Purpose:

This document outlines the basic requirements of any new features which must be added to the Cyclus ecosystem to achieve the project goals outlined in the README file.

Syncing to GitHub:

The GitHub syncing requirement is that this repo, which is stored locally at ~/Wisconsin/cyclus_fusion be pushed to GitHub every Friday whether changes have been made or not. This will ensure that in the worst-case scenario, the most progress I will lose is 1 week's worth. Pushes to the GitHub repo may be done more frequently as needed.

Desired Use Case:

The ultimate use case for this module will be to aid in answering some of the basic questions in the fusion fuel cycle space, such as:

1. Will fusion growth be supply limited?
2. What is the supply vs demand for tritium based on different input scenarios?
    a. What happens to tritium supply when planned fusion projects such as DEMO or ITER come online?
    b. What doubling times should the industry be aiminig for with their designs beyond simply achieving self sufficiecy?
        i. Is it worth getting to TBR=1.1 instead of TBR=1.05 in order to increase doubling time if CANDU or other fission reactors may be options for tritium startup supply/reserve supplies?
    c. How does the lifecycle of the CANDU fleet impact tritium availble to start up new fusion reactor projects?
3. How much could tritium startup inventory add to initial reactor construction costs?
4. Would it be worth fission companies pursuing tritium breeding based on potential future demands?

Additionally, the use case should be able to:

1. Set up a generic system that others can use and demonstrate the idea rather than making a statement about certain specific fusion designs
2. Be used by companies to make blanket or overall design decisions.

Project Evolution:

The first goal will be to implement a basic model of tritium cycles in a fusion reactor, with the user able to define only very high-level variables such as power, TBR_system, and reserve inventory. Using those inputs, a burn rate can be calculated (BR = Power * 55.8kg/yr/GW (Abdou et al. 2021)). After that archetype has been implemented, the custom inputs will be added as additional functionality, which will give the user more control over the Fusion Reactors behavior in the simulation. Finally, functionality to account for Li-6 enrichment will be added for an additional layer of complexity.

Inputs:

There are three sets of inputs which should be available to the user: Default, Custom, and Optional. The Default inputs list should allow the user to give broad definitions of their reactor and have some of the finer details of operation handled on the backend via currently accepted values and methods (obtained from Abdou et al. 2021), while the Custom inputs should be toggleable and allow the user to be much more specific about reactor physics. The optional inputs will be those which make sense to include, but do not affect reactor behavior (such as name, latitude, longitude, etc).

<u>Default Inputs:</u>

1. Power
2. TBR_system
3. Reserve Inventory
4. Input Recipe

<u>Custom Inputs:</u>

1. Tritium Burn Fraction
2. Fueling Efficiency
3. Injection Rate
4. Fueling Efficiency
5. Reserve Time
6. TBR_blanket
7. Availability Factor
8. Processing Time
9. Fraction Failing

Optional Inputs:

1. Longitude
2. Latitude

Outputs:

For the first stage of the project, it should be sufficient to output power, and an output_recipe vector with masses of Lithium, He, and Tritium. In a later stage of the project, as defined in the "project evolution" section, the Fusion Reactor archetype will be modified to account for Li-6 vs Li-7 enrichment and so the way the output_recipe vector is calculated will need to be changed to reflect this.

Interactions with other Modules within Project:

As of the early stages of this project, no modules besides the Fusion Reactor are envisioned. Additional modules may be added to the project later, though, as needed. Should that occur, this section should be revisited.

Interactions with other Modules in the Cyclus Ecosystem:

The Fusion Reactor facility archetype will need to interact with several other archetypes prepackaged with Cyclus/Cycamore. The basic interactions that the Fusion Reactor will need are to buy Tritium from a Source facility (CANDU or FFH initially), buy Lithium from a Source facility, sell Tritium to a Tritium Storage facility owned by the Institution tasked with building more Fusion Reactors, and sell Li/He waste to some Facility downstream, whether that be an Enrichment Facility or a Sink Facility.

The reason to have the Fusion Reactor sell excess tritium is to make sure that all the excess tritium is kept in a single location so that the institution knows when there's enough to build a new fusion facility. This is based on my current understanding of how institutions decide when to build more facilities. In the scenario where a NullInst is defined instead of some sort of growth institution, the Fusion Reactor should try to offload its excess tritium to a Sink Facility.

Bibliograpy:

(Abdou et al. 2021) -- "Physics and Technology considerations for the deuterium-tritium fuel cycle and conditions for tritium fuel self sufficiency"