U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Fuel Cycle Research and Development

Science Based Fuel Cycle Research and Development

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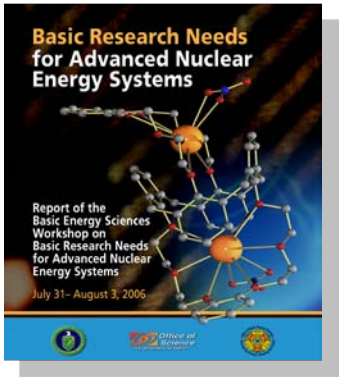
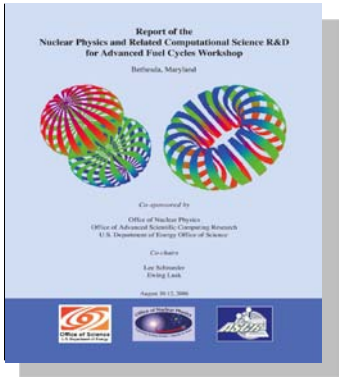
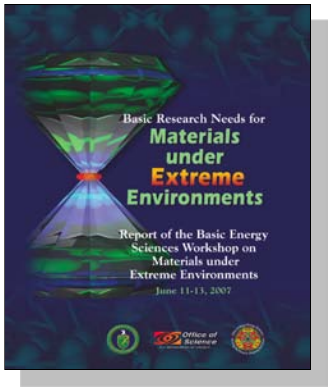
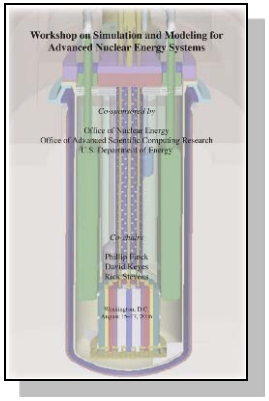
Former Programmatic Approach

- **Incremental improvement of existing technologies to allow for short-term (~20 years) deployment, driven by better utilization of Yucca Mountain**
  - Specific choice of technologies and integrated system (dictated by time frame and Yucca Mountain characteristics)
  - Challenges were well identified
  - Engineering approaches were chosen to address these challenges
  - Fundamental challenges had also been identified (2006 workshops), but were marginally acted upon (e.g., modeling and simulation)
- **The industrial approach resulted in very limited investment in the tools needed to develop a better understanding of fundamental processes**



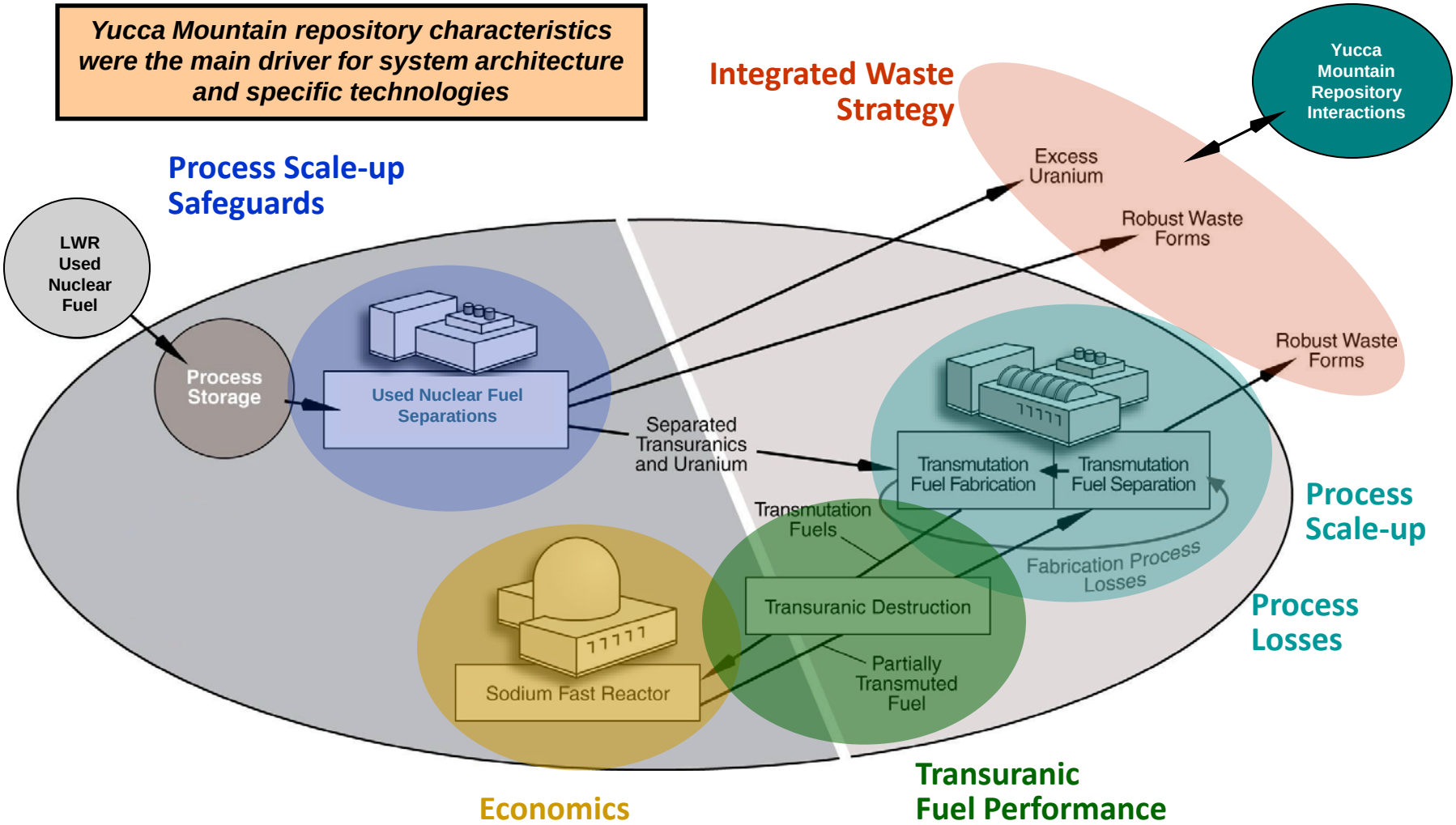






Past Definition of Technical Challenges

Yucca Mountain repository characteristics were the main driver for system architecture and specific technologies

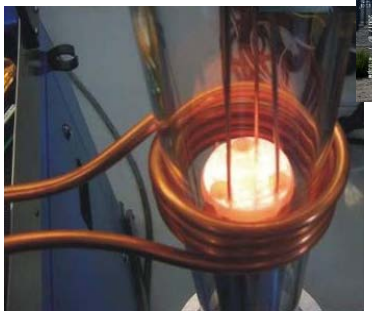


Proposed New Approach

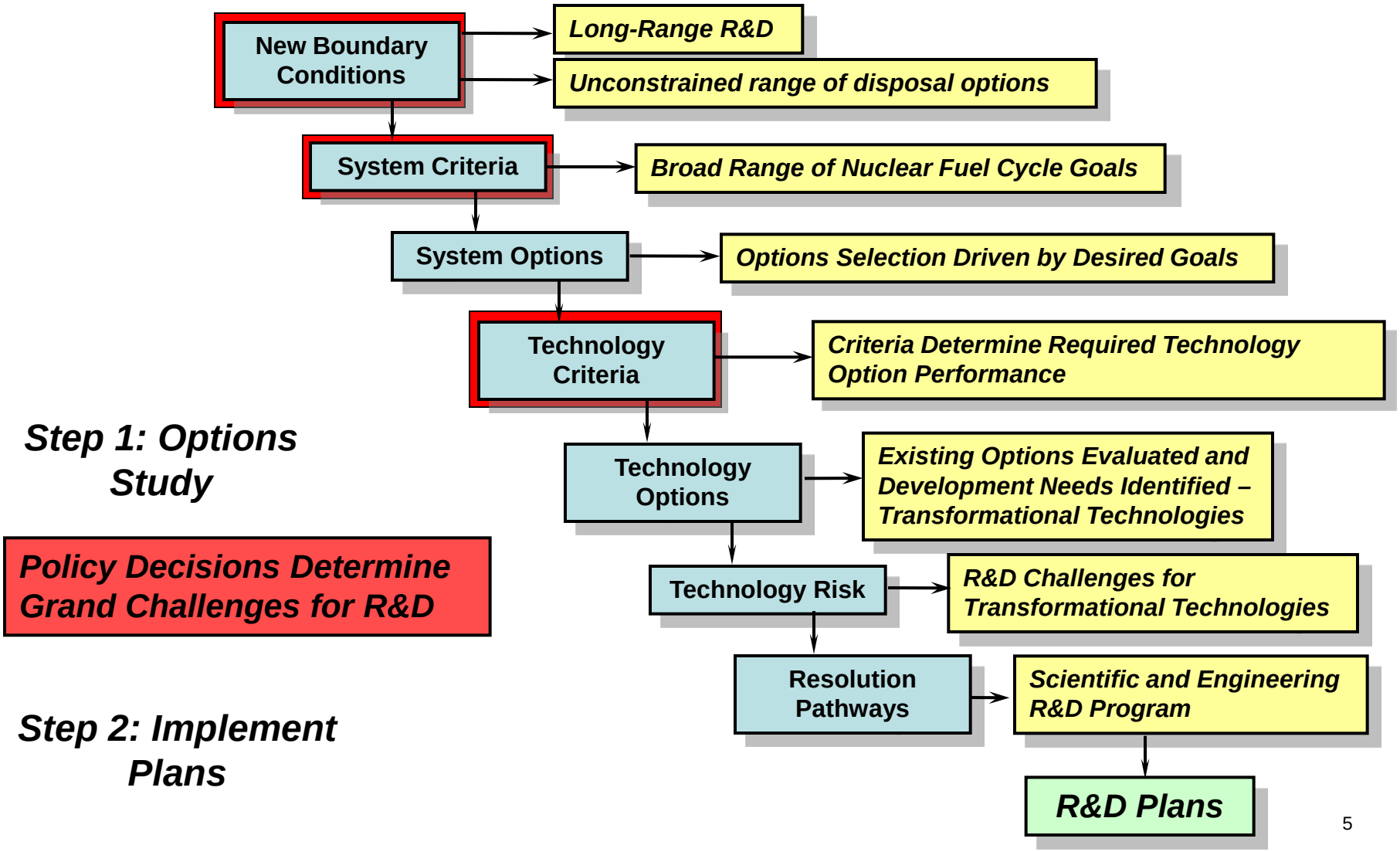
1. **Long term deployment of fuel cycle technologies**

2. **Based on an initial analysis of a broad set of options**

3. **Based on the use of modern science tools and approaches designed to solve challenges and develop better performing technologies**



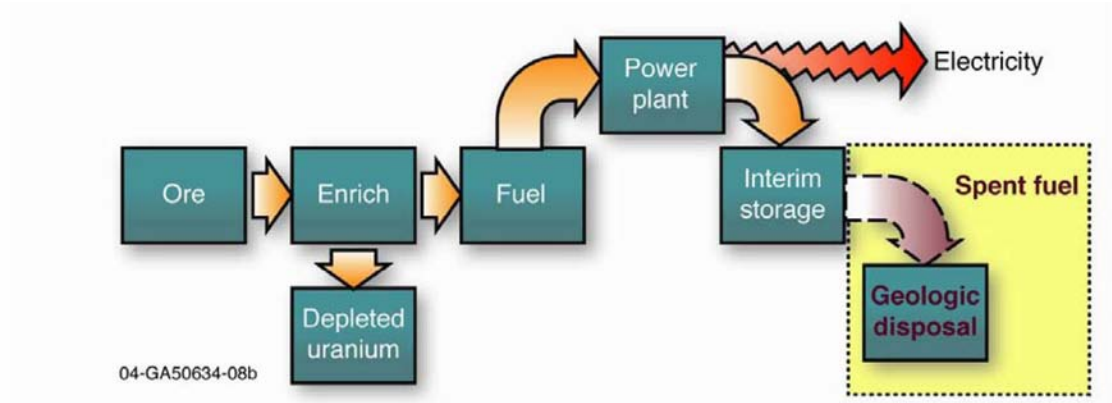
Proposed New Approach (2)



Advanced Nuclear Fuel Cycles

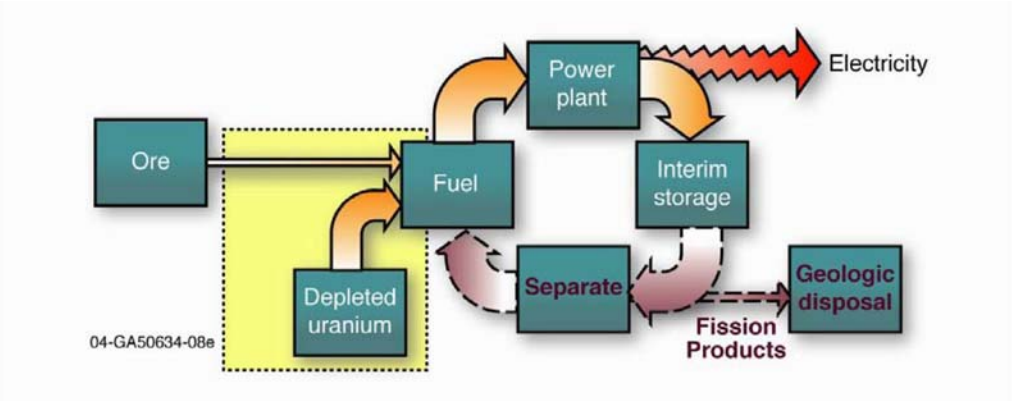
- **Advanced nuclear fuel cycles may be either once-though or recycle systems**
  - Once-through has direct disposal of all used fuel
  - Recycle involves processing of the used fuel for further treatment, including irradiation of some or all of the used fuel
- **The ability to develop advanced fuel cycles for each of these systems depends on needs**
  - Not necessarily the same for both systems
  - Can include novel approaches such as externally-driven sub-critical reactors for irradiation
  - Disposal is always a big concern, since there will always be highly radioactive wastes no matter what you do

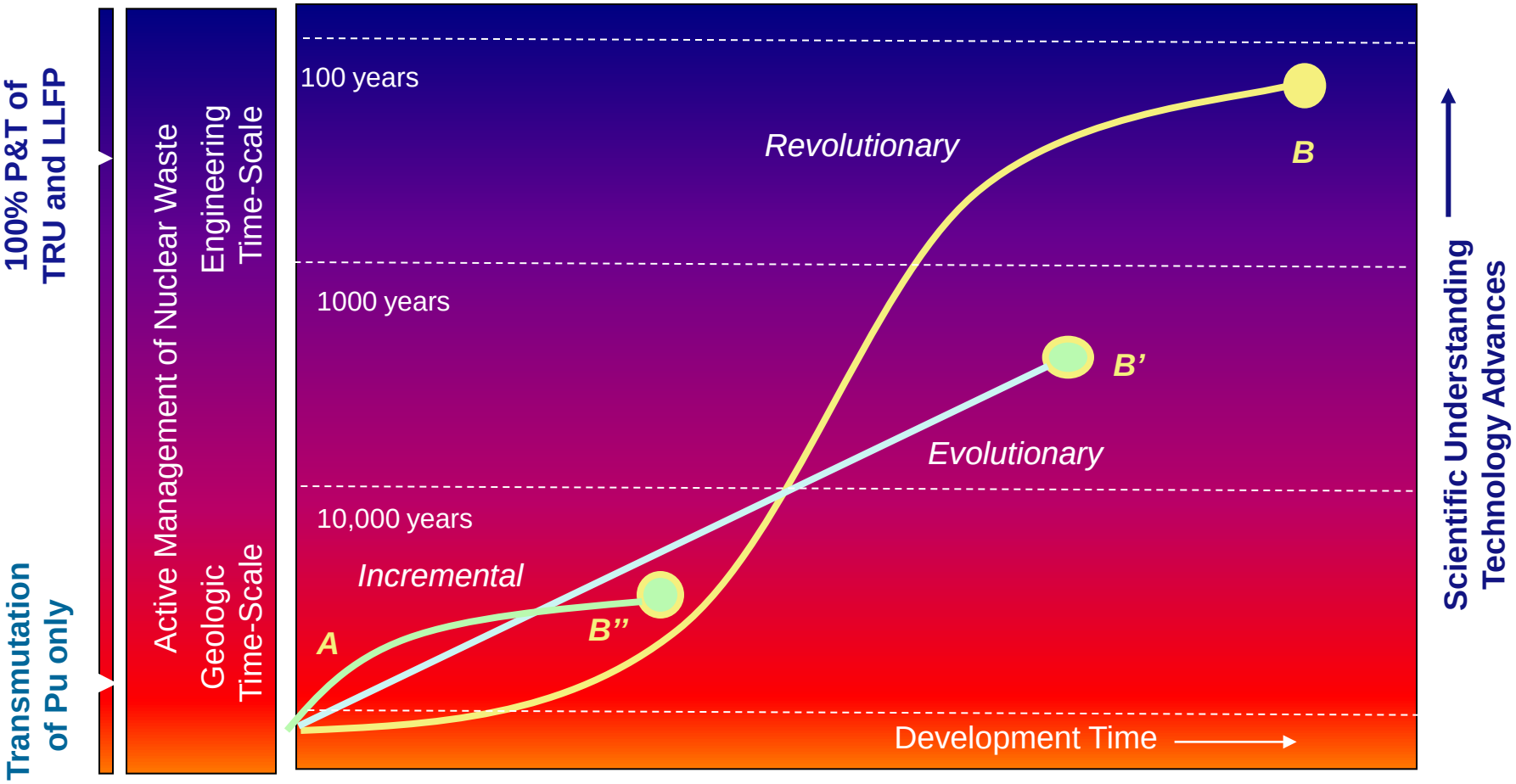
Advanced Once-Through Fuel Cycles



- **Disposal needs to accommodate the contents of spent fuel to provide the required long-term isolation**
  - Still requires significant robust disposal
  - Much higher burnup (basically complete consumption) is beneficial where actinides are the dominant risk contributors
    - *If fission products dominate risk, then burnup doesn't really matter*
    - *Irretrievable to prevent potential proliferation risk*
- **Resource availability is the other significant issue**
  - Higher burnup may provide better resource utilization

Advanced Recycle Nuclear Fuel Cycles



- **Disposal is still a dominant issue, but much different**
  - Fission product radiotoxicity by itself is much lower than for used fuel (UNF) about 60 years after discharge
  - Engineering issues such as decay heat are easier to deal with
  - Opportunities with much lower UNF/HLW disposal quantities
- **Recycle one or more actinides, possibly some fission products**
  - Waste management
  - Energy production
  - Proliferation risk reduction

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