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# Jordan's Nuclear Programme

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# Facts about Jordan

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- Population ~ 5.5 million
- Area ~ 34,445 square miles
- Capital – Amman (~ 40% of population)
- GDP ~ \$9.0 billion
  - Growth ~ 6.8% per year
- 25% of national budget is spent on energy imports

# Challenges

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- ❑ 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 resources

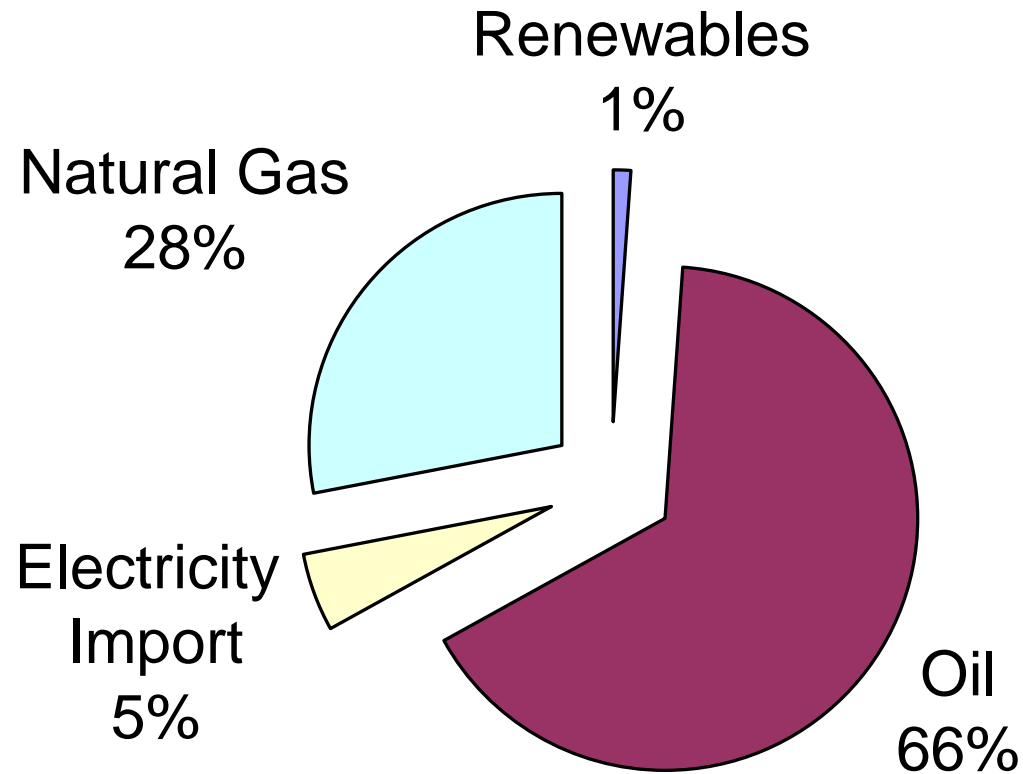
# Jordan Energy Options

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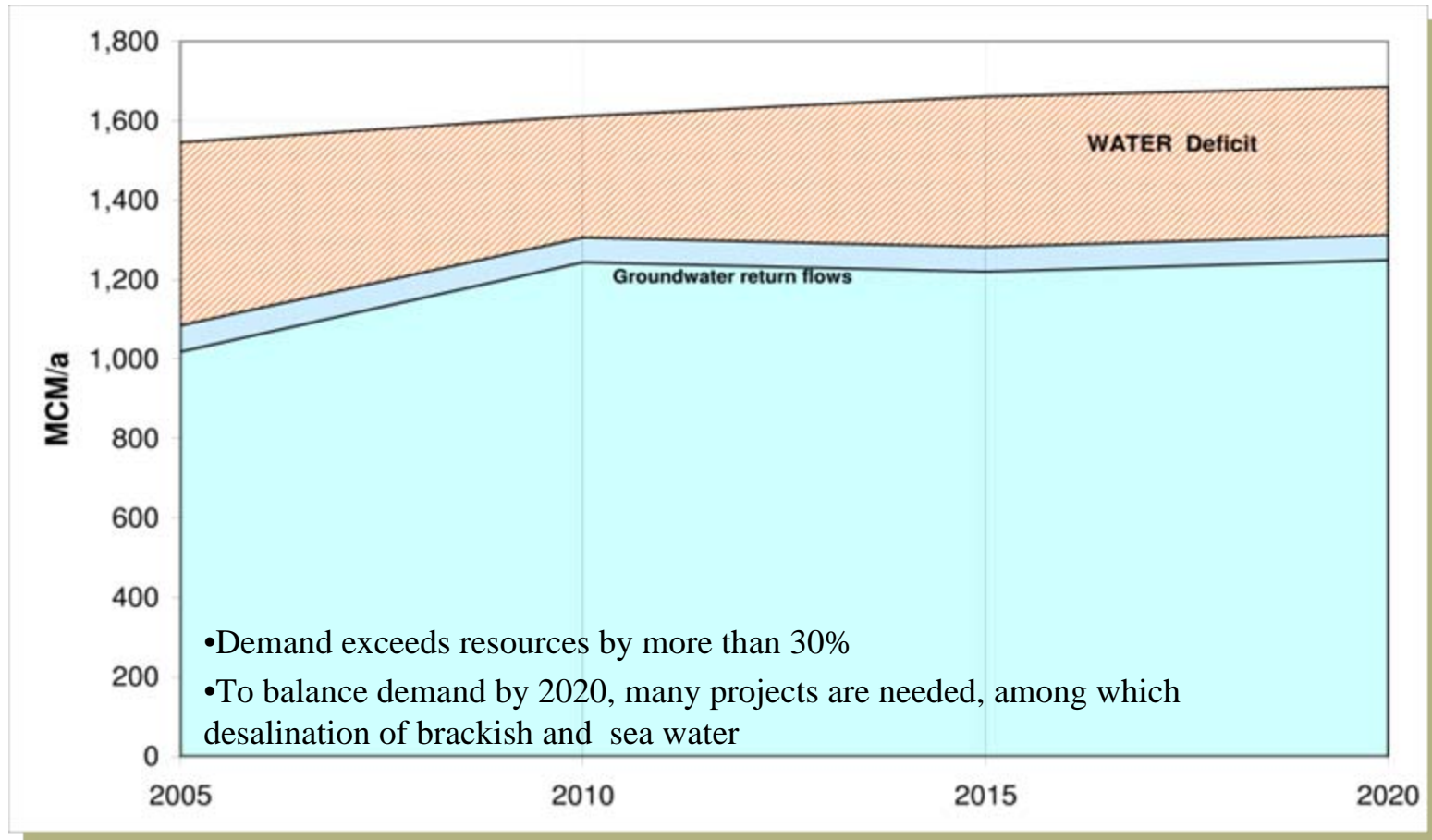
- ❑ Options are limited:
  - Natural Gas is a short term option and cannot be relied on for mid or longer term
  - Renewable technologies are mainly high cost, limited utilization, and cannot be base load
  - Oil shale, a limited medium term, reserved for special uses

# Energy Mix - 2007

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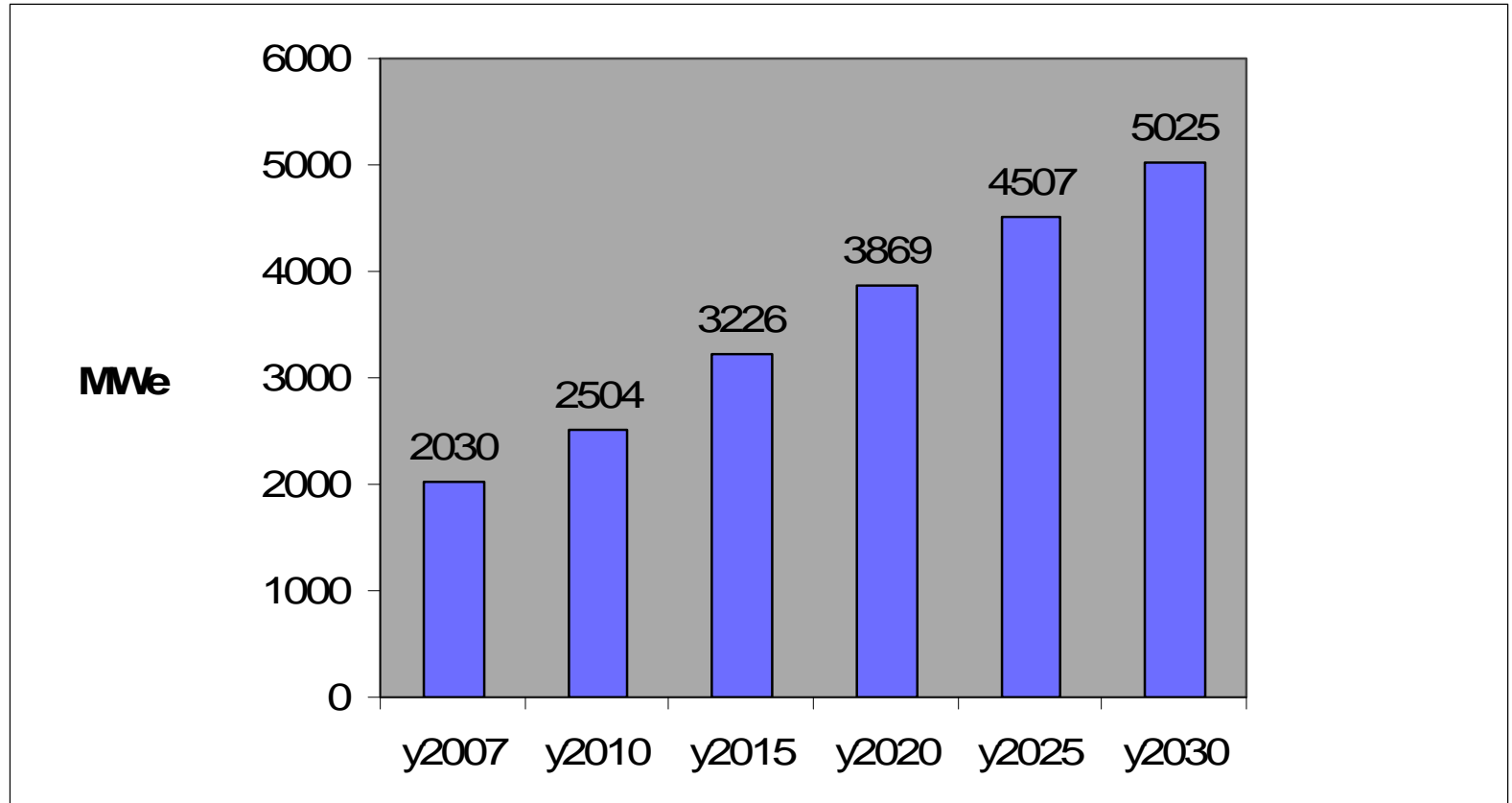


# Water Situation in Jordan



# Jordan Electric Load Forecast

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# Electricity Consumption

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- Jordan consumes now about 2000 kWh/yr per capita whereas
  - Europe 6,000-8000
  - North America 14,000
  
- 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

# Energy Vision

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- ❑ 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**

# Motivation for Nuclear Power

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- Basic forces drive the development of NP
  - Lack of indigenous resources
  - Desire to reduce dependence upon imported energy
  - Need to diversify the supplies (to enhance national security)
  - Need to protect the environment
  
- The relative importance of each of these drivers has varied considerably over time, and between countries, regions or groupings

# Challenges

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- Several challenges that need to be addressed in order to develop Jordan's nuclear energy program:
  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

# Jordan's Nuclear Strategy

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- ❑ Ensuring security of supply including fuel
- ❑ Leveraging of national Uranium asset
- ❑ 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

# Regulatory Reform

- ❑ The existing nuclear law was modified early this year to allow the creation of two independent commissions: Jordan Atomic Energy Commission (JAEC) and , Jordan Nuclear Regulatory Commission (JNRC)
- ❑ The two revised laws were ratified by parliament.

*This is consistent with the IAEA recommendations and the best international practice*

# Nuclear Legislation

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- ❑ Prior to 2001, nuclear activities were handled as a directorate in the Ministry of Energy & Mineral Resources
- ❑ In 2001, a new law of *Nuclear Energy and Radiation Protection* (29) was promulgated to substitute for the first law (14/1987)
  - Under this 2001 law the Atomic Energy Commission (JAEC) was established to undertake both promotion and regulation of nuclear applications in the country
- ❑ In July 2007, the 2001 law was modified and divided into two laws allowing the creation of two independent entities:
  - *Nuclear Energy Law* (42/2007) established the Jordan Atomic Energy Commission (JAEC)
  - *Nuclear Safety and Security and Radiation Protection Law* (43/2007) established the Radiation and Nuclear Regulatory Commission (RNRC)
- ❑ In Feb. 2008 the parliament adopted a further revision to law (42/2007) to upgrade JAEC to the level of a Commission with five commissioners reporting to the PM with the mandate to manage the nuclear program

# Jordan Nuclear Energy Program

**JNRC**

**(Regulation, Safety & Safeguards )**

**JAEC**

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

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

**Nuclear  
Sciences**

**Power Reactor**

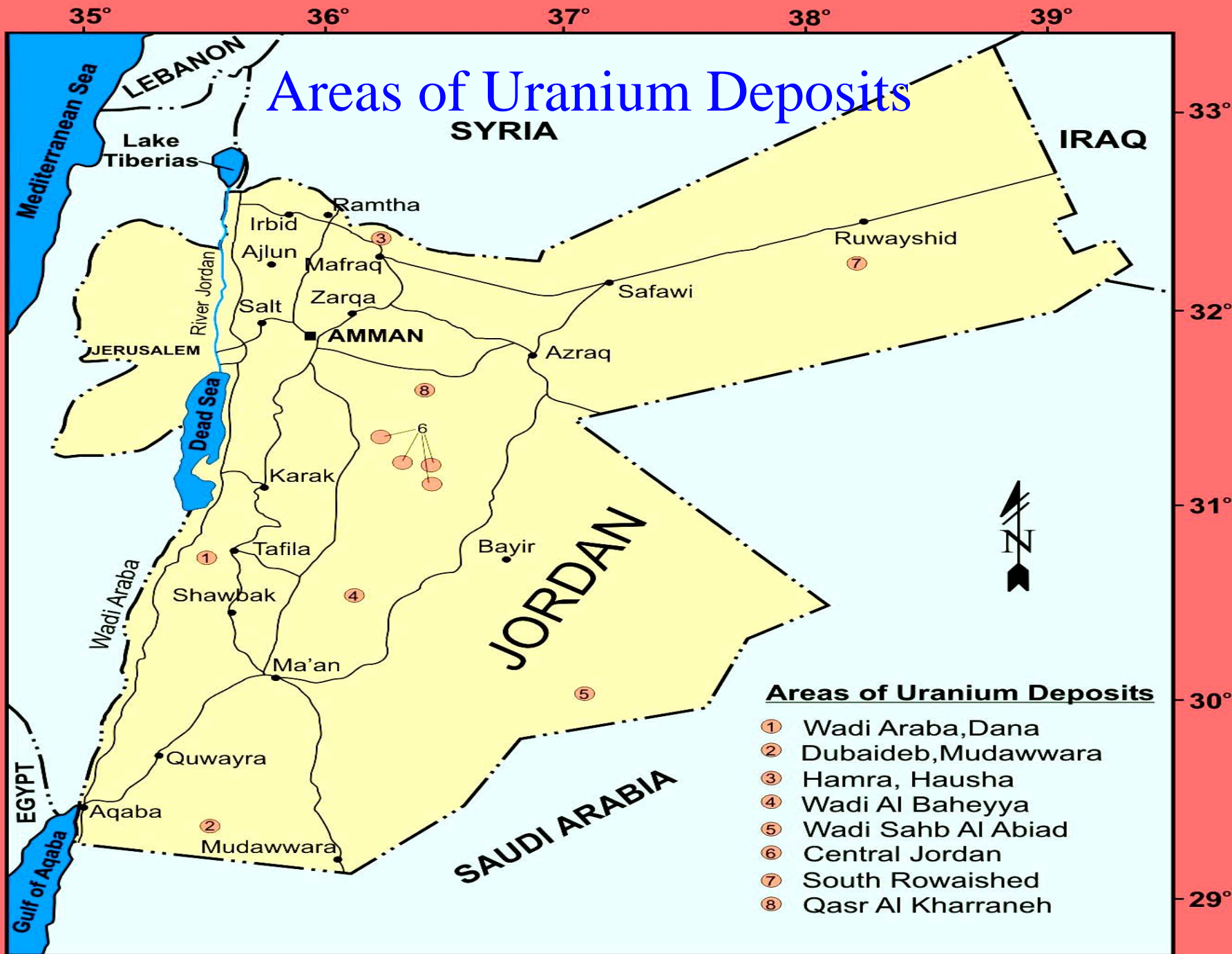
- 1. JERI (U deposits)**
- 2. JPMC (U in phosphates)**

**Research  
Reactor**

# 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



# Jordan Energy Resources Inc. (JERI)

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- ❑ Exploration of Uranium, Thorium & other heavy metals
- ❑ Mining of Uranium ore
- ❑ Milling and processing of yellow cake and other special nuclear heavy metals
- ❑ Provision of nuclear material needed for the civilian nuclear fuel cycle

# Human Resource Development

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- 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 in nuclear safety, security, and safeguards
- JU, YU, BAU have started MSc programs in nuclear physics & students are trained on the Van de Graaf & SESAME
- A Research Reactor (RR) is being studied to be established at JUST to allow for proper training of the nuclear engineers

# International Cooperation

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- 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. Korea
  8. Romania
  
- Signed NCA with France & China and negotiating with rest
  
- Signed MoUs with most and negotiating with rest

# General Criteria for Selection of Reactor

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

# Reactor Technology

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- Evolutionary Large Light Water Reactors  
*New features: improved reliability, enhanced safety*
  - LWR: (ABWR, ESBWR AP1000, APWR, APR-1400, EPR, ATMEA, VVER-1000)
- Advanced Heavy Water Reactor
- Small & Medium-Sized Reactors *New features: simplified systems, passive safety*
  - AP600, PBMR

# Road to Nuclear

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

# Evaluation Questions

- 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 the exploitation of uranium assets?
- 4 How does the proposal address fuel cycle, including fuel security and costs and waste management?
- 5 How does the generation technology proposed meet Jordanian selection criteria for the reactor? What is the safety record of the operator?

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THANK YOU