Some quotes and assumptions from the INL-KAERI Joint Fuel Cycle Study Report

Technical Feasibility

"Laboratory Scale Feasibility Study: The series of process operations were demonstrated at laboratory scale with approximately 100 grams of irradiated LWR fuel. A series of mixed uranium and transuranium (U/TRU) metal products were recovered that had acceptable concentration ratios.

"Integrated Recycling Test: The engineering scale IRT demonstrated that U/TRU metal can be recovered from irradiated oxide fuel, resulting in recyclable products and robust waste forms. The performance and integrity of metal fuel fabricated with these recycled products was examined through irradiation tests and PIE. The successful tests using irradiated fuels provided key parameters necessary to assess the technical feasibility of electrochemical recycling."

Economics

"Table 1. **Unit costs for the JFCS's reactor modules from the AFC-CBR** (2020 USD)

Cost	**Module**	**Units**	**Low**	**Mode**	**High**	**Mean**	**Probability distribution Function** (PDF)
PWR (overnight capital)	R1	$/kWe	2,601	4,523	6,559	4,561	Triangular
PWR (O&M, fixed component)	R1	$/kWe-yr	66	79	95	80	Triangular
PWR (O&M, variable component)	R1	$/kWh	0.0009	0.0021	0.0029	0.0020	Triangular
Fast Reactor (overnight capital)	R2	$/kWe	2,488	5,202	7,916	5,202	Triangular
Fast Reactor (O&M, fixed component	R2	$/kWe-yr	71	83	101	85	Triangular
Fast Reactor (O&M, variable component)	R2	$/kWh	0.0012	0.0024	0.0032	0.0023	Triangular
PHWR (overnight capital)	R5	$/kWe	2,488	4,410	6,332	4,410	Triangular
PHWR (O&M, fixed component)	R5	$/kWe-yr	66	79	95	80	Triangular
PHWR (O&M, variable component)	R5	$/kWh	0.0009	0.0021	0.0029	0.0020	Triangular

“Table 2. **Unit costs for the JFCS’s fuel cycle modules from the AFC-CBR** (2020 USD)

Fuel cycle cost	Module	Units	Low	Mode	High	Mean	PDF
Natural Uranium Mining and Milling	A1	\$/kgU	36	89	309	145	Triangular
Conversion	B	\$/kgU	5.94	11.89	17.83	11.89	Triangular
Enrichment	C1	\$/SWU	125	144	163	144	Triangular
PWR Fuel Fabrication	D1-1	\$/kgHM	226	396	565	396	Triangular
PHWR Fuel Fabrication	D1-7	\$/kgHM	130	226	339	232	Triangular
Metal Fuel Fabrication	D2	\$/kgHM	1,050	1,471	1,891	1,471	Triangular
Recycled Product Storage	E3	\$/kgHM	711	949	1,294	985	Triangular
Managed Decay Storage	E4	\$/kgCs-Sr	11,889	26,751	41,612	26,751	Triangular
Echem Separation and Metal Fuel Fab	F2/D2	\$/kgHM	2,101	2,731	3,361	2,731	Triangular
Echem Separation	F2	\$/kgHM	1,050	1,261	1,471	1,261	Triangular
HLW Conditioning and Packaging	G1-2E	\$/kgFP	14,285	17,953	21,546	17,928	Triangular
SF Conditioning and Packaging	G2	\$/kgHM	59	119	155	111	Triangular
LLW-A,B,C Conditioning and Packaging (solids)	G3-1	$\$/m^3$	1,189	1,783	4,993	2,655	Triangular
LLW-A,B,C Conditioning and Packaging (liquids)	G3-1	$\$/m^3$	3,923	13,078	26,156	14,386	Triangular
LLW-A,B,C Conditioning and Packaging (resins)	G3-1	$\$/m^3$	96,303	107,003	117,704	107,003	Triangular
LLW-GTCC Conditioning and Packaging (off-gas)	G4-1E	$\$/m^3$gas	9,511	13,316	17,834	13,554	Triangular
LLW-GTCC Conditioning and Packaging (TRU)	G5	$\$/m^3$	22,590	32,101	43,990	32,894	Triangular
Consolidated Interim Storage	I	\$/kgHM	232	520	634	462	Triangular
Near-Surface Disposal	J	$\$/m^3$	535	1,486	2,972	1,664	Triangular
DU Storage	K1-1	\$/kgHM	4.52	6.78	9.05	6.78	Triangular
DU Disposition	K1-2	\$/kgHM	9.05	20.35	54.28	27.89	Triangular
RU Storage	K3	\$/kgU	30	37	119	62	Triangular
RU Disposition	K3	\$/kgU	89	111	178	126	Triangular
HLW Deep Geologic Repository	L1	\$/kgHM	1,557	6,219	7,780	5,185	Triangular
SF Deep Geologic Repository	L1	\$/kgHM	300	622	906	609	Triangular
GTCC Intermediate Depth Disposal	L2	$\$/m^3$	2,409	3,989	5,568	3,989	Triangular

“Table 17. **Comparison of throughput and loss for the PWR once-through cycle and PWR pyro-SFR cycle**

Fuel Cycle Stage	**PWR OT cycle** [t-iHM/yr]		**PWR pyro-SFR cycle** [t-iHM/yr]	
	Throughput	**Loss**	**Throughput**	**Loss**
NU mining & milling	153.26	0	153.26	0
Conversion	153.26	0.15	153.26	0.15
Enrichment	153.11	0	153.11	0
DU disposal	136.5	0	136.5	0
PWR fuel fabrication	16.61	0.02	16.61	0.02
PWR SF conditioning & packaging	0	0	16.59	0
PWR SF interim storage	16.59	0	0	0
PWR SF disposal	16.59	0	0	0
PWR SF pyro	0	0	16.59	0.92
PWR SF pyro product storage	0	0	15.68	0
SFR SF pyro	0	0	3.24	0
SFR SF pyro product storage	0	0	2.89	0.35
RU disposal	0	0	15.31	0
SFR fuel fabrication	0	0	3.26	0

“Table 18. **Cost breakdown of the LCOE of total cost for the PWR OT cycle and PWR pyro-SFR cycle**

	PWR OT Cycle	**PWR pyro-SFR cycle**
Reactor capital cost [mills/kWh]	15.79	16.83
Reactor O&M cost [mills/kWh]	12.71	13.05
Front-end cost [mills/kWh]	6.76	4.38
Back-end cost [mills/kWh]	2.31	5.57
Total cost [mills/kWh]	37.57	39.83

Nonproliferation

“Material balance was evaluated using experimental and calculated values, with material unaccounted for and related uncertainty within the expected levels based on the analysis methods.”

“Conventional C/S measures such as optical surveillance and radiation portal monitors are expected to be directly applicable to a pyroprocessing facility, although implementing these C/S measures will require implementing safeguards by design from the earliest design stages.”

“The ER voltammetry probe was tested in the ER and was able to provide quantification of U and Pu concentrations with relative standard deviations less than 1%.”

“Based on U.S. and ROK safeguards performance models, and the performance of DA measurements in the study, a 30 MT/yr facility may be able to meet IAEA detection goals for abrupt material loss of a significant quantity.”

“With “best-case” measurement uncertainties and more frequent material balances, the IAEA goals may be achieved for facility sizes approaching about 200 MT/yr.”