Nuclear Fuel Reprocessing: Now We're Ready(?)

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Energy Independence

1960s and 70s

"In the United States, **nuclear power** was seen as an important element in America's ability to maintain **energy self-reliance** in the face of nervousness about its growing reliance on oil that increasingly had to be imported from the volatile Middle East"

http://www.tva.gov/sites/wattsbarnuc.htm

A Little Background

- Nuclear Power in America
  - Nuclear Weapons
  - Nuclear Reactors: Electricity Production
- The Nuclear Fuel Cycle
- The Nuclear Waste Problem

Nuclear Power: Basics

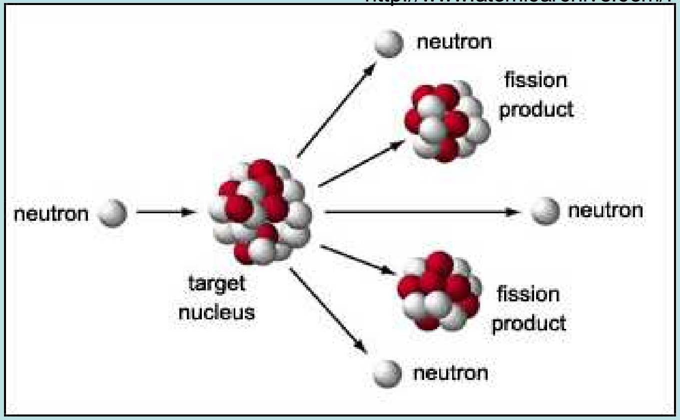
Nuclear Fission

- When the nucleus of an atom splits into two or more smaller nuclei

Nuclear Energy

- The controlled use of nuclear fission
- Nuclear energy is released when a fissile material such as uranium-235 is fissioned in a controlled nuclear chain reaction
- (The chain reaction that releases the energy of a nuclear weapon is rapid and uncontrolled)

http://www.atomicarchive.com/Fission/Fission1.shtml



Uranium

- Symbol – U, atomic # 92
- Occurs naturally in minerals
- Exists in three forms: U-238 (99.3%), U-235 (.7%), and U-234 (.006%)

Plutonium

- Symbol – Pu, atomic # 94
- Found rarely in nature; usually made from uranium

Nuclear Power: American History

Manhattan Project

Nuclear weapons development
and production – 1942-1946

"Atoms for Peace"

Eisenhower – December 1953

Photos: Wikipedia.org

Commercial nuclear power reactors

The first American commercial nuclear power plant was a pressurized water reactor built in 1957 in Shippingport, Pennsylvania

U.S. Policy and Regulation

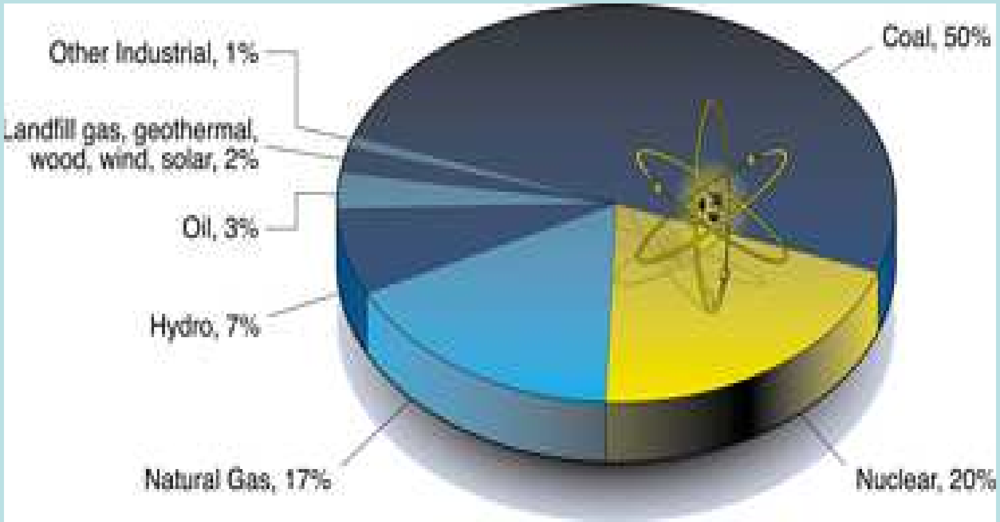
- Atomic Energy Act (1946)
  - Created the Atomic Energy Commission
  - Transferred control of nuclear materials from the Manhattan Project to the AEC
- Atomic Energy Act Amendments (1954)
  - Authorized AEC to license commercial reactors
- Treaty on the Non-Proliferation of Nuclear Weapons (1968)
  - Refrain from developing or acquiring nuclear weapons
- Energy Reorganization Act (1974)
  - Split the AEC into the NRC and ERDA
- Nuclear Nonproliferation Act (1978)
  - Governs peaceful nuclear exports by the U.S.

Nuclear Reactors: Energy Production

- The initial period of power plant construction brought the U.S. more than 100 electricity-producing nuclear reactors.
- 103 of are still operating.

http://www.masternewmedia.org/news/2006/05/08/usiran_raid_on_nuclear_fuel.htm

Nuclear reactors produce roughly 20 percent of the electricity consumed in the U.S. (In contrast, France gets 80% of its electricity from nuclear energy)



U.S. DOE

Nuclear Reactors: How do they work?

- The controlled (nuclear fission) chain reaction produces heat, which boils water, which produces steam, which drives a turbine, which generates electricity.
- Most nuclear reactors are Light Water Reactors (LWR) meaning that they are cooled and moderated with ordinary water.

The Nuclear Fuel Cycle

The Front End

- Exploration, mining, milling, uranium conversion, enrichment, fuel fabrication

The Service Period

- Use in a nuclear reactor
- Nuclear fuel is generally used for 12-18 months before it no longer generates enough heat

The Back end

- Storage, transportation, (reprocessing, transmutation), waste disposal

The Nuclear Fuel Cycle

1. Uranium Ore
2. Yellowcake (U_3O_8)
3. Enriched U (UF_6) 3.5-5% U-235
4. Nuclear Fuel (UO_2)
5. Fuel Rods (zirconium alloy)

1


3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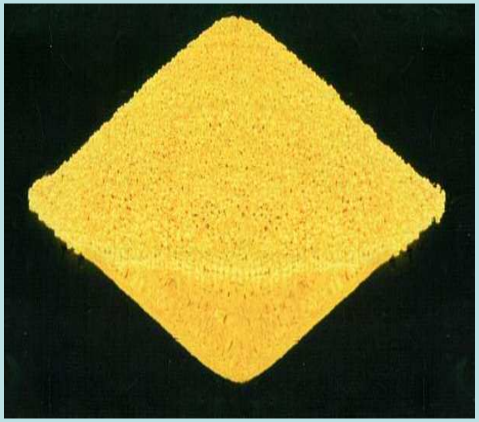

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Wikipedia.org

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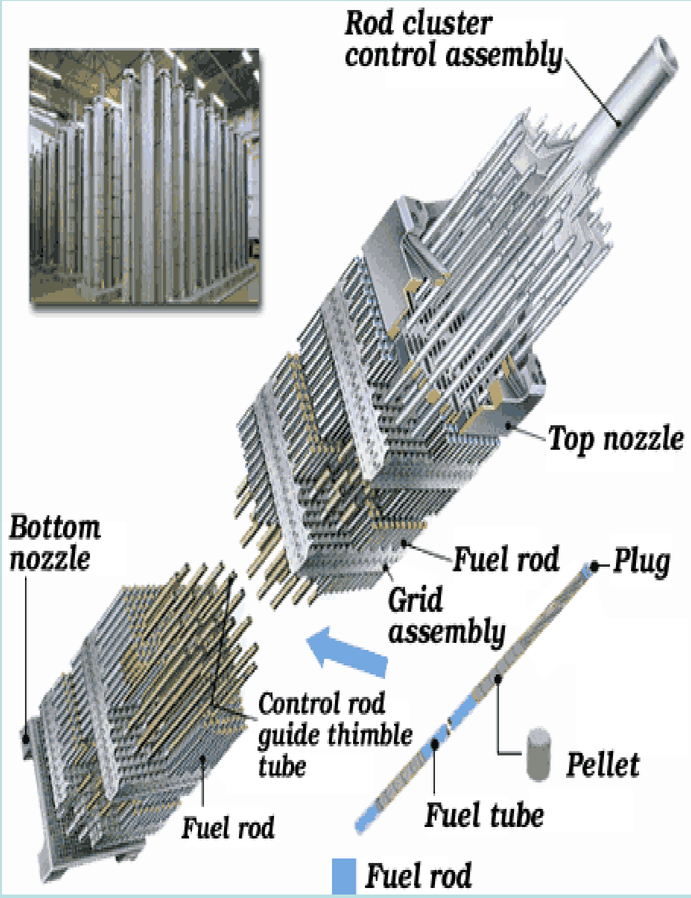
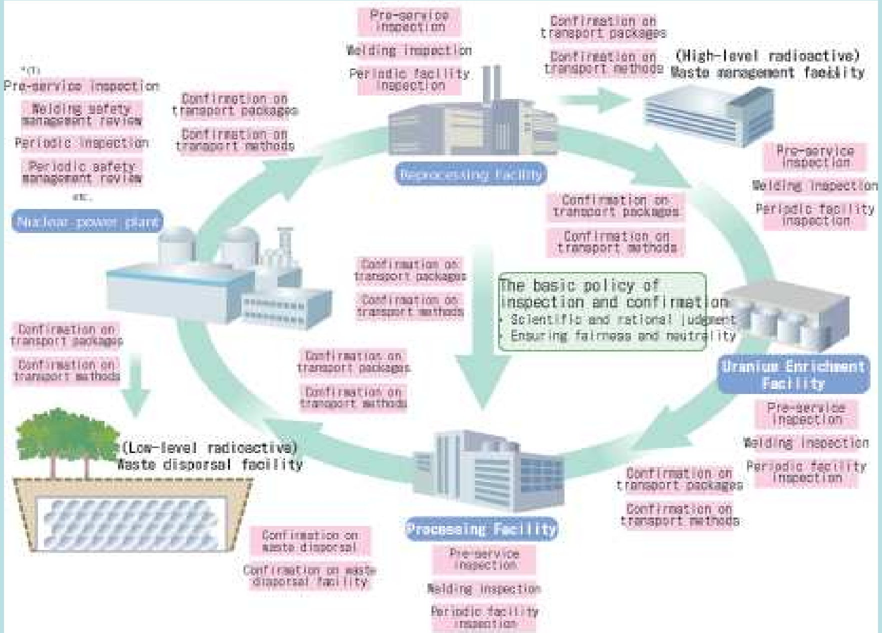


http://www.mnf.co.jp/images2/2img_pwr.gif

The Nuclear Fuel Cycle

Alternatives: The <u>"once-through"</u> fuel cycle versus the <u>"closed-loop"</u> (reprocessing) cycle

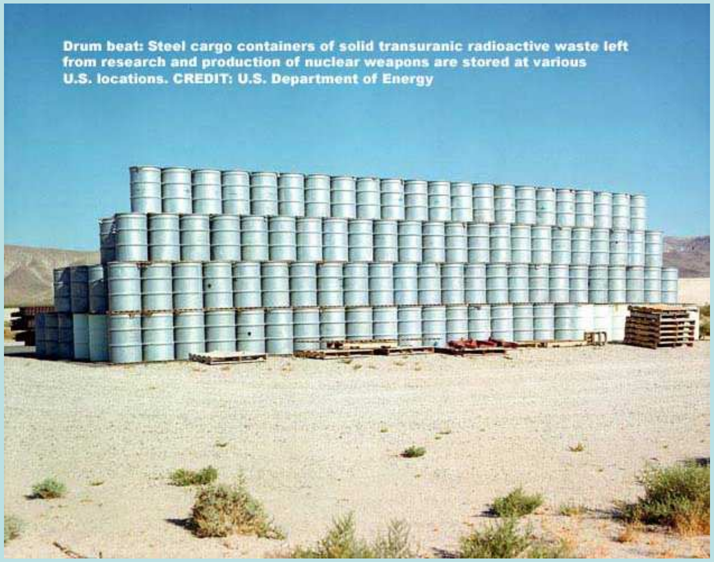
- The U.S. nuclear energy program was initially envisioned to operate with a closed cycle, but concerns (more later) abruptly changed the system into a once-through cycle.



http://www.jnes.go.jp/english/gyoumu/nenryou.html

The Nuclear Waste Dilemma

- To date, the U.S. has produced more than 50,000 metric tons of Spent Nuclear Fuel
- Where do we put the more than 2000 metric tons of radioactive waste generated in reactors each year?
  - Spent Fuel Pools
  - Dry cask storage
  - Geological Repository



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Yucca Mountain: America's geological repository?

The 1982 Nuclear Waste Policy Act

- Established geologic repositories as the long-term solution to the problem of storing high-level nuclear waste
- Set in motion the process to site and develop such repositories
- Required the federal government to open a permanent repository by 1998; minimum of two storage sites.

1987 Nuclear Waste Policy Amendments Act

- Reduced the number of possible sites to one (Yucca Mountain) and delayed the need for a second repository until 2010.
- DOE missed the 1998 deadline; Congress demanded that DOE prove Yucca workable; Viability assessment in 1998
- Spent fuel (and lawsuits against DOE) pile up

Yucca Mountain Cont'

February 2002

- DOE declared Yucca Mountain suitable as a repository

Today

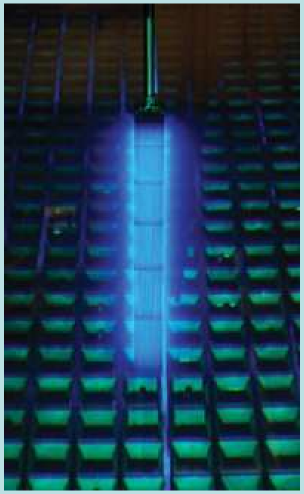
- Major political opposition in Nevada
- Still no storage at Yucca

http://www.nicholsoncartoons.com.au/cartoon_3857.html

On-site storage of SNF

Wet storage

- The great majority of spent nuclear fuel is initially stored as spent fuel assemblies in water-filled pools on power plant sites.
- The pools provide radiation shielding and cooling



http://infocusmagazine.org/5.2/eng_nuclear_plants.html

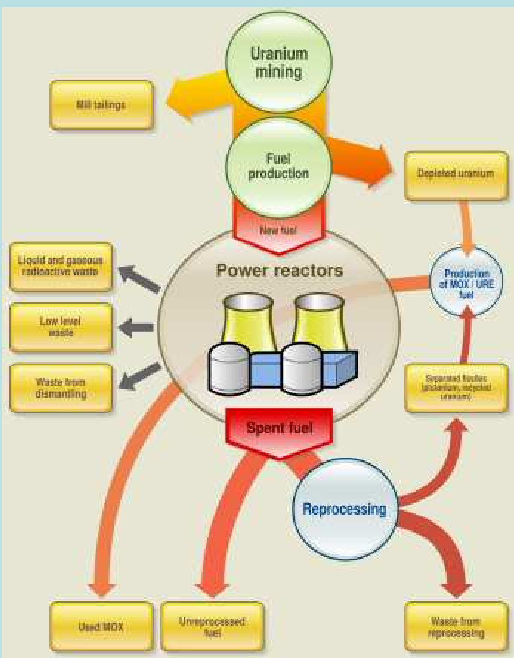
Dry Storage

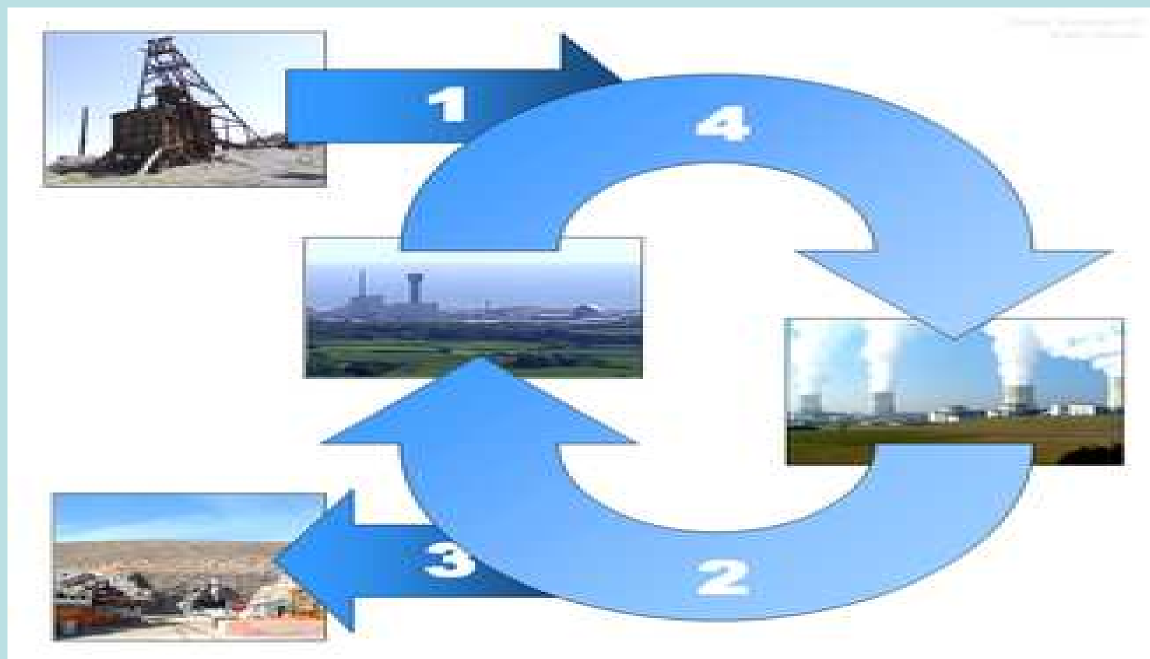
- Spent Fuel is usually placed in dry cask storage after 5 years in wet storage. (NRC regulation requires at least 1 year in wet storage.)
- Dry cask storage uses concrete or steel containers as a radiation shield and is cooled by inert gas or air.
- The casks are built to withstand the elements and accidents and do not require electricity, water, maintenance, or constant supervision

U.S. DOE

Reprocessing: A Solution?

<u>Reprocessing</u>: The chemical separation of spent nuclear fuel into its major components.





Wikipedia.org

Products of Reprocessing

- **Uranium**
  - .6% U-235 and 99.4% U-238
- **Plutonium**
- **Minor Actinides**
  - Americium
    - Major long-term heat source
  - Neptunium
    - Major source of radiation
  - Curium

U.S. DOE

- **Fission Products**
  - Strontium-90, Cesium-137
    - Generate large amounts of heat for the first 50-80 years after disposal
    - Removal from the repository would reduce the amount of space needed
  - Iodine-129, Technetium-99
    - Mobile isotopes that can easily travel through geological formations
    - Major contributors of radiation to biosphere

Reprocessing: Methods/Techniques

- **PUREX**: Plutonium and Uranium Extraction
  - Most widely used method
  - Results in a pure stream of plutonium
- **UREX**: Uranium Reduction Extraction
  - Replacement for PUREX
  - Results in pure uranium stream
  - The plutonium remains mixed with the fission products and minor actinides
- **UREX+**
  - Refinement of the UREX process
- **Pyroprocessing**
  - Reduces the liquid waste that remains in the UREX process

Reprocessing: History

- Reprocessing (PUREX) is developed in the 1940s to separate plutonium for use in nuclear weapons
- 1956 – AEC announces program to encourage private reprocessing industry
- Nuclear Fuel Services: West Valley Plant – Buffalo, NY
  - Operated from 1966 -1972
  - Reprocessed fuel from the defense weapons program; no commercial SNF reprocessed
  - Shut down for failure to meet regulatory requirements
- General Electric Company – Morris, IL
  - Plans to construct reprocessing facility – 1967
- Allied-General Nuclear Services – Barnwell, SC
  - Began construction of reprocessing plant – 197

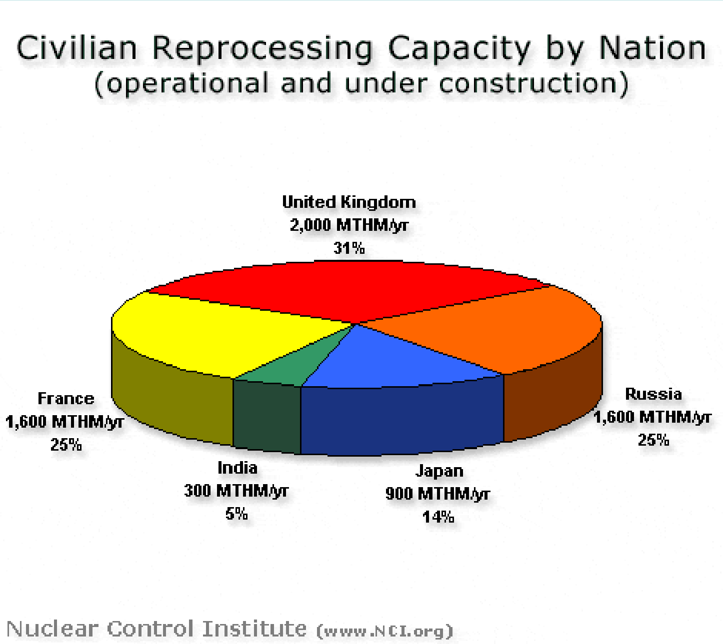
Meanwhile: The supply of uranium is increasing while the price is dropping

Reprocessing: History Cont’

- **1972** – GE halts construction and pulls application; stores SNF instead
- **1974** – India detonates a nuclear explosive using plutonium separated with U.S. Reprocessing technology
- **1976** – President Ford decides to delay commercialization of reprocessing activities in the U.S.
- **1977** – President Carter puts a moratorium on the U.S. commercial SNF reprocessing
- **1981** – President Reagan lifts the ban on commercial reprocessing
- **1992** – President Bush halts weapons production (reprocessing plutonium and enrichment of uranium); closure of PUREX plant in Hanford, WA
- **2006** – Department of Energy announces GNEP

International Reprocessing

- About 30% of the world's LWR spent fuel is reprocessed using PUREX
- Among the nuclear-armed states, France, India, Russia, and the United Kingdom engage in reprocessing
- Japan is the only non-nuclear-armed state that has a civilian reprocessing program



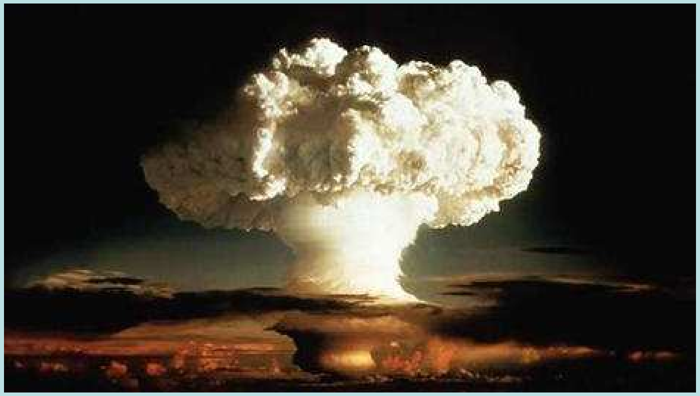
Reprocessing and Nuclear Terrorism

- Traditional spent nuclear fuel is **“self-protecting”** because the spent fuel assembly (containing the plutonium) has a radiation dose rate that would be fatal to a potential thief/terrorist (or scientist) within half an hour. [8]
- Once the plutonium is separated out, it is no longer “protected” by the radioactive fission products with which it was formerly mixed.

Separated plutonium: What's the big deal?

Proliferation concerns

- The worlds stockpile of separated civilian plutonium has reach 250 tons.
- The radiation dose rate from separated plutonium is so low that it can be safely carried in an airtight container.[8]
- Eight (8) kilograms of plutonium is required to produce a nuclear bomb.



Reprocessing: Then what?

Storage in a repository, or . . .

. . . <u>Waste Recycling</u>

- Definition: Transmuting or destroying the separated waste products of reprocessing. Transforms the long-lived radionuclides into short-lived ones. 12
- Reprocessing alone is not sufficient to reduce the volume and toxicity of used fuel, ensure adequate supplies of uranium, and achieve proliferation resistance.
- A transmutation program could transform the problem of long-term isolation in a geological repository (for 10s of thousands of years) to a less difficult problem of storage for several decades or a few hundred years.

Waste Recycling: History

- In the 60s and 70s it was expected that plutonium (from reprocessing) would be used to make start-up fuel for **plutonium breeder reactors** and combined with depleted uranium to produce **MOX fuel** for use in light water reactors.
- It was believed that production of nuclear energy based on Uranium-235 would **deplete the world's stock of uranium ore**, making the transition to uranium-efficient breeder reactors economical.
- When **huge deposits of ore** were discovered and world nuclear capacity reached only a fraction of the level projected, both reprocessing and breeder reactors were too costly to compete.

Methods of Recycling

- Transmutation involves inducing nuclear reactions in some form of non-traditional reactor.
- Fast reactors
- Breeder Reactors
- Burner reactors
- Fast Neutron Reactors

Results of Recycling

Waste products:

- No transmutation scheme is able to destroy all of the components of spent nuclear fuel.
- Most will require multiple passes through the reactor to recycle a significant amount.
- Some of the components, although reduced by volume, will be converted to more radioactive forms.

Benefits of Reprocessing and Recycling

- The ability to reduce the volume and toxicity of nuclear waste
  - A smaller, simpler repository
  - Extension of time before a second repository is necessary
- Closed fuel cycle – consistent uranium supply

Costs of Reprocessing

- Plutonium Stockpiles/Weapons Proliferation
- Environmental and health harms
- Terrorism
- Transportation of high level waste
- Reactor safety, worker health
- Economic cost
- New regulatory schemes

Reprocessing: Environmental Consequences

West Valley, New York

- In 2001, the GAO estimated that cleanup would take 40 years to complete and cost $4.5 billion.

"Superphenix" reactor, France

- Permanently shut down in 1987 after leaking 20 tons of sodium coolant.

"Monju" fast breeder reactor, Japan

- Shut down in 1995 after three tons of sodium leaked causing the reactor to overheat and burning holes in the cooling pipes.

THORP plant, Sellafield, UK

- Shut down in 2005 after a discovery of a massive leak of radioactive acid solution containing tens of tons of uranium and 160 kilograms of plutonium.

Environment, Health, Safety Cont'

"The near-term environmental impacts of reprocessing and recycling, even when balanced in part by the reduction in uranium mining, are likely to overwhelm the possible long-term environmental benefit of reduced exposures in a geological repository." [13]

Reprocessing: Economics

Case Study: France

"If France were to stop reprocessing in 2010, it would save $4-5 billion over the remaining life of its current fleet of power reactors."

Case Study: Japan

"Japan recently estimated that the total extra cost for reprocessing 32,000 tons of its spent fuel and recycling the plutonium would be about $60 billion.

GNEP: The Global Nuclear Energy Partnership

"The United States 'will build the Global Nuclear Energy Partnership to work with other nations to develop and deploy advanced nuclear recycling and reactor technologies. This initiative will help provide reliable, emission-free energy with less of the waste burden of older technologies and without making available separated plutonium that could be used by rogue states or terrorists for nuclear weapons. These new technologies will make possible a dramatic expansion of safe, clean nuclear energy to help meet the growing global energy demand.'"[18]

- Global Nuclear Energy Partnership Strategic Plan

What’s different?

Principles of GNEP:

- Expand nuclear power to help meet the growing energy demand
- Develop advanced reprocessing technologies that do not separate plutonium
- Develop advanced reactors that consume transuranics
- Provide reliable fuel services; *i.e.*, providing nuclear fuel and taking back spent fuel for recycling – without distributing reprocessing technologies
- Develop advanced proliferation resistant nuclear power reactors appropriate for developing countries
- Develop enhanced nuclear safeguards to monitor nuclear facilities and materials

Technology

There are three facilities required to implement the GNEP proposal:

1. A nuclear fuel reprocessing center to separate the components of spent fuel.
2. An advanced recycling reactor to transform the actinides (while producing electricity).
3. An advanced fuel cycle research facility for developing and improving fuel cycle technology.

Technology Cont’

Reprocessing:

- GNEP proposes the use of either UREX+ or Pyroprocessing.

Recycling:

- GNEP proposes the use of . . . well, they call them several things:
  - Advanced recycling reactors
  - Advanced burner reactors
  - Fast reactors
  - Liquid metal fast reactors
  - Fast neutron reactors
  - Sodium-cooled fast reactors

GNEP: Economics

- “The energy department requested $250 Million for fiscal 2007 to advance the GNEP initiative.”
- The estimated difference between reprocessing and direct disposal, as a percentage of the price of electricity is modest – about 3-5%. The total cost for the current fleet of U.S. reactors would add about $2 billion a year to the cost of nuclear-generated electricity. [13]
- The excess cost for a reprocessing system for the 62,000 tons of SNF currently slated for Yucca Mountain would likely be no less than $50 billion and could easily be over $100 billion.
- “World resources of uranium are likely to be economically recoverable at prices far below the “break-even” price for decades to come. Reprocessing and recycling will not be economically competitive until the price of uranium reaches $350-400 per Kilogram and disposal costs reach $3000 per kilogram
- Increasingly stringent environmental and safety regulations are expected to drive costs even higher. [10]

GNEP: Criticisms

- Certain technological aspects of GNEP such as pyroprocessing and advanced reactors will not be available for decades. [1]
- Absent the infrastructure needed to recycle the materials separated in reprocessing, there is no current benefit to reprocessing. [11]
- Dry cask storage offers the possibility of storing spent fuel cheaply, safely, and securely for decades, while leaving reprocessing options open for the future. [13]
- Reprocessing technologies are arguably more proliferation-prone than direct disposal and require more resources to operate, maintain, safeguard, and finance. [9]

GNEP: Feasibility

"For the plan to work . . . You're going to have to site 20-30 reprocessing plants and 500 or more reactors."

"Given the history of abandoned nuclear projects, it is not difficult to foresee that a multigenerational project to reprocess and recycle spent nuclear fuel would be abandoned half completed." [10]

"The proposal flies in the face of common sense and experience."

"There seems little doubt that licensing and building the new reactor types required would be an enormous institutional and political challenge." [13]

"The reprocessing and transmutation aspect of GNEP must be seen as a gamble, and an optional – not necessary – gamble."

"You know DOE can't develop a hole in the ground in Nevada . . . I don't know how they're going to do this."

What happened to Yucca Mountain?

"Technological advancements through GNEP could reduce the volume, thermal output, and radiotoxicity of waste requiring permanent disposal at the Yucca Mountain geologic repository. It is important to emphasize, however, that **GNEP does not diminish in any way the need for, or the urgency of, the nuclear waste disposal program at Yucca Mountain**. Yucca Mountain is still required under any fuel cycle scenario."

Do we need more nuclear power?

"In the early 1990s, it was generally assumed that most nuclear power plants would be closed and dismantled when their licenses ran out early in the 21st century. Although a few plants have closed, many more plant owners are applying for extensions of the licensing term through the NRC's relicensing process." [2]

Benefits of nuclear power

- **Hazardous Waste Production**

  "In countries with nuclear power, radioactive wastes comprise less than 1% of total industrial wastes. It produces far less waste material than fossil-fuel based power plants." [4B]

- **Air pollution/Global warming**

  "None of the waste that nuclear power plants generate is released into the environment[.] Even when the full power chain is evaluated, nuclear generation produces only about 9 grams of CO2 per kilowatt-hour." [2]

- **Radiation**

  "Nuclear power plants emit no radiation exceeding background levels" [2]

- **Dependence on foreign oil?**

  Less than 3% of domestic electricity production is generated from petroleum. That number is expected to drop in the future.[19]

Policy, Economics, and Regulation

"The **Energy Policy Act of 2005** . . . provides an unprecedented level of support to the industry. The act authorizes the energy department to enter into contracts with sponsors of nuclear power plants. The federal government will guarantee to pay certain costs incurred by the sponsors if . . . operation of the plant is delayed [because of licensing or litigation]." [2]

However . . .

"The economic profitability of nuclear power remains hard to predict." [2]

“Next-generation” nuclear reactors

“New designs for reactors involve relatively modest changes in LWR technology, emphasizing improved safety management and economical design.” [2]

However . . .

“There have been no technical breakthroughs or dramatic cost reductions in either separation or transmutation technologies” [19]

Energy Independence

"Spiraling prices for hydrocarbons and prospects of their imminent extinction are encouraging more and more countries to look at **nuclear energy** as an alternative means to <u>**ensure their sustainable development**</u>. [I]t's becoming increasingly important to **link** the objective need for an **expanded use of nuclear energy** with . . . securing access for interested countries to **nuclear fuel cycle products and services**."

Conclusions

- Given the inherent complexities, massive costs, environmental hazards, and security risks involved in recycling, programs like GNEP should be attempted only when necessary and technologically feasible. [16]
- Spent fuel stored at Yucca Mountain would remain available for reprocessing and transmuting for many decades." [10]
- The availability of safe, proven, low-cost dry cask storage technology will allow spent fuel to be stored for many decades – while reprocessing and recycling technologies, infrastructure, and regulatory framework can be established. [14]

References

1. "Stuck on a solution"
Allison McFarlane
Bulletin of the Atomic Scientists, May/June 2006
http://thebulletin.metapress.com/content/8l138g1h42h77301/fulltext.pdf
2. "Is Big LULU Back In Town? The Revitalization of Nuclear Power"
Fred Bosselman
Planning & Environmental Law, October 2005 Vol. 57, No. 10 | p. 3
3. "The Nuclear Fuel Cycle"
Uranium Information Center Ltd.
http://www.uic.com.au/nfc.htm
4.
A. "Nuclear Fuel Cycle"
Wikipedia
http://en.wikipedia.org/wiki/Nuclear_fuel_cycle
B. "Nuclear Power"
Wikipedia
http://en.wikipedia.org/wiki/Nuclear_power
C. "Nuclear Reprocessing"
Wikipedia
http://en.wikipedia.org/wiki/Nuclear_reprocessing

5. "The Global Nuclear Energy Partnership"
Energyscience.org
http://www.energyscience.org.au/FS14%20GNEP.pdf
6. "Storage of Spent Nuclear Fuel"
Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report (2006)
Board on Radioactive Waste Management
http://books.nap.edu/openbook.php?isbn=0309096472
7. "Nuclear Fuel Reprocessing: U.S. Policy Development"
Anthony Andrews
CRS Report for Congress RS22542, November 29, 2006
http://www.fas.org/sgp/crs/nuke/RS22542.pdf, or
http://cnie.org/NLE/CRSreports/06Dec/RS22542.pdf
8. "Plutonium and Reprocessing of Spent Nuclear Fuel"
Frank N. von Hippel
Science, Volume 293, Number 5539, Issue of 28 Sep 2001, pp. 2397-2398
http://www.princeton.edu/~globsec/publications/pdf/Sciencev293n5539.pdf
9. "Reprocessing: Just within reach?"
Stephanie Cooke
Bulletin of Atomic Scientists, Vol. 62, No. 4, July/August 2006, pp. 14-17
http://thebulletin.metapress.com/content/b2lth35562491562/fulltext.pdf
10. "Is U.S. Reprocessing Worth The Risk?"
Steve Fetter and Frank N. von Hippel
Arms Control Today, September 2005
http://www.armscontrol.org/act/2005_09/fetter-vonhippel.asp

11. “Nuclear Waste Disposal for the Future: The Potential of Reprocessing and Recycling”

Nuclear Energy Institute, March 2006

http://www.nei.org/documents/White%20Paper_Reprocessing%20and%20Recycling_0306.pdf

12. “Waste Transmutation: The Nuclear Alchemy Gamble”

Annie Makhiani and Hisham Zerriffi

Institute for Energy and Environmental Research

http://www.ieer.org/sdafiles/vol_8/8-3/transm.html

13. “Assessing the Benefits, Costs, and Risks of Near-term Reprocessing and Alternatives”

Matthew Bunn, BCSIA – Harvard University

http://bcsia.ksg.harvard.edu/BCSIA_content/documents/INMM06_MBunn.pdf

14. “The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel”

Matthew Bunn et al., December 2003

Project on Managing the Atom, BCSIA – Harvard University

http://bcsia.ksg.harvard.edu/BCSIA_content/documents/repro-report.pdf

15. “Securing the Nuclear Fuel Cycle: What Next?”

S.V. Ruchkin and V.Y. Loginov

IAEA Bulletin, IAEA, September 2006

http://www.iaea.org/Publications/Magazines/Bulletin/Bull481/pdfs/rushkin.pdf

16. "Peddling Plutonium: Nuclear Energy Plan Would Make the World More Dangerous"

Thomas Cochran and Christopher Paine

Natural Resources Defense Council, Analysis: March 2006

http://www.nrdc.org/nuclear/gnep/agnep.pdf

17. "Radioactive Wastes and the Global Nuclear Energy Partnership (GNEP)"

Robert Alvarez

Institute for Policy Studies, February 20, 2007

18. "Global Nuclear Energy Partnership Strategic Plan"

U.S. Department of Energy, Office of Nuclear Energy, Office of Fuel Cycle Management

January 2007

http://www.gnep.energy.gov/pdfs/gnepStrategicPlanJanuary2007.pdf

19. "Greenpeace Fact Sheet: The Global Nuclear Energy Partnership"

Greenpeace

http://www.greenpeace.org/usa/assets/binaries/lobal-nuclear-energy-partnersh

20. United States Department of Energy

http://www.energy.gnep.gov

Appendix

Reprocessing in Your Backyard?

General Electric Company and the Global Nuclear Energy Partnership

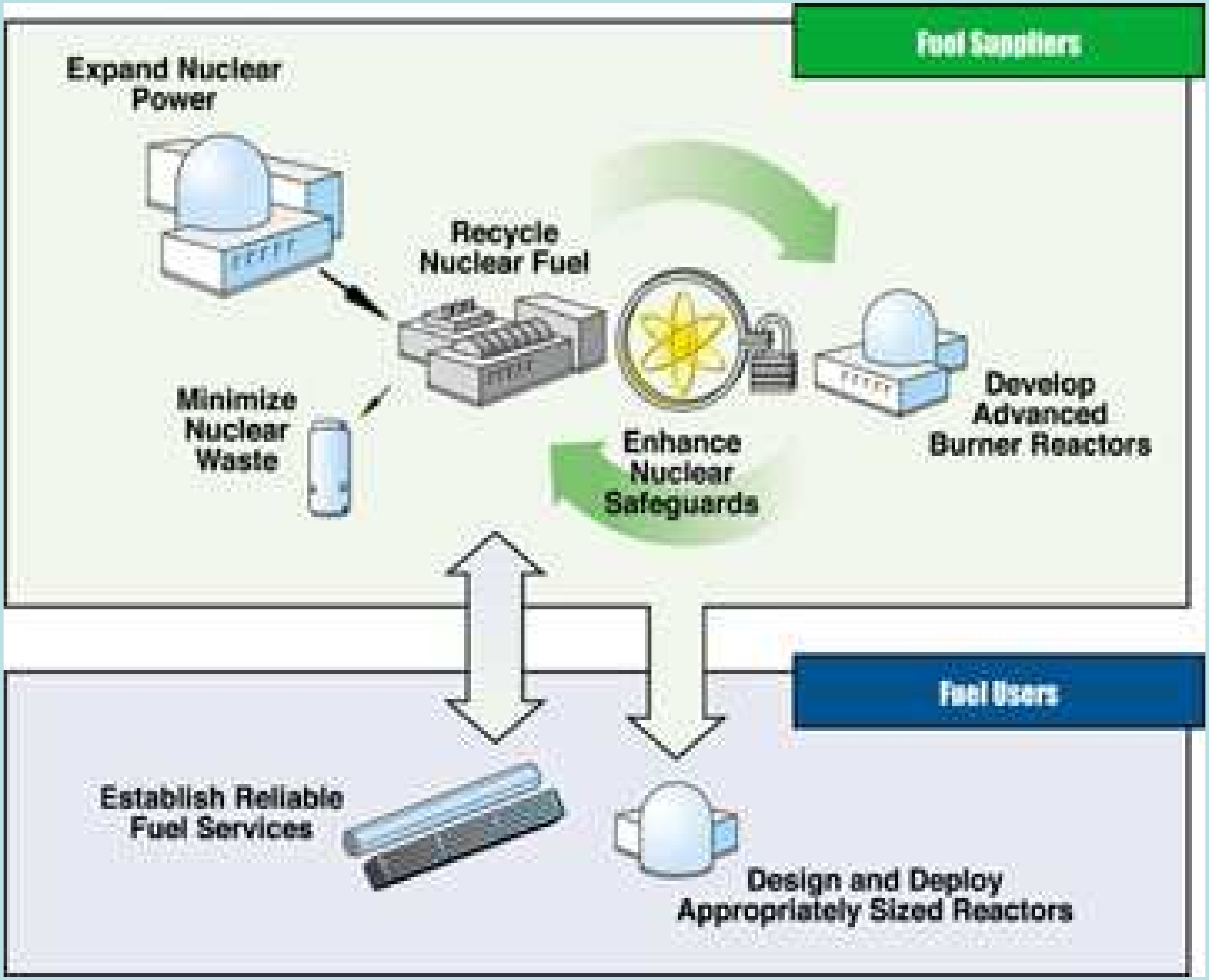
Images courtesy of the U.S. Department of Energy

See: www.gnep.energy.gov/

Maps courtesy of the U.S. Nuclear Regulatory Commission

Copied from: "Environmental Assessment for the License Renewal of the General Electric Morris Operation Independent Spent Fuel Storage Installation In Morris, Illinois"

GNEP's Closed Fuel Cycle



Technology

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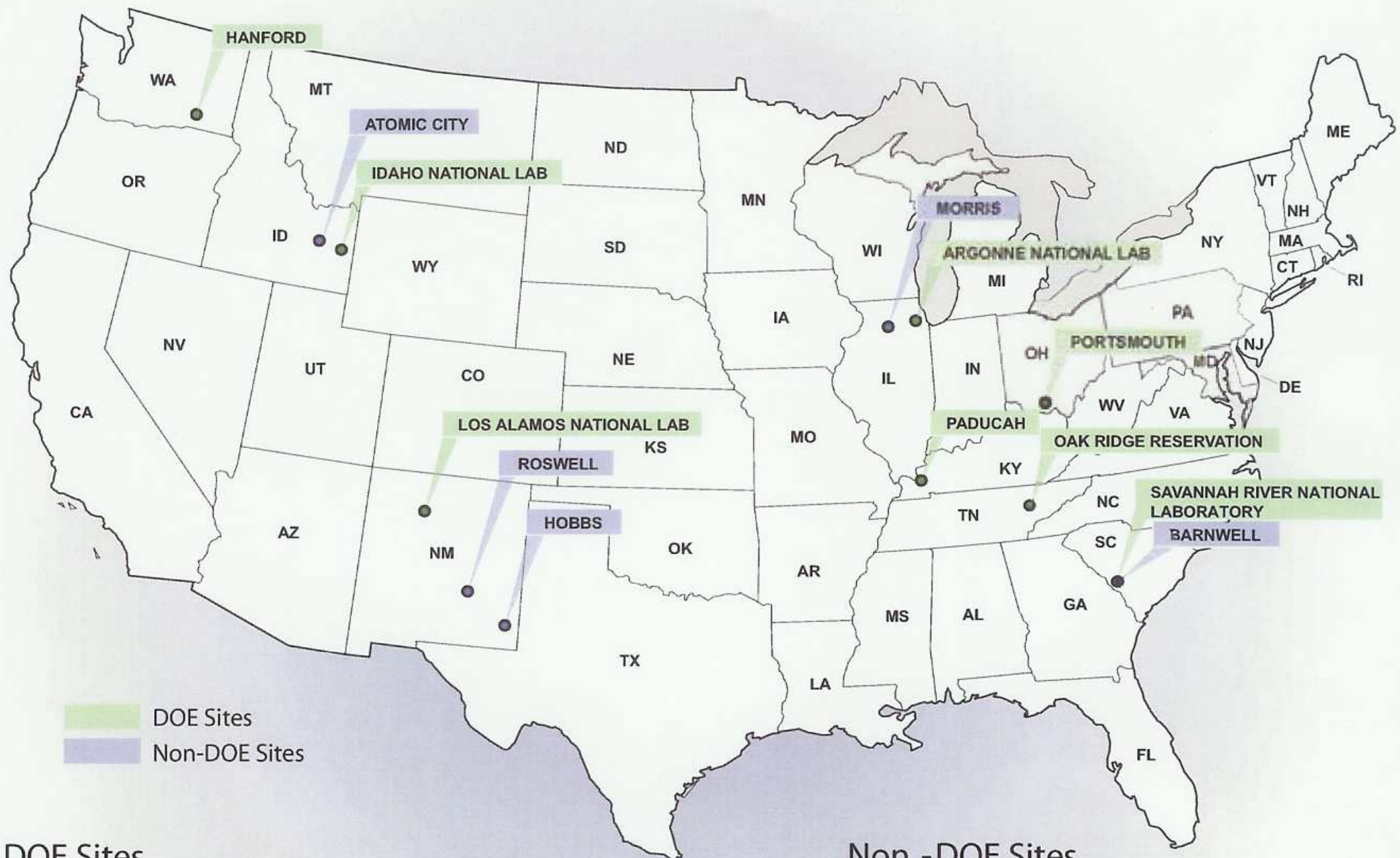
2. An advanced recycling reactor to transform the actinides (while producing electricity).
3. An advanced fuel cycle research facility for developing and improving fuel cycle technology.

Proposed Sites and Award Amounts

1. Atomic City, IDEnergy*Solutions*, LLC $915,4482.
2. Barnwell, SCEnergy*Solutions*, LLC $963,1513.
3. Hanford Site, WATri-City Industrial Development Council/Columbia Basin Consulting Group $1,020,0004.
4. Hobbs, NM Eddy Lea Energy Alliance $1,590,0165.
5. Idaho National Laboratory, IDRegional Development Alliance, Inc $648,7456.
6. **Morris, IL General Electric Company $1,484,8757.**
7. Oak Ridge National Laboratory, TNCommunity Reuse Organization of East Tennessee $894,7048.
8. Paducah Gaseous Diffusion Plant, KYPaducah Uranium Plant Asset Utilization, Inc. $664,6009.
9. Portsmouth Gaseous Diffusion Plant, OHPiketon Initiative for Nuclear Independence, LLC $673,76110.
10. Roswell, NMEnergy*Solutions*, LLC $1,134,52211.
11. Savannah River National Laboratory, SCEconomic Development Partnership of Aiken and Edgefield Counties $468,420



DOE Sites

- Argonne National Laboratory (Illinois)
- Hanford (Washington)
- Idaho National Laboratory (Idaho)
- Los Alamos National Laboratory (New Mexico)
- Oak Ridge Reservation (Tennessee)
- Paducah (Kentucky)
- Portsmouth (Ohio)
- Savannah River National Laboratory (South Carolina)

Non -DOE Sites

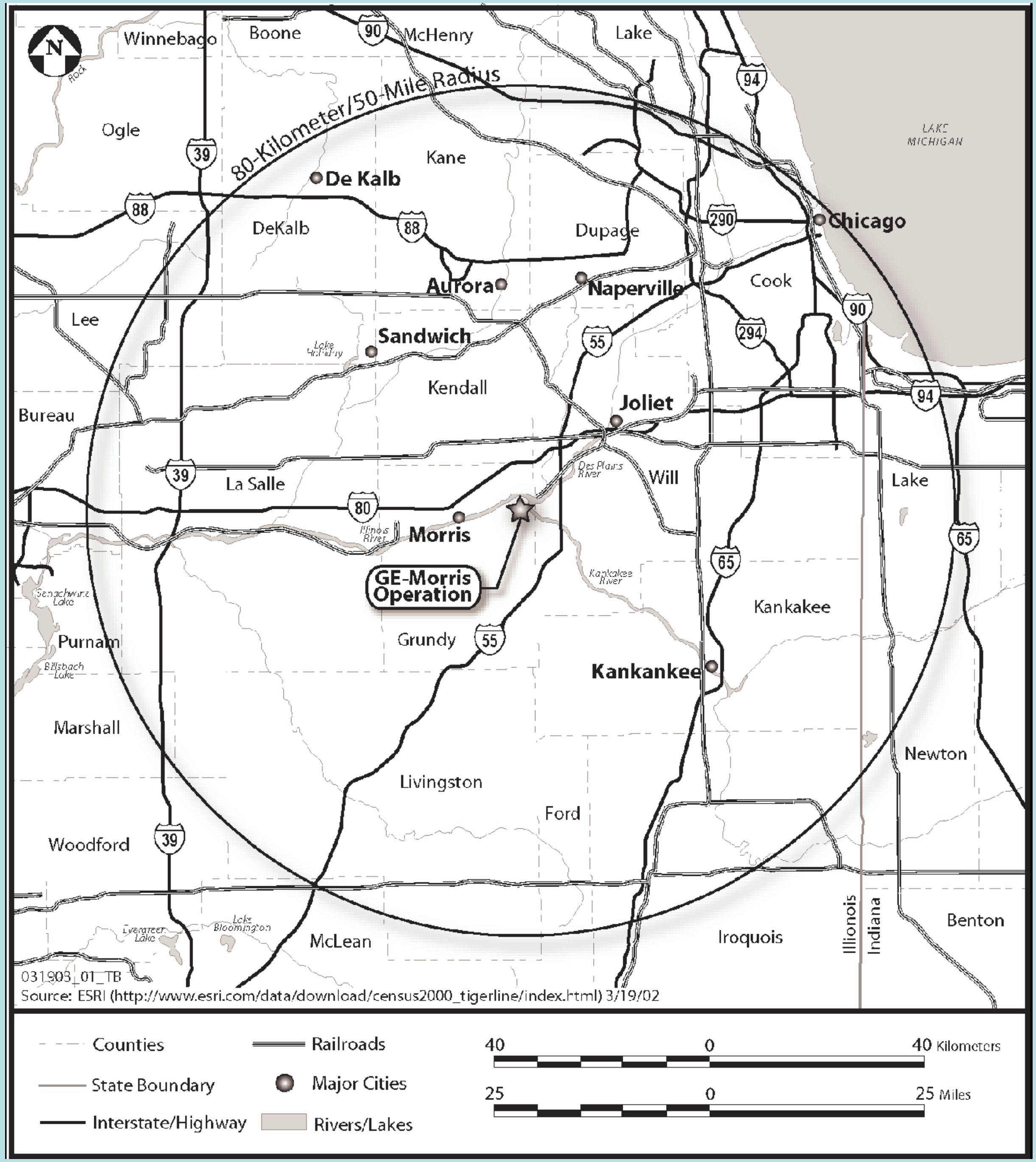
- Atomic City, Idaho
- Barnwell, South Carolina
- Hobbs, New Mexico
- Morris, Illinois
- Roswell, New Mexico

GE-Morris: Reprocessing Redux?

- GE originally designed the Morris facility as a spent fuel reprocessing plant in 1964, and in 1965, the AEC authorized GE to construct the facility
- In 1972, GE halted construction and in 1974 the AEC terminated the construction permit
- In 1975 the plant was licensed to receive and store up to 750 MTU of spent fuel
  - The GE-Morris Facility is the only away-from-reactor spent fuel pool in the U.S.
- In 2006, GE received $1.5 million to conduct a detailed siting study for GNEP facilities

Morris, Illinois in relation to Chicago and Major Suburbs

Note the location of Interstate Highways 55 and 80

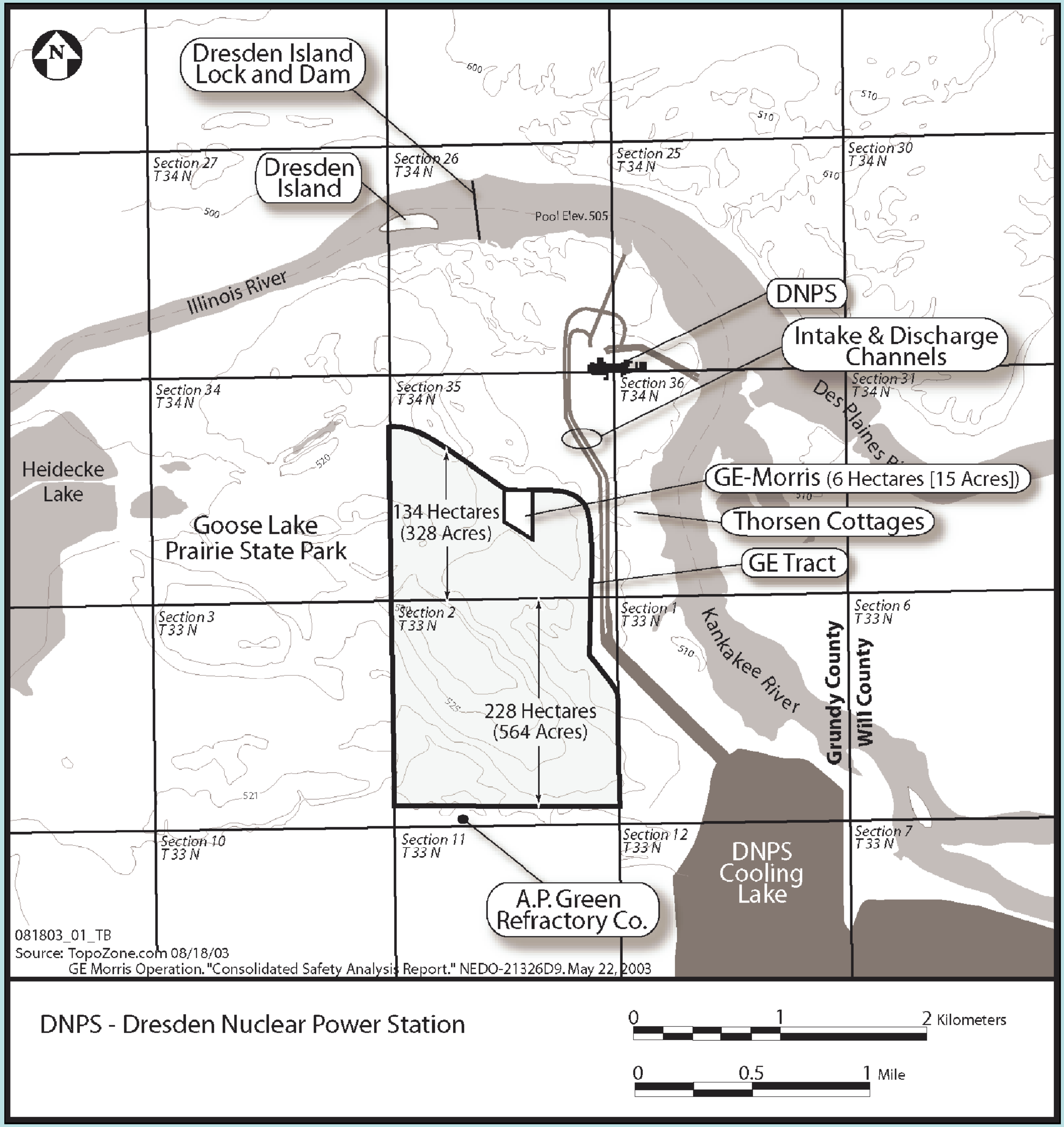


The GE-Morris (GEMO) Property

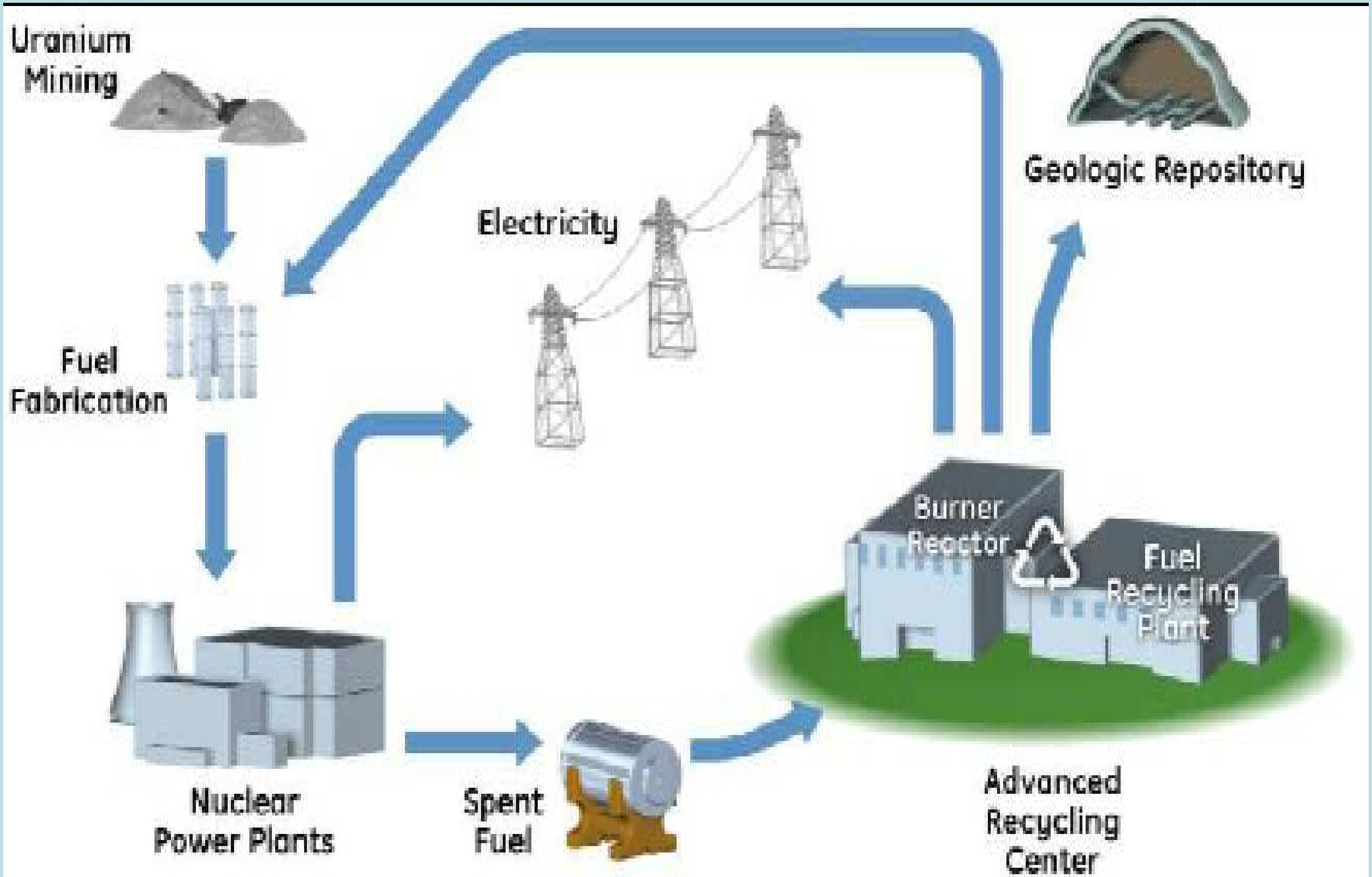
Note the location of the DNPS – Dresden Nuclear Power Station

Note the confluence of the Des Plaines and Kankakee Rivers which join to form the Illinois River

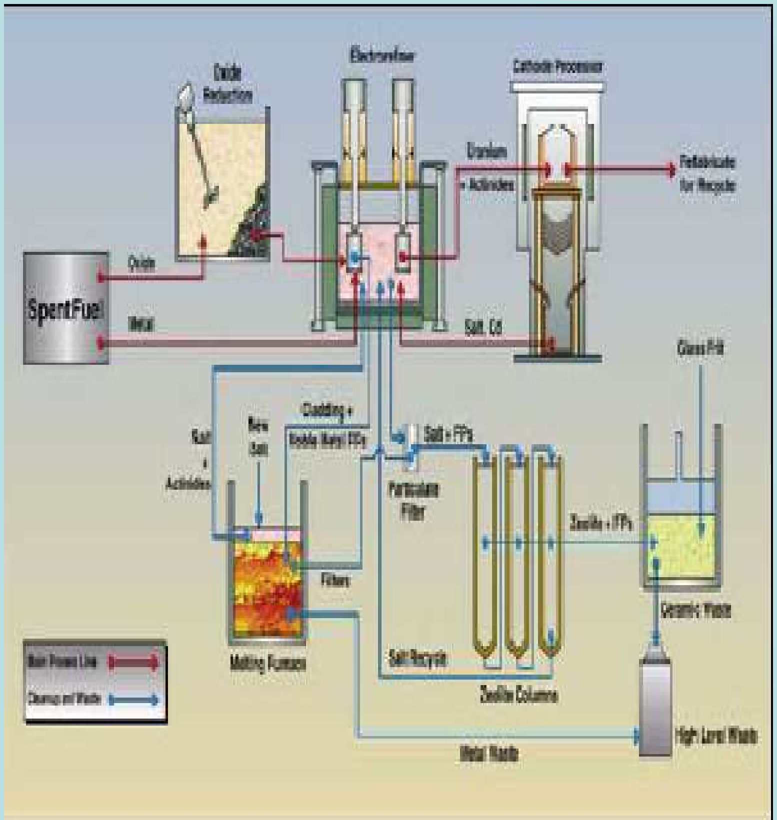
Note the location of Goose Lake Prairie State Park



GE's GNEP Integrated Solution

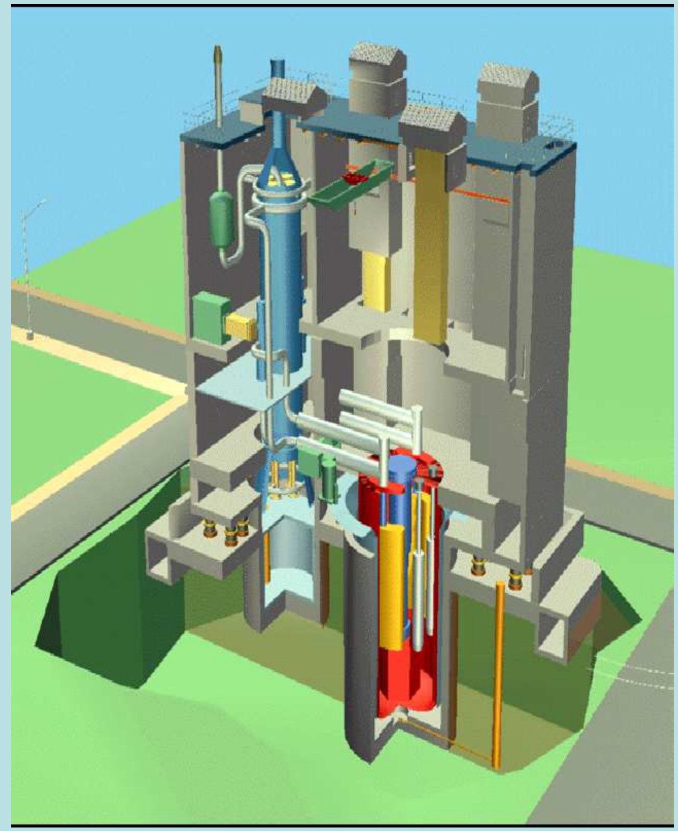


Reprocessing Facility
Pyroprocessing
Electro-refining



Removes all actinides together

Advanced
Burner/Recycling
Reactor
PRISM



Sodium Cooled

Metal or oxide fueled