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Joint Fuel Cycle Studies (JFCS)
Fuel Cycle Alternative Working Group (FCAWG)

"*How did we get to where we are now*?"

Kevin A. McMahon
US Laboratories Point of Contact for FCAWG
Sandia National Laboratories

Washington DC
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Outline

- Fuel Cycle Alternatives Working Group (FCAWG) History
- Points of Contact
- Used Fuel Disposition Subgroup
- System Evaluation Subgroup
- Storage & Transportation Subgroup

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*FCAWG Description – Storage, Transportation & Disposal

"…Used fuel storage and transportation are an inherent part of every fuel cycle. Research is being performed to evaluate fuel degradation effects over lengthy storage periods, the effect of marine environments on storage canisters and over-packs, and the benefits of various storage scenarios. The DOE and ROK can also jointly develop generic repository performance models and perform follow-on analysis for repository and disposal scenarios…"

*** Extracted from *Proposed Details for Joint Fuel Cycle Studies: Phase I,* April 2011**

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JFCS – FCAWG Representatives

- ***Fuel Cycle Alternatives Working Group co-chairs***:

William Boyle	US DOE	William.Boyle@doe.gov
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- ***Coordinators and points of contact for FCAWG***:

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Won Il Ko	ROK KAERI	nwiko@kaeri.re.kr

- ***Disposition Subgroup points of contact*** :

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Haeryong Jung	ROK KORAD	nohul@korad.or.kr

- ***Storage & Transportation Subgroup points of contact*** :

Ken Sorenson	US SNL	kbsoren@sandia.gov
Chunghyun Cho	ROK KORAD	skycho@korad.or.kr

- ***System Evaluation Subgroup points of contact*** :

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History of JFCS FCAWG

April 14, 2011: ROK and DOE NE53 met in Albuquerque to begin discussion of potential areas of collaboration under Fuel Cycle Alternatives. 6 areas of potential collaboration were developed from 20+ possible categories.

October 12-14, 2011: ROK and US DOE NE5 (UFDC included) met in Jeju Island, Korea to finalize the specific areas of collaboration under the Fuel Cycle Alternatives TWG. These areas involve collaboration between the US Used Fuel Disposition Campaign (UFDC) and the ROK MKE.

March 28, 2012: ROK and US DOE met in Daejeon where status and progress of the 6 areas of collaboration was discussed for the Disposition Subgroup of the FCA.

June 5-7, 2012: ROK and US DOE met at Sandia National Labs in Albuquerque. Status and progress was discussed and a ranking for the prioritization of the 6 collaboration areas was completed.

March 11-13, 2013: ROK and US DOE met at KAREI facilities in Daejeon. After tours of selected facilities, information was exchanged associated with agreed upon areas of collaboration.

July 10 - 11, 2013: ROK and US DOE met in DC and the Disposition and Storage & Transportation subgroups separated. Meetings to discuss proposed areas of collaboration occurred.

June 23 – 26, 2014: Areas of collaboration identified during previous meetings were reviewed, refined and prioritized. All three subgroups used the morning of the 25th to finalize the collaboration areas, identify deliverables and agree upon priorities.

April 28 – 30, 2015: Areas of collaboration identified during previous meetings were reviewed, refined and prioritized. All three subgroups used the morning of the 28^{h} for a plenary meeting together, then subsequently broke into the three subgroups for more detailed discussions:

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JFCS FCAWG Meeting April 28-30, 2015, Jeju Island, ROK

Participants

KORAD	US DOE)
Joowan Park	William Boyle
Chunhyung Cho	
Haeryong Jung	SNL
Taechul Moon	Kevin McMahon
Jaechul Ha	Yifeng Wang
Kyeonguk Kang	Geoff Freeze
	Ken Sorenson
KAERI	Robert Finch
Jongtae Jeong	
Won Il Ko	INL
Donghak Kook	Steve Marschman
Sanghoon Lee	
Woo Seok Choi	
Ki Seog Seo	LLNL
	Young Ham

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JFCS FCAWG Meeting April 28-30, 2015, Jeju Island, ROK

FCAWG Subgroups met in the morning of April 28 together, then met separately until a wrap up on the 30th.

Used Fuel Disposition Subgroup: ROK and US participants gave presentations on the works for tasks identified during the June 2014 meetings. Both sides agreed upon deliverables in the collaboration tasks.

System Evaluation Subgroup: ROK and US participants held discussions that were follow up to discussions between Dr. Ko and Mr. Dan Vega during the joint meeting of the SSWG/ERWG the week prior.

Storage & Transportation Subgroup: ROK and US participants gave presentations on the works. A broad subject range of discussion topics was covered during the session. Topics included experimental work, analytical/code development, details on the DOE/EPRI high burn up spent fuel data project and potential areas for collaboration. Both sides agreed upon deliverables in the collaboration tasks.

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FCAWG Disposition Subgroup– Areas of Collaboration

Tasks that were identified during the June 2014 meetings in the UFD subgroup are shown below. No changes to prioritization or groupings** were made at the April 2015 WG.

Immediate Interest

- Task 1: Evaluation tools for repository decisions
- Task 8: Borehole Research – Collaboration on planned deep borehole disposal research
- Task 2-1 merged with Task 2-2: Engineered and Natural barrier systems databases and Robust Materials for Disposal System for Spent Fuel

Future Interest (still considered important by ROK, but not immediate)

- Task 2-3: Natural System Evaluation – Joint field testing and modeling to support the study of high level waste disposal in crystalline geologic media
- Task 3: Spent fuel degradation, long term durability over geological time

** Task grouping numbers were originally assigned in 2013. ROK and US agreed to retain the grouping numbers originally assigned to maintain traceability to previous work of the FCAWG UFD Subgroup.

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FCAWG Disposition Subgroup – Task #1 "Evaluation Tools"

Evaluation tools for repository decisions **(FY 2012 – FY 2018)**

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Geoff Freeze	**SNL**	**gafreez@sandia.gov**

Background

The following activities specific to evaluation tools are shown here:

- *Refine generic repository reference cases*
  - *Update salt, granite, clay*
  - *Develop waste form degradation (UNF) conceptual model*
  - *Develop deep borehole modeling*
  - *Integrate updated conceptual models and capabilities into the PFLOTRAN-based system model architecture*
  - *Refine source term and EBS evolution model*
    - *Waste form degradation, waste package degradation, solubility limits*
  - *Integrate process models and couplings*
    - *Gas generation and multi-phase flow*
    - *Thermal effects*
    - *Far-field flow and transport (salt, clay diffusion, granite fracture flow)*
- *Perform simulations of selected reference cases*
  - *Demonstrate simulation and sensitivity analysis capabilities*
  - *Inform R&D planning*

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FCAWG Disposition Subgroup – Task #8, "Borehole Research"

Task 8: Borehole Research – Collaboration on planned deep borehole disposal research (FY2013~FY2018)

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Background

UFDC has considered the DBD as one of alternatives for the mined repository and ROK has requested to evaluate the applicability of the DBD concept as an alternative for final disposal of selected radioactive wastes.

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FCAWG Disposition Subgroup – Tasks 2-1, 2-2, 2-3 and 3

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Task 2-1: ***Engineered and Natural barrier systems databases (FY2012~FY2017)***
To share the geological data for the granite and various experimental data in the granite environment, and to collaborate on the performance of engineered and natural barrier systems

Task 2-2: Robust material for disposal system for spent fuel (FY2013~FY2018)
The major purpose of this task is to share the experience, experimental data and modeling techniques for selecting the appropriate materials for engineered barrier systems, which will help enhance the confidence in developing a mined repository system.

Task 2-3: Natural System Evaluation – Joint field testing and modeling to support the study of high level waste disposal in crystalline geologic media (KURT) (FY2013~FY2018)
Practical and joint use of KURT as a generic underground research laboratory to understand key technical issues related to granite repository concept development. Joint field testing and modeling to support the study of high level waste disposal in crystalline geologic media

Task 3: Spent Fuel Degradation (dates not specified)
R&D focusing on the long term durability of SNF over geological time.

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FCAWG Systems Evaluation Subgroup

- **Status of System Evaluation Subgroup**
  - System evaluation subgroup has exchanged technical information and materials through several working group meetings
    - US side provided VISION program for nuclear fuel cycle simulation and other material including research report on spent nuclear fuel management in the U.S.
    - KAERI provided several reports including dynamic fuel cycle model and preliminary cost estimation on pyroprocessing facility.
- **Action on regarding economic feasibility study**
  - Direction (at 5th Steering Committee Meeting)

"A discussion was also held regarding options to most appropriately study the economic feasibility, and this issue will be further discussed and reported on by the working groups at following the Technical Coordinating Committee and Steering Committee meetings"

  - Korean side (Mr Ko) proposed overall frame and approach for the economic feasibility study at the ERWG/SSWG joint meeting held in Jeju on April 22, 2015
  - US side (Mr F. Ganda and R. Weigeland) presented the economic analysis capability of the FCO(Fuel Cycle Option) Campaign at the previous ERWG/SSWG joint meeting held in INL on August 19, 2015.

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FCAWG Storage and Transportation Subgroup – Background

The Storage and Transportation Subgroup has met regularly as part of the JCFS:

- WG meeting at Sandia National Laboratories, June 5-7, 2012
- WG meeting in Washington DC, July 2013
- WG meeting in Gyeongju, November 2013
- WG meeting at Pacific Northwest National Laboratory, June 2014
- WG meeting in ROK at Jeju Island, April 2015

Detailed discussions from both sides regarding on-going research activities were presented.

Priorities of research and collaborations have been discussed at each WG meeting.

Priorities discussed have evolved over time. Identified priorities from 2013 and 2014 meetings are…..

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FCAWG Storage and Transportation Subgroup – Background

2013 Identified task priorities:

- Canister corrosion/SCC
- Cladding Investigation
- Transportability
- Aging Management
- Monitoring/Inspection Technologies

2014/2015 Identified task priorities:

- Canister corrosion/SCC
- Cladding Investigation:
  - Low burnup (KAERI) & High burnup (DOE)
- Storage thermal and structural analysis
- ~~Centralized storage siting and planning~~
- Transportability
- Aging Management
- Demonstration Programs
- Monitoring/Inspection Technologies
- Stronger collaborations (i.e., beyond exchange of technical reports)

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FCAWG Storage and Transportation Subgroup – Increased Collaboration

KAERI researchers on scientific exchange to US National Laboratories

- Dr. Ki-seog Seo is at Sandia National Laboratories for one year using ABACUS to perform finite element analyses on fuel under loads/transport
- Dr. Donghak Kook is at Idaho National Laboratory for one year examining cladding issues and waste forms other than commercial spent nuclear fuel

Proposed joint US/ROK project in the future

- Each country to share their gap analyses and prioritizations
- Determine an area of mutual interest of high priority
- Develop a joint research plan

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Closing Remarks

- Next FCAWG meeting was scheduled for June, 2016 in Las Vegas, Nevada USA. To be in conjunction with annual DOE NE UFD WG meeting, held at UNLV Science and Engineering facilities.