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Nuclear Energy University Programs (NEUP) Fiscal Year (FY) 2013 Annual Planning Webinar

Mission Supporting Fuel Cycle R&D (MS-FC1): Fuel Resources

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Office of Fuel Cycle Technologies
Office of Nuclear Energy

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Office of Fuel Cycle Technologies: an Integrated Approach

Front End

Uranium Resources

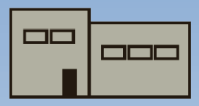
- Conventional production
- Innovative approaches
  - U Seawater

Fuel Fabrication

- Safety enhanced LWR fuel
  - Accident tolerance
- Higher performance
  - Improved burnup

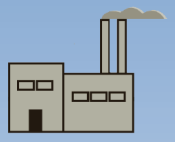
Reactors

Back End



Interim Storage

- Evaluating extended time frames
- Transport after storage



Recycle

- Separations
- Recycled fuel
- Secondary waste treatment

Disposal

- Alternative geologies
- Alternative waste forms

Optimize through systems analysis, engineering, and Integration

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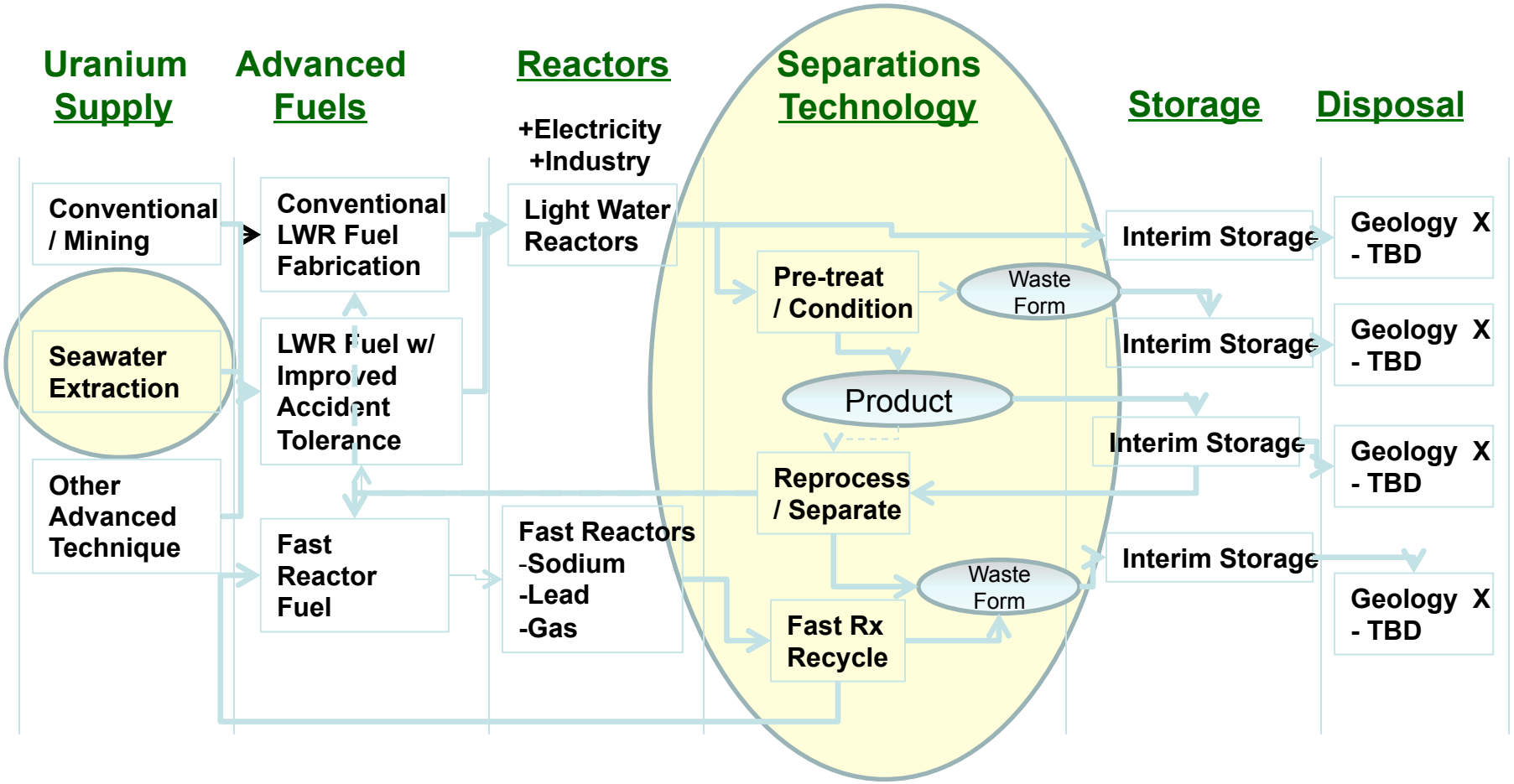
Fuel Cycle as a System



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Fuel Resources Overview

Nuclear Energy R&D Roadmap

"Fuel Resource Exploration and Mining – The availability of fuel resources for each potential fuel cycle and reactor deployment scenario must be understood… involvement in this area would be R&D to support investigation of long-term, 'game-changing' approaches such as recovering uranium from seawater."

Program Mission:

To identify and implement actions the Department of Energy can take to assure that economic nuclear fuel resources remain available for current and future nuclear fuel cycles

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Grand Challenges – Seawater Uranium Extraction

Vast potential resource in seawater: ~4,500 million tonnes (Mt) U

Potentially limitless supply of domestic nuclear fuel resources

2009 Red Book reported current world-wide estimates of terrestrial uranium conventional resource @ <$260 kg/U: 6.4 Mt U

Total undiscovered (prognosticated + speculative) resource: 10.4 Mt U

Challenge is low concentration: 3.3 ppb

Approximately 300,000 t seawater for 1 kg U

Seawater uranium would provide a price cap and centuries of uranium supply even with aggressive world-wide growth

R&D off and on since 1960s (Finland, France, Germany, Greece, Italy, Poland, Sweden, UK, India, China, Japan and USA)

DOE-NE re-started a moderate R&D program in FY11

Japan maintains by far the largest research investment and leads the technology development

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Seawater Uranium Extraction Technology Development in Japan

Dr. M. Tamada Presentation 2010

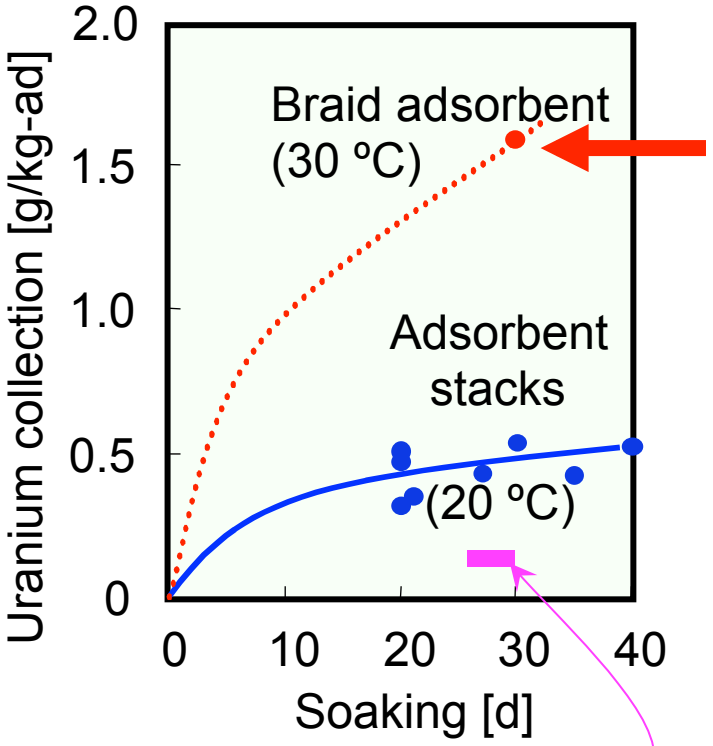
Resources with Japan current

Estimated 5.2×10^6 t/y

~0.2%

8×10^3 t/y

Demand of Japan in a year



- 10 ºC enhanced 1.5 times
- Efficient constant with seawater: 2 times

Hydrous titanium oxide adsorbent

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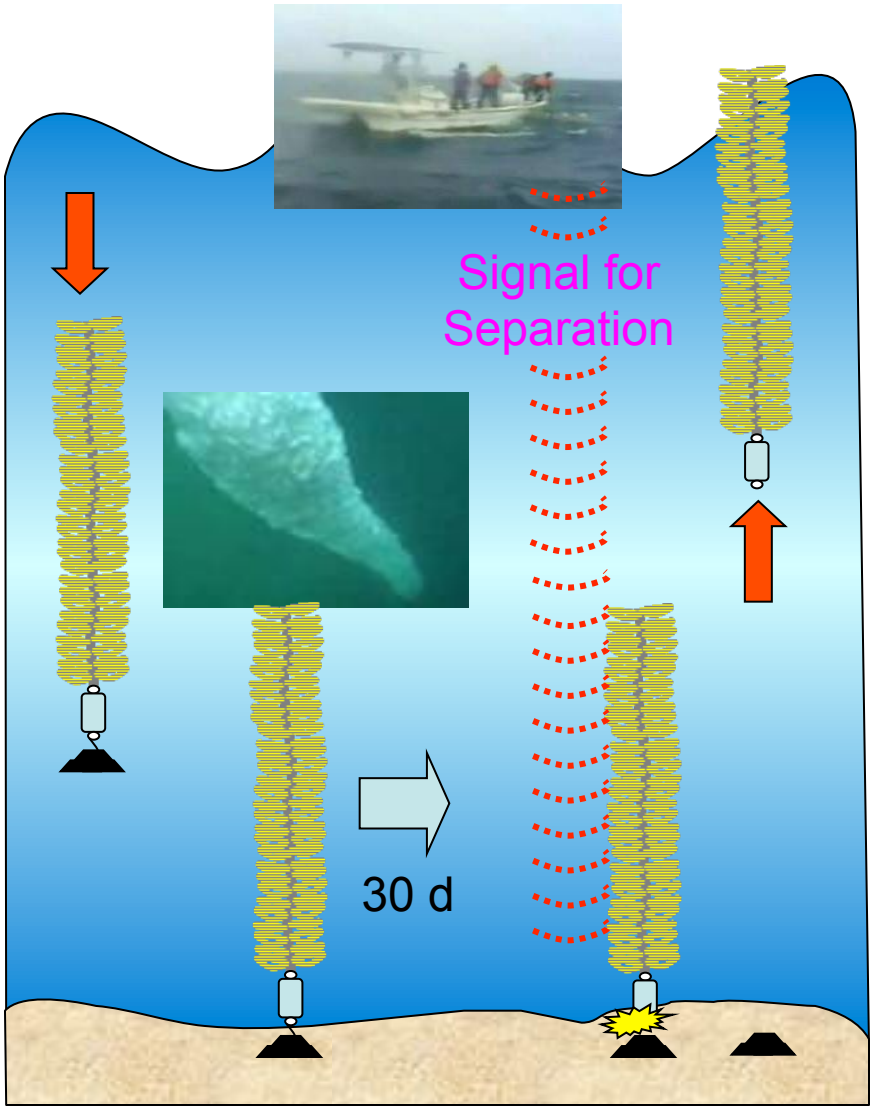
Seawater Uranium Extraction Technology Development in Japan

Dr. M. Tamada Presentation 2010



Okinawa Marine Experiment

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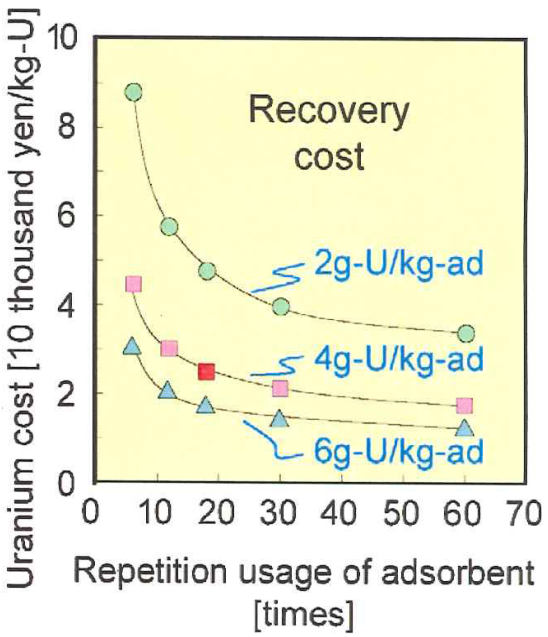
R&D Opportunities – Seawater Uranium Extraction



- Weekly spot price \$48/lb-U_3O_8 at October, 2009 is 12,000 yen/kg-U.
- Promising collection cost is 25,000 yen/kg-U. This price is twice of spot price.

Improved specific selectivity of the adsorbents

The JAEA's adsorbent has 10 and 18 times higher affinity to Fe and Pb, respectively.

A systematic approach to gain knowledge of thermodynamics, coordination modes, sorption mechanisms and kinetics

Need advances in our understanding of the subtle and complex chemical processes

Recent developments in nanoscience and nanomanufacturing technology enable technical breakthroughs in developing new adsorbents

To synthesize novel nanoscale materials with architectures tailored for specific chemical performance

To characterize adsorbent and dynamic chemical processes at the atomic and molecular level

To simulate and predict structural and functional relationships using modern computational tools

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Fuel Resources Workshop Report

- An R&D Roadmap for the program

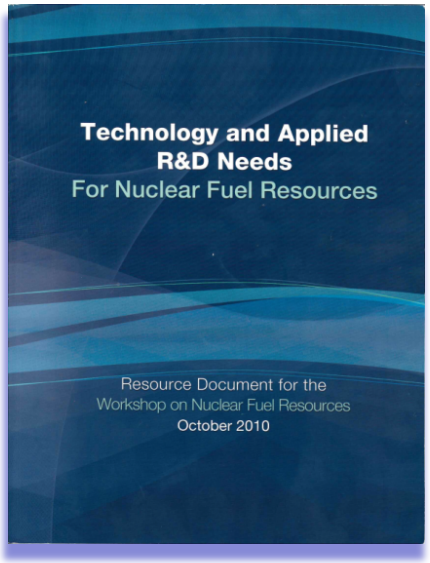
Workshop Co-chairs:

Charles W. Forsberg, MIT
J. Stephen Herring, INL
Phillip F. Britt, ORNL

Workshop Charge: *To evaluate the scientifically challenging and emerging research areas that have the potential to significant impact on technology development needs to ensure the availability of natural uranium resources for global nuclear expansion. The workshop output is a report that will outline research opportunities for future fuel resource technologies with a focus on recovery of uranium from seawater.*

***Plenary Speakers*:**

Jan Slezak*, IAEA, U Resource Estimation Red Book perspective
Bob Vance*, OECD, Projected Global Build Rates and U Demand
T. Shimizu, JAEA, Seawater U Extraction



"To make the collection of uranium from seawater more economically competitive, the workshop identified five future research directions: (1) molecular-level understanding of the coordination modes, sorption mechanisms, and kinetics of uranium extraction; (2) design and synthesis of functional ligands; (3) development of advanced sorbents (high-surface area polymer and hybrid supports); (4) development of new polymer sorbents via surface grafting techniques; and (5) development of innovative elution processes."

www.ornl.gov/sci/nuclearfuelresources/test/docs/overview/NE_Workshop_Report_Oct2010.pdf

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Seawater Uranium Extraction - Research Needs

- **Increase sorption capacity and selectivity in seawater environment**
  - Surface area (reduce the fiber size and/or change the fiber shape)
  - Functional group density (tailored nanostracture design and nanomanufacturing)
  - Grafting efficiency (irradiation with gamma, X-ray, e-beam, uv-vis, chemical methods)
  - Enhanced ligand design
    (computational modeling of functional ligands, hard/soft donors, stereochemistry)
- **Enhance adsorbent durability**
  - Increase the number of recycles or reuse of adsorbents
- **Improve U stripping methodology**
  - Carbonate solution, supercritical carbon dioxide (better U eluants offer longer adsorbent lifetimes, less costly and "greener" processing)
- **Understanding sorption mechanism, kinetics, and thermodynamics**
  - Advanced characterization tools to increase chemistry understanding
- **Inhibition of biofouling**
  - Coatings (surface sol-gel process)
  - Specialized polymer compositions and nanoporous adsorbents

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Seawater Uranium Extraction

- Activities & National Lab Lead Researchers

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