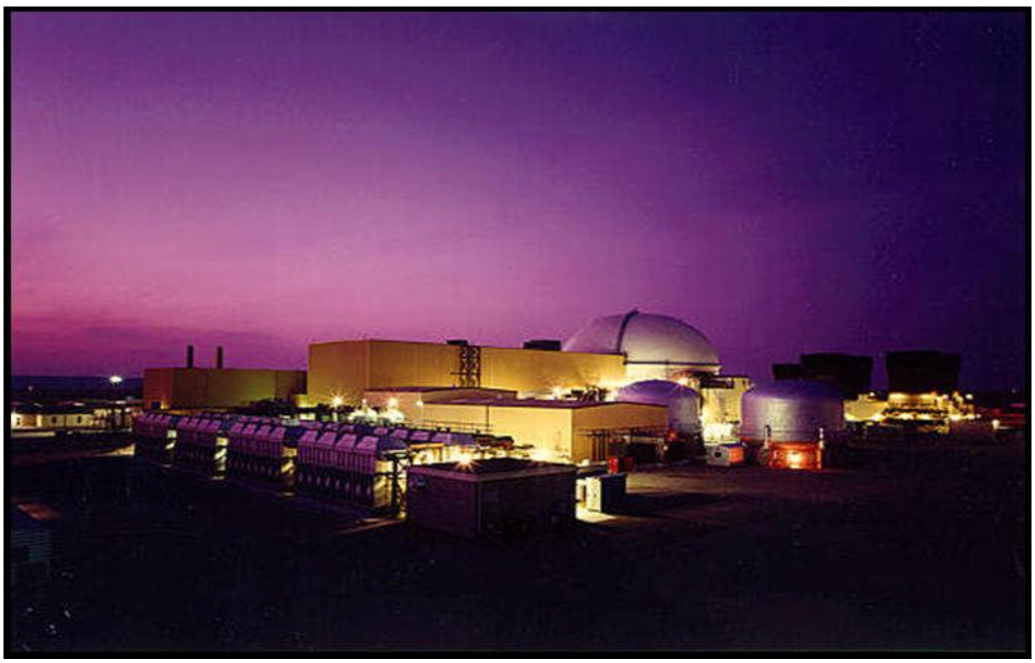
DE-FG07-07ID14798

Siting Study For Hanford Advanced Fuels Test & Research Center

April 30, 2007



Prepared By:
Columbia Basin Consulting Group
Richland, WA

Recipient: Tri-City Industrial Development Council (TRIDEC)
Recipient Project Director: Gary Petersen, TRIDEC

TRI-CITIES WASHINGTON
TRI-CITY DEVELOPMENT COUNCIL

DISCLAIMER

EXECUTIVE SUMMARY

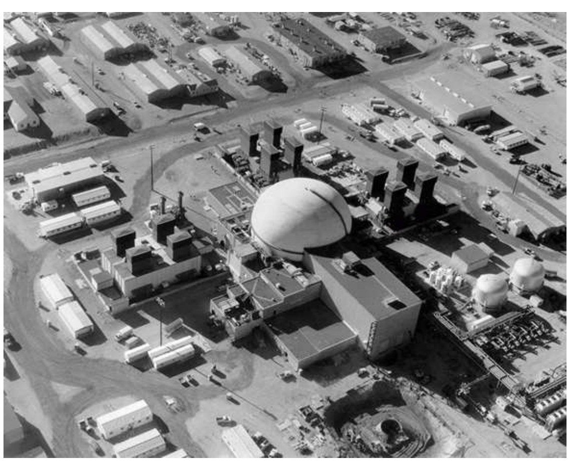
In January 2007, the Department of Energy (DOE) awarded a grant to the Tri City Development Council (TRIDEC) to manage a collaborative effort between the Columbia Basin Consulting Group (CBCG) and a TRIDEC-led consortium team. The purpose of the grant was to evaluate the Hanford Site as a potential location for critical fuels and advanced nuclear reactor facilities to support the Global Nuclear Energy Partnership (GNEP).

Energy Secretary Bodman stated, "*GNEP seeks to bring about significant, wide-scale use of nuclear energy through the development of better, more efficient and proliferation-resistant nuclear fuel cycles while reducing the volume of nuclear waste requiring ultimate disposal.*" The expansion of nuclear energy in the U.S. under GNEP is part of a comprehensive response to concerns regarding greenhouse gas production and nuclear non-proliferation.

The Fast Flux Test Facility is a 400 MWt, fast spectrum, sodium cooled research reactor. It is uniquely designed to test nuclear fuels and materials in a fast spectrum environment. Such fuels and materials testing and qualification is a necessary precursor to the deployment of the ***Sodium Fast Reactor (SFR)*** technology selected by DOE in December 2006 for the advanced recycle reactors necessary to close the fuel cycle.

The reactivation of the Fast Flux Test Facility (FFTF) complex and the Fuels and Materials Examination Facility (FMEF) represents an opportunity for DOE to *accelerate* a commercially viable and sustainable closed fuel cycle *by at least a decade.* DOE will gain a substantial reduction in programmatic risk through a cost-effective test program using existing facilities, and realize a multi-billion dollar savings compared to the cost for constructing new test or prototype facilities. The impacts may not become apparent until after the nation is committed to the selected path and these facilities are constructed and have begun operations.

The scope of work completed by CBCG, and reflected in this report, was to evaluate the licensing and regulatory issues associated with reactivation of the Fast Flux Test Facility complex as an ***Advanced Fuels Test and Research Center*** for test and qualification of advanced fast reactor fuels (metal or oxide) and recycle transmutation fuels in the fast spectrum environment.



Reactivation of the Fast Flux Test Facility to pre-shutdown condition would provide GNEP with the premier fast spectrum, sodium test reactor in the world. The plant's design features, configuration, and fuel examination equipment are unique attributes not found in any of the world's fast sodium reactors. Because the Fast Flux Test Facility has been specifically designed for a fuels test and examination mission, irradiated fuels can be physically examined 3-5 years earlier than in any other reactor facility currently available to GNEP.

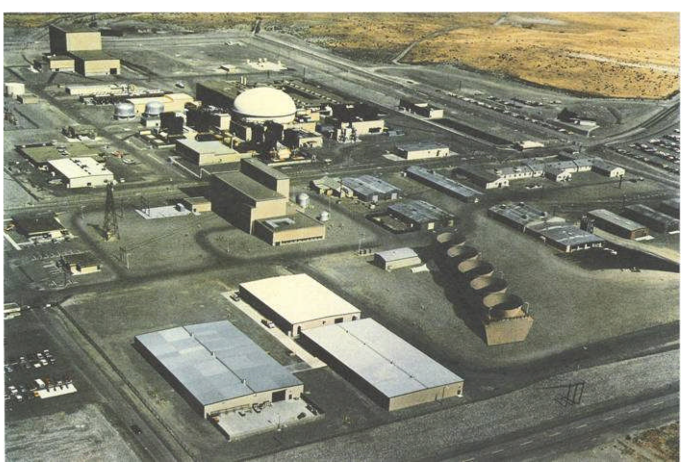
The Hanford 400 Area complex also provides existing facilities for test and prototype fuels fabrication, post-irradiation performance assessment and examination, and personnel training and qualification center for new technologies and sodium handling systems.

A Subject Matter Expert (SME) Panel was assembled and analyzed the key question of the 400 Area recovery capability. The Panel assessed recovery feasibility and provided a preliminary cost and schedule estimate for reactivation. The Panel was provided access to plant staff and documentation to assist in fact finding and status evaluation.

Key results of the review affecting the safe operation, licensing and permitting for reactivation of the FFTF to its pre-shutdown condition and use of FMEF for a GNEP mission to test performance and qualify actinide fuels for an advanced, fast spectrum reactor are as follows:

- There are no technical issues preventing reactivation and recovery of the FFTF.
- Plant Configuration Control with full plant documentation has been rigorously maintained.
- The FFTF is currently a fully permitted facility. Local and state permitting may be required for the FMEF as it has not previously been activated.
- As proposed the FFTF is to be returned to its pre-shutdown condition and design mission, therefore there are no unanalyzed safety issues or environmental impacts.
- DOE regulatory oversight may be transitioned to Nuclear Regulatory Commission and promote development of NRC infrastructure to support regulation of the SFR facilities
- Many FFTF test features are unique to any reactor in the world, e.g. the IEM Cell. These features are necessary and prerequisite to performing the test mission.
- FMEF and the Secure Automated Fabrication (SAF) fuel line can be modified for advanced fuels fabrication and post irradiation examination
- FFTF can be reactivated at a cost of approximately $500 Million. It can be available to pull rods in approximately 60 to 66 months – an aggressive but achievable estimate

During the mid-project review, DOE raised the question of the qualifications of FFTF as the commercial prototype Advanced Recycle Reactor. Since FFTF meets the specifications with the exception of electricity production, CBCG initiated a review of the feasibility and regulatory issues for adding a power generator to the FFTF for electricity generation.



The addition of a power generator to FFTF has been previously evaluated, providing detailed advanced conceptual designs and cost estimate information. The most recent evaluation was documented in the 1987 Power Addition Study completed by Stone and Webster Engineering Corporation. The 1987 Study which included an Advanced Conceptual Design Report planned a 48 month schedule for completion of the power addition following authorization to proceed with engineering and the final design. Energy Northwest provided a preliminary assessment of the economics of the power addition based on cost and technical data provided in the 1987 report.

In considering the FFTF as a prototype Advanced Recycle Reactor, the Team assumed the selection would be made as part of the GNEP Record of Decision (ROD) scheduled for June 2008. The conclusions for modification of the FFTF as the prototype Advanced Recycling Reactor are:

- If selected, a site specific National Environmental Protection Act (NEPA) action and safety assessment would be required prior to the start of modification work.
- The FFTF mission would be a dual role of fuel test and qualification, with the added mission of actinide destruction and power generation.
- The FFTF is fully suitable for testing either metal or oxide fuels.
- An assessment of the cost data and current information indicates the power addition would be approximately $250 million and have a generating capacity of 118 MWe.
- The economics of the power addition compare favorably with commercial electricity production, given the primary function of the facility is for fuel recycle and actinide burn.
- Reactivation of FFTF accelerates GNEP with the goal of nuclear waste volume reduction and mitigates the potential for orphaned high-level nuclear wastes remaining at Hanford.
- FFTF in this role does not alleviate the need for large scale commercial facilities with throughput capacity adequate to recycle the US nuclear spent fuels production.

In conclusion, the FFTF could be ready to pull rods for transmutation or advanced fuels testing in 60 to 66 months at a cost of $500 million. If a decision were made in 2008 to change the mission to the prototype Advanced Recycle Reactor, the facility could be modified with a power generator and be in commercial power operation in 48 months from the decision to proceed at a total facility reactivation and modification cost of approximately $750 million.

The FFTF has a high performance reliability history and can be operational by 2013. FFTF reactivation fulfills the needs stated in the December 2006 Gen IV strategy report for a fast reactor to complete transmutation fuels development and proof-test actinide management. Reactivation of the FFTF accelerates the December 2006 ABR operations target by seven years, and almost two decades earlier than previous timelines. The reactivation of the FFTF will also help to reestablish the infrastructure needed to deploy commercial-scale fast reactors, and begin building the experience base of reactor operations and the pool of trained personnel.

Converting the FFTF to a prototype Advanced Recycle Reactor provides significant advantages at the early program stage. The economics compare favorably to alternative generation capacity planned to meet near-term electricity demand needs in this region. The burn rate for actinide fuels in the FFTF is excellent for test or qualification purposes and provides a significant contribution to the reduction of stored high level wastes.

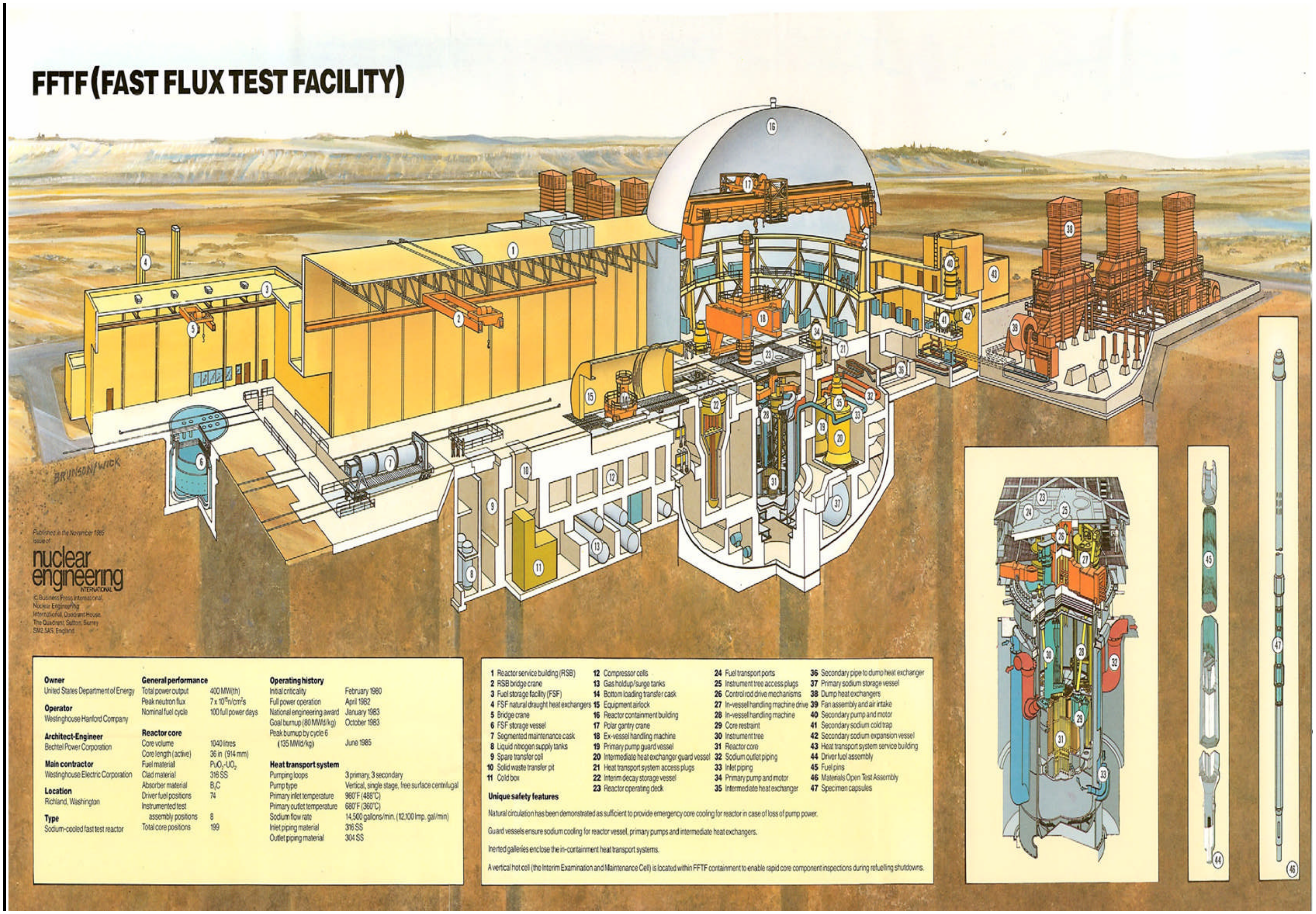

FFTF (FAST FLUX TEST FACILITY)
Published in the November 1985 issue of
nuclear engineering INTERNATIONAL
© Business Press International, Nuclear Engineering International, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS, England
BRUNSON/WICK
Owner
United States Department of Energy
Operator
Westinghouse Hanford Company
Architect-Engineer
Bechtel Power Corporation
Main contractor
Westinghouse Electric Corporation
Location
Richland, Washington
Type
Sodium-cooled fast test reactor
General performance
Total power output 400 MW(th)
Peak neutron flux 7 x 10^15 n/cm^2s
Nominal fuel cycle 100 full power days
Reactor core
Core volume 1040 litres
Core length (active) 36 in (914 mm)
Fuel material PuO2-UO2
Clad material 316 SS
Absorber material B4C
Driver fuel positions 74
Instrumented test assembly positions 8
Total core positions 199
Operating history
Initial criticality February 1980
Full power operation April 1982
National engineering award January 1983
Goal burnup (80 MWd/kg) October 1983
Peak burnup by cycle 6 (135 MWd/kg) June 1985
Heat transport system
Pumping loops 3 primary, 3 secondary
Pump type Vertical, single stage, free surface centrifugal
Primary inlet temperature 980°F (488°C)
Primary outlet temperature 680°F (360°C)
Sodium flow rate 14,500 gallons/min. (12,100 Imp. gal/min)
Inlet piping material 316 SS
Outlet piping material 304 SS
1 Reactor service building (RSB)
2 RSB bridge crane
3 Fuel storage facility (FSF)
4 FSF natural draught heat exchangers
5 Bridge crane
6 FSF storage vessel
7 Segmented maintenance cask
8 Liquid nitrogen supply tanks
9 Spare transfer cell
10 Solid waste transfer pit
11 Cold box
12 Compressor cells
13 Gas holdup/surge tanks
14 Bottom loading transfer cask
15 Equipment airlock
16 Reactor containment building
17 Polar gantry crane
18 Ex-vessel handling machine
19 Primary pump guard vessel
20 Intermediate heat exchanger guard vessel
21 Heat transport system access plugs
22 Interim decay storage vessel
23 Reactor operating deck
24 Fuel transport ports
25 Instrument tree access plugs
26 Control rod drive mechanisms
27 In-vessel handling machine drive
28 In-vessel handling machine
29 Core restraint
30 Instrument tree
31 Reactor core
32 Sodium outlet piping
33 Inlet piping
34 Primary pump and motor
35 Intermediate heat exchanger
36 Secondary pipe to dump heat exchanger
37 Primary sodium storage vessel
38 Dump heat exchangers
39 Fan assembly and air intake
40 Secondary pump and motor
41 Secondary sodium cold trap
42 Secondary sodium expansion vessel
43 Heat transport system service building
44 Driver fuel assembly
45 Fuel pins
46 Materials Open Test Assembly
47 Specimen capsules
Unique safety features
Natural circulation has been demonstrated as sufficient to provide emergency core cooling for reactor in case of loss of pump power.
Guard vessels ensure sodium cooling for reactor vessel, primary pumps and intermediate heat exchangers.
Inerted galleries enclose the in-containment heat transport systems.
A vertical hot cell (the Interim Examination and Maintenance Cell) is located within FFTF containment to enable rapid core component inspections during refuelling shutdowns.

Table of Contents

Acronyms

AAA	Advanced Accelerator Applications
ABR	Advanced Recycling Reactor
ACD	Advanced Conceptual Design
AEC	Atomic Energy Commission
AFIC	Advanced Fuel Cycle Initiative
ANL	Argonne National Laboratory
ANS	Advanced Nuclear Society
ASME	American Society of Mechanical Engineers
ATR	Advanced Test Reactor
ATW	Accelerator Transmutation of Waste
B&W	Babcock & Wilcox
CDE	Core Demonstration Experiment
CEA	French DOE counterpart
CEQ	Council on Environmental Quality
CLWR	Commercial Light-Water Reactor
CRA	Control Rod Assembly
D&D	Decontamination & Decommissioning
DFA	Driver Fuel Assembly
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S Department of Energy
DOE-RL	U.S Department of Energy- Richland Operations Office
EBR-II	Experimental Breeder Reactor-II
EIS	Environmental Impact Statement
EOI	Expression of Interest
EPA	U.S Environmental Protection Agency
EPRI	Electric Power Research Institute
ERDS	Emergency Response Data System
ESQ&H	Environment, Safety, Quality, and Health
FDA	U.S Food and Drug Administration
FFTF	Fast Flux Test Facility
FFTF-PA	Fast Flux Test Facility-Power Addition
FOIA	Freedom of Information Act
FMEF	Fuels & Materials Examination Facility
FSAR	Final Safety Analysis Report
FSF	Fuel Storage Facilities
FTE	Full-Time Equivalent
FY	Fiscal Year
GenIV	Generation-IV International Forum (GIF)
GFM	Government-Furnished Material
HEDL	Hanford Engineering Development Laboratory
HEU	Highly Enriched Uranium
HFIR	High Flux Isotope Reactor
I-297	Initiative-297 “Clean-up Act”
IAEA	International Atomic Energy Agency
INL	Idaho National Laboratory
I-NERI	International Nuclear Energy Research Initiative

LANL	Los Alamos National Laboratory
LLFP	Long-lived Fission Product
LMR	Liquid Metal Reactor
LTIV	Long-term Irradiation Vehicle
LWR	Light-Water Reactor
NI-PEIS	Nuclear Infrastructure-Programmatic Environmental Impact Statement
M&O	Management & Operations
MWt	Megawatts Thermal
MBA	Masters of Business Administration
MD	Materials Disposition
MOU	Memorandum of Understanding
MOX	Mixed Oxide
NAK	Sodium Potassium Coolant
NASA	National Aeronautics and Space Administration
NE	Office of Nuclear Energy, Science and Technology
NEPA	National Environmental Policy Act
NERAC	Nuclear Energy Research Advisory Committee
NERI	Nuclear Energy Research Initiative
NIH	National Institute of Health
NOI	Notice of Intent
NRC	U.S. Nuclear Regulatory Commission
O&M	Operations & Maintenance
ORNL	Oak Ridge National Laboratory
ORR	Operational readiness review
OTA	Open Test Assembly
PCAST	President's Committee of Advisors on Science and Technology
PNNL	Pacific Northwest National Laboratory
R&D	Research and Development
ROD	Record of Decision
RTG	Radioisotope Themoelectric Generator
SAR	Safety Analysis Report
SBK	Schnell-Brueter-Kernkfratwerksgesellschaft
SER	Safety Evaluation Report
SFR	Sodium Fast Reactor
SNF	Spent Nuclear Fuel
SNL	Sandia National Laboratories
S&M	Surveillance & Maintenance
SPD	Surplus Plutonium Disposition
SRE	Sodium Reactor Experiment
SRS	Savannah River Site
SSF	Sodium Storage Facility
START	Strategic Arms Reduction Treaty
TPA	Tri-Party Agreement
WBS	Work Breakdown Structure
Ecology	Washington State Department of Ecology

Chapter 1

FFTF Reactivation

1.0 INTRODUCTION & NEXT STEPS

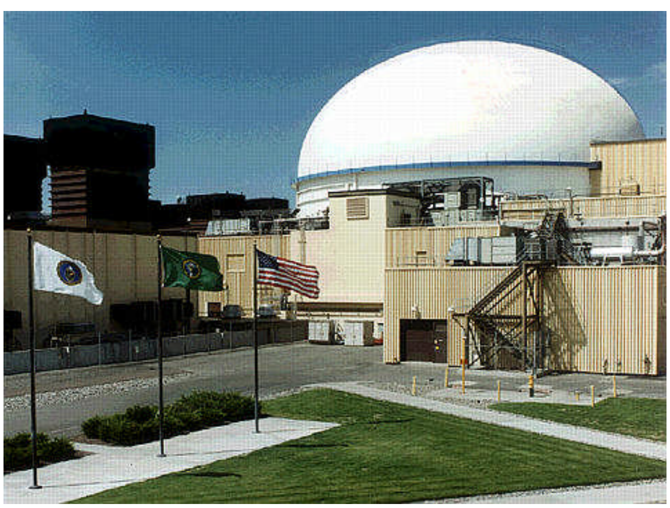
As a cornerstone of the Advanced Energy Initiative, Department of Energy initiated the Global Nuclear Energy Partnership which was announced by the President in February 2006. In January 2007, DOE awarded a grant to TRIDEC to manage a collaborative effort between CBCG and a TRIDEC-led consortium team to evaluate the Hanford Site as a potential location for critical fuels and advanced nuclear reactor facilities to perform the GNEP mission.

This report provides the results of the scoping study performed by CBCG under the Grant to identify local, regional, state and national regulatory and environmental permits to reactivate Hanford's FFTF and supporting 400 Area facilities as a Hanford Advanced Fuels and Research Center, including legislative or regulatory prohibitions that might prevent siting such a facility.

Under the TRIDEC Grant, CBCG evaluated use of the 400 Area facilities to support the mission needs for basic materials research, advanced fuels qualification testing and fuels transmutation testing.

The 400 Area complex was designed, certified, and built specifically for advanced nuclear fuels and materials testing. The FFTF is the only domestic fast neutron reactor capable of conducting actinide transmutation burnup testing and qualification of fast reactor fuels and materials.

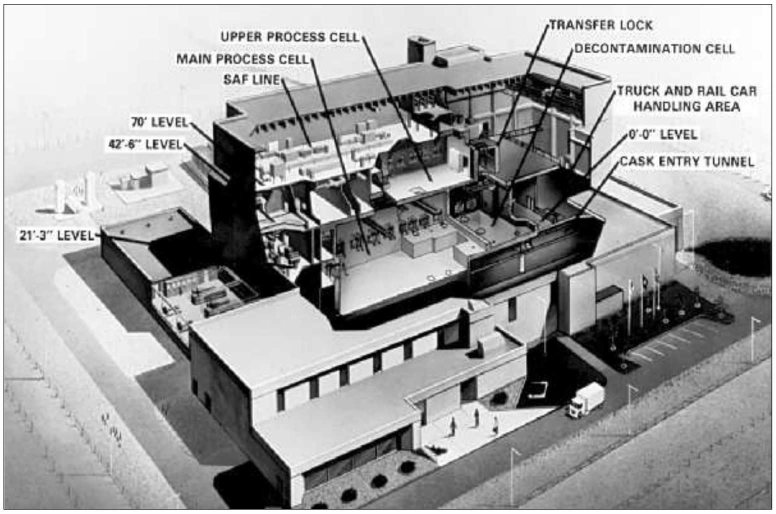
The FFTF, the adjacent FMEF, and the Maintenance and Storage Facility (MASF) have been proposed as an integrated nuclear research center to support the development, testing and qualification of advanced fuels and materials for use in the GNEP Advanced Recycling Reactor. These reactors are intended to generate power while consuming the problematic actinides which are long-lived, highly radioactive byproducts of the current fuel cycle.



The FFTF is a 400-megawatt (thermal) liquid-metal (sodium) cooled fast neutron flux nuclear test reactor owned by DOE. The facility is in the 400 Area of DOE's Hanford Site in southeastern Washington State.

The construction of FFTF was completed in 1978 and initial operation began in 1980. From April 1982 to April 1992, the FFTF operated successfully as a national research facility to test advanced nuclear fuels, materials, components, nuclear power plant operations and maintenance protocols, and reactor safety designs. During this time, the FFTF also produced a wide variety of medical and industrial isotopes, made tritium for the U.S. fusion research program, and conducted cooperative international research work.

The FMEF is a 250,000 ft^2 Category One structure constructed in the early 1980s. The FMEF was planned to support the United States breeder reactor program. It was designed specifically to manufacture large quantities of plutonium-oxide fuels and to manipulate (disassemble and inspect) irradiated fuel assemblies. The facility has never been used, and is available and almost ideally suited for direct support of the GNEP program. The FFTF and FMEF, individually, have irradiated fuels examination capabilities that are unique to any such facility in the world, including facilities in France, Japan, and Russia. In combination with other Hanford assets (complementary facilities, experienced personnel and community support), FMEF is a cost effective option for a major role in the GNEP mission.



Upgrading and restarting the 400 Area complex for the GNEP mission is estimated at about one-tenth the cost of new construction. Using Hanford's existing facilities to support GNEP and other missions represents a significant savings to the taxpayer and offers a near-term, environmentally advantageous solution to support the GNEP objectives.

The recycling technology will enable a 100-fold increase in the energy that can be produced from the uranium resource. Demonstration of the closed fuel cycle is prerequisite to establishing the fast reactor technology as a highly sustainable energy source for the future. Closure of the fuel cycle requires recovery of actinides from irradiated fuel, manufacture of new fuel subassemblies using this recycled material, and subsequent recovery of the actinides from the recycled fuel. Integral to this strategy is the irradiation of the test fuel subassemblies for sufficient time to demonstrate satisfactory fuel performance

Using the existing facilities at the FFTF complex for advanced fuels testing and qualification is within the original design parameters and does not represent a previously unreviewed safety question or environmental impact. Proceeding on the basis of upgrades to existing facilities rather than new construction, provides the GNEP the only option available which can be on-line a decade in advance of competitive approaches and about one-tenth the cost of new facilities.

Should DOE elect to proceed with reactivation of the FFTF to perform advanced fuels (oxide or metal) performance and qualifications testing, and transmutation fuels testing and qualification, and utilize the FMEF the recommended next steps would include:

- Suspend Plant Deactivation Activities through June 2008 for GNEP review.
- Verify workshop findings including piping service suitability through physical examination.
- Amend the January 2001 deactivation ROD.
- Develop an integrated flow-sheet for FFTF mission, and FMEF if needed.
- Develop Reactivation Plan for FFTF.
- Consider revise of 300 area facilities for sodium coolant control technology development.
- Initiate reactivation actions.

2.0 PROPOSED MISSION DISCUSSION

FFTF is available and fully capable of performing the reactor fuels and materials testing for developing transmutation fuels for Advanced Recycling Reactors. Early disassembly and examination of test fuel assemblies will provide key data to support selection of the transmutation fuel types. Once initial fuel selection is made the FFTF can operate with a full core to fine tune actinide management and proof-test the core designs.

FFTF provides the unique capability for early examination of irradiated fuel. An in-containment hot cell provides for disassembly and removal of test pins from a fuel bundle so they can be shipped to an examination laboratory within a few months. By comparison, commercial reactors as well as all existing fast reactors must wait years for an entire fuel element to cool.

The restart of the FFTF will also help to reestablish several areas of national capability necessary to sustain a sodium-cooled fast reactor program.

Long Term Fuel Development – Any early improvements make and/or deficiencies uncovered increase efficiency and provide certified safety. Underscoring the significance of this conclusion is Congressional testimony on the Advanced Burner Test Reactor. "*Nuclear fuel, because of the long lead time needed for irradiation testing, is always the critical path item in reactor development,… for transmutation in TRU fueled elements such testing is essential…" Dr. Neil Todreas, Massachusetts Institute of Technology, KEPCO Professor of Nuclear Engineering, Professor of Mechanical Engineering (Emeritus) and a leader in the Department of Energy's (DOE) Generation IV reactor initiative, April 6, 2006.*

Liquid Sodium Coolant Technology – A key mission element of the restarted FFTF is to revive the necessary engineering and knowledge base to fill, drain, and operate flowing sodium systems and for cleanup and purification of the sodium coolant; chemistry control; heating and cooling systems; and associated instrumentation and control.

Component Fabrication – Procurement of replacement parts will begin to reestablish domestic industrial fabrication capabilities for liquid metal cooled fast reactor components.

Reactor Start-up Fuel Fabrication – Facilities previously used for making both metal and oxide (ceramic) fast reactor fuels are currently operational but will require installation of new equipment and other updating to produce the needed fuel assemblies.

Reactor Design – Design resources and tools are available from the previous U.S. Fast Reactor Program and in most cases reflect international standards. However, the current design process includes conservative margins, and significant cost savings may be possible with higher fidelity simulation and optimization methods. Many of the existing codes are based on the computer architecture of twenty years ago. To overcome computing limitations, modeling assumptions were used to approximate physics phenomena, many of which can now be directly modeled as new fuel systems are designed.

Safety Analysis – The available fast reactor safety analysis tools developed in the United States also reflect the current standard and are used in all the major international fast reactor programs. As with reactor design codes, improvements are envisioned to provide more accurate analyses with modern simulation techniques.

Licensing and Regulation – The last fast reactors receiving U.S. regulatory approval were FFTF (test reactor, 1980) and FERMI-1 (commercial plant, 1966). Thus, the regulatory resources and competency to review fast reactor safety must to be reestablished.

3.0 SCOPE OF THE STUDY

This report addresses the restart of the FFTF for use as the Hanford Fast Spectrum Research Center, an expeditious path to the attainment of GNEP's need for developing and testing fast spectrum fuel for a successful Advanced Recycling Reactor program. It considers the technical viability and regulatory and permitting issues including legal and policy issues of using the FFTF as this resource.

The public outreach, community demographics, and general site infrastructure features work scopes are addressed in the "Sitting Study for the Use of Hanford Site for GNEP Facilities" submitted by TRIDEC in a companion report under this grant award.

In order for the identified regulatory and permitting requirements to be valid, the FFTF must be shown to be available and viable technically as well as compatible with DOE's policy.

Technical Viability - The FFTF is presently classified as in deactivation status. This study establishes the technical viability of recovery from deactivation including analysis of components, tasks, costs, and schedules.

Regulatory and Permitting - This task identifies local, regional, state and national regulatory and environmental permits required for this facility, including legislative or regulatory prohibitions that might prevent operating such a facility.

Legal and Policy Issues Relating to FFTF (NEPA Analysis) - This task evaluates applicable legal and policy environmental impact issues. That analysis emphasizes NEPA applications

4.0 PROJECT APPROACH DISCUSSION – APPROACH TO GRANT SCOPE COMPLETION

The team assembled for this project consisted of two groups. The individuals employed full-time by CBCG constitute the first group. Collectively, this group has extensive and in-depth experience in regulatory issues, legal requirements, scheduling, managing large and complex projects, and document generation.

The second group consisted of subject matter experts with a substantial history of experience in the construction and/or operation of Sodium Fast Reactors. These Subject Matter Experts (SME) were ably assisted by members of the current FFTF staff in working through a variety of technical issues where current plant status was a significant consideration.

Brief biosketches on the project team's education and experience are in Appendix 7.

5.0 FACILITIES DESCRIPTION

Fast Flux Test Facility -FFTF is a 400 megawatt sodium-cooled nuclear reactor built to test advanced fuels and materials in support of the national Liquid Metal Reactor (LMR) program.

FFTF is unique among test reactors in its size, flexibility in accommodating a wide variety of instrumented test assemblies, high neutron flux, high temperatures for testing, and accessibility for experiment control and measurement instrumentation. FFTF's instrumentation capability is unmatched by any other reactor of its kind in the world. The facility was built to the highest design and construction standards. Many of the quality assurance concepts used today in the commercial nuclear power industry were applied at FFTF.

The large test volume in FFTF allows the ability to test more materials and components when compared to other neutron sources. While other neutron sources may have similar neutron high energies or fluences, FFTF is unique in simultaneously providing these attributes in a single test facility. FFTF can also produce large quantities of epithermal neutrons by the use of moderating materials that slow down the neutrons in specific areas of the core. These distinctive flux tailoring features, coupled with its large core volume, the ability to vary power from a nominal 100 megawatts up to 400 megawatts, and highly instrumented testing capabilities, enable the reactor to function successfully as a multiple-mission nuclear science and irradiation services facility. Researchers from many countries have used FFTF for nuclear materials testing and fuel research.

FFTF can provide the United States with technical capabilities not available abroad -- capabilities sought out by other countries. The foreign fast reactor capabilities that do exist are rapidly diminishing. The last French fast reactor will soon be shut down. The Monju reactor in Japan has an uncertain future, and one reactor in Russia may be the only large fast reactor other than FFTF available.

In addition, FFTF's capability of producing essentially any neutron spectra desired makes it the preferred, and some cases the only tool for materials research that can support many of the new Generation IV power reactor design concepts.

Maintenance and Storage Facility - The MASF is a multi-purpose service center which supports FFTF. The main building contains a 28,000 ft.^{2} area serviced by a 60-ton overhead bridge crane. One half of this area is serviced by a 200-ton crane, and is 105 ft. high and contains floor space for repairs and maintenance of large equipment. It has below-grade shielded hot cells for sodium cleaning. A special feature is a large shielded enclosure that contains two shielded decontamination rooms. These can be used for both remote and hands-on cleaning of small equipment items and tools that are contaminated with radioactive material.

Fuels and Materials Examination Facility - The FMEF was constructed in the late 1970s and early 1980s as part of the LMR Program. The original mission for the facility included post-irradiation examination of irradiated fuels and materials as well as fast spectrum reactor test and driver fuel manufacture. The facility was originally designed to ERDA 6301 for missions that required enhanced safeguards and security. The facility was completed but not occupied for any programmatic mission. It is therefore uncontaminated and available to support GNEP. GNEP could use FMEF to fabricate fuel on a prototypic scale as well as to assemble FFTF Driver Fuel and actinide fuels that will be needed for GNEP.

The FMEF consists of a 98-foot high Process Building with an attached Mechanical Equipment Wing on the west side and an Entry Wing across the south side. The 175-foot wide by 270-foot long Process Building provides about 188,000 ft^2 of operations space. The 98-foot height makes the Process Building as tall as a seven-story office building. The Process Building also extends 35 feet below ground. The building is divided into six operating floors.

More detailed information is found in the Addendum to the "Fast Flux Test Facility Restart Issues" report in Appendix I.

6.0 FACILITIES OPERATING HISTORY

The 400 Area complex was constructed between 1970 and the early 1980s. It is comprised of three principal facilities; the FFTF, the MASF, and the FMEF. These facilities were built to support development of the LMFBR. When DOE suspended the LMFBR program in the early 1980s, the FFTF continued to operate, providing neutron irradiation services to a variety of users until 1992. At that time it was ordered to cease power operation and go into "hot stand-by" due to lack of mission.

The exterior construction and interior service systems (H&V, water, lighting) of the FMEF were completed in the early1980s. However, installation of the shielded windows and manipulators for the FMEF hot cells was not completed. No operation with radioactive material ever took place in the FMEF. FMEF was placed in lay up in the late 1990s.

6.1 Fast Flux Test Facility

The construction of the FFTF was completed in 1978. The Primary and Secondary Heat Transport Loops were filled with liquid sodium in 1978 and the first fuel assemblies were loaded into the reactor in November 1979. The reactor went critical on February 9, 1980 at just after 3:45 PM. The next two years were spent getting the plant ready for power operation and conducting a series of natural circulation cooling tests that proved natural convection cooling in the FFTF could remove decay heat if the plant lost all electrical power. From September 1981 to January 1982, physics testing and an extended full-power demonstration run were completed. In April 1982, the FFTF was declared operational and the first cycle of operation at 400 MWt began. The FFTF reactor was designed to operate for 100 days at 400 MWt. Each of these operating intervals was called a cycle of operation. In the interval between cycles, the reactor was refueled with mixed oxide (MOX) fuel assemblies and with various test assemblies. The refueling interval usually lasted about 3-4 weeks; thus, FFTF was able to complete about 3 cycles a year.

In July 1986, FFTF completed an extraordinary set of "Passive Safety Tests." These tests demonstrated that a sodium cooled fast reactor fueled with MOX fuel could withstand a loss of flow accident without scram (LOFWoS) with no core damage provided the core had some "gas expansion modules" (GEMs) in the radial reflector region. Following completion of the Passive Safety Tests, the FFTF was loaded with the Core Demonstration Experiment (CDE). The CDE fuel was MOX, but the cladding and duct material was HT9, a ferritic-martensitic alloy, which has an extremely low neutron swelling characteristic. A CDE fuel assembly could, in theory at least, stay in the core for a long time and achieve much higher fuel burnup than the standard LMFBR fuel which was clad in 316 20% cold worked stainless steel. The CDE fuel test was very successful, operating to peak burnup values beyond 20 atom percent burnup (200,000

MWD/MTHM). The CDE test was discontinued when the FFTF was put in “hot stand-by” in 1992.

In the ten years that FFTF operated at power, dozens of various prototype fuel assemblies were successfully tested. Some fuel tests demonstrated failure-free operation at nominal operating conditions. Other tests ran fuel assemblies to failure to find out when a fuel would fail. Some test fuel was intentionally operated at extreme thermal conditions to find out the effect of over-temperature operation on fuel pin lifetime. On occasion, at the request of the test sponsor, some fuel tests were run beyond cladding breach. In this type of test, the fuel assembly continued to operate in the core after initial cladding breach until delayed neutrons were detected in primary sodium due to delayed neutron precursor fission products being released through the breach into the sodium coolant. The test was removed from the core at this point. The FFTF also performed irradiation testing of absorber pins and various alloys that were being considered for advanced reactor applications. Throughout the operation of the reactor, the FFTF MOX driver fuel design was shown to be highly reliable. Driver fuel discharge burnup exceeded the design goal of 80,000 MWD/MTHM peak pellet burnup. Overall, FFTF operations were highly reliable as measured by the availability factor (Actual Time Available/ Planned Time Available). This factor was routinely between 95% and 100% for all of the years of FFTF operation.

During the period that the FFTF operated at power, there were no significant failures of any system. All sodium pumps, inert gas systems, sodium purification systems, fuel handling systems, and containment integrity systems worked as designed. There were two interesting incidents that were learning experiences for the plant technical staff. In the first, an electro-magnetic (EM) pump used to circulate primary sodium in a sodium purification loop failed through cavitation and caused radioactive sodium to spill into an inert cell. The radioactive sodium was cleaned up without incident and the failed EM pump was replaced. The second event was related to an anomalous bending of one of the reactor vessel refueling transfer ports. Depleted uranium metal is deployed around the reactor vessel head as radiation shielding. Uranium metal oxidizes readily when exposed to air, so the shield pieces were welded into steel cans to prevent exposure to air. One of the welds in a shield piece failed and the uranium began to oxidize. Uranium oxide takes up about twice the volume as the same weight of metal, so the uranium shield piece expanded and pressed ever harder against the fuel transfer port. The failed shield piece was found and replaced and the bent transfer port returned to its normal position.

After the FFTF had been in “hot stand-by” for about ten years, DOE decided that no DOE program needed a fast spectrum irradiation capability and FFTF began a deactivation process that is ongoing. Key steps in that process were the off-loading to dry storage of all fuel, and the draining of all sodium systems.

6.2 Maintenance and Storage Facility

The MASF was declared ready for use in 1982. The MASF supports the operation of the FFTF as the facility where large, sodium wetted, contaminated equipment can be cleaned and repaired. In this role, the operating history of MASF followed the FFTF operating mission with an occasional exception, such as when the large tank in MASF was used by another Hanford program to test a large pump. All the supporting systems in the MASF are available if the facility is needed to support FFTF operations again.

6.3 Fuels and Materials Examination Facility

The FMEF was completed in 1984. The FMEF was built to perform examinations of irradiated fuels and to fabricate fuel for the FFTF and the Clinch River LMFBR. Although the exterior of the FMEF was completed and building systems such as heating and ventilation, lighting, and plumbing were installed, the hot cells and laboratories were never activated and no test examinations were ever performed. The FMEF is in a laid-up condition and unoccupied.

7.0 REACTIVATION ASSESSMENT RESULTS

The technical review for safe recovery of the FFTF to pre-shutdown condition has yielded the following conclusions by the assessment team and expert review panel:

- FFTF is fully recoverable for reactivation as an advanced fuels test and qualification center.
- FFTF has unique test features among the world's reactors required for the GNEP mission.
- FFTF can be recovered and pull rods in 60 to 66 months at an estimated $500 million including a 20% contingency. This is an aggressive but achievable schedule.
- FMEF & SAF-Line are available for advanced fuels fabrication and examination.
- MASF is available for facilities and maintenance support.

The reactivation of the FFTF and supporting facilities will substantially reduce the programmatic risk to the GNEP program and facilitate the development of the commercially competitive facilities. The reactivation will:

- Provide a U.S. test bed for testing and qualification of advanced fuels and materials for Advanced Recycling Reactor.
- Provide facilities to verify fuel performance through irradiation of prototypic actinide fuel assemblies to goal burnup.
- Provide for the irradiation of actinide fuel assemblies through multiple recycles to prove performance.
- Avoid design accommodations & operations impacts of testing in the commercial Advanced Recycling Reactor.
- Avoid impact on the commercial business plan of the privately funded facilities from "test" mission risk elements.
- Provide these benefits in a timely & cost effective program.
- Provide a "high-confidence" business model based on reuse of proven facilities specifically designed for this function.

- Provide process prototype for NRC LMF licensing infrastructure reconstruction.
- Build DOE credibility with an early start commitment to GNEP.

8.0 LEGAL AND POLICY ANALYSIS

Legal and Policy Issues for Reactivation: Amend the January 19, 2001 ROD

Energy Secretary Bill Richardson, on January 19, 2001, issued a Record of Decision (ROD) based upon DOE's December 2000 EIS titled, "*FINAL Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility"* (NI-PEIS) (DOE/EIS-0310). Secretary Richardson summarized conclusions from the NI PEIS including that the FFTF would be permanently deactivated. Rationale specified in the ROD for deactivation of the FFTF was,

> "*Given that other existing facilities can meet DOE's near-term needs for isotope production and research, the Department believes that it should invest its funds in enhancing its existing infrastructure and exploring the potential of a new AAA facility as a long-term option to meet US research needs."*

Secretary Richardson's ROD reflected recognition in the uncertainty of the future, particularly with regard to the usefulness of the FFTF. His ROD stated, "DOE recognizes that significant uncertainties remain regarding the future of research and isotope production activities that could justify operation of the FFTF."

Technology Shift to Fast Reactor Transmutation of Waste

At the beginning of the 21st century the major technology shift was from accelerators to fast reactors. Fast reactors improve the performance of transmutation of wastes and uranium resource conservation, making the closed fuel cycle sustainable. This emphasis has been adopted by and expanded upon in the present Administration's GNEP program, as directed and appropriated by the Energy Policy Act of 2005.

The FY 2007 Energy and Water Development Appropriations bill addressed the Global Nuclear Energy Partnership (GNEP). Senate Committee Report 107-274 for H.R. 5427:

> Global Nuclear Energy Partnership. – The Committee Recognizes and appreciates the considerable investment this administration has made in this area and supports efforts to close the nuclear fuel cycle. It is imperative that the Federal Government support long-term research to discover ways to reduce the amount of nuclear waste and recycle the vast amount of untapped energy that remains in the current once-through nuclear fuel cycle. Faced with the reality of long-term storage needs and the fact that our Nation is unlikely to permit and license more than one permanent repository, out best alternative is to vastly reduce the amount of waste, the heat content, and the radiotoxicity of the spent fuel before permanent disposal. The President has proposed the Global Nuclear Energy Partnership as a multi-pronged technical approach to close the nuclear

> fuel cycle and encourage the recycling of uranium and destruction of long-lived actinides through advanced reactor technology. The budget supports the development of recycling technologies that have the opportunity to enhance the proliferation resistance of existing recycling or separation technologies.

Drivers for the post-2000 technology shift include the need for a sustainable fuel supply and the capacity and siting of repository facilities. The existing one pass, LWR fuel cycle requires an expansive repository volume and an unsustainable increase in uranium mining extraction. Drivers are predicated on economic timing.

The present economic and political cost of siting additional repositories is prohibitive, and the demand for domestically supplied fuel (nuclear or otherwise) has increased dramatically. The major benefits of the closed fuel supply come from recycling of the spent nuclear fuel to recover the beneficial energy and to segregate the small fraction of toxic elements. The sustainability of the closed cycle reduces the isolation burden such that a single repository is sufficient, and ensures a domestically sustainable nuclear fuel supply.

Procedures for Amending a Record of Decision

Rationale for a ROD is likely to continue, change and evolve, and NEPA and DOE have procedural provisions that address these changes. NEPA created the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR 1502.9(c)) and DOE NEPA regulations (10 CFR 1021.314).

DOE similarly recognizes the need for decision making flexibility to accommodate technological and policy shifts, and future uncertainties. DOE allows multiple RODS for a single EIS, and subsequent RODs can be drafted and executed for subsequent environmental assessments (EAs), supplement assessments (SAs), and supplemental EISs.

Amending the January 19, 2001 ROD to Direct Restart of the FFTF

Pursuant to NEPA and CEQ regulations, the Secretary of Energy can amend the January 19, 2001 ROD provided the addressed issue was initially reviewed in the NI PEIS. The NI PEIS reviewed the status of the FFTF for continued operations, limited operations, and restart to full capacity. Amending the initial ROD from status of permanent deactivation to restart is squarely within the parameters of the NI PEIS.

Further support for this conclusion can be found in the ROD itself. Under “Summary of Environmental Impacts” for the Secretary’s ROD it stated that none of the alternatives considered in the NI PEIS would have a significant environmental impact in any major area of concern. Specifically, the ROD states:

> “The only resources area that could be significantly impacted by the implementation of any of the alternatives is water use associated with the construction of new facilities. . . The largest effect on air quality would also occur during construction activities. .. . None of the alternatives would have had significant impact on regional economic areas. . . None of the alternatives at existing candidate sites would have had a significant effect on land use, visual resources, noise, water quality, geology and soils, ecology, cultural resources and

> environmental justice... *Hazardous waste generated under any of the alternatives or combination of alternatives could have been managed under the Department's existing waste management infrastructure. . . Environmental impacts, including human health and safety, transportation, socioeconomics, and environmental justice were estimated to be small for all of the alternatives and did not provide a reasonable basis for discriminating among alternatives*." (Author's italics.)

In summary, the NI PEIS (2000) gave a "hard look" to all potential environmental impacts associated with all alternatives for the FFTF: restart, deactivation, and continuation of present conditions. The document reported, and the subsequent ROD concluded that environmental impacts were estimated to be small for any of the considered alternatives. Impacts were sufficiently minimal to conclude that the environmental impact analysis did not provide a reasonable basis for making a choice among alternatives. Given this information, no additional EIS is needed for restarting the FFTF. The subsequent step is a procedural one: Amend the January 19, 2001 ROD to restart the FFTF.

9.0 WASHINGTON STATE AND COUNTY PERMITS

State and county permits and licenses for the FFTF and 400 Area complex are listed in Table 4-1 below. These permits include Hanford site-wide permits and the permits that have been issued specifically for activities at the 400 Area. In each instance the permittee or licensee is DOE although implementation of the applicable conditions is assigned to the site services contractors. As a federal agency, DOE is exempted from the scope of some permitting activities, particularly those related to construction approval (e.g., building code conformance) under the purview of county government.

If the current deactivation activities were to be suspended and the facilities at the 400 Area complex returned to operational status, it is reasonable to expect that one or more of the existing permits would require some modifications to reflect the revised status. This is most likely true of the permits that relate to gaseous emissions. No additional permits would be required for a change in operational status of the 400 Area complex.

In addition to compliance with the permits identified in Table 4-1, DOE and its contractors are subject to many regulatory requirements that are outside the scope of the permits. These include such things as solid waste handling, refrigerant management, and community right-to-know reporting (hazardous material inventories). For these regulatory requirements, the 400 Area complex directly benefits from DOE Hanford Site infrastructure that provides essential environmental management services. A permit supervisor located at FFTF provides environmental oversight.

If the 400 Area complex facilities were conveyed to a private sector entity by lease or transfer of ownership, the existing permits would need to be modified to authorize operations by the new entity. A change to the existing owner/operator configuration would likely result in Benton County assuming a primary oversight role for new construction and significant modifications. The terms and conditions of state-issued permits would remain largely unchanged although a water right would need to be established and documented for the existing wells. A transfer to a private sector entity would probably result in a loss of access to the existing Hanford Site environmental monitoring and waste disposal services.

Table 9-1. Washington State and County Permits and Licenses

Permit/License	Administering Agency / Washington Administrative Code (WAC) or Regulation	Status
Air Emissions Permit	Dept of Ecology / WAC 173-400, 173-401, 173-460, 173-480 Dept of Health / WAC 246-247 Benton Clean Air Authority / BCAA Reg. 1	Air emissions from FFTF and 400 Area facilities are covered under the umbrella of the Hanford Site Air Operating Permit (December 2006). The permit incorporates the terms and conditions of three agencies: Ecology for non-radiological emissions, Health for radiological emissions, BCAA for asbestos abatement and open burning. A change to FFTF operations that has the potential to increase existing emissions would trigger the requirement to file a Notice of Construction.
Wastewater Discharge Permit	Ecology/WAC 173-216	FFTF has no discharges to surface waters that would require a National Pollutant Discharge Elimination System (NPDES) permit. Process water is discharged to onsite percolation ponds under a State Waste Discharge Permit (September 2003). A change to FFTF operations that has the potential to change the quality of the effluent or increase the flowrate could trigger the requirement to file an application for permit modification. Other discharges to the soil column at FFTF such as stormwater, condensate streams, and wash water are permitted in accordance with a Hanford site-wide State Waste Discharge Permit (February 2005). Sanitary wastes at FFTF are piped to a neighboring treatment facility operated by Energy Northwest. Energy Northwest provides for the permitting and compliance activities related to this wastewater stream.
Hazardous Waste Permit	Ecology/WAC 173-303	Most hazardous waste generated at FFTF is managed at facilities outside the 400 Area. DOE has applied to Ecology for a Treatment, Storage, & Disposal (TSD) permit to store waste sodium at FFTF. Once issued this permit will be integrated into the Hanford Facility RCRA TSD Permit.
Water Right Permit	Ecology/WAC 173-152, 508-12	Water for FFTF is supplied from onsite wells. As a Federal agency operating on a federal reservation, DOE is not required to have a state-issued Certificate of Water Right to withdraw the ground water. A different ownership configuration could change the water right aspect.

Drinking Water System Permit	Health/WAC 246-292, 246-294	DOE has a Drinking Water System Operating Permit for the 400 Area potable water system. Certified operators provide oversight.
Underground Storage Tank (UST) Permit	Ecology/WAC 173-360	The FFTF power generator fuel storage tank is permitted under a Hanford site-wide UST permit.
Low-Level Radioactive Waste Disposal Permit	Ecology/WAC 173-326 Health/WAC 246-249	A permit is not required to dispose of low-level rad waste generated at FFTF because the facility has access to DOE Hanford waste disposal facilities. Under a different ownership configuration wastes from the facility may need to be disposed of at the commercial waste site under a Site Use Permit.

9.1 Washington State Initiative 297 (I-297) Status Review

The Cleanup Priority Act (CPA) RCW 70.105 E et. seq., commonly known as I-297, is a 2004 State initiative passed by the voters of Washington. I-297 directed DOE to cleanup all waste on the Hanford site prior to receiving or generating any additional nuclear waste. I-297 also assessed the Federal government a surcharge based upon the Hanford Clean-up budget or the Congressional budget request, whichever is higher. The surcharge has been estimated at $1.2 million per year. This Initiative was supported by nearly all voters with the exception of the counties adjacent to Hanford.

In response, the Federal government successfully challenged I-297 in Federal District Court. The Washington Department of Ecology and citizen's groups, Yes on I-297: Protect Washington, et. al., appealed the decision to the Ninth Circuit Court. As of April, 2007, the Court has not reviewed the appeal.

The Washington Initiative Process is unique as compared to other American legislative processes. The Initiative process gives citizens the opportunity to initiate voter participation in the legislative process. The process is as follows: a petition can be written to create or modify law. The petition is then circulated. If a small (4-8%) percent of the voting populace from the prior gubernatorial election signs the petition, then the certified initiative can be placed on the ballot. I-297 attempted to regulate federal actions on federal lands. This result overlooks substantially complex issues legal in nature and germane to national security. DOE's initial predecessor agency was the Atomic Energy Commission (AEC). The missions of the original AEC were to protect national security, and to develop and provide a sustainable energy source for the world. These missions have remained applicable via the Atomic Energy Act of 1954.

DOE's many nuclear operations create various waste streams, repositories and 114 cleanup sites across the country. Different waste forms are regulated by different legislation and government authorities. Not uncommonly waste products may be regulated under multiple authorities, local, state and federal. I-297 interferes with many existing regulatory efforts and does not offer a solution that is more protective of the environment.

If I-297 were to be implemented then DOE's entire national clean-up effort would be interrupted, with detrimental consequences for the entire nation, including reprisals by other states. The U.S. Supremacy Clause of the U.S. Constitution exists, in part, so that the Federal government can implement federal policy without concern that its authority will be usurped by a single state or other small constituency. The U.S. District Court ruled against Initiative 297.

9.2 Tri-Party Agreement, M-81 Deactivation Milestones

Review of M-81 Milestones

Many of the original TPA milestones have been completed. Any impacts on restart relating to completed milestones are necessarily incorporated into the detailed discussions of restart issues elsewhere in this document.

Required M-81 Milestone Modifications

Milestone	Title & Status	Due Date
M-81-10-T-01	*Submit Final Sodium Disposition Report* Activity is on schedule	07/31/07
M-92-10	*Submit Hanford Site Sodium disposition Report to Ecology*. Activity is on schedule.	07/31/07
M-81-00A-T04	*Complete Transfer of Special Fuel to DOE's Idaho National Engineering Laboratory for Consolidated Storage*. Activity is on schedule.	03/31/09
M-92-09	*Establish Milestones and/or Target Dates if Needed for Acquisition of New Facilities, Modifications of Existing Facilities, and/or Modification of Planned Facilities Necessary for Storage, Treatment/Processing, and Disposal of Hanford Site Sodium.* Activity is on schedule.	07/31/09
M-81-14	*Complete FFTF Sodium Drain.* Essentially complete, but DOE plans to drain the large MHTS valves by end of FY 2007 before declaring milestone complete.	09/30/09
M-81-15	*Submit FFTF Surveillance and Maintenance Plan*. Activity on schedule.	06/30/10
M-81-00A	*Complete FFTF Facility Transition and Initiate the Surveillance and Maintenance Phase.* Activity is on schedule.	02/28/11
M-81-00A-T05	*Complete Auxiliary Plant Systems Shutdown.* Activity is on schedule.	02/28/11

Since all of these milestones are predicated upon the permanent deactivation of FFTF, the treatment of all of them in the event of restart would be the same. Essentially, all milestones having to do with the deactivation of FFTF would have to be renegotiated.

Further, there are four milestones which call for specific action as opposed to the generation of a document. Milestones M-81-00A-T04, M-81-14, M-81-00A and M-81-00A-T05 are currently in progress toward completion. If the cost of restart is to be minimized, instructions need to be issued at the earliest possible date that work is to be stopped on these milestones.

10.0 FEDERAL REGULATION & OPERATING AUTHORITY

DOE, as owner and operator, will be responsible for the regulation and operating authority for the FFTF and the associated 400 area facilities. However, several options are available for determining how this process will be carried out. These options are outlined below.

- **Regulatory Oversight** - An initial determination whether FFTF restart and/or subsequent operations should be regulated by DOE or the NRC. NRC guides for reactor analysis and refurbishment for restart would likely be used in either case, but there could be differing requirements applicable to supporting programs that would be significant. Examples are the applicability of 10 CFR 830 for DOE reactors, Operator Certification for NRC operators, differing seismic requirements -- all of which could have significant costs if the current FFTF programs were changed to conform to NRC standards. It is because of this potential cost impact that the selection of which regulatory path to follow should be carefully weighed in terms of cost and benefit.

In this discussion, we consider that activities and regulatory requirements for restarting FFTF are separate and distinct from activities and requirements governing operations after approval to operate has been granted by the regulatory authority. Therefore we have two FFTF phases – startup, and operations – and two regulatory entities – DOE, and NRC. This two-by-two matrix has four possible permutations:

Case 1 – DOE governs both startup and operations.
Case 2 – The NRC governs both startup and operations.
Case 3 – DOE governs startup; the NRC governs operations.
Case 4 – The NRC system governs startup; DOE governs operations.

Some considerations of these options are summarized below:

- **Case 1** - *DOE Regulated Facility* - Under this standard approach, DOE would provide the regulatory review and DOE standards would be adopted for both restart and subsequent operations. This option is probably the least expensive in both time and resources. It would require DOE to staff up to develop the regulatory capability for LMRs and to set up an organizational system for credibly separating the “applicant” from the “regulator” side of the NE organization. In all likelihood, any analytical work would need to be contracted to one of the national laboratories that may still have staff knowledgeable in LMR safety technology. The principal disadvantage of this is that DOE does not have the same degree of regulatory credibility as the NRC. Further, it would not provide any incentive for the NRC to begin staffing up in LMR capability—which could provide a “jump start” for subsequent NRC reviews of future GNEP projects.

- **Case 2** - *NRC Regulated Facility* - This option would likely be considerably more expensive than Case 1—both in time and resources. Since the demise of the CRBR project, plus subsequent activity related to the GE PRISM design, the NRC has had no incentive to retain LMR expertise, so this capability would have to be rebuilt. The cost for this rebuilding would have to be borne by either DOE or through a Congressional reallocation. On the other hand, NRC records associated with the detailed NRC review conducted for the construction and approach to power operation of FFTF still exist, and an updating for FFTF restart should be possible with a reasonably modest effort. NRC regulatory oversight for subsequent FFTF operations would entail considerable changes from the present mode of operation and could become a critical path item. However, successful transfer of FFTF operations from DOE to the NRC system would provide substantial credibility for FFTF and would pave the way for subsequent GNEP projects, such as the Advanced Recycling Reactor, that are scheduled to come under the regulatory purview of the NRC.

- **Case 3** - *Regulatory Unit Approach* - This option would likely cost more than Case 1, but it would allow the FFTF to restart under existing rules and procedures to minimize the impact up to the point of achieving full power operation. This path is based upon the assumption that the potentially overly restrictive seismic requirements of DOE could be appropriately modified to correspond to actual risk considerations. Assuming that an appropriate working relationship with the NRC could be worked out early, a parallel effort to convert the subsequent FFTF operations to conform to NRC regulations should provide a smooth transfer. This path could follow the model implemented by the US Enrichment Corporation—wherein a 5-year transition was employed to transfer all facility supporting programs from DOE orders and regulations into the NRC format.

- **Case 4 –** *NRC Restart Case* - It may be possible to use NRC to perform a regulatory review for restart and then revert back to DOE operating procedures. This case would essentially mirror the original FFTF startup, wherein a detailed NRC review was conducted to ensure that LMRs could be licensed, but once in operation the FFTF was operated under DOE regulatory jurisdiction. This process could be repeated and it would provide both credibility and consistency. However, it could cause considerable disruption in the process and become the highest cost option—both in time and resources.

11.0 PLANT REACTIVATION AUTHORIZATION & LICENSING CONSIDERATIONS

Return to Safe Operations – Pre-Shutdown Configuration

Following is a very brief summary of the major issues in restarting the FFTF, as determined by the Workshop Team. The complete discussion of all of these issues is found in the "Fast Flux Test Facility Restart Issues" document, attached.

- Critical Issues

  Requalification of the Decay Heat System Boundary - The integrity of the sodium system boundaries important to decay heat removal must be confirmed. These boundaries are the reactor vessel and the primary and secondary heat transport systems. It is necessary to verify that the sodium drain and subsequent cooling to ambient temperature has not degraded the stainless steel piping and components to the point that the decay heat boundary integrity is compromised. Without this assurance, the reactor cannot be restarted.

  Operability of Refueling Equipment - The operation of refueling equipment inside the reactor vessel was reviewed for possible impacts. The primary change from normal operations that could adversely affect the refueling system is draining sodium from the reactor vessel, thus exposing in-vessel equipment to cover gas.

Resolution of Hole and Chips in Core Basket - A ¾-inch hole was drilled through a plate inside the reactor vessel below the core support area in order to install a sodium drain pump for removing the sodium from the lower areas of the vessel. The issues are effects of loose chips and alteration of the sodium flow path within the reactor vessel.

Design Basis Earthquake - FFTF was designed with a design basis earthquake acceleration of 0.25g. The value was established through a geophysical analysis of known faults and bore hole testing conducted on the FFTF site. The analysis and pertinent data, references 1, 2, and 3, were reviewed by the NRC during the 1972 construction approval stage of the plant. The site geology and seismology were revisited in 1978 during review of the FSAR. The NRC concluded, as documented in the SER, that no changes in criteria were warranted.

- Early Decisions
  Decide Regulatory Path for FFTF Restart - A significant early decision is to determine whether FFTF restart and/or subsequent operations should be regulated by DOE or the NRC.

  Refill Primary & Secondary Loops with Sodium - Sodium drained from FFTF systems was transferred to carbon steel tanks in the Sodium Storage Facility (SSF), and kept in solid form under positive pressure high-purity argon gas. This sodium is anticipated to be suitable for reuse in FFTF systems, but proof of that fact is required. If the sodium cannot be reused, then approximately 250,000 gallons of high-purity reactor-grade sodium must be produced, procured, and brought to the FFTF site.

  Identify and Qualify Core Components - Driver Fuel Assemblies (DFAs), Control Rod Assemblies (CRAs), and reflectors are consumable core components and compose the FFTF reactor core. Shut down actions at the FFTF disposed of the remaining supply of most of the useable core components, so the core component supply line must be re-established in order to load the First Core and to provide replacement components as spent core components are discharged in subsequent operation.

- Other Significant Issues
  Reconstitute, Revise FSAR - Determine the major administrative decisions and technical efforts that will be required to reconstitute the Final Safety Analysis Report for the restart of FFTF.

  Infrastructure Needs as Hanford Shuts Down - FFTF will need some infrastructure services, now provided by the site, past the time that these services are scheduled to be discontinued (2013). FFTF can not perform its mission without arranging for alternate suppliers of these needed infrastructure services, such as certain electrical utility services, fire protection, road maintenance, telecommunications, and safeguards & security.

  Establish Sodium and Gas Tag Analysis Capability - The capability for sodium and cover gas chemical analysis and analysis of tag gas isotopes released from breached fuel pins no longer exists. Ability to verify the purity of the sodium and cover gas is essential to restart and operation of FFTF. If experiments are to be gas-tagged, capability to analyze the tag gas isotopes is required in order to expeditiously locate any cladding breaches. This ability is important since it will probably be necessary to quickly identify experimental fuel assemblies containing breached fuel cladding, even if they are not to be immediately removed.

Refill NaK Heat Transfer Loops - The FFTF used three relatively small sodium-potassium alloy (NaK) loops for removing heat from auxiliary systems (total NaK volume was ~870 gallons). Access to the two NaK loops in the lower regions of the containment building (primary cold trap and IDS cooling) was very difficult, and sodium piping was available in close proximity to the NaK piping. It was therefore decided to flush these two NaK loops with primary sodium by installing sodium-NaK cross-connections and then draining them to the maximum extent practical.

Hiring and Qualification of Technical Staff - The current staffing level of Operators, Engineers, and Crafts employed at the FFTF is insufficient to support recovery and restart of the reactor and its supporting facilities.

Implementation of Listed Plant Upgrades - Some plant modifications are currently in progress to improve safety, reliability, and efficiency of operations in shutdown. If FFTF is directed to restart, several upgrades are planned in order to return systems to operation, improve reliability, conform to current standards, improve efficiency, or minimize waste.

Primary HTS Snubber Testing - There are approximately 3,500 seismic snubbers at FFTF. Some of these require periodic inspection. The Primary HTS snubbers were not tested during operation because of their inaccessibility. Due to "FFTF Shut Down" actions, the primary cells are now open and accessible. Therefore, a test program of the primary seismic Category I supports/snubbers must be implemented.

Revise Security Threat Level Plan - The requirements for Security changed dramatically after the events of 9/11. These requirements will be evaluated and changes to the security systems at FFTF identified.

Plant Configuration Verification

Through its years of operation, FFTF continuously has been a model for efficient configuration management and document control through deactivation. For example:

- The FSAR was prepared to commercial standards and reviewed by the Nuclear Regulatory Commission and the Advisory Committee on Reactor Safeguards.
- The FSAR has been maintained under strict configuration management.
- Operating and maintenance procedures have been maintained after corresponding systems have been suspended.
- Plant systems have been held under strict design control with Change Notices made to the baseline drawings to reflect deactivation changes maintaining strict configuration control.
- All documentation is indexed and recoverable.
- System assessments of the operability of FFTF equipment have been completed.
- Quality Assurance record documentation for plant systems has been maintained.

11.1 Fuel Supply

Fuel Supply for the Fast Spectrum Research Center

The Fast Spectrum Research Center will use conventional FFTF fast reactor driver fuel to provide a fast neutron flux environment to test, under prototypic conditions, advanced fuels and materials supporting the development of advanced actinide recycle fuel systems. The Advanced Fuels Test and Research Center has the flexibility under the FFTF Authorization Basis to allow simultaneous testing of multiple assembly loadings of diverse recycle fuel systems. This permits "side-by-side" comparison of different candidate fuel systems in assembly configurations prototypic of irradiation and thermal conditions expected in the Advanced Recycling Reactor. Operating as a fuels and materials test reactor, the FFTF will irradiate candidate recycling fuel assemblies to goal burnup and provide fuel performance data at more extreme operating conditions to support the licensing by the NRC of a commercial recycling reactor.

The FFTF will operate using conventional fast reactor fuel, similar to that already approved under its Authorization Basis, to perform irradiation testing of individual “experimental” actinide fuel assemblies of interest to the sponsoring programs. During this phase, FFTF will be fueled with either MOX fuel and/or enriched uranium (EU) as an oxide or binary metal alloy fuel form. Driver fuel will be procured by DOE. Procurement options are discussed in the “Fuel Supply Options” section below.

After the Programs have selected the fuel system to be used, the FFTF can be converted to an all “actnide fuel” core to operate using a lead prototype core. In this role, the FFTF would to support further development of recycling fuel as well as burn significant quantities of actinide fuel and demonstrate recycling fuel performance to even higher burnup levels. When the commercially operated Nuclear Fuel Recycling Center comes online and begins producing recycled fuel, the FFTF could use this fuel to continue operations until its programmatic mission is completed.

FFTF Conventional Fuel Supply Options

A supply of new Driver Fuel Assemblies (DFAs) will have to be developed to provide fuel for the FFTF because there is not enough available fuel to complete a core loading. An additional 133 DFAs need to be procured to reload and operate the FFTF at 400 MW for 2 years. About 43 “new” DFAs will be combined with the remaining 32 “old” fresh MOX DFAs to makeup the first core. The balance of the “new” DFAs (90) would be needed to refuel over the first 2 years of operation. An additional 60 “new” DFAs per year would be needed after the initial 2-year period was over.

There are two options for “new” DFAs. The first is the use of SNR-300 MOX fuel if it is still available to DOE. A total of 156 “new” DFAs could be fabricated from this fuel for use in the FSRC. That would be sufficient fuel to load the first core and operate for 2.3 years. After that another source of “new” DFAs must be developed using the second option which is EU fuel. This is a Uranium Oxide fuel that is very similar in design and performance to “old” FFTF MOX fuel.

11.2 Waste Generation

Upon restart FFTF will be run for 20 or more years continuing its original mission of fast spectrum nuclear fuels research testing, moving into using actinide fuel recovered from commercial spent nuclear fuel. The waste generated will be the same as for previous operations.

- Air Quality – Intermittent operation of emergency diesel generators.

- Water Resources
  - Ground water withdrawal from wells (~260 Ml/yr)
  - Process waste water transferred to the 400 Area percolation pond (~100 Ml/yr)
  - Sanitary Sewage transferred to the Energy Northwest treatment system (~6 Ml/yr)
  - Low-level liquid radioactive waste resulting from washing sodium from reactor components transferred to the 200 Area Effluent Treatment Facility based on 60 fuel elements/yr. (~25 Kl/yr)

- Ecological Resources – No impact to threatened or endangered species.

- Cultural Resources – No prehistoric, historic, or paleontological sites have been identified in or around the 400 Area.

- Radiological Impacts – Incremental accidental releases were analyzed to result in 0.0044 total latent cancer death among the population surrounding the FFTF site and support sites after 35 years of operation.

- Hazardous Chemical Impacts – Associated with emergency diesel fuel and exhaust.

- Waste Management
  - No high-level radioactive waste or transuranic waste outside of spent fuel would be generated.
  - Solid low-level radioactive waste packaged and transferred to low-level radioactive burial grounds. (~3,000 cubic meters over 35 years)
  - Mixed low-level radioactive waste packaged and stored in accordance with the Tri-party agreement for Hanford. (~150 cubic meters over 35 years)
  - Hazardous waste packaged in DOT containers and transferred for commercial disposal.
  - Spent nuclear fuel will be stored on site in sodium-filled storage tanks. After ten years fuel will need to be transferred to dry storage or transferred for processing. (~60 fuel elements per year at full power; ~2 metric tons of heavy metal per year)

12.0 REACTIVATION SCHEDULE AND COSTS

The Expert Panel Workshop developed a preliminary cost estimate and schedule of activities for plant recovery on a best estimate basis. The Panel developed the estimates with input from plant staff and used the “PNNL 2000 Program Scoping Plan for the FFTF, A Nuclear Science and Irradiation Services User Facility” as the baseline, escalated to 2007 dollars.

The activities required to reverse deactivation actions were identified during the workshop and estimated as adders to the baseline figures, with duplications or redundant actions deleted. The result indicates that recovery can be accomplished for approximately $500 million. As shown below.

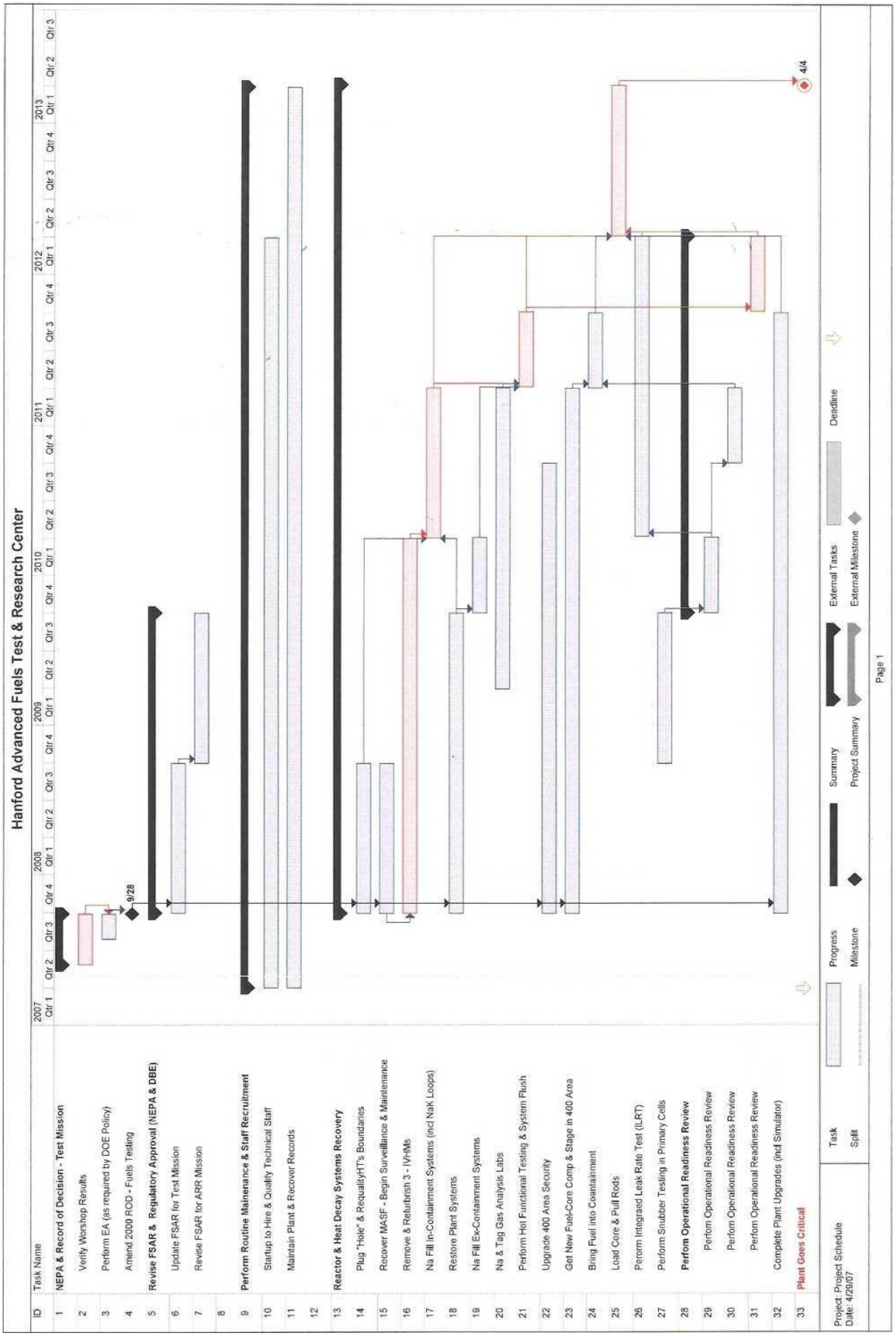
FFTF Reactivation Expert Panel Cost Estimate
($ 000)

ACTION (Durations)	2000 PEIS 2000	2000 PEIS Escalated 2007	2007 FFTF Reactivation 2007
Startup to Hire and Qualify Technical Staff (12 months)			$863
Plug "Hole" and Requalify HTS Boundaries (12 months)			$2,150
Remove & Refurbish 3 - IVHMs (30 months)			$8,000
Recover MASF --> Begin Surveillance & Maintenance (12 months)			$1,500
Na fill Ex-Containment Systems (6 months)			$300
Na fill In-Containment Systems (incl. NaK Loops) (12 months)			$500
Complete Plant Upgrades (including Simulator) (48 months)*	$46,100	$56,697	$31,200
Restore Plant Systems (including reversing Na-drain Mods) 24 months)			$17,500
Revise FSAR & Get Reg. Approval (incl. NEPA & DBE) (36 months)	$15,500	$19,063	$9,000
Perform Hot-Function Testing (6 months)	$400	$492	$492
Na & Tag Gas Analysis Labs (24 months)			$7,000
Upgrade 400 Area Security (36 months)			$31,000
Get New Fuel - Core Comp. and stage in 400 Area (42 months)			$37,200
Bring Fuel Into Containment (6 months)			$500
Load Core and PULL RODS (12 months)	Performed by Existing Plant Forces		
Perform Integrated Leak Rate Test - ILRT (24 months)	$800	$984	$984
Perform Operational Readiness Review(s) ORRs	$1,500	$1,845	$1,845
Perform Snubber Testing in Primary Cells (12 months)			$1,400
Total Cost for Resolving Recovery/Restart Issues , $ K	$64,300	$79,081	$150,034
Profile of Technical Staff to Operate FFTF (FTE)	$203,857	$250,719	$234,400
Electricity, Inert Gas, Roads, Commodities, & Spares	$33,000	$40,586	$40,000
Grand Total for Recovery / Restart over 5 year schedule	$268,157	$329,799	$424,434
Total Cost Estimate With 20% Contingency	**$321,789**	**$395,759**	**$509,321**

* Note: “Plant Upgrade items included in 2000 PEIS estimate have been broken out in separate line items for the GNEP reactivation estimate

The Panel, with input from the CBCG Staff and plant staff, developed a schedule for the identified activities that were necessary for restart. These activities encompassed the activities listed in the 2000 PEIS and the recovery activities identified as necessary as a result of deactivation actions performed since the 2000 PEIS preparation.

This schedule represents an aggressive but achievable effort to provide DOE a near-term fast spectrum, sodium test reactor to perform the missions critical to the GNEP program.


Hanford Advanced Fuels Test & Research Center
ID Task Name
1 NEPA & Record of Decision - Test Mission
2 Verify Worshop Results
3 Perform EA (as required by DOE Policy)
4 Amend 2000 ROD - Fuels Testing
5 Revise FSAR & Regulatory Approval (NEPA & DBE)
6 Update FSAR for Test Mission
7 Revise FSAR for ARR Mission
8
9 Perform Routine Mainenance & Staff Recruitment
10 Startup to Hire & Qualify Technical Staff
11 Maintain Plant & Recover Records
12
13 Reactor & Heat Decay Systems Recovery
14 Plug "Hole" & RequalifyHT's Boundaries
15 Recover MASF - Begin Surveillance & Maintenance
16 Remove & Refurbrish 3 - IVHMs
17 Na Fill In-Containment Systems (incl NaK Loops)
18 Restore Plant Systems
19 Na Fill Ex-Containment Systems
20 Na & Tag Gas Analysis Labs
21 Perform Hot Functional Testing & System Flush
22 Upgrade 400 Area Security
23 Get New Fuel-Core Comp & Stage in 400 Area
24 Bring Fuel into Coantainment
25 Load Core & Pull Rods
26 Perorm Integraed Leak Rate Test (ILRT)
27 Perform Snubber Testing in Primary Cells
28 Perfom Operational Readiness Review
29 Perfom Operational Readiness Review
30 Perfom Operational Readiness Review
31 Perfom Operational Readiness Review
32 Complete Plant Upgrades (incl Simulator)
33 Plant Goes Critical
2007 2008 2009 2010 2011 2012 2013
Qtr 1 Qtr 2 Qtr 3 Qtr 4
9/28
4/4
Project: Project Schedule
Date: 4/29/07
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 1

13.0 GNEP PROGRAMMATIC RISKS/BENEFITS IMPACT

This discussion is based on two premises:

1. Testing for proof-of-concept is a vital, necessary part of the GNEP program in order to ensure success, and
2. Testing must begin at the earliest possible date because the window of opportunity for transmuting fuel will eventually close.

The FFTF has a key role to play in reducing the programmatic risk inherent in the GNEP program:

- Testing of transmutation fuel (an Advanced Recycling Reactor critical path item) can begin 10-13 years earlier than with a commercial prototype Advanced Recycling Reactor.

- FFTF as a user test bed can facilitate early international consensus on a proof-of-performance commercial demonstration Advanced Recycling Reactor.

- FFTF and 400 Area can provide a user test bed for vendors to validate their proposed core, transmutation fuel concepts, and materials/design-of-construction.

- The U.S., the international community, and bidders on the Advanced Recycling Reactor can have a higher standard of fuel-design validation relative to computation & engineering-only validation.

- The FFTF and the 400 Area complex can provide 'integrated risk-reduction' and optimize the use of appropriated funds by demonstrating the remote assembly of the transmutation fuel pins and subassemblies.

- With FFTF, the transmutation fuel proof-of-performance experiments can be designed and built now, and be made ready for testing just after FFTF startup.

- The FFTF can reduce programmatic risk to the first commercial Advanced Recycling Reactor by providing continued operating experience on fast reactor operations and sodium-cooled systems, and factoring this data into the design requirements and cost estimates and uncertainty analyses for the Advanced Recycling Reactor.

Chapter 2

GNEP Assignment For Advanced Recycling Reactor Mission To FFTF

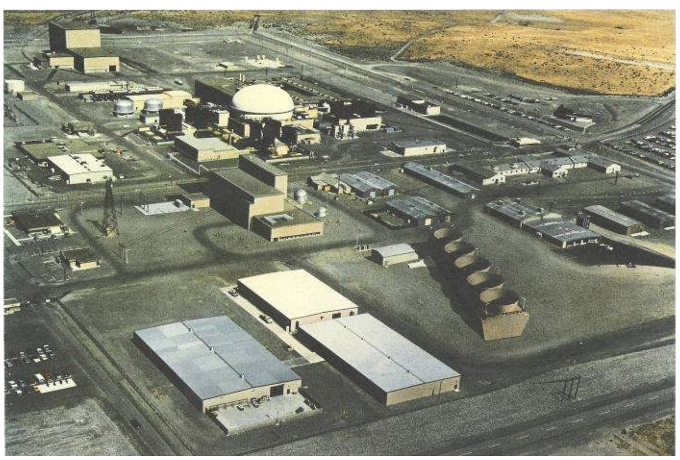
1.0 INTRODUCTION

FFTF potential as the prototype Advanced Recycling Reactor

A cornerstone of the Advanced Energy Initiative is the Global Nuclear Energy Partnership (GNEP). GNEP is designed to close the nuclear fuel cycle though recycling and destruction of actnides in an Advanced Recycling Reactor, specified as a sodium cooled fast reactor.

In January 2007, DOE awarded a Grant to the Tri City Development Council (TRIDEC) to manage a collaborative effort between the Columbia Basin Consulting Group (CBCG) and a TRIDEC lead consortium team to evaluate the Hanford Site for locations for siting GNEP Facilities. Under this effort, the CBCG review Team responded to a discussion initiated by DOE during the mid-project review concerning the potential for FFTF to meet the specification requirements for the commercial prototype Advanced Recycling Reactor. The FFTF meets the reactor type requirements and the lower end of the facility specification for power production, and with the addition of a power addition for electricity generation, the FFTF meets the specified requirements electricity production for the commercial prototype Advanced Recycling Reactor.

A power addition option to the FFTF has been previously evaluated, including an evaluation completed by Stone & Webster Engineering Corp. in 1987. The 1987 effort produced an Advanced Conceptual Design report which evaluated the technical and economic feasibility of a steam turbine power addition.



Rendition of Fast Flux Test Facility with Power Addition

Based on an available 297 MWt of energy for power production, the power addition yielded a generation capacity 118 MWe.

The Fast Flux Test Facility, with the Power Addition, can function as an integrated nuclear research center and technology prototype recycling reactor.

The review of available literature and previous design information indicates the FFTF is capable of contributing to the effort to reduce the high level waste inventory and, with addition of a power generator, meet the objectives of the Advanced Recycling Reactor of actinide destruction and economical electricity production.

2.0 MISSION STATEMENT – PROTOTYPE ADVANCED RECYCLING REACTOR

The FFTF in the mission as a commercial prototype Advanced Recycling Reactor with the power generator addition, can perform three critical roles:

- Advanced fuels testing & performance qualification (Primary Mission)
  - Fast Reactor Driver Fuel Optimization
  - Actinide Fuel test & qualification
  - Recycling Actinide Fuel test & qualification

- Actinides destruction through extended operations, and

- Power production through extended operations

Because of the relatively near-term startup schedule for the FFTF and modification window, the FFTF as the commercial prototype Advanced Recycling Reactor can also provide a center of excellence for personnel training, regulatory infrastructure development, and new systems or components testing and performance evaluation.

Inherent in this discussion is the assumption that the FMEF may be used for fuels assembly or post-irradiation examination, an assignment of the Advanced Recycling Reactor mission to the FFTF does not include a presumption of assignment of the fuels recycling or reprocess function to Hanford.

Although the FFTF does have a meaningful burn rate for actinides and can contribute to the nations high level waste reduction effort, the actinide burn rate is two orders of magnitude below that necessary to support a commercial level fuels processing center.

3.0 SCOPE OF THE STUDY

This report addresses the conversion of the FFTF for service as a prototype Advanced Recycling Reactor, as discussed during the midterm review at DOE. It does not address the restart of the FFTF for use as the Hanford Advanced Fuels Test and Research Center, which is the subject of Section I.

The feasibility of a power generating addition is based on a 1987 detailed Advanced Conceptual Design report. That study examined the power addition technical viability including analysis of configuration, components, tasks, costs, and schedules. During the technical workshop, the mission capabilities and limitations of the facility were discussed. Regulatory and permitting issues, environmental and safety considerations, and options for changing the use of the facility from a permitted test reactor to this new mission from a NEPA analysis standpoint are presented.

4.0 ADVANCED RECYCLING REACTOR MISSION ASSESSMENT RESULTS

The conclusions for modification of the FFTF as prototype Advanced Recycling Reactor are:

- The selection decision of the FFTF a commercial prototype Advanced Recycling Reactor would be made as part of the GNEP Record of Decision scheduled for June 2008.
- If selected, a site specific NEPA action and safety assessment would be required prior to the start of modification work.
- The FFTF recycling reactor mission would be a dual role of fuel test and qualification, with the added mission of actinide destruction and power generation.
- The FFTF performing the function of a recycling reactor will provide a platform for industry personnel, sodium handling training and systems, the NRC regulatory infrastructure, and supporting technology development.
- The 1987 Advanced Conceptual Design Report planned a 48 month schedule for completion of the power addition following authorization to proceed with engineering and final design.
- A preliminary assessment of the Report cost data and current information indicates that the power addition would be approximately $250 million and have a generating capacity of 118 MW. The economics of the power addition compare favorably with current commercial electricity production given that the primary function of the reactor facility is for fuel recycle and actinide burn.

4.1 FFTF Actinide Burn Rate

Actinide elements are consumed in a nuclear reactor primarily by the fission process. The “burn rate” of actinide fuel in the FFTF is 407 gmHM (Heavy Metal) per full-power day. The FFTF has a full power rating of 400 MWt (Mega-Watts thermal power). However, this does not mean that 407 gm of transuranic elements will be consumed “on net” each day.

If depleted uranium is in the reactor’s fuel, then a small portion of the fissions occurring in the actinide fuel will be in U-238 and not in plutonium or the higher actinide elements. This results in a burn rate for transuranic elements that is less than 407 gmHM per day. For example, in an FFTF MOX Driver Fuel Assembly (DFA), U-238 is 75% of the heavy metal content of the fuel and accounts for 7.4% of the fissions in the reactor.

If actinide fuel assemblies, similar to FFTF DFAs, made up the entire reactor, 377 gmHM per day of transuranic elements would be consumed. However, that is not quite the full story. While 377 grams of transuranic elements were undergoing fission, some new plutonium was being made by neutron capture in U-238. For an FFTF MOX DFA, 0.45 atom of Pu-239 is made by neutron capture in U-238 for every atom destroyed by fission. Since 407 grams of actinides underwent fission, 183 grams of Pu-239 were made. On net then, only 194 gmHM of transuranic elements are destroyed in one day's operation at 400 MWt.

In one year of full power operation, FFTF would consume 70,810 gmHM or 70.8 kgHM of transuranic elements. However, reactors need to shutdown to be refueled and to have routine maintenance performed. Typically, FFTF operates at a plant capacity factor of 0.85, because of needed outages, the net consumption of transuranic elements would be reduced by 15% to 60.2 kgHM per year. Another way to view this is: every year, discharged actinide fuel assemblies from the FFTF would go to the recycling facility with 60.2 kgHM less transuranic elements than they originally contained.

The destruction rate of transuranic elements may be improved by reducing the amount of uranium in the actinide fuel assembly. If a non-fertile diluent were used in place of uranium in the fuel, then the amount of transuranic elements burned would increase. For FFTF operating as a prototype recycling reactor with a capacity factor of 90%, this change results in 133 kgHM a year of transuranic elements being consumed. To achieve this destruction rate, the actinide fuel could not contain any uranium. Not having any U-238 in the reactor changes some core characteristics. The Doppler defect would be smaller than it is in the MOX fueled core. This would mean that the power coefficient would also be smaller, but would still remain negative. The reactivity lost each day would be larger than it is in a MOX fueled core. This will require higher worth control rods to allow 100-day cycles. The control rod bank worth will need to be about twice as strong as the current control rod bank. A higher bank worth can be achieved by increasing the B-10 enrichment in the boron carbide pellets used in the control rods.

Reducing uranium in the actinide fuel has the potential to improve the fuel cycle cost for the recycling reactor. By burning more "net" plutonium in each operating cycle, fewer spent fuel recycle passes will be needed to consume a given amount of plutonium; this results in a lower fuel cycle cost.

Depending on the uranium content in the actinide fuel assembly, FFTF operating as a prototype recycling reactorcan destroy between 60.2 and 133 kgHM a year.

4.2 Power Addition

A comprehensive study to evaluate the addition of a electrical power generating capability to the FFTF was issued in 1987. The major new facilities required for the power addition are the Steam Generator Building and the Power Generation plant. The Power Generation plant would be outside the FFTF security fence. The plant consists of the Turbine Generator building, an Administration & Maintenance building, cooling towers, and a Chlorination building.

The existing main heat transport system (HTS) of the FFTF consists of three essentially identical sodium-cooled loops to remove reactor heat. Each HTS is composed of a primary loop and a secondary loop. The reactor vessel is common to all three primary loops; the secondary loops are all independent. Heat from the reactor is transferred to the Intermediate Heat Exchangers (IHXs), and then to the secondary loops. The heat is currently rejected from the secondary loops to ambient air via forced airflow Dump Heat Exchangers (DHXs). (See Figure 4.2-01)

The FFTF Power Addition will install steam generators on two of the three secondary HTS loops. The third, or east loop, contains a tornado protected DHX and will remain in its present configuration to provide a dedicated emergency heat removal path.

The reference configuration for the Power Addition uses one evaporator and one superheater module in each secondary loop. The superheater and evaporator module will be in series with the existing DHXs. During normal operation of the power generation plant, the DHX fans will be off and the airflow dampers closed to limit heat loss to the atmosphere.

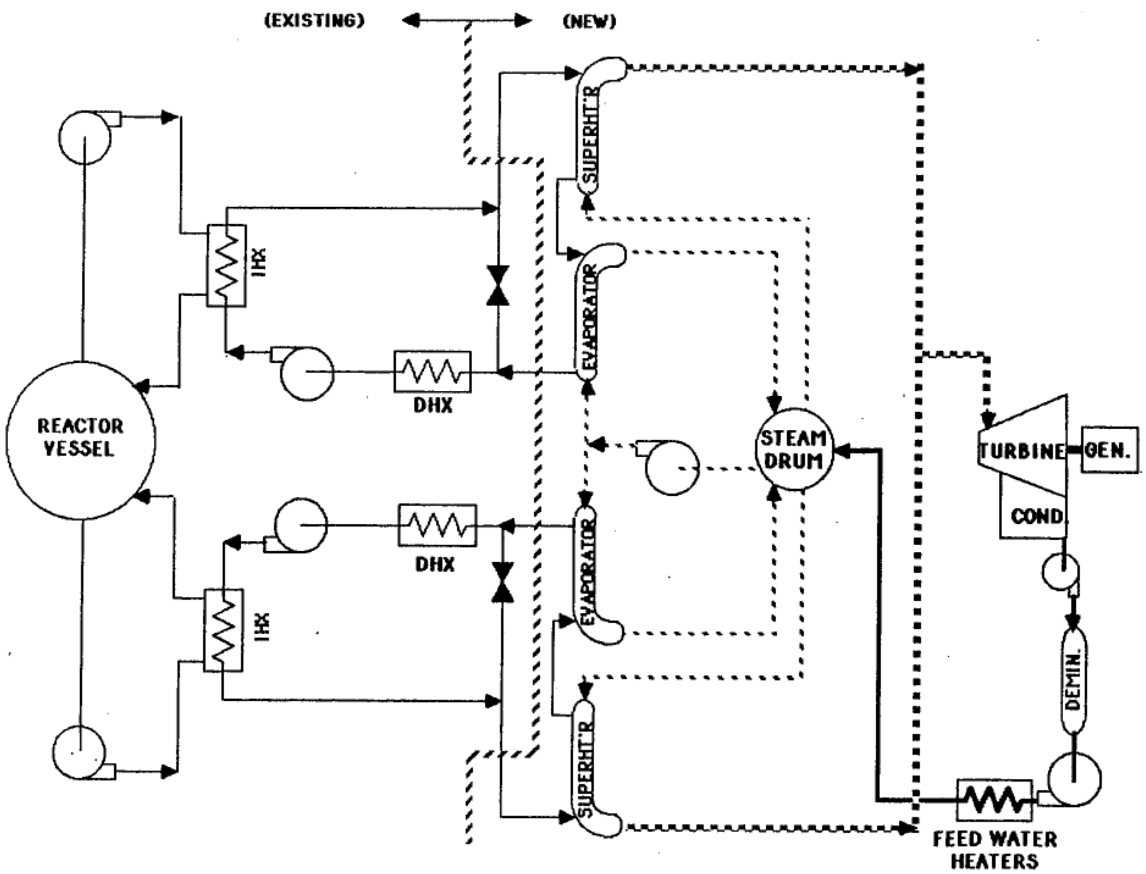


Figure 4.2-1 FFTF Power Addition Schematic

5.0 NEPA

Regulatory, Licensing and Permitting Issues Applicable to Siting for FFTF as an Advanced Recycling Reactor on the Hanford Site

<u>The Advanced Recycling Reactor using FFTF: Background</u>
The Advanced Recycling Reactor is one of three proposed domestic facilities in support of the GNEP program. As evaluated here the FFTF would be the commercial prototype Advanced

Recycling Reactor with the addition of an electrical generating power addition (PA), It may be referred to as the FFTF Power Addition (FFTF-PA). The power generator will convert waste heat from the FFTF into electricity using steam generator technology developed as part of the Liquid Metal Reactor (LMR) program.

The function of the recycling reactor is to transmute recycled actinide fuels while generating electricity from the resulting thermal energy. The recycling reactor requires sodium-cooled fast reactor (SFR), for converting long-lived radioactive actinide elements (e.g. plutonium and other transuranics) into shorter-lived radioactive elements. Transmutation achieves at least four GNEP goals (1) close the fuel cycle for efficient management of actinides and fertile uranium (2) reduce toxicity and fissile content of waste thus reducing the isolation burden (3) reduce potential proliferation products that can be attractive to terrorists, and (4) provide a source of electricity through conversion of waste forms.

Important safety features of the FFTF-PA SFR would include a long thermal response time, a large margin to coolant boiling, a primary system that operates near atmospheric pressure, and an intermediate sodium system between the radioactive sodium in the primary system and the water and steam in the power plant.

Issues and Required Actions

An Environmental Impact Statement (EIS) that Satisfies NEPA and SEPA

In contrast to restarting the FFTF in its original role as a fast spectrum fuels test reactor, a facility that has had its potential environmental impacts reviewed at length, its modification for electricity production would require additional environmental evaluation. Consistent with this need, DOE presently is preparing a GNEP Programmatic EIS (GNEP PEIS) (72 FR 331). This document is being prepared pursuant to the National Environmental Policy Act (NEPA) and NEPA CEQ implementing regulations at 10 CFR 1021.

NEPA requires federal agencies which propose to implement actions that *may* have a *substantial impact* on the environment to draft either an Environmental Assessment (EA) or the more extensive document, an EIS. Similar to NEPA in scope Washington State also has a State Environmental Policy Act (SEPA) codified in RCW Chapter 43.21 C. Under SEPA an EIS is required when there is *a reasonable probability that the proposed action(s) may have more than a moderate adverse effect* on the environment. This lower trigger standard requires an EIS more frequently than one required under NEPA. Under SEPA an EIS is a prerequisite to acquiring other environmental permits.

A State agency may adopt an EIS prepared under NEPA qualifications as a SEPA document if the State Department of Ecology determines the EIS is adequate. Given DOE's emphasis on GNEP, DOE's GNEP PEIS may be quite comprehensive and satisfy any SEPA requirements. Alternatively a joint DOE/State of Washington EIS can be prepared.

Facility Ownership Shapes Scope of Regulations, Licensing and Permitting Issues

Regulation, licensing, and permitting issues turn upon facility ownership. Facilities can be owned by DOE or a commercial contractor. In broad, general terms, Federal government ownership equates with DOE regulation while commercial ownership equates with Nuclear Regulatory Commission (NRC) regulation. If the facility is owned by the Federal Government and operated by DOE, many DOE Directives would apply to construction and operation of the center. DOE Directives are issued under the authority of Section 161(i)(3) of the Atomic Energy Act of 1954 (AEA, 1954)(42 USC 2011). DOE Directives can be accessed at: http://www.directives.doe.gov/.

The FFTF is in Hanford's 400 Area which has been extensively characterized by previous environmental evaluations.

Private Interest Ownership and Expedited Licensing and Permitting Through EFSEC

For purposes of environmental analysis, the lead agency is determined by whether facility is owned by the federal government or private interests. If privately owned with a generating capacity of 350 megawatts (Thermal) or more, the lead agency is the Washington Energy Facility Site Evaluation Council (EFSEC). Statutory authority for this agency is found at RCW Chapter 80.50.

EFSEC is a Washington State agency comprised of a Governor appointed Chairman and representatives from five state agencies, various representatives from the geographic regions where potential projects may be located, and state agencies that can opt-into review of the EIS. The purpose of EFSEC is to create a one-stop licensing agency for major non-hydro energy projects.

If the EFSEC determines that the proposed facility will produce minimal adverse effects on the environment and ecology, and meets its construction and operating standards then it recommends that a SCA be approved and signed by the Governor. As a one-stop licensing agency, the EFSEC is intended to expedite projects beneficial to Washington State. It accomplishes this task by coordinating all of the evaluation and licensing steps. If a project is approved by EFSEC then it specifies the considerations of construction and operation, issues permits in lieu of any other individual state or local agency authority, and manages an environmental and safety oversight program for facility and site operations.

Nuclear Regulatory Commission (NRC) Regulation and Oversight

If the Advanced Recycling Reactor is NRC regulated and is approved by the EFSEC, presumably this agency will interact with the NRC. NRC licensing requirements include a construction permit and operating license, or combination of each. Permits and licensing require submittal of a preliminary and final safety report, a physical security plan, and a safeguard contingency plan. NRC then will prepare a safety evaluation report and EIS before issuing permits and licenses. NRC has several guidance documents applicable to licensing requirements for new reactors. These guides can be accessed at http://www.nrc.gov/reading-re/doc-collections/reg-guides/.

Federal Government Ownership

First point, if the Advanced Recycling Reactor was owned by the federal government and operated by DOE, DOE Directives issued under the authority of the AEA, 1954 would apply. Statutes, in addition to NEPA and SEPA that are potentially applicable if DOE has ownership include those that address issues of waste, air quality and water quality among other lesser concerns. Regarding waste issues, the Resource Conservation and Recovery Act (RCRA) (40 CFR 260) and the Washington State Hazardous Waste Management Act (WAC 173-303) apply. Both EPA and Washington State Department of Ecology have authority pursuant to these statutes to regulate hazardous waste (all categories), mixed waste and associated disposal issues.

Second, the Clean Air Act would be a consideration although a conformity determination is probably unnecessary because the Hanford Site is located in a Clean Air Act attainment area, (40 CFR 81.348). Other air emission permitting issues would be under the authority of the Department of Ecology. For example, EPA standards apply to the emission of radionuclides from DOE facilities. Emissions from radionuclides to the ambient air from DOE facilities are not to exceed 10 mrem per yr (40 CFR 61.92).

Third, wastewater discharges to land would require a State Wastewater Discharge Permit from the Department of Ecology. These permits generally limit the quantity and concentration of pollutants that may be discharged to the land.

Fourth, water issues are covered by the Clean Water Act (33 USC 1341), and the Department of Ecology issues applicable permits. The Clean Water Act requires those who may make discharges to navigable waters (the Columbia River) to gain a certification from the State that such discharges will comply with the Clean Water Act. Other water issues relate to water rights. An Advanced Recycling Reactor may not need certification from the Department of Ecology as DOE has asserted a federally reserved water withdrawal right with respect to its operations at Hanford.

These four points cursorily address the larger environmental regulatory, licensing and permitting concerns: water, air and waste. There are various other applicable statutes and regulations, such as Emergency Planning and Community Right-to-Know Act, which are discussed in greater detail in the Tri-Cities Washington Tri-City Development Council's, document *Siting Study for Use of Hanford Site for GNEP Facilities*.

6.0 FFTF POWER ADDITION COST & SCHEDULE

This section contains an estimated cost and schedule of the FFTF Power Addition. The below estimate is based on the cost for FFTF recovery as presented in Chapter 1. These costs are summarized in the upper portion of the below table.

The cost for the power addition was taken from the 1987 "FFTF Power Addition Advanced Conceptual Design Report," prepared by Stone & Webster Engineering Corporation. The total design and construction costs for the power addition were estimated at $158 million. An escalation rate of 2.5% per year through 2007 was applied to the 1987 data. The escalated cost of the FFTF Power Addition is estimated to be $250 to $260 million.

FFTF Reactivation with Power Addition

ACTION	2000 PEIS 2000	2000 PEIS Escalated 2007	2007 GNEP 2007
FFTF Recovery Costs to Pre-Sutdown Condition			
Total Cost for Resolving Recovery/Restart Issues	$64,300	$79,081	$150,034
Profile of Technical Staff to Operate FFTF	$203,857	$250,719	$234,400
Electricity, Inert Gas, Roads & Commodities, Spares	$33,000	$40,586	$40,000
Grand Total for Recovery / Restart over 5 year schedule	$268,157	$329,799	$424,434
	1987 Power Study		**2007 GNEP**
Power Block Addition - Advanced Recycle Reactor Mission	1987		2007
Power Generation & Transmission Plant	$49,925		$81,808
FFTF Modifications	$53,885		$88,297
Distributable Construction Costs	$8,304		$13,607
State Sales Tax	$8,886		$14,561
Indirect Cost	$21,000		$34,411
Escalation to Complete	$16,000		$26,218
Grand Total for Power Addition	$158,000		$258,901
Total Cost Estimate Recovery & Power Addition	$426,157		$683,335
Contingency @ 20%	$852		$1,367
Total Cost Estimate With 20% Contingency	**$427,009**		**$684,702**

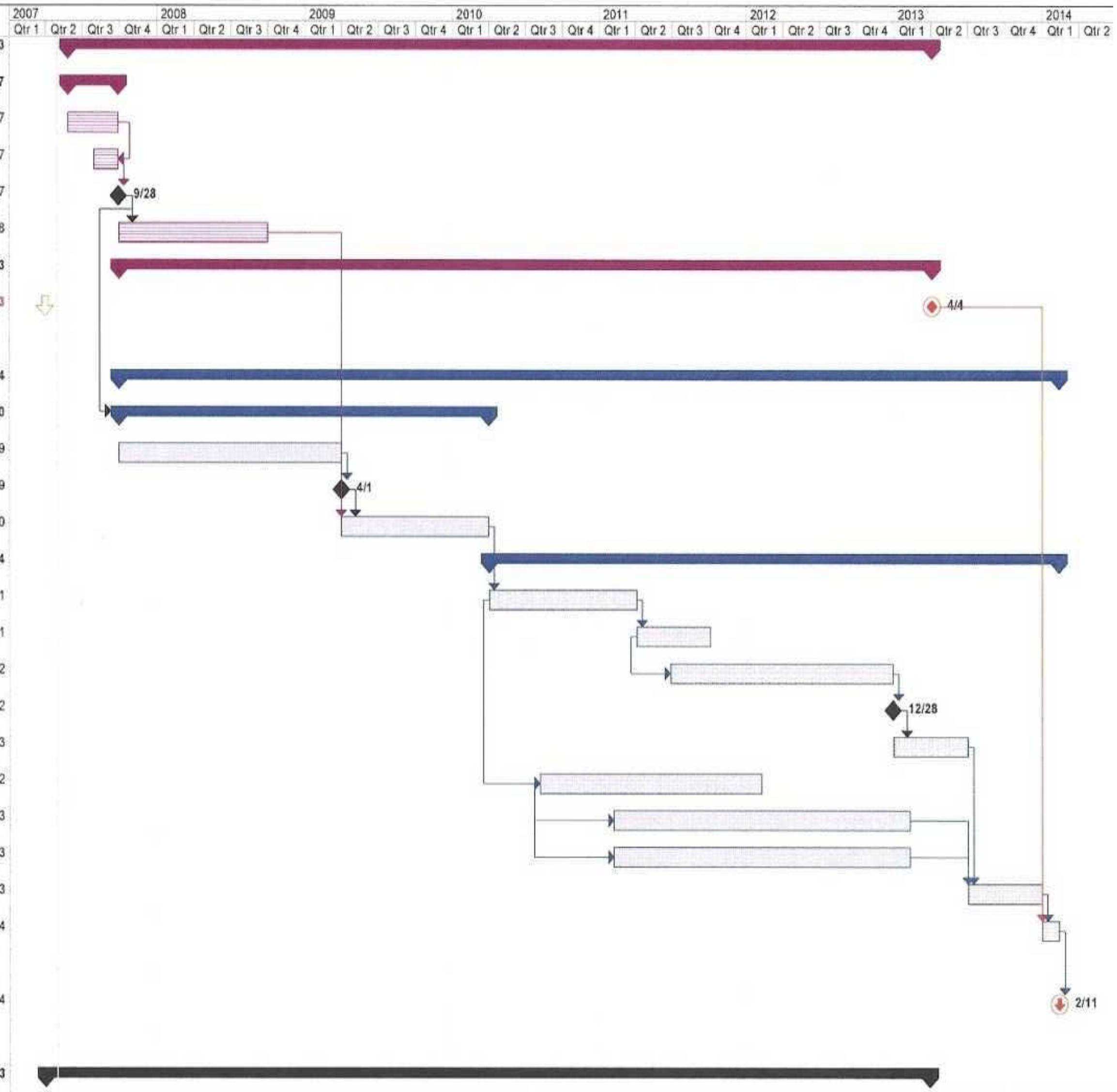
* Note: FFTF Recovery Costs detailed in the FFTF Reactivation Report

Although independent, the projected schedule for the addition of the power generator is built upon the recovery schedule developed in Chapter 1. It was assumed that the addition of an electrical generating capability to the FFTF would begin following an assignment decision in the GNEP EIS Record of Decision.

This schedule represents an aggressive but achievable effort to provide to DOE a near-term fast spectrum, sodium test reactor and power addition to perform the prototype recycling reactor missions critical to the GNEP program.

Hanford 400 Area Commercial Prototype Advanced Recycling Reactor

ID	Task Name	Start	Finish
1	**FFTF REACTIVATION ACTIVITES**	**5/28/07**	**4/4/13**
2	**NEPA & Record of Decision - Test Mission**	**5/28/07**	**9/28/07**
3	Verify Worshop Results	5/28/07	9/28/07
4	Perform EA (as required by DOE Policy)	7/30/07	9/28/07
5	Amend 2000 ROD - Fuels Testing	9/28/07	9/28/07
6	Update FSAR for Test Mission	10/1/07	9/30/08
7	**Reactor & Heat Decay Systems Recovery**	**10/1/07**	**4/4/13**
27	**Plant Goes Critical**	**4/4/13**	**4/4/13**
28			
29	**POWER ADDITION ACTIVITES**	**10/1/07**	**2/11/14**
30	**NEPA & Record of Decision - ARR Mission**	**10/1/07**	**4/2/10**
31	Perform EIS for Power Addition & Fuels Mgmt	10/1/07	4/1/09
32	Issue ROD for ARR Mission	4/1/09	4/1/09
33	Revise FSAR for ARR Mission	4/2/09	4/2/10
34	**Power Addition Project**	**4/5/10**	**2/11/14**
35	Perform Definitive Design	4/5/10	4/5/11
36	Design Steam Generators	4/6/11	10/5/11
37	Procure Steam Generators	6/29/11	12/28/12
38	Receive Steam Generators	12/28/12	12/28/12
39	Install Hx in Sodium Secondary Loops	12/31/12	7/1/13
40	Procure Power Components	8/9/10	2/8/12
41	Erect Power Block	2/8/11	2/8/13
42	Erect Electrical Power Systems	2/8/11	2/8/13
43	Starup & Test	7/2/13	12/31/13
44	Connect to Grid	1/1/14	2/11/14
45			
46	**Declare Advanced Recycle Reactor Operational**	2/11/14	2/11/14
47			
48	**Perform Routine Mainenance & Staff Recruitment**	**4/2/07**	**3/29/13**



Project: Project Schedule ARR
Date: 4/29/07

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

7.0 RISKS/BENEFITS IMPACT TO ARR MISSION ASSIGNMENT

A sodium-cooled Advanced Recycling Reactor would destroy long-lived radioactive elements (e.g., plutonium and other transuranics) by converting them to shorter-lived radioactive elements in a transmutation fuel while generating electricity. DOE and the GNEP Program have identified the optimization of appropriated funds as an important objective. Further, it is recognized by DOE that additional proof-of-performance is necessary to establish the GNEP objectives and to provide confidence to a commercial scale closed fuel-cycle operation. There are two key risk reduction points:

- Provision of a power addition capability on FFTF will establish additional data and confidence in liquid metal-to-water heat exchangers and their costs, maintenance requirements, and operating efficiencies.

- The FFTF and the 400 Area complex can provide 'integrated risk-reduction' and optimize the use of appropriated funds by demonstrating the remote assembly of the transmutation fuel pins and subassemblies.

Global Nuclear Energy Partnership Reference

American Nuclear Society (ANS). 2005, Fast Reactor Technology: A Path to Long-Term Energy Sustainability, Position Statement 74, November.

Battelle (Battelle Memorial Institute), 1999, *Program Scoping Plan for the Fast Flux Test Facility*, PNNL-12245, Rev. 1, Richland, WA August.

Burke, T.M., 2004, *FFTF Liquid Metal Systems Disposition Plans & Progress*, Track-0953, Richland, WA, October.

Cruickshank, Andrew, 1985, *FFTF-a Facility for the Future*, Nuclear Engineering International, November.

DOE (Department of Energy) 2000, *Nuclear Infrastructure Nonproliferation Impact Assessment*, DOE/NE-0119, Office of Arms Control and Nonproliferation, Washington D.C, September.

DOE (Department of Energy) 2000, *Draft Programmatic Environment Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility*, Cost Report for Alternatives, August.

DOE (United States Department of Energy), 2000, *Hanford, Diversification, and the Tri-Cities Economy*, DOE/RL-2000-32, Richland, WA, June.

DOE (United States Department of Energy), 2000, *Final Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Facility*, DOE/EIS-0310, Vol. 1-Vol. 3, Washington, DC, December.

DOE (Department of Energy), 2003, *The U.S. Generation IV Implementation Strategy*, Office of Nuclear Energy, Science and Technology, September.

DOE (Department of Energy), 2004, *Nuclear Waste Policy*, Office of Civilian Radioactive Waste Management, Washington, D.C. March.

DOE (United States Department of Energy), 2005, *Draft Environment Impact Statement for the Proposed Consolidation of Nuclear Operations Related to Production of Radioisotope Power Systems*, DOE/EIS-0373D, Washington, DC, June.

DOE (United States Department of Energy/NEPA), 2005, *Recommendations for the Supplement Analysis Process*, Office of NEPA Policy and Compliance, Washington, DC, July.

DOE (United States Department of Energy), 2005, *Advanced Fuel Cycle Initiative: Objectives, Approach, and Technology Summary*, Office of Nuclear Energy, Science and Technology, Washington DC, May.

- Page 11; Uranium[6] Energy Potential

DOE (United States Department of Energy), 2006, *Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project*, DOE/EA-1547D, Richland, WA, February.

DOE (Department of Energy), 2006, *The U.S Generation IV Fast Reactor Strategy*, Office of Nuclear Energy, DOE/NE-0130, December.

DOE (Department of Energy), 2006, *Adavanced Fuel Cycle Initiative (AFCI) Comparison Report*, Office of Nuclear Energy, July.

DOE (Department of Energy), 2006, *Notice of Intent to Prepare the Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site*, Federal Register, Vol. 71, No.22, February 2.

Doebler, Steve V., 2001, *DOE Cost and Schedule Review*, Track-0953, Richland, WA, June 20-22.

Harville, “Harv” L., 2007, *FFTF Plant System Status*, Track-0953, Richland, WA, March.

Hulvey R.K., 2001, *Deactivation Cost and Schedule*, Track-0953, Richland, WA, March.

Klos D.B., 2001, *Summary*, Track-0953, Richland, WA, June 20-22.

Klos D.B., 2001, *FFTF Project Cost and Schedule Overview*, Track-0953, Richland, WA, June 20-22.

Madia, William J. (PNNL), 1999, *Fast Flux Test Facility (FFTF) Program Scoping Plan*, U.S DOE, July 29.

Nielsen, D.L., 1999, *Fast Flux Test Facility Data Request in Response to Data Call for Nuclear Infrastructure Programmatic Environmental Impact Statement*, BWHC-9958233, B & W Hanford Company, Richland, WA, December 21.

Nuclear Energy Agency, 2002, *Accelerator-driven Systems (ADS) and Fast Reactors (FR) in Advanced Nuclear Fuel Cycles*, A Comparative Study, Paris, France.

Orbach, Raymond L. PhD. (DOE), 2007, *Before the Subcommittee on Energy and Environment House Science and Technology Committee*, Budget Proposal, March 7.

Pacific Northwest National Laboratory (Battelle Institute), 1997, *Medical Isotope Production at the Fast Flux Facility- A Technical and Economic Assessment*, PNNL-SA-29502 Richland, WA, November.

Pacific Northwest National Laboratory (Battelle Institute), 1999, *Isotope Production at the Hanford Site*, PNNL-12228, Richland, WA, June.

Stokes, William J., 2006, *Washington State Global Nuclear Science & Energy Research Center*, Global Nuclear Energy Partnership (GNEP), July 14.

Stone & Webster Engineering Corporation, 1987, *FFTF Power Addition*, Advanced Conceptual Design Report, SWEC-16812, December.

Todreas, Neil E. PhD, 2006 *Hearing on R&D Priorities in the Global Nuclear Energy*

Partnership, <www-me.mit.edu/people/personal/todreas.htm> Cambridge, MA, April 6.

U.S Atomic Energy Commission, 1972, *Fast Flux Test Facility*, Environmental Statement, WASH-1510, Richland, WA, May.

Waldo, James B., 1989, *Fast Flux Test Facility Fuel Handling Experience- November 1979 to August 1988,* Westinghouse Hanford Company, Nuclear Technology Vol. 86, Richland, WA, March 21.

Washington State Department of Health, 2004, *Final Environment Impact Statement*, DOH Publication 320-031, Volume 1, Richland, WA, May 28.

Witherspoon, Wiley V, 2007, *Fuel Off-Load*, Track-0953, Richland, WA, March.

Witherspoon, Wiley V, 2007, *Base and Expedited Restart Cost and Schedule*, Track-0953, Richland, WA, March.

APPENDIX I

Restart Issues

Table Of Contents

1. Restart Issues

FFTF EXPERTS MEETING ON RECOVERY AND RESTART

Conducted in the 400 Area - Hanford Site
March 5 - 9, 2007

A team of subject matter experts (SMEs) met March 5 - 9, 2007 in the 400 Area of the Hanford Site to assess the status of the Fast Flux Test Facility (FFTF) and its operating staff to determine if it is feasible to recover the plant from its current shut down condition and return it to operation to support the Global Nuclear Energy Partnership (GNEP) program. The Team met at the 400 Area in order to see first-hand the material condition of the plant and to have direct and frank discussions with the technical staff at the FFTF concerning challenges to recovering the plant and returning it to full power (400 MWT) operation.

The Team was composed of recognized authorities in materials science, fast reactor physics, fast reactor operations, nuclear reactor safety, fast reactor engineering systems, and fast reactor fuel and control rod design and performance. In addition, the SMEs were intimately familiar with the FFTF and its past operating performance. None of the SMEs are currently employed at the FFTF.

The SMEs used a straightforward process to define issues important to the recovery and restart of the FFTF. They received an overview briefing on GNEP and the current round of detailed siting studies being sponsored by the Department of Energy (DOE). The SMEs were then briefed by key FFTF technical personnel. The SMEs were given a thorough tour of the FFTF by the FFTF Operations Manager and the FFTF Plant Manager. After this "in-briefing," they met as a group to list issues that they agreed were "essential" to recovering the plant from its current shut down configuration and return it to full power operation.

Twenty-five issues were defined by the SMEs. Their issues were classified into three categories - Critical, Early Decisions, and Significant. "Critical" issues were those that must be resolved in order for FFTF to operate at full power again. "Early Decision" issues were those items that required early action in order to prevent delay in recovering the Plant. "Significant" issues were those that required resolution but did not necessarily need early action. The 25 were apportioned - six as Critical, seven as Early Decision, and twelve as Significant. The SMEs then reviewed the entire collection and decided that nine of these were not, in fact, separate issues, but were covered under another issue or were not issues for recovery or restart at all. Thus, the 25 became 16 issues:

- Critical – 4
- Early Decision – 3
- Significant - 8

The SMEs divided themselves into five technical subgroups to develop topical outlines for each issue. The outlines became writing assignments, given to specific expert authors. Each author was tasked with drafting the paper that addresses the issue. Each paper was then reviewed by one or more of the other SMEs to assure quality and technical accuracy. All of the papers were then edited into this document for consistency of format, and overall readability.

Each of the Issue Papers provides a summary of the issue, a path for resolution, and a rough estimate of the cost to resolve the issue.

SUMMARY OF RESULTS

- **No Issues Prevent Restart**

- The most **significant challenges** are: requalification of the Decay Heat Removal System boundary, re-establishing the supply line for Driver Fuel Assemblies (DFAs), and hiring and qualifying technical staff.

- The following **"DO NOT DO" actions** are recommended as immediate considerations for DOE in order to preserve the FFTF as a viable restart option:

  (1) Do not demolish the 337 building (a site cleanup action), until the spare IVHM, IT, and Primary Pump have been removed.

  (2) Do not cut into any primary loop isolation valve or check valve to drain residual sodium.

  (3) Do not change over from argon cover gas to "cheaper" nitrogen cover gas.

  (4) Do not demolish the 309 building IEMC mockup (a site cleanup action), until brackets and mountings have been removed from the mockup.

  (5) Do not discard pin weighing/cutting equipment in IEM Cell.

- The recovery and restart of FFTF will take about **5 years and $500M**.

CRITICAL ISSUES

1. Requalification of the Decay Heat System Boundary

Issue Statement:
The integrity of the sodium system boundaries important to decay heat removal must be confirmed. These boundaries are the reactor vessel and the primary and secondary heat transport systems. It is necessary for the decay heat boundary to be intact in order that decay heat can safely be removed from the reactor. It is necessary to verify that the sodium drain and subsequent cooling to ambient temperature has not degraded the stainless steel piping and components to the point that the decay heat boundary integrity is compromised. Without this assurance, the reactor cannot be restarted.

Technical Issues
There are two concerns regarding the integrity of the decay heat boundary.

On the sodium-wetted surfaces on the inside of the systems, has the residual sodium reacted with materials in the cover gas, or introduced materials into the cover gas, to produce harmful species that could corrode or otherwise be deleterious to the stainless steel piping and components.

The second, and probably more serious, concern is on the outside of the piping and components, particularly that part of the secondary system that was outside containment and exposed to the weather after secondary system drain. Specifically, did moisture from the outside air condense on the stainless steel and cause "intergranular corrosion" of the stainless steel. Much of the stainless steel has been heated to temperatures above 800 ^{o}F during plant operation. It has therefore experienced precipitation of chromium carbide at its grain boundaries. This condition is known as "sensititization". Even parts of the primary and secondary system that have not been heated to 800^{o}F will have some sensitized stainless steel in regions adjacent to weldments. Stainless steel that has been "sensitized" is more susceptible to intergranular corrosion under some conditions. If the steel has been significantly corroded by this mechanism, the properties (strength, ductility, and toughness) will be degraded, possibly to the point where the integrity of the decay heat boundary cannot be guaranteed.

In addition, the dump heat exchanger module tube bundles may have experienced introduction of some foreign material, such as bird waste. The potential for the presence of those materials, or their reaction products with moisture, on the properties of the dump heat exchanger material will need to be examined.

System Status:
The sodium has been drained from the reactor vessel and the primary and secondary system piping and components, and the systems have cooled to ambient temperature.

The sodium was drained from the primary and secondary systems in 2003 and 2004. The interior of the systems is maintained with a positive pressure of argon gas. This condition minimizes or eliminates the potential for formation of sodium compounds that could be detrimental to the properties of the stainless steel. The outside surfaces of the piping are covered with a thin oxide coating typical of stainless steel exposed to air at elevated temperatures.

The small diameter piping in the auxiliary systems (not the main piping systems) has been penetrated several times during plant operation and for shutdown. In all cases, extreme care was taken to maintain inert gas cover to avoid reaction of sodium with the atmosphere and formation of sodium compounds inside the piping system. Many sodium-cooled reactors and sodium test systems have been routinely penetrated for repairs, modification, etc. and returned to full operation with no harmful effects.

The very pure sodium in FFTF primary and secondary systems is almost inert to stainless steel even at high temperatures. Material loss would be measured in microinches or tens of microinches. Extensive examinations of materials removed from sodium systems show that there is no intergranular corrosion by sodium on sensitized stainless steel.

Resolution
The program described below will provide information on the potential for intergranular corrosion, corrosion on the internal surfaces, and potential degradation of material properties. This will enable us to verify the integrity of the decay heat boundary.

The condition of the piping and components will be evaluated as follows:

- Review prior experience with sensitized stainless steel under conditions that bound the FFTF experience envelope.

- Assess potential for introduction of foreign materials to the surface of the systems, particularly the dump heat exchanger modules.
- Evaluate the potential for water accumulation in regions where water could come in contact with exterior surfaces of piping and components.
- Define and conduct a visual inspection and nondestructive examination (NDE) survey of representative sites in the systems, guided by the results of the investigations described above. (NOTE: this will be a significant effort.)
- Verify maintenance of positive cover gas pressure in primary and secondary systems.
- Analyze samples of the incoming cover gas to verify that it is indeed cryogenic quality (low parts per million impurities)
- Obtain samples of the reactor cover gas to verify the systems are tight and potentially harmful species such as oxygen and moisture are not leaking in.
- If cover gas quality is suspect, consider visual examination of piping and component interior surfaces.

Have the results independently reviewed.

We anticipate that this effort will be successful because:

- As mentioned, extensive experience shows that the FFTF sodium is almost inert to stainless steels. Several sodium-cooled nuclear reactors have operated for more than 30 years with no degradation of the heat transport systems.
- Maintenance of a positive pressure cover gas should inhibit any degradation to the inside surface of the piping during the time period after drain.
- Atmospheric corrosion of stainless steel (which is driven by condensation of water on the stainless steel surface) at ambient temperatures experienced by FFTF systems since drain is generally not severe, especially in the relative dry, non polluted atmosphere typical of Hanford. Atmospheric corrosion is much more severe in industrial atmospheres containing such species as chlorine and sulfur dioxide than in the conditions typical of Hanford. Intergranular corrosion of stainless steel typically occurs under much more severe environments than the Hanford atmosphere.

Cost & Time Estimate
Estimated at 6-15 months, depending on the difficulty of access to critical areas, and the amount of NDE required. Cost $600K-$1.2M depending on the same factors.

Constraints
Destructive examination, such as cutting into the system to remove samples, is to be avoided.

2.0 Establish Operability of Equipment Needed to Refuel.

Issue Statement
The operation of refueling equipment inside the reactor vessel was reviewed for possible impacts. The primary change from normal operations that could adversely affect the refueling system is draining sodium from the reactor vessel, thus exposing in-vessel equipment to cover gas.

Technical Issues
The only in-reactor vessel components that would be adversely affected by sodium drain are the In Vessel Handling Machines (IVHM). Draining the FFTF primary sodium system has

uncovered the in-vessel portions of the IVHMs. Previous experience with lowering the sodium level for only a few days showed a negative effect on their operability due to oxides interfering with certain bearings. It is expected, therefore, that they will not function without removal for refurbishment.

Resolution
Plan for removal and refurbishment of the three IVHMs prior to sodium fill. This is a long lead activity and should be completed in parallel with preparations for sodium fill.

Cost & Time Estimates
A. Start up MASF Large Diameter Cleaning Vessel. $1M.
B. Pull IVHMs, transfer to MASF and clean. $5M
C. Refurbish the IVHMs to repair currently identified operating deficiencies (Toe Bearings and drives, main bearings). $1.5M
D. Return IVHMs and reinstall. $1M

Overall, two and one half years' activity will be needed.

3. Resolve Core Basket Hole and Chips in Core Support Structure Issues

Issue Statement
A ¾-inch hole was drilled through a plate inside the reactor vessel below the core support area in order to install a sodium drain pump for removing the sodium from the lower areas of the vessel. The issues are effects of loose chips and alteration of the sodium flow path within the reactor vessel. See Figure 1.

Technical Issues
- The hole is a path for some chips to potentially migrate down into the inlet plenum. The chips (see Figure 2) result from enlarging the hole through the tube above the plenum plate and drilling the hole itself. The chips are primarily within the low pressure plenum beneath the core support structure. Chips that get into the high pressure inlet plenum could migrate into the core region due to the high turbulence and sodium velocities there. Chips that fall through the hole into the high flow inlet plenum below could possibly be carried into fuel elements and control rods in the core region. Chips that remain in the low-pressure plenum region with its low flow velocities will remain there without harm.

System Status
- The effect of the hole on flow and pressure distribution is not sufficient by itself to warrant plugging.

Resolution
- The hole, if left open, will cause only minor changes in flow and pressure distribution within the reactor vessel. The emergency shutdown control rod functions were reviewed for possible impacts resulting from chips entering the core region. The control rods were found to have sufficiently large internal clearances that they would not be affected.

Plug the hole.

- The primary concern is possible migration of chips from the low pressure plenum down through the hole into the inlet plenum where they have the greatest chance of being swept up into the core region. A simple insert can be installed to plug the hole using the same tool path used by the drill string.
- Plugging the hole in the plenum plate will prevent chips from migrating from the low pressure plenum down into the inlet plenum.
- The worst case of chips flowing into a fuel assembly is partial blockage of cooling flow. The effects of a local flow blockage in a fuel assembly were addressed in the FFTF Final Safety Analysis Report. Based on a combination of test results and analyses, it was concluded that even in the worst case, cladding temperatures would remain well below the cladding integrity limit. This is, therefore, not a concern.
- Flows in the low pressure region will be insufficient to move chips into any area of concern.

Filter sodium flowing into the core region.

- Although no problems are anticipated from chips that could be carried into the core region, removal of any stray chips that may have entered the inlet plenum and are light enough to be carried into the core assemblies is recommended. Place filter assemblies in selected open core positions where high flow rates will deposit any mobile chips.

Cost & Time Estimate
17 Core filter Assemblies @ $50K plus design -- $950K;

Constraints
After sodium fill, due to IVHM requirements, to operate under sodium for filter installation prior to refueling the reactor.

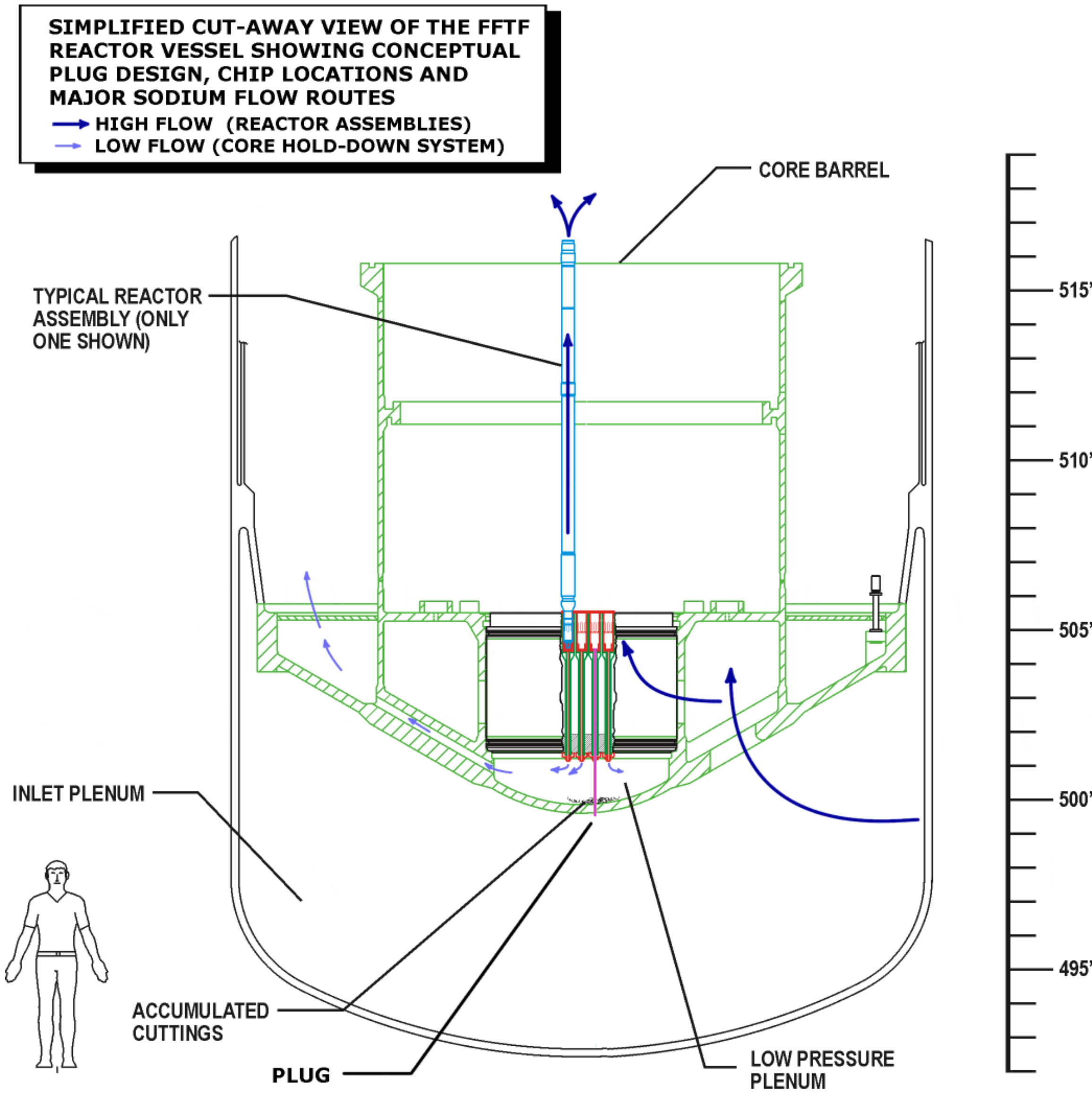


Figure 1- Location of Hole Drilled in FFTF Reactor Internal Structure
NOTE: The hole location is indicated by the PLUG location.

Figure 2 – Chips Created During Test Drilling in a Mockup Unit

4. Design Basis Earthquake

Issue Statement
FFTF was designed with a design basis earthquake acceleration of 0.25g. The value was established through a geophysical analysis of known faults and bore hole testing conducted on the FFTF site. The analysis and pertinent data, references 1, 2, and 3, were reviewed by the NRC during the 1972 construction approval stage of the plant. The site geology and seismology were revisited in 1978 during review of the FSAR. The NRC concluded, as documented in the SER, that no changes in criteria were warranted.

Technical Issues
Within this same period of time, siting activities were initiated for three commercial nuclear power plants nearby the FFTF (WNP 1, 2, and 4). Overall testing and exploratory drilling was also conducted at these sites and a Safe Shutdown Earthquake (which is equivalent to FFTF design basis earthquake) acceleration of 0.25g established and approved at the PSAR construction permit stage for the plants.

Subsequent to the 1978 acceptance of the seismic design criteria for FFTF, additional evaluations have been conducted to further characterize the ground motion response on the Hanford Site to earthquakes. Certain of these studies are based on a probabilistic approach (reference 4). Other studies have been performed to support construction of the WTP. These studies conclude that the earthquake responses at other Hanford sites are different than originally determined. However, the WTP concerns were related to the characterization of the geology immediately beneath the site and its effect on modeling expected ground motions at the WTP site, and not a result of new geological discoveries within the distances that could impact other projects, including FFTF. The probabilistic approach for developing seismic criteria used an encompassing methodology to establish performance categories for specific Hanford areas. The recent studies have not identified new or more severe faults or earthquakes or soil characteristics in the vicinity of FFTF, but have culminated in establishing more conservative seismic design criteria.

The FFTF site geological and seismological studies established a DBE of magnitude 6.8 located 9.8 miles from the site and at a focal depth of 6 miles (Rattlesnake Hills - Wallula Fault). Geophysical field measurements were made to establish representative geotechnical properties of the site. These site properties together with the DBE magnitude and distance from the site were used to calculate the maximum ground acceleration that would be induced at the site in the event the DBE should occur. As previously stated, this deterministic approach was approved by the NRC in 1972 and again in 1978 in the appropriate SERs.

Geophysical and seismological studies for the three commercial nuclear plant sites that are near FFTF were reviewed and approved (references 5 and 6) by the NRC to support construction and/or licensing activities for these sites. These studies established a DBE acceleration of 0.25g, the same value as used in the design and construction of the FFTF. They also used a deterministic approach which is typical for all commercial reactors.

Resolution

With the 400 Area site well-characterized, and since the original FFTF design was not based on a probabilistic approach and no new faults have been identified, the original DBE acceleration of 0.25g for FFTF remains applicable. Therefore, it is proposed that no changes in the NRC approved basis be made. Further, it is believed that the results will satisfy the intent of DOE Order 420.1B, which requires a re-evaluation of the seismic criteria for the facility every ten years and to provide recommendations to DOE.

If this approach is found to be unsatisfactory, then substantial analyses and possible modifications would be required to qualify the FFTF to higher seismic values.

Cost & Time Estimates

The cost and schedule for this activity is estimated to be $0.5M and three months.

References:

1. JABE-WADCO-02, Seismic Design Criteria For The Fast Flux Test Facility Richland, Washington, July 1975
2. JABE-WADCO-03, A Summary Report-Seismic Evaluation and Development of Ground Acceleration and Response Spectra for the FFTF Site, February 1971
3. JABE-WADCO-04 and Supplement 1, Supplementary Geologic Evaluations for Seismic Evaluation of the FFTF Site, February 1971
4 NUREG-0358, "Safety Evaluation Report related to the operation of Fast Flux Test Facility,' August 1978
5. WHC-SD-W236A-TI-002, Probabilistic Seismic Hazard Analysis for DOE Hanford, 1996
6. NUREG-0892, Supplement 1, Safety Evaluation Report related to the operation of WPPSS NUCLEAR PROJECT NO 2, August 1982
7. NUREG-75/036, Safety Evaluation of the Washington Nuclear Projects 1 & 4 Docket Nos. 50-460 and 50-513, May 1975

B. EARLY DECISIONS

1. Decide Regulatory Path for FFTF Restart

Issue Statement
A significant early decision is to determine whether FFTF restart and/or subsequent operations should be regulated by the DOE or the NRC.

Technical Issue
Whereas NRC guides for reactor analysis and refurbishment for restart would likely be used for either case, there could be differing requirements applicable to supporting programs that would be significant. Examples are the applicability of 10CFR830 for DOE reactors, Operator Certification for NRC operators, differing seismic requirements--all of which could have significant costs if the current FFTF programs were changed to conform to NRC standards. It is because of this potential cost impact that the selection of which Regulatory Path to follow should be carefully weighed in terms of cost and benefit. Our approach discussed below considers the benefits and costs of each option. The Department of Energy will ultimately determine the path appropriate for the FFTF contractor to follow.

Resolution
There are two major parts associated with this issue. The first is which federal agency should be engaged for the regulatory aspects of restart, and the second is which agency should be the regulatory body for subsequent operation.

The tables below summarize the pros and cons associated with the approach for both situations.

Table 1. Regulatory Considerations for Reactor Startup

	PRO	**CON**
NRC	1. NRC has more public credibility than DOE for reactor regulation. 2. FFTF had a complete NRC review prior to initial startup 3. DOE would likely use NRC guidelines in any case 4. Plant Technical Specifications were developed under NRC guidelines 5. A favorable regulatory climate exists 6. More realistic (risk-base) seismic requirements may exist with the NRC 7. FFTF involvement would bring the NRC up to speed for subsequent GNEP work	1. There would be a time delay due to re-staffing at the NRC 2. An updating of accident types and analysis may be required due to updates in the NRC requirements (based on input from the experience at Energy Northwest)
DOE	1. FFTF currently operates under DOE supporting programs, e.g.: • USQ Process • Training & qualification • Quality Assurance • Startup & Restart • Worker Protection	1. Some time delay is required for re-staffing at DOE (but perhaps less than for NRC re-staffing)

Table 2. Regulatory Considerations for Subsequent Reactor Operations

NRC	1. This would pave the way for future GNEP facility operations.	1. All procedures for supporting programs would need to be rewritten. 2. Other disruptions from current operating guidelines may be required.
DOE	1. Current procedures implementing DOE programs could be retained (after returning to pre-shutdown conditions). 2. This would be consistent with other DOE-owned facilities.	1. This path would lose the potential for FFTF operations to test the NRC system for subsequent GNEP facility operations.

There are four possible scenarios associated with the regulatory options:

Case 1 – Use the DOE system for both startup and subsequent operations
Case 2 – Use the NRC system for both startup and subsequent operations
Case 3 – Use the DOE system for startup but switch to the NRC system for subsequent operations
Case 4 – Use the NRC system for startup but revert to the DOE system for subsequent operations.

We offer the following observations regarding these four possibilities:

Case 1: This option is probably the least expensive in terms of both time and resources. It would require the DOE to staff up to develop the regulatory capability for Liquid Metal-Cooled Reactors (LMRs) and to set up an organizational system for credibly separating the "applicant" from the "regulator" side of the NE organization. In all likelihood, any analytical work would need to be contracted to one of the national laboratories that may still have staff knowledgeable in LMR safety technology. The principal disadvantage of this option is that the DOE does not have the same degree of regulatory credibility as the NRC. Further, it would not provide any incentive for the NRC to begin staffing up in LMR capability—which could provide a "jump start" for subsequent NRC reviews of future GNEP projects.

Case 2: This option would likely be considerably more expensive than Case 1—both in time and resources. Since the demise of the Clinch River Breeder Reactor project and the cessation of licensing activity for the PRISM reactor project, the NRC has had no incentive to retain LMR expertise, so this capability would have to be rebuilt. The cost for this rebuilding would have to be borne by either the DOE or through a Congressional reallocation. On the other hand, NRC records associated with the detailed NRC review conducted for the construction and approach to power operation of FFTF still exist, and an updating for FFTF restart should be possible with a reasonably modest effort. NRC regulatory oversight for subsequent FFTF operations would entail considerable changes from the present mode of operation and could become a critical path item. However, successful transfer of FFTF operations from the DOE to the NRC system would provide substantial credibility for FFTF and would pave the way for subsequent GNEP projects, such as the Advanced Recycle Reactor, that are scheduled to come under the regulatory purview of the NRC.

Case 3: This option would likely cost more than Case 1, but it would allow the FFTF to restart under existing rules and procedures to minimize the impact up to the point of full power operation. This path is based upon the assumption that the potentially overly restrictive seismic requirements of the DOE could be appropriately modified to correspond to actual risk considerations. Assuming that an appropriate working relationship with the NRC could be worked out early, a parallel effort to convert the subsequent FFTF operations to conform to NRC regulations should provide a smooth transfer. This path could follow the model implemented by the US Enrichment Corporation—wherein a 5-year transition was employed to transfer all facility supporting programs from the DOE orders and regulations into the NRC format.

Case 4: This case would mirror the original FFTF startup, wherein a detailed NRC review was conducted to ensure that LMRs could be licensed, but once in operation the FFTF was operated under DOE regulatory jurisdiction. This process could be repeated and it would provide both credibility and consistency. However, it could cause considerable disruption in the process and become the highest cost option—both in time and resources.

Cost & Time Estimate
All four of these options need to be discussed in depth with both the DOE and the NRC to properly weigh all considerations. Without the benefit of such discussions, it is very difficult to estimate the cost and schedule for the overall effort. Lacking such input, a reasonable estimate at this time might be about 36 months and about $8M.

2. Refill Primary and Secondary Loops with Drained Sodium from SSF

Issue Statement
Sodium drained from FFTF systems was transferred to carbon steel tanks in the Sodium Storage Facility (SSF), and kept in solid form under positive pressure high-purity argon gas. This sodium is anticipated to be suitable for reuse in FFTF systems, but proof of that fact is required. If the sodium cannot be reused, then approximately 250,000 gallons of high-purity reactor-grade sodium must be produced, procured, and brought to the FFTF site.

Technical issues
Such large quantities of high-purity sodium are not readily available, and obtaining that sodium would add several years to the schedule and cost tens of millions of dollars.

Several details need to be addressed:

- Most of the secondary system sodium, which contains a small amount of tritium as its only radioactivity, was kept separate from sodium drained from the primary system, the Interim Decay Storage (IDS) vessel, and the Fuel Storage Facility (FSF). However, it was necessary to mix a small amount of secondary system sodium with the more radioactive sodium from the other three sodium systems. As a result, there will be a shortfall of approximately 18,000 gallons of sodium if the secondary system is refilled only with sodium that has not been mixed with the more radioactive sodium from the other systems.

- The primary sodium and FSF sodium now contain several thousand parts per million (ppm) of potassium, as a result of mixing the sodium-potassium alloy (NaK) with the primary sodium during the operation to flush the NaK out of the primary cold trap and IDS cooling systems. The NaK in the FSF cooling system was removed from the system and mixed with the FSF sodium before transferring that sodium to SSF. The FFTF sodium contained several hundred ppm of potassium before mixing with the NaK. The levels of potassium in sodium exceeds the RDT (Reactor Development Technology, a predecessor of the NE organization) standard of 1000 ppm. Initial investigation into the effect of the higher level of potassium thus far has not determined anything that would be detrimental to FFTF performance. That investigation will continue; see next section.

- Sodium from the retired Hallam test reactor and Sodium Reactor Experiment (SRE) is currently stored at Hanford. The Hallam sodium is maintained in several tanks under positive pressure of argon, and the gas pressure is monitored. The SRE sodium is maintained under inert gas cover in 55 gallon drums. There is sufficient volume of Hallam sodium to make up the 18,000 gallon requirement. The Hallam sodium contains a small amount of tritium; the concentration is believed to be approximately equal to the FFTF secondary system concentration. The SRE radionuclide content is less well defined.

- If neither the Hallam nor SRE sodium is suitable for use, new reactor grade sodium must be procured. The same statement is true for the sodium presently stored in SSF.

System Status
The interiors of the carbon steel tanks were thoroughly cleaned and sealed before the sodium was transferred into them. The tanks were filled with inert gas immediately after they were cleaned and the inert gas status has been maintained since then. The gas pressure in the tanks is monitored. The SSF contains four tanks fully shielded from the weather, and is adjacent to the FFTF buildings. All pipelines used for sodium transfer are also inside buildings or in underground pipeways. The storage tanks and transfer piping are trace heated so that sodium can be transferred out when required.

Resolution
We believe that the sodium in SSF is acceptable for reuse in FFTF. Sodium purity was maintained during FFTF operation and standby, verified by online instrumentation and chemical and radiochemical analysis. Resolution consists of the following:

- Review drain and storage history of existing FFTF sodium, including verifying tank by tank makeup of sodium.
- Verify that higher potassium level in sodium is acceptable. It is noted that two experimental fast reactors, EBR-I in the United States and Dounreay Fast Reactor in the United Kingdom, had sodium-potassium alloy (NaK) as the coolant.
- Verify radionuclide content of sodium, including Hallam and SRE sodium.
- Determine cost and schedule requirements for obtaining approximately 18,000 gallons of high-purity reactor grade sodium.
- Determine acceptability of Hallam and SRE sodium for reuse in secondary system; define quantity of new sodium that would be required. Note that there may be a cost/time/benefit tradeoff study to do. Using the Hallam and/or SRE sodium if possible will benefit the Hanford site by making use of material already there. However, it may be less expensive and quicker to simply procure new sodium, especially if only part of the Hallam and SRE sodium is required.

Cost & Time Estimates
3-4 months/$40K-$60K for analysis; $200K-$600K for sodium depending on which sodium is to be used and its availability. The sodium cost includes obtaining the sodium and transporting it to

FFTF, and constructing and qualifying whatever transfer equipment and procedures would be required to get the sodium into FFTF.
If all new sodium is required, several years and $10M-$20M would probably be necessary, based on initial FFTF experience, escalated to today's costs.

Note that the cost and time requirements for performing the actual sodium transfer back into FFTF are not included here.

3. Identify and Qualify Core Components

Issue Statement
Driver Fuel Assemblies (DFAs), Control Rod Assemblies (CRAs), and reflectors are consumable core components and compose the FFTF reactor core. Shut down actions at the FFTF disposed of the remaining supply of most of the useable core components, so the core component supply line must be re-established in order to load the First Core and to provide replacement components as spent core components are discharged in subsequent operation.

Technical Issues
FFTF requires expendable core components for start-up and subsequent operation. The requirements vary depending upon power level and plant factor, but are summarized in table I assuming operation of 300 days per year at a power level of 400 megawatts. Start-up requirements for control assemblies are independent of power level, whereas the requirements for reflectors and fuel assemblies may vary with power level. It may be possible for example to reduce the number of fuel assemblies required for start-up from 75 to as low as 65 by reconfiguring the core for operation at a reduced power level, although analyses would be required to refine this rough estimate. Annual consumption requirements would be expected to depend linearly upon the number of equivalent full power days per year.

Table I. FFTF Core Component Requirements for Full Time Operation at 400 Megawatts

	Fuel Assemblies	Control Assemblies	Reflector Assemblies
Start Up	75	9	108
Consumption Rate (Units per year at Full Power Operation)	60	2	6

Resolution

Options for Initial Load of Fuel Assemblies
There are six potential sources to provide the initial load of fuel assemblies. These are summarized in Table II. All sources will require review of fabrication data, and history of storage/usage. However, some sources have significant issues which must be resolved which are also summarized along with a means of resolving the issue.

Table II

Potential Sources for Initial Core Loading of Fuel				
Type	Description	Number of Assemblies	Significant Issues	Issue Resolution
A	Unirradiated Fuel Stored Under Clean Conditions	32	None	na
B	Unirradiated Fuel Assemblies Stored in Sodium, Then Drained, Washed in Water and Stored	23	Potential NaO Corrosion	Test and Qualification Progam, or
				Procure Hardware, Provide/Identify Assembly Facility
C	Unirradiated Fuel Pins Stored Under Clean Conditions	9	Requires Hardware and Assembly Facility	Procure Hardware, Provide/Identify Assembly Facility
D	SNR Fuel	156	May be difficult to obtain and document	negotiation/discussions
			Requires Hardware and Assembly Facility	Procure Hardware, Provide/Identify Assembly Facility
E	Partially Irradiated fuel assemblies Drained of Sodium, Washed in Water and Stored Under Clean Conditions	139	Potential NaO Corrosion	Test and Qualification Progam
F	New Fuel	na	Requires Hardware and Assembly Facility	Procure Hardware, Provide/Identify Assembly Facility
			Requires HEU or PU	Identify Source of HEU or PU
			Requires Fuel Pellets or Fuel Slugs (Fabrication Facility)	Identify /Provide Fabrication Facility

There are essentially no issues associated with the use of the 32 fresh assemblies that have been stored in clean conditions (Type A).

23 fuel assemblies (Type B) that were never irradiated were in sodium at the time of deactivation. The sodium was drained from these assemblies and they were cleaned of sodium and washed with water before storage in clean conditions.

The potential issue associated with using these assemblies is that small amounts of residual sodium in the form of sodium oxide may have formed (during washing) and remained in a crevice where the end hardware (inlet nozzle) is joined to the duct. If the assembly is returned to service with a residual amount of oxide in the crevice, there is a potential for corrosion and degradation of the mechanical properties of the weld joint over time at the higher temperatures. The crevice is on the inside of the duct, so it can not be inspected without destruction of the hardware. This issue has been evaluated in the past and assemblies that have been exposed in this manner have been destructively examined with the conclusion that little potential for corrosion exists. However, these studies were not able to remove all doubt and decisions have been made in the past to not use assemblies exposed to sodium and cleaned with water, whether irradiated (Type E) or not (Type B).

Restoring full confidence in the long term integrity of the hardware for these assemblies would likely take an extensive program involving destructive examination of several assemblies and perhaps incorporation of a stress test within the IEM cell as a qualification requirement for all of these assemblies. The issue can be resolved for the unirradiated assemblies (Type B) by removing the pins and rebuilding the assembly with new hardware, which would require long lead-times to procure the hardware and identify/prepare the assembly facility.

Type C describes pins that have not been irradiated or incorporated in assembly hardware. Some of these pins have non-conformance reports that would need to be resolved before use, but it is estimated that collectively there are enough pins for about 9 assemblies. The issue is that there is no hardware available for the pins.

Type D is the fuel that was fabricated for the SNR 300 German reactor. The potential to use this fuel in the FFTF has had extensive study. The fuel pins are very similar to the FFTF design, and analyses have shown that they would perform satisfactorily in FFTF at the design power of 400 MW. The fuel is built into gridded assemblies of 166 fuel pins each. There are 205 of these which, if downloaded and placed in standard 217 pin FFTF driver fuel assemblies, would yield 156 assemblies. The 166 pin gridded assemblies would neither fit into FFTF nor provide sufficient reactivity for a viable core, so rebuilding is required. The pins themselves are a different design but studies were done that showed a slight modification to the pin end caps without exposing the interior of the pins to the atmosphere would allow them to be fitted into standard FFTF subassembly hardware.

Industrial capability is believed to exist that could ship the 166 pin gridded assemblies to the US from their present location at Dounreay in the UK and transfer the pins to the FFTF assembly design. This would require procurement of assembly hardware and pin wire wrap, and full qualification of the facility to the rigorous FFTF standards. These pins contain no gas tags as do the FFTF pins but this is not seen as a particularly difficult problem for operations. Detailed core wide performance analyses would be required but this capability still exists at Hanford. The transfer of the SNR fuel will require governmental permissions to ship the assemblies to the U. S. But international agreements exist with other countries, e.g., the U.S.—Ukraine Nuclear Fuel Qualification Project (UNFQP), so this should not be difficult.

Using partially irradiated fuel (Type E) is also an option for a portion of the initial core load. However, if it is determined it is not advisable to use irradiated fuel, then it is necessary to procure new fuel.

New fuel (Type F) is also an option. Procurement of new hardware and operation of an assembly facility would need to be established for this option, as it also is for types (B) and (C). The additional requirement would be the ability to procure/manufacture the fuel. The use of HEU instead of PU might facilitate this. It is possible that some existing oxide production facilities could produce HEU fuel at the needed enrichment, but this requires further study. Metal fuel is also a possibility

In summary, there appears to be 3 options for providing the initial load of fuel for the FFTF.

(a) Develop a test and qualification program to qualify some of the irradiated fuel assemblies for reuse (i.e. resolve the sodium oxide corrosion issue). This could enable startup without the need for an assembly facility and procurement of core hardware. However development of the test program and acquiring the data required to fully resolve the issue might take as long as the procurement of the hardware. It is not clear that facilities are currently available to perform the testing that would be needed to qualify the irradiated assemblies.
(b) Start of an assembly facility and procure hardware (ducts, end hardware, etc.) for reconstitution of unirradiated fuel assemblies. 64 assemblies could be provided from fuel existing within the US, which might enable low power startup and operation until the SNR fuel could become available. This option is estimated to take approximately 42

months: 24 months to procure double vacuum melted steel; an additional 12 months to fabricate the hardware; and 6 months to build the assemblies. Commercial facilities may be available for assembly, or alternatively DOE facilities such as the FMEF SAF facility might be activated. It should be noted that duct and end hardware will also be needed for control rods and reflectors. Taken as a whole, this favors option (b) over option (c) for fuel.

(c) Production of new fuel to supplement existing US fuel. This option would be important if it is determined that the SNR fuel (Type D) becomes difficult to acquire and would also provide a source for sustained operation of the FFTF after the initial fuel is consumed. It requires the same assembly and hardware activities as option b and additionally require the establishment of a facility to make the fuel pellets (or slugs if metal fuel is used) and load the pins. Additional hardware to be procured would be the fuel pin cladding and end fittings. It is likely that this option could also be accomplished within the 42 month time frame, as development of the fuel pellet/slug fabrication capability could be conducted in parallel with the other efforts. The option could also provide fuel for the sustained operation of FFTF after the initial supply of fuel. Establishment of the capability could substantially enhance the ability to fabricate test and qualification fuel that will be required in the conduct of the GNEP program. More study is needed to determine if commercial facilities could produce oxide HEU pellets, or if a DOE facility, such as FMEF SAF would be needed. INEL has experience with metal fuel production, and may still have facilities for production of metal fuel.

Fuel Supply Options for Sustained Operation of FFTF
Approximately 60 assemblies per year are required, starting about 2 years after FFTF startup. This requirement would be reduced at lower power and/or by the amount of test assemblies. There are at least 4 viable options that could be considered for supply.

(a) Supply from within the US: This is the same as option (c) above
(b) Supply from Japan: Capabilities exist, but discussion needed.
(c) Supply from France: Capabilities exist, but discussion needed.
(d) Supply from Russia: Capabilities exist, but discussion needed.

Control Rod Assemblies
The FFTF requires nine control rods for startup and operation. Nine are currently in the reactor, but two will likely need replacement before startup, and an additional two to three will be needed during the first year of full power operation. The average consumption rate is about two control rods per year at 400 MW. There are no spare control rods available.

The control rod design is roughly similar to a driver assembly except that the pins are slightly larger in diameter and are loaded with boron carbide pellets. The pellets are expected to be easy to obtain as they are used extensively in existing commercial reactors, and suppliers that have been used in the past are still in operation. The critical path to obtaining control rod assemblies will be in procuring the hardware, which is similar to the fuel assemblies. The same sources of steel, tubing, and duct can be used. Based upon the discussion of fuel assemblies, it is expected that the control rods could be available for loading within 42 months.

Reflector Assemblies
The FFTF requires 108 reflector assemblies. 60 of these are inner assemblies, which are 12’ in length. 48 are outer assemblies and are 11’ in length. Seven of the inner assemblies need to be replaced before startup, and an additional seven outer assemblies need to be replaced after the

first cycle. There are currently 17 spare assemblies. Thus there are adequate reflectors for start up, but replacements need to be available within a reasonable period after start up. There have been no issues identified for reflector supply. Because of long lead times, however, procurement must be initiated early, at about the same time as for the fuel hardware and the control rods.

Cost & Time Estimates

There will be costs to qualify vendors and manufacturers again, since this capability was lost when FFTF was shut down. These costs are in addition to the costs discussed below.

Because there are many supply options for FFTF DFAs, only a rough estimate of the cost of driver fuel can be made at this time. Based on historical costs, a MOX DFA costs about $0.5M to produce assuming no cost for the plutonium and uranium oxide feed powder. A rough estimate for cost of an HEU DFA is $0.25M not including the cost of HEU oxide powder. The cost to rebuild SNR fuel pins into an FFTF DFA was estimated to be $0.25M. Based on these estimates, the cost for making the DFAs for FFTF restart and subsequent 5 core re-loads (90 DFAs) is given below for three supply scenarios.

- Just FFTF MOX: 43 new DFAs to combine 32 existing unirradiated DFAs for the first core, and 90 new DFAs for subsequent cores to make a total of 133 new DFAs for a cost of $66.5M.
- FFTF DFAs with SNR MOX: 43 SNR DFAs to combine with 32 existing unirradiated DFAs for the first Core and 90 SNR DFAs for subsequent cores to make a total of 133 SNR DFAs at a cost of $33.2 M.
- New FFTF DFAs with HEU made by an American vendor: 43 new HEU DFAs to combine with 32 existing unirradiated DFAs for the first core and 90 HEU DFAs for subsequent cores, to make a total of 133 HEU DFAs for a cost of $33.2M.

The first two years of 400 MW operation only require 90 DFAs for reloads because the initial core is composed of all fresh fuel. There is a transition effect as the core loading assumes an equilibrium composition that reduces the number of feed assemblies for the second and third cycles.

C. OTHER SIGNIFICANT ISSUES

1. Reconstitute and Revise the Final Safety Analysis Report

Issue Statement

Determine the major administrative decisions and technical efforts that will be required to reconstitute the Final Safety Analysis Report for the restart of FFTF.

Technical Issue

All reactors (DOE and NRC) are required to have a safety analysis report. This is a very large multi-volume document describing the facility, hazards, accident analyses, controls and institutional safety programs. Since the FFTF last operated in 1992, almost all facets dealing with operating the reactor have been removed from the safety analysis report. It will be a major task to reconstitute the report, incorporating new changes to the facility and all topics required by the current regulations. It will be important to designate the regulator/reviewer and the methodology for the safety analysis report as soon as possible so that this major project can be initiated and in-process issues can be resolved.

Resolution
Three major steps are involved:

Step 1 is to determine the owner, regulator and methodology. The "methodology" is the document stating how the safety analysis report is to be written.

The original FFTF safety analysis report was written in accordance with "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants – LMFBR Edition." While this is largely appropriate, special methodology direction will need to combine this with latest commercial and DOE practices. The "owner" and "regulator" relationships will need to be established early for these initial and ongoing decisions to be resolved efficiently.

Step 2 is to determine "preliminary" documented safety analysis report (PDSA) requirements and, based on those requirements, write the PDSA.

10 CFR 830.206 requires a preliminary documented safety analysis (i.e. preliminary safety analysis report) to be written for major modifications to nuclear facilities. The PDSA is the process whereby facility hazards are identified, controls to prevent and mitigate potential accidents involving those hazards are proposed, and commitments are made for design, construction, operations, and disposition so as to assure adequate safety at the facility. Approval of this new document may be a prerequisite for procurement and construction activities. The Final Safety Analysis Report during reactor operation provided most of the analyses required to demonstrate the safety of the new reactor. DOE and/or the regulator should state what additional specific issues need to be addressed, such as actions taken during facility deactivation, the new core design, and institutional programs to which the contractor commits. It is recommended that these new issue descriptions, in conjunction with the prior approved FSAR, would constitute the required PDSA.

Step 3 is to rewrite and submit the new Final Safety Analysis Report (FSAR).
The new FSAR would contain much of the information and analyses from the FSAR approved for FFTF operation, but would also include:

- Some detailed information from System Design Descriptions.
- Answers to NRC/ACRS questions in Supplements that were previously added at the end of the FSAR.
- New equipment, core load, etc. for the restart.
- New analyses that may be required (e.g. seismic, probabilistic risk assessment).
- Analyses that may need to be reperformed due to improved analysis codes.
- New subjects (e.g. more on institutional safety programs).
- Removal of excessive information based on commercial experience.

This is a large, multi-year project. It is recommended that a firm with commercial safety analysis report upgrade experience be contracted to team with facility personnel. They would provide much of the software application (word processing, web interface and linking ability) and guidance on level of detail in the various areas. To the extent commercial/NRC practices are followed, this contractor could advise on a report structure to support aspects such as the NRC USQ process, risk based regulation, and commercial Technical Specifications. For this project, it is imperative that an early decision on the FSAR methodology and regulation be made and that the regulator be available for guidance and decisions.

Cost & Time Estimate
$5 million over a 3 year period.

2. Infrastructure Needs as Hanford Shuts Down

Issue Statement
FFTF will need some infrastructure services, now provided by the site, past the time that these services are scheduled to be discontinued. FFTF can not perform its mission without arranging for alternate suppliers of these needed infrastructure services, such as certain electrical utility services, fire protection, road maintenance, telecommunications, and safeguards & security.

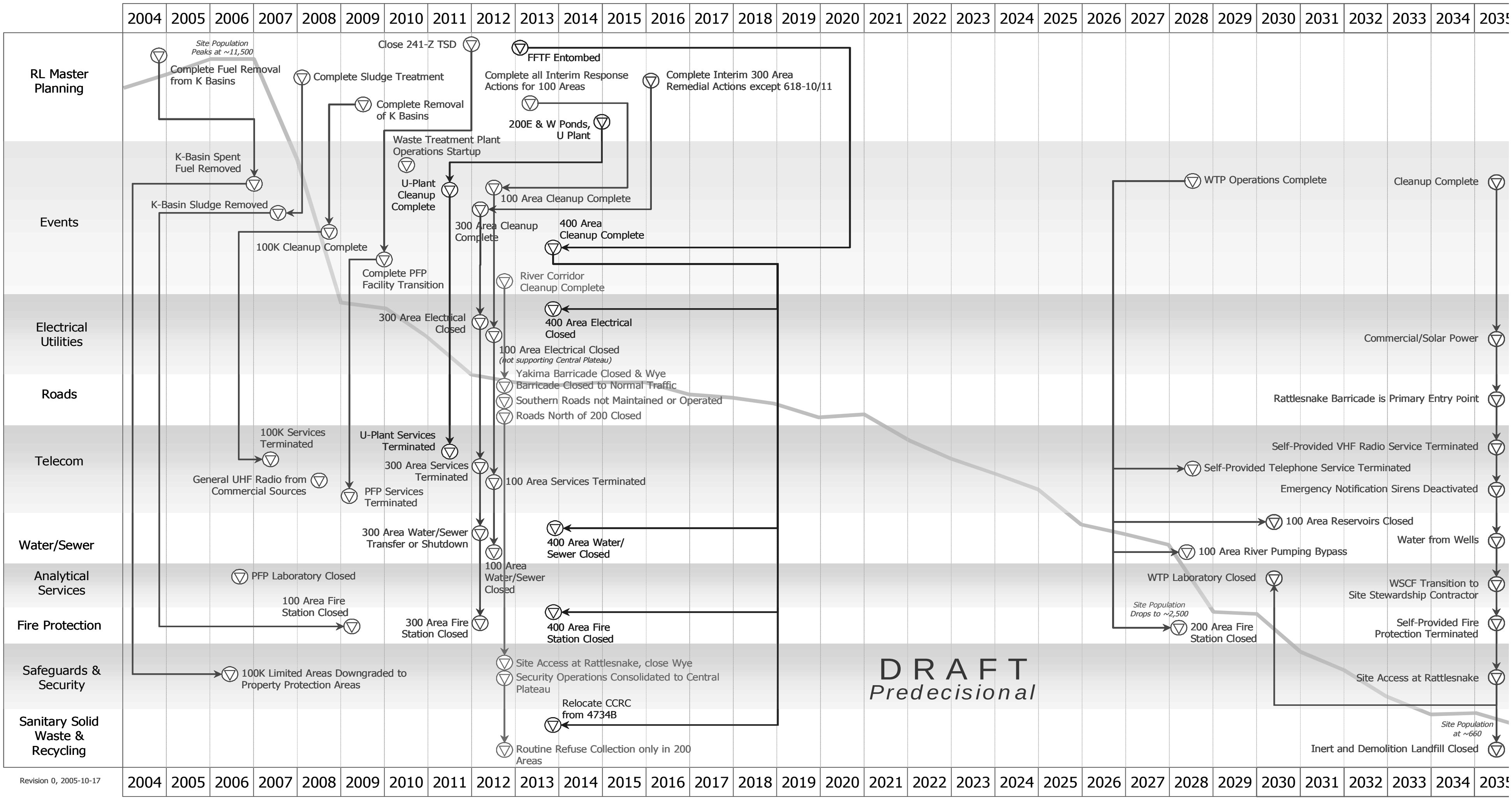
Technical Issue
The Hanford Site infrastructure will be reduced as closure activities continue through 2035. The current draft schedule is shown in HNF-25939, *HANFORD INFRASTRUCTURE CLOSURE ALIGNMENT PLAN*, and included here for information.

Needed Hanford Site infrastructure services will have to be negotiated and/or alternative services purchased. The first major service reduction is the planned 300 Area electrical distribution system closure in 2011. The 400 Area fire station, water and sewer systems are scheduled to be closed in 2013. The loss of these needed services will not impact the FFTF mission until 2011, so there are no immediate impacts. The FFTF Recovery and Restart will be impacted beyond 2011 unless these services are continued beyond the *Hanford Infrastructure Closure Alignment Plan* Level 0 target dates, or other providers are found.

Resolution:
Prior to 2011, needed infrastructure services scheduled to be eliminated will need to be identified and alternate providers identified and contracts negotiated.

Cost & Time Estimate
One to two years prior to the reduction in needed infrastructure services (2009 – 2010) the infrastructure reduction schedule will be reviewed, alternate providers identified and contracts negotiated. Estimated cost is one man-year effort. $100K

Closure Services & Infrastructure Level 0 Schedule



Fluor Hanford

Graph line indicates FFTF employment levels as deactivation continues

3. Establish Sodium and Gas Tag Analysis Capability

Issue Statement
The capability for sodium and cover gas chemical analysis and analysis of tag gas isotopes released from breached fuel pins no longer exists. Ability to verify the purity of the sodium and cover gas is essential to restart and operation of FFTF. If experiments are to be gas-tagged, capability to analyze the tag gas isotopes is required in order to expeditiously locate any cladding breaches. This ability is important since it will probably be necessary to quickly identify experimental fuel assemblies containing breached fuel cladding, even if they are not to be immediately removed.

Technical Issues
Capability for complete analysis of sodium and cover gas, and gas tag isotopes, was set up in the Hanford 300 Area, about eight miles distant from FFTF. This equipment operated in exemplary fashion during FFTF power operation. Since standby and shutdown, however, this equipment has become mostly inoperative and the space it occupies has been converted to other uses. Further, transport of the radioactive sample materials over the public highway between FFTF and the 300 Area, a nuisance in past years, would be much more difficult today. A laboratory in the 400 Area, in the FFTF building itself or in the Maintenance and Storage Facility, is required.

Present FFTF driver fuel is “gas tagged”; that is, a mixture of inert gas isotopes is placed inside each fuel pin before it is sealed. Each fuel assembly has a unique tag gas mixture. If a fuel pin develops a cladding breach, the tag gas is released into the cover gas where a sample can be taken for analysis by a mass spectrometer and the leaking fuel assembly identified. This system was very effective during FFTF power operation. It may be desirable to incorporate this analysis capability directly into the FFTF cover gas system.

The SNR fuel being considered for FFTF use is not gas tagged, but the FFTF fuel with further irradiation capability is gas tagged. It will probably be desirable to require that experimental fuels to be irradiated in FFTF be gas tagged.

The analysis of sodium and cover gas, and the use of gas tags, is a mature technology. A series of RDT/ASTM standards was developed for this effort; it is anticipated that they are still useable with some updating. [RDT is Reactor Development Technology, a predecessor of today’s NE organization. ASTM is American Society for Testing and Materials.]

Resolution

- Review existing analysis procedures and anticipated plant operating conditions to more precisely establish needs. Include in this effort a review of past and present analysis techniques to determine whether procedures need to be modified to be compatible with modern equipment. [The previous standard was written in the early 1970s.]

- Establish equipment, facilities, and staff requirements for a sodium and cover gas analysis laboratory in the 400 Area. There is a modern chemistry laboratory in the Hanford 200-West area, but it is approximately 20 miles away. The expertise of the staff at that facility and at Pacific Northwest National Laboratory will be used to complete this part of the task. It is noted that significant additions would need to be made to the 200-West laboratory for sodium, cover gas, and gas tag analysis, and the problem of sample transport over a public highway would remain if the analyses were to be done at 200-West.

- Acquire and train staff.
- Acquire, set up, and operationally qualify equipment.
- Revise plant sampling procedures as necessary, and train plant staff. The existing sampling procedures were kept up to date and worked very well during FFTF operation.
- Define equipment requirement for gas tag analysis, procure, set up, and operationally qualify equipment.
- Acquire staff (it may be some of the same people as for chemical analysis) for gas tag analysis, and train them.
- Develop/revise plant procedures for gas tag sampling analysis as needed.

Cost & Time Estimate
About 2 years for the entire effort.

$150K to define sodium and cover gas sampling needs, $5M-$10M for a fully equipped laboratory with trained staff. About $40K to define gas tag sampling and analysis requirements, $1M-$2M for equipment with trained staff.

If gas tags are not to be used, then the gas tag analysis equipment is obviously not required.

4. Refill NaK Heat Transfer Loops

Issue Statement
The Fast Flux Test Facility (FFTF) used three relatively small sodium-potassium alloy (NaK) loops for removing heat from auxiliary systems (total NaK volume was ~870 gallons). Access to the two NaK loops in the lower regions of the containment building (primary cold trap and IDS cooling) was very difficult, and sodium piping was available in close proximity to the NaK piping. It was therefore decided to flush these two NaK loops with primary sodium by installing sodium-NaK cross-connections and then draining them to the maximum extent practical.

Technical Issues
The NaK used in the FFTF is a low melting point (approximately 9ºF) eutectic alloy of sodium and potassium metals. It is used in heat transport systems where there is a desire to avoid the need for electrical trace heating for economic or safety reasons. At FFTF the primary cold trap and the two fuel storage vessels (Interim Decay Storage (IDS), and Fuel Storage Facility (FSF)) were cooled with NaK. While the use of NaK has some advantages over sodium during system operation, it represents a greater hazard during plant decontamination and decommissioning activities since it remains liquid at ambient temperature and can form unstable compounds. Because of these hazards, there was a desire to eliminate all NaK from the three systems during the plant deactivation process.

This resulted in a small increase in the potassium content of the primary sodium (from a few hundred to a few thousand parts per million) and frozen sodium residuals in the loop rather than liquid NaK residuals. The few thousand parts per million of potassium in the primary sodium has essentially no effect on the physical characteristics (e.g., the sodium melting point remains essentially unchanged at 208ºF).

System Status
There was no convenient way to flush the FSF NaK loop with sodium. Therefore that loop was drained to the maximum extent practical and the NaK was then transferred into the FSF sodium. The residual NaK was subsequently cleaned from the FSF NaK system using a superheated steam process. Some sections of piping had to be removed to perform the drain and cleaning.

Resolution
It is expected that the two in-containment NaK loops can be recovered by simply refilling them with newly procured NaK and initiating circulation; the residual sodium should be "dissolved" into the NaK. Prior to attempting this recovery a detailed evaluation (possibly involving in-plant testing) will be performed to identify where accumulations of frozen sodium may exist and may impact the planned recovery. If necessary, these sections may have to be removed or trace heated to assure system recovery. For example, it is anticipated that the diffusion cold traps may have to be replaced.

It is not clear whether the FSF NaK cooling loop will have to be recovered. It is only needed if the decay heat inventory in the storage vessel reaches 50 kW. The inventory was just approaching this value at the end of the previous ten years of FFTF operation. If necessary, the system could be restored by reinstalling piping sections previously removed to perform the drain and cleaning. Again, new NaK would have to be procured.

Cost & Time Estimate
It is anticipated that recovery of the two in-containment loops would require about a year and cost approximately $100K (required as part of FFTF restart). If required (decay heat inventory reaches 50 kW), recovery of the FSF NaK cooling system would also take about a year and $100K, but this recovery would not have to occur until several years after FFTF restart, if at all. If the FSF decay heat inventory reaches 50 kW, the second FSF NaK loop, which was not previously filled, would also have to be brought into service to provide redundancy.

5. Hiring and Qualification of Technical Staff

Issue Statement
The current staffing level of Operators, Engineers, and Crafts employed at the FFTF is insufficient to support recovery and restart of the reactor and its supporting facilities.

Technical Issues
To perform workscope associated with recovery of plant systems and re-authorization of FFTF as an operating fast spectrum reactor, additional technical personnel must be hired and qualified to work in the facility. Because FFTF will be authorized as a Category 1 Nuclear Facility, technical personnel must demonstrate significant in-depth knowledge of the Authorization Basis including strict adherence to procedures, maintaining configuration control of the facility, and conduct of operations. The technical staff can have a direct impact on employee, facility, or public safety, and the training they receive is critical to the successful restart and operation of the FFTF.

Training provided by the FFTF training organization must satisfy all issues associated with documenting that a technical staff member is qualified to perform his or her authorized function. No work involving critical systems at a nuclear facility can be performed by an individual who is not documented as "qualified."

Resolution
To provide the cadre of qualified technical personnel to accomplish recovery and restart workscope, the FFTF training organization must be staffed, training assets restored, and additional engineers, operators and craft personnel hired. It takes months to years to qualify personnel; thus, returning the FFTF to operation begins with the training organization. Resolving the staffing and qualification issue begins by laying out a time phased assessment of technical staff needed as FFTF progresses from a Category 2 Nuclear Facility (its current classification) back to Category 1. For example, a certain number of qualified reactor operators will be needed once the primary and secondary heat transport loops have been refilled with sodium. The FFTF will have to have 24/7 coverage by qualified operators from that point on. Five operation crews will be needed to man the plant. If each crew needs five operators to manage circulation of sodium, then 25 qualified operators will have to be trained and available at that time. The Training Department needs to plan for appropriate training sessions and qualification testing to certify the 25 operators before 24/7 operation can begin.

Qualification training requirements for technical staff is determined by regulatory authority requirements and standards. The Training Department must prepare a Training Implementation Matrix (TIM) that prescribes the specific qualifications for a particular technical position. The "old" FFTF TIM will be updated depending on which agency is selected by DOE to be the "regulator" for the reactor. Using the updated TIM, Training can determine if additional training assets are required to qualify and maintain qualification of technical staff. Based on the updated TIM and the recovery schedule, a forecast of training services can be made for the entire path to restart. This forecast will form the basis of a resource loaded schedule of training activities. The need for training services will determine the requirements for training staff and classroom facilities.

Cost & Time Estimate
Assuming that technical staff requirements will be similar to those needed to support past operations of the reactor, the time phased assessment of personnel needs can be developed with a modest effort of 0.5 man-month (MM). Updating the TIM once the regulatory authority is determined may take 6MM of effort. Estimating the numbers of trainers, physical assets needed for training, and a resource loaded schedule for training might take 2MM. The total effort to determine what the training department needs to look like and when it needs to start training activities is estimated to be 8.5 MM.

6. Implementation of Listed Plant Upgrades

Issue Statement
Some plant modifications are currently in progress to improve safety, reliability, and efficiency of operations in shutdown. If FFTF is directed to restart, several upgrades are planned in order to return systems to operation, improve reliability, conform to current standards, improve efficiency, or minimize waste.

Upgrades and Cost Estimates

- **Plant Protection System -** Upgrade SCRAM breakers, power supplies, and signal conditioners ($500K)

- **Zero-Time-Out Motor Generator Sets -** Upgrade Zero-Time-Out (ZTO) motor generator sets with solid state electronic units ($600K)
- **Plant Data System** - Upgrade plant data system computers ($3,000K)
- **Cooling Towers -** Upgrade the conductivity metering system on three cooling towers and replace the electronic sensors and controls ($300K)
- **Electrical Distribution Transformers -** Install new transformers to replace all PCB filled units in the plant. Some Plant transformers have been removed, but not all ($3,200K)
- **Chiller Controls** - Upgrade chiller controls ($500K)
- **Elastomer Seal Replacement -** Replace elastomer seals (as needed) with advanced seal technology. This would be done during the start-up phase ($100K)
- **Fire System Control Panel Upgrade -** ($2,000K)
- **Security System Upgrades** - Reinstate security systems commensurate with handling and storage of fissile material. This upgrade item is discussed briefly in a companion issue paper "Security Systems Require Upgrades to Meet New Requirements" ($31,000K)
- **Control Room Upgrades -** ($15,000K)
- **In-Vessel Handling Machine Control System Upgrades -** ($500K)
- **Reactor Simulator Upgrades -** Continue the upgrade program for the simulator that was in progress when the decision to place FFTF in Standby was made ($6,000K)

Total estimated cost for all items is $62.7M.

7. Primary HTS Snubber Testing

Issue Statement

There are approximately 3,500 seismic snubbers at FFTF. Some of these require periodic inspection.

Technical Issues

The FFTF Surveillance and In-Service Inspection (SISI) requirements document (Doc. WHC-SD-FF-SISI-006) stipulates that essentially 1/3 of the normally accessible seismic Category I supports/snubbers shall be examined during the life of the plant with 1/3 of these being examined every six years. A representative sample of 10% of the seismic Category I supports/snubbers located in normally inaccessible areas (e.g. primary HTS cells) shall be examined when access permits. Testing of the Secondary HTS snubbers was conducted, in accordance with this document, throughout the operation of FFTF. The Primary HTS snubbers were not tested during operation because of their inaccessibility. Due to "FFTF Shut Down" actions, the primary cells are now open and accessible. Therefore, a test program of the primary seismic Category I supports/snubbers must be implemented.

Acceptable snubber performance on the primary systems is necessary to assure that the primary decay heat removal safety boundary will be maintained in concert with a Design Basis Earthquake (DBE).

Resolution

Based on statistical arguments not every snubber must be tested. The population of snubbers that should be tested will depend on selecting a sufficient representative sample and on the failure rate found as testing begins. If no failures are found, then fewer tests are needed. But if a significant number of snubbers fails testing, then the sample population must be increased to assure snubber functionality during a Design Basis Earthquake (DBE) event. It is conservatively assumed that half the snubbers, or approximately 700, may end up being tested to provide assurance of snubber functionality.

Cost & Time Estimate

A rough estimate of the cost and time needed to perform snubber testing in the normally inaccessible cells can be developed knowing there are approximately 1400 primary snubbers installed in these cells.

A testing crew can test 2-3 snubbers per day. If we hire four test crews (three men on a crew), snubber testing will take about six months to complete. Some of the larger snubbers may require a four-man crew, and some of the snubbers are difficult to access and will require scaffolding to be erected. The labor cost for this effort is six man-years or about $0.9M. In addition there will be some cost for replacement snubbers and test materials. Those costs are estimated to be $0.5M. The total cost for snubber testing adds up to $1.4M and 6 - 12 months depending on how many crews can work in the plant at one time.

Constraints

Based on previous testing experience, spare snubbers (particularly for small piping) will need to be staged to minimize schedule impacts. Limited testing of snubbers in the primary cells was conducted in 1997. Some failures of the small piping snubbers was noted and attributed in part to red powder (rust) collecting in critical areas of the snubbers. Similar failures were noted in the Dump Heat Exchangers, and were corrected by installing boots. Based on these findings, the percentage of snubbers that will be tested in the primary cells will be assessed, recognizing that it will be significantly greater than the 10% figure in the SISI document.

8. Revise Security Threat Level Plan

Issue Statement

Security systems will need to be upgraded to meet new requirements.

Technical Issues

The requirements for Security changed dramatically after the events of 9/11. These requirements will be evaluated and changes to the security systems at FFTF identified. FFTF no longer handles Category I nuclear material. Issuance of a restart order will require FFTF to resume these operations. The security requirements for Category I nuclear facilities have changed dramatically and will require upgrades to existing equipment along with other physical upgrades at the perimeter and within the facility.

Resolution

When FFTF is selected for the next round of evaluations, a team will be formed made up of representatives from Safeguards & Security, FFTF staff, and scheduling to evaluate the new requirements and develop a cost and schedule estimate.

Cost & Time Estimate

The requirements evaluation is expected to take approximately 20 man-months to complete.

Energy Northwest provided a figure of ~$30M as their cost to upgrade the security systems at their facility based on new NRC security requirements. A similar cost was provided for physical upgrades at a Category I nuclear facility on the Hanford Site. It is assumed that the value will be similar at FFTF and that it will take approximately 36 months to hire, train and clear the required security forces and complete all facility upgrades.

9.0 Overview of the Fuels and Materials Examination Facility (FMEF) as a Supporting Facility for GNEP

The Fuels and Materials Examination Facility (FMEF), adjacent to the FFTF in the 400 Area at Hanford, is currently in layup. The FMEF was constructed in the early 1980s as part of the U.S. Breeder Reactor Program. The original mission for the facility included post-irradiation examination of irradiated fuels and materials as well as breeder reactor (FFTF and CRBR) test and driver fuel manufacture. The facility was originally designed to ERDA 6301 for missions that required enhanced safeguards and security. The facility was completed but not occupied for any programmatic mission. It is therefore uncontaminated and available to support GNEP. GNEP could use FMEF to fabricate fuel on a prototypic scale as well as to assemble FFTF Driver Fuel and actinide fuels that will be needed for GNEP.

The FMEF consists of a 98-foot high Process Building with an attached Mechanical Equipment Wing on the west side and an Entry Wing across the south side. The 175-foot wide by 270-foot long Process Building provides about 188,000 square feet of operations space. The 98-foot height makes the Process Building as tall as a seven-story office building. The Process Building also extends 35 feet below ground. The building is divided into six operating floors, which are identified by elevation relative to ground level and primary function. Each floor was originally designed to serve a specific function, such as a Secure Automated Fabrication line, Fuel Fabrication, Chemistry, and so on.

The top floor, 70 foot level, contains the Secure Automated Fabrication Line which was constructed to manufacture mixed oxide fuel pellets at a rate of 8 kgs/hour (~7500 pellets). The SAF line is separated into three processing areas (powder, pellets, pins) and designed to run remotely. All process equipment is contained in shielded glove box type structures which provide the capability to process fuel materials with higher radiation exposures, such as would be needed for GNEP. The powder and pellet area equipment completed pre-operational testing and was ready for hot start up prior to termination of the supporting fast reactor program. All process equipment for the SAF line is still installed, although the remote control equipment will need replacement.

The 21 foot and 42 foot elevation floors were designed to house numerous chemistry laboratories to support the facility mission. All service wiring and piping was installed, although no process equipment now exists on these floors. The 42 foot level includes a large hot cell structure with numerous services and manipulator ports. The 21 foot level includes a Special Nuclear Material Storage (SNM) vault, which is complete with handling robot and stacker/retriever system in the controlled storage area. This equipment is still in place.

The 0 foot level (ground floor/entry level) contains a very large process cell in the very middle of the facility. This cell is four floors high and was originally designed for chemical separation processing development. The base of the cell is on the -17 foot level, below grade. The hot cell windows and manipulators would need to be procured if use of the cell is required. This floor also contains the control room for facility services (installed and operational prior to shutdown) and the access vestibules for controlled entry. The truck lock, and access to other facility services are also on this level.

The -17 foot level also contains numerous laboratory sized hot cells, and rotating equipment rooms for facility services.
The -35 foot level also contains numerous small and mid-sized hot cells, many of which have manipulators, shielded windows, and other support equipment that was installed to support the Radioisotope Thermal Generator Mission prior to the program being moved to another DOE site.

The FMEF is an attractive facility to support the GNEP. It is clean, and able to meet the early reactor fuel fabrication needs of GNEP. It also offers other capabilities in supporting chemical separation process development. It is estimated that the FMEF could be made ready for nuclear operations in 3-5 years, depending on the mission needs of GNEP for the facility.

FMEF Completion

The Fuels and Materials Examination Facility is essentially complete structurally, electrically and environmentally (HVAC). All plant systems would have to be reenergized and restarted. However, other than the effects of disuse for the intervening years, there are no perceived problems with reactivation of the facility.

In reactivating the FMEF, the new mission of support for GNEP will dictate the plans for restoring functionality to the building. Modifications of existing configurations of either systems or structure will need to be defined and effected in the correct sequence to avoid unnecessary duplication of effort and possibly reworking of previously accomplished steps.

Bringing FMEF back to operation in support of GNEP should be a straightforward, relatively inexpensive task.

APPENDIX II

Fuel Supply

FFTF Fuel Supply and Spent Fuel Storage

FFTF Fuel Supply Options

The FFTF (Fast Flux Test Facility) will use conventional fast reactor driver fuel to provide a fast neutron flux environment to test, under prototypic conditions, advanced fuels and materials supporting the development of advanced actinide recycle fuel systems. The FFTF has the flexibility to allow simultaneous testing of multiple assembly loadings of diverse recycle fuel systems. This permits "side-by-side" comparison of different candidate fuel systems in assembly configurations prototypic of irradiation and thermal conditions expected in the Advanced Recycling Reactor. Operating as a fuels and materials test reactor, the FFTF will irradiate candidate recycling fuel assemblies to goal burnup and provide fuel performance data at more extreme operating conditions to support the licensing by the NRC (Nuclear Regulatory Commission) of a commercial recycling reactor.

The FFTF will operate using conventional fast reactor fuel, similar to that already approved under its Authorization Basis, to perform irradiation testing of individual "experimental" actinide fuel assemblies of interest to the sponsoring programs. During this phase, FFTF will be fueled with either MOX (mixed oxide) fuel and/or EU (enriched uranium) as an oxide or binary metal alloy fuel form. Driver fuel will be procured by DOE. Procurement options are discussed in the "Fuel Supply Options" section below.

After the Programs have selected the fuel system to be used in the recycling reactor, the FFTF can be converted to an all "Advanced Recycling Reactor fuel" core. In this role, the FFTF would support further development of recycling fuel as well as burn significant quantities of actinide fuel and serve to demonstrate recycling fuel performance to even higher burnup levels. When the commercially operated Nuclear Fuel Recycling Center comes online and begins producing driver fuel for the recycle program, the FFTF could use this commercially supplied fuel to continue operations until its programmatic mission is completed.

FFTF Conventional Fuel Supply Options

A supply of new Driver Fuel Assemblies (DFAs) will have to be developed to provide fuel for the FFTF because there is not enough available fuel to complete a core loading. There are only 32 fresh MOX DFAs available to be loaded into the FFTF as part of the restart core loading. Although there are some DFAs with low burnup, the washing procedure that was used to put these irradiated DFAs into dry storage makes the qualification of these DFAs problematic. There also are some loose MOX fuel pins in storage at the Hanford Site. While these pins could be qualified for operation, there are at most only enough pins for 9 additional DFAs--assuming the enrichment levels are available in the right quantities (217) to make complete assemblies.

An additional 133 DFAs need to be procured to reload and operate the FFTF at 400 MW for 2 years. About 43 "new" DFAs will be combined with the remaining 32 "old" fresh MOX DFAs to make up the first core. The balance of the "new" DFAs (90) would be needed to refuel over the first 2 years of operation. An additional 60 "new" DFAs per year would be needed after the initial 2-year period was over. The total amount of fuel that would be needed depends on how long the FFTF will be used as a fuels and materials test irradiation facility. NRC approval of the selected actinide fuel system will be needed before commercial production of recycle fuel can begin. Until such fuel is available in sufficient quantities, there are two options for obtaining sufficient "new" fuel.

Option 1 --SNR-300 MOX Fuel

Use MOX fuel pins fabricated for Germany's cancelled SNR-300 reactor if still available to DOE. The enrichments and physical size of the SNR-300 fuel pins are almost the same as those used in the original FFTF MOX DFAs. The SNR-300 fuel pins would need to be down loaded from SNR-300 duct assemblies, wire wrapped, undergo a slight revision to their end caps, inverted for proper fuel location, and reloaded into new FFTF style fuel ducts. This is a straightforward procedure and could be done without a glove box. The estimated cost to do this is $40M. A total of 156 "new" DFAs could be fabricated for use in the FFTF. That is enough fuel to load the first core and operate for 2.3 years. After that, another source of "new" DFAs must be developed by the method described as option 2.

Option 2 –New Enriched Uranium (EU) Fuel

Enriched uranium (EU), can be used either as the sole source of new fuel or in conjunction with SNR-300 rebuilt "new" DFAs if cost and timing is preferable. In this option, EU (24% to 32% U-235 enrichment range) is used as uranium dioxide pellets to build fuel pins that are very similar in design and performance to "old" FFTF MOX fuel pins. Because plutonium is not involved, glove box operations are avoided, making the cost to produce this fuel lower than that for MOX fuel. EU can also be fabricated into a binary alloy, sodium bonded, metal fuel pin that can be assembled into a "new" DFA for FFTF. Several full sized metallic fuel assemblies were irradiated to goal burnup in FFTF. An "all metallic fuel" FFTF core would have acceptable safety characteristics and be able to perform the irradiation testing needed to license the ARR actinide fuel. Whether SNR-300 fuel is used or not, if the irradiation testing program takes longer than 2 years to complete (which is probably the case), the EU fuel option will have to be developed. The cost estimate for fabricating 60 "new" EU DFAs (a year's worth of fuel) is $15M, exclusive of the cost of EU blended oxide or metal.

Comments on the use of SNR-300 Fuel Pins and EU Fuel Pins

Using existing SNR-300 fuel pins has several advantages. The welded fuel pins can be used without having to be opened, which is a big advantage. Additionally, some of the SNR-300 MOX pellets were made from once burned LWR discharged plutonium. This fuel would provide the Program a "head start" in the irradiation of actinide oxide fuel that will eventually be produced in the Nuclear Fuel Cycling Center. The discharged SNR-300 fuel would therefore be very similar to transuranic fuel discharged from an recycling reactor. This material would be available for evaluation years earlier than reprocessed U.S. LWR transuranic material.

There is, however, an uncertainty involved with the use of SNR-300 fuel. It is not clear that the "chain of custody" of the fuel has been maintained. The "chain of custody" is important because it is needed to prove that nothing has happened to the fuel pins over the past 20 years that might compromise fuel pin integrity.

Using EU has some obvious advantages as well. A U.S. fuel commercial fuel vendor can make EU fuel pellets or binary alloy metallic slugs. Since SNR-300 fuel by itself cannot meet all the FFTF fuel needs as a fuels-and-materials test reactor, the cost to develop EU fuel pins must be incurred at some point. Using EU as a driver fuel for the FFTF will increase fissile inventory (20% greater than MOX) requiring a 20% decrease in operating flux level. Additionally, the value of "beta-effective" for the core will be higher, which is likely to provide a slightly better transient response capability (an advantage).

Loading Pins into Driver Fuel Assemblies

The final step in fabricating "new" Driver Fuel Assemblies is to load fuel pins into fuel ducts and weld on the handling socket and nozzle. For purposes of supporting the test reactor operating phase (Phase 1), an assembly and storage facility located in the 400 Area is recommended. The FMEF (Fuels and Materials Examination Facility) has a "Fuel Assembly Annex" that has been designed to load pins into ducts and to store completed DFAs until they are needed by the reactor. This annex would need to be equipped and staffed. Only the annex would be needed, so the rest of the FMEF would be available for other activities or remain essentially vacant. Added security measures would be needed to protect the annex and the stored fuel. The security measures would be very similar to those needed at the FFTF and should be a modest cost addition.

Spent Fuel Storage Capacity at FFTF

FFTF has sufficient spent fuel capacity in sodium-filled fuel storage vessels to hold more than seven years worth of spent fuel assemblies at full power operations. Before capacity is reached selected fuel will be washed in the IEM Cell and transferred to dry storage or shipment. One full-power-year of FFTF operation will generate approximately 60 spent fuel assemblies.

Stages of FFTF Fuel Storage

FFTF has three stages of in-sodium decay heat removal fuel storage locations. These locations take the fuel elements from directly out of the reactor and then progressively to longer term storage vessels as the fuel cool until decay heat has decreased to the point that they are cool enough for transfer to long term dry storage or shipment for processing.

Fuel elements pulled directly from the reactor core are stored in locations inside the reactor vessel for several weeks until they have cooled enough for handling by the refueling machine. At this point the fuel can either be sent to the Interim Examination & Maintenance Cell inside the FFTF containment for disassembly, and extraction of selected fuel pins for transfer to an analytical laboratory for assessment, or transferred to the Interim Decay Storage (IDS) vessel for further cooling. The IDS vessel is inside the FFTF containment as has 102 fuel storage positions. Fuel remains here until it is cool enough to be temporarily removed from sodium under gas cooling for the move to the Fuel Storage Facility (FSF). The FSF is a 466 position sodium filled vessel located off the Reactor Service Building outside of containment. Here the fuel continues to decay until it is cool enough to have the sodium washed off. It is then can be placed in dry storage or shipped for processing. Dry storage modules hold six or seven fuel elements and normally are placed on an outdoor pad within a security fence.

APPENDIX III

Power Addition

Fast Flux Test Facility – Power Addition, Stone and Webster Engineering Co., 1987 (recap)

In 1983, the Department of Energy (DOE) requested the Westinghouse Hanford Company (WHC) to explore the possibility of converting the waste heat from the operation of the Fast Flux Test Facility (FFTF) into electricity using the technology developed in the Liquid Metal Reactor (LMR) program. The result of that study was a conceptual design that confirmed the technical feasibility and the potential economic attractiveness of a power generation addition to the FFTF.

Based on these results, in 1986, the City of Richland, together with the Benton and Franklin County Public Utility Districts, proposed a detailed evaluation of the feasibility of a utility-owned generation facility at the FFTF using the steam generators developed for the LMR. This proposal led to a Cooperative Agreement between DOE and the three southeastern Washington utilities which called for the development of an advanced conceptual design (ACD) and cost estimate, plus plans for the financing, power marketing and other considerations necessary to determine the practicality of the Power Addition as a privately-owned electrical-generation facility.

The principal condition for the FFTF Power Addition (FFTF-PA) study was the design and construction of a power addition, including any modifications required to the FFTF, would be privately financed.

The primary tasks of the FFTF Power Addition study included:

1. Development of an ACD for the power generation plant and the associated modifications to the existing FFTF which together comprise the FFTF-PA.

2. Preparation of a detailed cost estimate and schedule for the construction and operation of the FFTF-PA which includes the energy payments to the DOE and an estimate of the cost of power from the FFTF-PA.

3. Analysis of the operating characteristics of the FFTF with the Power Addition and performance of the necessary safety and environmental evaluations to assure that the FFTF with the Power Addition preserves the FFTF safety functions and complies with applicable FFTF general design criteria which were established during the original review of the FFTF by DOE, the NRC staff and the Advisory Committee on Reactor Safeguards (ACRS).

4. Determination of the appropriate legal entity to own and operate the power generation plant and the legal and contractual arrangements between the owner and operator of the power generation plant and DOE.

5. Preparation of the plan for privately financing the construction and operation of the FFTF-PA and marketing the power output.

6. Evaluation of the economic and programmatic benefits to DOE from the construction and operation of the FFTF-PA.

A cooperative Agreement was initiated in December 1986 proceed to a conclusion inconsistent with the positive direction summarized in this report.

Summary

An in-depth review of the design was performed by participants from the FFTF-PA project , DOE, the LMR Advanced Design Studies, and the EBR-II facility. This review confirmed that the design approach selected for the FFTF-PA was technically sound and consistent with LMR operating experience.

Preparations began for an in-depth cost estimate, supported by vendor budget cost quotations for major components. The design was finalized when the safety assessment document was issued by WHC, cost reduction studies were completed by both WHC and SWEC, and preliminary constructibility and schedule assessments were completed by SWEC.

A comprehensive safety assessment of the Power Addition was initiated, with objectives:

- To provide a comprehensive safety evaluation of the proposed power addition and its interface with the existing safe operating envelope of the FFTF.
- To support the safety review process of the FFTF-PA and to provide to a potential owner a measure of assurance that the design, as presented, will comply with current regulatory requirements and that DOE has successfully completed its review in accordance with DOE requirements and orders.

The results of the safety assessment were incorporated into a formal report. An independent external review was conducted by an ad hoc committee of safety experts selected by DOE from the LMR community. The results of the independent reviews, together with the resolution of identified issues, were presented to the NRC as an over check of the adequacy of the scope of the review and the review process. This approach was provided a high degree of confidence that the potential public impact of the Power Addition had been appropriately addressed and that the potential financial risk as a result of safety considerations was acceptably low.

System Design

The existing main heat transport system (HTS) of the FFTF consists of three essentially identical sodium-cooled loops to remove reactor heat.

Each HTS is composed of a primary loop (the reactor vessel being common to all three loops) and a secondary loop (the three secondary loops being completely separate from each other). Heat is transferred from the reactor to the intermediate heat exchangers (IHX's) and then to the secondary loops. The heat is currently rejected from the secondary loops to ambient air via forced air flow dump heat exchangers (DHXs).

The FFTF-PA will install steam generators on two of the three secondary HTS loops. The third, or east loop (which contains a tornado protected DHX), will remain in its present configuration and thus provide a dedicated emergency decay heat removal path. Design Parameters are shown in Table 1.

Economic and programmatic considerations have dictated maximum use of available LMR hardware, the most important of which were the "hockey-stick" steam generator components. Although these units had not been fabricated, the long-lead materials were available and the design documentation was complete.

The reference configuration for the FFTF-PA uses one evaporator and one superheater module in each secondary loop. In this configuration, the LMR steam generator modules in the FFTF-PA will be operating under conditions very similar to their original LMR design conditions.
The superheater and evaporator module were to be located in series with the existing DHXs. During normal operation of the power generation plant, the DHX fans would be off and the air flow dampers closed to limit heat loss from these units. This configuration retained the proven capability of the seismically qualified DHXs to provide the redundant natural circulation decay heat removal function in response to design basis accident scenarios and preserved the current safety posture of the FFTF in this area.

The steam generator building will be located within the FFTF security area in close proximity to the south and west DHX's. The steam generators and associated equipment in the steam generator building will remain in the custody of DOE and be operated by FFTF personnel from the reactor control room. Power generation equipment (turbine, condensate and feedwater pumps, cooling towers, etc.) are operated by utility personnel from a separate control room in the power generation plant building. Since the FFTF does not depend on the facilities outside the security fence for any safety functions, this operating mode is acceptable.

Table 1 Key FFTF-PA Design Parameters 100% Load

Parameter	Value
Total Plant Duty, MWt	297.3
Gross Electrical Output, MWe (approx.)	118
Net Electrical Output, MWe (approx.)	110
Number of FFTF Loops Supplying PA	2
Superheater Steam Flow Rate, lb/hr	514,800
Superheater Steam Outlet Temperature, °F	863
Superheater Steam Outlet Pressure, psig	1,750
Secondary Sodium Hot Leg Temp., °F	866
Secondary Sodium Cold Leg Temperature, °F	595

Schedule

The overall project duration from the start of detailed design to commercial operation was 48 months. Major elements of this schedule include a 28-month construction period and a 9-month period for final tie-ins, startup and checkout operations. The critical completion path was through the procurement, fabrication and installation of the steam generators followed by tie-in of sodium lines with the existing FFTF facilities, and operational testing of the steam generators and power generator equipment.

Cost

The total design and construction cost was $158M excluding financing costs. Financing costs were included in the cost-of-power calculations. The cost basis assumed start of design October 1, 1988, construction started September 1989 and commercial operation began October 1992.
The direct cost portion of the estimate was segregated into two categories; work outside the FFTF protected area identified as Power Generation Plant and Transmission Facilities and work inside the FFTF protected area. The total cost for the Power Generation Plant was $77M. For the FFTF Modification, the total cost was $81M.

Conclusions

The results of the ACD study established that the Power Addition is both technically feasible and economically attractive. Safety and environmental aspects appear to present no significant concerns. The estimated capital cost resulted in a cost to power ratio of less than $1800/kWe which was very competitive with contemporaneous utility estimates for new generation capability. In summary, the ACD study confirmed that the FFTF-PA would be viable and cost effective.

APPENDIX IV

NEPA Discussion

Legal and Policy Issues for Reactivation: Amend the January 19, 2001 ROD

Background: ROD Amendment Requires Supporting NEPA Documentation

The National Environmental Policy Act, 42 U.S.C. Sections 4321-4370d ("NEPA"), requires Federal agencies to consider any proposed major Federal action within the context of how that action will affect the environment. If the action(s) may have a *significant* impact on the quality of the environment, then the proposing Federal agency is required to draft an Environmental Assessment (EA). The EA will conclude the action(s) potentially does or does not have a significant effect on the environment. If the proposed action(s) are found to potentially significant effects on the environment then NEPA requires preparation of an environmental impact statement (EIS).

An EIS document requires detail of high quality from multiple sources. Accurate scientific analysis, expert agency comments, and public scrutiny are essential components. The purpose of the EIS and its detailed nature is two-fold: first, to ensure that the proposing agency is well informed about the environmental impacts of their decisions; second, to offer other government agencies and the public an opportunity to participate in the information process. This second purpose affords the proposing agency and all other interested parties an opportunity to gain a broader perspective regarding considered actions. This opportunity makes it more likely that the purpose and policy of NEPA will meet the letter and spirit of the law. This process has been defined by the courts as the "hard look" test.

NEPA only requires agencies to scrutinize the environmental effects of considered actions. The statute does not direct a specific outcome even if an EIS could suggest one particular action is definitively more environmentally desirable than other considered alternatives.

Nuclear Infrastructure Programmatic Environmental Impact Statement (NI PEIS)

Pursuant to NEPA, DOE in December 2000 published an EIS that addressed the nation's nuclear infrastructure titled "*FINAL Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility"* (NI-PEIS) (DOE/EIS-0310). The document's title refers to DOE's mandated mission as stated in the Atomic Energy Act of 1954 (AEA 1954). This legislation lists DOE's three missions as 1) undertaking research and development activities related to development of nuclear power for civilian use; 2) ensuring the availability of isotopes for medical, industrial, and research applications; and 3) meeting the nuclear material needs of other Federal agencies. The legislation also emphasizes that successful execution of these directives is crucial to the nation's national security.

The title for the NI PEIS makes specific reference to the Fast Flux Test Facility (FFTF). The FFTF is explicitly mentioned because it is the only facility in DOE's infrastructure that can meet the needs of all three missions.

The NI PEIS's introduction evaluates how well DOE's existing nuclear infrastructure supports the missions specified in the AEA of 1954. The document concludes that in recent decades DOE's nuclear facility infrastructure has diminished due to shutdown of facilities. Facility shutdown has hampered DOE's ability to satisfy increasing demands.

This conclusion is consistent with the findings of the Nuclear Energy Research Advisory Committee's (NERAC) basic finding: **the capabilities of currently operating DOE facilities could not meet projected U.S. needs for nuclear material production and testing or research and development.**

The NI PEIS (2000) addresses six alternatives. DOE's preferred alternative was to apply its existing infrastructure. DOE concluded that the current infrastructure would serve the needs of the research and isotope communities for the "next several years." The alternative for the longer-term future was development of a conceptual design for an Advanced Accelerator Applications (AAA) facility. This facility would be used to evaluate spent fuel transmutation and conduct various nuclear research missions. Regarding the FFTF, DOE chose to permanently deactivate the facility.

Energy Secretary Bill Richardson's NI PEIS Response: January 19, 2001 ROD

Energy Secretary Bill Richardson, on January 19, 2001, issued a Record of Decision (ROD) based upon the NI PEIS (2000). Secretary Richardson summarized conclusions from the NI PEIS including that the FFTF would be permanently deactivated. Rationale specified in the ROD for deactivation of the FFTF was,

> *"Given that other existing facilities can meet DOE's near-term needs for isotope production and research, the Department believes that it should invest its funds in enhancing its existing infrastructure and exploring the potential of a new AAA facility as a long-term option to meet US research needs."*

Secretary Richardson's ROD reflected recognition in the uncertainty of the future, particularly with regard to the usefulness of the FFTF. His ROD stated, "DOE recognizes that significant uncertainties remain regarding the future of research and isotope production activities that could justify operation of the FFTF."

Technology Shift: Initiative (AFCI) with Emphasis on Fast Reactor Transmutation

Secretary Richardson in his 2001 ROD stated that infrastructure needs could be met by "exploring the potential of a new AAA facility as a long-term option to meet US research needs." New AAA infrastructure became an insufficient option due to cost ($280 billion) and technology. This conclusion was made by Secretary Richardson's successor, Secretary Abraham, on March 6, 2002 in his testimony before the House Energy and Water Appropriations Subcommittee and described in DOE's September 2002 report "Advanced Fuel Cycle Initiative: The Future Path for Advanced Spent Fuel Treatment and Transmutation Research." This 2002 report encapsulates demonstrable shifts in Administration policy relative to transmutation research, development and implementation.

The major policy shift was accelerators to fast reactors as recommended by NERAC's Subcommittee on Advanced Nuclear Transformation Technology. The Subcommittee chaired by Nobel laureate Burton Richter gave recommendations consistent with current GNEP direction: to achieve targeted benefits from transmutation of wastes, fast spectrum reactors are required. Demonstration scale proof-of-performance of these advanced technologies will require new fuel fabrication and fast spectrum test facilities.

Dr. Richter's visionary recommendations have subsequently been reflected in the Energy Policy Act of 2005, and the present Administration's GNEP program. The FY 2007 Energy and Water Development Appropriations bill addressed the Global Nuclear Energy Partnership (GNEP). Senate Committee Report 107-274 for H.R. 5427:

> Global Nuclear Energy Partnership. – The Committee Recognizes and appreciates the considerable investment this administration has made in this area and supports efforts to close the nuclear fuel cycle. It is imperative that the Federal Government support long-term research to discover ways to reduce the amount of nuclear waste and recycle the vast amount of untapped energy that remains in the current once-through nuclear fuel cycle. Faced with the reality of long-term storage needs and the fact that our Nation is unlikely to permit and license more than one permanent repository, out best alternative is to vastly reduce the amount of waste, the heat content, and the radiotoxicity of the spent fuel before permanent disposal. The President has proposed the Global Nuclear Energy Partnership as a multi-pronged technical approach to close the nuclear fuel cycle and encourage the recycling of uranium and destruction of long-lived actinides through advanced reactor technology. The budget supports the development of recycling technologies that have the opportunity to enhance the proliferation resistance of existing recycling or separation technologies.

Drivers for the post-2000 technology shift include the need for a sustainable fuel supply and the capacity and siting of repository facilities. The existing one pass, LWR fuel cycle requires an expansive repository volume and an unsustainable increase in uranium mining extraction. Drivers are predicated on economic timing.

The present economic and political cost of siting additional repositories is prohibitive, and the demand for domestically supplied fuel (nuclear or otherwise) has increased dramatically. The major benefits of the closed fuel supply come from recycling of the spent nuclear fuel to recover the beneficial energy and to segregate the small fraction of toxic elements. The sustainability of the closed cycle reduces the isolation burden such that a single repository is sufficient, and ensures a domestically sustainable nuclear fuel supply.

Procedures for Amending a Record of Decision

The circumstances affecting major Federal actions that may have a significant impact on the quality of the environment are likely to be continuing, change and evolve, and NEPA and DOE have procedural provisions that address these changes. NEPA created the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR 1502.9(c)) and DOE NEPA regulations at 10 CFR 1021.314.

DOE similarly recognizes the need for decision making flexibility to accommodate technological and policy shifts, and future uncertainties. DOE allows multiple RODS for a single EIS, and subsequent RODs can be drafted and executed for subsequent environmental assessments (EAs), supplement assessments (SAs), and supplemental EISs.

The Secretary of Energy has the authority to draft and execute subsequent RODS at will (10 CFR 1021.315(e)). The only limitations for change are procedural. Preceding documentation, with particular emphasis on the original EIS, shapes the parameters for subsequent decisions, in particular RODs. The Secretary must limit the subject matter of subsequent RODS to environment impact issues addressed in previous documentation. Each issue addressed in a ROD must have been subject to the "hard look" test required by a properly drafted EIS.

Amending the January 19, 2001 ROD to Direct Restart of the FFTF

Pursuant to NEPA and CEQ regulations, the Secretary of Energy can amend the January 19, 2001 ROD provided the addressed issue was initially reviewed in the NI PEIS. The NI PEIS reviewed the status of the FFTF for continued operations, limited operations, and restart to full capacity. Amending the initial ROD from status of permanent deactivation to restart is squarely within the parameters of the NI PEIS.

Further support for this conclusion can be found in the ROD itself. Under "Summary of Environmental Impacts" for the Secretary's ROD it stated that none of the alternatives considered in the NI PEIS would have a significant environmental impact in any major area of concern. Specifically, the ROD states:

> "The only resources area that could be significantly impacted by the implementation of any of the alternatives is water use associated with the construction of new facilities. . . The largest effect on air quality would also occur during construction activities. .. . None of the alternatives would have had significant impact on regional economic areas. . . None of the alternatives at existing candidate sites would have had a significant effect on land use, visual resources, noise, water quality, geology and soils, ecology, cultural resources and environmental justice... *Hazardous waste generated under any of the alternatives or combination of alternatives could have been managed under the Department's existing waste management infrastructure*. . . *Environmental impacts, including human health and safety, transportation, socioeconomics, and environmental justice were estimated to be small for all of the alternatives and did not provide a reasonable basis for discriminating among alternatives*." (Author's italics.)

In summary, the NI PEIS (2000) gave a "hard look" to all potential environmental impacts associated with all alternatives for the FFTF: restart, deactivation, and continuation of present conditions. The document reported, and the subsequent ROD concluded that environmental impacts were estimated to be small for any of the considered alternatives. Impacts were sufficiently minimal to conclude that the environmental impact analysis did not provide a reasonable basis for making a choice among alternatives. Given this information, no additional EIS is needed for restarting the FFTF. The subsequent step is a procedural one: Amend the January 19, 2001 ROD to restart the FFTF.

APPENDIX V

FSAR Review

1.0 Safety Analysis and Assessments

Review of FFTF FSAR and Safety Basis Documents

FSAR

The FFTF FSAR was originally prepared to the guidelines provided in NRC Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants-LMFBR Edition," February 1974. The LMFBR Edition is typical of the FSAR format and content guideline for Light Water Reactors presented in RG 1.70 Rev 2 issued in September 1975 and Rev 3 issued in November 1978 for Commercial Nuclear Power Plants. Since the FFTF was exempt from licensing, the FFTF FSAR was submitted to the NRC by the Department of Energy for review and to provide advice regarding safety issues and the adequacy of the FFTF design. This review was completed prior to plant operation. The NRC issued NUREG-0358, "Safety Evaluation Report related to the operation of Fast Flux Test Facility," August 1978 and Supplement 1, May 1979, summarizing the result of their review and conclusions.

Since deactivation, the FFTF staff has updated the FSAR to be consistent with the current plant condition as it proceeds to eventual decommissioning. This activity has resulted in removal of a significant amount of information from the FSAR. Although the information is not lost, the FSAR would have to be updated to reflect the plant condition at startup and any new mission requirements appropriately addressed. In addition, Site Characteristics described in Chapter 2 would be updated to reflect changes in such topics as population distribution, nearby industry and meteorology. NRC reviews, if requested to support startup and continued DOE regulation or as part of a transition to an NRC licensed operator would be more efficiently completed if the FSAR is closely formatted and the content level is similar to those for commercial nuclear power plants.

RG 1.181, Rev 0, " Content of the Updated Final Safety Analysis Report in Accordance with 10 CFR 50.71(e)," 9/1999, endorses the use of NEI 98-03 for the purpose of periodic updating and revising the FSAR. This RG provides guidance for updating the FSAR within the framework of those Regulatory Guides which describe the required content of FSARs and would be used during the updating process.

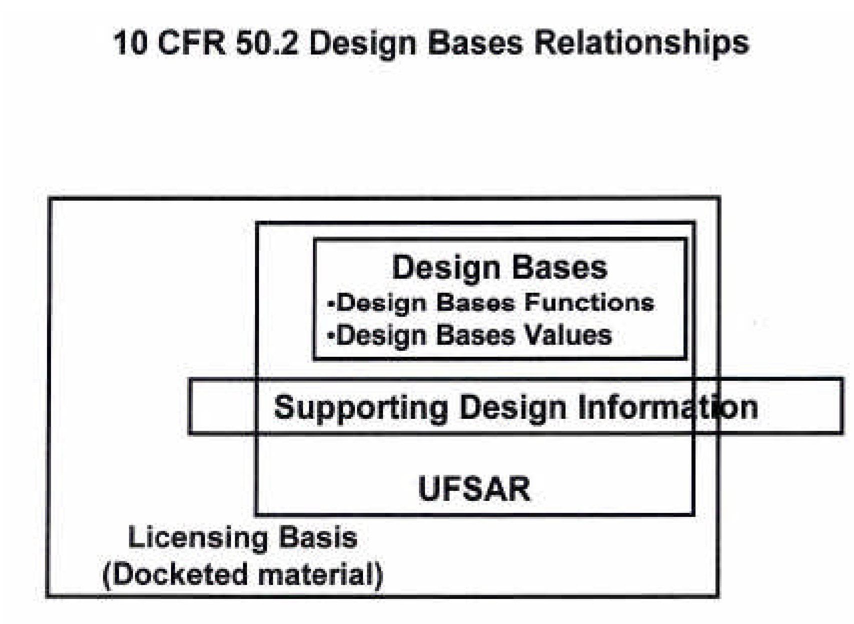
Technical Specifications

The Plant Technical Specifications (TS) are currently included as Chapter 17 of the FSAR. This document has also been updated to reflect the current status of the plant and would have to be reconstructed. The format and content of the current TS is similar to those that existed for a commercial nuclear power plant in the early 1980s. (Commercial plant Technical Specifications were removed from the FSAR submitted at the time of license application and issued by the NRC as part of the facility Operating License. They no longer reside in the FSAR and changes are controlled in accordance with 10 CFR 50.90, Application for amendment of license or construction permit.) Beginning in the 1990s, most if not all commercial plants implemented a Technical Specification Improvement program based on a series of NUREG documents issued for each type of reactor and manufacturer (NUREG-1430 through 1434). This improvement program greatly enhanced the TS by focusing on the risk significant issues while moving less significant but important specifications to a Technical Requirements Manual (TRM). Separate bases documents were also created for the TS and TRM. The result was a series of documents that were easier to apply in the operation of a plant. The FFTF TS would be upgraded to the format and content afforded by the improvement program.

Design Bases (Safety Bases)

Design bases information included in the FSAR was consistent with RG 1.70 guidelines. This information was structured after a series of documents prepared for the FFTF called 'System Design Descriptions.' A review of the level of detail included in the FFTF FSAR showed detail similar to commercial FSARs of the same time period. In the 1980s, the NRC has found that as a result of different levels of content and information from one facility to another, the FSAR, by itself, did not adequately describe the facility design bases. This deficiency was caused by lack of rigor in updating facility FSARs to reflect changes or incomplete and inconsistent design bases information in the original FSAR. As a result the industry was weak in the ability to retrieve, interpret and understand their plant design bases. The problem was further impacted by staff turnover due to attrition and retirement and resulted in a loss of important historical background for the facility. Consequently, licensees were encouraged to prepare design bases documents to address the lack of accurate and readily retrievable design bases information. The industry responded by initiating design bases reconstitution programs. FFTF restart would include a design bases reconstitution program to replace the current System Design Descriptions (SDD) with a more comprehensive Design Bases Document (DBD). In addition to a comprehensive design bases, the DBD would provide supporting design information. The supporting design information consists of detailed design information that provides a full understanding of the design bases either directly or by reference, e.g., safety analyses, calculations drawings, etc. The DBD can then be used to support updating the FFTF FSAR.

RG 1.186 Rev 0, "Guidance and Examples for Identifying 10 CFR 50.2 Design Bases", December 2000, endorses Appendix B to NEI 97-04, November 2000. Appendix B provides an acceptable approach to the preparation and content of design bases documents. The relationship between the Design Bases, Supporting Design Information, FSAR and Licensing Basis (Similar to DOE Authorization Basis) is shown on the figure below taken from NEI 97-04, Revision 1, "Design Bases Program Guidelines," February 2001. NEI 97-04, Revision 1 includes Appendix B, November 2000.



2.0 Regulatory Oversight

NRC Regulated Facility

Background

The FFTF was designed, constructed and operated in accordance with DOE regulations and/or certain NRC regulations in effect at that time. Typically, the NRC regulations applied were identified in DOE Orders or Guides as acceptable for implementing DOE regulation. Prior to operation, DOE requested that the NRC provide advice and guidance regarding the adequacy of the FFTF design and technical specifications to ensure safe operation. The NRC (including the Advisory Committee on Reactor Safety (ACRS) and various NRC consultants) reviewed the design of the FFTF and concluded that the guidance provided by 10 CFR 50 Appendix A, General Design Criteria for Nuclear Power Plants, modified where necessary to include unique LMFBR technology, provided an adequate basis for the safety evaluation of FFTF. The NRC concluded and documented in the FFTF Safety Evaluation Report, that there is reasonable assurance that the FFTF can be operated without undue risk to the public.

Regulatory Approach

Regulation of the FFTF under the NRC represents a viable option for providing federal oversight for plant operation. This option would most likely occur if the facility were leased to an independent entity that would operate and maintain the facility in the performance of its operational mission. It could also be applied if the facility is operated under contract to a private entity. To accomplish this objective, an agreement between DOE and NRC would establish a separate regulatory unit within the NRC Headquarters and Regional Offices. This NRC unit would require training on LMFBR technology and the original design basis for the plant and supporting facilities. DOE and NRC would establish agreements and understandings with respect to the specific DOE Orders, Guides and other regulations that would remain in effect for use by the NRC to support their regulatory oversight. For the most part, to become a NRC regulated facility, NRC would apply NRC regulatory guidance to the facility and the FFTF would in effect meet the intent of NRC licensing requirements if not become a fully licensed facility. DOE would continue to provide regulatory oversight for any FFTF activities that are established to restart the plant until the NRC regulatory unit is in place to assume the regulatory responsibilities.

If leased to an independent entity, that entity may be required to obtain a license to possess source material and special nuclear material in accordance with the requirements of 10 CFR 30, 10 CFR 40 and 10 CFR 70 if control is no longer maintained under the provision of existing DOE Orders.

As a benefit to the overall GNEP, the NRC regulatory unit thus established would be in place to support the siting, design, construction and operation of the Consolidated Fuel Treatment Center (CFTC), referred to as the Nuclear Fuel Recycling Center and Advanced Burner Reactor (ABR), referred to as the Advanced Recycling Reactor, two additional major facilities within the GNEP complex.

A very important part of current NRC Regulatory Oversite and implementation of new regulations relies on the existence of a living Probabilistic Risk Assessment (PRA) for the facility. In 1988, the NRC initiated action, by issuing Generic Letter 88-20 dated November 23, 1988 and later supplements 1 through 5, requiring all commercial nuclear power plants to prepare Individual Plant Evaluations (IPE) addressing the risks associated with the operation of the plant. The commercial plant IPEs were submitted to the NRC for their review and subsequent acceptance as valid for the facility. These IPEs are being maintained and updated and are being used to implement many risk based regulations at each plant. A PRA was prepared for the FFTF at the same time using the Generic Letter guidance. To effect an efficient and safe and reliable operation of the FFTF under NRC regulatory oversite will require updating the FFTF PRA and submitting it for NRC review. This action is important to gain acceptance for utilization of many recently issued NRC issued risk based regulatory guides.

3.0 Implementation

Implementation would focus on revising and updating existing programs and procedures to conform to the NRC regulations and guides or DOE orders and guides as agreed to by the NRC and DOE. Several of these programs are discussed.

Programs

Several programs and processes established to support initial FFTF operation were examined by the NRC prior to plant operation to determine if they were consistent with requirements established for commercial light water reactors. One of these programs, the Operational Quality Assurance Program was established in accordance with DOE Orders. This program and its associated implementing procedures were evaluated and found to address the criteria of 10 CFR 50 Appendix B and key implementing NRC Regulatory Guides in an acceptable manner. Since deactivation of the FFTF, certain changes have occurred in the NRC approach to implementing quality assurance at commercial nuclear plants. Examples are noted in the application of commercial grade dedication and corrective action. The current FFTF Quality Assurance Program and implementing procedures would be evaluated and updated to current NRC requirements, guidelines and approved standards.

Another program evaluated to support FFTF operation was the Emergency Plan. The Emergency Plan was found to include all of the elements required for commercial nuclear power plants as detailed in 10 CFR 50 Appendix E and the plan followed the format prescribed in Regulatory Guide 1.101. This program and implementing procedures would be reviewed and conformed to current NRC requirements and guidelines while continuing as a part of the Hanford Site Emergency Plan for DOE-RL owned facilities.

Recent Regulatory Guides

Many NRC Regulatory Guides were applied during the design, construction and operation of the FFTF. These guides were typically identified in DOE Orders and the FFTF FSAR. The NRC is continually updating and releasing new Regulatory Guides (RGs) to address industry issues and concerns. The revisions to previously applied RGs and new RG issued since startup will be evaluated for applicability to FFTF. The regulatory guides can be accessed at the following web site: http://www.nrc.gov/reading-rm/doc-collections/reg-guides/. Table 1, provides a list of many of the recent regulatory guides that the commercial industry is using or has used to address these issues and concerns.

Many of these RGs provide a cooperatively developed NRC/industry approach to resolution of the issues addressed in the RG. If the NRC becomes involved in the restart of FFTF either as the sole regulatory unit or in concert with a DOE regulatory unit, these topics will most likely have to be addressed and implemented to gain NRC acceptance. The extent to which they are addressed and the requirements implemented will depend on the unique characteristics of the FFTF and other nearby facilities when compared to a commercial LWR. However, the concepts included within each will remain appropriate.

This list is not intended to be complete. Other important RGs may be identified and new RGs of interest may be issued as the FFTF restart activities are accomplished. Interaction between DOE, NRC and a future operator will help in establishing the appropriate approach to take on these issues.

Documents Included in a License Application

10 CFR 34 defines the technical and administrative operating documents that are typically submitted as part of an application for an operating license. Several of these documents were prepared and submitted by DOE for review by the NRC to support initial operation. These documents will become a significant portion of the plant licensing bases and key in establishing a basis for NRC Regulation. The discussion on "Processing Basis Documents" identifies those documents that are typically part of the license application. Most of these documents and programs were prepared to support initial startup and operation of the FFTF. New required or existing documents and programs would be prepared or updated to current regulation guidelines and requirements as agreed to by DOE and NRC.

Licensed Operator Training

Operator training and qualification would be required to support plant restart activities. For a commercial nuclear power plant, the basic requirements for this activity are described in 10 CFR 50.120, Training and Qualification of Nuclear Power Plant Personnel. RG 1.8 Rev 3, "Qualification and Training of Personnel for Nuclear Power Plants," is the primary RG for implementing this CFR. RG 1.8 endorses ANSI/ANS-3.1 1993, "Selection, Qualification and Training of Personnel for Nuclear Power Plants." 10 CFR 55, Operator's Licenses, specifically describes the requirement for a systems approach for the requirements of Operator and Senior Plant Operator Training. The Institute of Nuclear Power Plant Operations (INPO) provides an acceptable systems approach to training and provide accreditation that a licensees training program meets the regulatory requirements. The two primary INPO documents for this purpose are: INPO 02-001, "The Objectives and Criteria for Accreditation of Training in the Nuclear Power Industry" and INPO 02-002, "The Process for Accreditation of Training in the Nuclear Power Industry."

Plant Simulator Facilities

10 CFR 55.46 describes the requirements for a Plant Simulator Facility. The existing FFTF simulator facility would be updated to meet the requirements of 10 CFR 55.46 for a plant-referenced facility and will accurately simulate plant operation and response. The NRC would be involved in approving the facility and its use in conducting licensed operator training.

Table 1 Regulatory Guides

Regulatory Guide	Comments
RG 1.78, Rev 1, ”Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release,” 12/2001	Guidance for ensuring the Control Room will remain habitable following postulated release of chemicals, process streams and radiation on site, on highways and adjacent facilities is provided. (Adjacent facilities would include Columbia (EN), highways, and other DOE facilities on the Hanford Reservation.) This RG is used in conjunction with RGs 1.194 and 1.196 listed below.
RG 1.91, Rev 1, ”Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants,” 02/1978	This topic is associated with potential for damage to plant facilities.
RG 1.97, Rev 4, ”Criteria For Accident Monitoring Instrumentation For Nuclear Power Plants,” 06/2006	This RG provides guidance on the parameters monitored and accuracy for instrumentation that is required for event and accident monitoring. The instruments play a major role in providing information to the emergency response organizations and NRC/DOE under ERDS.
RG 1.114, Rev 2, “Guidance to Operators at the Controls and to Senior Operators in the Control Room of a Nuclear Power Unit,” 05/1989	
RG 1.155, Rev 0, ”Station Blackout,” 08/1988 (Issued June 1988, reissued August 1988 with corrected tables)	This RG Implements 10 CFR 50.63, Loss of all AC Power, and the requirements to ensure the plant can be safely shutdown and maintained in a safe shutdown condition until AC electrical power can be restored. The FSAR should reflect the analysis of this event.
RG 1.160 Rev 2, ”Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” 03/1997 RG 1.182 Rev 0, ”Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants,” 05/2000	Implements 10 CFR 50.65, Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants. (This CFR is commonly referred to as the Maintenance Rule). The RG endorses NUMARC 93-01, Rev 3, July 2000 as an acceptable implementation method. Implementation draws on the plant PRA.
RG 1.181, Rev 0, ”Content of the Updated Final Safety Analysis Report in Accordance with 10 CFR 50.71(e),” 09/1999	NEI 98-03 is endorsed for the purpose of periodic updating and revising the FSAR. It provides guidance for updating the FSAR within the framework of guides which describe the required content of the FSAR
RG 1.186, Rev 0, ”Guidance and Examples for Identifying 10 CFR 50.2 Design Bases,” 12/2000	NEI 97-04, Appendix B, dated November 2000 is endorsed as an acceptable method for identifying design bases.
RG 1.187, Rev 0, ”Guidance for	10CFR 50.59 was revised in 1999. The

Implementation of 10 CFR 50.59, Changes, Tests, and Experiments," 11/2000	original intent of this rule, which was to identify those changes which require NRC approval, was clarified. The old NSAC-125 concept of "Safety Evaluation" was removed from the implementation processes. NEI 96-07, Rev 1 is endorsed as an acceptable method for implementation. (The determination of whether an activity is safe is performed during the appropriate change process and not during the 50.59 Review Process.)
RG 1.194, Rev 0, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," 06/2003	Guidance on determining atmospheric relative concentration (Chi/Q) values in support of design basis control room radiological habitability assessments at nuclear power plants is provided. The RG endorses the use of a computer code, ARGON 96, as an acceptable methodology for determining Chi/Q.
RG 1.196, Rev 1, "Control Room Habitability at Light-Water Nuclear Power Reactors," 01/2007	This RG establishes the requirements for a program to continually ensure that control room envelope habitability is maintained following plant modifications and does not degrade during normal operation.
RG 1.197, Rev 0, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors," 05/2003	Periodic testing methods for the control room habitability envelope are provided to ensure the habitability descriptions and analyses documented in the FSAR remain valid.
RG 1.201, Rev 0, "Guidelines for Categorizing Structures, Systems, and Components in Nuclear Power Plants According to Their Safety Significance," 05/2006	This RG implements 10 CFR 50.69 by providing a method for establishing the safety significance for structures, systems and components (SSC). The determination uses the plant PRA and allows alternate approaches for such requirements as inservice inspection and testing for certain categories of SSC.

Licensing Basis Documents

1. Operating License. Draft prepared by the Licensee. Reviewed and issued with conditions, if any, by the NRC.

2. Final Environmental Statement--Updated to reflect any change in mission.

3. Final Safety Analysis Report, 10 CFR 50.34(b). The Updated FSAR shall be evaluated against the Standard Review Plan (SRP) in affect on either May 17, 1982 or the SRP in effect six months prior to the application (10 CFR 50.34(h)). 10 CFR 100 provides additional information on Site Criteria typically addressed in FSAR Chapters 1 and 2.

4. Physical Security Plan and Safeguards Contingency Plan, 10 CFR 50.34(c) and (d). These documents and the facilities will have to be updated as required to include changes in NRC requirements.

5. Emergency Plan, 10 CFR 50.47
   In addition to the licensees Site Emergency Plan, 10 CFR 50.33(g) requires that, as part of a licensee application, the applicant shall submit radiological emergency response plans of the State and local governmental entities that are wholly or partially within the plume exposure pathway Emergency Planning Zone (10 mile radius) as well as plans for of State governments wholly or partially within the ingestion zone pathway (50 mile radius).

6. Operational Quality Assurance Program (OQAPD), 10 CFR 50 Appendix B, 10 CFR 71(g), Transportation Packages and 10CFR 72(h), Independent Spent Fuel Storage

   The OQAPD describes the program(s) and controls that will be in-place to address each of the 18 Criteria identified in 10 CFR 50 Appendix B. In addition it defines the qualification requirements for Quality Assurance Personnel, identifies the quality affecting regulatory guides and standards committed to and the licensee position associated with each of them, and established the independent review groups, both on and off site that will be established to review all matters of nuclear safety.

7. Technical Specifications (TS) and Bases (TSB), 10 CFR 50.36(a).
   The format for and content of the TS and TSB are provided by reference to a NUREG for the specific LWR type involved. The NUREG describes a TS Improvement Program which allowed changes in the format and content of the original NRC TS that were issued as part of the Operating License. The TS Improvement Program separated the TS into four documents. The TS, remains a part of the license and changes are controlled by the requirements of 10 CFR 50.90, 10 CFR 50.91 and 10 CFR 50.92 and are submitted to the NRC for approval. The TSB became a separate document controlled by the provisions of 10 CFR 50.59. In addition, two new documents called the Technical Requirements Manual (TRM) and TRM Bases were created. These documents include those old format specifications that were determined to be less significant. Changes to the TRM and Bases are controlled by 10 CFR 50.59.

- The Administrative Controls Section of the TS includes the requirements for several supplemental programs and processes. Several of theses programs are required by other provisions of 10 CFR and the requirements for these programs are more specifically described in the TS. Some of the programs may be completely described in the TS and others may become separate documents. They are:

    - Offsite Dose Calculation Manual (ODCM)
    - The TS describes the requirements for the ODCM. It is issued as a standalone document and implemented and controlled through separate procedures.
    - Primary Coolant Sources Outside of Containment
    - Includes Preventive Maintenance, Inspection and Integrated System Leakage Testing
    - The requirements are implemented and controlled by separate procedures
    - Radioactive Effluent Controls - Replaces 10 CFR 50.36(b), Environmental TS
    - The TS requirements are contained in the ODCM and implemented and controlled through separate procedures.
    - Component Cyclic or Transient Limit-Fatigue Monitoring and Analysis
    - The TS requirements are implemented and controlled by separate procedures.
    - In-service Testing (ASME Section XI)

- A standalone program plan is issued, implemented and controlled through separate procedures
- Ventilation Filter Testing Engineered Safety Feature HEPA
- Implemented and controlled through separate procedures
- Explosive Gas and Storage Tank Radiological Monitoring
- Implemented and controlled by separate procedures
- Diesel Fuel Oil Testing
- Implemented and controlled by separate procedures
- Technical Specification Bases Control Program
- Implemented and controlled by separate procedures
- Safety Function Determination Program
- An aid to operators for assessing system safety function operability
- Primary Containment Leakage Testing 10 CFR 50 Appendix J
- A standalone program document implemented and controlled by separate procedures.

8. Technical Requirements and Bases Manual, NUREG, TS Improvement Program

9. Offsite Dose Calculation Manual (ODCM)

10. Containment Leakage Rate Testing Program, 10 CFR 50.54(o) and Appendix J

11. In-service Inspection Program, 10 CFR 50.55(a)

12. In-service Testing Program, ASME Section XI

13. NPDES Permit   Not required for FFTF because were no surface water discharges from the facility and none are currently planned. A change in mission could require an NPDES Permit.

APPENDIX VI

ADVANCED BURNER REACTOR RISK DISCUSSION

ADVANCED BURNER REACTOR RISK DISCUSSION
THE ROLE OF FFTF IN REDUCING THE PROGRAMMATIC RISK

The U.S. Generation IV Fast Reactor Strategy, December 2006 (DOE/NE-0130) presents the United States strategy for developing a closed nuclear fuel cycle. This document describes the proposed technology options, the role of the sodium fast spectrum reactor, and collaborations in going forward to provide the United States with a next-generation nuclear power capability that will last well into the next century. A key element of the strategy is based on a closed fuel cycle that uses Advanced Recycling Reactors powered with transmutation fuel.

DOE planning documents now indicate that a commercial prototype advanced recycling reactor will be the predecessor to the production recycling reactors, with both a power demonstration role and a test bed role for transmutation fuel. The recycling reactors will be a sodium cooled reactor and initially fueled with a mixed-oxide core. The private sector would submit proposals to design, construct and operate the recycling reactors.

The U.S. Generation IV Fast Reactor Strategy makes four key points relative to areas that FFTF can contribute to the GNEP programmatic risk reduction:

- "GNEP seeks to develop world-wide consensus…"
- "DOE's strategy for selecting a fast reactor technology has been revised to place more weight on the probability of success of a near-term fast reactor demonstration project. Given the prominence of GNEP and DOE's desire to optimize the use of appropriated funds, ….."
- "…considerable research and development is necessary in order to achieve the Technical Readiness level of 'proof of performance'…"
- "Proof of Performance-The concept is known to be technically feasible, and there is considerable performance data, but the economics of scale up to commercial scale is uncertain. Large-scale demonstrations on portions of the processes are performed, yielding final performance specifications including statistical assessments and initial indications of economic performance."

SECTION A FFTF-AN ADVANCED FUELS TEST AND QUALIFICATION CENTER

The proposed role of the FFTF as a fuels and test qualification center provides direct support to DOE in successfully addressing these four key points identified in the U.S. Generation IV Strategy.

1. WORLD WIDE CONSENSUS

The U.S. Generation IV Strategy integrates the United States with the international community to develop the recycling reactors and associated closed fuel cycle. FFTF can be a user test bed to establish international consensus on a commercial demonstration recycling reactors. Testing of a critical path item (transmutation fuel) can begin 10-13 years earlier than with the new facility, and may provide a broader spectrum of options with more statistical data. A technical decision such as that required to provide an internationally accepted closed fuel cycle that is intended to last through the next century should have plentiful statistical data. There is a risk that the prototype reactor will be a compromise between power production and testing, and cannot or will not be allowed to provide adequate statistical data for good decision making or for establishing international consensus. The commercial prototype may have one of two concepts:

- The first concept is a power production facility without closed loop test positions. This could mean that transmutation fuel proof-of-performance tests and materials margins tests may add risk to the facility. If this were to be the case, after contract award, the testing may be compromised to ensure low risk commercial power production with their facility.

- The second concept is for facility to have objectives for both commercial power production and closed loop testing for transmutation fuels and materials, in which case there may be significant risk that either one or both of these objectives are compromised. These competing objectives can lead to the compromising of one or both objectives and result in erroneous extrapolations on: how long it takes to design and build a true commercial facility; what a true commercial facility will cost; the efficiency of operations, and; the design for the transmutation fuel core leading to an flawed initial core for the Advanced Recycling Reactor (ARR).

2. IMPROVE THE PROBABILITY OF SUCCESS AND OPTIMIZE THE USE OF APPROPRIATED FUNDS

The initial decisions in the GNEP program may establish technical commitments for a transition to 20% of the U.S. nuclear plants to be Advanced Recycling Reactors and eventually for up to 80% of the U.S. reactors to be fast reactors. The FFTF and the 400 Area can provide a user test bed for vendors who want to validate their proposed core, transmutation fuel concepts, and materials/design-of-construction. By using the FFTF, the U.S., the international community, and bidders on the ABR can have a higher standard of fuel-design validation relative to engineering-only validation that may be the basis for commercial prototype proposals. Therefore, there could be less cost and schedule contingency (and less risk) than will exist with out test data in vendor proposals for that portion dealing with the eventual transmutation fuel role. Options developed and advancements made in proliferation resistant fuel, an enormously critical concern by the U.S. and the international community, with FFTF test positions provides significant risk reduction since vendor proposals can then be supported by validated and statistically significant test data.

The FFTF and the 400 Area Complex can provide 'integrated risk-reduction' and optimize the use of appropriated funds by providing a demonstration capability for not only testing transmutation fuel within FFTF, but also by demonstrating the remote assembly of the transmutation fuel pins and subassemblies, and by demonstrating the reprocessing of transmutation fuel within the Fuels and Materials Examination Facility. This risk reduction comes from: minimizing the requests for appropriated funds for new shielded assembly and reprocessing facilities and the associated risk of budget cuts; minimizing the transportation of tested assemblies to any new or existing pilot reprocessing plant; and maximizing the likelihood of obtaining statistical and validated data for decisions that lead to a robust and correct closed fuel cycle.

In addition to providing proof-in-principle for the closed fuel cycle using transmutation fuel, the use of the FFTF and the 400 area complex may eliminate funding request for up to $1.5B for new shielded facilities for transmutation fuel assembly and reprocessing demonstration; and for a differential funding request of potentially more than $5B for the difference between the cost of upgrading the FFTF and a new commercial prototype.

3. RESEARCH AND DEVELOPMENT NEEDED FOR PROOF OF PERFORMANCE

Sodium-cooled Fast Reactor (SFR) maturity is with mixed-oxide fuel and sodium cooling. FFTF, a sodium cooled reactor, can provide statistical proof-of-performance for the immature portions of the recycling reactor transmutation fuel options and performance, and material design margins. This provides a life-cycle risk reduction to the closed fuel cycle decision process. There can be early life-cycle risk assessment and risk reduction of the closed fuel cycle with FFTF because of the FFTF test positions, thereby yielding additional time by the U.S. and the international partners to correct or refine closed-fuel cycle concepts and details. The new facility approach may take up to 15-20 years through licensing, design, construction, baseline operation, and transmutation fuel testing, to confirm the technical assumptions and the engineering analysis of the proposed transmutation fuel design. The FFTF (and the FFTF test positions and Interim Examination Cell) can begin providing the statistical data for the transmutation fuel cycle within 5-7 years to confirm the assumptions and engineering analysis for both fuel design and performance, and reprocessing design and performance. This difference in time of 10-13 years between FFTF and a new facility to begin transmutation fuel testing is schedule and cost risk reduction that is available to the U.S. as 'free' schedule and cost contingency.

4. PROOF OF PERFORMANCE

With FFTF, the transmutation fuel proof-of-performance experiments can be designed and built now, and be made ready for testing just after FFTF startup. With the prototype reactor the transmutation proof-of-performance in-core experiments cannot be designed and fabricated until the prototype reactor is into the final design stages-and then there is risk that design changes will render the experiments incorrect and they will need to be redesigned and re-fabricated unless their design is not initiated until construction has begun.

Also, an operating baseline will need to be established with the new facility prior to inserting test assemblies. This could be 6 months to a year after the startup of the new facility. Additionally, unless the facility is designed with hot cell examination capability within containment such as FFTF, the fuel test assemblies will have to cool for up to two years before they can be shipped to a radiological laboratory. The FFTF, by virtue of having a hot cell within containment, can begin disassembling a fuel pin bundle immediately after discharge from the core. Removed fuel pins can then be shipped to a radiological hot cell for examination.

SECTION B FFTF- A PROTOTYPE FOR THE GNEP ADVANCED RECYCLING REACTOR

The discussion in Section A above identifies the areas that the FFTF and the 400 AREA Complex can provide risk reduction to the GNEP program by serving as a test bed for transmutation fuel assembly, and testing.

The FFTF can also reduce programmatic risk to the first commercial recycling reactor by providing continued operating experience on the fast reactor operations and the sodium-cooled systems, and factoring this data into the design requirements for the recycling reactor and the subsequent cost estimates and uncertainty analysis on these cost estimates. Provision of a power generation capability on FFTF will establish additional data and confidence in liquid metal-to-water heat exchangers and their costs, maintenance requirements, and operating efficiencies to further reduce risks to the U.S. GNEP program. It is believed that this power production demonstration can be structured to provide sufficient data for the commercial recycling reactor design. Previous studies and proposals have shown that the addition of power production to the FFTF is within the present industry capability and is not a technology development issue.

APPENDIX VII

Columbia Basin Consulting Group
Brief Biographical Sketches

Project Team

CBCG Staff

William J. Stokes, President, CBCG - Mr. Stokes has over 30 years experience in the management, systems engineering, construction engineering, and maintenance of nuclear and conventional power generation facilities and safety critical DOE non-reactor nuclear facilities. He has extensive experience in identification, analysis and delineation of programmatic and systems requirements for complex new facilities engineering, retrofit or upgrade projects. Mr. Stokes has applied his project management skills to the area of independent power development projects, privatization of surplus DOE weapons complex facilities and commercialization of major DOE project initiatives, including two major proposals to DOE regarding the FFTF complex. BSME, Drexel Univ.

Peter W. Gibbons - Project/Program Manager with over 30 years experience and expertise managing projects focused on technology development and implementation across the DOE Complex and in Russia. Projects ranged in size from small teams in technology development to integrated national technology programs. Mechanical System Cognizant Engineer for Examination Cell and other equipment at FFTF for 15 years. BS Mechanical Engineering – University of California, Berkeley

Carl G. Holder, MBA - Principal in New Horizon Technologies, Inc. (NHT), a technology firm specializing in isotopes, principally in gamma isotopes for medical products sterilization and food irradiation. NHT recently completed an Initiatives for Proliferation Prevention (IPP) project investigating the availability, suitability and use of Europium isotopes for gamma sterilization. Has extensive work with National Environmental Policy Act (NEPA) document preparation.

James Madsen - Over 40 years experience in project management, planning, and control; systems engineering management processes; development, implementation, and continuous improvement of management information systems; strategic planning and balanced scorecard development. Experience includes major projects in energy, nuclear waste management, defense, and aerospace industries. Worked with contractors and consultants to the Department of Energy, Department of Defense, National Aeronautics and Space Administration, and electric utilities. Performed work in both consulting and employee roles. B.A. in Psychology - California State University at Los Angeles, Los Angeles, CA (1968). M.S. in Management Science - West Coast University, Los Angeles, CA (1971)

Michelle Sheffield, J.D., Ph.D. - Licensed attorney in Texas and Colorado. Studied medical ethics at the University of Texas Medical Branch, taught medical jurisprudence and participated in grand rounds as a lawyer-bioethicist. BS Cum Laude, Political Science, Texas A&M University. Ph.D. Management and Policy Sciences, Univ. of Texas. J.D., University of Houston School of Law. Ph.D. Univ. of Texas Health Science Center at Houston School of Public Health. Doctoral Dissertation: "Occupational Beryllium Exposure: Reconciling Federal Policies, Regulations and Contractor Implementation Guides to Protect Worker Health." Other publications.

Gerald Woodcock, MBA - Nearly thirty years at Hanford in management and professional positions. With Westinghouse Hanford, responsible for several Contractor fee goals; Manager of

Plans and Budgets; Manager of Inventory Planning and Control; Manager of Property Classification & Accounting. Instructor in Systems Engineering, Washington State University Tri Cities, 1997. Published in the Gonzaga Law Review. American Nuclear Society Presidential Citation. BS Industrial Technology, California Polytechnic University, 1966. MBA Finance, United States International University (now Alliant University), 1971.

Subject Matter Expert Panel

Dave Lucoff, MBA Ph.D. - More than 30 years' technical and management experience in the nuclear industry. Prior to retirement (July, 2001), was Site Area Director of the Test Reactor Area (TRA) at the INEEL. Before joining INEEL in 1999, Dr. Lucoff held technical and management positions at the Hanford Site (20 years) with the majority of his assignments associated with the Fast Flux Test Facility (FFTF). Qualified as "Operations Engineer" (OE) at the FFTF prior to becoming the FFTF Operations Manager where he directed day to day operations. Was Program Manager of the Advanced Reactor Program at Hanford where he led efforts to identify new missions for the FFTF. Last position at the FFTF was Deputy Plant Manager. Technical background is centered around LMR design, safety, and performance. Was involved in Core Design activities at the FFTF. Undergraduate training and Ph.D. in Nuclear Engineering, University of Wisconsin - Madison. MBA, University of Washington (with Honors) with concentration in Operations Management. American Nuclear Society "Reactor Technology Award," 1997. The Award recognized his accomplishments…"in introducing and leading the development of fast and thermal reactor safety and control technologies."

William F. Brehm, Ph.D. **-** Thirty-six years at the Hanford Nuclear Site, working for several different contractors in senior technical and management positions. Proven record at mission accomplishment, staff development, and resource management. Experienced accident/incident investigator. Primary technical expertise is alkali metals technology and materials/metallurgical engineering. B.S., MIT, Materials Science; M. S. and Ph. D., Cornell, Materials Science.

Sol Guttenberg - Twenty-nine years of various engineering management positions at the FFTF, encompassing the design, construction, startup and operational phases of the facility. Also developed the Project Office initial shutdown planning logic and managed the Power Addition Project proposal utilizing excess CRBRP steam generators for electrification. Had the lead for preparing the key Technical Information Document in support of the FFTF Multi-Mission proposal. B.S. in Chemical Engineering Cum Laude, The Polytechnic Institute of Brooklyn, 1955. Master's Degree in Mechanical Engineering, University of Pittsburgh, 1961.

Robert D. Leggett, Ph.D. **-** Nearly 40 years in the nuclear field, beginning at Westinghouse Bettis working on the Nautilus - the world's first nuclear powered submarine - and ending as Project manager of a $100 million a year LMR program at Hanford that included the FFTF and many of the experiments being conducted in that facility. At Hanford, involved with numerous technology exchanges with the United Kingdom, Japan, Switzerland the USSR, and the European community. Bachelor and MS degrees from Ohio State University. Ph.D. from Carnegie Institute of Technology (now Carnegie Mellon) - all in Metallurgical Engineering. Theses emphases were in corrosion.

Jerry L. Straalsund, Ph.D. **-** Served most of his career in the areas of materials and chemical sciences associated with advanced energy systems and processes. Instrumental in testing and measuring materials performance in fast reactor environments, particularly in the areas of irradiation-induced creep and void swelling in materials. Management positions included Center

Manager for the Materials and Chemical Sciences Center at Battelle Pacific Northwest National Laboratory, and Manager of Materials Science and Technology for Westinghouse Hanford Company. B.S. Physical Metallurgy, Ph.D. Engineering Science, Washington State University. Selected Outstanding Senior in the College of Engineering

James P. Waldo, P. E. - Five years Manager of the FFTF Reactor Systems Testing. Responsible for sodium fill of the FFTF plant, hot functional testing, plant-controlling procedures for the initial power ascent, and full-power acceptance testing. BSME Montana State College, 1960.

Alan E. Waltar, Ph.D. **-** Currently Senior Advisor to Pacific Northwest National Laboratory (PNNL), Richland, WA. Recently retired as Director of Nuclear Energy. Professor and Head, Nuclear Engineering, Texas A&M University 1998 - 2002, where he helped to build that program into the largest Department of Nuclear Engineering in the nation. With Westinghouse Hanford Company, leadership related to regulatory approvals and subsequent operations at the Fast Flux Text Facility. President, American Nuclear Society 1994-1995. He was elected a Fellow of the Society in 1984. B.S.E.E., University of Washington, 1961. M.S. Nuclear Engineering, MIT, 1962. Ph.D. Engineering Science, University of California, Berkeley, 1966.