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

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IAEA URAM, Vienna | 23-27 June 2014

COAL ASH: URANIUM RESOURCES AND PRODUCTION CAPACITIES

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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MAIN ISSUES AND CHALLENGES

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 ?

KNOWN URANIUM+COAL DEPOSITS

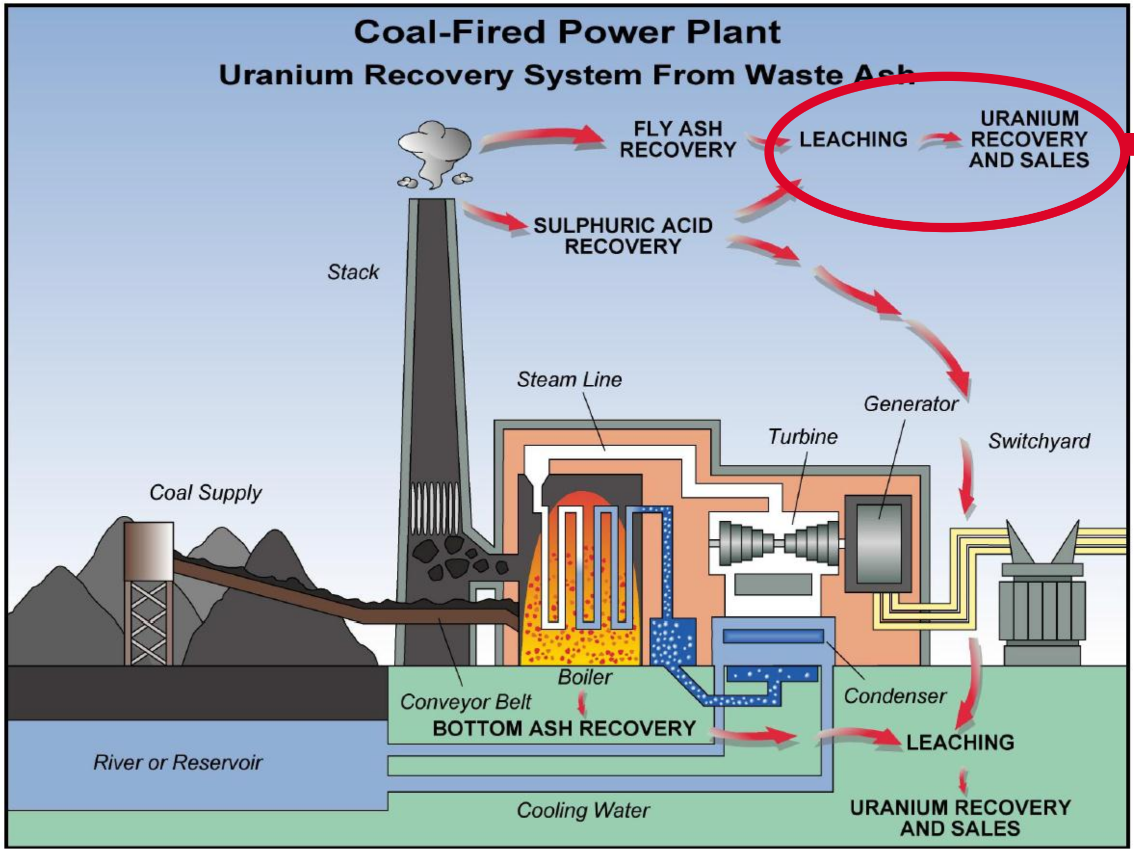
- **UDEPO Uranium Database** (IAEA): well documented!
  - Identified **“lignite-coal”** uranium deposits
  - **~400 ktU (>400ppm)**
  - Lignite-coal category: only **the most promising deposits**

➡ 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

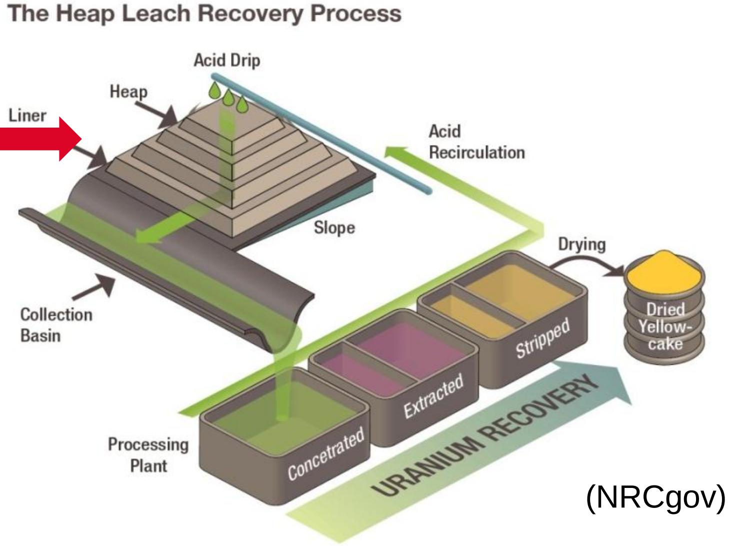
- Prospective approach (long-term): also needs to assess the whole resource (even **uranium as a potential by-product** and potentially lower grades)
  - UDEPO: not all the reported quantities are in the coal itself. Springbok Flats: uranium lies in sandstone layers, in-between coal layers.
  - We focused 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 the ashes rather than feed coal
- Recovering sulphur dioxyde from flue gases
- Heap leaching of coal-ash piles



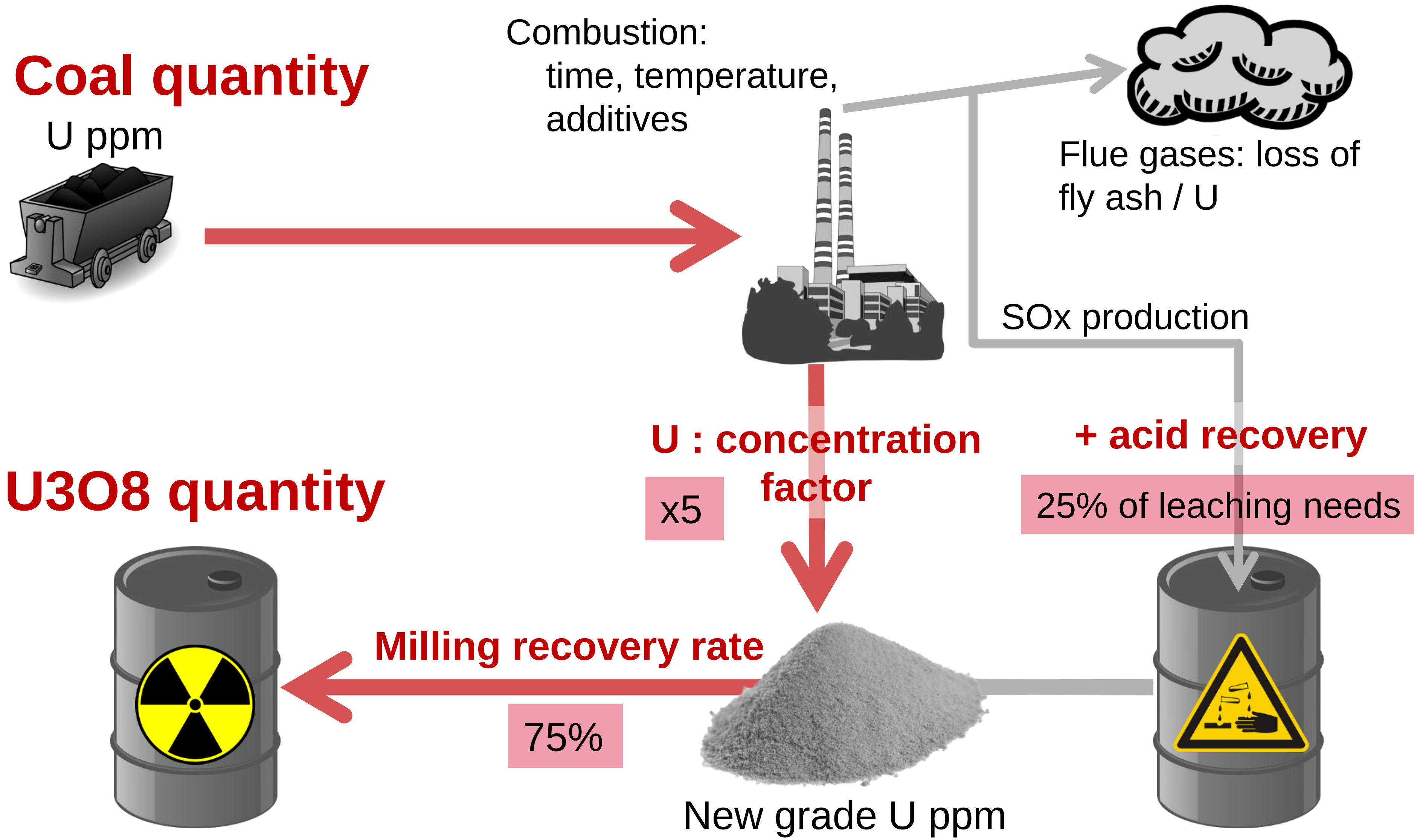
(Wildhorse Energy)



(NRCgov)

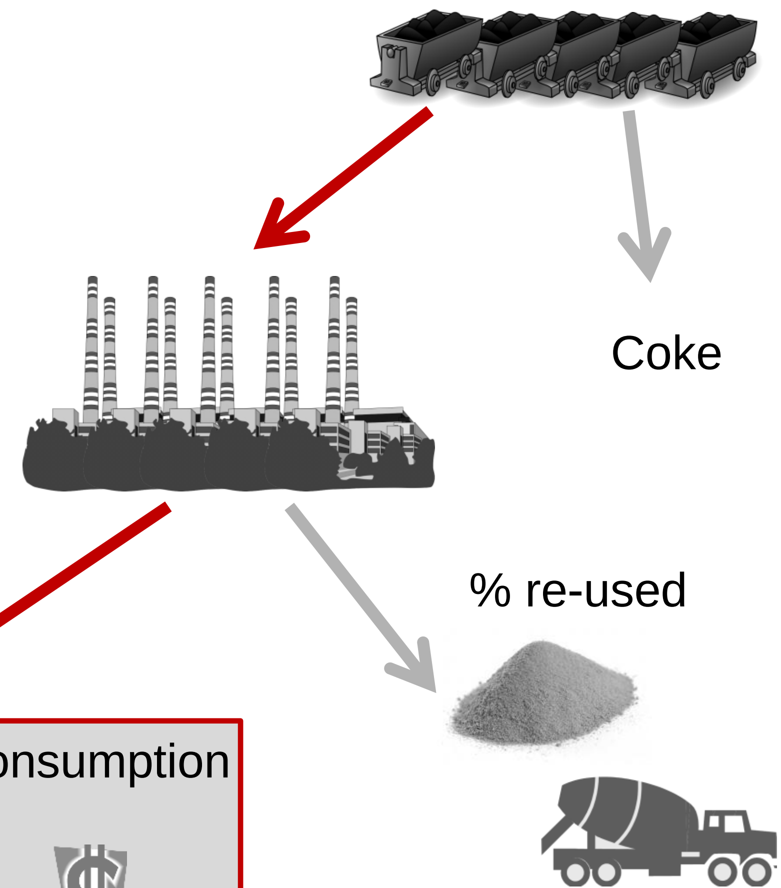
2 companies:
Sparton Resources
Wildhorse Energy

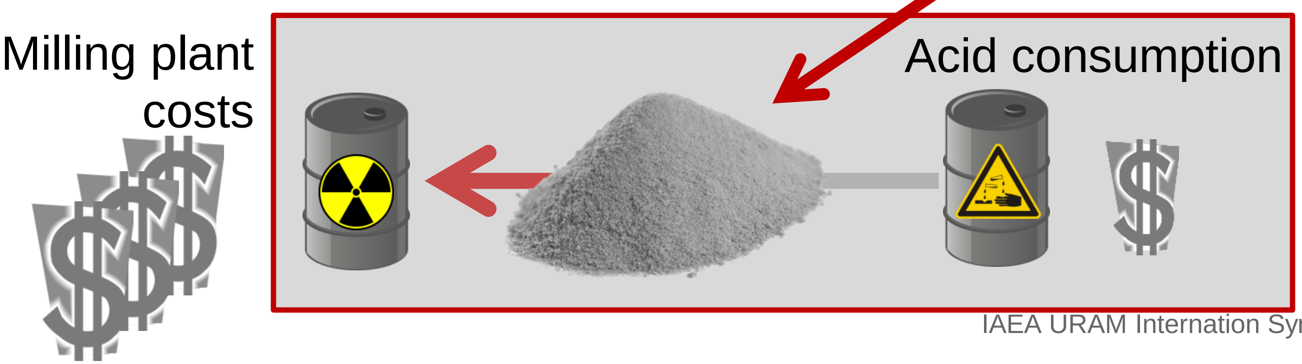
KEY PARAMETERS IN PROCESS FLOW



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





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URANIUM QUANTITIES IN COAL RESOURCES

	World						China
Primary product	Coal		Lignite		Coal + lignite		
Category	Proved reserves	Additional resources	Proved reserves	Additional resources	Proved reserves	Additional resources	Proved reserves
Quantities (Gt)	**690-750**	**610-17120**	**150-280**	**170-4150**	**840-1030**	**780-21270**	**115-418**
Mean grade in U	**3.4 ppm**		**12.0 ppm**		**4.7 ppm**		**2.31 ppm**
Uranium quantities (MtU)	**2.4-2.6**	**2.1-58.2**	**1.8-3.4**	**2.0-49.8**	**4.0-4.9**	**3.6-100.0**	**0.26-0.97**

- References
  - Coal quantities: Enerdata 2012, German Federal Institute for Geosciences 2011
  - U grades: USGS World Coal Quality Inventory, Yang 2007

URANIUM QUANTITIES IN ASH PILES

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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TECHNICAL CONSTRAINTS TO AVAILABILITY

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Primary product	Coal		Lignite		Coal + lignite		
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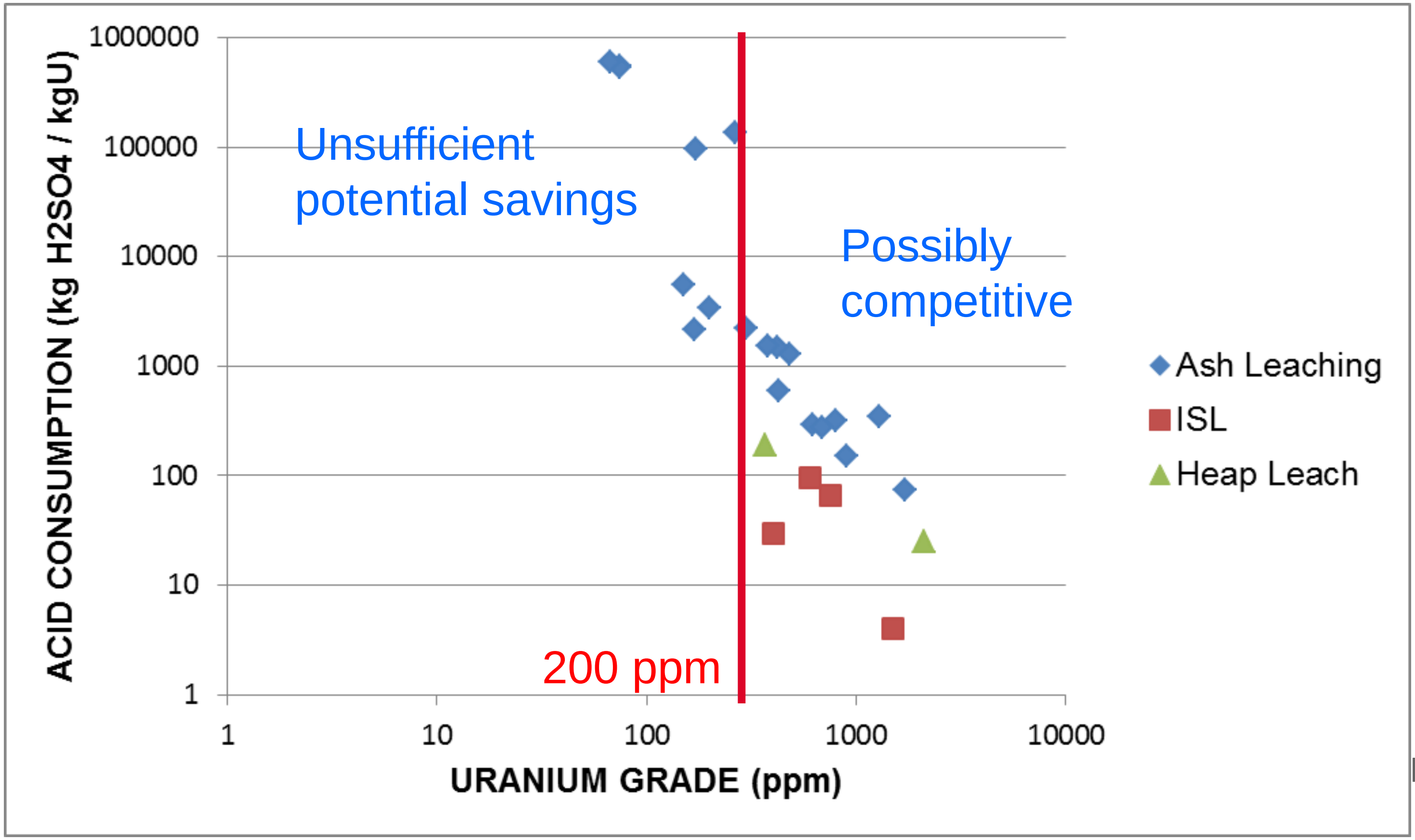
Technically accessible resources (75%)	**1.8-2.0 MtU**	-	**1.4-2.5 MtU**	-	**3.0-3.7 MtU**	-	**200-700 ktU**

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
- Order of magnitude, Sparton China : 44-77 $/kgU (2013: 15 $ / 2007: 53$)



POTENTIAL RESERVES

Area	World						China
Primary product	Coal		Lignite		Coal + lignite		
Category	Proved reserves	Additional resources	Proved reserves	Additional resources	Proved reserves	Additional resources	Proved reserves
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Technically accessible resources (75%)	1.8-2.0 MtU	-	1.4-2.5 MtU	-	3.0-3.7 MtU	-	200-700 ktU
Percentage > 40 ppm	Extrapolating USGS World Coal Quality Inventory **1%**		**7%**		**2%**		
Potential reserves	**15-20 ktU**		**95-180 ktU**		**60-70 ktU**		

LIMITS TO PRODUCTION CAPACITIES

Area	World			China
Primary product	Coal	Lignite	Coal + lignite	
2012 consumption in energy sector	5120 Mt	880 Mt	6000 Mt	2600 Mt
Mean grade in U	3.4 ppm	12.0 ppm	4.7 ppm	2.31 ppm
Available part of coal-ash	**Assumed 33%**	**Assumed 60%**	**33-60%**	**33%**
Max theoretical production capacity	**4.3 ktU/y**	**4.7 ktU/y**	**7-13 ktU/y**	**1.5 ktU/y**

- Leaching recovery rate: 75%

LIMITS TO PRODUCTION CAPACITIES

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Primary product	Coal	Lignite	Coal + lignite	
2012 consumption in energy sector	5120 Mt	880 Mt	6000 Mt	2600 Mt
Mean grade in U	3.4 ppm	12.0 ppm	4.7 ppm	2.31 ppm
Available part of coal-ash	**100% of high-grade coal-ash is made available for U production**			
Percentage > 40 ppm	1%	7%	2%	
« Realistic » production potential	**150 tU/y**	**550 tU/y**	**400 tU/y**	

- 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)

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Thank you for your attention !

Questions ?

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