Institute for Building Systems Engineering Dresden
Research and Application GmbH
Prof. Oschatz - Prof. Hartmann - Prof. Werdin

Manual for the EVIA-Tool „Calculation of building air infiltration and exfiltration“

Client: EVIA - European Ventilation Industry Association

Contractor: ITG Institute for Building Systems Engineering Dresden
Research and Application GmbH

Editors: Dipl.-Ing. C. Knaus
Prof. Dr.-Ing. T. Hartmann

Dresden, January 2019

Contents

1 Basics 3

2 Structure and operation of the tool 5

Step 1: Starting the tool 5

Step 2: General project and object details 6

Step 3: Data of the building 8

Step 3.1: General building information 8

Step 3.2: Information of the calculated flat 9

Step 3.3: Ventilation System 10

Step 4: Climate parameters 24

Step 5: Terrain information 27

Step 6: Input building characteristics 30

Step 6.1: Configuration of the rooms 30

Step 6.2: General information of the room 32

Step 6.3: Connection data 37

3 Changes of the input data/Calculation of variants 56

4 Calculation examples 58

Example 1: Apartment in an apartment building 58

Example 2: Small mid-terrace house 65

5 Bibliography 74

1 Basics

The basis for the tool is a physical calculation model which is described in the EN 15242 – “Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration”.

The Hardy-Cross procedure is used for the mathematical solution. It is a very common and proven method, which is based on an approximation procedure. It is often used for water and gas supply networks and is implemented in the tool.

For this method it is necessary to know all so called independent circuits (Kirchhoff´s loop rule) of a building, see Figure 1. A circuit illustrates a concluded flow path via connections (to the outside or between different rooms). The starting point and the endpoint are identical and characterized by constant mass flows. Furthermore, the equations of the junctions (Kirchhoff´s point rule) are required to determine clearly the mass flows. At any junction (room) the sum of the current mass flows into that junction is equal to the sum of the current mass flow out of that junction. Junctions are characterized by variable mass flows but constant compression ratio.

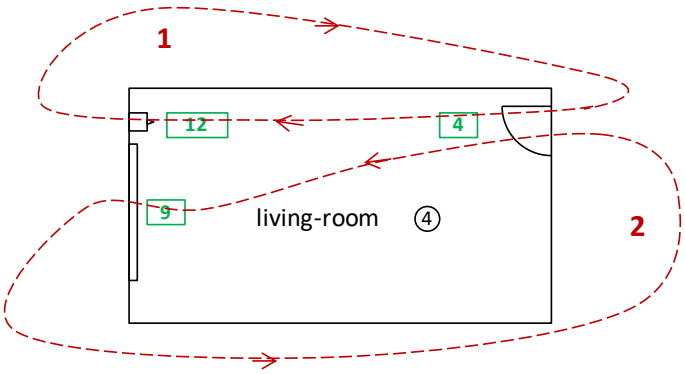


Figure 1: Hardy-Cross procedure – illustration of Kirchhoff´s loop rule

Calculations of the perfusion of a building with up to 20 rooms distributed over one or more floors are possible. The maximum of connections of one room is also 20. For each room supply and/or exhaust air volume flows can be defined by a ventilation system. To minimize the calculation effort useful, all defined air volume flows are constant and independent of the pressure conditions at the building.

The calculation of the building air infiltration an exfiltration under steady-state conditions is performed with constant conditions defined by the user:

- Wind (wind direction and wind speed, obstacles and shape of the building)
- Temperature (inside and outside, in consideration of vertical flow resistance)
- Ventilation systems (Characteristic curve of the supply and exhaust air fan, characteristics of pressure loss)
- Building (air tightness of the building envelope (n_{50}), distribution of leakages, determination of flow resistance (doors, joints, windows, air inlets))

Using the defined conditions following data can be determined:

- Wind pressure for each opening
- Air tightness, which is split relatively (ratio of the area of the outer walls or fixed portion) to the respective external connection)
- Aerodynamic pressure factor for each connection of the building (C_p-Value)

The air flow rates for all connections to the outside (for example joints of windows or air inlets) and between the rooms (for example joints of doors) can be calculated for defined steady-state conditions with this tool in consideration of wind pressure, thermal lift and - if there is one - the ventilation system.

Changes in version 1.1:

- Extension of Cp values for buildings with an aspect ratio of 1:1 or 2:1
- Consideration of main and secondary wind directions
- Automatic optimization of the calculation exactness

Changes in version 1.2:

- Integration of device characteristics for centralized and decentralized ventilation units
- Consideration of single room ventilation units with and without storage type heat exchanger

2 Structure and operation of the tool

Step 1: Starting the tool

By clicking the “Start Input” button in the worksheet “Input” the calculation tool starts. The program window (shown in Figure 2) appears. This window gives a compact description of the calculation tool.

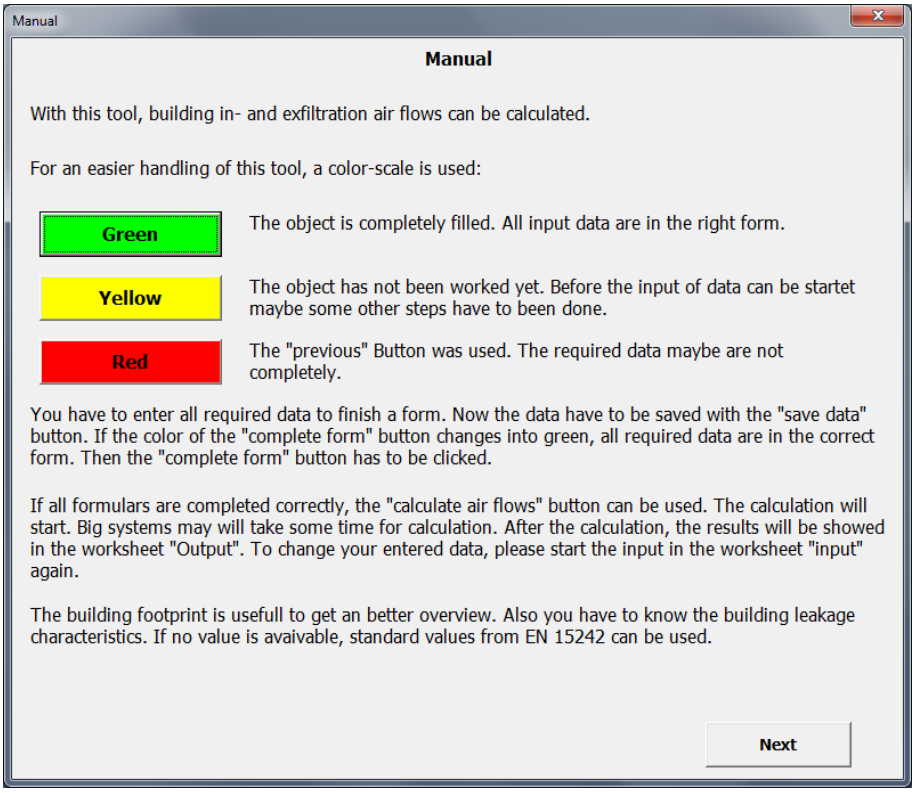


Figure 2: Information window – description of the calculation tool

Click on the „Next” button to go to the next step.

Step 2: General project and object details

In the input mask “Overview” (Figure 3) under the heading project details the user can provide information regarding the designer, the date and comments. Under the heading object details following input fields can be filled:

- Name
- Street
- Postal code
- Location
- Country.

After choosing the calculation unit: m³/h, m³/s or l/s further input fields are enabled, see Figure 4.

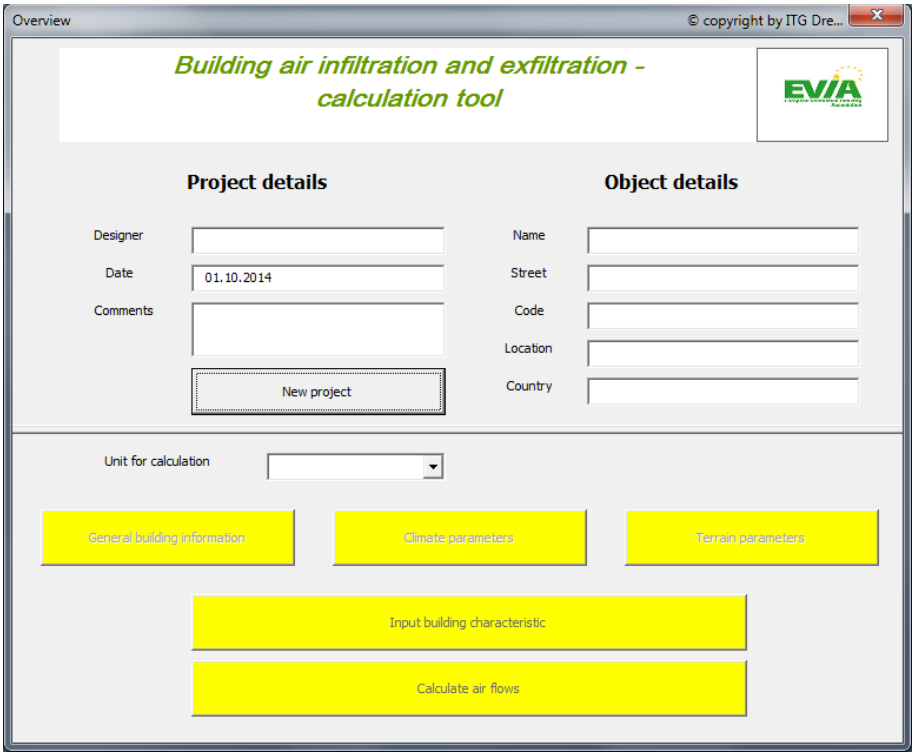


Figure 3: Input mask "Overview"

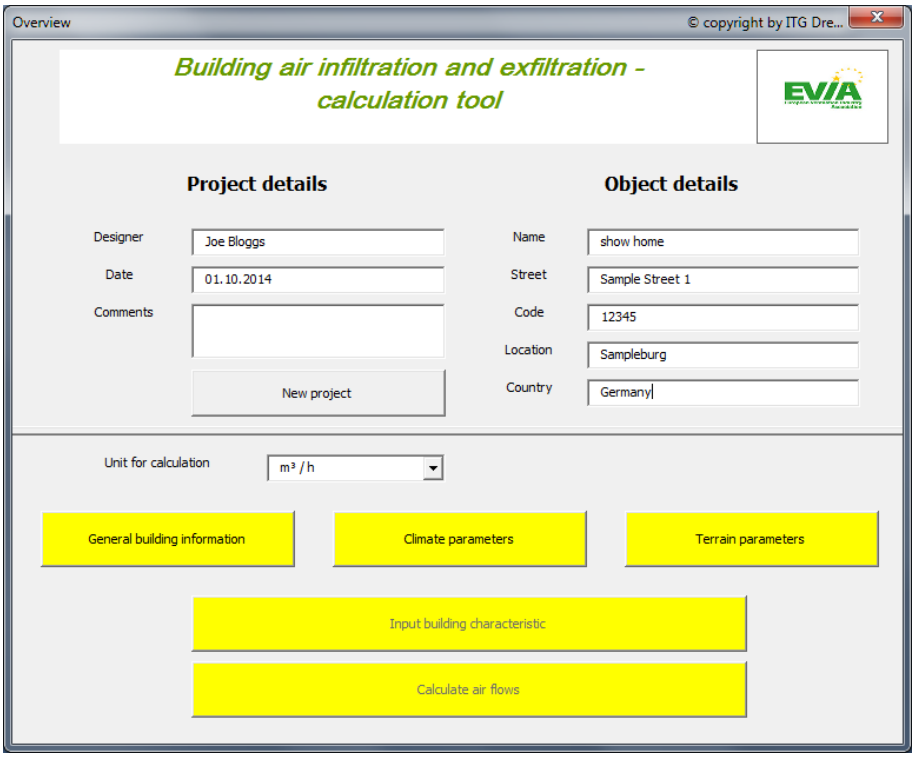


Figure 4: Input mask "Overview" with enabled input fields

Step 3: Data of the building

The input mask “General building information“ (Figure 5) is divided into three aspects:

- General building information
- Information of the calculated flat
- Ventilation system

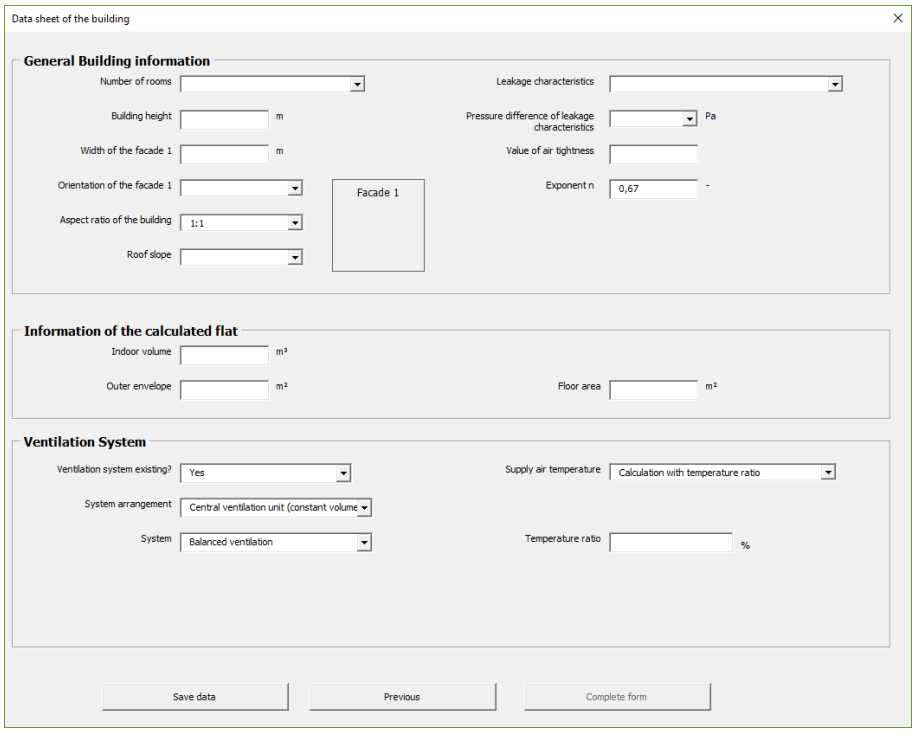
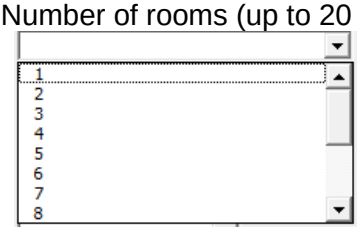


Figure 5: Input mask "General building information"

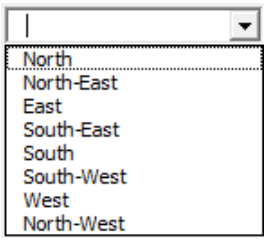
Step 3.1: General building information

In the aspect “General building information” the user can provide following details:

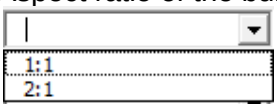
- Number of rooms (up to 20 rooms)



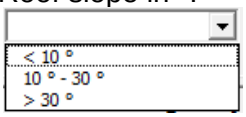
- Building height in m
- Width of façade 1 in m
- Orientation of façade 1



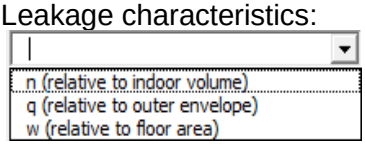
- Aspect ratio of the building



- Roof slope in °:



- Leakage characteristics:



- Pressure difference of leakage characteristics in Pa:

- Value of air tightness in m³/(h·m²)
- Exponent n (registered default value 0,67)

Step 3.2: Information of the calculated flat

In the aspect “Information of the calculation flat” the input field, which is needed for the calculation, is highlighted in yellow depending on the selected leakages characteristics. The three possible input fields are:

- Indoor volume in m³ (selecting n (relative to indoor volume)), see Figure 6
- Outer envelope in m² (selecting q (relative to outer envelope))
- Floor area in m² (selecting w (relative to floor area))

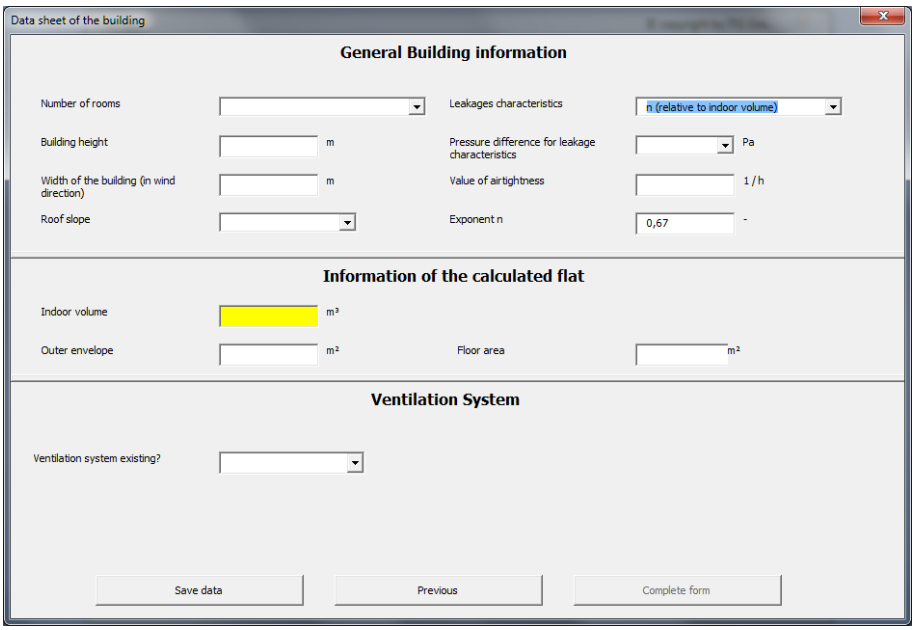
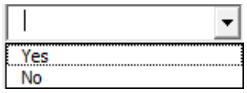


Figure 6: Input mask "General building information" with yellow highlighted input field for the indoor volume

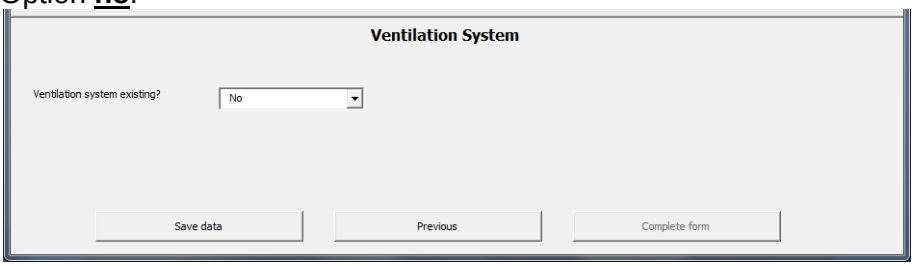
Step 3.3: Ventilation System

Information regarding the air-handling system can be given in the aspect “Ventilation system“:

- Ventilation system existing?

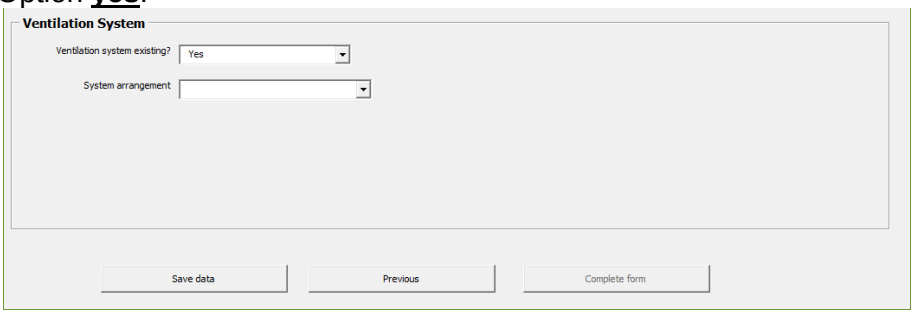


Option **no**:



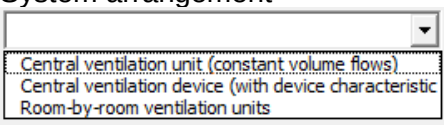
If there is no ventilation system, no further information is necessary.

Option **yes**:

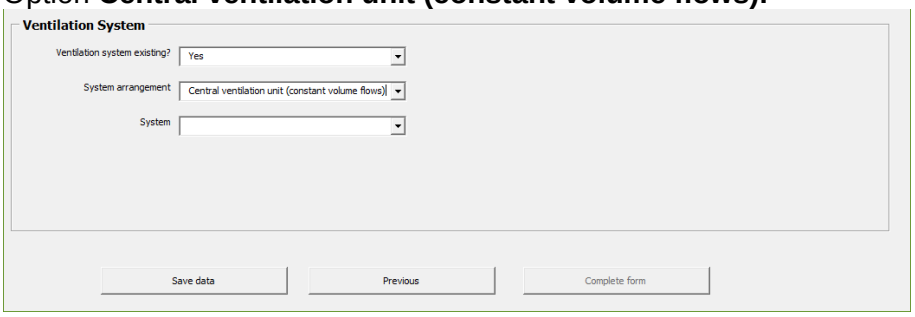


If there is a ventilation system, further information is required:

- System arrangement

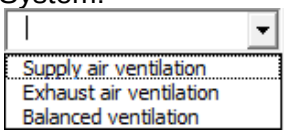


Option **Central ventilation unit (constant volume flows):**

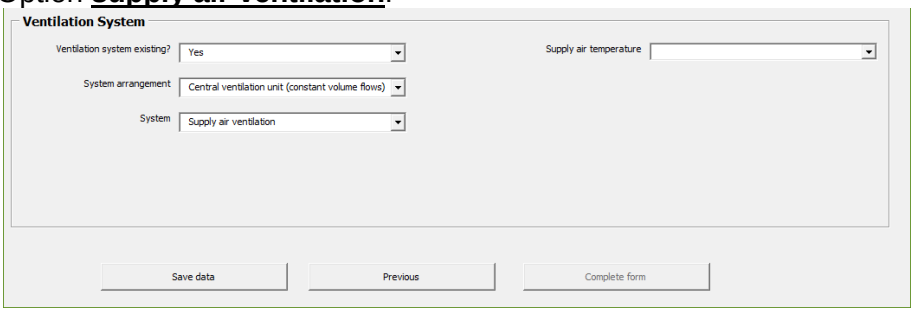


If there is a central ventilation unit with constant volume flows in the dwelling , further inputs are necessary:

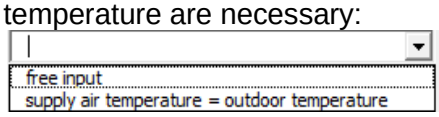
- System:



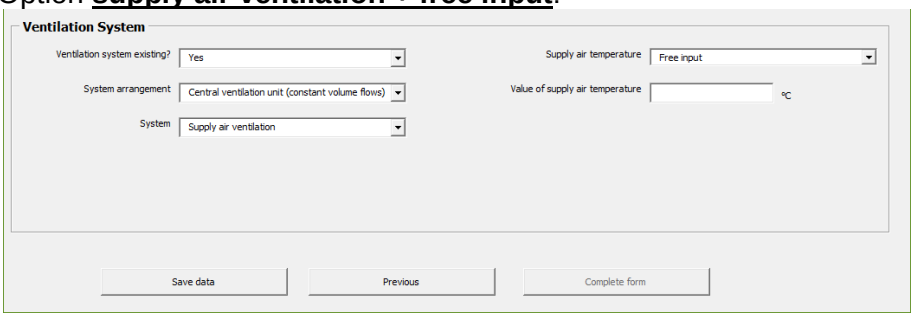
Option **<u>supply air ventilation</u>**:



If the ventilation system is a supply air ventilation system, details about the supply air temperature are necessary:

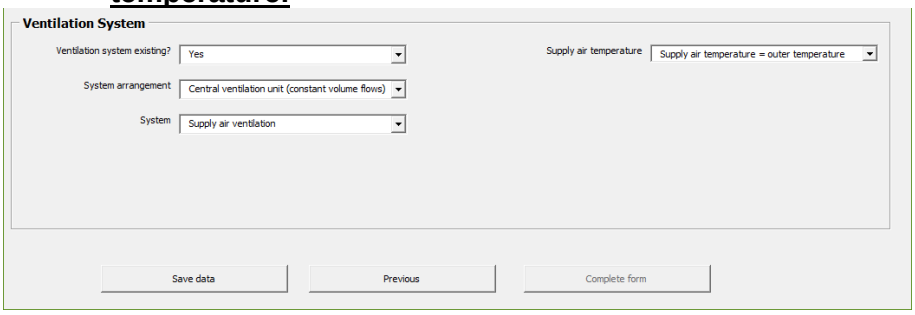


Option **<u>supply air ventilation + free input</u>**:



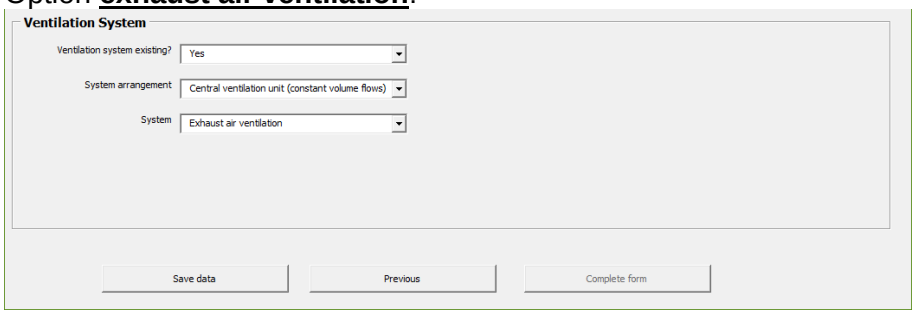
In the input field which appears the user can enter the supply air temperature in °C.

Option **<u>supply air ventilation + supply air temperature = outdoor temperature:</u>**



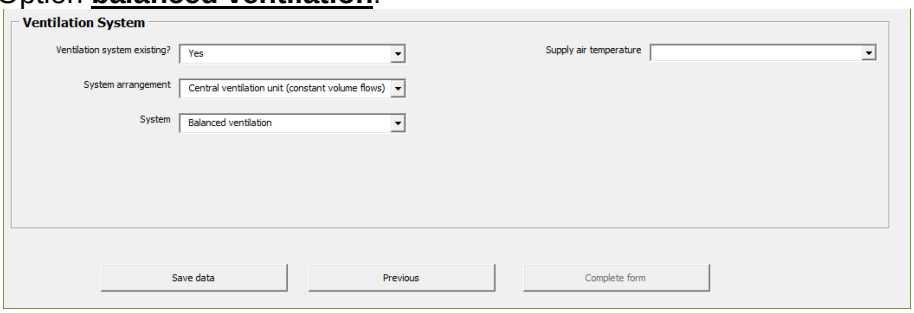
No further information is required.

Option **exhaust air ventilation**:

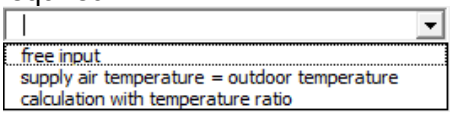


If the ventilation system is an exhaust air ventilation system, no further information is necessary.

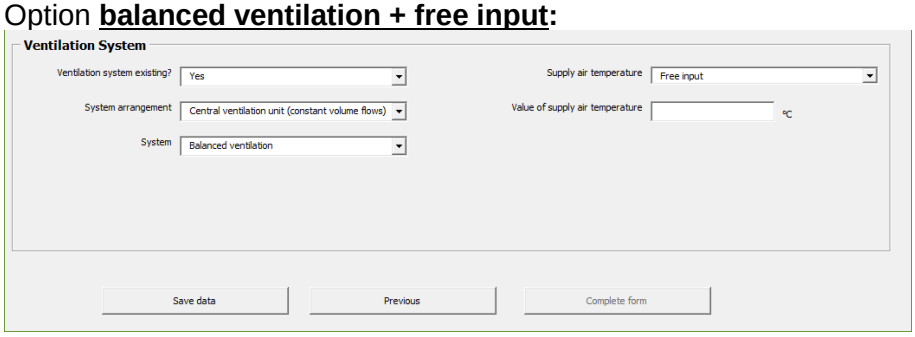
Option **balanced ventilation**:



If there is a balanced ventilation system, details about the supply air temperature are required.

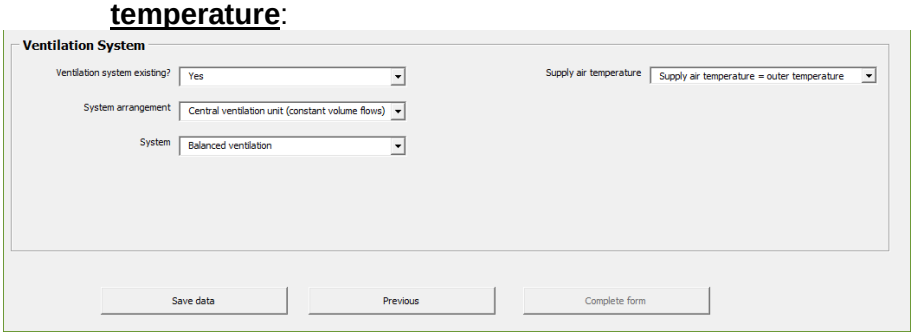


Option **balanced ventilation + free input:**



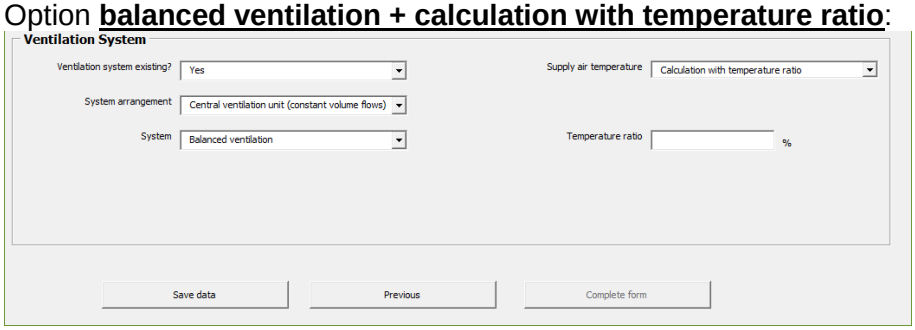
In the input field which appears the user can enter the supply air temperature in °C.

Option **balanced ventilation + supply air temperature = outdoor temperature**:



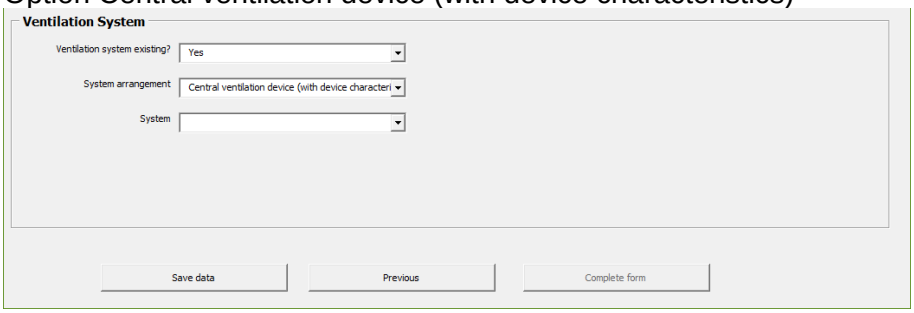
No further information is required.

Option **balanced ventilation + calculation with temperature ratio**:



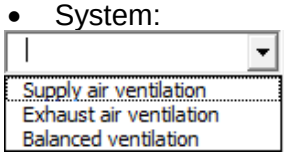
In the input field which appears the user can enter the temperature ratio in %.

Option Central ventilation device (with device characteristics)

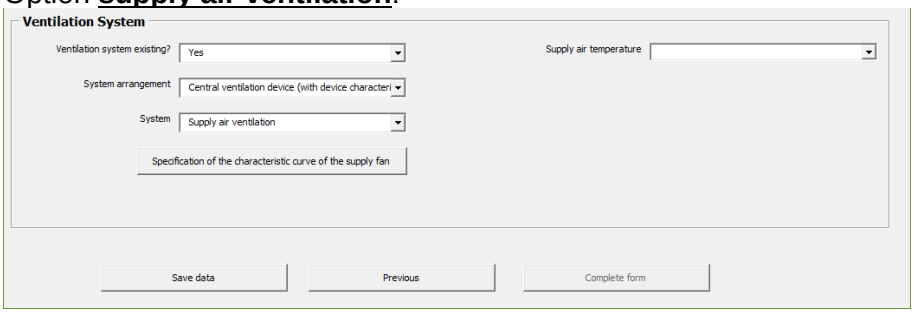


If there is a central ventilation unit with device characteristics in the dwelling , further inputs are necessary:

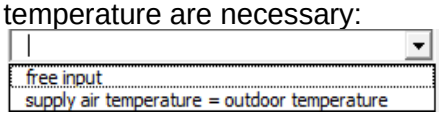
- System:



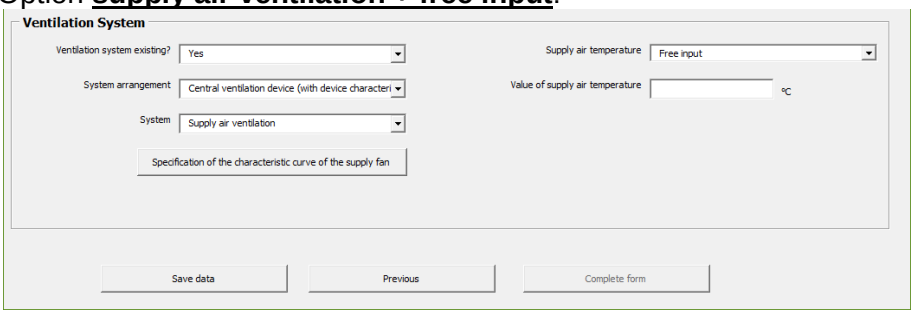
Option **supply air ventilation**:



If the ventilation system is a supply air ventilation system, details about the supply air temperature are necessary:

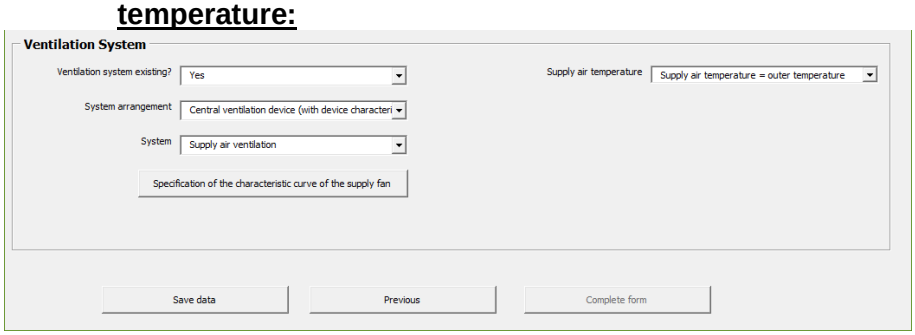


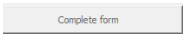
Option **supply air ventilation + free input**:



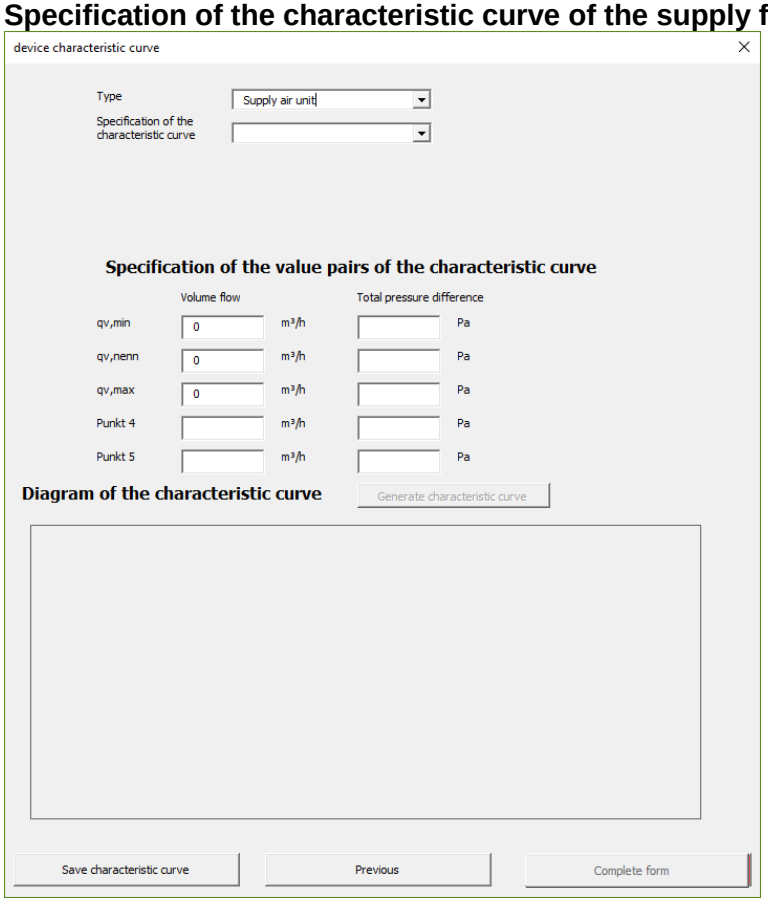
In the input field which appears the user can enter the supply air temperature in °C.

Option **supply air ventilation + supply air temperature = outdoor temperature:**

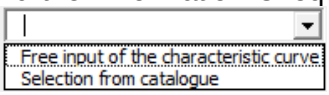


No further information is required. 

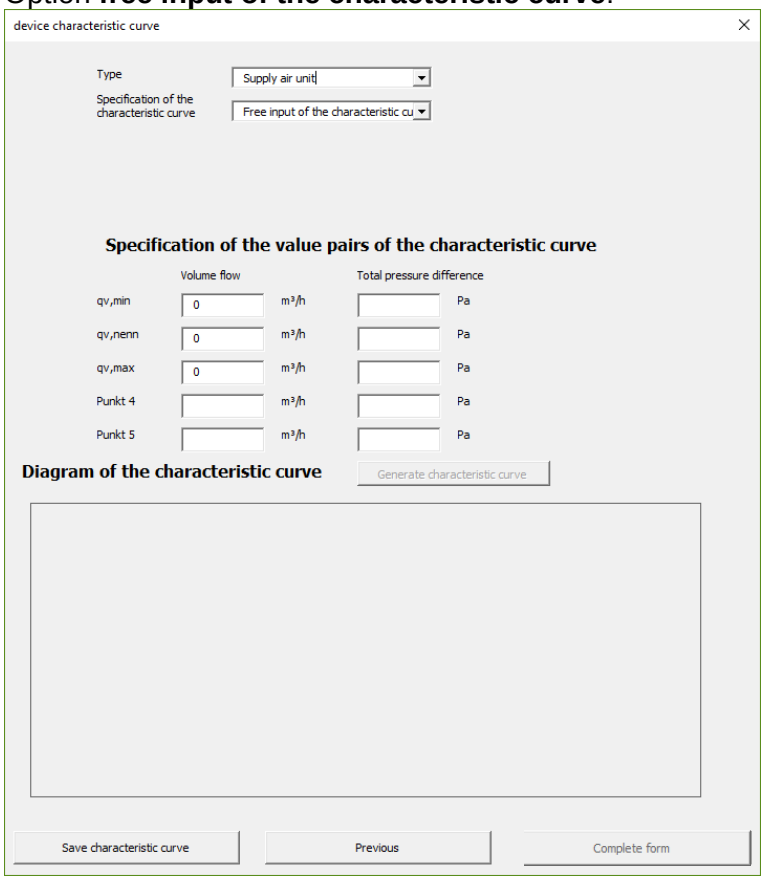
Specification of the characteristic curve of the supply fan



Further information is required to specify the characteristic curve:

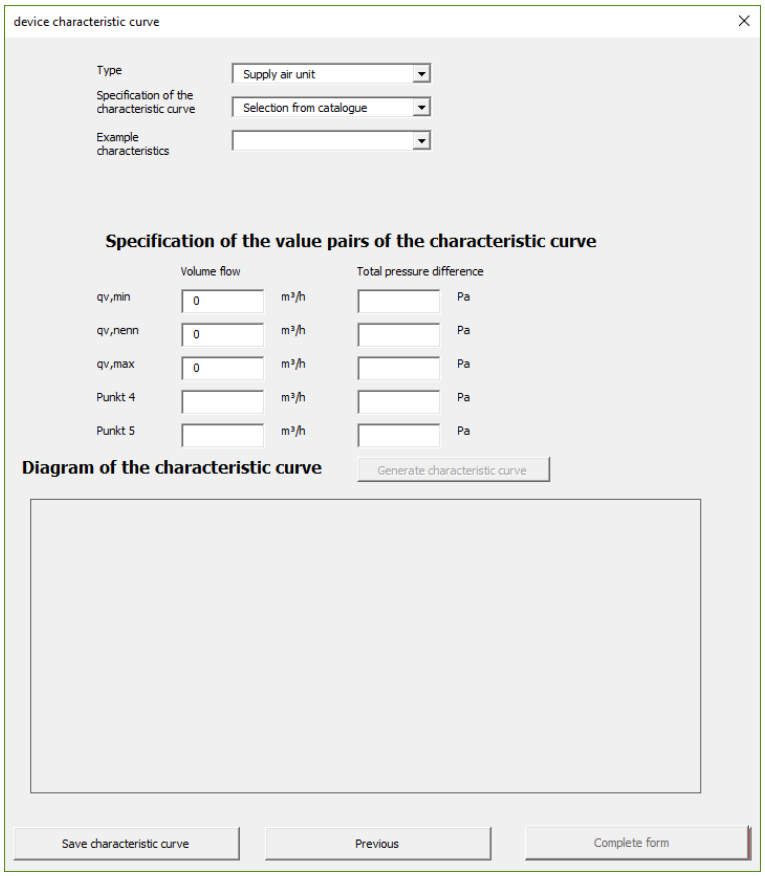


Option **free input of the characteristic curve**:

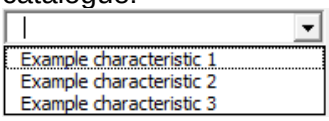


To determine the characteristic curve of the supply air unit, at least 3 volume flows and the corresponding total pressure difference are required (minimum air volume flow, nominal air volume flow and maximum air volume flow). The specifications for two further value pairs are optional.

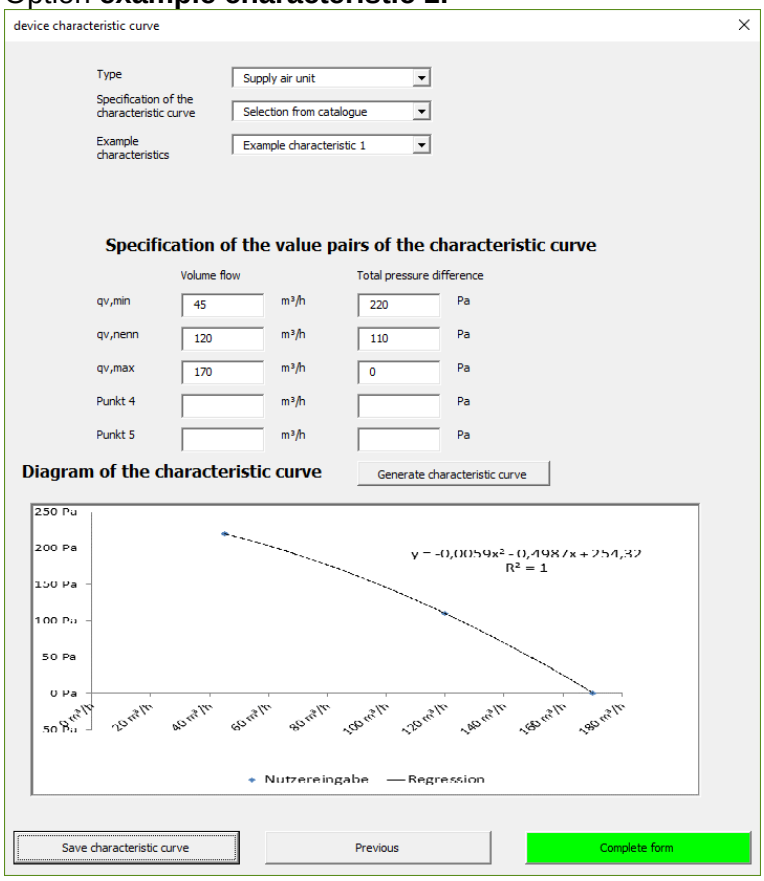
Option **selection from catalogue**:



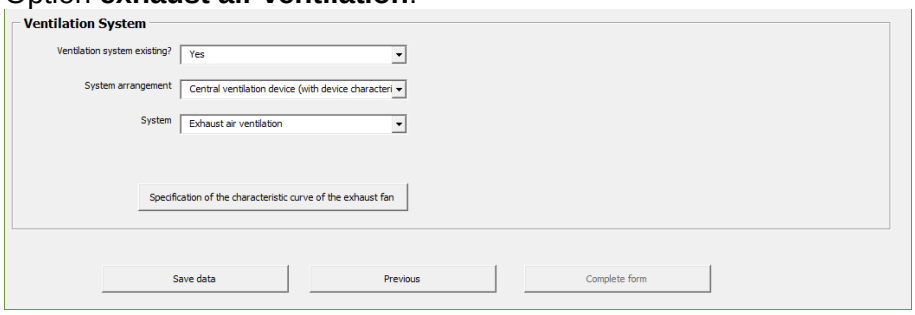
Further information is required to select the characteristic curve from the catalogue:



Option **example characteristic 1:**

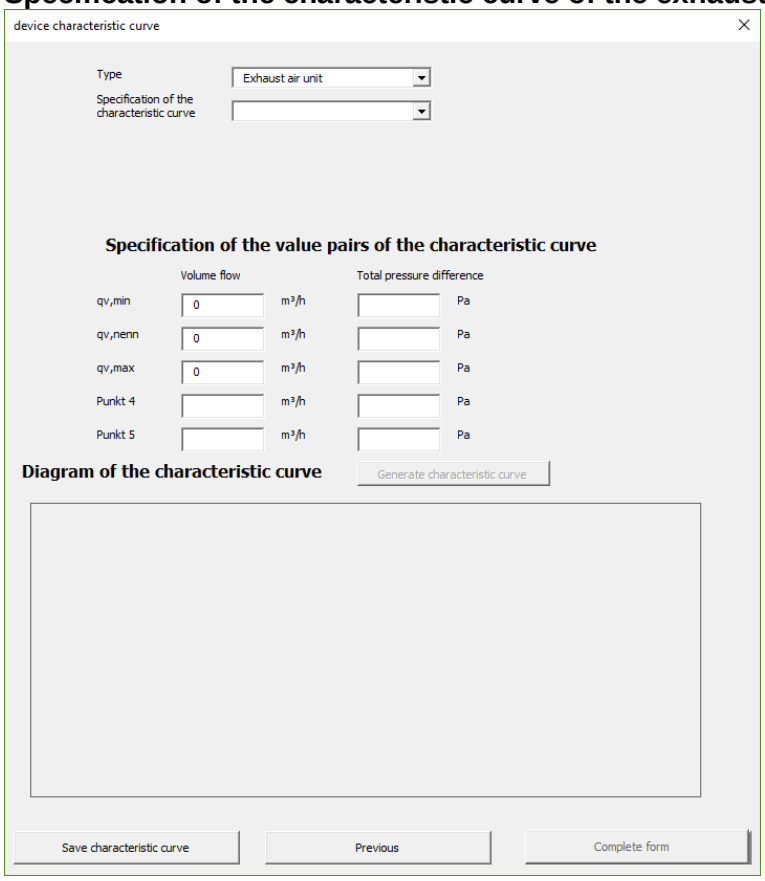


Option **exhaust air ventilation**:

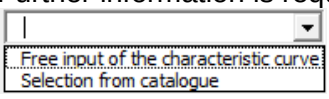


If an exhaust air ventilation system is selected as the ventilation system, then only information on the characteristic curve of the exhaust air fan is required.

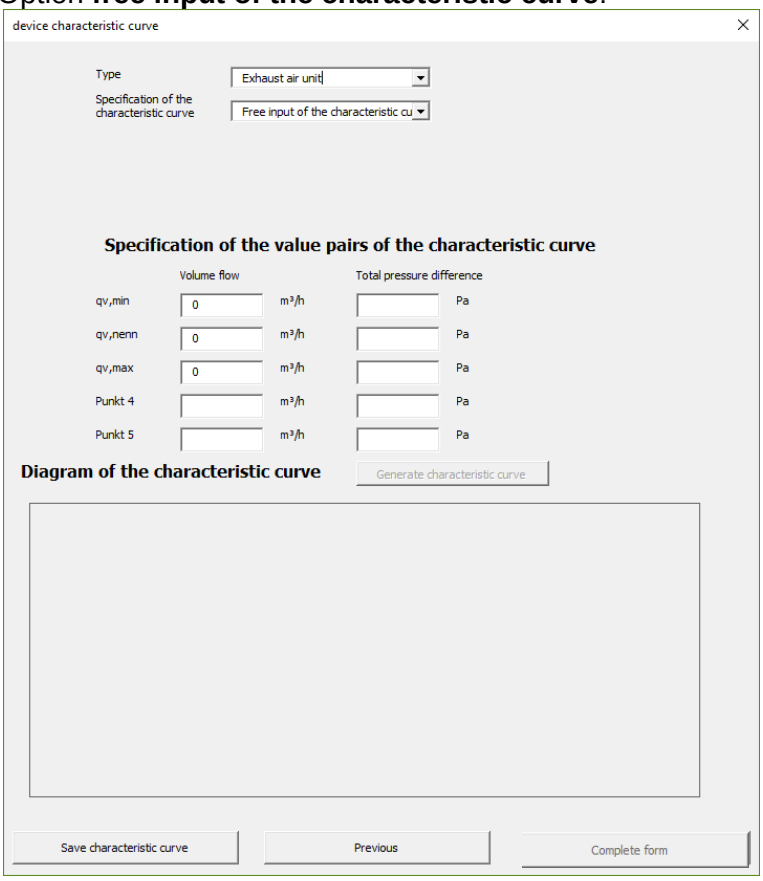
Specification of the characteristic curve of the exhaust fan:



Further information is required to specify the characteristic curve:

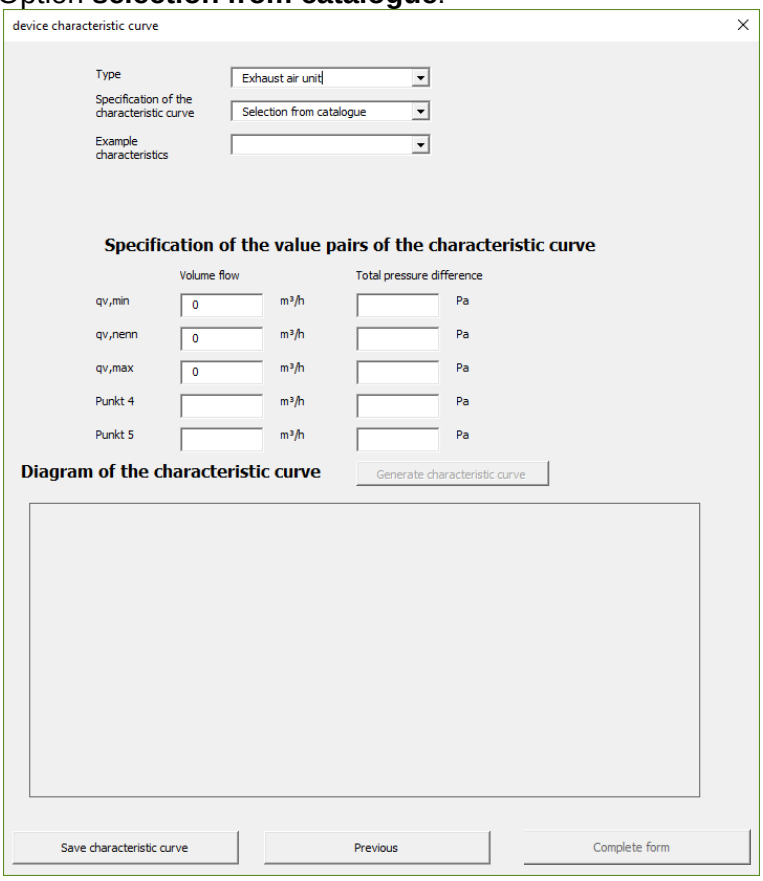


Option **free input of the characteristic curve**:

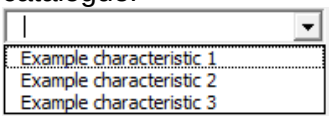


To determine the characteristic curve of the supply air unit, at least 3 volume flows and the corresponding total pressure difference are required (minimum air volume flow, nominal air volume flow and maximum air volume flow). The specifications for two further value pairs are optional.

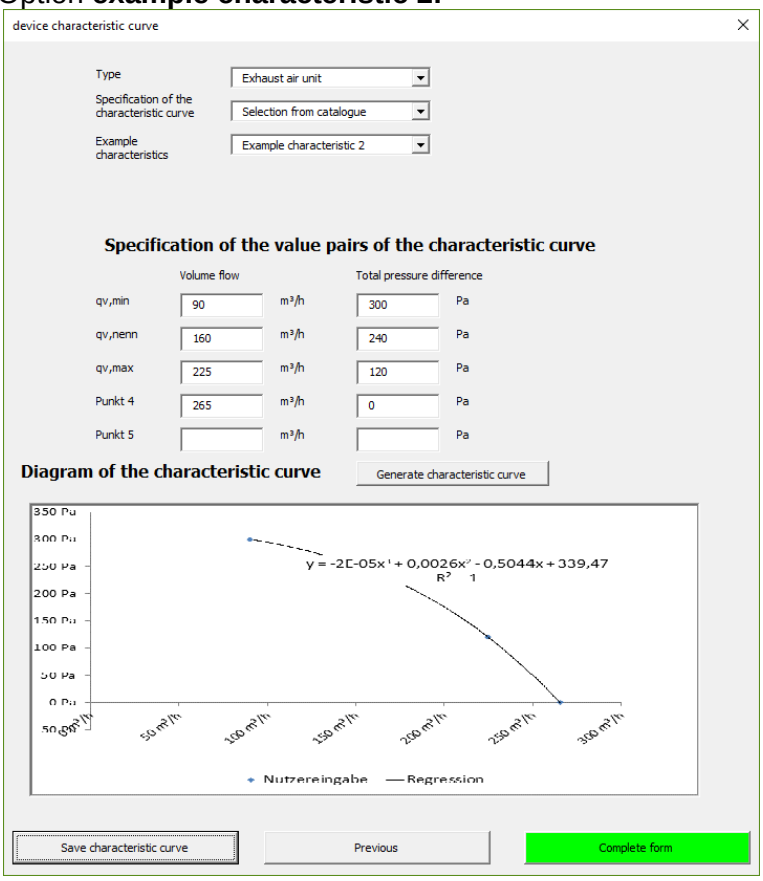
Option **selection from catalogue**:



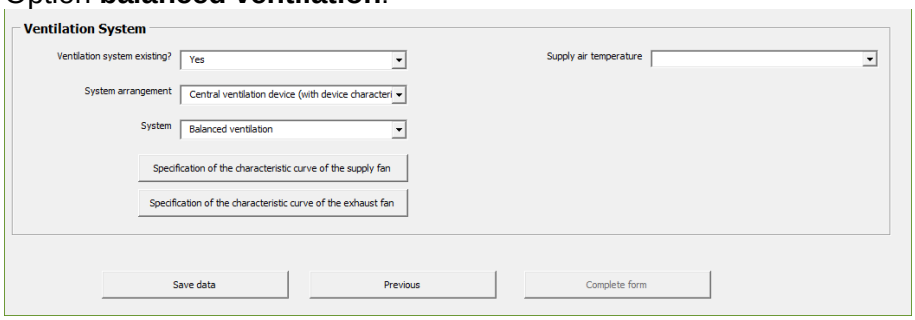
Further information is required to select the characteristic curve from the catalogue:



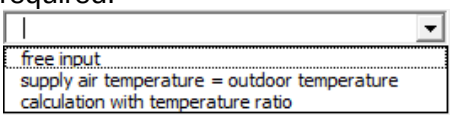
Option **example characteristic 2:**



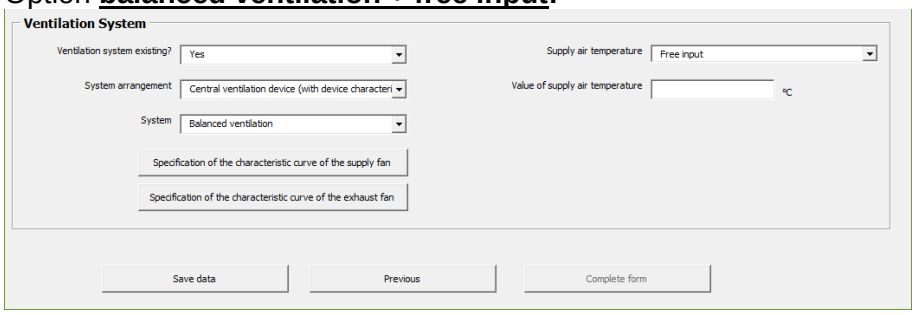
Option **balanced ventilation**:



If there is a balanced ventilation system, details about the supply air temperature are required.

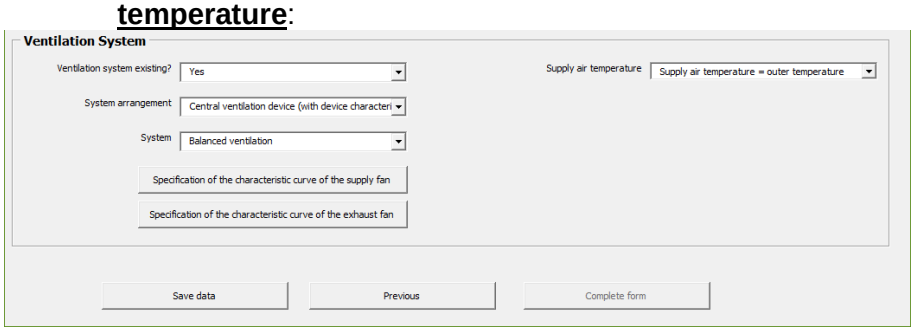


Option **balanced ventilation + free input:**



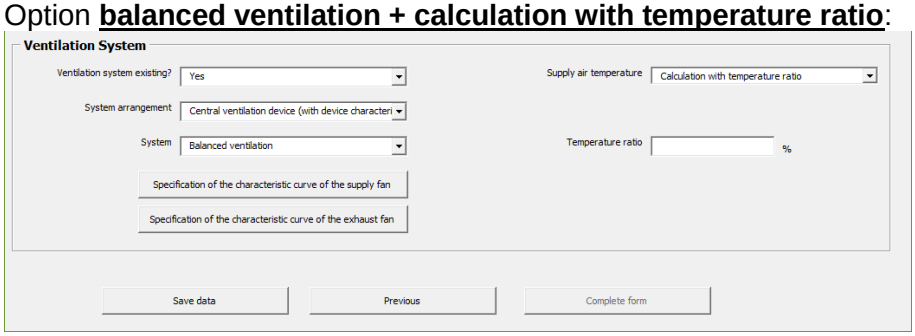
In the input field which appears the user can enter the supply air temperature in °C.

Option **balanced ventilation + supply air temperature = outdoor temperature**:



No further information is required.

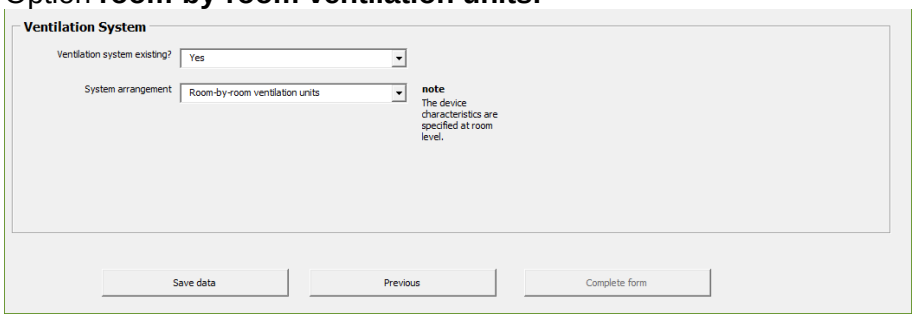
Option **balanced ventilation + calculation with temperature ratio**:



In the input field which appears the user can enter the temperature ratio in %.

Specification of the characteristic curve of the supply and exhaust fan:
See here for the information in the supply air ventilation option and exhaust air ventilation option.

Option **room-by-room ventilation units:**



Further information on device characteristics at room level. No further inputs are required in this user form.

By clicking on the “Save data” button all entered data are saved and can be used for the calculation, see Figure 7. Activating the “Complete form” button closes the current input mask and the “Overview” window appears. If the required data are complete, the “General building information” button will turn green, see Figure 8. The explanation concerning to the “traffic lights” is shown in Figure 2.

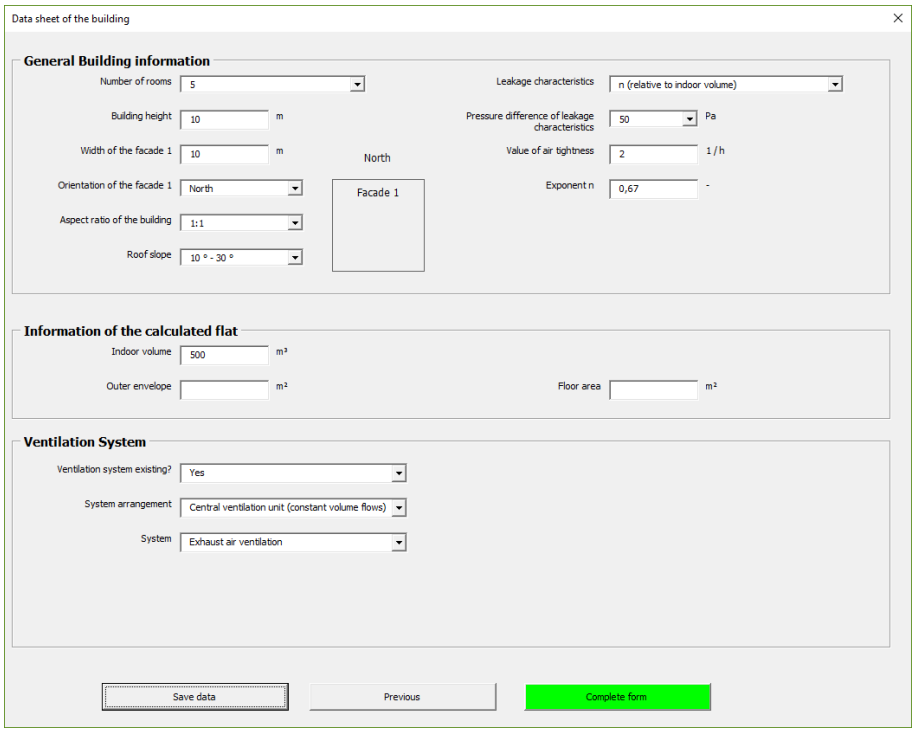


Figure 7: Input mask “General building information” after saving the entered data

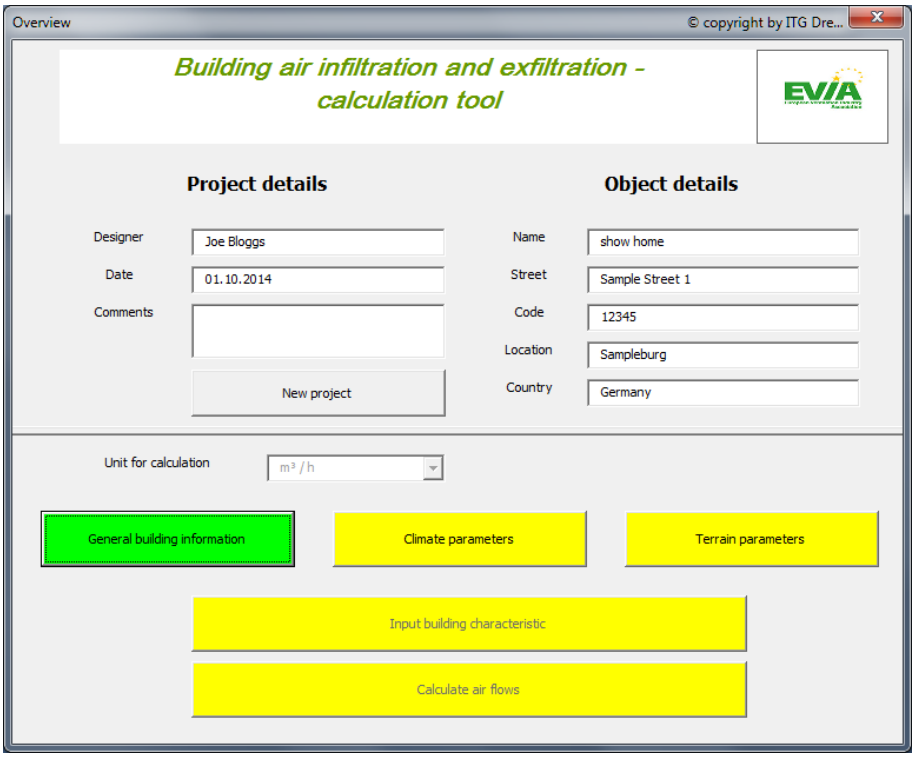


Figure 8: Input mask “Overview” with complete required data in the “General building information” window

Step 4: Climate parameters

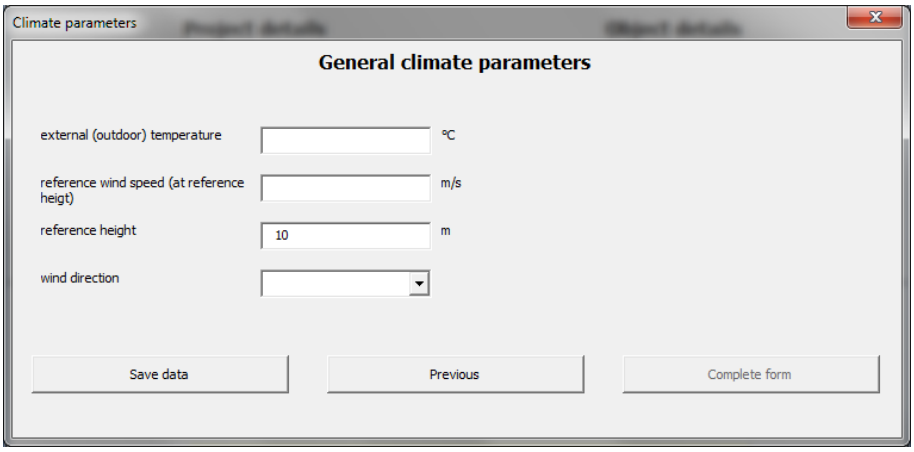
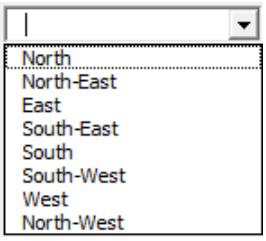


Figure 9: Input mask "Climate parameters"

In the input mask ”Climate parameters“ (Figure 9) information regarding the following values has to be completed:

- External (outdoor) temperature in °C
- Reference wind speed (at reference height) in m/s
- Reference height in m (registered default value 10 m)

- Wind direction



By clicking on the “Save data” button all entered data are saved and can be used for the calculation, see Figure 10. Activating the “Complete form” button closes the current input mask and the “Overview” window appears. If the required data are complete, the “Climate parameters” button will turn green, see Figure 11. The explanation concerning to the “traffic lights” is shown in Figure 2.

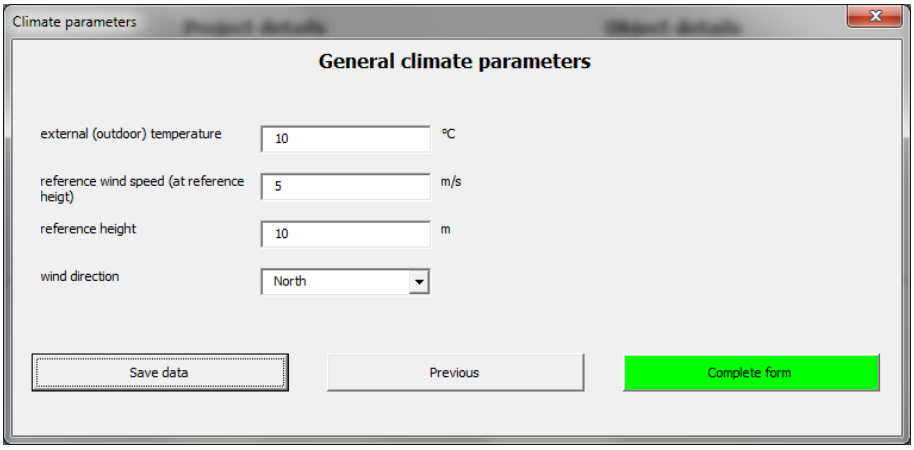


Figure 10: Input mask “General climate parameters” after saving the entered data

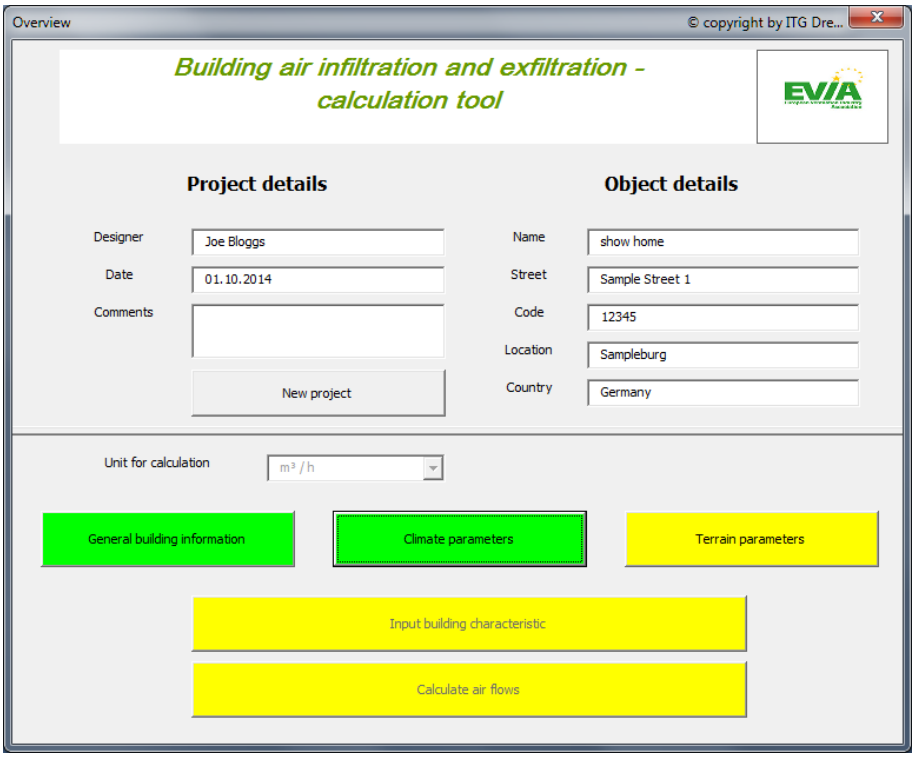


Figure 11: Input mask “Overview” with complete required data in the “General building information” window and the “Climate parameters” window

Step 5: Terrain information

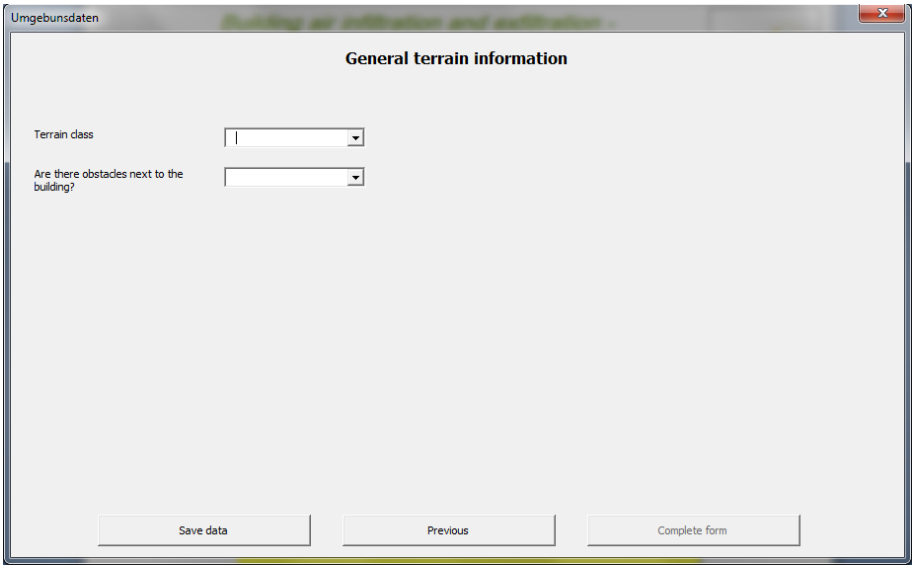
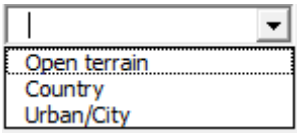


Figure 12: Input mask "General terrain information"

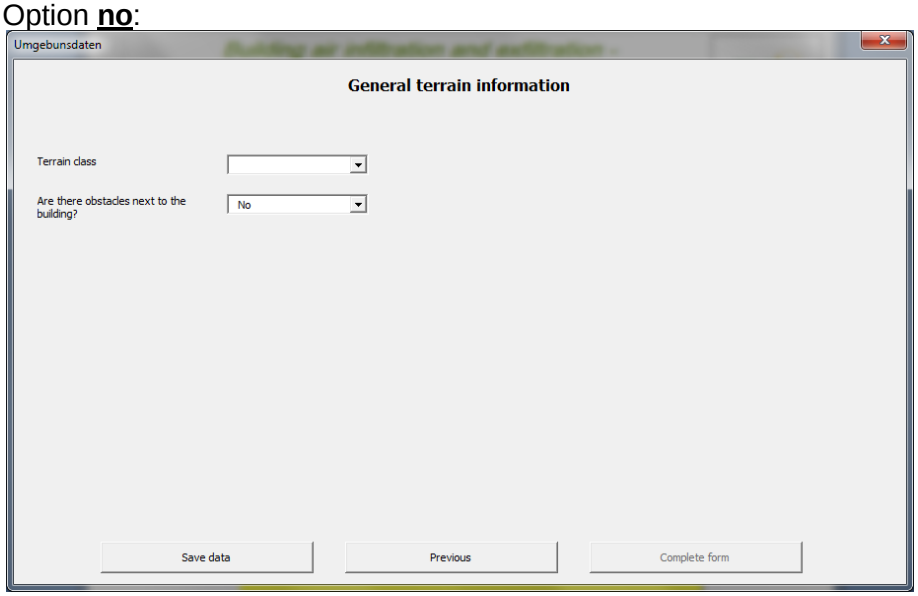
Depending on the selection made in the input mask „General terrain information" (Figure 12) different input fields have to be filled with information from the user:

- Terrain class



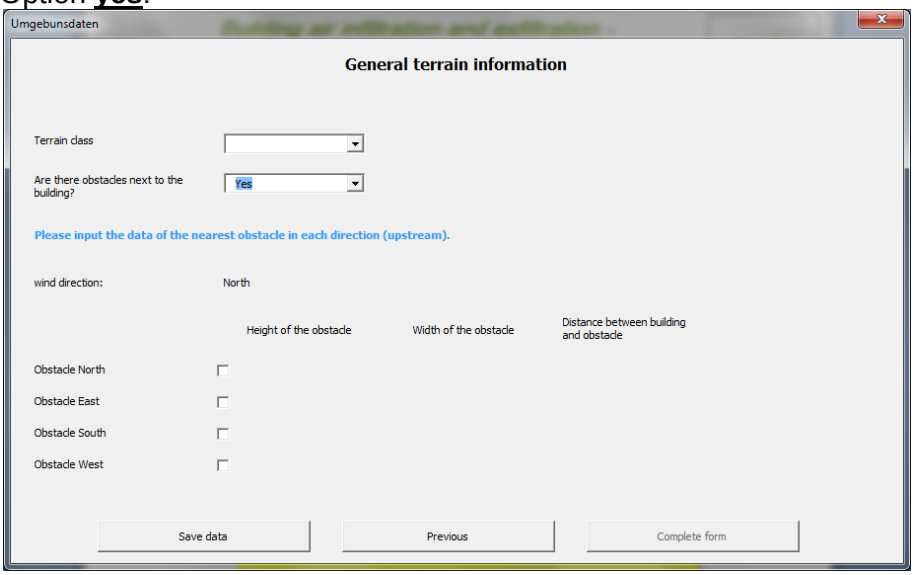
- Are there obstacles next to the building?

Option **no**:



If there are no obstacles next to the building, which are at least half of the height of the building, no further information is necessary.

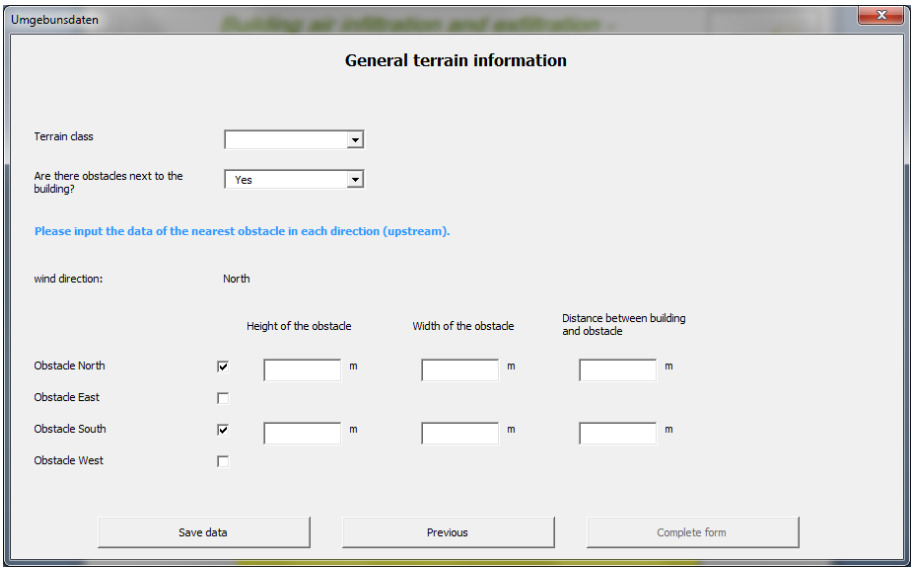
Option **yes**:



If there are obstacles next to the building, which are at least half of the height of the building, the orientation of the obstacle/the obstacles is/are required.

If this information is entered, further input fields are enabled:

- Height of the obstacles in m
- Width of the obstacles in m
- Distance between building and obstacles in m



By clicking on the “Save data” button all entered data are saved and can be used for the calculation, see Figure 13. Activating the “Complete form” button closes the current input mask and the “Overview” window appears. If the required data are complete, the “Terrain parameters” button will turn green, see Figure 14. The explanation concerning to the “traffic lights” is shown in Figure 2.

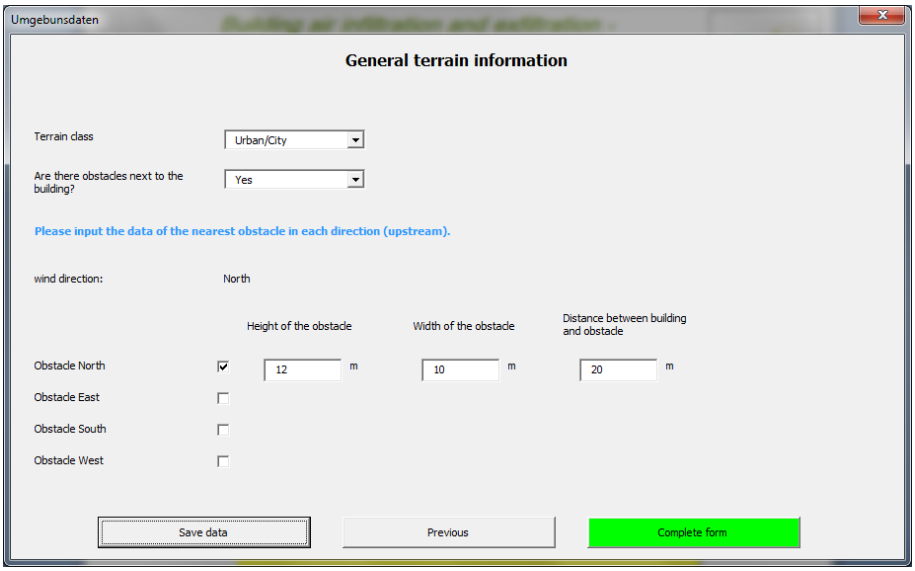


Figure 13: Input mask „General terrain information" after saving the entered data

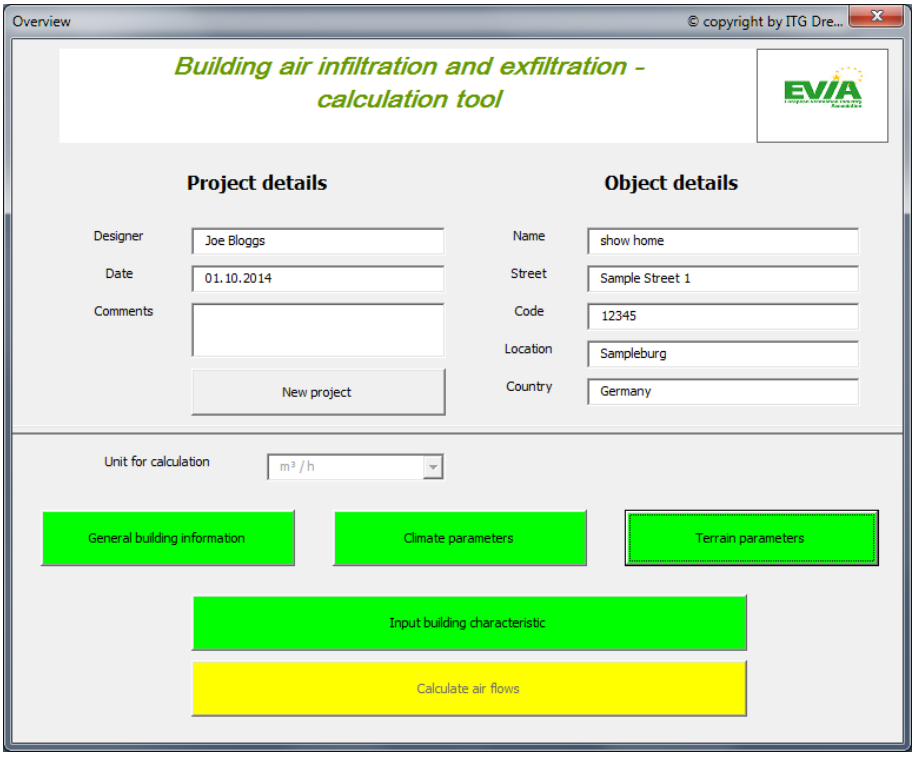


Figure 14: Input mask "Overview" with complete required data in the "General building information" window, the "Climate parameters" window and the "Terrain parameters" window

Step 6: Input building characteristics

Step 6.1: Configuration of the rooms

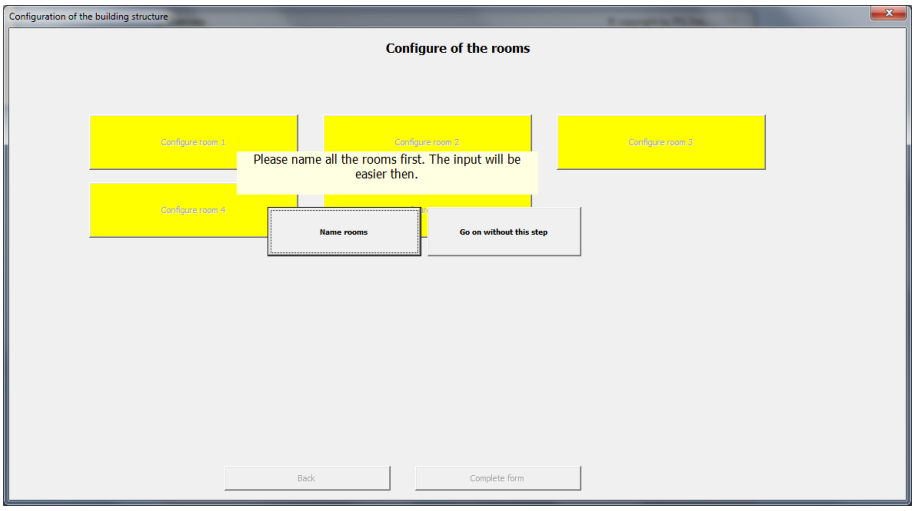
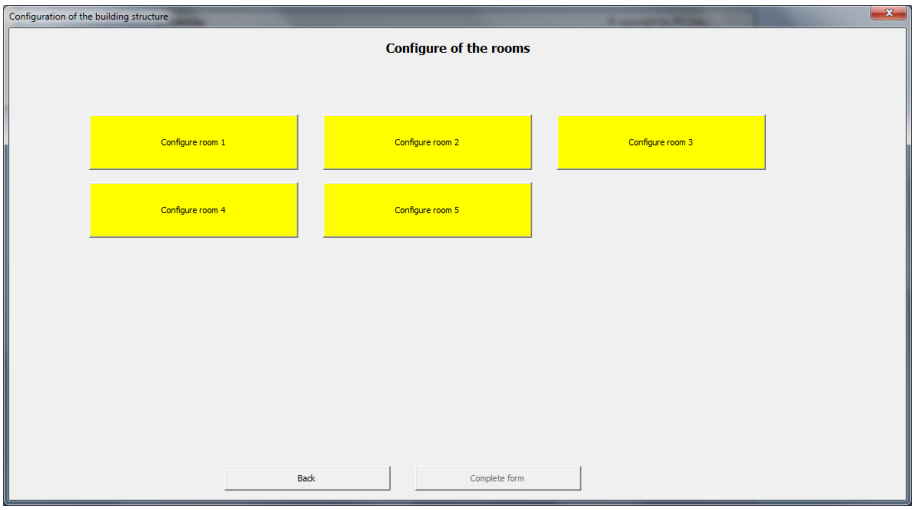
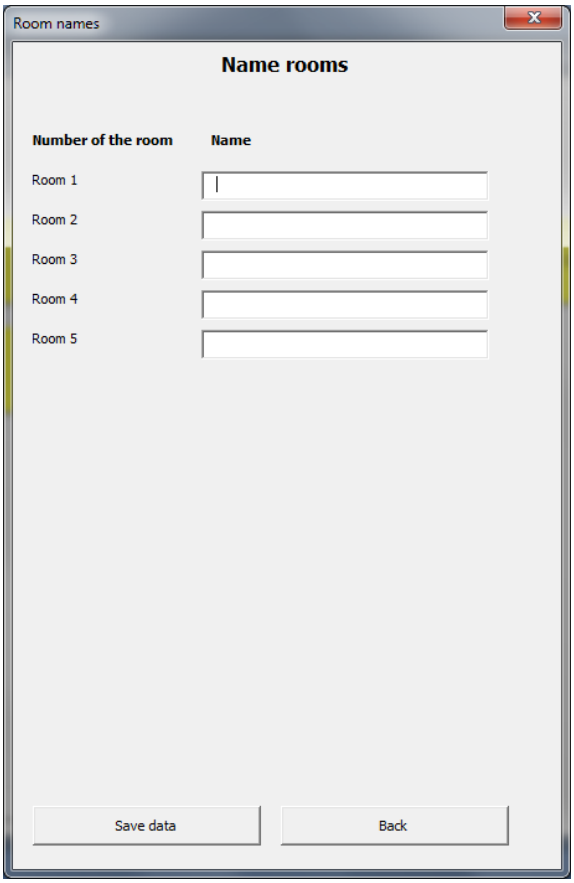


Figure 15: Input mask “Input building characteristics“

Before the rooms are configured, it is possible to name the rooms for easy entry. If the possibility is not chosen the rooms will retain their nomenclature like “room 1”, “room 2” etc. and the configuration of the individual rooms can start.

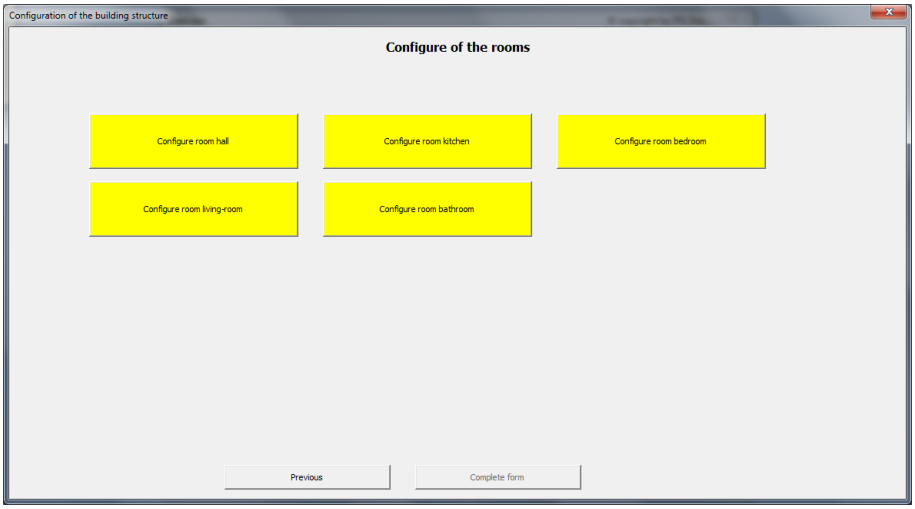


If the possibility is chosen to name the rooms, another window will open where the individual nomenclature can be entered.



After clicking the “Save data” button the configuration of the individual rooms can start.

Note: If “central device (with device characteristic)" is selected, an additional virtual room representing the central device is added.



After choosing a room by activating the corresponding button for this room, for example “Configure room 5” respectively “Configure room bathroom”, the input mask “General information of the room” appears, see Figure 16.

Step 6.2: General information of the room

Room data for central unit with constant volume flows:

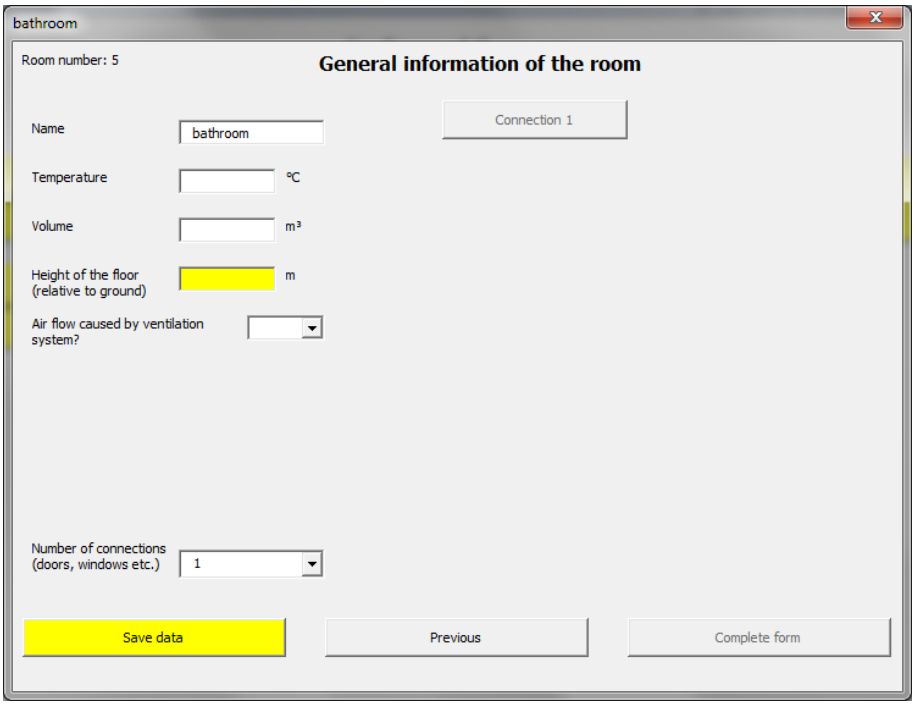
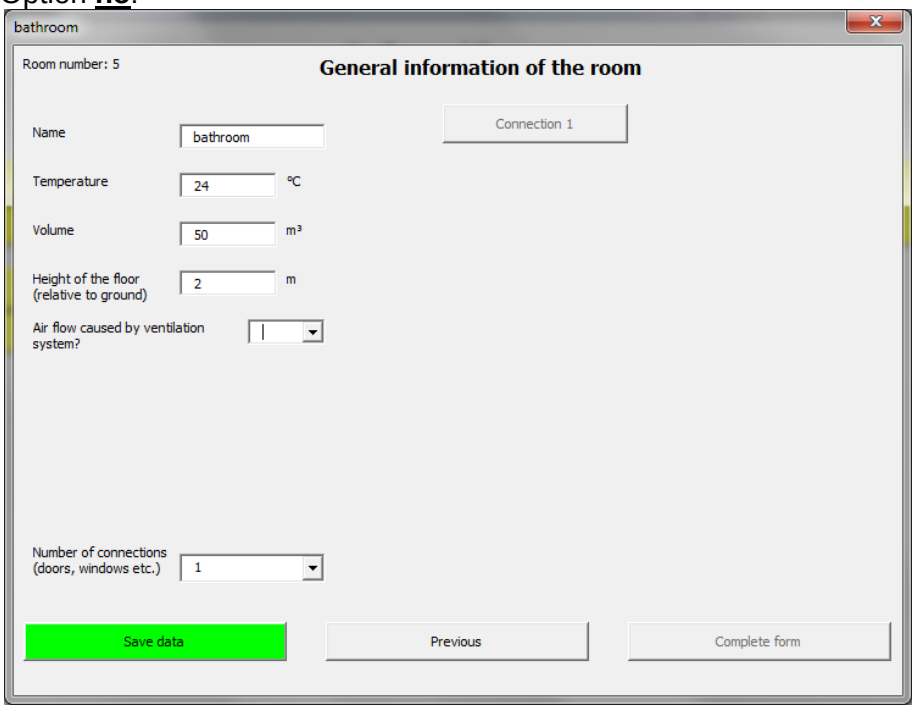


Figure 16: Input mask „General information of the room”

The data entered in this input mask refer to the selected room and following values:

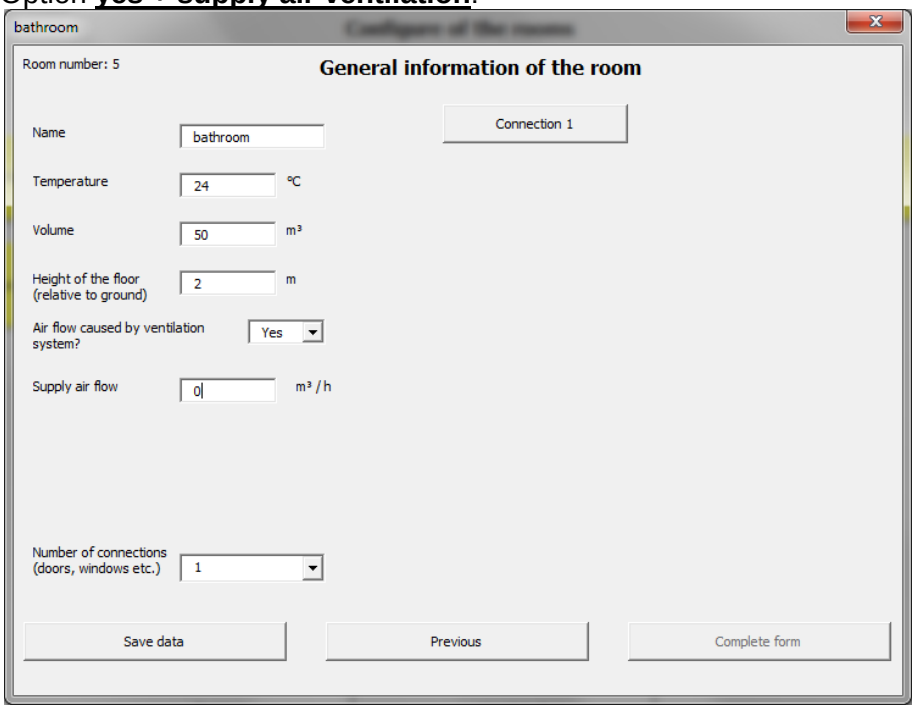
- Temperature in °C
- Volume in m³
- Height of the floor (relative to ground) in m
- Air flow caused by ventilation system?

Option **no**:



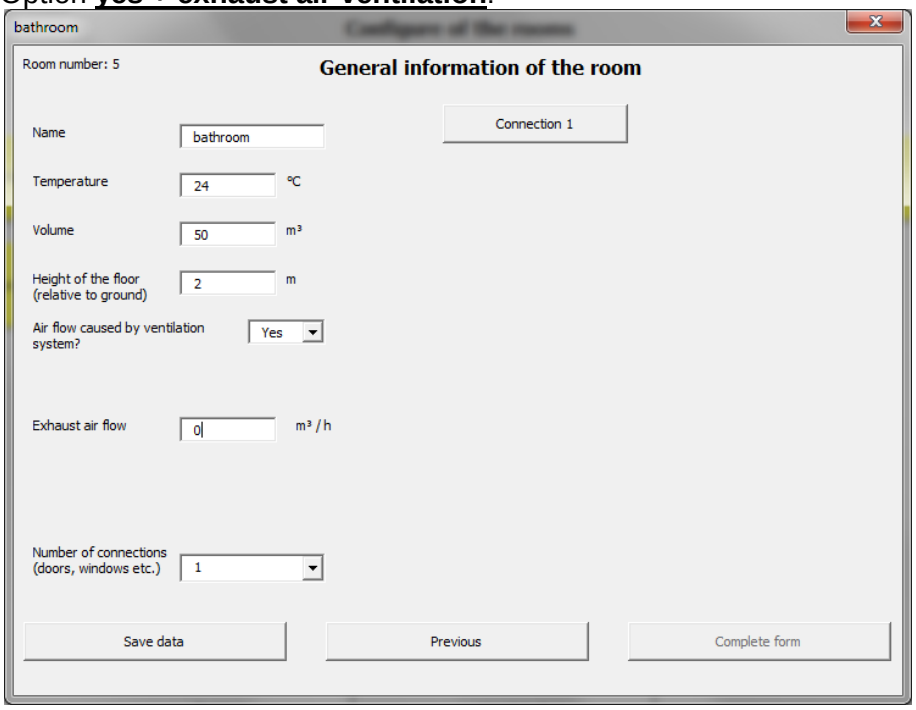
No further information is required.

Option **yes + supply air ventilation**:



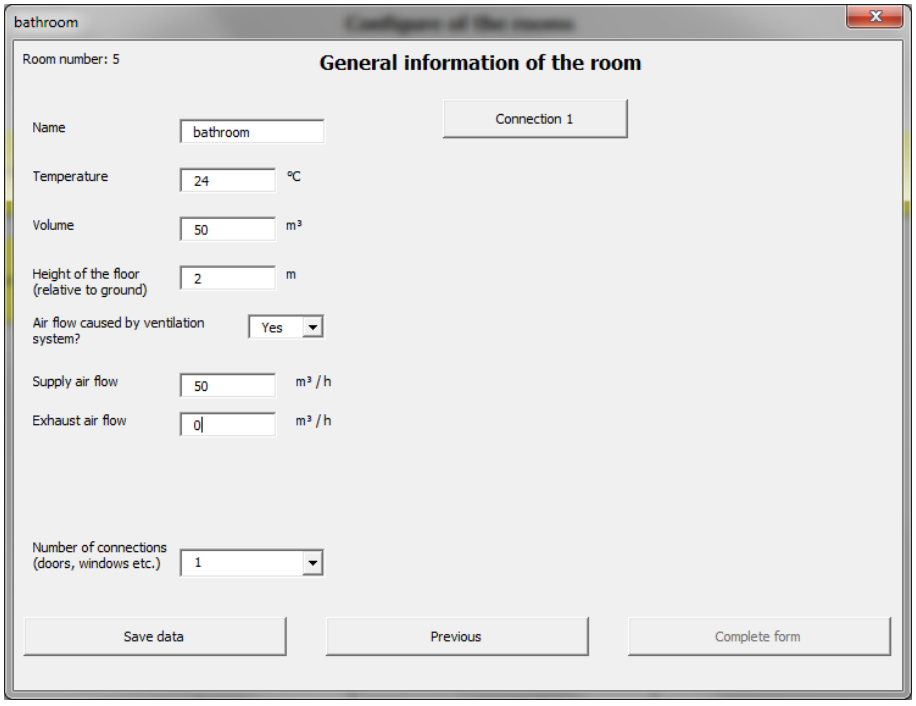
Information regarding the supply air flow in m³/h has to be completed.

Option **yes + exhaust air ventilation**:

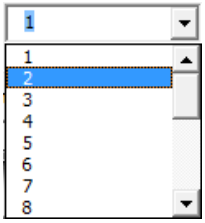


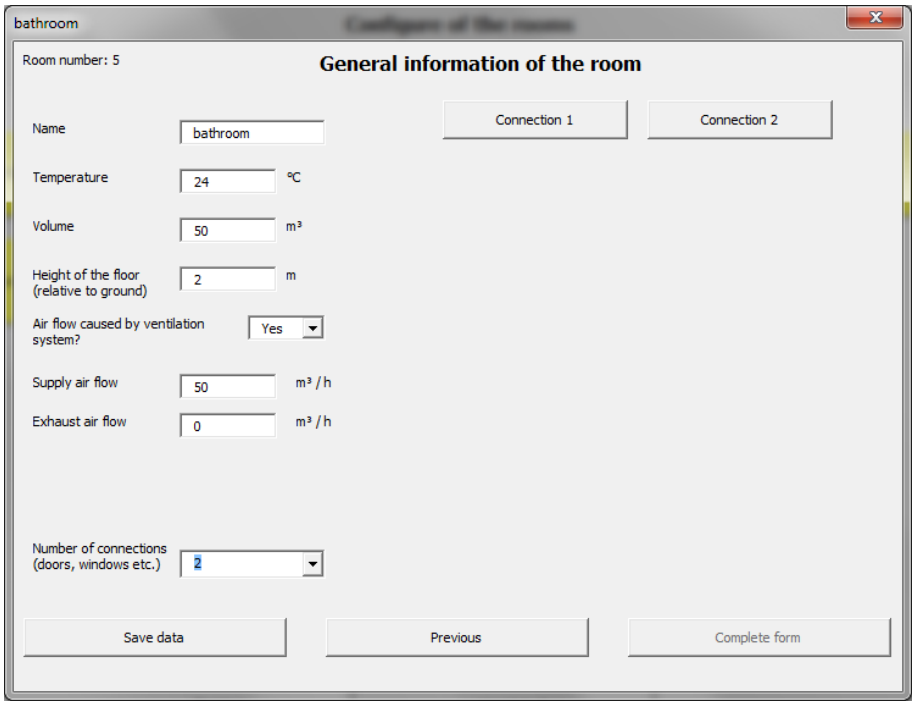
Information regarding the exhaust air flow in m³/h has to be completed.

Option **yes + balanced ventilation**:
Information regarding the supply and the exhaust air flow (both in m³/h) has to be completed.



- Number of connections (doors, windows etc.) (up to 20 connections per room)





By activating for example the “Connection 1“ button the input mask “Connection data” appears, see Figure 18.

Room data for central device with information on device characteristics or room-by-room ventilation units:

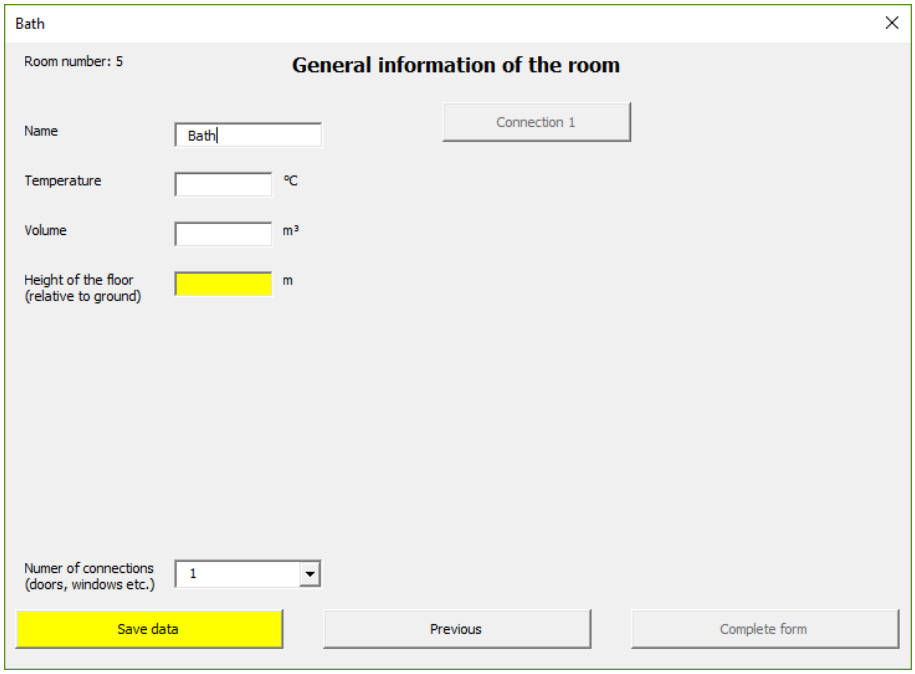
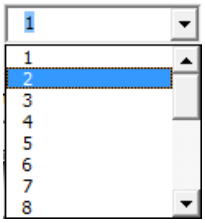
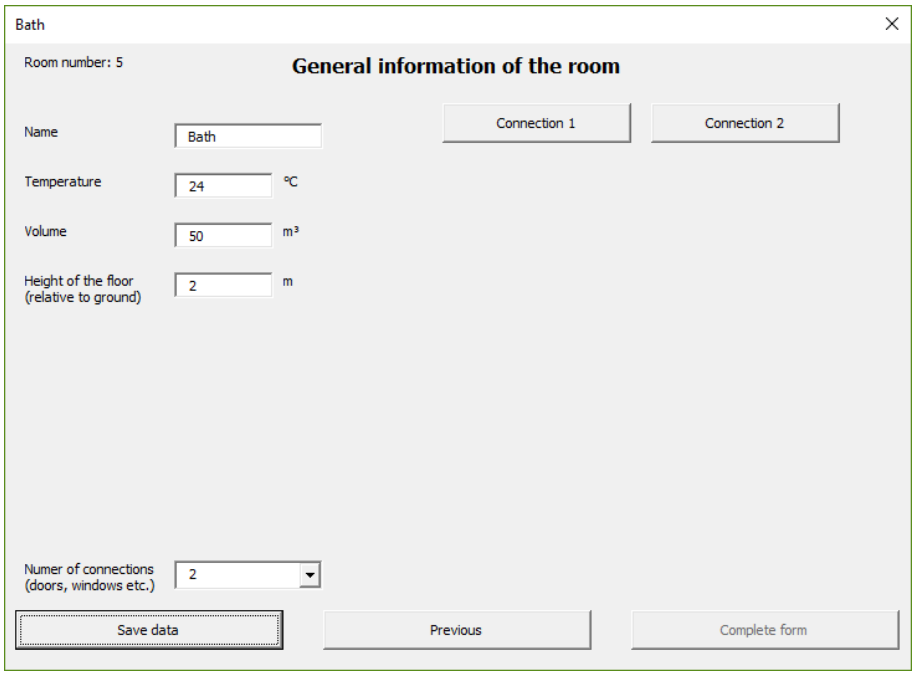


Figure 17: Input mask „General information of the room"

The data entered in this input mask refer to the selected room and following values:

- Temperature in °C
- Volume in m³
- Height of the floor (relative to ground) in m
- Number of connections (doors, windows etc.) (up to 20 connections per room)





By activating the button e.g. "Connection 1" the input mask "Connection data" opens, see Figure 18.

Step 6.3: Connection data

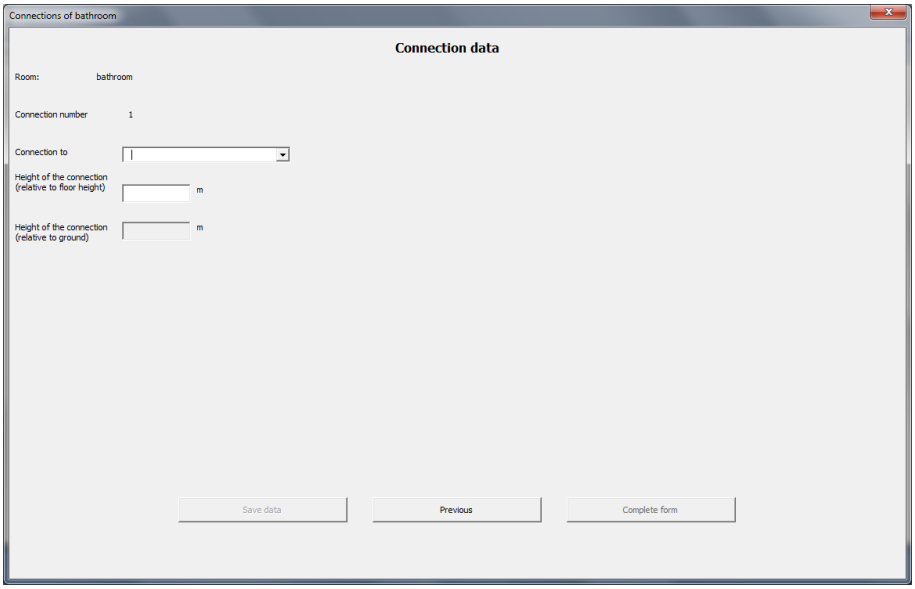
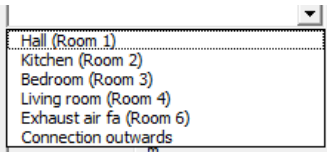


Figure 18: Input mask "Connection data"

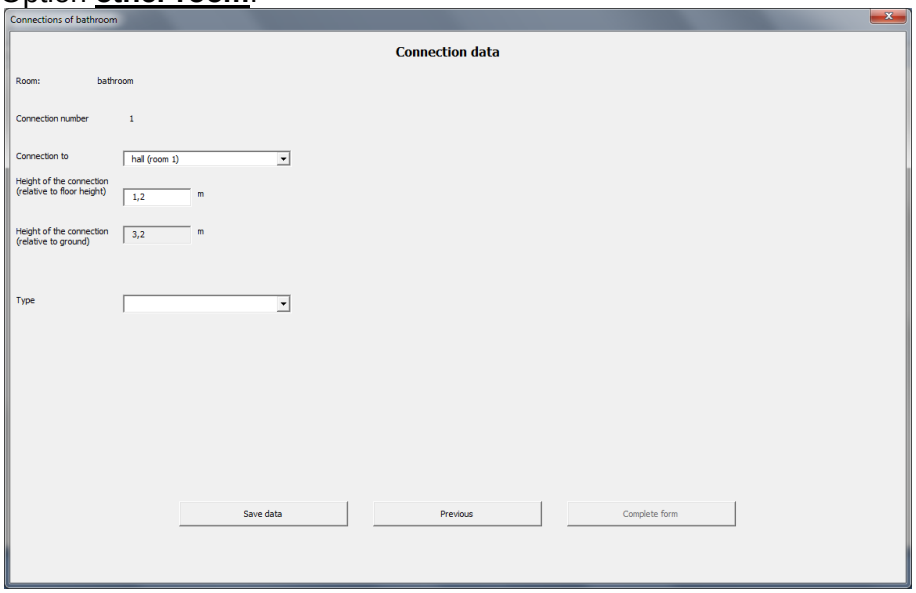
In addition to the information about which room is selected and the global connection number further data are required:

- Height of the connection (relative to floor height) in m
- Connection to

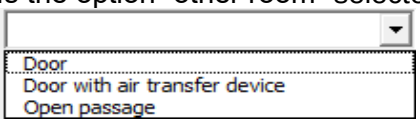


Note: The selection of a fan is only possible if there is a central device with device characteristics.

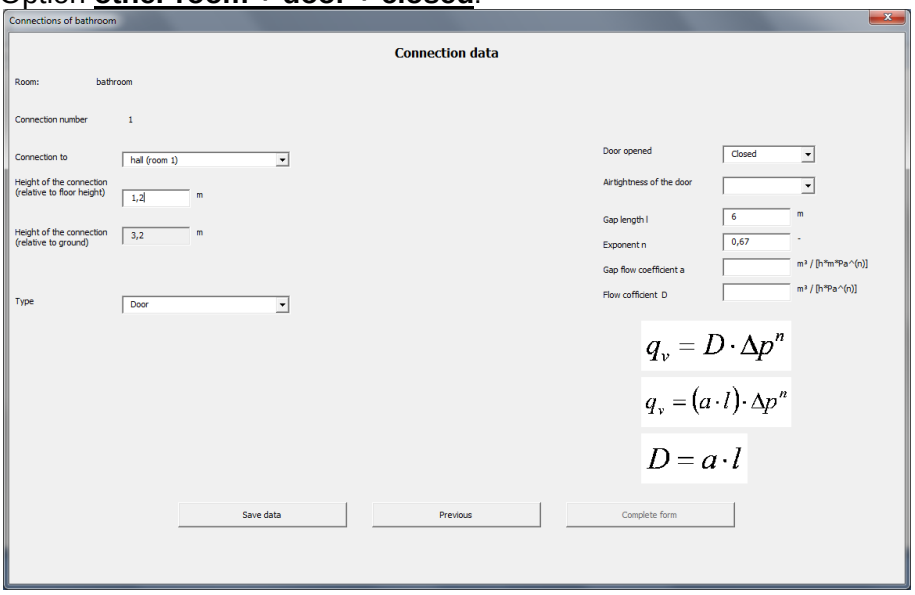
Option **other room**:



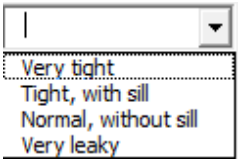
Is the option “other room” selected, information regarding the type has to be entered:



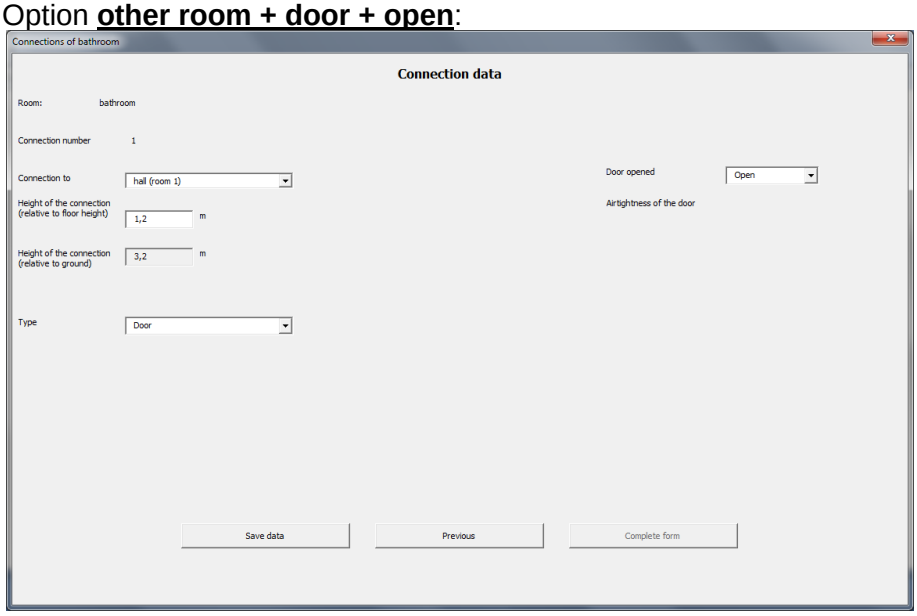
Option **other room + door + closed**:



Data about the air tightness of the door have to be completed:

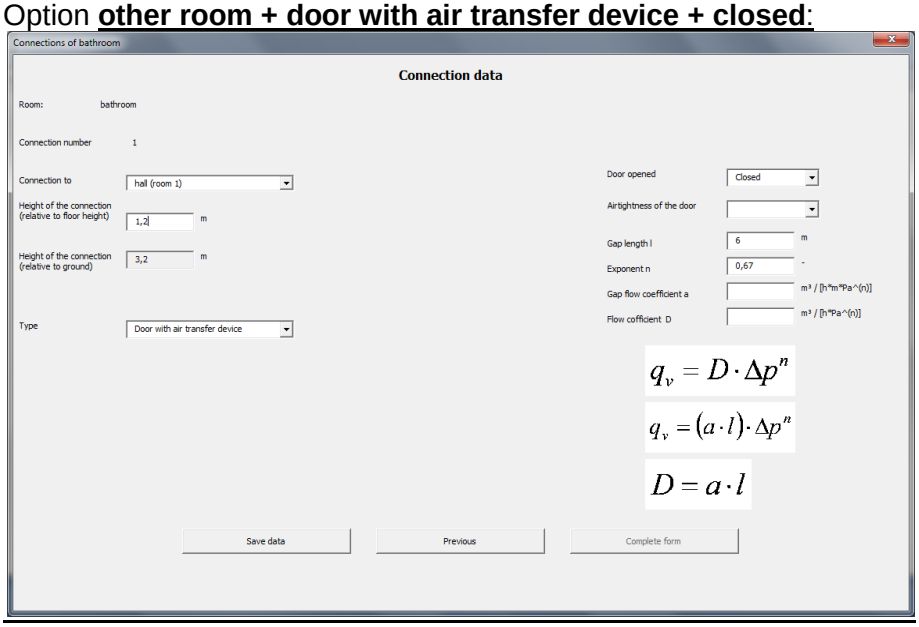


Option **other room + door + open**:

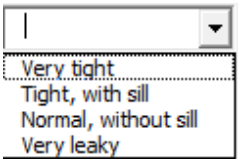


No further information is required.

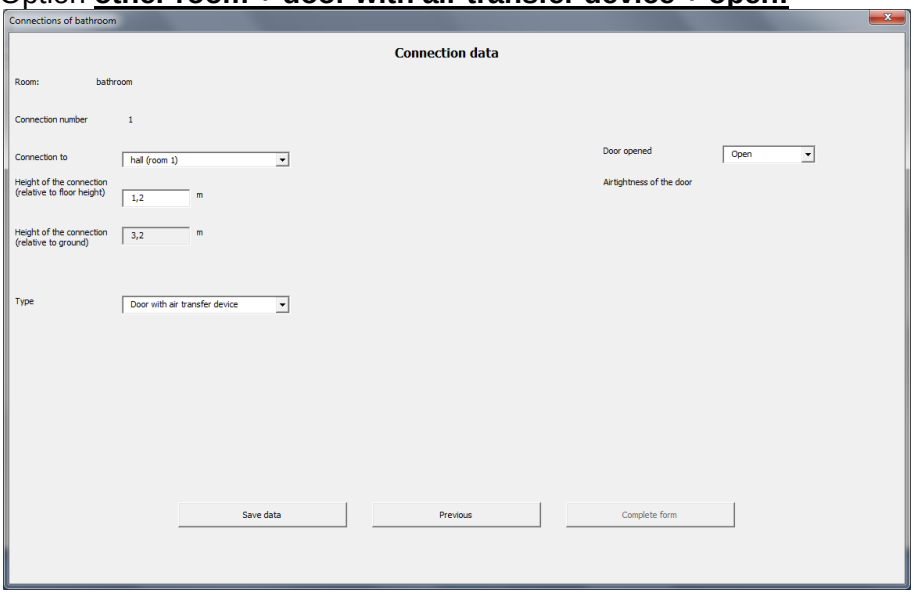
Option **other room + door with air transfer device + closed**:



Data about the air tightness of the door have to be completed:

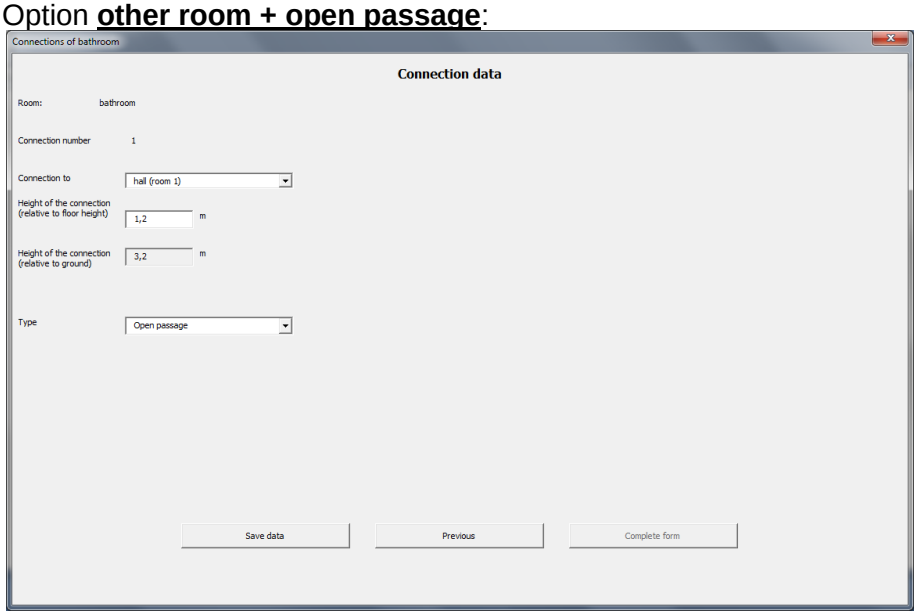


Option **other room + door with air transfer device + open:**



No further information is required.

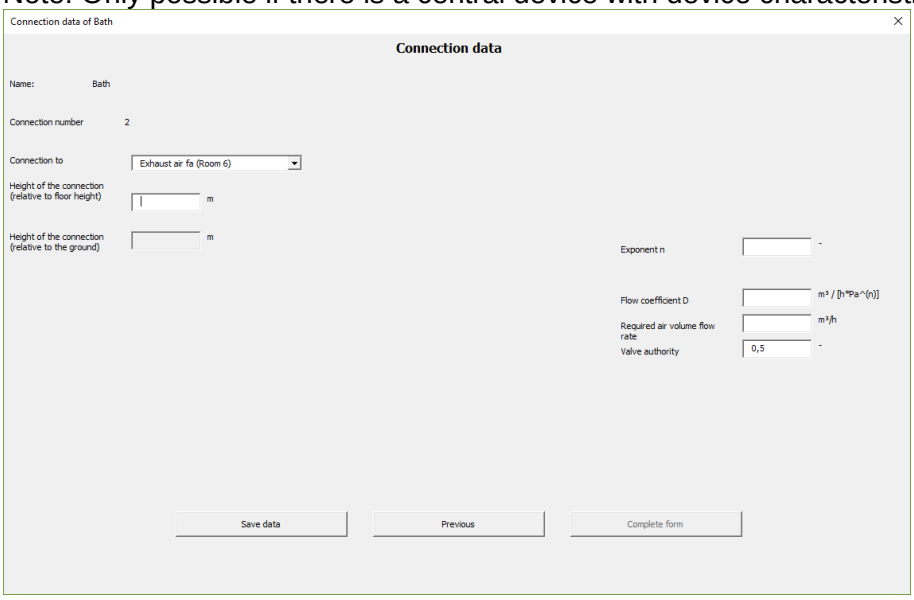
Option **other room + open passage**:



No further information is required.

Rooms with only one connection like storerooms with a door and no window are not taken into account in the calculation. Under steady-state conditions there is only very small air flow volume along the joints of the door due to the thermal lift between the lower and the upper joint of the door. Nevertheless, if these rooms should be taken into account in the calculation the door has to be split into two or more connections with different heights. The resulting air flow volumes are very small and there is a short-circuit flow around the door. The calculated air exchange rate doesn`t represent the real local air exchange rate of the room.

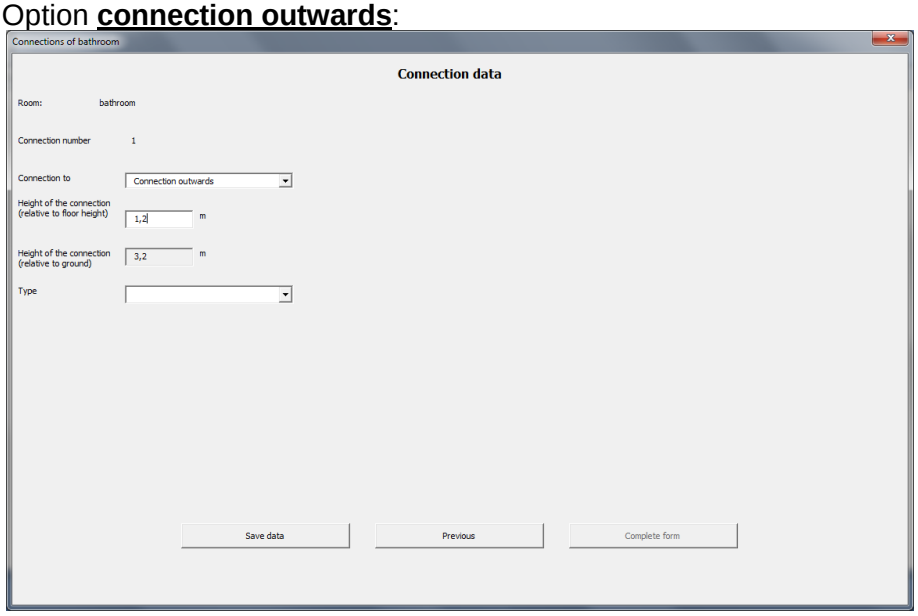
Option **fan**:
Note: Only possible if there is a central device with device characteristics.



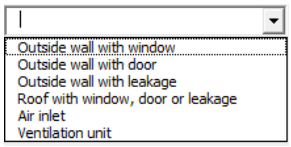
Additional information is necessary:

- Exponent n,
- Flow coefficient D,
- Required air volume flow rate,
- Valve authority (default value 0.5)

Option **connection outwards**:

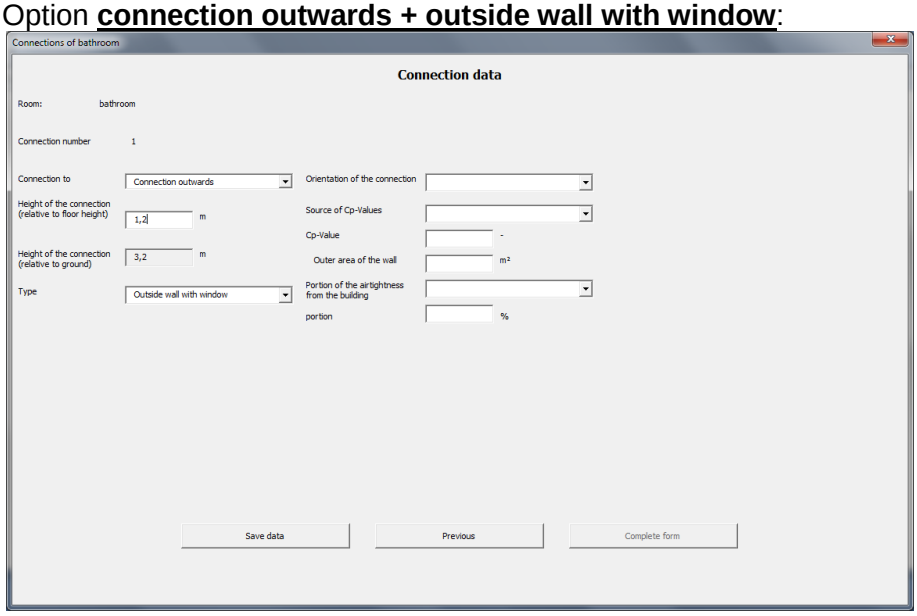


Is the option “Connection outwards” selected, information regarding the type has to be entered:



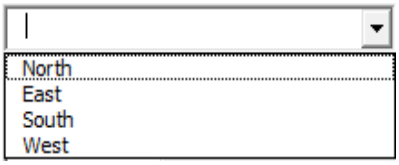
Note: The selection of a ventilation unit is only possible if room-by-room ventilation units are present.

Option **connection outwards + outside wall with window**:

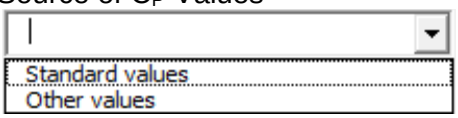


Details about following values have to be completed:

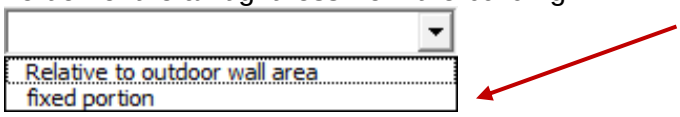
- Orientation of the connection



- Source of C_P-Values

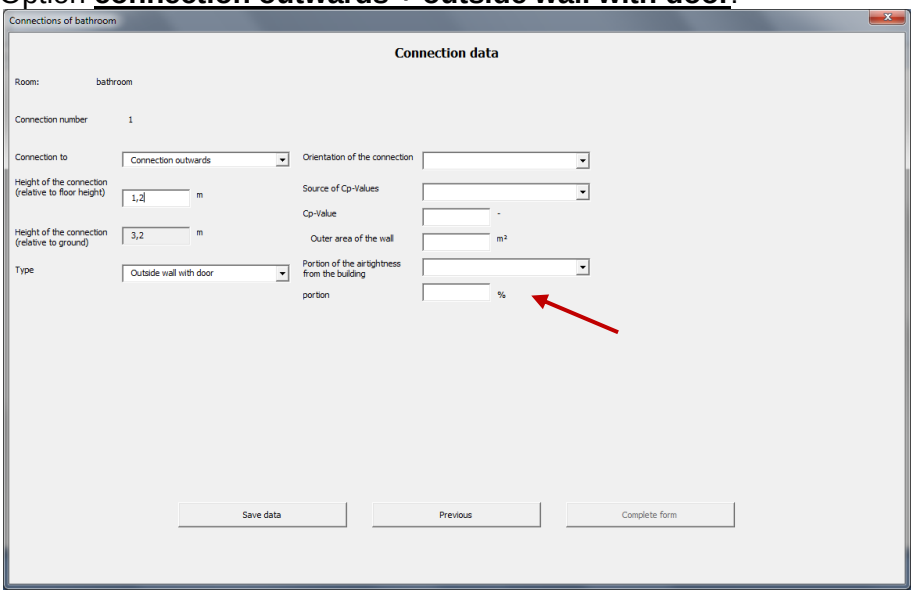


- C_p-Value
- Outer area of the wall in m²
- Portion of the air tightness from the building



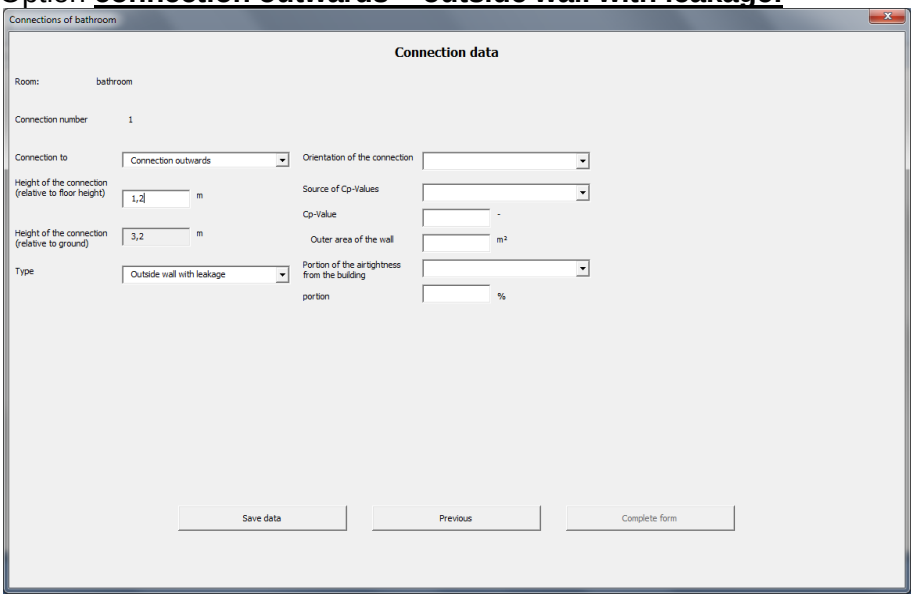
  If the values of air tightness of all connections are determined relative to the outdoor wall area, the portion can be changed manual for example can be reduced by opening the input mask “Connection data” again (portion of the leak of the roof rises).
- Portion in %

Option **connection outwards + outside wall with door**:



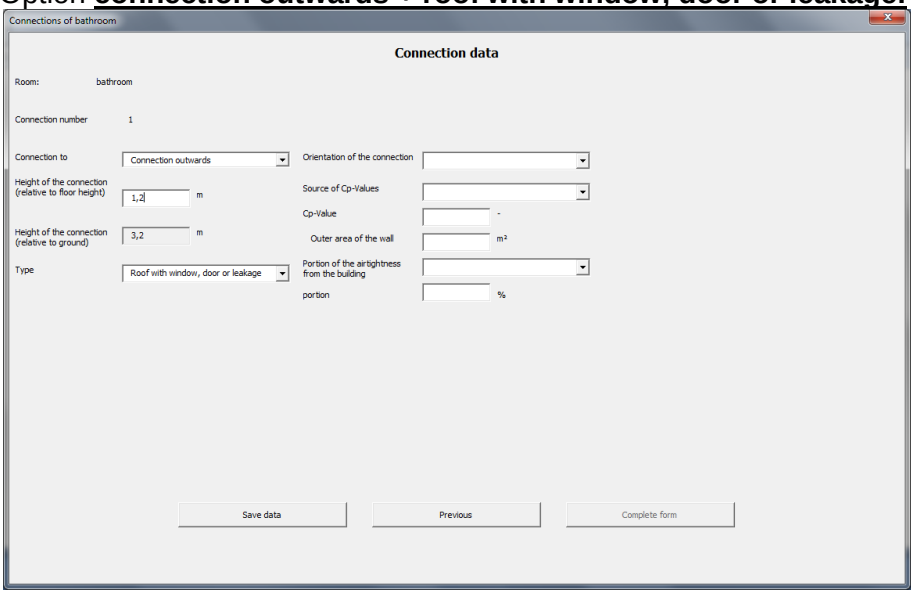
Data required to complete the input, see option connection outwards + outside wall with window.

Option **connection outwards + outside wall with leakage:**



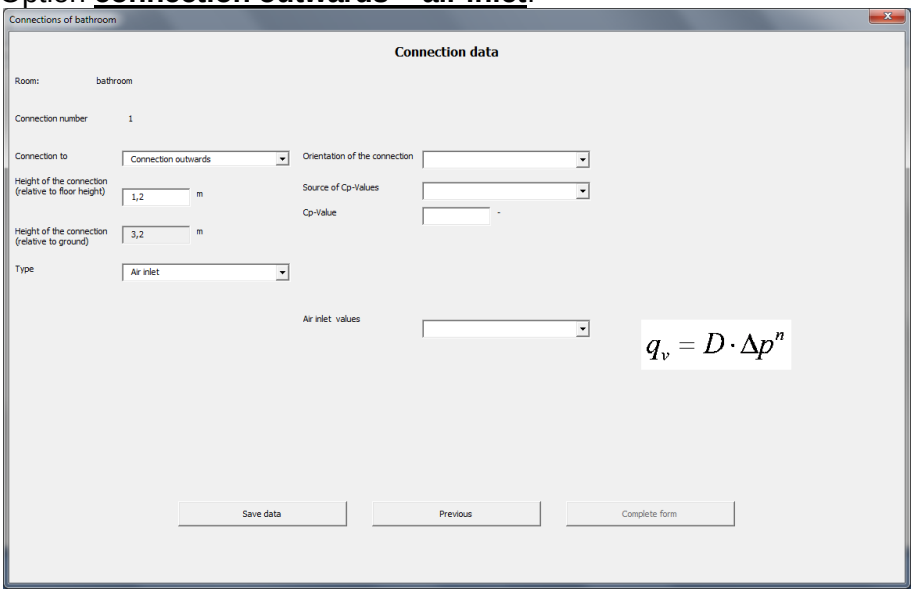
Data required to complete the input, see option connection outwards + outside wall with window.

Option **connection outwards + roof with window, door or leakage:**



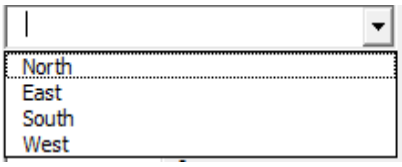
Data required to complete the input, see option <u>connection outwards + outside wall with window.</u>

Option **connection outwards + air inlet**:

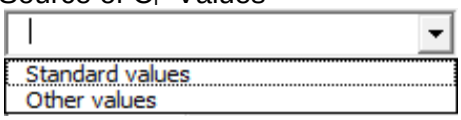


Data about the following values have to be completed:

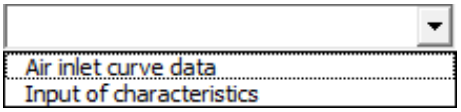
- Orientation of the connection



- Source of C_P-Values

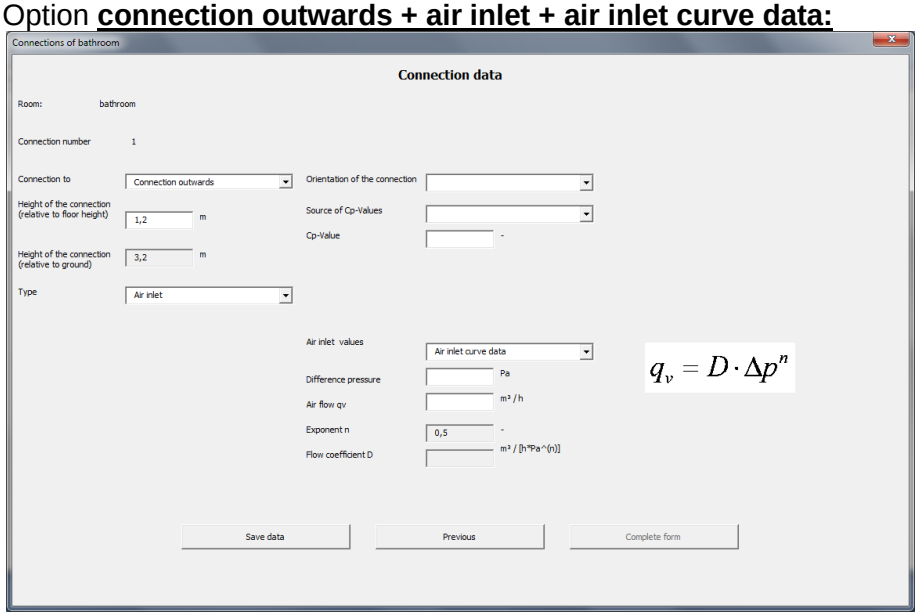


- C_p-Value
- Air inlet values



The input of the air inlet values can be done by entering the flow coefficient and the exponent of the air inlet or by selecting a point of the characteristic curve of the air inlet.

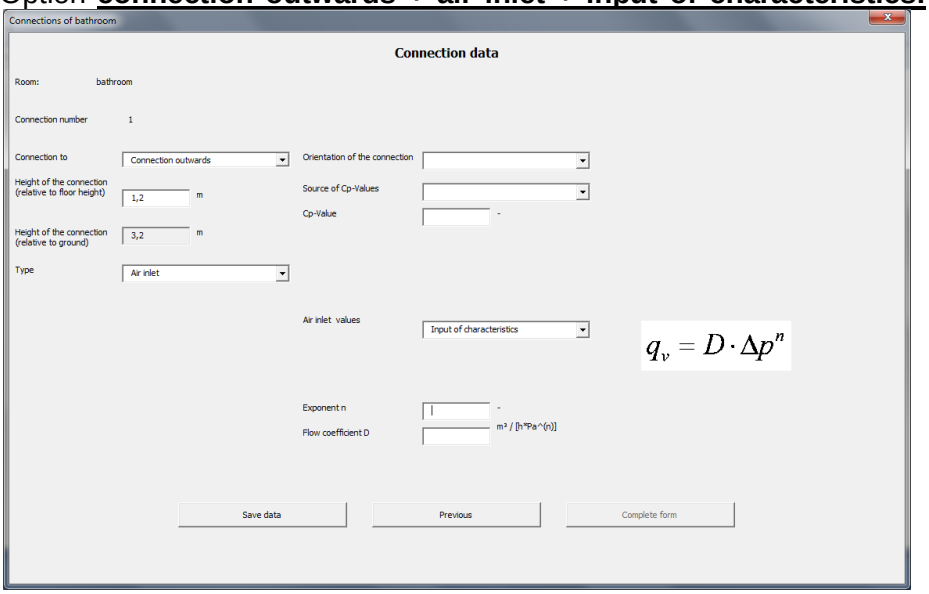
Option **connection outwards + air inlet + air inlet curve data:**



Data about the following values are necessary:

- Differential pressure in Pa
- Air flow q_v in m³/h

Option **connection outwards + air inlet + input of characteristics:**



Data about the following values are necessary:

- Exponent n
- Flow coefficient D in $\frac{m^3}{h \cdot Pa^n}$

By clicking on the "Save data" button all entered data are saved and can be used for the calculation, see Figure 19 und Figure 20.

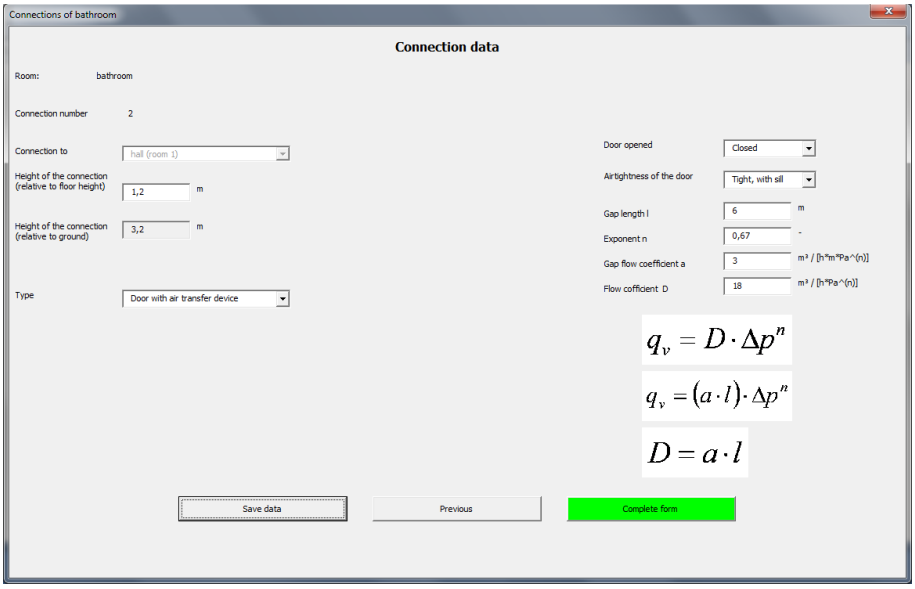


Figure 19: Input mask "Connection data" after saving the entered data for a connection to another room

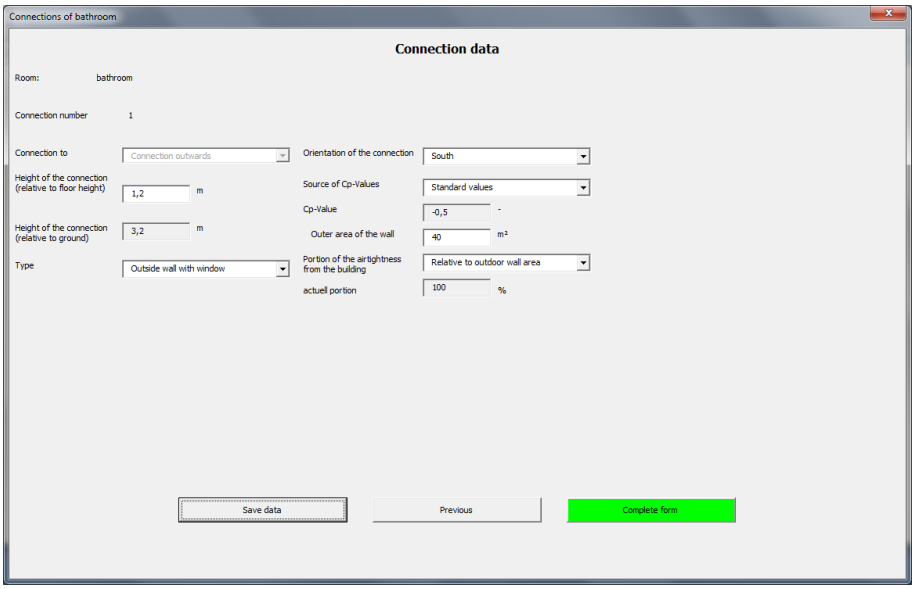
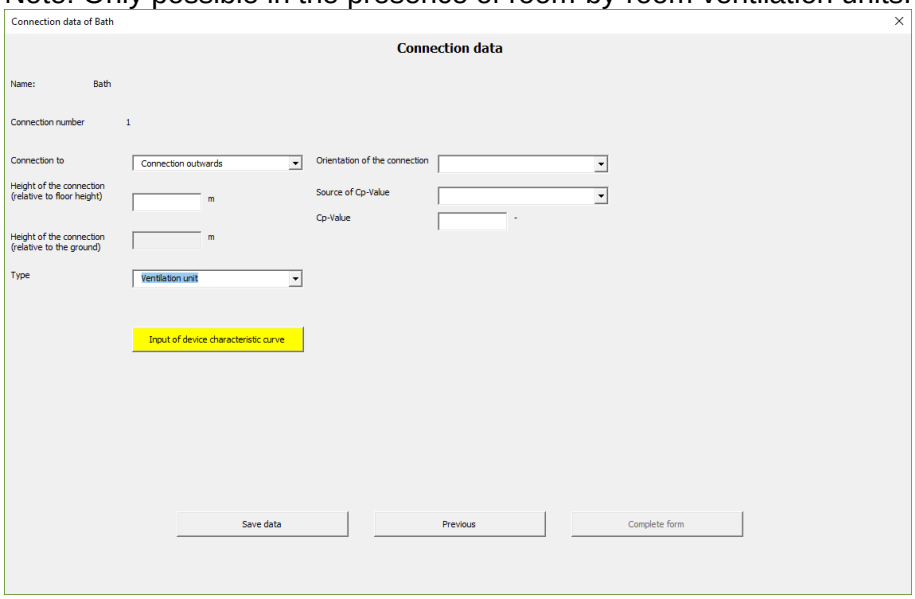
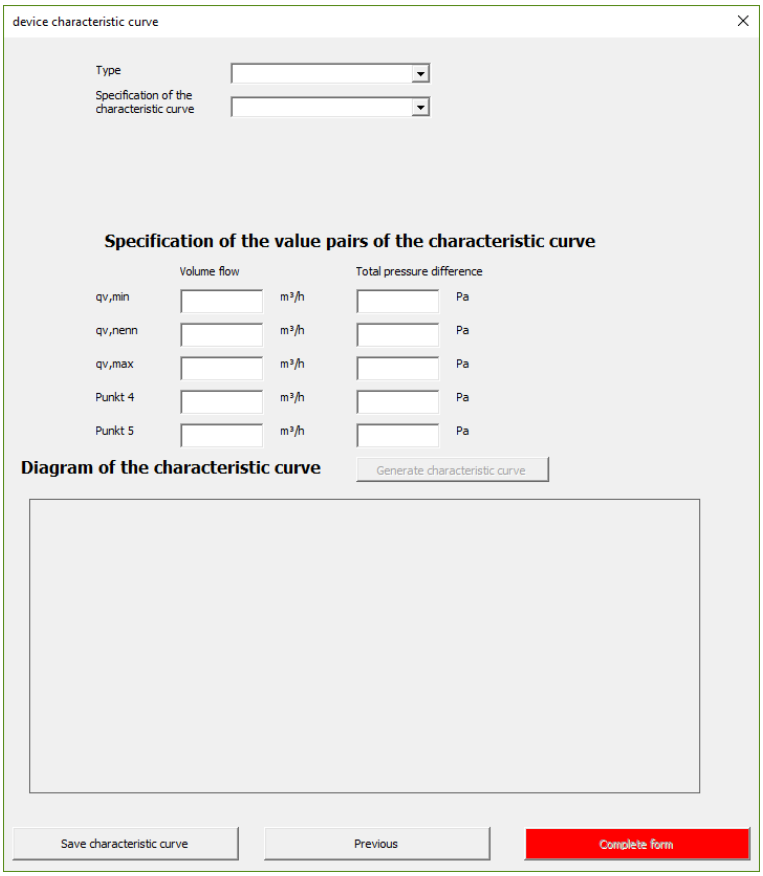


Figure 20: Input mask “Connection data” after saving the entered data for a connection to the outdoor

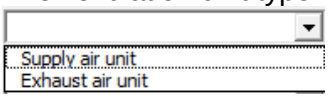
Option **ventilation unit**:
Note: Only possible in the presence of room-by-room ventilation units.



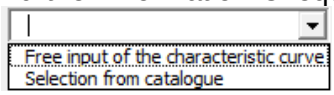
The characteristic curve for room-by-room ventilation units is entered when the connections are specified.



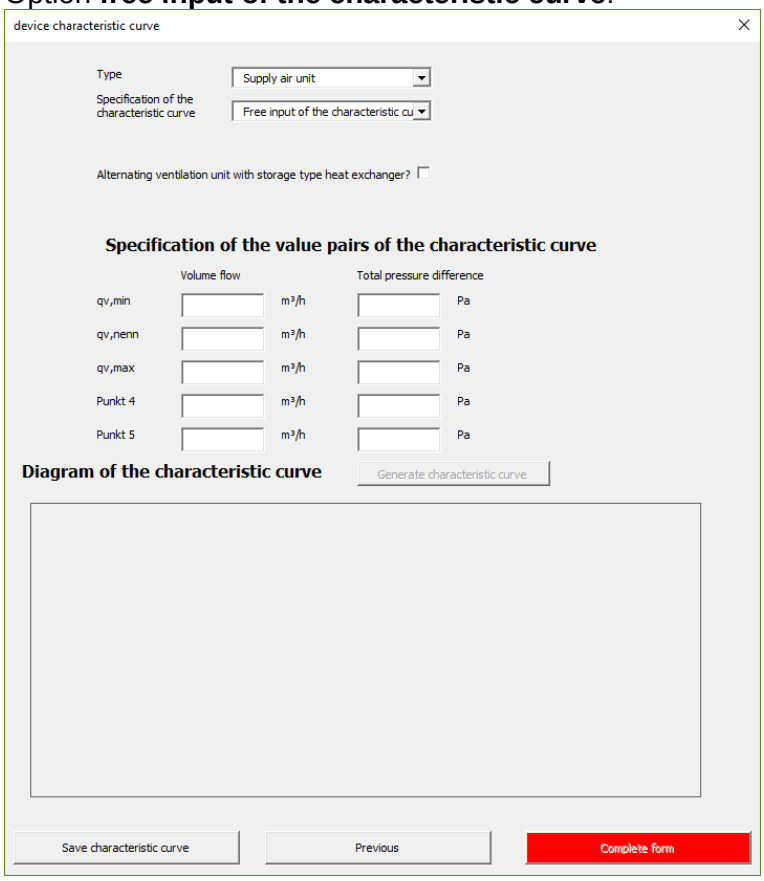
The ventilation unit type must be defined:



Further information is required to specify the characteristic curve:

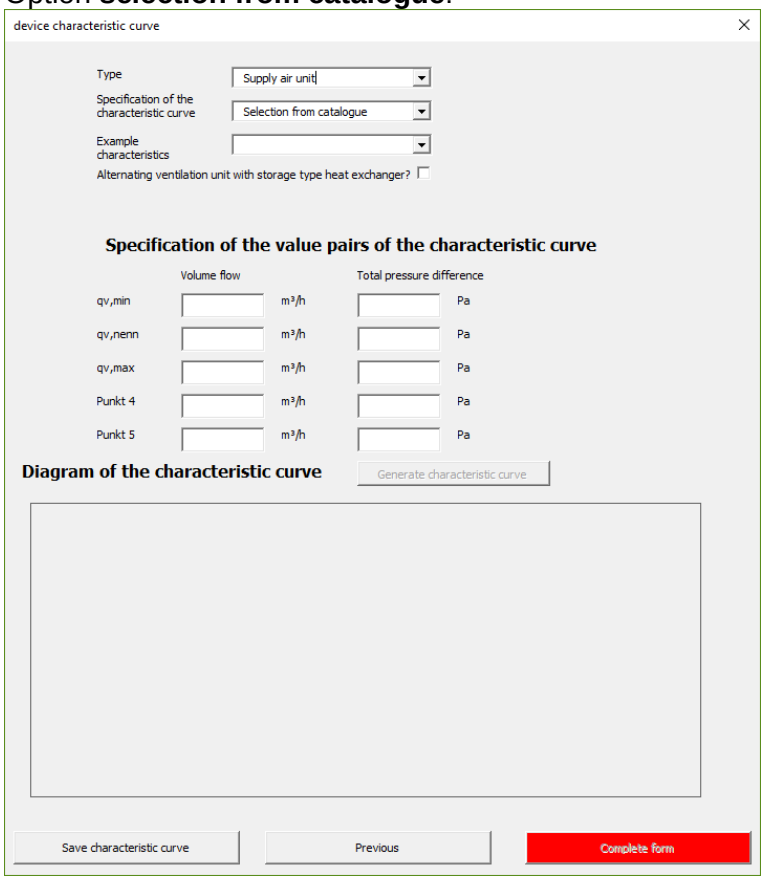


Option **free input of the characteristic curve**:

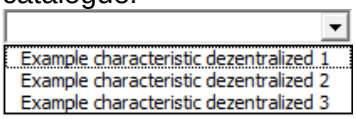


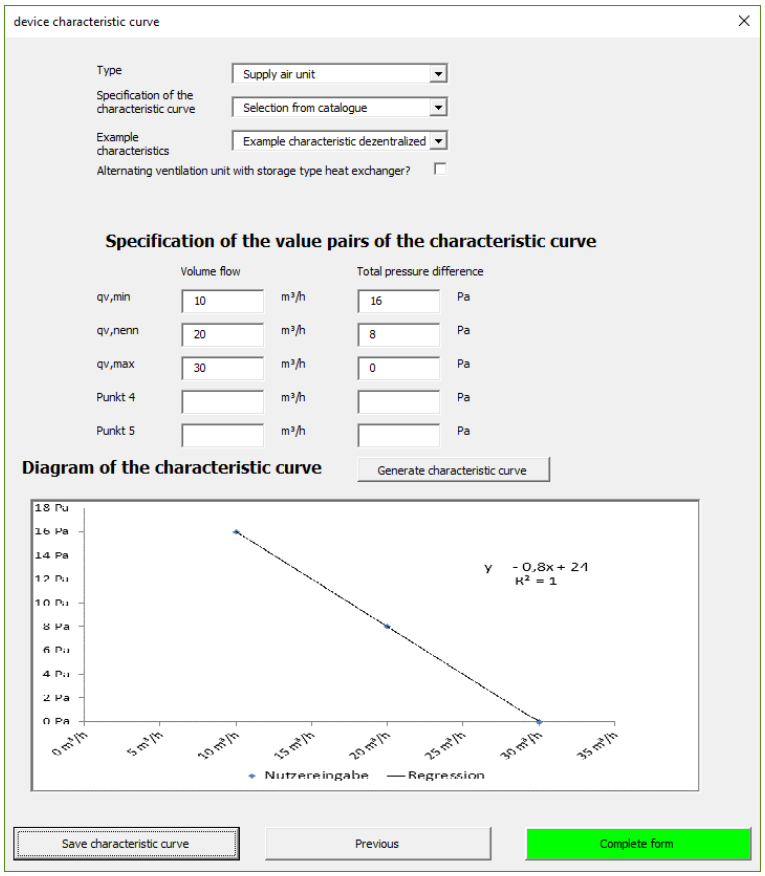
To determine the characteristic curve of the supply air unit, at least 3 volume flows and the corresponding total pressure difference are required (minimum air volume flow, nominal air volume flow and maximum air volume flow). The specifications for two further value pairs are optional.

Option **selection from catalogue**:

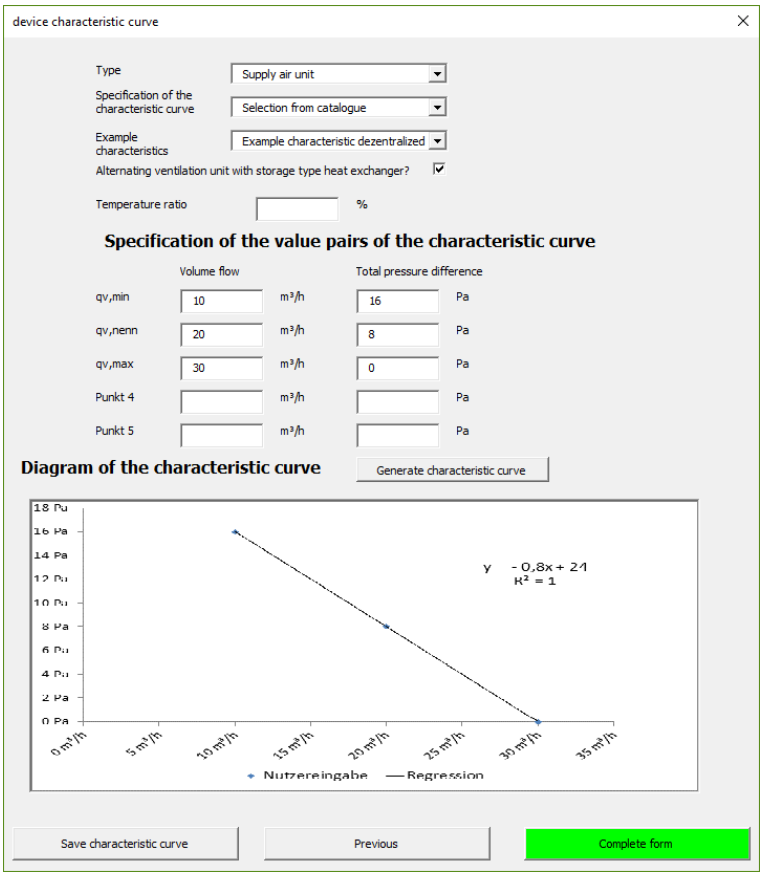


Further information is required to select the characteristic curve from the catalogue:





If there is an alternating ventilation unit with storage type heat exchanger, this can be selected and the degree of temperature change can be specified.



Activating the “Complete form” button closes the current input mask. Activating the “Complete form” button closes the current input mask and the “General information of the room” window appears where the next connection can be defined. If the required data are completed in the input masks “Connection data” the buttons will turn green, see Figure 21. If the required data are completed in the input mask “General information of the room” and the “Save data” button is activated the entered data are saved and can be used for the calculation. The explanation concerning to the “traffic lights” is shown in Figure 2.

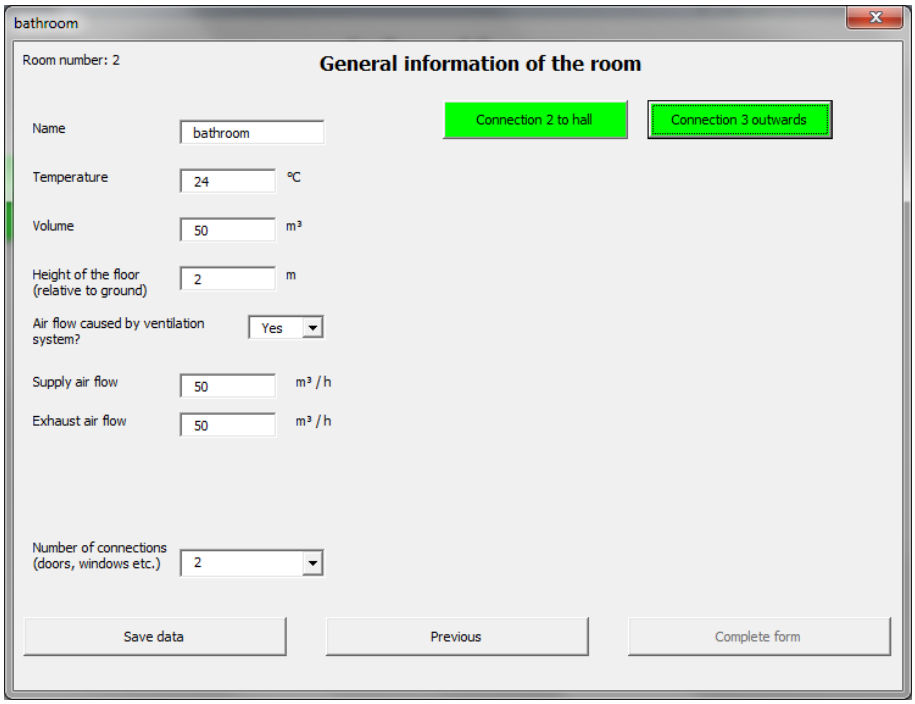


Figure 21: Input mask “General information of the room” after entering the complete information about all connections of the room and saving the data

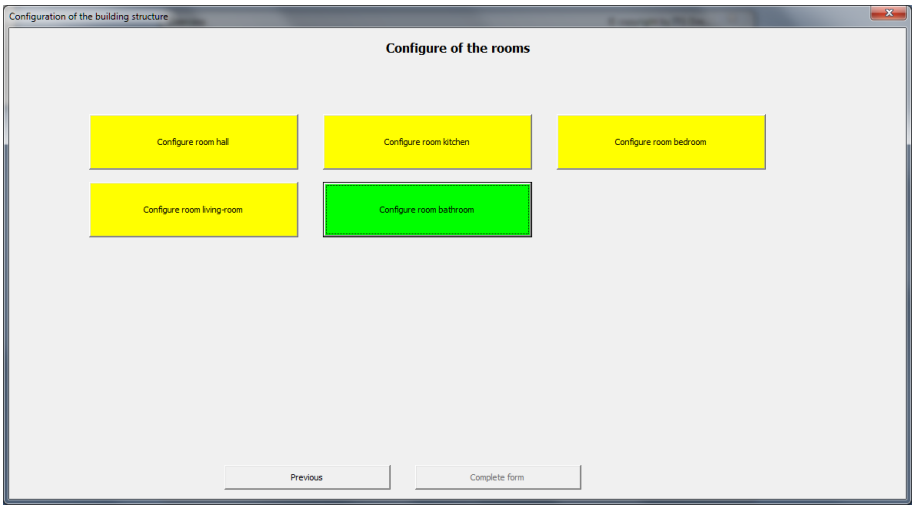


Figure 22: Input mask „Configure of the rooms” before completing the configuration of all rooms

Activating the “Complete form” button closes the input mask “General information of the room” and the input mask “Configure of the rooms” appears, see Figure 22. If the configuration of all rooms is finished, the “Configure room X” buttons turn green, see Figure 23.

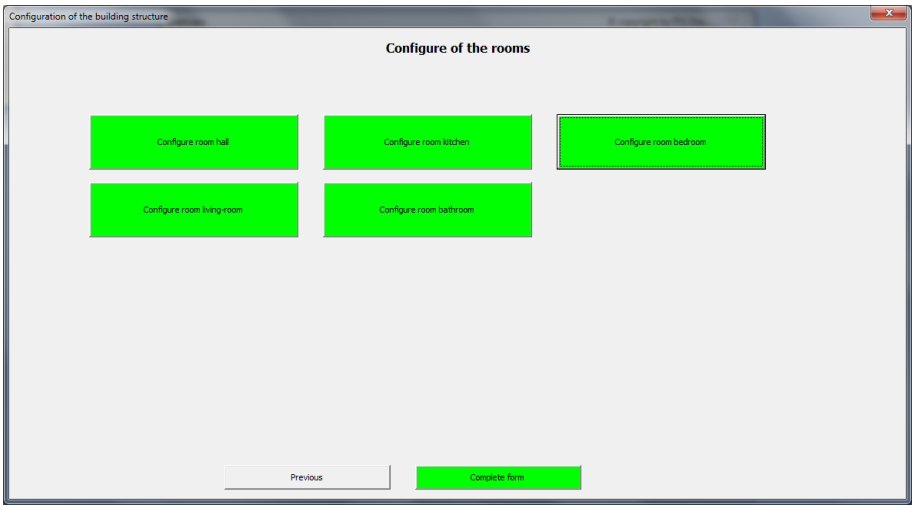


Figure 23: Input mask „Configure of the rooms” after completing the configuration of all rooms

By clicking the “Complete form” button the input mask “Overview” appears, see Figure 24.

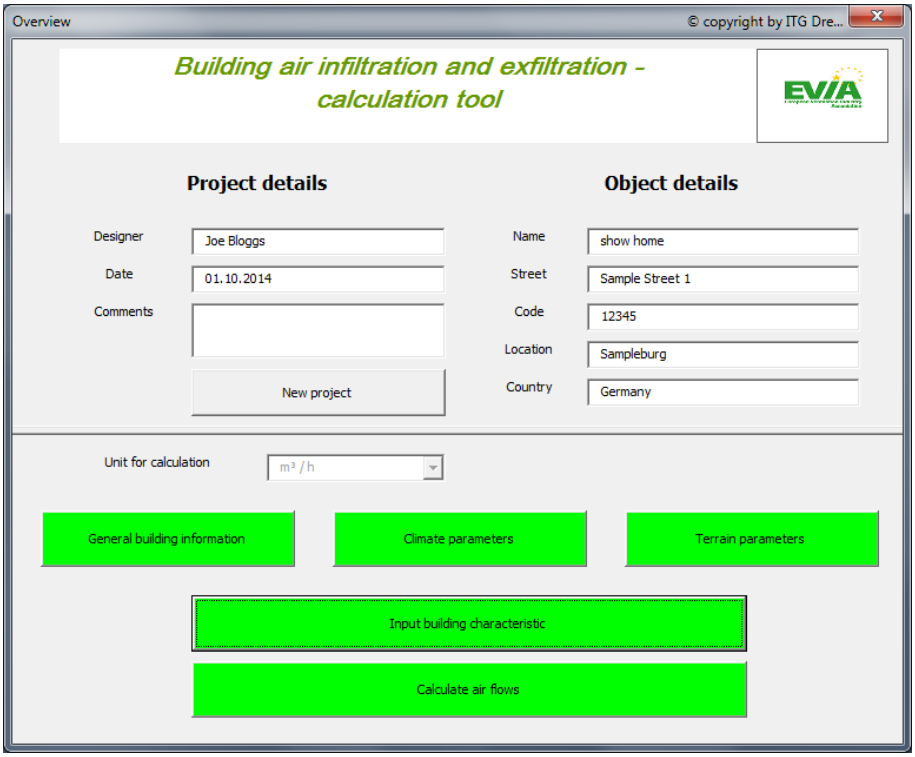


Figure 24: Input mask “Overview” after entering all required inputs which are necessary to calculate the air flows

Activating the “Calculate air flows” button the calculation starts.

An information field appears (see Figure 25) with the information that the automatic optimization of the calculation exactness is activated and this can lead to an increased calculation time. The progress of the calculation can be monitored discontinuously in the status bar of Excel. If a calculation time of 15 minutes is reached, the algorithm stops and the user also receives a message box, see Figure 26.

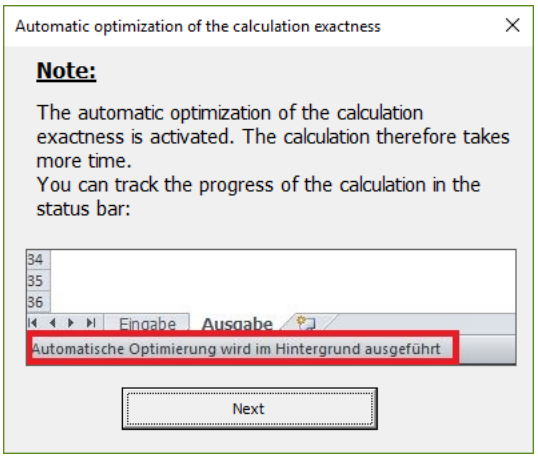


Figure 25: Note field for automatic optimization of the calculation exactness

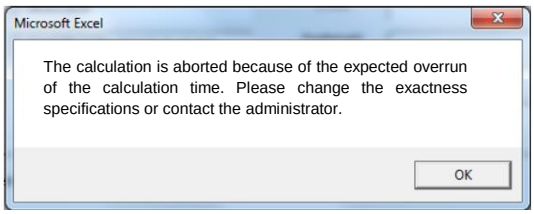
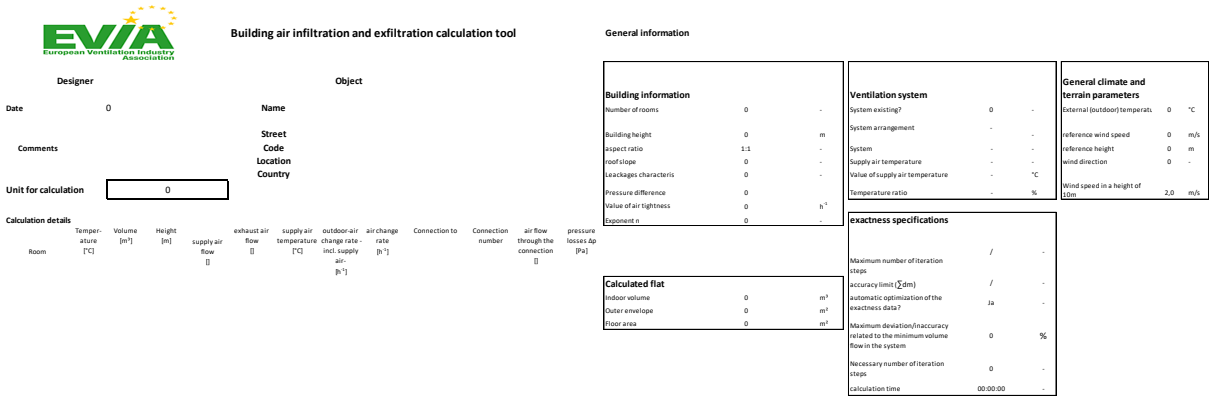


Figure 26: Note field for aborting the algorithm due to timeout

The results are shown in the worksheet “Output”, see Figure 27.



Connection data

start	end	number	type	orientation	Cp-value	wall area [m²]	Portion of the air tightness of the building [%]	height (absolut) [m]	flow coefficient [m³/(s*Pa^n)]	Exponent [-]

Figure 27: Table with the outputs

3 Changes of the input data/Calculation of variants

It is possible to calculate variants by changing conditions like wind direction, air tightness of the building envelope, ventilation systems, etc. in relevant input masks. All changes have to be saved and completed.

Input data can be rejected or changed in the previous input mask by clicking the “Previous” button, see Figure 28.

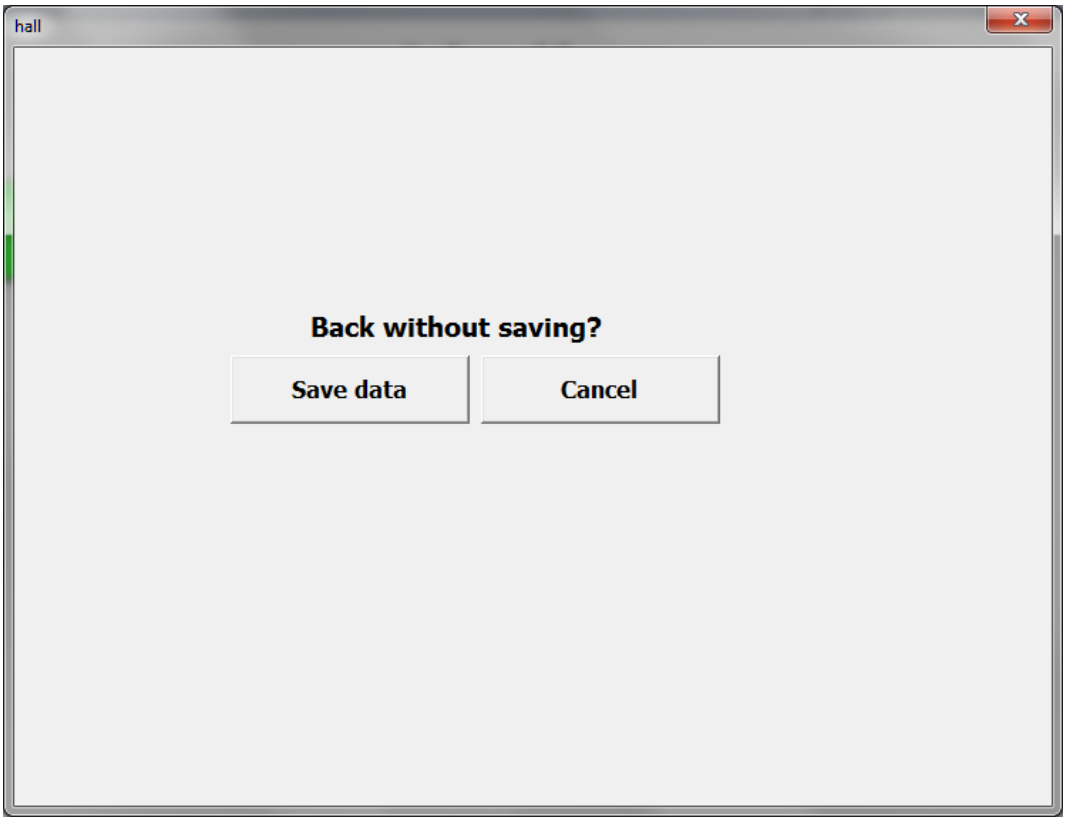


Figure 28: Message window ”Back without saving?“

Changing the number of rooms (adding rooms or reducing the number of rooms) can be done in the input mask “General building information” as long as there do not exist the first connection. After entering the first connection it is not possible to change the number of rooms in this project and a new project has to be started, see Figure 29.

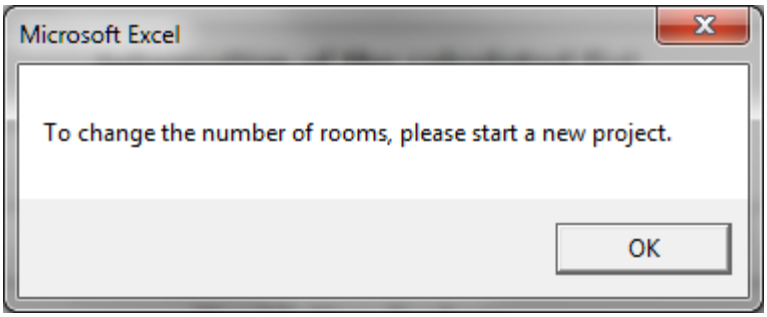


Figure 29: Message window: subsequently changing the number of rooms

If the choice has been made for the arrangement of the ventilation systems (central unit (constant volume flow), central device (with device characteristics), room-by-room units), this cannot be changed again within the project. If the choice of the arrangement of the ventilation system is to be changed, a new project must be created.

Changes of the connection of the rooms like orientation, type or increase the number of connections can be done without problems in the relevant windows “General information of the room”, see Figure 30 and Figure 31. However to reduce the number of the connection, a new project has to be started or a saved version has to be used.

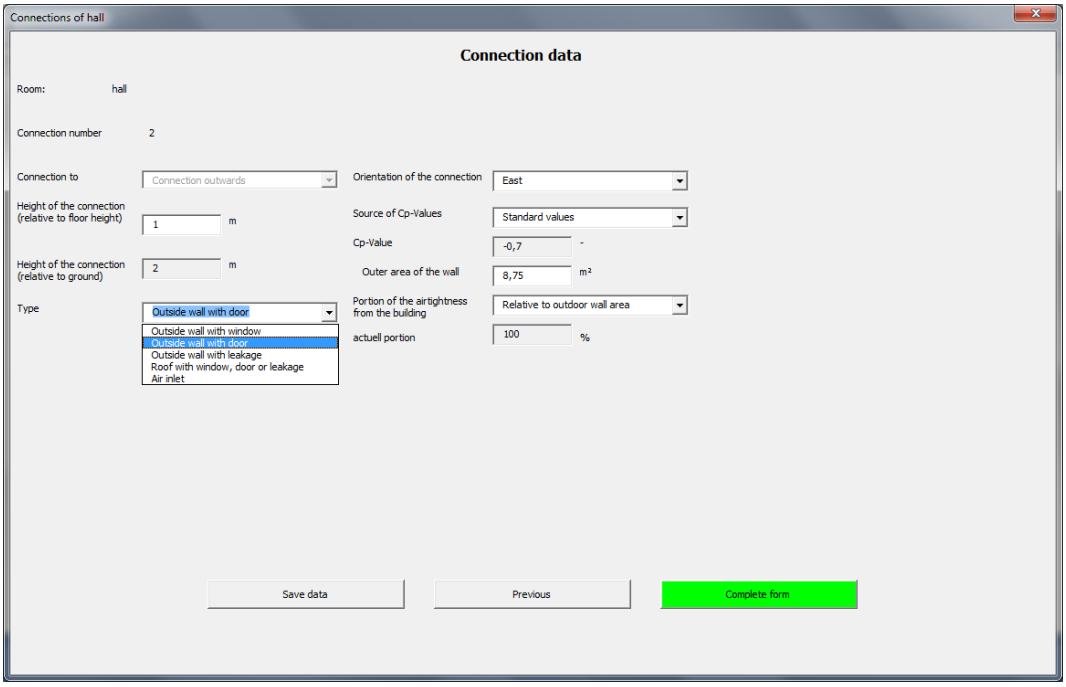


Figure 30: Input mask "Connection data“ for changing the for example oriantation, typ, etc.

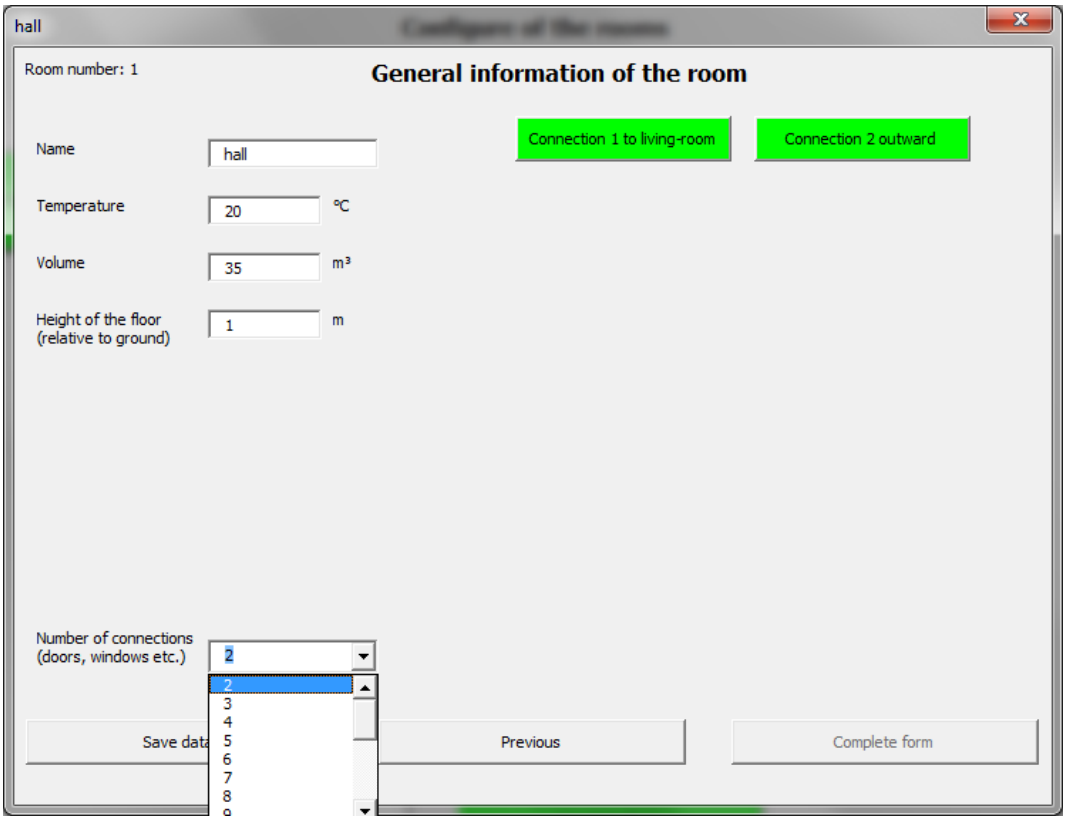


Figure 31: Input mask "General information of the room" for changing the number of connections

4 Calculation examples

Example 1: Apartment in a multi-family building

In the first example the building in- and exfiltration air flows of an apartment in a multi-family building is calculated. Figure 32 shows the floor plan of the apartment. The numbers in the boxes (green) illustrate the connections.

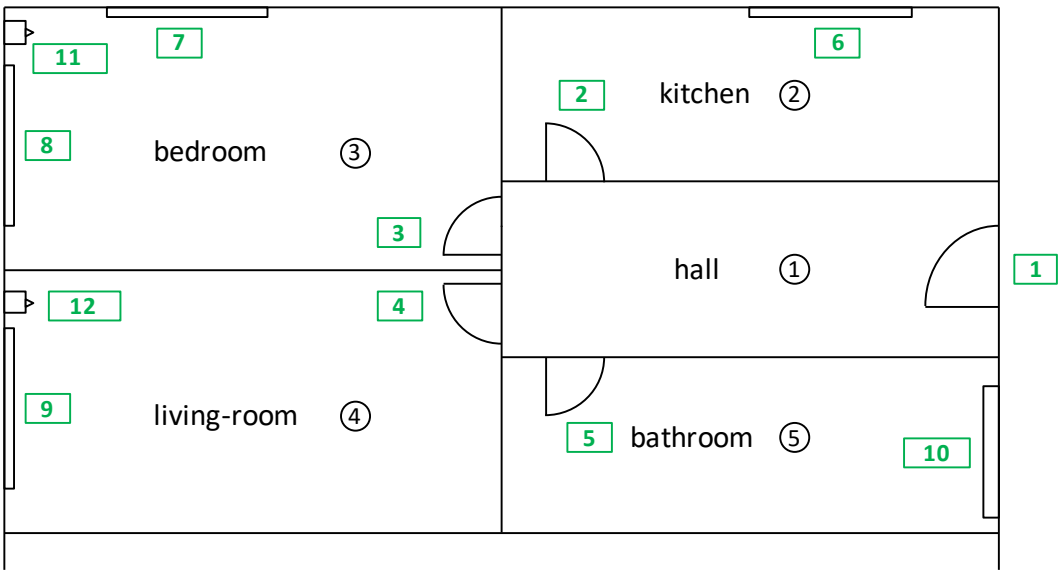


Figure 32: Floor plan of the apartment

Figure 33 to Figure 35 show the conditions for the apartment regarding to general information about the building (Step 3:), the climate data (Step 4: Climate parameters) and the environmental data (Step 5: Terrain information).

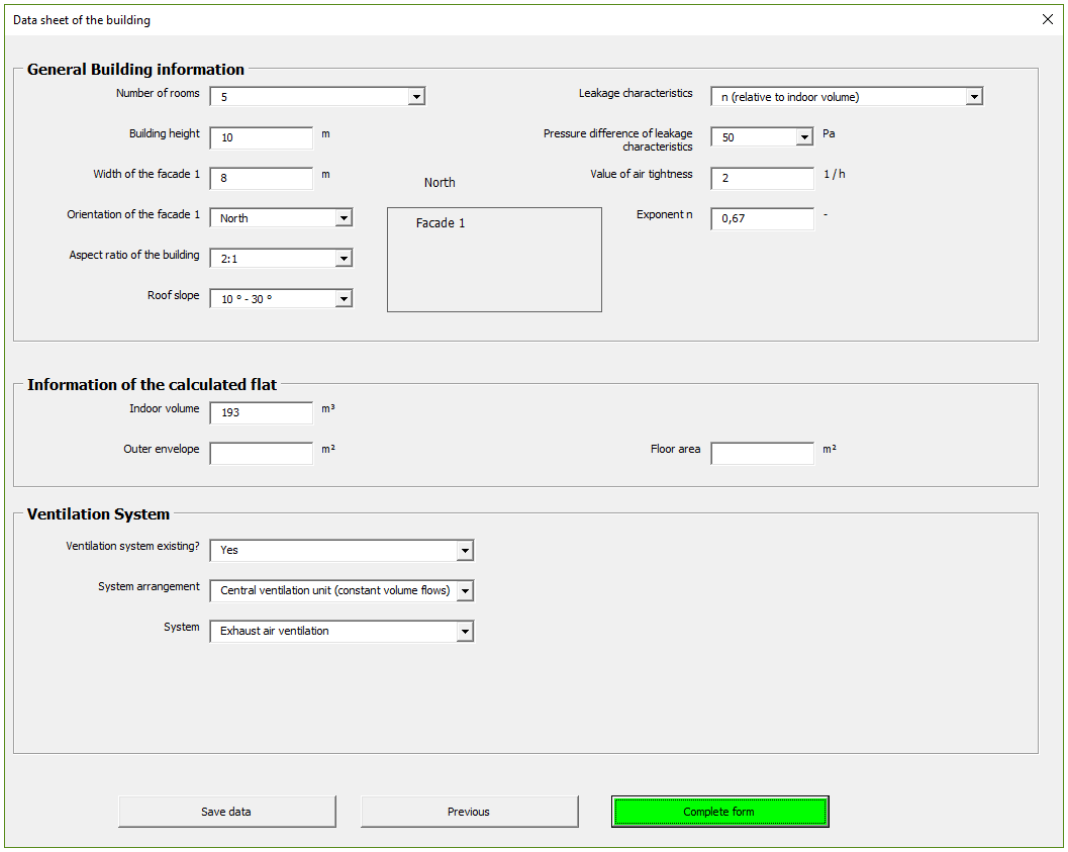


Figure 33: General data about the apartment

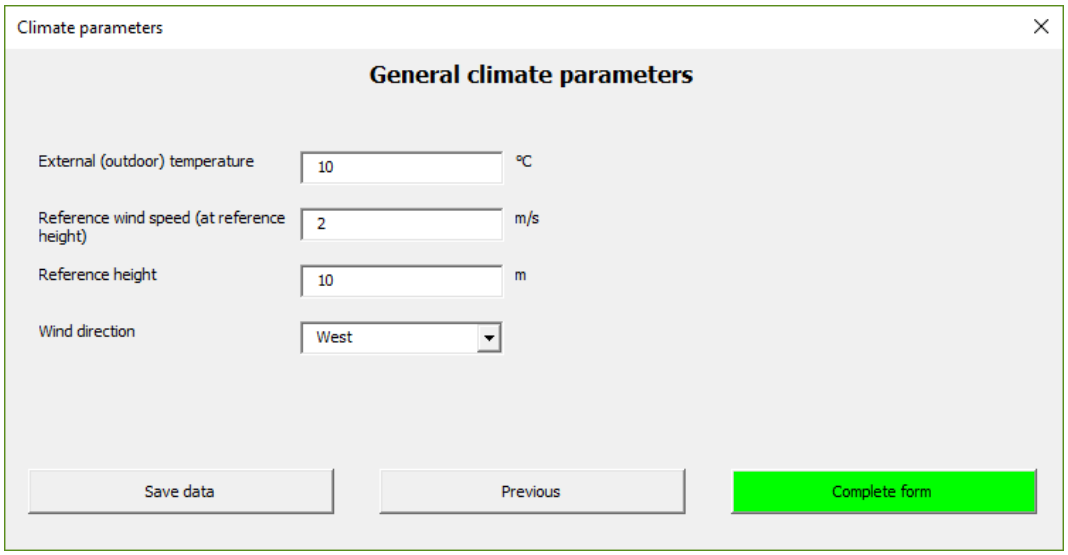


Figure 34: Climate data of the apartment

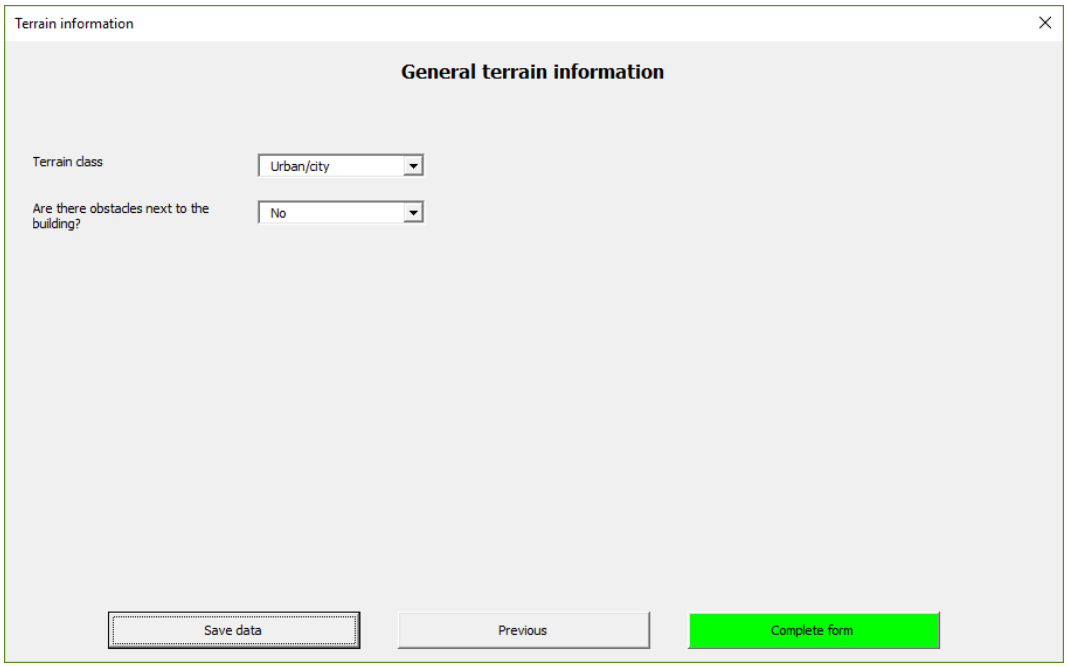


Figure 35: Environmental data of the apartment

Information about the room and all connection of this room - exemplarily for the kitchen - are illustrated in Figure 36 to Figure 38.

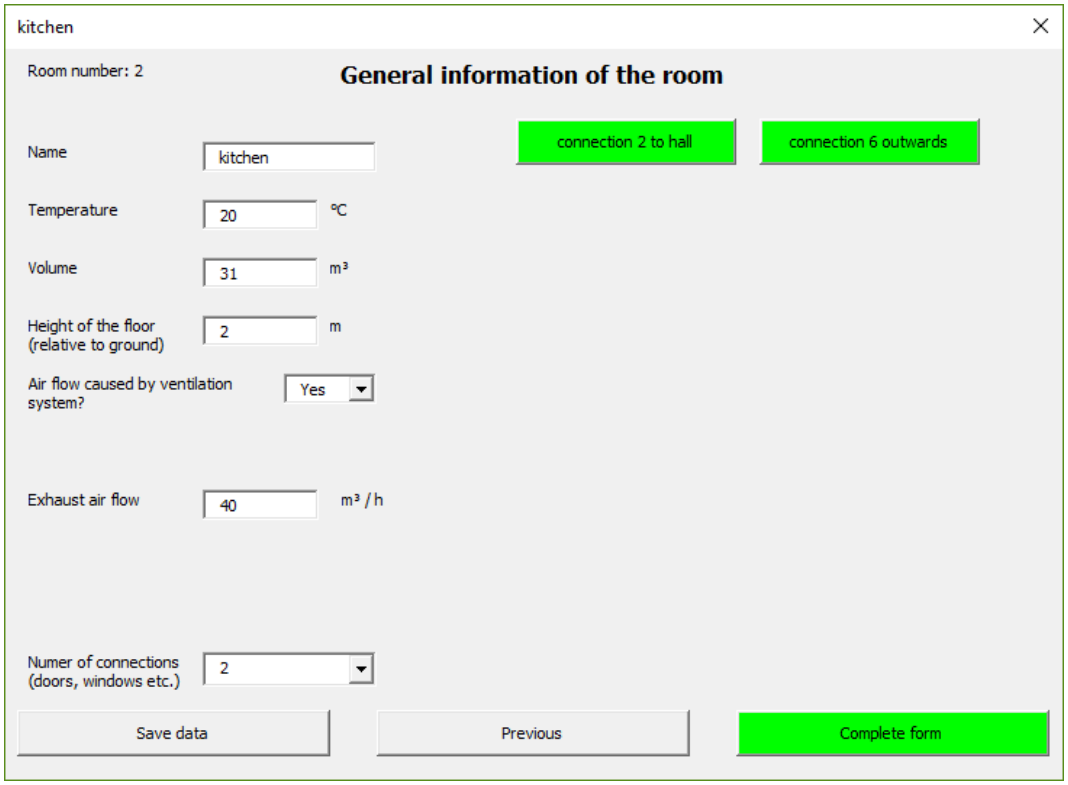


Figure 36: Input mask “General information of the room” for the kitchen

Figure 37: Input mask ”Connection data“ for the kitchen – connection to the hall

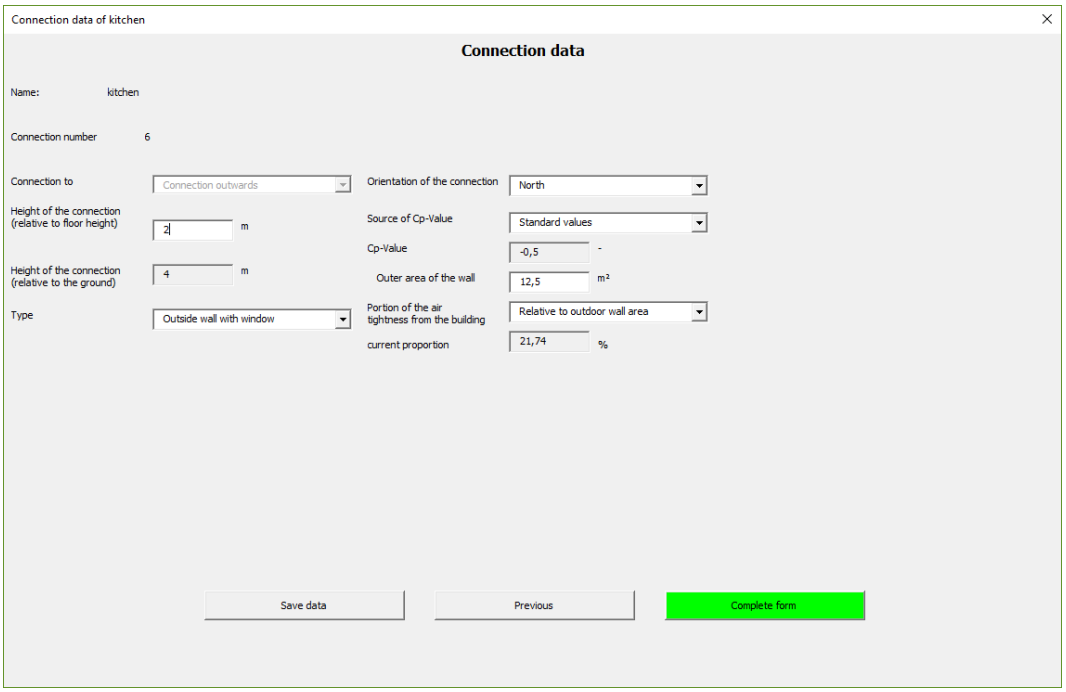


Figure 38: Input mask “Connection data” for the kitchen – connection to the outside

The following tables show the results of the calculation for the apartment.

Building air infiltration and exfiltration - calculation tool

Designer		**Object**	
Date	14.01.2019	**Name**	Joe Bloggs
Comments		**Street**	Sample Street 1
		Code	12345
		Location	Sampleburg
		Country	Germany

Calculation details

m³/h

Room	Temper-ature [°C]	Volume [m³]	Height [m]	supply air flow [m³ / h]	exhaust air flow [m³ / h]	supply air temperature [°C]	outdoor -air change rate -incl. supply air- [1/h]	air change rate [1/h]	Connection to	Connection number	air flow through the connection [m³ / h]	Pressure losses Δp [Pa]
hall	20	31	2	0	0	10	0,05	2,28	outside	1	-1,68	0,42
									kitchen	2	33,75	0
									bedroom	3	-34,34	0,51
									living-room	4	-34,63	0
									bathroom	5	36,96	0,57
kitchen	20	31	2	0	40	10	0,19	1,28	hall	2	-33,75	0
									outside	6	-6,04	1,06
bedroom	18	50	2	0	0	10	0,67	0,67	hall	3	34,34	0,51
									outside	7	-2,39	0,27
									outside	8	-8,98	2,63
									outside	9	-22,02	2,08

Room	Temper-ature [°C]	Volume [m³]	Height [m]	supply air flow [m³ / h]	exhaust air flow [m³ / h]	supply air temperature [°C]	outdoor -air change rate -incl. supply air- [1/h]	air change rate [1/h]	Connection to	Connection number	air flow through the connection [m³ / h]	Pressure losses Δp [Pa]
living-room	22	50	2	0	0	10	0,66	0,66	hall	4	34,63	0
									outside	10	-9,53	2,87
									outside	11	-23,68	2,41
bathroom	24	31	2	0	40	10	0,08	1,27	hall	5	-36,96	0,57
									outside	12	-2,42	0,77

General information

Building information

Number of rooms	5	-
Building height	10	m
aspect ratio	2:1	-
roof slope	10 ° - 30 °	-
Leackages characteristics	n (relative to indoor volume)	-
Pressure difference	50	1/h
Value of air tightness	2	h-1
Exponent n	0,67	-

Calculated flat

Indoor volume	193	m³
Outer envelope	0	m²
Floor area	0	m²

Ventilation system

System existing?	Yes	-
System arrangement	Central ventilation unit (constant volume flows)	-
System	Exhaust air ventilation	-
Supply air temperature	-	-
Value of supply air temperature	-	°C
Temperature ratio	-	%

Extactness specifications

Maximum number of iteration steps	/	-
accuracy limit (∑dm)	/	-
automatic optimization of the exactness data?	Yes	-
Maximum deviation/inaccuracy related to the minimum volume flow in the system	5,05	%
Necessary number of iteration steps	70	-
calculation time	00:00:00	-

General climate and terrain parameters

External (outdoor) temperature	10	°C
reference wind speed	2	m/s
reference height	10	m
wind direction	West	-
Wind speed in a height of 10m	2,0	m/s

connection data										
start	end	number	type	orientation	Cp-value [-]	wall area [m²]	portion of building leakage [%]	height (absolut) [m]	flow coefficient [m³/(s*Pa^n)]	Exponent n [-]
hall	outside	1	Outside wall with door	East	-0,7	6,25	10,87	3	-	0,67
kitchen	hall	2	Door	-	-	-	-	3	2,78E+02	0,67
bedroom	hall	3	Door	-	-	-	-	3	1,50E-02	0,67
living-room	hall	4	Door	-	-	-	-	3	2,78E+02	0,67
bathroom	hall	5	Door	-	-	-	-	3	1,50E-02	0,67
kitchen	outside	6	Outside wall with window	North	-0,5	12,5	21,74	4	-	0,67
bedroom	outside	7	Outside wall with window	North	-0,5	12,5	21,74	4	-	0,67
bedroom	outside	8	Outside wall with window	West	0,5	10	17,39	4	-	0,67
bedroom	outside	9	Air inlet	West	0,5		0	4,25	4,39E-03	0,50
living-room	outside	10	Outside wall with window	West	0,5	10	17,39	4	-	0,67
living-room	outside	11	Air inlet	West	0,5		0	4,25	4,39E-03	0,50
bathroom	outside	12	Outside wall with window	East	-0,7	6,25	10,87	4	-	0,67

Example 2: Small mid-terrace house

In the second example the building in- and exfiltration air flows of a small mid-terrace house is calculated. Figure 39 shows the floor plan of the house. The numbers in the boxes (green) illustrate the connections.

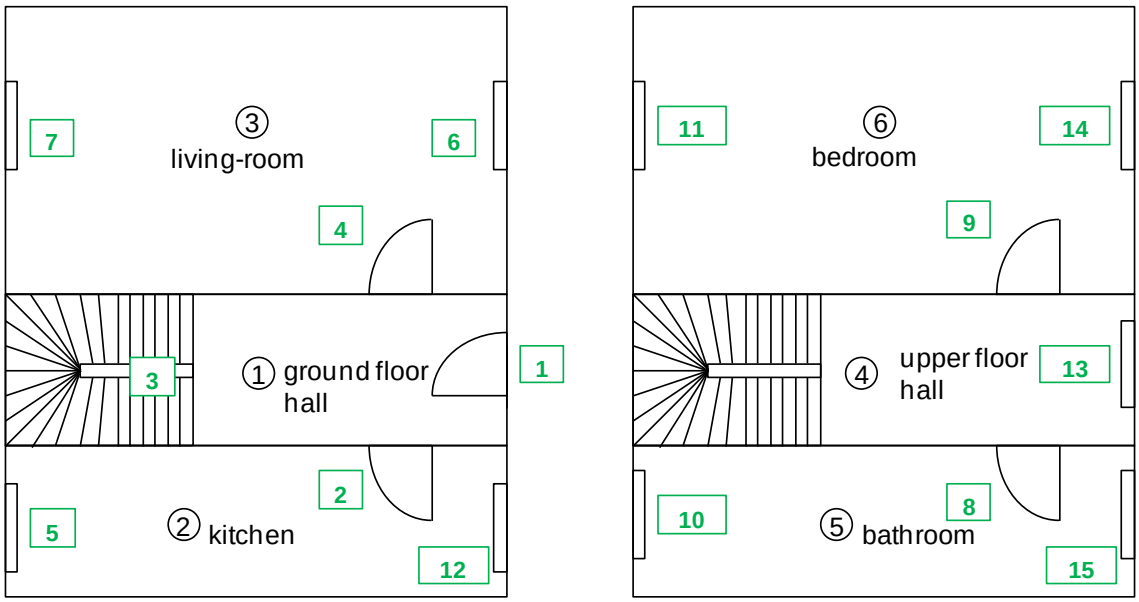


Figure 39: Floor plan of the mid-terrace house (left: ground floor, right: upper floor)

Figure 40 bis Figure 42 show the conditions for the house regarding to general information about the building (Step 3:), the climate data (Step 4: Climate parameters) and the environmental data (Step 5: Terrain information).

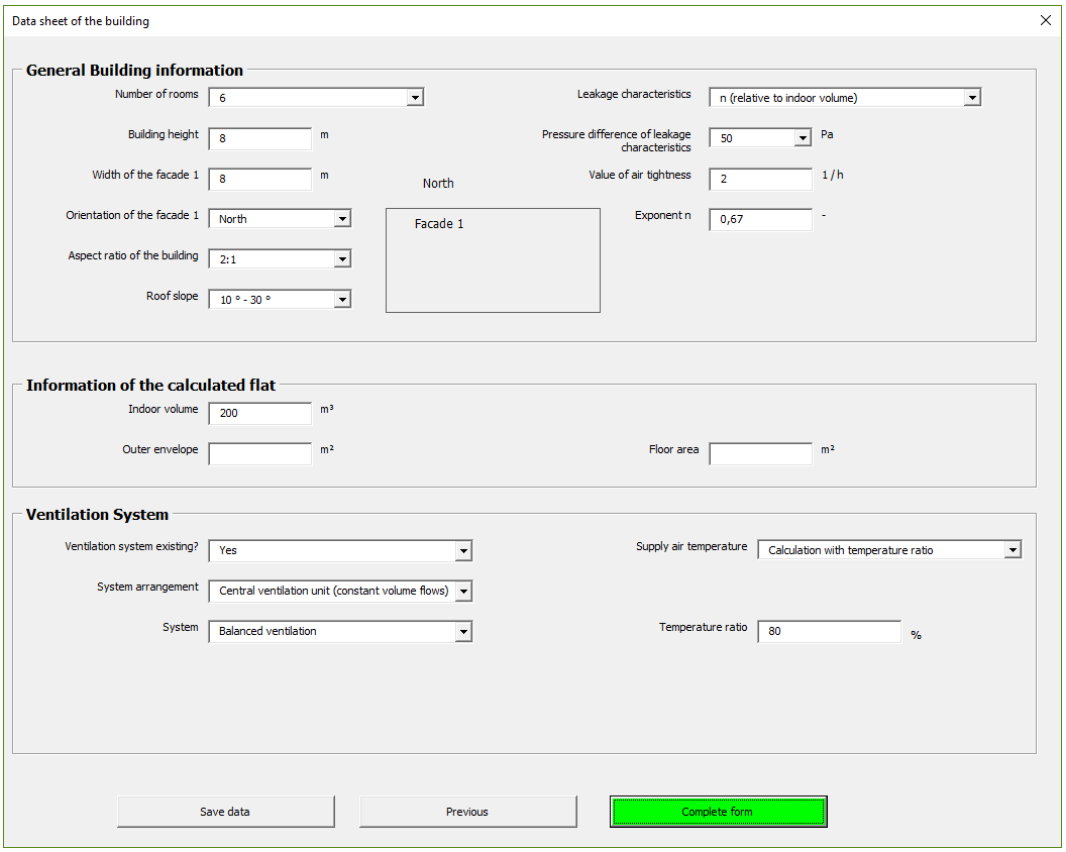


Figure 40: General data about the house

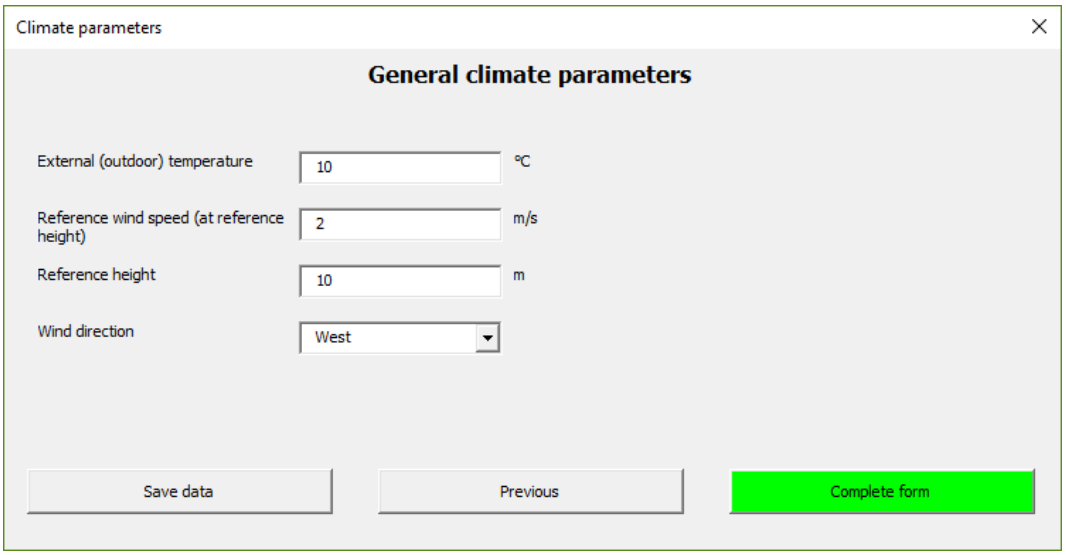


Figure 41: Climate data of the house

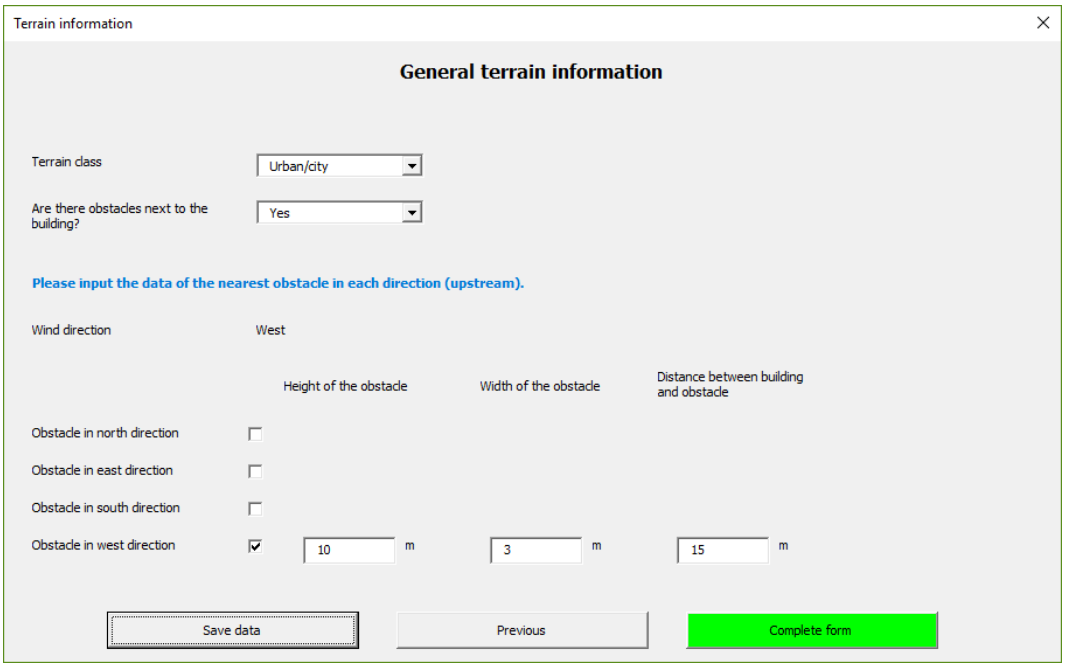


Figure 42: Environmental data of the house

Information about the room and all connection of this room - exemplarily for the living-room - are illustrated in Figure 43 to Figure 46.

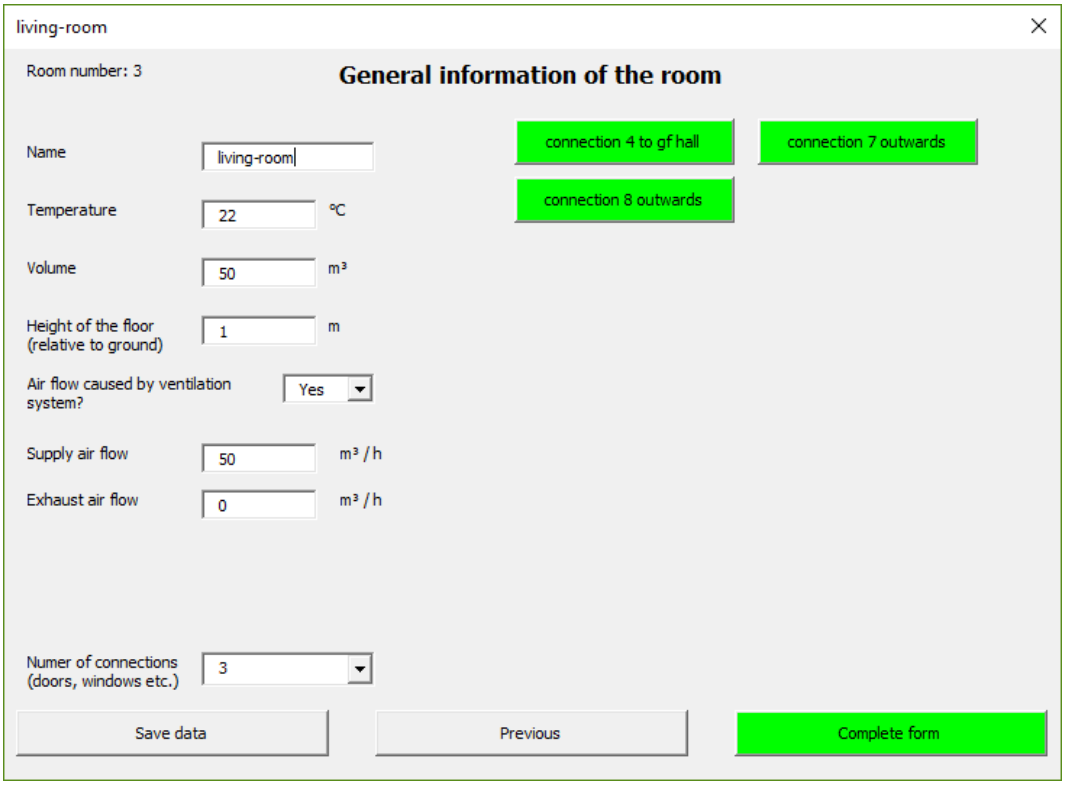


Figure 43: Input mask „“General information of the room” for the living-room

Figure 44: Input mask “Connection data” for the living-room – connection to the ground floor hall

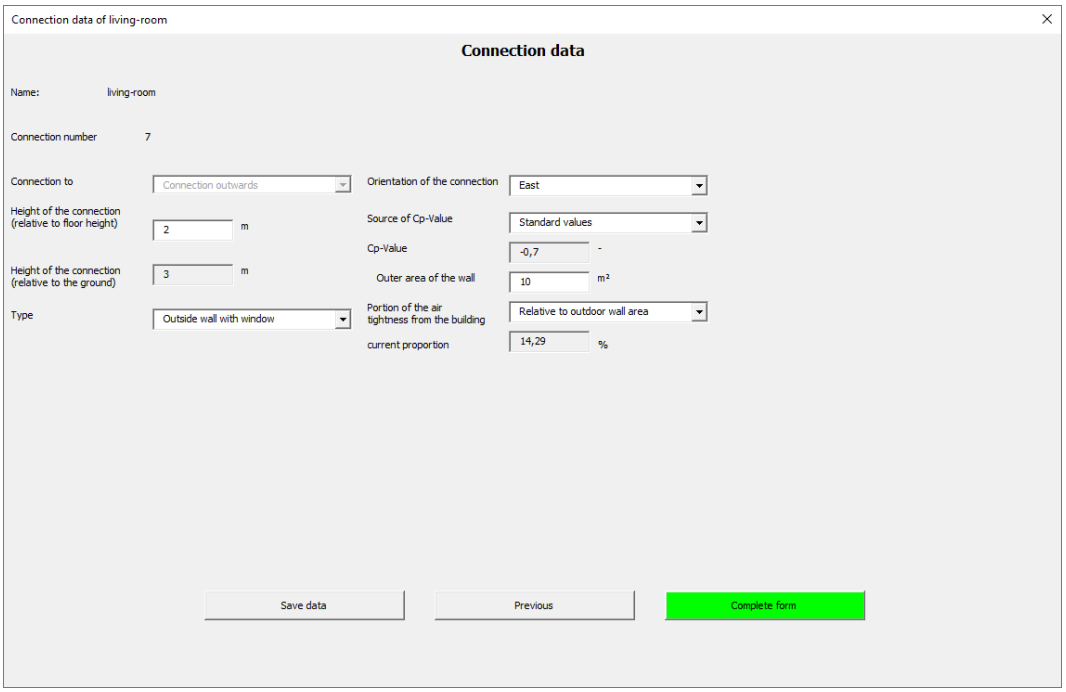


Figure 45: Input mask “Connection data” for the living-room – connection to the outside 1

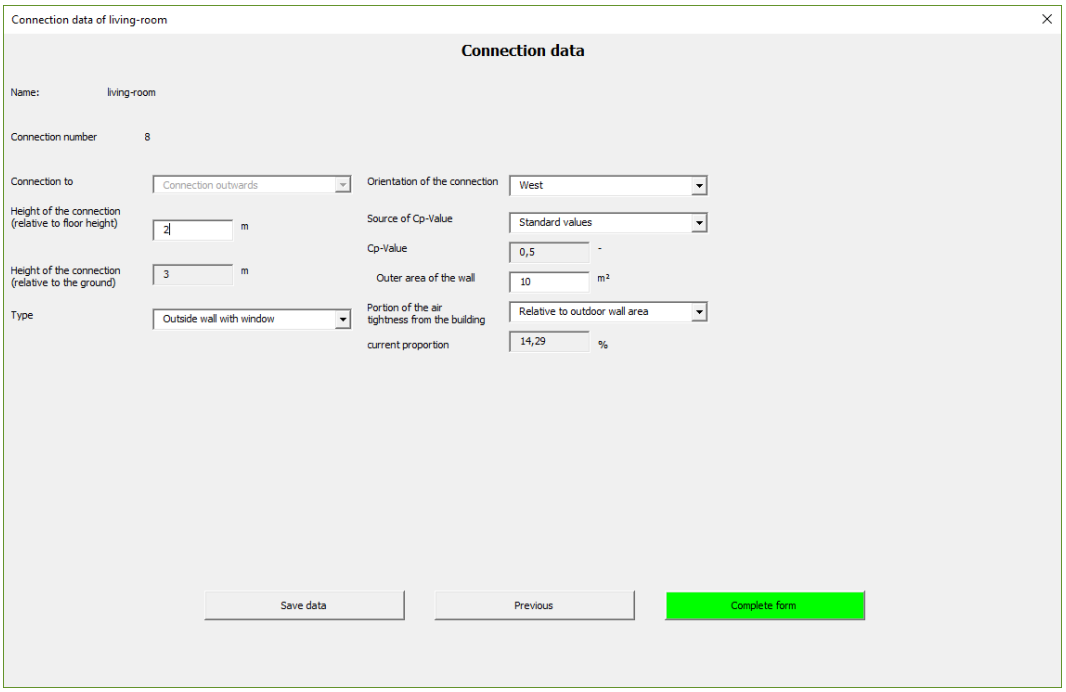


Figure 46: Input mask “Connection data” for the living-room – connection to the outside 2

The following tables show the results of the calculation for the house.

Building air infiltration and exfiltration - calculation tool

Designer		**Object**	
Date	14.01.2019	**Name**	Joe Bloggs
Comments		**Street**	Sample Street 1
		Code	12345
		Location	Sampleburg
		Country	Germany

Calculation details

Room	Temper-ature [°C]	Volume [m³]	Height [m]	supply air flow [m³ / h]	exhaust air flow [m³ / h]	supply air temperature [°C]	outdoor -air change rate -incl. supply air- [1/h]	air change rate [1/h]	Connection to	Connection number	air flow through the connection [m³ / h]	Pressure losses Δp [Pa]
gf hall	20	25	1	0	0	19,27	0	2,18	outside	1	0,72	0,23
									kitchen	2	53,32	0,99
									uf hall	3	-1,3	0
									living-room	4	-53,1	0
kitchen	20	25	1	0	60	19,27	0,26	2,39	gf hall	2	-53,32	0,99
									outside	5	-5,07	4,06
									outside	6	-1,38	0,58
living-room	22	50	1	50	0	19,27	1,14	1,14	gf hall	4	53,1	0
									outside	7	4,85	1,28
									outside	8	-7,18	2,4

Room	Temper-ature [°C]	Volume [m³]	Height [m]	supply air flow [m³ / h]	exhaust air flow [m³ / h]	supply air temperature [°C]	outdoor -air change rate -incl. supply air- [1/h]	air change rate [1/h]	Connection to	Connection number	air flow through the connection [m³ / h]	Pressure losses Δp [Pa]
uf hall	20	25	3,75	0	0	19,27	0	1,68	gf hall	3	1,3	0
									bathroom	9	38,17	0,6
									bedroom	10	-42	0,7
									outside	11	2,82	1,57
bathroom	24	25	3,75	0	40	19,27	0,13	1,66	uf hall	9	-38,17	0,6
									outside	12	-3,35	2,19
									outside	13	2,2	1,06
bedroom	18	50	3,75	50	0	19,27	1	1	uf hall	10	42	0,7
									outside	14	1,19	0,18
									outside	15	6,6	2,01

General information									
Building information				**Ventilation system**				**General climate and terrain parameters**	
Number of rooms	6	-		System existing?	Yes	-		External (outdoor) temperature	10	°C
Building height	8	m		System arrangement	Central ventilation unit (constant volume flows)	-		reference wind speed	2	m/s
aspect ratio	2:1	-		System	Balanced ventilation	-		reference height	10	m
roof slope	10 ° - 30 °	-		Supply air temperature	-	-		wind direction	West	-
Leackages characteristics	n (relative to indoor volume)	-		Value of supply air temperature	Calculation with temperature ratio	°C				
Pressure difference	50	1/h		Temperature ratio	80	%		Wind speed in a height of 10m	2,0	m/s
Value of air tightness	2	h-1								
Exponent n	0,67	-		**Extactness specifications**						
				Maximum number of iteration steps	/	-				
Calculated flat				accuracy limit (∑dm)	/	-				
Indoor volume	200	m³		automatic optimization of the exactness data?	Yes	-				
Outer envelope	0	m²		Maximum deviation/inaccuracy related to the minimum volume flow in the system	6,06	%				
Floor area	0	m²		Necessary number of iteration steps	70	-				
				calculation time	00:00:00	-				

connection data										
start	end	number	type	orientation	Cp-value [-]	wall area [m²]	portion of building leakage [%]	height (absolut) [m]	flow coefficient [m³/(s*Pa^n)]	Exponent n [-]
gf hall	outside	1	Outside wall with door	East	-0,7	5	7,14	2	-	0,67
kitchen	gf hall	2	Door	-	-	-	-	2	1,50E-02	0,67
uf hall	gf hall	3	Open passage	-	-	-	-	3,625	2,78E+02	0,67
living-room	gf hall	4	Door	-	-	-	-	2	2,78E+02	0,67
kitchen	outside	5	Outside wall with window	West	0,5	5	7,14	3	-	0,67
kitchen	outside	6	Outside wall with window	East	-0,7	5	7,14	3	-	0,67
living-room	outside	7	Outside wall with window	East	-0,7	10	14,29	3	-	0,67
living-room	outside	8	Outside wall with window	West	0,5	10	14,29	3	-	0,67
bathroom	uf hall	9	Door	-	-	-	-	4,75	1,50E-02	0,67
bedroom	uf hall	10	Door	-	-	-	-	4,75	1,50E-02	0,67
uf hall	outside	11	Outside wall with window	East	-0,7	5	7,14	5,75	-	0,67
bathroom	outside	12	Outside wall with window	West	0,5	5	7,14	5,75	-	0,67
bathroom	outside	13	Outside wall with window	East	-0,7	5	7,14	5,75	-	0,67
bedroom	outside	14	Outside wall with window	West	0,5	10	14,29	5,75	-	0,67
bedroom	outside	15	Outside wall with window	East	-0,7	10	14,29	5,75	-	0,67

5 Bibliography

[1] F. Eibisch, Luftvolumenströme durch In- und Exfiltration an Gebäuden – Entwicklung eines physikalisch hergeleiteten, analytischen Berechnungsalgortihmus und Umsetzung in einem excelbasierten Planungstool, bachelor's thesis, 2013

[2] EN 15242, Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration, 10772 Berlin: Beuth Verlag GmbH, German version EN 15242:2007

[3] EN 13829, Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:1996, modified), 10772 Berlin: Beuth Verlag GmbH, German version EN 13829:2001

[4] DIN 1946-6, Raumlufttechnik- Teil 6: Lüftung von Wohnungen – Allgemeine Anforderungen zur Bemessung, Ausführung und Kennzeichnung, Übergabe/Übernahme (Abnahme) und Instandhaltung, [Ventilation and air conditioning - Part 6: Ventilation for residential buildings - General requirements, requirements for measuring, performance and labeling, delivery/acceptance (certification) and maintenance], 10772 Berlin: Beuth Verlag GmbH, 2009.