Model Initialization and Debugging

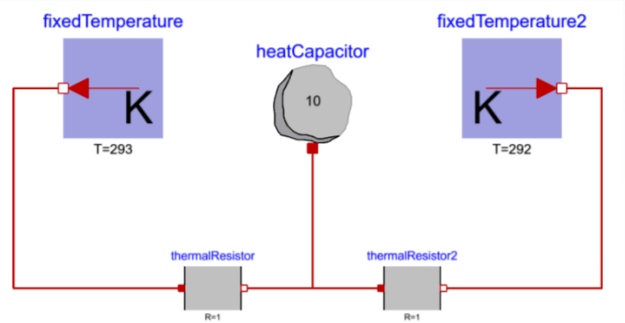
Presented by Modelon

Equation based modeling

Where does it all come from?

- State variables
- Linear systems
- Nonlinear systems

```
1  model HeatCapacitor
2    parameter Modelica.Units.SI.HeatCapacity C "Heat capacity of element (=cp*m)";
3
4    Modelica.Units.SI.Temperature T(start=293.15) "Temperature of element";
5    Modelica.Units.SI.TemperatureSlope der_T(start=0) "Time derivation of temperature (=der(T))";
6
7    .Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_a port annotation( ••• );
8
9  equation
10   T = port.T;
11   der_T=der(T);
12   C*der(T)=port.Q_flow;
13   annotation( ••• );
14 end HeatCapacitor;
```



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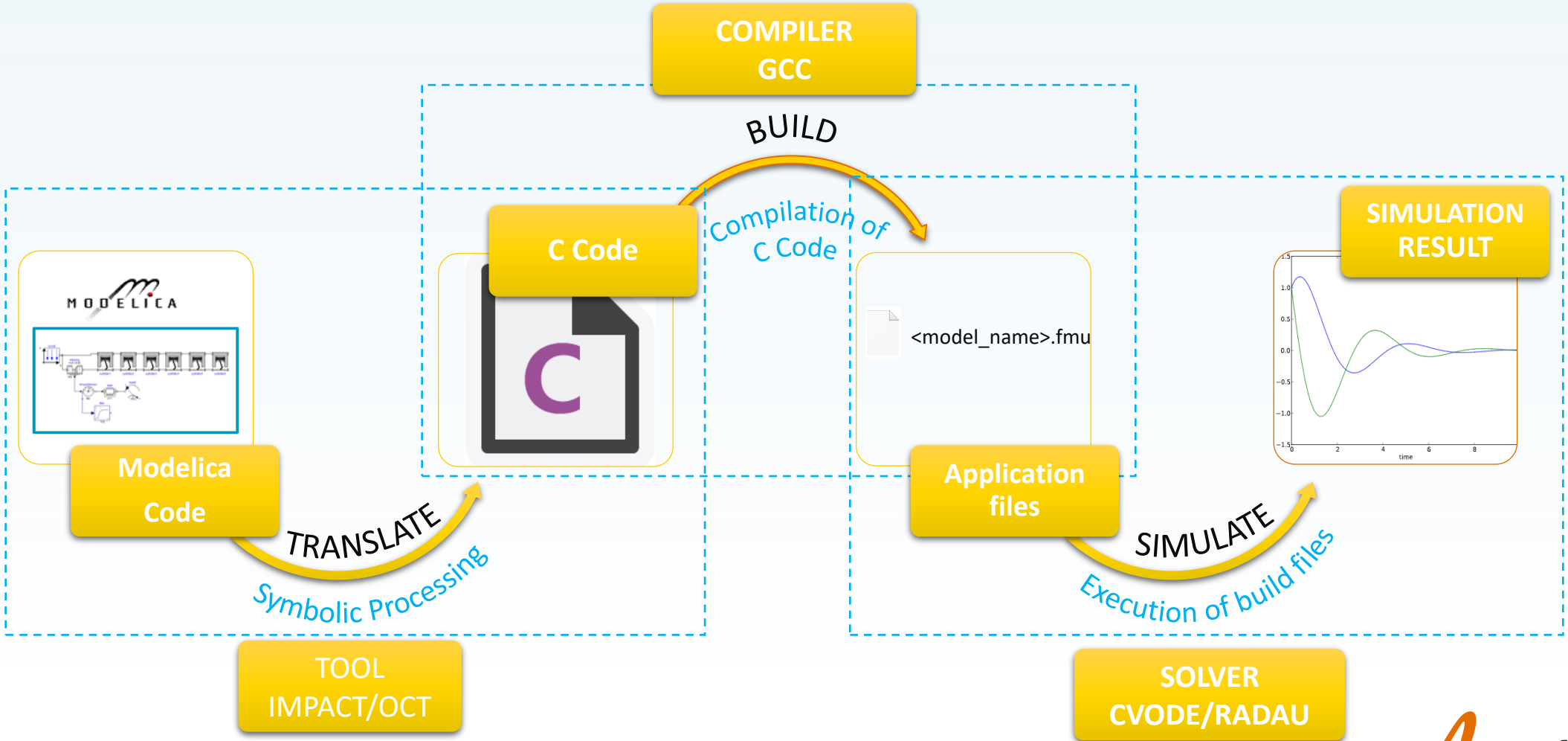
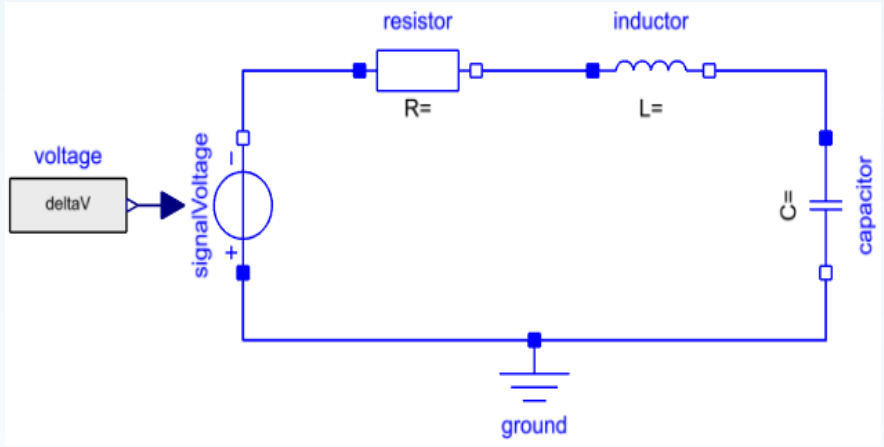
Compilation and Simulation



Causalization and sequencing



Reduce to minimum number of equations and select states

$$\begin{cases} u_0 = \Delta V & (1) \\ u_R = R i_R & (2) \\ u_L = L \frac{di_L}{dt} & (3) \\ i_C = C \frac{du_C}{dt} & (4) \\ i_R = i_0 & (5) \\ i_L = i_0 & (6) \\ i_C = i_0 & (7) \\ \Delta V = u_R + u_L + u_C & (8) \end{cases}$$

1 means: variable is in equation

Structure incidence matrix

	u_0	i_0	u_R	i_R	u_L	$\frac{di_L}{dt}$	$\frac{du_C}{dt}$	i_C
(1)	1	0	0	0	0	0	0	0
(2)	0	0	1	1	0	0	0	0
(3)	0	0	0	0	1	1	0	0
(4)	0	0	0	0	0	0	1	1
(5)	0	1	0	1	0	0	0	0
(6)	0	1	0	0	0	0	0	0
(7)	0	1	0	0	0	0	0	1
(8)	1	0	1	0	1	0	0	0

Triangularization
(Block) Lower Triangle

	u_0	i_0	i_R	i_C	u_R	$\frac{du_C}{dt}$	u_L	$\frac{di_L}{dt}$
(1)	1	0	0	0	0	0	0	0
(6)	0	1	0	0	0	0	0	0
(5)	0	1	1	0	0	0	0	0
(7)	0	1	0	1	0	0	0	0
(2)	0	0	1	0	1	0	0	0
(4)	0	0	0	1	0	1	0	0
(8)	1	0	0	0	1	0	1	0
(3)	0	0	0	0	0	0	1	1

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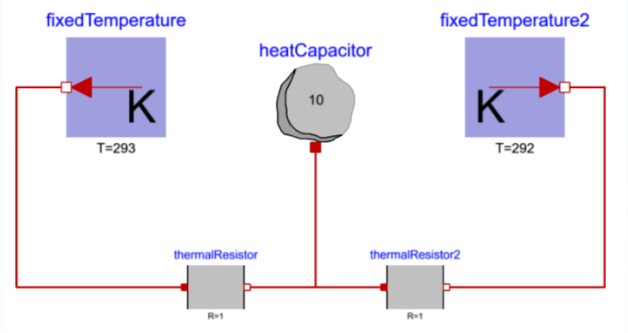
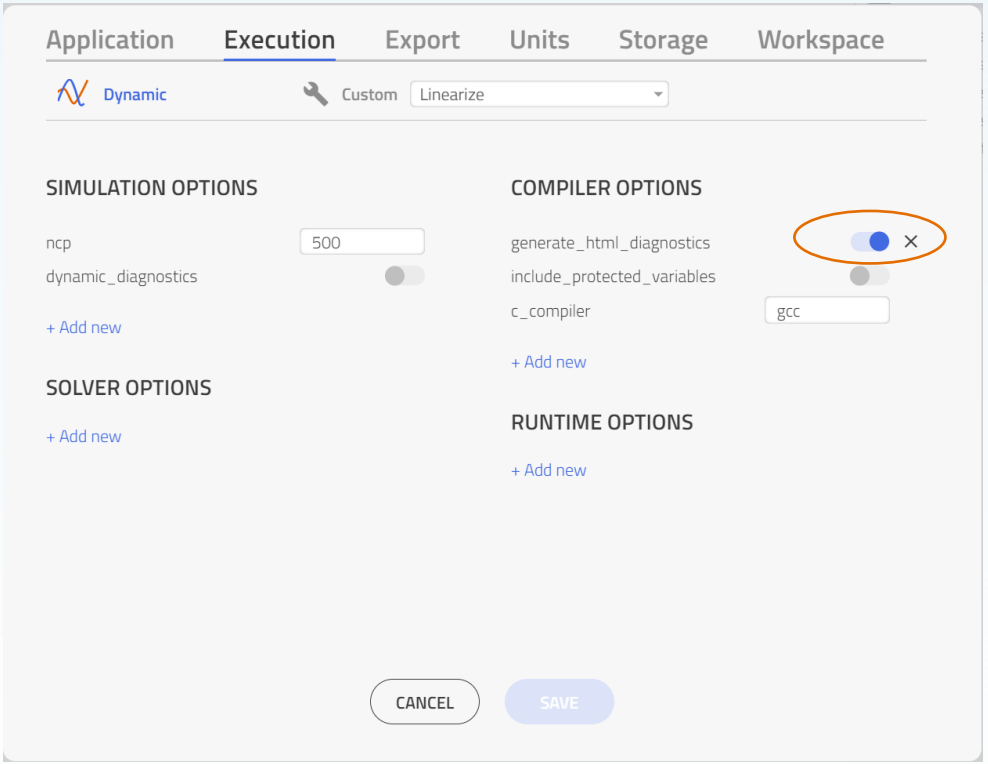
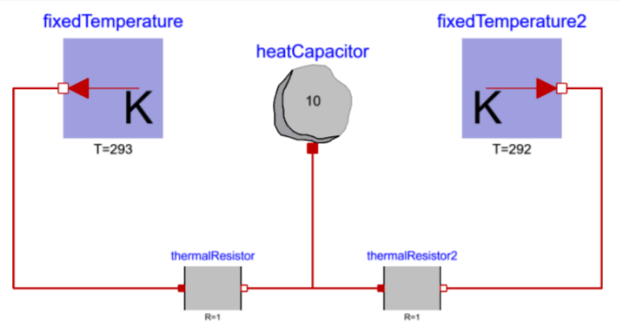
Modelon Impact diagnostics

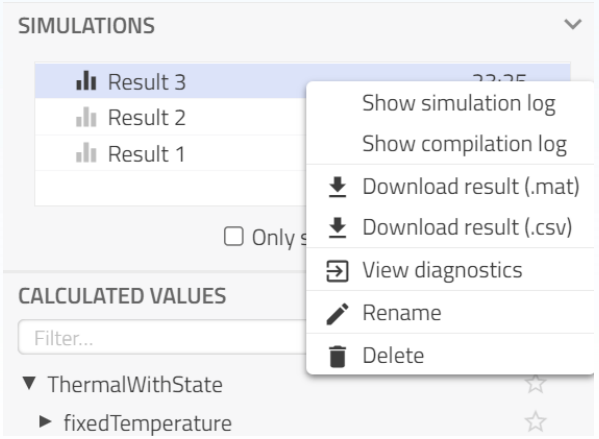
- generate_html_diagnostics

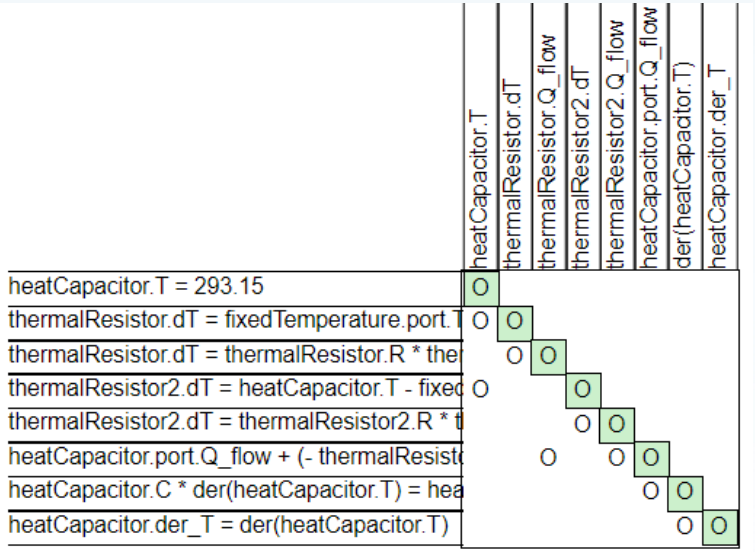




Modelon Impact diagnostics

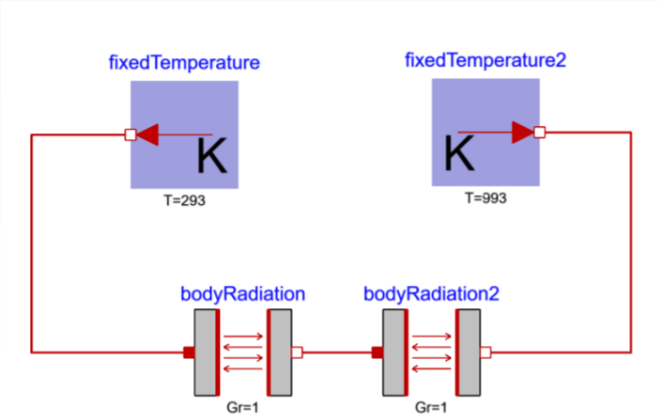






Linear and non-linear equations

- Some models are not possible to sort completely
- Blocks with interdependency along diagonal
  - Linear or non-linear system



	bodyRadiation.Q_flow	bodyRadiation.port_b.T	bodyRadiation.dT	bodyRadiation2.dT
bodyRadiation.Q_flow = bodyRadiation.Gr *	O	X		
bodyRadiation.Q_flow = bodyRadiation2.Gr *	O	X		
bodyRadiation.dT = bodyRadiation.port_a.T -		O	O	
bodyRadiation2.dT = bodyRadiation.port_b.T		O		O

Separate Initial and Dynamic equation systems

- Modelica allows for separate equations for initial conditions

```
  parameter  Modelica.Units.SI.Temperature T_start "initial temperature";
  .Modelica.Units.SI.Temperature T "Temperature";
  .Modelica.Units.SI.HeatFlowRate q_flow(nominal=10000) "heat flow rate";
  .Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_a port annotation( ••• );
equation
  der(T)*m*c = q_flow;
  q_flow = port.Q_flow;
  T = port.T;

initial equation
  T = T_start;
```

- This effectively means that the Initial problem and Dynamic problem, will generate separate code to be solved for

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Best practice

- Use diagnostics to get better understanding of your system
- Identify:
  - States
  - Nonlinear iteration variables
- Verify that they are initialized properly

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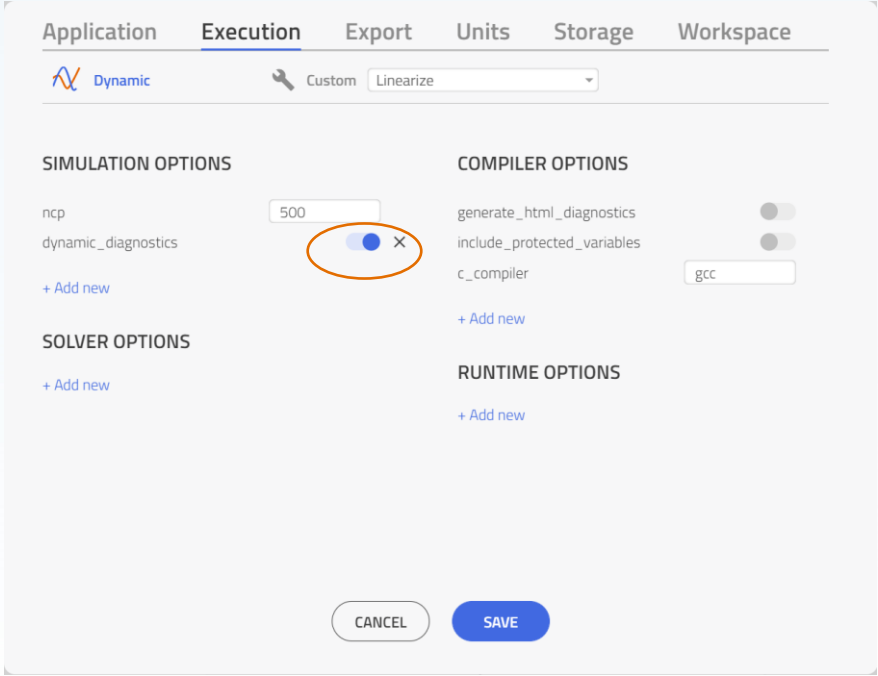
Best practice

- Create subsystem tests for standard operating conditions
- Once tested and verified, integrate into system model

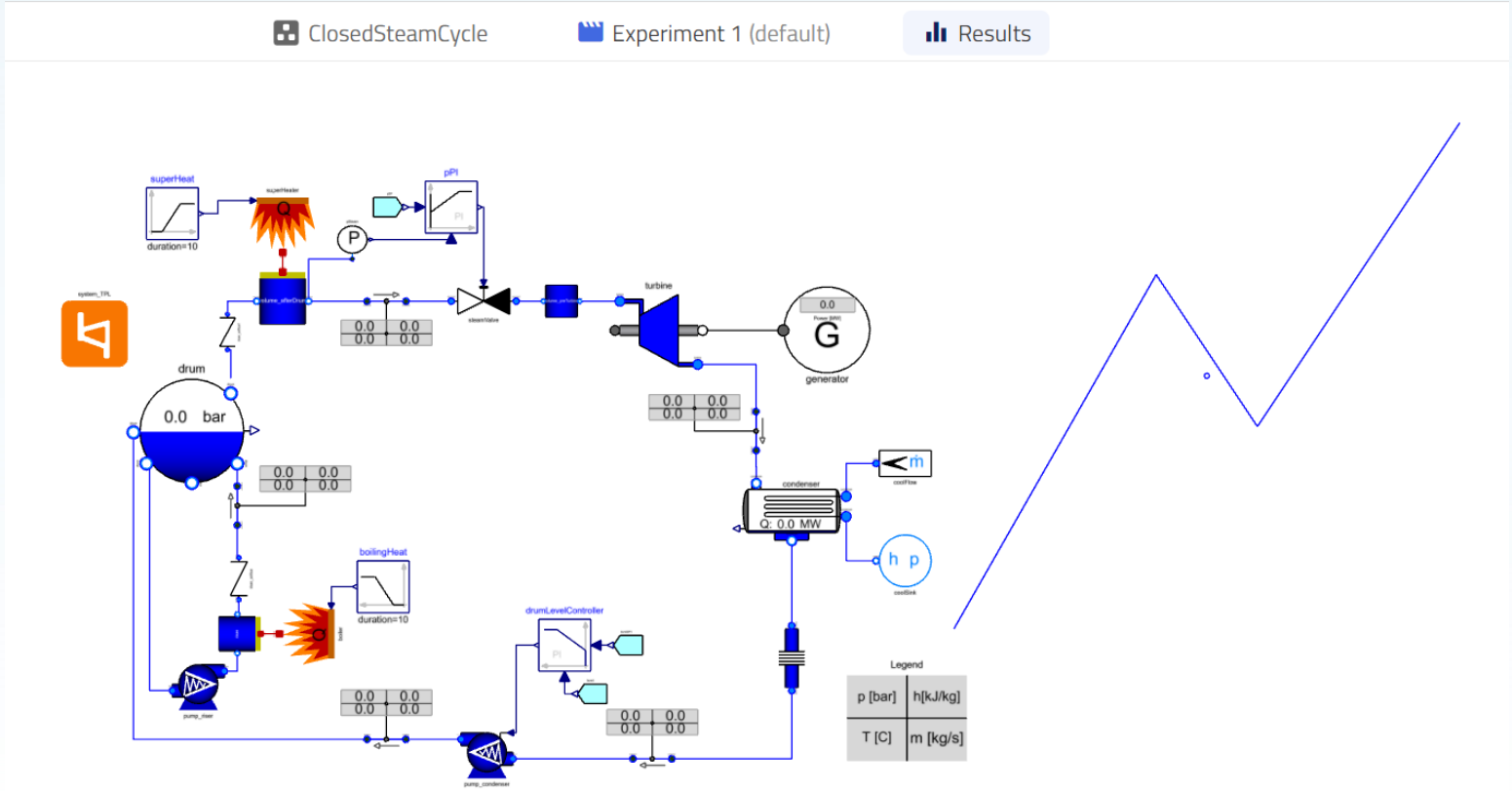
- Aggregate initial conditions using records or parameters that can be propagated

Dynamic diagnostics

- If your model is initializing but not running as expected
- Enable dynamic_diagnostics
- Simulation results will include solver diagnostics



Example: Closed Steam Cycle



Accurate Simulations. Better Decisions.