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Approaches to Reducing Proliferation Risk in the Civilian Nuclear Fuel Cycle: International Control or Management of Sensitive Technologies

Weapons of Mass Destruction Non-Proliferation Science and Policy

Political Science #400; Sociology #398

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What's the Problem? What's the Solution?

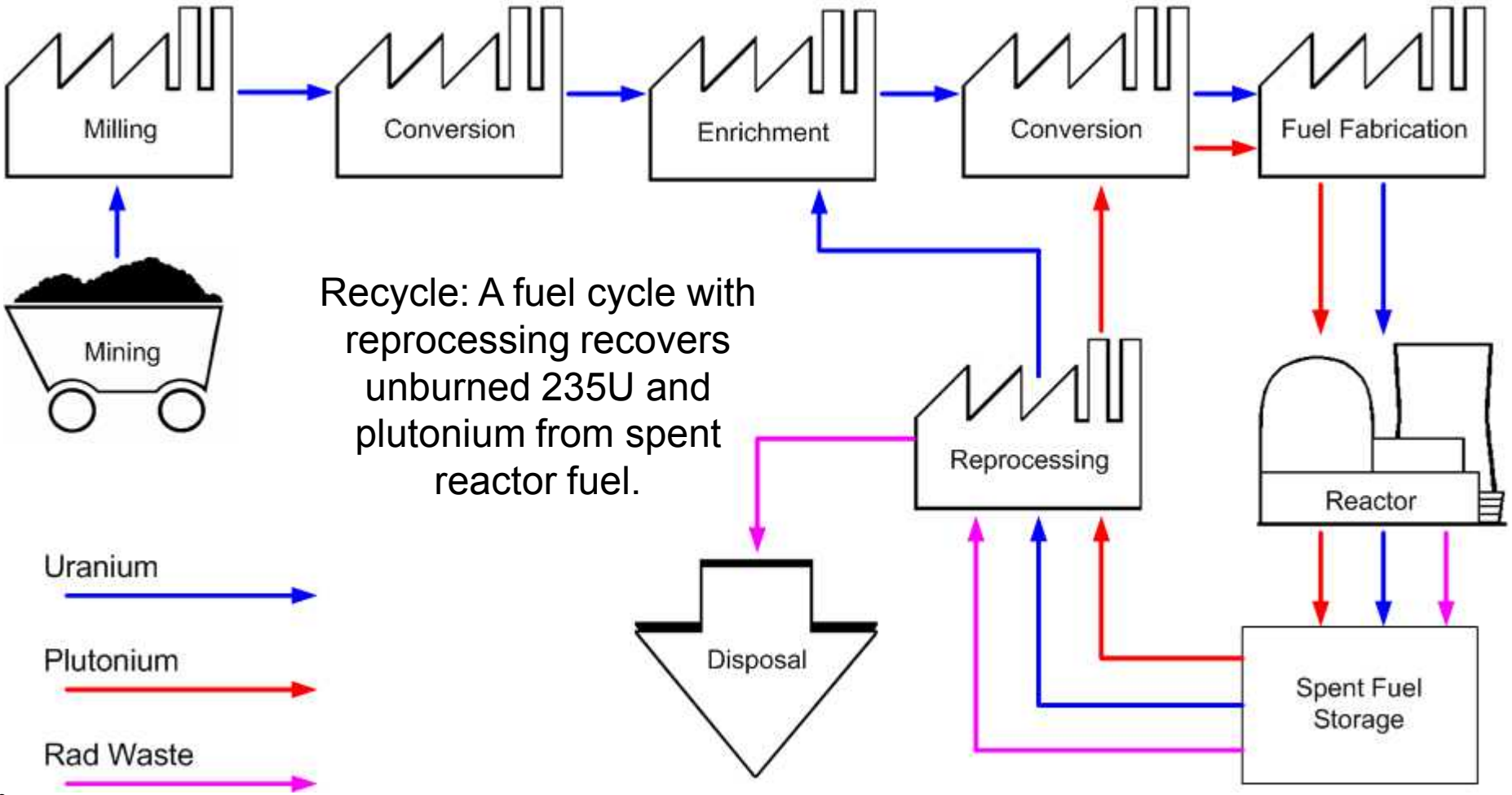
- "**. . .by developing atomic energy for peaceful uses, you reach the nuclear weapon option. There are not two atomic energies.**"

  David Bergman, former Chair, Israeli Atomic Energy Commission

- **Goal: Reduce the risk that states can acquire the capabilities to develop nuclear weapons; Maintain a separation between peaceful and non-peaceful uses of nuclear energy**
  - **Reduce the risk that states might believe that their neighbors were acquiring the capabilities to develop nuclear weapons**
- **Elements of a nuclear weapons capability**
  - **Material**
  - **Technology**
  - **Expertise**
  - **Motivation**
- **Solutions**
  - **Restrict access to key elements**
  - **Monitor the use of key elements**
  - **Reduce the motivation**

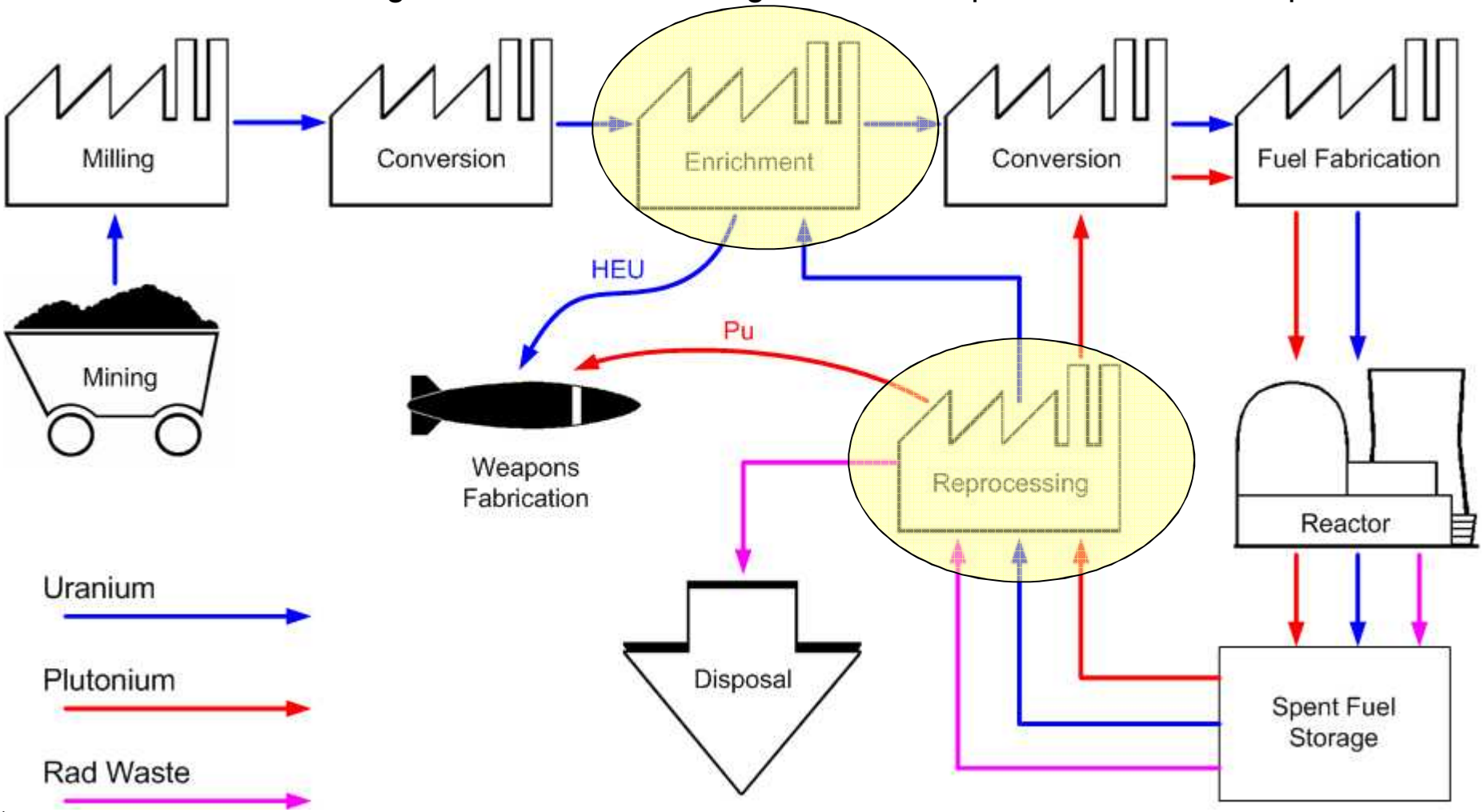
Restricting the dispersion of sensitive materials and technologies can limit opportunities and reduce misperceptions

The Civilian Nuclear Fuel Cycle: A Review

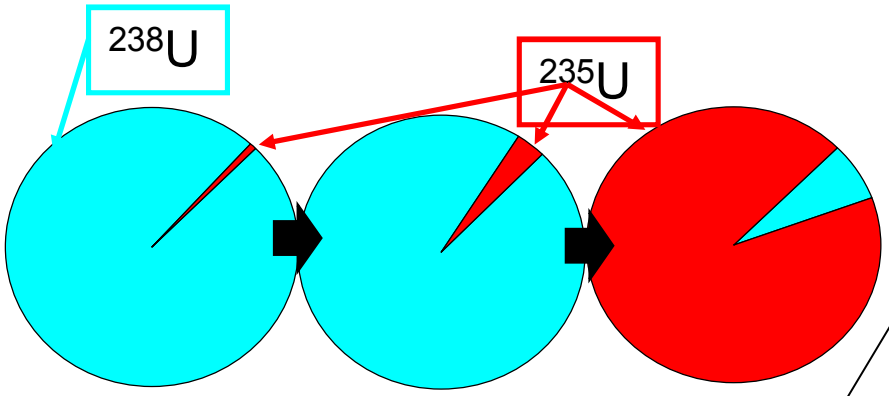


The Civilian Nuclear Fuel Cycle: A Review

Plutonium and high-enriched uranium might be used to produce nuclear weapons.

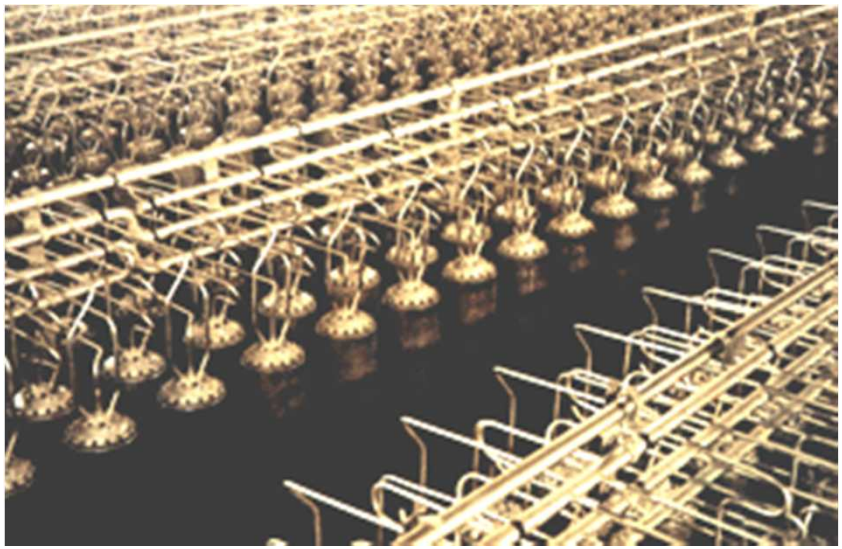


Review: Uranium Enrichment



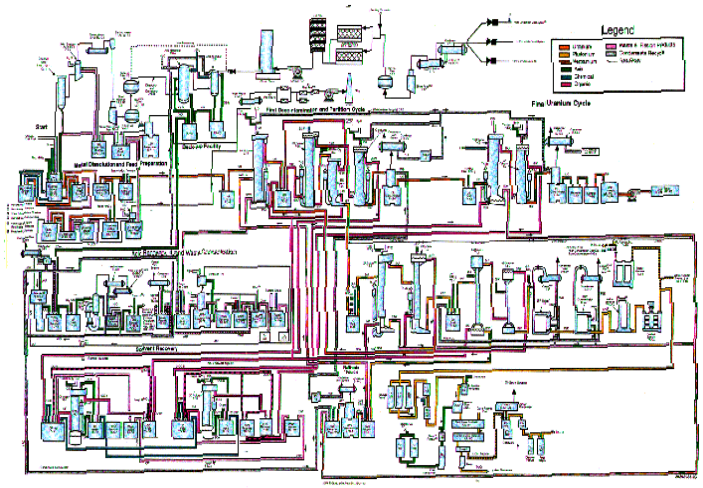
- **Enrichment methods**
  - **Gas Centrifuge: spin uranium hexafluoride gas**
  - **Gaseous Diffusion: force UF6 gas through a membrane**
  - **Electromagnetic Isotope Separation (EMIS)**
  - **Aerodynamic/Jet Nozzle**
  - **Laser Methods**
  - **Chemical Methods**

- **Gas centrifuge**
  - **Can be small**
  - **Low energy consumption**
  - **Easy to reconfigure**
  - **Technology available (A.Q. Khan)**



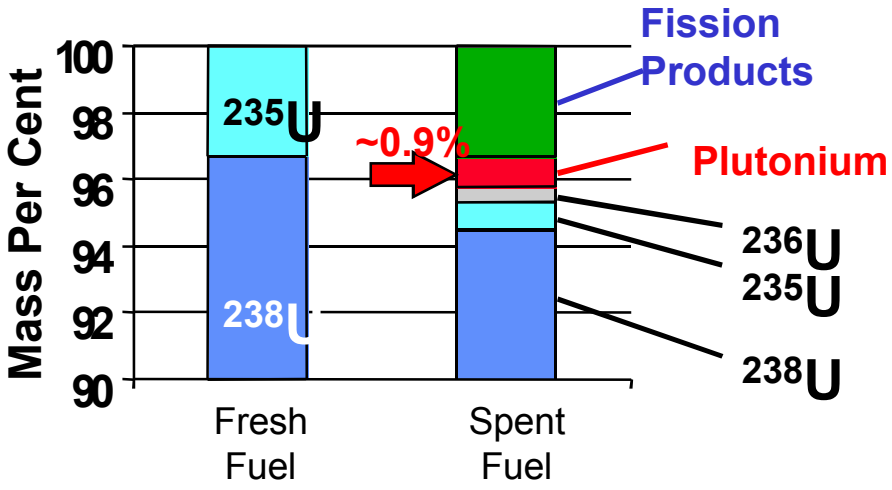
Review: Reprocessing

- Chemical separation of elements
- Current commercial method – PUREX
  - Plutonium and Uranium Recovery by Extraction
- Other methods
  - UREX, COEX (no Plutonium separation)
  - Pyroprocessing



PUREX Chemical Flow Scheme

Light-water reactor fuel:



Origins

- **"Three Nation Agreed Declaration on Atomic Energy" (November 1945) - U.S., UK and Canada**
  - **Atomic weapons are a type of weapon "in the employment of which no single nation can in fact have a monopoly"**
  - **Willing "to proceed with the exchange of fundamental scientific literature for peaceful ends with any nation that will fully reciprocate"**
  - **But, limit information about atomic energy until safeguards against improper use developed**
  - **Proposes international control**
  - **US., UK and Soviet Union propose a United Nations Atomic Energy Commission (UNAEC) - 27 December 1945**

Preventing Misuse: International Control of Technology, Facilities, and Activities

- ***Report on the International Control of Atomic Energy*** **(Acheson-Lilienthal Report - March 1946)**
  - **". . .no prospect of security. . .in a system of international agreements . . . controlled only by a system which relies on inspection and similar police-like methods."**
  - **An effective safeguards system must look to "the promise of man's future well-being as well as to his security"**
  - **Proposed an international agency to conduct all "intrinsically dangerous operations in the nuclear field"**

Dean Acheson and David Lilienthal

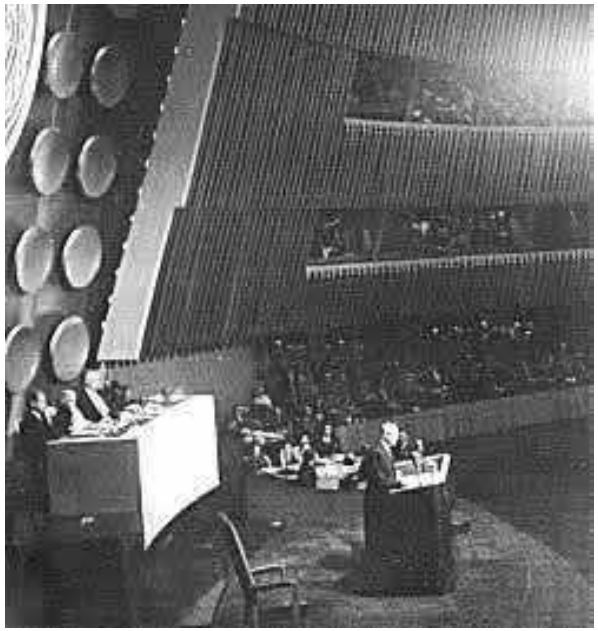
- **Dangerous activities should be carried out by an international authority**
  - **Safe activities should be left to states**
  - **Authority must also have a development function**
- **Dangerous:**
  - **Mining and refining of uranium and thorium**
  - **Uranium enrichment**
  - **Production and separation of plutonium**
  - **R&D in atomic explosives**

Preventing Misuse: International Control
The Baruch Plan

- **Baruch Plan (June 1946)**
  - **Bernard Baruch appointed to** United Nations Atomic Energy Commission by President Truman
  - **Proposes the creation of an International Atomic Development Authority to control "all phases of the development and use of atomic energy, starting with the raw material and including:**
    - **All potentially dangerous atomic energy activities**
    - **Control and inspection of all other atomic activities**
    - **Promoting the beneficial uses of atomic energy**
    - **Research and development to put the Authority "in the forefront of atomic knowledge and thus to enable it to comprehend, and therefore to detect, misuse of atomic energy."**
  - **The US proposed turning over all of its weapons if others would agree not to produce them.**
  - **Soviet Union rejected the plan**
    - **Argued UN was dominated by U.S. and could not be trusted**
  - **Also attacked on economic grounds**

Preventing Misuse: Rules and Verification Atoms for Peace (1953)

- **Speech by President Eisenhower to the UN General Assembly**
  - Nuclear energy development can occur on a national basis
  - Create an international agency to share material and equipment under safeguards
  - Seeks to create a uranium bank with contributions from U.S. and Soviet Union
  - Facilities and technologies offered in return for political commitment to peaceful use



Preventing Misuse: Rules and Verification
International Atomic Energy Agency (1957)

- **International Atomic Energy Agency**
  - Premised on the belief that it was possible to establish verifiable rules and conditions
  - Promote peaceful uses
  - Authorized to administer safeguards, but only in limited circumstances:
    - IAEA supplies assistance
    - State requests safeguards
    - Requested by parties to a bilateral or multilateral agreement

Objective:

"to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world."

Preventing Misuse: Rules and Verification
The NPT (1968) and Safeguards

- **NPT**
  - All non-nuclear weapons state (NNWS) parties must conclude a comprehensive safeguards agreement (CSA) with the IAEA
    - NNWS insisted that safeguards obligations not infringe on NPT Article IV "inalienable right . . . to develop research, production and use of nuclear energy for peaceful purposes"
    - Minimize intrusion and protect commercial interests
- **Safeguards**
  - Focus on nuclear material

Sounds good, right?

Smiling Buddha

- India's "Peaceful Nuclear Explosion" (May 18, 1974)
- Did the regime fail?
- What effect did responses have?

Pokhran

Indira Gandhi

- **Responses**
  - **Establishment of the Nuclear Suppliers Group**
  - **1975 NPT Review Conference:**

    "regional or multilateral nuclear fuel cycle centres may be an advantageous way to satisfy, safely and economically, the needs of many States, while, at the same time facilitating protection and the application of safeguards."

Export Control

- **Article III.2 of the NPT**
  - **Signatories shall not provide "designed or prepared equipment or material for the processing, use or production of special fissionable material."**
- **Zangger Committee (1972)**
  - **Maintains a Trigger List (triggering safeguards as a condition of supply) of nuclear-related strategic goods to assist NPT Parties in identifying equipment and materials subject to export controls.**
- **Nuclear Suppliers Group (1974)**
  - **Voluntary arrangement of 45 supplier states**
  - **Requires recipients to implement safeguards**
- **Implementation of national export control laws**
  - **Training and assistance programs**
- **UNSCR 1540**

Is technology denial a successful long-term strategy?

Multilateral Approaches to Fuel Cycle Services

- **Goals**
  - Restrict access to, or reduce the spread of, sensitive fuel cycle technologies (enrichment and reprocessing)
    - Attempt to control misuse rather than detect it
  - Ensure security of supply
- **Potential models:**
  - Supplier state commitments (market based)
    - With or without international guarantees
    - E.g., Long-term contracts plus a fuel bank
  - Multinational ownership
    - Shareholders vs. Operators
  - International control

1970s

- Regional Nuclear Fuel Cycle Centers (1975-1977)
  - Pool resources; Focus on reprocessing
  - Technically valid; Economically attractive
  - Concerns about: Technology transfer, Physical protection, Host country obstruction
  - No action taken
- International Nuclear Fuel Cycle Evaluation (INFCE) (1977-1980)
  - Multinational fuel cycle facilities; storage of plutonium
  - Proliferation resistant fuel cycles and improved safeguards
  - No single approach better than another
  - Impact of technical measures limited
  - No demand for international storage
- International nuclear fuel supply agency or authority (1978)
  - Fuel bank

1980s

- Committee on International Plutonium Storage (IPS) (1978-1982)
  - Convened to consider IAEA storage and management of plutonium under Article XII.A.5
  - Group failed to reach agreement on how such a system should work, where material would be stored, rules of access, "what is *excess* plutonium?"
- Committee on Assurances of Supply (CAS) (1980-1987)
  - Role of IAEA in multilateral fuel cycle service systems
    - Should fuel and technology suppliers be able to impose their own constraints?
  - Group failed to reach agreement on same issues as IPS Committee
- Conference for the Promotion of International Cooperation in the Peaceful Uses of Nuclear Energy (UNCPICPUNE) (1987)

All failed. Why?

Commitments and conditions of membership?

Multinationalism in Action

- EUROCHEMIC - Belgium (1957-1979)
  - Reprocessing training center
  - NOT a means of averting the spread of technology
  - Couldn't compete with national facilities
- United Reprocessors Group (URG) (1970s)
  - UK, France, Germany
  - Rationalize existing capacity; Avoid competition
  - Did cause Germany to postpone development of national capability
- URENCO (ongoing)
  - UK, Germany, Netherlands - Facilities in all three states
  - Sell services
  - AQ Khan
- EURODIF (ongoing)
  - Original shareholders: France, Italy, Spain, Belgium (and Iran!) - One facility (France)
  - Services for members
  - Iran still a shareholder but receives no services

All restricted technology transfer but did so for commercial reasons

Why did enrichment consortia succeed where reprocessing consortia failed?

IAEA Study: "Multilateral Approaches to the Nuclear Fuel Cycle" (2005)

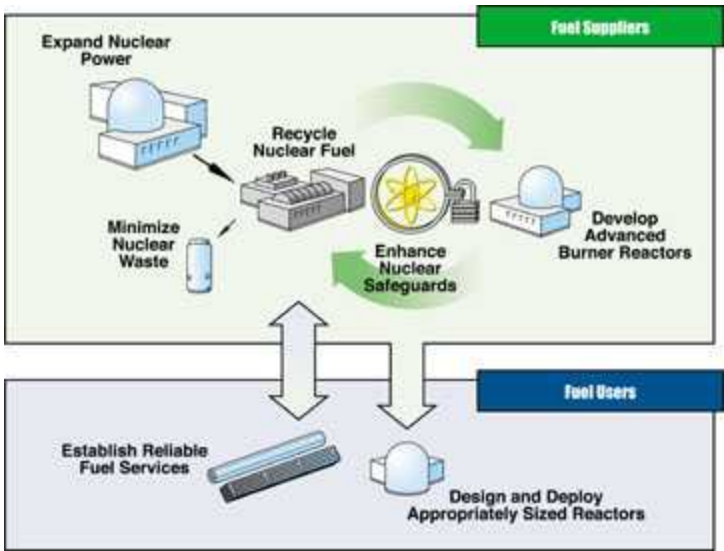
- "Towards a Safer World" - Dr. Mohamed ElBaradei
- Mandate:
  - Analyze options
  - Overview of policy, legal, security, economic, institutional, and technological incentives and disincentives
- Options identified
  - Assurance of supply not involving ownership
  - Conversion of existing facilities to multinational facilities
  - Construction of new joint facilities
- Findings
  - Uranium enrichment can be handled by the market
  - Enough reprocessing capacity exists – no need for new facilities
  - No market for spent fuel disposal
  - Political issues matter most
  - Voluntary participation model more likely to succeed than binding

"A joint undertaking with multinational staff puts all participants under a greater scrutiny from peers and partners, a fact that strengthens non-proliferation and security." Bruno Pellaud - Chairman

Global Nuclear Energy Partnership

- "Greater Energy Security in a Cleaner, Safer World"!!
- Two kinds of states:
  - Fuel Cycle Nations - Reactors and fuel cycle facilities
  - Reactor Nations - Lease fuel
- Technologies
  - Advanced reprocessing (no separated Plutonium; minimize waste; more proliferation resistant)
  - Fast burner reactors (minimize waste)
  - Advanced safeguards
- Questions
  - Voluntary or binding?
  - Technology driven?
  - Economical?
  - When will benefits be realized?
  - Haves and have nots?

- Implementing Elements
  - Nuclear Power Expansion
  - Proliferation-Resistant Recycling
  - Minimized Nuclear Waste
  - Advanced Burner Reactors
  - Reliable Fuel Services
  - Appropriately Sized Reactors
  - Nuclear Safeguards



Do We Need a New Bargain (and if so, what is it?)

- Current bargain:
  - "inalienable right" (Art IV) in return for assistance and promise not to develop weapons

- Is the "regime" broken or weakened? Why?
- Does greater control over the spread of technology help?
  - Does it create new risks?
- Are the "suppliers" trustworthy?
- What does it say if you don't participate?

Questions for 27 March Exercise:

- What is the proper (necessary) balance of benefits and restrictions?
- How do multilateral approaches fit (or not fit) with other nonproliferation tools?
- Should the IAEA (or other international bodies) play a role?
- Under what conditions would you supply services?
- Under what conditions would you participate as a "user"?