Report to NEAC of the Fuel Cycle Subcommittee

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Burton Richter (Chairman)

Darleane Hoffman

Raymond Juzaitis

Sekazi Mtingwa

Ron Omberg

Joy Rempe

Dominique Warin

NEAC has Four Subcommittees

Fuel Cycle

Reactor

Infrastructure

International

Their Missions Overlap to a Degree

Recommendation: NEAC needs to develop a coordination mechanism for its subcommittees.

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FY 2011 Budget Request

Program:	FY 2010 Approp	FY 2011 Request
Research & Development		
Nuclear Energy Enabling Technologies	0	99,300[a]
Integrated University Program	5,000	0
Re-Energyse	0	5,000
Reactor Concepts RD&D	0	195,000[a]
Generation IV Nuclear Energy Systems	220,137	0
Nuclear Power 2010	105,000	0
Fuel Cycle Research and Development	136,000	201,000[a]
International Nuclear Energy Cooperation	0	3,000
Infrastructure		
Radiological Facilities Management	72, 000	66,818
Idaho Facilities Management	173,000	162,482
Idaho Sitewide S&S	83,358	88,200
Program Direction	73,000	91,452
Congressionally Directed Projects	**2,500**	**0**
Total NE:	**869,995**	**912,252**

Significant Changes

- Nuclear Energy Enabling Technologies
  - New program to develop crosscutting technologies and transformative breakthroughs with applicability to multiple reactor concepts and fuel cycle approaches
- Reactor Concepts RD&D
  - New program, replacing the Generation IV Nuclear Energy Systems Program, to continue reactor RD&D activities, including the Next Generation Nuclear Plant, and to initiate a Small Modular Reactors effort
- Fuel Cycle R&D
  - Redirected from near-term technology deployment to long-term, results-oriented, science-based R&D
- Nuclear Power 2010
  - Nuclear Power 2010 Program closeout after the successful completion of its goals and objectives
- International Nuclear Energy Cooperation
  - New program to support NE's international engagement and other relevant international commitments in civilian nuclear energy matters

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Fuel Cycle R&D Budget Request

Budget Summary ($ in thousands)		
Program Element	FY 2010 Approp	FY 2011 Request
Separations and Waste Forms	41,615	31,324
Advanced Fuels	29,651	40,000
Transmutation R&D	4,288	0
Modeling & Simulation	26,009	15,570
Systems Analysis & Integration	14,783	15,664
Materials Protection, Accountancy & Controls for Transmutation	6,826	7,814
Used Nuclear Fuel Disposition	9,124	45,000
Modified Open Cycle	0	40,000
SBIR/STTR	3,704	5,628
Total:	136,000	201,000

- **Mission**
  - Research and develop nuclear fuel and waste management technologies that will enable a safe, secure, and economic fuel cycle.
- **FY 2011 Planned Accomplishments**
  - Examine 3 fuel cycle strategies: once-through, modified open, and full recycle.
  - Continue to develop advanced concepts for electrochemical processing and alternative waste forms.
  - Begin to develop innovative fuel systems that support advanced fuel cycles.
  - Provide technical expertise to inform decision-making for storage, transportation, and disposal of used nuclear fuel and radioactive waste.

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National Program Summary

Country	Material to be Disposed	Centralized Storage	Geologic Environments	URL	Site-Selection	Anticipated Start of Repository Operations
Finland	SNF		Granite, Gneiss, Grandiorite, Migmatite	ONKALO (Granite)	Site at Olkiluoto Selected	2020
Sweden	SNF	CLAB - Oskarshamn	Granite	Aspo (Granite)	Site at Osthammar Selected	2023
France	HLW and ILW		Argillite and Granite	Bure (Argillite)	Site near Bure Selected	2025
Belgium	HLW		Clay/Shale	Mol (clay)	Not Initiated	~2040
China	HLW		Granite		Preliminary Investigations Underway - Beishan in Gobi Desert	~2050
Switzerland	HLW	Wulenlingen (ZWILAG)	Clay and Granite	Mont Terri (Clay) Grimsel (Clay)	Initiated	No sooner than 2040
Japan	HLW		Granite and Sedimentary	Mizunami (Granite) Horonobe (Sedimentary)	Initiated	No Decision Made
Canada	SNF		Granite and Sedimentary	Pinawa (Granite) - being decommissioned	Initiated	No Decision Made
United Kingdom	HLW and ILW		Undecided		Initiated	No Decision Made
Germany	HLW, SNF, heat generating ILW	Gorleben and Ahaus	Salt	Gorleben (Salt)	On Hold	No Decision Made
Republic of Korea	SNF	Envisioned	Granite	Korea Underground Research Tunnel (Granite, Shallow)	Not Initiated	No Decision Made
Spain	No Decision Made	Siting Process Initiated	Granite, Clay, Salt		Not Initiated	No Decision Made

Source: Nuclear Waste Technical Review Board, 2009. Survey of National Programs for Managing High-Level Radioactive Waste and Spent Nuclear Fuel

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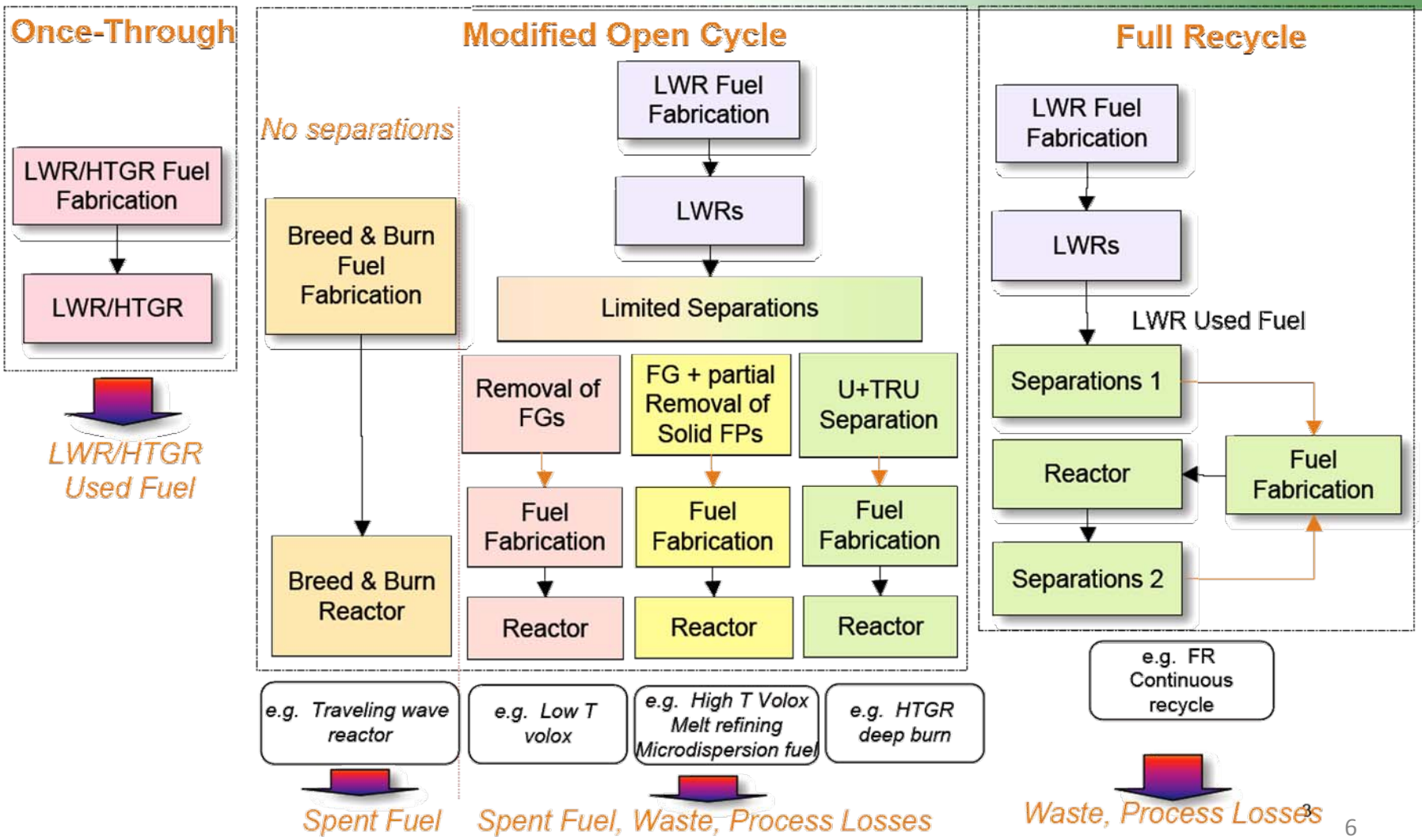
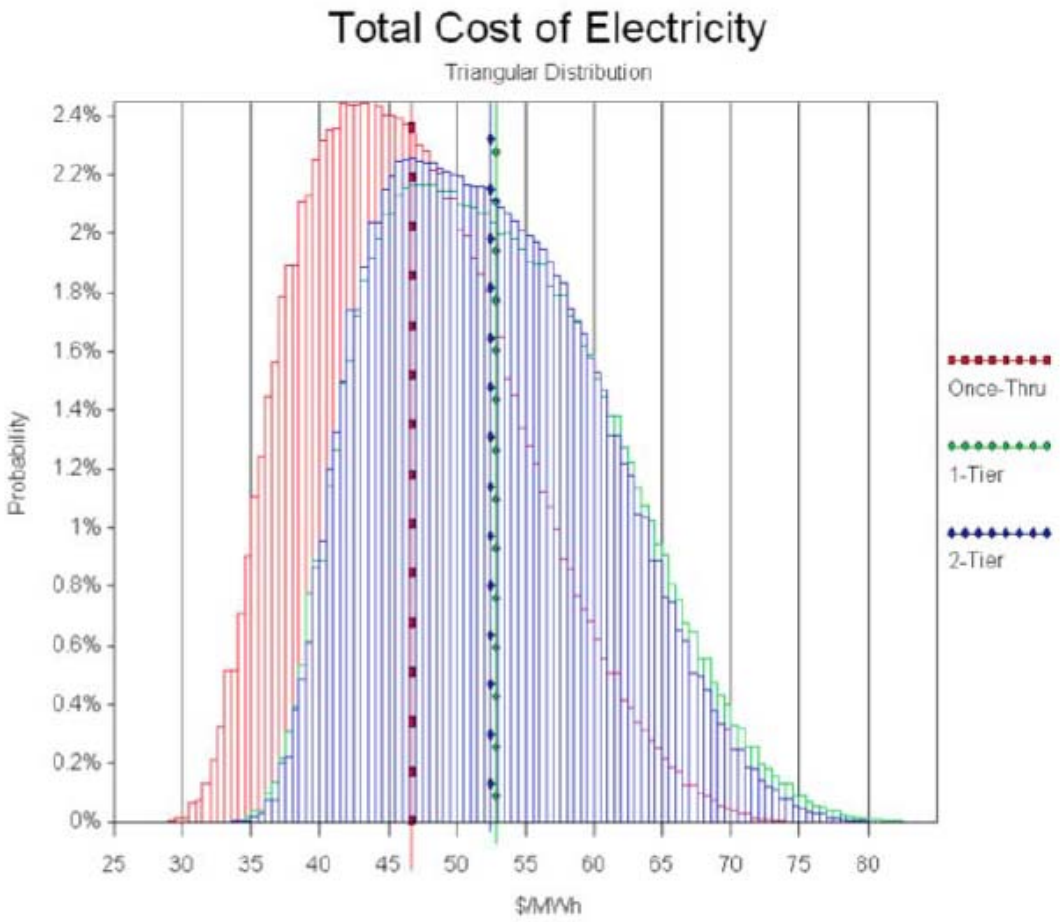
Advanced Fuels Campaign supports multiple Fuel Cycles Options



Fuel Options

- **There are two basic fuel options**
  - Uranium-based (U, U/Pu, U/TRU, Pu, Pu/MA, …)
  - Thorium / fissile–based (U/Th, U/Th/U233, Th/U233, Pu/Th, …)
- **Waste Management**
  - Thorium/uranium options can have different waste attributes as compared to uranium/plutonium, but the differences do not appear to be significantly large, or necessarily beneficial or detrimental
  - Strongly dependent on the details of the implementation
- **Proliferation Risk**
  - Thorium/fissile-based and uranium-based appear to have similar proliferation risk (U233/U232 and RG Pu239 have similar attractiveness)
- **Sustainability**
  - Both uranium-based and thorium/fissile-based have similar resource requirements for the same fuel cycle implementation
- **Both fuel types affect the other performance measures in a similar manner, i.e., overall there appears to be no significant difference between U/Pu and Th/U**
  - However, different fuel cycle technologies may be enabled with thorium

Economics of Once-through and Recycle



- From the "Advanced Fuel Cycle Cost Basis" Report and the "Dynamic Systems Analysis Report for Nuclear Fuel Recycle"
- Difference in the estimate of the mean is small compared to the uncertainties in overall costs

In FY'10, Novel Concepts are solicited from National Laboratories

- The white papers and the associated presentations were reviewed by a panel on behalf of the campaign
- 21 white papers were received from ANL, BNL, INL, LANL, LLNL, ORNL SNL, SRNL
- Each concept was presented to a review panel on Feb. 8 - 9, 2010.
- Review Panel
  - Dave Alberstein, (retired LANL)
  - Michael Cappiello, (FCRD TIO) (Chairperson)
  - George Copeland, (retired ORNL)
  - Madeline Feltus (DOE-NE)
  - Robert Hill (ANL, FCRD Reactors Campaign Director)
  - Richard Hobbins, (retired INL)
  - Leon Walters (retired ANL)

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Feasibility studies for 3 concepts started. Feasibility demonstration plans are being written for others

- Advanced metallic fuel concept for high performance to ultra-high burnup (ANL/INL)
- Vented Fuel/Getter Concept for High Burnup Fuels (BNL)
- Uranium Alloy Metal Fuel for LWRs (PNNL)

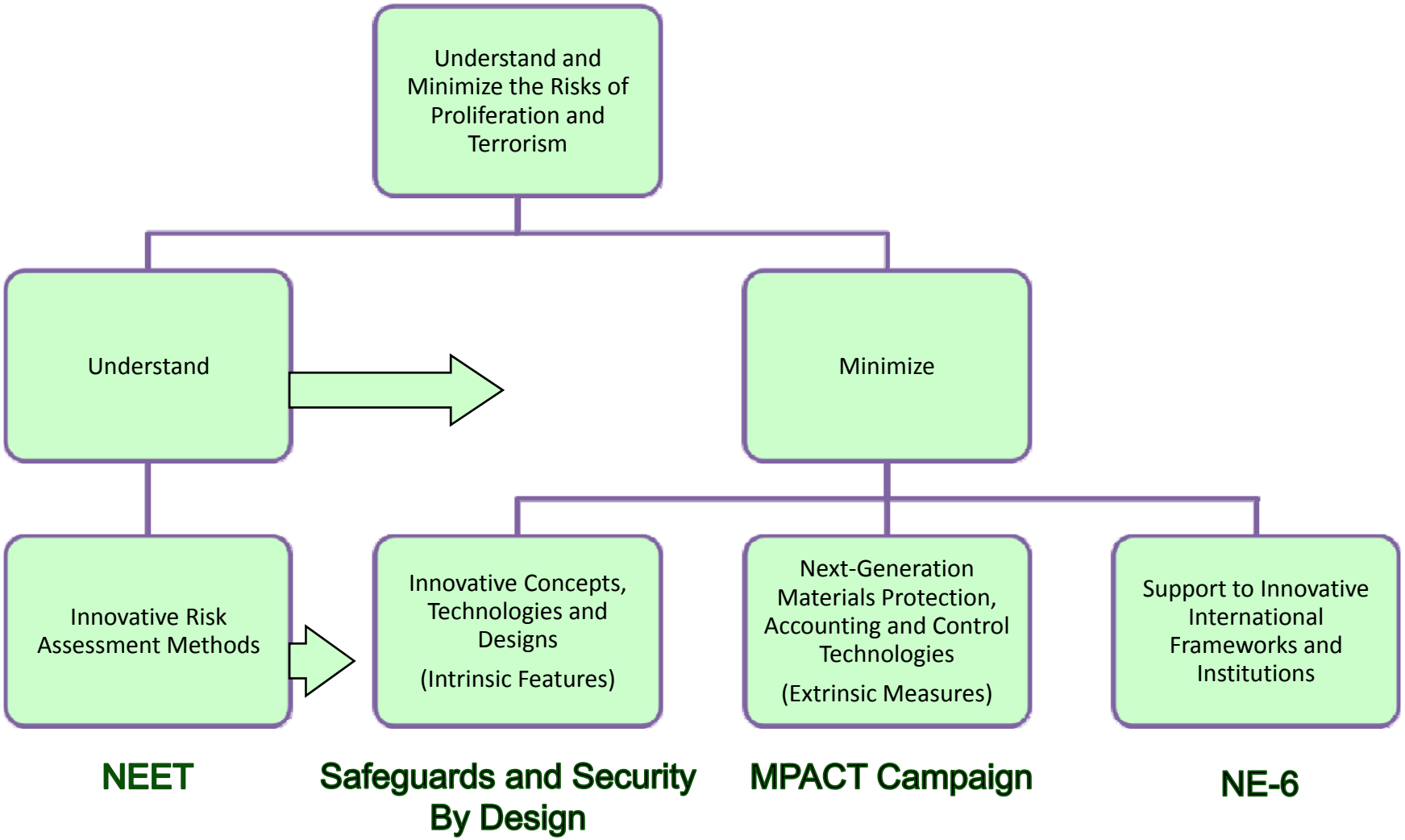
- Dispersion Fuels for High Burnup (INL)
- Ultra-High Burnup Metallic Inert Matrix Fuel Concept (LLNL)
- An Advanced High Integrity Gas Cooled Fast Reactor Fuel (SRNL)
- Multi-Layer Co-Extruded Metallic Fuels for Fast Reactors (SRNL)
- Enhanced Thermal Conductivity and Grain Boundary Engineering for Oxide Fuels (ORNL)
- High-Burnup Ceramic Composite Fuels (micro-dispersion) (LANL)

- Thorium Fuel Development Plan (BNL)

Uranium Resources

- Red Book 16 M tonnes @ $130/kg= 1300 LWR GWe x 60 years
- Fuel resource is part of decision on breeders
- Sea water has huge amount though very dilute.
- Japan leading and cost now is estimated at $900/kg
- At $250/kg electricity costs go up by 0.5 cent/KWh
- US is now working on advanced extraction
- Good subject for computer modeling

Anti-proliferation Program



Recommendation

DOE should convene a group of top scientists, from both inside and outside the Federal system of laboratories and agencies, to begin the process of standardizing a set of metrics by which proliferation potential can be measured. A process for peer review of reports should be formulated.

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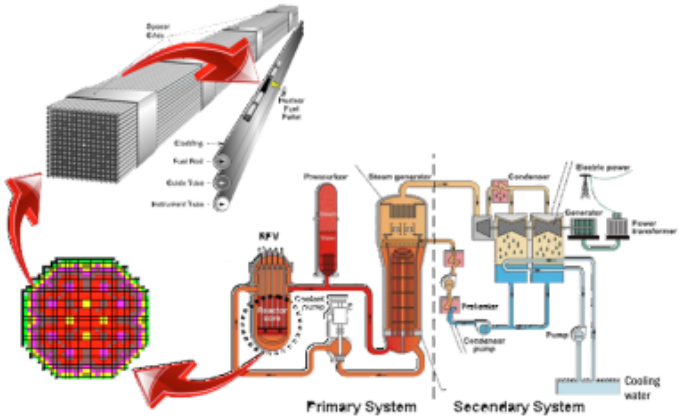
Energy Innovation Hub for Modeling & Simulation –

A key Secretarial Initiative

- Consortium for Advanced Simulation of Light-water-reactors (CASL) selected to manage the Hub on May 28, 2010
- Create a "multi-physics computational environment" that can be used by a wide range of practitioners to conduct predictive calculations of the performance of reactors for both normal and off-normal conditions."
- Dramatically advance modeling and simulation and high performance computing to create a "virtual" model of an operating reactor.
- Improve our scientific understanding of reactor systems to increase the pace of innovation and reduce overall costs to deploy and operate.



Recommendations

1) Maintain an effective experimental program to run parallel with the modeling and simulations effort in order to verify its predictions. This has not received the attention it deserves, nor do we see a budget line to allow the necessary experiments to be done.

2) Include input from NNSA and the Office of Science from the start.

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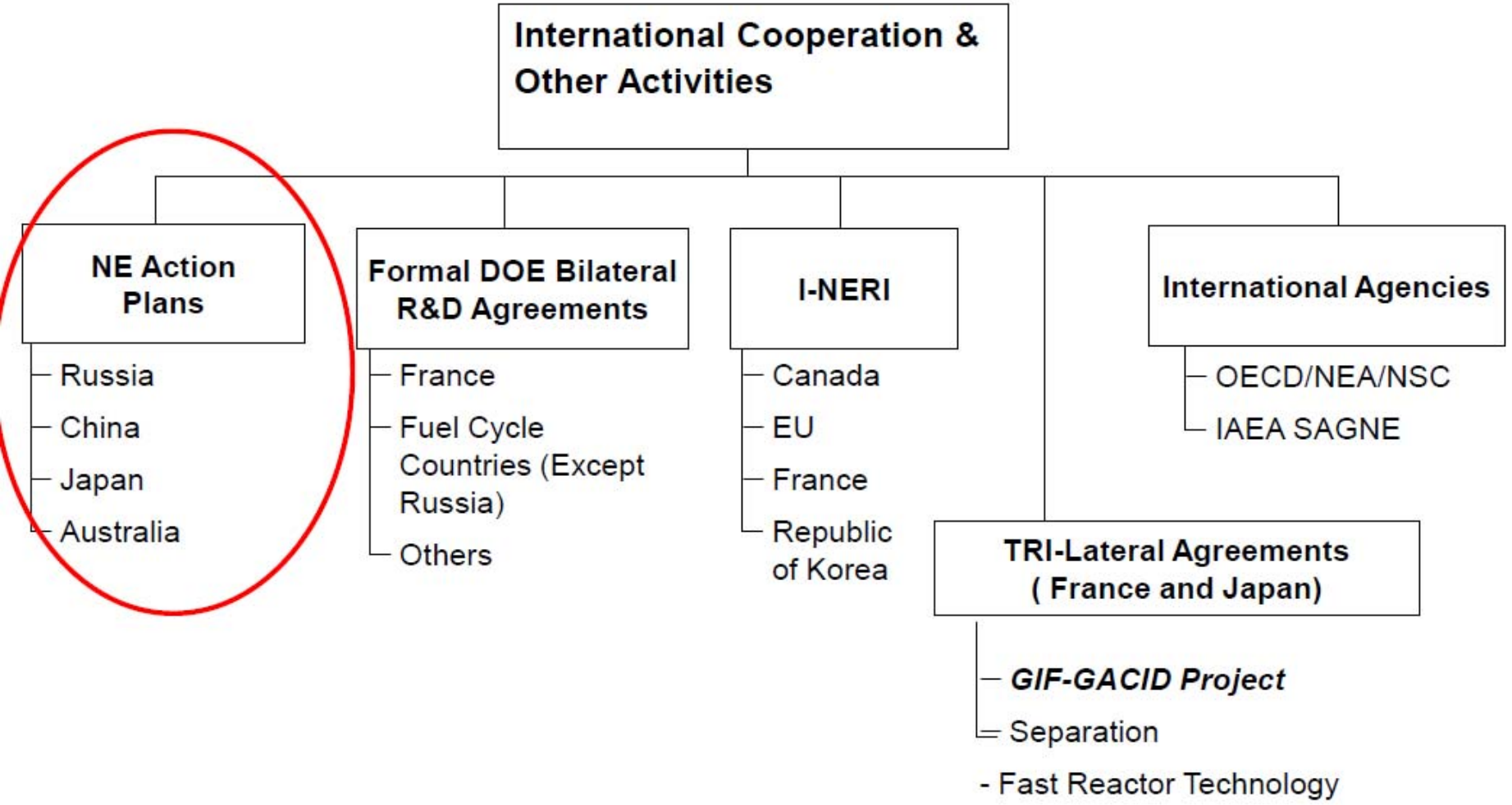
International R&D Cooperation and Other Activities



Recommendation

NE should investigate the possibility of new types of international agreements that would allow larger-scale sharing of time on experimental facilities with appropriate financial support either in cash or in kind.

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Nuclear Energy University Program Strengthened