Superstructure Release

CCSI™
Carbon Capture Simulation Initiative

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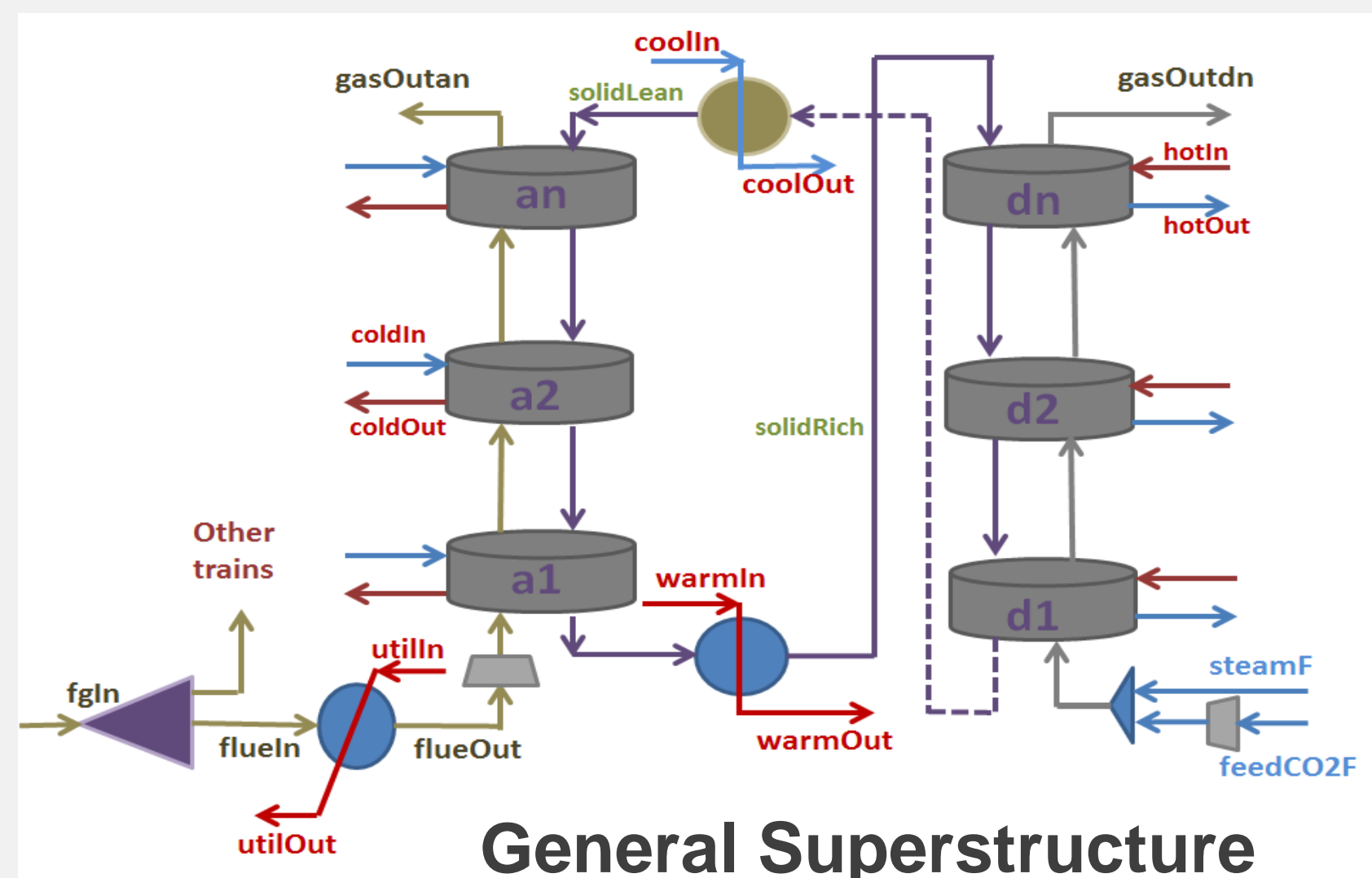
Problem Statement

General Superstructure

Objectives
- Seek the optimal process topology.
- Seek the design and operating conditions.
- Embed surrogate models of reactors.
- Achieve at least 90% capture target.
- Minimize cost of electricity.

Components of Superstructure Formulation

Initial Definition
- Variables definition
- Parameters definition
- Equations definition

Economic modules
- Capital cost of Sc plant and capture system
- Fixed operating & maintenance cost
- Total variable cost & fuel cost

Process modules
- Material balances
- Hydrodynamic/Energy balances
- Reactor surrogates from **ALAMO**

Bounds for variables

Mixed Integer Nonlinear Programming

GAMS Modeling Platform
super. *gms* files

Global Optimization Solvers
BARON (Carnegie Mellon University)
LINDOGLOBAL (LINDO system .Inc)
DICOPT (Carnegie Mellon University)
SBB (ARKI consulting and development A/S)

Optimal Solution
super. *lst* files

A 3rd party license, namely, GAMS license and the GAMS software will be needed to be procured from www.gams.com in order to run the superstructure formulation

Results Summary

Model statistics

BLOCKS OF EQUATIONS	72	SINGLE EQUATIONS	323
BLOCKS OF VARIABLES	66	SINGLE VARIABLES	942
NON ZERO ELEMENTS	2,466	NON LINEAR N-Z	1,210
DERIVATIVE POOL	10	CONSTANT POOL	226
CODE LENGTH	5,706	DISCRETE VARIABLES	9

Solve summary

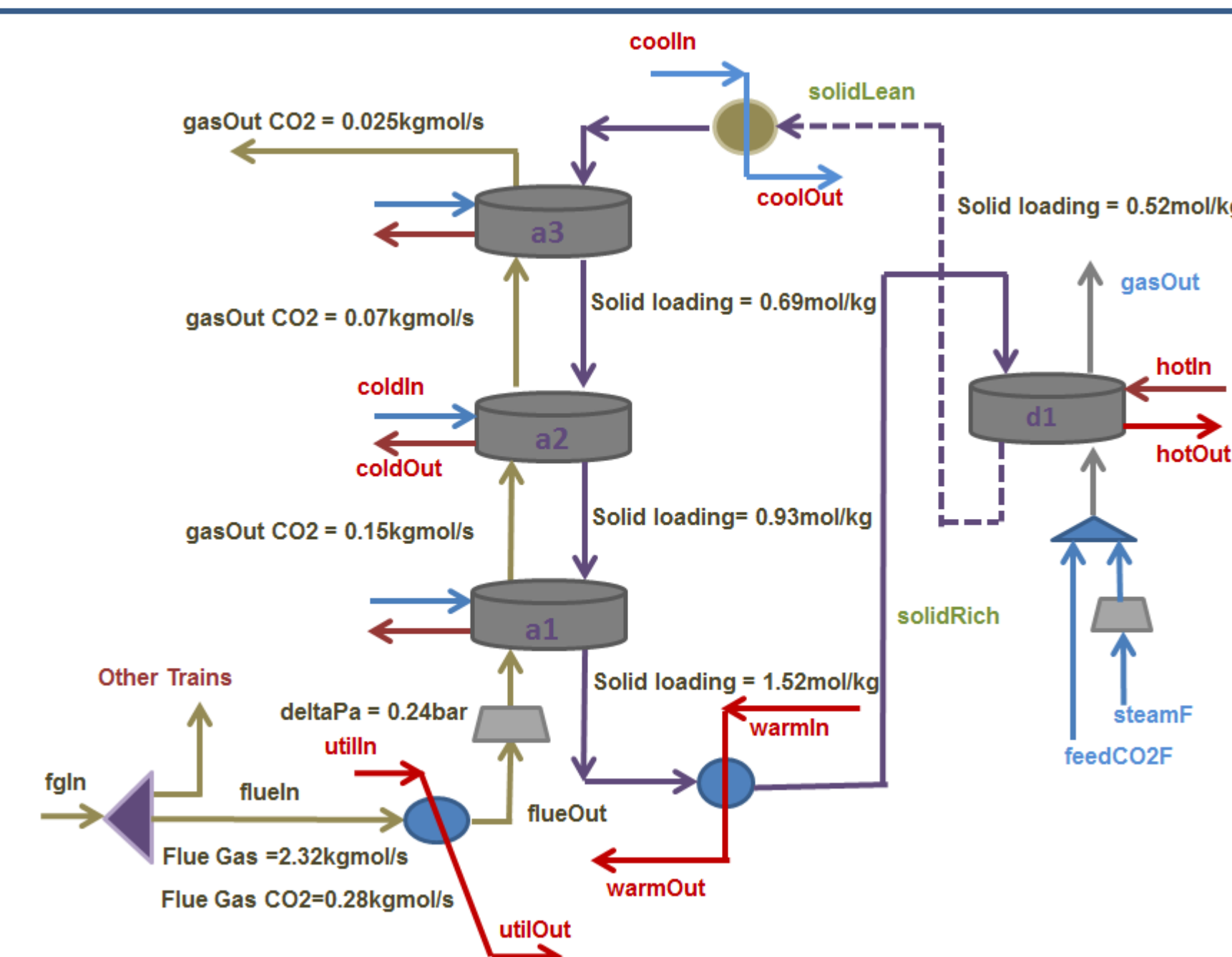|			
MODEL	ProSyn	OBJECTIVE	fplus
TYPE	MINLP	DIRECTION	MINIMIZE
SOLVER	BARON	FROM LINE	799

**** SOLVER STATUS   1 Normal Completion
**** MODEL STATUS   8 Integer Solution
**** OBJECTIVE VALUE   19528.2260

Optimal topology

---- VAR   y   1 if stage s is ever utilized

	LOWER	LEVEL	UPPER	MARGINAL		LOWER	LEVEL	UPPER	MARGINAL
a1	.	1.000	1.000	EPS	d1	.	1.000	1.000	EPS
a2	.	1.000	1.000	EPS	d2	.	.	1.000	EPS
a3	.	1.000	1.000	EPS	d3	.	.	1.000	EPS
a4	.	.	1.000	EPS	d4	.	.	1.000	EPS

Optimal Design/Operation Levels

*Cost of Electricity based on calculated capture system with base plant. + $48/MWh to account for compression, transport & storage
**Number of train in parallel

Variables	Lower	Value	Upper
COE ($/MWh)		142*	
Capital Cost ($M)		287.4	
Derate(MW)		119	
Nu**		12	

Features and Future Release

- One can obtain an optimal design under different conditions and requirements.
- The number of stages of adsorbers /regenerators and the relevant design and operation conditions are determined simultaneously.
- Superstructure formulation provides the optimal topology for simulation-based optimization framework.
- The future version of superstructure formulation will be capable of selecting between different reactor types (e.g. fluidized bed reactor vs. moving bed) .

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