

**IDAES**<sup>®</sup>  
Institute for the Design of  
Advanced Energy Systems

# IDAES Visualization

**Dan Gunter**, Sheng Pang, Sarah Poon, Cody O'Donnell  
Stakeholder Summit 2023



# Visualization is important

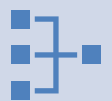


IDAES models are built in Python code, but..



Complex models are routinely diagrammed

Validation: are the connections correct  
Communication to others (and yourself)



Diagrams provide context for model properties

Stream values, unit values, constraints, structure



Visualization is much more than diagrams (of course)

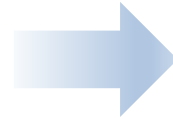
Plots of results, visual diagnostics, etc.

# IDAES has a visualization tool “built in”

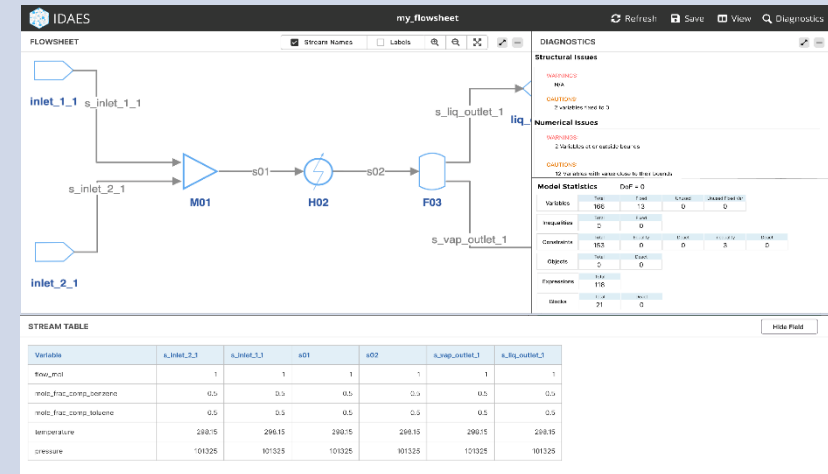
With the addition of one line of code to your Jupyter Notebook or script..



```
model = build_model()  
model.visualize("my_flowsheet")
```



..you get a web-based UI that automatically displays a model diagram and a stream table..



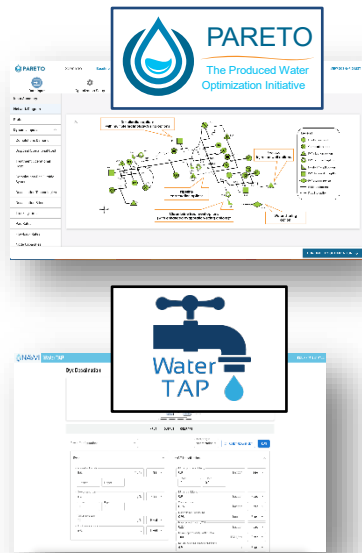
..and retains a connection to the model so you can interact with it.



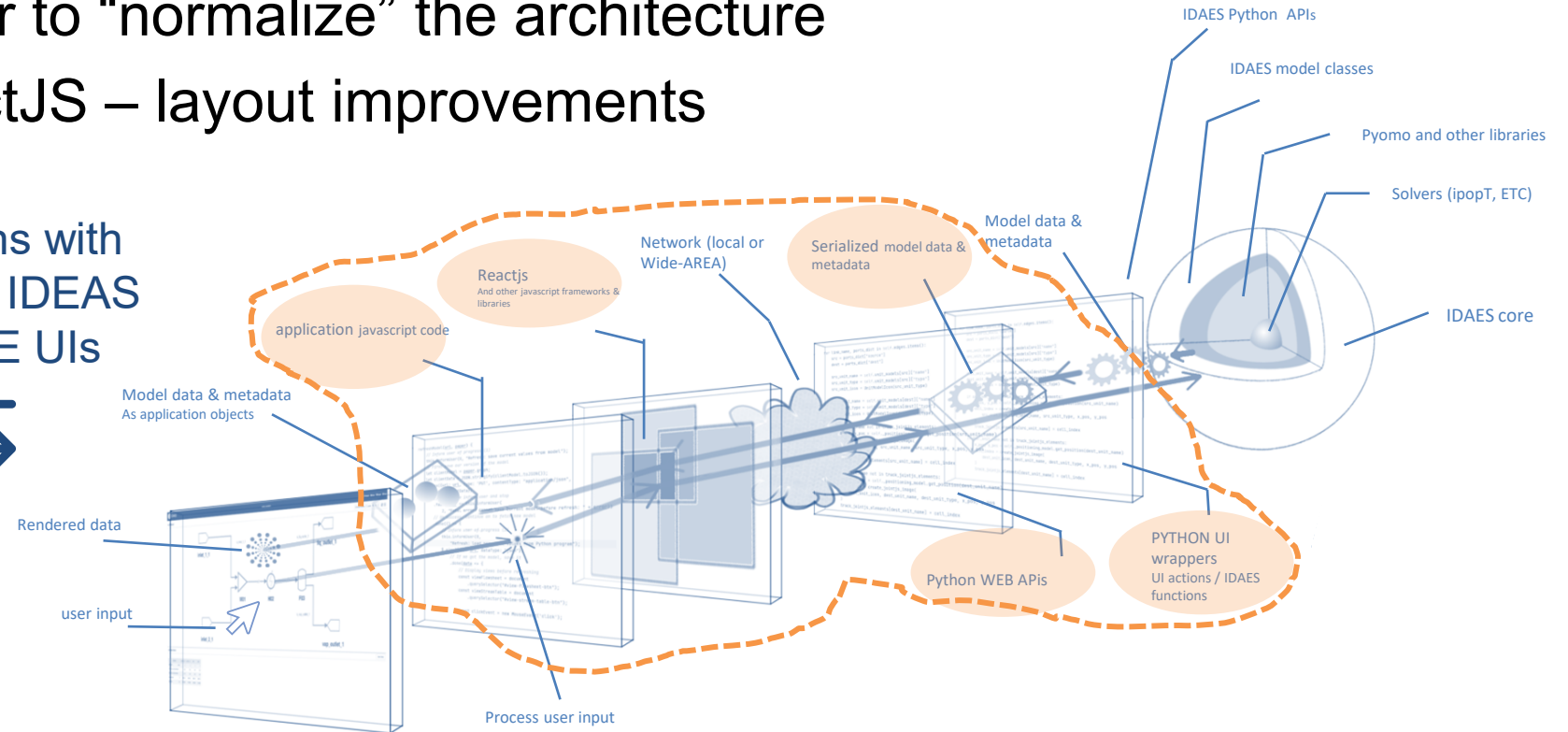
We call this tool the **Flowsheet Visualizer (FV)**

# Latest changes for the FV

- Important refactor to “normalize” the architecture
- Re-do UI in ReactJS – layout improvements

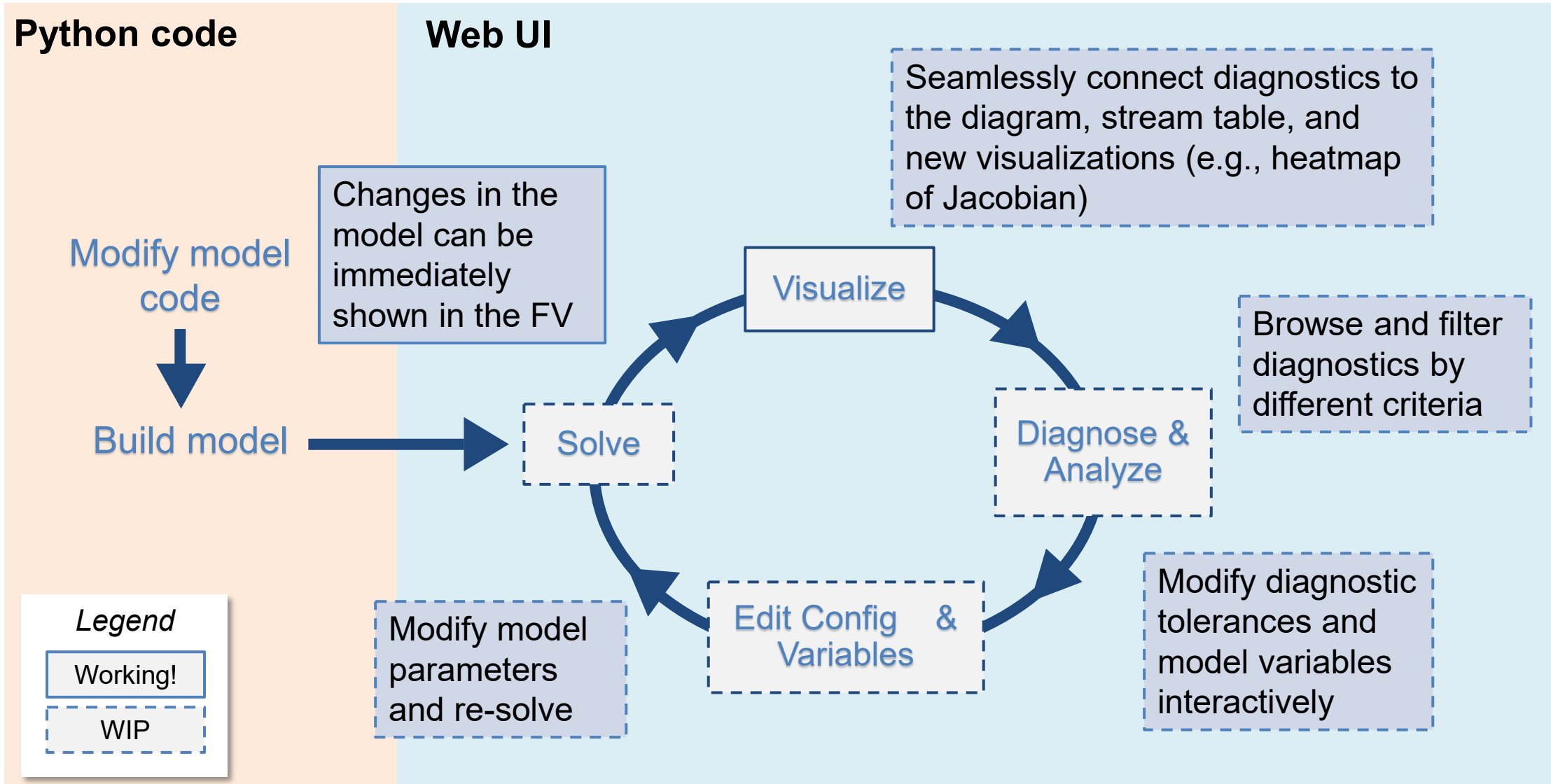


Aligns with  
other IDEAS  
PSE UIs



We are preparing the way for incorporating new, interactive elements, starting with: IDAES Diagnostics

# Plans for diagnostics (..and beyond!)



# Diagnostics Prototype Screenshot



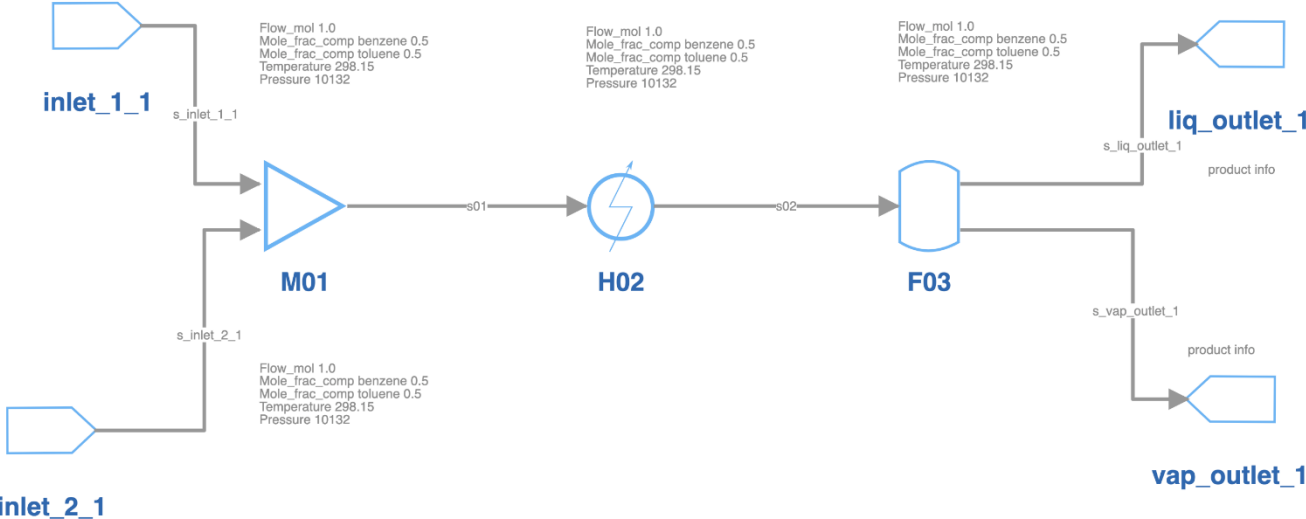
sample\_visualization

Refresh Save Export View Diagnostics

**FLWSHEET**

Stream Names Labels

**DIAGNOSTICS**



**STREAM TABLE**

Hide Fields

Variable		s_inlet_2_1	s_inlet_1_1	s01	s02
flow_mol	mol/s	1	1	1	1
mole_frac_comp benzene	-	0.5	0.5	0.5	0.5
mole_frac_comp toluene	-	0.5	0.5	0.5	0.5
temperature	K	298.15	298.15	298.15	298.15
pressure	Pa	101325	101325	101325	101325

**ISSUES**

2 Caution

**CONFIG**

Name	Value
variable bounds absolute tolerance	0.0001
variable bounds relative tolerance	0.0001
variable bounds violation tolerance	0
constraint residual tolerance	0.00001
variable large value tolerance	10000
variable small value tolerance	0.0001
variable zero value tolerance	1e-8
jacobian large value caution	10000
jacobian large value warning	100000000
jacobian small value caution	0.0001
jacobian small value warning	1e-8

**STATISTICS**

DoF	Value			
	0			
Variables	Value	Unused	Fixed	Ineq
	166	166	166	166
Inequalities	Value			
	0			
Constraints	Value	Eq	Ineq	
	153	153	153	
Objects	Value	Deact		
	0	0		
Blocks	Value	Deact		
	21	21		
Expressions	Value			
	118			

# Diagnostics Prototype Screenshot Detail

**DIAGNOSTICS** ↗ —

**ISSUES** ▼  
▶ 2 Caution

**CONFIG** ▼

Name	Value
variable bounds absolute tolerance	0.0001
variable bounds relative tolerance	0.0001
variable bounds violation tolerance	0
constraint residual tolerance	0.00001
variable large value tolerance	10000
variable small value tolerance	0.0001
variable zero value tolerance	1e-8
jacobian large value caution	10000
jacobian large value warning	100000000
jacobian small value caution	0.0001
jacobian small value warning	1e-8

**STATISTICS** ▼

DoF	Value			
	0			
Variables	Value	Unused	Fixed	Ineq
	166	166	166	166
Inequalities	Value			
	0			
Constraints	Value	Eq	Ineq	
	153	153	153	
Objects	Value	Deact		
	0	0		
Blocks	Value	Deact		
	21	21		
Expressions	Value			
	118			

# Browse to view cautions

**DIAGNOSTICS**

**ISSUES** ▾

- ▾ 2 Caution
  - ▾ Caution 1: variables with extreme values
    - ▶ extreme\_values : 72
  - ▾ Caution 2: variables close to their bounds
    - ▶ var\_near\_bounds : 12

**CONFIG** ▾

Name	Value
variable bounds absolute tolerance	0.0001
variable bounds relative tolerance	0.0001
variable bounds violation tolerance	0
constraint residual tolerance	0.00001
variable large value tolerance	10000
variable small value tolerance	0.0001
variable zero value tolerance	1e-8
jacobian large value caution	10000
jacobian large value warning	100000000
jacobian small value caution	0.0001
jacobian small value warning	1e-8

**STATISTICS** ▾

DoF	Value	0
Variables	Value	166
	Unused	166
	Fixed	166
	Ineq	166
Inequalities	Value	0
Constraints	Value	153
	Eq	153
	Ineq	153
Objects	Value	0
	Deact	0
Blocks	Value	21
	Deact	21
Expressions	Value	118



# View variables with “extreme values”

**DIAGNOSTICS**

**ISSUES** ▾

- ▾ 2 Caution
  - ▾ Caution 1: variables with extreme values
    - ▾ extreme\_values : 72

Search

fs.M01.minimum_pressure[0.0,1]	101324.99999999999
fs.M01.minimum_pressure[0.0,2]	101324.99999999997
fs.M01.inlet_1_state[0.0].mole_frac_comp[toluene]	0.00001
fs.M01.inlet_1_state[0.0].pressure	101325
fs.M01.inlet_2_state[0.0].mole_frac_comp[benzene]	0.00001
fs.M01.inlet_2_state[0.0].pressure	130000
fs.M01.mixed_state[0.0].pressure	101324.99999999997
fs.M01.inlet_1_state[0.0].mole_frac_phase_comp[Liq,toluene]	0.00004226501650736347
fs.M01.inlet_1_state[0.0].mole_frac_phase_comp[Vap,toluene]	0.000016239937390247786
fs.M01.inlet_1_state[0.0].pressure_sat_comp[benzene]	101327.63707622685
fs.M01.inlet_1_state[0.0].pressure_sat_comp[toluene]	38933.18380178968
fs.M01.inlet_1_state[0.0].enth_mol_phase[Liq]	59403.464839923574
fs.M01.inlet_1_state[0.0].enth_mol_phase[Vap]	89602.98646808404
fs.M01.inlet_1_state[0.0].enth_mol_phase_comp[Liq,benzene]	59404.366946131
fs.M01.inlet_1_state[0.0].enth_mol_phase_comp[Liq,toluene]	24005.117152243132
fs.M01.inlet_1_state[0.0].enth_mol_phase_comp[Vap,benzene]	89602.59458088383
fs.M01.inlet_1_state[0.0].enth_mol_phase_comp[Vap,toluene]	58559.44869427196
fs.M01.inlet_2_state[0.0].mole_frac_phase_comp[Liq,benzene]	0.000018948688821340677
fs.M01.inlet_2_state[0.0].mole_frac_phase_comp[Vap,benzene]	0.00004334161298390463
fs.M01.inlet_2_state[0.0].pressure_sat_comp[benzene]	297350.9006893184
fs.M01.inlet_2_state[0.0].pressure_sat_comp[toluene]	129996.82889148161
fs.M01.inlet_2_state[0.0].enth_mol_phase[Liq]	25813.44309761046
fs.M01.inlet_2_state[0.0].enth_mol_phase[Vap]	59876.807741757904
fs.M01.inlet_2_state[0.0].enth_mol_phase_comp[Liq,benzene]	60968.170946131
fs.M01.inlet_2_state[0.0].enth_mol_phase_comp[Liq,toluene]	25812.518818909797
fs.M01.inlet_2_state[0.0].enth_mol_phase_comp[Vap,benzene]	90653.83510796717
fs.M01.inlet_2_state[0.0].enth_mol_phase_comp[Vap,toluene]	59874.87498323029
fs.M01.mixed_state[0.0].pressure_sat_comp[benzene]	156860.8353206145
fs.M01.mixed_state[0.0].pressure_sat_comp[toluene]	63534.71863733716
fs.M01.mixed_state[0.0].enth_mol_phase[Liq]	38039.7329520597
fs.M01.mixed_state[0.0].enth_mol_phase[Vap]	77818.48958992377
fs.M01.mixed_state[0.0].enth_mol_phase_comp[Liq,benzene]	59130.24754889732
fs.M01.mixed_state[0.0].enth_mol_phase_comp[Liq,toluene]	23688.34207264077
fs.M01.mixed_state[0.0].enth_mol_phase_comp[Vap,benzene]	89419.03516967919
fs.M01.mixed_state[0.0].enth_mol_phase_comp[Vap,toluene]	58229.5304920868

# Filter variables by name (etc.)

**DIAGNOSTICS** ↗ -

**ISSUES** ▾

▼ 2 Caution

▼ Caution 1: variables with extreme values

▼ extreme\_values : 72

🔍 fs.M01.inlet\_1\_state[0.0]

fs.M01.inlet_1_state[0.0].mole_frac_comp[toluene]	0.00001
fs.M01.inlet_1_state[0.0].pressure	101325
fs.M01.inlet_1_state[0.0].mole_frac_phase_comp[Liq,toluene]	0.00004226501650736347
fs.M01.inlet_1_state[0.0].mole_frac_phase_comp[Vap,toluene]	0.000016239937390247786
fs.M01.inlet_1_state[0.0].pressure_sat_comp[benzene]	101327.63707622685
fs.M01.inlet_1_state[0.0].pressure_sat_comp[toluene]	38933.18380178968
fs.M01.inlet_1_state[0.0].enth_mol_phase[Liq]	59403.464839923574
fs.M01.inlet_1_state[0.0].enth_mol_phase[Vap]	89602.98646808404
fs.M01.inlet_1_state[0.0].enth_mol_phase_comp[Liq,benzene]	59404.366946131
fs.M01.inlet_1_state[0.0].enth_mol_phase_comp[Liq,toluene]	24005.117152243132
fs.M01.inlet_1_state[0.0].enth_mol_phase_comp[Vap,benzene]	89602.59458088383
fs.M01.inlet_1_state[0.0].enth_mol_phase_comp[Vap,toluene]	58559.44869427196

▼ Caution 2: variables close to their bounds

▶ var\_near\_bounds : 12

🔍 Search

fs.M01.inlet_1_state[0.0].mole_frac_comp[benzene]	1
fs.M01.inlet_1_state[0.0].mole_frac_comp[toluene]	0.00001
fs.M01.inlet_1_state[0.0].mole_frac_phase_comp[Liq,benzene]	0.9999677349834927
fs.M01.inlet_1_state[0.0].mole_frac_phase_comp[Liq,toluene]	0.00004226501650736347
fs.M01.inlet_1_state[0.0].mole_frac_phase_comp[Vap,benzene]	0.9999937600626098
fs.M01.inlet_1_state[0.0].mole_frac_phase_comp[Vap,toluene]	0.000016239937390247786

**CONFIG** ▾

Name	Value
variable bounds absolute tolerance	0.0001
variable bounds relative tolerance	0.0001

# Advanced interactive explorations

IDAES

sample\_visualization

Refresh
Save
Export
View
Diagnostics

**FLWSHEET**

Stream Names
Labels
Search
Zoom

1a. Highlight on diagram

**DIAGNOSTICS**

**ISSUES**

- 2 Caution
- Caution 1: variables with extreme values
- extreme\_values : 72

1. Select variable in caution

fs.M01.inlet_1_state[0].u.j.pressure	101325
fs.M01.inlet_1_state[0].mole_frac_phase_comp[Liq,toluene]	0.00004226501650736347
fs.M01.inlet_1_state[0].mole_frac_phase_comp[Vap,toluene]	0.000016239937390247786
fs.M01.inlet_1_state[0].pressure_sat_comp[benzene]	101327.63707622685
fs.M01.inlet_1_state[0].pressure_sat_comp[toluene]	38933.18380178968
fs.M01.inlet_1_state[0].enth_mol_phase[Liq]	59403.464839923574
fs.M01.inlet_1_state[0].enth_mol_phase[Vap]	89602.98646808404
fs.M01.inlet_1_state[0].enth_mol_phase_comp[Liq,benzene]	59404.366946131
fs.M01.inlet_1_state[0].enth_mol_phase_comp[Liq,toluene]	24005.117152243132
fs.M01.inlet_1_state[0].enth_mol_phase_comp[Vap,benzene]	89602.59458088383
fs.M01.inlet_1_state[0].enth_mol_phase_comp[Vap,toluene]	58559.44869427196

- Caution 2: variables close to their bounds
- var\_near\_bounds : 12

2a. Filter variables shown in issues

fs.M01.inlet_1_state[0].mole_frac_comp[benzene]	1
fs.M01.inlet_1_state[0].mole_frac_comp[toluene]	0.00001
fs.M01.inlet_1_state[0].mole_frac_phase_comp[Liq,benzene]	0.9999677349834927
fs.M01.inlet_1_state[0].mole_frac_phase_comp[Liq,toluene]	0.00004226501650736347
fs.M01.inlet_1_state[0].mole_frac_phase_comp[Vap,benzene]	0.9999937600626098
fs.M01.inlet_1_state[0].mole_frac_phase_comp[Vap,toluene]	0.000016239937390247786

**STREAM TABLE**

Variable	s_inlet_2_1	s_inlet_1_1	s01	s02
flow_mol	mol/s	1	1	1
mole_frac_comp benzene	-	0.5	0.5	0.5
mole_frac_comp toluene	-	0.5	0.5	0.5
temperature	K	298.15	298.15	298.15
pressure	Pa	101325	101325	101325

1b. Highlight in stream table

**CONFIG**

Name	Value
variable bounds absolute tolerance	0.0001
variable bounds relative tolerance	0.0001
variable bounds violation tolerance	0
constraint residual tolerance	0.00001
variable large value tolerance	10000
variable small value tolerance	0.0001
variable zero value tolerance	1e-8
jacobian large value caution	10000
jacobian large value warning	100000000
jacobian small value caution	0.0001
jacobian small value warning	1e-8

**STATISTICS**

DoF	Value
	0
Variables	Value
	Unused
	Fixed
	Ineq

# Integration with other PSE projects

- All the capabilities of the Flowsheet Visualizer can be potentially embedded into other Web UIs
- Capabilities being developed in e.g. WaterTAP can be “ported” to the FV
- Towards an open (and open-source) UI “ecosystem”...

**WaterTAP** Dye Desalination

DEGREES OF FREEDOM: 3

RETURN TO LIST PAGE

INPUT OUTPUT COMPARE

Analysis Type: optimization

RESET FLOWSHEET RUN

Feed

Volometric flow rate: 120 m<sup>3</sup>/h Free

Dye concentration: 2.5 g/L Free

TDS concentration: 50 g/L Fixed

Solution temperature: 298 K Fixed

RHGO Nanofiltration

NF pump motor efficiency: 0.9 fraction Free

Water recovery: 0.75 fraction Fixed

Mass removal fraction, dye: 0.98 fraction Fixed

Mass removal fraction, TDS: 0.27 fraction Fixed

NF Water permeability Coefficient, A: 100 LMH/bar Fixed

Net driving pressure across membrane: 6.9 bar Fixed

Embed diagram and tools

Set variables and solve models

**IDAES** Flowsheet Visualizer

inlet\_1\_1

M01

H02

F03

liq\_outlet\_1

vap\_outlet\_1

inlet\_2\_1

STREAM TABLE

Variable	inlet_1_1	inlet_2_1	M01	H02
inlet_1_1	1	1	1	1
inlet_2_1	0.5	0.5	0.5	0.5
inlet_3_1	0.5	0.5	0.5	0.5
temperature	298.15	298.15	298.15	298.15
pressure	101325	101325	101325	101325

DIAGNOSTICS

CONFIG

Name	Value
variable bounds absolute tolerance	0.0001
variable bounds relative tolerance	0.0001
variable bounds rotation tolerance	0
constraint residual tolerance	0.00001
variable large value tolerance	10000
variable small value tolerance	0.0001
variable zero value tolerance	1e-8
jacobian large value warning	10000
jacobian large value warning	100000000
jacobian small value warning	0.0001
jacobian small value warning	1e-8

STATISTICS

DoF	Value
Variables	100
Uniqueness	166
Fixed	150
Free	166

Variables

Variable	Value
inlet_1_1	1
inlet_2_1	0.5
inlet_3_1	0.5
temperature	298.15
pressure	101325

Objects

Object	Value	DoF	Unit
inlet_1_1	1	0	mol
inlet_2_1	0.5	0	mol
inlet_3_1	0.5	0	mol
temperature	298.15	0	K
pressure	101325	0	Pa

# Visualization Summary



The Flowsheet Visualizer (FV) can easily visualize IDAES models today



Interactive access to IDAES Diagnostics Toolkit is being actively added

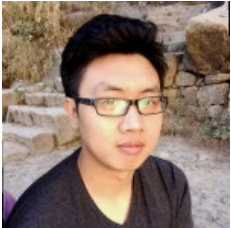


This will make the FV a more useful tool across IDAES PSE

# Please come talk to us! We want your feedback



Dan Gunter, team lead



Sheng Pang, primary UI developer



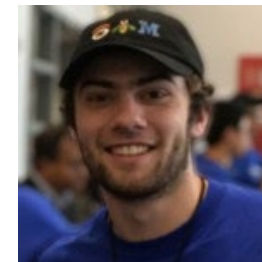
Sarah Poon, User Experience (UX)



*Cody O'Donnell, UI developer (emeritus, not attending)*

## UI-related Sessions

- Posters
  - IDAES Visualizer
  - WaterTAP
- Talks: WaterTAP UI
- Demos:
  - WaterTAP UI
  - PARETO UI



Mike Pesce, UI developer  
[WaterTAP, PARETO]