Demand Driven Deployment Capabilities in Cyclus

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Background

CYCLUS

- Agent-based framework [1]
- Agent types: facilities, institutions, and regions
- Compatible with plug-in libraries
- Gives users ability to customize agents

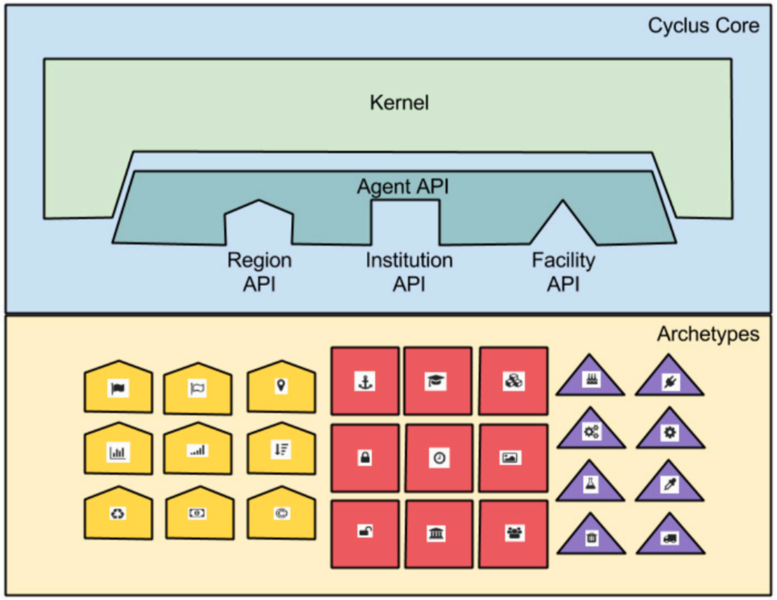

Figure 1: Cyclus has a modular architecture [1]

CYCLUS

Gap in capability: User must define when support facilities are deployed

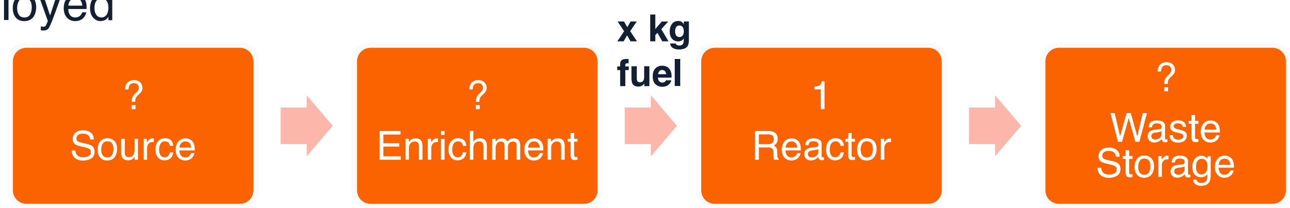

Figure 1: User defined Deployment Scheme

Bridging the gap: Developed demand-driven deployment capability in Cyclus, d3ploy.

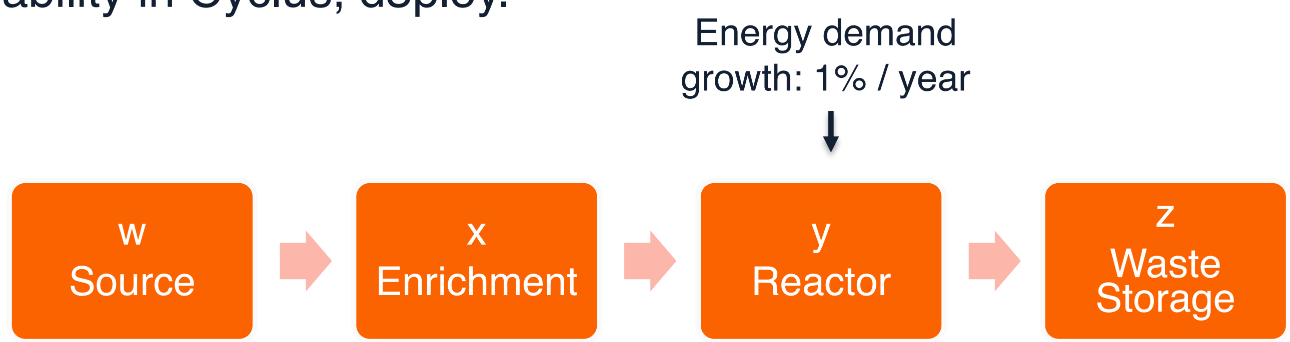

Figure 2: Demand Driven Deployment Scheme

Goal

- **Automatic deployment of supporting fuel cycle facilities in Cyclus**
- **Demonstrate transition scenarios with no power undersupply**

Acknowledgements

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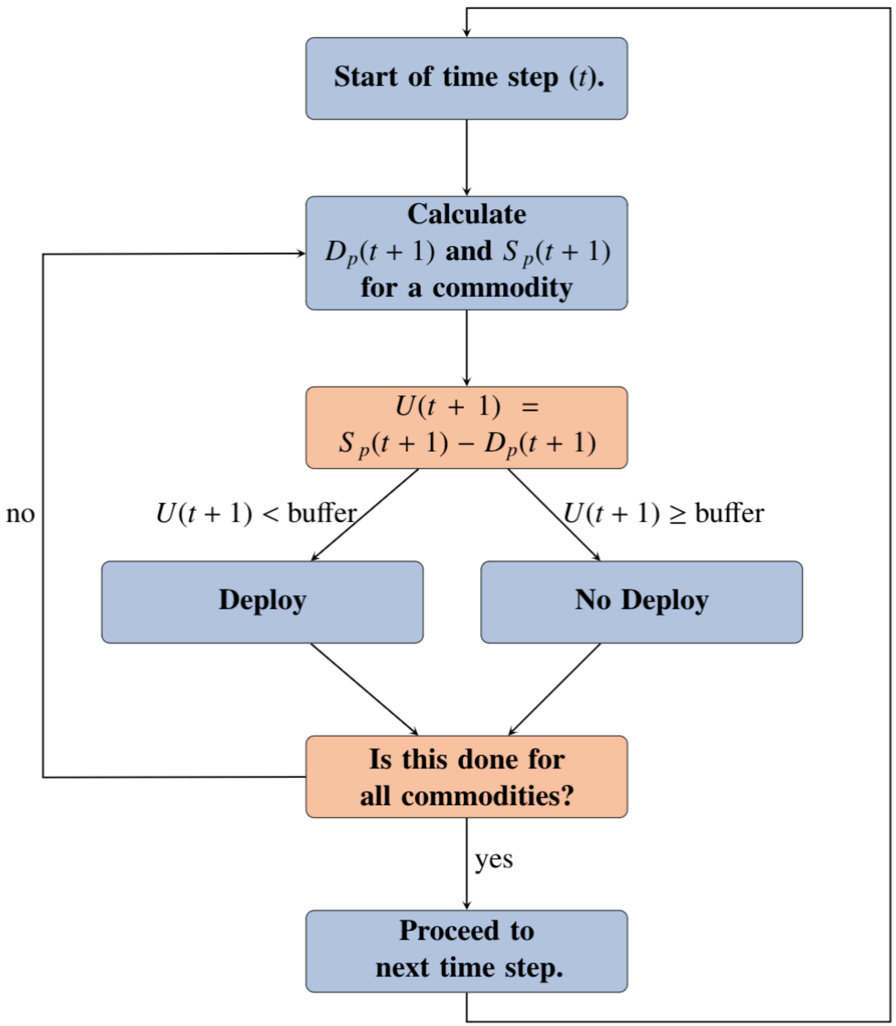
D3ploy – Input Parameters

	Input Parameter	Examples
Required	Demand driving commodity	Power, Fuel, Plutonium, etc.
	Demand equation	P(t) = 10000, sin(t), 10000*t
	Facilities it controls	Fuel Fab, LWR reactor, SFR reactor, Waste repository, etc.
	Capacities of the facilities	3000 kg, 1000 MW, 50000 kg
	Prediction method	Power: fast fourier transform Fuel: moving average Spent fuel: moving average
	Deployment driven by	Installed Capacity/Supply
Optional	Supply Buffer type	Absolute
	Supply Buffer size	Power: 3000 MW Fuel: 0 kg Spent fuel: 0 kg
	Facility preferences	LWR reactor = 100-t SFR reactor = t-100
	Facility constraint	SFR reactor constraint = 5000kg of Pu

Table 1: D3ploy Input Parameters

D3ploy – Logic Flow



D_p : Predicted demand
S_p : Predicted supply
$U = S_p - D_p$

Figure 3: D3ploy logic flow

Prediction Methods

- Non-Optimizing Methods
  - Demand Response
  - Moving Average
  - Autoregressive Moving Average
  - Autoregressive Heteroskedasticity
- Deterministic Methods
  - Fast Fourier Transform
  - Polynomial Fit
  - Exponential Smoothing and Holt-Winters
- Matrix Solution
  - Uses supply and demand to create a system of equations in matrix form.
  - Solving the matrix returns the number of facilities required at a given time-step.

D3ploy – Simulation Description

	Input Parameter	Simulation Description
Required	Demand driving commodity	Power
	Demand equation	10000 MW
	Facilities it controls	Source, reactor, sink
	Capacities of the facilities	3000 kg, 1000 MW, 50000 kg
	Prediction method	Power: fast fourier transform Fuel: moving average Spent fuel: moving average
	Deployment driven by	Installed Capacity
Optional	Supply Buffer type	Absolute
	Supply Buffer size	Power: 3000 MW Fuel: 0 kg Spent fuel: 0 kg
	Facility preferences	-
	Facility constraint	-

Table 2: D3ploy Simulation Description

Constant Power Demand: Reactor Deployment

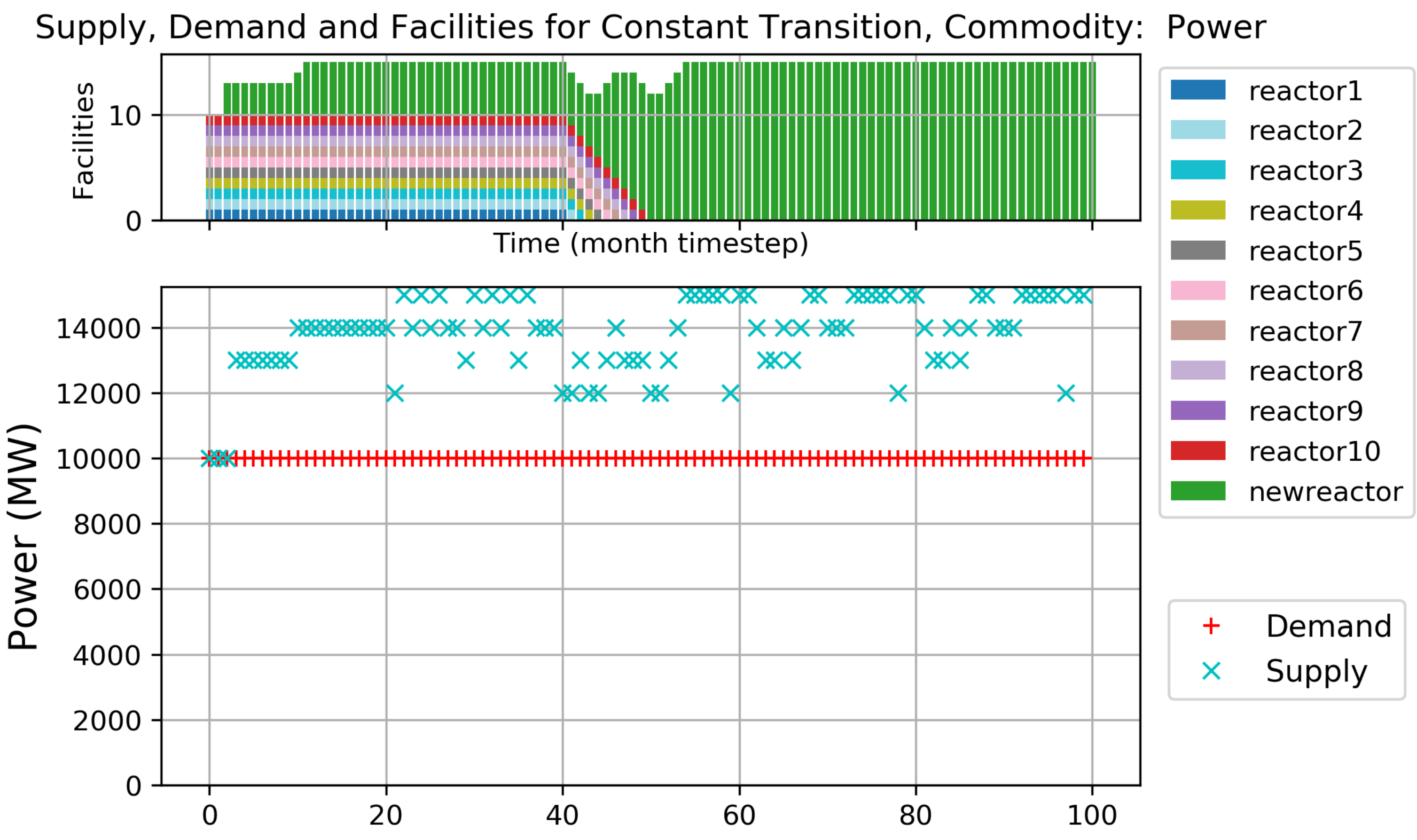


Figure 4: Power commodity supply and demand for transition scenario of constant 10000MW power demand

Constant Power Demand: Supporting Facility Deployment

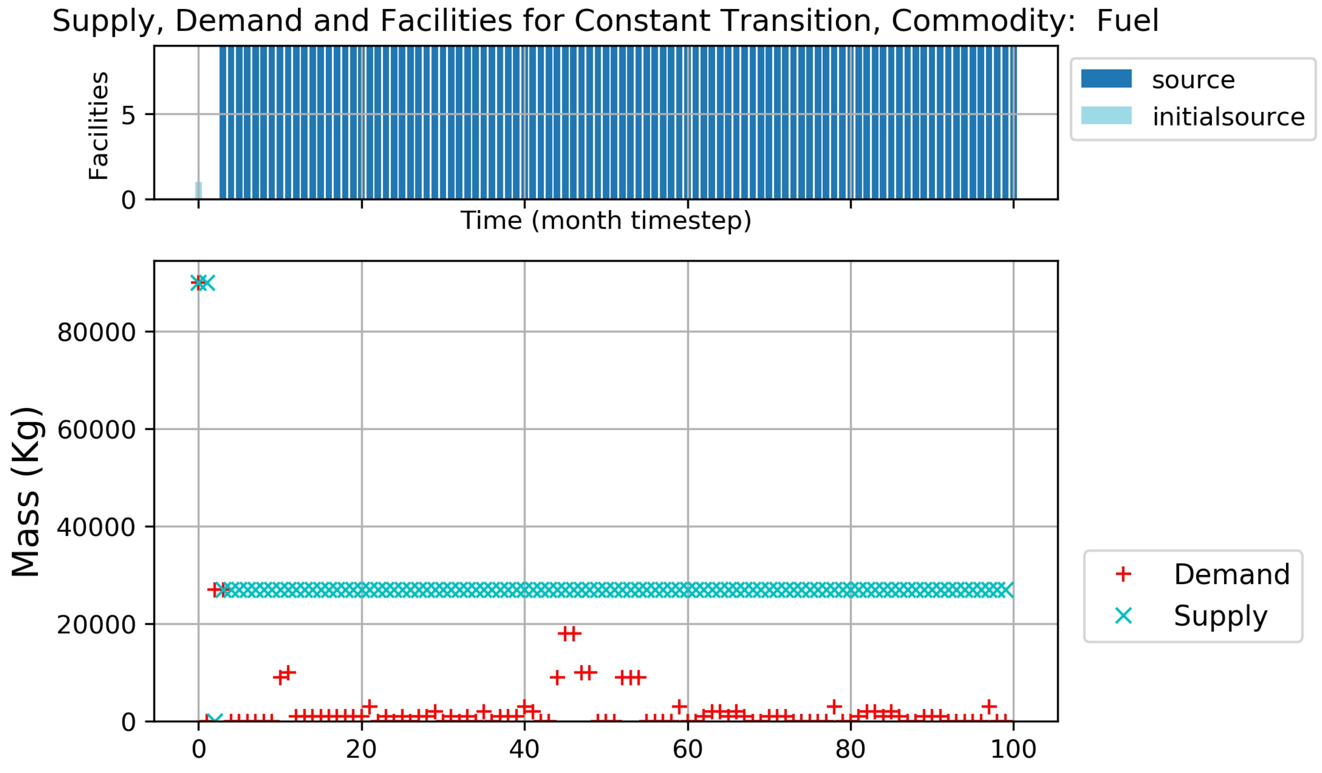


Figure 5: Fuel commodity supply and demand for transition scenario of constant 10000MW power demand

Constant Power Demand: Supporting Facility Deployment

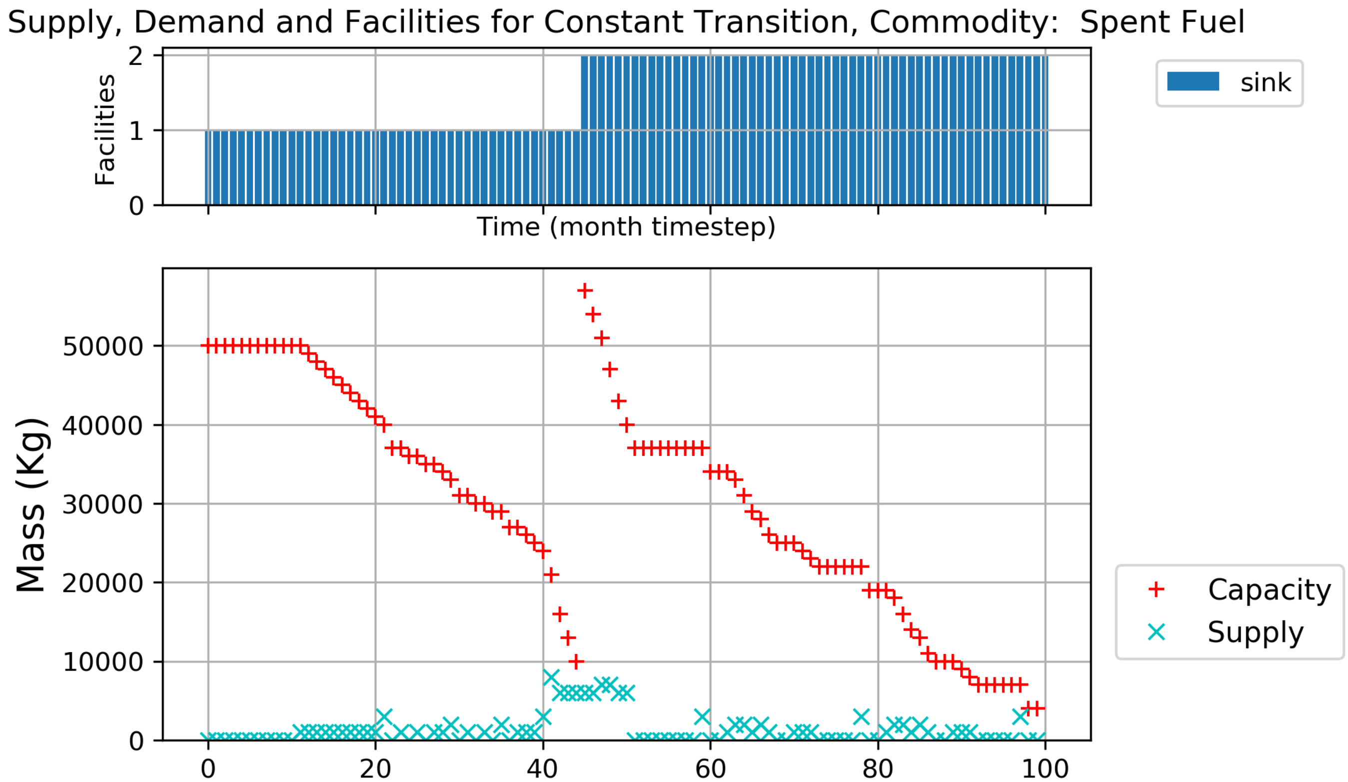


Figure 6: Spent Fuel commodity supply and demand for transition scenario of constant 10000MW power demand

Linear Power Demand: Reactor Deployment

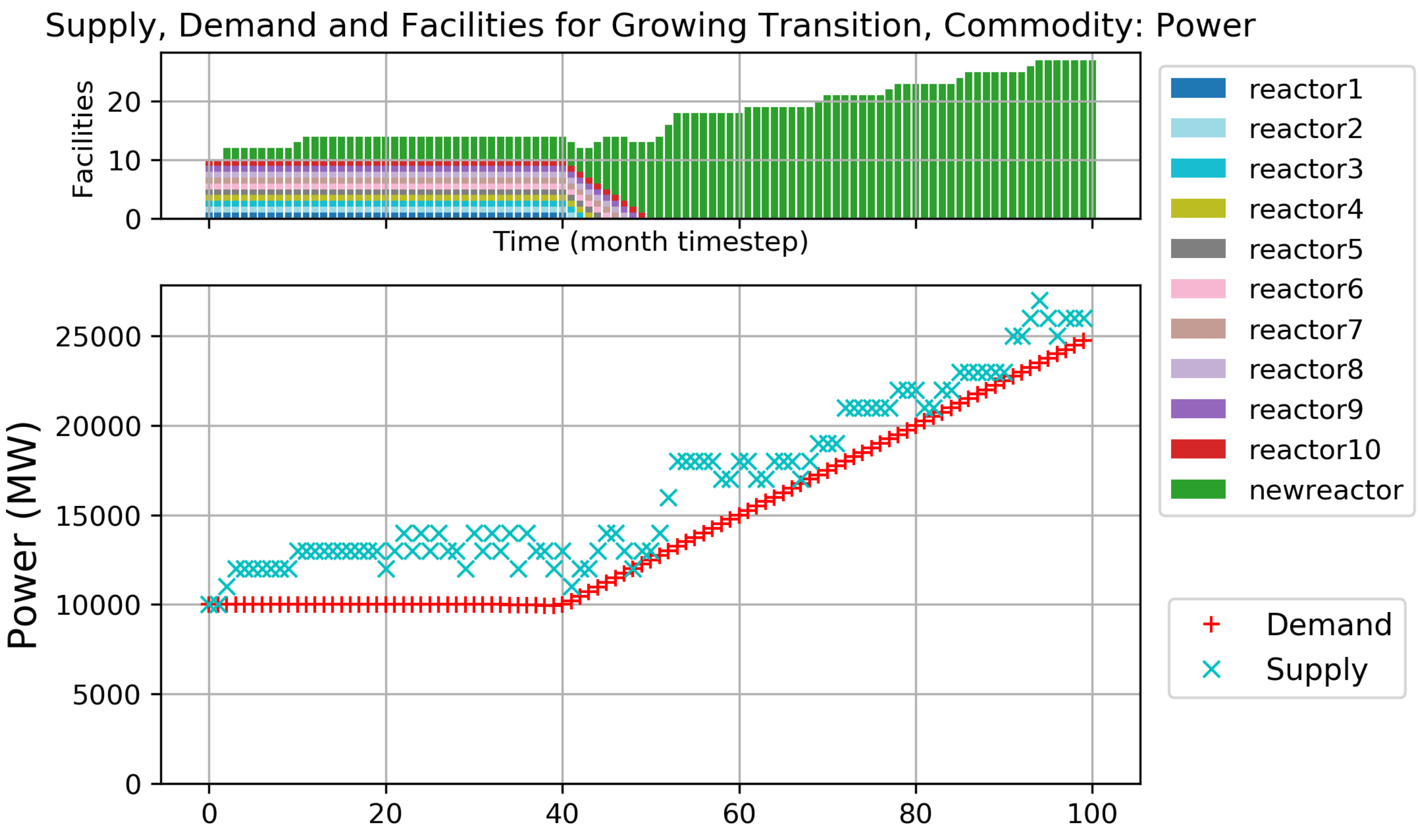


Figure 7: Power commodity supply and demand for transition scenario of linearly increasing power demand

Linear Power Demand: Supporting Facility Deployment

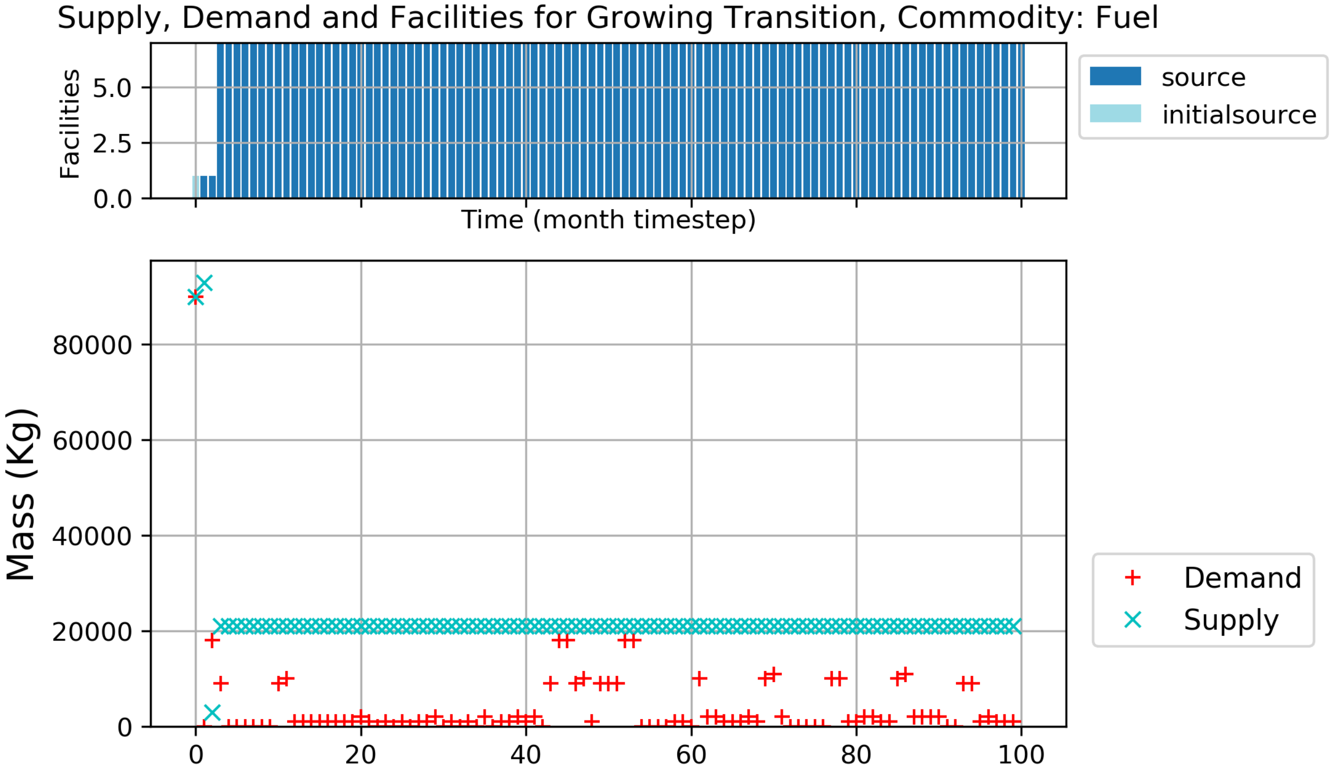


Figure 8: Fuel commodity supply and demand for transition scenario of linearly increasing power demand

Linear Power Demand: Supporting Facility Deployment

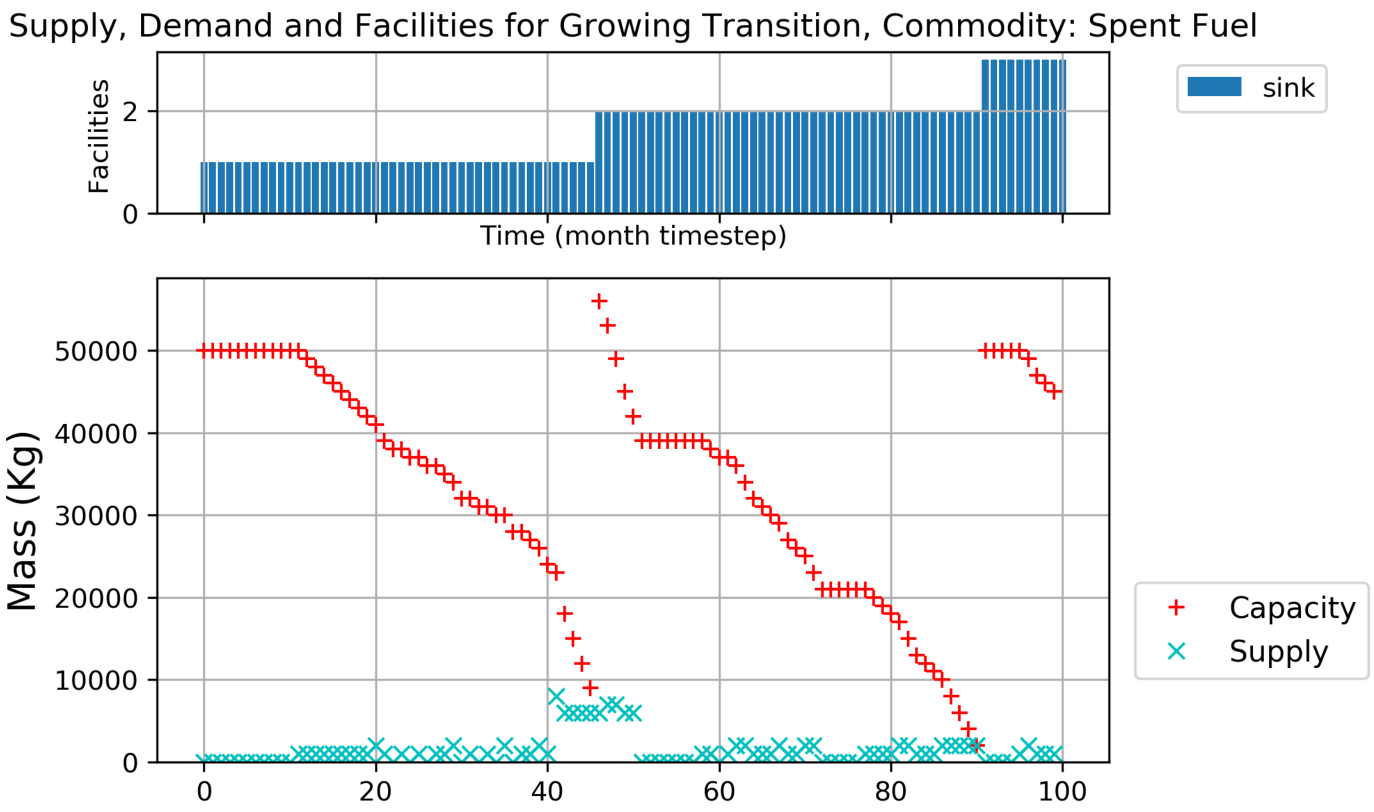


Figure 9: Spent fuel commodity supply and demand for transition scenario of linearly increasing power demand

Sinusoidal Power Demand: Reactor Deployment

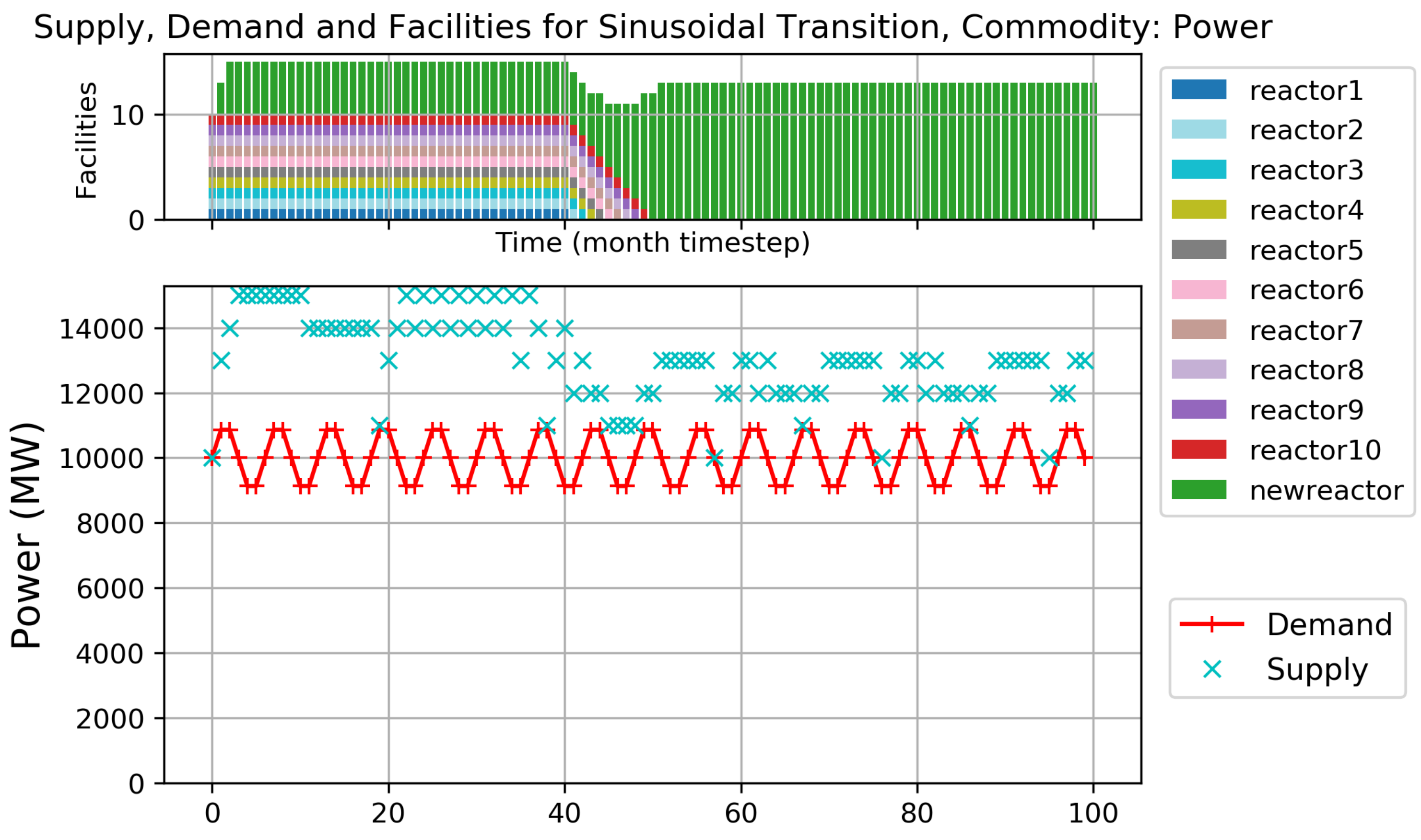


Figure 10: Power commodity supply and demand for transition scenario of sinusoidal power demand

Sinusoidal Power Demand: Supporting Facility Deployment

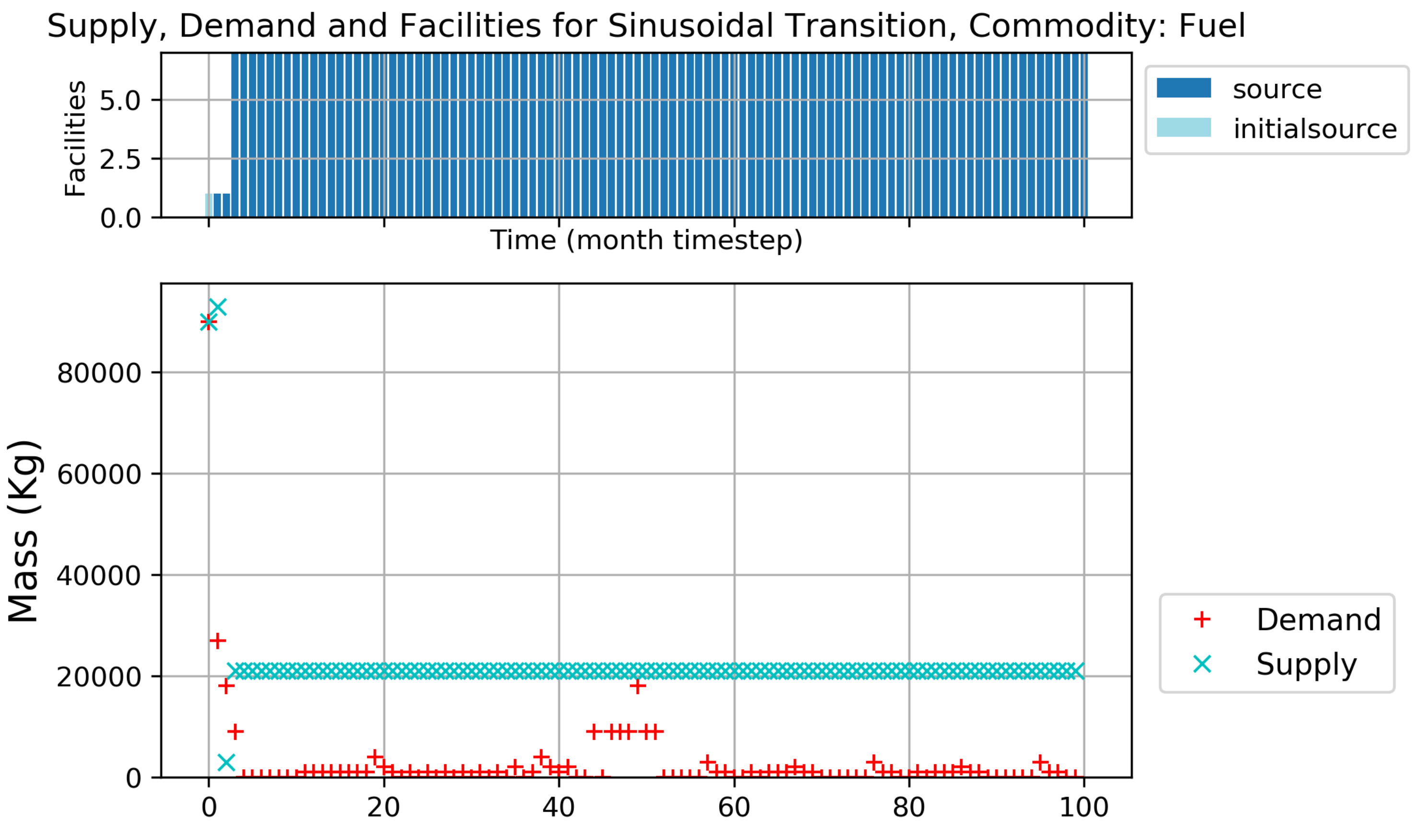


Figure 11: Fuel commodity supply and demand for transition scenario of sinusoidal power demand

Sinusoidal Power Demand: Supporting Facility Deployment

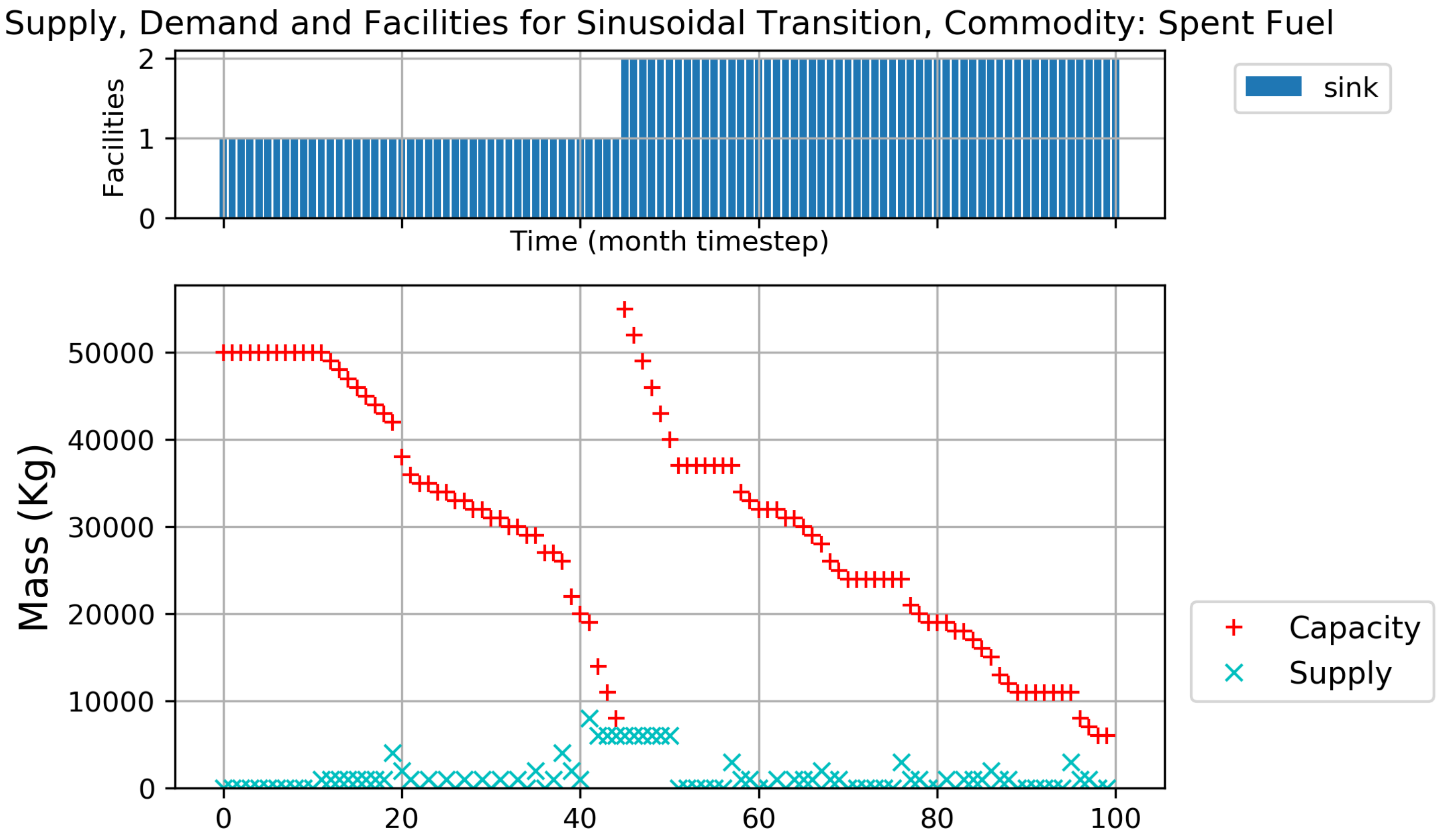


Figure 12: Spent fuel commodity supply and demand for transition scenario of sinusoidal power demand

Conclusions

❖**Demand driven deployment capabilities in Cyclus** are important to automate setting up of transition scenarios.

❖**Future Work:** Similar power demand transition scenarios extended to include more nuclear fuel cycle facilities such as reprocessing facilities etc.

References

[1]: K. D. HUFF, M. J. GIDDEN, R. W. CARLSEN, R. R. FLANAGAN, M. B. MCGARRY, A. C. OPOTOWSKY, E. A. SCHNEIDER, A. M. SCOPATZ, and P. P. H. WILSON, “Fundamental concepts in the Cyclus nuclear fuel cycle simulation framework,” Advances in Engineering Software, 94, 46–59 (Apr. 2016).

Thank You

Any Questions?

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