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# Jordan's Nuclear Energy Programme

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Chairman

Jordan Atomic Energy Commission

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# Jordan Overview



- Total area: 89 213 sq. Km

- Sea Port: Aqaba

- Coastline: 26 Km

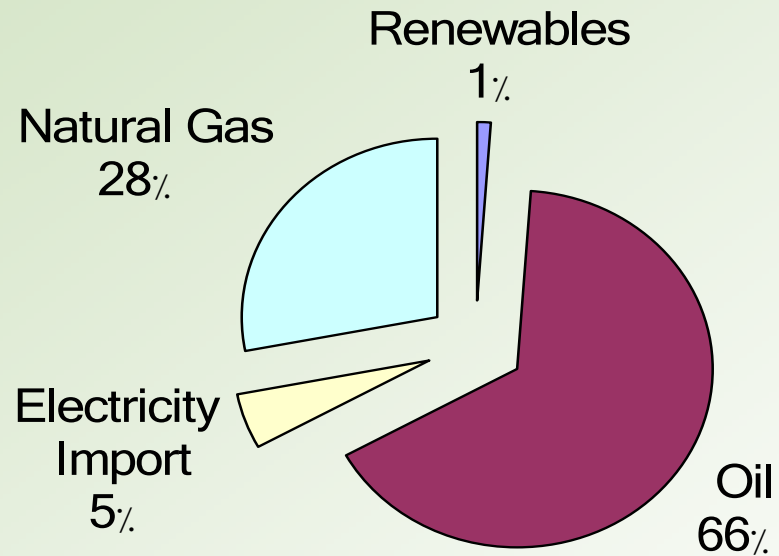
- Population: 5.723 million  
31% (15- 29) 38% (below 15)

- Climate: Mediterranean & Arid Desert

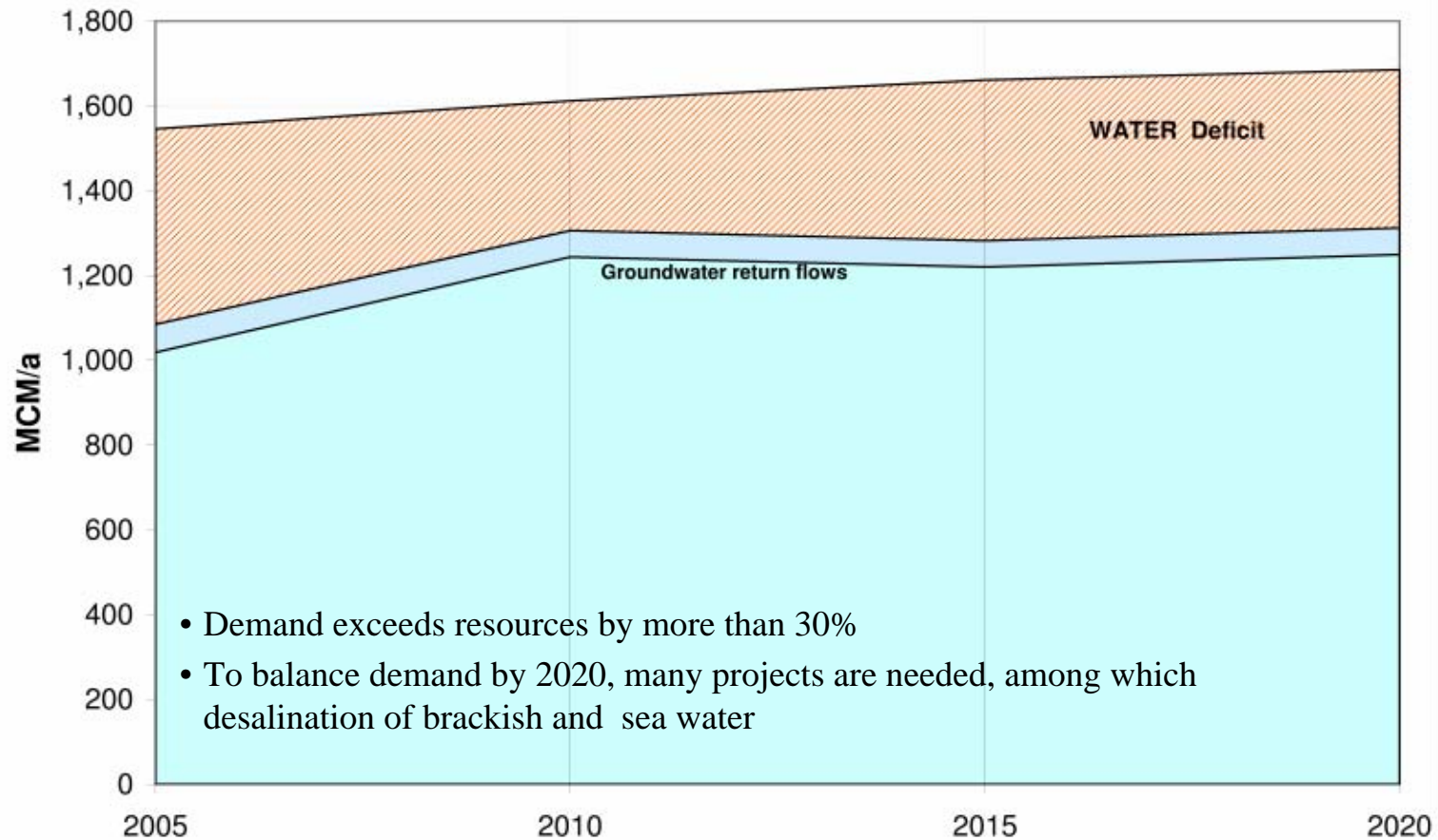
# Challenges

- 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

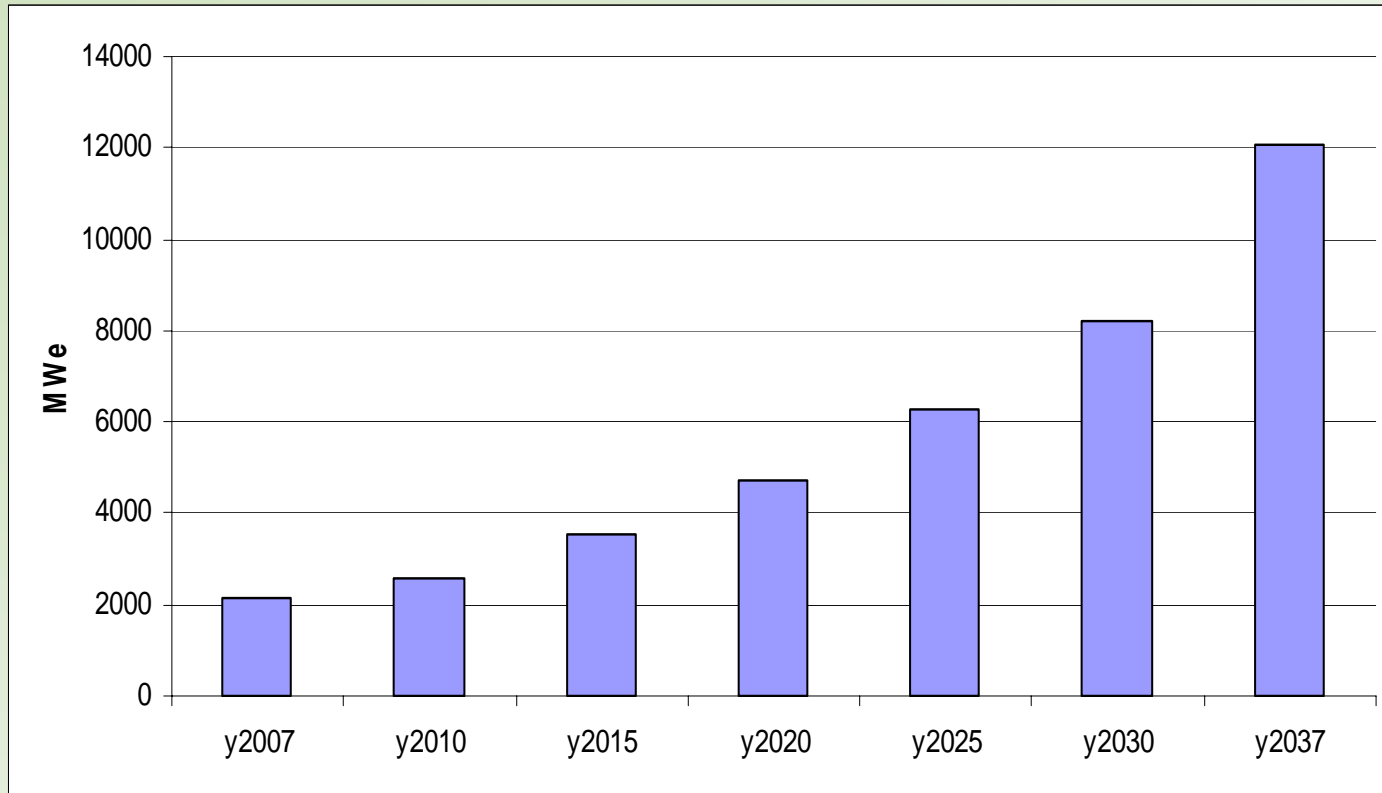
# Energy Mix - 2007



# Water Situation in Jordan



# Jordan Electric Load Forecast



# 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

# Reorganization of the Nuclear Authorities

- Establishing nuclear and radiological safety authorities under the supervision of Prime Minister
  - The existing 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)
- Coordination of licensing process with other regulatory institutions





# Jordan's Nuclear Energy Programme

**JNRC**

**(Regulation, Safety & Safeguards )**

**JAEC**

**Int.  
Cooperation  
(NCA's)**

**Fuel Cycle  
(U, Th, Zr)**

**Nuclear  
Sciences**

**Power Reactor**

1. JERI (U deposits)
2. JPMC (U in phosphates)

**Research  
Reactor**

Jordan Atomic Energy Commission



# Conventions and Agreements

	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
<i>Convention on Nuclear Safety</i>	2009-09-10	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
Convention on the Physical Protection of Nuclear Material	2009-10-07	Accession : 2009-09-07

# Conventions and Agreements (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

# Challenges

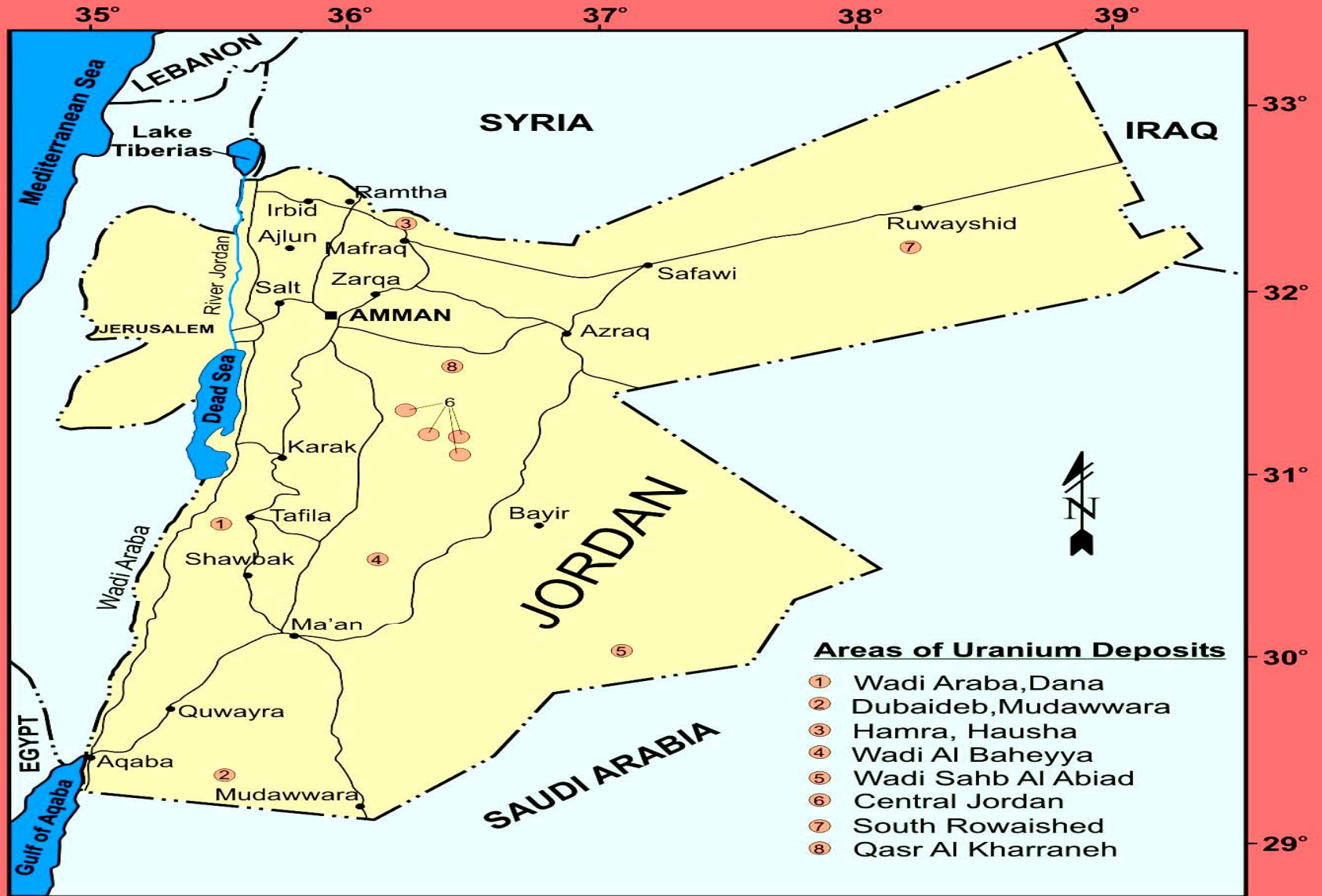
- Several challenges need to be addressed in order to develop Jordan's nuclear energy programme:
  1. Exploitation of Uranium
  2. Funding
  3. Fuel cycle and waste management
  4. Choice of reactor technologies and implementation
  5. Human resources development
  6. Political environment

# Uranium Deposits in Jordan

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- Jordan is endowed with significant Uranium resources
- There are many indications for deposits but much is still unexplored
- Only Central Jordan has been somewhat explored with estimates of nearly 70,000 metric tons

# Areas of Uranium Deposits



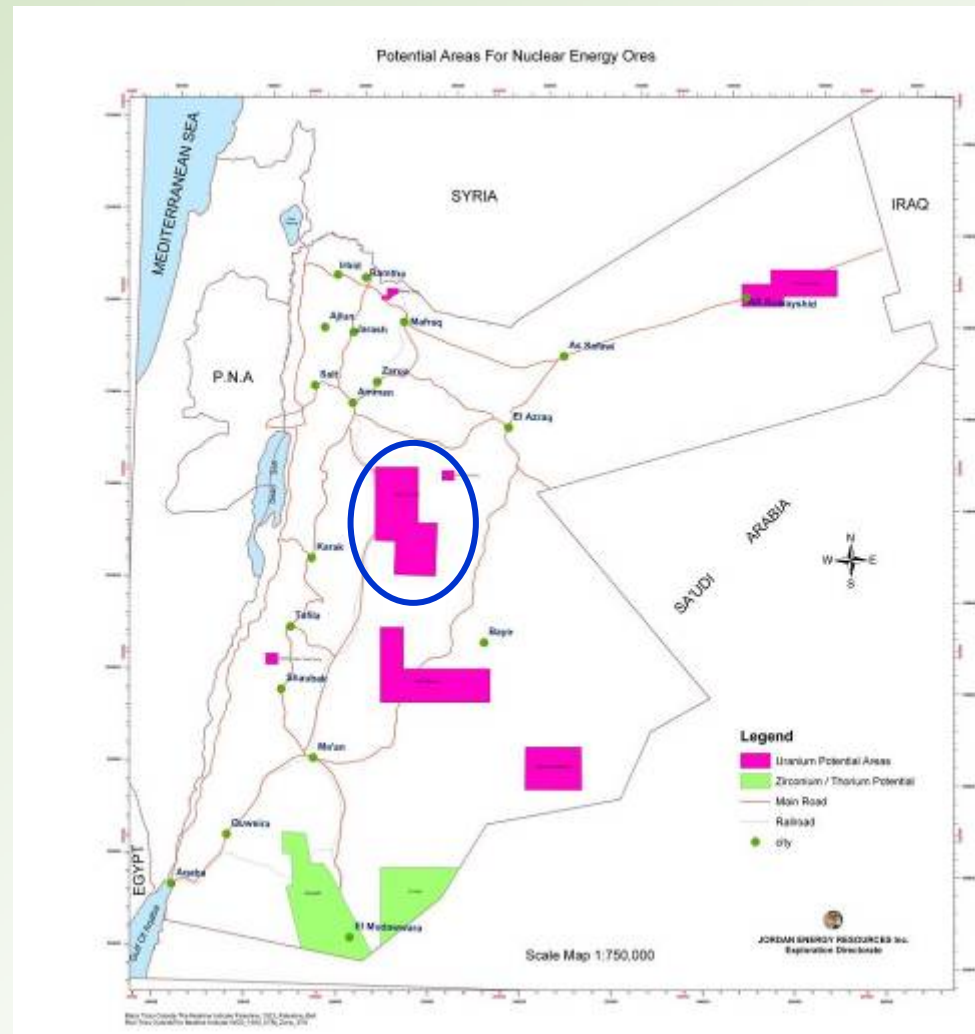
# Main Scope

- September 30th 2008
  - Exploration Agreement on “Central Jordan”
    - 2 shareholding companies created
      - Nabatean Energy
        - *JV JAEC (51%) & AREVA (49%)*
      - **Jordanian French Uranium Mining Co**
        - *JV AREVA NC (50%) & JERI (50%)*
  
- January 14th 2009 Effective Date
  - *Milestones*
    - ***T+6 « Relinquishment of»Zone C (14/07/2009)***
    - ***T+18 Go to BFS (14/07/2010)***
    - ***T+36 End of Feasibility (14/01/2012)***



# Uranium Potential of Central Jordan

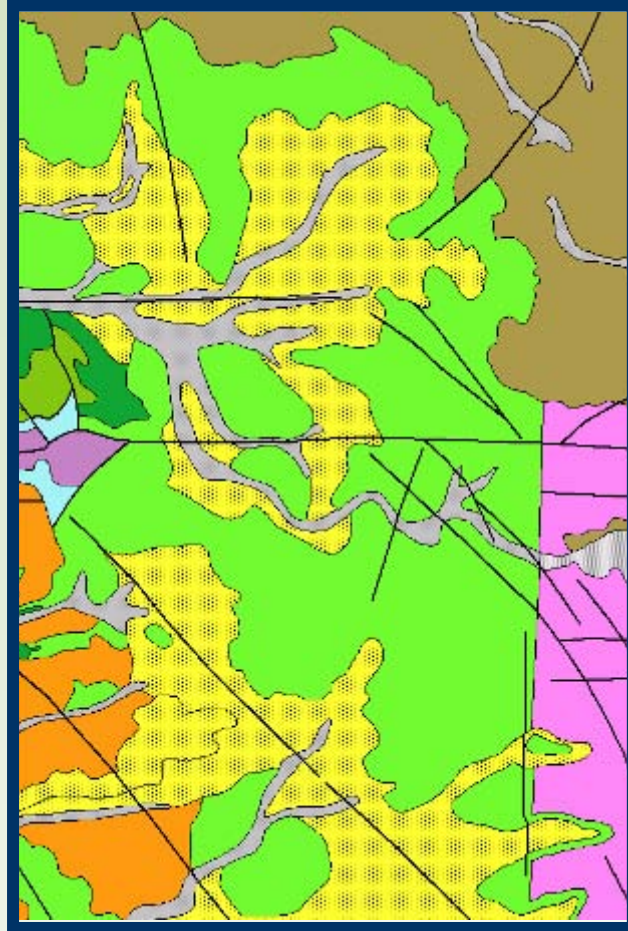
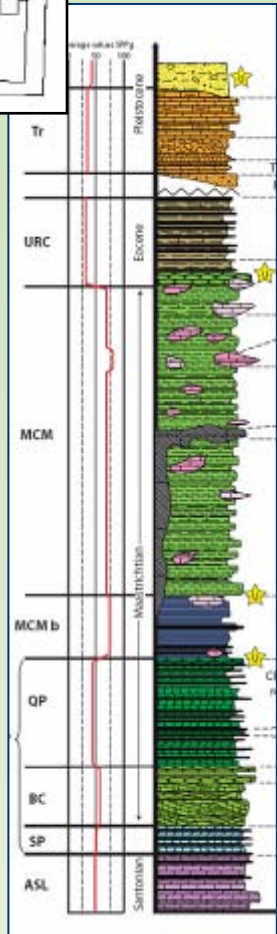
- Occurrences of Uranium revealed by work carried out by NRA
- Uranium potential confirmed by on-site visits of AREVA geologists
- Differences between NRA and AREVA results to be further analyzed
- Full geological exercise to be conducted by AREVA to confirm preliminary findings



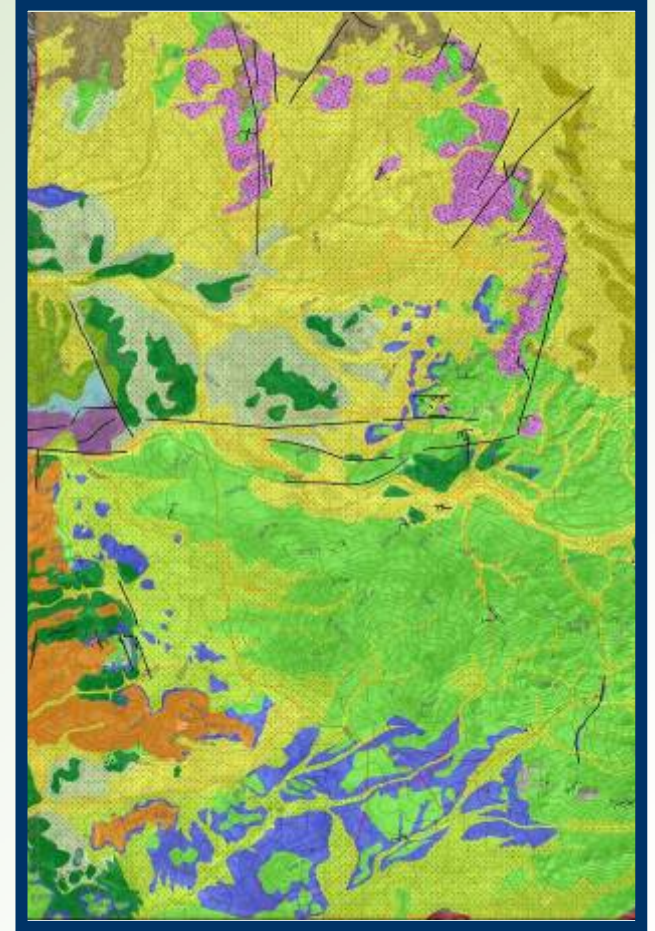


# Mapping

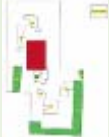
1km



Digitalized 1:50 000 Central Jordan map

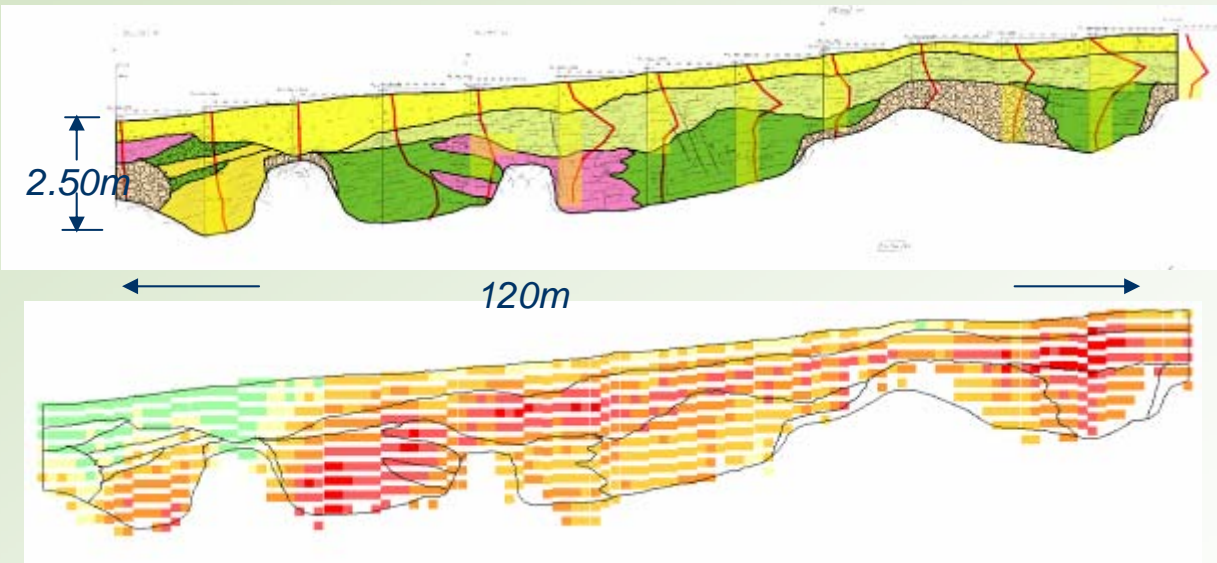


Fertile Zone area mapped by JFUMC



# *Trench Program in the FZ*

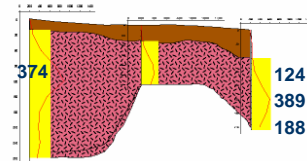
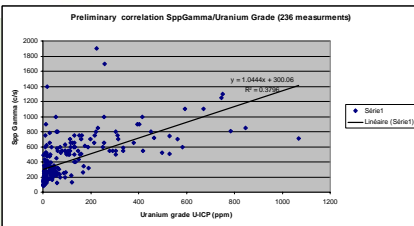
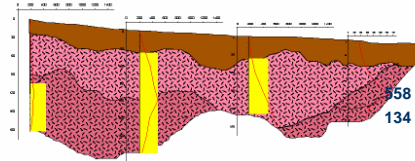
- Understand and evaluate the continuity of Uranium mineralization
  - 29 trenches (2660 m)
- 681 samples collected & analyzed at JAEC's labs .



# Examples of Trenches FZ-T07 and FZ-T16



	AVERAGE
PECSUP / PL	3.91
DECNODIN / MCM	392.275
CALCRAY/MCM	150.561
WAMAMO / MCM_b	161.406
CALMO / MCM_b	61.227



# Logging Equipment and Tools



***JAR has been equipped with special logging laboratory that was designed for JAR Central Jordan Uranium licensed area:***

1. Logging laboratory trailers
2. Geophysical borehole logging probes
3. Cables and winches
4. Tripods
5. Computers
6. Logging software

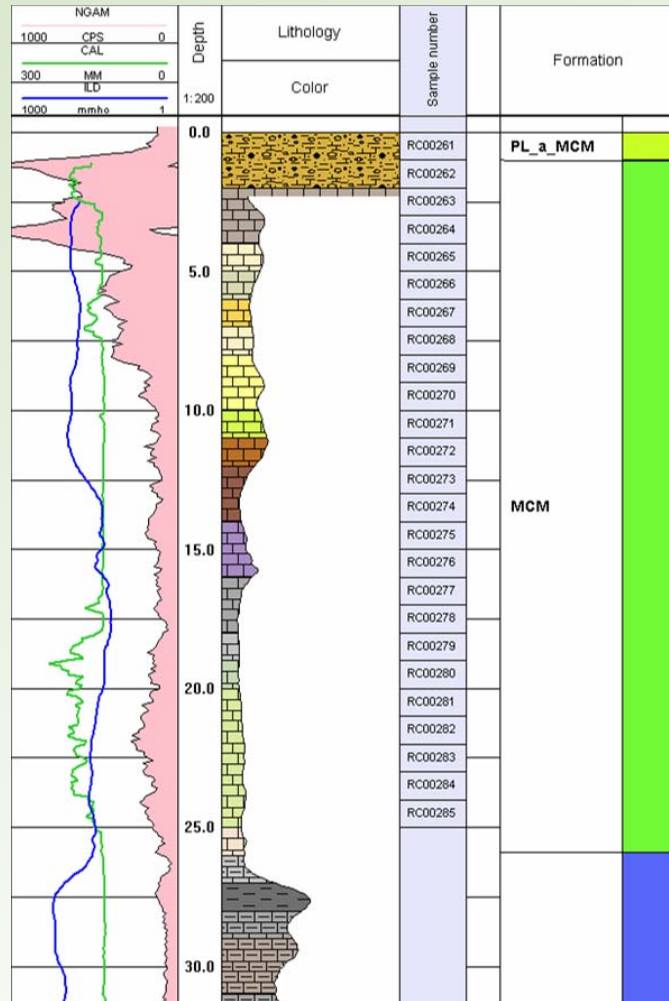
# Drilling Work

1. Drilling
2. Logging
3. Sample description

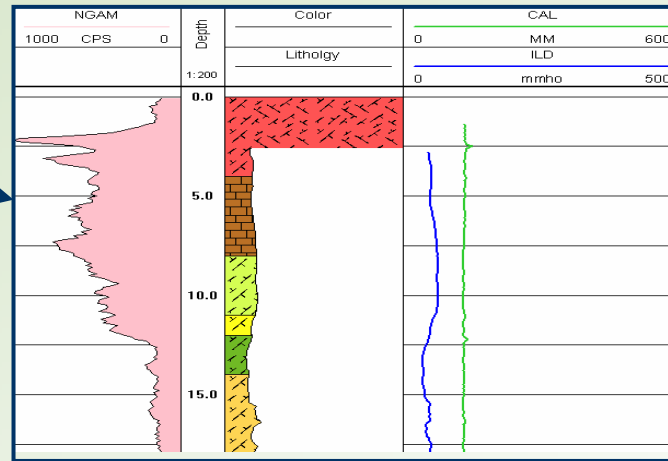
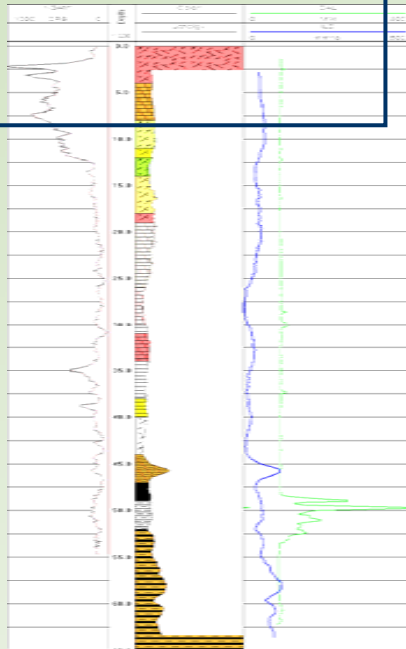
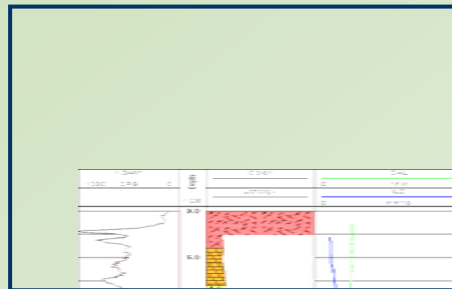


**U ppm**

RC00262	92	107,8
RC00263	174	189,3
RC00264	352	382,3
RC00265	212	226,5
RC00266		231,2
RC00267		223,7
RC00268		143,9
RC00269		102,7



# Example of Logging Result



FZRC\_0006\_1

- High radiometric background between 1 and 12 m deep
- Peak reaching 1000 cps at 2.20 m

# Site Selection

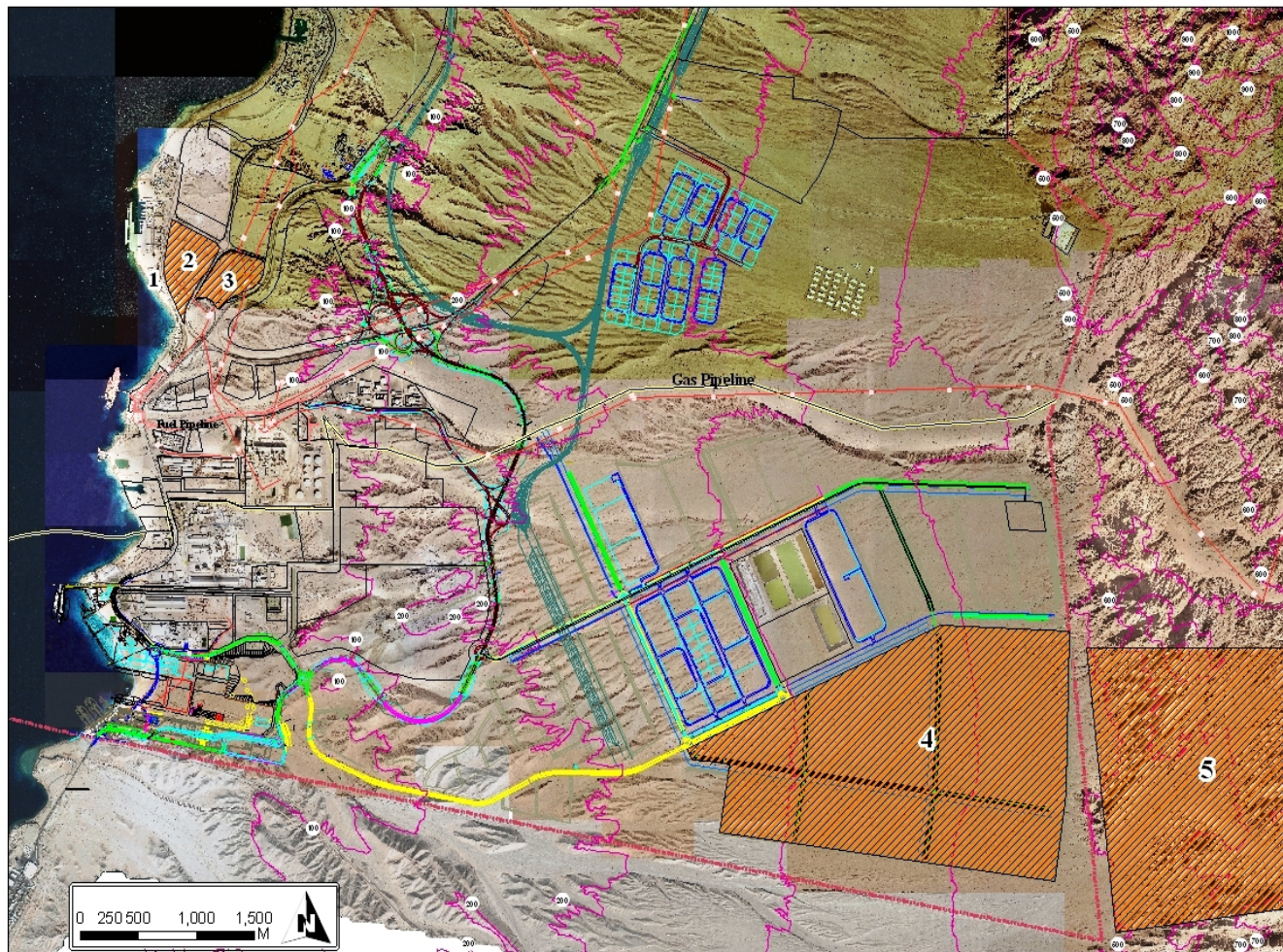
**Preliminary regional analysis was carried out for identification of potential sites for NPP, followed by screening of these sites and selecting candidate sites.**

**The analysis was based on the following IAEA and other international agencies 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 Candidate Site



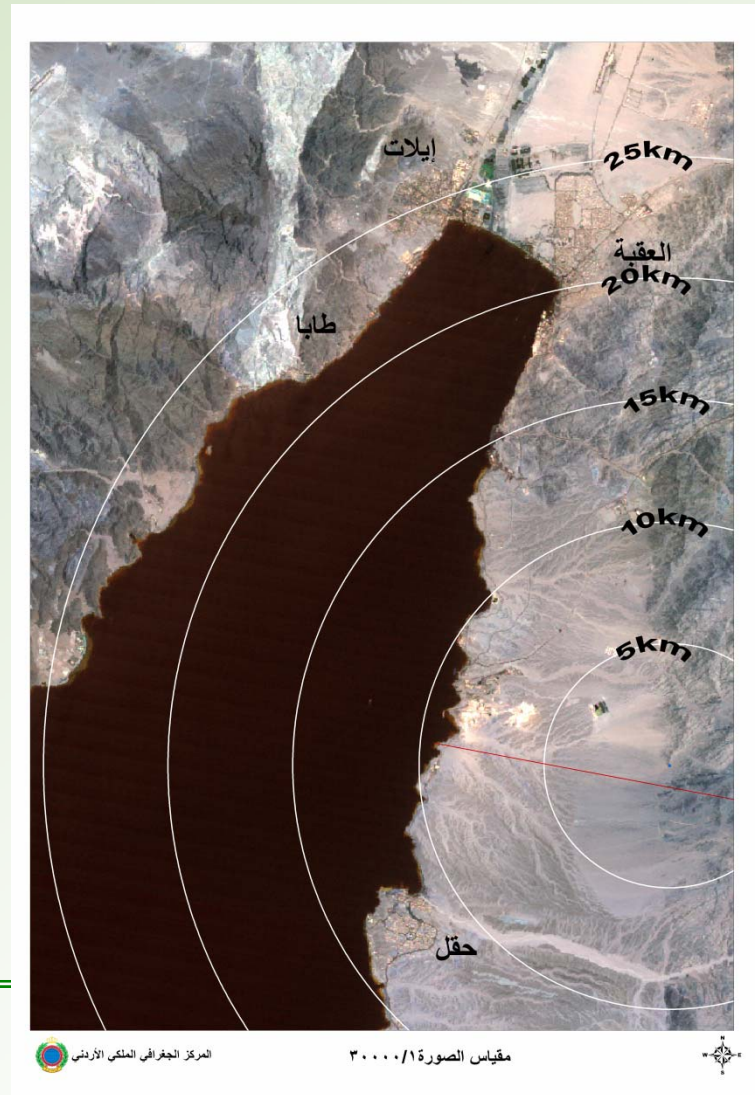
# Site Selection and Characterization Milestones

- 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 28<sup>th</sup> ,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 1<sup>st</sup> ,2009.
  - Site selection and characterization contract signed with Tactele on September 12, 2009.
- Completion of the site selection and characterization work by the end of 2010.
- Site approval by the JNRC by mid 2011.

# Emergency Planning

In order to minimize health and safety risks, a buffer and emergency zones should be identified around the NPP:

1. **The Exclusion Zone (the NPP site); extends to 1 km from the plant.**
2. **The Protective Zone ( Low Population Zone); extends to 5 km from the plant.**
3. **The Emergency Planning Zone; extends to 20 km from the plant.**



# Human Resources Development

- Jordan University of Science and Technology - established a nuclear engineering dept. to graduate future reactor operators holding BSc degrees in nuclear engineering
- An active training TC programme with IAEA
- JU, YU, BAU have started MSc programs in nuclear physics & students are trained on the Van de Graaf & SESAME
- An RfP for Research Reactor (RR) has been issued to allow for proper training of the nuclear engineers and other uses

# Nuclear Research Reactor

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- 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 infrastructures

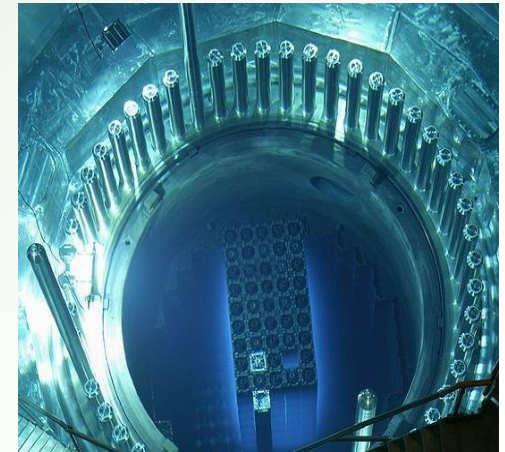
# Request for Proposals (RFP)

- January 15<sup>th</sup> 2009, RFP was issued
- For Design and Construction of Research and Training Reactor
- Complete and detailed, including:
  - Objective, Scope of Work and Pricing
  - Reactor Power and Type
  - Licensing, Regulatory and EIA
  - Technology Localization & Transfer
  - Location and Siting
- All major RR vendors were invited to participate



# 5 MW Research Reactor

- Four international bids received
  - Russia, ATOMSTROYEXPORT
  - China, ZHONGYUAN Co (CNNC)
  - Korea, KAERI / DAEWOO
  - Argentina, INVAP
- May 18th 2009, Technical Evaluation Committee was formed
- Additional information was sent to all prospective vendors
- Companies continued to update their offers



# KAERI Reactor

- 20/4/2009 Site Visit
- 25/10/2009 RR Committee
- 19/11/2009 HANARO Reactor
  - 5 MW upgradeable to 10 MW
  - Open Pool, H<sub>2</sub>O
  - Flux/Power Ratio  $2.9 \times 10^{13}$
  - MTR plate type fuel 18FA Core
  - Average Discharge Burnup 70%
  - Cycle Length 50 days /1 Assembly
  - 5 Assemblies /year (250 EFPD)
  - Fuel supplied for 3.5 years

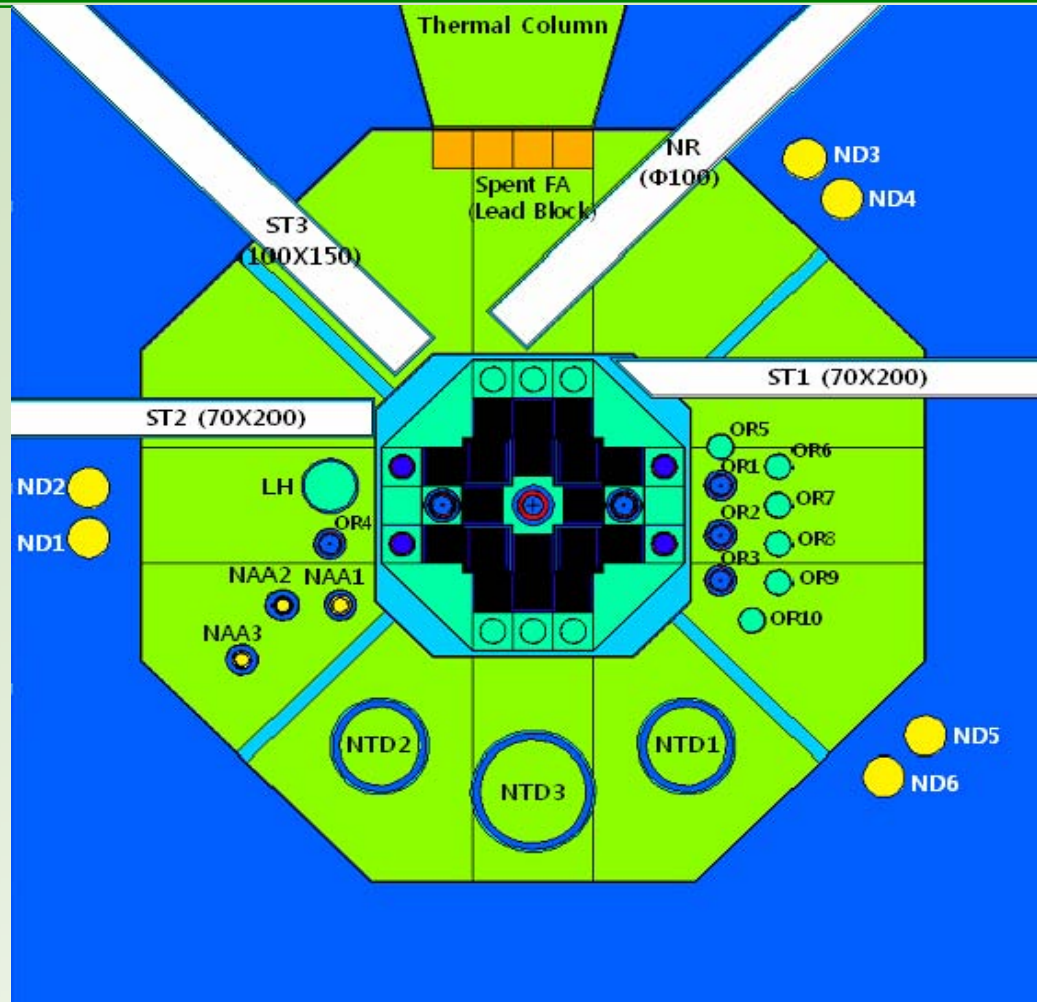




# Top Two Comparison

Reactor Buildings	KAERI	INVAP	Comments
<b>A. Reactor Confinement Building</b>			
Area (square meters)	2198	4000	This area includes reactor, auxiliary, and training
Number of Floors	6	5	
<b>B. Auxiliary Building</b>			
Area (square meters)	2418		
Number of Floors	6		
<b>Radioisotope Production Facility</b>			
Area (square meters)	2457	650	
Number of Floors	3		
<b>Training Center + Guard House</b>			
Area (square meters)	1000		4 classrooms, 1 auditorium+ visitor gallery+offices
Number of Floors	2		
<b>Truck Access and Entrances</b>			
Area (square meters)	200		
Number of Floors	1		
<b>Cooling Towers and Pump House</b>			
Area (square meters)	200	100	
Number of Floors	1	1	
<b>Total Area (square meters)</b>	<b>8475</b>	<b>5000</b>	

# KAERI Reactor



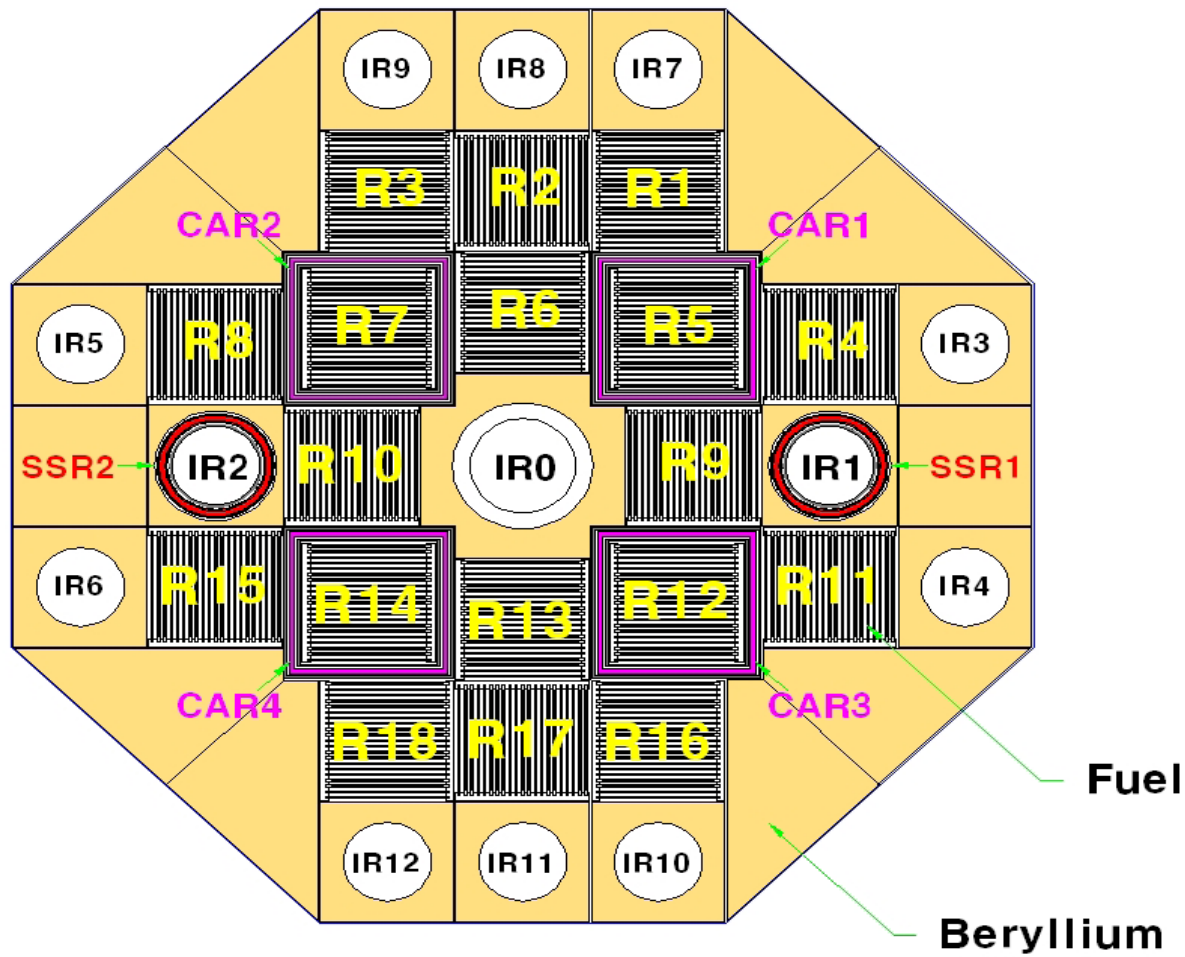


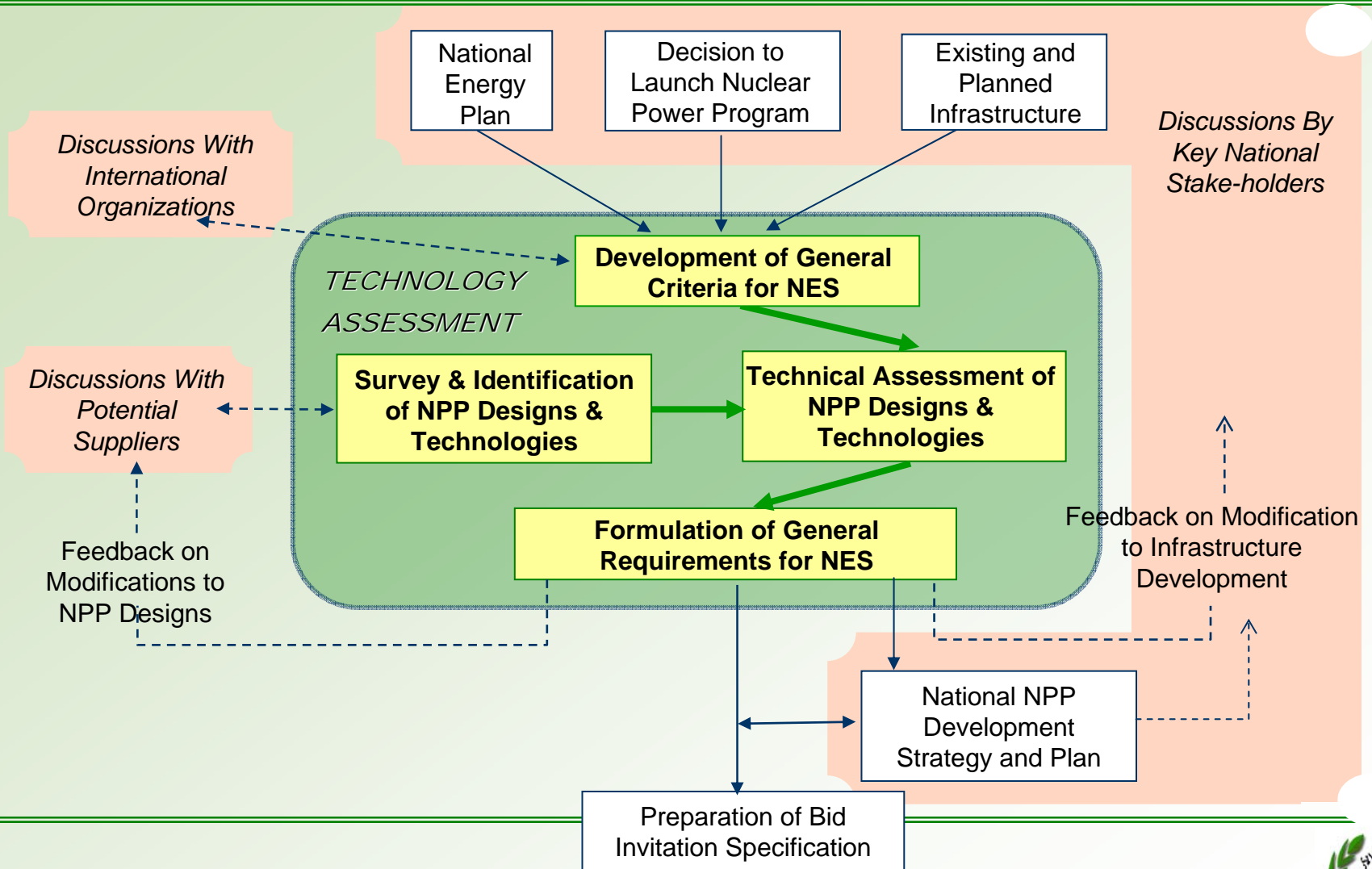


Figure 3.1-5 Floor 0 layout of the reactor building and the RIPF building

# International Cooperation

- Engaged the following countries and explored with them solutions to Jordan's challenges :
  1. USA
  2. Canada
  3. France
  4. Russia
  5. China
  6. UK
  7. South Korea
  8. Romania
  9. Spain
  10. Argentina
  11. Japan
  
- Signed NCA with France, China, South Korea ,Canada , Russia , UK, Argentina and Spain.
  
- Ongoing negotiations with USA , Japan, Romania and Czech Rep.

# Technology Assessment



# General Criteria for Selection of 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-? MWe

# 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 **ATMEA** (Areva & Mitsubishi)
- 1000 MWe **OPR** and 1400 MWe **APR** (KHNP and KEPCO)
- 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)



# ATMEA I



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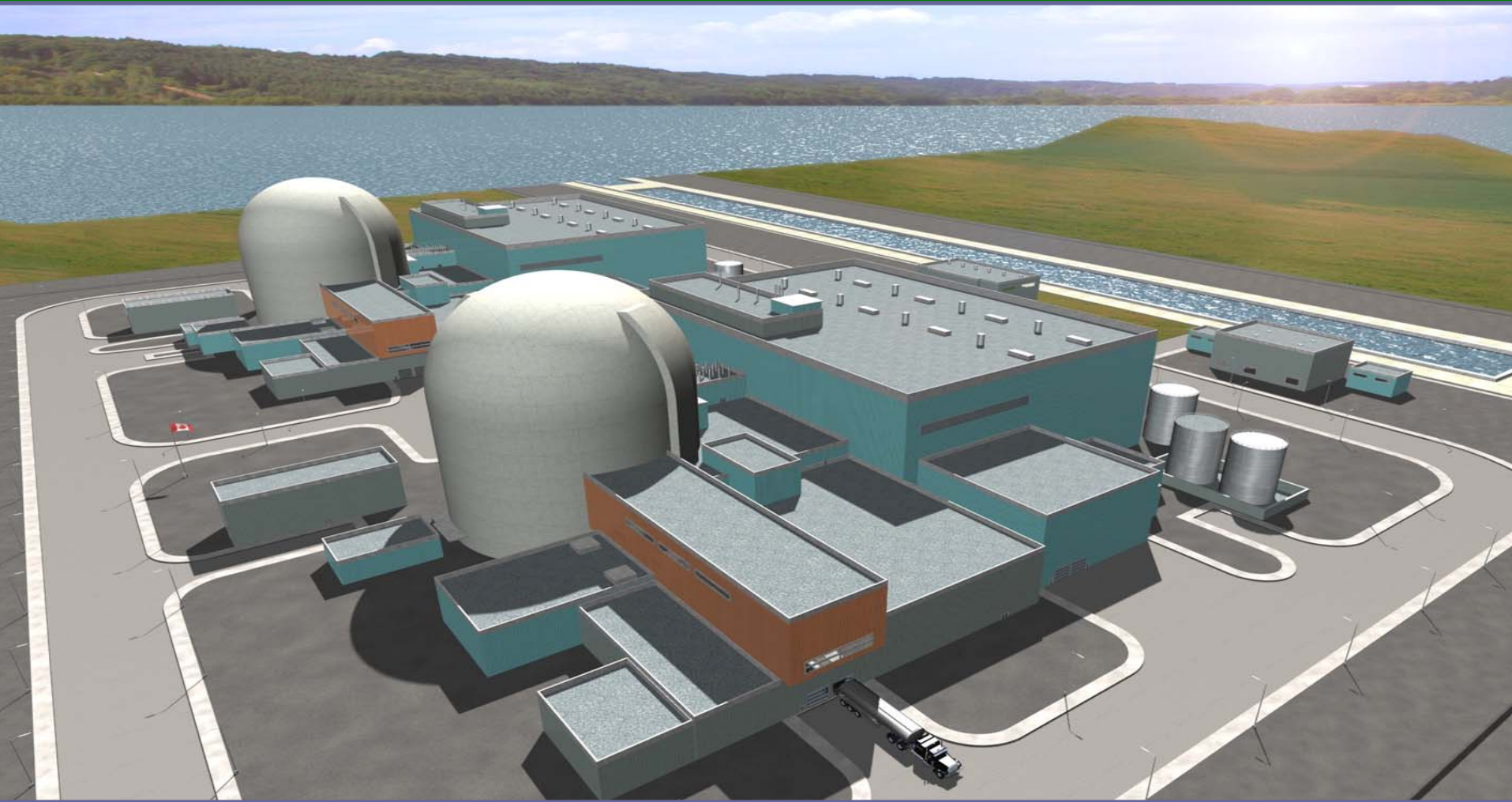
# APR-1000



# VVER-1000



# Enhanced CANDU 6 (EC6)



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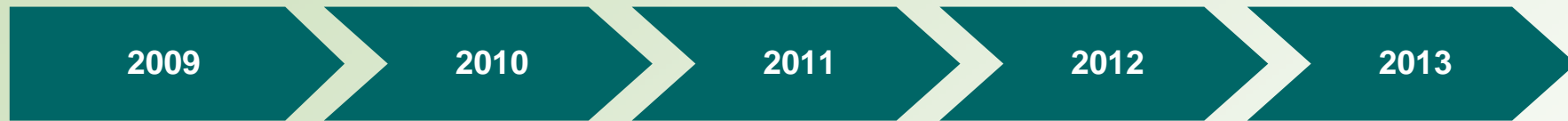
# Major Issues for Assessment

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- Economics and plant size
- Operability/Reliability/Maintainability
- Constructability including schedule
- Licensability and safety
- Project related issues including national participation & infrastructure development
- Owner's scope of supply
- Supplier and vendor issues including capabilities
- Financing options
- Sustainability



# 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

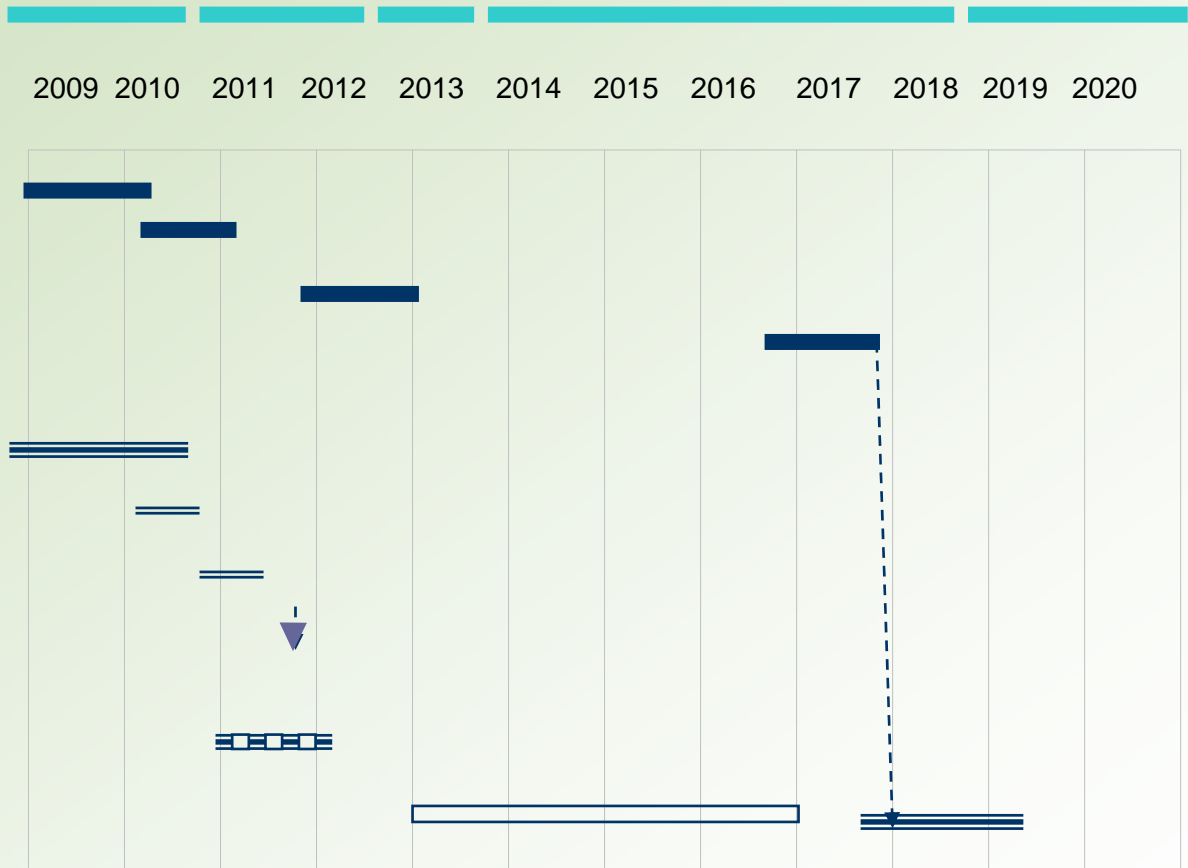
- Siting & Licensing
- Site selected and characterized
    - Early Site Permit
  - Construction licence
  - Operating licence

PROCUREMENT

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

IMPLEMENTATION

- Site preparations
  - Construction
- Commercial operation



# Grid Stability and Adaptability

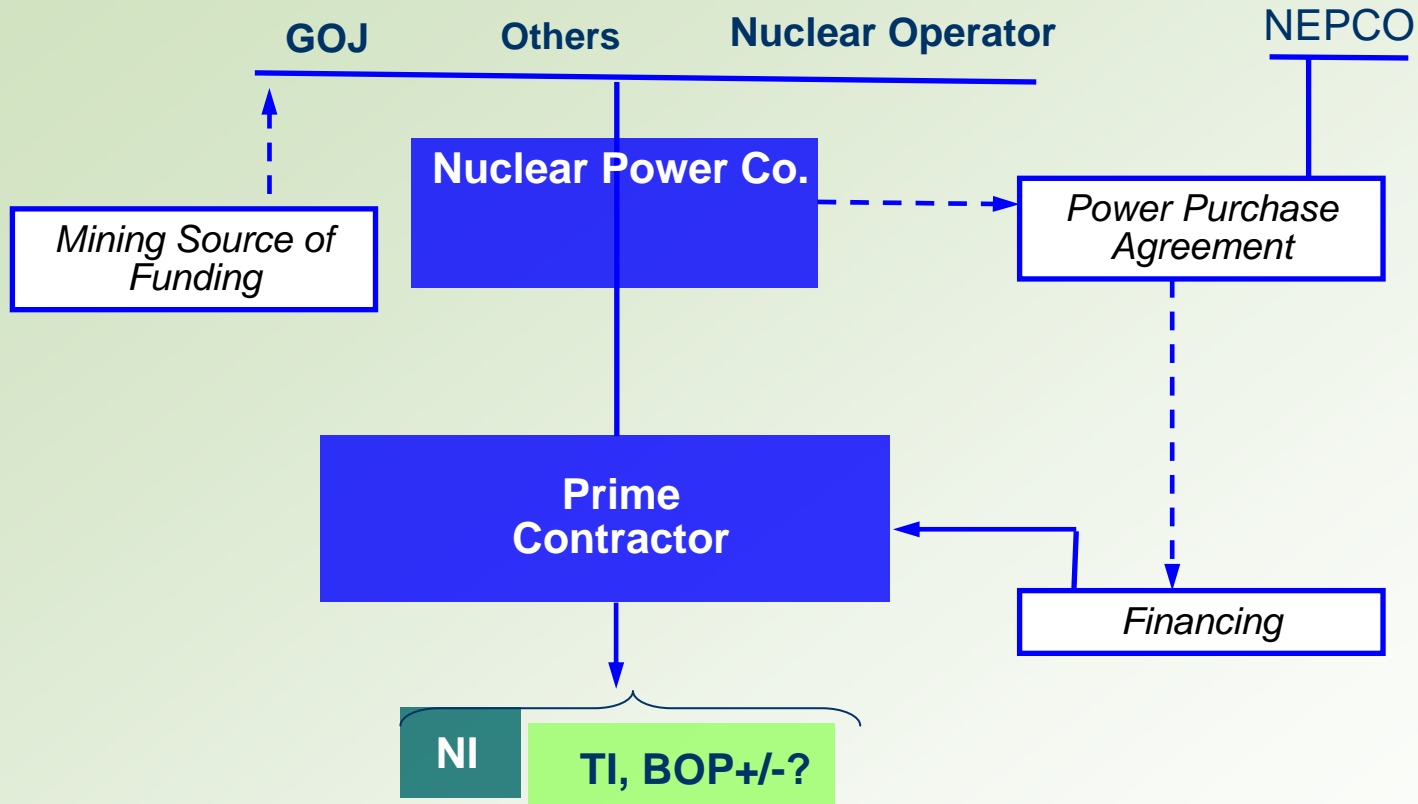
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- An agreement was signed on Feb. 18, 2009 between NEPCO and ELEC PROMOTION (France) to address the stability of Jordan's T&D network from introduction of large sized NPP through a 0.5M euro grant from the French Ministry of Finance





# Setting Up of Nuclear Company



# Pre-Construction Consulting Services

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## *Scope of Work*

- Feasibility and Financial Assessment
- Optimization Studies
- Technology Assessment
- Tender Preparation and Evaluation
- Preparation of Contractual Options
- Signed contract with Worley Parsons on Nov.15, 2009.

# Overall Evaluation Process

1. What are the deliverables to ensure the country is ready? What are the impacts 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, costs 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?

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# Thank You

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Jordan Atomic Energy Commission

