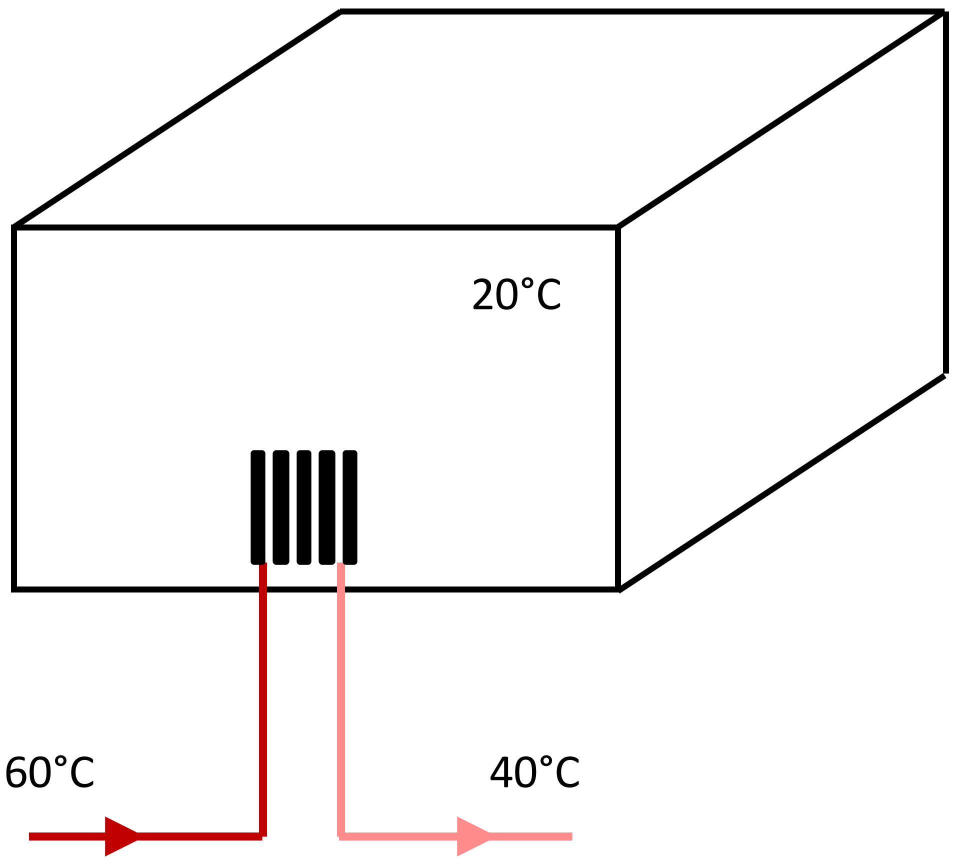
Modelica-based simulation of building and district energy systems

Session 7: Hands-on training / Heating system

Alessandro Maccarini

SESSION 7 – Heating system

- Create a model of a heating system with ideal radiator
- Create the control logic



- **First, we need to size our heating system!** This is because we will need to insert some parameters in the various components that are related to the system sizing.
  1. The heating peak load is 230 W.
  2. What's the nominal (peak) water mass flow rate required?

(SEE NEXT PAGE FOR THE SOLUTION – in red)

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STEP 1 - Model of a heating system with radiator

1. Create a new model **Radiator** in Components.
2. Drag and drop the following models:

- `Modelica.Fluid.Interfaces.FluidPort_a (1)`
- `Modelica.Fluid.Interfaces.FluidPort_b (1)`
- `Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_a (1)`
- `Modelica.Blocks.Sources.Constant (1)`
- `Modelica.Blocks.Math.Gain (1)`
- `Modelica.Thermal.HeatTransfer.Sources.PrescribedHeatFlow (1)`
- `Buildings.Fluid.HeatExchangers.SensibleCooler_T (1)`

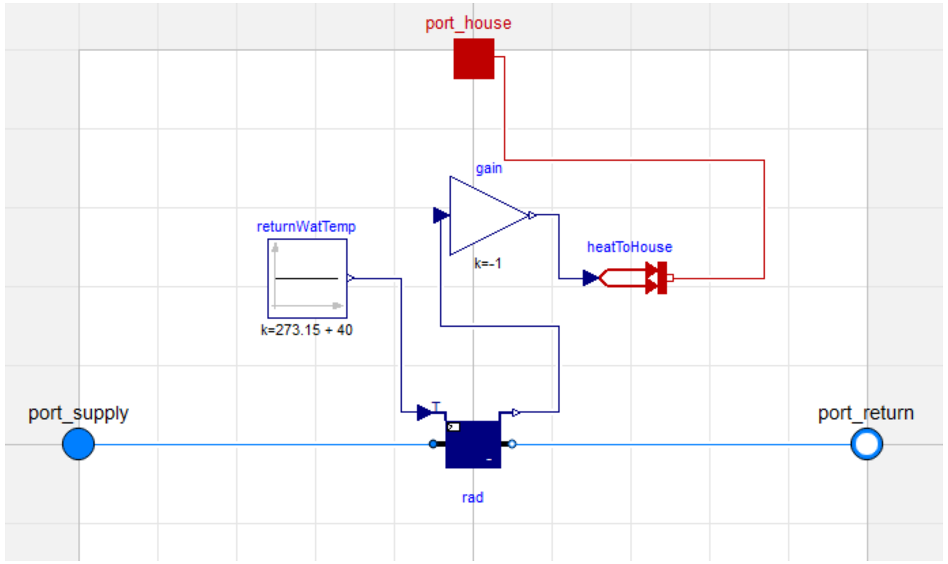

Figure 7.1: Connections in **Radiator**

5. Connect the components according to figure 7.1.
6. Give to parameters the values according to the table on the right
7. Go to the icon view and draw a simple icon of a radiator

Component	Parameter	Value
returnWatTemp	k	273.15+40
gain	k	-1
rad	Medium	Water
	QMin_flow	-230 W (heating peak load)
	m_flow_nominal	0.0027 kg/s (water flow rate)
	dp_nominal	0 Pa
port_supply	Medium	Water (Package with model for liquid water with constant density)
port_return	Medium	Same medium as port_supply

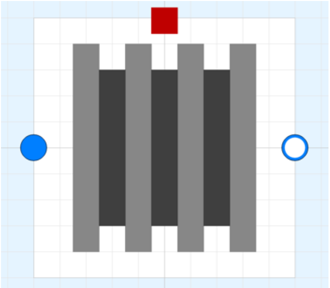
Figure 7.2: Icon of **Radiator**

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STEP 2 - Model of a single-zone house with heat port for heating

1. Duplicate **HouseWallWin** and create a new model **HouseWallWinRad** in Building
2. Drag and drop the following models:

   - `Modelica.Thermal.HeatTransfer.Interfaces.HeatPort_a (1)`

3. Connect the components according to Fig. 7.3

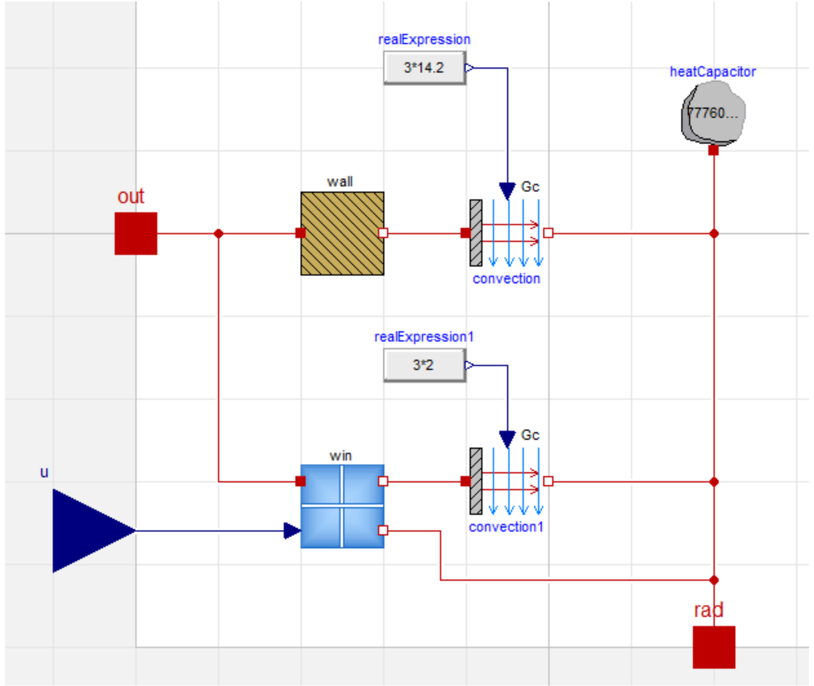

Figure 7.3: Connections in **HouseWallWinRad**

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STEP 3 – Connect the heating system to the house and simulate

1. Duplicate Experiment2 and create a new model **Experiment3** in Building
2. Drag and drop the following models:

- `SimpleHouse.Components.Radiator (1)`
- `Modelica.Blocks.Sources.Constant (1)`
- `Buildings.Fluid.Sources.MassFlowSource_T (1)`
- `Buildings.Fluid.Sources.Boundary_pT (1)`
- `Buildings.Fluid.Sensors.TemperatureTwoPorts (1)`

3. Change class of HouseWallWin into HouseWallWinRad
4. Connect the components according to Fig. 7.4
5. Give to parameters the values according to the table below

Component	Parameter	Value
watFlow	k	0.0027
watSource	Medium	Water
	use_m_flow_in	True
	T	60°C
senTem	Medium	Water
	m_flow_nomial	0.0027
WatSink	Medium	Water

6. Simulate the model for 2 days and explore results (plot the air temperature in the house)

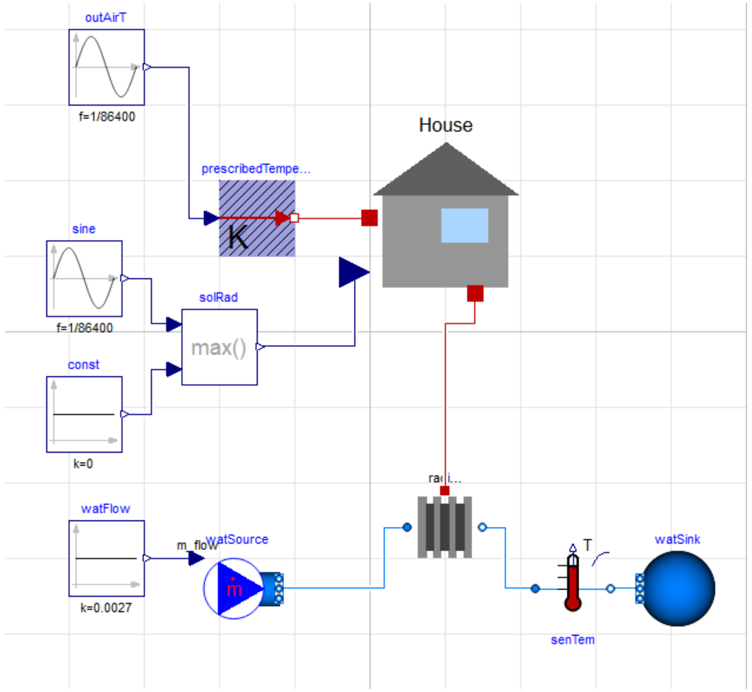

Figure 7.4: Connections in **Experiment3**

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Results

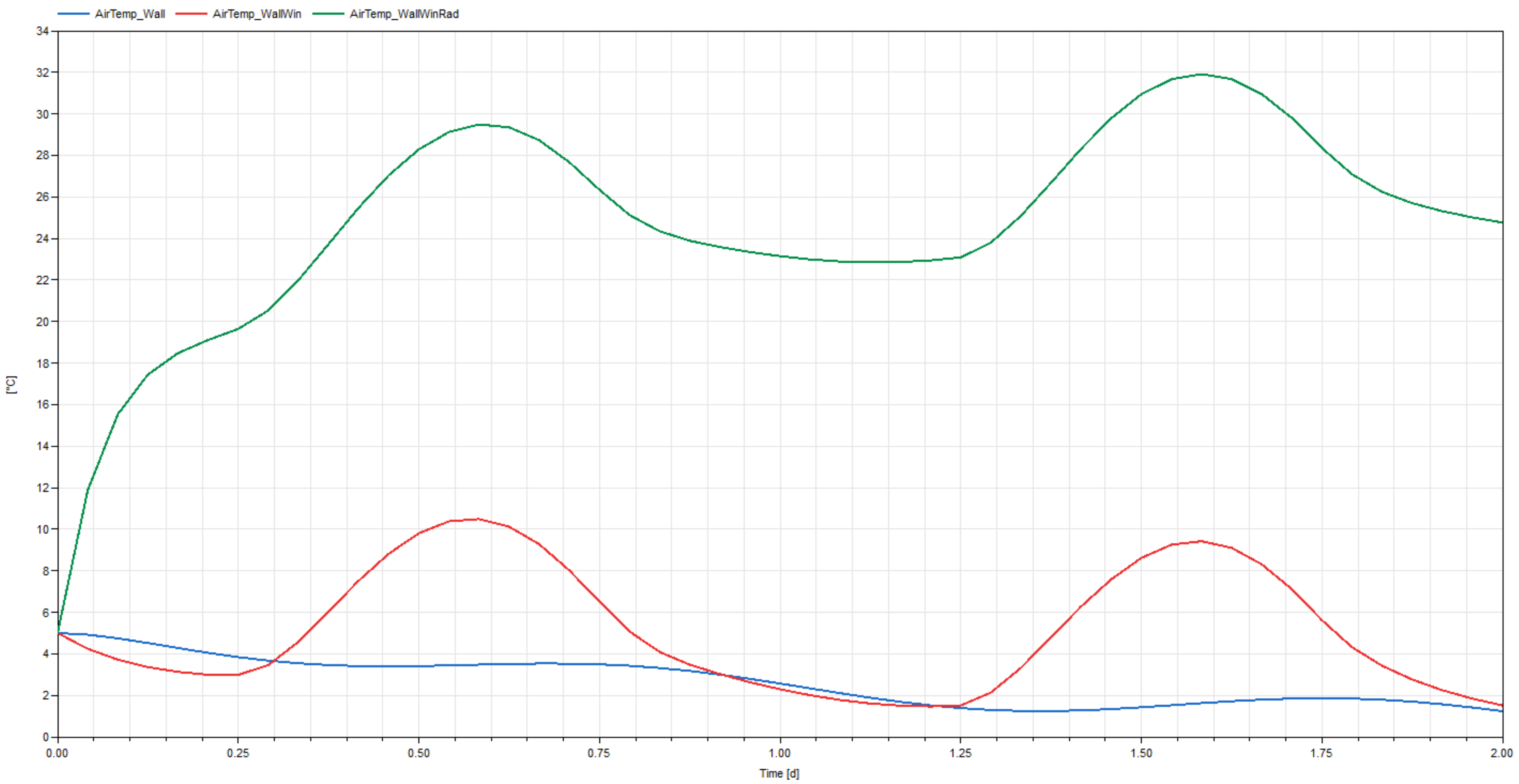
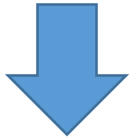


Figure 7.5: Temperature profiles (Experiment1 vs Experiment3 vs Experiment2)

We are delivering the nominal heat flow rate constantly…



We need a controller that varies the water flow rate according to the actual needs

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STEP 4 – Create an on/off controller to vary the water flow rate in the heating system

1. Duplicate Experiment3 and create a new model **Experiment4** in Building
2. Drag and drop the following models:

- `Buildings.Controls.OBC.CDL.Conversions.BooleanToReal(1)`
- `Buildings.Controls.OBC.CDL.Reals.Hysteresis(1)`
- `Modelica.Thermal.HeatTransfer.Sensors.TemperatureSensor (1)`

3. Connect the components according to Fig. 7.6
4. Give to parameters the values according to the table below

Component	Parameter	Value
hys	uLow	273.15 + 19
	uHigh	273.15 + 21
mWat_flow	realTrue	0
	realFalse	0.0027

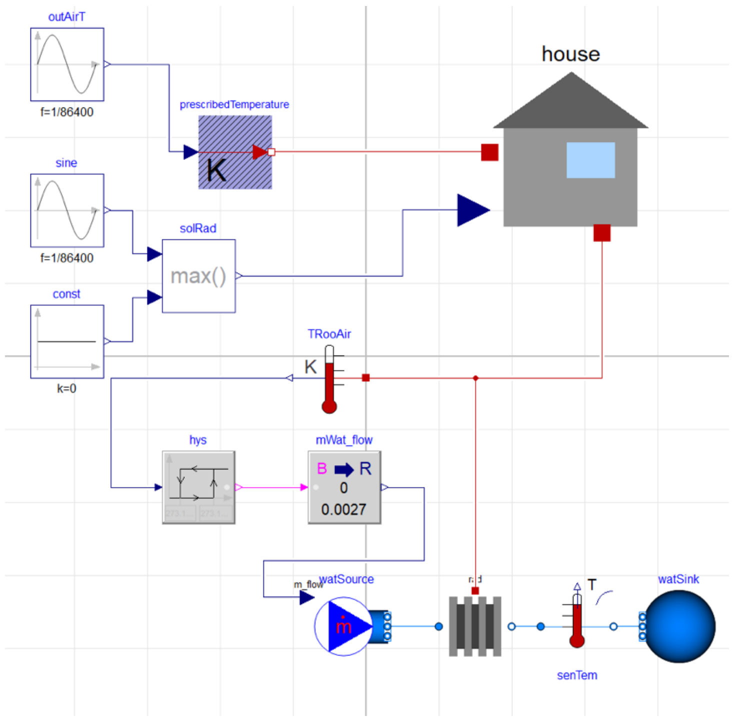

Figure 7.6: Connections in **Experiment4**

5. Simulate the model for 2 days and explore results (plot the air temperature in the house and the heat flow rate)

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Results

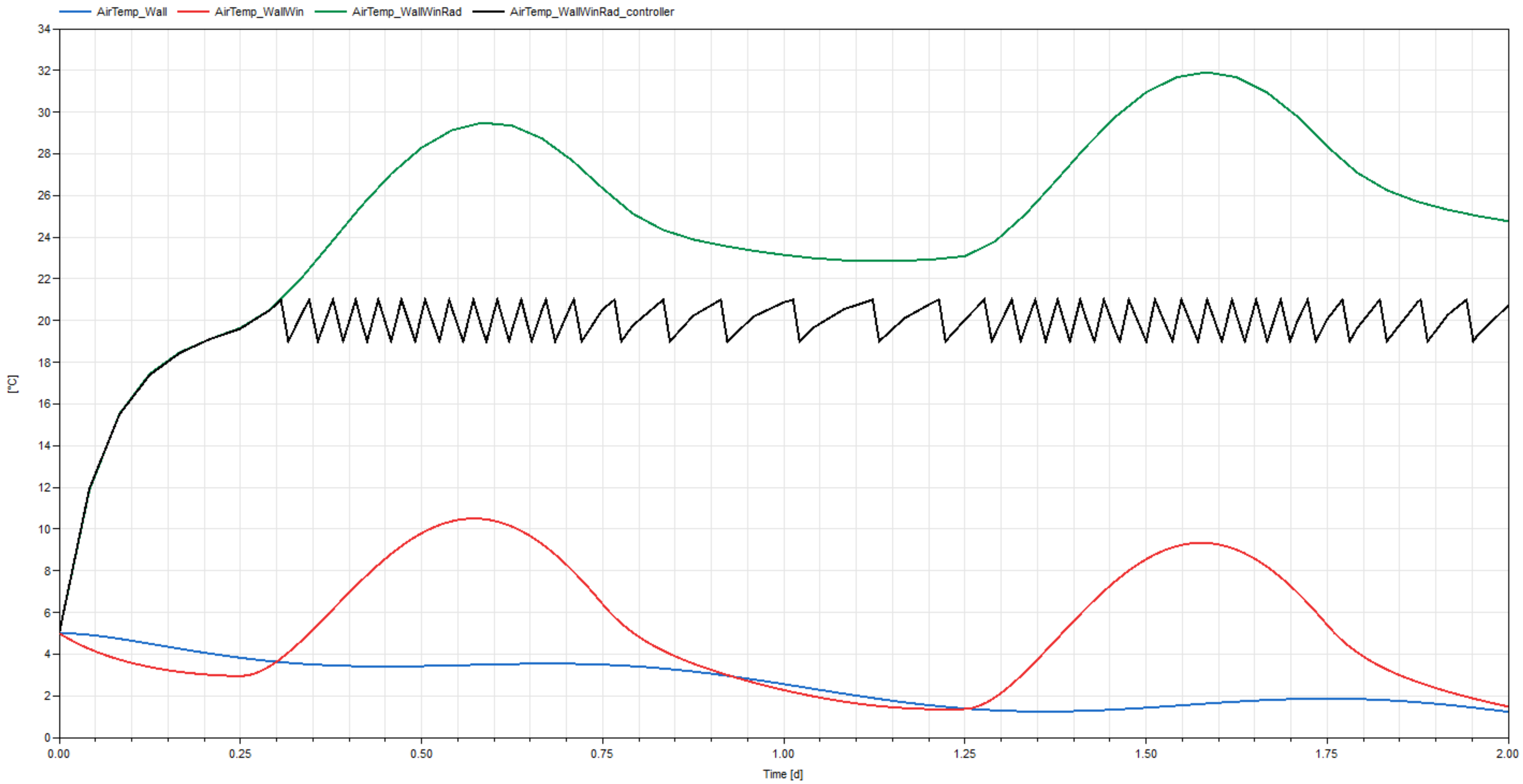

Figure 7.7: Temperature profiles (Experiment1 vs Experiment2 vs Experiment3 vs Experiment4)

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Results

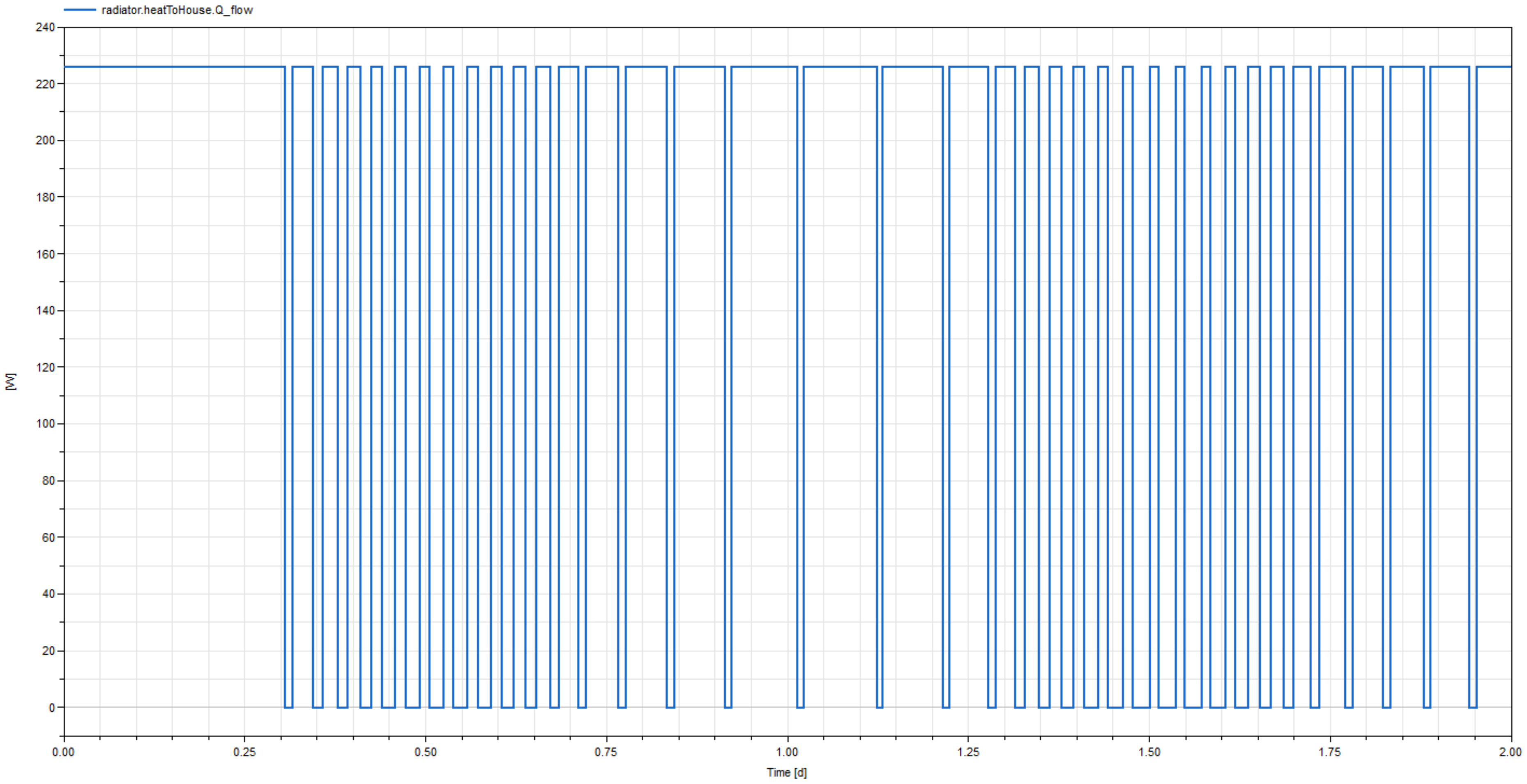

Figure 7.8: Heat delivered by the radiator

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STEP 5 – How would the heating system react to extreme winter conditions?

1. Duplicate Experiment4 and create a new model **Experiment5** in Building
2. Change the values of the following parameters:

Model	Parameter	Value
Sine (outdoor air temperature)	Offset	263.15
Sine (solar radiation)	Amplitude	0

3. Simulate the model for 2 days and explore results. Plot the air temperature in the house. Is the heating system still able to keep 20°C?