

Nuclear Power in the Middle East

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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

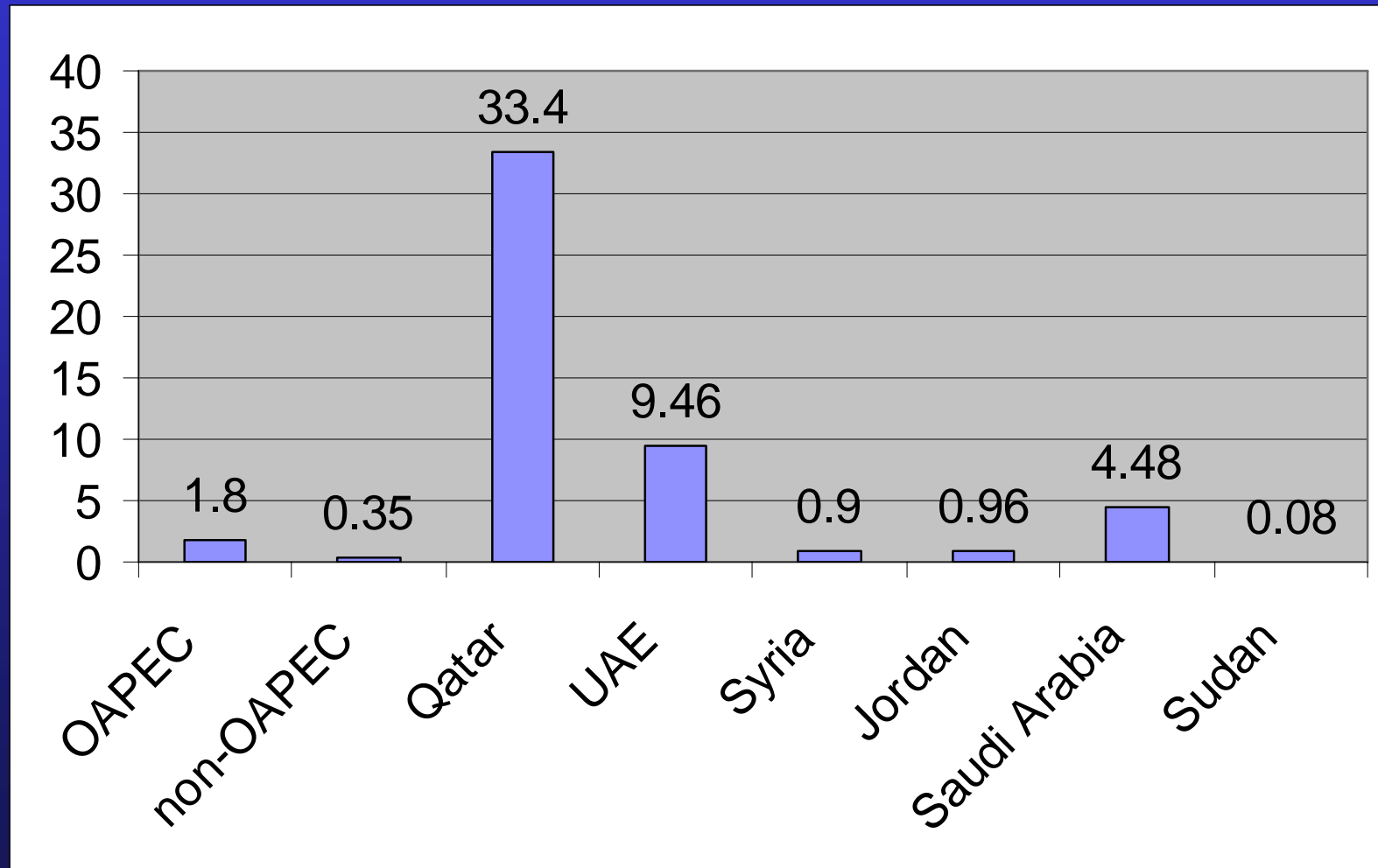
Drivers for Development of New Energy Options

- 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.

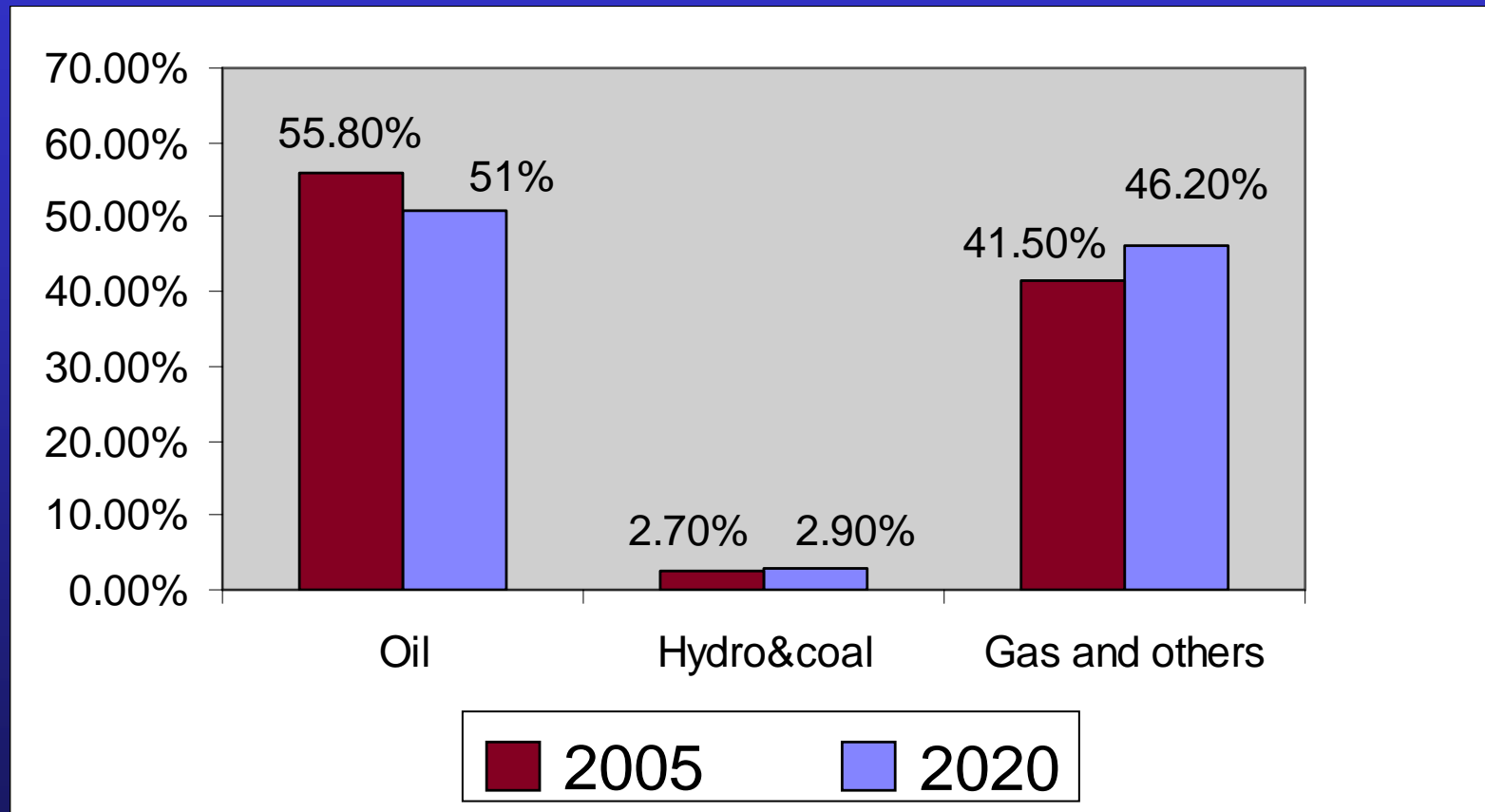
Electricity Consumption

- 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)



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

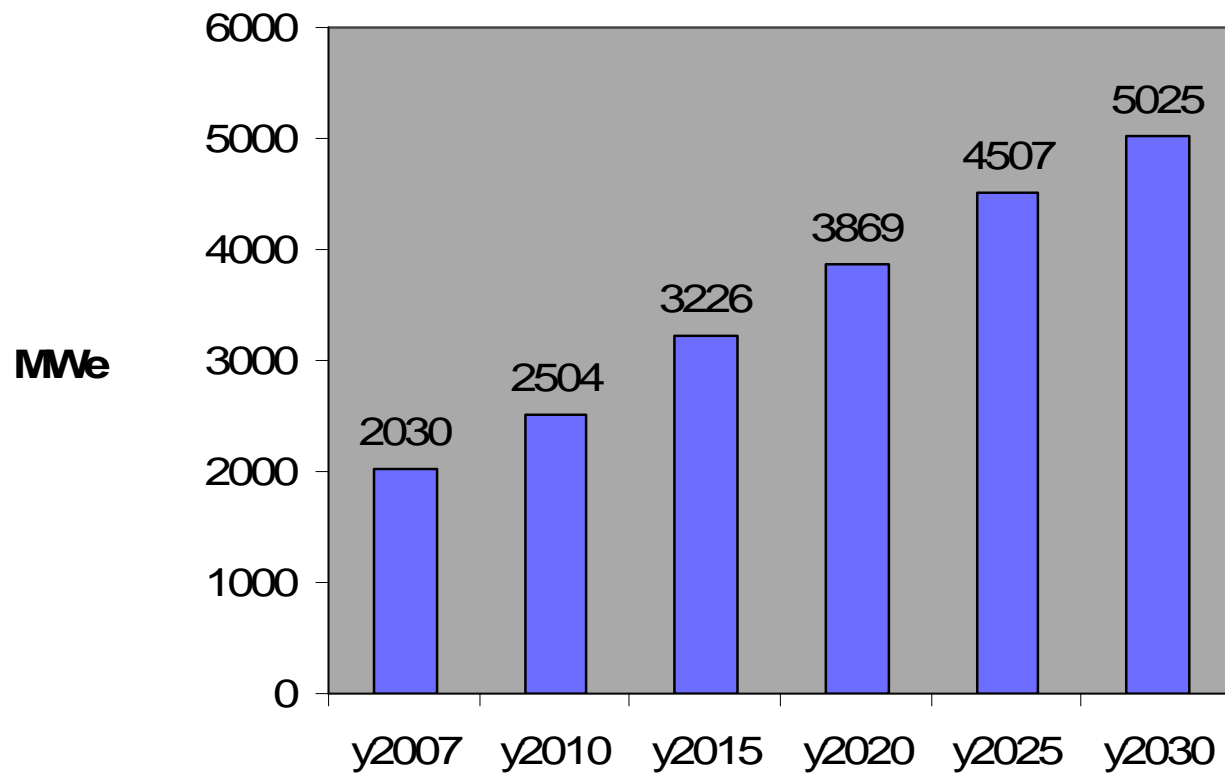
- Jordan energy demand is projected to grow due to:
 - population growth
 - economic growth
 - industrialization
 - water pumping and desalination
- Main assumptions:
 - Pop ~7.5 million in 2020; 9.2 M by 2030
 - GDP (%/yr)

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



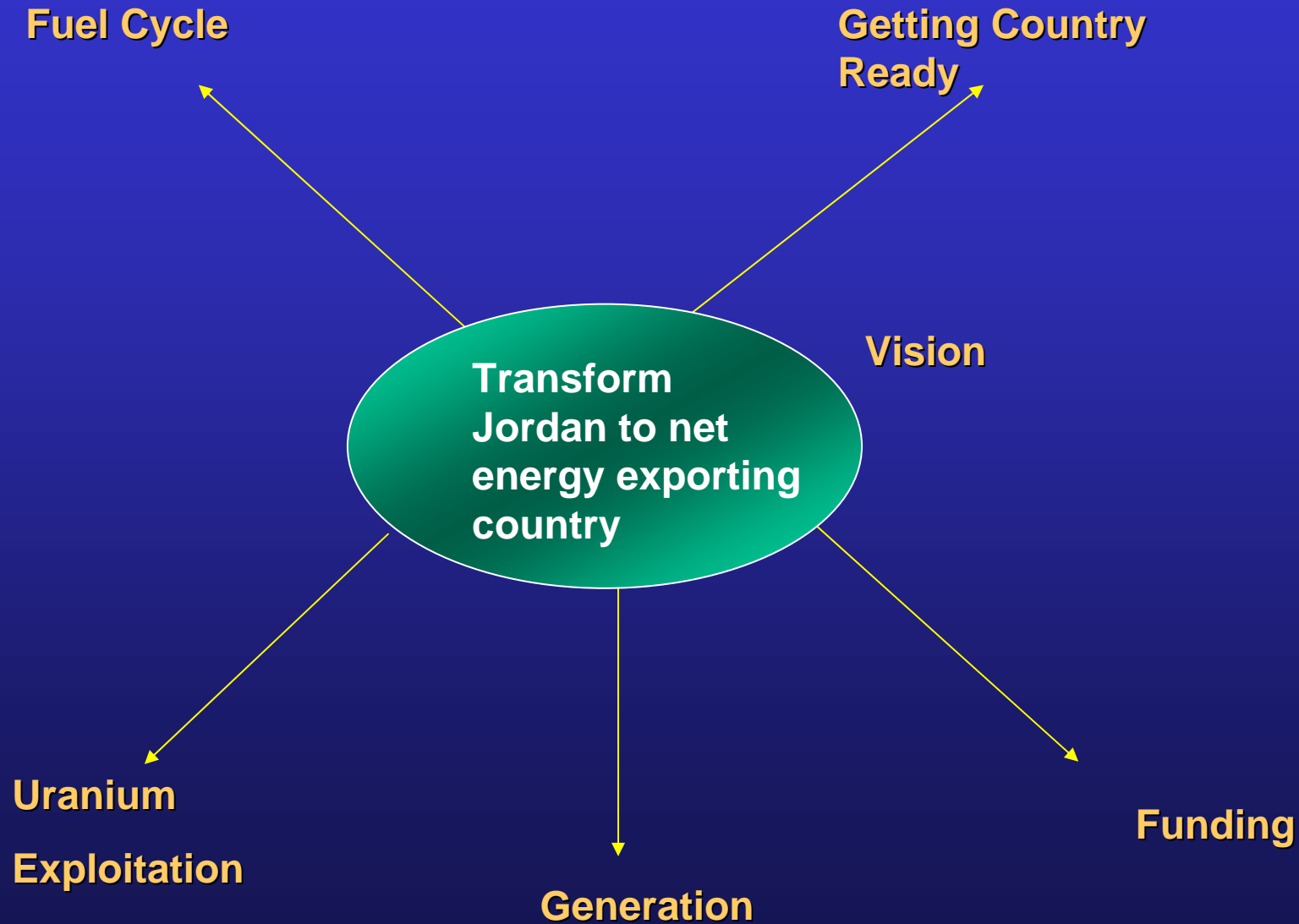
Vision

- 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

Vision & Five Measures



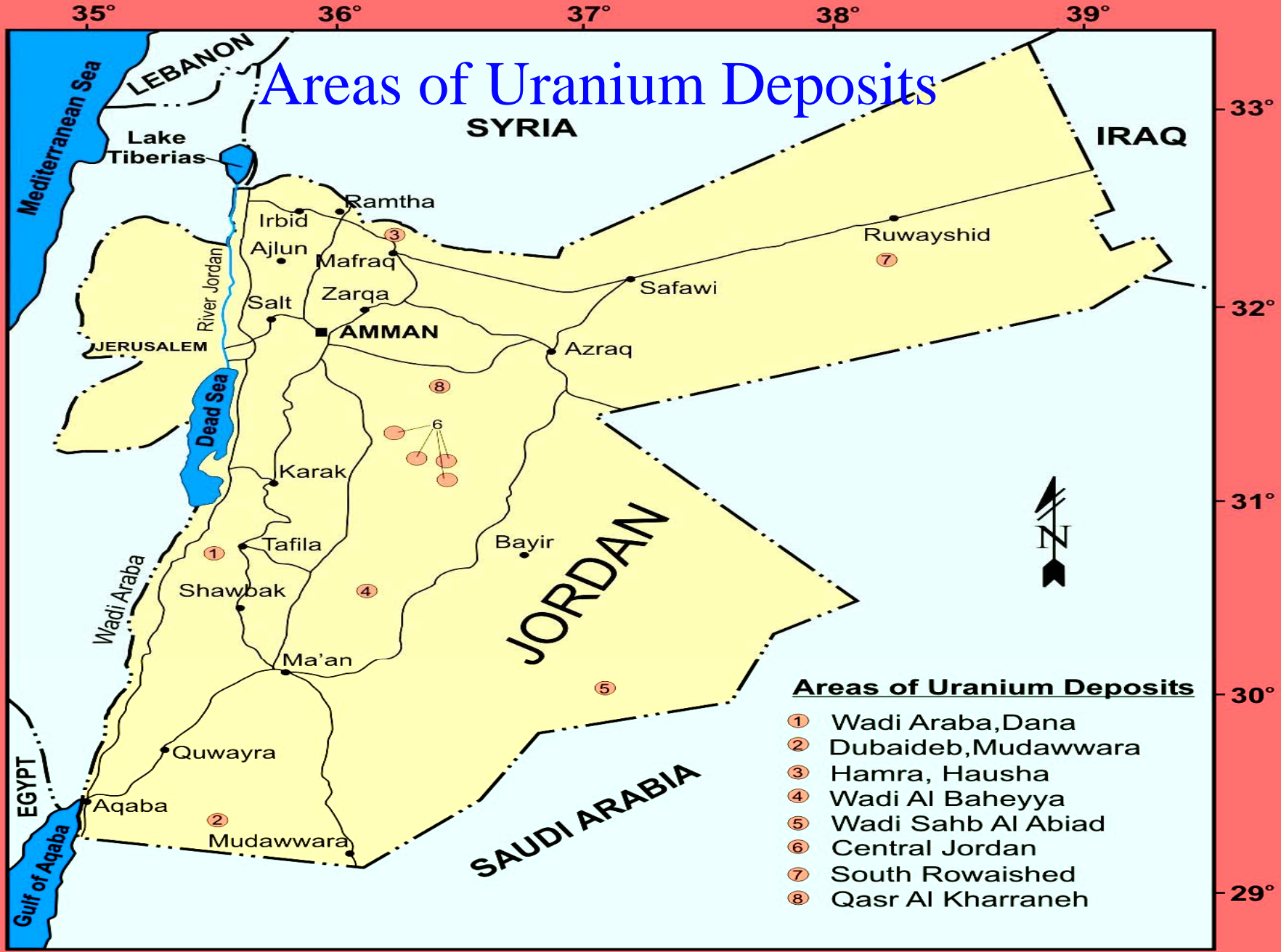
Five Measures

1. Generation. Policy : privatized but with Gov. equity IPP 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: 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



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)

Regulatory Reform

- 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