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The Nuclear Fuel Cycle

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The Nuclear Fuel Cycle

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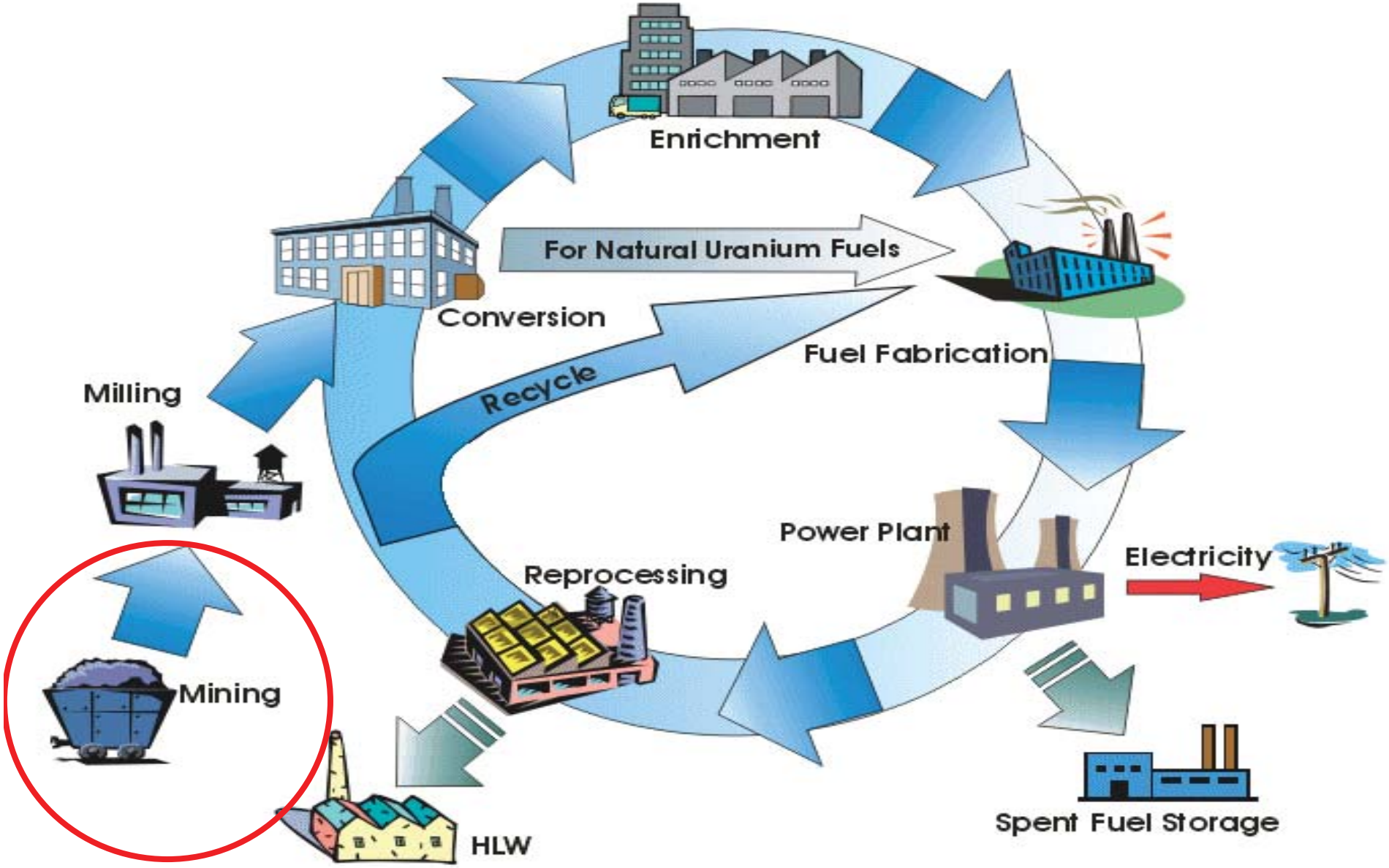
Content of the Presentation

- Uranium Production
- Conversion
- Enrichment
- Reactor Fuel Fabrication
- In-Reactor Fission
  - (change in composition)
- Spent Fuel Management
- Spent Fuel Recycle
- Disposal

Nuclear Fuel Cycle



Exploration

- A complex process to find a uranium deposit
  - a reliable geological model needed
- Three main methods used:
  - Geological methods (remote sensing, geologic mapping, drilling, trenching etc.)
  - Geochemical methods (sampling, analyses, advanced methods-dating, isotope studies)
  - Geophysical methods (radiometric, geomagnetic, geoelectric, gravimetric, seismic etc. methods and borehole logging)

Exploration

- May begin with non-intrusive activity, often called prospecting - walking , looking at outcrops, etc; no serious sampling is usually undertaken at this stage
- Initial work usually includes airborne surveys of areas that look prospective from a basic geological survey
- Ground studies and drilling follow
- Drilling will get closer spaced as targets are located
- Final stage is proving up a deposit during the EIS and project preparation phase

Uranium Exploration

Uranium Exploration

Exploration Drilling

Mining Methods

Uranium is mined in one of three ways:

- Open pit, including surface excavations
- Underground with tunnels, galleries etc.
- In-situ leach mining – ISL [also ISR or solution mining]

In 2008 about 10% of mined uranium production was as a by-product from the mining of other minerals

Nabarlek Uranium Mine, Australia

Mining Methods: Open Pit

Open pit / surface excavations

- ~25% produced this way in 2008
- Relatively large footprint at the surface
- Large stockpiles of waste rock, sub-economic ore and/or overburden
- Potential for waste water, drainage and seepage to cause environmental problems
- May be a possibility for in-pit disposal of tailings

Ranger Uranium Mine, Australia

World #2 producing mine

Mining Methods: Open Pit

Rossing Mine, Namibia, 2008

(World #3 producing mine)

Kayelekera Mine, Malawi

Mining Methods: Underground

Underground mining

- ~40% of 2008 mined uranium production
- Much smaller waste rock production volumes, frequently very little at the surface
- Smaller infrastructure footprint at the surface
- May be possible to dispose of much of the waste underground as backfill in the workings
- Some processing may be possible underground

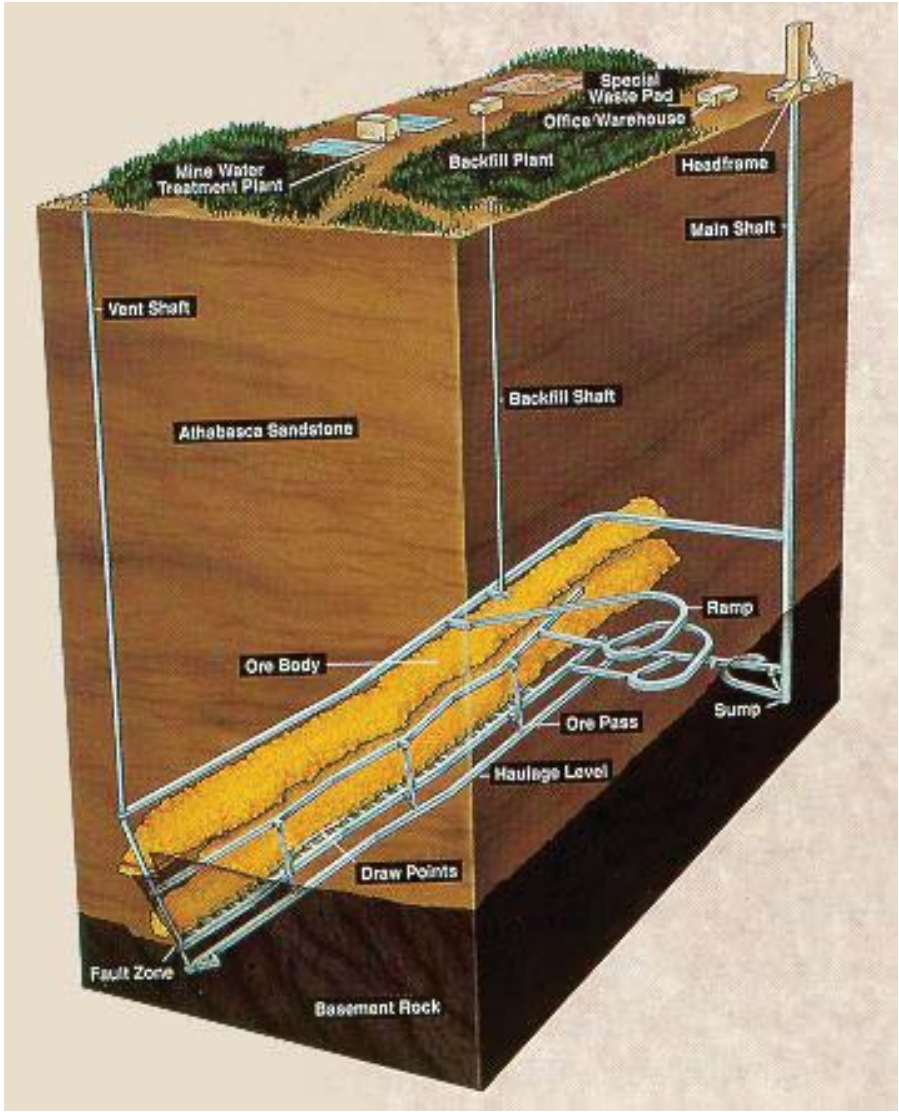
McArthur River uranium mine, Canada

World #1 Producing mine

Mining Methods: Underground

Note:

- the main access shaft
- Ventilation shafts
- Underground network
- Small waste piles at surface

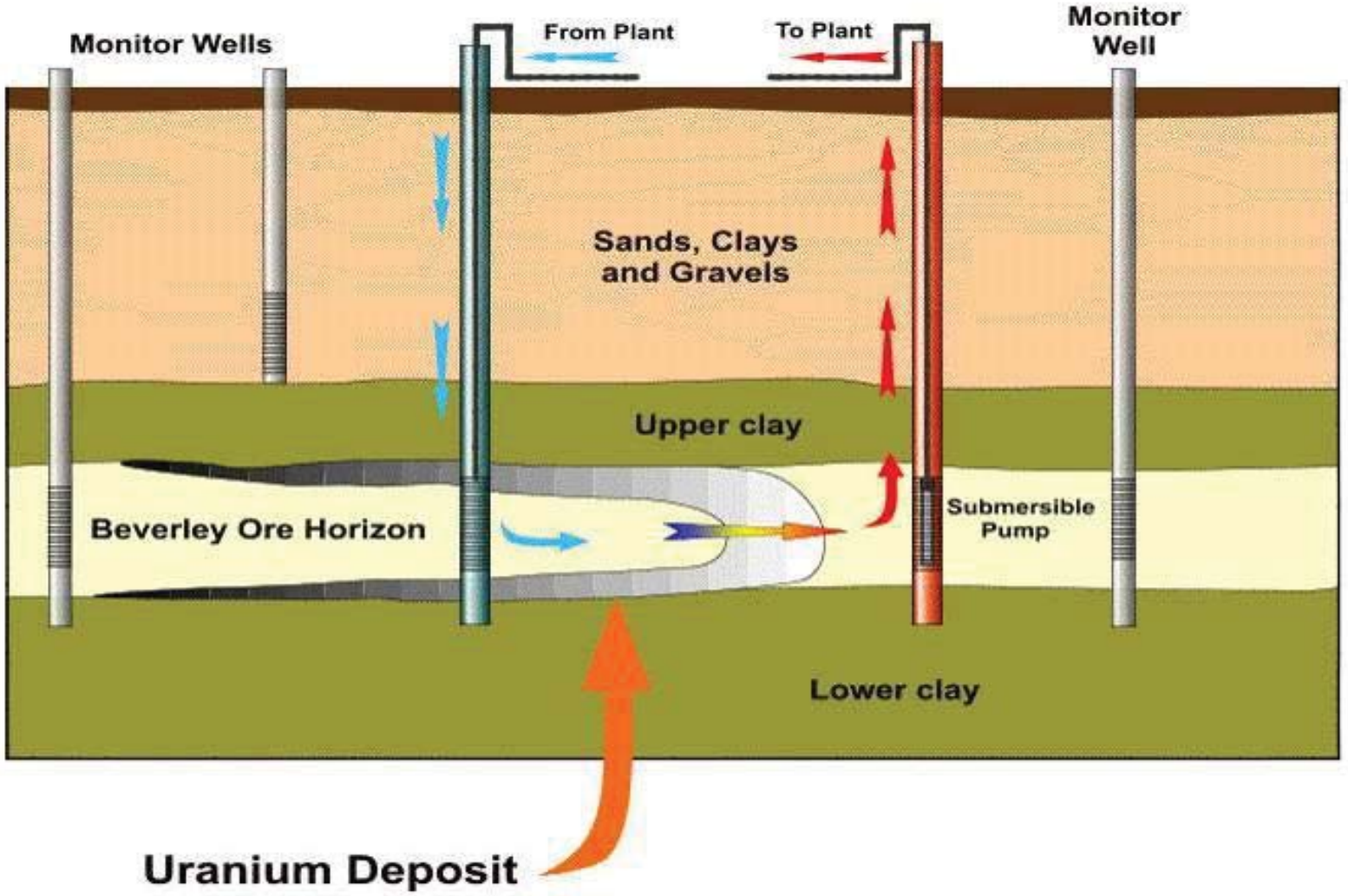


Mining Methods: In-situ Leach (ISL)

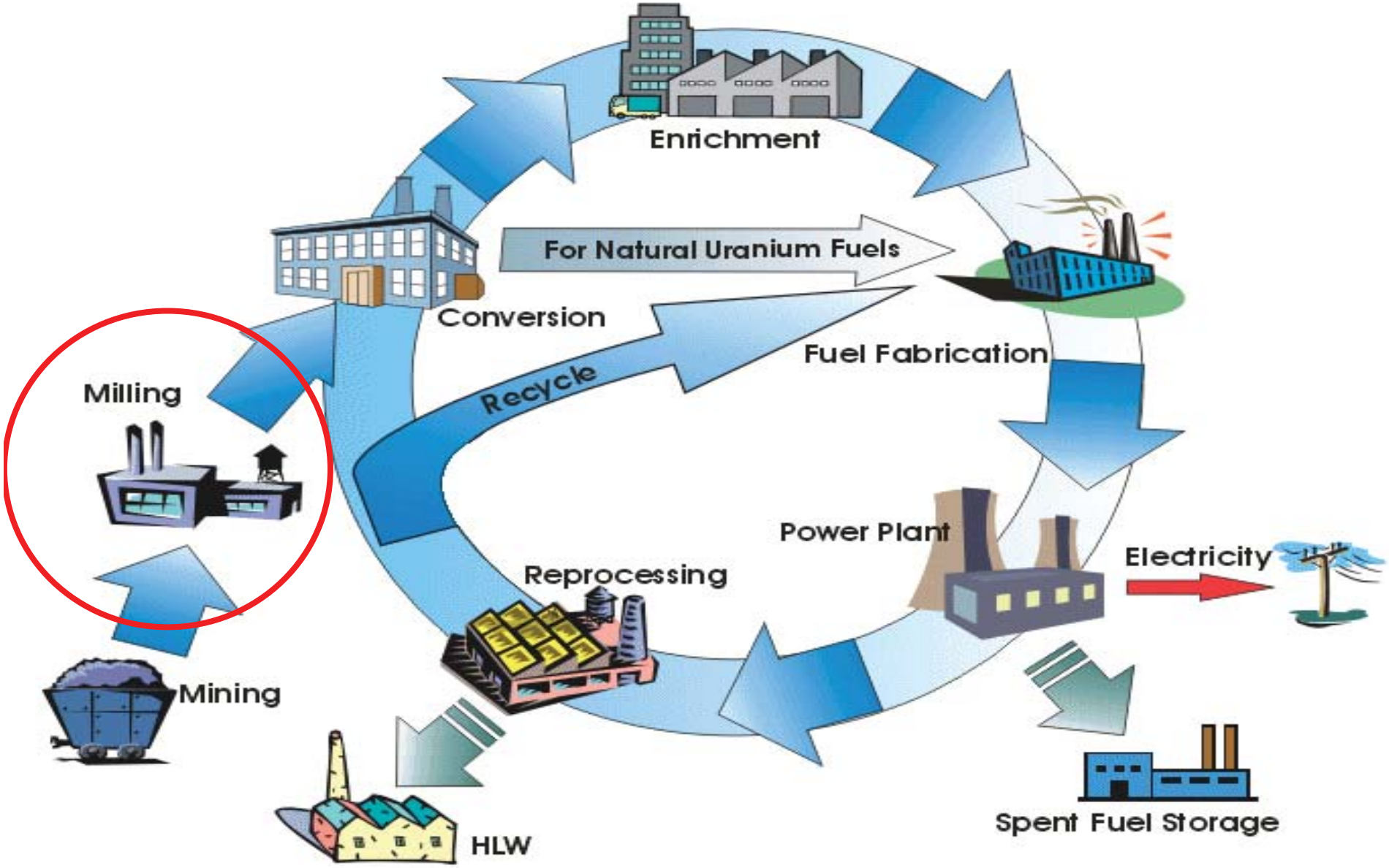
- Sometimes may be called solution mining or ISR (in situ recovery)
- ~28% of world mined uranium was produced this way in 2008
- Can be acid or alkali leach solution
- Very small volume of waste generation
- Limited surface disturbance

Beverley ISL mine, Australia

Uranium Mining Methods: In-situ Leach Mining (ISL)



Nuclear Fuel Cycle



Uranium Recovery Process

- Crushing
- Grinding
- Leaching
- Liquid-solid separation
- Purification and concentration
- Precipitation and drying
- Packing & dispatch

Uranium mill, Ranger mine, Australia

Yellow Cake

- Product is called “yellow cake” but can be any uranium concentrate: UO_4, U_3O_8, ADU, MgDU etc
- These products may be coloured reddish, orange to yellow naturally; or dark green to grey or black when calcined
- Packed in drums & shipped to conversion plant

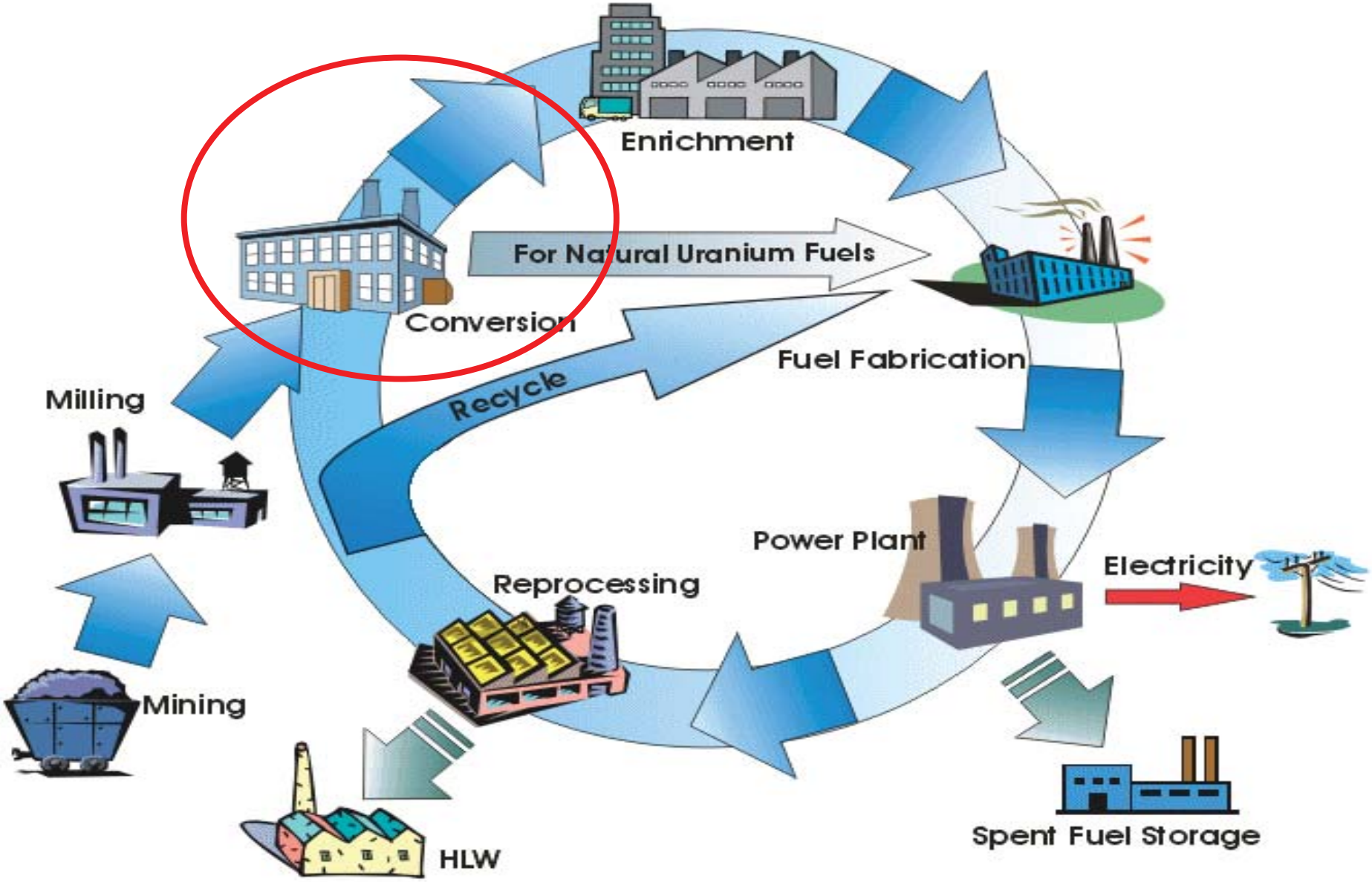
Yellowcake in the packing plant at Beverley.

Heathgate Resources

Calcined U_3O_8

Drums of U_3O_8 being loaded Cameco

Nuclear Fuel Cycle



Conversion

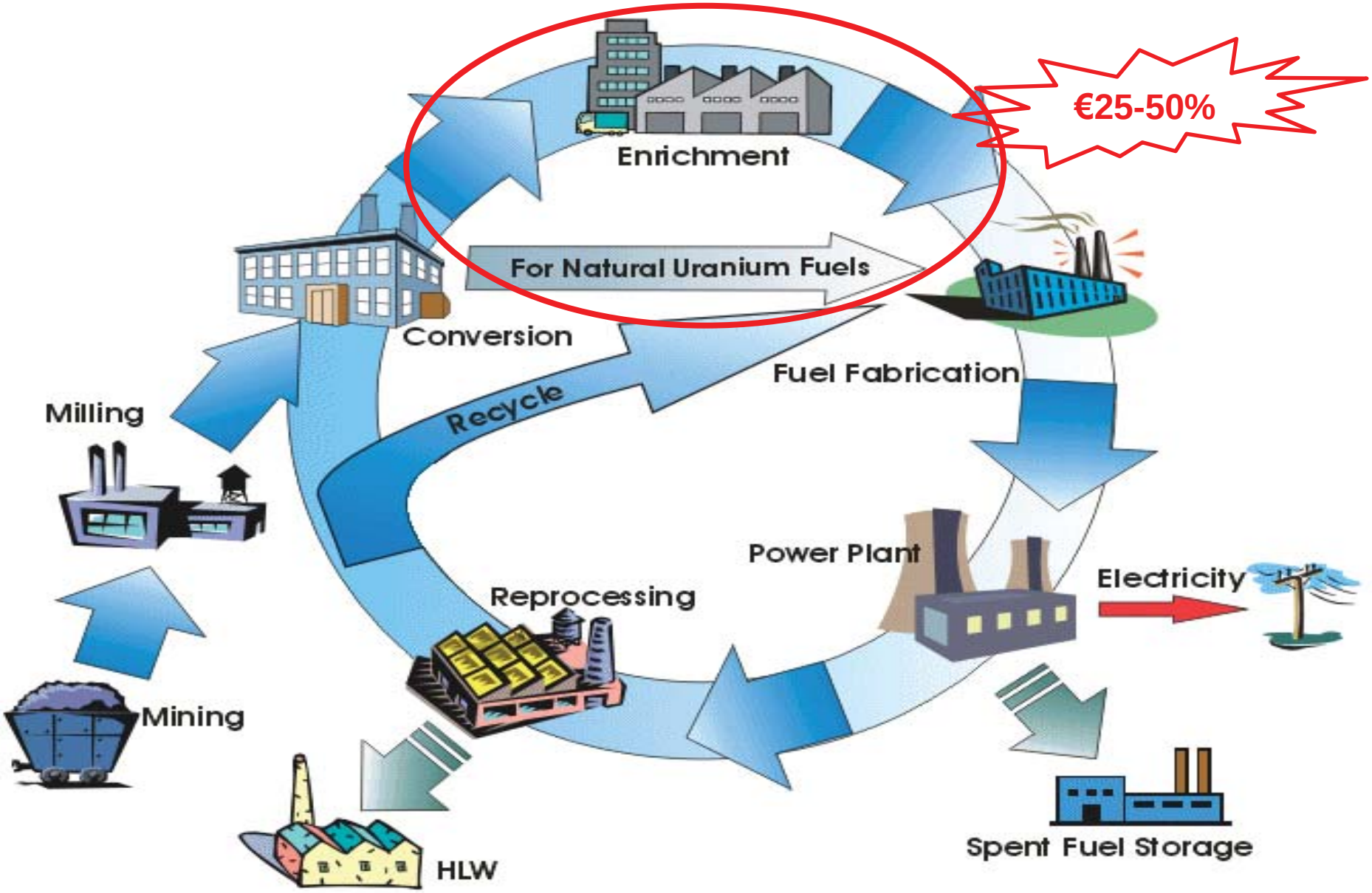
Uranium is processed to convert it from one chemical form to another.
Usually from U_3O_8 to UF_6

Typical of industrial chemical processing

Shown are:

- Yellowcake (U_3O_8)
- Uranyl nitrate solution
- Solid ammonium diuranate
- Uranium dioxide

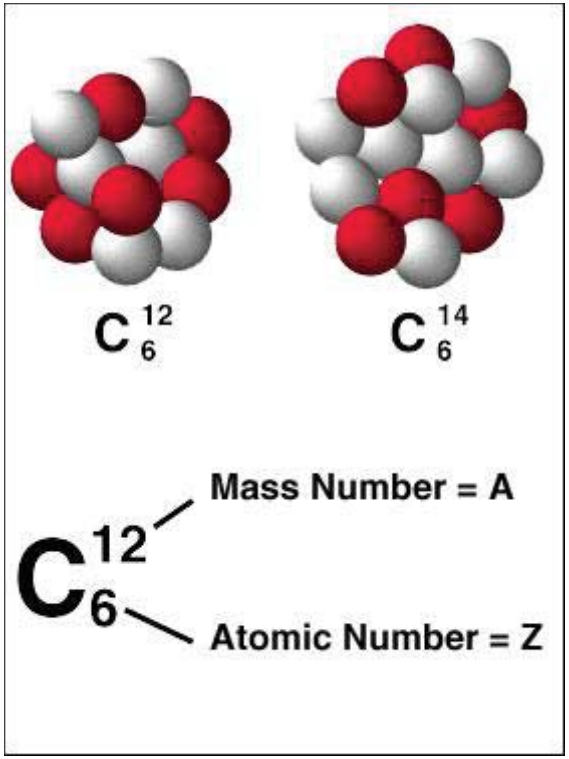
Nuclear Fuel Cycle



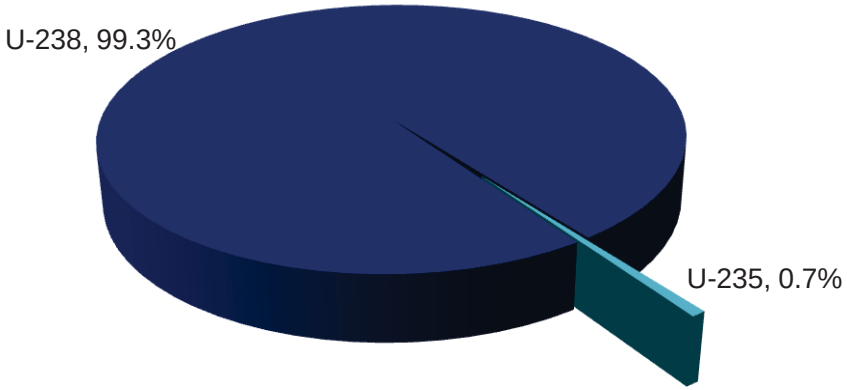
Enrichment

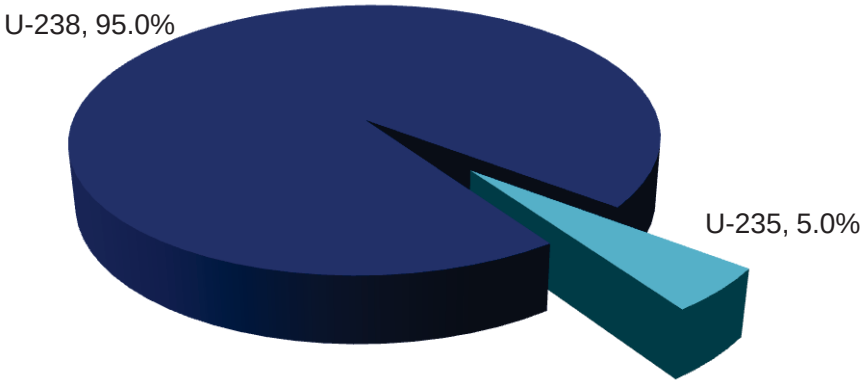
Isotopes

- The nucleus contains both protons and neutrons.
- Chemical properties determined by protons
- Neutrons affect the nuclear properties

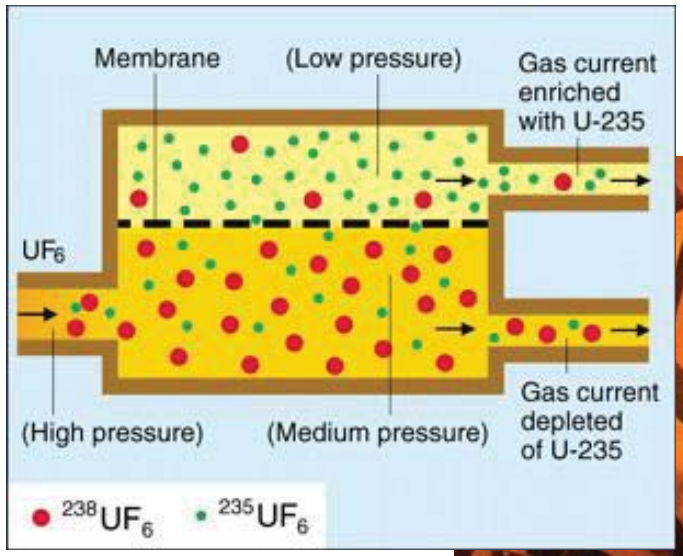


Enrichment



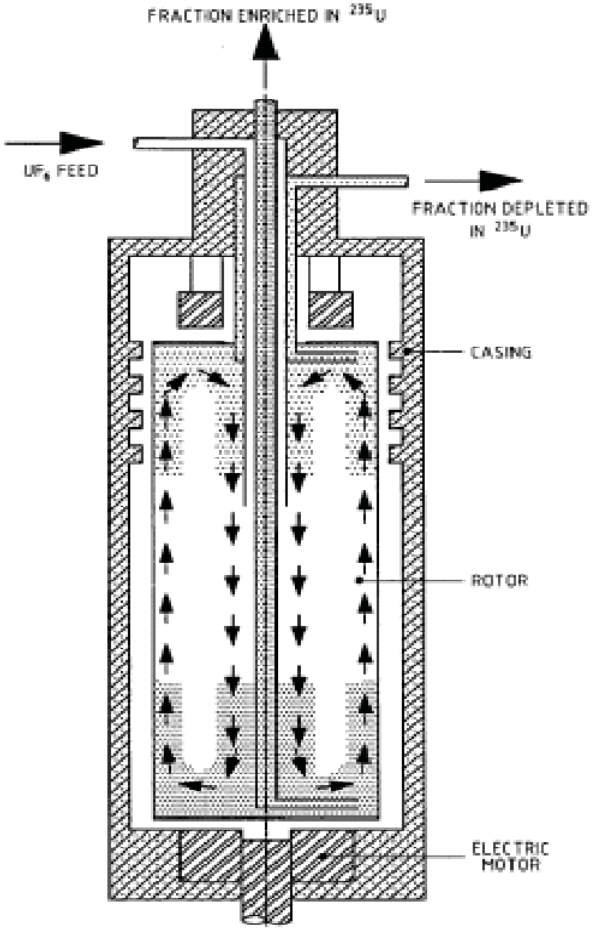


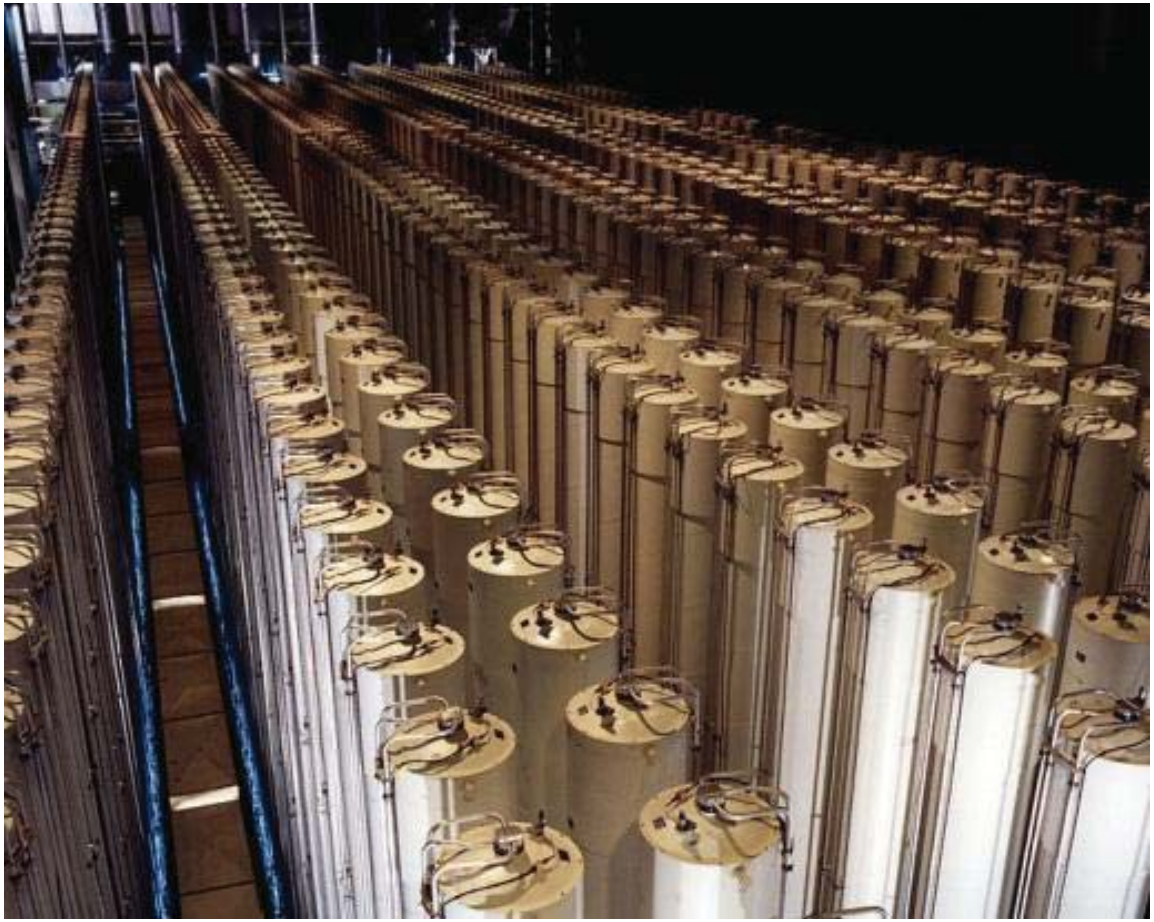
Enrichment: Gaseous Diffusion



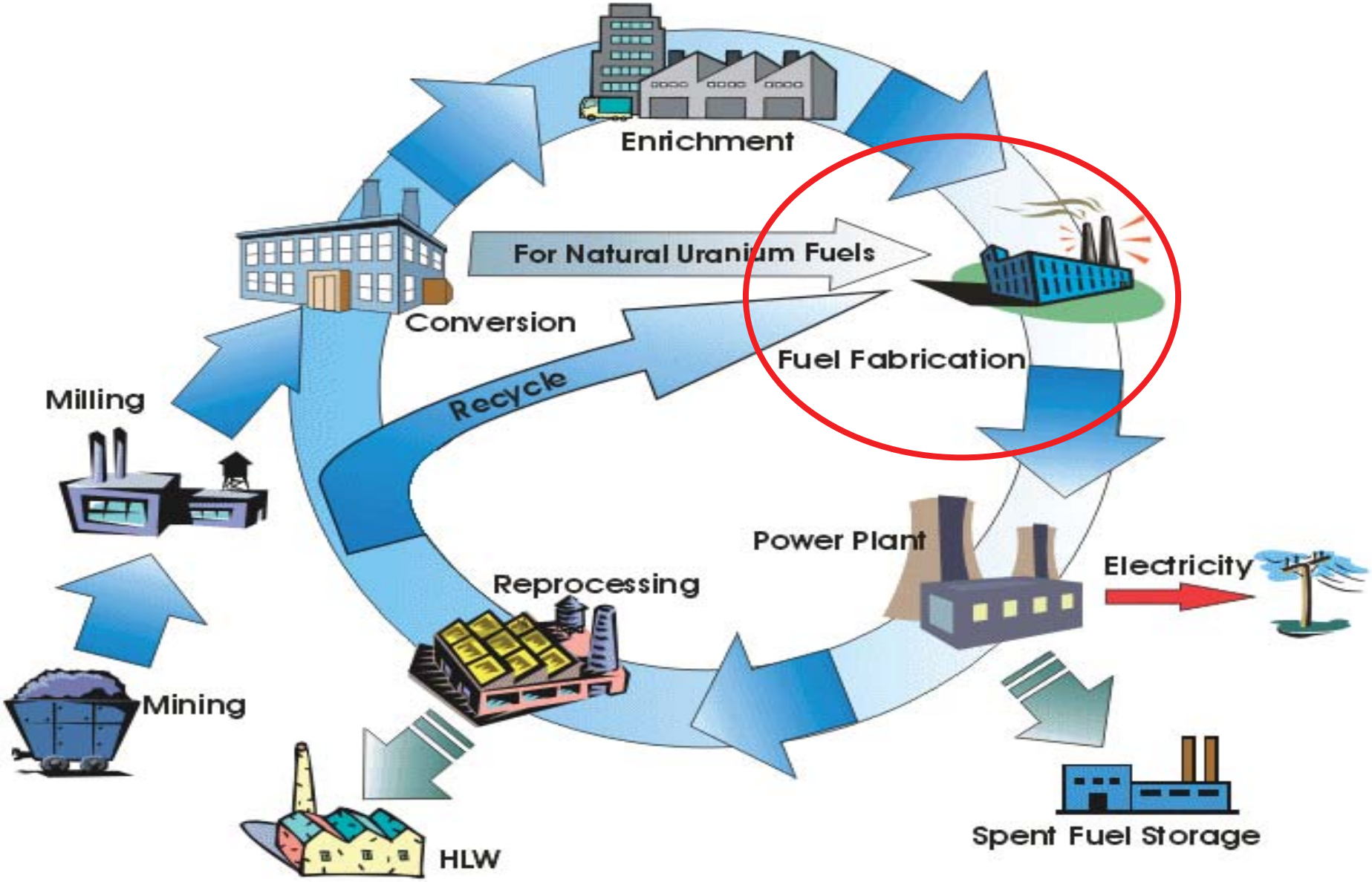
Enrichment: Gaseous Diffusion

Enrichment: Centrifuge

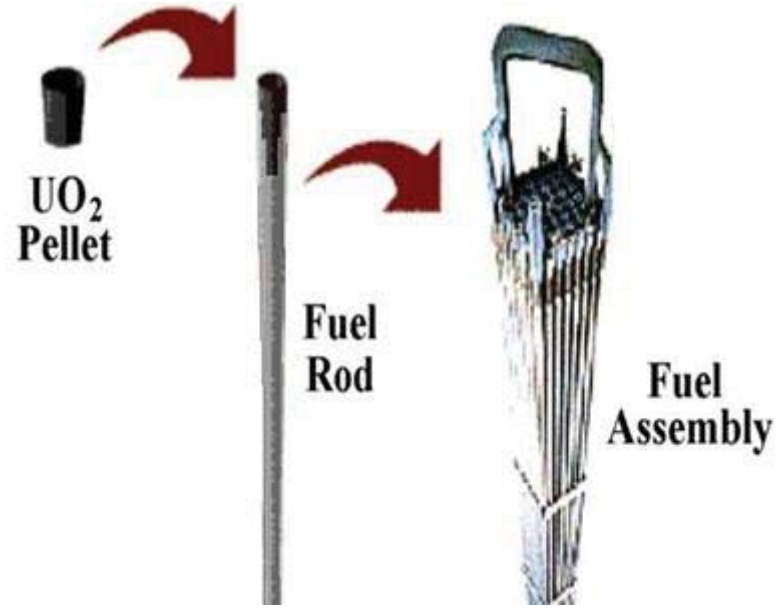




Nuclear Fuel Cycle



Fuel Fabrication



UO2 Powder
- Mill
- Press
- Sinter

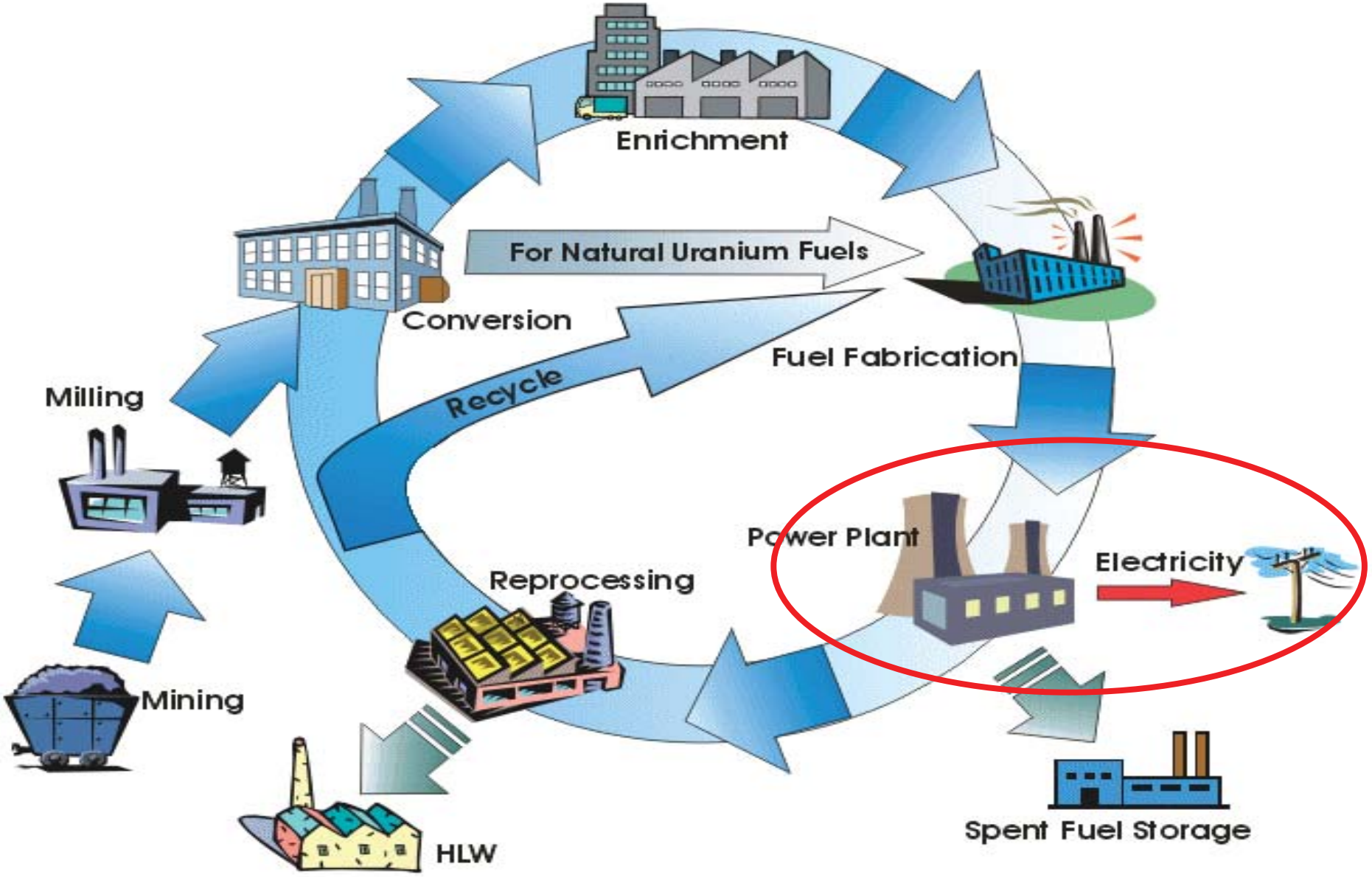
Pellets
- Grind
- Sheath

Elements
- Assemble

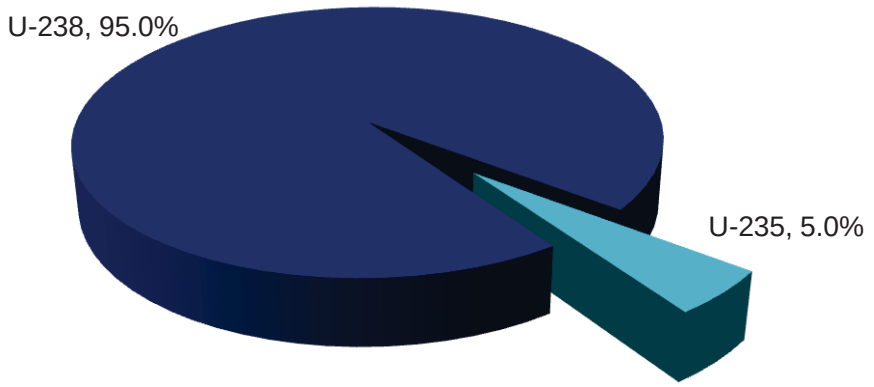
Assemblies

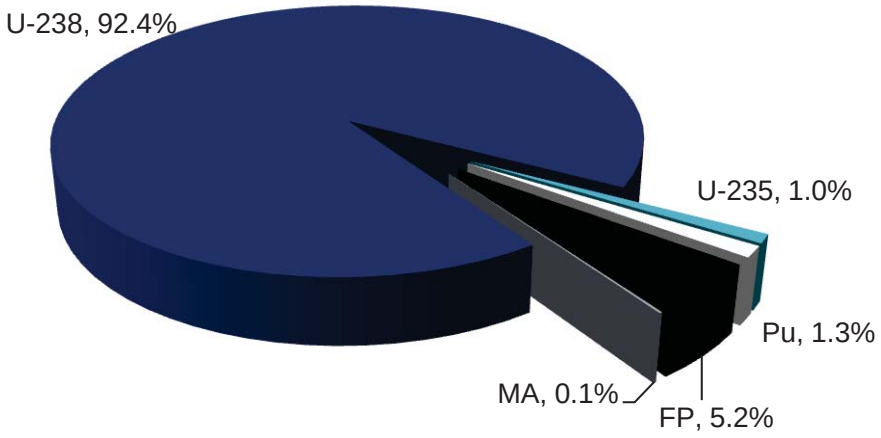
Fuel Fabrication

Nuclear Fuel Cycle

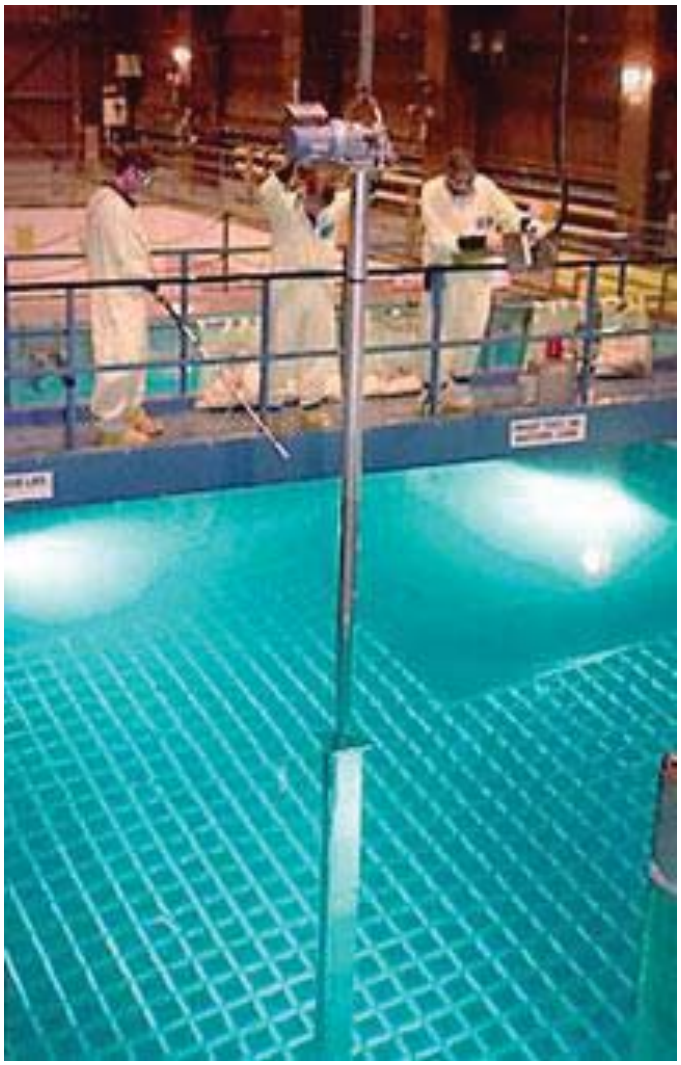


Spent Fuel

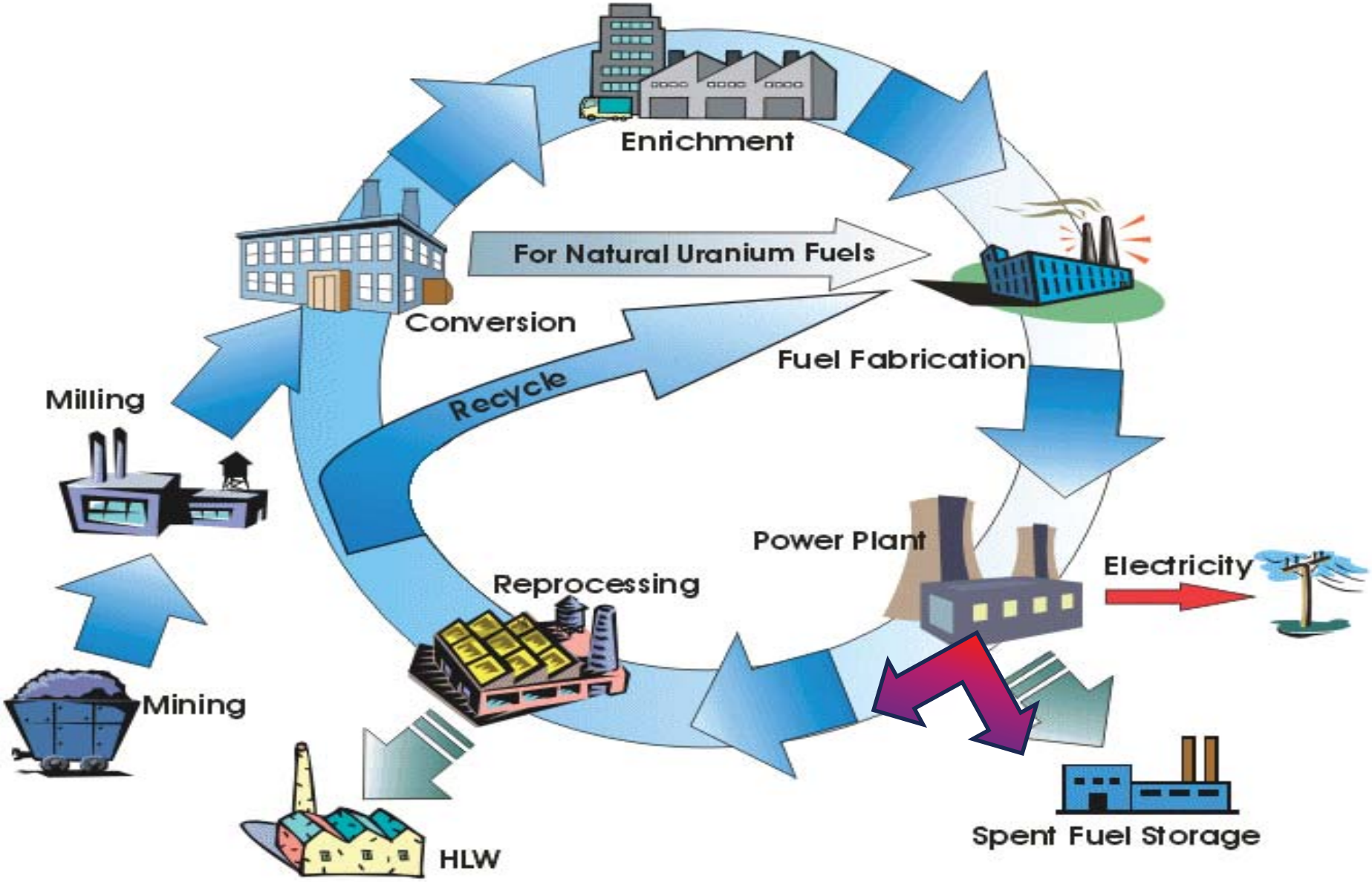




Spent Fuel



Nuclear Fuel Cycle



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Thank you for your attention