U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Assessing America's Nuclear Future – A Review of the Blue Ribbon Commission's Report to the Secretary of Energy

Wednesday, February 8, 2012
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Purpose

On Wednesday, February 8, 2012, at 10:00 a.m. in Room 2318 of the Rayburn House Office Building, the Committee on Science, Space, and Technology will hold a hearing entitled *"Assessing America's Nuclear Future – A Review of the Blue Ribbon Commission's Report to the Secretary of Energy."* The purpose of this hearing is to examine the recommendations contained in the Blue Ribbon Commission on America's Nuclear Future (BRC) Report to the Secretary of Energy, as well as broader science and technology issues associated with spent nuclear fuel management.

Witnesses

- **Lieutenant General Brent Scowcroft (Ret.)**, Co-Chairman, Blue Ribbon Commission on America's Nuclear Future
- **The Honorable Richard Meserve**, Commissioner, Blue Ribbon Commission on America's Nuclear Future
- **The Honorable Pete Lyons**, Assistant Secretary of Nuclear Energy, Department of Energy

Nuclear Waste Management Policy Background

All nuclear related activity, whether associated with research, commercial, military or other uses, generates waste byproducts of varying radioactivity. These byproducts range from low-level waste such as tools, equipment, and clothing to high-level waste such as used fuel and reactor components. Under the Low-Level Radioactive Waste Policy Act, first enacted in 1980 and amended in 1985, each state is responsible for low-level radioactive waste generated within its borders.[1] In contrast, the federal government is responsible to take title and dispose of high-level waste (as defined in 42 U.S.C. 10001)[2] under the Nuclear Waste Policy Act of 1982 (NWPA).

[1] P.L. 96-573 and P.L. 99-240.

[2] 42 U.S.C. §10001 Section 12 - The term "high-level radioactive waste" means - (A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation.

Today, 104 commercial nuclear power reactors supply approximately 20 percent of U.S. electricity. Each reactor uses about 20 metric tons of uranium fuel per year, and collectively the industry creates 2,000 to 2,400 metric tons of spent fuel on an annual basis (one metric ton is about 2,200 pounds).[3] This spent nuclear fuel, considered high-level waste, is currently stored at the generation site in spent fuel pools (to cool the most recently used fuel rods) or in above ground dry casks.

In addition to storage at operating nuclear reactors, spent nuclear fuel is also currently held at nine decommissioned U.S. reactor sites throughout the country.[4] The Department of Energy (DOE) currently manages radioactive material at multiple locations in the United States. The largest site is located in Hanford, Washington followed by the Savannah River Site in South Carolina, and Idaho National Laboratory in Idaho Falls, Idaho.

History of Waste Management Policy[5]

For over fifty years, a deep geological repository has been examined as an option for radioactive waste disposal. The BRC notes "the conclusion that disposal is needed and that deep geologic disposal is the scientifically preferred approach has been reached by every expert panel that has looked at the issue and by every other country that is pursuing a nuclear waste management program."[6]

In the 1970's, the U.S. government began detailed study of specific disposal sites. In 1982, Congress passed the NWPA and provided a statutory framework to govern the disposal of U.S. high-level waste.[7] In 1987, Congress amended the NWPA and designated Yucca Mountain as the sole location for a deep geological repository. In 2002, Congress reaffirmed the selection of Yucca Mountain as a high-level radioactive waste repository.[8] After decades of exhaustive evaluation and study, in 2008, DOE submitted a License Application for a High-Level Waste Geologic Repository at Yucca Mountain (License Application) to the Nuclear Regulatory Commission (NRC).

In February 2010, the Department of Energy (DOE) announced its intention to withdraw the License Application for Yucca Mountain. Concurrently, the Administration moved to close the Office of Civilian Radioactive Waste Management, the office directed by the NWPA to execute DOE's nuclear waste management programs. The NRC's Atomic Safety and Licensing Board (ASLB) rejected DOE's Motion to Withdraw on June 29, 2010, stating DOE did not have the authority under the NWPA to withdraw the License Application. The ASLB decision was appealed to the full Commission. In September 2011, the Commission issued a decision stating

[3] "*Blue Ribbon Commission on America's Nuclear Future Report to the Secretary of Energy,"* p. 14, January 2012. Accessible at: http://brc.gov/sites/default/files/documents/brc_finalreport_jan2012.pdf
[4] A list of decommissioned sites and quantities of stranded fuel can be found in the BRC Report, p. 36.
[5] For further information, see *"Review of the Blue Ribbon Commission on America's Nuclear Future Draft Recommendations*" Joint Subcommittee Hearing Charter at http://science.house.gov/sites/republicans.science.house.gov/files/documents/hearings/102711_charter.pdf
[6] BRC Report p. 27
[7] P.L. 97-425.
[8] P.L. 107-200.

that the Commission was evenly divided on the appeal and directed the ASLB to complete all necessary and appropriate case management activities.

Until further regulatory or legal action is taken to permit the License Application to move forward or be withdrawn, it remains pending before the Commission. As a result, no long-term nuclear waste management program is currently in place. The Administration stated its intention to wait for the BRC's recommendations prior to developing a new nuclear waste management policy.

The Fiscal Year (FY) 2012 Consolidated Appropriations bill directed the Department of Energy to develop a strategy for the management of spent nuclear fuel within six months of the issuance of BRC's final report.[9]

Background on the Blue Ribbon Commission's Final Report

On January 29, 2010, President Obama issued an Executive Order directing the Secretary of Energy to establish a Blue Ribbon Commission on America's Nuclear Future to "conduct a comprehensive review of policies for managing the back of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of civilian and defense used nuclear fuel and nuclear waste."[10] The BRC states Secretary Chu "directed that the Commission was not to serve as a siting body" and the BRC did not evaluate "Yucca Mountain or any other location as a potential site for the storage of spent nuclear fuel or disposal of high level waste."[11] The BRC also did not take a position on the Administration's request to withdraw the License Application.

The 15 member Commission[12] operated under the authority outlined in the Advisory Committee Charter. The BRC held numerous open meetings and site visits in an effort to operate the BRC in an "open and inclusive manner."[13] The BRC and its subcommittees conducted 32 public events[14] to inform its report. The BRC released a draft report on July 29, 2011 for a three month public comment period. Following the release of the draft report, the BRC held five regional public meetings to solicit feedback and public comment on its report and received over 2000 public comments from a wide variety of stakeholders and interested parties on all aspects considered under the BRC's charter.[15] Additionally, the BRC sought outside legal opinions and commissioned 25 papers to inform its final report.[16]

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[9] Conference Report accompanying H.R. 2055, p. 25. Accessible at: http://rules.house.gov/Media/file/PDF_112_1/legislativetext/HR2055crSOM/psConference%20Div%20B%20-%20SOMl%20OCR.pdf

[10] The White House, *"Memorandum for the Secretary of Energy*: *Blue Ribbon Commission on America's Nuclear Future*," January 29. 2010. Accessible at: http://brc.gov/index.php?q=page/executive-order

[11] Letter from BRC to the Honorable Steven Chu, January 26, 2012.

[12] Complete Membership listed in Appendix A.

[13] Blue Ribbon Commission on America's Nuclear Future, *"About the Commission."*Accessible at: http://brc.gov/index.php?q=page/about-commission

[14] The full list of meetings and events can be found at: http://brc.gov/index.php?q=calendar/

[15] Public Comments can be found at: http://brc.gov/index.php?q=comments

[16] A Full list of BRC Commissioned Papers is found in BRC Report Appendix D.

In addition to its explicit charge, the Commission identified a number of issues associated with nuclear waste management warranting closer consideration. For example, in November, 2011 the BRC established an Ad Hoc Subcommittee on Co-Mingling of Defense and Commercial Waste to reexamine President Reagan's decision that high level defense waste could be disposed in a repository for commercial waste as required by the NWPA. The BRC also requested legal analyses of near-term actions that could be accomplished under current statutory authority[17] and issues associated with modifying the contract governing the legal relationship between DOE and utilities generating nuclear power.[18]

Blue Ribbon Commission Subcommittee Structure and Recommendations

The BRC was divided into three subcommittees: Reactor and Fuel Cycle Technology (RFCT), Transportation & Storage (TS), and Disposal.

The Reactor and Fuel Cycle Technology Subcommittee was formed to consider issues relating to the "evaluation of existing fuel cycle technologies and R&D programs."[19] The Subcommittee specifically evaluated the options using criteria to include "cost, safety, resource utilization and sustainability, and the promotion of nuclear nonproliferation and counter-terrorism goals."[20] The RFCT Subcommittee submitted its draft report on June 20, 2011, centering on four key recommendations:

> (1) "provide stable, long-term [Research, Development, and Demonstration] RD&D support for advanced reactor and fuel cycle technologies," to achieve both near-term safety improvements and performance of existing light-water reactor technology and longer-term efforts to identify potential "game-changing" nuclear technologies and systems;
> (2) coordination of energy policies and programs across the federal government and more federal support for energy-related research, development, demonstration, and deployment;
> (3) additional RD&D funding for the NRC to "accelerate a regulatory framework and supporting anticipatory research for novel components of advanced nuclear energy systems;" and
> (4) continued international leadership to address global non-proliferation concerns and improve safety and security of nuclear facilities and materials worldwide.[21]

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[17] Van Ness Feldman, PC, *"Legal Analysis of Commission Recommendations for Near-Term Actions,*" July 29, 2011. Accessible at: http://brc.gov/sites/default/files/documents/vnf_legal_authorities_memo_legal_authorities_memo_revised_20111011_final_clean_1.pdf

[18] Van Ness Feldman, PC, *"Legal Background and Questions Concerning the Federal Government's Contractual Obligations Under the 'Standard Contracts' with 'Utilities,'"* December 20, 2010. Accessible at: http://brc.gov/sites/default/files/documents/20101220_standard_contract_memo_revised_final_2.pdf

[19] Blue Ribbon Commission on America's Nuclear Future Advisory Committee Charter. Accessible at: http://brc.gov/index.php?q=page/charter

[20] Ibid.

[21] Blue Ribbon Commission on America's Nuclear Future, "*Reactor and Fuel Cycle Technology Subcommittee Report to the Full Commission*," June 20, 2011. Accessible at: http://brc.gov/sites/default/files/documents/rfct_fullreport_rev20june11.pdf

The Transportation and Storage Subcommittee addressed the question, "[s]hould the United States change the way in which it is storing used nuclear fuel and high level waste while one or more final disposal locations are established?"[22] The TS Subcommittee issued its report on May 31, 2011, focusing on seven key recommendations:

> (1) expeditiously establishing consolidated interim storage facilities;
> (2) continued research on current storage technologies;
> (3) removal of spent fuel stored at decommissioned reactor sites;
> (4) establishment of a new quasi-governmental waste management organization;
> (5) a "science-based, consent-based, transparent, phased, and adaptive" approach to "develop and implement all aspects of the spent fuel and waste management system;"
> (6) continued coordination for the transport of spent fuel and high-level waste; and
> (7) restructuring the manner in which the Nuclear Waste Fund (NWF) is accessible.[23]

The Disposal Subcommittee addressed five issues contained in the BRC Charter:

- Options for permanent disposal of used fuel and/or high-level nuclear waste, including deep geological disposal;
- Options to make legal and commercial arrangements for the management of used nuclear fuel and nuclear waste in a manner that takes the current and potential full fuel cycles into account;
- Options for decision-making processes for management and disposal that are flexible, adaptive, and responsive; options to ensure that decisions on management of used nuclear fuel and nuclear waste are open and transparent, with broad participation; and
- The possible need for additional legislation or amendments to existing laws, including the Nuclear Waste Policy Act of 1982, as amended.[24]

The Disposal Subcommittee also made seven recommendations to the BRC:

> (1) moving forward with the development of one or more permanent deep geological facilities for permanent disposal of high-level nuclear waste;
> (2) establishment of a new single-purpose organization to handle the transportation, storage, and disposal of nuclear waste;
> (3) access of that organization to the balance of the NWF;

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[22] Blue Ribbon Commission on America's Nuclear Future "Transportation & Storage." Accessible at: http://brc.gov/index.php?q=subcommittee/transportation-storage

[23] Blue Ribbon Commission on America's Nuclear Future, *"Transportation and Storage Subcommittee Report to the Full Commission,"* May 31, 2011. Accessible at: http://brc.gov/sites/default/files/documents/draft_ts_report_6-1-11.pdf

[24] Blue Ribbon Commission on America's Nuclear Future, *"Disposal Subcommittee Report to the Full Commission Draft*," June 1, 2011. Accessible at http://brc.gov/sites/default/files/documents/draft_disposal_report_06-01-11.pdf

(4) a new approach to site and develop nuclear waste management and disposal facilities in the United States that is consent-based, transparent, phased, adaptive, and standards- and science-based;
(5) joint coordination of regulatory responsibilities and safety standards between the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency;
(6) involvement of key stakeholders, including all affected levels of government, and providing the respective stakeholders direct authority over aspects of regulation, permitting, and operations in order to protect interests and generate confidence; and
(7) retaining the Nuclear Waste Technical Review Board for independent technical advice and review.[25]

The full BRC incorporated the Subcommittee recommendations into eight high-level strategic recommendations:

1.) A new, consent-based approach to siting future nuclear waste management facilities.
2.) A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
3.) Access to the funds nuclear utility ratepayers are providing for the purpose of nuclear waste management.
4.) Prompt efforts to develop one or more geologic disposal facilities.
5.) Prompt efforts to develop one or more consolidated storage facilities.
6.) Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available.
7.) Support for continued U.S. innovation in nuclear energy technology and for workforce development.
8.) Active U.S. leadership in international efforts to address safety, waste management, non-proliferation, and security concerns.[26]

Nuclear Energy Research and Development Activities and Issues

Current DOE Nuclear Energy R&D Portfolio

The primary mission of the Office of Nuclear Energy (NE) is to "advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs by resolving technical, cost, safety, proliferation resistance, and security barriers through research, development, and demonstration as appropriate."[27] All of NE's R&D programs could ultimately impact long-term nuclear waste management decisions. Differing technologies will produce different forms of nuclear waste, which affect disposal options.

The FY 2012 Consolidated Appropriations bill provided NE $769 million, a $32 million (4.3 percent) increase above FY 2011 levels. Within the NE R&D portfolio, the primary program

[25] BRC Disposal Subcommittee report.
[26] BRC Report, p. vii.
[27] Department of Energy, Nuclear Energy "Our Mission." Accessible at: http://nuclear.energy.gov/neMission.html

areas are fuel cycle ($187 million) and reactor concepts ($115 million). Additionally, the President's FY 2012 budget requested included a new NE research program for "Nuclear Energy Enabling Technologies" (NEET), which received $75 million in FY 2012. A new Small Modular (SMR) Licensing Technical Support Program received $67 million to partner with industry to accelerate development and licensing of SMRs necessary for commercial development.

Table 1 – Department of Energy Nuclear Energy Funding Levels (In Millions)

Major Programs	FY 2011 Enacted	FY 2012 Enacted
Reactor Concepts RD&D	169.0	115.5
Fuel Cycle R&D	359.0	187.4
LWR SMR Licensing Technical Support	0.0	67.0
Nuclear Energy Enabling Technologies	0.0	74.9
NE TOTAL*	**737.1**	**768.7**

* Total numbers do not add due to the exclusion of non-R&D activities such as facilities operations and security.

The Fuel Cycle R&D program conducts research on three basic fuel cycle technologies: once-through, modified-open, and full recycle. The Reactor Concepts program advances new reactor technologies such as high temperature gas-cooled reactors and reactors that "burn" a higher percentage of fuel. The NEET program intends to develop crosscutting technologies and transformative breakthroughs applicable to multiple reactor concepts and fuel cycle technologies. NEET also supports the Consortium for Advanced Simulation of Light Water Reactors (CASL) Energy Innovation Hub. Funded at $24 million in FY12, the CASL Hub seeks to create a "virtual" reactor by applying supercomputing technologies to develop advanced capabilities to simulate nuclear reactors.

BRC R&D Examination

Currently all operating nuclear reactors employ the same general technology, a "once-through" light water reactor that uses nuclear fuel just once before leaving significant volumes to be placed in a pool of water to cool. Secretary Chu directed the BRC to "look at all the science and technology and all the other things that would influence how we deal with the back end of the fuel cycle." The BRC notes, "the integrated and flexible strategy that [they] propose for nuclear waste management puts a premium on creating and preserving options that could be employed

by future generations to respond to the particular circumstances they face. [Research, development, and demonstration] is a key to maximizing those options."[28]

However, the BRC also found that "no currently available or reasonably foreseeable reactor and fuel cycle technology developments – including advances in reprocessing and recycling technologies – have the potential to fundamentally alter the waste management challenge this nation confronts over at least the next several decades if not longer."[29] The Commission did not find consensus on a particular technology pathway. Specifically, the report states:

> "As a group we concluded that it is premature at this point for the United States to commit irreversibly to any particular fuel cycle as a matter of government policy given the large uncertainties that exist about the merits and commercial viability of different fuel cycles and technology options. Rather, in the face of an uncertain future, there is a benefit to preserving and developing options so that the nuclear waste management program and the larger nuclear energy system can adapt effectively to changing conditions."[30]

The report compares four different nuclear technology options in the context of safety, cost, sustainability, non-proliferation and counter-terrorism, and waste management. For more information, see Appendix B.

Key Issues for Committee Consideration

Three decades have passed since the NWPA was signed into law, but the Federal Government is no closer to accepting commercial spent nuclear fuel than it was in 1982. As spent fuel remains stored around the country at each reactor site, the financial liability of the Federal Government continues to steadily increase, and is estimated by DOE to be over $20 billion if the Federal Government begins accepting waste in 2020. The BRC suggests a renewed effort to site a permanent repository could take another twenty years. The massive 2011earthquake and tsunami that devastated Japan and led to a crisis at the Fukushima nuclear plant serve as a stark reminder of the consequences of the government's failure to meet its obligations.

Some components of BRC's recommended strategy can be accomplished immediately without the necessity of amending the NWPA. However, key recommendations, such as the creation of a new sole-purpose organization for managing waste and selection of a new site for a permanent repository, will require legislative action. Key questions include:

- What near-term steps should be pursued to put DOE on a path to fulfill its statutory requirement to accept and dispose of commercial spent nuclear fuel?
- How can DOE's current research, development, and demonstration activities influence future waste management options? How can DOE better prioritize its NE RD&D programs in light of the BRC's review?

[28] BRC Report, p. 99
[29] BRC Report, p. 100.
[30] BRC report, p. 101.

- How can a new single-purpose organization be structured and have the necessary resources to find a solution for nuclear waste? What would that organization's responsibilities include?
- How would a new "consent-based siting process" work in practice?

Appendix A

List of Blue Ribbon Commission Members and Subcommittee Structure[31]

- **Lee Hamilton** - Co-Chair
- **Brent Scowcroft** - Co-Chair
- **Mark Ayers** - President, Building & Construction Trades Department, AFL-CIO
- **Vicky A. Bailey** - Principal, Anderson Stratton Enterprises, LLC
- **Albert Carnesale** - Chancellor Emeritus and Professor, UCLA
- **Pete V. Domenici** - Senior Fellow, Bipartisan Policy Center; former U.S. Senator (R-NM)
- **Susan Eisenhower** - President, Eisenhower Group, Inc.
- **Sen. Chuck Hagel** - Distinguished Professor, Georgetown University; Former U.S. Senator (R-NE)
- **Jonathan Lash** – President, World Resources Institute
- **Allison Macfarlane** - Associate Professor of Environmental Science and Policy, George Mason University
- **Richard A. Meserve** - President, Carnegie Institution for Science and Senior Of Counsel, Covington & Burling LLP; former Chairman, U.S. Nuclear Regulatory Commission
- **Ernie Moniz** - Professor of Physics and Cecil & Ida Green Distinguished Professor, Massachusetts Institute of Technology
- **Per Peterson** - Professor and Chair, Department of Nuclear Engineering, University of California - Berkeley
- **John Rowe** - Chairman and Chief Executive Officer, Exelon Corporation
- **Phil Sharp** - President, Resources for the Future

Reactor and Fuel Cycle Technology

Co-Chair(s):	Ex Officio(s):
Per Peterson	Brent Scowcroft
Pete V. Domenici	Lee Hamilton

Albert Carnesale
Susan Eisenhower
Allison Macfarlane
Richard A. Meserve
Ernie Moniz
Phil Sharp

Transportation and Storage

[31] For full biographies see: http://brc.gov/index.php?q=commission-members

Co-Chair(s):	Ex Officio(s):
Phil Sharp	Brent Scowcroft
Richard A. Meserve	Lee Hamilton

Mark Ayers
Vicky A. Bailey
Albert Carnesale
Pete V. Domenici
Ernie Moniz
John Rowe

Disposal

Co—Chair(s:)	Ex officio(s):
Chuck Hagel	Brent Scowcroft
Jonathan Lash	Lee Hamilton

Mark Ayers
Vicky A. Bailey
Susan Eisenhower
Allison Macfarlane
Per Peterson
John Rowe

Appendix B

TABLE 4. A COMPARISON OF THE EXISTING ONCE-THROUGH, CONVENTIONAL LIGHT-WATER REACTOR FUEL CYCLE WITH REPRESENTATIVE ADVANCED NUCLEAR ENERGY SYSTEMS IN THE LONG TERM[276]

Criterion	Once-Through LWR	Once-Through with High-Temperature Reactor
Nuclear Energy Description	Clad uranium oxide fuels irradiated in LWRs with evolutionary improvement	High-temperature reactors (such as those using graphite-based fuels) capable of temperatures over 600°C operating on a once-through fuel cycle. Being pursued in DOE's Next Generation Nuclear Plant project
	SAFETY	
Reactor and fuel cycle safety[277]	Baseline, with potential for further improvement	Potential for improvement; all must meet similar regulatory requirements
	COST	
Capital and operating costs	Baseline	Test reactors have operated well, but demo (Fort St. Vrain) was unreliable. Fuel costs are uncertain and may be high. RD&D is needed on to provide a basis for design, licensing, and evaluating long-term economic viability.
	SUSTAINABILITY	
Uranium utilization[278]	Baseline	Similar uranium requirements although can vary by design
Climate change impacts	Baseline	Potential for major reduction in carbon dioxide by using nuclear process heat in fossil-energy-intensive industries and to produce hydrogen for non-carbon-based transportation fuels
Energy security	Baseline	Potentially large benefit in reducing petroleum imports now used to fuel non-electricity sectors
	NON-PROLIFERATION AND COUNTER-TERRORISM	
Non-proliferation	Baseline	Reference designs require similar enrichment capacity capable of producing 8%-20% uranium enrichment. Fuel is more difficult to reprocess than LWR fuel.
Counter-terrorism	Baseline	Similar to baseline
	WASTE MANAGEMENT	
Disposal safety: toxicity and longevity of waste	Baseline	Repository: Similar to baseline Fuel Cycle: Similar public and occupational risk from mining and milling
Volume of waste[280]	Baseline	~10X increase in SNF volume going to repository. About the same non-mill tailings LLW as baseline.
Repository space requirements	Baseline	~25% reduction due to higher reactor efficiency.

LWR Modified Open Cycle	Fast-Spectrum Reactor with Closed Fuel Cycle
Clad uranium- and mixed-oxide fuels irradiated in LWRs with evolutionary improvements. MOX fuel is irradiated once and then sent to repository.	Fast-spectrum liquid-metal-cooled reactors capable of continuous recycle of actinides
SAFETY	
Potential for improvement; all must meet similar regulatory requirements	Potential for improvement; all must meet similar regulatory requirements
COST	
Capital cost increased because of need to build reprocessing and MOX fuel fabrication plants. Operating costs also increased due to the high cost of fabricating fuels containing Pu. Cost of electricity increased a few to several percent. Technology is relatively mature with evolutionary improvements largely in the hands of industry.	Previously built reactors (mostly prototype/demo) were often unreliable and not economic. Significant capital cost for recycle facilities. RD&D is needed to provide a basis for design, licensing, and evaluating long-term economic viability.[278] Operating costs relative to baseline largely depend on the future price of uranium, fuel fabrication cost, and operational reliability.
SUSTAINABILITY	
~19% reduction in uranium requirements	~95% reduction in uranium requirements
About the same as the baseline	About the same as baseline
About the same as the baseline	Modest benefit from potential for long term reliance on indigenous uranium resources
NON-PROLIFERATION AND COUNTER-TERRORISM	
Involves use of reprocessing, enrichment, and MOX fuel fabrication technology, and deployment of facilities for same. Increased proliferation risk from substantial normalized inventory of Pu or Pu-plus other actinides in reactors and the fuel cycle.	Involves use of reprocessing and plutonium-bearing fuel fabrication technology, and deployment of facilities for same. Enrichment technology needed during transition to fast reactors. Increased proliferation risk from substantial normalized inventory of Pu or Pu-plus other actinides in reactors and the fuel cycle.
Involves production and inventory of co-processed nuclear materials (U/Np/Pu) and 5%-10% enriched uranium, and fuels containing same. Increased security risk due to separated materials and additional facilities and transportation.	Involves production and inventory of co-processed nuclear materials (U/Np/Pu) and fuels containing same. Increased security risk due to separated materials and additional facilities and transportation.
WASTE MANAGEMENT	
Repository: Noticeable reduction in the amount of TRU in wastes. Tailored waste form for ~90% of the HLW Fuel Cycle: 15%–20% reduction in fuel cycle public and occupational risk from reduced mining and milling. Although there is an increase in emissions from reprocessing, overall risk is reduced as a result of reduced risks on the front end.	Repository: Tailored waste form for fission products; potential for reduction in long-term repository dose from TRU elements if recycle is sustained for decades to centuries Fuel Cycle: ~85% reduction in fuel cycle public and occupational risk from reduced mining and milling, increase from emissions from reprocessing
Similar repository waste volume: less SNF/HLW, more secondary waste. ~20% decrease in near-surface wastes, esp. mill tailings and depleted uranium. Besides mill tailings and depleted uranium, about the same amount of LLW as baseline.	~40% increase in repository waste volume: less HLW, more secondary waste. ~95% decrease in near-surface wastes, primarily due to mill tailings and depleted uranium. ~40% decrease in non-mill tailings LLW due to greatly reduced throughput in the front end of the fuel cycle.
Similar to baseline, with some reduction in long-term decay heat generation.	~75% decrease in repository space required when TRU are recovered and recycle is sustained over many decades to a couple of centuries.