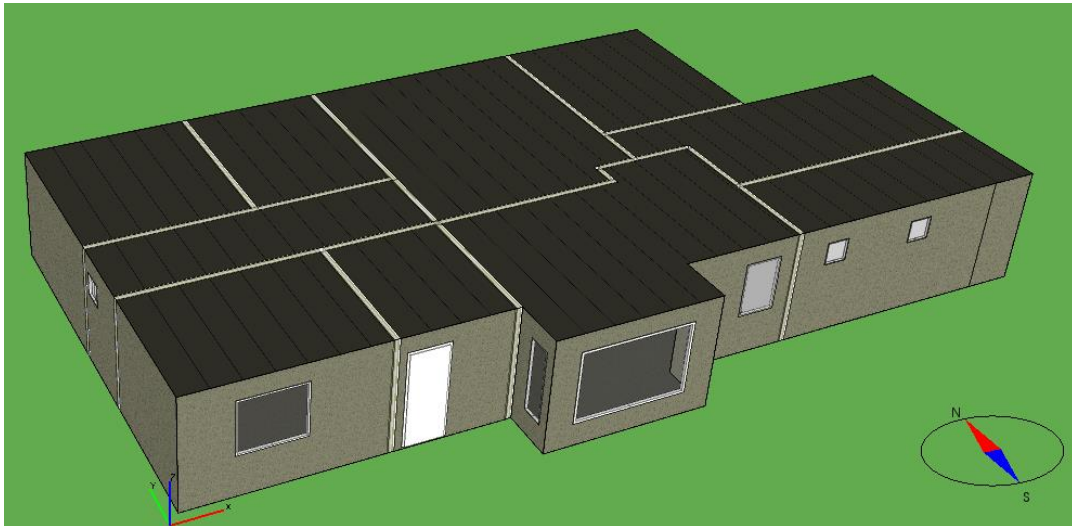


IDA Indoor Climate and Energy

Basic Course

ANNUAL ENERGY SIMULATION OF A WHOLE BUILDING

Guide



Purpose

Steps 1-4 of this guide is the third part of the IDA ICE basic course 1, where you get started with the IDA ICE standard level. Steps 5-8 is the second part of the IDA ICE basic course 2, where you get more experienced with the IDA ICE standard level. You learn how to perform a whole year energy simulation for a multiple zone building. During this guided exercise, we go through the following tasks:

- IFC import and zoning from IFC spaces
- Location, Climate and Wind profile
- Defaults and site plan/shading
- Infiltration, thermal bridges, ground properties and system losses
- Air handling unit and Plant
- Some input tables
- Energy calculation
- Looking at energy reports and input data reports

To get more support, also use the getting started guide, accessible over the "Help" menu within the IDA ICE software.

This exercise requires the preceding guided exercise "Indoor Climate of a single zone" and "Power demand for multiple zones".

Background

Energy calculations are requested in many countries in order to control if the energy efficiency requirements of the Building Codes and standards are fulfilled. Even building certification systems like LEED, BREEAM or Swedish Miljöbyggnad requires an annual energy calculations. For some countries there are specific IDA ICE extensions (so called "Localizations") implemented, which makes it easier to perform energy calculations according to different building codes.

Instructions

In this exercise we will perform a quick and easy whole-year energy calculation for a typical dwelling house in Northern Europe.

Step 1

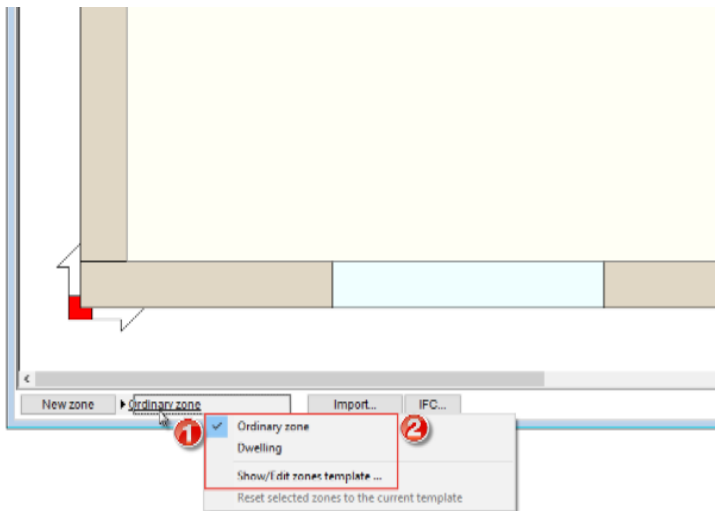
Import of an IFC file (Industrial Foundation Classes – a type of 3D-model) prepare zone templates.

- a. Open a new project by clicking on . This opens a new IDA ICE project with some predefined default values.

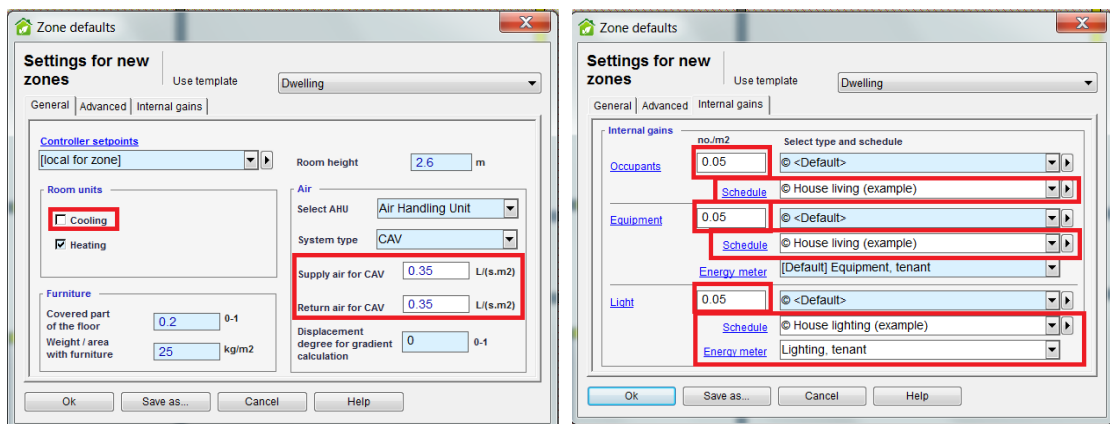
Note: For specific (national) building energy codes, you can use other buttons (included in national IDA ICE localizations) for opening new projects with default values defined by the building energy codes. This mainly includes usage data (defined within the “zone templates”), but also how energy reports will be presented (defined by “energy meters”).

Save your project as *Energy-MyGuide.idm* or any other suitable name and save it in a suitable place.

- b. In order to import the IFC file go to the **Floor plan** tab, click on the “IFC...” button and select “Import”. Browse to the folder where IDA ICE is installed on your computer and further to *...samples\ICE\ifc\Single family house.IFC*. Use default settings for the pop-up dialog “Preferences” and click “OK”. The same for the second dialog “Add/replace CAD”.
- c. Now - when the IFC model has been imported - go to the **3D** tab and have a look at it. If you click on “Show...” or right-click on the main interface, you can select “Visual filter...” and then choose which objects you want or don’t want to view. If you unmark “IFC model”, you will see the building body that has been created automatically from the imported ifc file.
- d. Go back to the **Floor plan** tab. From here, one can now insert the zones for the simulation. Their usage data will always be based on the selected zone template (“Ordinary zone” by default). When using localizations, appropriate zone templates can be selected by clicking on the active zone template name (“Ordinary zone” by default):



- e. Either select the zone template for dwelling included in your localization, or make your own template by clicking on the active zone template name “Ordinary zone” and selecting “Show/Edit zones template...”. Click on “Save as...” to save your new zone template and name it *Dwelling*. As cooling systems in dwellings is less common in Nordic countries, we will choose to have only heating units for default zones. Change supply and exhaust ventilation air flows to 0.35 l/s,m2. Switch to the **Advanced** tab and change room unit power for cooling to 0 W/m2. Finally go to the “Internal gains” and change the settings as in figure below. Click “OK” to finalize your new zone template.

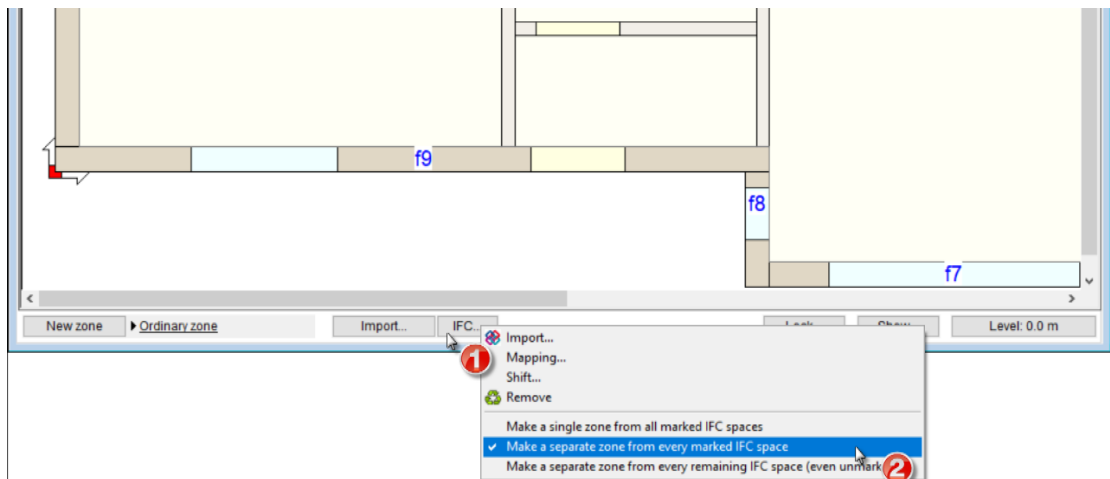


Note: More information about creating zone templates can be found in the getting started guide. How zone templates can be stored in so called “resource containers” will be explained in another lesson “Getting more experienced with IDA ICE”.

Step 2

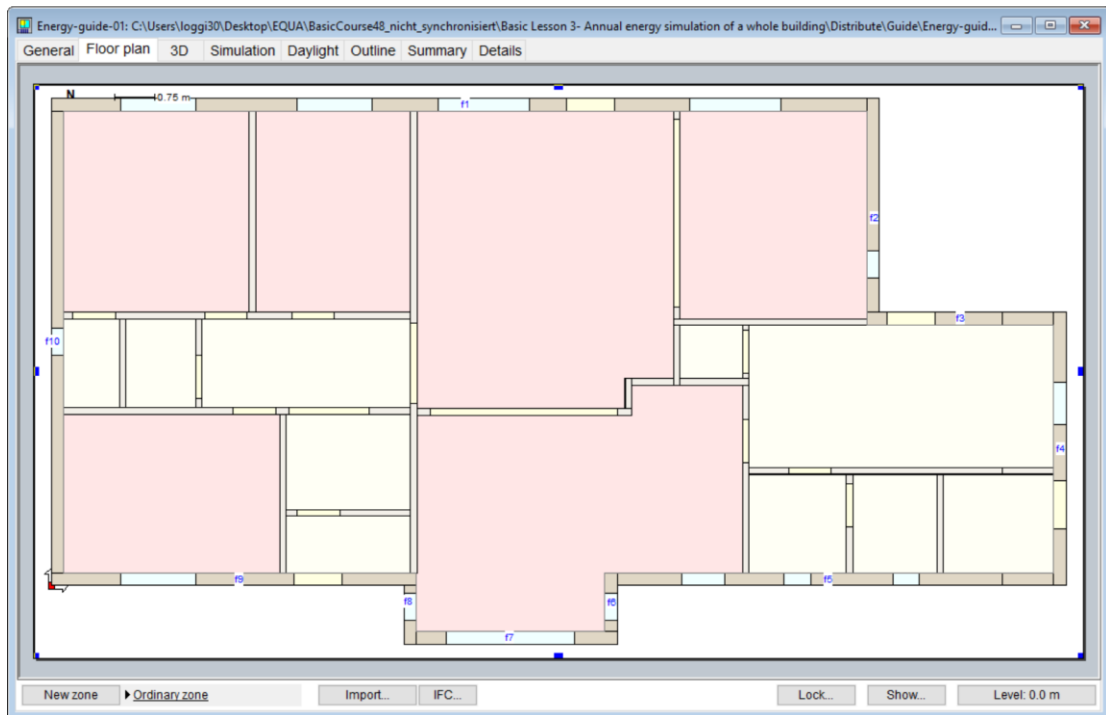
Convert imported IFC spaces to **IDA ICE zones**.

- a. First click on the “IFC...” button and select “Make a separate zone every marked IFC space”:



Note: There are three different options on how to insert new zones from IFC spaces. Either you can make one single zone from all of the marked IFC spaces or you can make a separate zone from every marked space. The third option is to make separate zones from all of the (marked or unmarked) IFC spaces that are not yet converted to zones.

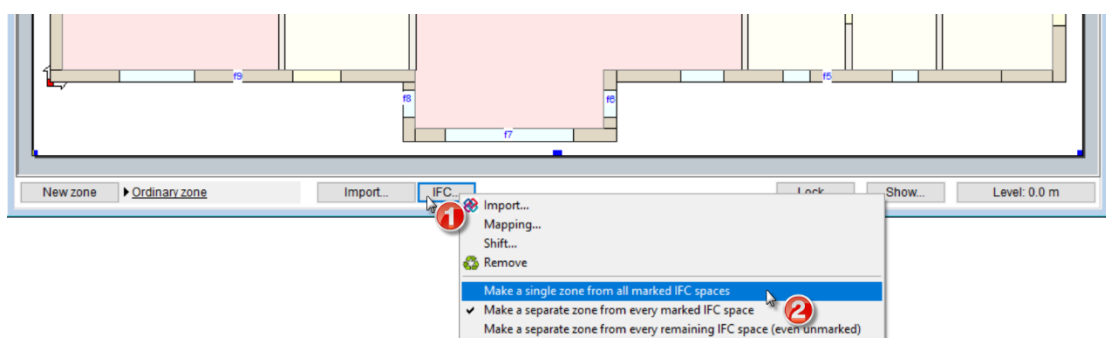
- b. Mark the ifc spaces as in the figure below and click “New zone”. Your 6 zones will be based on the chosen template, in this case our newly created template *Dwelling* (or the template for dwellings from your building energy code).



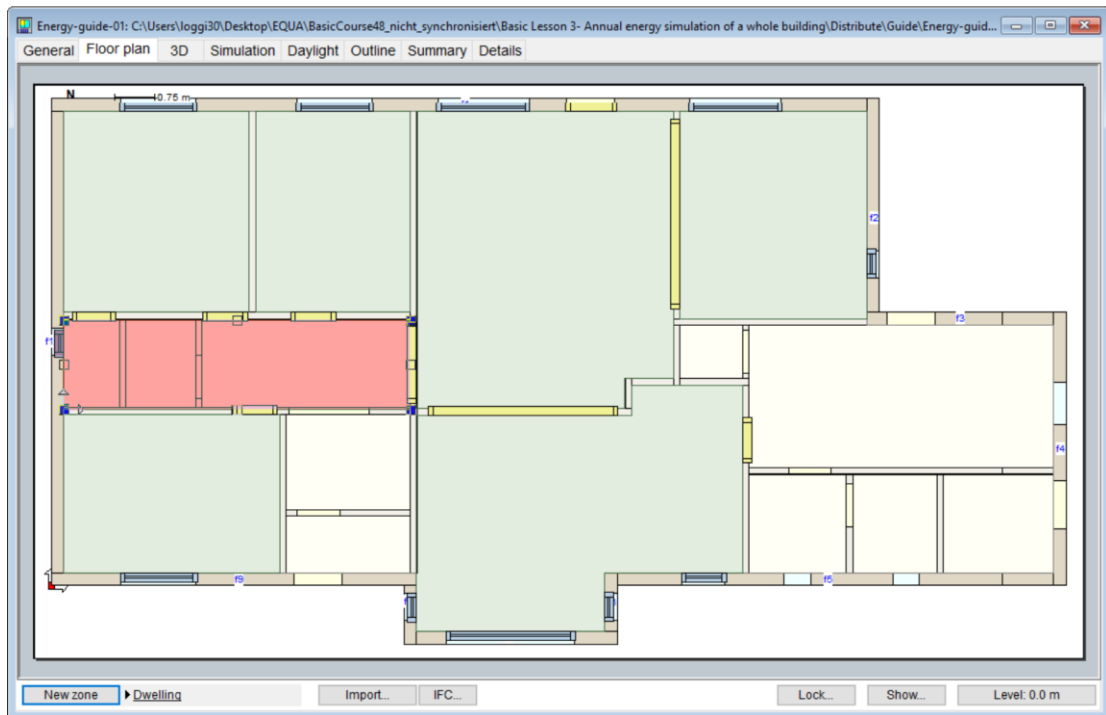
Note: You can mark multiple zones by clicking on those one after the other, or by pressing the left mouse button and dragging the marker over all zones to be marked.

Note: You might get some warnings about wrong mapping of building materials. If so, rightclick on the warning field and choose “Clear messages”.

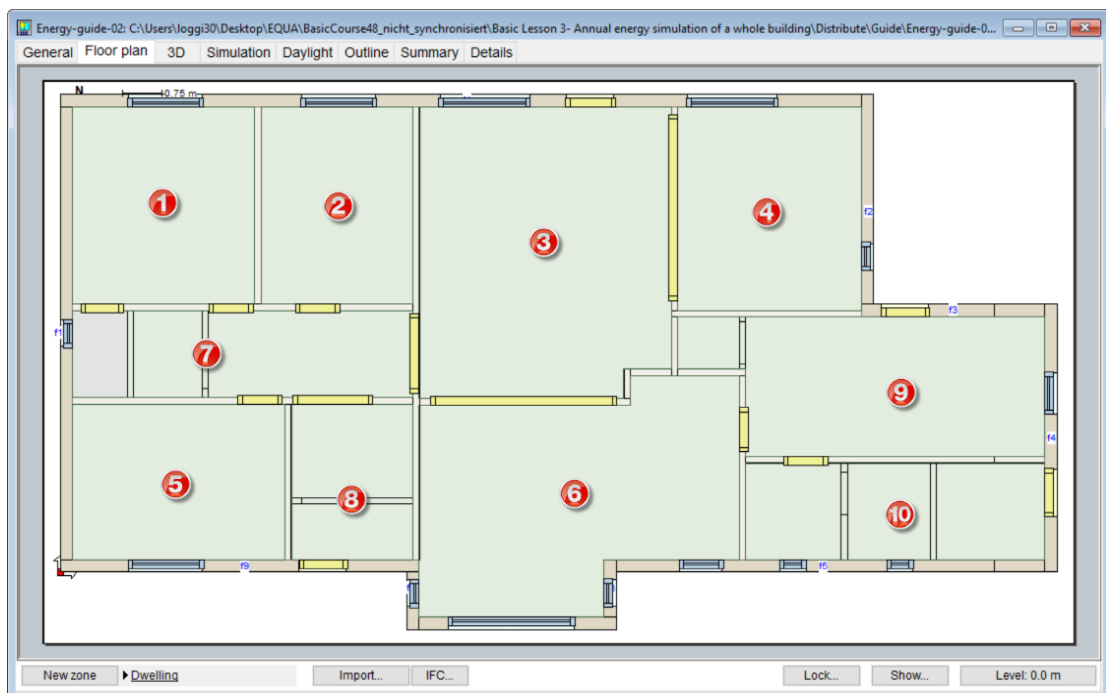
- c. Click on the “IFC...” button and select “Make a single zone from all marked IFC spaces”:



- d. Mark the three zones as shown in the figure below and insert a 7th zone by clicking on the “New zone” button.



- e. Do the same for 3 more zones in order to get the following 10 zones:

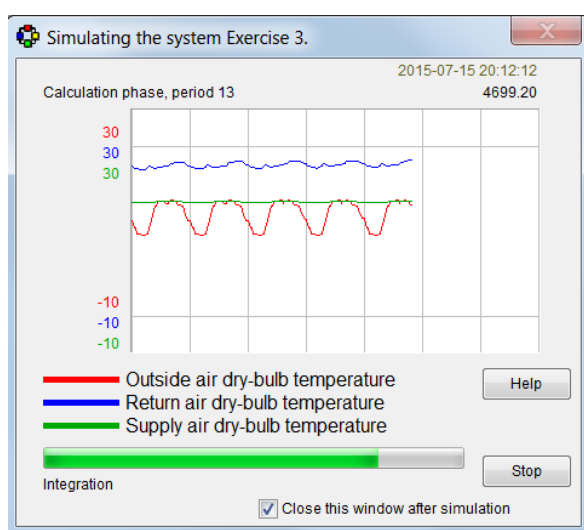


- f. Change the name of zone 9 from “Bathroom-1” to “Laundry room” by rightclicking on the zone and selecting “Rename...”.

- g. Have look at your model in the 3D view. Can you make the picture to look like this?:



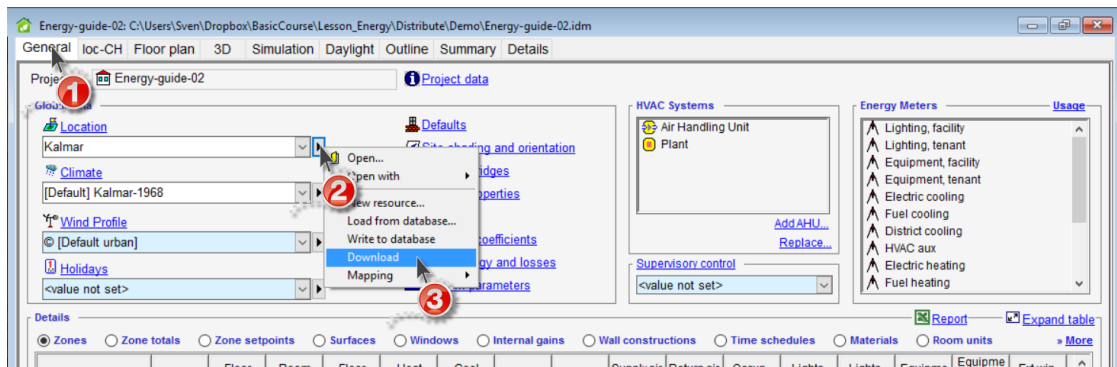
- h. A good thing to do while modelling is to “test simulate” the model often in order to see if everything is all right. You can do this by pressing  in the upper menu. You do not have to wait until simulation is done. You can press “Stop” and “Abort” to interrupt the simulation. If the model starts to simulate and the dialog box like in figure below appears, you are ready with the geometry.



Step 3

Fill in the rest of the **input data**.

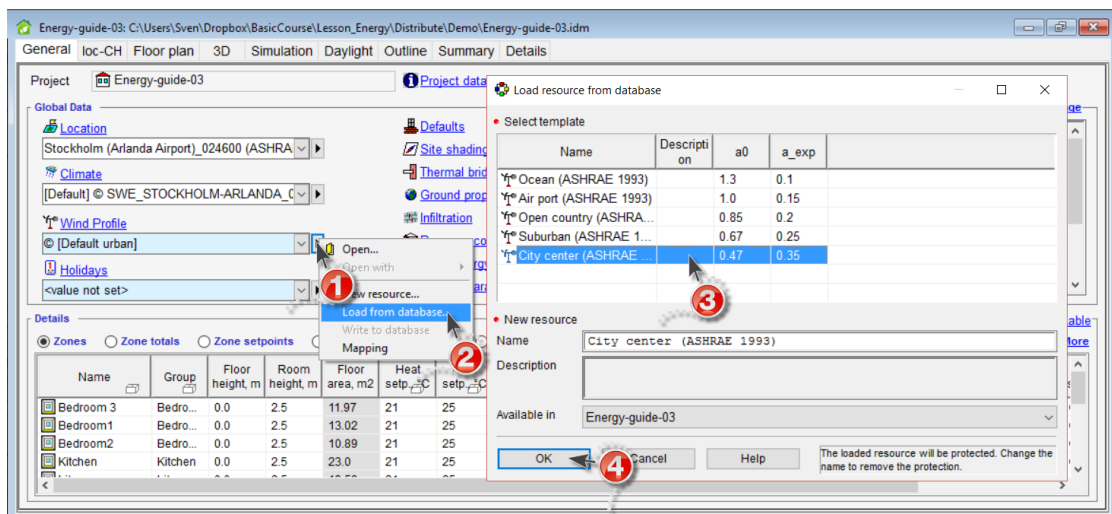
- a. From the **General** tab download location "Stockholm - Arlanda":



In the list of all available ASHRAE locations, jump to "S" for Sweden and select "Stockholm (Arlanda Airport)".

Note: Within the "location" data object, the geographical location of your building is described as well as design day weather data for winter and summer. When downloading a location from the ASHRAE list, you additionally get a whole-year climate file from ASHRAE, describing a "typical" year for this location. You can read more about location and climate in the getting started guide, chapter 7.

- b. Select "City center" wind profile from the IDA ICE database:



- c. Click on  **Defaults** to define your default input data (see getting started guide or lesson “Power”, Step 1). According to the input data which you find at the end of the document, your constructions should be following (use materials from resources or load from the IDA ICE database):
- *External wall:*
 - 26 mm “Gypsum”,
 - 30 mm “Air in 30 mm vert. air gap”,
 - 200 mm “Light insulation”,
 - 9 mm “Chip board (example),
 - 30 mm “Air in 30 mm vert. airgap”,
 - 120 mm “Brick (example)”

-> **U = 0.155 W/(m²K)**
 - *Roof:*
 - 3 mm “Copper (example)”,
 - 25 mm “Wood),
 - 250 mm “Light insulation”,
 - 26 mm “Gypsum”

-> **U = 0.135 W/(m²K)**
 - *External floor (excl. ground):*
 - 10 mm “Wood”,
 - 15 mm “Chip board (example)”,
 - 200 mm “Concrete”,
 - 200 mm “Light insulation”

-> **U = 0.166 W/(m²K)**
 - *Glazing:*

U = 0.9 W/(m²K), g = 0.6, T = 0.55
 - *Door:*

Choose your own construction in order to get U = 1.2 W/(m²K).
 - *Integrated window shading:*

“Blind between panes (BRIS)”

Check that your construction has the above mentioned U-value before clicking “OK”. Use predefined input wherever you cannot find the information in the input data list.

Note: For all walls, roofs and floors with no otherwise specified construction, the here defined default construction will now automatically be applied.

- d. Close the form for Building defaults and select the table “Windows”. Change the frame factor for all windows to 0.15. After having changed it for the first window, you can copy this value to the rest of the rows by right-clicking on the first cell and selecting “Copy” and then marking the rest of the frame factor column, right-clicking and selecting “Paste”:

Details

Zones

Zone totals

Zone setpoints

Surfaces

Windows

Internal gains

Wall constructions

Time schedules

Materials

Room units

Energy meters

Air handling units

Report

Name	Type	Group	Zone	Face	Slit height from ground, m	Slit height from floor, m	Area, m2	Slope, Deg	Glazing	g (SHGC)	T	Glazing U, W/m2.K	Frame U, W/m2.K	Win total U, W/m2.K	Int shading	Control	Schedule	Ext shading	Opening control	Opening schedule		
Bedroom 3 Wall...	Window	Bedroom	Bedroom	Lounder	0.9	0.9	180.0	90.0	1.68	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Bedroom 1 Wall...	Window	Bedroom	Bedroom	Lounder	0.9	0.9	0.0	90.0	1.68	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Bedroom 2 Wall...	Window	Bedroom	Bedroom	Lounder	0.9	0.9	0.0	90.0	1.68	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Kitchen Wall 3 f...	Window	Kitchen	Kitchen	Lounder	0.9	0.9	180.0	90.0	0.96	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Kitchen Wall 4 f...	Window	Kitchen	Kitchen	Lounder	0.5	0.5	90.0	90.0	0.8	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Kitchen Wall 5 f...	Window	Kitchen	Kitchen	Lounder	0.5	0.5	180.0	90.0	3.84	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Kitchen Wall 6 f...	Window	Kitchen	Kitchen	Lounder	0.5	0.5	270.0	90.0	0.8	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Library Wall 3 f...	Window	Library	Library	Lounder	0.5	0.5	0.0	90.0	2.72	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Library Wall 4 f...	Window	Library	Library	Lounder	0.5	0.5	90.0	90.0	0.8	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Living room Wa...	Window	Living r...	Living r...	Lounder	0.5	0.5	0.0	90.0	2.72	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Bathroom 2 Wal...	Window	Bathroom	Bathroom	Lounder	1.6	1.6	270.0	90.0	0.25	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Bathroom Wall ...	Window	Bathroom	Bathroom	Lounder	1.6	1.6	180.0	90.0	0.25	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Bathroom Wall ...	Window	Bathroom	Bathroom	Lounder	1.6	1.6	180.0	90.0	0.25	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...
Laundry room 1...	Window	Bathroom	Lounder	Lounder	0.9	0.9	90.0	90.0	0.96	[Default...	0.6	0.54	0.9	0.15	2.0	1.065	[Default...	Sun	@ Alwa...	No ext...	Sched...	@ Nev...

In the same way change the U-value for the frame to 1.5 W/(m²K) for all of the windows.

Note: The default setting for integrated shading control is “Sun”, which means that blinds are drawn when solar radiation level exceeds a certain limit - 100 W/m² by default at the outside of the glazing. This limit value as well as the sensor position can be changed in the **General** tab under “System parameters”. In this exercise, we keep the integrated shading control as it is.

Step 4

Now it is time to do our first **energy simulation**.

- a. Go to the **Simulation** tab. Before simulation you should choose to log some additional variables. To do that click  [Requested output](#). Select “Heat balance” and “Air flows in zone”. Click “OK” to close the “Requested output” form.

Note: For large models, logging the sources of reports may occupy significant disk space.

- b. Click  [Setup](#) and change percentage of internal gains to 100 %. Press “Run”. This simulation will take around 6 minutes. Time for a coffee...?

Note: The simulation process in general can be described as follows: The first popup window represents the creation of a mathematical model (equation system) of the building. The second popup window shows the equations being solved time step by time step. IDA ICE has an adaptive equation time step which means that the time step shortens automatically if there is a lot of events going on in the model (for example, fans that turn on and off, internal gains that varies, changes in solar shading position etc.) in order to get more accurate results.

- c. When simulation finishes, the results pop up automatically. Click [Delivered Energy](#) which you can find at the lower right corner. The delivered energy report gives an overview over all energy delivered to the building. It includes the energy being lost in the HVAC system (generator efficiencies, see  [Defaults](#)) as well as the energy being lost in the distribution system (distribution system losses, see  [Extra energy and losses](#)).

Note: Due to many possibilities of different input, your results might differ from the results in the figure below.

Note: The results in this report is often compared to the building code or the requirements of the certification systems, which have simpler model approaches. To find reasons for the differences, it would be necessary to do similar simplifications even in the IDA ICE model, which can be difficult without deep knowledge about how to influence these.

Note: There is a small cooling energy consumption in the model. The reason for this is the air handling unit maintaining supply air temperature at 16 °C. We will remove this cooling in step 6.

Note: Energy consumption for heating might be unreasonable low. Depending on what zone templates you have used, internal loads might be high. In reality, there will hardly be full occupancy in all rooms 24 hours the whole year long (which is the case in the zone templates we created in step 1). We will consider this and adapt the internal load data in step 8.

		Delivered Energy Report	
Project		Building	
Customer		Model floor area	143.3 m ²
Created by	Sven Moosberger	Model volume	358.1 m ³
Location	Stockholm (Arlanda Airport)_024600 (ASHRAE 2013)	Model ground area	175.5 m ²
Climate file	SWE_STOCKHOLM-ARLANDA_024600 (IW2)	Model envelope area	457.0 m ²
Case	Energy-guide-04	Window/Envelope	4.2 %
Simulated	10.01.2018 11:37:52	Average U-value	0.1793 W/(m ² K)
		Envelope area per Volume	1.276 m ² /m ³

Building Comfort Reference

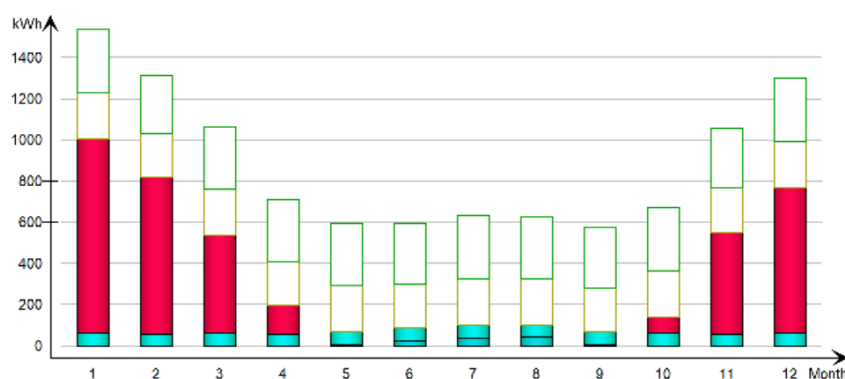
Percentage of hours when operative temperature is above 27°C in worst zone	31 %
Percentage of hours when operative temperature is above 27°C in average zone	24 %
Percentage of total occupant hours with thermal dissatisfaction	15 %

Delivered Energy Overview

	Purchased energy		Peak demand
	kWh	kWh/m ²	kW
Electric cooling	116	0.8	0.32
HVAC aux	718	5.0	0.09
Total, Facility electric	834	5.8	
Fuel heating	3612	25.2	3.59
Domestic hot water	0	0.0	0.0
Total, Facility fuel*	3612	25.2	
Total	4446	31.0	
Lighting, tenant	2628	18.4	0.72
Equipment, tenant	3596	25.1	0.54
Total, Tenant electric	6224	43.5	
Grand total	10670	74.5	

*heating value

Monthly Purchased/Sold Energy



Month	Facility electric		Facility fuel (heating value)		Tenant electric	
	Electric cooling (kWh)	HVAC aux (kWh)	Fuel heating (kWh)	Domestic hot water (kWh)	Lighting, tenant (kWh)	Equipment, tenant (kWh)
1	0.0	60.0	947.3	0.0	222.9	309.4
2	0.0	56.1	764.3	0.0	208.9	283.6
3	0.0	60.2	477.1	0.0	223.1	300.7
4	0.0	58.6	137.5	0.0	215.4	296.3
5	6.7	61.0	0.5	0.0	222.6	305.0
6	24.7	59.6	0.1	0.0	215.0	292.1
7	37.5	62.0	0.0	0.0	223.0	309.5
8	41.6	62.0	0.0	0.0	223.0	300.8
9	5.9	59.3	0.0	0.0	214.9	292.2
10	0.0	60.6	81.1	0.0	223.4	309.4
11	0.0	58.4	494.8	0.0	213.4	292.0
12	0.0	60.2	709.1	0.0	221.9	305.1
Total	116.4	718.1	3611.8	0.0	2627.5	3596.1

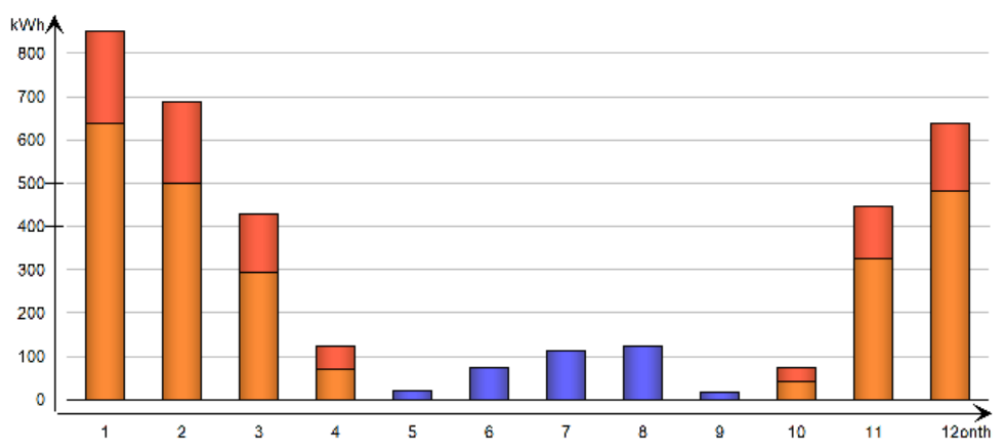
- d. In the **Summary** tab, click on [Systems energy](#). The systems energy report provides an overview over the energy delivered by all HVAC systems to the distribution systems of the building. It includes the energy being lost in the distribution system (distribution system losses, see ⚡ [Extra energy and losses](#)), but not the energy being lost in the HVAC system (generator efficiencies, see 🏠 [Defaults](#)).

 SIMULATION TECHNOLOGY GROUP		Systems Energy	
Project		Building	
Customer		Model floor area	143.3 m ²
Created by		Model volume	358.1 m ³
Location		Model ground area	175.5 m ²
Climate file		Model envelope area	457.0 m ²
Case		Window/Envelope	4.2 %
Simulated		Average U-value	0.1793 W/(m ² K)
		Envelope area per Volume	1.276 m ² /m ³

Used energy

kWh (sensible and latent)

Month	Zone heating	Zone cooling	AHU heating	AHU cooling	Dom. hot water
1	639.5	0.0	213.1	0.0	0.0
2	498.7	0.0	189.2	0.0	0.0
3	292.4	0.0	136.9	0.0	0.0
4	70.3	0.0	53.4	0.1	0.0
5	-0.0	0.0	0.5	20.1	0.0
6	0.0	0.0	0.1	74.2	0.0
7	-0.0	0.0	0.0	112.4	0.0
8	0.0	0.0	0.0	124.8	0.0
9	0.0	0.0	0.0	17.8	0.0
10	42.7	0.0	30.3	0.0	0.0
11	325.3	0.0	120.0	0.0	0.0
12	482.2	0.0	156.0	0.0	0.0
Total	2351.1	0.0	899.5	349.3	0.0



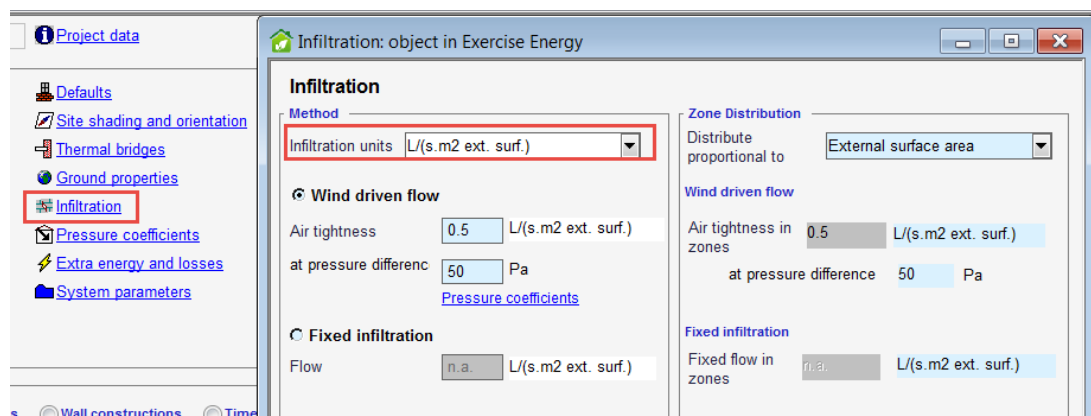
Step 5

Most of the building input data is set in the “Global Data” section at the upper left corner of the **General** tab. You have already configured “Location”, “Climate”, “Wind Profile” and “Defaults”. In this step we go through **all the other input**.

- Click on  [Site shading and orientation](#). Here you can insert shading buildings and change orientation of the building. Try to insert a shading building and change its height. Try also to change the orientation of the building by rotating the north arrow.
- Click on  [Thermal bridges](#) and fill in the values according to the input data report at the end of this document. You can find more information about it in the *getting started guide*, chapter 10.
- Click on  [Ground properties](#). Here you can choose to calculate heat transport to the ground either according to ISO 13370 or a simpler one-dimensional model called *Ice3*. Ground layers are created by the same way as building constructions.

Note: Observe that the default ground model includes 100 mm insulation layer. Make your own ground model with 1 m soil and no insulation. Select the same layers even for the ground layers outside basement walls. Read the information text in the yellow field and close the form by clicking “OK”.

- Click on  [Infiltration](#). There are two calculation methods – wind driven flow and fixed infiltration. Select wind driven flow. Leave air tightness at 0.5, but change the unit to l/s*m2 ext.surface at 50 Pa pressure difference.



Note: Wind driven infiltration flow is modelled by one leak towards ambient for each external wall of each zone. To get wind driven air flow through these leaks, pressure coefficients must be set for each building face. We will do this next (see below).

Note: Interzonal air exchange is always taken into account within the IDA ICE models. In order to be able to balance the mass flow for each zone, a minimal leakage area (it is 0.0001 m² for the largest external wall of each zone) is needed.

- e. Click on  [Pressure coefficients](#). Values there can be entered manually (e.g. copied from Excel) which could be obtained by a CFD calculation. However there is a simplified method to set the pressure coefficients with predefined values. Click on “Auto fill” and select “Sheltered”.
- f. Click on  [Extra energy and losses](#). Set the average hot water use to 25 kWh/m² floor area and year. This consumption is excluding losses due to a hot water circulation circuit.

Note: You can also set a schedule for the domestic hot water usage that could be useful for power demand calculations.

- g. Set the Domestic hot water circuit losses to 0 W/m² and change the heating systems losses to 10 % of heat for room units delivered by plant. Assume that there are no losses due to cooling distribution or ventilation air ducts.
- h. At the bottom of the same form you can find “Additional Energy Use”, where you can insert items that consumes energy but are not a part of a heat balance for any zone. These items could be outdoor lighting, heating cables for rain water drains etc. According to input data list there is a 0.17 W/m² continuous effect of facility electricity. Add a new Extra energy item and change its name by rightclicking, selecting “Rename” and writing “Remaining facility electricity”. Click on the empty field for Energy meters and choose the meter called “Equipment facility”. The “Extra energy and losses” form should now look like this (input f-h):

Extra energy and losses: object in Energy-guide-05

Extra energy and losses

Domestic hot water use

Average hot water use: kWh/m2 floor area and year

Distribution of hot water use: © Uniform

[T_DHW = 55°C (incoming 5°C); find further details in [Plant](#) and Boiler; DHW can, optionally or additionally, also be defined at the zone level]

[The curve is automatically rescaled to render given average total usage]

Distribution System Losses

Domestic hot water circuit: W/(m2 floor area) % to zones*

Heat to zones: % of heat delivered by plant (incl. delivered to ideal heaters) % to zones*

Cold to zones: W/m2 floor area % to zones*

Supply air duct losses: W/m2 floor area, at dT_duct _to_zone 7 °C % to zones*

None Good Typical Poor Very poor

[*Share of loss deposited in zones according to floor area]

Plant Losses

Chiller idle consumption: W Boiler idle consumption: W

Additional Energy Use

[Add...](#) [Remove](#)

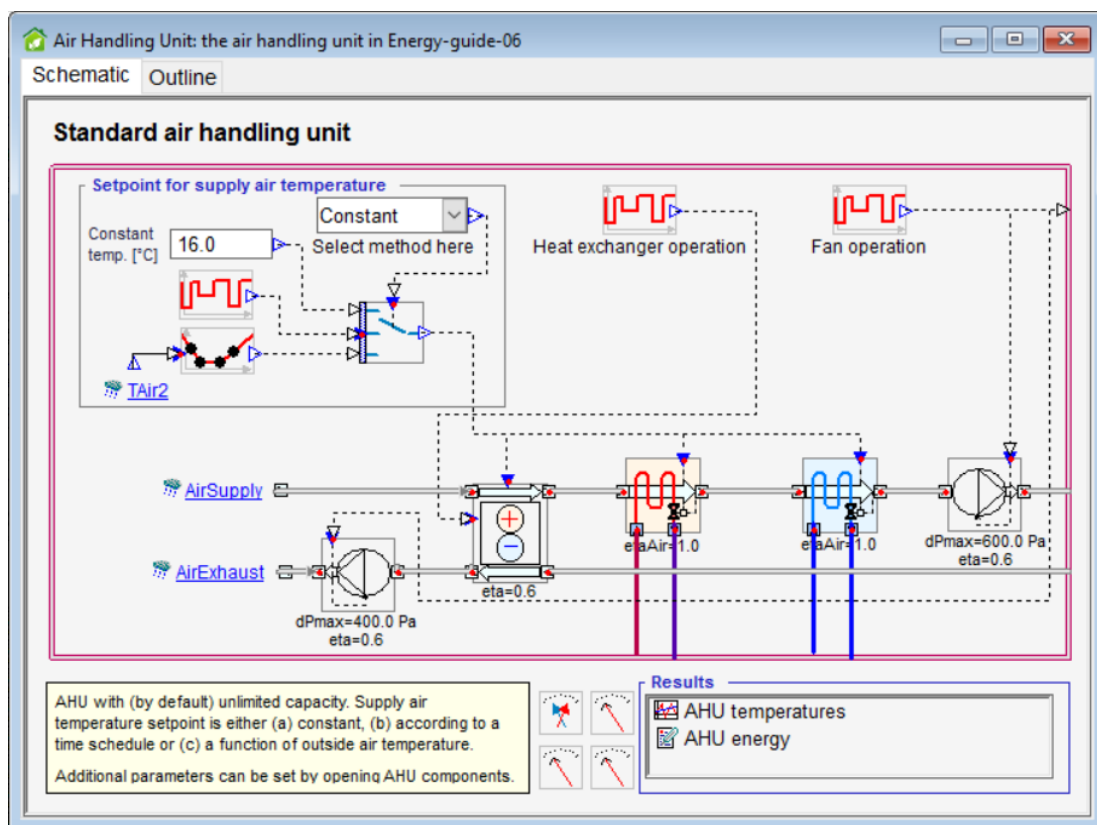
Name	Nominal power, kW	Nominal power, W/m2	Nominal power, total [kW]	Schedule	Energy meter
Remaining facility e...	0	0.17	0.02435	© Always on	Equipment, facility

- i. Now you have made several changes. Save the model and “test-simulate” it.

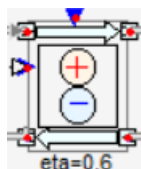
Step 6

We proceed with the **ventilation system**. You find it in the “HVAC Systems” section of the **General** tab. There can be no, one or several air handling units at the same model and there are a number of different predefined air handling units to choose from. You find these by clicking [Add AHU...](#) or [Replace...](#). We will use the “standard air handling unit” in this exercise.

- a. There is already an air handling unit inserted to our model. It is called “Air Handling Unit”. Doubleclick on it to open its schematic view:

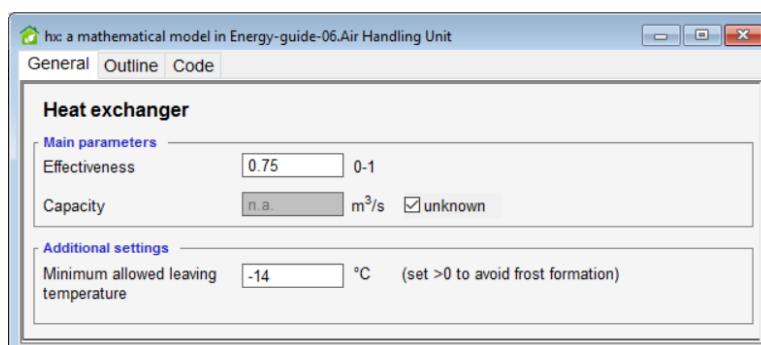


- b. Heat recovery: Begin by opening the heat exchanger by doubleclicking on its symbol:

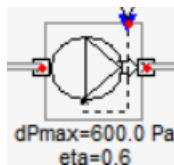


Change the effectiveness to 75%. Here you can also set the minimum allowed leaving temperature to imitate the defrosting. In this case it is assumed to have a rotating heat exchanger which is not so sensitive for frost. So change the temperature to -14°C.

Note: If the system has variable air flow you should fill in even design air flow at which the heat exchange grade is fulfilled. Leave it "Unknown" this time.



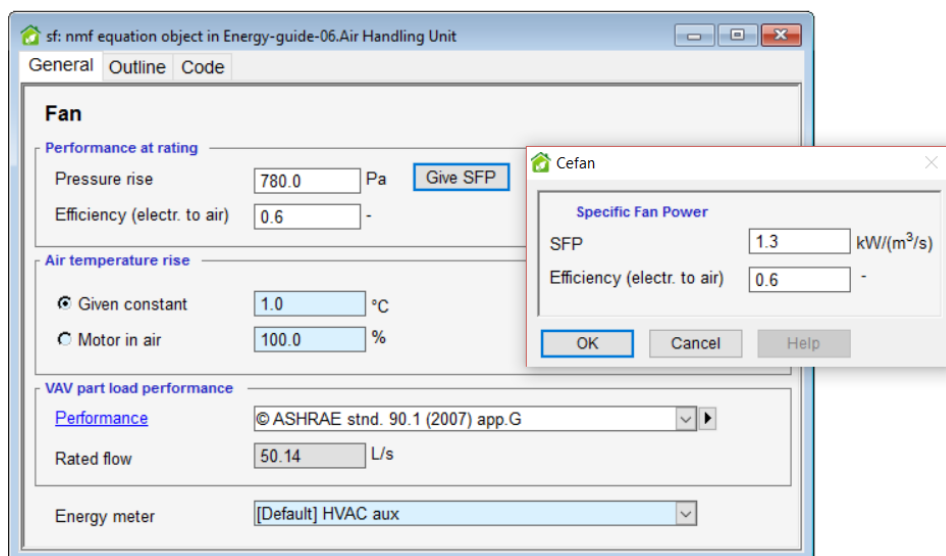
- c. Fans: Open supply and exhaust air fans by doubleclicking on their symbols:



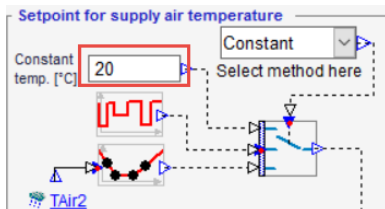
Specific fan power for our air handling unit is assumed to be 2.0 kW/(m³/s). Divide it between the fans by giving 1.3 to supply fan and 0.7 to exhaust fan.

Note: Here you can also set an air temperature rise due to fan motor. It is set to 1°C by default. We leave it at this.

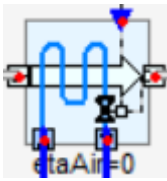
Note: In case of variable air flow you can give a design air flow and polynomial that describes the fan power and air flow ratio. We leave this curve as defined in ASHRAE 90.1 app. G.



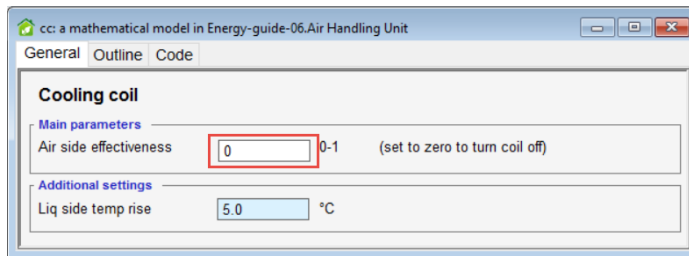
- d. Control of supply air temperature: Set the supply air temperature to constant 20°C:



- e. Cooling: Open the cooling coil by doubleclicking on it:



It is not common to have cooling in residential buildings in northern Europe. Turn it off by setting effectiveness of the cooling battery to 0:



- f. Fan schedule: In upper right corner you can set the time schedule for the fans. Leave the air handling unit operate continuously.
- g. Ventilation air flows: Now you will adjust ventilation air flows. You can either do it by opening every zone like in lesson “Indoor Climate of a Single Zone” or by opening “Zone totals” in the **General** tab. Define supply and exhaust air flows as follows. At the end check the balance between total supply and exhaust air flow.

Details

☒ Zones ☒ **Zone totals** ☐ Zone setpoints ☐ Surfaces ☐ Windows ☐ Internal gains ☐ Wall constructions ☐ Time schedules ☐ Materials ☐ Rep...

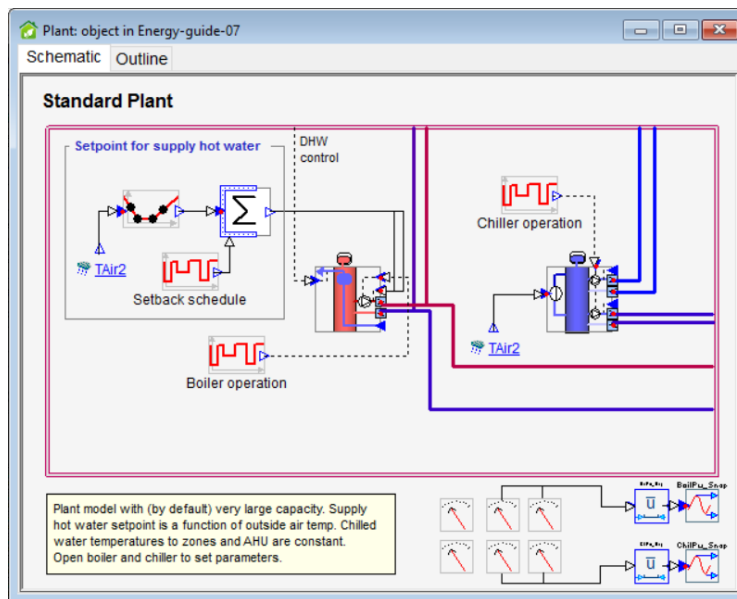
Name	Group	Floor height, m	Zone multiplier	M*Area, m2	M*Supply air, L/s	M*Return air, L/s	M*Occupants, items	M*Lights, W	M*Lights, kWh	M*Equipment, W	M*Equipment, kWh	M*Volume, m3	M*Walls above gr., m2	M*Walls below gr., m2
Bedroom 3	Bedro...	0.0	1	11.97	10.0	0.0	0.5985	59.85	399.7	44.888	299.75	29.92	15.828	0.0
Bedroom1	Bedro...	0.0	1	13.02	9.999	0.0	0.651	65.1	434.7	48.825	326.04	32.56	16.38	0.0
Bedroom2	Bedro...	0.0	1	10.89	10.0	0.0	0.5445	54.45	363.6	40.838	272.7	27.24	5.56	0.0
Kitchen	Kitchen	0.0	1	23.0	0.0	15.0	1.15	115.0	767.9	86.25	575.96	57.49	14.358	0.0
Library	Library	0.0	1	13.58	20.0	0.0	0.679	67.9	453.4	50.925	340.06	33.94	14.927	0.0
Living room	Living r...	0.0	1	26.21	20.0	0.0	1.311	131.1	875.5	98.325	656.59	65.52	7.3975	0.0
Bathroom2	Bathro...	0.0	1	10.75	0.0	15.0	0.5375	53.75	358.9	40.313	269.2	26.88	3.8975	0.0
Entrance	Entran...	0.0	1	6.861	0.0	10.0	0.3431	34.31	229.1	25.733	171.84	17.15	3.9025	0.0
Laundry room	Bathro...	0.0	1	16.47	0.0	15.0	0.8235	82.35	549.9	61.763	412.43	41.18	12.555	0.0
Bathroom	Bathro...	0.0	1	10.5	0.0	15.0	0.525	52.5	350.6	39.375	262.94	26.25	16.468	0.0
Total			10	143.251	69.999	70.0	6.631	716.31	4783.3	537.235	3587.51	358.13	111.27...	0.0

Note: In order to have air flows between supply and exhaust air zones, there must be leaks inserted in the internal walls. In your model there are already internal doors modeled (doors were included in IFC model) which gives the necessary leak area.

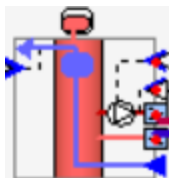
Step 7

Heating and cooling **plant**.

- a. Doubleclick on the "Plant" to open its schematic view:

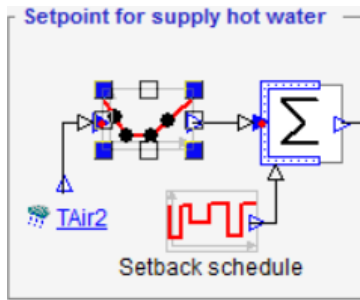


- b. Boiler: Open the boiler by doubleclicking on its symbol and check the input parameters (we leave them all as they are):



Note: The boiler converts purchased energy, e.g. gas, electricity or district heat, to warm water with given temperature and pressure for circulation through water based heat exchangers in the building. It also consumes energy for production of domestic hot water and pumping. Boiler efficiency is by default constant, as specified in the Defaults form.

- c. Open the diagram for "Setpoint for supply hot water". Depending on the heat distribution system you might have to change it. Leave it like it is.



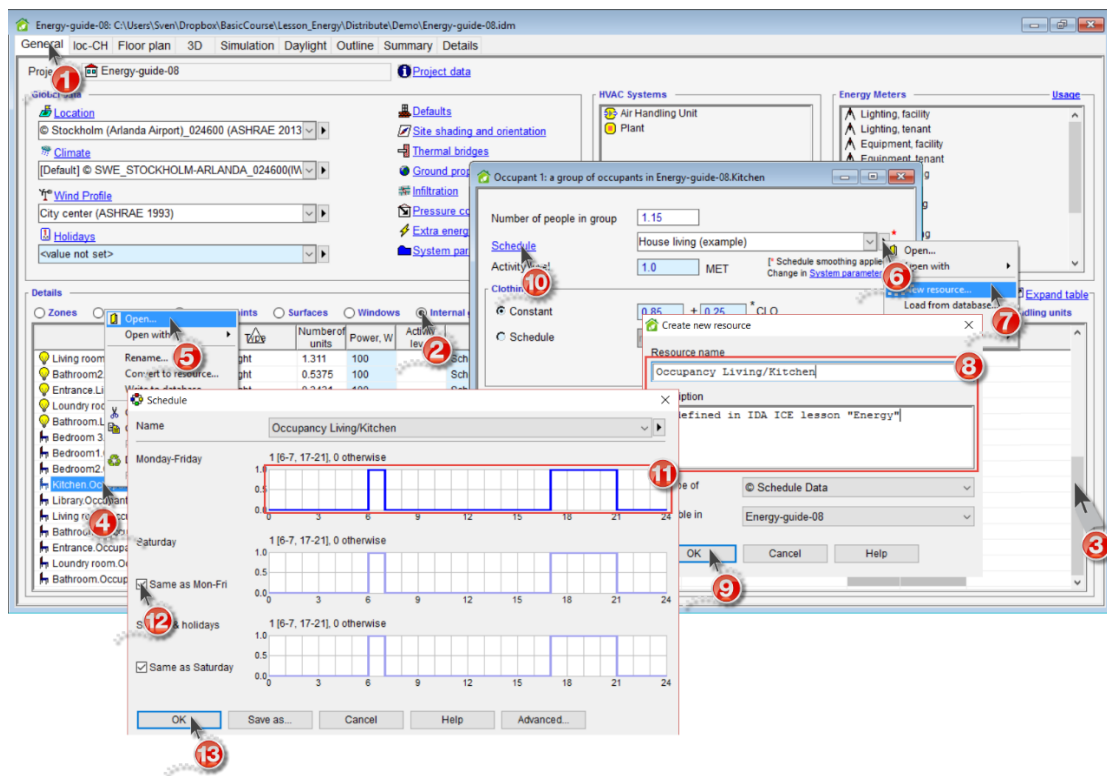
Note: If you have combined systems with e.g. heat pumps, solar energy, wind turbines etc., you can replace the ordinary plant with “ESBO-PLANT”. You can also build your own tailored plants.

Step 8

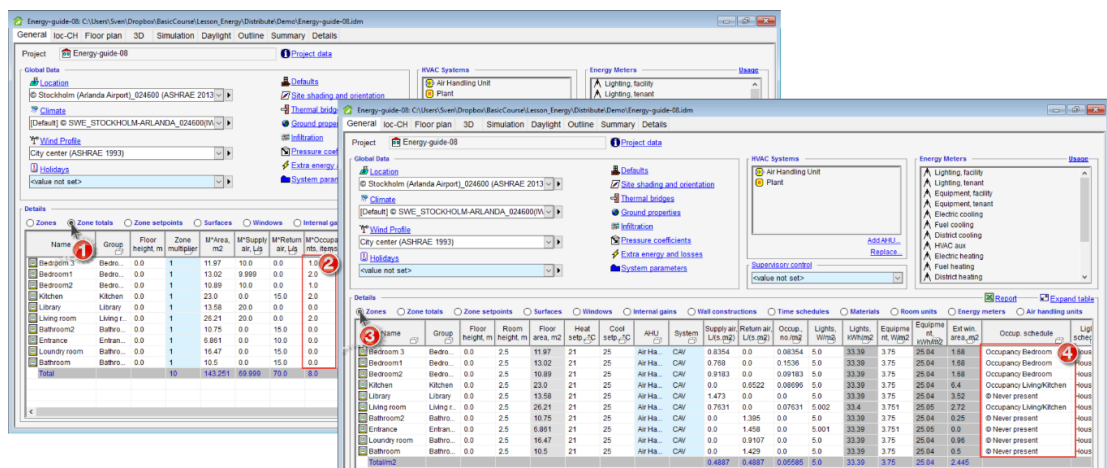
Our annual energy model is almost completed. The last remaining thing we might have to amend is the **internal gains**.

Note: One of the difficulties is to place the occupants in the building in a way that the same person is not in two rooms at the same time and to define occupancy schedules representing the real use of the building. E.g. Swiss standards only define one “average” time schedule with 1 Person per 50 m² for single family houses and one “average” time schedule with 1 Person per 30 m². This makes it simple for the zoning, as all persons are always spread homogenously over living and sleeping areas as well as hall and bathrooms. In this step we will create a more reasonable occupancy pattern for dwellings. As both Swedish and Swiss standards define 14 presence hours per person and day, we will make sure to have the same. At the moment we do have 1 Person per 20 m² with a presence of 16 hours per day.

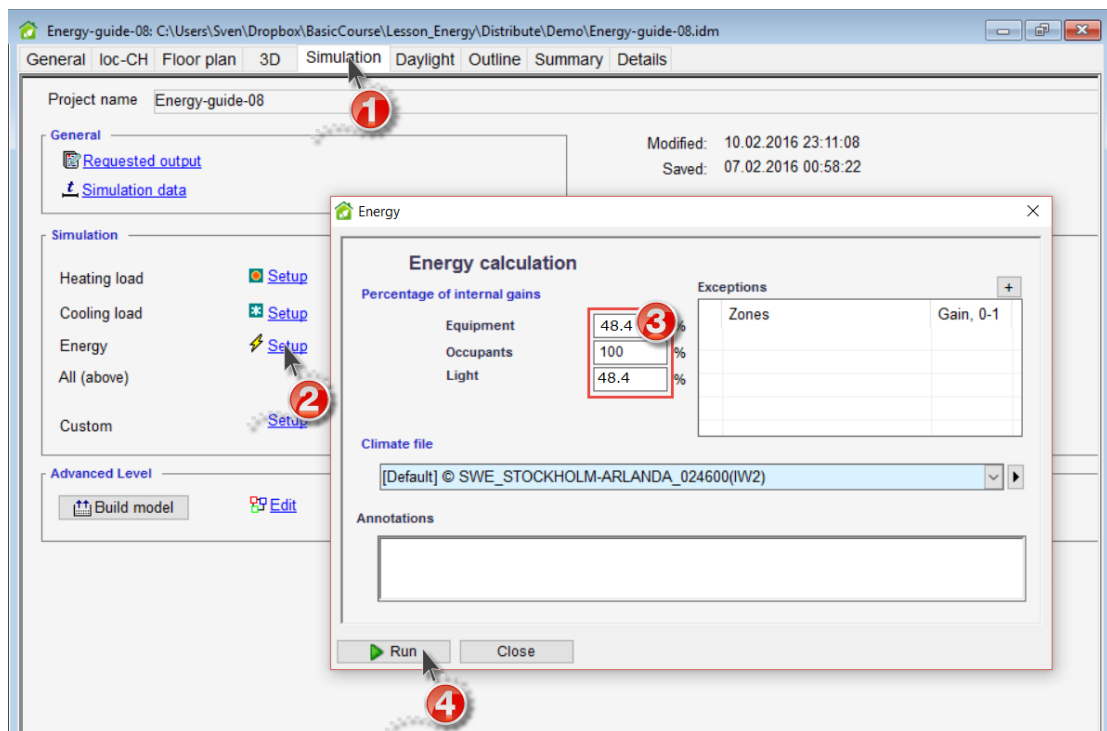
- a. Go to the **General** tab and activate **Internal gains**. Sort the internal gains by type by clicking on the column title “Type”. Rightclick on the cell for Schedule for zone *Kitchen* and choose “Open”. Create your own schedule and name it “Occupancy Living/Kitchen”. Adjust the schedule to 6-7 and 17-21 every day.



- b. Do the same with the occupant of Bedroom 3. Name the new occupancy schedule “Occupancy Bedroom” and define it 0-6 and 21-24 every day.
- c. Spread these occupants over all zones in order to have 4 persons in the house with 14 hours presence hours per day:



- d. According to last energy calculation (step 4) tenant electric consumption of lighting and equipment is 43.4 kWh/m². Our goal is to have 30 kWh/m² and only 70 % of the heat produced can be taken into account. Go to the **Simulation** tab, press on “Energy Setup” and adjust the percentage of internal gains for light and equipment to $30/43.4 \times 0.7 = 48.4\%$. Run the energy calculation again.



- e. Study the results and compare it with the previous energy simulation. Discuss the results – does your building meet the requirements that are set by your country's Building Code? What could be done to reduce the use of energy? If you have time try, different ideas and see how much energy you can save.

		Delivered Energy Report	
Project		Building	
		Model floor area	143.3 m ²
Customer		Model volume	358.1 m ³
Created by	Sven Moosberger	Model ground area	175.5 m ²
Location	Stockholm (Arlanda Airport)_024600 (ASHRAE 2013)	Model envelope area	457.0 m ²
Climate file	SWE_STOCKHOLM-ARLANDA_024600 (IW2)	Window/Envelope	4.2 %
Case	Energy-guide-08	Average U-value	0.231 W/(m ² K)
Simulated	10.01.2018 11:59:41	Envelope area per Volume	1.276 m ² /m ³

Building Comfort Reference

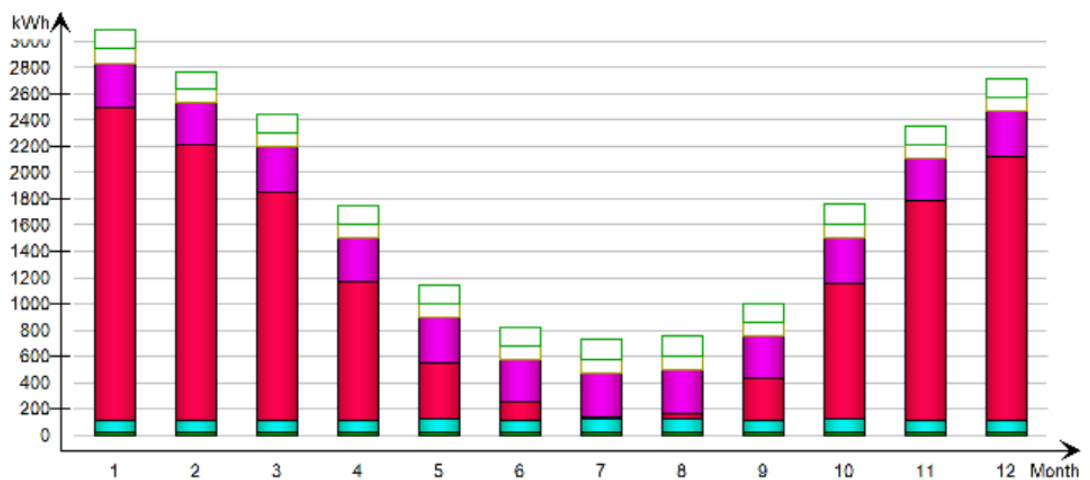
Percentage of hours when operative temperature is above 27°C in worst zone	1 %
Percentage of hours when operative temperature is above 27°C in average zone	0 %
Percentage of total occupant hours with thermal dissatisfaction	11 %

Delivered Energy Overview

	Purchased energy		Peak demand
	kWh	kWh/m ²	kW
■ Equipment, facility	214	1.5	0.02
■ Electric cooling	0	0.0	0.0
■ HVAC aux	1197	8.4	0.14
Total, Facility electric	1411	9.8	
■ Fuel heating	12930	90.3	5.55
■ Domestic hot water	3991	27.9	0.45
Total, Facility fuel*	16921	118.1	
Total	18332	128.0	
■ Lighting, tenant	1280	8.9	0.35
■ Equipment, tenant	1744	12.2	0.26
Total, Tenant electric	3024	21.1	
Grand total	21356	149.1	

*heating value

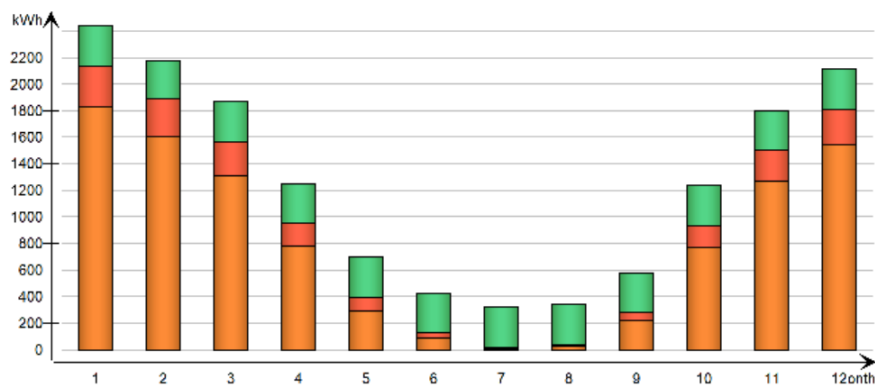
Monthly Purchased/Sold Energy



		Systems Energy	
Project		Building	
		Model floor area	143.3 m ²
Customer		Model volume	358.1 m ³
Created by	Sven Moosberger	Model ground area	175.5 m ²
Location	Stockholm (Arlanda Airport)_024600 (ASHRAE 2013)	Model envelope area	457.0 m ²
Climate file	SWE_STOCKHOLM-ARLANDA_024600 (IW2)	Window/Envelope	4.2 %
Case	Energy-guide-08	Average U-value	0.231 W/(m ² K)
Simulated	10.01.2018 11:59:41	Envelope area per Volume	1.276 m ² /m ³

Used energy

kWh (sensible and latent)					
Month	Zone heating	Zone cooling	AHU heating	AHU cooling	Dom. hot water
1	1826.0	0.0	312.9	0.0	304.2
2	1604.0	0.0	284.6	0.0	284.6
3	1314.0	0.0	250.4	0.0	304.2
4	778.6	0.0	173.3	0.0	294.4
5	292.6	0.0	98.2	0.0	304.2
6	92.4	0.0	32.5	0.0	294.4
7	9.1	0.0	2.0	0.0	304.2
8	24.9	0.0	9.7	0.0	304.2
9	222.3	0.0	62.4	0.0	294.4
10	771.4	0.0	162.4	0.0	304.2
11	1273.0	0.0	231.5	0.0	294.4
12	1542.0	0.0	264.8	0.0	304.2
Total	9750.2	0.0	1884.7	0.0	3591.6



Utilized free energy

kWh (sensible and latent)									
Month	AHU heat recovery	AHU cold recovery	Plant heat recovery	Plant cold recovery	Solar heat	Ground heat	Ground cold	Ambient heat	Ambient cold
1	1127.0	0.0							
2	1030.0	0.0							
3	941.0	0.0							
4	714.8	0.0							
5	508.0	-0.7							
6	319.2	-0.6							
7	222.1	-0.2							
8	238.6	-1.3							
9	412.8	-0.0							
10	678.4	0.0							
11	876.9	0.0							
12	982.7	0.0							
Total	8051.5	-2.8							

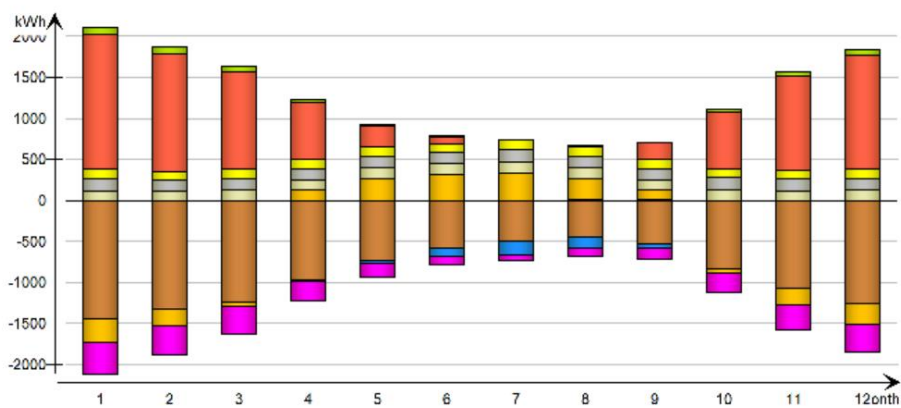
Note: A report that includes all energy consumption at zone level can be created by clicking on [Multizone...](#) in the **Summary** tab. This report helps to find the main heat losses of your building.

		Energy for whole building	
Project		Building	
Customer		Model floor area	143.3 m ²
Created by		Model volume	358.1 m ³
Location		Model ground area	175.5 m ²
Climate file		Model envelope area	457.0 m ²
Case		Window/Envelope	4.2 %
Simulated		Average U-value	0.231 W/(m ² K)
		Envelope area per Volume	1.276 m ² /m ³

All zones

kWh (sensible only)

Month	Envelope & Thermal bridges	Internal Walls and Masses	Window & Solar	Mech. supply air	Infiltration & Openings	Occupants	Equipment	Lighting	Local heating units	Local cooling units	Net losses
1	-1444.7	-0.4	-279.5	-0.6	-390.1	120.9	150.0	108.7	1643.6	0.0	91.4
2	-1326.1	-0.4	-195.2	-0.6	-354.3	113.0	137.5	101.5	1443.8	0.0	80.3
3	-1243.2	-0.9	-55.3	-1.1	-324.9	121.9	145.8	108.5	1182.9	0.0	65.7
4	-975.6	-1.9	123.1	-8.5	-245.3	119.5	143.7	104.9	700.8	0.0	38.9
5	-732.1	1.6	271.0	-42.1	-158.5	125.3	147.9	108.3	263.4	0.0	14.7
6	-577.2	-2.2	323.9	-112.5	-92.5	125.7	141.6	104.9	83.2	0.0	4.6
7	-491.7	-0.5	335.8	-168.9	-74.6	132.7	149.9	108.3	8.2	0.0	0.5
8	-441.9	8.1	256.2	-145.5	-87.9	132.1	145.8	108.4	22.4	0.0	1.2
9	-524.9	3.5	119.3	-48.7	-133.0	125.7	141.6	104.7	200.1	0.0	11.0
10	-827.5	0.2	-54.3	-5.0	-231.6	126.0	150.0	108.4	694.3	0.0	38.6
11	-1075.0	-0.3	-196.2	-1.1	-303.4	119.3	141.7	105.1	1145.5	0.0	63.8
12	-1251.1	-0.1	-254.5	-0.7	-338.6	122.2	148.0	108.8	1387.9	0.0	77.3
Total	-10911.0	6.8	394.3	-535.3	-2734.6	1484.4	1743.7	1280.5	8776.0	0.0	488.0
During heating (MIXED h)	-9273.0	116.1	-654.2	-54.9	-2532.5	928.6	1286.8	917.7	8775.7	0.0	482.3
During cooling (MIXED h)	-656.7	-105.9	482.9	-229.7	-87.3	270.8	173.9	152.2	0.0	0.0	0.1
Rest of time	-981.3	-3.4	565.6	-250.7	-114.8	285.0	283.0	210.6	0.3	0.0	5.6



Envelope transmission

kWh

Month	Walls	Roof	Floor	Windows	Doors	Thermal bridges
1	-314.8	-387.9	-272.0	-347.1	-161.2	-308.8
2	-275.8	-339.5	-285.7	-315.5	-143.0	-282.1
3	-239.7	-288.5	-332.2	-290.1	-125.1	-257.8
4	-166.1	-186.3	-339.9	-225.9	-86.9	-196.4
5	-98.7	-96.2	-342.0	-172.9	-51.5	-143.8
6	-58.5	-41.6	-346.1	-130.6	-27.3	-103.6
7	-44.1	-29.3	-308.5	-118.1	-20.2	-89.5
8	-51.9	-54.0	-218.0	-118.3	-27.1	-90.8
9	-96.7	-119.0	-140.3	-143.1	-50.6	-118.3
10	-173.8	-224.8	-150.4	-215.5	-92.2	-186.2
11	-242.0	-301.1	-167.3	-271.5	-124.5	-240.2
12	-275.4	-345.7	-219.2	-305.9	-141.8	-269.1
Total	-2037.5	-2413.9	-3121.7	-2654.6	-1051.4	-2286.5
During heating	-1864.7	-2279.3	-2119.5	-2251.6	-1005.4	-2004.2
During cooling	-56.8	-21.1	-483.1	-138.1	-4.0	-92.0
Rest of time	-116.0	-113.5	-519.1	-264.9	-42.0	-190.3

Input data report

Parameters	Value	Source
Building envelope	External wall: 26 Gypsum, 30 air, 200 insulation, 9 wind board, 30 air, 120 bricks -> $U = 0.155 \text{ W/(m}^2\text{K)}$ Roof: 3 copper, 25 wood, 250 insulation, 26 gypsum -> $U = 0.135 \text{ W/(m}^2\text{K)}$ External floor(excl. ground): 10 wood, 15 chip board, 200 concrete, 200 insulation -> $U = 0.166 \text{ W/(m}^2\text{K)}$ Door $U = 1.2 \text{ W/(m}^2\text{K)}$	IDA ICE database
Thermal bridges	External wall / internal slab 0.11 W/(m K) External wall / internal wall 0.045 W/(m K) External wall / External wall 0.08 W/(m K) External windows perimeter 0.05 W/(m K) External doors perimeter 0.03 W/(m K) Roof / External walls 0.08 W/(m K) External slab / External walls 0.08 W/(m K) Balcony 0 W/(m K) External slab / Internal walls 0.02 W/(m K) Roof / Internal walls 0.02 W/(m K)	-
Infiltration	$0.5 \text{ L/(s m}^2\text{)}$ at 50 Pa. The model has a right wind pressure at every time step of the equation solver. Building is located in “Sheltered” place for wind.	-
Windows	Glazing $U = 0.9 \text{ W/(m}^2\text{K)}$, $g = 0.6$ Glazing shading: Blind between panes when needed Frame factor 15 % with Frame U-Value = $1.5 \text{ W/(m}^2\text{K)}$	
Geometry and zoning	Most zones are created from one room, some rooms are merged into one zone.	
Room heating units	Setpoint for the radiators is $22 \text{ }^\circ\text{C}$ in all rooms.	
Heating system	District heating	
Air handling unit	Mechanical supply and exhaust air with heat recovery 75% and SFP = 2	
Ventilation air flows	Supply air: 10 L/s in all bedrooms, 20 L/s in the living room and 20 L/s in the library Exhaust air: 15 L/s in kitchen, 15 L/s in both bathrooms, 15 L/s in the laundry, 10 L/s in the entrance	
Occupancy	4 persons, present 14 h/day	Sveby
Lights and electric equipment	Yearly consumption 30 kWh/m^2 , 70 % of the heat to zones	Sveby
Facility electricity	$1.5 \text{ kWh/(m}^2\text{year)}$, always on. Corresponds to 0.17 W/m^2 .	
Domestic hot water	$25 \text{ kWh/(m}^2\text{year)}$	Sveby
Distribution system losses	10 % of heat delivered by plant to room heating units, 50 % of the heat to zones	
Climate file	Stockholm_Arlanda_IW2	