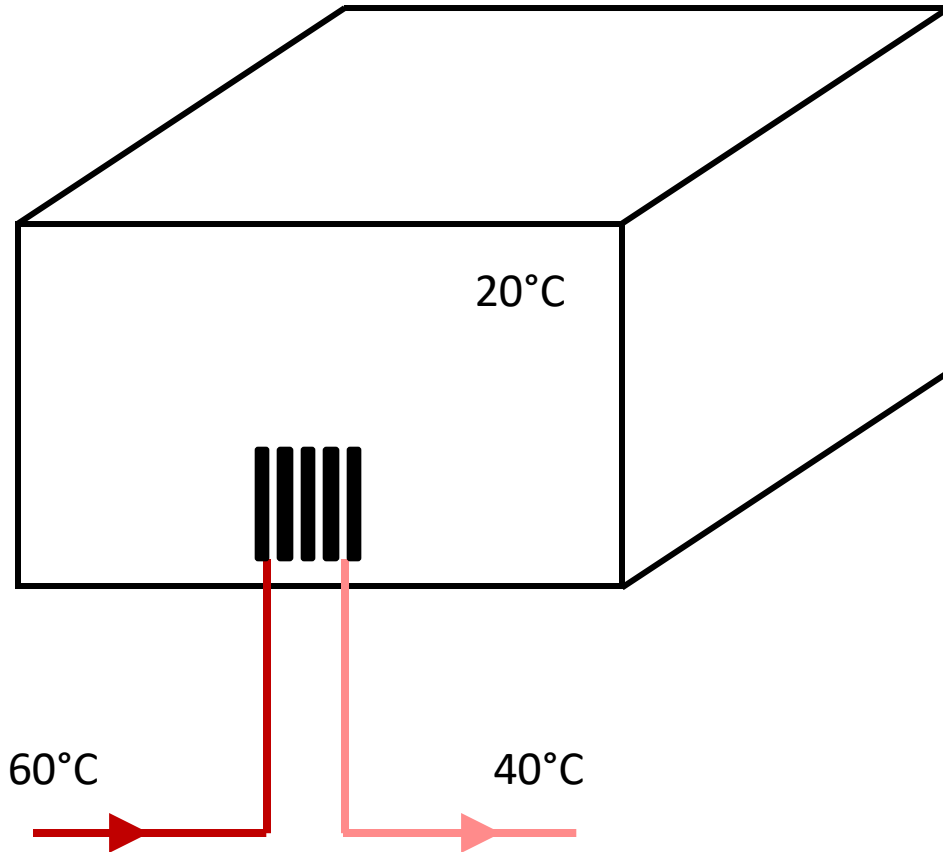


# Modelica-based simulation of building and district energy systems

**Session 7:** Hands-on training / Heating system

## 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*)

# SESSION 7 – Heating system

## 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)

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
- A schematic icon of a radiator. It features a central vertical stack of four grey rectangular fins. To the left of the fins is a blue solid circle representing a fluid port, and to the right is a blue hollow circle representing another fluid port. Above the central stack of fins is a small red square, likely representing a control valve or sensor.
- Figure 7.2: Icon of **Radiator**
- A detailed block diagram showing the internal connections of the Radiator component. The diagram is set against a light grey grid. On the left, a blue solid circle labeled 'port\_supply' is connected to a blue square block labeled 'rad'. The 'rad' block has two output ports on its right side. One output is connected to a blue hollow circle labeled 'port\_return'. The other output is connected to a blue triangular gain block labeled 'gain' with the parameter 'k=-1'. The 'gain' block's output is connected to a red line that leads to a red square labeled 'port\_house'. A feedback loop is shown where a red line from 'port\_house' goes through a blue gain block labeled 'gain' with the parameter 'k=1' and then connects back to the 'rad' block. A blue box labeled 'returnWatTemp' with the parameter 'k=273.15 + 40' is connected to the 'rad' block and the 'gain' block. A red line labeled 'heatToHouse' connects the 'rad' block to the 'port\_house'.
- Figure 7.1: Connections in **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  |
- 3

## SESSION 7 – Heating system

### 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

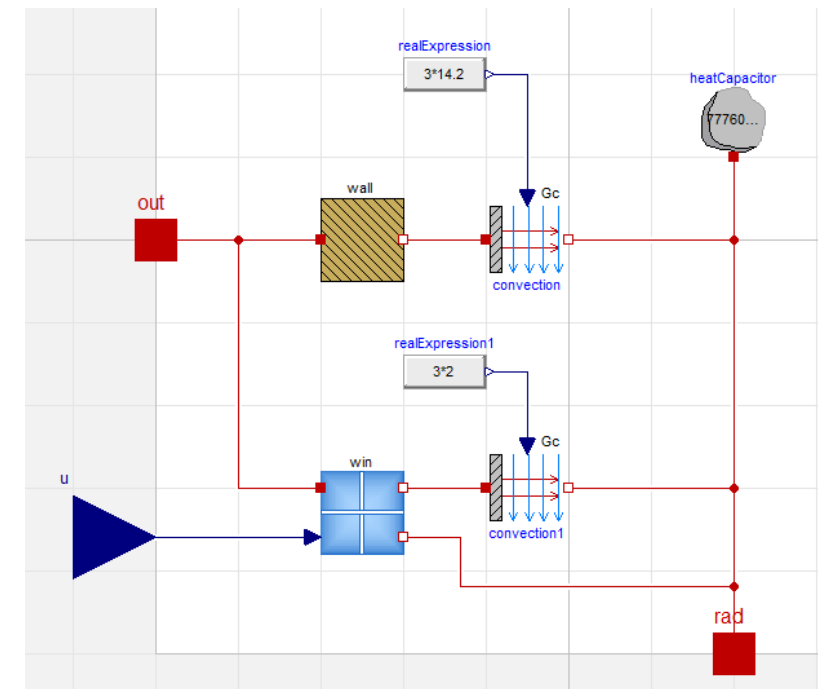


Figure 7.3: Connections in **HouseWallWinRad**

## SESSION 7 – Heating system

### 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)

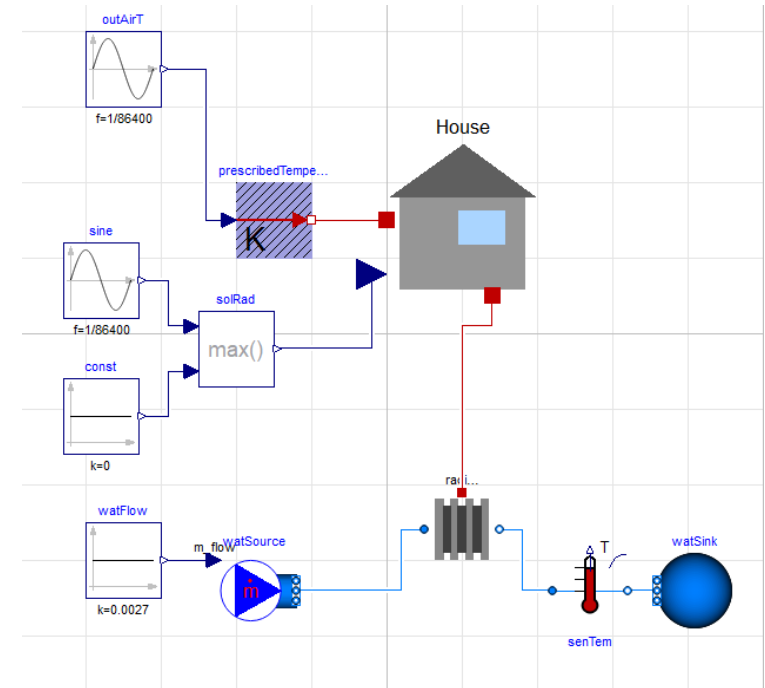


Figure 7.4: Connections in **Experiment3**

# SESSION 7 – Heating system

## Results

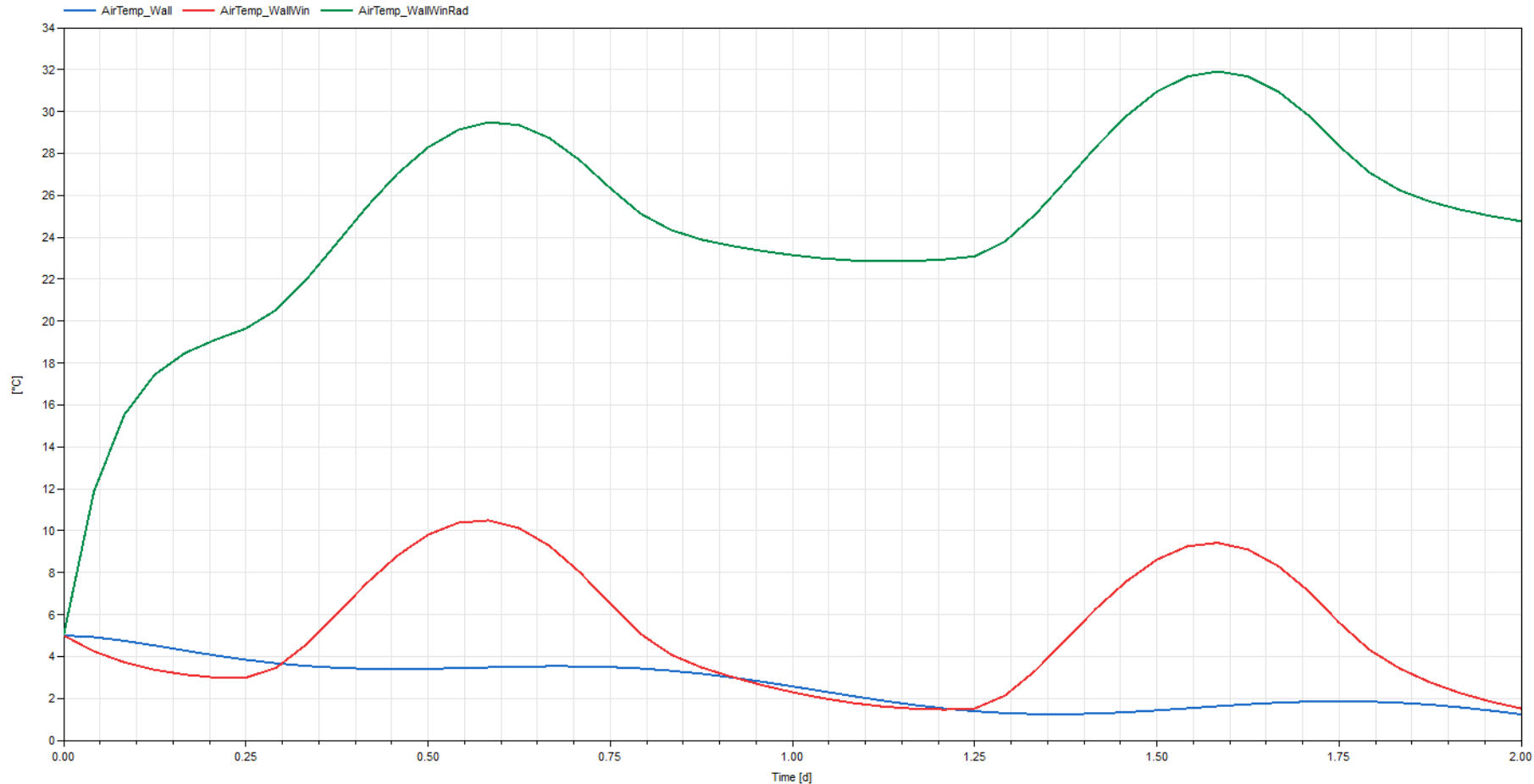


Figure 7.5: Temperature profiles (Experiment1 vs Experiment3 vs Experiment2)

We are delivering the nominal heat flow rate constantly...



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

# SESSION 7 – Heating system

## 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

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

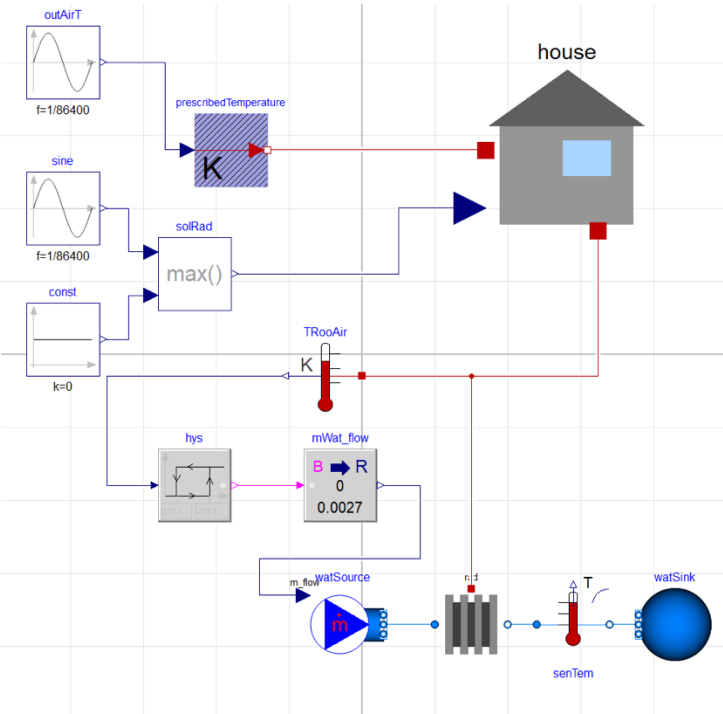


Figure 7.6: Connections in **Experiment4**

# SESSION 7 – Heating system

## Results

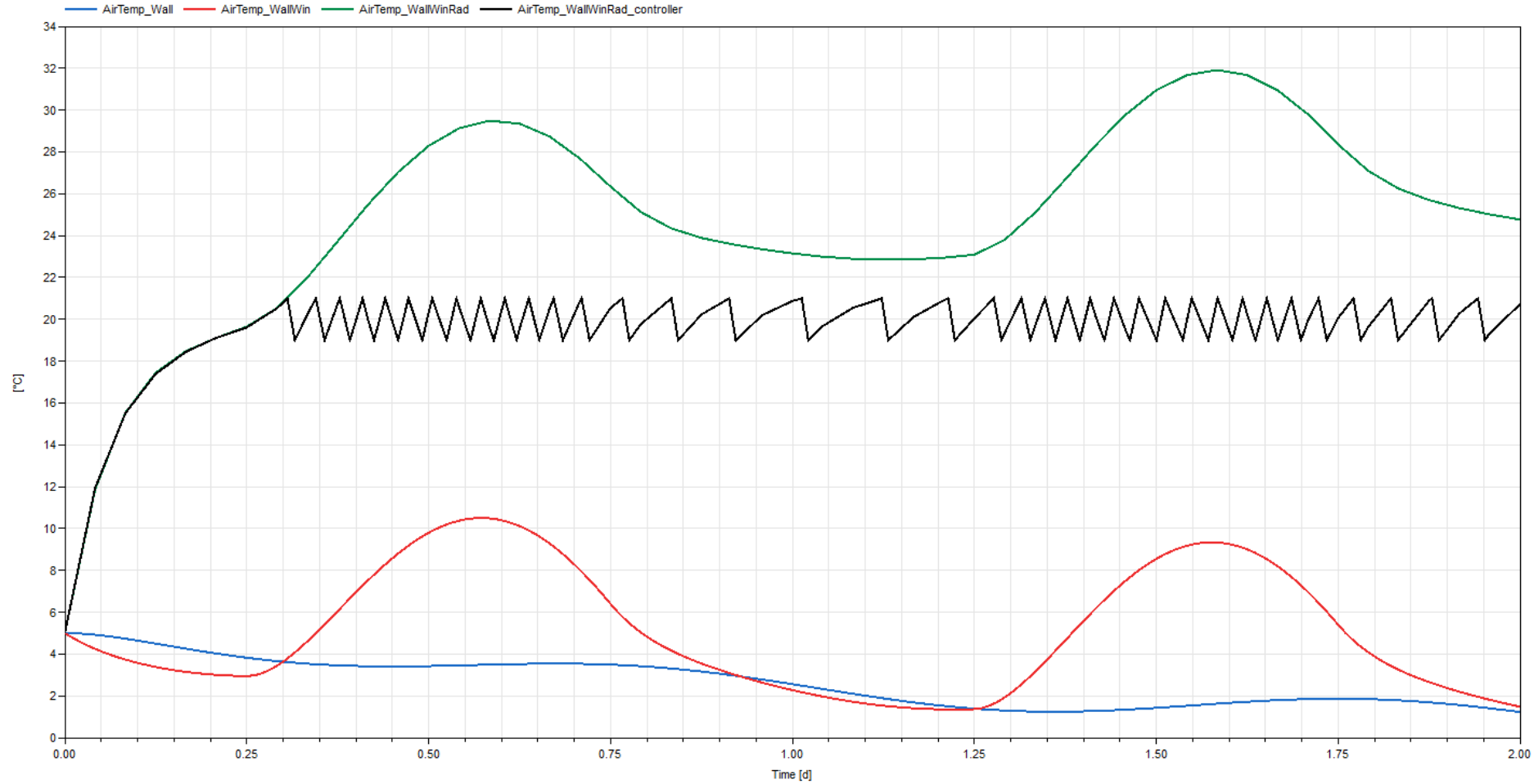


Figure 7.7: Temperature profiles (Experiment1 vs Experiment2 vs Experiment3 vs Experiment4)



# SESSION 7 – Heating system

## Results

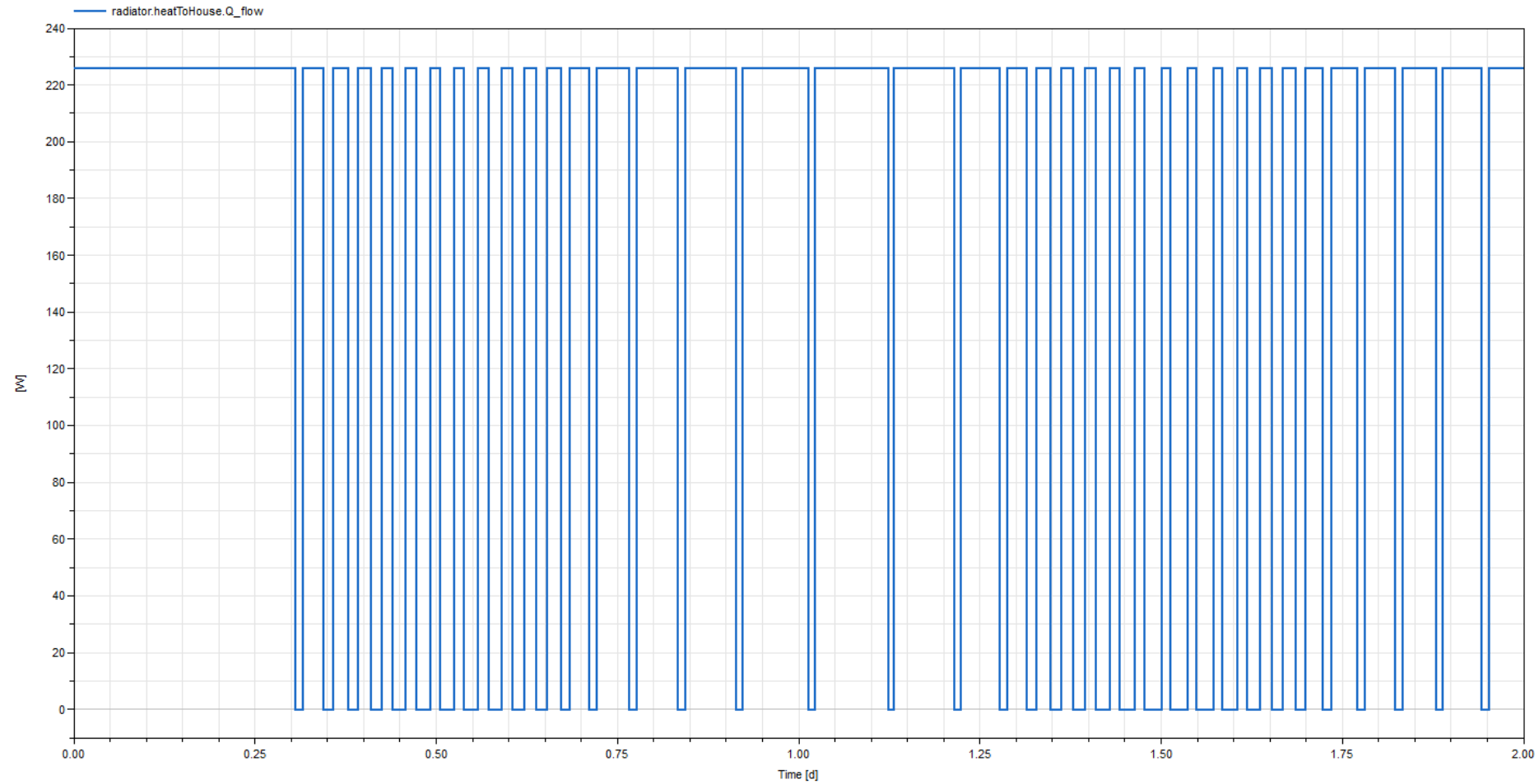


Figure 7.8: Heat delivered by the radiator

# SESSION 7 – Heating system

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?

