The Technical Agenda for Future US-ROK Nuclear Cooperation?

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July 2010: U.S. & ROK Workshop on Nuclear Fuel Cycles and Nonproliferation
SNAPSHOT: Current ROK R&D

- 12 NPR’s under construction, planned or on order
- Involvement in Gen-IV
- 100 MWe SMART reactor
- DUPIC technologies (KAERI+AECL)
- Pyroprocessing (KAERI+SNU)
Current ROK R&D: Success

UAE Deal

Hanaro

Jordan
Past and Present
SNAPSHOT: US-ROK Nuclear Cooperation: History

1960’s -1970’s - TRIGA Research Reactors (General Atomics)

1978 – Kori Unit 1 (Westinghouse)

1991 – DUPIC (Agreement with US and Canada)

2003 – I-NERI work on many topics (26 completed, 11 in proc)

2006 – Start of KAERI-10 Project
US-ROK Nuclear Cooperation: The Joint Standing Committee (JSNEC)

- forum for intergovernmental nuclear energy cooperation
- Cover broad topics in nuclear energy development
- Meetings held alternately in ROK and US, 2010 is in ROK
- The new agreement could also give formal recognition to, and elevate the status of JSNEC

Ref: Fred McGoldrick, Center for US-Korea Policy
ref: Dohee Hahn, April 15 2010 JH U.
US-ROK Nuclear Cooperation: GNEP Multilateral Fora

PR Reprocessing

Strengthen Safeguards

Minimize Waste

Develop Fast Reactors

GNEP (2006): Provide services - discourage others from developing their own domestic fuel cycle.

Promote “cradle-to-grave” fuel services

Placed emphasis on UREX+ and Pyro believing to be more PR

Pres. Obama has ended most of GNEP.
US-ROK Nuclear Cooperation: GIF Multilateral Fora

Goals: Sustainability, Cost, Safety, PR and Physical Protection

Sodium Fast Reactors

VHTR
US-ROK Nuclear Cooperation: INPRO Multilateral Fora

International Project on Innovative Nuclear Reactor and Fuel Cycles

Participated since beginning but has 31 members

Focus on measuring PR

Led Case Study: DUPIC

ref: Dohee Hahn, April 15 2010 JH U.
KAERI-10 US-ROK Collab @ INL

Song et al, Nucl. Tech and Eng., VOL.42 NO.2 APRIL 2010

Goals

• Assessment of the LLW characteristics of the pyroprocessing U product
• Electrorefining experiments with graphite cathodes

• Group actinide recovery experiments
• Demonstration of fuel fabrication with spent fuel
• Process Modeling and Simulation
I-NERI US-ROK Collaboration

- 18 projects since 2005 covering diverse topics
- Currently **11 projects still expected to continue** according to 2009 report?

Source: I-NERI 2009 Annual Report
US Position on Pyroprocessing?

- Obama Administration has not articulated its policy on pyro clearly, although generally opposed to reprocessing
- **Pyroprocessing = reprocessing?** No policy statement – not the relevant question
- ROK wants “advanced consent” for alteration in form or content as in US-India deal to be included in next Civil Nuclear Cooperation Agreement
- Ultimately- US-ROK cooperation will depend on outcome
Scenarios for US-ROK Cooperation
SNF Management

Absolutely necessary
Absolutely critical
(need to be creative
-stakes are too high)

Back End R&D

Geological Repository
Alternative Disposal
Interim Storage R&D
Waste Package R&D

COMPONENT 1

Recycle Scenario
Piece 1
Or
Once Through
Scenarios for US-ROK Cooperation
SNF Management

• Dependent on how the framework will be renegotiated.

“Advanced Consent for Alteration Form or Content”

Unlikely

“US would request legally binding commitment to no PUREX”
F. McGoldrick

“Back End R&D in the case where ‘advanced consent’ is given, and in the right panel activities which are independent of US approval.”

Figure: Back-end R&D in the case where “advanced consent” is given, and in the right panel activities which are independent of US approval.
Scenarios for US-ROK Cooperation
SNF Management

"Advanced Consent for alteration of form or content"

If NO there are other options

No Coop US Labs
Coop Work Other Country (Russia/China)
Cooperative Work in Extra-territorial Territory on Korean Soil

Consequences??
Consequences?
Consequences??
Consequences????

Recycle Scenario
Piece 2

Most Preferred

All Four Options Have Consequences!

Most Preferred
Still need to solve!

COMPONENT 1

Back End R&D

Geological Repository

Alternative Disposal

Interim Storage R&D

Waste Package R&D
Specific Areas of Cooperation in the Future if Issue Resolved
Multi-Disciplinary International Study on the Benefits of the IFR-Like Fuel Cycle in Korea

• In-depth, multi-disciplinary analysis on the cost, volume reduction in waste, social acceptance, nonproliferation aspects, safeguards, political, etc of the entire fuel cycle for various fuel cycle scenarios.

“Because politics is more complicated and difficult than physics”
Albert Einstein

• Multi-attribute analysis: ways to combine “seemingly” un-quantifiable aspects such as social acceptance etc. (see: PNNL-14294 for a range of techniques)
FR + GR Safeguard Challenges

• Develop NDA methods for accurate assay of Pu and actinide content in the presence of minor actinides.
  - Curium and other MA complicate the assay for Pu and HEU
  - TRU-bearing fuels will need to be tested for their sensitivity to NDA techniques

• Detecting diversions and defective pins in spent TRU fuel also require sensitive NDA techniques.

• Perimeter? A/G or U/G? Verification Techniques
Future Pyroprocessing Cooperation

Goals

• Share knowledge on pyroprocess technology
• Resolve outstanding technical issues such as
  - Increase in throughput (batch-criticality)
  - Reduction in pyro waste volumes
  - Scale up from lab-scale
  - Development of nuclear MC&A
• Further development of Advanced Spent Fuel Conditioning Process Facility (ACPF)
Collaboration on MA Loaded FR Fuels

- MA bearing transmutation fuels early stage of development
  - lab scale fabrication
  - small amount of out of pile testing
  - small amount of irradiation tests
- Increase % Am-241 (increase affects safety)
Collaboration on Alternative Disposal Options
Collaboration on Alternative Disposal Options

Off-Shore Geological Repository

Long Term Interim Storage

Exploring the continental shelf for low geological risk nuclear waste repository sites using petroleum industry databases: a UK case study

S. Stewart

200 Craigie Drive, Dundee DD4 7UE, UK

Received 15 May 2001; accepted 14 April 2002
Collaboration on Alternative Disposal Options

Deep Borehole Disposal

SANDIA REPORT
SAND2009-4401
Unlimited Release
Printed August 2009

Deep Borehole Disposal of High-Level Radioactive Waste

Patrick V. Brady, Bill W. Arnold, Geoff A. Freeze, Peter N. Swift, Stephen J. Bauer, Joseph L. Kanney, Robert P. Rechard, Joshua S. Stein

Estimate for 109,300 MTHM
“Total Life-cycle cost for a hypothetical borehole disposal program of 71 B$ (2007)”
Training Korean Future NP Analysts

(Shameless Self Promotion)
• US is an important partner in the development of Korea’s nuclear technology

• US and ROK have collaborated to develop advanced nuclear technology through programs such as KAERI-10 and I-NERI and many others.

• Increasing spent fuel serious problem to both-both should work together to solve it.
Developing Korean Nonproliferation Curriculum

Shameless Self Promotion
(CD Passing the Baton Available)
Pyroprocessing Deployment

- Multinational facility in South Korea
  - US and ROK work together to develop pyroprocessing technologies
  - Unlike similar multilateral proposals on the Front End these require the interested parties to refrain from developing indigenous reprocessing technology. I.e. some sovereignty is given up

- Pyroprocessing in the United States, Russia or China
  - Prevent breakout scenarios
  - Safeguards/monitoring/confidence in process
  - Product could be shipped to third state and diverted, and Pu separated
Advanced Spent Fuel Cond. Process Facility (ACPF)

Goals:

• Experience in hot cell operation
• System design improvement
• Greater transparency in process
• Front-end pyroprocess processes in a hot cell
  - decladding, spent fuel handling, remote operation, electroreduction

Safeguards (IAEA+LANL)

IAEA submission of DIQ in 2006, and facility attachment in 2007