Nuclear Fuel Cycle

Many nuclear fuel cycle options are possible

- Argonne is involved in research and technology development related to understanding the science and technology of current and potential future nuclear fuel cycles

Enrichment

- Concentrate the U-235 isotope as required by technology
- Natural uranium contains 0.7% U-235
- Current U.S. reactors require around a concentration of 4%
- Other reactor technologies typically require between 0.7% (no enrichment) and around 20%
- Large amount of depleted uranium results from enrichment

Energy Production Reactor

- Relies on U-235 to sustain fission reaction
- Utilization of resources limited to about 1% in current reactors
- Used fuel can either be disposed or recycled
- If recycled, can be used to start other types of energy production reactors or recycle can be used to consume materials that are more challenging from a waste management point of view

Argonne Research

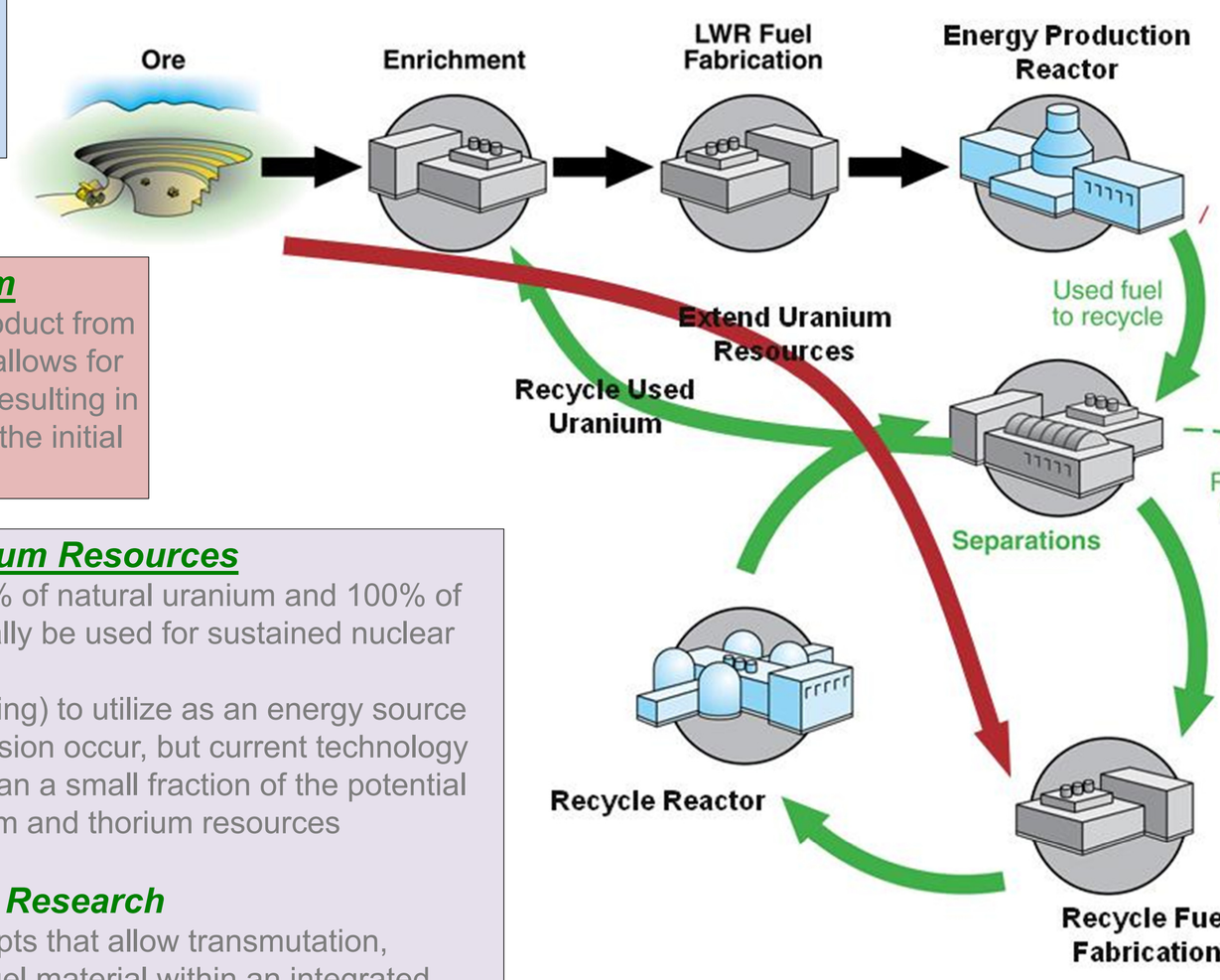
- Improved safety and economics through a variety of research including improved modeling and understanding of the important phenomenon during normal and accident conditions

Ore

- All fuel cycles begin with uranium and/or thorium which are the only naturally available fissionable elements
- Which of these is used as the primary fuel source shapes the fuel cycle
- Uranium-235 isotope is the only natural isotope capable of sustaining a nuclear reaction

LWR Fuel Fabrication

- Existing commercial fabrication of very low radiation level fuel



Geologic Repository

- Long-term isolation will be required for all fuel cycle options
- Spent fuel material that is not recycled will require isolation
- Even with recycle, fission products and process losses will still need isolation

Argonne Research

- Understand the behavior of nuclear waste in a repository and design a complete nuclear fuel cycle system that optimizes its performance

Recycle Used Uranium

- Recovering a clean uranium product from the separation of the used fuel allows for the potential for re-enrichment resulting in greater energy production from the initial ore mined

Extend Uranium Resources

- With current reactors, over 99% of natural uranium and 100% of natural thorium cannot practically be used for sustained nuclear energy production
- Requires transmutation (breeding) to utilize as an energy source
- Some internal breeding and fission occur, but current technology requires recycle to get more than a small fraction of the potential energy from the natural uranium and thorium resources

Argonne Research

- Argonne has developed concepts that allow transmutation, recycle, and utilization of the fuel material within an integrated facility (Integral Fast Reactor), where only small amounts of natural uranium or waste depleted uranium is shipped to the site and the residual fission product wastes is sent to high-level waste disposal

Separations

- Chemical segregation of individual elements or group of elements for either re-use or production of appropriate waste form

Argonne Research

- Chemistry Division researches the many ways to recycle in a safe and efficient manner as needed for the particular fuel cycle option

Recycle Reactor

- Many options for primary and secondary objectives: Energy Production only; Primary Energy / Secondary Waste Management; Primary Waste Management / Secondary Energy; or Waste Management only
- Materials recycled for energy production are the primary fissile and fertile materials; for uranium systems – Pu-239 primary fissile isotope; for thorium systems – U-233 primary fissile isotope
- Materials recycled primarily for waste management are the long-lived radioactive materials produce in the reactor; for uranium systems – Transuranic elements; for thorium systems – Trans-thorium elements; and for both systems – long-lived fission products

Argonne Research

- Reactor concepts that can accomplish the wide range of potentially desirable recycle schemes in a safe and efficient manner
- Analyses under a very wide range of assumptions to look for robust concepts that may be adapted in the future

Recycle Fuel Fabrication

- The often highly radioactive recycled materials are manufactured into fuel for use in the recycle reactor
- Might be integrated with separations as a combined process

Argonne Research

- Understand the very complex behavior of nuclear fuel under the very harsh conditions in a nuclear reactor to ensure they perform as designed
- Develop the technology to manufacture these highly radioactive fuels in an efficient way while assuring they meet the high quality nuclear standards

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