
Jordan's Nuclear Programme: Challenges & Opportunities

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Jordan Overview



- Total Area: 89 213 sq. Km
- Sea Port: Aqaba
- Coastline: 26 Km
- Population: 5.723 million
31% (15- 29) 38% (below 15)
- Climate: Mediterranean & Arid Desert
- GDP: \$16.5 billion
- Per Capita: \$2,879
- Annual GDP Growth: 7% (2000-2007)

Challenges

- Growing energy demand
- Increasing energy costs
- Lack of conventional energy resources
- Increasing dependence on imported fuel
- Scarcity of water resources
- Degradation of environmental conditions due to increasing consumption of fossil fuel resources

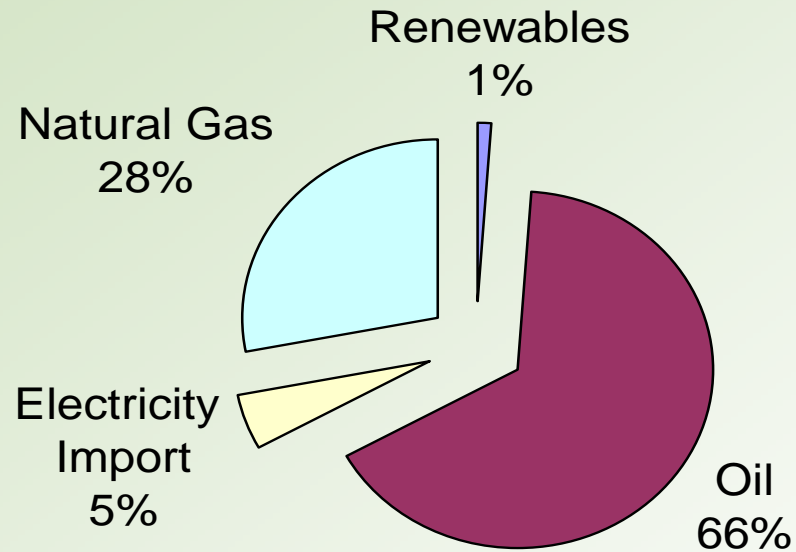


Jordan Energy Options

- Options are limited:
 - Natural Gas is a short term option and cannot be relied on for mid or longer term .
 - Renewable Technologies are mainly high cost, limited utilization, and cannot be base load .
 - Oil Shale, a limited medium term, reserved for special uses .

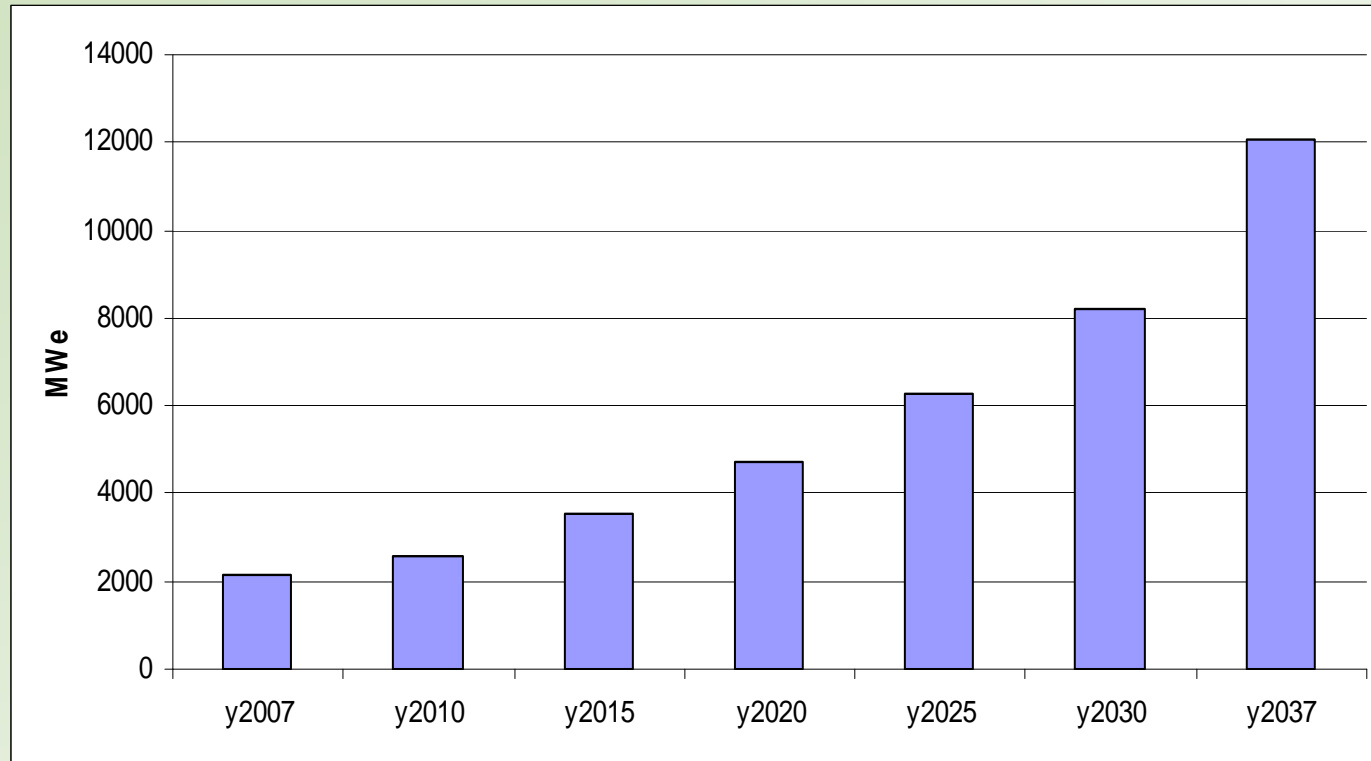


Energy Mix - 2007



Energy imports:
\$3.2 billion
= 24% of imports
=20% of GDP

Jordan Electric Load Forecast (2009)

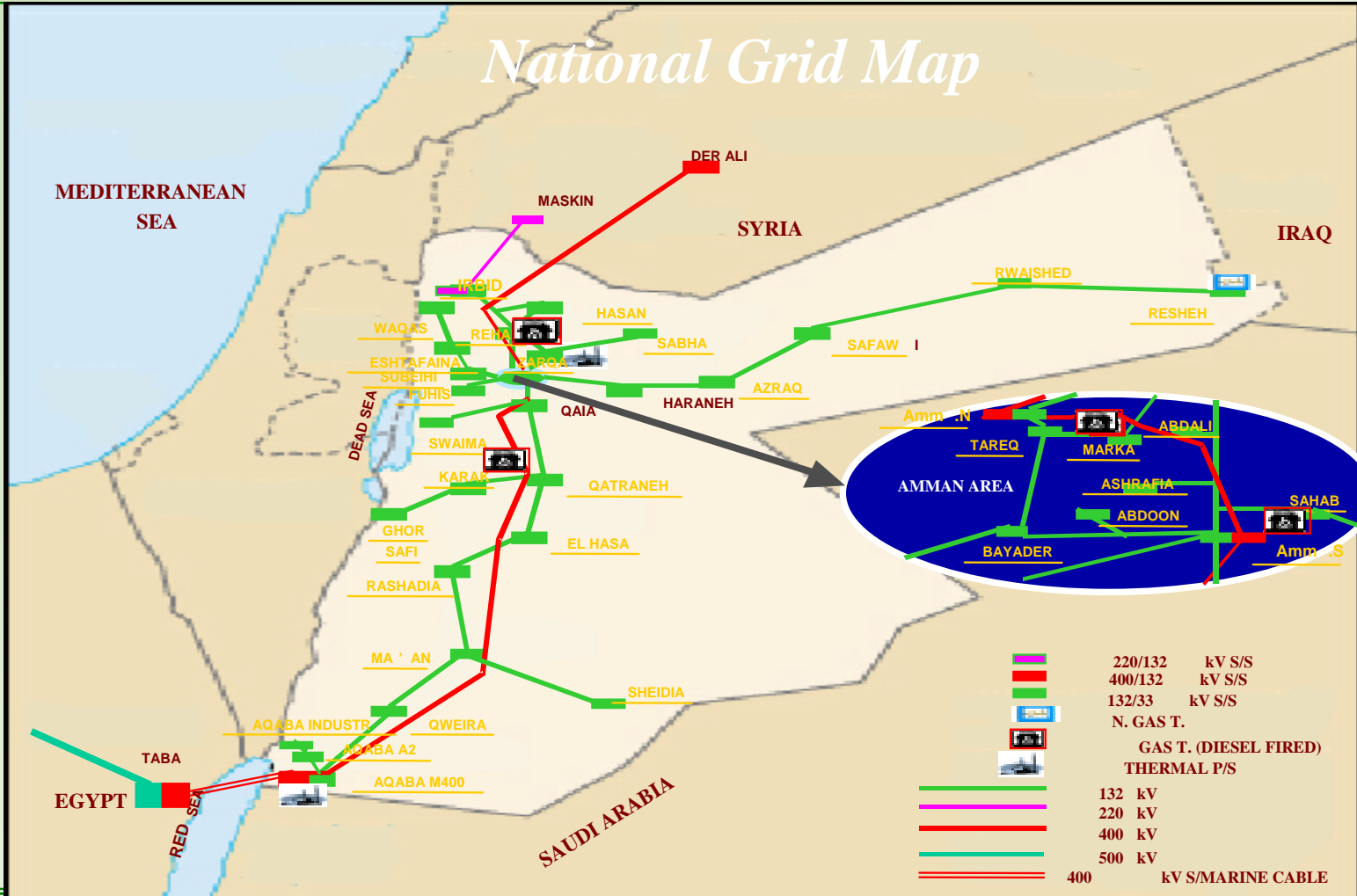


Electricity Consumption

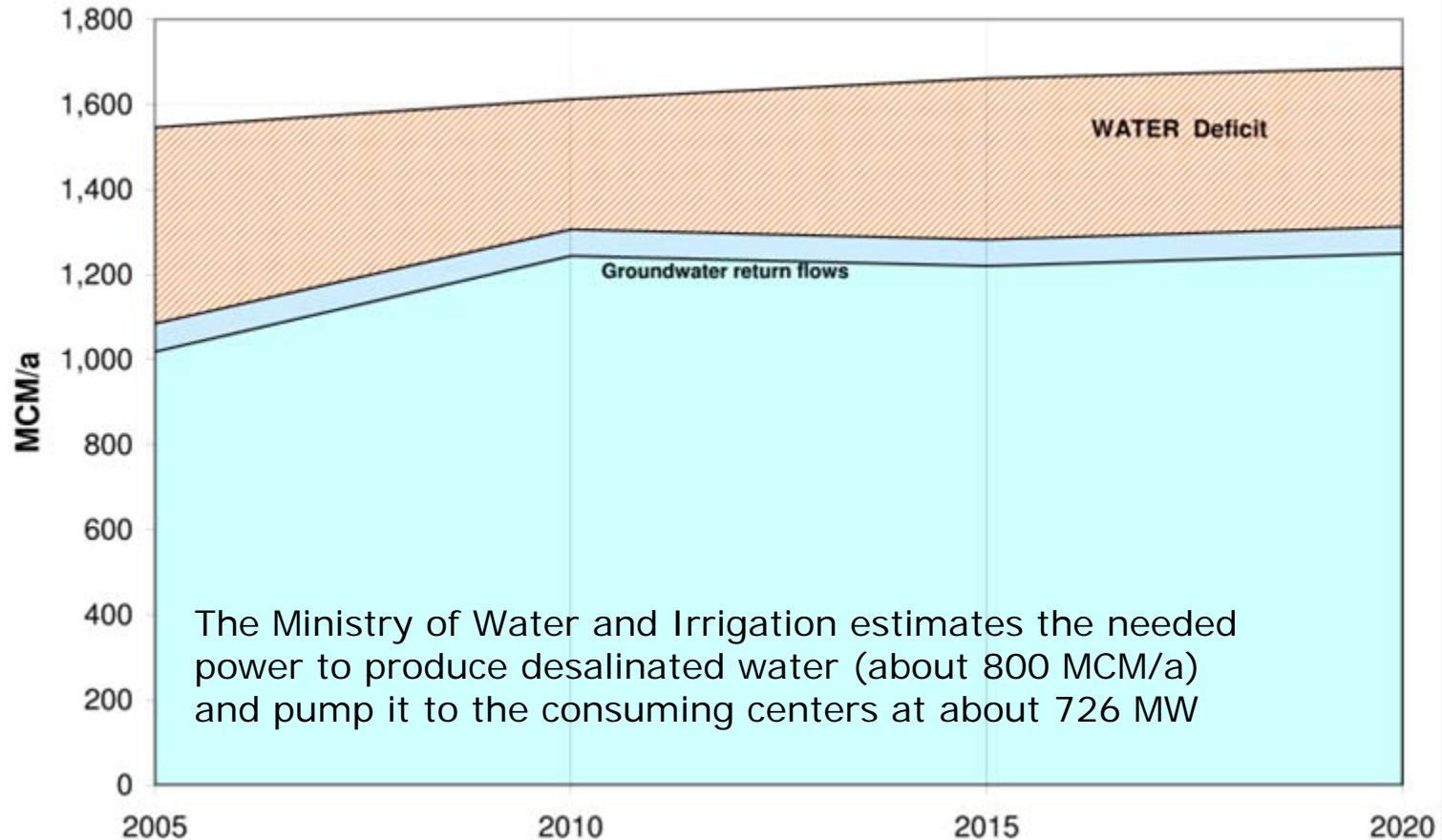
- Jordan consumes now about 2000 kWh/yr per capita whereas
 - Europe 6,000
 - North America 14,000
 - China
- By 2030, Jordan's per capita consumption nearly doubles
- Electricity is central to achieving sustainable development goals---HDI is closely correlated with high kWh/capita



Regional Interconnection



Water Situation in Jordan



Programme Vision

- Transform Jordan from net energy importing to net electricity exporting country by 2030
- Make available power to fuel economic growth at low cost
- Go for major transformation away from fossil fuel



The Transformation

Present Situation

- Lack of natural resources
- Energy importer
- Dependent on energy supplies
- Scarcity of water resources
- BUT
- Rich with trainable human resources
- Uranium potential
- Well placed geographically and politically

Transformation

Opportunity to transform Jordan into a net exporter of electricity by implementing a nuclear program using national Uranium assets

Jordan's Nuclear Strategy

- Ensuring security of supply including fuel
- Leveraging of national Uranium assets
- Promoting public/private partnerships
- Ensuring effective technology transfer and national participation in all phases
- Providing for water desalination and eventually hydrogen production
- Development of spin-off industries
- Enhancing electricity export
- Enabling competitive energy-intensive industries



Challenges

- Several challenges need to be addressed in order to develop Jordan's nuclear energy programme:
 1. Siting, technology choice, and grid limitation
 2. Exploitation of Uranium
 3. Fuel cycle and waste management
 4. Human resources development
 5. Funding
 6. Political environment

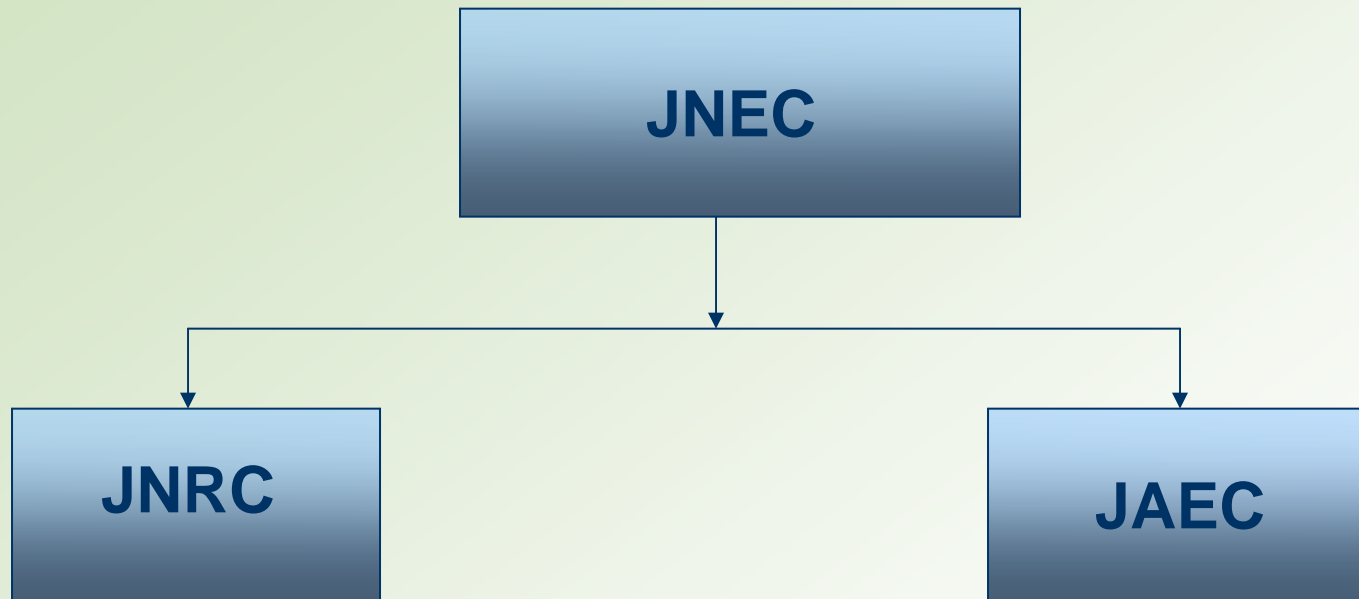


Five Measures

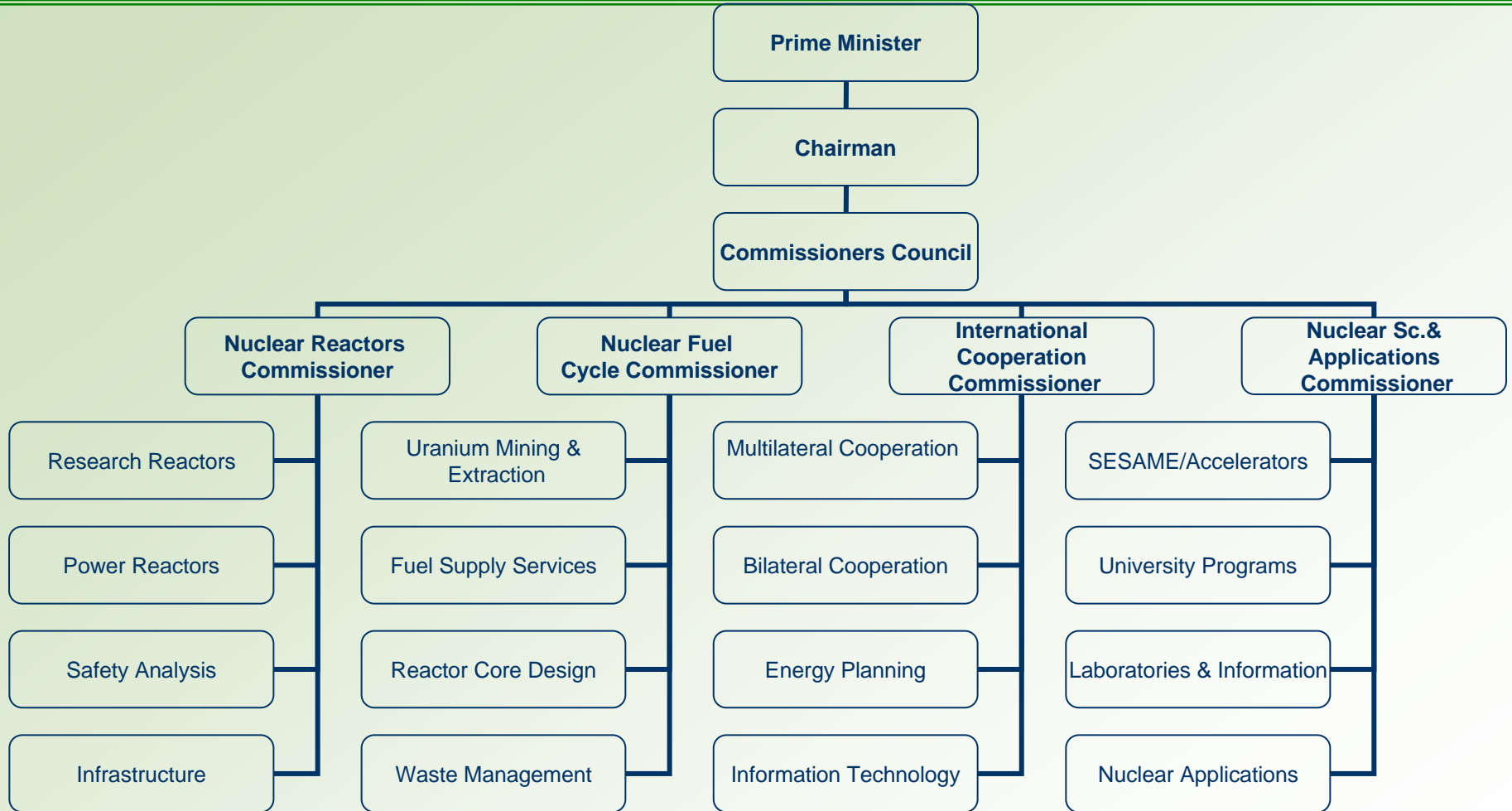
1. **Generation.** Policy : privatized but with Gov. equity (PPP model). International nuclear operator with safe record + investment for the plant
2. **Uranium Exploitation.** Policy : maximize sovereignty while creating value from resource. Avoid concessions
3. **Fuel Cycle:** Negotiate assurances for fuel services including waste disposal
4. **Getting Country Ready:**
 1. Investment for all studies
 2. Investment in training and HR
 3. Investment in infrastructure
5. **Funding** : Investigate creative financing methods that minimize central Gov. resources

Reorganization of the Nuclear Authorities

The Nuclear Law was modified in 2007 to allow the creation of two independent commissions: Jordan Atomic Energy Commission (JAEC) and Jordan Nuclear Regulatory Commission (JNRC)



Jordan Atomic Energy Commission



Legal Framework

| | In Force | Status |
|---|------------|---|
| Agreement on the Privileges and Immunities of the IAEA | 1982-10-27 | Acceptance: 1982-01-27 |
| Convention on Early Notification of a Nuclear Accident | 1988-01-11 | Signature: 1986-10-02 Ratification: 1987-12-11 |
| Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency | 1988-01-11 | Signature: 1986-10-02 Ratification: 1987-12-11 |
| Convention on Nuclear Safety | Feb. 2009 | Signature: 1994-12-06 |
| Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA) | 1989-02-05 | Signature: 1974-12-05 |
| Co-operative Agreement for Arab States in Asia for Research Development and Training Related to Nuclear Science and Technology (ARASIA) | 2002-08-20 | Acceptance: 2002-08-20 |



Legal Framework (2)

| | In Force | Status |
|--|-------------------|------------------------------------|
| Application of Safeguards in connection with the Treaty on Non-Proliferation of Nuclear Weapons (with protocol) | 1978-02-21 | Signature: 1974-12-05 |
| 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 Non-Proliferation of Nuclear Weapons | 1998-07-28 | Signature: 1998-07-28 |
| Convention on the Physical Protection of Nuclear Materials | | Will be ratified next month |
| Civil Liability for Nuclear Damage | | Under consideration |

International & Bilateral Cooperation

❑ International (IAEA, GNEP)

❑ Bilateral

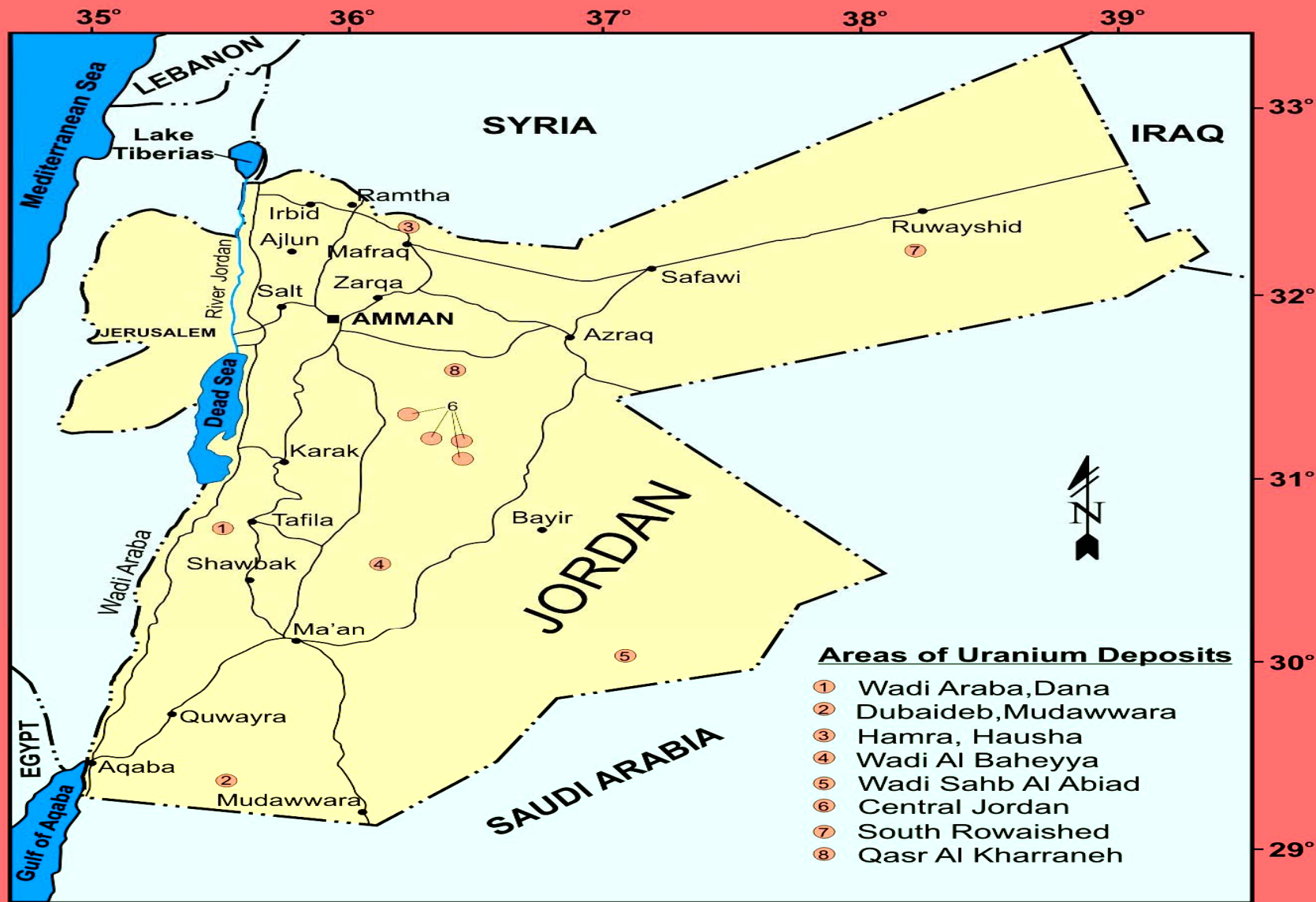
1. USA
2. Canada
3. France
4. Russia
5. China
6. UK
7. South Korea
8. Romania
9. Spain
10. Japan

- Signed NCAs with France, China, South Korea and Canada
- Expected to sign NCAs with Romania, Russia and UK in Q2-2009
- Ongoing negotiations with USA and Japan



Uranium Exploitation

Areas of Uranium Deposits



Uranium Exploitation in Central Jordan

- A beauty contest was conducted
- Three major companies were short listed in the order: Areva, Rio Tinto, SinoU
- Negotiations were concluded with Areva on Uranium exploration in Central Jordan and an Agreement was signed in Paris on Sep.30,2008



Current Activities in Uranium Exploitation

- Areva started since Oct. 2008 field work in Central Jordan with promising results so far
- A JV Mining company, named “The Jordan French Uranium Mining Company” was registered on Dec. 18, 2008
- Negotiations on the Mining Agreement are underway

Trenching



» *Understanding of the genetic model of the mineralization*

» **21 Trenches**

» **Length = 100 – 200 m**

» **Depth = 2.5 – 4 m**

» **Width = 1.5m**



» **All trenches were lithologically described, radiometric measured and sampled for chemical analyses**



» **The aim of these trenches is the study of the homogeneity and the repartition of the Uranium**

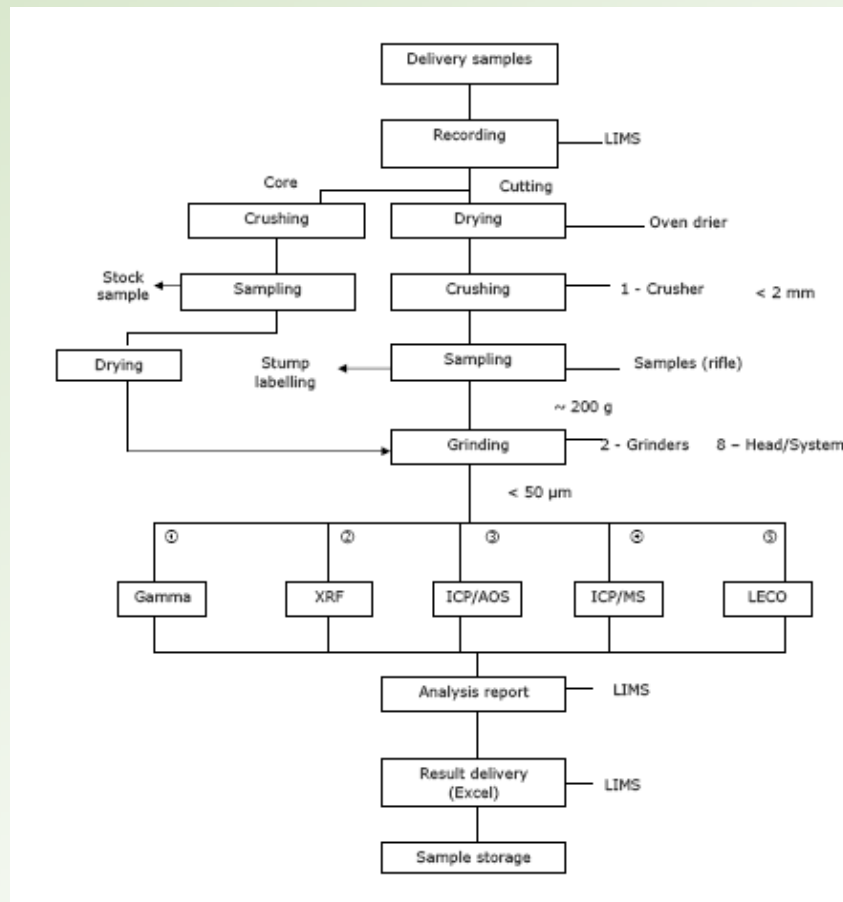
Uranium Exploitation in Other Regions

- A joint team from SinoU (China) and our company JERI started in Oct. 2008 exploration work outside Central Jordan (Mafreq and Wadi Bahiyeh)
- A MoU with Rio Tinto for prospecting in three areas outside Central Jordan was signed on Feb. 23, 2009



JAEC Uranium Labs

- Gamma Spectroscopy
- WDXRF
- ICP-OES
- ICP-MS



Siting Study



Site Selection

Preliminary regional analysis was carried out for identification of potential sites for NPP, followed by screening of these sites and selecting candidate sites.

The analysis was based on the following IAEA criteria:

1. The suitability of the site for heavy construction:
 - A. *The topography, morphology, and ground stability.*
 - B. *The geology, structural geology, and soil mechanics.*
 - C. *The seismology of the area.*
2. The possible impact of human induced events on safety of the NPP.
3. The availability of water for steam generation, cooling, and other uses.
4. The distance from the electrical transmission network.
5. The possible impact on public health and environment under normal operation and in case of accident.
6. The economical feasibility of the site.

The Selected Sites

The potential Sites:

A. Aqaba Sites, where it can use the sea water for cooling:

- Site at the sea shore where it can use the sea water for direct cooling.
- Site at 9 km to the east of Gulf of Aqaba shoreline at the Saudi borders.
- Site at 6 km to the east of Gulf of Aqaba shoreline.
- Site at 22 km to the north of Gulf of Aqaba shoreline.

B. Wadi Araba.

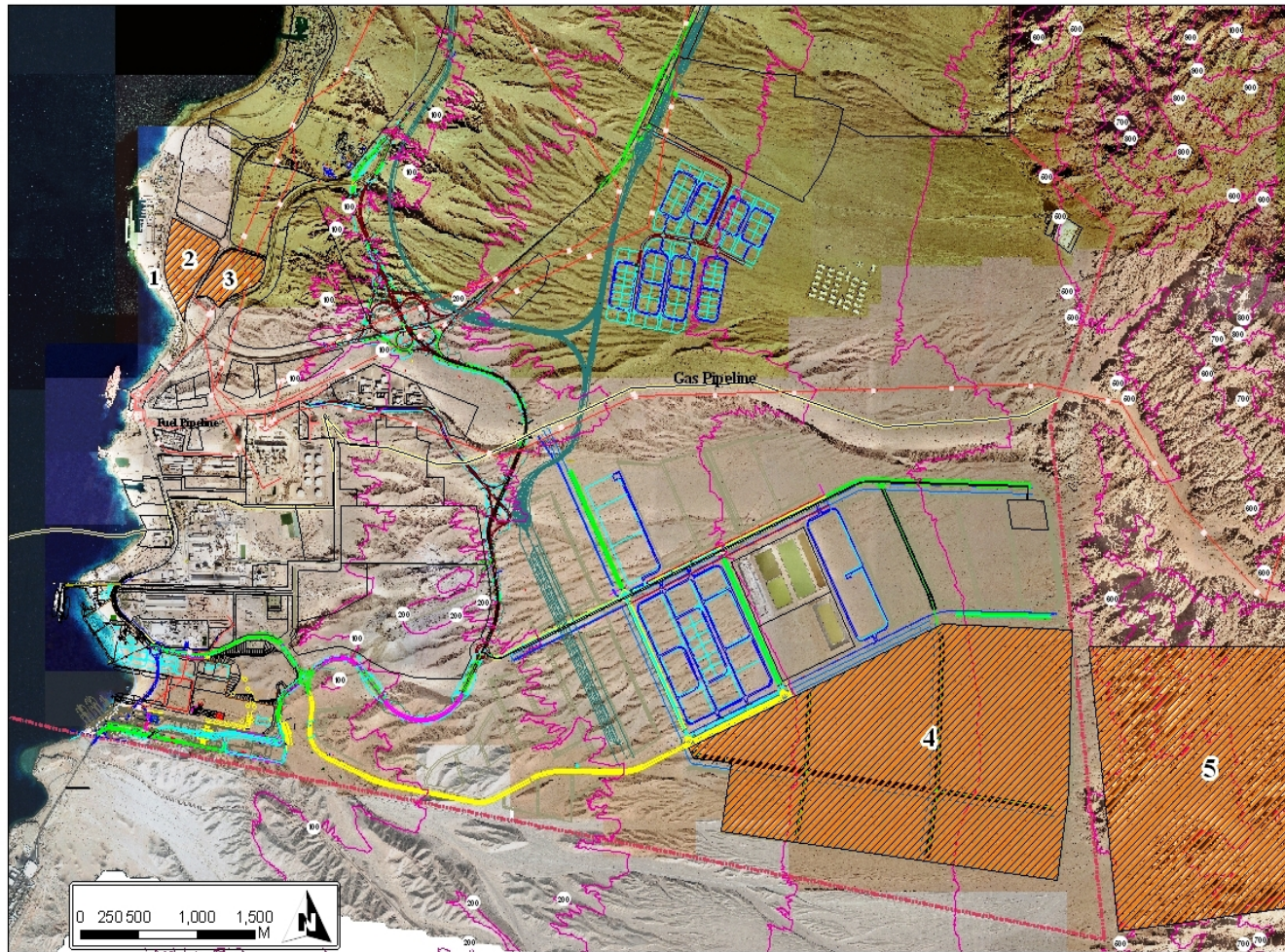
C. Al-Khirbeh Al Samra.

D. Wadi Al Hammad.

The Candidate Sites in Aqaba:

- The Preferred Site (**Area No. 5 in the map**) is located approximately 9 km east of the Gulf of Aqaba coast line, at an elevation of 450 meters above sea level. It lies at the foothill of the eastern mountain ridge which consists of granite igneous rock and gravel sediments of weathered granite debris, sandstone, siltstone and marl clay.
- The Alternate Site (**Area No. 4 in the map**) is located approximately 6 km east of the Gulf of Aqaba coast line, at an elevation of about 300 meters above sea level. It is a flat area, consisting entirely of recent deposits of loose gravel, sandstone, siltstone and marl clay.
- A desalination plant, pumping station and other related facilities (**Areas No. 1,2 and 3 in the map**), will be located on the coast of the Gulf of Aqaba, where Reverse Osmosis technology will be used to supply the NPP with the required amount of fresh water. The desalinated water will be pumped from the plant to the NPP.

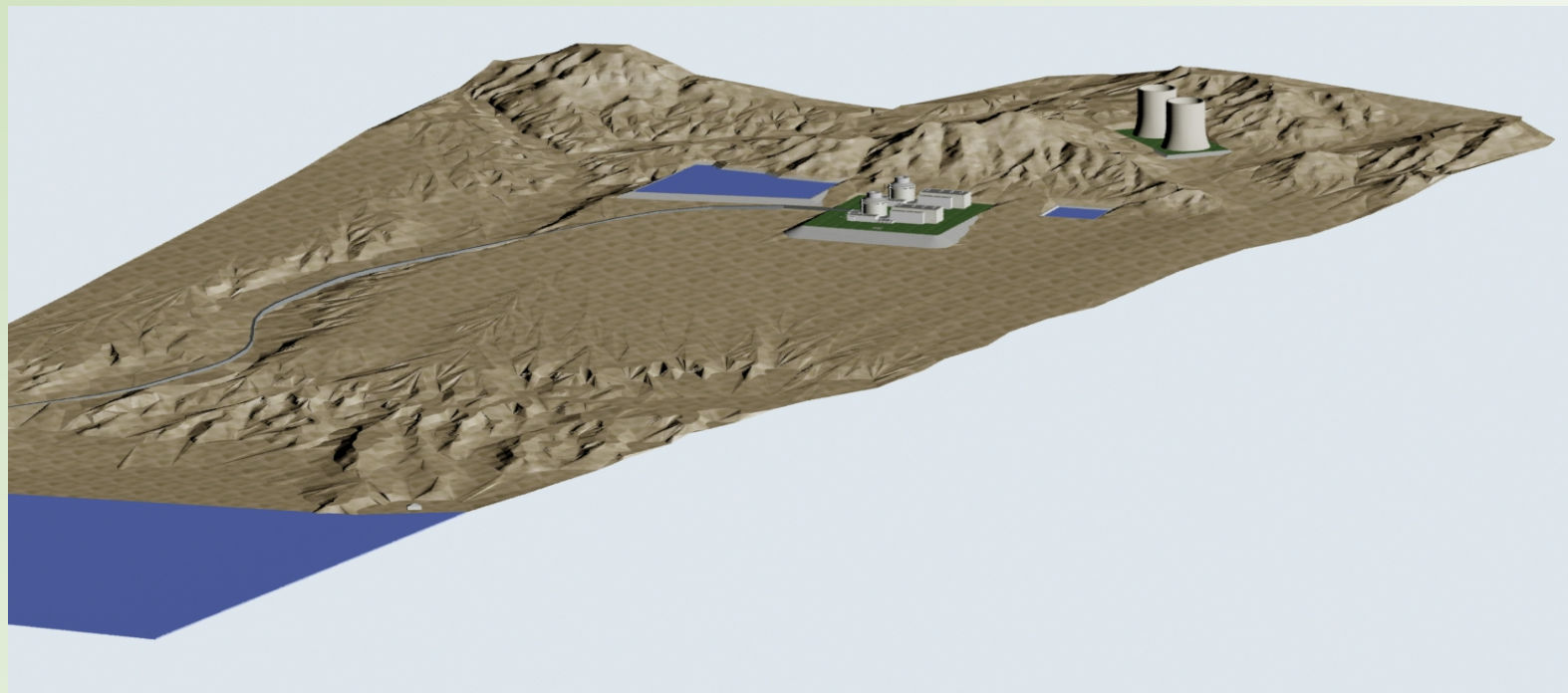
The Candidate Sites



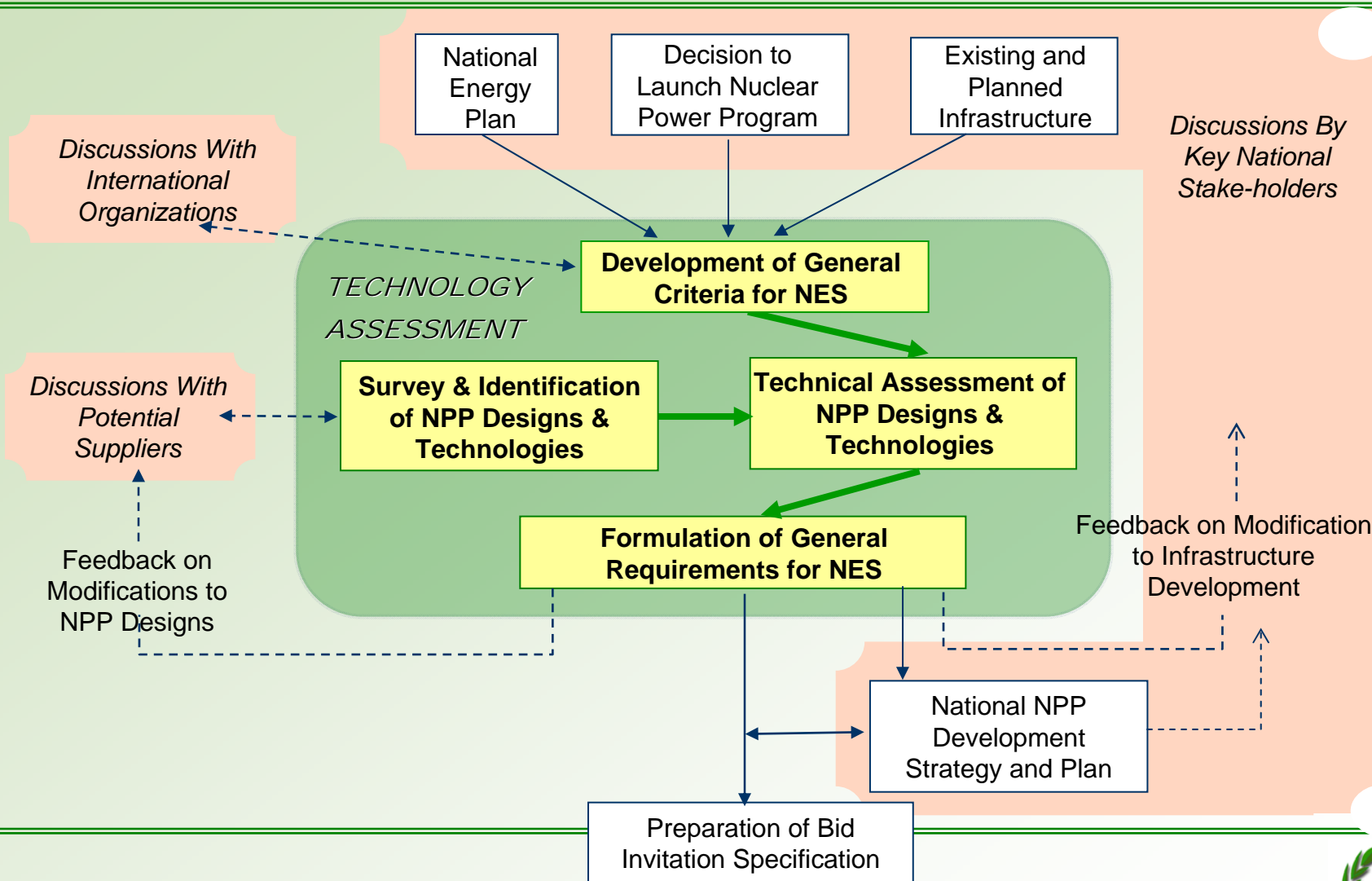
Site Selection and Characterization Milestones

- Step 1 : Regional survey, Aqaba selected as a suitable location.
- Step 2 : Site selection & characterization which entails all the necessary data and reports such as:
 - Geology- geophysics- cooling water requirements- risk assessment- grid connections- human induced events and land use- Environmental Impact Assessment...etc;*
 - An RFP for site selection and characterization study has been launched on December 28th ,2008, where 17 international expert houses have been invited. Only 8 international consultants showed interest in this study and participated in the site visit conducted on February 1st ,2009.
 - The dead line for submission of final proposal for the study is April 15, 2009.
 - **The evaluation process will take 2 months.**
 - The expected date for awarding the site selection and characterization contract will be in June, 2009.
- Completion of the site selection and characterization work by the end of 2010.
- Site approval by the JNRC by mid 2011.

Artist's View of Jordan's NPP Site



Technology Assessment



General Criteria for Selection of NPP Reactor

- Safety and reliability (Generation III)
- Simplicity, standardization & modularization
- Waste considerations
- Diversion-Resistance
- Cost considerations
- Fuel cycle considerations
- Desalination compatibility
- Cooling water requirements
- Potential spin-off industry
- Size 700-1400 MWe

Reactor Technology

- Evolutionary Large Light Water Reactors *New features: improved reliability, enhanced safety*
- Advanced Heavy Water Reactor
- Small & Medium-Sized Reactors *New features: simplified systems, passive safety*



EVOLUTIONARY WATER COOLED REACTOR DESIGNS

Evolutionary LWRs

- 1380 MWe **ABWR** (Toshiba); 1360 or 1500 MWe **ABWR** (GE-Hitachi);
- 1700 MWe **ABWR-II** (Japanese utilities; GE-Hitachi or Toshiba);
- 1540 MWe **APWR** & 1700 MWe **APWR+** (Mitsubishi)
- 600 MWe **AP-600**; 1100 MWe **AP-1000**; and 335 MWe **IRIS** (Westinghouse)
- 1550 MWe **ESBWR** (GE-Hitachi)
- 1545 MWe **EPR** and 1250 MWe **SWR-1000** (Areva)
- 1100 MWe **ATMEA1** (Areva & Mitsubishi)
- 1000 MWe **OPR** and 1400 MWe **APR** (KHNP and Korean Industry)
- 1000 MWe **CPR** (CGNPC); 650 MWe **CNP** (CNNC) and 600 MWe **AC-600** (NPIC)
- 1000 MWe **WWER-1000 /1200** (V-392); **WWER-1500**; and **WWER-640** (V-407) (AtomEnergProm)

Evolutionary HWRs

- 700 MWe **Enhanced CANDU-6** (AECL)
- 1000 MWe **Advanced CANDU (ACR)** (AECL)
- 540 MWe & 700 MWe **HWR** (NPCIL)
- 700 MWe **AHWR** (BARC)

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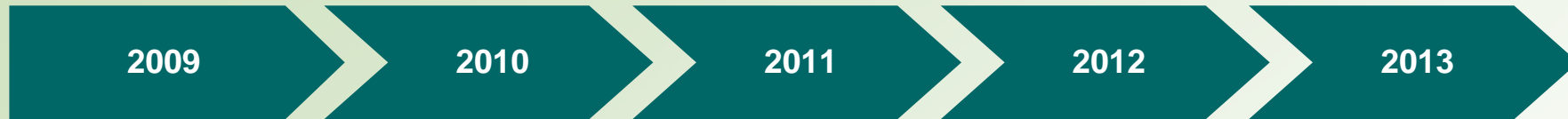
*Workshops were held by
respective vendors at JAEC to
present their designs*

Grid Stability and Adaptability

- An agreement was signed Feb. 18, 2009 between NEPCO and ELEC PROMOTION (France) to address the stability of Jordan's T&D network from introduction of large sized NPP through a 0.5M euros grant from the French Ministry of Finance



Road to Nuclear Pre-Construction



- Drawing of legal & administrative framework
- Definition of the training and education program
- Site identification
- Pre-feasibility studies
 - Site characterisation
 - Training and education of the NPP project team (15)
 - Feasibility studies
 - Site preparation
 - NPP contracting process
 - Start of HV grid adaptation
- Training and education of the NPP operation team (150)
- Engineering, procurement and construction of the NPP
 - HV grid adaptation

Overall Schedule

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

SITING & LICENSING

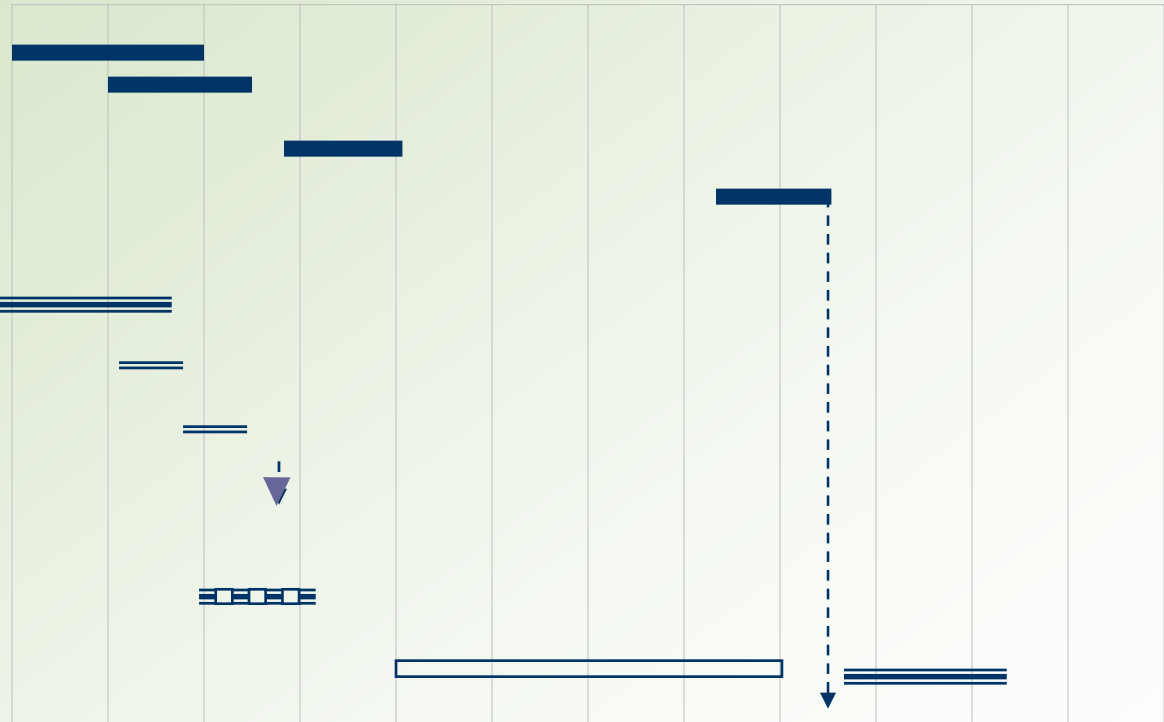
- Site selected and characterized
 - Early Site Permit
- Construction licence
- Operating licence

PROCUREMENT

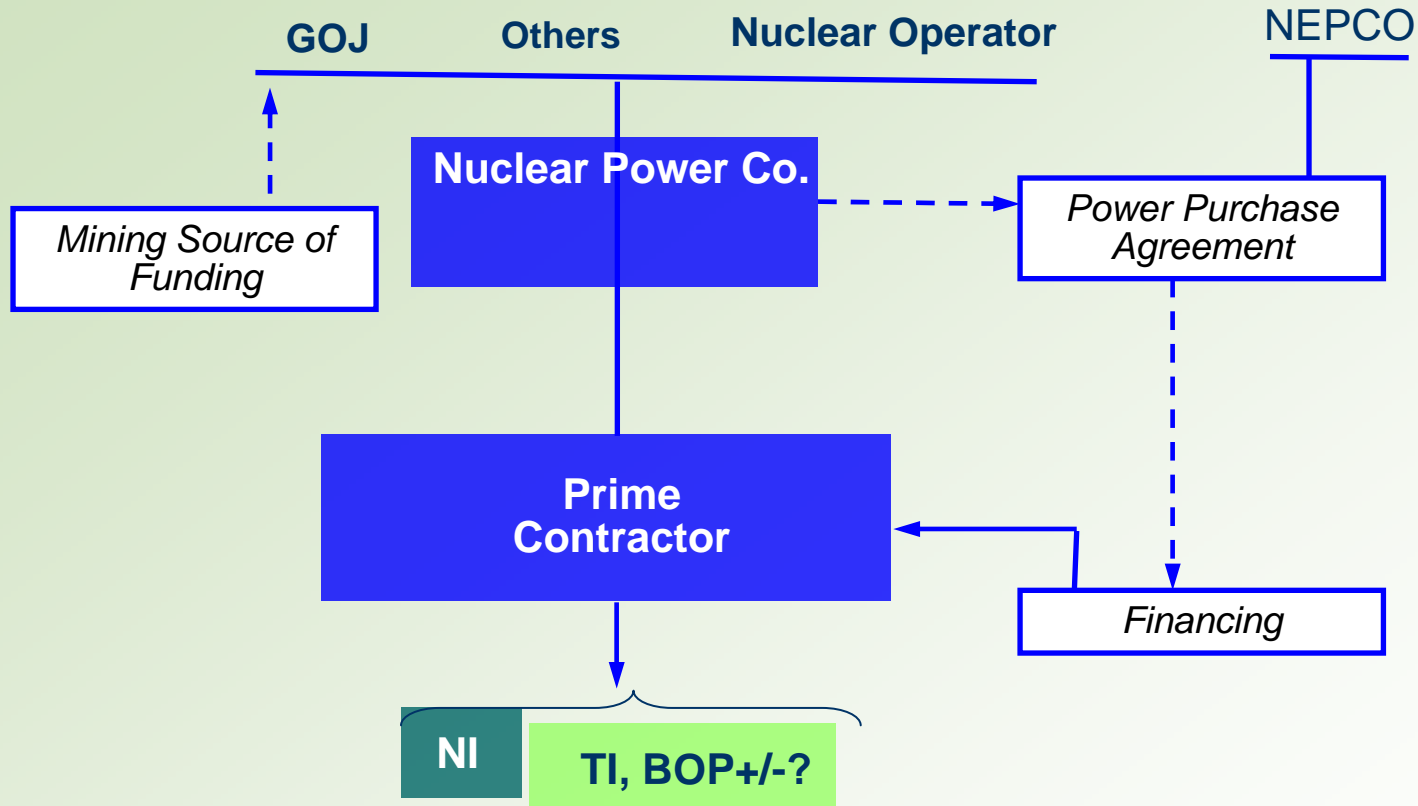
- Feasibility studies
 - Bid request
- Bid evaluation
- Main contracts

IMPLEMENTATION

- Site preparations
 - Construction
- Commercial operation



Setting Up of Nuclear Company



Pre-Construction Consulting Services

Scope of Work

- Feasibility and Financial Assessment
- Optimization Studies
- Technology Assessment
- Tender Preparation and Evaluation
- Preparation of Contractual Options



Human Resources Development

- Jordan University of Science and Technology - established a nuclear engineering dept. to graduate future reactor operators holding B.Sc. degrees in nuclear engineering
- JU, YU, BAU have started M.Sc. programs in nuclear physics & students are trained on the Van de Graaf & SESAME
- A subcritical assembly is under procurement from China for JUST
- An RfP for Research Reactor (RR) has been issued to allow for proper training of nuclear engineers & operators and other technicians



Nuclear Research Reactor

- The research and test reactor would serve as an integral part of the nuclear technology infrastructure
- It will become the focal point for a Nuclear Science and Technology Center (NSTC)
- Play the primary role in educating and training the upcoming generations of nuclear engineers and scientists
- Provide irradiation services in support of the Jordanian industrial, agricultural and health/medical infrastructure



Increase in JAEC Staffing

| Year | Total | Technical |
|------|-------|-----------|
| 2007 | 77 | 43 |
| 2008 | 118 | 64 |
| 2009 | 192 | 110 |

Training Programme

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



Training Programme (2)

- Normally part of every contract that JAEC negotiates
 - 50 for Uranium Mining and Extraction (with AREVA)
- Project management training is included as part of the Pre-Construction Consultancy Services
- Nuclear operators training will be included in the contract for the NPP
- OJT training by international experts
- Close cooperation for training and expert visits with top laboratories
- IAEA TC and projects



Public Awareness

- Workshops will be conducted to inform decision makers, planners, and national legislators in the government, utilities, press, public opinion leaders, and regulatory commission on NPP development and infrastructure issues
- Special workshops will be conducted in Aqaba region for public at large and main stakeholders



Overall Evaluation Process

1. What are the deliverables to ensure the country is ready? What is the impact on job creation and technology transfer?
2. What is the approach to resolve our financial constraints?
3. What is the wealth creation to Jordan from Uranium assets?
4. How does the proposal address fuel cycle, including fuel security, cost and waste management?
5. How does the proposed generation technology meet our selection criteria for the reactor? What is the safety record of the operator?



Thank You

Jordan Atomic Energy Commission

