Nuclear Power in the Middle East

Dr. Khaled Toukan, Minister of Higher Education & Scientific Research
Amman, Jordan
Middle East

- The Middle East is a historical and political region of Africa-Eurasia

- The Middle East traditionally includes countries or regions in Southwest Asia and parts of North Africa
  - Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Somalia, Syria, Turkey, the United Arab Emirates, and Yemen

- In this presentation, I will focus mainly on Arab countries and include in addition those in North Africa combined as the “Region”
Aggregation is Misleading

- Arab countries are at differing stages of development, with different resource endowments and income levels.
- On average per capita income in the region is high, but this disguises enormous differences between countries:
  - In Egypt, income is about $4000 per capita but 44% of the population lives on less than $2 a day.
  - While, UAE has an average income of $22,000 per capita.
- Several non-oil economies rely heavily on aid, capital inflows and remittances from workers in the oil-producing countries.
- Poverty is widespread in several countries.
Countries in the Region are Facing Different Challenges

- Growing energy demand
- Increasing energy costs
- Lack of conventional energy resources
- Increasing dependence on fossil resources
- Scarcity of water resources
- Degradation of environmental conditions due to increasing consumption of fossil resources
Drivers for Development of New Energy Options

• Four basic forces:
  – to reduce the cost to the consumer
  – to reduce the cost of electricity to industry
  – to protect the environment
  – to diversify the supplies (to enhance national security)
Energy Demand for Arab Countries

- Demand increased by 3.8%/yr from 1985 to 2005 while the world was at 1.6%/yr
- Arab share in 2005 world demand was only 4%
- Energy intensity (E/GDP) has declined from 1.55 in the period 1985-90, to 0.74 in the period, 2000-05
- Per capita energy consumption grew at 1.3%/yr in the period 1985-2005
- Average per capita consumption reached 1.28 toe in 2005 but with much disparity between countries
Per Capita Consumption (toe/yr)
Energy Demand Projections

• Despite continued decline in energy intensity, energy demand is projected to grow due to:
  – population growth
  – economic growth (GDP)
• OAPEC Reference Scenario (2005-2020) main assumptions:
  – Pop ~ 460 M in 2020 , ~2-4.4 %/yr
  – GDP ~ 2-5.6 %/yr (varies by country)

Note: OAPEC: Organization of Arab Petroleum Exporting Countries. It includes Algeria, Bahrain, Egypt, Iraq, Kuwait, Libya, Qatar, Saudi Arabia, Syria, Tunisia and the United Arab Emirates.
Electricity Consumption

• Arab countries consume about 1750 kWh/yr per capita whereas
  – Europe 6,000
  – North America 14,000
  – Developed countries 8,000

• Electricity is central to achieving sustainable development goals and HDI is closely correlated with high kWh/capita
Regional Energy Demand Projections (1)

- Regional demand is projected to grow at 3.7%/yr according to OAPEC’s Reference Scenario (2006)
- Only 44% of the additional regional energy demand over the projection period will be met by oil and 3.2% by hydro and coal
- *Hence, it is assumed that natural gas will fill the gap and supply the remaining 52.8% of the demand*
Regional Energy Demand Projections (2)

- **Oil**
  - 2005: 55.80%
  - 2020: 51%

- **Hydro & Coal**
  - 2005: 2.70%
  - 2020: 2.90%

- **Gas and Others**
  - 2005: 41.50%
  - 2020: 46.20%
Desalination

• Arab countries are the biggest users of desalination technology, with over 50% of the world’s capacity

• GCC such as Saudi Arabia, the UAE and Kuwait use dual-purpose power and desalination plants on a major scale

• R&D are needed to develop dual-use plants to produce water at less than $0.50/m3 and power at $0.02/kWh
Implications

• Looking at the region as an aggregate, oil and gas will dominate the supply until post-2020
• Non-fossil sources are projected to play minor role in the region’s future in business-as usual assumptions OAPEC scenario and other projections, entrenching the singular dependence of the region on hydrocarbon resources
• However, it is highly uncertain that such overoptimistic assumptions about the supply of natural gas will be met, especially for non-OAPEC countries
• Nuclear will offer an insurance to highly uncertain supplies and escalating costs
Nuclear Power

• NP offers a medium to long term alternative electricity option for the Middle East
• Worldwide prospect of NP is improving
• The barriers facing the development of the nuclear industry are being addressed favorably:
  – Public acceptance
  – Reactor and fuel cycle safety
  – Disposal of high-level nuclear waste
  – Proliferation risk
  – Nuclear security
  – Economic competitiveness
Benefits for the Economy

- Provides economically competitive electricity
- Reduces pollution and greenhouse gas emissions
- Displaces use of oil
- Creates demand for new services and products
- Creates new employment opportunities in high-tech and manufacturing
- Enhances industrial development and higher standard of living
- Provides low cost energy source for seawater desalination & process heat
Near Term Challenges

- High investment cost
- Human resources
- International & regional political climate
- Infrastructure
  - Fabrication and manufacturing capacity
  - Engineering capability
  - Skilled construction trades
  - Transmission grid & reliability
Political Support for Nuclear Power

• Interest in nuclear power in the Region is not new
• As far as 1994, the Arab League urged its member states to enhance education in nuclear science and technology
• In 2006, the Arab League reiterated its call and more specifically for establishing a regional reactor project
• Officials from the Gulf Co-operation Council (GCC), in their December 2006 meeting, said they were exploring the possibility of creating a shared nuclear programme
• The Arab League, at the end of its summit meeting in March 2007, "called on the Arab states to expand the use of peaceful nuclear technology in all domains"
Misleading Perceptions

• There are wrong perceptions in some circles that pursuit of nuclear technology by the Arab states is
  – to “counter Iran’s growing political hegemony in the region”, or
  – nuclear hedge against Iran
Countries Expressing Interest in Nuclear Power

- Jordan +
- Egypt +++
- UAE
- Qatar
- Yemen
- Algeria +
- Morocco +
- Saudi Arabia
- Tunisia +
- Yemen
Recent Developments

Egypt
• Planning to build 4 reactors with the first to be completed within the next 10 years most likely at El-Dabaa, about 60 miles west of Alexandria.

Algeria
• Signed with Russia an agreement on nuclear development in January 2007 and in June an MoU with USA

Libya
• Recently signed a nuclear cooperation agreement with France

GCC
• In February, 2007, the IAEA promised the GCC to provide technical expertise to speed up their plan

UAE
• Recently promised by France assistance in launching its civilian nuclear programme
Options for Nuclear Power

New Generation for Design

• Evolutionary Large Light Water Reactors (LWRs: ABWR, ESBWR AP1000, APR-1400, EPR)
  – New features: improved reliability, enhanced safety features
• Advanced Heavy Water Reactor (ACR, CANDU-6& 9)
• Advanced Small & Medium-Sized Reactors (SMR)
  – New features: simplified systems, passive safety
  – LWR:AP-600, SMART (330 MWth), CAREM (25 MWe), VPBER-600, IRIS, NHR-200
  – Gas Cooled : GT-MHR (284 MWe), PBMR (120 MWe), HTTR (30 MWth)
Jordan as Case Study
Energy Demand

• Jordan energy demand is projected to grow due to:
  – population growth
  – economic growth
  – industrialization
  – water pumping and desalination

• Main assumptions:
  – Pop ~7.5 million in 2020; 9.2 M by 2030
  – GDP (%/yr)
    - 4.4–5.1 (2005-09)
    - 3.1 – 3.8 (2010-14)
    - 2.9– 3.6 (2015- )
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 medium term, should be reserved for liquid fuels and not for electricity
Jordan Electric Load Forecast

<table>
<thead>
<tr>
<th>Year</th>
<th>MWe</th>
</tr>
</thead>
<tbody>
<tr>
<td>y2007</td>
<td>2030</td>
</tr>
<tr>
<td>y2010</td>
<td>2504</td>
</tr>
<tr>
<td>y2015</td>
<td>3226</td>
</tr>
<tr>
<td>y2020</td>
<td>3869</td>
</tr>
<tr>
<td>y2025</td>
<td>4507</td>
</tr>
<tr>
<td>y2030</td>
<td>5025</td>
</tr>
</tbody>
</table>
Vision

• Transform Jordan from net energy importing to net energy exporting country by 2030
• Make available power to fuel economic growth at low cost
• Policy question: Go for major transformation away from fossil fuel and use economy of scale or be limited by restrictions and build SMR?
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
Transform Jordan to net energy exporting country

Vision & Five Measures

Fuel Cycle

Getting Country Ready

Vision

Uranium Exploitation

Generation

Funding
Five Measures


2. **Uranium exploitation.** Policy: maximize sovereignty while creating value from resource. Avoid concessions.

3. **Fuel cycle:** Enrichment, waste, guarantees.

4. **Getting country ready**
   - Investment for all studies
   - Investment in training and HR
   - Investment in infrastructure

5. **Funding:** Investigate creative financing methods that do not demand central Gov resources.
Uranium Deposits in Jordan

• Jordan is endowed with rich uranium resources
• There are many indications for deposits but much is still unexplored
• Only Central Jordan has been somewhat explored
Areas of Uranium Deposits

1. Wadi Araba, Dana
2. Dubaideb, Mudawwara
3. Hamra, Hausha
4. Wadi Al Baheyya
5. Wadi Sahb Al Abiad
6. Central Jordan
7. South Rowaished
8. Qasr Al Kharraneh
Uranium Reserves

• Deposits explored in central Jordan are mainly on the surface with avg thickness of 1.5 m with overburden of ~ 0.5 m

• Bearing material (carbonate rocks) is fine grained & brittle and hence easy to mine (open cast mining) with minimum hazard from radon
Uranium in Phosphates

- In the 80s, Jordan established a micro pilot plant to evaluate the extraction of uranium from phosphoric acid but that effort stopped in the 90s
- Revisit the feasibility of extraction under new price regime of uranium
National Roadmap (1)

- Establish a national company to undertake uranium exploitation
- Carry out a detailed feasibility study of nuclear power plant, including the tradeoffs of single vs. dual use (for seawater desalination)
- Establish a nuclear engineering degree programme at a Jordanian University
- Establish a multi-purpose on-campus research reactor for training, education and research
- Conduct a survey of national capabilities to identify HR gaps and train national experts
National Roadmap (2)

- Establish national criteria to decide reactor type and supplier
- Start parallel exploration with key countries & suppliers (USA, France, Canada, Russia, China)
- Negotiate nuclear cooperation agreements with USA, EURATOM, Canada, France and Russia
- Carry out a preliminary Plant Siting study
- Explore creative financial options
A Government-Owned Company was Established (JERI)

Mission

• Exploration of Uranium, Thorium & other heavy metals
• Mining of Uranium ore
• Extraction of Uranium from phosphates
• Milling and processing of yellow cake and other special nuclear heavy metals
• Provision of nuclear material needed for the civilian nuclear fuel cycle
International Treaties

Jordan is a party to:

• Treaty on the Non-Proliferation of Nuclear Weapons (NPT)
• Full-scope Safeguards (IAEA)
• Additional Protocol (IAEA)
The existing nuclear law was modified and divided into two laws allowing the creation of two independent entities: A Nuclear Energy Authority and another, a Regulatory Authority. The two revised laws were ratified by parliament. This is consistent with the IAEA recommendations and the best international practice.
Tentative Criteria for Selection of Reactor Types

- Safety and reliability
- Simplicity, standardization & modularization
- Waste disposal and storage
- Diversion-Resistance
- Cost consideration
- Fuel cycle considerations
- Desalination compatibility
- Cooling water requirements
- Potential spin-off industry
S&T Collaboration

• Nuclear science, technology and applications provide many areas of regional collaboration
• Common facilities for R&D
• Regional fuel cycle facilities
• SESAME offers an example
Concluding Remarks

• Nuclear power offers an important medium to long term alternative option for the Region for both electricity generation and water desalination. It provides an insurance policy

• To fully benefit from nuclear power in the Region, all countries need to accept the application of IAEA full-scope safeguards to all their nuclear activities

• Aim for establishment of a nuclear-weapon-free zone (NWFZ) in the Region

• IAEA should facilitate and demonstrate the benefits of peaceful applications of nuclear energy in the Region

• IAEA has great responsibility to facilitate the achievement of a (NWFZ) in the Region
THANK YOU