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Closing the US Fuel Cycle: Siting Considerations for the Global Nuclear Energy Partnership Facilities – Siting the Advanced Fuel Cycle Facility

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ABSTRACT

The Global Nuclear Energy Partnership (GNEP), launched in February, 2006, proposes to introduce used nuclear fuel recycling in the United States (U.S.) with improved proliferation-resistance and a more effective waste management approach. This program is evaluating ways to close the fuel cycle in a manner that introduces the most advanced technologies of today and builds on recent breakthroughs in U.S. national laboratories while drawing on international and industry partnerships. Central to moving this advanced fuel recycling technology from the laboratory to commercial implementation is the development and siting of three proposed GNEP facilities: the Consolidated Fuel Treatment Center (CFTC), the Advanced Burner Reactor (ABR), and the Advanced Fuel Cycle Facility (AFCF). These three projects are envisioned to introduce used fuel separations, advanced fuel fabrication, and fast reactor technology in a manner that efficiently recycles material, produces the most energy out of the existing inventory of used fuel, and improves our ability to manage nuclear waste. The CFTC and ABR are sited under GNEP but will depend on industry involvement and will not be covered by this paper. This paper will cover considerations for siting the AFCF. The AFCF will provide the U.S. with the capabilities required to evaluate technologies that separate used fuel into reusable material and waste in a proliferation-resistant manner. The separations technology demonstration capability is coupled with a remote transmutation fuel fabrication demonstration capability in an integrated manner that demonstrates advanced safeguard technologies.

INTRODUCTION

As part of President Bush's Advanced Energy Initiative, the Global Nuclear Energy Partnership (GNEP) has three key elements supporting domestic U.S. Nuclear Energy Strategy:

(1) The expansion of nuclear power to help meet growing energy demand in an environmentally sustainable manner.
(2) The development, demonstration, and deployment of advanced technologies for recycling used nuclear fuel that do not separate plutonium, with the goal over time of ceasing separation of plutonium and eventually eliminating excess stocks of civilian plutonium and drawing down existing stocks of civilian used fuel.
(3) The development, demonstration, and deployment of advanced reactors that consume transuranic elements from recycled Light Water Reactor (LWR) and fast spectrum reactor used nuclear fuel.

These elements are envisioned in a manner that will improve the waste management and the proliferation-resistance over those practices used today.

As part of the GNEP strategy [1], three projects were proposed in support of GNEP. Current planning calls for two industry-led projects: a nuclear fuel recycling center to separate used light water reactor fuel and transmutation fuel and to fabricate transmutation fuel, and an advanced recycling reactor in which the transmutation fuel will be consumed. These two projects fulfill elements 2 and 3 above. The third project proposed under GNEP is the Advanced Fuel Cycle Facility (AFCF). This facility is envisioned as a multi-functional research, development, and demonstration facility that bridges the gap between laboratory-scale development and commercial deployment of advanced technologies that are needed to achieve the fuel recycling, waste management, and proliferation-resistance objectives of GNEP.

Figure 1 illustrates how these three facilities are intended to work together in order to achieve the goals of both GNEP and the President's Advanced Energy Initiative. The Consolidated Fuel Treatment Center (CFTC) — one of the industry-led GNEP projects — will receive used nuclear fuel and perform the necessary separations step to provide feedstock for fuel fabrication, also to be performed at the CFTC. The CFTC design throughput for used LWR fuel is on a commercial scale The CFTC will provide the fuel assemblies for the Advanced Burner Reactor (ABR), the second of the two GNEP industry-led projects. These two projects have relatively near-term goals and will be developed in cooperation with industry partners. Various fuel types, reactor designs, and business plans are under current consideration. The AFCF, on the other hand, has long-term research, development, and demonstration (RD&D) goals. As an RD&D facility, it will seek new and improved ways to perform used fuel separations, develop stable waste forms, optimize fuel fabrication technologies, and produce Lead Test Assemblies (LTAs) for fast spectrum reactors. As a demonstration facility, it will deploy viable technologies on an engineering scale, a necessary step for commercialization.

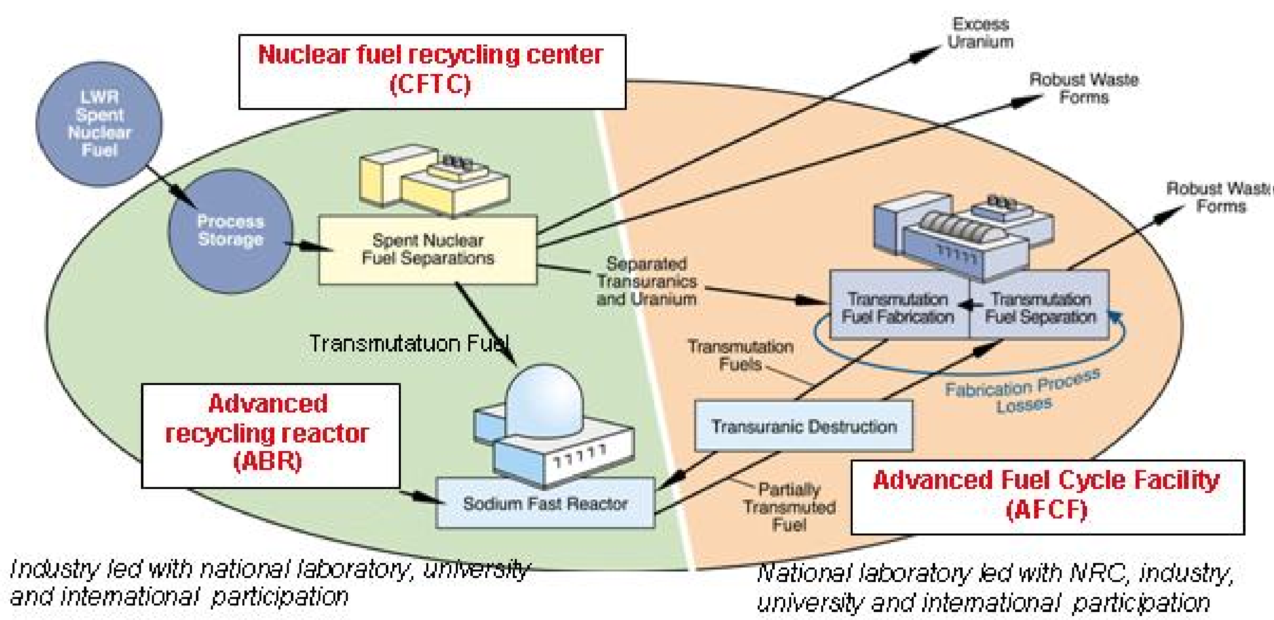

Fig. 1. The three major projects proposed under GNEP

Establishing these used fuel recycling capabilities domestically will also enable the United States to strengthen its cooperation with international partners. Key elements supporting the U.S.'s international efforts include:

(1) The establishment of supply arrangements among nations to provide reliable fuel services worldwide for generating nuclear energy, by providing nuclear fuel and taking back used fuel for recycling, without spreading enrichment and reprocessing technologies,
(2) The development, demonstration, and deployment of advanced, proliferation resistant nuclear power reactors appropriate for the power grids of developing countries and regions
(3) The development, in cooperation with the International Atomic Energy Agency, of enhanced nuclear safeguards to effectively and efficiently monitor nuclear materials and facilities, to ensure commercial nuclear energy systems are used only for peaceful purposes.

Because the AFCF is a U.S. Department of Energy (DOE), laboratory-led project that will be built on a DOE site, this paper focuses on the AFCF and the role it plays within the GNEP program. This paper considers important factors that must be addressed when establishing an advanced fuel cycle research, development, and demonstration facility in the U.S. and a focus on the technology requirements. The paper also covers the benefits of having the capabilities envisioned for the AFCF, which includes potential partnerships with industry, universities, international organizations, and regulatory agencies in the conduct and analysis of advanced technology demonstrations in preparation for their employment in commercial applications.

ADVANCED FUEL CYCLE FACILITY OVERVIEW

The AFCF will provide needed research, development, and demonstration capabilities supporting the initial and continuing activities of the program. The concept of AFCF includes the integration of four hot cell components:

- Aqueous Separations Process
- Electrochemical Separations Process
- Transmutation Fuel Fabrication
- Multi-Function Research and Development (R&D) Module

Each of these components will contribute to the development and demonstration of new waste forms and safeguards technology supporting the GNEP objectives. By providing these capabilities, the AFCF will support the commercialization of technologies first introduced in U.S. DOE laboratories and possibly laboratories from GNEP's international partners.

A conceptual building layout of the AFCF is shown in Figure 2. The facility is expected to be able to receive used fuel by both truck and rail and to place it in either wet or dry storage, as required. From there, the used fuel will undergo either aqueous or electrochemical separations in order to extract the useful components that can be refashioned into new fuel. That operation will be done in the Transmutation Fuel Fabrication module. A multifunction R&D module will be used to develop processes on a bench-scale first, and if successful there, may then be deployed on an engineering scale at the AFCF.

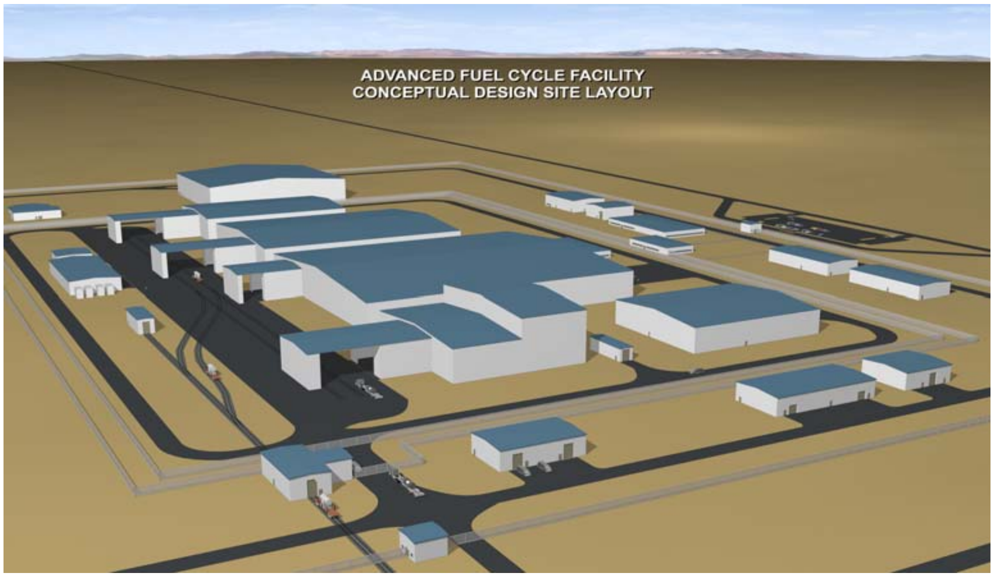

Fig. 2. A conceptual building layout of the Advanced Fuel Cycle Facility

A major goal of the GNEP program is to reduce the amount of waste sent to a geologic repository. This is to be done by closing the fuel cycle. Since the late 1970's, however, the U.S. has not been engaged in reprocessing used nuclear fuel. The uranium ore is mined, enriched, and fabricated into fuel assemblies, then placed in a power reactor for electricity generation. The used fuel is then placed into storage waiting for final disposition. This is known as the open or once-through fuel cycle. However, there is still much energy content in the used fuel that, if extracted, can be fabricated into new fuel while at the same time removing radioactive components that reduce the waste, toxicity, and heat load on a geologic repository. This is known as a closed fuel cycle. The open and closed fuel cycles are illustrated in Figures 3 and 4.

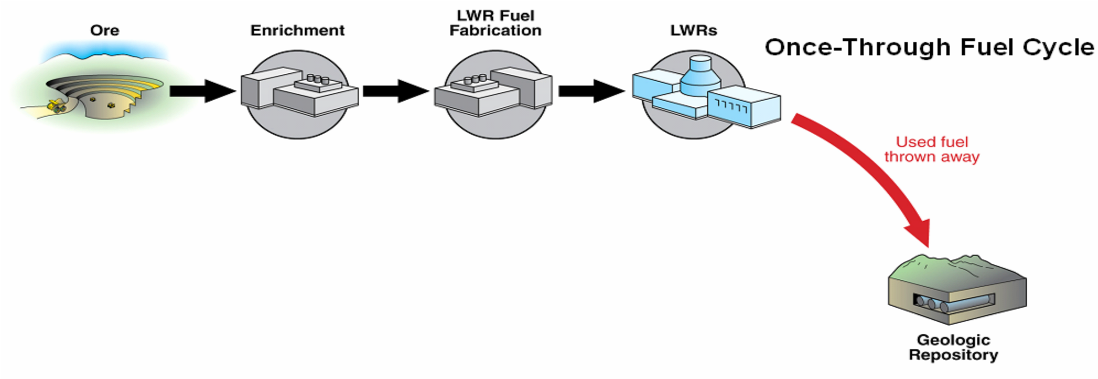

Fig. 3. Major steps for an open, or once-through, fuel cycle

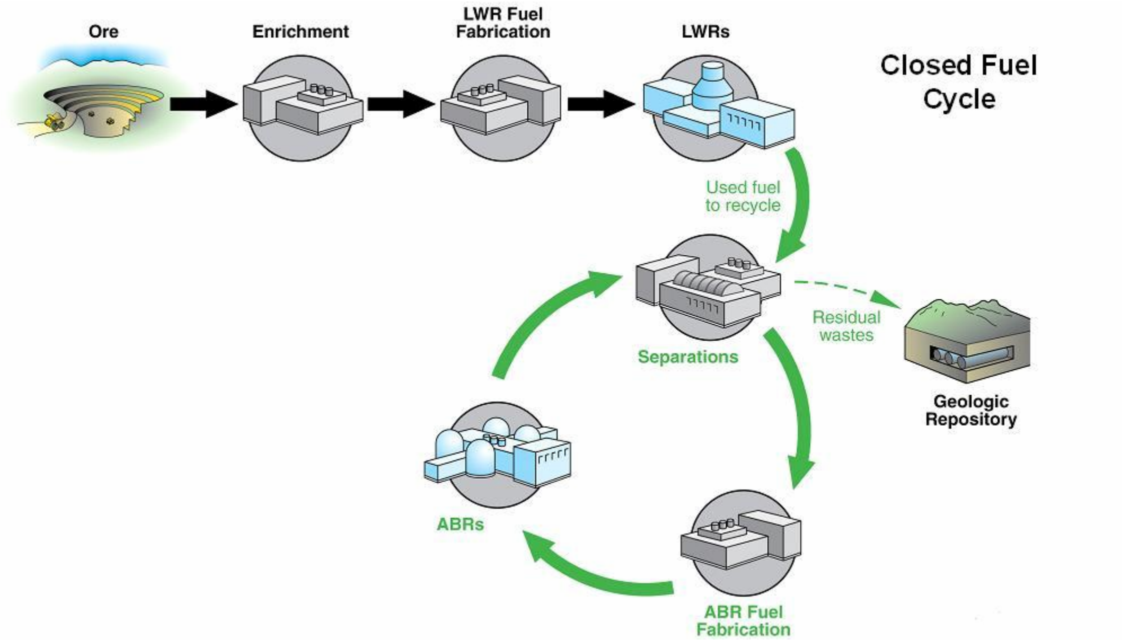

Fig. 4. Major steps for a closed fuel cycle under GNEP

ADVANCED FUEL CYCLE FACILITY MISSION NEED AND COMPONENTS

The AFCF will develop used light water reactor fuel recycling technologies from bench-scale concept testing through engineering-scale demonstrations. The AFCF will be the only facility in the world where transuranic feed materials can be fabricated into fresh transmutation fuel for a fast spectrum recycling reactor at full-size assembly scale. This step is required for qualifying such fuel for subsequent use in an Advanced Burner Reactor, also envisioned under GNEP. Equally important, the AFCF will afford a practical test bed for development and demonstration of advanced instrumentation for materials protection, control, and accountancy. As part of the "safeguards by design" strategy, demonstration of near real-time accountability for special nuclear materials and improved transparency of operations will give the U.S. the opportunity to establish a new "world standard" for design and operation of a future fuel cycle. Advanced waste form technology will also be developed and demonstrated at the AFCF. These mission areas are summarized in Figure 5, in which it illustrates how the AFCF spans the gap between laboratory-scale R&D and commercial-scale recycling.

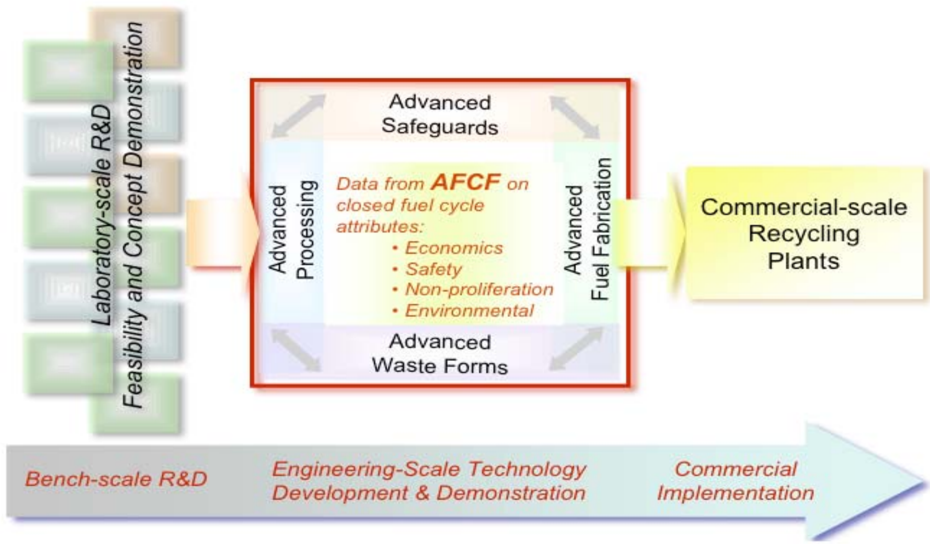

Fig. 5. Summary of AFCF Mission [2]

Aqueous Separations Processing

The AFCF will demonstrate advanced aqueous separations technologies that provide the feedstock for the production of transmutation fuels in a more proliferation-resistant manner than those deployed today. This will be true for both product and waste streams. The key advancement from existing technology will be the avoidance of producing pure plutonium; plutonium will be extracted with other elements in a manner that reduces the attractiveness of the product. By doing so, these separations processes will increase the barriers to and prevent the use of the fuel feed product for the purpose of making nuclear weapons. Examples of these advanced aqueous separations technologies are the suite of UREX+ separations modules currently being developed at DOE laboratories and the COEX^{TM} technologies developed by the AREVA company.

In addition to advanced aqueous processes that do not separate pure plutonium in the product stream, technology under development today will separate radioisotopes into waste forms that can be managed in a way that matches their risks to the most appropriate disposition methods. For example, by removing significant fractions of cesium, strontium and transuranic isotopes from light water reactor fuel before disposal, the remaining fractions (mostly fission products) can effectively increase the capacity of the proposed Yucca Mountain repository.[3] Once separated and captured into stable waste forms, cesium and strontium could be placed in decay storage for several half-lives then followed by disposal as low-level waste or other means that protects the public at lower cost. The separated transuranic material could be loaded into fuel that undergoes transmutation in a fast spectrum reactor (i.e., an Advanced Burner Reactor). Additional streams can be produced with the advanced aqueous separations technologies in AFCF. These include separating technetium and placing it into a less soluble form, thus reducing its mobility in a geologic repository. Another example is improved emissions treatment and capture to reduce the release of iodine-129 and tritium from the levels of existing recycling plants.

Figure 6 shows how the capacity of a geologic repository can be effectively increased if certain waste streams and recyclable materials are removed to reduce the heat generated by the waste placed in the proposed repository. For example, removing 90% of Cs and Sr, as well as 90% of transuranics (Pu, Am, and Cu), the effective capacity of the proposed repository may increase as much as a factor of ten. While the effective improvements shown in Figure 6 that reduce heat load may not be fully realized in early commercial applications of advanced aqueous separations, sustained effort in the development and demonstration of this technology in a facility such as the AFCF will lead to enhanced efficiencies and improvements. Other important factors that determine effective capacity of the proposed repository are the radiotoxicity and volume of the disposed waste. Evolutionary improvements in separations and waste form technology that reduce the radiotoxicity and volume of waste generated during the recycling process can also be realized from the operations of the AFCF.

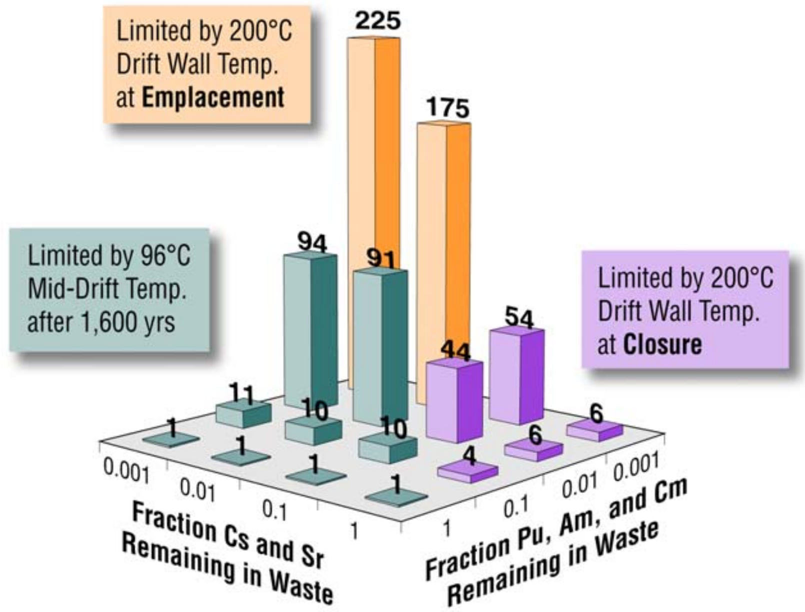

Fig. 6. Potential Drift Loading Increase Factor for Used LWR Fuel

Electrochemical Processing

Electrochemical processing, also called pyrochemical processing or electrorefining separations, was originally developed to recycle metal fast spectrum reactor fuel, but can also be used to recycle used light water reactor fuel in non-metallic forms (e.g. oxides). This process performs used fuel separations in a manner that supports the GNEP objectives by providing transmutation fuel and improving waste management with improved waste forms. It also performs these functions with improved proliferation-resistance.

To electrorefine a metal fuel, the chopped fuel is placed in an anode basket that is submersed in a molten salt (sodium chloride) bath. The metals are then “oxidized” and go into the sodium chloride solution where they exist as cationic chlorides. At this point, cesium chloride and strontium chloride can be “drawn down” and removed from the salt bath. The uranium and transuranic cations remaining in solution are then reduced at the cathode where they plate out as the purified metals. Two cathodes are currently seen as required, one with a potential optimized to collect metallic uranium, and another cathode with a different potential that will collect both uranium and transuranics. These potentials need to be optimized in order to minimize any fission products that might plate out. Electrorefining non-metallic fuels follows the same process except the used fuels must first be “reduced” to their metallic forms prior to their being electrorefined as discussed above. The various steps involved are illustrated Figure 7.

The waste streams generated by the electrochemical process may be managed in a manner similar to those described in Aqueous Separations Processing section. This technology may also be better suited for smaller throughput applications because of lower unit costs at that scale.

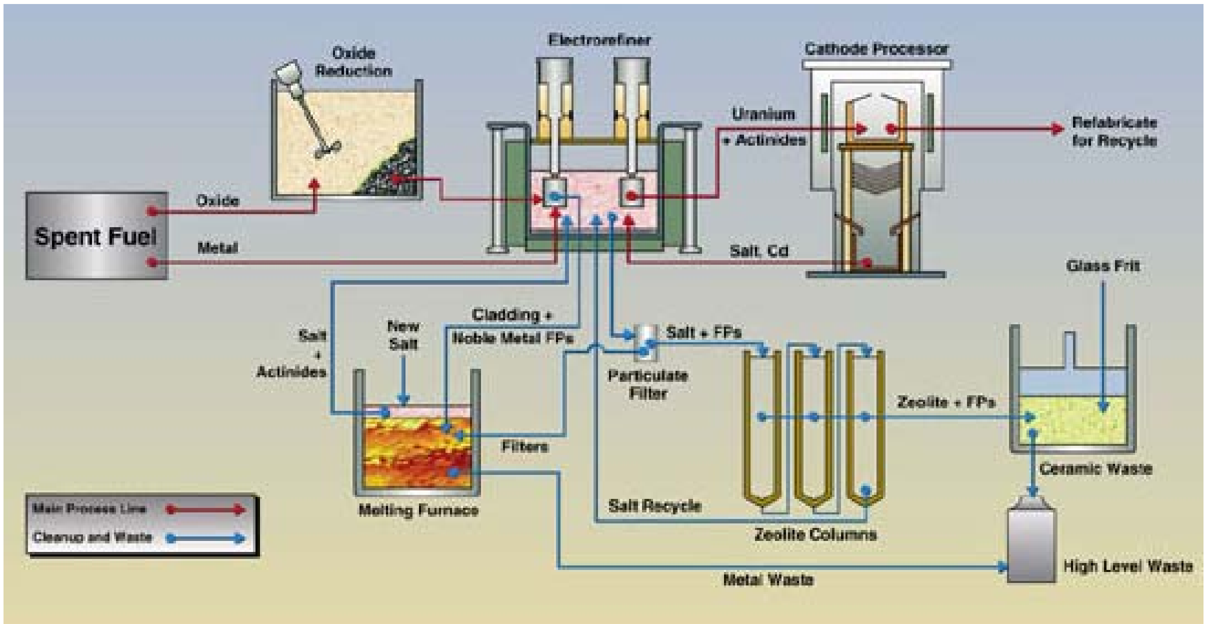

Fig. 7. Electrochemical Processing

Remote Transmutation Fuel Fabrication

The unique capability planned for the AFCF is the assembly-sized remote fuel fabrication component. The capability is needed to limit worker exposure to high dose rates emitted by the uranium-transuranic feed material used to fabricate fuel pellets, pins, assemblies and targets. This capability will make the AFCF the first facility of its kind. As planned, it will have advanced measuring and sampling capabilities that ensure the highest standards of Quality Control. The key product of this component will be Lead Test Assemblies for fuel qualification in fast spectrum recycling reactors. Beyond the initial test assemblies produced, it will be used to refine and improve remote fuel fabrication for future fuel designs.

Multi-Purpose Hot Cell for Research and Development

To support the demonstration work being conducted at AFCF, a multi-purpose bench-scale R&D module is being considered in the conceptual design. It is envisioned to provide demonstration support, as well as conduct original small-scale research into advanced technologies for future demonstrations in the AFCF. A strong dependence on existing laboratory hot cell capability around the DOE complex will remain in order to bring DOE's best ideas to the demonstration point at AFCF.

PARTNERSHIPS AND USERS

The AFCF will provide a world class, highly flexible demonstration platform that can bring the world's best innovations in nuclear fuel recycling technology from the laboratory to the commercial market. To realize this vision, many partnerships can be formed to maximize the impact of AFCF. Each of these partners can be a source of funding to support the ongoing operations of this highly capable facility.

- Host Site and Community
- Other DOE Laboratories
- Universities
- Industry
- Foreign Governments
- Regulatory Agencies

In short, the AFCF is envisioned as a DOE-owned user facility to assist all stakeholders in the development of proliferation-resistant advanced fuel recycling technologies and safeguards with improved waste management features.

ADVANCED FUEL CYCLE FACILITY SITING

The following sections address the DOE's process for identifying reasonable alternatives for siting the proposed AFCF.

Identification of Reasonable Alternatives to be Analyzed for Siting the Advanced Fuel Cycle Facility

The sites identified as reasonable alternatives are being evaluated in the GNEP Programmatic Environmental Impact Statement (PEIS) to support a potential site selection in the pending Record of Decision (ROD) for the GNEP PEIS.

Site Screening Criteria

DOE established two site screening criteria that were used to downselect the original number of candidate sites to a subset of six that are reasonable alternatives for siting the AFCF. These six sites are discussed in detail in the GNEP PEIS. The first of these two criteria limits the potential sites to only current DOE sites. The second criterion limits the potential sites to those DOE sites with current or recent operational experience and facilities relevant to the AFCF mission.

Criterion 1: Current DOE Sites

The Assistant Secretary for Nuclear Energy has chosen to limit the reasonable alternatives to current DOE sites for the following reasons:

- The proposed research, development, and demonstration mission is an extension of ongoing DOE activities and continued DOE management and regulation would provide for the flexibility of operations required for a facility of this type.
- Many infrastructure requirements, such as security, operations in compliance with DOE Orders and Technical Standards, electrical power, water, emergency response, and regulatory compliance already exist at DOE sites.
- Current capability within the DOE complex to support a research facility is adequate such that it is not reasonable to expand the DOE complex and assume the additional cost and management issues that such expansion would entail.

The 15 DOE sites evaluated as potential host sites for the AFCF were:

1. Argonne National Laboratory (ANL)
2. Brookhaven National Laboratory (BNL)
3. Hanford Site
4. Idaho National Laboratory (INL)
5. Lawrence Berkeley National Laboratory (LBNL)
6. Lawrence Livermore National Laboratory (LLNL)
7. Los Alamos National Laboratory (LANL)
8. Nevada Test Site (NTS)
9. Oak Ridge National Laboratory (ORNL)
10. Paducah Site (Paducah)
11. Pantex Plant Site (Pantex)
12. Portsmouth Site (Portsmouth)
13. Sandia National Laboratories (SNL)
14. Savannah River Site (SRS)
15. Waste Isolation Pilot Plant (WIPP)

Criterion 2: Current Operational Facilities and Experience

The 15 DOE sites listed above were evaluated based on operational facilities and experience related to the four proposed AFCF components discussed above: aqueous separations, electro-refining, fuel fabrication, and waste forms processing. Those sites with engineering or production scale experience were given more weight than those sites with only laboratory-scale experience because the AFCF would develop technologies at the laboratory scale and demonstrate the application of those technologies on an engineering scale.

The operating experience criterion is important due to the significant issues involved in operations, maintenance, radiological controls, and conduct of operations with these types of facilities. Each of the four AFCF process lines has unique design and operational requirements. Sites with existing experience in these areas have the support infrastructure, design staff, operations staff, and maintenance staff to be able to anticipate and respond to issues that arise during construction and operations.

DOE identified six DOE sites as having current operational facilities and current or recent experience in the areas of nuclear fuel fabrication, aqueous separations, electro-refining, and waste forms processing. While other sites in the DOE complex have some capabilities in these areas, the following six sites are considered to have the most extensive facilities and experience base in the DOE complex:

1. ANL
2. Hanford Site
3. INL
4. LANL
5. ORR
6. SRS

The nine remaining sites listed under Criterion 1 were determined not to have sufficient operational experience and facilities to make them reasonable alternatives for the AFCF. For more details, see the **Evaluation of Existing Experience and Facilities to Support AFCF Operations** section below.

Scoping comments identified the NTS as a site to be considered for siting the AFCF. However, based on the experience criteria, NTS does not have the facilities or operational experience described. This would lead to significantly longer and more costly facility design, construction, training, and operational start-up issues. As a result, NTS is not a reasonable alternative and was not evaluated as a potential site location for the AFCF.

Potential Greenfield and Brownfield Sites

The GNEP PEIS evaluated siting the proposed AFCF at a greenfield location at each of the above six sites. In addition, the GNEP PEIS evaluated modification of two existing facilities as reasonable alternatives: the Fuels and Materials Examination Facility (FMEF) at the Hanford Reservation (Hanford) site in Washington (additional site) and the Fuel Processing Restoration (FPR) facility at INL. Neither facility currently has the capability required by the AFCF. However, the facilities are not contaminated (never operated) and either facility could be modified for one of the AFCF process lines with sufficient capacity for engineering-scale demonstrations and at least a 50-year design life.

F-Canyon at SRS was also considered a possibility for a brownfield site as it has capabilities similar to those required for the aqueous processing module of the AFCF. The site, however, is heavily contaminated and would require extensive retrofitting for an aging facility. As a result, F-Canyon was determined to not be a reasonable alternative.

No other existing DOE facilities were deemed to have sufficient capacity (ability to process the necessary throughput of materials or physical space requirements), capability (including consideration of contaminated facilities and the types of operations required by the AFCF), or life expectancy with respect to the needed capabilities of the AFCF. This includes existing facilities at ANL, LANL, and ORR. Each of these sites would be a greenfield location for one or more of the AFCF operational components.

Evaluation of Existing Experience and Facilities to Support AFCF Operations

The fifteen initial candidate sites were evaluated for their suitability to support one or more of the four AFCF major operations: (1) electrochemical separations, (2) aqueous separations, (3) fuel fabrication, and (4) waste forms processing. Results of this evaluation are summarized in Table I, where green color indicates that a specific facility has both operational experience and facility capabilities significant to AFCF operations, yellow color indicates that a site has some experience and capabilities, and red color means it has little or no experience or capability relevant to the AFCF.

In order to evaluate these sites, detailed knowledge of each site's capabilities as they pertain to the AFCF mission was compiled. This information was captured in 2006 in response to the *Energy Policy Act* of 2005, which required DOE to identify facility and equipment capabilities, as well as personnel experience, across the DOE complex. The Complex-Wide Capability Report (CWCR) that resulted from this examination provided the basis for this site evaluation. This information is publicly available in the *2007 Update of the DOE Complex-Wide Inventory of Civilian Nuclear Facilities, Equipment, and Other Assets,* published as part of the Ten-Year Site Plan for INL.

The facilities, equipment, and expertise described in the CWCR encompass all of NE's missions, not just those of the AFCF. Consequently selection criteria were needed to identify capabilities that have the potential to further AFCF mission objectives. To this end, the following five selection criteria were developed:

- Experience in aqueous separations
- Experience in electrochemical separations
- Experience in fuel fabrication
- Experience in high level waste (HLW) forms processing
- Available operational or uncompleted facilities that could support the AFCF mission that have at least 30 years useful life and would be able to be retrofitted to have comparable capabilities for one of the AFCF modules. For available or uncompleted facilities, a useful life of 30 years was considered to be sufficient for evaluation for this criterion rather than the expected life for the AFCF of 50 years.

Once relevant facilities and expertise were identified, color rankings were then assigned to each site for each of the four AFCF operational areas. Because the AFCF is intended to be a research, development, and demonstration facility on an engineering scale, those sites that have experience with throughput rates on a pilot, engineering, or production scale were been given more weight than those sites with only laboratory-scale experience.

It should be understood that even though a specific facility may receive a green evaluation for one or more of the AFCF major unit operations, this does not mean that site has already demonstrated the same technology or a different technology on the scale expected to be demonstrated by the AFCF. For example, an engineering-scale demonstration of one of the UREX + suite of processes may be performed in the AFCF. These are aqueous separations processes that have hitherto not been demonstrated on an engineering scale, although small-scale demonstrations have been performed at some of the DOE sites. Capturing this and related experience is essential to furthering the AFCF mission.

From Table I, note that six sites have both the expertise and facility capabilities that could be expanded or built upon to meet AFCF requirements and long-term goals (these sites are indicated by the green areas in Table I). Those six sites are:

- ANL: electrochemical separations, HLW processing, aqueous separations
- Hanford Site: aqueous separations, HLW processing.
- INL: electrochemical separation, aqueous separations, high level waste processing.
- LANL: fuel fabrication.
- ORR: fuel fabrication.
- SRS: aqueous separations, fuel fabrication, HLW processing

Subsequent sections of this paper elaborate on each site's specific capabilities and experience as they relate to AFCF operational requirements.

Table I. Current Operational Expertise and Facilities Evaluation

	Available Existing Facilities	**Electrochemical Separations**	**Aqueous Separations**	**Fuel Fabrication**	**HLW Processing**
AFCF Needs (design basis)	Process Building = 50,631 m^2 (545,000 sq.ft.) Support Buildings = 34,838 m^2 (375,000 sq. ft.)	1 MTHM/yr	25 MTHM/yr	1 MTHM/yr	21 MT/yr - vitrified, 26 MT/yr - other
ANL					
BNL					
INL	FPR[a]				
LANL					
LBNL					
LLNL					
NTS					
ORNL					
Paducah					
Pantex					
PNNL	FMEF[b]				
Portsmouth					
SNL					
SRS	F-Canyon[c]				
WIPP					

[a] FPR – Facility 50 percent completed, applicable to the aqueous processing module for the AFCF, not contaminated, currently available – would require some retrofit. Balance of facilities would be constructed.
[b] FMEF – Applicable to the fuel fabrication portion of AFCF, not contaminated, currently available – would require retrofit. Balance of facilities would be constructed.
[c] F-Canyon - Applicable to the aqueous processing module for the AFCF, heavily contaminated, would require extensive retrofit in an aging facility. Balance of facilities would be constructed.

Facilities and Equipment Essential or Potentially Useful to the Advancement of the Advanced Fuel Cycle Facility Mission

The following information for each site listed in Table I is based on the DOE-Wide CWCR for the DOE complex. This report tabulates individual laboratory inventories of facilities, equipment, and other assets that were deemed essential or potentially useful to the advancement of the DOE nuclear energy mission. Consequently many of the items listed therein are not relevant to the AFCF mission. Therefore the selection criteria described above were applied to each site in order to identify relevant site capabilities.

As noted above, the CWCR was compiled in response to a mandate from the *Energy Policy Act* of 2005. National laboratories or other DOE facilities that do not have inventory information included in the report either did not submit an inventory to the preparers of the report or the facilities and equipment were deemed not relevant to the missions of the NE (although they might be relevant to other DOE offices and programs). Those DOE sites *not* covered in the CWCR but listed in Table I are the NTS, Paducah, Pantex, Portsmouth, and WIPP sites. These sites are not R&D facilities but serve other DOE missions such as a geologic disposal for weapons transuranic waste (WIPP), storage of radioactive materials (NTS), and uranium enrichment (Paducah and Portsmouth). Each of these sites was assigned "red" ratings for each of the major operations to be performed at the AFCF. They are included in Table I for completeness and not discussed further in this paper.

Argonne National Laboratory

ANL received green ratings in Table I for electrochemical separations, aqueous separations, and fuel fabrication. ANL has extensive experience with electrochemical processing on a pilot scale. This work has been performed in the **Chemical Engineering Building**. ANL also hosts a team of world-class aqueous chemists who have pioneered the development of the UREX+ separations processes. Fabrication of metal fuels has been done in the **Energy Technology and Material Science** facility.

Brookhaven National Laboratory

BNL does work primarily in support of the Office of Science, but also supports the NE's mission to supply medical isotopes. BNL did not receive green or yellow ratings for any of the AFCF's major operations. It, however, does possess a number of hot cells and analytical equipment of potential use to the AFCF mission. These facilities currently primarily support medical isotope production, purification, and qualitative analysis carried on at the Brookhaven Linac Isotope Producer (BLIP) facility and may be of limited availability to AFCF.

Hanford Site

Hanford received green ratings for aqueous separations and high level waste processing. Aqueous separations experience is located in the **Radiochemical Processing Laboratory** described below and as a result of its long association with, and proximity to, the Hanford site where there is an extensive history of used fuel separations and high-level waste management.

Idaho National Laboratory

INL has expertise, facilities, and equipment of fundamental value to AFCF operations. INL received green ratings for three of the four AFCF operations: electrochemical separations, aqueous separations, and HLW processing. INL also received a yellow rating for fuel fabrication. Electrochemical processing of sodium-bonded used nuclear fuel has been conducted on the engineering scale at the **Fuel Conditioning Facility**. Although not specifically listed in the Complex-Wide Capability Report, aqueous separations and HLW management have taken place at the Idaho Chemical Processing Plant and fabrication of fuel for a sodium fast reactor (the EBR-II) was done at the **Fuel Manufacturing Facility**.

Lawrence Berkeley National Laboratory

LBNL received no green or yellow ratings for any of the AFCF operational units. Much of the work conducted at LBNL is in support of basic research supported by the Office of Science and is not relevant to AFCF requirements. However, high performance computing capabilities at the National Energy Research Scientific Computing Center (NERSC) are potentially useful to AFCF for reactor modeling, simulations, and transmutation fuels development for a fast reactor.

Lawrence Livermore National Laboratory

LLNL is a Department of Defense laboratory and received no green or yellow ratings with regard to the four AFCF operations. However, LLNL possesses analytical facilities and equipment potentially useful to the AFCF mission. Among them is the High Energy Radiography Facility, which specializes in nondestructive evaluation methods, primarily radiography, radioscopy, and computed tomography of materials and components. In the area of high performance computing, the Terascale Simulation Facility houses the ASC/IBM Blue Gene/L computer system. This facility is a premier high performance computing site with over 100 million CPU hours allocated for unclassified science simulations that could be used for transmutation fuels development and reactor modeling and simulations.

Los Alamos National Laboratory

LANL received a green rating for fuel fabrication. This work takes place in the **Plutonium Building** at the Fuel Component Fabrication and Assembly laboratory and the Fuel Synthesis and Fabrication laboratory. The Plutonium Building also houses fuel characterization equipment, a fuels research facility, furnaces, hot presses, and welders.

Oak Ridge Reservation

ORR received a green rating for fuel fabrication, and yellow ratings for aqueous separations and HLW processing. Fabrication of transuranic-bearing targets has been performed at the **Radiochemical Engineering Development Center (REDC)**, and coated particles at the **Uranium** and **Sol-Gel Laboratories**, described below. The fabrication and irradiation of these targets is important to the design of the fuel fabrication capabilities of the AFCF. Aqueous separations on the laboratory scale have also been performed in the REDC. As part of ORNL's long history of aqueous separations technology development, there is a matching history and expertise of nuclear materials/used fuel management and the management of the HLW streams resulting from their work.

Sandia National Laboratories

SNL received no green or yellow ratings with regard to the four AFCF major operations. The site, however, does possess the **Annular Core Research Reactor (ACRR), which is** useful for transient fuel testing, fuel development, and safety. The ACRR includes a neutron radiography facility potentially useful for fuels and materials examination. Computational capabilities at SNL are extensive and include the Thunderbird Computing Facility and the Red Storm Super Computing Facility, both potentially suitable for AFCF modeling and simulations.

Savannah River Site

SRS received green ratings for aqueous separations, fuel fabrication, and high level waste processing due to related extensive experience vested in their work force and facilities. Large-scale aqueous separations have taken place in the **F-Canyon,** the **HB-line Facility,** and the **H Canyon.** Fuel fabrication is undertaken at the **Reactor Fuel Fabrication Laboratory (RFFL).**

CONCLUSION

As a flexible, multi-purpose demonstration facility, the AFCF will provide the U.S. with a powerful and unique capability to quickly bring innovative nuclear fuel recycling technology from the laboratory to the commercial market with high confidence. The siting of AFCF capabilities at one or more of the six DOE laboratories being evaluated as potential sites in the GNEP PEIS will be addressed as part of the 2008 GNEP ROD. Once built, the AFCF will support existing nuclear fuel recycling operations, help reduce the inventory of accumulated used nuclear fuel, and improve the waste management practices into the future.

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