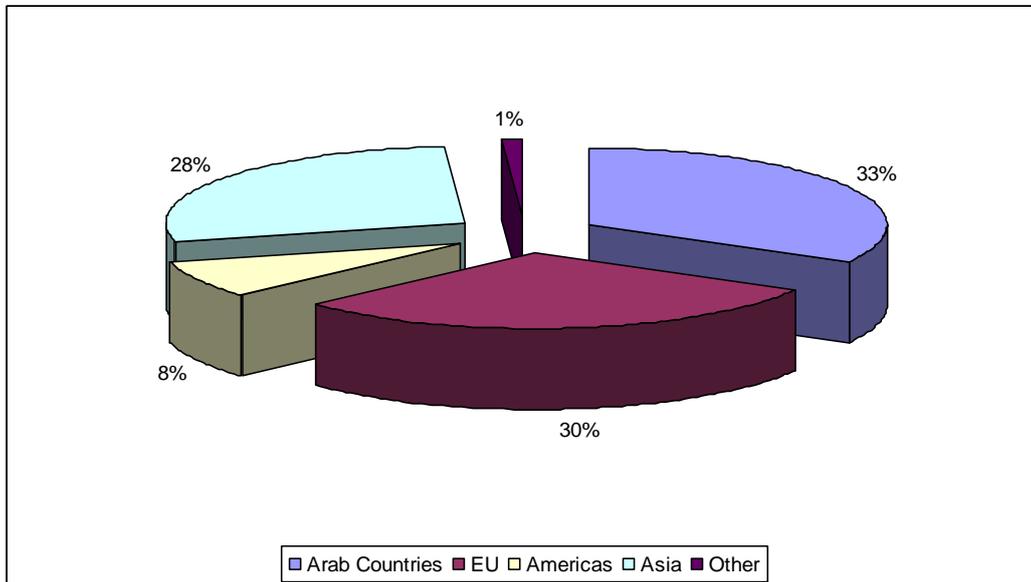
Source: Jordanian Investment Board

Imports

The main imports to Jordan are crude oil, natural gas, textiles and garments, transport equipment, machinery and vegetable products.

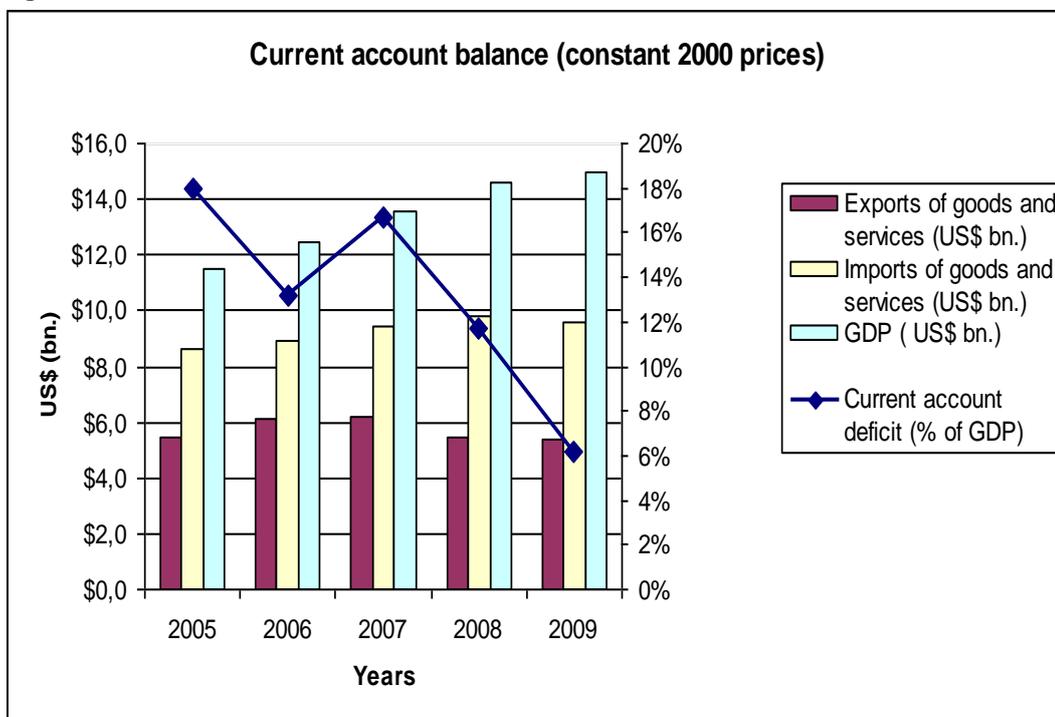


Figure 16 Import Markets for Jordan



Source: Jordanian Investment Board

Figure 17 Account Balance



Source: World Development Indicators from the World Bank, Jordanian Government data and Economist Intelligence Unit (EIU)



Figure 17 shows increasing import dependency. The current trend in the trade balance is a gradual increase in imports and gradual decrease in exports. This means that if the fuel price escalates due to external events outside Jordan's control, the current account deficit will shift steeply upwards.

1.6. Future Economic Development of Jordan

Strongly positioned as a small, open and developing economy, Jordan will experience strong economic growth, according to International Monetary Fund (IMF) forecasts. Building a nuclear power plant will enhance GDP growth, total economic output, employment and labour income, during both construction and operation periods.

The growth in output is directly linked to the growth in electricity demand. According to the Nuclear Power Plant Pre-feasibility Study for Jordan, carried out in cooperation with the IAEA, each 1% increase in GDP growth results in a 0.93% increase in energy demand.

Figure 10 shows that households already consume the largest share of electricity, and their annual percentage increase in electricity consumption is accelerating each year. Therefore, the growth in electricity demand will be permanent and those that will benefit most from access to secure and affordable electricity will be Jordanian households.

The inflation rate in Jordan is forecast to be around 5% per annum according to IMF projections. However, the consumer price index in Jordan reflects the fluctuation of international oil and food prices as well as the strength of the US dollar, since the Jordanian dinar is pegged to the US dollar. In the case of an unpredicted international oil or gas price increase, or devaluation of the US dollar, the inflation level could escalate significantly and create disruptions in the economy.

Unemployment is another macroeconomic indicator which, given the increasing labour force, might become an issue for the Government if the Jordanian economy does not create sufficient employment opportunities. Long-term and stable job opportunities are needed and the Government is currently looking for ways to address this concern.

Increasing imports, of which approximately 23% are fuel imports, widen the current account deficit when international oil and gas prices increase. The Jordanian current account balance is highly sensitive to oil imports. Note that the apparent decreasing trend of the current account deficit, as shown in Figure 17, could be misleading because although oil prices have plummeted in the last two years, they have recently recovered, and are likely to stay high in the future.

2. Direct Impact from Nuclear Power Plant Construction and Operation

Projected benefits of the project are based on anticipated project expenditures, electricity generation and employment for a 2,000 MW nuclear power plant. Construction expenditures drive the model in the construction stage, and demand for electricity is the driving mechanism in the operation phase.



2.1. Power Project Spending

The costs presented in this section for the construction and operational phase are for two 1,000 MW units and are based on external consultants' proprietary information about the costs of construction and operation for a nuclear power plant of this scale.

These expenditures will take the form of infrastructure investments, purchases of local products and services, and labour costs. The data differentiate between expenditures for equipment and materials, and expenditure on labour. The direct impact on the economy comes through the expenditures made by the project in the local economy. Estimated total capital expenditure is US\$8,436 million, distributed across eight years of construction. The assumption for the annual local share of these costs is 36% of the total annual project's cost amount.

Expenditures During Construction Period

The assumed total plant cost for the construction is split into US\$5,526 million for equipment and materials and US\$2,910 million for labour costs, over eight years of construction, as shown in Table . The construction period ends when the power plant is connected to the grid.

Total local costs for equipment and materials for the entire construction period are around US\$1,660 million and the local labour costs are around US\$1,390 million, which together result in approximately US\$3,050 million of project expenditure in the local economy.

Industrial sectors that will benefit from the construction of the nuclear power plant include general machinery and equipment, and primary metal products. These direct costs for the construction of the power plant will also create demand and output in other industry sectors. These are presented below.

Labour costs include construction labour, engineering and professional services, project management, construction site supervision, commissioning and start-up services. Labour costs take into account salaries, state and local taxes, overheads, consumables and profits. These components create additional effects through additional budget revenues which will be captured by the multiplier effect. The assumption used in the analysis is that labour income will be around 60% of total all-in labour rates. About 60% of the total average US labour cost is made up of workers' basic wages. This standard is used as a basis for this report's assumptions.

Table 7 Distribution of Total Capital Expenditures During the Construction Period

PLANT and OWNER'S COST	Years							
	1	2	3	4	5	6	7	8
Cash flow distribution (%)	6%	10%	14%	20%	20%	14%	10%	6%



Revenues Generated During Operational Period from Electricity Sales

The estimated total value of electricity sales in a year is US\$973.7 million for a 2,000 MW nuclear power plant, based on an electricity price of US\$65/MWh.

The estimated amount of combined expenditure and electricity sales creates demand in the economy, and represents the direct impacts. Using the Input-Output (I-O) model, the secondary impacts of electricity sales are quantified. Expenditure during the operational period on repair and maintenance costs, fuel costs and income tax was not considered in the quantification of secondary benefits, to show clearly the impact on the economy of the electricity that would be sold.

2.2. People Directly Employed by the Power Plant

The direct effect of a nuclear power plant project on employment in Jordan is represented by the newly created jobs during the construction and operation periods, summarised in the table below. The figures are based on the external consultant’s proprietary information about the level of employment in nuclear power plants during different phases. The figures are indicative and are used solely for the purpose of the analysis.

Construction Phase

Table 8 Employment During Construction

Phases	Year	Total employment	Local employment
a) Initial stage	1	1,299	680
	2	1,752	923
b) Advanced stage	3-4	3,983	2,585
c) Full-scale construction	5-7	4,964	3,287
d) Completion stage and pre-startup period of the nuclear power plant	8	1,728	1,007



Operation Phase

Table 9 Employment During Operation

	Year	Total employment	Local employment (newly created jobs)
Commissioning and operation of the completed nuclear power plant	9-69	1,080	1,026

As well as directly created employment at the power plant, jobs are created in other industry sectors because of indirect effects. This total impact on employment was calculated by dividing the total economic output in different sectors by the output per worker.

The direct effects on the economy in terms of newly created jobs and newly created demand (output) are based on the figures above. The next chapter will assess the secondary impacts: the additionally created demand, and employment. The domestic share of purchased goods and services and local expenditure on labour serve as the key inputs in the I-O model. When project expenditures are entered into the I-O matrix, they induce changes in the intermediate production of each industry sector and result in an increase in the overall economic output.

3. Socioeconomic Impact Evaluation

Secondary impacts are assessed using an Input-Output model. This is an analytical tool which has been extensively used to analyse energy and environmental policies. The model is based on the national I-O table for 2006 provided by Jordan’s Department of Statistics. The socioeconomic analysis is static and is designed to show the total impact on the economy in terms of output, employment and the increase in labour income. It assumes that the inter-industry relationships are similar to those in 2006, and the project cost data provided are in constant prices as of 2010.

3.1. Multiplier Effects and Estimation of Multipliers

The multipliers show the additional economic value created in the economy as a result of US\$1 investment in an industry sector or one newly created job.

Multiplier levels vary constantly depending on the overall structure of the economy, and the links between different parts of the economy. The higher the multiplier’s value, the larger the impact on the economy. Multiplier effects can be developed for different categories such as employment, income and industry output.

The socioeconomic assessment carried out for Jordan using the I-O model calculates multiplier factors. If the direct output, employment or income results are multiplied by the multiplier factors, the secondary effects become internalised and the total economic



impact of the project is shown. The specific multipliers of the nuclear power plant project are calculated below.

The direct and indirect multipliers demonstrate the actual change in industry output from US\$1 spent in the sector, taking into account the inter-industry transactions and the intermediate demand created.

The induced multiplier shows the change in the income levels of households as a result of US\$1 spent in the sector.

The sum of the two multipliers is the total multiplier for the chosen sector. The idea behind the multipliers is to show that one unit of output in an industry sector triggers many inter-industry transactions, as well as demand for intermediate products over and above demand created by the initial project. These increase the total output of the economy.

3.2. Estimation of the Total Impact on Economic Output and GDP, Employment and Labour Income Using the Input-Output Model

I-O model analysis helps in quantifying additionally created (secondary) output, employment or income, which is usually not measured in the project's financial models.

These secondary effects result from direct investment made in equipment, materials and labour in the Jordanian economy during the construction period. The secondary effects during the operation period result from the sale of electricity generated by the plant.

During the operation period, the costs for labour, repair and maintenance, and fuel also create a multiplier effect. For the purpose of this analysis, the impacts during the construction period are triggered by investment in the construction sector and the impacts during the operation period are triggered by the sale of electricity.

Construction Period

Impact on Economic Output

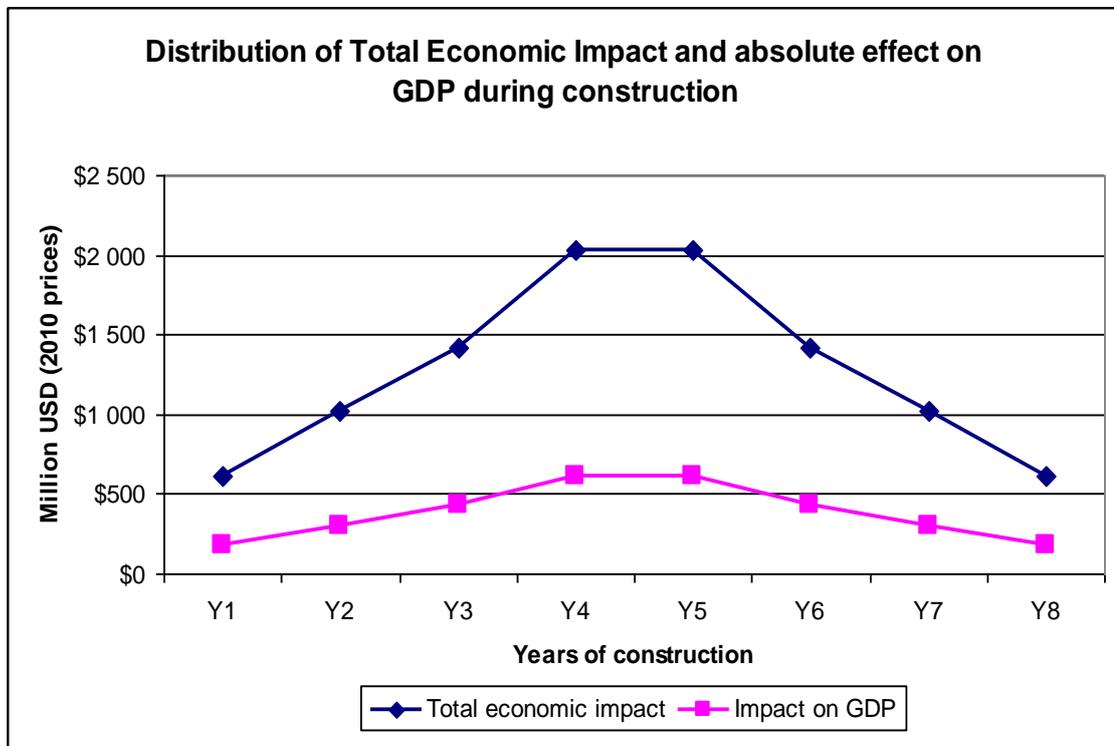
Based on the assumptions for direct expenditure and directly created employment, over the eight years of construction, the model projects a total impact on the economy of US\$10,161 million at 2010 prices.

This total impact will be higher at the peak of construction (US\$2,032 million at 2010 prices) and lower at the beginning and the end of construction (US\$610 million at 2010 prices).

The graph below shows the impact on total economic output and the absolute impact on GDP in millions of dollars at 2010 prices.



Figure 18 Total Economic Impact and the GDP Effect



The I-O analyses are valuable since they show not only the direct impact on GDP but also the additionally created intermediate demand. In other words, the total effect on the economy is much greater than its direct, visible effect. This is the multiplier effect.

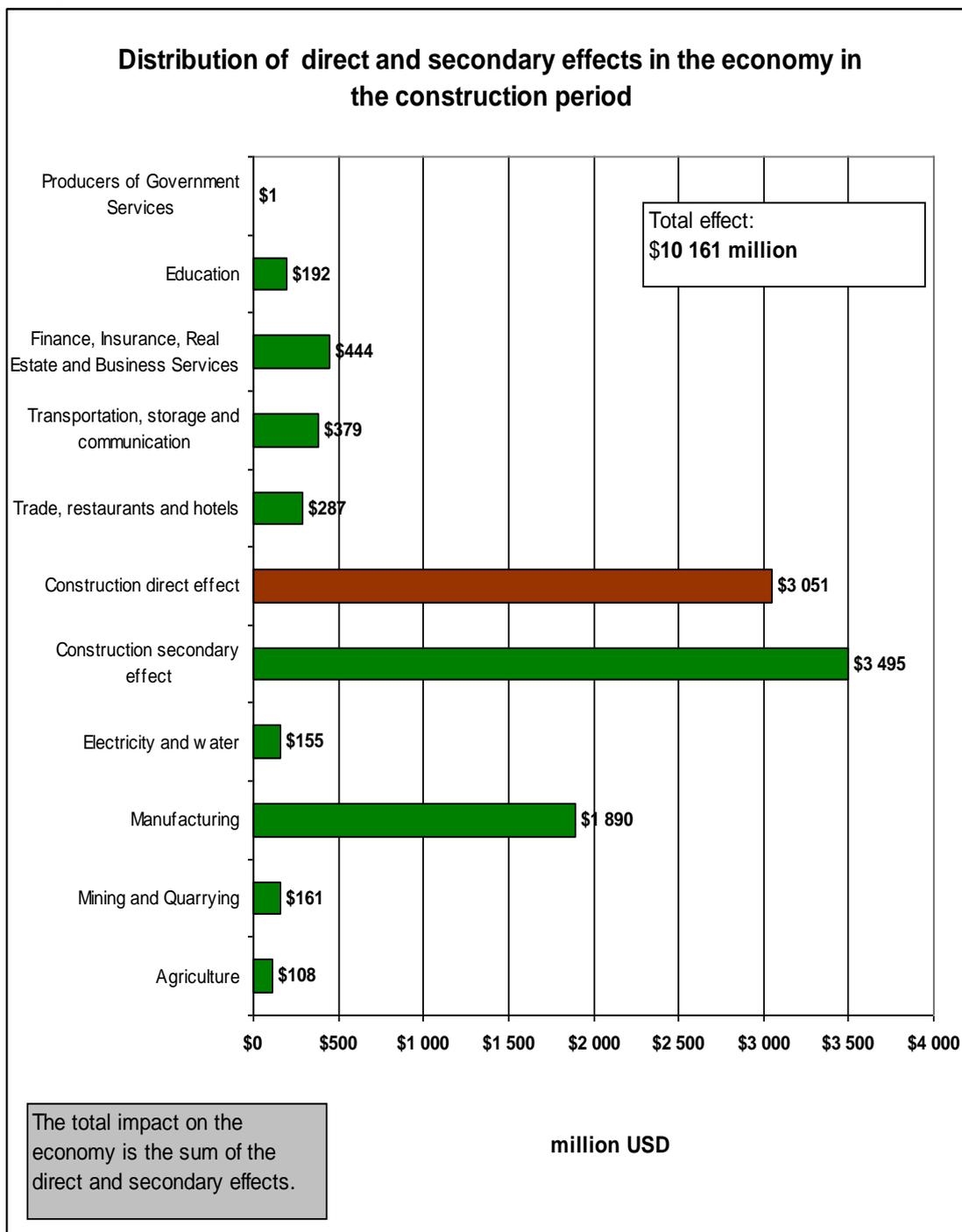
The total economic impact for the eight years is equal to US\$10,161 million (2010 prices). Given an assumed direct impact of US\$3,051 million (2010 prices), this suggests a multiplier of 3.3. This in turn means that each US\$ spent in the construction sector as a result of the nuclear power plant construction creates additional output of US\$3.3, which is spread across all industry sectors in the Jordanian economy.

These analyses demonstrate that at the peak of construction (year four) annual GDP (in constant prices at 2010 levels) will increase by US\$609 million in absolute terms.

The distribution of the additional impact across economic sectors is presented graphically in Figure 19.



Figure 19 Distribution of Economic Impacts on Economic Output



The additionally created (secondary) output creates additional labour income and employment which will not be taken into account if we consider only the direct costs for construction of the nuclear power plant.



Impact on Employment

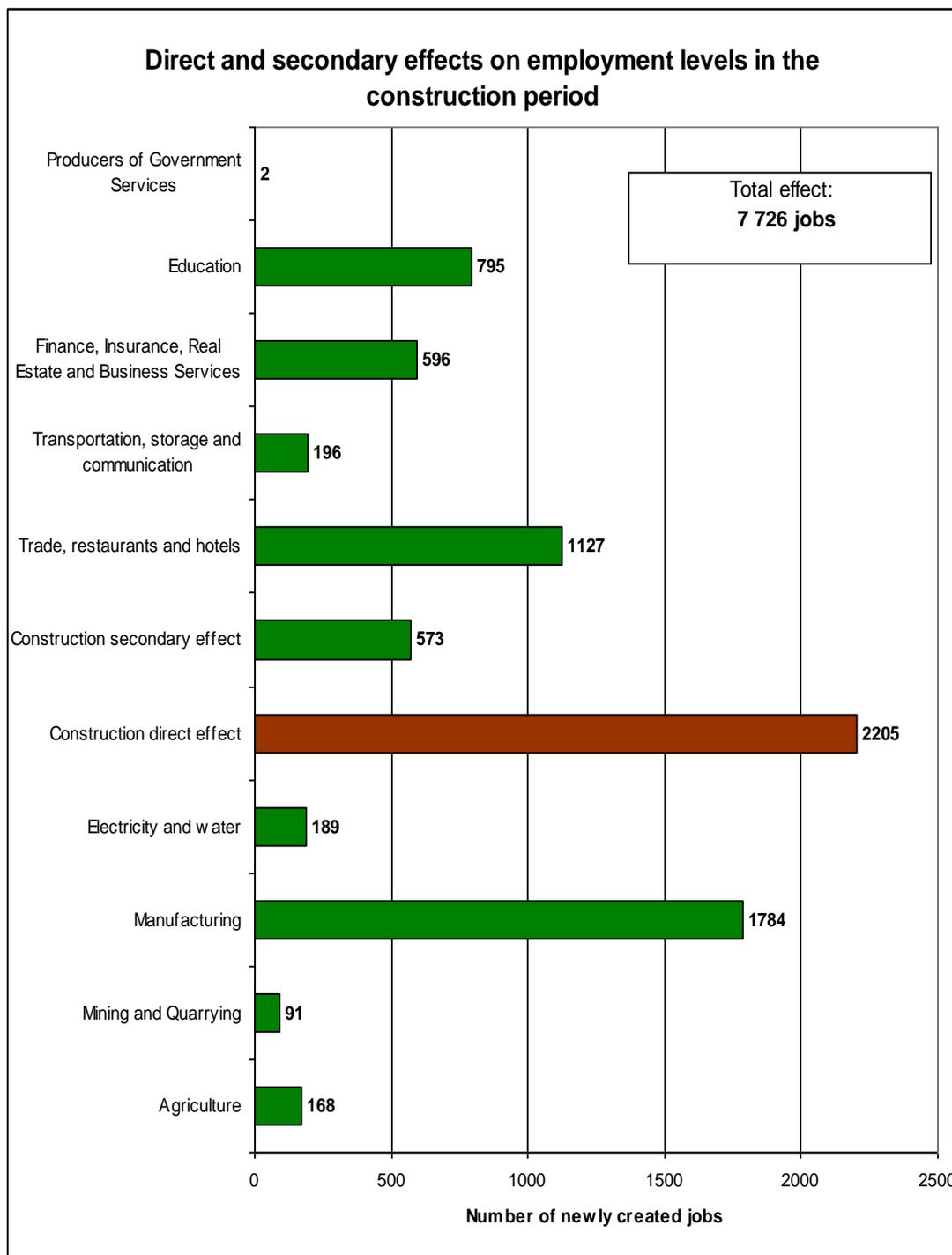
The increase in economic output impacts the level of employment. The I-O model uses the directly created employment at the power plant as the input. It then estimates how much additional employment will be created in the economy through industry inter-relationships.

Average employment during the construction period is assumed to be 2,205 people. The I-O table was used to calculate the economic output per employee, which was used to calculate the total wider impact on employment. The employment created in intermediate product manufacture is also considered.

During the years of construction, 5,448 jobs would be indirectly created in the economy, in addition to the estimated 2,205 through direct employment on the project. This is a multiplier effect of 3.5. The total annual average impact on the economy is the creation of 7,726 new jobs which are distributed among all economic sectors, as shown in Figure 20. However, the total impact will be lower at the beginning and end of the construction period and higher at the peak of construction, as shown in Figure 21.



Figure 20 The Effect of Nuclear Construction on Employment

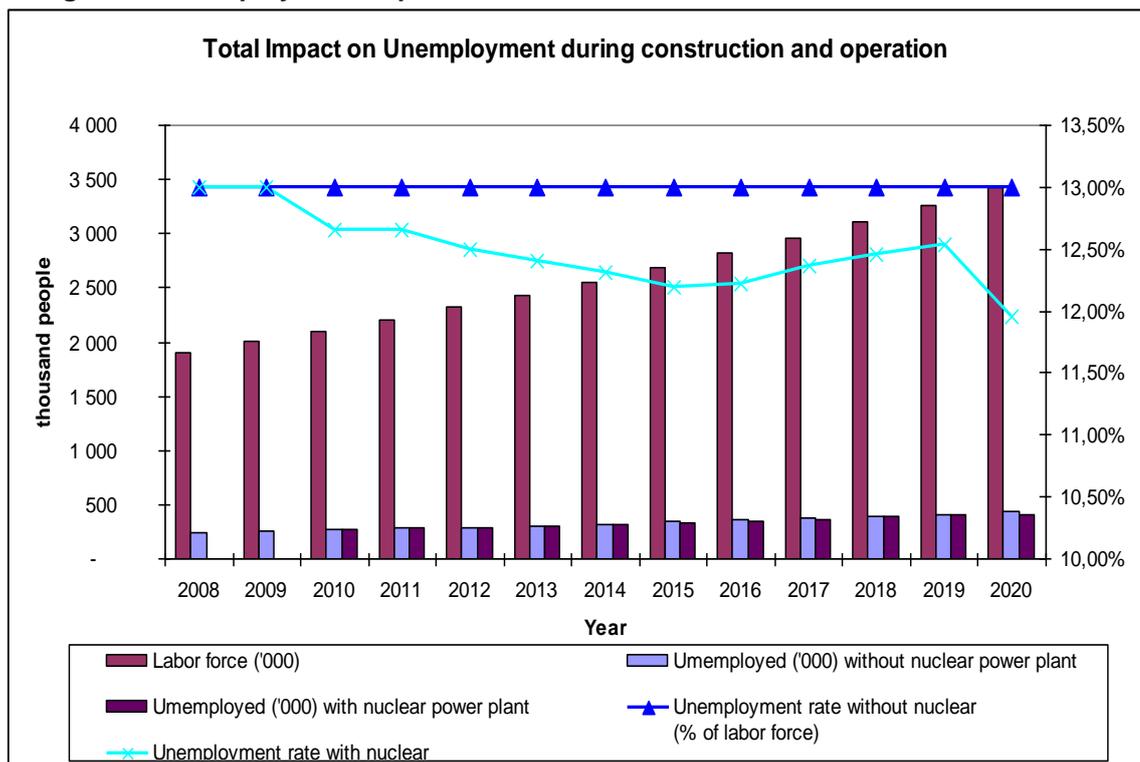


The total impact on employment during the construction phase is significant. Each person employed in the construction sector as a direct result of the project creates on average



between three and four additional jobs in the economy. The impact on employment is highest in the construction, manufacturing, trade and education sectors.

Figure 21 Unemployment Impact



Based on the assumption of a labour force annual growth of 5% and an unemployment rate of 13% in the period 2008-2020, the building of one nuclear power plant will reduce unemployment by almost 1% at the peak of construction.

The increased output and subsequent increase in employment stimulates changes in labour income, which increases as a result of the direct cost of labour at the power plant. This in turn creates a multiplier effect for labour income in other sectors.

Impact on Labour Income

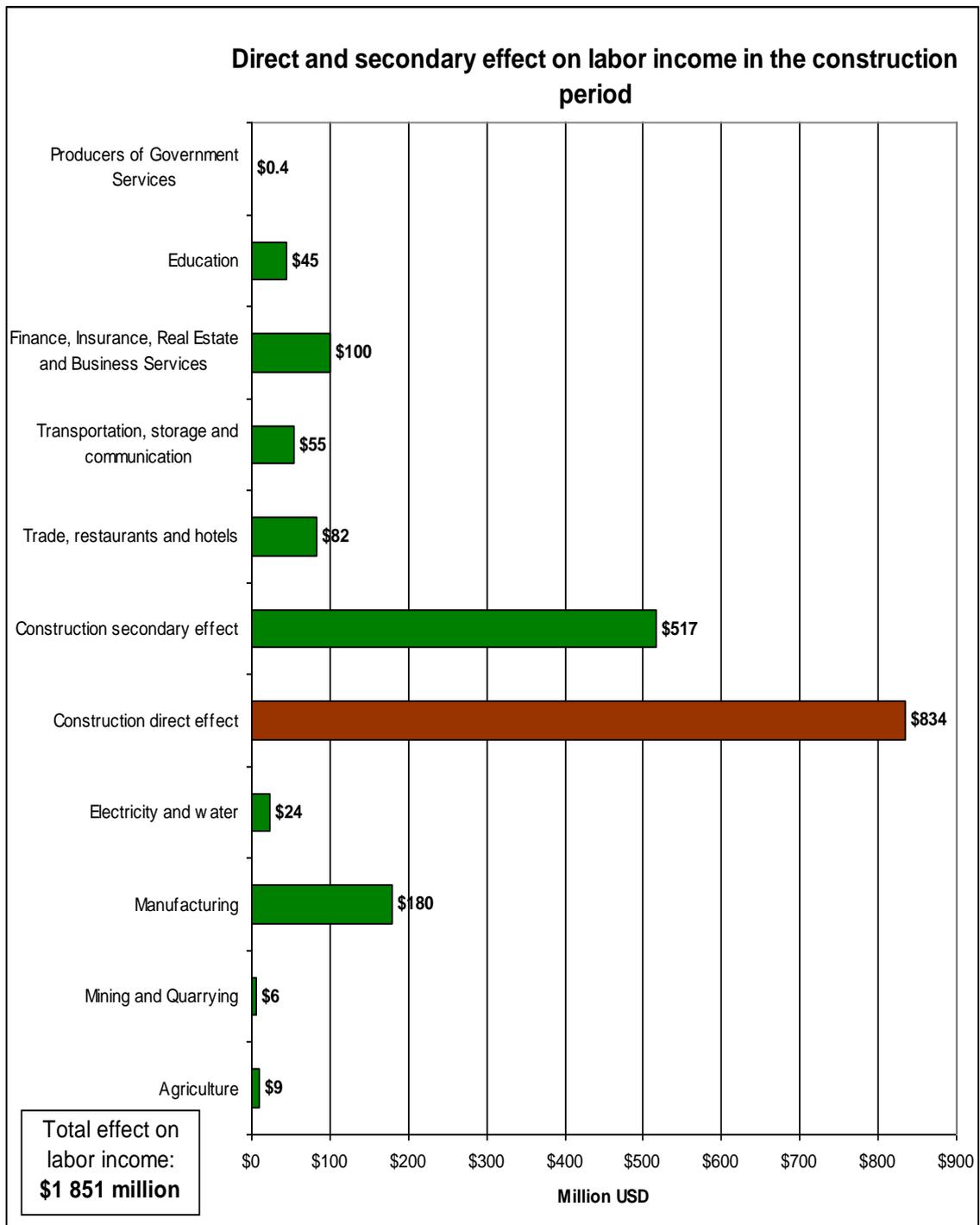
For the whole construction period of eight years, the total impact on labour income is estimated at US\$1,851 million (2010 prices). The estimated labour income multiplier is 2.2. This means that each US\$ spent on labour in the construction sector creates an additional US\$2.2 increase in labour income across the economy as a whole.

The increase in labour income is based on the overall impact on the economy, taking into consideration intermediate production and final production.

The distribution of effects on labour income across different economic sectors is graphically presented in Figure 22.



Figure 22 Distribution of Economic Impacts on Labour Income Levels



Building a nuclear power plant will also boost tax revenues. The total effect on tax revenues is equal to US\$526 million for the whole eight-year construction period.



The second part of the analysis considers changes in output, employment, labour income and tax revenue during the operation of the nuclear power plant. The methodology used for calculating the impacts is the same as for the construction period, but with the difference that this time, the sector where the direct effect is realised is electricity and not construction.

Operation Period

The I-O model was applied to evaluate the impact on the economy as a result of the generated electricity from the power plant in one year of operation, using 2010 prices. The annual increase of electricity output is calculated at US\$974 million, based on the assumption of 2,000 MW of power and an electricity price of US\$65/MWh.

The annual increase in total economic output is US\$2,616 million. Around 30% of this impact, or US\$785 million, is through the additional effect on annual GDP, and the other 70% – around US\$1,831 million – is through intermediate output.

The increase in economic output and the new directly created jobs at the power plant create additional jobs in other economic sectors. Each person employed in the electricity sector as a direct result of the operation of the power plant creates 23 jobs in the whole economy.

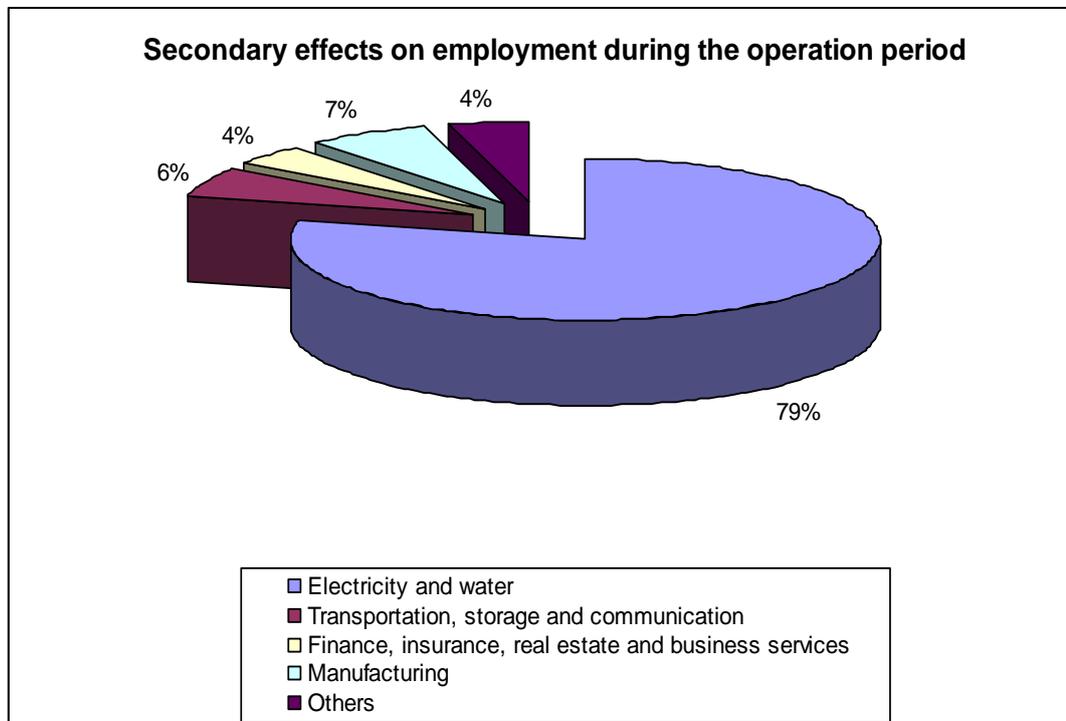
So 1,026 jobs directly created at the power plant during the operation period create an additional 22,728 jobs in the economy.

Please note that the static Input-Output model assumes that 1,026 jobs will be created in the first year of operation but in reality this figure covers all the new job opportunities created throughout the whole operation period of the nuclear power plant. Therefore the effect of additionally created jobs will be spread across the whole operation period of 60 years.

The multiplier effect of directly created employment in the electricity sector also shows that the Jordanian economy is highly interrelated with the development of the electricity sector, and emphasises the benefits from the directly created employment on the labour market for all economic sectors in Jordan. The distribution of the additionally created jobs is shown in Figure 23.



Figure 23 Secondary Effects on Employment in the Jordanian Economy



The new jobs created during operation of the power plant, assuming that the plant starts operation in 2020, will decrease the unemployment rate by more than 1%. This can be seen in Figure 21, based on the assumptions of 5% annual growth in the labour force and a constant level of unemployment of 13%.

The high multiplier effect related to job creation in the whole Jordanian economy during operation shows the importance of this sector and the strong inter-industry relationships that stimulate employment in all sectors of the economy.

There is also a significant impact on labour income in the electricity sector and the other sectors in the economy. The I-O model calculates a multiplier of 7.9. Annually, the total impact on labour income in all economic sectors (including the electricity sector) is US\$237 million (2010 prices).

The methods needed to calculate the effect on tax revenues during the plant's operation period are complex. The Input-Output table for 2006 shows that electricity generation in the country was subsidised at that time. However, since the policy of electricity subsidy has been changed, it is assumed that the subsidies calculated as a result of the Input-Output modelling will appear as tax revenues. Based on this assumption the I-O model calculates annual tax revenue of around US\$31 million.



V. Jordan's Nuclear Energy Programme

1. Programme Background

1.1. Programme History

Jordan became a member of the International Atomic Energy Agency (IAEA) in 1966, and has started close cooperation with the Agency to prepare for a safe and secure nuclear programme.

Before 2001, nuclear activities were handled by the Nuclear Energy Department at the Ministry of Energy and Mineral Resources.

In 2001, the Nuclear Energy and Radiation Protection Law (Law No. 29 for 2001) established the Jordan Nuclear Energy Commission (JNEC) to both promote and regulate nuclear energy in the country.

In November 2006, a high-level Ministerial Committee chaired by the Prime Minister was established to develop a roadmap for implementing the nuclear energy programme. The Committee set up the Nuclear Energy Programme Implementing Organisation (NEPIO).

In July 2007 two Laws (Nos. 42 and 43) took on the remit previously covered by Law No. 29 for 2001. Law No. 42 for 2007 covered the establishment of the Jordan Atomic Energy Commission (JAEC) and Law No. 43 for 2007 concerned the establishment of the Jordan Nuclear Regulatory Commission (JNRC). Thus, the division of responsibilities between the promotion and regulation of applications for nuclear plants was clearly defined.

In January 2008, Law No. 42 for 2007 was amended, empowering the JAEC to lead the development and implementation of nuclear strategy and to manage the nuclear energy programme.

The Higher Committee was replaced by an Inter-ministerial Committee in 2009. The new Committee was chaired by the Minister of Planning, and included representatives from the Ministries of Energy, Environment, Finance, Water and Irrigation. The Chairman of JAEC and Director-General of JNRC were also Committee members.

In 2010, a new Higher Committee chaired by the Prime Minister replaced the previous Inter-ministerial Committee, and in July 2010, a NEPIO Steering Committee was established.

1.2. Institutions Directly Involved in Implementing the Nuclear Programme

This section lists the nuclear authorities in Jordan and their role in implementing nuclear power projects in the country.



Ministry of Energy and Mineral Resources (MEMR)

MEMR's strategic objectives include creating opportunities for the private sector to invest in energy projects, optimising energy consumption in all sectors, and improving their efficiency. The Ministry has taken control of planning for the energy sector in terms of regulations, formulation of general policies and policy implementation.

Jordan Atomic Energy Commission (JAEC)

The Jordan Atomic Energy Commission is an independent body mandated to articulate a vision, strategy and roadmap to develop the use of nuclear technology for research, applications and generating electricity. JAEC acts as the effective NEPIO (Nuclear Energy Programme Implementing Organisation) for Jordan.

The Commission represents Jordan locally and internationally in all areas related to nuclear energy and manages and executes various projects of the Jordan Nuclear Programme.

Its other objectives include developing a national plan for nuclear human resources, and carrying out impact assessments on various economic sectors throughout the cycle of nuclear use. JAEC also provides guidance, oversight and approval of uranium exploration, including mining activities and exploration of financial options related to the Jordan Nuclear Programme.

JAEC has solicited, negotiated and is currently implementing installation of a 5 MW multi-purpose research reactor and sub-critical assembly at the Jordan University of Science and Technology, for educational and research purposes. These facilities will be an integral part of a future nuclear research and development centre in the country.

In 2007, JAEC established Jordan Energy Resources Incorporated (JERI), a wholly owned company that will serve as JAEC's commercial arm, developing, exploiting and marketing Jordan's natural uranium resources, as well as vanadium, zirconium and thorium.

JAEC also operates laboratories for the analytical measurement of uranium and is responsible for locating partners to explore Jordan's uranium deposits. JAEC and French company AREVA signed an exploration agreement to explore uranium deposits in central Jordan. JAEC is negotiating additional agreements with other international companies to explore uranium deposits in other areas of the country.

JAEC's policy is to leverage Jordan's industrial capacity, in particular construction companies, architecture and engineering firms, and the cement and steel industries, to support the construction of the nuclear power programme.

Jordan Nuclear Regulatory Commission (JNRC)

JNRC was empowered by Parliament as an independent body to promulgate the legal, regulatory and security framework for implementing the nuclear programme.

It is responsible for Jordan's general policy in the field of nuclear safety, nuclear security, and radiation protection. The main task of JNRC, as for any nuclear regulatory authority, is to regulate and control the use of nuclear energy and ionising radiation.



More details on the nuclear regulatory authorities are provided in the following chapters.

1.3. Human Resource Development

The Hashemite Kingdom of Jordan invests heavily in education and the development of Jordanian human resource capital, compared to its neighbours. A large share of Jordan's GDP is used for education aimed at developing a labour force that can meet the demands of the modern market.

The literacy rate in Jordan is 92% (2007 figures) of the total adult population, which creates a good basis for the development of human resource capital in the country. Jordan also has a significant number of science graduates. The statistics show that 25 universities in Jordan (10 public and 15 private) produce 8,097 graduates in scientific fields and 398 postgraduates. These numbers are further increased if science graduates from the 439 community colleges are added.

Educational and training programmes for implementing the nuclear energy programme entail a long-term educational and training strategy. This strategy includes formal education in universities and community colleges, facility-specific training provided by the vendor of the reactor, and training performed by experienced power utility organisations to help the initial operation of the nuclear power plant.

JAEC's strategic objectives for human resource capital include:

- Further development of nuclear undergraduate programmes in nuclear engineering.
- Establishing a centre of excellence in collaboration with countries with advanced nuclear power programmes.
- Collaborating with regional and international agencies on nuclear power and safety.
- Providing scholarships through coordination between JAEC and foreign academic institutions.

Some educational institutions have set up their own nuclear studies departments. For example, the Jordan University of Science and Technology (JUST) offers a five-year Bachelor's degree in Nuclear Engineering. Standards for this degree have been extremely high from the very beginning, with only the best students admitted.

The first group of 18 students enrolled in 2007, and the long-term plan is to have approximately 25 students starting every year. The proposed enrolment of students depends on the pace of development of the nuclear energy programme, and will be increased if necessary to meet demand.

JUST also has an exchange programme with several universities in the United States (North Carolina State University, the University of Illinois, Virginia Tech, Ohio State University and University of California). More and more new graduates and staff are sent abroad to receive training or complete their postgraduate education in fields related to nuclear engineering. So far, the candidates have attended additional education courses in France, China, Korea, the Russian Federation and the United States.

Two other institutions with educational programmes in nuclear energy are the University of Jordan and Al-Balqa Applied University, which have Master's programmes in nuclear sciences. Other nuclear-related programmes in Jordanian universities also exist, for example in civil engineering, chemistry, physics, computer engineering, and mechanical and industrial engineering.



With respect to knowledge transfer, Jordan and France recently signed a Memorandum of Understanding which stipulates the establishment of a Centre of Excellence for Energy and Mega Projects, related to three programmes:

- Master's programme in nuclear safety at JUST.
- Master's programme in project management at Jordan University.
- Advanced Training programme at Al-Balqa Applied University.

1.4. Research Facilities

JAEC is in charge of developing research facilities that will support and enable the development of human resources necessary for the nuclear energy programme.

Jordan Center for Nuclear Research

The cornerstone of Jordan's Center for Nuclear Research will be a 5 MW multi-purpose research reactor. The high-performance reactor will be designed and constructed by Korea Atomic Energy Research Institute (KAERI) and Daewoo Engineering and Construction Company.

Based at the Jordan University of Science and Technology campus near the city of Irbid, the reactor will be used by all interested universities in Jordan to support education and research. Construction started in 2010, and will finish by 2015.

The reactor is only one part of the comprehensive Center for Nuclear Research, which also includes a radio-isotope production facility, a cold neutron source research facility, a radioactive waste facility for the research reactor, and an education and training building. In the second phase of the project, there is an option to construct a fuel fabrication plant.

This facility might eventually become a regional centre which will offer IAEA training courses and host conferences with international significance and reach.

SESAME (Synchrotron Light for Experimental Science and Applications in the Middle East)

Synchrotron is a very advanced source of light, used for scientific experiments and research. Thanks to a donation from Germany, the SESAME (Synchrotron Light for Experimental Science and Applications in the Middle East) international centre has recently been established in Jordan, under the auspices of UNESCO.

SESAME is the first synchrotron radiation (SR) facility in the Middle East. SESAME will have an enormous impact on science and technology in the Middle East and the Mediterranean region, in many fields of basic and applied science.

Developed under the auspices of UNESCO, the SESAME facility has been established as an autonomous intergovernmental research centre modelled on CERN. Its current members are: Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. Observer countries are France, Germany, Greece, Italy, Japan, Kuwait, Portugal, the Russian Federation, Sweden, Switzerland, the UK and the USA. Jordan has provided the building that will house the accelerator complex and associated infrastructure. The facility, located in Allan, was formally opened in November 2008.



From the beginning, training has been a vital element in fulfilling SESAME's capacity-building role, and preparing potential users to make good use of the facilities. SESAME users will be based in universities and research institutes across the region. They will visit the laboratory periodically to carry out experiments, generally in collaboration with other institutions. IAEA has actively supported SESAME's goal of building human capacity and fostering greater international collaboration in the region since the start of the project.

Scientists from the entire region are involved in SESAME, including several who have worked in Western laboratories for many years. Thanks to this, SESAME has attracted numerous scientists in the Middle East, and the SESAME Scientific and Beamline Advisory Committees have already received more than 70 proposals from the region for SESAME's science programme. The main domains of research will be condensed matter physics, material science, molecular biology, nano-science, archaeology, environmental studies and medical research.

2. Development of Jordan Nuclear Power Plant Programme

2.1. Studies Conducted to Support the Development of Nuclear Power in Jordan

Several studies have been conducted to consider nuclear power implementation in Jordan. Energy Resources International Inc. (ERI) conducted a preliminary assessment of a nuclear power plant option in Jordan in 2006. The study evaluated the future need for new electric generation capacity and compared existing baseload options with the potential nuclear power option.

Following the study, ERI recommended nuclear power and established a roadmap for the move towards implementing it. Furthermore, the US Lawrence Livermore National Laboratory, in cooperation with the US Department of Energy, conducted a feasibility study for a commercial-sized nuclear energy facility. The study used a financial, risk-based approach of co-generating both electricity and clean water to meet expanding industrial, agricultural and consumer sectors.

Pre-feasibility Study

The next step was to develop a pre-feasibility study, which looked at the location of Jordan's first nuclear power plant and focused on integrating nuclear power into the existing and future power generating system. The study was prepared by a joint team from JAEC and the National Electric Power Company (NEPCO).

Site Selection and Characterisation Study

In 2009, JAEC launched environmental and feasibility studies for the location of Jordan's first nuclear power plant. An external international consultant was contracted to make a study of the selected site and characteristics of the future plant. This examined the proposed site in line with IAEA and US Nuclear Regulatory Commission standards.

Pre-construction Consultancy Services



In November 2009, JAEC awarded a contract to an external consultant to perform pre-construction consultancy services to assist in evaluating the nuclear technology most suitable for Jordan's first nuclear power plant. Support will also be provided to develop Jordan's long-term nuclear fuel strategy, to create a spent fuel and radioactive waste management strategy, and to review the Environmental Impact Assessment.

Network Study

In 2010, a network study was prepared to update Jordan's transmission plan, and address the ability of Jordan's network to accommodate a large new nuclear power plant.

2.2. Current Stage of Development of the Nuclear Energy Programme

Plant Site

The site selection for the Jordanian nuclear power plant is ongoing. The original site under consideration was close to Aqaba, in the south of Jordan, but the terrain and its high elevation above the water source would require extensive extra work. Attention has now shifted to a site north of Amman. The new site includes an area of approximately 10 km² of flat and undulating terrain large enough to build two nuclear units. This site is about 750 m above mean sea level and the topographics of the site area do not present a barrier to construction.

A heavy-load capacity road and/or railway facilities will need to be built to transport heavy equipment and raw materials during construction.

The site is located near the main wastewater treatment plant in Jordan. The quantity of treated wastewater is believed to be sufficient to meet the cooling water requirements of the nuclear power plant.

Considering the local constraints and the water resources, a closed plant cooling system with mechanical draft type cooling towers is being considered. Based on projections for the quality of available wastewater, it is likely that tertiary water treatment will be required.

Plant Technology

Jordan is in a competitive dialogue (CD) with three prospective technology vendors. The goals of the CD are to ensure that Letters of Intent are issued and the final contract signed in sufficient time to allow the project to be completed on time, and that the contract incorporates all elements needed for successful project implementation.

The CD process is conducted according to the highest applicable standards. It is completely transparent to potential technology vendors and other stakeholders. The preferred technology vendor is expected to be selected by the end of 2011.

The CD process is ongoing and no nuclear technology has been selected. Two main types of nuclear technology are presently being considered for the first Jordanian nuclear power plant: pressurised water reactor and pressurised heavy water reactor. Both technologies are mature and proven, based on many hours of reliable operation worldwide over past decades.

The considered plant designs are Generation III and Generation III+.



Implementation Plan

The financial feasibility study for the project is being done by an external consultant. The main goal of the study is to produce a comprehensive financial analysis of the project, which can then be used by financial institutions to assess the creditworthiness of the nuclear power plant.

Selection of a strategic partner who will take an equity share of the project is running in parallel with the process to choose the most appropriate technology and associated vendor.

An international advisory company has been retained to help establish the Jordan Electric Utility Company, which will own and operate the plant. It is likely that this utility will have features of a public–private partnership, as it will be part-owned by the Government and part-owned by one or more international investors. The equity share and identity of the owners are still being negotiated.

The current schedule estimates that the preferred technology vendor will be selected by the end of 2011, and the contract with the vendor signed by the end of 2012.

Pre-construction activities will start early in 2012, and a construction permit is expected to be granted by local authorities in 2015. It is estimated that construction will be complete by the end of 2019, and the first Jordanian nuclear power plant will be commissioned in 2020.



VI. Safety and Security of the Nuclear Power Plant

The Government has fully recognised the prime importance of safety and security in developing the Jordanian nuclear energy programme. All steps undertaken by the institutions involved demonstrate that nuclear and radiation safety and security are fundamental aspects of Jordanian policy, and have the highest priority in the Jordanian nuclear programme.

The Government and JAEC are fully aware of the necessity of introducing and implementing the highest safety standards in all phases of the nuclear power plant project life cycle – including selection of the site and the technology, construction, operation and maintenance, and plant decommissioning. This would also include accompanying activities, such as nuclear fuel and radioactive waste management.

1. Legal and Organisational Aspects

Clear signals that the Hashemite Kingdom of Jordan is highly committed to safety include:

- Signature and ratification of the international treaties and conventions in the safe use of nuclear energy.
- Establishment of a clear organisational infrastructure for implementing the nuclear programme.
- Clear division of responsibilities.
- Involvement of IAEA in developing Jordan's nuclear regulatory infrastructure.
- Nuclear cooperation agreements and international cooperation.

Jordan works in very close cooperation with the IAEA and considers the IAEA's active participation as an assurance that all international IAEA safety and security standards will be properly reflected in Jordanian nuclear law and applicable regulations.

Jordan also benefits from worldwide nuclear experience through the involvement of the European Commission and international consultants. Jordan will strictly adhere to international nuclear standards.

2. Safety of the Technology

JAEC has defined a clear set of criteria for selecting the nuclear technology, and most of these criteria have a direct or indirect impact on safety and security.

This is shown by its decision to consider only Generation III and III+ advanced reactor technology: only a contemporary design meeting the highest safety and security standards will be implemented. The main criteria used for selecting the future designs and design providers of Jordanian nuclear technology include in particular:

- Core damage frequency (CDF).
- Consideration of beyond design basis events (severe accidents) in the design of the plants – prevention and mitigation.



- Consideration of the impact of crashing a large commercial aircraft into the plant, and the effect of external explosions, seismic and other external events in the design.
- Consideration of operator accident mitigation strategies (management guidelines, procedures and training to prepare for a severe accident, including loss of a large amount of equipment).
- Radiological parameters during normal operation and accidents (design basis and beyond) – the effective dose to the population, quantity of releases to the environment.
- Modern man-machine interface.
- Minimisation of the exclusion zone.
- Implementation of digital instrumentation and control.
- Redundancy and diversification of safety systems.
- Introduction of passive components and systems.
- Reliability and security of fuel supply and proposed options for spent fuel management.
- Generation, quantity and treatment of radioactive waste.
- Existence and implementation of a Quality Management Programme.
- Consideration of Jordan's site-specific seismicity (a design that is highly capable of responding to seismic events will be deemed essential).

The unfolding Japanese nuclear accident is a subject of major interest within the nuclear community. It will continue to receive intense global media coverage.

Generally, the nuclear community continues to believe that nuclear energy must be, and therefore will be, a growing part of the global energy portfolio for decades to come. With respect to the potential impact of the Japan accident on the Jordan nuclear programme, there are two points to note:

- All countries with an interest in nuclear power, including those with operating nuclear plants. as well as countries such as Jordan which are developing a nuclear energy programme, will need to assess the Japan event and determine any impacts on their respective nuclear programmes.
- The Japan incident is the result of rare and extreme natural events impacting 40-year-old plants. For Jordan, key actions are likely to include:
 - (1) redoubled perusal of appropriate siting criteria and methodical review of the siting;
 - (2) re-affirmation of the commitment to Generation III and III+ advanced reactor technology which could not suffer the types of failure that occurred in Japan;
 - (3) carefully developed, modern operator accident mitigation strategies;
 - (4) continued close cooperation with the IAEA and adherence to what are likely to be evolving international safety standards.



3. Security and Non-proliferation Aspects

There is a close link between the safety and security of nuclear energy on the one hand, and non-proliferation on the other.

To ensure the absence of undeclared nuclear material and activities or diversion of nuclear material for weapons purposes, an international non-proliferation regime has been developed. This regime consists of:

- An international institutional framework for non-proliferation based on the Non-proliferation Treaty and comprehensive IAEA safeguards, agreements and protocols.
- International verification measures (the IAEA safeguards system plus regional and bilateral agreements).
- Export controls on nuclear materials, specified facilities, equipment and other materials, including dual-use technologies and materials.
- National physical protection measures and material accounting and controls measures, as well as IAEA recommendations on physical protection.

The political commitment of Jordan to security and non-proliferation began with the signature of the Non-proliferation Treaty in 1970, followed by the signing of two protocols (in 1974 and 1998) on the application of safeguards.

The next step is to establish a set of procedures and technical measures to introduce proliferation-resistant features into the nuclear energy activities of Jordan. As far as design is concerned, special attention will be paid to those characteristics that facilitate the implementation of safeguard application measures.

4. Radioactive Waste Management

The Hashemite Kingdom of Jordan is committed to implementing radioactive waste management measures so as to avoid imposing undue burdens on future generations.

JAEC is aware of the issues surrounding radioactive waste, whether it is low and intermediate-level waste, high-level waste or spent nuclear fuel.

In line with the national policy, a national radioactive waste management strategy is under development. The strategy will investigate and evaluate all options for long-term management of spent nuclear fuel. In addition, JAEC is assessing the readiness of several national institutions to handle waste issues, and is taking steps to sign and bring into force the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management.

5. Nuclear Fuel Management

Jordan's experience with the nuclear fuel cycle is limited to the exploration of uranium ore. With respect to other nuclear fuel cycle-related activities, the country is investigating various proposals for multilateral or international fuel assurance schemes in addition to commercial deals.



6. The Environment

The basis of environmental laws and regulations that govern environmental issues in the Hashemite Kingdom of Jordan was originally provided by the 1995 Law No. 12 on Environmental Protection.

Environmental issues have evolved since then, with the 2006 Environment Protection Law No. 52 now the primary legislation that addresses environmental protection issues in Jordan. This Environmental Protection Law was included in a package of temporary laws issued in 2003, officially endorsed by the Parliament in 2006, and issued as Law No. 52 of 2006.

Law No. 52 specifies that the Ministry of the Environment is the competent authority for the protection of the environment in the Kingdom, and official and national authorities will be bound to implement the instructions and resolutions issued under the provisions of this Law. It provides the Ministry with all the necessary judicial powers it requires for implementation.

The Law foresees that an Environmental Impact Assessment of nuclear power plants will be undertaken and a corresponding report reviewed by the responsible organisations. Draft guidance on the review of the Environmental Impact Assessment has already been prepared by JNRC for radiation-related impacts. The guidance consists of requirements, acceptance criteria and a methodology for assessing radiation-related impacts, and fully complies with IAEA requirements and best international practice.

7. Physical Security

Physical security for all nuclear facilities and materials will be the responsibility of the Jordan Armed Forces (JAF). An agreement between the Jordan Atomic Energy Commission and JAF will help:

- Provide a secure environment for assets.
- Deter, detect, delay and respond to malicious acts by using the essential elements of physical protection systems.
- Maintain the confidentiality, integrity and availability of information and systems.

Two levels of security plan will be approved. The first will cover the whole of Jordan while the second will be tailored to each nuclear facility or assembly.

The Government is responsible for building specialist national teams of representatives from concerned national institutions. These teams will be responsible for nuclear facilities, and be in charge of overall national nuclear security.



VII. Transparency and the Geopolitical Environment

One of the key aims of Jordan's nuclear energy programme is to serve as a role model in the region for the safe use of nuclear power and for implementing the programme in a transparent manner. The country's commitment to transparency is the only viable approach that will ensure international acceptance and credibility for Jordan's nuclear programme.

1. Geopolitical Specifics Regarding Nuclear Power in the Middle East

The necessity for nuclear power in developing countries, and in particular the Middle East, is underestimated by the industrialised countries.

The conventional perception of the Middle East is that of a "rich" oil-producing region. However, it is clear that some countries in the Middle East are actually suffering under the cost of high oil prices.

A case in point is Jordan, a country where a high proportion of GDP is spent on energy imports. As was shown above, one of the major challenges for Jordan is to decrease its dependence on oil and gas imports.

Jordan is located at an intersection of geopolitical and economic interests both locally and globally. The relations between the countries, and their unsettled conflicts, combined with the unclear nuclear programme objectives of some of Jordan's neighbours, raise significant concerns at regional and international levels about nuclear deployment in this region. These concerns relate to the credibility of countries' peaceful intentions for nuclear power use and, as a result, to the ability of their governments to ensure the security and non-proliferation of nuclear material.

Nevertheless there has been a significant increase in interest in nuclear power in Middle Eastern and North African countries. Most of these countries have been considering development of nuclear power as a preferred option to satisfy their energy needs, bring multiple social and economic benefits to the region, and ensure sustainable economic development.

Jordan will show complete transparency to establish confidence in its peaceful intentions. It will take effective action towards nuclear non-proliferation and nuclear security. It will ensure that it can handle the project in compliance with the internationally accepted legal framework and safety standards. However, in order to sustain and enhance the contribution of nuclear power as an energy option in the Middle East, all countries in the region must accept IAEA safeguards related to all of their nuclear activities, which in turn will lead to the establishment of a zone free of nuclear weapons.



2. Transparency in Nuclear Power Project Implementation

Transparency will be applied in the processes of selecting, constructing and operating Jordan's first nuclear power plant, both by the JAEC and the involved regulatory agencies. This will ensure the clarity and availability of information on all aspects of the nuclear power generation process.

2.1. Compliance with International and Domestic Legal Regime Related to Non-proliferation and Safety

In keeping with its desire for transparency in its nuclear activities, Jordan is committed to implementing all key international legal instruments pertaining to security, non-proliferation and liability, and to ensuring that the resulting obligations are strictly followed by all parties.

Jordan will continue to sign bilateral agreements with all interested nuclear countries, ensuring commitment to non-proliferation, better understanding and cooperation with respect to its nuclear programme.

Jordan is determined to establish an internationally compliant, domestic legal framework. This will be essential to securing international political acceptance of its nuclear energy programme, encouraging bilateral relations with countries with technical and human resources, attracting suppliers and operators, and obtaining financing.

2.2. High Level of Commitment to Transparency

Transparency will be a core principle of communication and interaction with all project stakeholders at national, regional, and international levels.

Since JAEC and JNRC report directly to the Prime Minister, Jordan is committed to the highest level of responsibility for developing its nuclear programme in a transparent and internationally acceptable manner. All efforts will be applied to establish a reliable system for regular communication of the programme's development, including its decision-making process.

To the maximum allowable extent, access to information and original documents will be provided, thus avoiding speculation based on misinformation. This will engender trust in the institutions managing Jordan's nuclear programme.

This policy requires active cooperation with the media, which is an important forum for making information available to all stakeholder segments, including the general public both locally and globally. The media will be given access to documents, reports, licence applications and all other written documents that do not contain sensitive security or intellectual property information.

They will be invited to participate in meetings, hearings and forums during the development of regulations so they can get accurate information regarding the design and operation of the nuclear facilities, the actions of the managing organisations, and plans for the expansion of all programmes.



Periodic information events for the media will be organised to improve their knowledge and understanding. Regular news releases will keep the media up to speed with the latest nuclear programme developments.

Jordan's openness regarding its nuclear energy programme and its desire to exchange knowledge and experience with other countries is proved by multiple engagements with countries from different parts of the world.

2.3. Openness to International Organisations

Audits, Inspections and Assistance from International Bodies

In line with international and domestic obligations, both JAEC and JNRC are taking a proactive approach by communicating openly with international organisations charged with safeguarding neighbouring states from nations developing nuclear capability.

Both JAEC and JNRC foster an open relationship with such entities by fully accommodating regular audits and inspections by official international bodies, notably the IAEA, of all facilities engaged in nuclear material processing or power generation. One of the first steps in this direction was the arrangement to have all safety-related regulations reviewed by the IAEA.

Both JAEC and JNRC have been actively engaging international expert assistance in nuclear implementation. In this way JAEC and JNRC not only benefit from the accumulated database of knowledge and experience, but also open their activities to external monitoring. This provides the best evidence that Jordan is observing internationally approved practices.

Transparent and Clearly Defined Procedures

The process of selecting international partners and contractors will continue to be carried out in accordance with clearly defined and fully transparent procedures, and its results will be communicated to interested stakeholders. A clear, transparent record of safe operations in countries that are parties to the Non-proliferation Treaty (NPT), and have safeguard agreements in place, will be among the leading selection criteria for potential commercial partners.

Cooperation between the Public and Private Sectors

To earn credibility in the international community, Jordan is considering adopting a public-private partnership model and contracting out much of the short-term responsibility for future plant operation and maintenance to a qualified international operator.

The involvement of experienced and reputable foreign commercial partners will ensure transparency from the early phases of the project, starting with the initial decision-making and siting, through to plant design, construction and operation.

Jordan will foster other forms of cooperation between and within regulatory bodies, private sector institutions, universities, research institutes and non-governmental organisations. This will stimulate an environment of continuous improvement by learning



from the experience of other nations, especially those with an extensive history involving the control, processing and use of nuclear materials.

Active Involvement in International Forums

To take advantage of the large amount of data available, JAEC will actively seek membership and participation in international forums to exchange ideas, and to discuss problem areas, new developments and operating experience for all industries using nuclear materials and nuclear technologies in Jordan.

This philosophy is shared by all agencies within the Jordanian borders that have authority over the use, transport, safeguard and control of nuclear materials and processes.

2.4. Stakeholder Involvement in Decision-making Including the General Public

JAEC will foster an environment of open and transparent dialogue with all stakeholders involved in the generation of electricity through nuclear power, following the principle “engage, interact and cooperate”.

Transparent Communication with the General Public

Stakeholder involvement is an integral part of the step by step process of decision-making.

Stakeholder involvement will include sharing information, consulting, having dialogue, or public deliberations on decisions. JAEC’s goal of informing and communicating will be implemented by developing and disseminating public information materials appropriate for their intended audience – materials that are adapted to the starting position of each stakeholder sector so they can be easily understood.

To provide easy access to information, JAEC will issue booklets, provide internet sites and set up information centres in Jordan’s capital, Amman, and near the construction site, as well as creating travelling exhibitions in the regions of interest.

Floor for Discussions and Opportunities to Share Different Views

Stakeholders will have the opportunity to communicate their views and opinions in detail, as well as to learn from other stakeholders.

Opinion surveys will be organised by JAEC to measure the level of project acceptance by specific stakeholder segments as well as to identify and address issues of public and social interest. Other effective forms of dialogue will include face-to-face meetings with interested stakeholders, discussions with relevant experts on topics of public interest, and web-based public forums.

At every important step of the decision-making process, JAEC will actively seek comments from interested parties using a pre-established public review procedure. All challenges with merit will receive full consideration and, when necessary, will be referred to a higher authority for resolution.



Each and every comment received that passes reasonable acceptance criteria will be handled and addressed through a pre-established documented process open for all interested parties to review.

The interested parties will be involved in amending rules and regulations that are judged to have a large impact on the nuclear industry. This will be arranged through reviews and discussions carried out in public forums to ensure that all aspects of the proposed modification have been addressed and thoroughly investigated before adoption and implementation.

JAEC will offer for public comment all changes to rules and organisations that will directly affect the operation of nuclear facilities licensed for commercial operation. All parties with legitimate concerns will have the opportunity to submit comments and attend public meetings before these changes are adopted as the rules and regulations for nuclear facilities.

One clear piece of evidence of Jordan's intentions and ambitions to lead a transparent nuclear energy programme is the number of treaties and conventions the country has signed and ratified according to IAEA standards and requirements. IAEA's active participation at the request of Jordan ensures that all its safety and security standards and best practices and lessons learnt will be reflected in Jordan's nuclear programme, regulatory environment, design and implementation and operation. A detailed review of the progress and specifics of these efforts is presented in the following chapter.

VIII. International Obligations, Agreements and Cooperation

Jordan adheres strictly to international nuclear standards through signature and ratification of the relevant treaties and by involving IAEA in the development of Jordan's nuclear regulatory infrastructure.

The IAEA's active participation ensures that all its safety and security standards will be reflected properly in Jordan's nuclear laws and regulations.

1. IAEA, International Cooperation, and Guidance

The International Atomic Energy Agency (IAEA) is the world's centre of nuclear cooperation and works for the safe, secure and peaceful use of nuclear technologies. It was set up as the world's 'Atoms for Peace' organisation in 1957 within the United Nations.

The Hashemite Kingdom of Jordan joined the IAEA in 1966, and Jordan was elected in September of 2010 to the Agency's Board of Governors for 2010-2012.

Over the years the IAEA Technical Cooperation Programme with Jordan has been very comprehensive, covering a range of subjects. From 1976 to 2008, 43 Technical Cooperation projects have been implemented, covering nuclear and radiation safety and nuclear security, general atomic energy development, application of isotopes and radiation in food and agriculture, and isotope hydrology and applications of isotopes and radiation in industry.



Over the same period, 29 regional and inter-regional projects in which Jordan participated were completed. From 1994 to 2008, the technical assistance received by Jordan through national projects amounted to US\$8.5 million in equipment, expertise and training.

Three main goals underpin the IAEA's principles:

Safeguards and Verification

The IAEA works to prevent the further proliferation and spread of nuclear weapons. It is the world's nuclear inspectorate, with more than five decades of verification experience. Inspectors check that safeguarded nuclear material and activities are not used for military purposes.

The IAEA inspects nuclear and related facilities under safeguard agreements with more than 150 member states. Most agreements are with member states that have, just like Jordan, internationally committed not to acquire nuclear weapons. They are concluded pursuant to the global Treaty on the Non-proliferation of Nuclear Weapons (NPT), for which the IAEA is the verification authority.

Safety and Security

The IAEA works to protect people and the environment from harmful radiation. It helps countries to upgrade nuclear safety, and prepare for and respond to emergencies. Work follows international conventions, standards and guidance. The main aim is to protect people and the environment from harmful radiation.

In the field of safety, nuclear installations, radioactive sources, radioactive materials in transport, and radioactive waste are covered. A core element is setting and promoting the application of international safety standards for managing and regulating activities involving nuclear and radioactive materials.

In the field of security, nuclear and radioactive materials and nuclear installations are included. The focus is on helping states prevent, detect and respond to terrorist or other malicious acts such as the illegal possession, use, transfer and trafficking of nuclear materials, and to protect nuclear installations and transport against sabotage.

Science and Technology

The IAEA works to mobilise peaceful applications of nuclear science and technology for critical needs in developing countries.

It is the world's focal point for scientific and technical cooperation in the nuclear field. The work contributes to fighting poverty, sickness, and pollution of the earth's environment, and to other global Millennium Development Goals established by the United Nations for a safer and better future.

The main activities are:

- Technical Cooperation – The IAEA supports cooperative projects achieving tangible social and economic benefits for people in developing countries.



- Research and Development – Jointly with institutes and laboratories worldwide, the IAEA supports research and development on critical problems facing developing countries. This work targets food, health, water and environmental areas where nuclear and radiation technologies can make a difference.
- Energy and Electricity – The IAEA helps countries assess and plan their energy needs, including nuclear generation of electricity. Emphasis is placed on the role of innovative and advanced technologies vital to meeting the world's rising energy needs.

2. Nuclear Treaties and Conventions

2.1. Nuclear Non-proliferation Treaty

The purpose of the Nuclear Non-proliferation Treaty is to limit the spread of nuclear weapons throughout the world, making it a safer place for all of humanity, while at the same time promoting the peaceful use of nuclear energy for the benefit of all states endorsing this policy.

The Hashemite Kingdom of Jordan, recognising the benefits to mankind, fully subscribes to the philosophy, principles, intent and articles of this treaty. Jordan signed the agreement in July 1968, becoming one of a present total of 185 countries engaged in a combined effort to make nuclear energy safe and secure.

In December 1974, Jordan signed the safety agreement for Application of Safeguards in Connection with the Treaty on Non-proliferation of Nuclear Weapons.

And in July 1998, the country signed the 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.

2.2. Civil Nuclear Liability

Limitation on civil liabilities arising from nuclear accidents is a cornerstone of nuclear programmes in all countries that have adopted the use of commercial nuclear technology for the generation of electric power within their borders.

These limitations make the financial risk acceptable to the nuclear plant owners who, by international convention, are solely responsible for the consequences of accidents at their facilities, irrespective of the parties that may have contributed to the event.

Several international conventions have established methods, rules and procedures for limiting this liability by planning for the financial effects, assigning a required third party insurance coverage and initiating the litigation that follows an assumed accident. The Government of Jordan is taking steps to establish such limitations within the country's borders.



2.3. Convention on Nuclear Safety

In an effort to promote continuous improvement in the safe operation of a nuclear facility and to legally commit states to maintain a high level of safety, the Convention on Nuclear Safety was adopted in Vienna in June 1994.

The Hashemite Kingdom of Jordan signed the Convention on Nuclear Safety in December 1994. The agreement was ratified in June 2009 and entered into force three months later in September 2009.

The obligations of the contracting parties, as well as Jordan, are based to a large extent on applying the safety principles for nuclear installations contained in the IAEA Safety Fundamentals document, The Safety of Nuclear Installations (IAEA Safety Series No. 110, published 1993).

These obligations cover legislative and regulatory frameworks, regulatory bodies and technical safety obligations. The safety obligations cover siting, design, construction, operation, the availability of adequate financial and human resources, the assessment and verification of safety, quality assurance and emergency preparedness.

The goal of the Convention was not to impose an additional legal requirement to enforce the operating facility's licensing commitments, but rather to provide an incentive-based instrument for nuclear plant operators, which share a common interest in sharing methods and procedures that improve nuclear operating safety.

The Convention allows a participating contracting party to submit reports that are peer reviewed at scheduled review meetings. This provides a forum for exchange of the ideas and methods practised at the contracting party's facility, which contributes to the knowledge pool of safe and efficient operations.

The process of presenting reports at the review meetings and answering questions from the other parties helps each contracting party to achieve a high level of safety in its civil nuclear programme.

2.4. Other International Treaties that Jordan has Signed and Ratified

Convention on Physical Protection of Nuclear Material

The Hashemite Kingdom of Jordan joined the Convention in September 2009, and the Convention entered into force in October 2009.

The Convention is the only international, legally binding undertaking in the area of physical protection of nuclear material. It establishes measures related to the prevention, detection and punishment of offences relating to physical protection of nuclear material. The scope of the present Convention is twofold: it applies to nuclear material used for peaceful purposes in international nuclear transport, and it contains additional provisions related to nuclear material employed for peaceful purposes in domestic use, storage and transport.



Convention on Early Notification of a Nuclear Accident

The Hashemite Kingdom of Jordan signed the Convention on Early Notification of a Nuclear Accident in October 1986. The agreement was ratified in December the following year, and entered into force in January 1988.

This Convention establishes a notification system for nuclear accidents that have the potential for release across national borders, and could thus be a relevant safety matter for another state.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

The Hashemite Kingdom of Jordan signed the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency in October 1986. The agreement was ratified in December 1987 and entered into force in January 1988.

This Convention sets out an international framework for cooperation between the IAEA and other parties for help and support in the event of nuclear accidents or radiological emergencies.

Parties are obliged to ensure protection of nuclear material at the levels specified in the Convention. This material should be used for peaceful purposes within their territories, or on board a ship or aircraft during international nuclear transport.

Comprehensive Test Ban Treaty

The treaty was signed in September 1966 and ratified in Jordan in August 1998.

2.5. Other International Treaties which Jordan has Signed, and is in the Process of Ratifying

- Convention for the Suppression of Acts of Nuclear Terrorism (signed November 2005).
- Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water (signed May 1972).
- Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea Bed and the Ocean Floor and in the Subsoil (signed May 1972).
- Revised Guiding Principles and General Operating Rules to Govern the Provision of Technical Assistance by the Agency (signed February 1989).
- Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA) (signed February 1989).
- Amendment to the Convention on the Physical Protection of Nuclear Material (accepted in October 2009; signature and ratification are pending).



2.6. International Treaties under Consideration which will be Implemented in the Near Future

- Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention.
- Convention on Supplementary Compensation for Nuclear Damage.
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

3. Nuclear Cooperation Agreements

3.1. Nuclear Weapons Free Zone Agreement

A Nuclear Weapons Free Zone (NWFZ) is a specified region in which countries commit themselves not to manufacture, acquire, test or possess nuclear weapons.

Five such zones exist in the world but none are in the Middle East. Article VII of the Non-proliferation Treaty, of which Jordan is a signatory as noted above, affirms the right of countries to enter into agreements to establish such zones.

An NWFZ is a logical extension of the Non-proliferation Treaty and the proposal to establish a regional zone has been considered and debated since 1974. Those efforts have not yet been successful, and other attempts were made in the early 1990s, with the Government of Jordan playing a significant role.

Once these efforts are re-established, Jordan will set the stage in helping Middle Eastern countries to come to agreement, and in producing incentives and opportunities that benefit from the peaceful use of nuclear energy.

3.2. International Framework for Nuclear Energy Cooperation (IFNEC) (Formerly Global Nuclear Energy Partnership – GNEP)

The GNEP was formed by the USA in 2006 to form international partnerships to promote the use of nuclear power and to reduce nuclear waste and the possibility of nuclear proliferation.

The Hashemite Kingdom of Jordan is one of the 16 countries that became GNEP partners by signing the GNEP Statement of Principles in September 2007. GNEP changed its name to the International Framework of Nuclear Energy Cooperation (IFNEC), along with a change in some of the basic principles, in June 2010.

The newly adopted vision statement reads: “The Framework provides a forum for cooperation among participating states to explore mutually beneficial approaches to ensure that the use of nuclear energy for peaceful purposes proceeds in a manner that is efficient, safe, secure, and supports non-proliferation and safeguards.”



This new partnership provides the opportunity for all member states to fully engage in the use, development, and sharing of nuclear technology that will provide safe and secure benefits of nuclear power to all. The stated goal of this association is to share technology while preventing the proliferation of nuclear weapons by reducing nuclear waste through spent fuel reprocessing that makes it difficult to extract weapons-grade materials.

The Hashemite Kingdom of Jordan has been among the first countries to join the International Framework of Nuclear Energy Cooperation.

It has hosted two events in this field – the GNEP steering group meeting in May 2008 and the IFNEC executive committee meeting in November 2010. These meetings were designed to foster bilateral and multilateral discussions between established and aspiring nuclear states from all over the world.

The fact that such meetings took place in Jordan is another sign of Jordan's commitment to pursue peaceful nuclear energy development. The meetings are important for the Kingdom in gathering international support for its programme.

3.3. Cooperative Agreement for Arab States in Asia for Research, Development, and Training Related to Nuclear Science and Technology (ARASIA)

This agreement was established to promote cooperation, information-sharing and the identification of joint programmes that will further the use of peaceful nuclear energy technology in the Arab states.

The agreement provides for a multinational approach to fund and perform research into the continuing development of nuclear technology and to participate on a world stage by helping to advance nuclear knowledge.

At present there are eight parties in this agreement, some of which have operating nuclear power plants as part of their well-established near-term power solutions.

The Hashemite Kingdom of Jordan became a signatory of this agreement in August 2002.

3.4. Other Agreements

- The Comprehensive Safeguards Agreements Between Jordan and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-proliferation of Nuclear Weapons (signed December 1974).
- Agreement on the Privileges and Immunities of the IAEA.

4. International Cooperation

Jordan has engaged many countries in discussing solutions to energy and nuclear power challenges facing Jordan. They include: the United States, Canada, France, the Russian Federation, China, the UK, South Korea, Romania, Spain, Argentina, Japan, Turkey and Romania.



Nuclear Cooperation Agreements (NCAs) have been signed with France, China, South Korea, Canada, Russia, the UK, Argentina, Spain, Japan, Turkey, Romania and Italy. NCAs with the United States, Armenia, Ukraine and the Czech Republic are being actively pursued. NCAs provide a framework to foster closer bilateral ties related to the discussion and exchange of materials and information on nuclear matters.

IX. Regulatory Framework

Fulfilment of requirements and compliance with all signed treaties and conventions is under the control of the Jordanian nuclear regulator, which independently establishes and pursues comprehensive nuclear legislation. As mentioned earlier in the report, the Jordanian nuclear regulatory framework has been developed with the close cooperation and guidance of the IAEA.

1. Historical Development of the Jordanian Nuclear Regulatory Regime

Jordan has started to establish its national nuclear infrastructure in the last decade with a view to launching a nuclear programme.

Before 2001, nuclear activities were handled by the Nuclear Energy Department at the Ministry of Energy and Mineral Resources.

In 2001, the Nuclear Energy and Radiation Protection Law (No. 29 for 2001) was issued. This established the Jordan Nuclear Energy Commission. At the beginning of Jordan's nuclear energy programme, no clear distinction was made between activities associated with the promotion and development of nuclear activities and those related to nuclear safety and regulation.

In July 2007, the Nuclear Energy and Radiation Protection Law was replaced by two laws establishing two independent entities, namely:

- The JAEC, pursuant to the Nuclear Energy Law (No. 42 for 2007, amended in 2008 to allow for the establishment of the Board of Commissioners).
- The Radiation and Nuclear Regulatory Commission (JNRC), pursuant to the Radiation Protection and Nuclear Safety and Security Law (No. 43 for 2007, further amended in March 2008).

With Laws No. 42 and No. 43, a clear separation was made between activities for the promotion and development of nuclear power under JAEC, and activities related to nuclear safety regulation under JNRC.

Law No. 43 of 2007 established JNRC and defined its structure, responsibilities, obligations and powers.



Presently, Jordan is refining its nuclear regulatory infrastructure with the assistance of IAEA, the European Commission and an external consultant. For this purpose a new nuclear law is being drafted. It will address all radiological aspects as well as those related to nuclear safety and security. It will include a framework for the following aspects, among others:

- Emergency preparedness and response.
- Mining and milling of radioactive ores.
- Decommissioning of nuclear facilities.
- Transport of radioactive material and waste.
- Radioactive waste and spent fuel management.
- Civil liability for nuclear damage.
- Safeguards, import and export controls.
- Nuclear security, physical protection and illicit trafficking.

This new law is envisaged for 2011. Once it is issued, JNRC will prepare the related implementing regulations, instructions and guides to further refine regulatory requirements. In fact, drafting of many of the required regulations has already started. The detail of these draft regulations is sufficient to enforce the new nuclear law soon after it is issued.

2. Description of the Structure, Roles, Responsibilities and Staffing of JNRC

2.1. Structure of JNRC

JNRC is chaired by the Director General and is supervised by the Board of Directors (hereafter referred to as the Board). The Board comprises:

- The Director General of JNRC, who is also the Chairman of the Board.
- A representative of JAEC recommended by the Chairman of JAEC.
- A Ministry of Health representative recommended by the Minister.
- A Ministry of the Environment representative recommended by the Minister of the Environment.
- Two people of Jordanian nationality, experienced and specialising in nuclear science, recommended by the Prime Minister.



JNRC reports directly to the Prime Minister and is functionally separated from any entity with responsibilities or interests that could unduly influence its decision making. It is therefore an effective independent nuclear regulatory authority. This is a confirmation that the regulatory structure is established following IAEA requirements.

JNRC has about 100 staff members working in the head office in Amman and about another 100 staff members working in the border control office with responsibility for controlling the trans-border transfer of nuclear and radioactive material.

2.2. Responsibilities, Duties, Power, and Tasks of JNRC and the Board

JNRC, in coordination with the Board, is tasked with formulating general policy in nuclear safety, nuclear security and radiation protection. This policy is submitted to and approved by the Cabinet.

JNRC and the Board are responsible for efficient implementation of the policy. This includes, among other things, drafting a new nuclear law and creating the corresponding regulations, instructions and guidelines for implementing the requirements defined in this law.

The main responsibility of JNRC, as for all other nuclear regulatory authorities, is to regulate and control the use of nuclear energy and ionising radiation. This responsibility is fulfilled through regulatory requirements based on the general policy mentioned above, and by verifying that these requirements have been fulfilled.

JNRC ensures the protection of the environment, human health and property from the hazards of radiation, including exposure to ionising radiation. However, this does not relieve the person or organisation responsible from its prime responsibility for safety.

Another duty of JNRC is to review licence and permit applications. If it is satisfied by the safety demonstration of the licensee or applicant, it grants the related licence or permit. Fulfilment of the licence and permit conditions is then verified by JNRC.

JNRC is responsible for establishing and maintaining a system to account for and control all nuclear and radioactive materials in Jordan, and to monitor and disclose cases of illicit trafficking of nuclear and radioactive materials.

In carrying out this responsibility, JNRC must comply with relevant international treaties that Jordan has signed and ratified. All treaties, conventions and agreements signed and/or ratified by Jordan have already been presented in this document.

JNRC is also responsible for verifying that radioactive exposure rates of imported goods remain within permissible limits defined by the regulator.

2.3. JNRC and International Cooperation

As discussed above, Jordan has signed several bilateral agreements with countries using nuclear energy as part of their energy generation mix. Active cooperation between



nuclear regulators is highly recommended by the IAEA through formal and informal relationships within the international community.

In 2010 Jordan was selected as the pilot case for the Regulatory Cooperation Forum (RCF), an initiative of the IAEA. The RCF has identified a number of gaps, mainly related to management systems, siting, and human resource development. It helps JNRC to close these gaps.

Besides extensive cooperation with the IAEA, JNRC currently receives support from a group of Western European Nuclear Regulatory Authorities (NRAs) and Technical Support Organisations (TSOs) within the European Commission (EC) cooperation project.

EC support is in methodology transfer, regulatory infrastructure, and training. The cooperation projects with the United States are mainly in border monitoring and training related to nuclear safety and security. With South Korea, JNRC has established a cooperation project related to the first Jordan nuclear research reactor which is of South Korean design.

3. Analyses of the Jordan Regulatory Framework

3.1. Establishment of Jordan's Regulatory Infrastructure

The establishment of the Jordanian nuclear regulatory infrastructure will comply with national legal obligations. Any new law or revision of an existing law needs to be reviewed by the Bureau of Legislation before it is discussed within the Council of Ministers. It is then transmitted for approval to Parliament, returned to the Council of Ministers, and finally endorsed by the King.

New or revised regulations follow the same procedure, except the step involving Parliament, which is not needed. Once the law or regulation is endorsed by the King it is published in the Official Gazette and enters into force.

Lower-level legislation, such as instructions and regulatory guides, provides details on how to implement the requirements defined in laws and regulations. Instructions and guides are developed under the leadership of JNRC and are discussed and approved by JNRC's Board.

The described procedure for establishing Jordan's nuclear regulatory legislation is comparable to those of most other nuclear countries. Since higher-level legislation (in which important regulatory requirements are defined) needs to pass the Council of Ministers, Parliament (in the case of laws), and then be endorsed by the King, JNRC is relieved from potential pressure from outside influences. JNRC and the Board are therefore effectively independent in their decision-making.



3.2. Experience and Staffing of JNRC

JNRC is a relatively young organisation, established in 2007. Since its creation it has recruited approximately 200 staff members, of which about 100 work in the border control office at Jordan's borders.

Most of the experts have graduated from Jordanian universities in areas such as nuclear and medical physics or civil, electrical, mechanical and hydraulic engineering. Its competency therefore covers the main legal and technical aspects of radiation protection and nuclear power engineering.

3.3. JNRC Future Development

JNRC will continue to develop and further improve the expertise of its staff. As with other relatively new organisations, JNRC faces the challenge of meeting high expectations regarding its staff performance with minimal experience. It is very committed and ambitious in investing in its human resource capital so that its expertise meets required international standards and its responsibilities within Jordan's nuclear energy programme are fulfilled according to the IAEA's expectations.

The first priority of JNRC is to establish and implement the nuclear regulatory legislation. Through cooperation with the IAEA, the European Commission, and its consultant, JNRC experts receive on-the-job training that enables them to gain the necessary experience and knowledge to implement the requirements defined in this legislation.

Another JNRC objective is to address the licensing of the first Jordan nuclear research reactor, which is under construction and scheduled to be operational in 2015.

In the near and mid-term, a key JNRC objective is to prepare its experts for the review of the first Jordan nuclear power reactor's licensing submission. As recommended by the IAEA, JNRC plans to establish strong relations with the NRA and the Technical Support Organisation (TSO) of the vendor country providing the nuclear island. This approach will ensure the best possible transfer of experience and knowledge and will facilitate the Jordan-specific review of licensing applications.

X. Conclusion

From a global perspective, many countries are increasingly turning to nuclear power as a safe, reliable and economically proven energy generation technology. Jordan is one of 65 countries currently expressing interest in nuclear power.

The development of a peaceful, civilian nuclear energy programme is based on an in-depth evaluation and understanding of Jordan's future energy needs. The Government has decided that nuclear energy is the only way to meet the energy, water and economic challenges the country is facing. Unless Jordan adds substantial electricity production capacity, the Kingdom faces major difficulties in supporting the growth of its population, satisfying water needs and improving living standards.



A pre-feasibility study has demonstrated that the most affordable future generation mix includes nuclear power, and there is a range of additional benefits provided by nuclear power. These include:

- Strategic energy independence and reduced volatility in electricity production cost.
- Utilisation of Jordanian natural resources (uranium).
- Power for water desalination.
- Reduction of air pollution and CO₂ emission.

A socioeconomic benefit analysis of the impact of construction and operation of a nuclear power plant in Jordan demonstrates that, when the secondary impact on GDP, employment and labour income is taken into account, the benefits of nuclear power plant construction and operation are much larger than the direct effects.

The Hashemite Kingdom of Jordan, as a small and open economy which is highly dependent on importing energy resources for electricity generation, will increase its economic output, advance human resource development and lower the unemployment rate. This is because the spin-off effects from newly created jobs in the electricity sector will be significant.

Jordan has a comprehensive civilian nuclear energy programme which includes plans for extracting natural uranium, developing human resources and constructing research facilities. The nuclear power plant is at the stage of nuclear technology vendor selection, and it is expected to come online in 2020.

Jordan is pursuing a peaceful, civilian nuclear energy programme that upholds the highest standards of safety, security, non-proliferation and operational transparency. One of the indications that Jordan is adopting the highest standards with regard to transparency is the signature and ratification of a number of relevant nuclear-related treaties regarding non-proliferation, safety, civil nuclear liability and several other issues.

The unfolding accident in Japan has attracted global media coverage, but the nuclear community continues to believe that nuclear energy will be a part of the future energy generation mix. Jordan will independently assess the Japanese event and its effect on the Jordanian nuclear energy programme. Furthermore, Jordan is committed to:

- (1) redoubled perusal of appropriate siting criteria and methodical review of the siting.
- (2) re-affirmation of the commitment to Generation III and III+ advanced reactor technology which could not suffer the types of failure that occurred in Japan.
- (3) carefully developed, modern operator accident mitigation strategies.
- (4) continued close cooperation with the IAEA and adherence to what are likely to be evolving international safety standards.