Prospects of nuclear energy in terms of their uranium fuel supply

Nikolaus ARNOLD, Wolfgang KROMP
Institute of Security- and Risk Sciences,
University of Natural Resources and Life Sciences, Vienna

Werner ZITTEL
Ludwig-Bölkow-Systemtechnik GmbH

World Resources Forum 2011, Sep 19-21, 2011
Background

- Re-organisation of energy supply and the efforts to reduce greenhouse gas emissions → nuclear energy propagated

- Uranium as fuel
  - No significant progress alternative fuel cycles and reactors (Gen. 4)
  - Fuel base for current nuclear reactor fleet
    - availability is basis for expansion capability and reach
  - Annual demand ~ 70000 t natural Uranium equivalent

- Fulfilment of demand
  - Stocks (incl. nuclear weapons)
  - Mining
  - Reprocessing (RepU, MOX)

Comparison of Production and Demand; Data: IAEA
Background / Scope of work

- **Rise in uranium prices in 2007**
  - Inflexible market
  - Development of new deposits requires long lead times → financial risk for potential investors

- **The aim of the work carried out**
  - Identify structures and main actors of the uranium market.
  - Analysis of historical developments.
  - Introduction of scenarios to forecast the uranium market.
  - Comparison of supply scenarios and nuclear growth scenarios

Source: Euratom Supply Agency
Methodology (1)

- **Data basis**
  - Annual company reports, official sources
  - Amounts & classifications of resources, ore quality, capacity of the production, historical data, planned developments and expansions

- **Detailed assessments of approximately 70 production facilities**

- **Adding up the individual production is a regional or global picture of the production**

*Northern Kharasan 1*
Capacity: 1000 t p.a.
IR (recoverable): 31000 t U
Expansion planned: 3000 t p.a.
Methodology (2)

- **Bellshaped curve (Hubbert)**
  - Describes exponential growth in a limited (resources) space
  - Used for potential approximation
    - when no detailed data or
    - (currently) no mining takes place

- Can not completely coincide with the true course of production of a uranium mine
  - Limitations of the market and the infrastructure
  - faster reaching the production capacity
Resources - Definitions

- Conventional Resources
  - Identified Resources
    - Reasonably Assured Resources (RAR)
    - Inferred Resources
  - Undiscovered Resources

- Unconventional Resources
  - Seawater, Phosphates
Global Distribution - RAR

- About 4.4 million tU <260 $ / kg identified worldwide
- 60% in 4 Countries
- more than 90% in 11 Countries
- 20% in a single deposit (Olympic Dam)
Global Distribution – Identified Resources

<table>
<thead>
<tr>
<th>Country</th>
<th>&lt;40$/kgU</th>
<th>&lt;260$/kgU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0</td>
<td>1679000</td>
</tr>
<tr>
<td>Brazil</td>
<td>139900</td>
<td>278700</td>
</tr>
<tr>
<td>China</td>
<td>67400</td>
<td>171400</td>
</tr>
<tr>
<td>Canada</td>
<td>366800</td>
<td>544600</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>44400</td>
<td>832100</td>
</tr>
<tr>
<td>Jordan</td>
<td></td>
<td>111800</td>
</tr>
<tr>
<td>Namibia</td>
<td></td>
<td>284200</td>
</tr>
<tr>
<td>Niger</td>
<td>17000</td>
<td>275500</td>
</tr>
<tr>
<td>Russia</td>
<td></td>
<td>566300</td>
</tr>
<tr>
<td>South Africa</td>
<td>155300</td>
<td>295600</td>
</tr>
<tr>
<td>Ukraine</td>
<td>5700</td>
<td>223600</td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td>472400</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td></td>
<td>114600</td>
</tr>
<tr>
<td>World Total</td>
<td>796500</td>
<td>6306300</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>456500</td>
</tr>
</tbody>
</table>

- 6.3 million tU <260 $ / kg
- 65% in 5 Countries
- almost 90% in 11 Countries
- 19% Olympic Dam
Key Countries

- Major countries based on uranium production and resources
  - Australia, Namibia, Niger, Canada, Kazakhstan, Russia
- Australia
  - Olympic Dam – limit for production
- Kazakhstan
  - Growth vs. reach
- Other countries with potential influence on the uranium market
  - U.S., China, South Africa, Brazil, Ukraine, Uzbekistan

Figures: Historical uranium production
Production scenario Kazakhstan
Supply scenarios

Scenarios of global uranium availability based on RAR.
Supply scenarios
Grades and lead times

- Global distribution by grades
  - Few highly concentrated – much of lower concentration
  - Historically operated in a "better" mining deposits

- Mining lead times
  - The most easily accessible deposits have been taken already in operation until 1975.
  - Stricter environmental regulations
  - Low uranium prices have delayed the launch of new mines.
  - Previous selection of deposits via economic criteria → increasingly unfavorable projects must be developed
Conclusions

• Production scenarios
  – RAR
    • With the currently known RAR - no growth in the reactor park can be supported!
    • Peak production is expected around 2020.
  – Identified resources
    • Can support growth, but do not cover more than one requirement of 100,000 tU in 2050
    • Peak in production around 2030

• Future uranium market influenced by
  – Australia, Canada, Kazakhstan, Niger and Namibia partially by Russia and the United States.

• Balance in production and demand seems possible
  – temporarily reduced demand for secondary ressources
  – rapid growth of production in Kazakhstan
    • Rapid expansion may lead to an equally rapid decline
Conclusions

• Resources do not match the available supply quantity

• Lead times up to 30 years
  – global supply security needs forward-looking planning
  – Planning time of companies only short-term
  – Production in Kazakhstan signalize, that enough uranium is available and therefore slow down additional exploration

• Other frame conditions
  – Technical (eg Cigar Lake)
  – Political & Social
  – other bottlenecks (eg ISL-acid)
TODO

Thank you!

• Contact:
  Nikolaus Arnold
  Institut für Sicherheits- und Risikowissenschaften
  Borkowskigasse 4
  1180 Wien
  nikolaus.arnold@boku.ac.at