URANIUM FROM COAL ASH: RESOURCE ASSESSMENT AND OUTLOOK ON PRODUCTION CAPACITIES

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IAEA URAM, Vienna | 23-27 June 2014
CONTEXTUAL BACKGROUND

Issues and challenges
Milling process flow
Key parameters

RESOURCE ASSESSMENT

From coal resources
From coal-ash piles

OUTLOOK ON RESERVES AND PRODUCTION

Technical constraints
Coal ash compared with other U productions
Potential reserves
Limits to production capacities
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COAL ASH: URANIUM
RESOURCE ASSESSMENTS AND PRODUCTION CAPACITIES
Strategic challenges

- Long-term supply
  - Small production when demand was high (Cold War)
  - Significant supply source in case of new tensions on global supply?

- China
  - **Coal**: world 1st producer (~50% of world production)
  - **Uranium**: increasing imports and demand
    - 2010: needs of 3900 tU vs. 1350tU in domestic production
    - 2030: Demand 12300 to 16200 tU!
  - Typical mine lead time ~ 10 years

**Impacts on environmental and health hazards?**
UDEPO Uranium Database (IAEA): well documented!

- Identified “lignite-coal” uranium deposits
- ~400 ktU (>400ppm)
- Lignite-coal category: only the most promising deposits

UDEPO provides a good tool to follow rising projects in which uranium could be produced from coal either as a primary product or a co-product

Prospective approach (long-term): also needs to assess the whole resource (even uranium as a potential by-product and potentially lower grades)

- UDEPO: not all the reported quantities are in the coal itself. Springbok Flats: uranium lies in sandstone layers, in-between coal layers.
- We focused on uranium production from coal ash, that is when uranium resources are precisely in the coal itself and considered as a by-product.

We based our research on coal databases (USGS, Enerdata).
MILLING PROCESS FLOW

- Milling the ashes rather than feed coal
- Recovering sulphur dioxide from flue gases
- Heap leaching of coal-ash piles

(NRCgov)

2 companies:
Sparton Resources
Wildhorse Energy

(Wildhorse Energy)
Coal quantity

U ppm

U3O8 quantity

Milling recovery rate

75%

New grade U ppm

U : concentration factor

x5

25% of leaching needs

Combustion:
time, temperature, additives

Flue gases: loss of fly ash / U

SOx production

+ acid recovery

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KEY PARAMETERS IN GLOBAL SUPPLY

- Reserves & annual production of coal
  - U grades

- Coal consumption in energy sector
  - Annual coal-ash production
  - Part of coal-ash available for milling

- Production capex & opex
  - Compared with other uranium productions
  - Cut-off grade

- Milling plant costs

- Coke

- % re-used

- Acid consumption

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## URANIUM QUANTITIES IN COAL RESOURCES

<table>
<thead>
<tr>
<th>Primary product</th>
<th>Coal</th>
<th>Lignite</th>
<th>Coal + lignite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Proved reserves</td>
<td>Additional resources</td>
<td>Proved reserves</td>
</tr>
<tr>
<td>Quantities (Gt)</td>
<td>690-750</td>
<td>610-17120</td>
<td>150-280</td>
</tr>
<tr>
<td>Mean grade in U</td>
<td>3.4 ppm</td>
<td>12.0 ppm</td>
<td>4.7 ppm</td>
</tr>
<tr>
<td>Uranium quantities (MtU)</td>
<td>2.4-2.6</td>
<td>2.1-58.2</td>
<td>1.8-3.4</td>
</tr>
</tbody>
</table>

### References
- Coal quantities: Enerdata 2012, German Federal Institute for Geosciences 2011
- U grades: USGS World Coal Quality Inventory, Yang 2007
148 Gt of coal burnt since the 70’s:

- 21 Gt of coal-ash stored in piles
- 190 to 500 ktU

Hypothesis:

Re-use rate of ashes equals US one (1970-2010)
Coal mean grade from 2 to 5 ppm
Concentration factor equals 5
Coal consumption history of energy sector (Enerdata)

Uncertainties

- Mean grade (improved by re-use of some ashes?) and grade distribution (got worse after dilution?)
- Risk of dilution: coal homogenization at the powerplant when it is not mine-mouth
- Concentration factor, badly known
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</tr>
<tr>
<td>Technically accessible resources (75%)</td>
<td>1.8-2.0 MtU</td>
<td>-</td>
</tr>
</tbody>
</table>
ECONOMIC COMPARISON WITH OTHER SOURCES

- Leaching reagent consumption: the BIG part of opex
  - > ISL and typical “heap leaching” projects
  - Significant potential savings from SOx recovery at the powerplant (up to 25%). Essential but they vary a lot depending on coal quality

![Graph showing acid consumption vs. uranium grade]
## POTENTIAL RESERVES

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<td>Mean grade in U</td>
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<td>2.31 ppm</td>
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<td>Uranium quantities (MtU)</td>
<td>2.4-2.6</td>
<td>1.8-3.4</td>
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<tr>
<td></td>
<td>2.1-58.2</td>
<td>2.0-49.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.26-0.97</td>
</tr>
<tr>
<td>Technically accessible resources (75%)</td>
<td>1.8-2.0</td>
<td>1.4-2.5</td>
</tr>
<tr>
<td></td>
<td>MtU</td>
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</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>200-700 ktU</td>
<td></td>
</tr>
<tr>
<td>Percentage &gt; 40 ppm</td>
<td>Extrapolating</td>
<td>USGS World Coal</td>
</tr>
<tr>
<td></td>
<td>1%</td>
<td>7%</td>
</tr>
<tr>
<td>Potential reserves</td>
<td>15-20 ktU</td>
<td>95-180 ktU</td>
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### LIMITS TO PRODUCTION CAPACITIES

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<tr>
<td><strong>Available part of coal-ash</strong></td>
<td>Assumed 33%</td>
<td>Assumed 60%</td>
</tr>
<tr>
<td><strong>Max theoretical production capacity</strong></td>
<td>4.3 ktU/y</td>
<td>4.7 ktU/y</td>
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Leaching recovery rate: 75%
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<tr>
<td><strong>Available part of coal-ash</strong></td>
<td>100% of high-grade coal-ash is made available for U production</td>
<td></td>
</tr>
<tr>
<td><strong>Percentage &gt; 40 ppm</strong></td>
<td>1%</td>
<td>7%</td>
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<tr>
<td><strong>« Realistic » production potential</strong></td>
<td>150 tU/y</td>
<td>550 tU/y</td>
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- 2012 mining production: 58 ktU (WNA)
CONCLUSION

- Uranium production from coal-ash is **technically feasible**
  - In some situations, it could reach commercial development
  - In such case, fast lead time will be a plus

- **Technically accessible resources** are significant (1.1 to 4.5 MtU)
  - Yet most of those are low grade

- Potential reserves don’t exceed 200 ktU (cut-off grade = 200 ppm)

- By-product uranium production => constrained production capacities
  - **Realistic production potential < 700 tU/year**
  - ~ 1% of current needs

Coal ash will not be a significant source of uranium for the 21st century

- Even if production constrains are released (increase in coal consumption)
Thank you for your attention!

Questions?