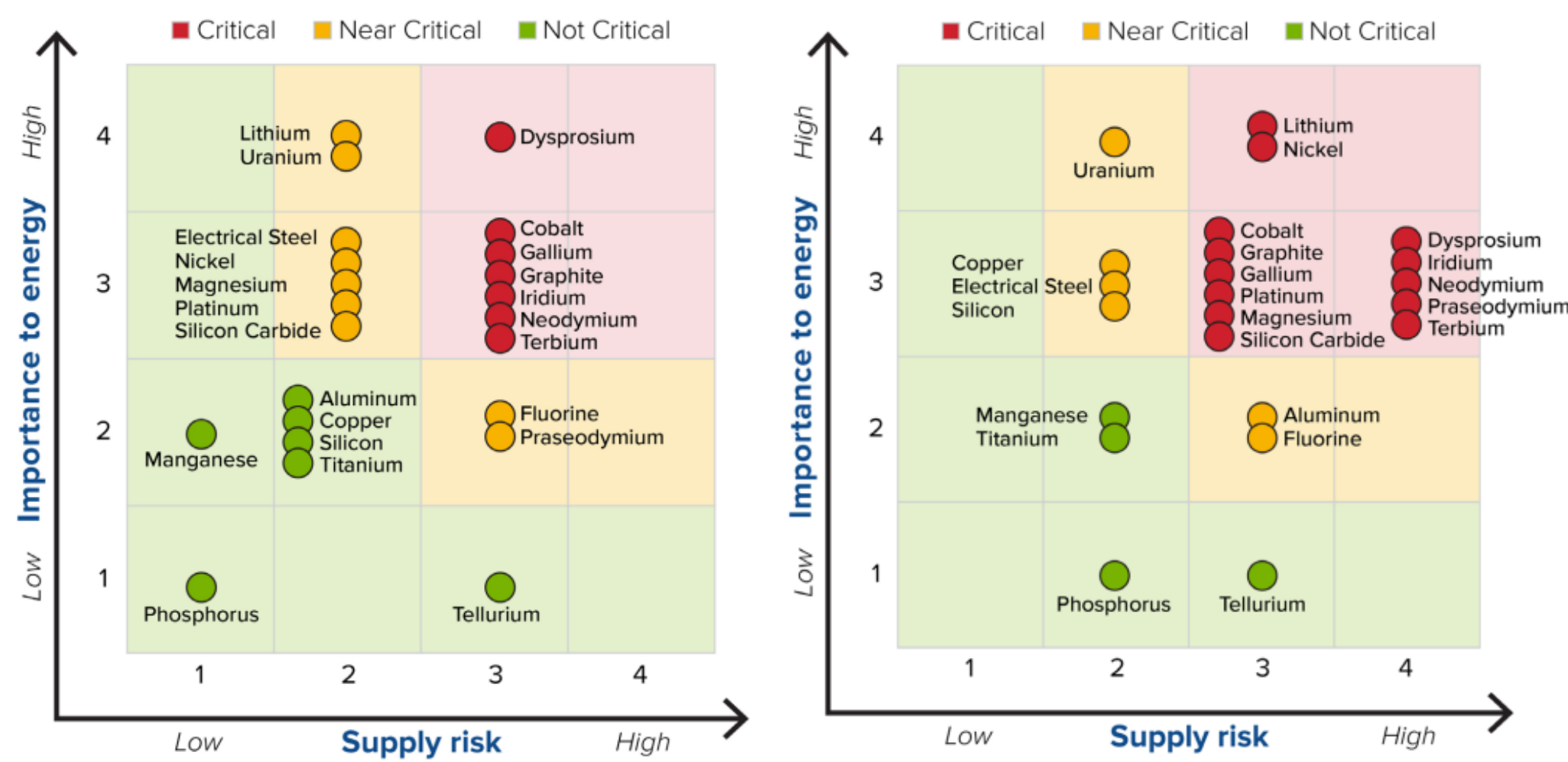


Critical Minerals

- The global effort to curb carbon emissions is accelerating demand for clean energy technologies and critical minerals they rely on
- Provide essential and specialized properties while having no easy substitutes
- Are assigned as critical by the Secretary of the Interior
- The estimated value of rare-earth compounds and metals imported by the United States in 2022 was \$200 million^[2]

SHORT TERM 2020-2025

MEDIUM TERM 2025-2035



Case Study

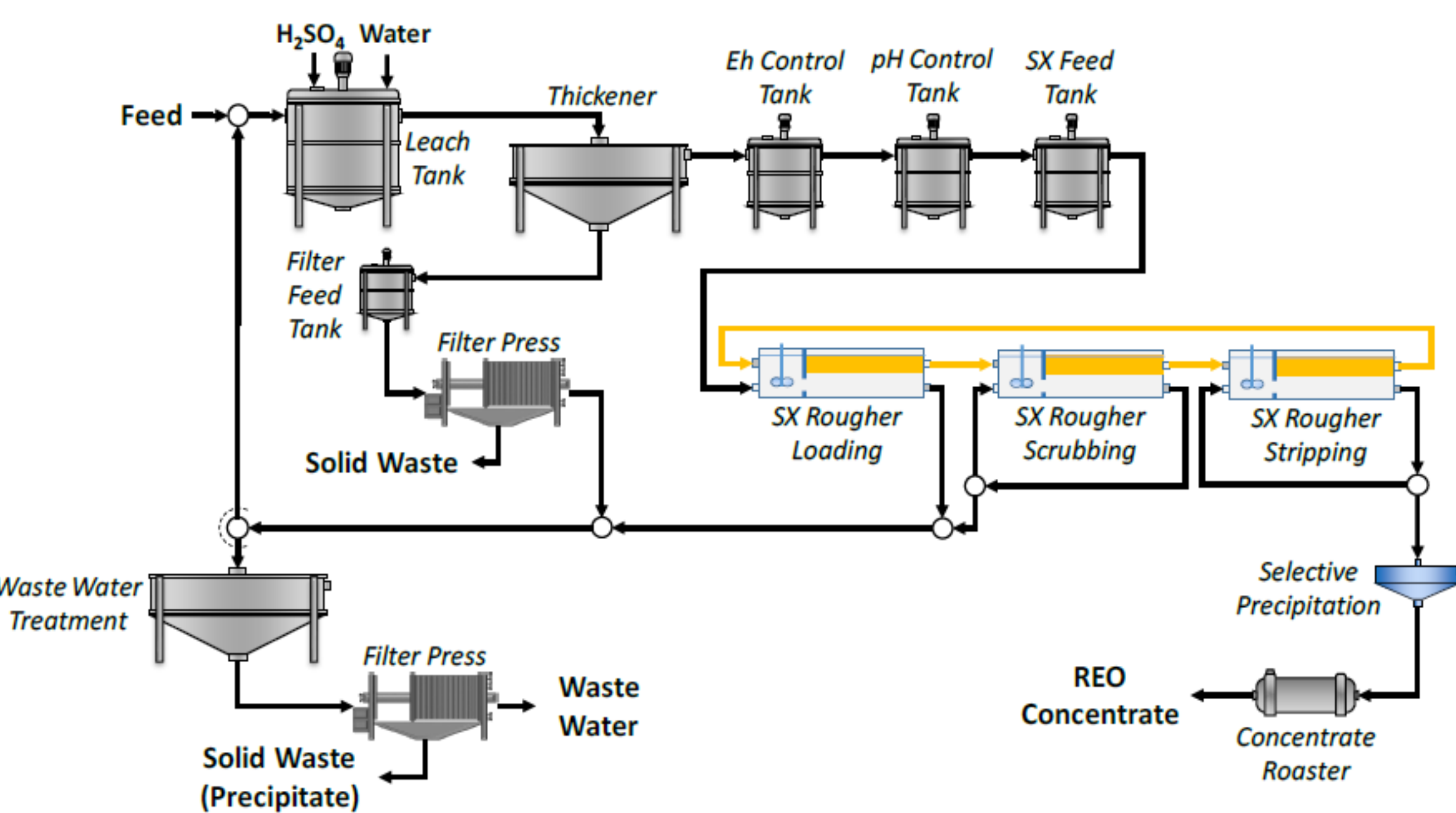
University of Kentucky pilot plant:

Objective:

- Recovery of Rare earth elements (REE) from coal and coal byproducts in a cost-effective and environmentally benign manner

Feed:

- Two distinctly different coarse refuse materials (i.e., West Kentucky No. 13 and Fire Clay coal seams).
- Three secondary sources (i.e., heap leach process and naturally formed acid mine drainage system).



Flowsheet of the pilot-scale leaching and solvent extraction circuits^[3]

Unit Models Developed

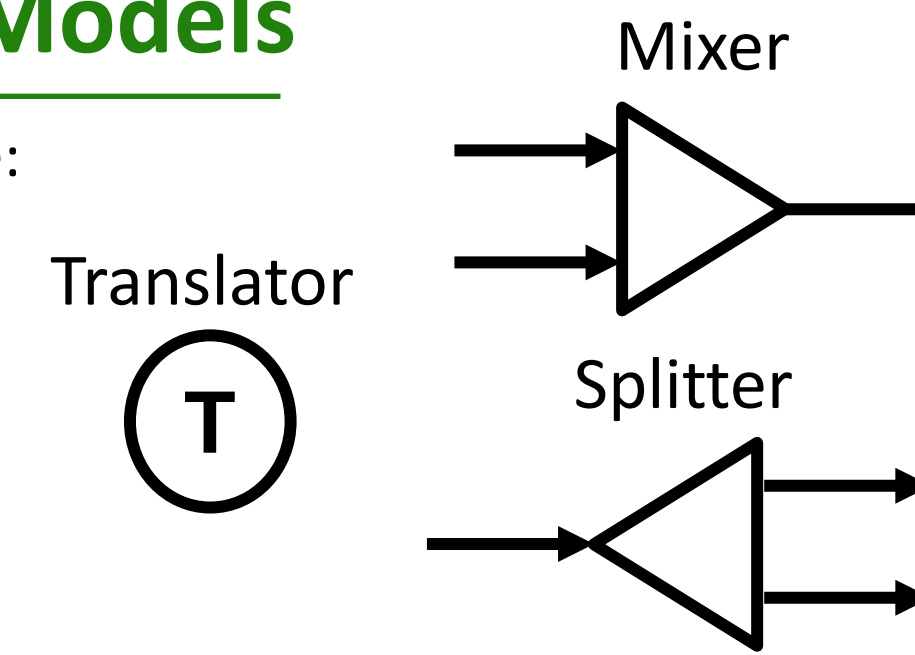
PrOMMiS flowsheet objective:

Create a flowsheet to utilize advanced equation-oriented (EO) modeling capabilities

- Conceptual Design
- Design of Experiments
- Uncertainty Quantification
- Detailed Process Optimization

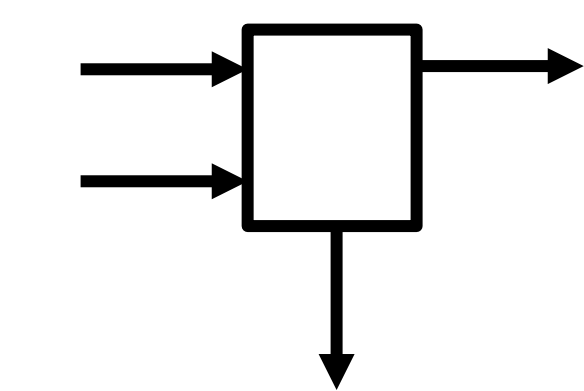
IDAES Existing Models

- PrOMMiS leverages existing IDAES infrastructure:
- Flowsheet
- Control volume block
- Properties class
- Arcs and ports (streams connecting unit models)
- Existing unit models
- Feeds and products



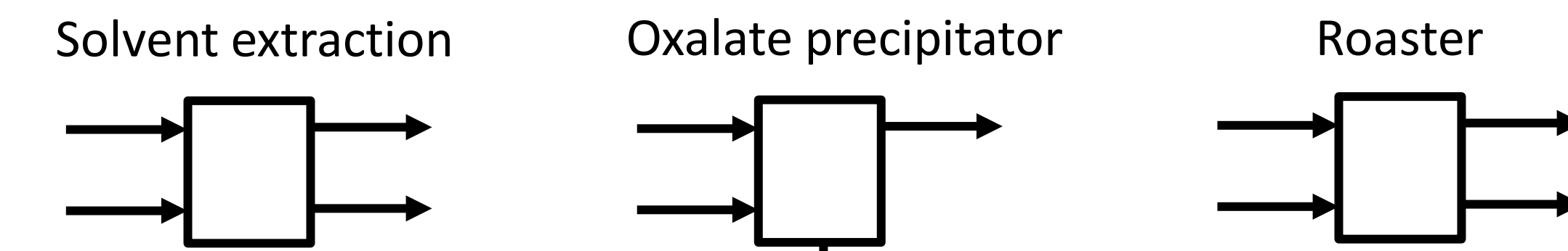
PrOMMiS General Models

Multi-stream contactor



- General purpose model for unit operations involving mass and energy transfer between multiple immiscible streams.
- Provides a general framework for writing each stream's necessary material, energy, and momentum balances and includes terms for inter-stream transfer phenomena.
- The model also supports modeling these systems as a series of finite elements

PrOMMiS Process-Specific Models



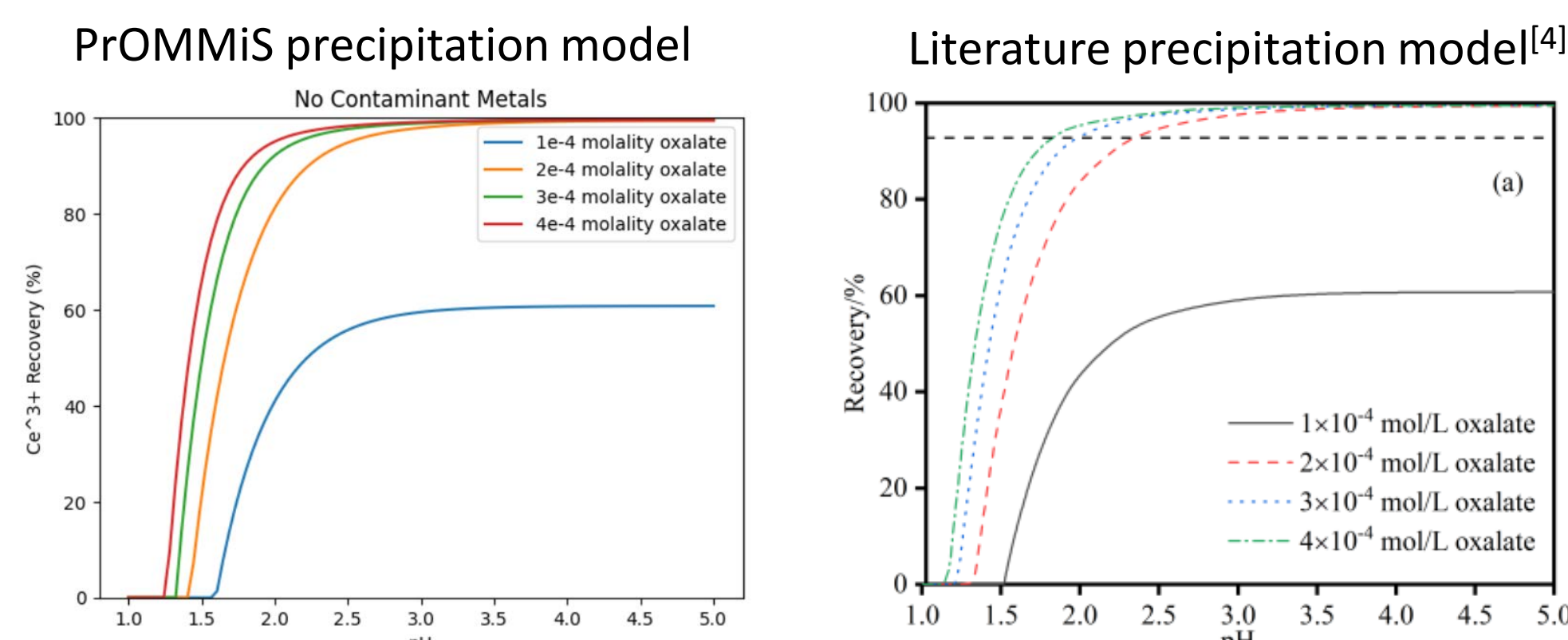
Property models:

- Leaching (leach solution, solid coal), oxalate precipitate (aqueous and precipitate), roasting (gas), solvent extraction (aqueous and organic)

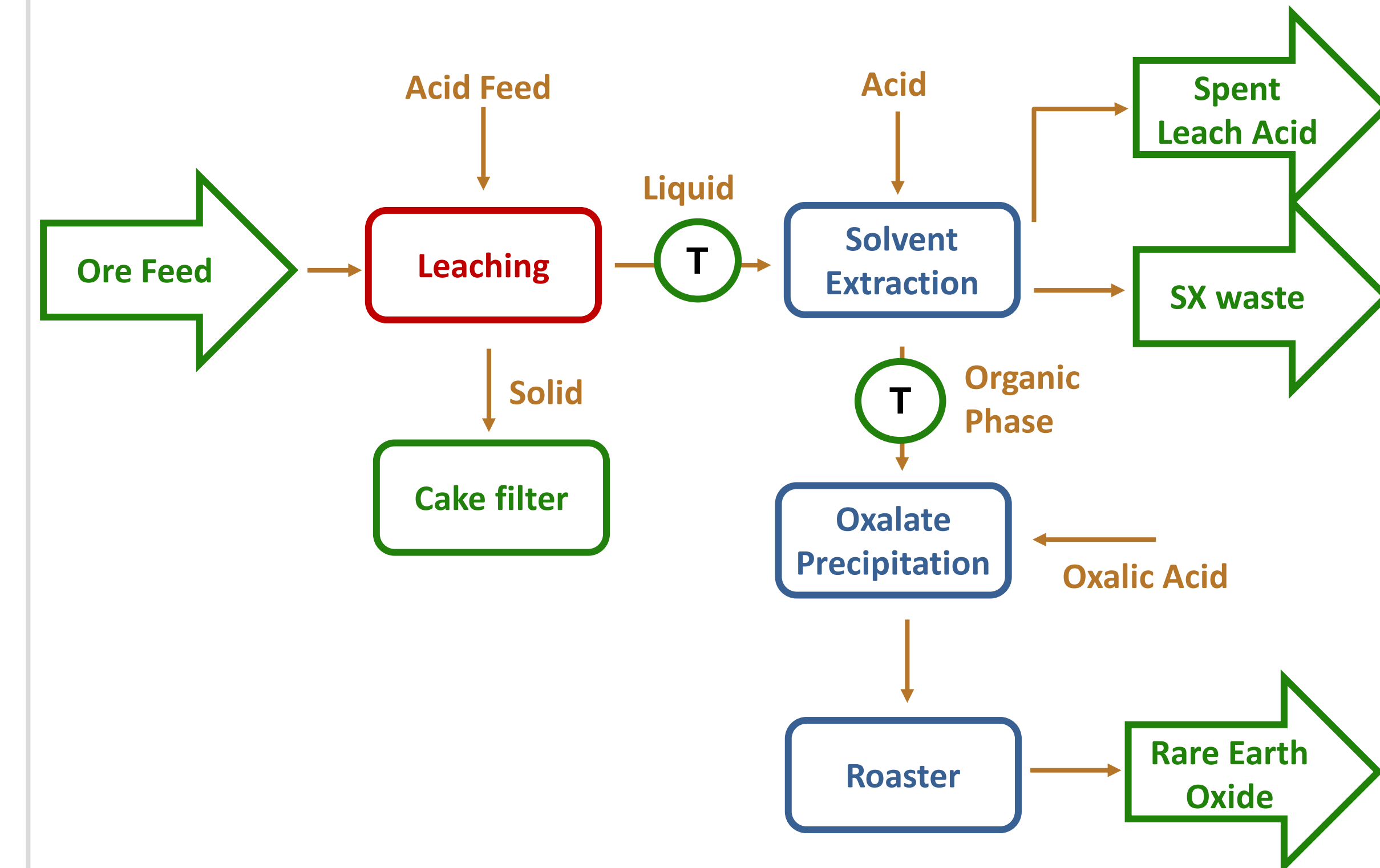
Reaction models:

- Leach reaction model, Precipitate equilibrium model

Models show accuracy compared to literature models



Current Flowsheet



Ongoing Work

- Incorporate unit models required for full flowsheet analysis and unit models to interchange technologies for future process analysis
- Incorporate external solutions for detailed chemistry models
- Incorporate data-driven models for partition coefficient models for solvent extraction
- Work to obtain required property model parameters:
 - Reduce parameter uncertainty
 - Work with experimental teams associated with the UK study
- Detailed modeling and optimization of processes identified through conceptual design
- Work with UK pilot plant to see what improvements can be implemented

Acknowledgements

For more information, please reach out to Thomas Tarka, PrOMMiS Technical Director (Thomas.Tarka@netl.doe.gov)

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