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Electrochemical Processing of Used Fuel

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Introduction

- **Principles followed in establishing the used LWR & FR fuel treatment processes**
  - Industrially practicable and economic
  - Safeguardable system that meets U.S. non-proliferation objectives
  - Maximize actinide recovery to maximize resource utilization and enhance repository performance
  - Encapsulate fission product waste in engineered waste forms that can be disposed in an environmentally responsible manner; approach also enhances repository performance
  - Minimize secondary waste production

- **Flowsheet consists of five functional areas**
  - Head-end operations
  - Oxide to metal conversion
  - Actinide and fission product separations
  - Material recycle
  - Waste Management

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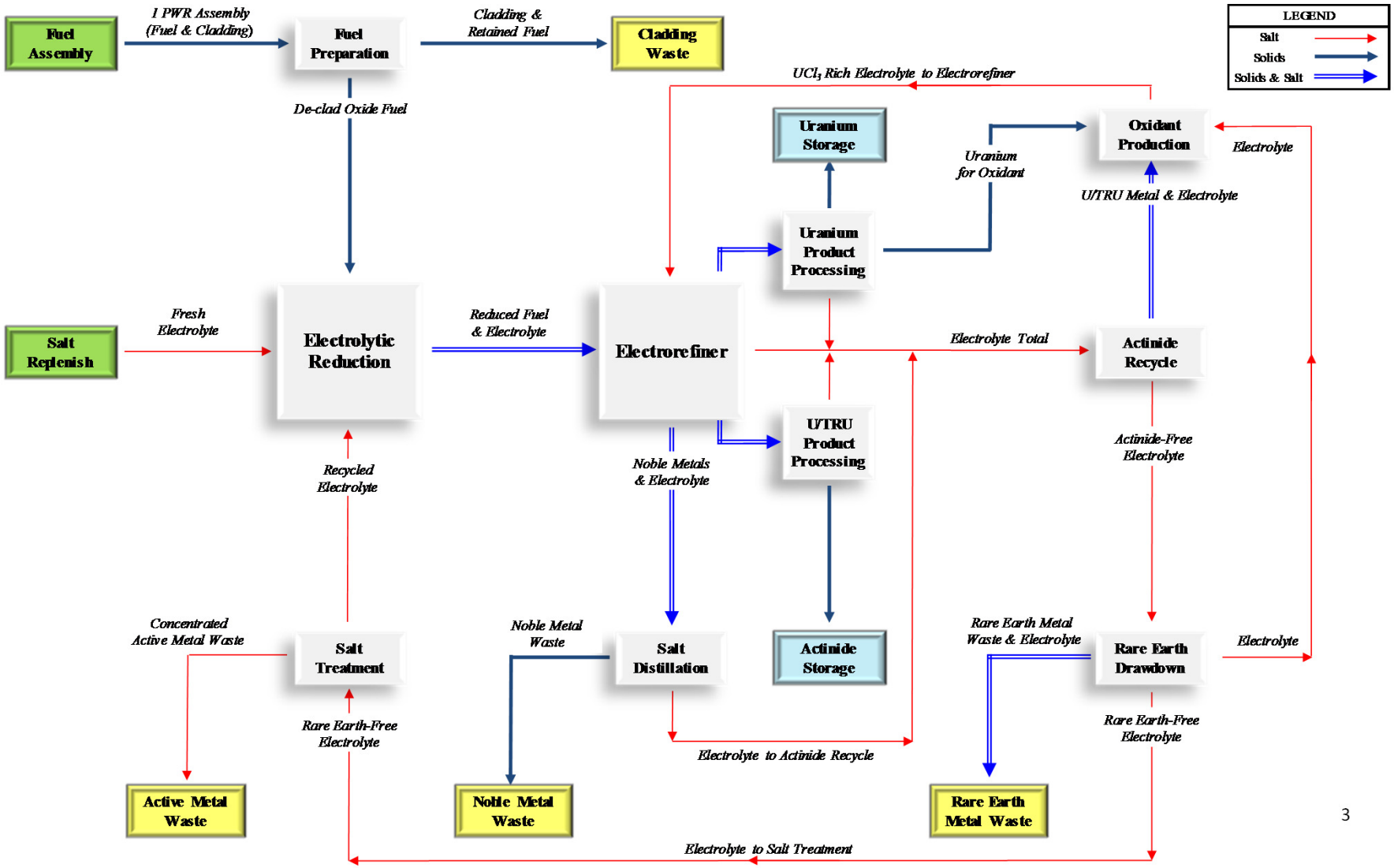
Example Flowsheet for Treatment of Used Fuel



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Types of Process & Facility Monitoring

- **Process operational parameters**
  - Process cell atmosphere monitoring and control
  - Temperature monitoring and control
  - Leak detection
  - Position sensing
  - Remote handling
  - Remote maintenance
  - Commercial, off-the-shelf technology
- **Process equipment parameters**
  - High current, low voltage power system
  - Electrode potentials vs. reference electrode
  - Amount of charge passed
  - Salt level and density (or masses) in equipment and in transfer operations
  - Amount of salt removed/added
  - Composition of molten salt (sampled and real-time)
    - *Electroanalytical methods – CV, SWV, CA, DP, ASV, etc*
    - *Spectroscopic methods – UV-Vis, LIBS, etc*
  - Gas flow rates
- **Process streams/products**
  - Composition of molten salt (sampled and real-time)
    - *Electroanalytical methods – CV, SWV, CA, DP, ASV, etc*
    - *Spectroscopic methods – UV-Vis, LIBS, etc*
  - Composition of U and U/TRU product
  - Off-gas composition
- **NDA analysis**
  - Composition of initial used fuel feed material
  - Composition of material transfers to waste processing (i.e. actinide-free)

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Electroanalytical Monitoring of Process Salts

- **Examined several electroanalytical methods for monitoring U and TRU in process salt**
  - Square wave voltammetry, chronoamperometry, differential pulse voltammetry, cyclic voltammetry
- **For quantitative measurements, electrode area must be fixed or controlled**
  - Successfully used standard addition of electrode area by controlled changes in immersion depth
  - Plot of i_{peak} vs Δh gives line with slope corresponding to concentration
  - Improve statistics with multiple measurements at multiple immersion depths to ~1% RSD
- **Most promising technique to date is cyclic voltammetry**
  - Gives linear response over typical concentration range
  - Peak current is proportional to concentration
  - Results are in good agreement with chemical analysis
  - Semi-differential treatment improves baseline resolution of reduction peaks

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