CMSBuilder Webinar 2024

Steven Sutton and Adam Scharf

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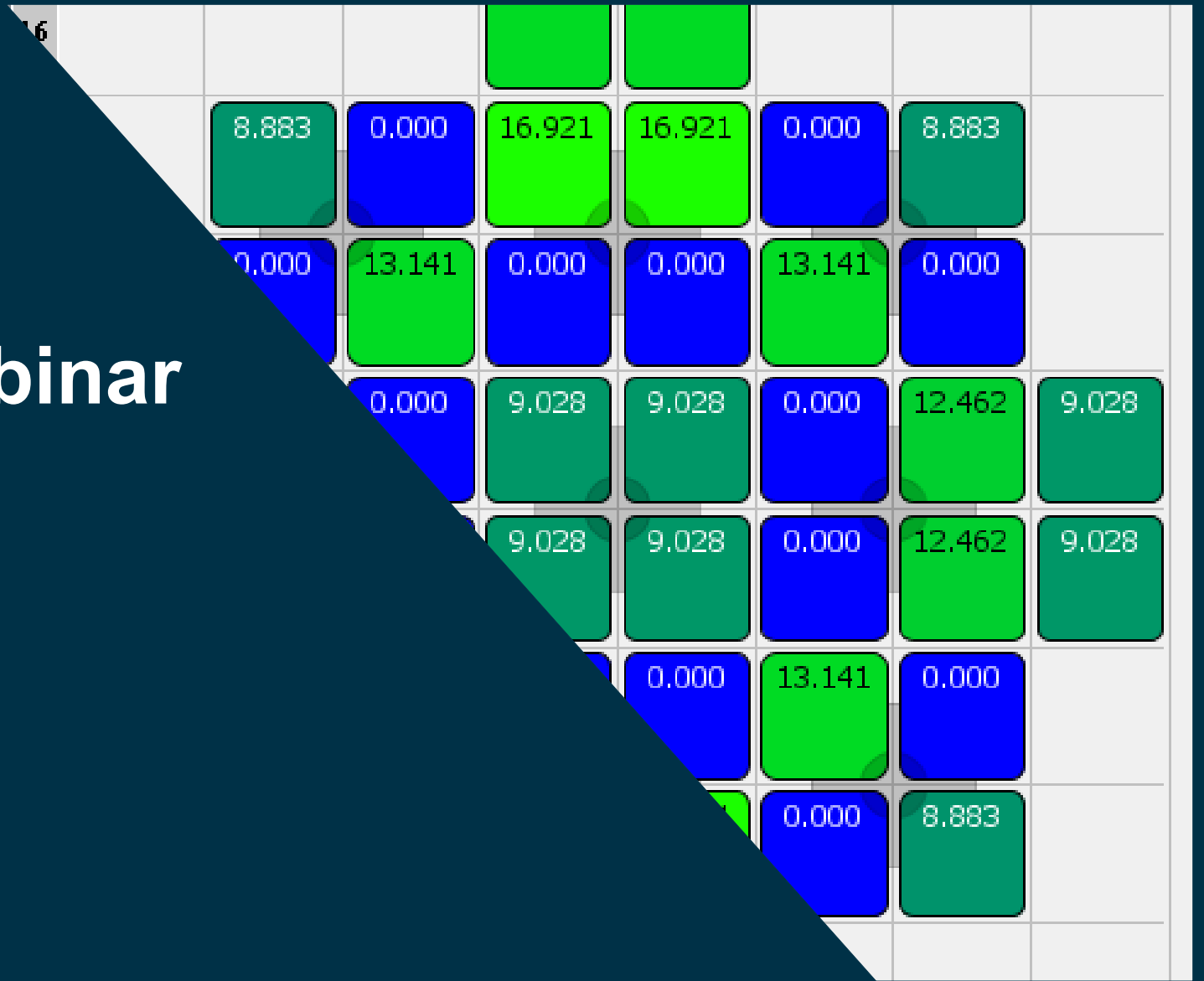


Background/Introduction

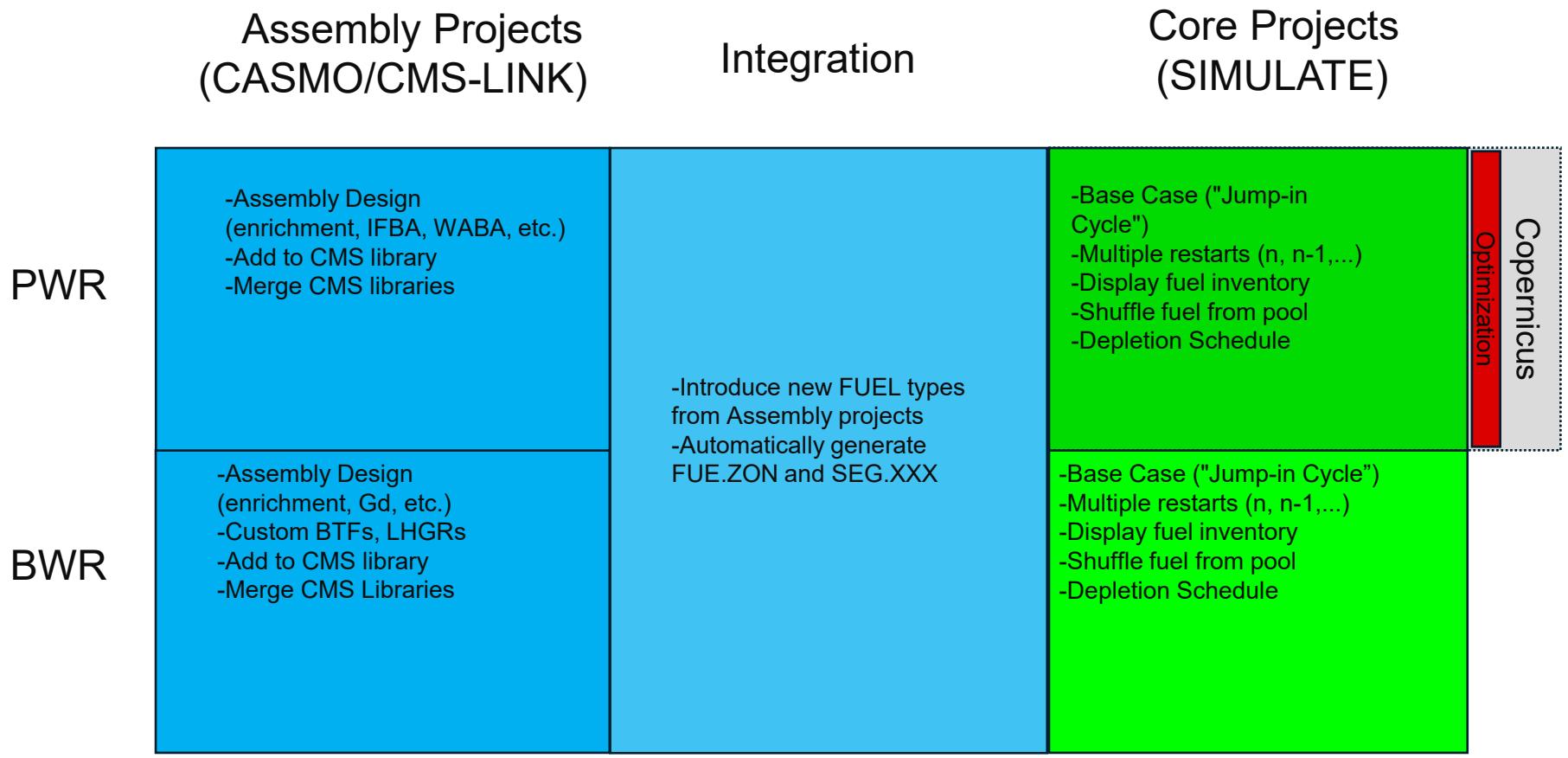
XIMAGE (X/11 Interactive Multicycle Analysis and Graphical Environment) is a Point-and-Click loading pattern design and multicycle scoping tool. XIMAGE couples the neutronics methodology of **SIMULATE** with a strong emphasis on ease-of-use and graphic visualization. Designed to run on Unix workstations using the X11/Motif windowing system.

Separate versions of XIMAGE (BWR) and XIMAGE/SIMAN (PWR) are currently in production.

CMSBuilder is a Point-and-Click loading pattern design tool and single-cycle scoping tool that builds on the user experience developed in XIMAGE over many years of usage. CMSBuilder couples the advanced methodology of **CMS**, emphasizing ease of use and graphic visualization. Designed to run on any OS supported for CMS.

A single version of CMSBuilder supports all LWR technologies.

What Is CMSBuilder?



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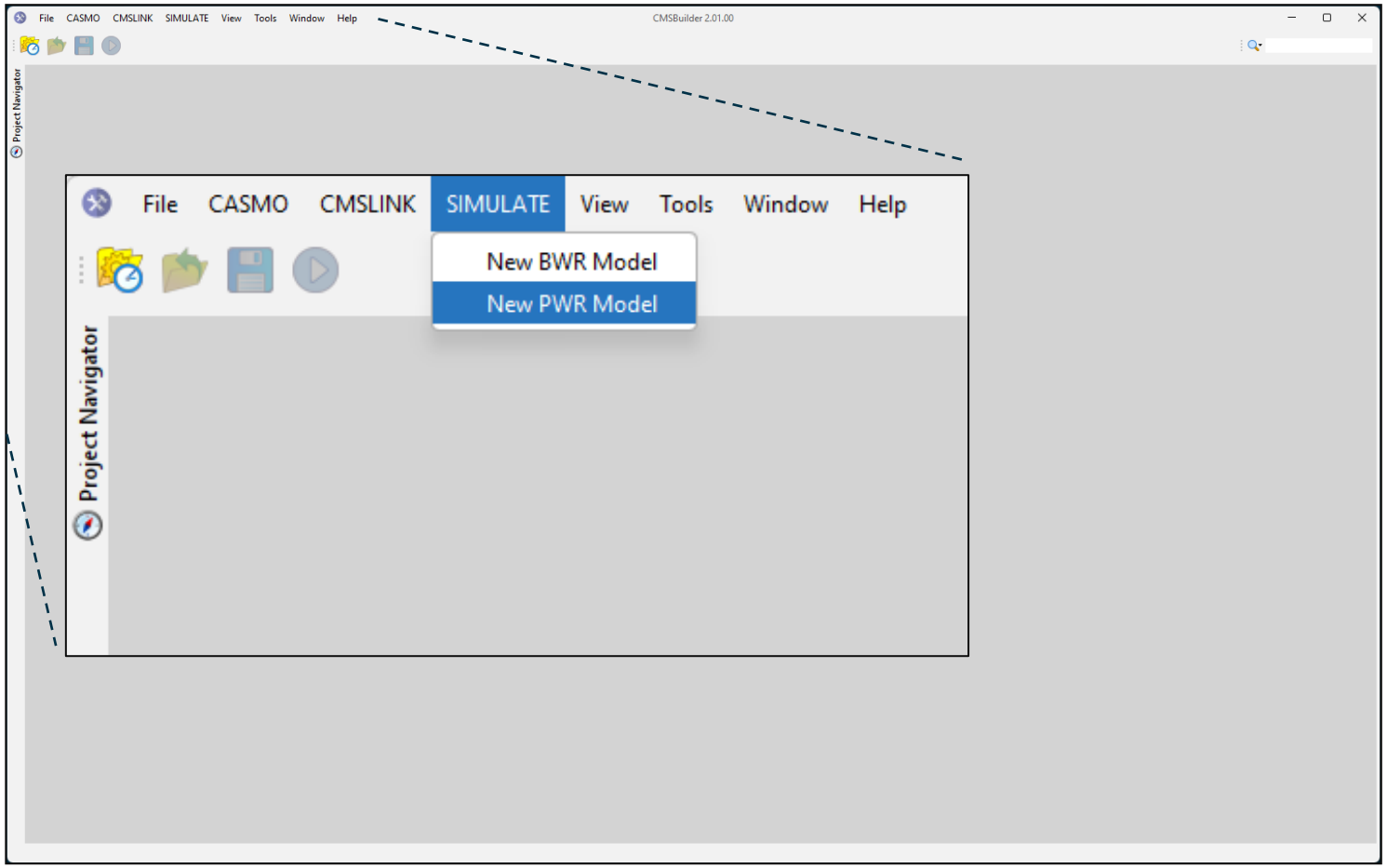
Features

- Loosely coupled to CMS Base Codes: CASMO, CMSLINK and SIMULATE
- Wizard-driven project creation
- Focused, flexible windowed environment
- Cross platform: Windows, Linux …
- CASMO
  - Graphical bundle design
- CMSLINK
  - Library consolidation
- SIMULATE
  - On-the-fly fresh fuel design for the core model
  - Point-and-click or drag-and-drop design core design
  - Summary display of fresh and depleted fuel available
  - Flexible cycle depletion
  - Graphical core map with key design parameters
  - Summary display of loading patterns analyzed and cycle depletion
  - Loading pattern library
  - Utilizes CMSView edits for output to HDF5 format

SIMULATE Model



Creating a new PWR SIMULATE modeling project.

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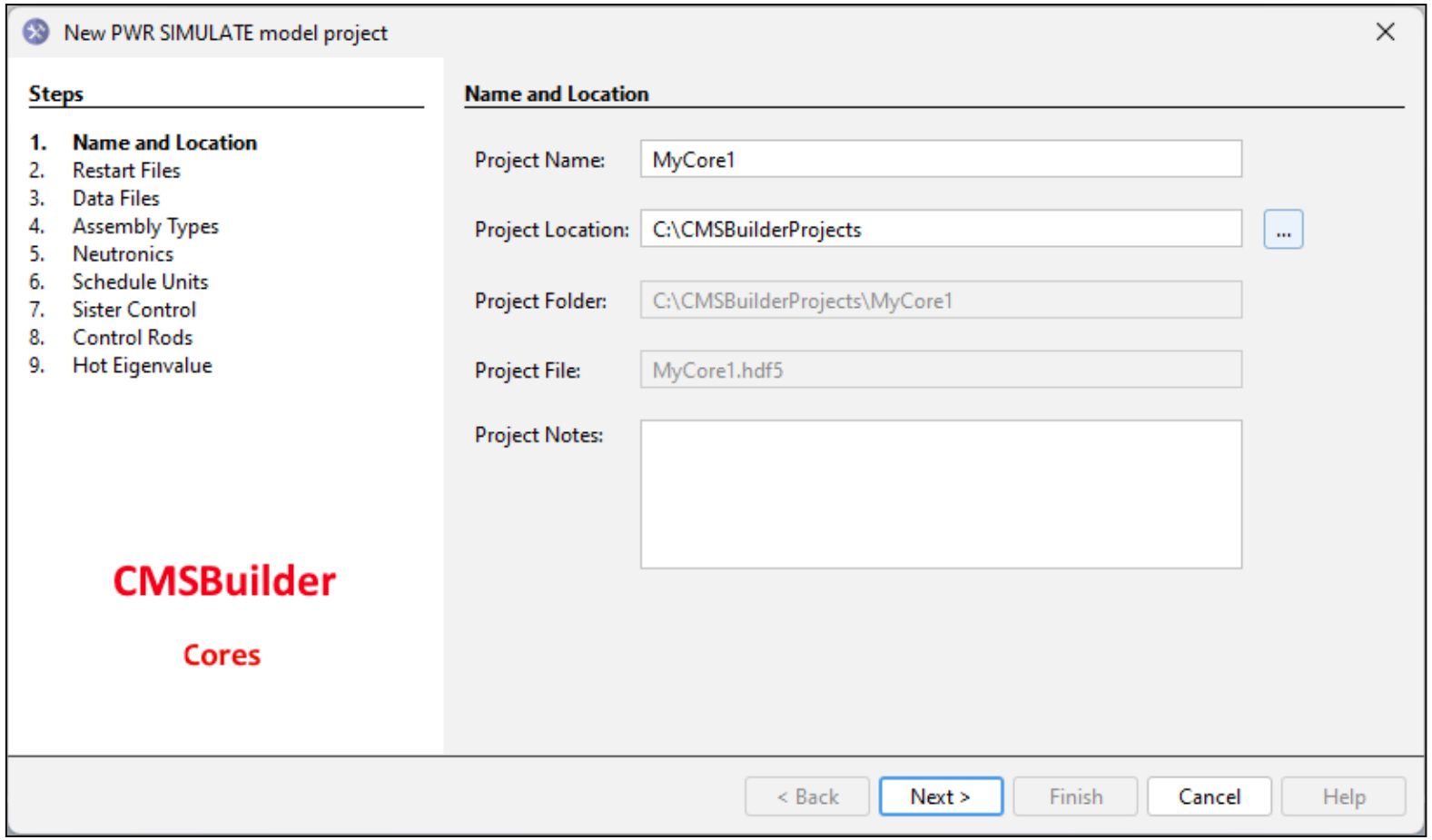
SIMULATE Project Creation Wizard



User provides key fuel cycle design parameters, restart files, cross-section ”pool” library, and neutronic parameters for SIMULATE using the wizard.

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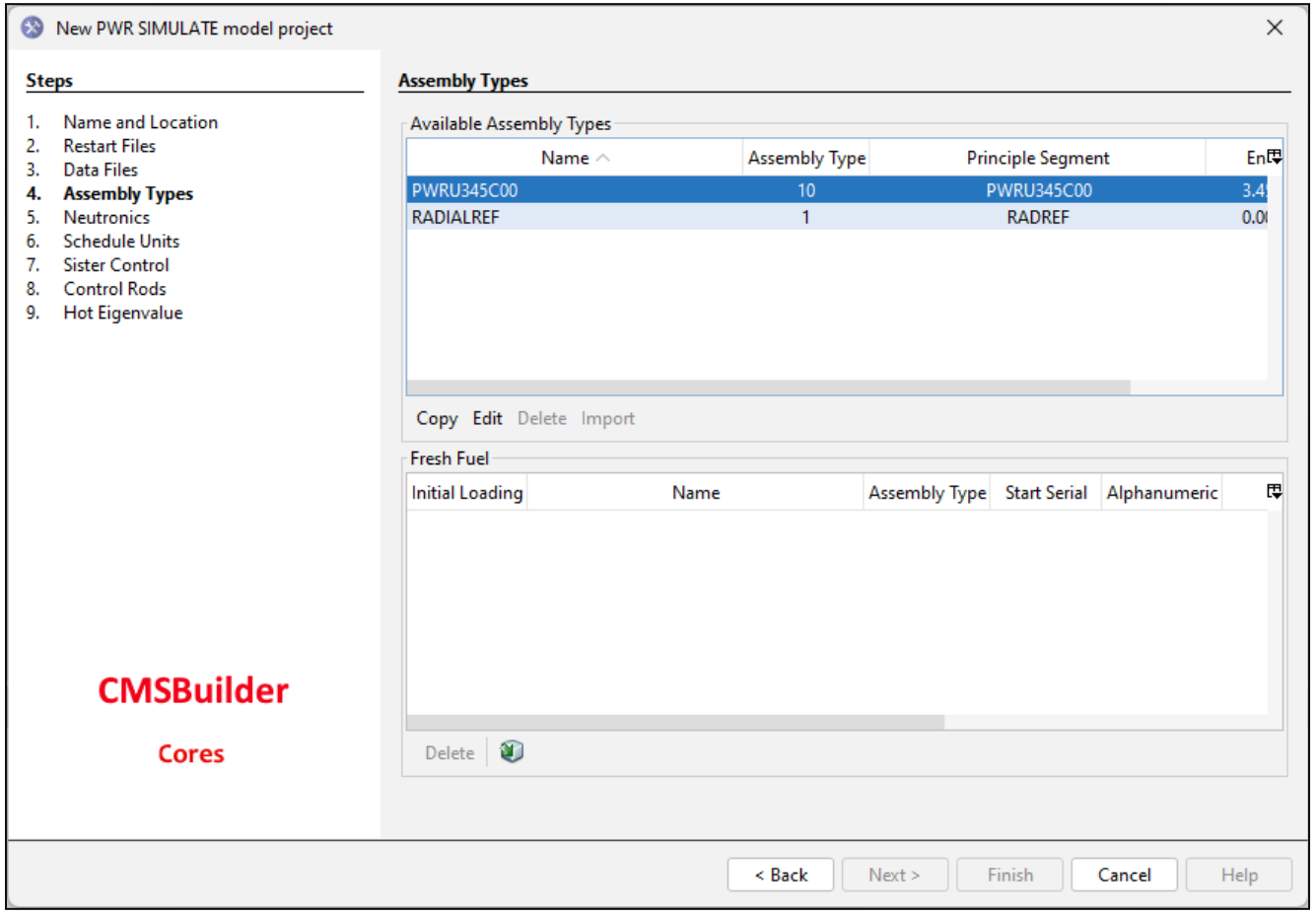
On-the-Fly Fresh Fuel



Copy an existing assembly type as a template for a new design assembly type.

Define fresh fuel loading quantity for the design cycle.

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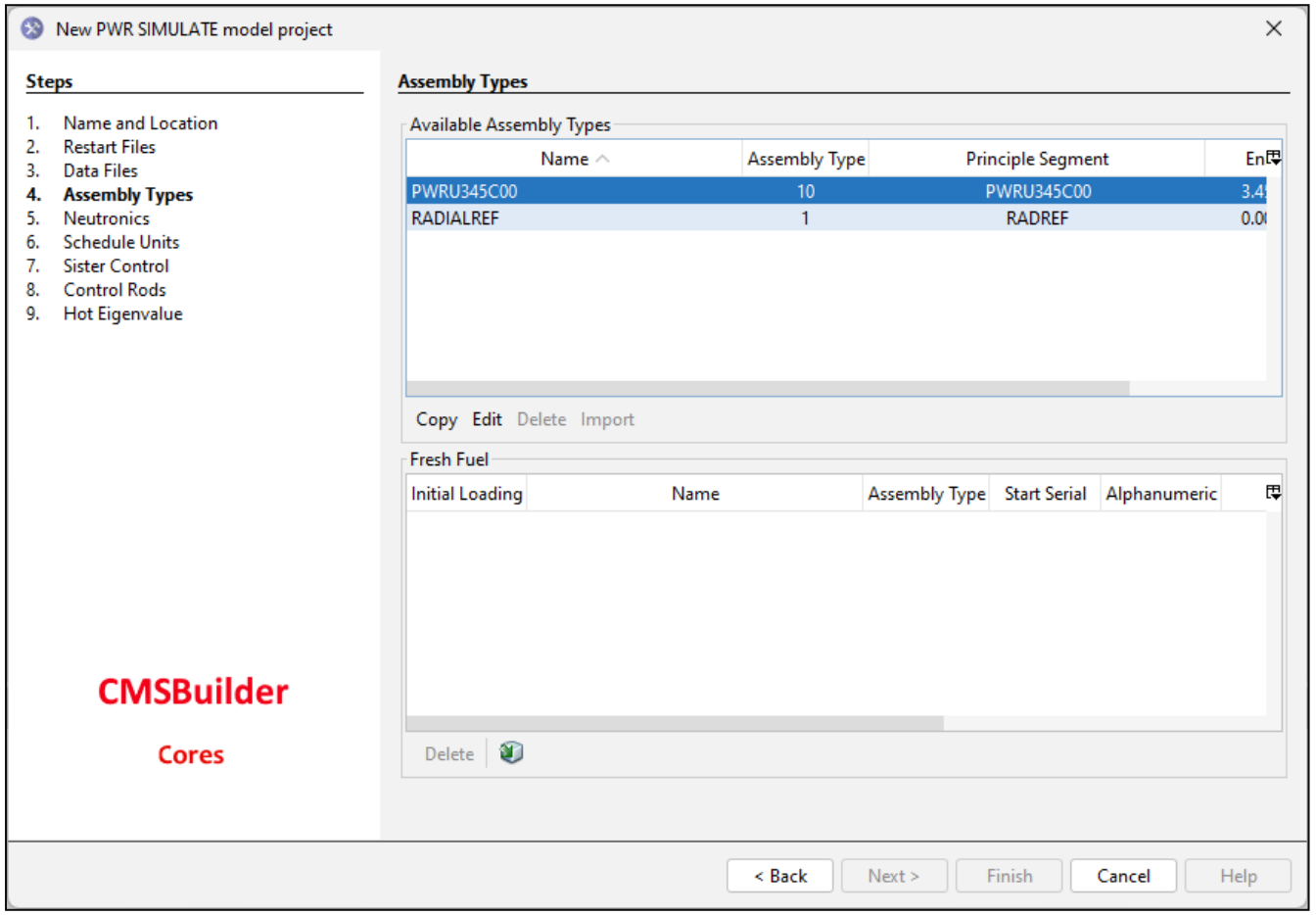
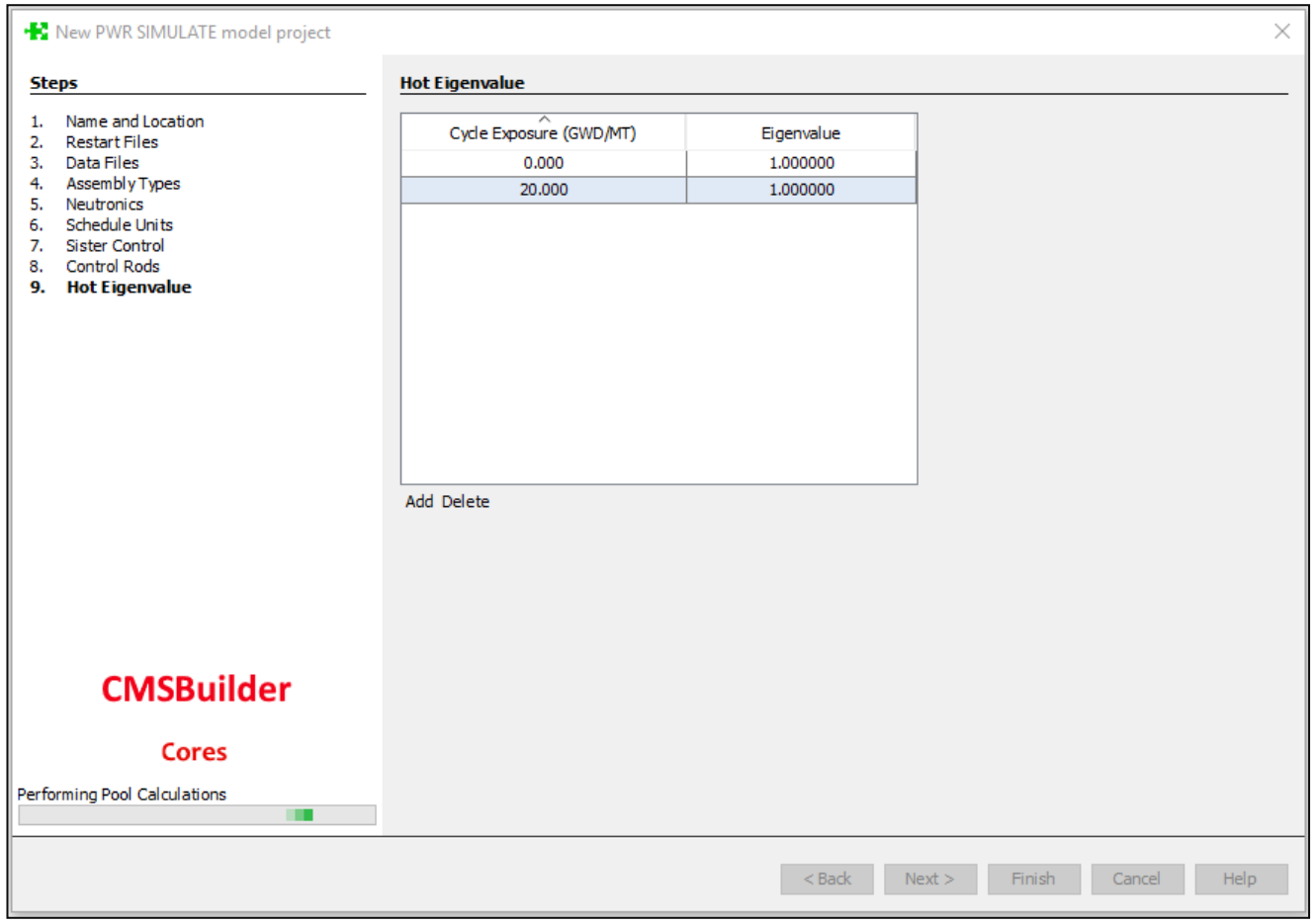
Fuel Editing



Edit existing and new fuel types.

Replace segments of previously used fuel assembly types to simulate burnable poison removal or insertion.

Initiate Model Creation



Finish to start pool calculations, auto load core, and run the initial BOC case.

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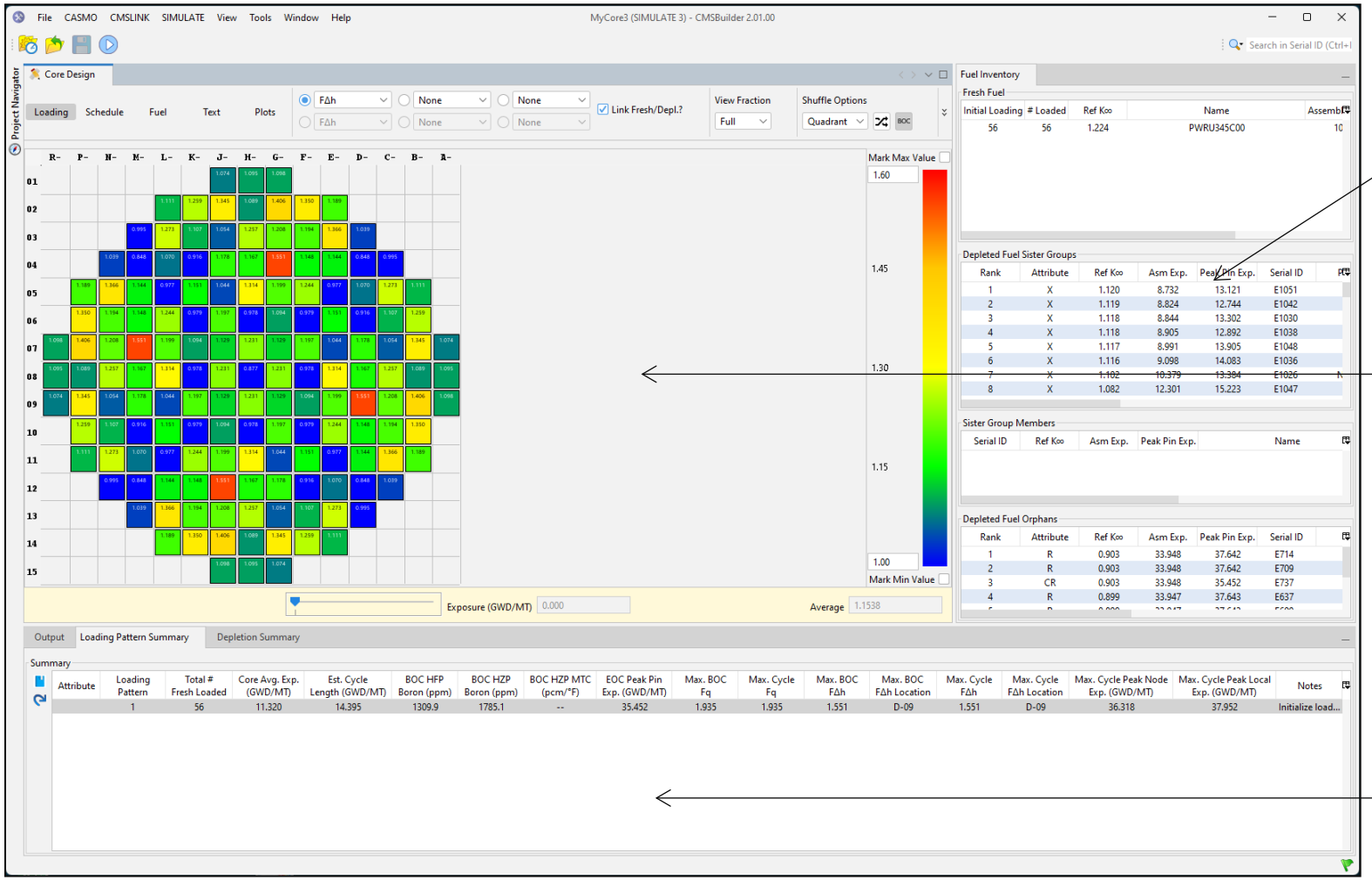
CMSBuilder Window Layout



Fuel Inventory

Core Design

Summaries

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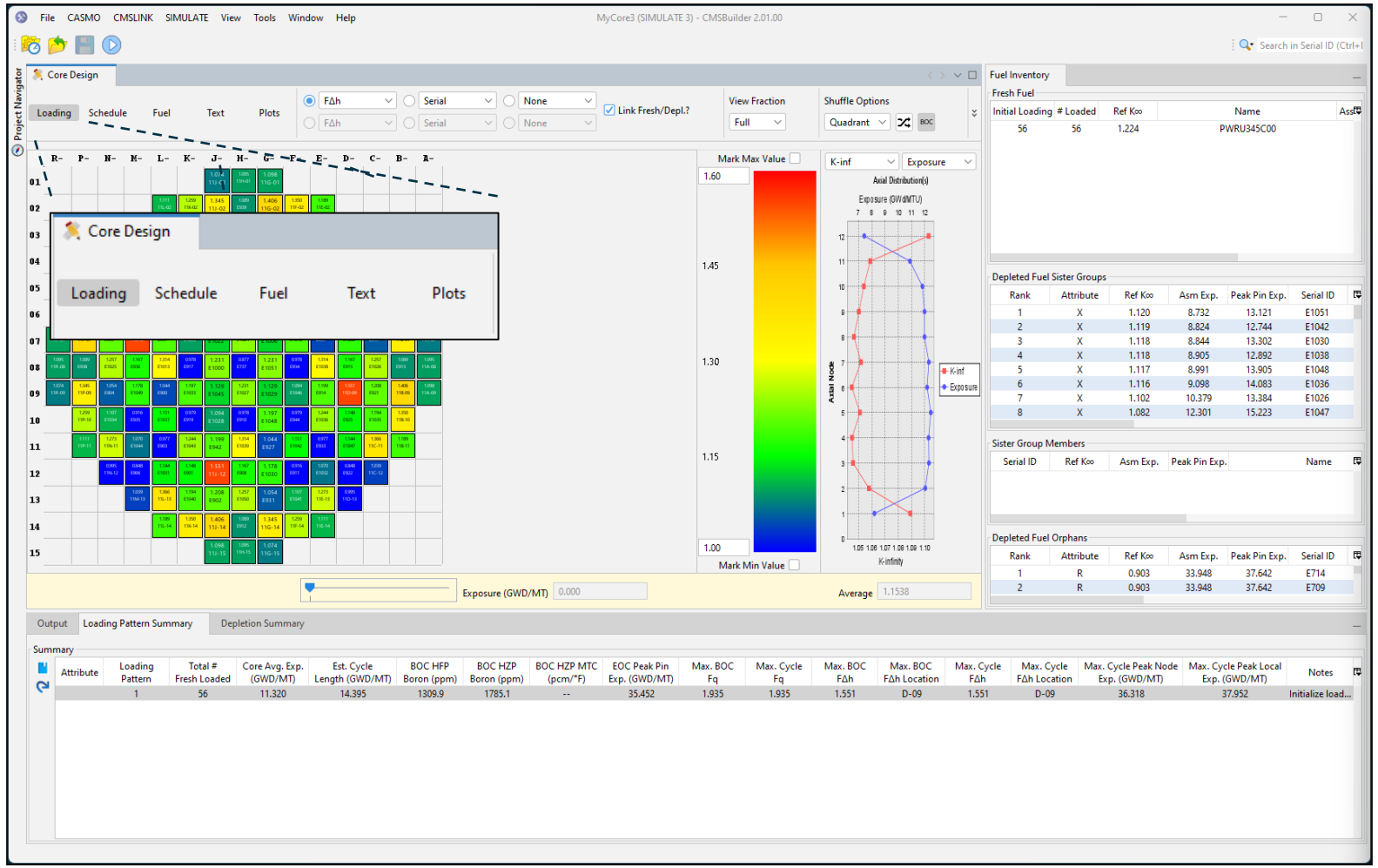
Core Design Window - Loading



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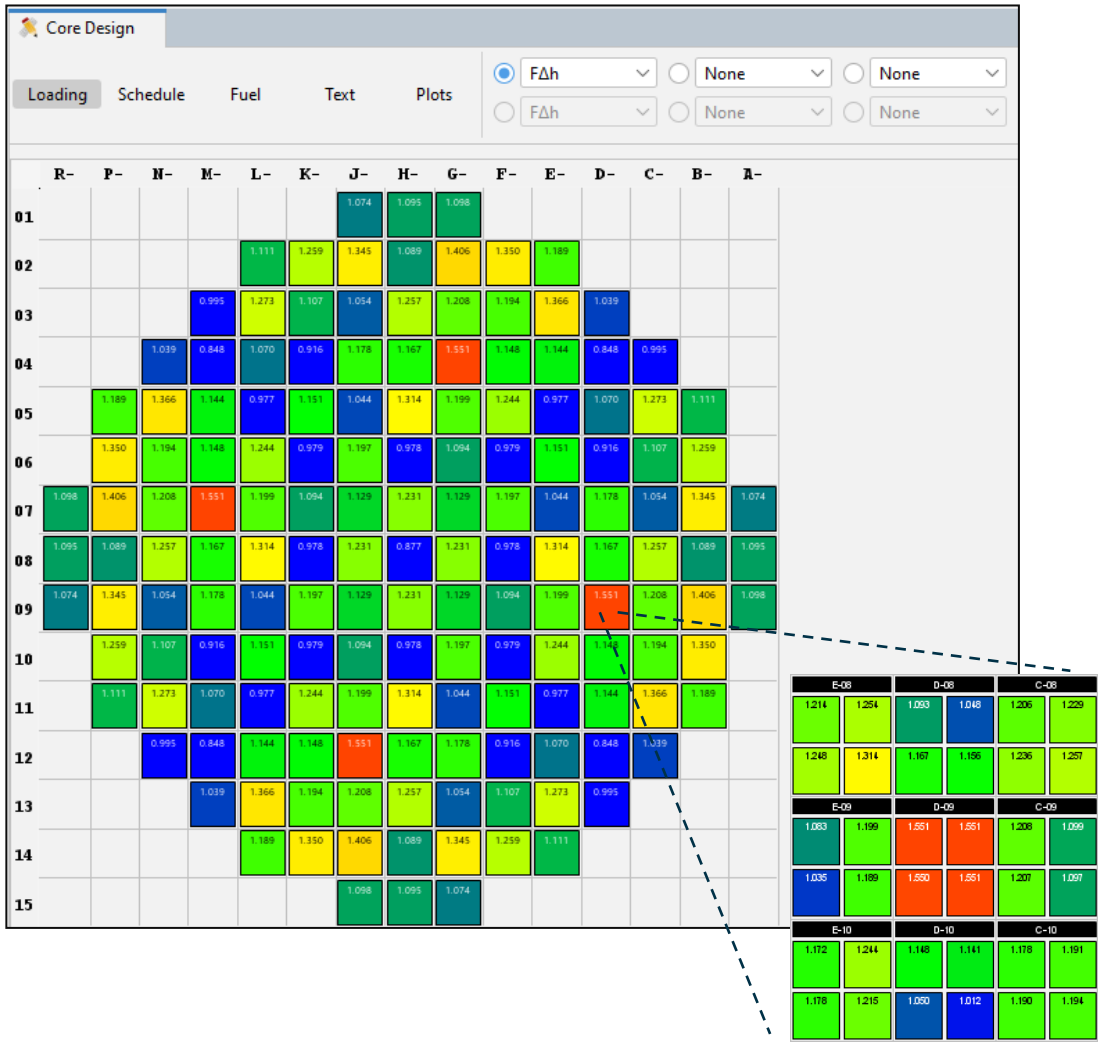
Loading



- Graphical core map with key parameters. Users select up to 3 display items per assembly: Serial ID, Exposure, Power, etc.
- Shuffle fuel
- View radial nodal values (2x2 intranodal mesh)

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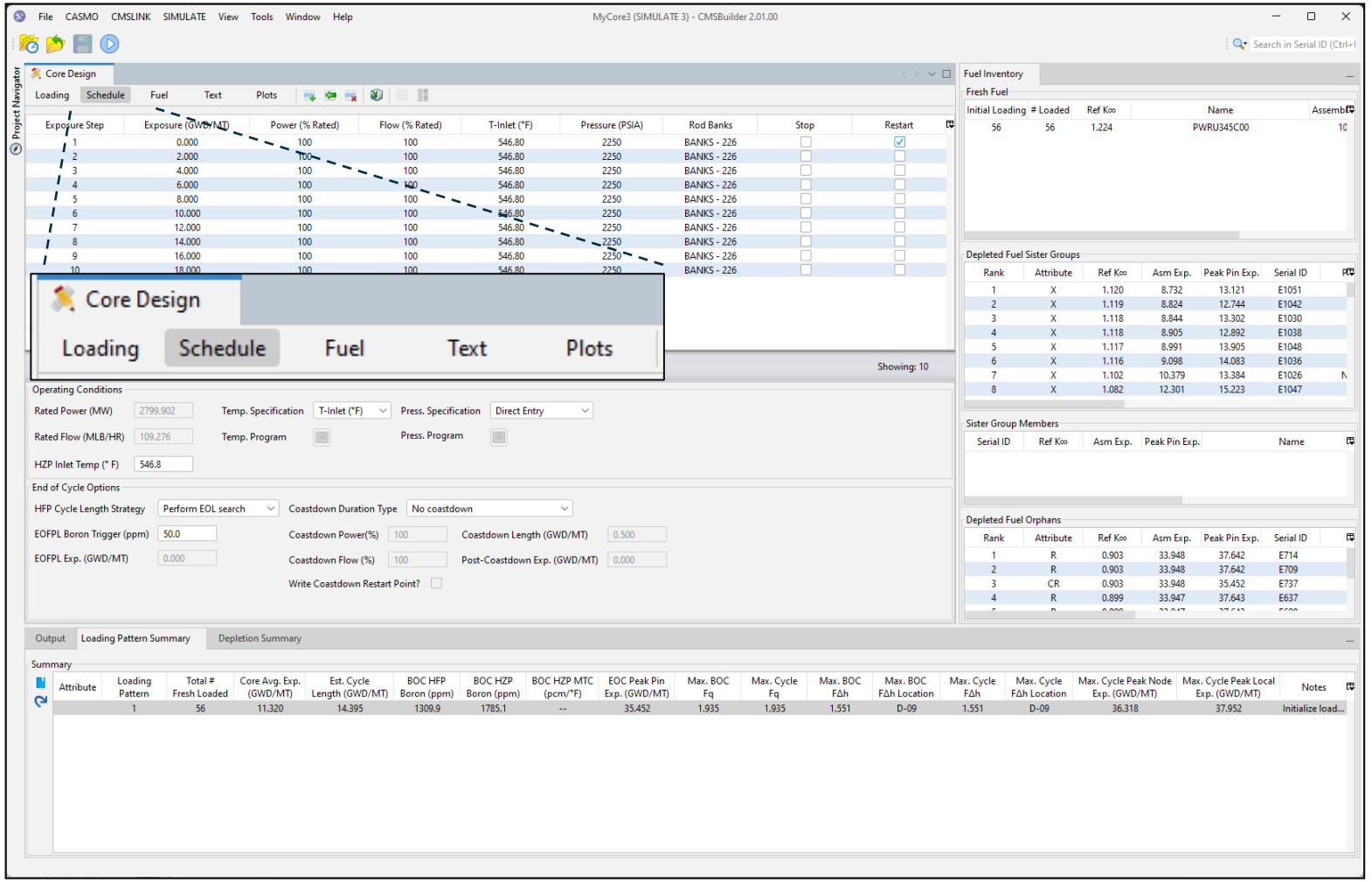
Core Design Window - Schedule



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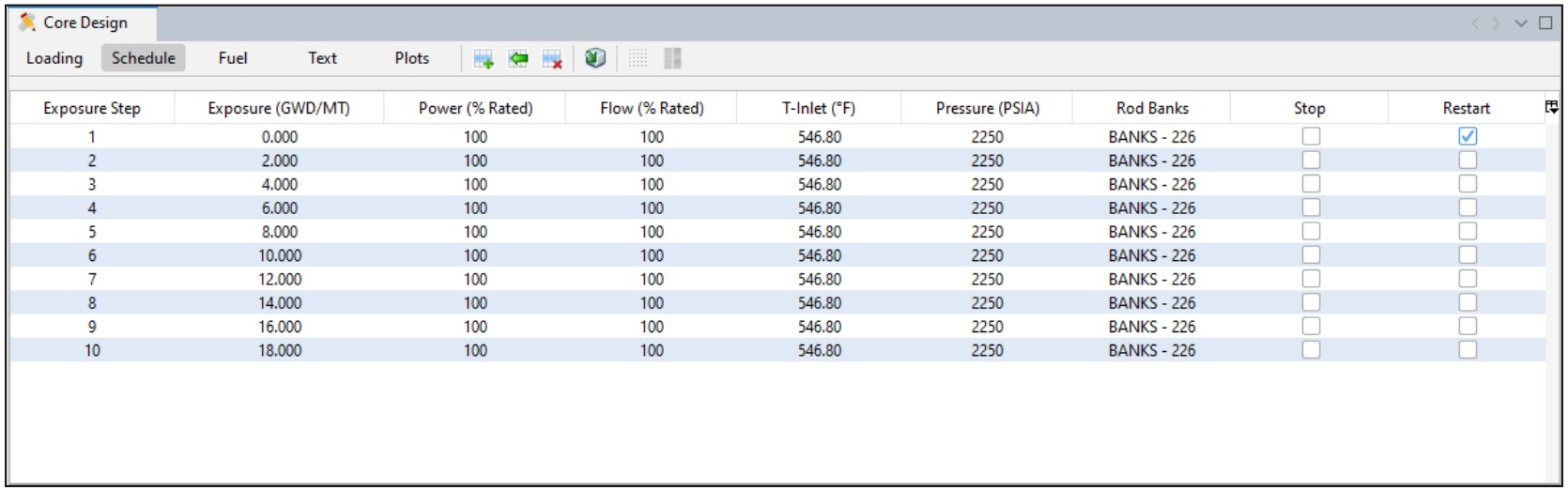
Schedule



Exposure Step	Exposure (GWD/MT)	Power (% Rated)	Flow (% Rated)	T-Inlet (°F)	Pressure (PSIA)	Rod Banks	Stop	Restart
1	0.000	100	100	546.80	2250	BANKS - 226	☐	☑
2	2.000	100	100	546.80	2250	BANKS - 226	☐	☐
3	4.000	100	100	546.80	2250	BANKS - 226	☐	☐
4	6.000	100	100	546.80	2250	BANKS - 226	☐	☐
5	8.000	100	100	546.80	2250	BANKS - 226	☐	☐
6	10.000	100	100	546.80	2250	BANKS - 226	☐	☐
7	12.000	100	100	546.80	2250	BANKS - 226	☐	☐
8	14.000	100	100	546.80	2250	BANKS - 226	☐	☐
9	16.000	100	100	546.80	2250	BANKS - 226	☐	☐
10	18.000	100	100	546.80	2250	BANKS - 226	☐	☐

- Allows users to modify the default depletion schedule
- Modify statepoint conditions, rod banks
- Add stop points
- Import depletion schedule from a restart

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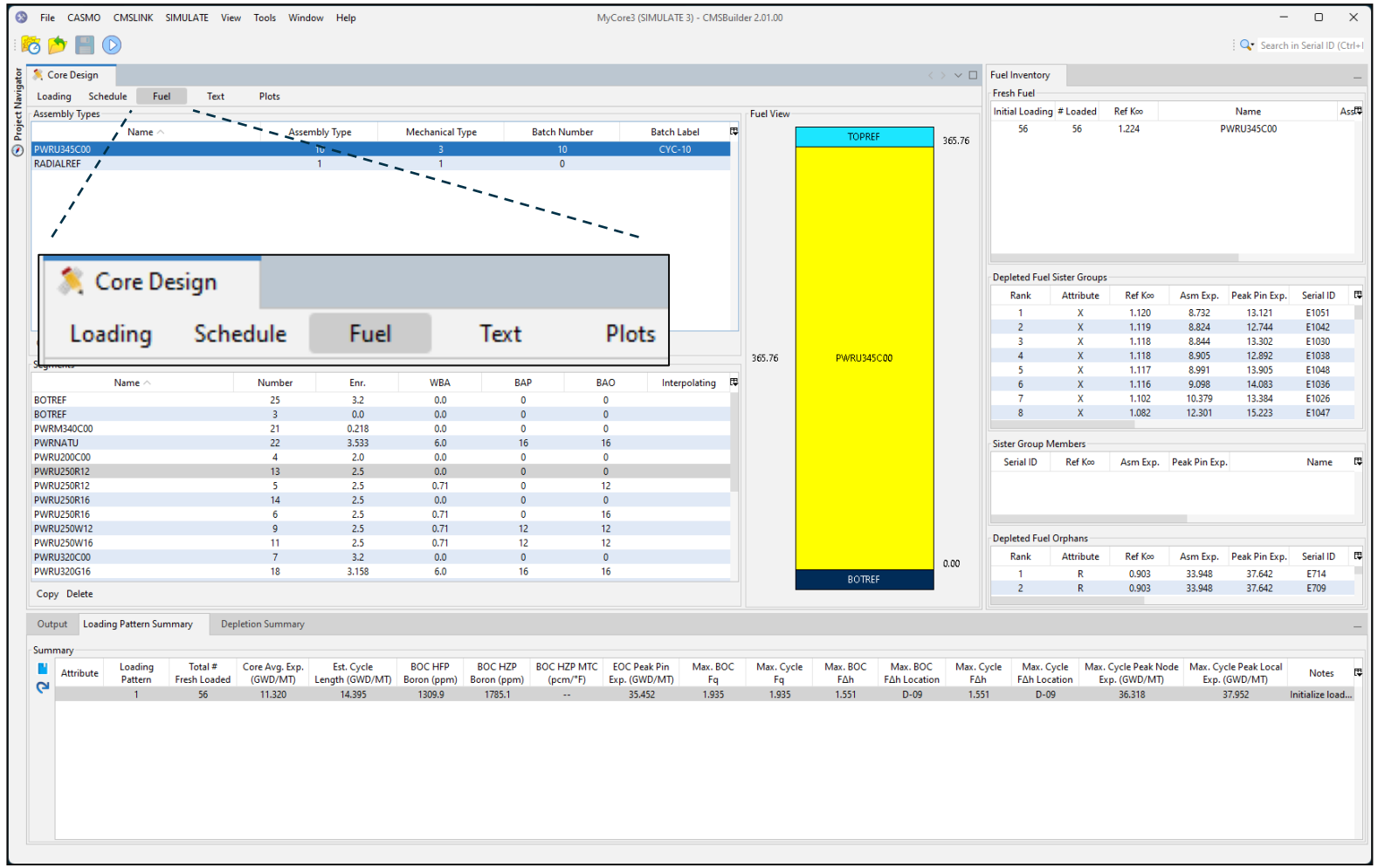
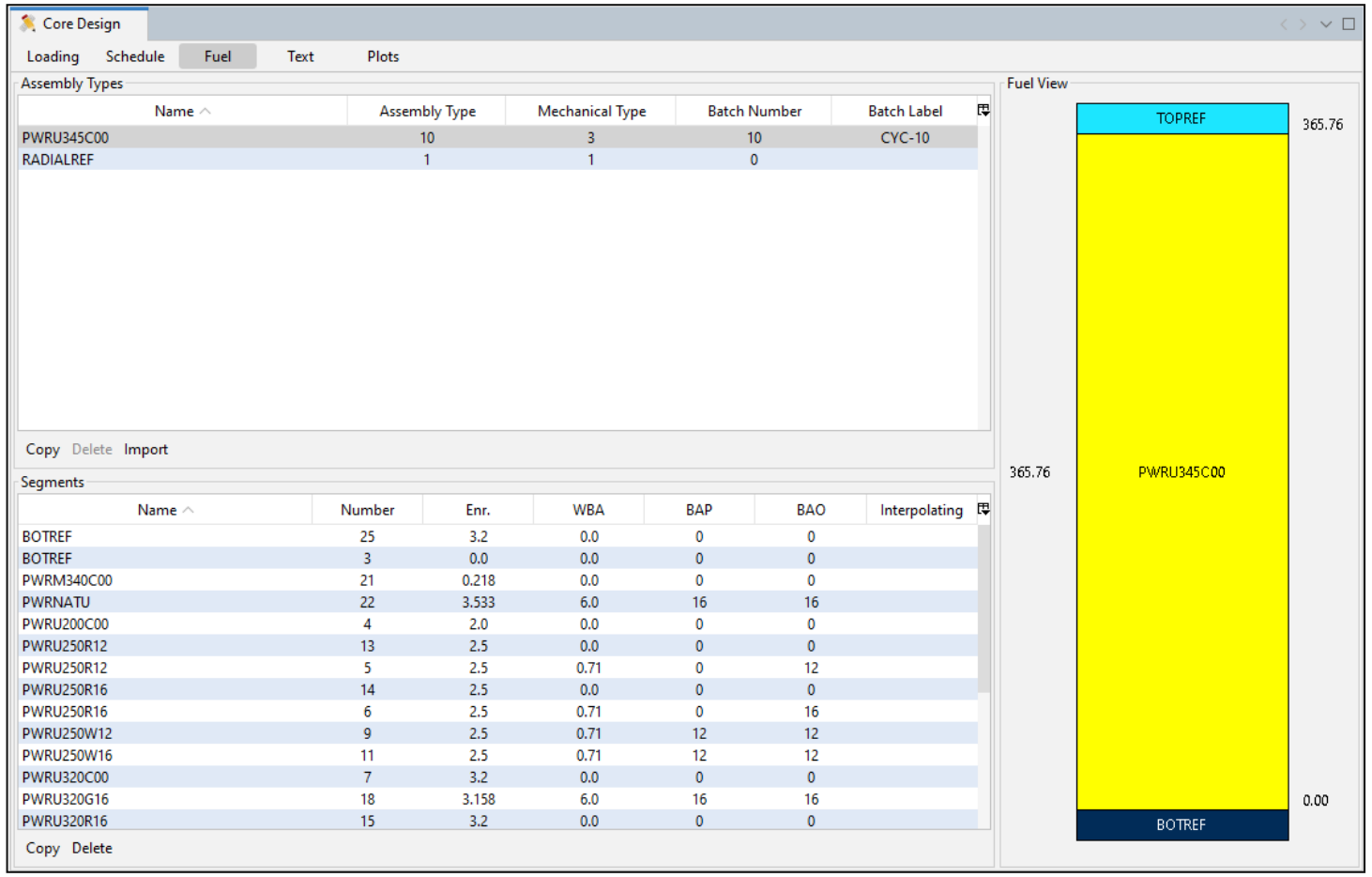
Core Design Window – Fuel



Fuel



- Copy an existing assembly type as a template for a new design assembly type.
- Adjust scoping segments
- Remove/Insert burnable poison

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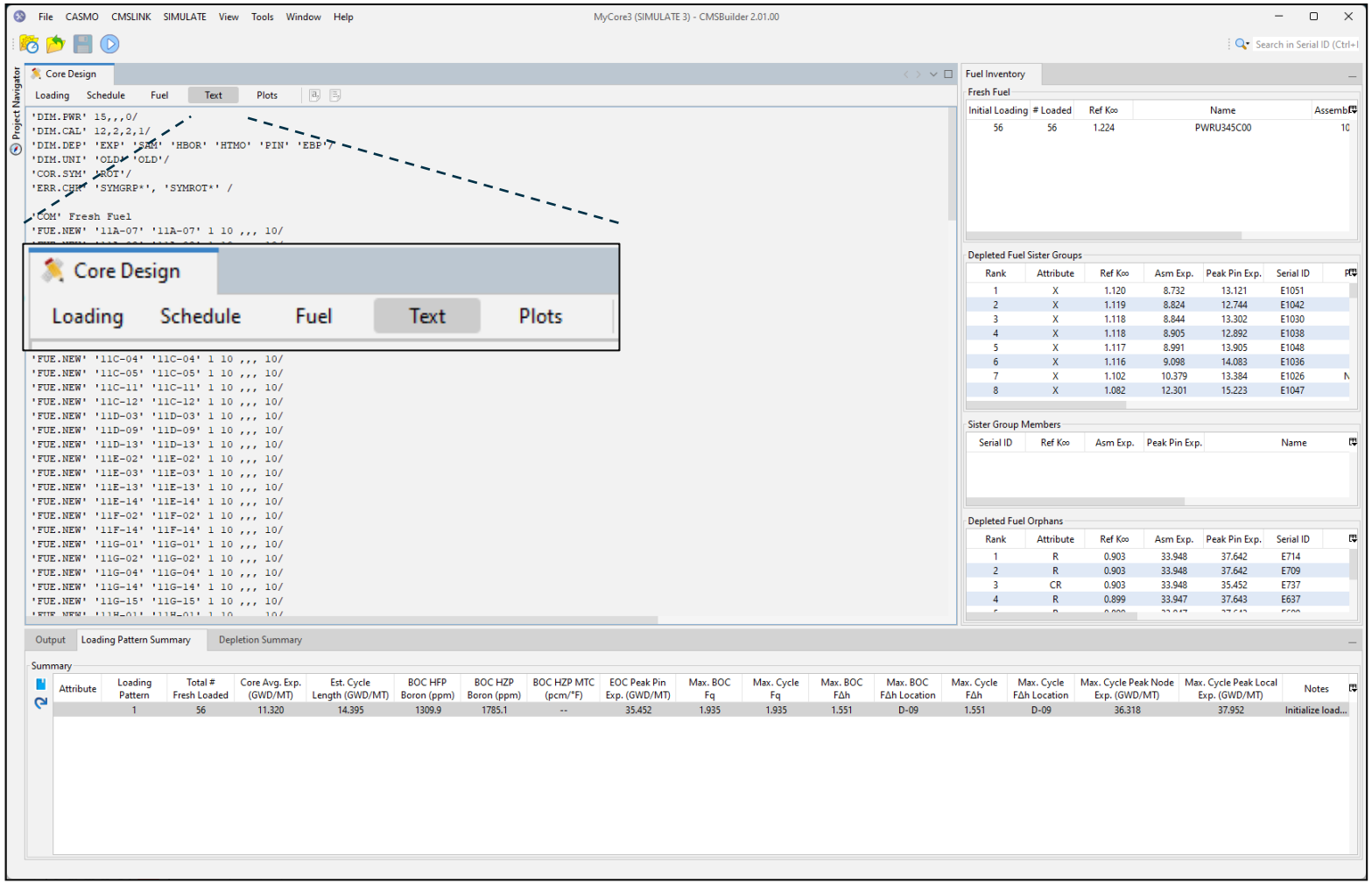
Core Design Window - Text



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Text

Core Design

Loading | Schedule | Text

```
********UGM2018.inp********
'DIM.PWR' 17,,,1/
'DIM.CAL' 24 4 2 2/
'DIM.DEP' 'EXP' 'SAM' 'HBO' 'HTF' 'HTM' 'PIN' 'MBP' 'HCR' 'FLN'/
'DIM.UNI' 'OLD' 'OLD'/
'COR.SYM' 'ROT'/

'FUE.SER' 6/
 1  1                                        Z041   Z040          Z033   Z048
 2  1                              Y019   Z021   BB11   BB35   AA31   BB38   BB14   Z020   Y022
 3  1                       AA76   BB03   BB23   AA02   AA60   BB67   AA53   AA07   BB26   BB06   AA70
 4  1                AA71   BB19   AA09   Z065   BB55   Z005   BB63   Z004   BB58   Z064   AA16   BB18   AA75
 5  1         Y023   BB07   AA13   AA48   BB47   Z053   AA33   AA19   AA37   Z052   BB50   AA47   AA12   BB02   Y018
 6  1         Z017   BB27   Z061   BB51   AA21   AA68   AA41   BB43   AA50   AA61   AA24   BB46   Z068   BB22   Z024
 7  1 Z045    BB15   AA08   BB59   Z049   AA62   BB31   Z010   Z028   Z015   BB30   AA67   Z056   BB54   AA01   BB10   Z044
 8  1 Z034    BB39   AA54   Z001   AA38   AA51   Z016   BB71   AA28   BB70   Z009   AA44   AA36   Z008   AA59   BB34   Z039
 9  1         AA32   BB68   BB64   AA20   BB44   Z025   AA25   AA77   AA27   Z027   BB42   AA18   BB62   BB66   AA30
10  1 Z037    BB36   AA57   Z006   AA34   AA42   Z011   BB72   AA26   BB69   Z014   AA49   AA40   Z003   AA56   BB37   Z036
11  1 Z042    BB12   AA03   BB56   Z054   AA65   BB32   Z013   Z026   Z012   BB29   AA64   Z051   BB57   AA06   BB13   Z047
12  1         Z022   BB24   Z066   BB48   AA22   AA63   AA52   BB41   AA43   AA66   AA23   BB49   Z063   BB25   Z019
13  1         Y020   BB04   AA10   AA45   BB52   Z050   AA39   AA17   AA35   Z055   BB45   AA46   AA15   BB05   Y021
14  1                AA73   BB20   AA14   Z062   BB60   Z002   BB61   Z007   BB53   Z067   AA11   BB17   AA69
15  1                       AA72   BB08   BB28   AA05   AA55   BB65   AA58   AA04   BB21   BB01   AA74
16  1                              Y024   Z018   BB16   BB40   AA29   BB33   BB09   Z023   Y017
17  1                                            Z046   Z035          Z038   Z043
0 0

'RES'
  's5.m2boc22.res' 0.000
  's5.m2eoc21.res' 15.201
  's5.m2eoc20.res' 15.182
/
'LIB' 'MP2-Cycle_20_23.lib'/
```

← SIMULATE input

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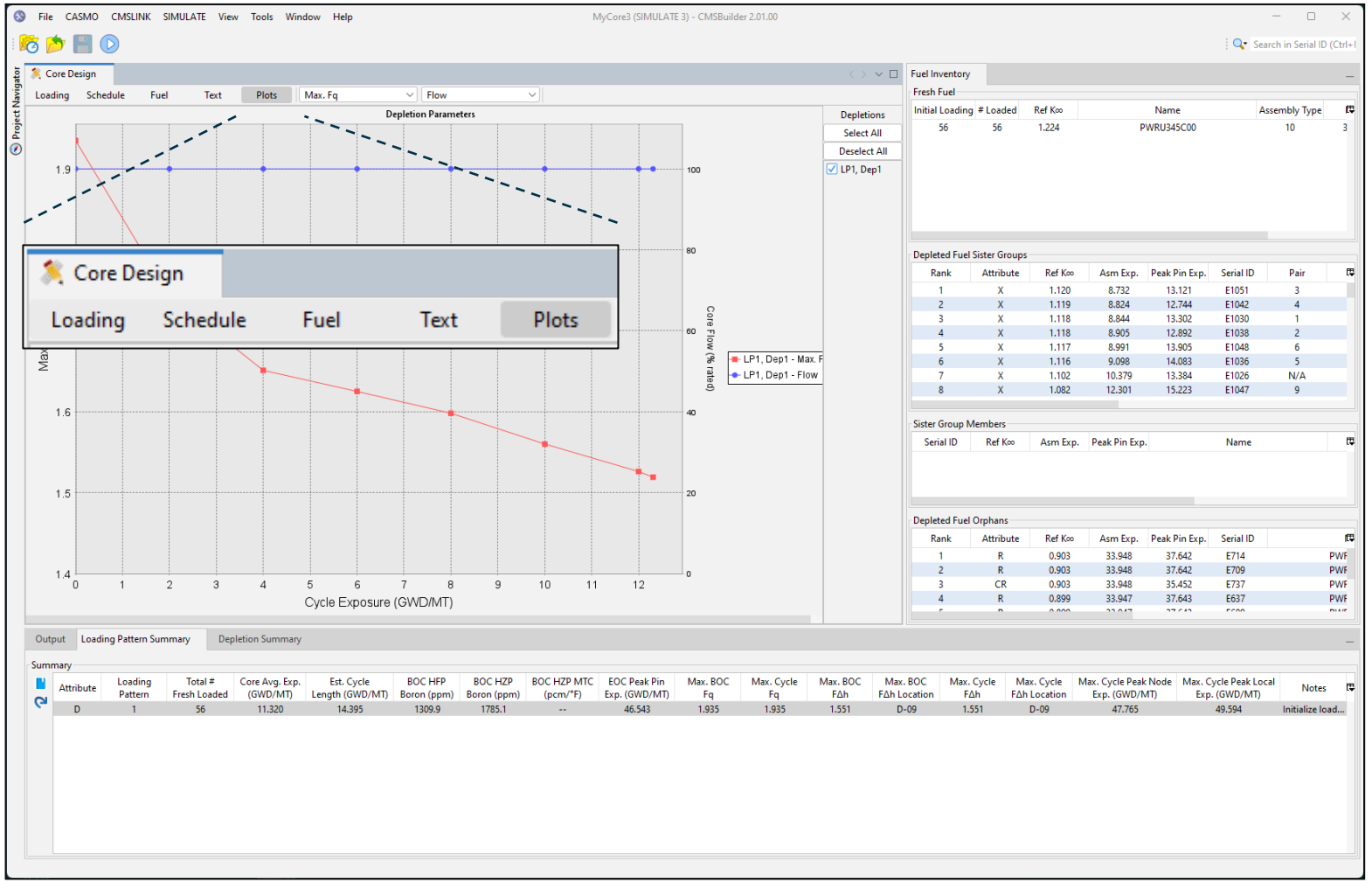
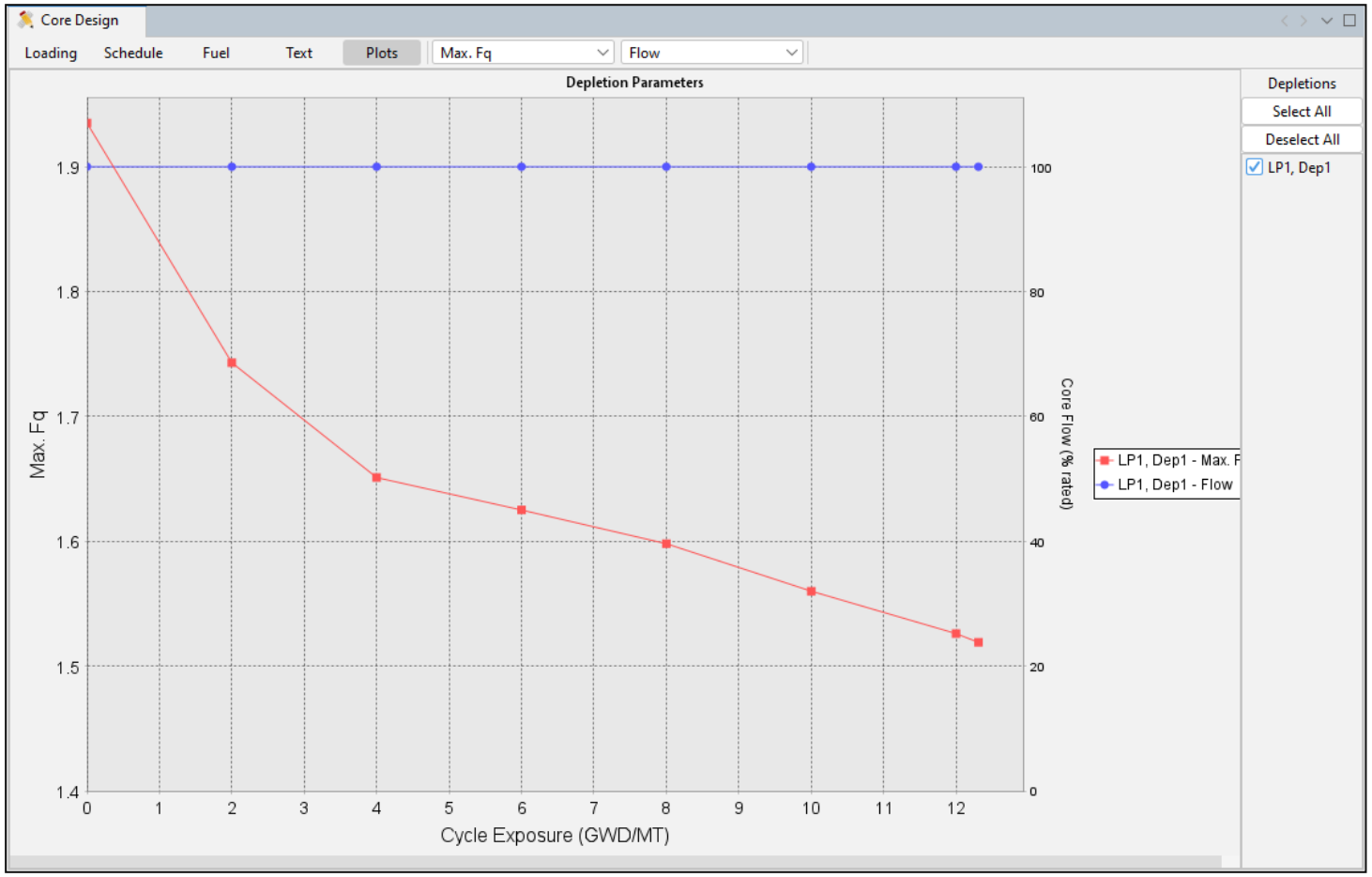
Core Design Window - Plots



Plots



Plot of burnup-dependent core parameters for comparison across core exposures for loading patterns

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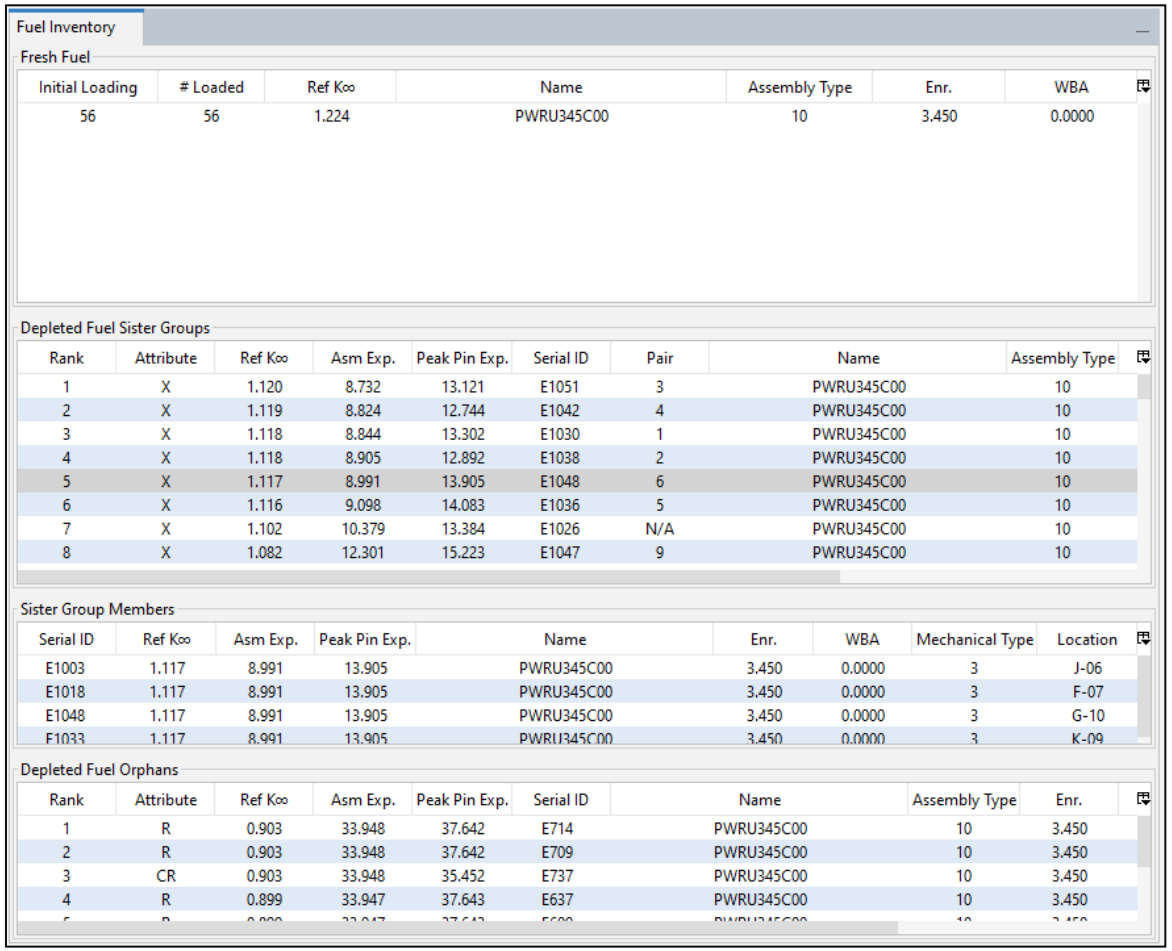
Fuel Inventory Window



Fuel Inventory

Fresh Fuel

Initial Loading	# Loaded	Ref K∞	Name	Assembly Type	Enr.	WBA
56	56	1.224	PWRU345C00	10	3.450	0.0000

Depleted Fuel Sister Groups

Rank	Attribute	Ref K∞	Asm Exp.	Peak Pin Exp.	Serial ID	Pair	Name	Assembly Type
1	X	1.120	8.732	13.121	E1051	3	PWRU345C00	10
2	X	1.119	8.824	12.744	E1042	4	PWRU345C00	10
3	X	1.118	8.844	13.302	E1030	1	PWRU345C00	10
4	X	1.118	8.905	12.892	E1038	2	PWRU345C00	10
5	X	1.117	8.991	13.905	E1048	6	PWRU345C00	10
6	X	1.116	9.098	14.083	E1036	5	PWRU345C00	10
7	X	1.102	10.379	13.384	E1026	N/A	PWRU345C00	10
8	X	1.082	12.301	15.223	E1047	9	PWRU345C00	10

Sister Group Members

Serial ID	Ref K∞	Asm Exp.	Peak Pin Exp.	Name	Enr.	WBA	Mechanical Type	Location
E1003	1.117	8.991	13.905	PWRU345C00	3.450	0.0000	3	J-06
E1018	1.117	8.991	13.905	PWRU345C00	3.450	0.0000	3	F-07
E1048	1.117	8.991	13.905	PWRU345C00	3.450	0.0000	3	G-10
E1033	1.117	8.991	13.905	PWRU345C00	3.450	0.0000	3	K-09

Depleted Fuel Orphans

Rank	Attribute	Ref K∞	Asm Exp.	Peak Pin Exp.	Serial ID	Name	Assembly Type	Enr.
1	R	0.903	33.948	37.642	E714	PWRU345C00	10	3.450
2	R	0.903	33.948	37.642	E709	PWRU345C00	10	3.450
3	CR	0.903	33.948	35.452	E737	PWRU345C00	10	3.450
4	R	0.899	33.947	37.643	E637	PWRU345C00	10	3.450

← Fresh Fuel

← Sister Groups - conceptual groups of fuel positioned in symmetric locations

← Sister Group Members – assemblies comprising selected group

← Orphans – assemblies not part of a sister group (i.e., center assembly)

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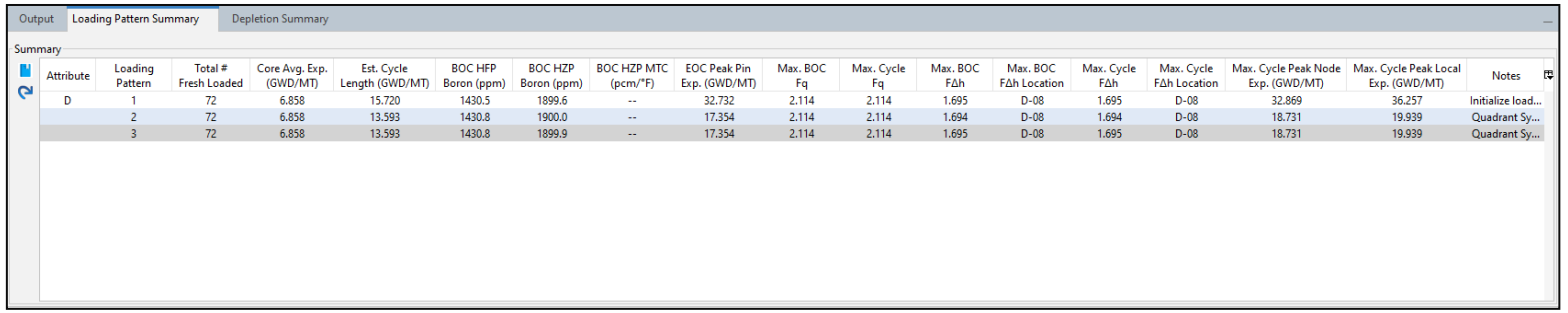
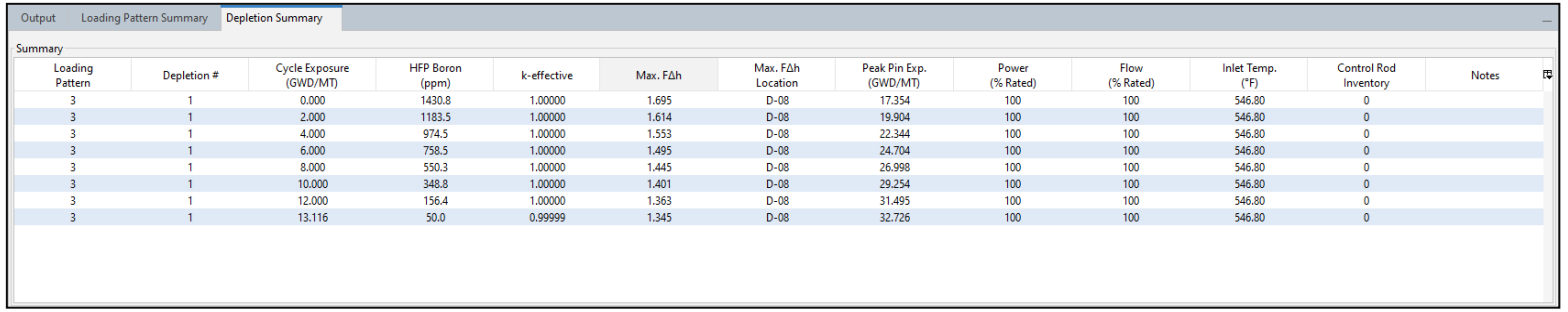
Loading Pattern and Depletion Summary Windows

Loading Pattern Summary - During manual shuffle at BOC, this scrolling user configurable list allows a comparison of all loading patterns considered



Attribute	Loading Pattern	Total # Fresh Loaded	Core Avg. Exp. (GWD/MT)	Est. Cycle Length (GWD/MT)	BOC HFP Boron (ppm)	BOC HZP Boron (ppm)	BOC HZP MTC (pcm/°F)	EOC Peak Pin Exp. (GWD/MT)	Max. BOC Fq	Max. Cycle Fq	Max. BOC FΔh	Max. BOC FΔh Location	Max. Cycle FΔh	Max. Cycle FΔh Location	Max. Cycle Peak Node Exp. (GWD/MT)	Max. Cycle Peak Local Exp. (GWD/MT)	Notes
D	1	72	6.858	15.720	1430.5	1899.6	--	32.732	2.114	2.114	1.695	D-08	1.695	D-08	32.869	36.257	Initialize load...
	2	72	6.858	13.593	1430.8	1900.0	--	17.354	2.114	2.114	1.694	D-08	1.694	D-08	18.731	19.939	Quadrant Sy...
	3	72	6.858	13.593	1430.8	1899.9	--	17.354	2.114	2.114	1.695	D-08	1.695	D-08	18.731	19.939	Quadrant Sy...

Depletion Summary - The user configurable list indicates the performance of the core at each statepoint during depletion



Loading Pattern	Depletion #	Cycle Exposure (GWD/MT)	HFP Boron (ppm)	k-effective	Max. FΔh	Max. FΔh Location	Peak Pin Exp. (GWD/MT)	Power (% Rated)	Flow (% Rated)	Inlet Temp. (°F)	Control Rod Inventory	Notes
3	1	0.000	1430.8	1.00000	1.695	D-08	17.354	100	100	546.80	0	
3	1	2.000	1183.5	1.00000	1.614	D-08	19.904	100	100	546.80	0	
3	1	4.000	974.5	1.00000	1.553	D-08	22.344	100	100	546.80	0	
3	1	6.000	758.5	1.00000	1.495	D-08	24.704	100	100	546.80	0	
3	1	8.000	550.3	1.00000	1.445	D-08	26.998	100	100	546.80	0	
3	1	10.000	348.8	1.00000	1.401	D-08	29.254	100	100	546.80	0	
3	1	12.000	156.4	1.00000	1.363	D-08	31.495	100	100	546.80	0	
3	1	13.116	50.0	0.99999	1.345	D-08	32.726	100	100	546.80	0	

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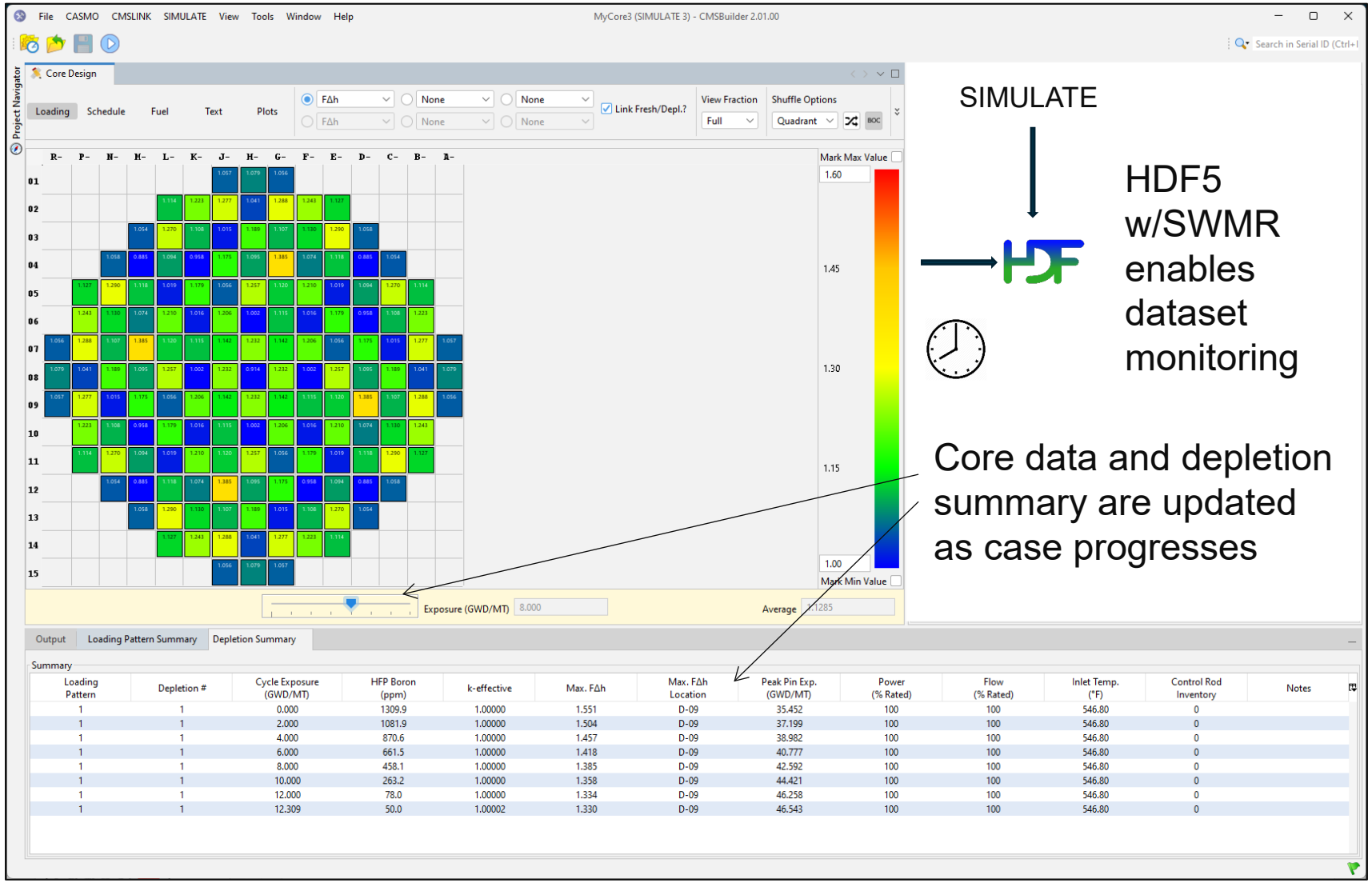
Realtime Updates



Loading Pattern	Depletion #	Cycle Exposure (GWD/MT)	HFP Boron (ppm)	k-effective	Max. FΔh	Max. FΔh Location	Peak Pin Exp. (GWD/MT)	Power (% Rated)	Flow (% Rated)	Inlet Temp. (°F)	Control Rod Inventory	Notes
1	1	0.000	1309.9	1.00000	1.551	D-09	35.452	100	100	546.80	0	
1	1	2.000	1081.9	1.00000	1.504	D-09	37.199	100	100	546.80	0	
1	1	4.000	870.6	1.00000	1.457	D-09	38.982	100	100	546.80	0	
1	1	6.000	661.5	1.00000	1.418	D-09	40.777	100	100	546.80	0	
1	1	8.000	458.1	1.00000	1.385	D-09	42.592	100	100	546.80	0	
1	1	10.000	263.2	1.00000	1.358	D-09	44.421	100	100	546.80	0	
1	1	12.000	78.0	1.00000	1.334	D-09	46.258	100	100	546.80	0	
1	1	12.309	50.0	1.00002	1.330	D-09	46.543	100	100	546.80	0	

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Demo