Modelica-based simulation of building and district energy systems

SESSION 11 – District heating system: Part I

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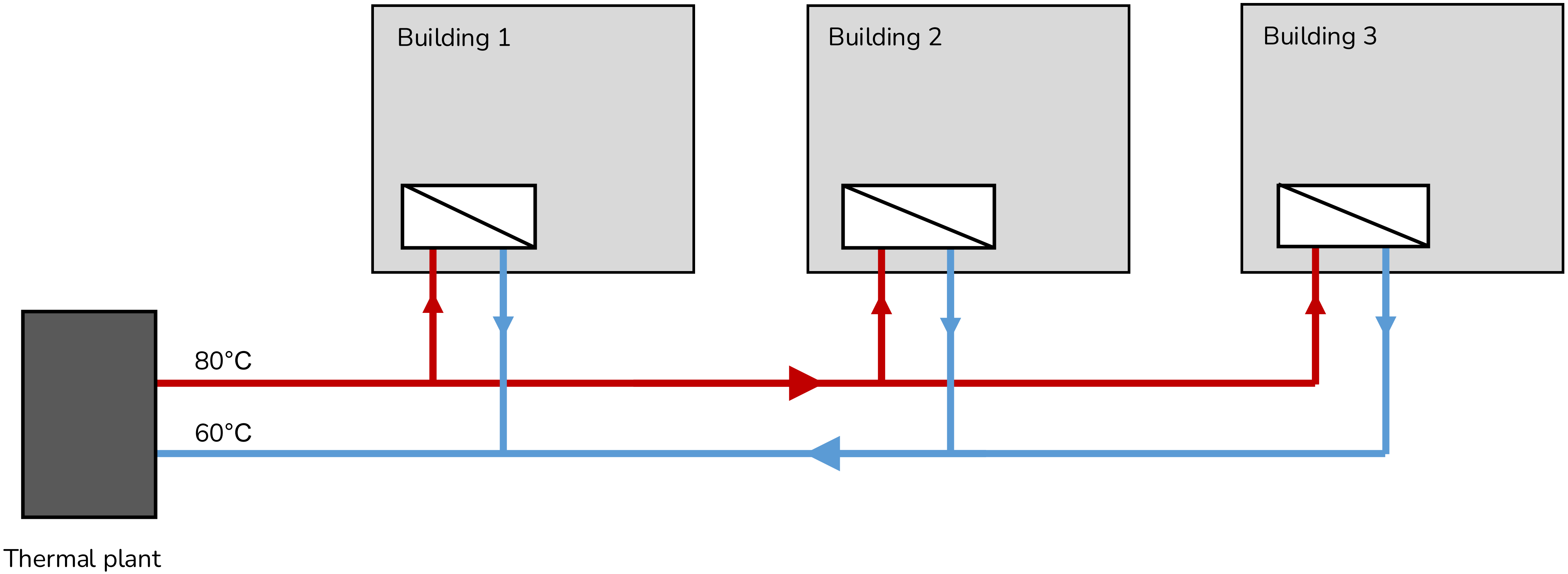
GOAL: To create a model of a simple district heating system supplying heat to 3 buildings

- STEP 1: Generation of heating demand profiles
- STEP 2: Modeling the substation
- STEP 3: Modeling the thermal plant
- STEP 4: Creating the piping network with ground heat losses
- STEP 5: Adding the additional (cluster of) buildings



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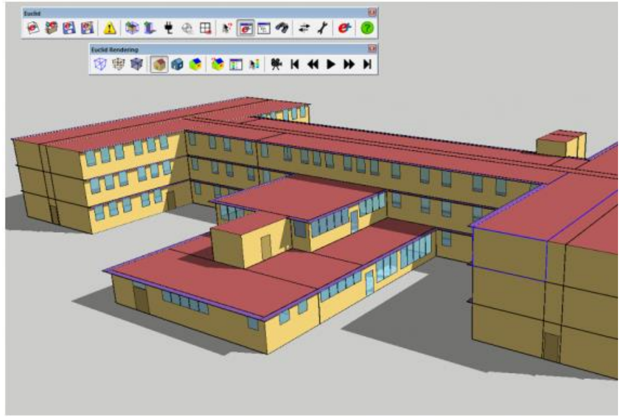
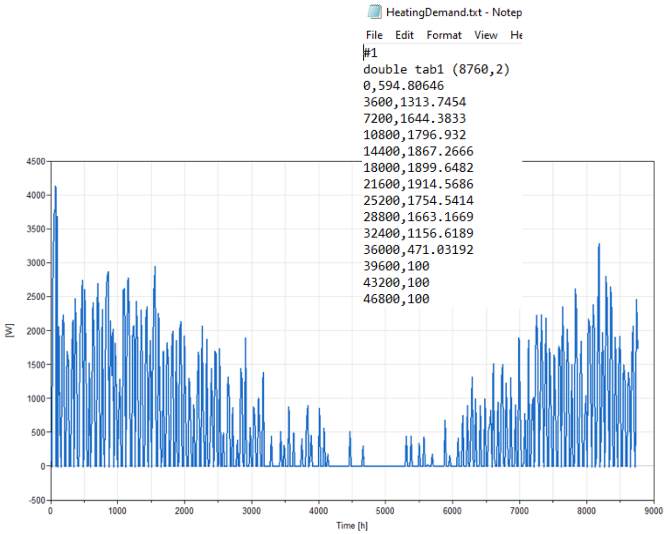
STEP 1: Generation of heating demand profiles

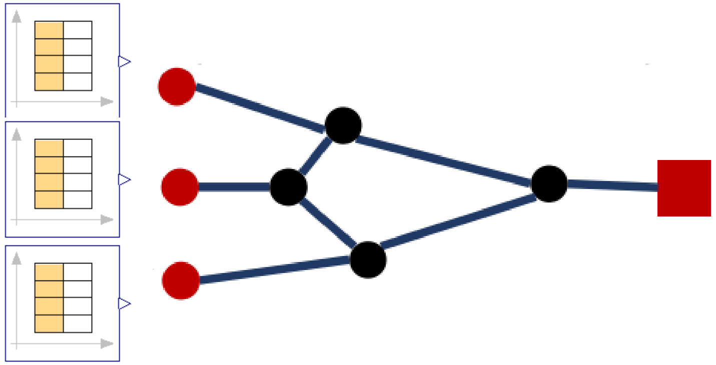
To reduce computing time, district heating simulations typically involve **decoupling** of heating demand and heating supply –> heating demand is represented by time series and fed into the heating supply model



Annual simulation of heating demand



Export of hourly values (e.g. .csv, .txt files)



Input into district heating model as time series *(CombiTimeTable)*

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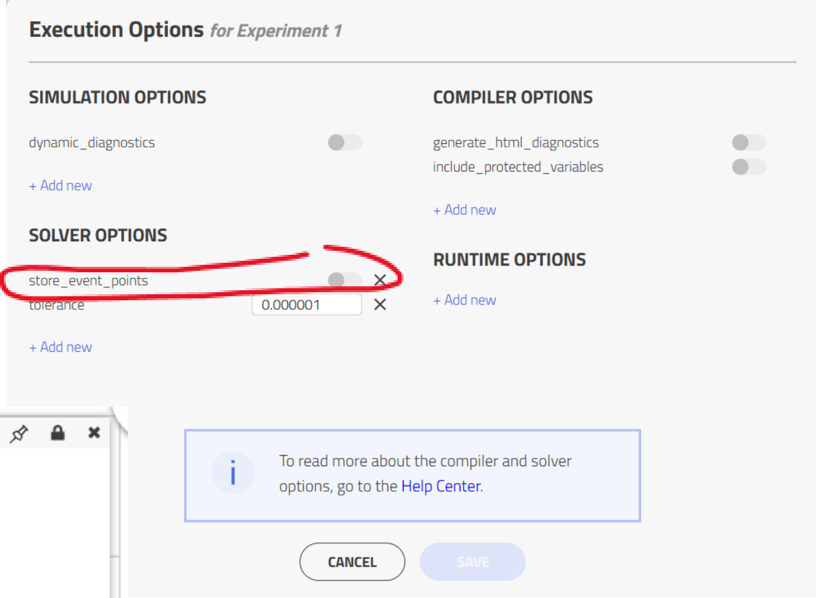
STEP 1: Generation of heating demand profiles

1. Simulate the model *Buildings.ThermalZones.ISO13790.Validation.BESTEST.Case600* for one year.
2. Go to the simulation tab, click on “Setup” and set “Interval length” to 3600s. This will enable exporting hourly data. Then go to the sub-tab “Output”, and deselect “Store variables at events”. This will ensure that you will have the right amount of data points.
3. Simulate the model, then plot the variable *gaiHea.y* to visualize the heating demand of the building.
4. To export the values, right click save button in the plot window to download the data as a file.



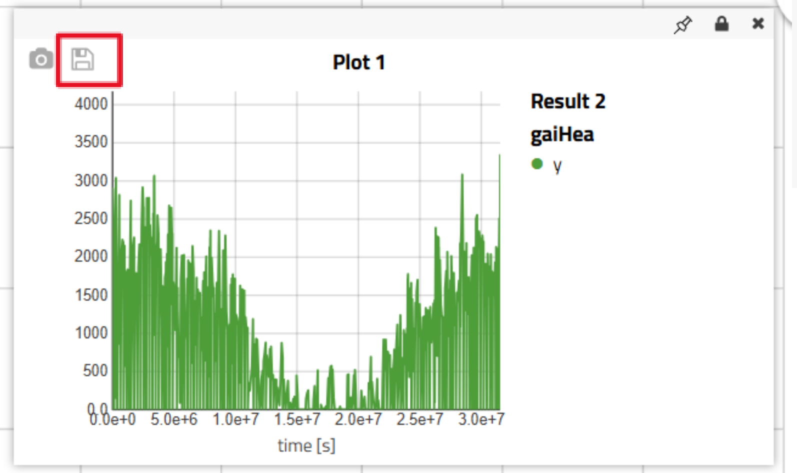
5. To make the file readable by the *CombiTimeTable,* we need to edit the file. Open the file with a text editor (e.g. Notepad) and write the following lines of code at the top of the file

HeaDem_hourly.txt - Notepad

File Edit Format View Help

```
#1
double tab1 (8760,2)
0,494.80643
3600,1213.7451
7200,1544.3743
10800,1696.8582
14400,1767.1819
18000,1799.6141
```

6. Check that your file actually has 8760 data point rows (typically you export 8761 rows, so you need to delete the last one)
7. Save in .txt format



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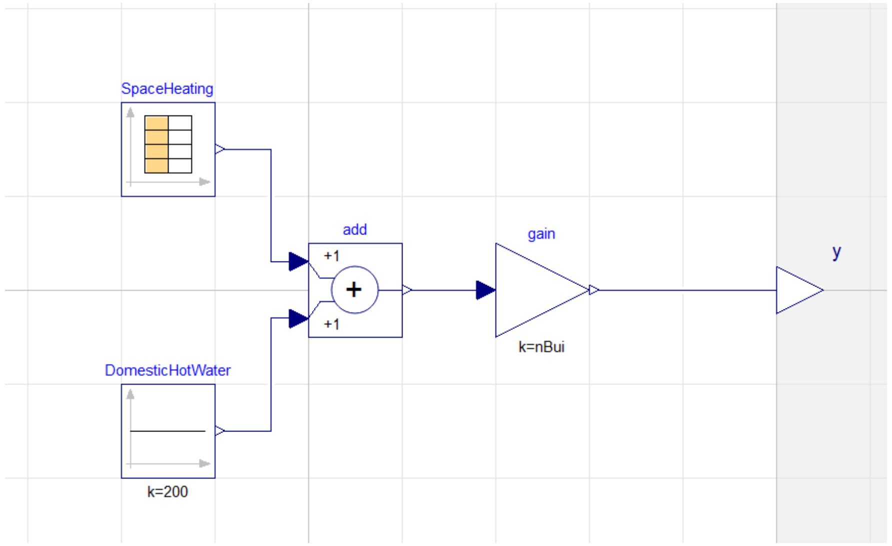
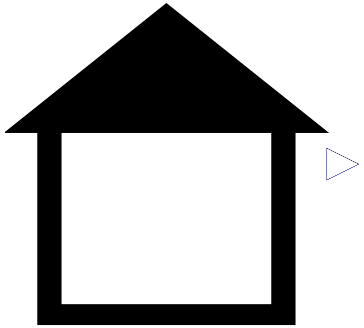
STEP 1: Generation of heating demand profiles

7. Create a new package called **Day3.** Then create two sub-packages called **Components** and **Experiments**
8. In the package Components, create a new model called **HeatingDemand**
9. Drag and drop the following blocks:



   - `Modelica.Blocks.Sources.CombiTimeTable (1)`
   - `Modelica.Blocks.Math.Gain (1)`
   - `Modelica.Blocks.Math.Add (1)`
   - `Modelica.Blocks.Sources.Constant (1)`
   - `Modelica.Blocks.Interfaces.RealOutput (1)`

10. Connect the components as illustrated in the figure
11. Create a new parameter (text editor) called nBui, which represents the number of buildings, and it is used to scale up the loads
12. Use a value of k=200 for the Constant block, which represent a constant load of domestic hot water equal to 200 W.
13. Parametrize the CombiTimeTable as shown in the next slide
14. The file path will probably be different ☺
15. Make an icon
16. Simulate the model for one year with nBui=1 and nBui=2. What happens when changing the value of nBui?



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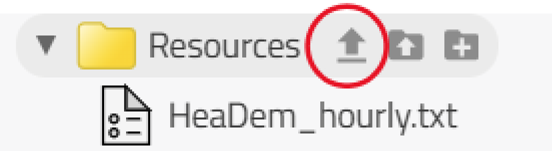
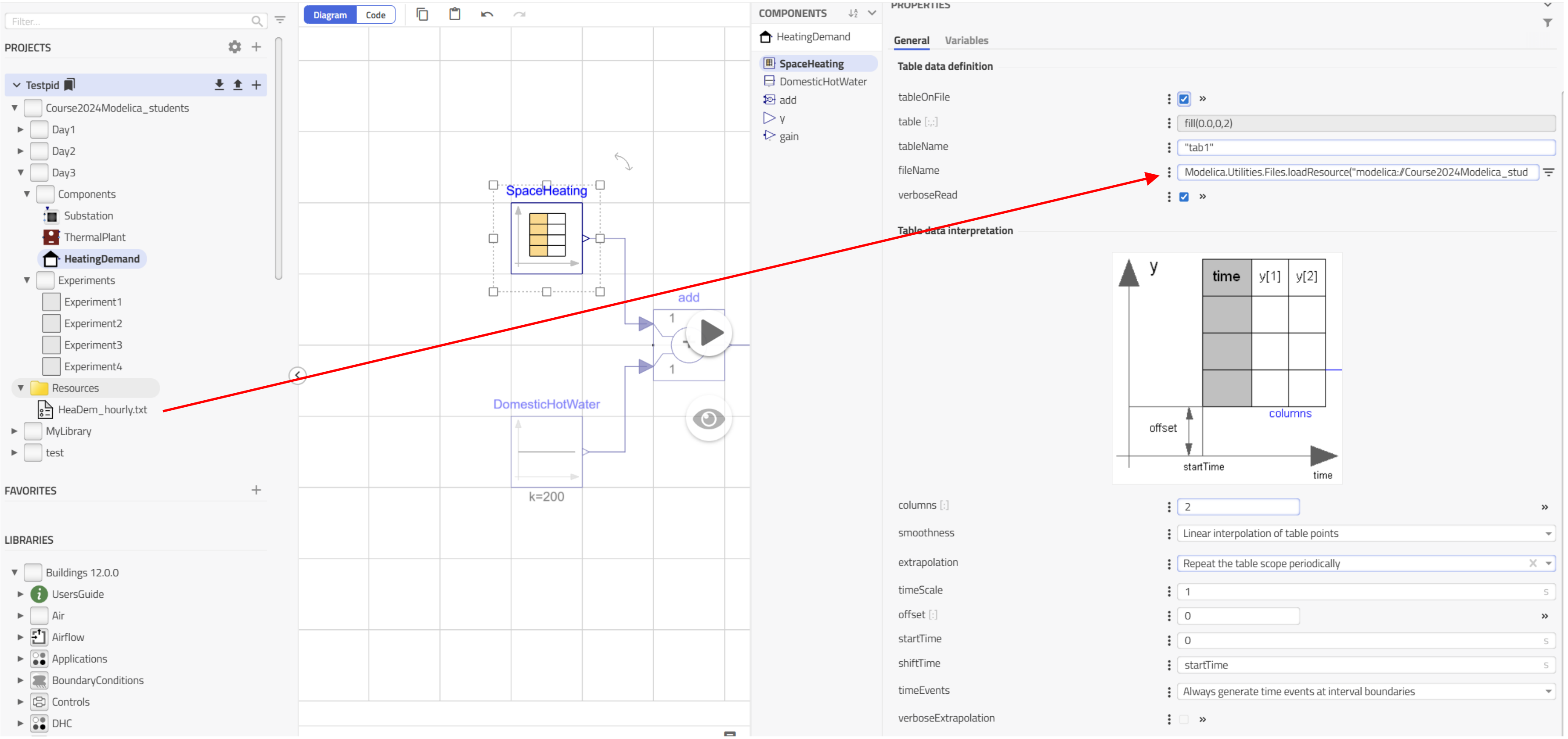
STEP 1: Generation of heating demand profiles

Upload data profile to Resource folder:



Drag file from package browser to “filename”



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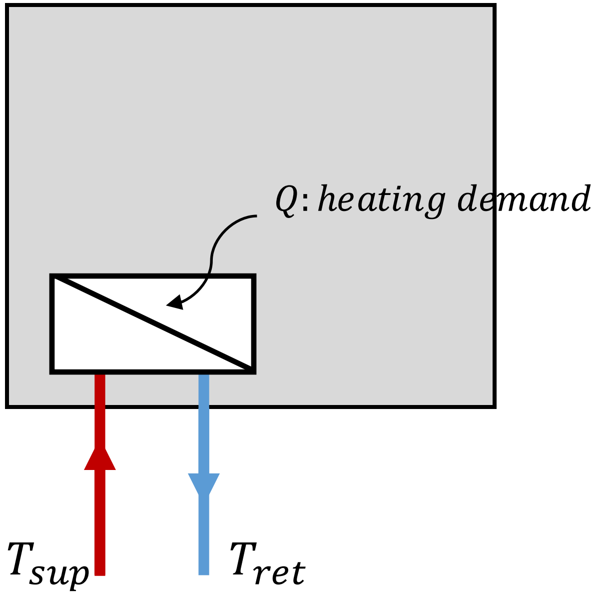
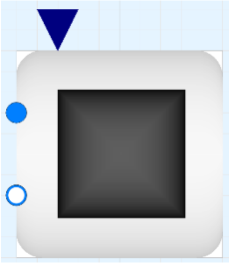
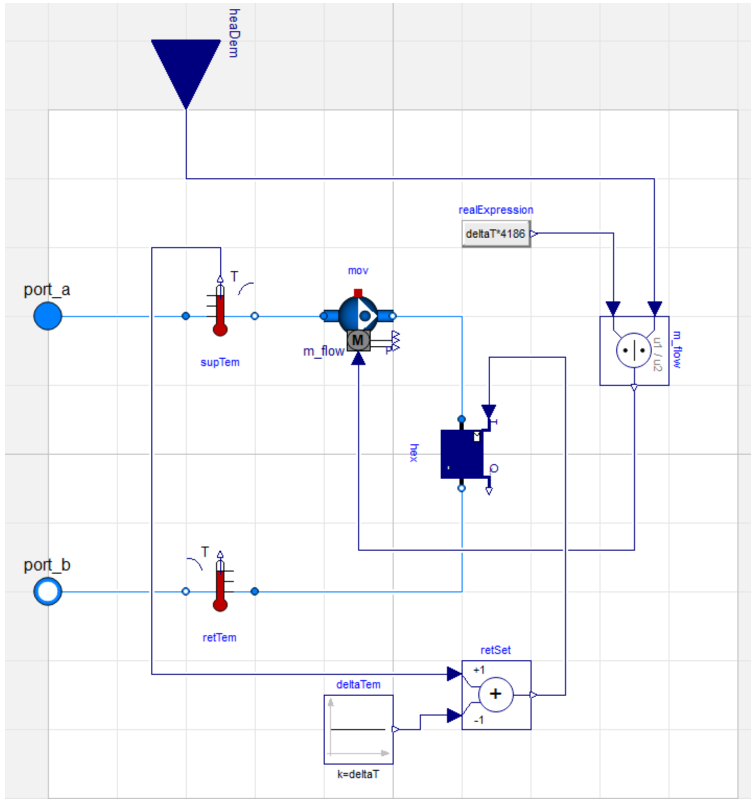
STEP 2: Modeling the substation



$$\dot{m} = \frac{Q}{c_p(T_{sup} - T_{ret})}$$

1. Create a new model called **Substation** in the package **Components**.
2. Drag and drop the following components:
   - `Modelica.Fluid.Interfaces.FluidPort_a (1)`
   - `Modelica.Fluid.Interfaces.FluidPort_b (1)`
   - `Buildings.Fluid.HeatExchangers.SensibleCooler_T (1)`
   - `Buildings.Fluid.Sensors.TemperatureTwoPort (2)`
   - `Buildings.Fluid.Movers.Preconfigured.FlowControlled_m_flow (1)`
   - `Modelica.Blocks.Sources.RealExpression (1)`
   - `Modelica.Blocks.Math.Division (1)`
   - `Modelica.Blocks.Math.Add (1)`
   - `Modelica.Blocks.Sources.Constant (1)`
   - `Modelica.Blocks.Interfaces.RealInput (1)`





3. Connect the components according to the figure
4. Create a parameter (text editor) for the temperature difference supply-return (maybe you call it *deltaT* and give a default value*)*.
5. Create a parameter (text editor) for the nominal mass flow rate (maybe you can call it *m_flow_nom* and give a default value)
6. What should you write in the *RealExpression?* Look at the equation on the left and think about it…
7. Assign the parameter *m_flow_nom* to all relevant components.
8. Assign a value = 100 Pa to dp_nominal in *SensibleCooler_T*
9. Make an icon

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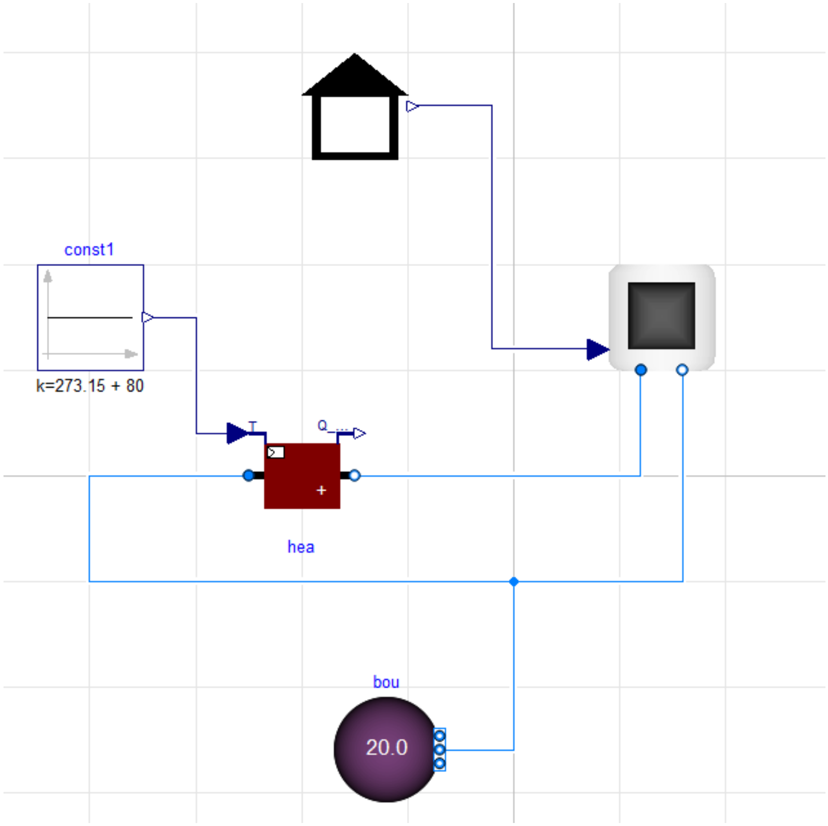
STEP 2: Let’s test our substation model connected to the heating demand profile

1. Create a new model in the package Experiments called **Experiment1**.
2. Drag and drop the following components:’

   - `Buildings.Fluid.HeatExchangers.Heater_T (1)`
   - `Modelica.Blocks.Sources.Constant (1)`
   - `Buildings.Fluid.Sources.Boundary_pT (1)`
   - `Day3.Components.HeatingDemand`
   - `Day3.Components.Substation`

3. Set a value of 20 K for the temperature difference in the substation, and calculate the value for the nominal mass flow rate (use the maximum heating load and then the simple equation provide in the previous slide)
4. Assign a value = 100 Pa to dp_nominal in *Heater_T*
5. Simulate the model for one year
6. Plot supply and return water temperatures and the mass flow rate



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