PyRe: A Cyclus Pyroprocessing Archetype

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Outline

Motivation

What is the goal?

PyRe will be used to answer the following questions

- What is the effect of introducing pyroprocessing plants in the fuel cycle?
- How do various facility designs affect throughput and efficiency?
- Where in a pyroprocessing plant will monitoring most effectively detect material diversion?

The first two can be directly answered by the archetype. The third requires data analysis via diversion algorithms.

Diversion

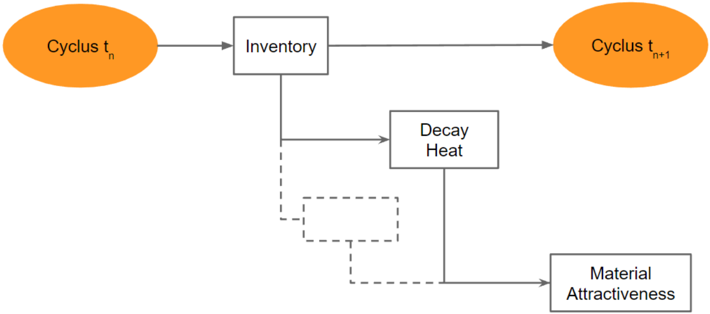

Figure 1: Diversion detection methods within Cyclus ??.

Outline

Methodology

How does PyRe work?

PyRe does the following with an input stream and facility configuration parameters:

- Pass fuel to voloxidation.
- Generate efficiencies from parameters.
- Multiply stream by efficiency matrix.
- Record stream compositions.
- Repeat for each process.

Cyclus

What is Cyclus?

Cyclus is a modular agent based fuel cycle simulator for tracking commodity transactions between facilities.

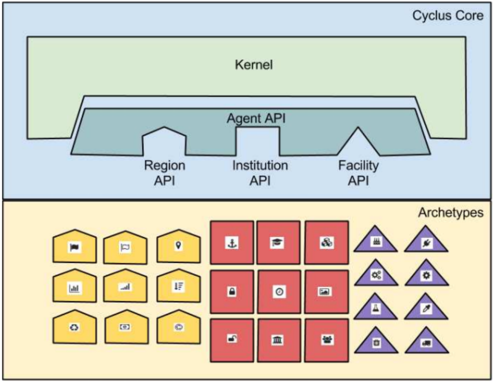

Figure 2: Cyclus Archetype framework and API**??**.

Why Cyclus?

Cyclus allows the construction of specific scenarios through the addition of archetypes. These archetypes are modular and the transactions can be tracked.

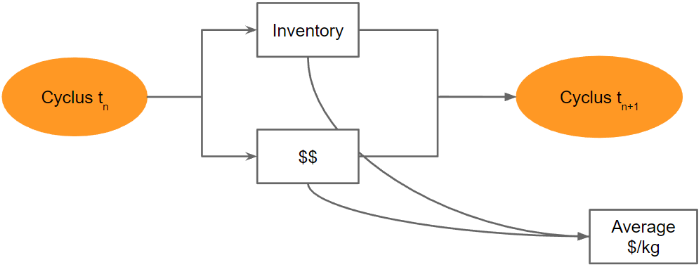

Figure 3: Cyclus tracks material flow through the fuel cycle.

Assumptions

Cyclus Requirements

- Modular.
- Time step $\geq$ 1 month
- Streams must be in a trade-able form.
- Parameters are constant for the simulation.
  - Equation input toolkit under development.
- Diversion detection must be added after.

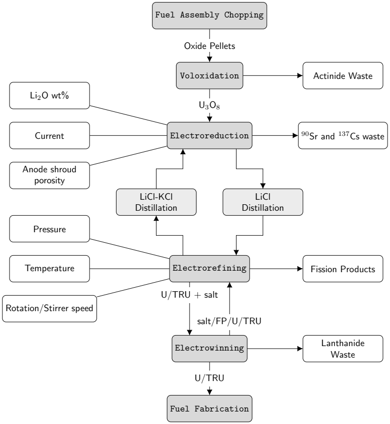

Figure 4: PyRe material flowchart **??**.

Subprocesses

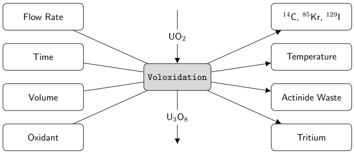

Figure 5: Voloxidation material balance area **??**.

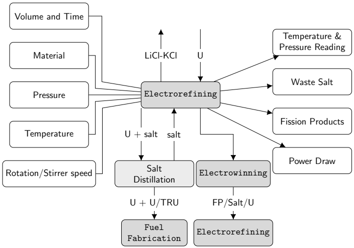

Figure 7: Refining material balance area **??**.

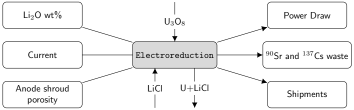

Figure 6: Reduction material balance area **??**.

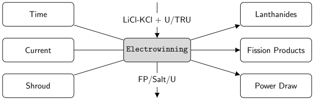

Figure 8: Winning material balance area.

Outline

Average Sim

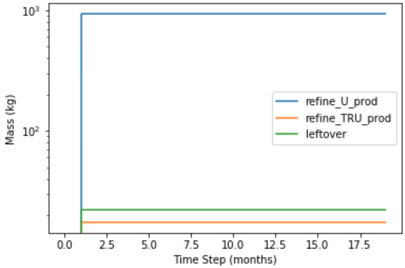

Figure 9: Product time series of a simple simulation.

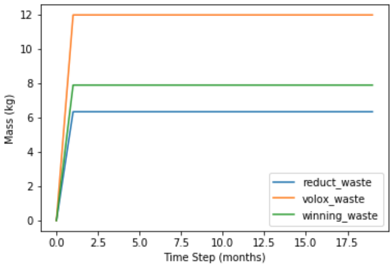

Figure 10: Waste time series of a simple simulation.

Isotopic Composition of Waste Streams

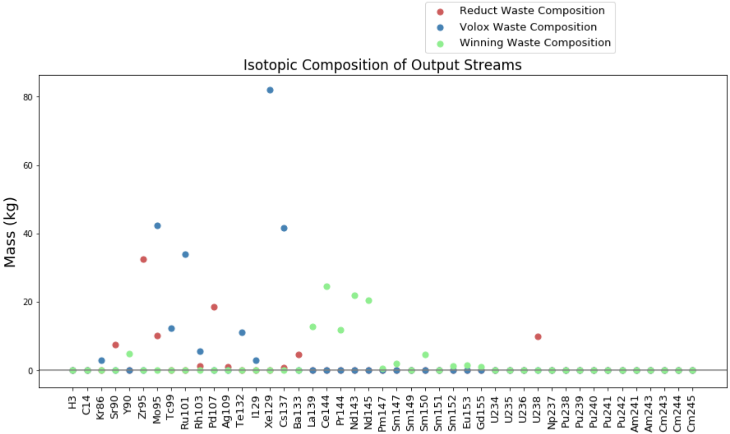

Figure 11: Isotopic Composition of Average Waste Streams

Current Diversion

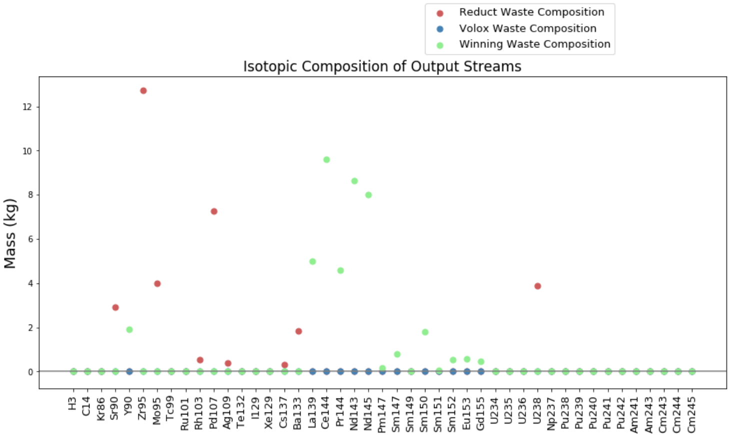

Figure 12: Isotopic Composition of Current Diverted Waste Streams

Isotopic Range

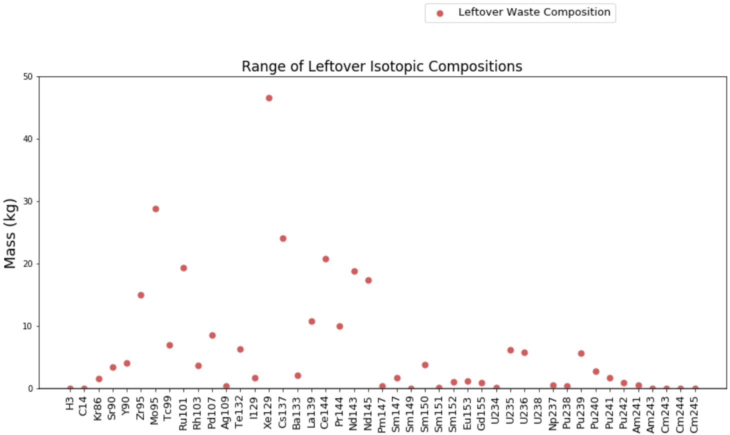

Figure 13: Range of Isotopic Values

Outline

Future Work

We have shown that PyRe allows Cyclus to simulate a simple pyroprocessing scenario. Future work includes:

- Increase scenario complexity - test shadow diversion
- Improve user input
  - Allow user-defined equations as input
- Chemistry detail

Uses of PyRe:

In the beginning we marked the following objectives:

- What is the effect of introducing pyroprocessing plants in the fuel cycle?
- How do various facility designs affect throughput and efficiency?
- Where in a pyroprocessing plant will monitoring most effectively detect material diversion?

Diversion Algorithm

The first two questions can be answered through the addition of PyRe to Cyclus. However, to address the last we must employ an algorithm to analyze small differences between multiple simulations. The following are being considered to provide 'online' diversion detection:

- Cumulative Sum (CUSUM)
- Maximum likelihood

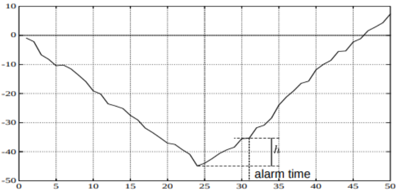

Figure 14: Example of a cumulative sum alarm from Basseville. **??**

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References I