WNA Worldwide Overview on Front-End Nuclear Fuel Cycle’s Growth (Supply and Demand)

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World Nuclear Association - WNA

The trade association of the global nuclear industry with a worldwide membership

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- WNN: http://www.world-nuclear-news.org

Our membership makes us unique, global and truly representative

- Over 180 industry enterprises from over 30 countries
- Over 90% of world uranium production and nuclear power generation
PART I

OVERVIEW OF FRONT-END NUCLEAR FUEL CYCLE’S: GROWTH
World Uranium and Nuclear Power

Countries with major uranium deposits
Nuclear power stations in operation

[World map showing uranium deposits and nuclear power stations]

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The Nuclear Fuel Cycle

Mining  Conversion  Enrichment

Uranium  Plutonium  Fuel fabrication

Reprocessing

Nuclear Power Plant

Front-end  Reactors & Services  Back-end
Demand for nuclear fuel depends on two factors:

- **Number and size of reactors** in operation
- **How they are run** - load/capacity factors, enrichment level, burn-up and tails assay

Reactor operators buy separately uranium and conversion, enrichment and fuel fabrication services.
Considers 3 scenarios approach to nuclear power demand (2007-2030):

- Reference case
- Upper case
- Lower case

Generic assumptions underlie each scenario on:

- nuclear economics
- public acceptance
- impact of climate change debate and electricity market structure
Nuclear power capacity to 2030, GWe net
2007 Market Report

![Graph showing nuclear power capacity to 2030, with three scenarios: Lower, Reference, and Upper. The graph indicates a steady increase in capacity from 2007 to 2029, with the Upper Scenario showing the highest capacity growth.](image-url)
Nuclear power capacity to 2030, GWe net
2009 Market Report draft
URANIUM MINING: GROWTH
Distribution of Uranium resources

![Map showing distribution of Uranium resources around the world.](image)

- Canada: 443,800
- United States: 342,000
- Brazil: 278,700
- Niger: 225,500
- Namibia: 282,400
- South Africa: 340,600
- Ukraine: 89,900
- Kazakhstan: 816,100
- Mongolia: 62,000
- China: 39,300
- Russian Federation: 172,400

Legend:
- Red: Reasonably assured resources
- Blue: Inferred resources
- 89,900 Total resources (tonnes of uranium)
## Low cost (<$80/kg) uranium reserves, thousand tonnes U

<table>
<thead>
<tr>
<th>Country</th>
<th>Reserves (tU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>714</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>344</td>
</tr>
<tr>
<td>Canada</td>
<td>329</td>
</tr>
<tr>
<td>South Africa</td>
<td>206</td>
</tr>
<tr>
<td>Russia</td>
<td>172</td>
</tr>
<tr>
<td>Brazil</td>
<td>157</td>
</tr>
<tr>
<td>Namibia</td>
<td>145</td>
</tr>
<tr>
<td>Ukraine</td>
<td>127</td>
</tr>
<tr>
<td>USA</td>
<td>99</td>
</tr>
<tr>
<td>Others</td>
<td>155</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2438 tU</strong></td>
</tr>
</tbody>
</table>

*Source: Red Book*
# World Uranium production 2008, tU

<table>
<thead>
<tr>
<th>Country</th>
<th>tU</th>
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</thead>
<tbody>
<tr>
<td>Canada</td>
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<td>Australia</td>
<td>8430</td>
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<td>Namibia</td>
<td>4366</td>
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<tr>
<td>Russia</td>
<td>3521</td>
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<tr>
<td>Niger</td>
<td>3032</td>
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<td>Uzbekistan</td>
<td>2338</td>
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<tr>
<td>USA</td>
<td>1430</td>
</tr>
<tr>
<td>Others</td>
<td>3292</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43930 tU</strong></td>
</tr>
</tbody>
</table>
U requirements to 2030, tU
2007 Market Report

[Graph showing U requirements from 2003 to 2030, with three scenarios: Lower, Reference, and Upper. The graph indicates a steady increase in requirements over time.]
Uranium requirements to 2030, tU - 2009 Market Report draft
Implied need for primary uranium production - requirements less secondary supplies
1. U market has sound supply up to 2015-20 but meeting demand becomes likely more challenging thereafter

2. Primary U supply (mining) needs to rise sharply to meet rising market demand
   - Canada and Australia will expand, key increases from Kazakhstan, new producing countries in Africa

3. In-situ leach (ISL) will represent a greater share but conventional mining is to remain dominant

4. Secondary supplies will remain important:
   - Ex-military material, commercial inventories, MOX-RepU
URANIUM CONVERSION:
GROWTH
Conversion - Basics

Enrichment for light water reactors (PWR) requires conversion to UF$_6$ - [Serves 90% of all nuclear reactors]

CANDU reactors require direct conversion to UO$_2$

5 major UF$_6$ conversion suppliers - Cameco, Springfields, Comurhex, ConverDyn and Rosatom

UO$_2$ conversion by Cameco and domestic suppliers in Argentina, China, India and Romania
UF₆ conversion requirements to 2030, tU
## Uranium Conversion Outlook

1. **UF₆** conversion will expand to cope with rising demand
   - Replacement of present plant in France, and expansion of facilities elsewhere

2. Small-scale UO₂ conversion facilities may continue in a few countries but Cameco will remain dominant

3. World **UF₆** conversion demand will rise steadily in line with overall U requirements
URANIUM ENRICHMENT: GROWTH
Enrichment - Basics

U-235 is enriched from 0.71% (natural) to 3-5% (typical): [Such fuel is needed for 90% of power reactors]

2 main technologies - older gaseous diffusion and more recent centrifuges

Investment in laser enrichment so far remains unrewarded by commercial application

Note: Effort to enrich measured in Separative Work Units (SWUs)
Enrichment - Supply

4 large suppliers of primary enrichment services
- USEC (USA), Areva (France), Urenco (Western Europe) and Rosatom (Russia)

USEC and Areva use gas diffusion, Urenco and Rosatom use centrifuges

JNFL (Japan) and CNNC (China) also primary suppliers

Heavy current investment in new centrifuge plants by USEC, Areva and Urenco in USA and by Areva in France
Enrichment requirements to 2030
Uranium Enrichment Outlook

1. The key change is the gradual replacement of older gas diffusion plants (France, USA) by gas centrifuge plants.

2. Elsewhere, Western Europe and Russia will likely expand their centrifuge capacity.

3. Investors in the SILEX laser technology will try to commercialise it within the next 5 years.
Overall Outlook on NFC Front-End Growth

U Mining
Sound growth until 2015-2020. Becomes challenging thereafter

U Conversion
Sound growth with rising demand

U Enrichment
Sound growth with rising demand. Technology change

Thank you for your attention
Questions?
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