

# ***PYROMETALLURGICAL WASTE STREAMS AND WASTE FORM DEVELOPMENT FROM THE TREATMENT OF USED OXIDE FUEL***

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## ***Echem Waste Stream Flowsheet***

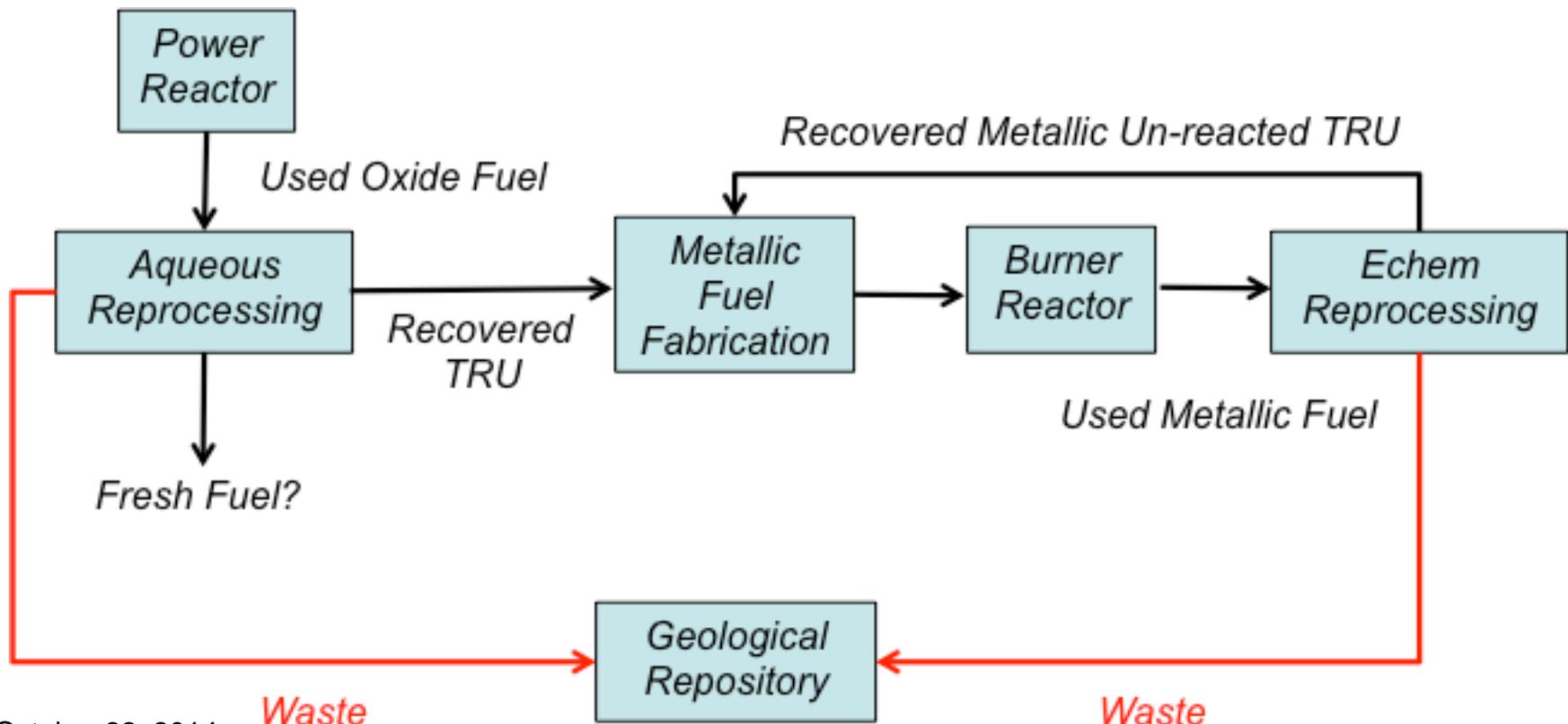
- Evaluation of waste stream treatment and waste forms developed for pyrometallurgical/electrochemical (Echem) treatment of used oxide fuel
- Waste stream process flowsheet developed to estimate mass and volumes of waste streams/waste forms

# Waste Forms Evaluated

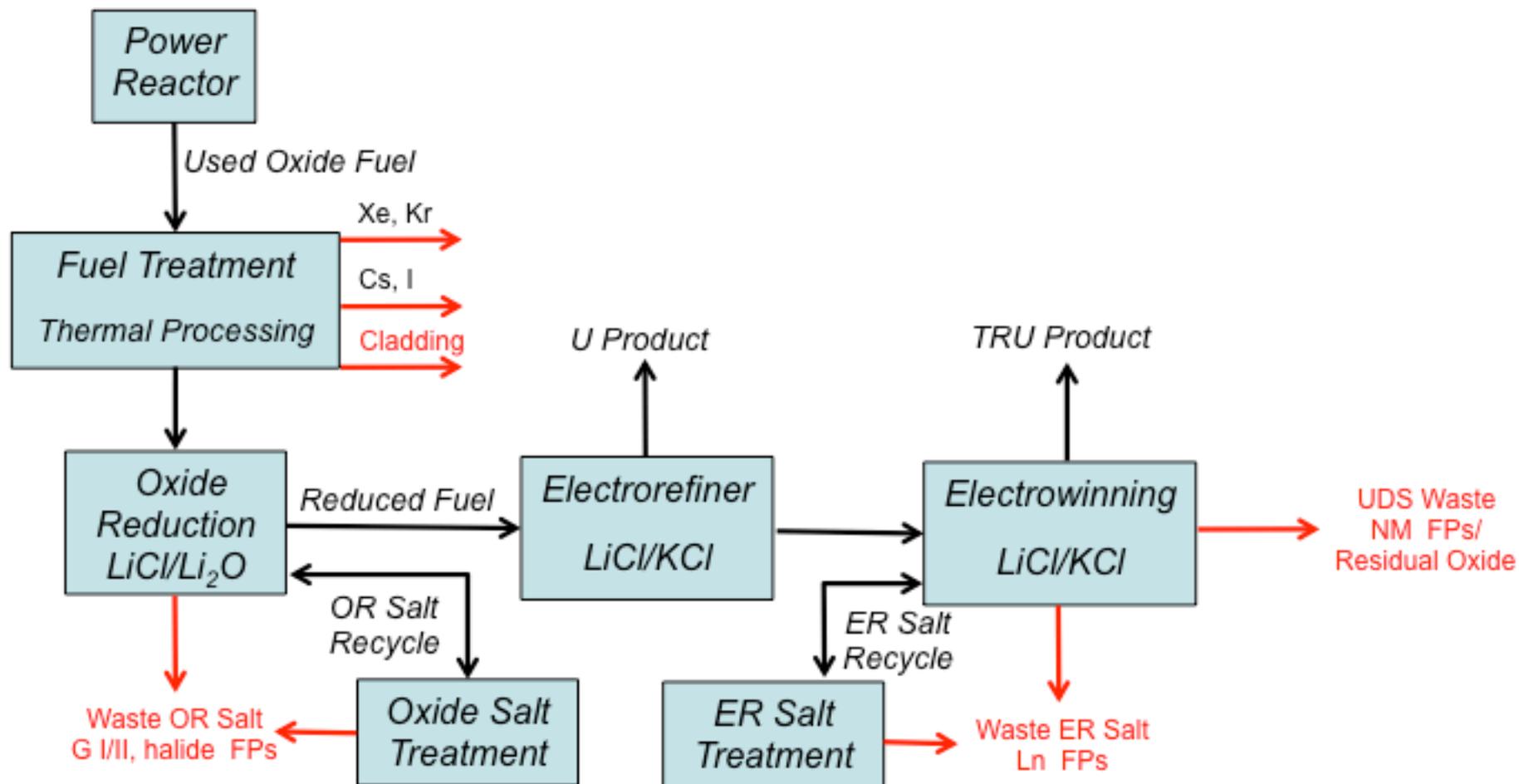
- Ceramic Waste Form (Baseline Waste Form)
  - Glass-bonded sodalite developed at ANL
  - All fission products incorporated in mineral or as oxide/oxychlorides in glass phase
  - Waste loading in this study: 10 wt% chloride loading
- Tellurite-Glass Waste Form
  - TeO<sub>2</sub>-PbO glass developed at PNNL
  - TeO<sub>2</sub>-PbO glass with a high solubility for metal halides
  - Waste loading for this study: 10 wt% chloride loading
- SAP Waste Form
  - SiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub>-P<sub>2</sub>O<sub>5</sub> ceramic developed at KAERI
  - Incorporate all metal fission products as metal aluminosilicates or metal phosphates
  - Waste loading for this study: 33 wt% chloride loading
- ZIT Waste Form
  - Phosphate-based ceramic developed at KAERI
  - Zinc Titanate (Zn<sub>2</sub>TiO<sub>4</sub>)-CaHPO<sub>4</sub>-SiO<sub>2</sub>-B<sub>2</sub>O<sub>3</sub> where Ln fission products form LnPO<sub>4</sub> monazite-like host phases
  - Waste loading for this study: 40 wt% waste loading
- Alloy Waste Forms
  - Stainless steel-15Zr or Zr-8SS waste forms developed at ANL
  - Nobel metal fission products partition between Fe-solid solution and FeZr<sub>2</sub> intermetallic phases
  - Waste loading for this study: 4 wt% noble metal

# US Advanced Closed Fuel Cycle

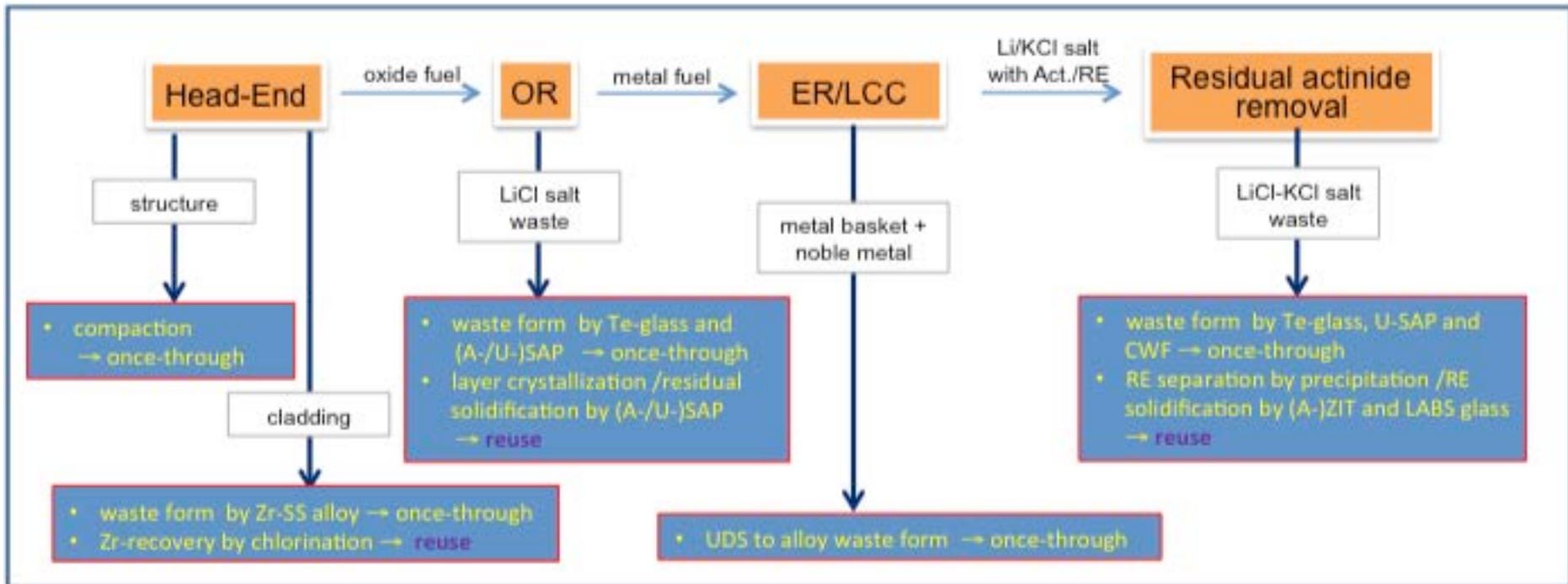
- Overall objectives: produce power, minimize waste generation
- First hole (repository) very expensive; however, second hole or expanded hole perhaps not so expensive (experience with Waste Isolation Pilot Plant)
- Ultimately economic/public safety of TRU recovery – transmutation will be compared to direct disposal in geological repository



# Echem Processing of Used Oxide Fuel



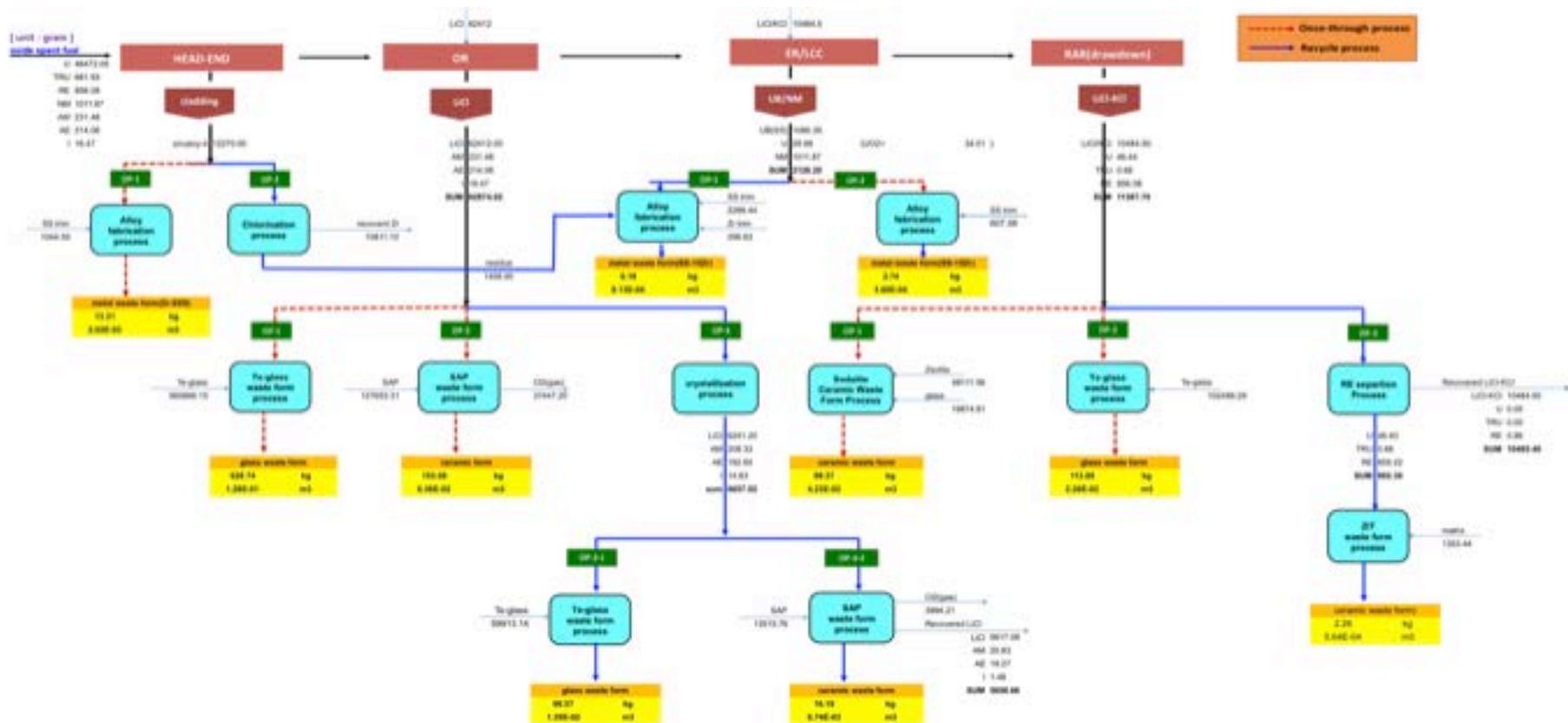
# Echem Waste Stream Treatment and Waste Forms



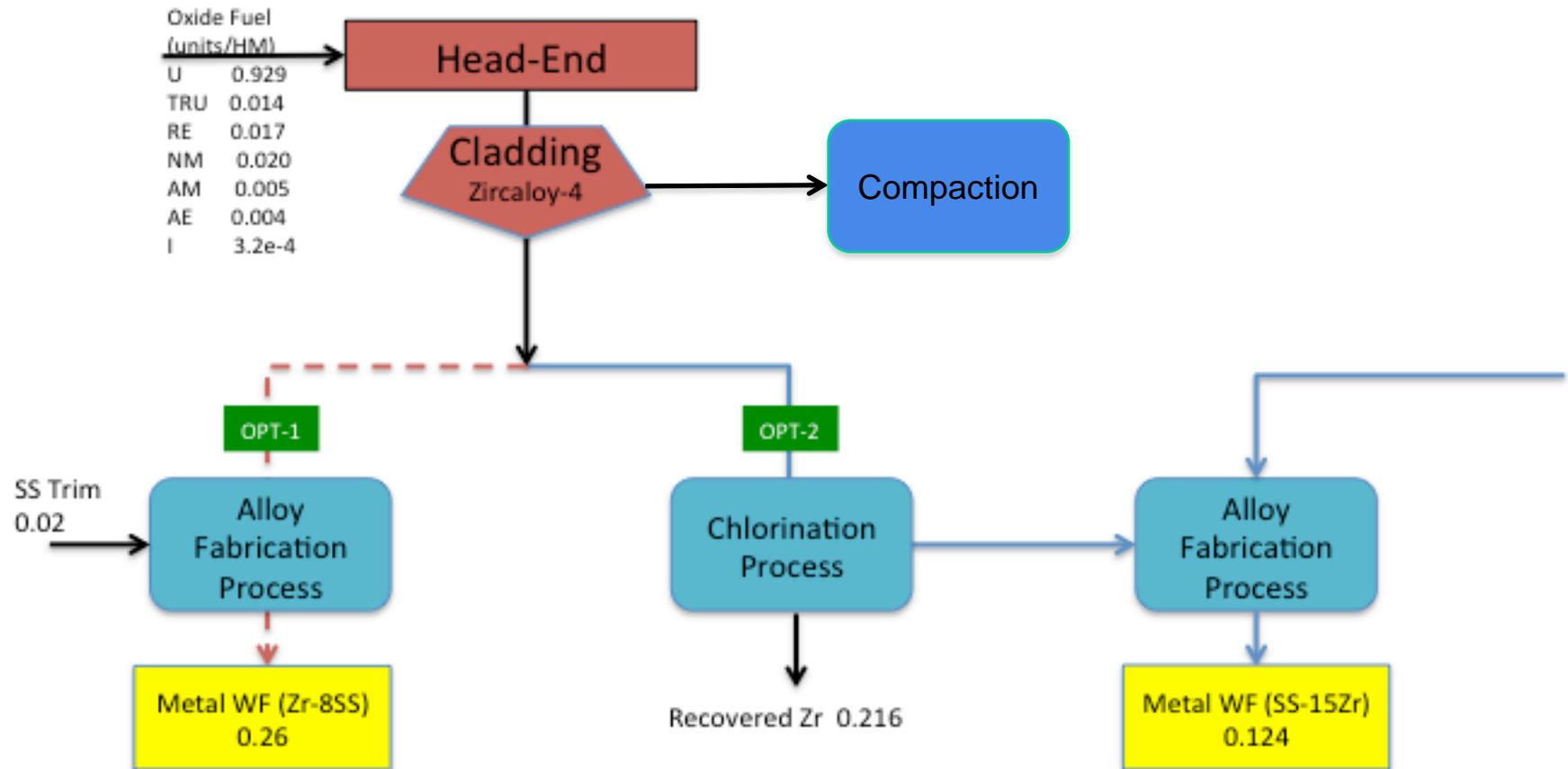
## Assumptions

- fuel: 1 unit (4.5wt%-U235, 55,000 MWD/MTU, 10yr-cooling)
- salt: 0.4 unit-OR salt, 0.2 unit-eutectic ER salt
- ideal pyroprocessing: no loss
- no high temperature treatment in head-end process
- FPs in LiCl salt: G-I/II, Eu, I, Te
- FPs in LiCl-KCl salt: RE, actinides (after RAR process, < 100ppm )
- NM (Tc): in basket
- Mass flow group: AM, AE, RE, U, TRU, NM(Tc), FP(I, Te)

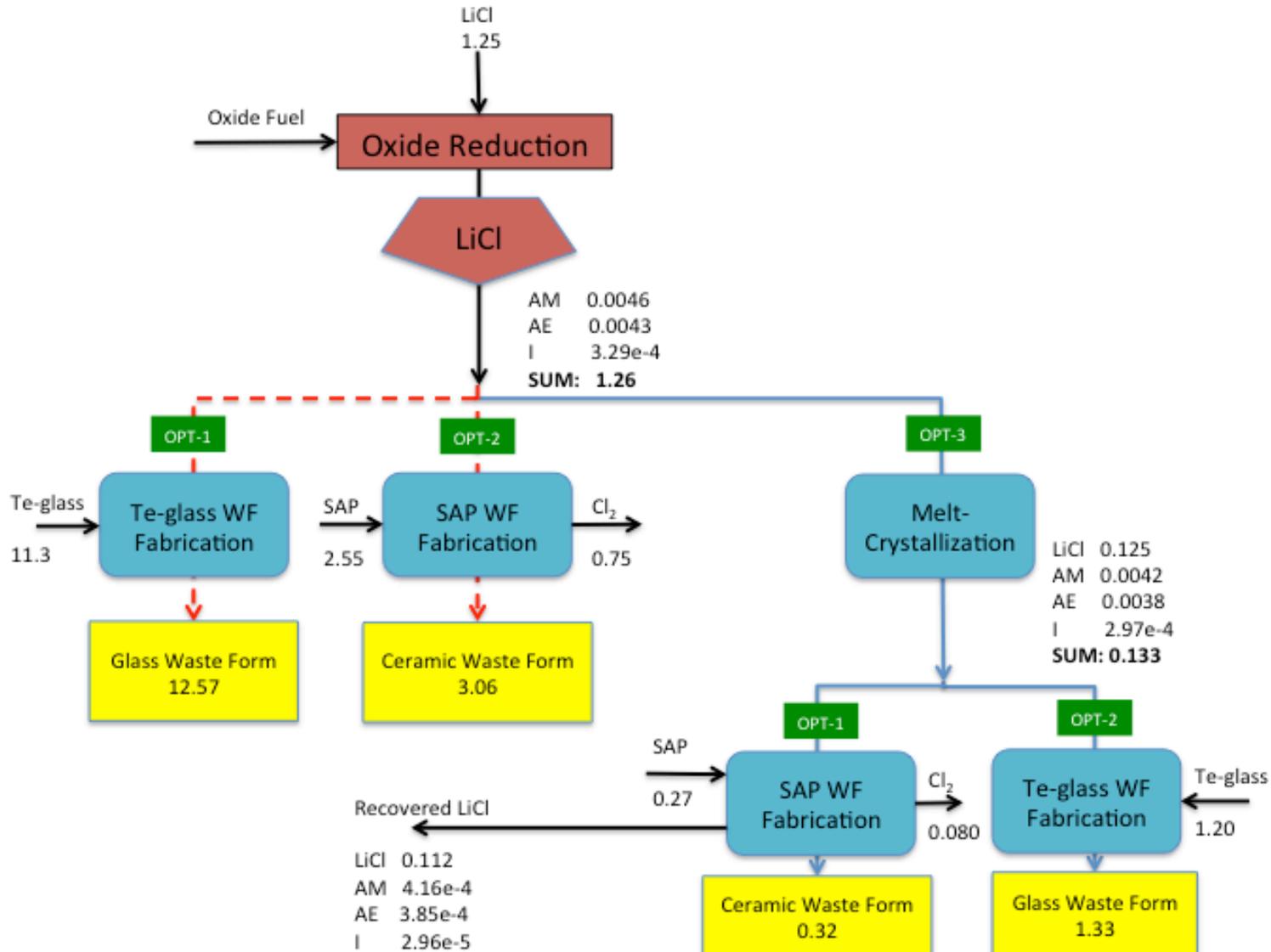
# Echem Waste Stream Flowsheet



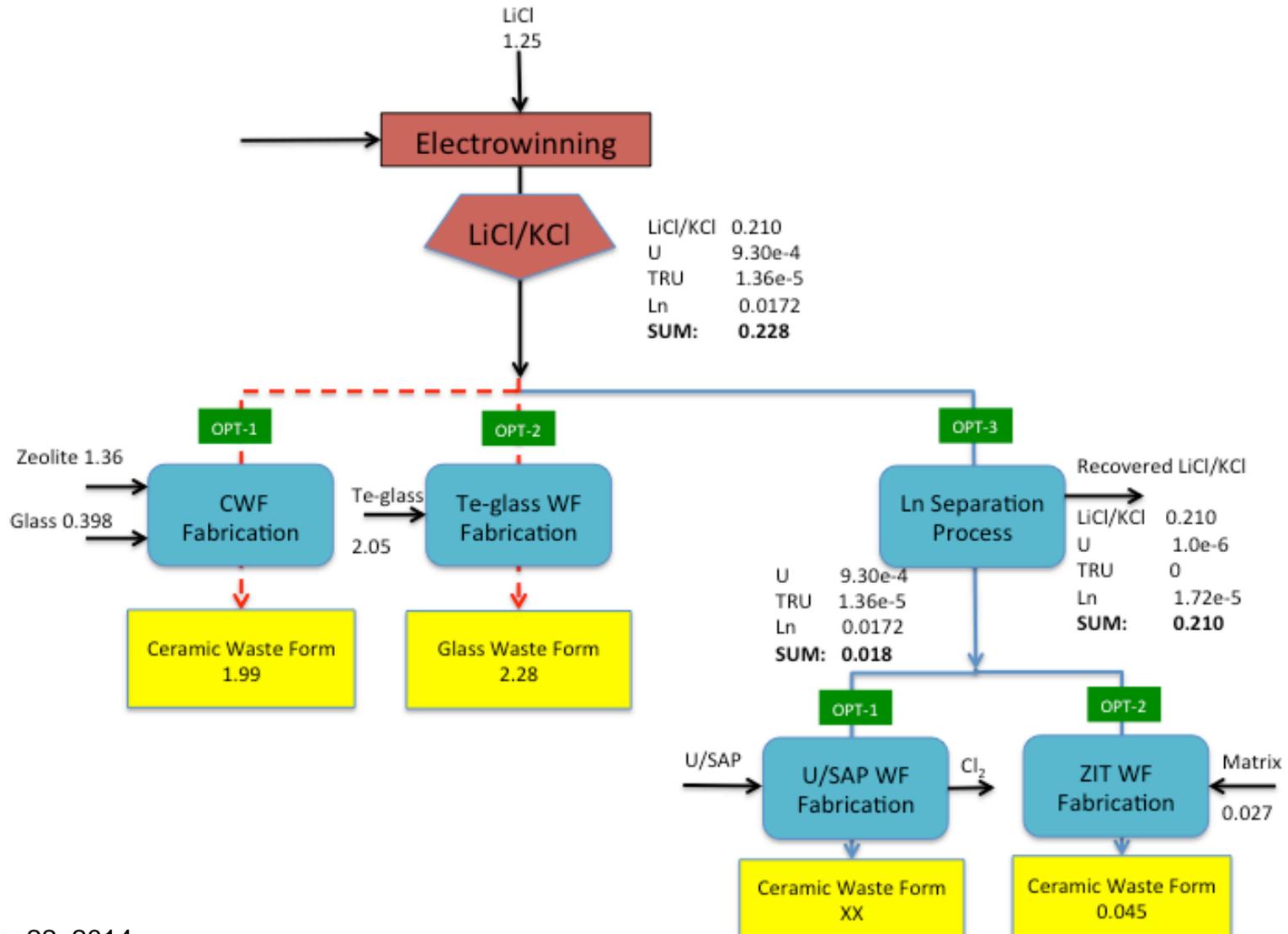
# Cladding Treatment



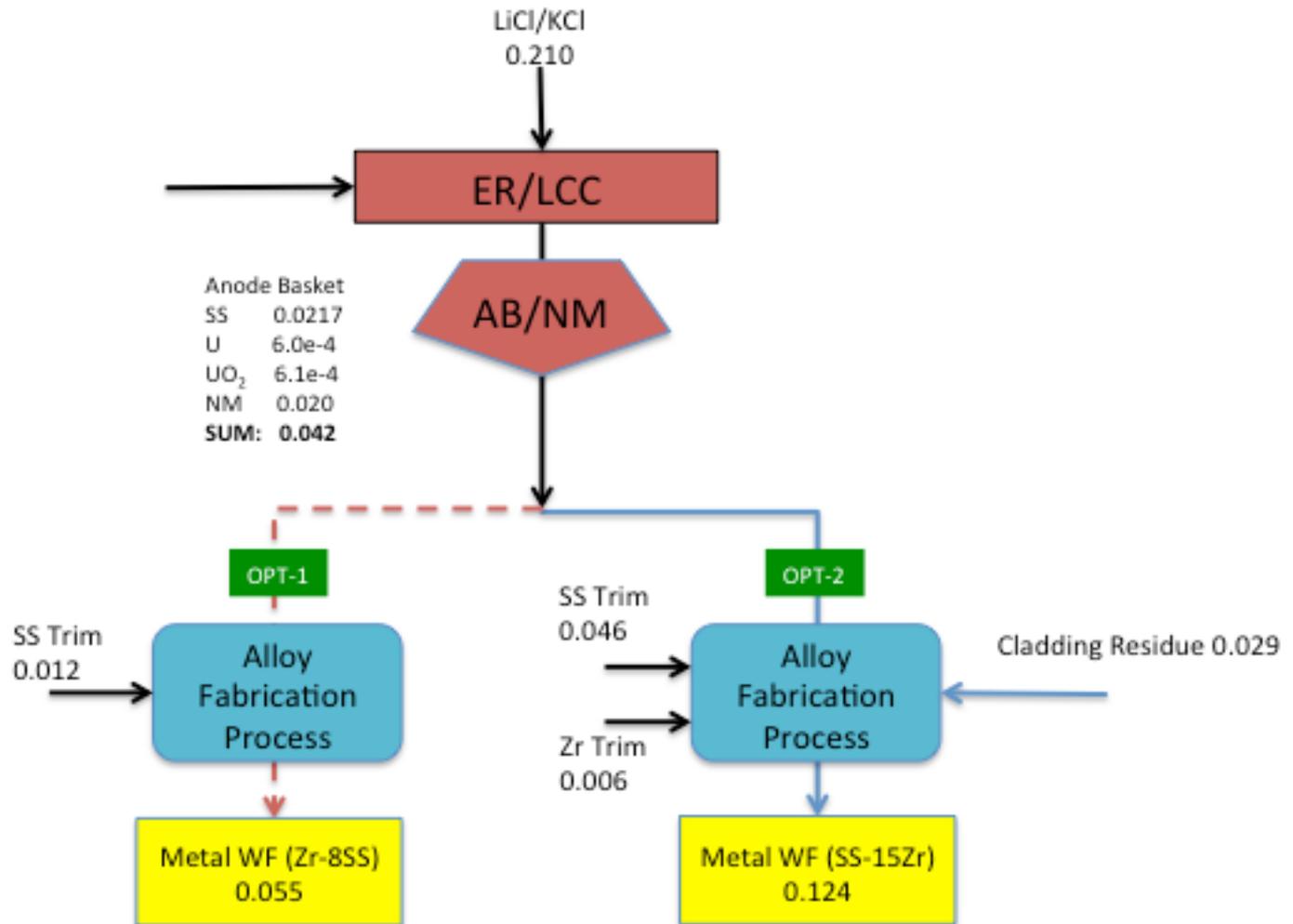
# OR Salt Treatment



# ER Salt Treatment



# UDS Treatment



# Summary of Waste Form Mass and Volume For Treatment of 100 kg Used Oxide Fuel

waste	waste form	once through		recycle	
		kg	m3	kg	m3
cladding	metal(Zr-8SS)	26.6	0.004		
OR salt	Te-glass	1257	0.256		
	SAP	306	0.128		
	Te-glass			133	0.028
	SAP			32.4	0.014
ER salt	CWF	200	0.084		
	Te-glass	228	0.043		
	ZIT			4.52	0.0012
UB/NM	metal(SS_15Zr)	5.48	0.0008	12.4	0.0016

once-through				recycle			
max		min		max		min	
kg	m3	kg	m3	kg	m3	kg	m3
1517	0.304	537	0.217	150	0.031	49.2	0.017

