

## IDA ICE CIBSE-Validation

### Test of IDA Indoor Climate and Energy version 4.0 according to CIBSE TM33, issue 3

## Report

### 2007-12-17

## **Imprint**

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<b>Filename</b>	r_20070314_ICE-Validation-CIBSE_V1.2.doc	

## Abstract

Test	Result	Remarks
G1	( <del>✗</del> )	Slight overprediction of radiation in the morning.
G2	<del>✗</del>	
G3	<del>✗</del>	G3.1: The wall construction dialog of IDA ICE presents U-value for external walls only. As this U-value is not used in the simulation, this is not a failure of the simulation code.
G4	<del>✗</del>	
G5	<del>✗</del>	
G6	<del>✗</del>	TM33 Reference model is not specified concerning sky temperature. Model for irradiative heat to the room has to be simplified in order to correspond to the TM33 reference model. Definition of resultant temperature? The TM33 reference results seem to be incorrect...?
G7	<del>✗</del>	
G8	<del>✗</del>	ICE long wave radiation model has to be simplified in order to correspond to the TM33 reference model.
G9	<del>✗</del>	
G10	<del>✗</del>	
E1	( <del>✗</del> )	A <del>✗</del> B <del>✗</del> C <del>✗</del> Cooling load is correct.
		D <del>✗</del> E( <del>✗</del> ) - Min. temp. too low F <del>✗</del>

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# 1. Test G1: Database

## 1.1 Implementation in IDA ICE

### 1.1.1 Test G1A: Building material thermal properties

The requested building materials are implemented in CIBSE\_G1-31.idm and in the database of UK localization of IDA ICE:

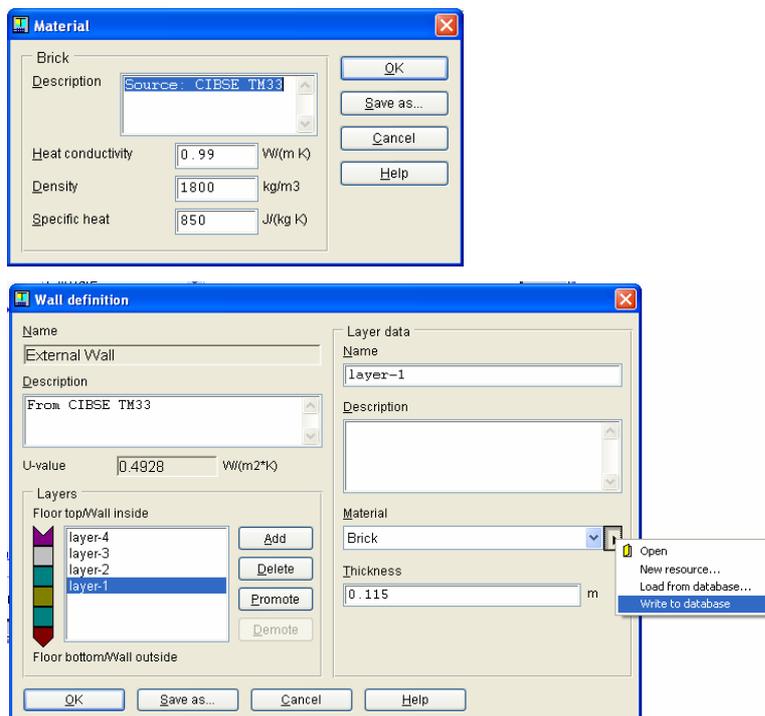


Figure 1: Writing material properties to the IDA ICE database

### 1.1.2 Test G1B: Climate data

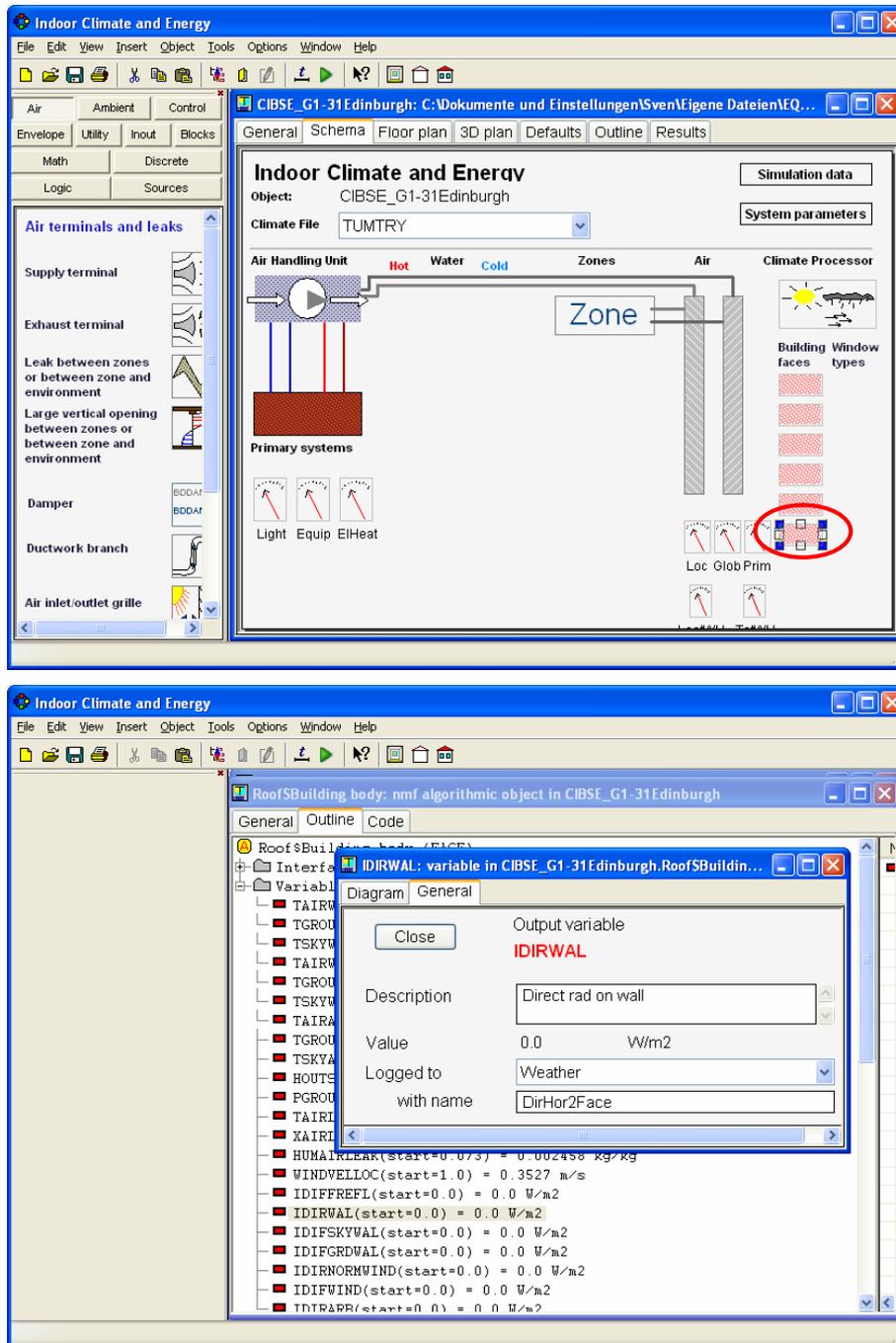
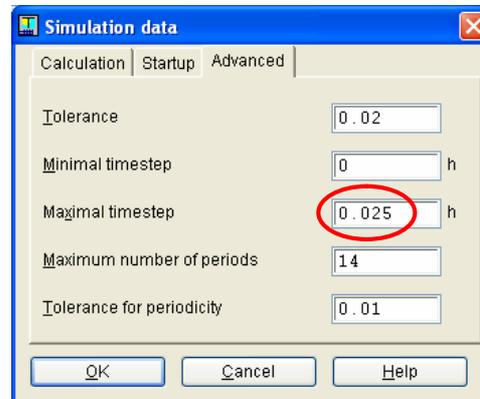
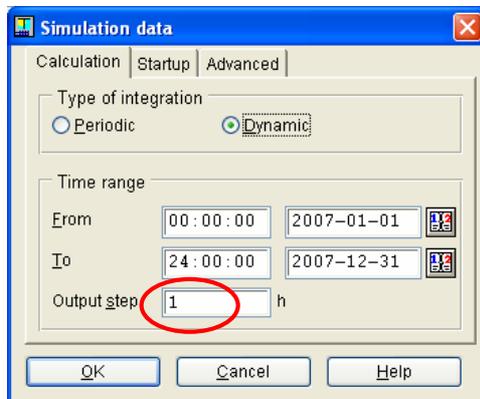


Figure 2: 3 variables of the roof face model to be logged to any output-file.



### 1.1.3 Test G1C: Loads and schedules

The database for occupancy load related to Building Regulations (UK National Calculation Methodology [2]) is implemented in the UK localization of IDA ICE.

The activity level affects the metabolic heat rate from occupancies to the zone:

$$\text{Heat rate per person} = 104.4 * \text{met}$$

The latent percentage of the heat from occupants is not normally chosen, as it is calculated by the program based on Fanger's correlations. To get a fixed rate, a person may also be represented by a piece of equipment with given moisture and CO<sub>2</sub> loads.

## 1.2 Results

### 1.2.1 Test G1A: Building material thermal properties

<ul style="list-style-type: none"> <li>■ Acoustic tile                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.06 W/(m K)</li> <li>■ Density = 400 kg/m<sup>3</sup></li> <li>■ Specific heat = 840 J/(kg K)</li> </ul> </li> <li>■ Asbestos cement                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.36 W/(m K)</li> <li>■ Density = 700 kg/m<sup>3</sup></li> <li>■ Specific heat = 1000 J/(kg K)</li> </ul> </li> <li>■ Brick                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.99 W/(m K)</li> <li>■ Density = 1800 kg/m<sup>3</sup></li> <li>■ Specific heat = 850 J/(kg K)</li> </ul> </li> <li>■ Brick inner leaf                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.56 W/(m K)</li> <li>■ Density = 1700 kg/m<sup>3</sup></li> <li>■ Specific heat = 1000 J/(kg K)</li> </ul> </li> <li>■ Carpet                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.058 W/(m K)</li> <li>■ Density = 20 kg/m<sup>3</sup></li> <li>■ Specific heat = 1000 J/(kg K)</li> </ul> </li> <li>■ Cast concrete                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 1.13 W/(m K)</li> <li>■ Density = 2000 kg/m<sup>3</sup></li> <li>■ Specific heat = 1000 J/(kg K)</li> </ul> </li> <li>■ Cement screed                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 1.4 W/(m K)</li> <li>■ Density = 2000 kg/m<sup>3</sup></li> <li>■ Specific heat = 850 J/(kg K)</li> </ul> </li> <li>■ Concrete                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 2.1 W/(m K)</li> <li>■ Density = 2400 kg/m<sup>3</sup></li> <li>■ Specific heat = 850 J/(kg K)</li> </ul> </li> <li>■ Covering                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.23 W/(m K)</li> <li>■ Density = 1500 kg/m<sup>3</sup></li> <li>■ Specific heat = 1500 J/(kg K)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>■ EPS insulation 50mm                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.04 W/(m K)</li> <li>■ Density = 15 kg/m<sup>3</sup></li> <li>■ Specific heat = 1300 J/(kg K)</li> </ul> </li> <li>■ Expanded polystyrene                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.035 W/(m K)</li> <li>■ Density = 25 kg/m<sup>3</sup></li> <li>■ Specific heat = 1400 J/(kg K)</li> </ul> </li> <li>■ Glass                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 1.06 W/(m K)</li> <li>■ Density = 2500 kg/m<sup>3</sup></li> <li>■ Specific heat = 1000 J/(kg K)</li> </ul> </li> <li>■ Insulation 1                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.04 W/(m K)</li> <li>■ Density = 30 kg/m<sup>3</sup></li> <li>■ Specific heat = 850 J/(kg K)</li> </ul> </li> <li>■ Insulation 2                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.04 W/(m K)</li> <li>■ Density = 50 kg/m<sup>3</sup></li> <li>■ Specific heat = 850 J/(kg K)</li> </ul> </li> <li>■ Masonry                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.79 W/(m K)</li> <li>■ Density = 1600 kg/m<sup>3</sup></li> <li>■ Specific heat = 850 J/(kg K)</li> </ul> </li> <li>■ Medium weight concrete                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 1.4 W/(m K)</li> <li>■ Density = 1900 kg/m<sup>3</sup></li> <li>■ Specific heat = 1000 J/(kg K)</li> </ul> </li> <li>■ Mineral fibre                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.035 W/(m K)</li> <li>■ Density = 30 kg/m<sup>3</sup></li> <li>■ Specific heat = 1000 J/(kg K)</li> </ul> </li> <li>■ Outer brick                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.84 W/(m K)</li> <li>■ Density = 1700 kg/m<sup>3</sup></li> <li>■ Specific heat = 800 J/(kg K)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>■ Plaster 1                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.7 W/(m K)</li> <li>■ Density = 1400 kg/m<sup>3</sup></li> <li>■ Specific heat = 850 J/(kg K)</li> </ul> </li> <li>■ Plaster 2                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.21 W/(m K)</li> <li>■ Density = 900 kg/m<sup>3</sup></li> <li>■ Specific heat = 850 J/(kg K)</li> </ul> </li> <li>■ Plywood sheathing                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.14 W/(m K)</li> <li>■ Density = 530 kg/m<sup>3</sup></li> <li>■ Specific heat = 1800 J/(kg K)</li> </ul> </li> <li>■ Sandstone                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 2.3 W/(m K)</li> <li>■ Density = 2600 kg/m<sup>3</sup></li> <li>■ Specific heat = 1000 J/(kg K)</li> </ul> </li> <li>■ Tiles                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.23 W/(m K)</li> <li>■ Density = 1500 kg/m<sup>3</sup></li> <li>■ Specific heat = 1300 J/(kg K)</li> </ul> </li> <li>■ Timber                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.15 W/(m K)</li> <li>■ Density = 650 kg/m<sup>3</sup></li> <li>■ Specific heat = 1600 J/(kg K)</li> </ul> </li> <li>■ Timber board                             <ul style="list-style-type: none"> <li>■ HEAT-COND = 0.165 W/(m K)</li> <li>■ Density = 650 kg/m<sup>3</sup></li> <li>■ Specific heat = 1600 J/(kg K)</li> </ul> </li> </ul>
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Table 1: Building materials in the IDA ICE database for UK localization.

## 1.2.2 Test G1B: Climate data

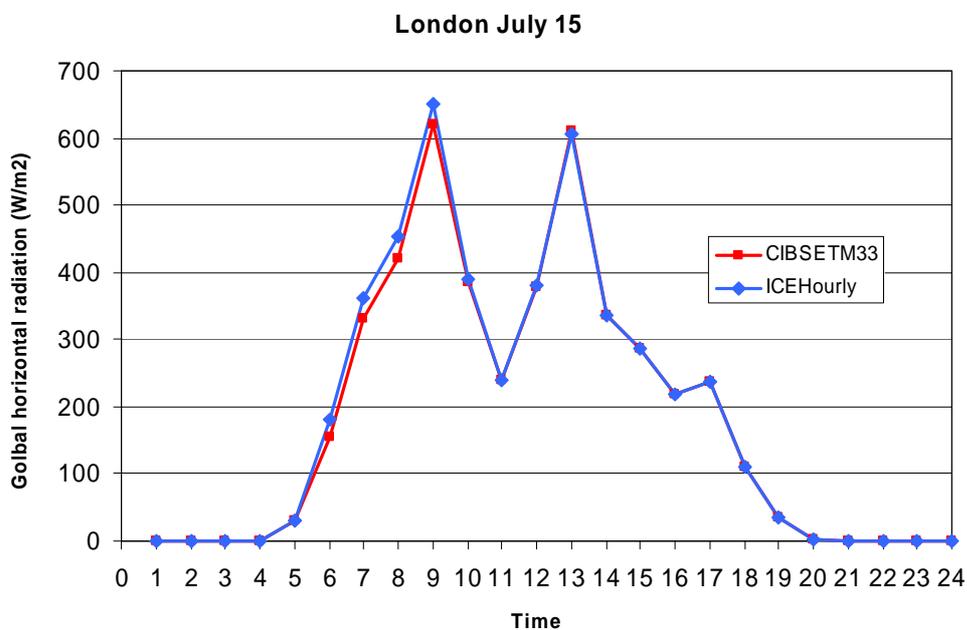


Figure 3: Global horizontal radiation (Maximal timestep = 0.025).

IDA ICE slightly overpredicts the global horizontal radiation in the morning (test G1B). The reason for this is the combination of two facts:

1. The program does not store solar data in terms of radiation on a horizontal surface but rather as beam radiation i.e. direct solar radiation on a surface perpendicular to the ray.
2. IDA ICE relies on instantaneous (spot) measurements of all input (and output) signal, while the CIBSE file shows temperature as spot values and solar radiation as averages of the hour preceding the given measure.

Variable	Basis	Value for stated climate data set					
		London		Manchester		Edinburgh	
		CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4
Temperature (°C)	Jan. 6; 10:00 am	6.1	6.1	-1.3	-1.3	6.6	6.6
	July 15; 2:00 pm	19.1	19.1	15.3	15.3	14.6	14.6
	February average	4.5	4.5	4.8	4.8	2.7	2.7
Wind speed (m/s)	Jan. 6; 10:00 am	5.66	5.67	2.06	2.06	7.2	7.20
	July 15; 2:00 pm	4.63	4.63	4.63	4.63	3.09	3.08
	February average	3.46	3.46	3.24	3.24	4.92	4.93
Global solar radiation (W/m <sup>2</sup> )	Jan. 6; 10:00 am	59	59	67	78	54	56
	July 15; 2:00 pm	336	337	238	239	210	211
	February average	212	212	194	193	189	190

Table 2: Test G1B: Climate data test results.

Hour	Temp / °C	Solar radiation / W/m <sup>2</sup>					
		Global (horiz.)		Diffuse			
		CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4
1	14	14.0	0	0	0	0	
2	13.3	13.3	0	0	0	0	
3	12.2	12.2	0	0	0	0	
4	11	11.0	0	0	0	0	
5	11.5	11.5	30	30	20	20	
6	12.1	12.1	155	181	54	54	
7	13.2	13.2	332	363	131	131	
8	15.1	15.1	420	452	98	98	
9	16.9	16.9	619	652	110	110	
10	17.8	17.8	385	391	269	269	
11	17.5	17.5	239	241	231	231	
12	18.3	18.3	379	380	360	360	
13	19.2	19.2	610	605	409	409	
14	19.1	19.1	336	337	334	334	
15	19.4	19.4	287	287	279	279	
16	18.9	18.9	218	218	216	216	
17	18.8	18.8	238	237	235	235	
18	18.8	18.8	110	109	104	104	
19	18	18.0	35	35	35	35	
20	17	17.0	2	1	1	1	
21	13.4	13.4	0	0	0	0	
22	13	13.0	0	0	0	0	
23	12.9	12.9	0	0	0	0	
24	12.8	12.8	0	0	0	0	

Table 3: Test G1B: Climate data for London, July 15.

### 1.2.3 Test G1C: Loads and schedules

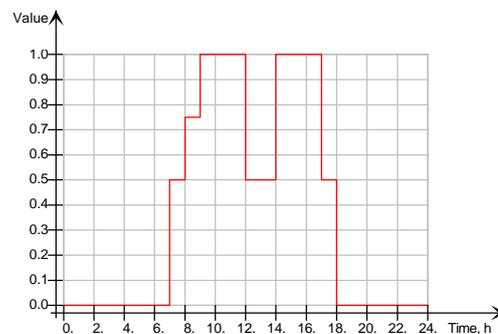
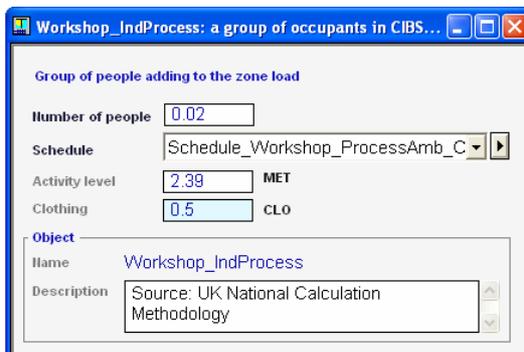
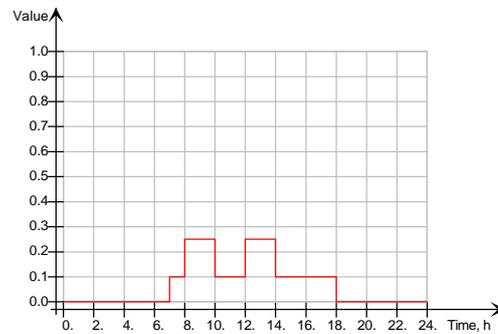
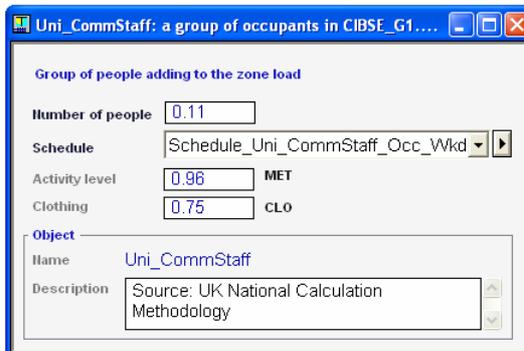
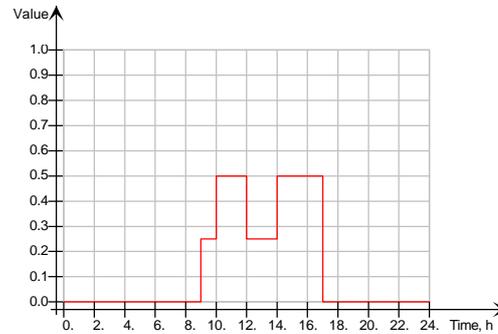
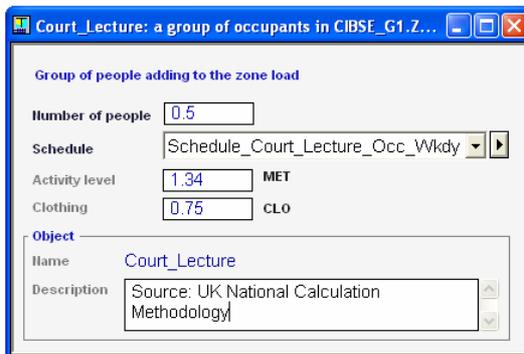
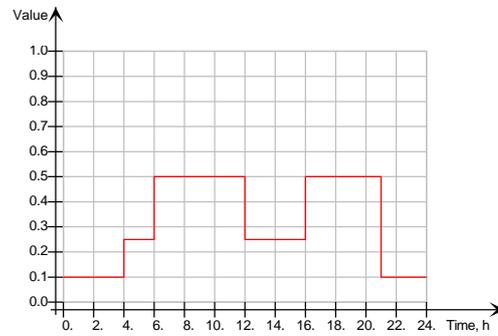
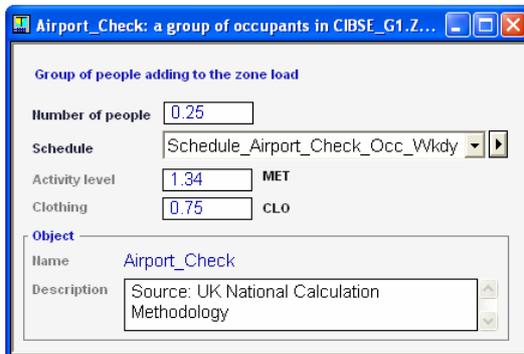


Figure 4: Occupancy schedules in the IDA ICE database for UK localization.

## 2. Test G2: Solar position

### 2.1 Implementation in IDA ICE

**Location**

**Position**

Country: UK  
 City: London, Heathrow  
 Latitude: 51.48 Deg Elevation: 24 m  
 Longitude: 0.45 Deg Time zone: 0 h

**Design days**

	Winter	Summer	
Dry-bulb min	-4.0	18.2	Deg-C
Dry-bulb max	0.6	27.4	Deg-C
Wet-bulb max	-0.2	18.7	Deg-C
Wind direction	20	90	Deg
Wind speed	2.7	4.5	m/s
Clearness number	1.0	1.0	0-1

**Object**

Name: London/Heathrow  
 Description: Data from ASHRAE Fundamentals 2001

Close Save Save as... Help

**Location**

**Position**

Country: UK  
 City: Manchester  
 Latitude: 53.25 Deg Elevation: 78 m  
 Longitude: 2.27 Deg Time zone: 0 h

**Design days**

	Winter	Summer	
Dry-bulb min	-4.2	17.6	Deg-C
Dry-bulb max	-0.4	25.2	Deg-C
Wet-bulb max	-1.1	17.3	Deg-C
Wind direction	90	130	Deg
Wind speed	2.5	3.9	m/s
Clearness number	1.0	1.0	0-1

**Object**

Name: Manchester  
 Description: Data from ASHRAE Fundamentals 2001

Close Save Save as... Help

**Location**

**Position**

Country: UK  
 City: Edinburgh  
 Latitude: 55.95 Deg Elevation: 41 m  
 Longitude: 3.35 Deg Time zone: 0 h

**Design days**

	Winter	Summer	
Dry-bulb min	-5.9	14.0	Deg-C
Dry-bulb max	-1.85	22.1	Deg-C
Wet-bulb max	-2.35	16.3	Deg-C
Wind direction	250	250	Deg
Wind speed	0.7	4.2	m/s
Clearness number	1.0	1.0	0-1

**Object**

Name: Edinburgh  
 Description: Data from ASHRAE Fundamentals 2001

Close Save Save as... Help

## 2.2 Results

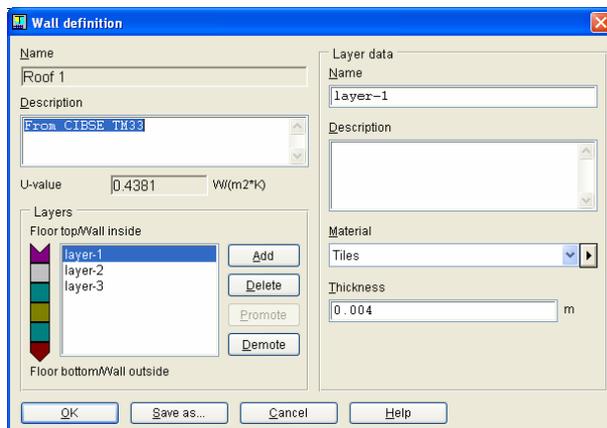
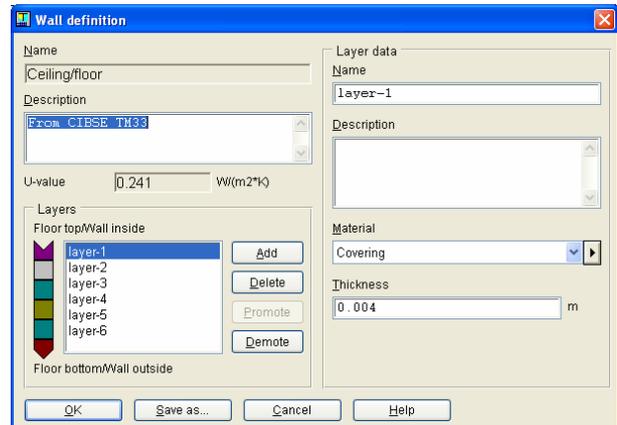
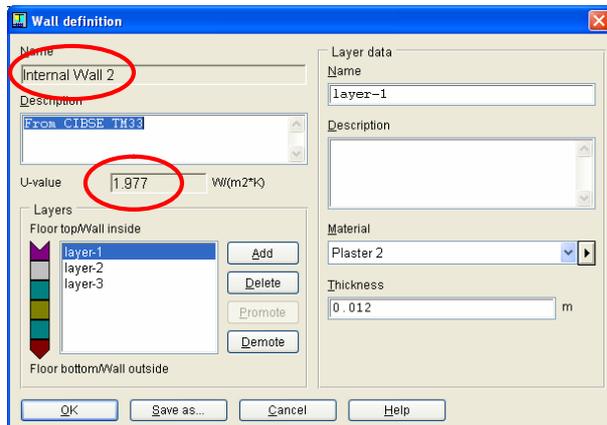
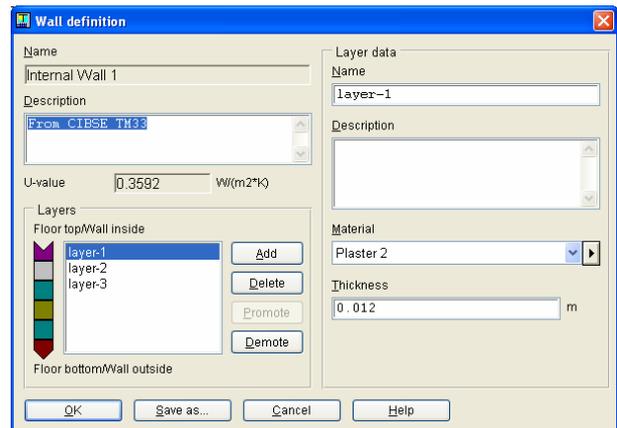
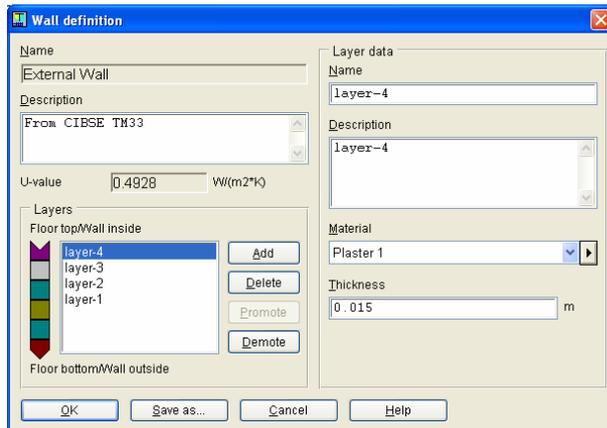
Time (hh/dd/mm)	Azimuth		Altitude		Azimuth		Azimuth		Altitude		Altitude	
	CIBSE TM33	ICE 4										
	1200/22/12	180.0	179.7	177.3	177.0	10.6	10.6	178.3	178.0	13.3	13.3	15.1
1500/27/02	224.1	223.7	220.2	220.0	18.3	17.7	221.9	221.6	19.9	19.3	20.4	19.9
1200/21/06	178.4	178.4	173.7	173.7	57.4	57.4	175.2	175.2	60.1	60.1	62.0	61.9
1000/20/10	151.1	151.6	149.1	149.5	19.7	18.3	149.6	150.1	22.3	21.0	24.4	23.0

Table 4: Test G2

### 3. Test G3: Basic thermal calculations

#### 3.1 Implementation in IDA ICE

##### 3.1.1 Test G3.1 Static conduction test

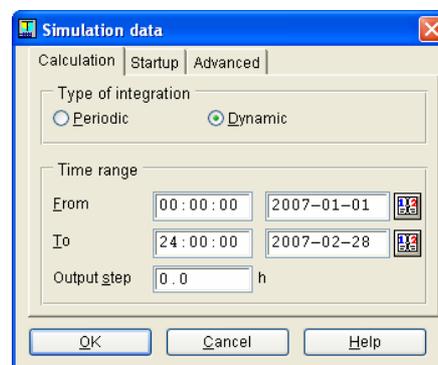
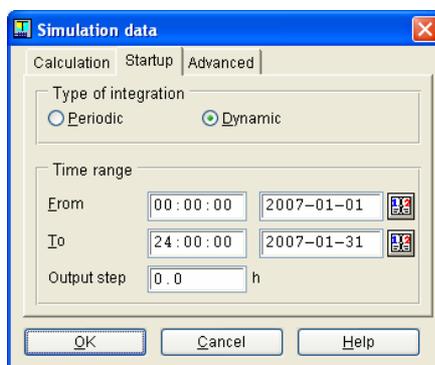


### 3.1.2 Test G3.2: Dynamic conduction test

*Climatic file:*

1	20.00	50.00	0.4253	0.00	0.00	0.00
2	20.00	50.00	0.4253	0.00	0.00	0.00
:						
743	20.00	50.00	0.4253	0.00	0.00	0.00
744	20.00	50.00	0.4253	0.00	0.00	0.00
745	30.00	50.00	0.4253	0.00	0.00	0.00
746	30.00	50.00	0.4253	0.00	0.00	0.00
:						
8759	30.00	50.00	0.4253	0.00	0.00	0.00
8760	30.00	50.00	0.4253	0.00	0.00	0.00

*Simulation data:*



*Building:*

- G3.2.1: 1.4 m x 1.4 m x 1.4 m
- G3.2.2: 1.2 m x 1.2 m x 1.2 m
- G3.2.3: 1.61 m x 1.61 m x 1.61 m
- G3.2.4: 1.61 m x 1.61 m x 1.61 m

*Zone:* 1m x 1m x 1m

*Exhaust air for CAV:*  $10^{-6} \text{ l / (s m}^2\text{)}$

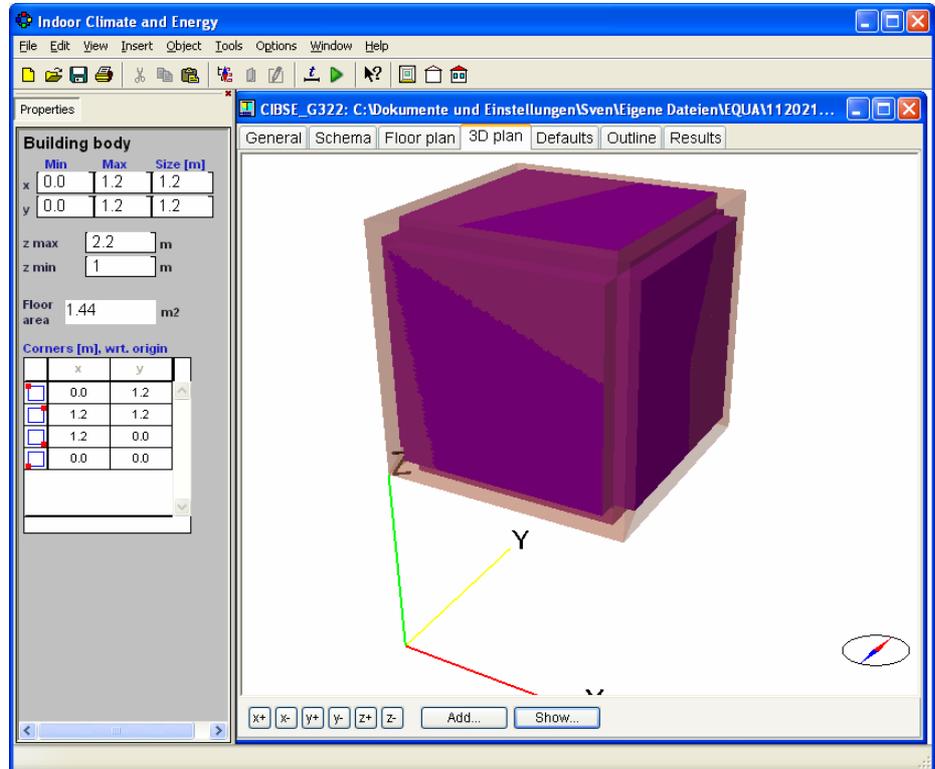
*Controller setpoints:* office, basic control

*Internal loads and masses:* No

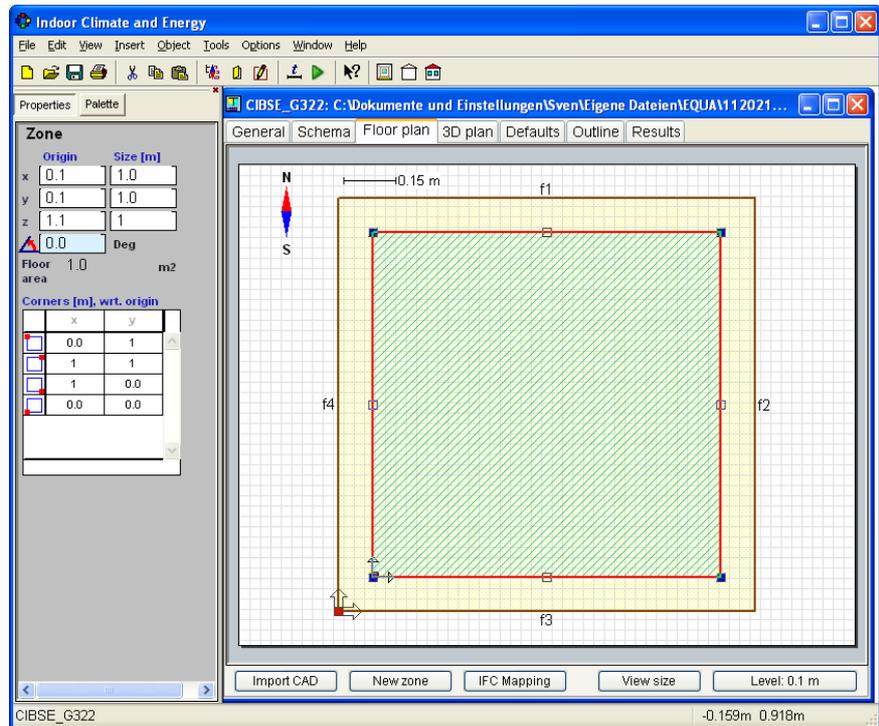
*Wall constructions:* These values can be entered 1:1. But one has to be aware of the fact that the order of the layers is from inside to outside for walls, however from top to bottom for floors and ceilings. Therefore the order of layers of ceilings is the opposite of that of the walls and floors.

*Wall surfaces:* Longwave emissivity  $10^{-6}$

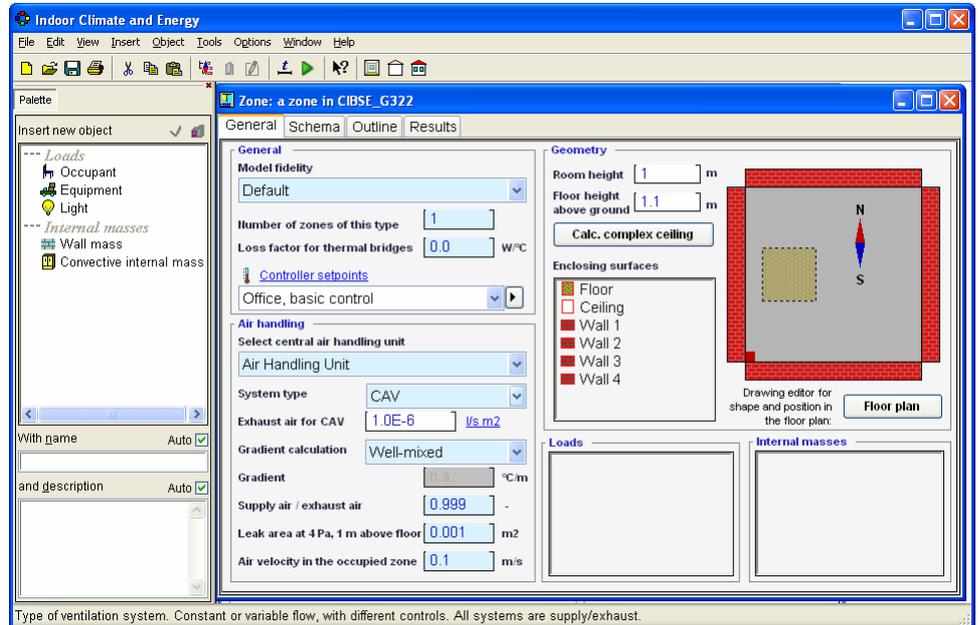
3D plan:



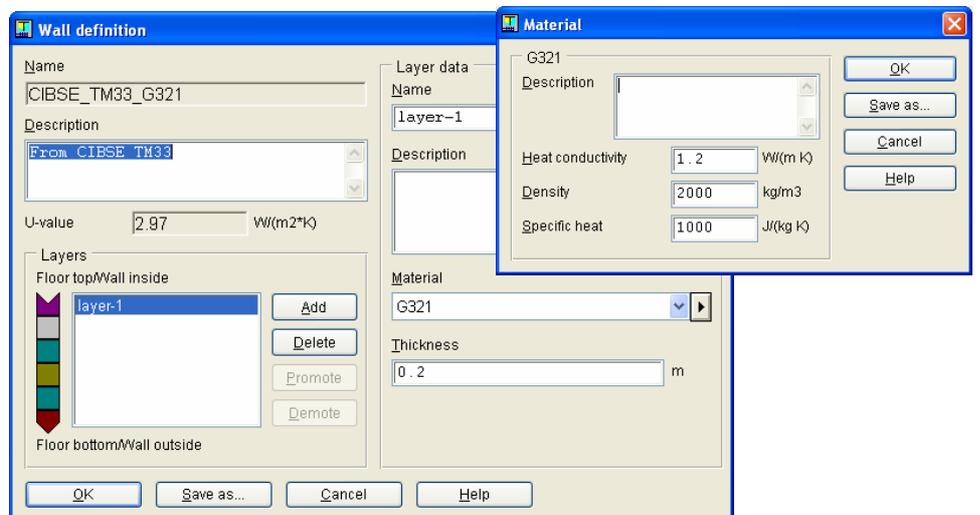
Floor plan:



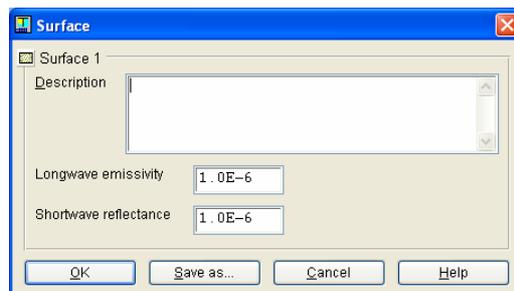
Zone:



Walls:

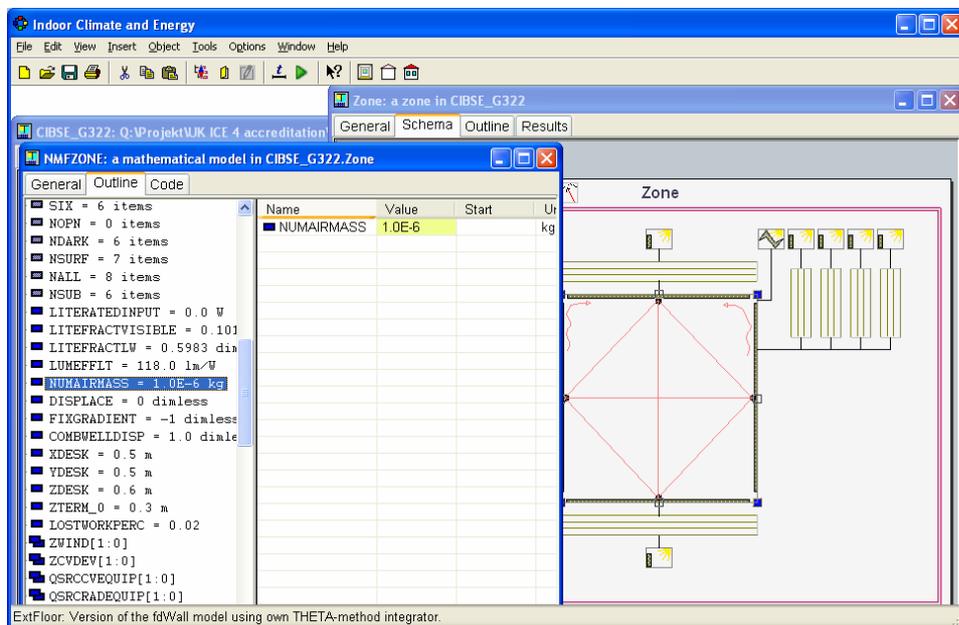


Surfaces:



Advanced level:

Reduce the numerical air mass to close to zero (for test G3.2.2):



### 3.2 Results

Construction	Transmittance /W m <sup>-2</sup> K <sup>-1</sup>	
	CIBSE TM33	ICE
External wall	0.49	0.49
Internal wall 1	0.35	Not presented
Internal wall 2	1.68	Not presented
Floor (upward heat flow)	0.24	0.24
Ceiling (downward heat flow)	0.23	0.24
Roof 1 (Upward heat flow)	0.44	0.44
Window 1	2.94	Not presented
Window 2	1.72	Not presented

Table 5: Test G3.1: Derived properties test results.

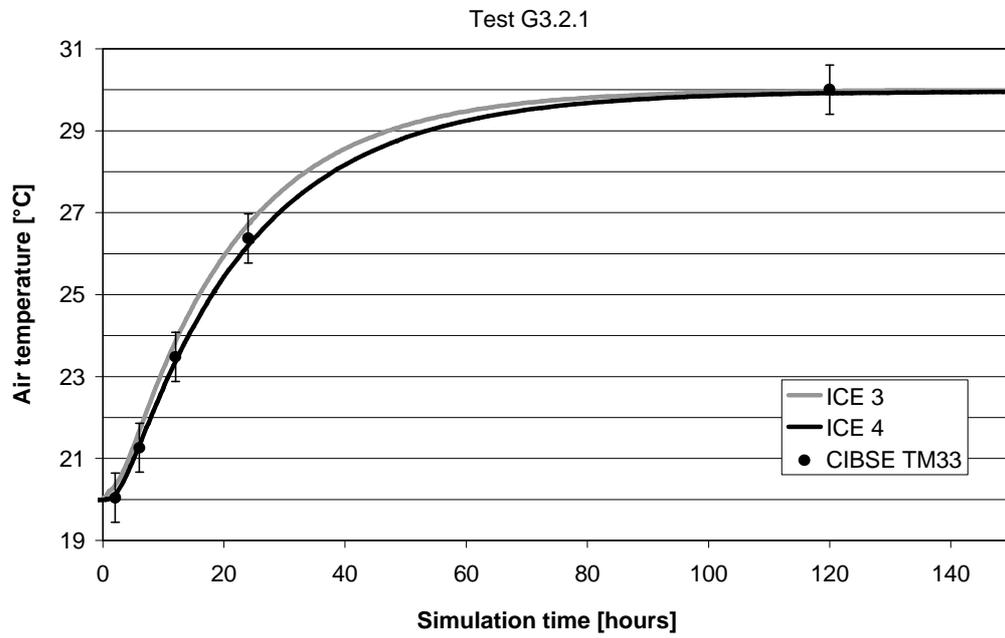


Figure 5: Test G3.2.1 results.

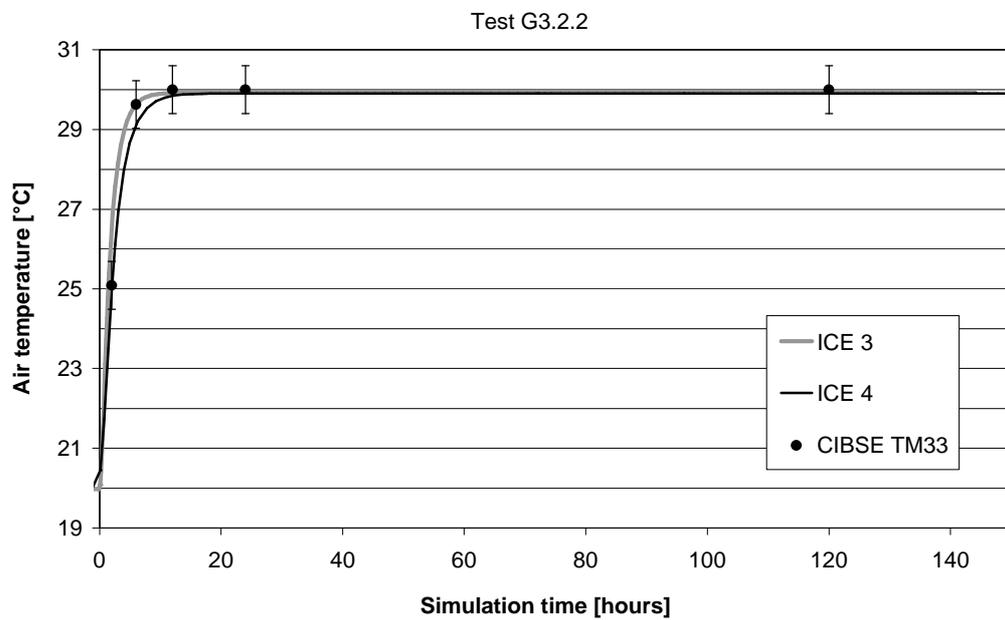


Figure 6: Test G3.2.2 results.

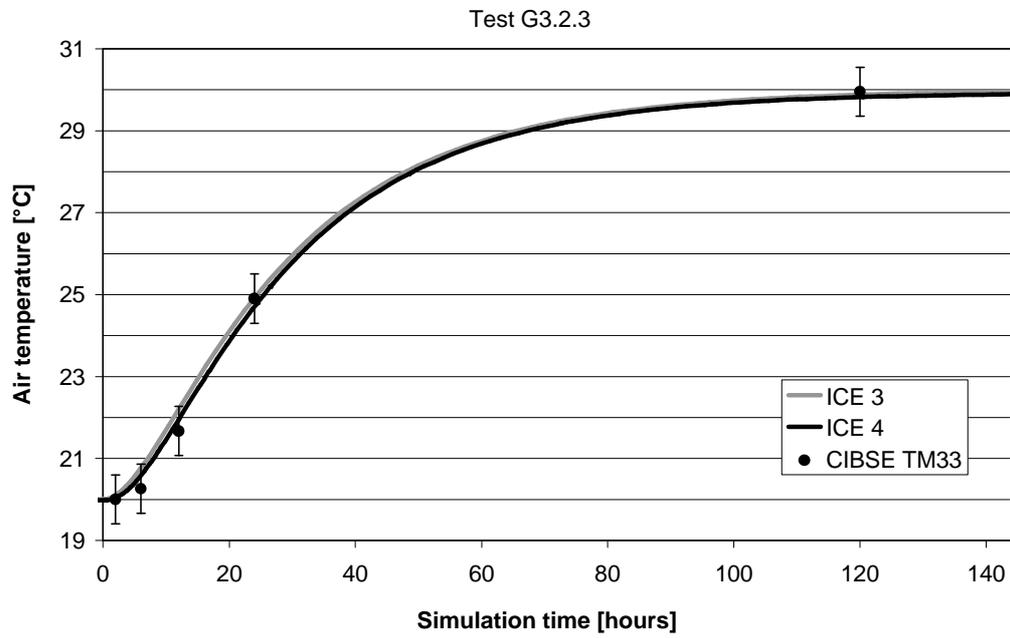


Figure 7: Test G3.2.3 results.

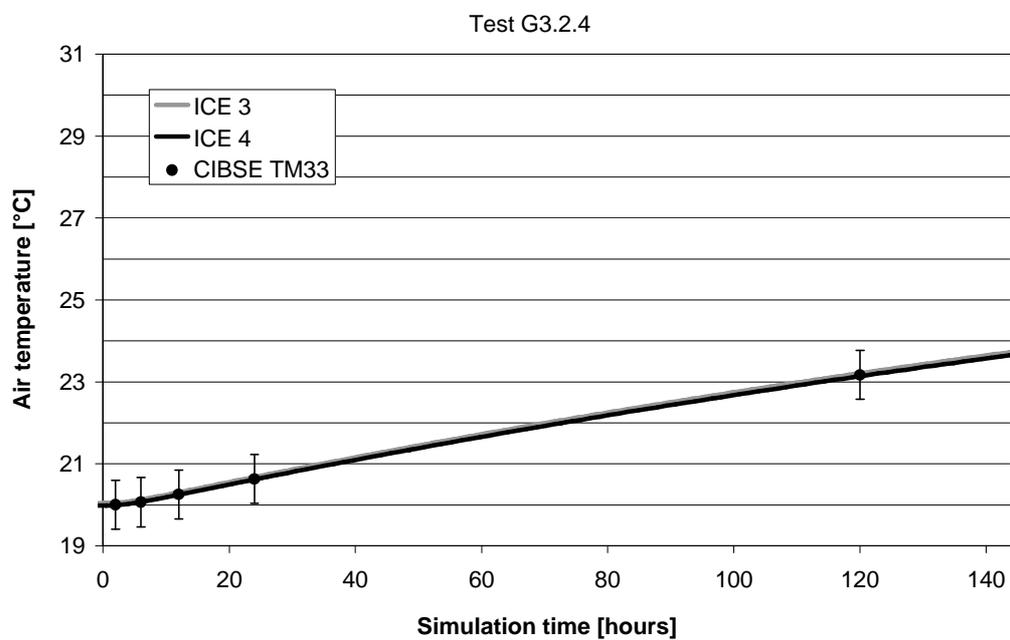


Figure 8: Test G3.2.4 results.

## 4. Test G4: Solar shading

### 4.1 Implementation in IDA ICE

*Location:*

*Climatic file:*

Not important

*Simulation data:*

*Building:*

Big enough

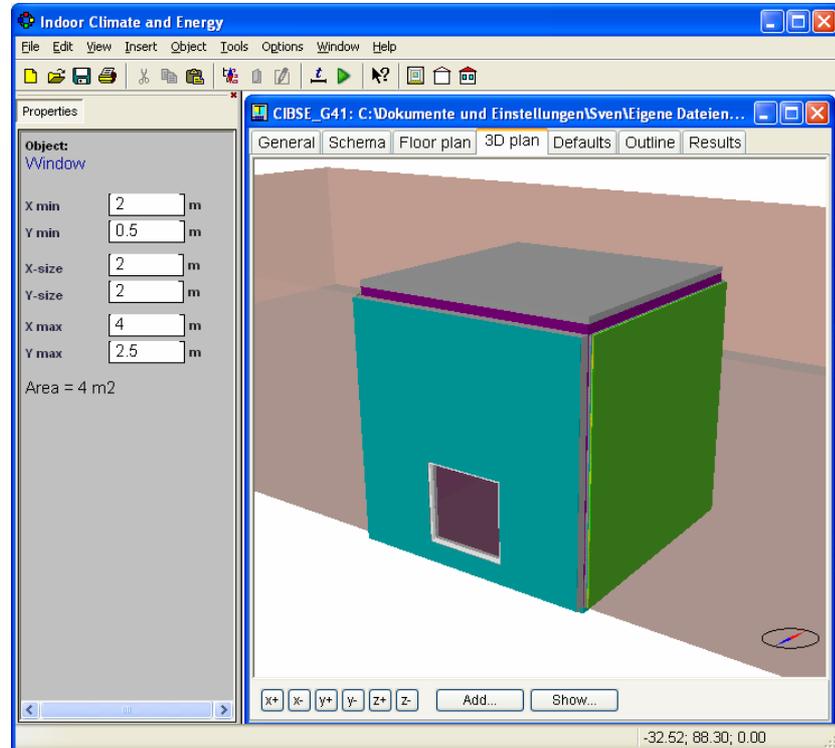
*Zone:*

6m x 6m x 6m

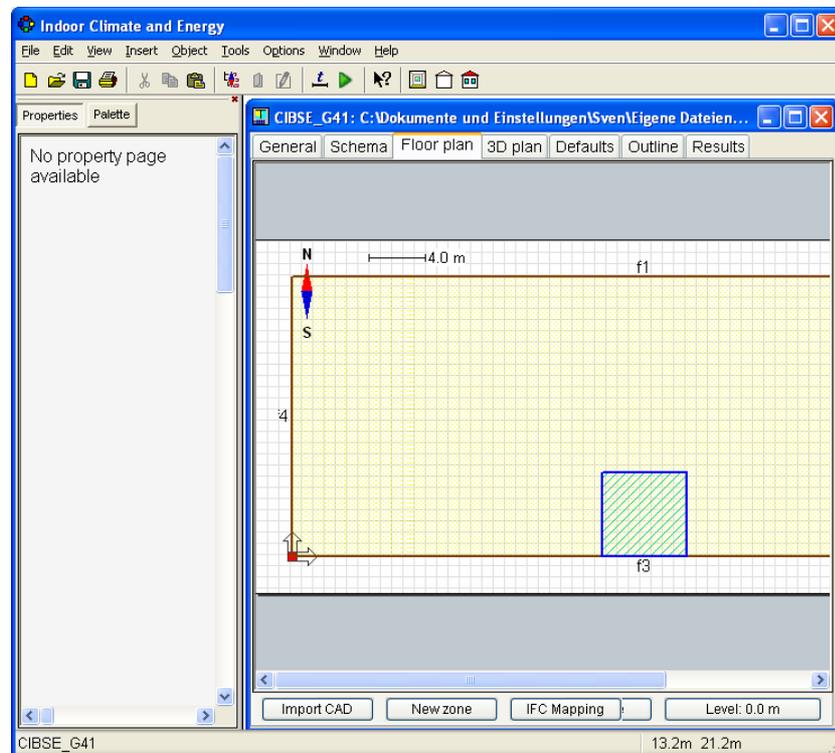
*Window:*

2m x 2m, 0.5 m over floor

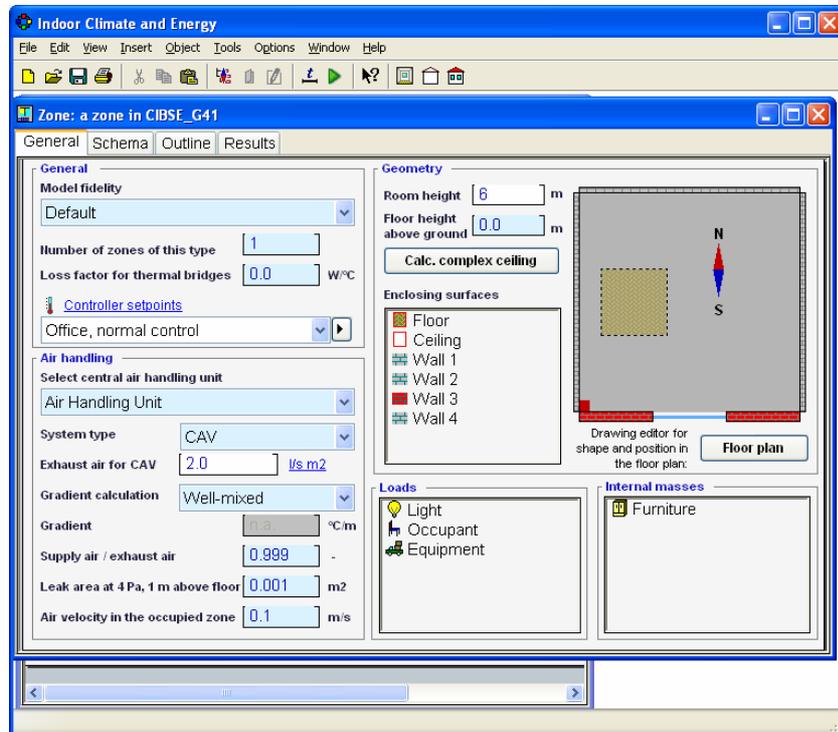
3D plan:



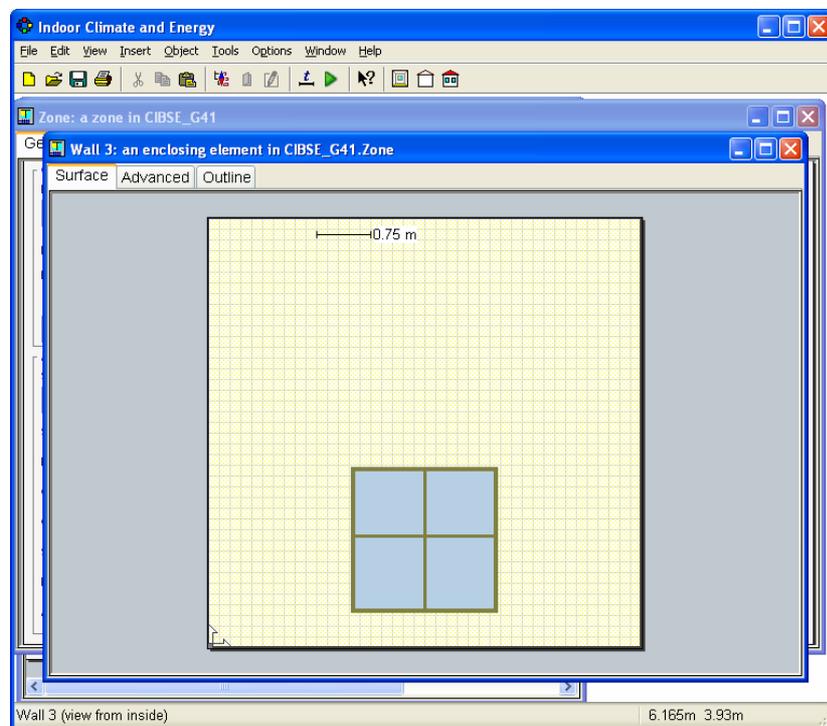
Floor plan:



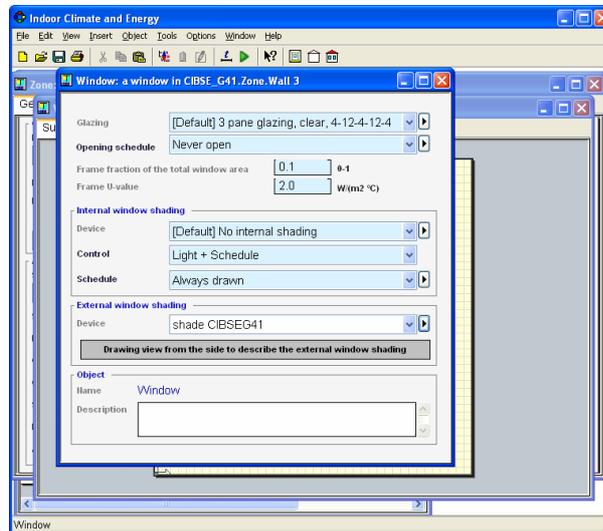
Zone:



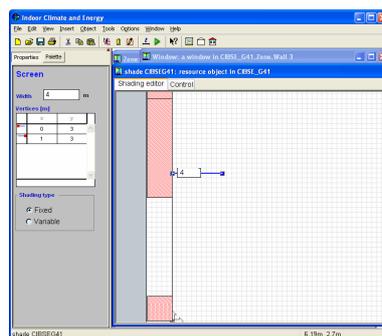
Wall 3:



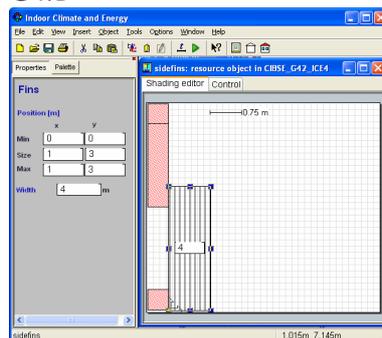
Window:



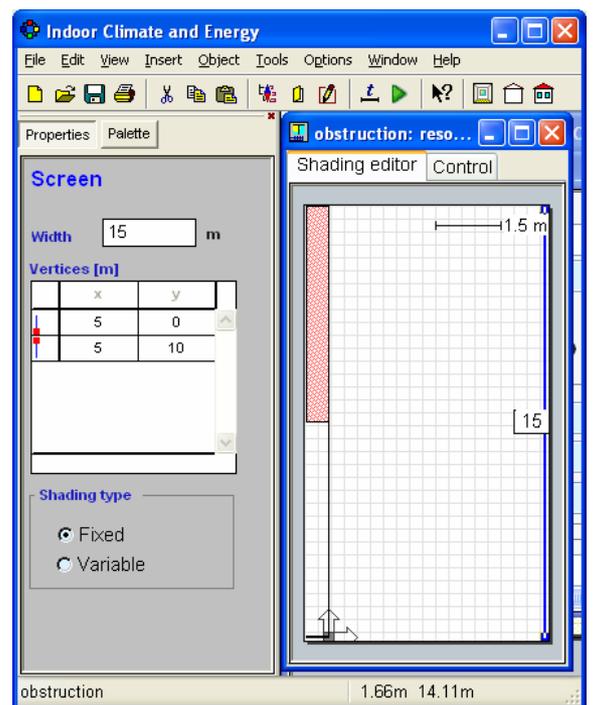
External Shading:



G4.1

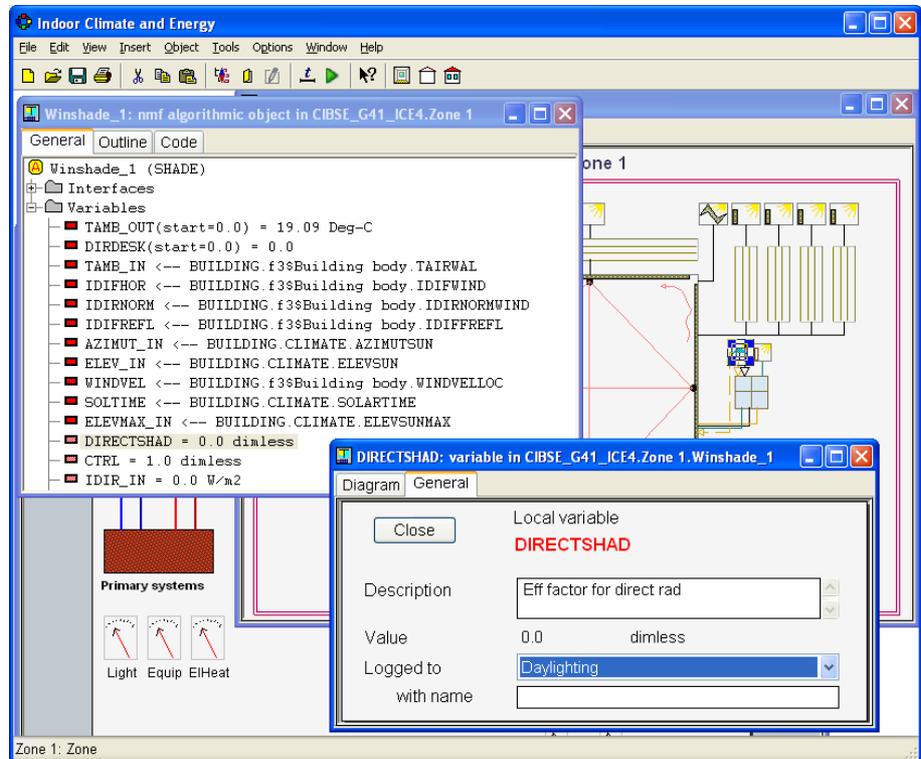


G4.2



G4.4

To do in advanced level:



## 4.2 Results

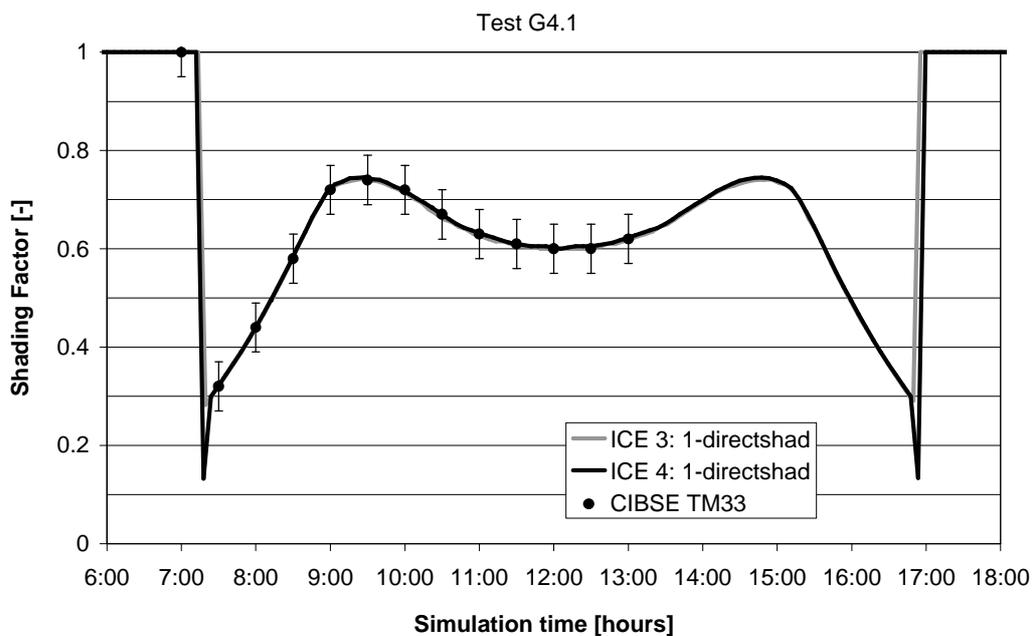


Figure 9: Test G4.1 results with invoke timestep for shading-geometry = 0.1.

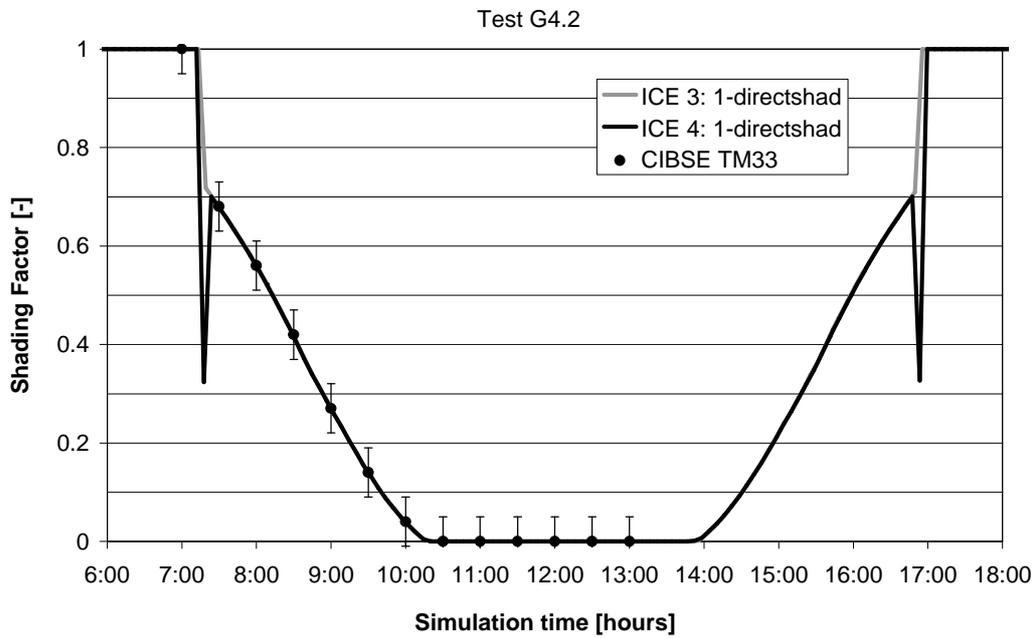


Figure 10: Test G4.2 results.

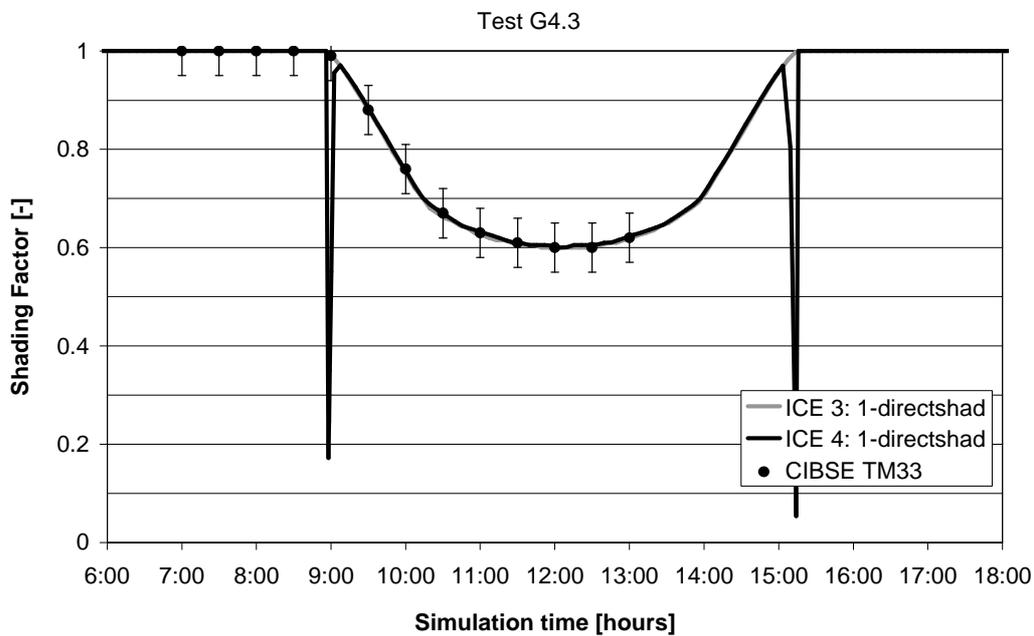


Figure 11: Test G4.3 results.

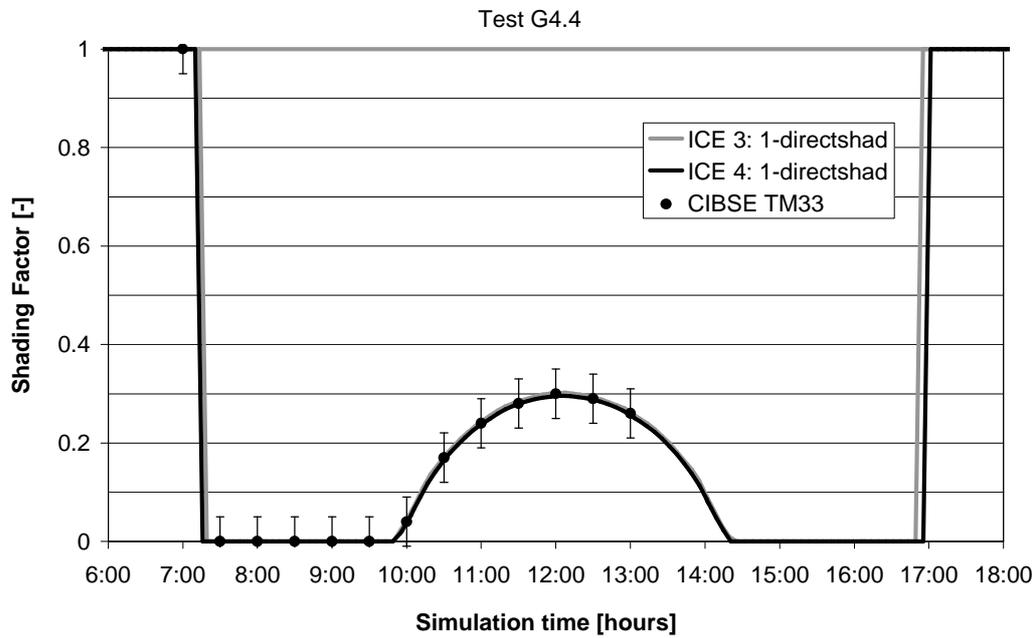


Figure 12: Test G4.4 results.

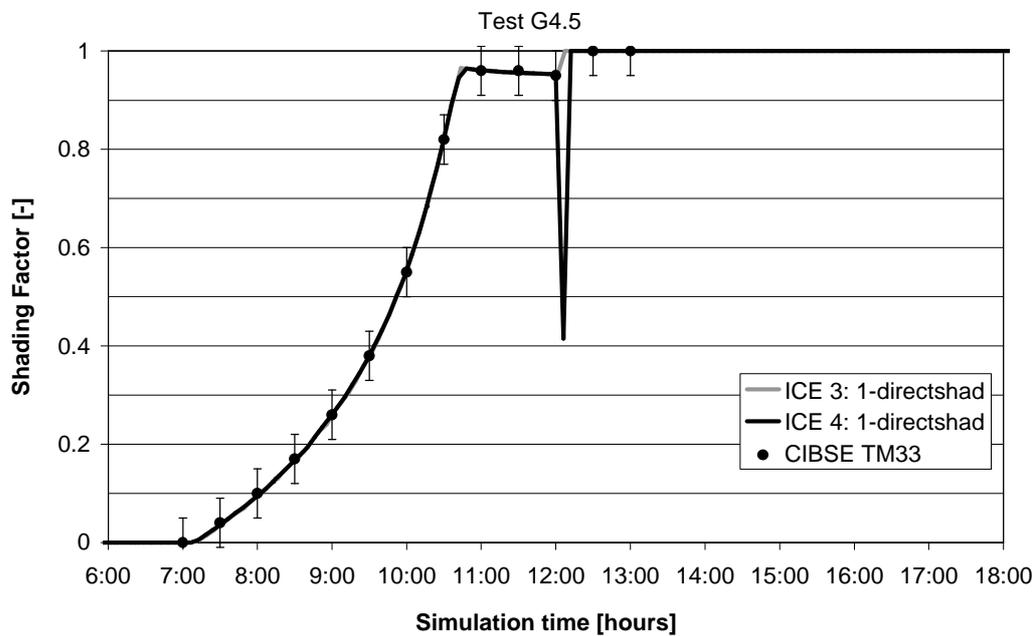


Figure 13: Test G4.5 results.

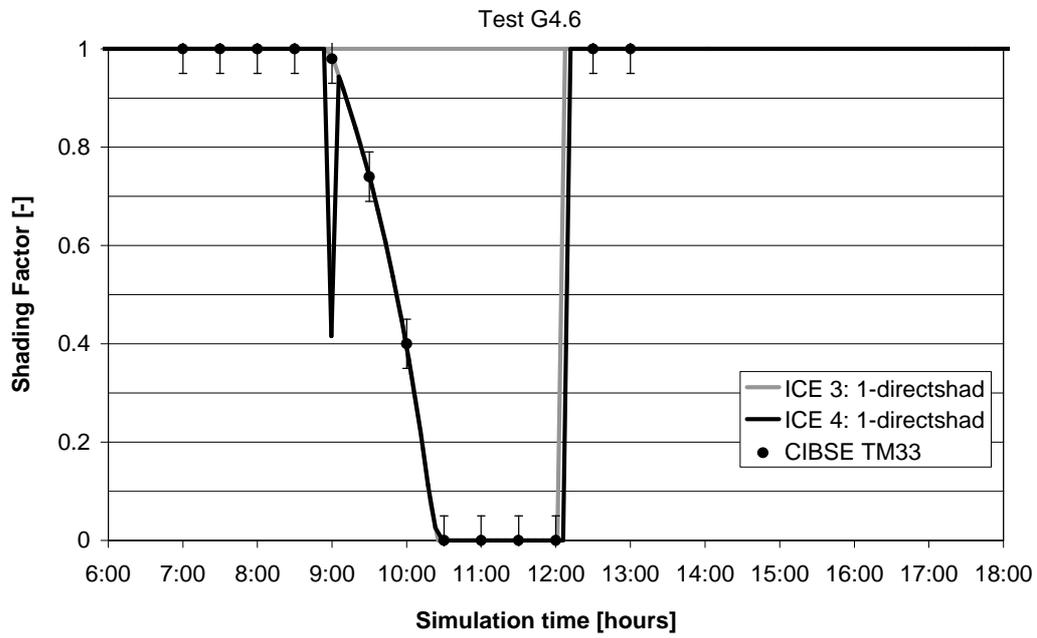
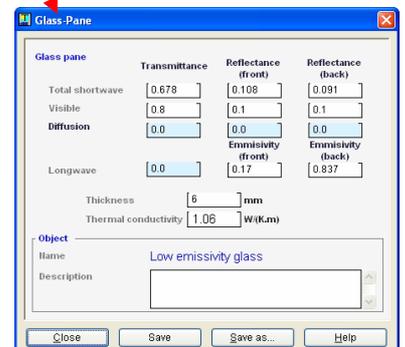
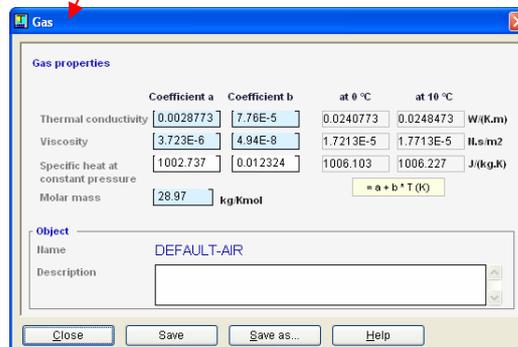
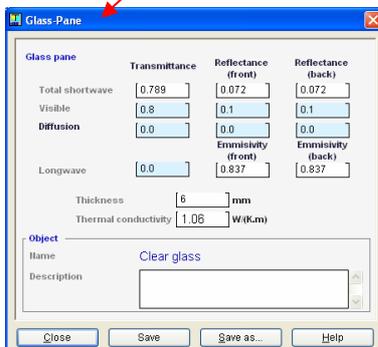
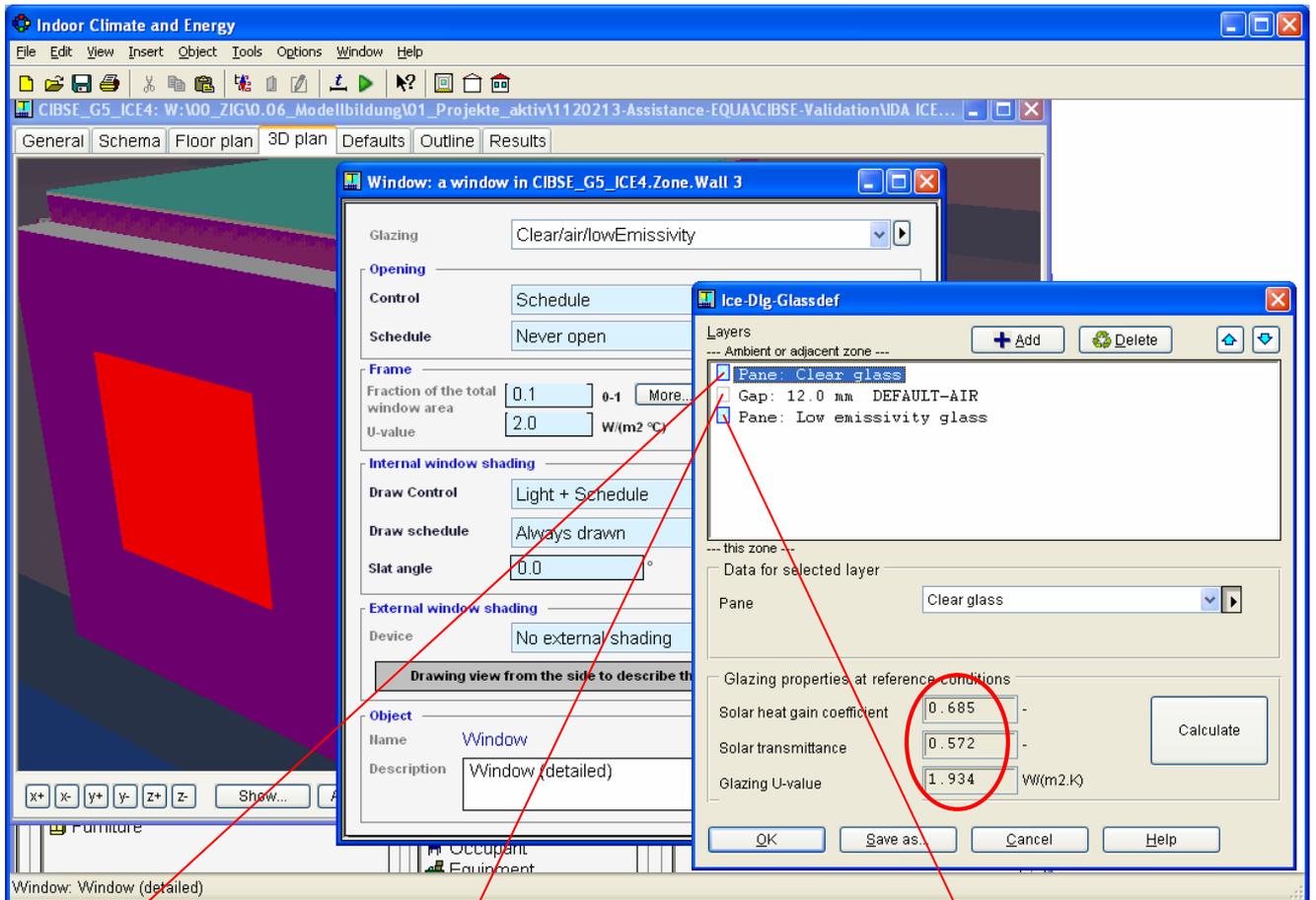


Figure 14: Test G4.6 results.

## 5. Test G5: Glazing properties

### 5.1 Implementation in IDA ICE



## 5.2 Results

System (outside to inside)	g-value				U-value / $\text{Wm}^{-2}\text{K}^{-1}$			
	Air		Argon		Air		Argon	
	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4
Clear/clear	0.72	0.723	0.72	0.724	2.83	2.852	2.68	2.685
Clear/low emissivity	0.701	0.704	0.68	0.704	1.92	1.934	1.64	1.627
Absorbing/low emissivity	0.44	0.443	0.44	0.439	1.92	0.943	1.64	1.627
High performance/ clear	0.37	0.374	0.37	0.373	1.58	1.595	1.24	1.225
Clear/clear/clear	0.64	0.635	0.64	0.635	1.88	1.900	1.74	1.754

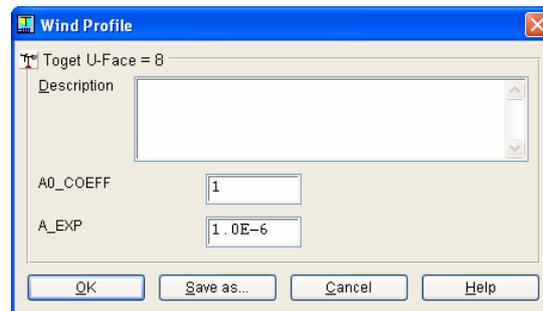
## 6. Test G6: Steady state heat loss from rooms

### 6.1 Implementation in IDA ICE

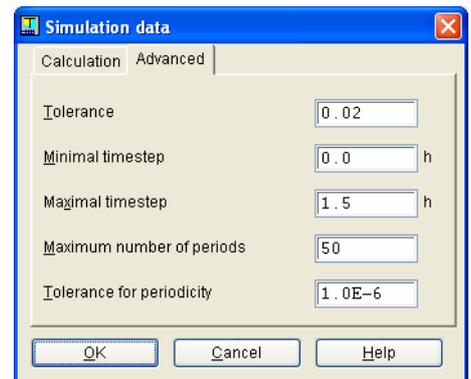
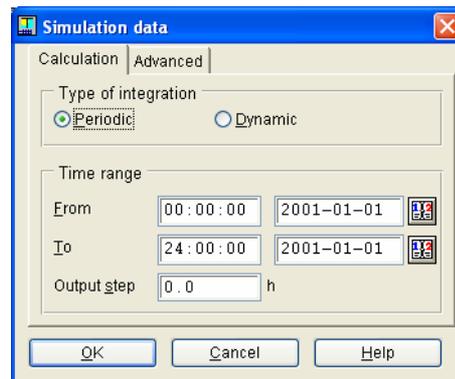
Climatic file:

1	-4.00	50.00	0.00	0.2506	0.00	0.00
8760	-4.00	50.00	0.00	0.2506	0.00	0.00

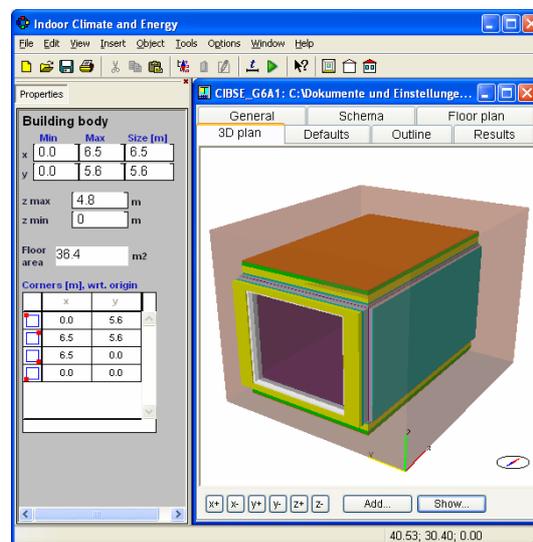
Wind profile:



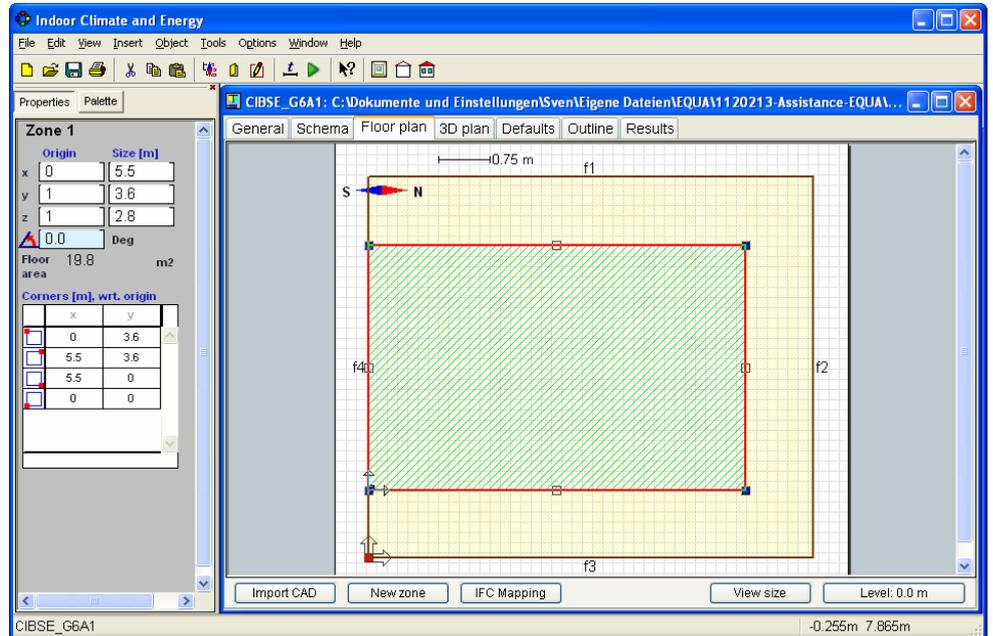
Simulation data:



3D plan:

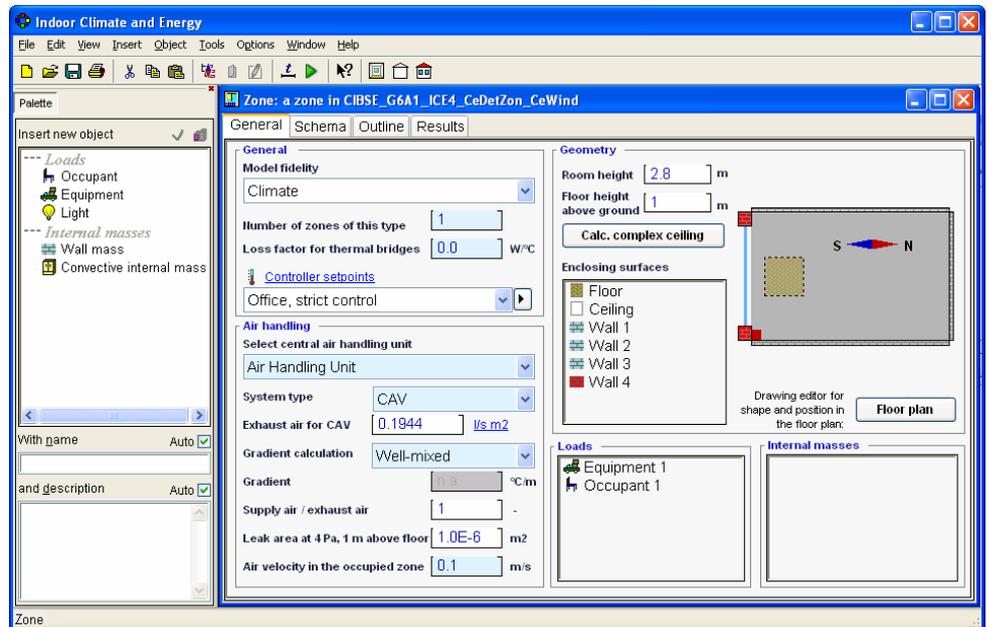


Floor plan:

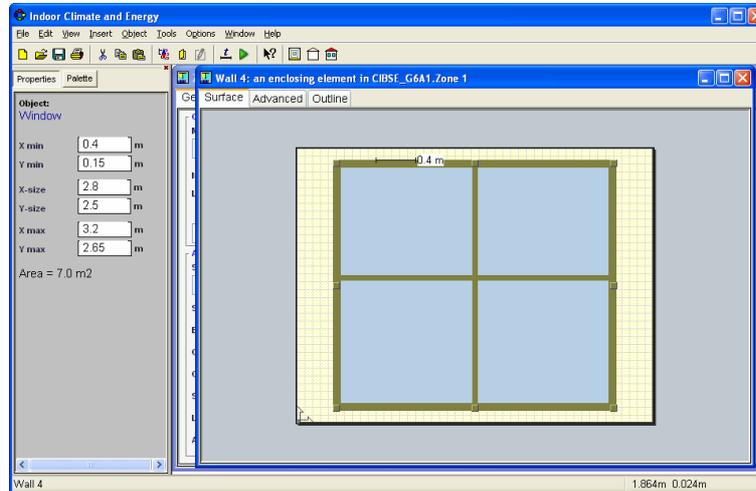


Zone:

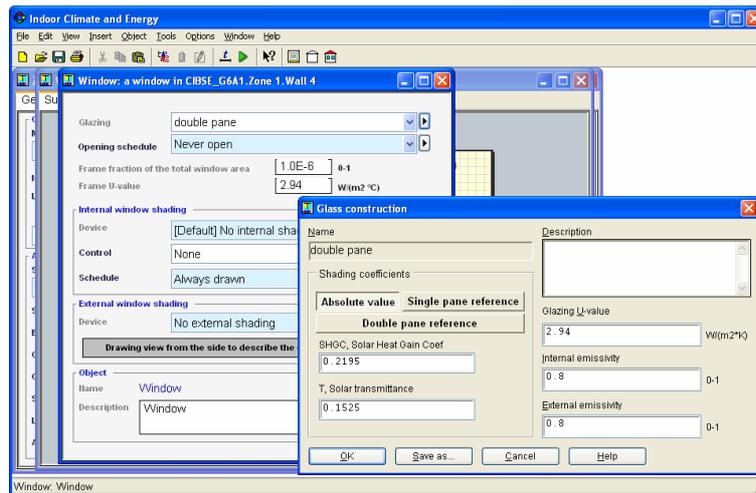
5.5 m x 3.6 m x 2.8 m



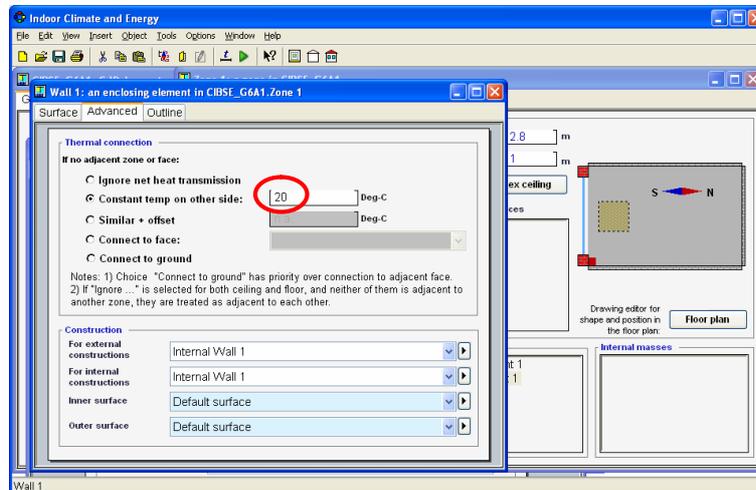
Window:



Window:



Adjacent zone temperature:



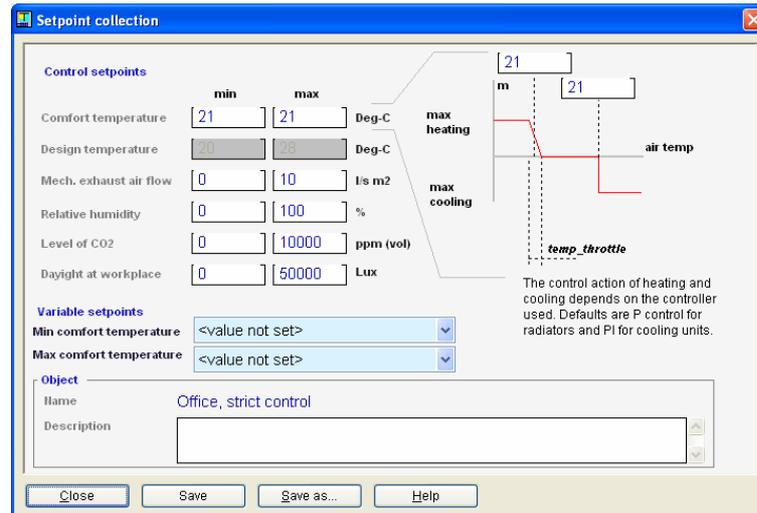
Wall constructions:

Can be entered 1:1. The order of the construction layers of the floor is not clear from CIBSE TM33, but does not have any influence to the results because of static conditions.

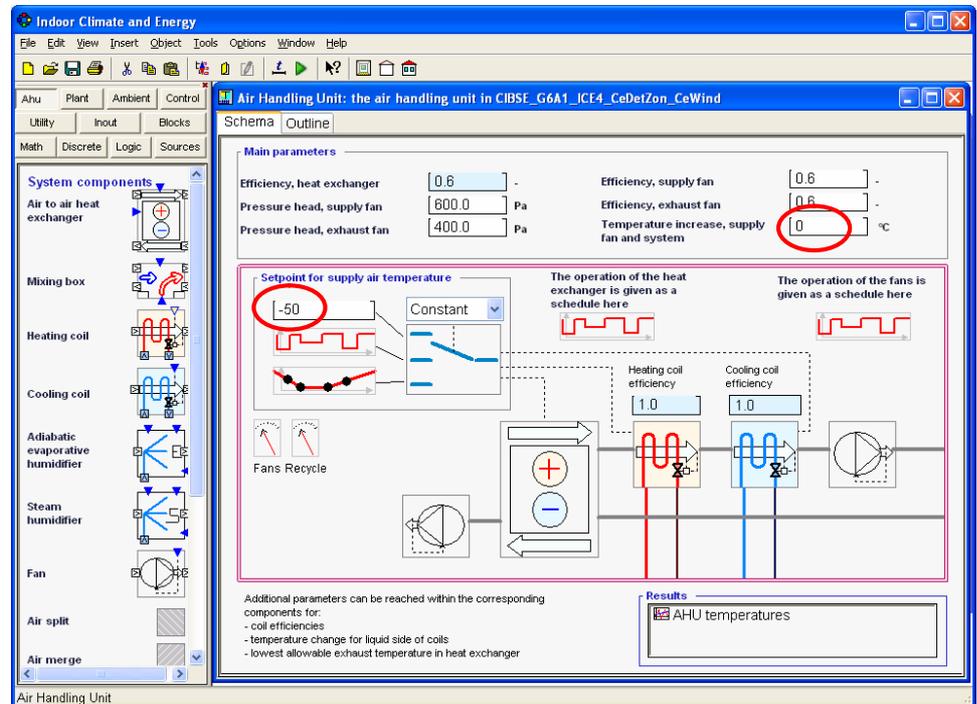
Wall surfaces:

Longwave emissivity 0.9 -> default

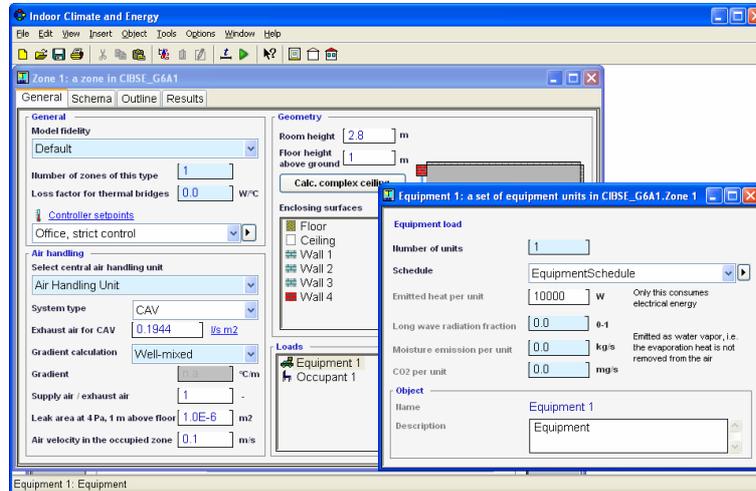
Controller setpoints:



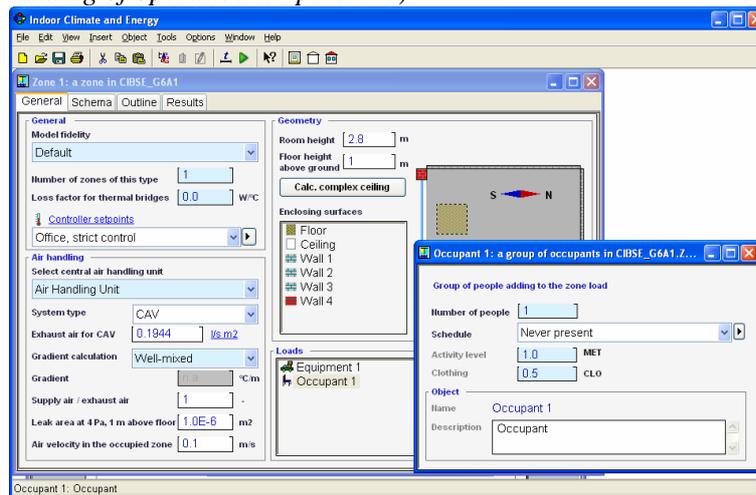
No air preconditioning:



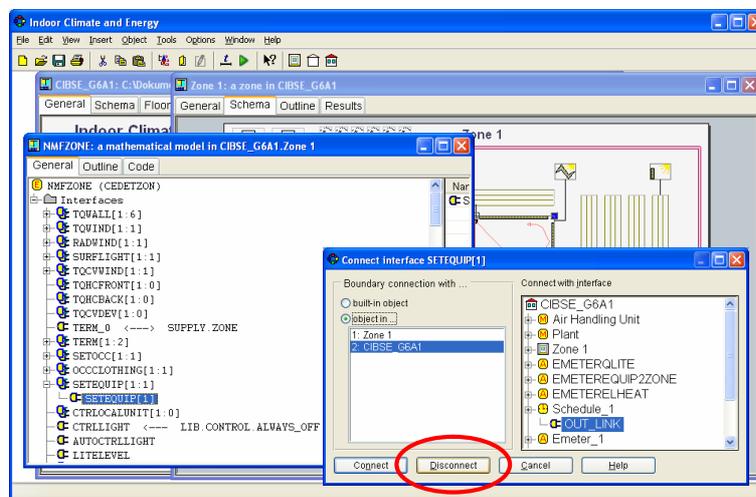
Prepare heat emitter:

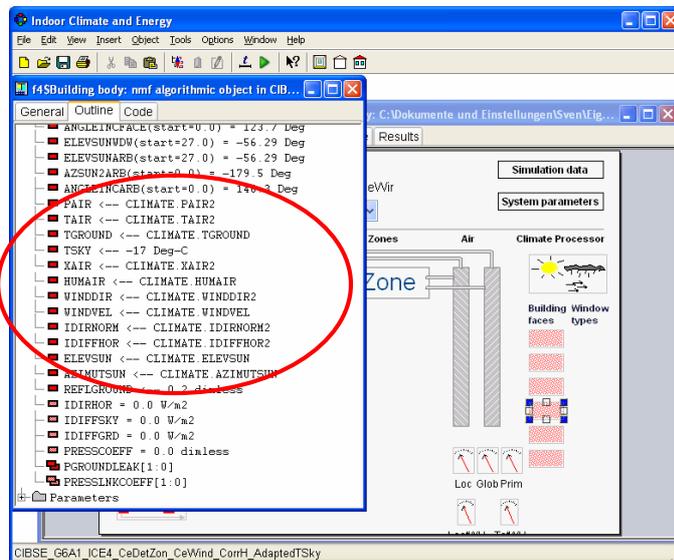
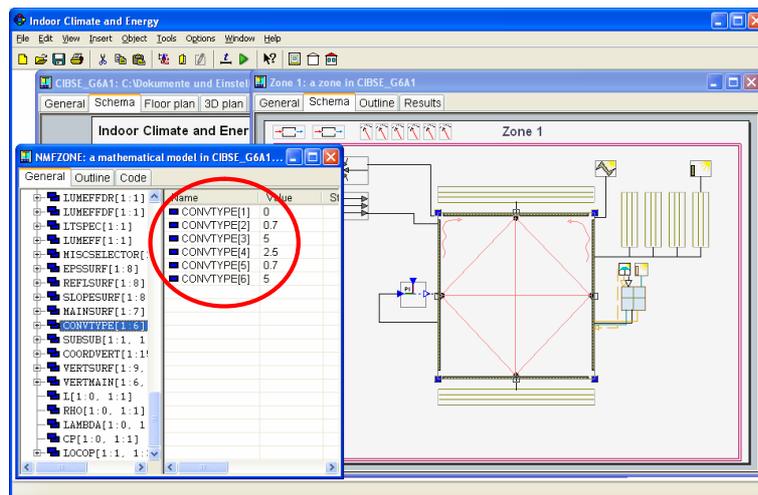
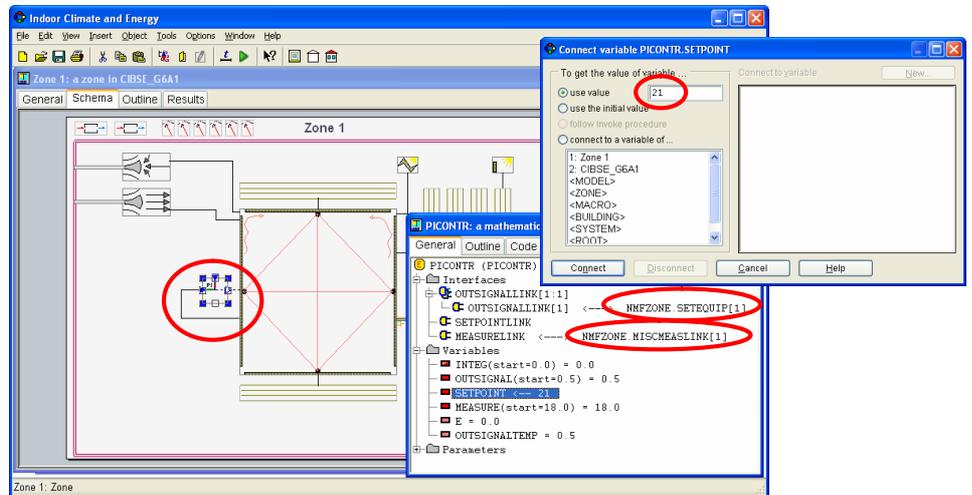


Never present occupant (for reading of operative temperature):



Advanced level:





*NMF-Code:*

The code cedetzon.nmf has to be simplified in order to correspond with the Tm33 reference model: Instead of distributing the irradiative heat to all surfaces, it is distributed to the walls, floor and ceiling only. **No part of the irradiative heat hits the window surface**

Changed parts of the code:

New parameter:

Area            ATotWall            C\_P

Parameter processing:

ATotWall := Sum i=1, nwall ASurf[i] END\_SUM;

Call of function:

CALL lwfacrad(nWall, ASurf, ATotWall, psilwrad);

## 6.2 Results

Test	Model	Temperature (°C) of stated surface							Air temp. / °C	Res. Temp /°C	
		Number CIBSE:	1	2	3	4	5	6			7
		Number ICE:	5	4	3	6	2	1			7
A1	Reference		20.5	20.6	20.5	19.4	20.9	20.2	11.1	22.2	21.0
	Basic		20.6	20.6	20.6	19.0	20.9	20.1	11.1	22.2	21.0
	Simple		This method is not recommended for surface temperatures							22.1	
	ICE 4		20.5	20.7	20.5	19.3	20.9	20.2	11.3	22.1	20.9
A2	Reference		20.8	21.0	20.8	19.7	20.9	20.8	11.2	21.3	?? 20.7 ??
	Basic		20.9	20.9	20.9	19.4	21.0	20.8	11.2	21.3	20.7
	Simple		This method is not recommended for surface temperatures							21.3	
	ICE 4		21.1	21.2	21.1	19.9	21.2	21.0	11.4	21.6	21.0
	ICE 4*		20.8	20.9	20.8	19.6	20.9	20.7	11.2	21.2	20.6
B1	Reference		20.2	19.0	19.0	19.2	20.8	19.7	11.0	22.8	21.0
	Basic		20.3	18.9	18.9	18.9	20.8	19.6	10.9	22.8	20.9
	Simple		This method is not recommended for surface temperatures							22.6	
	ICE 4		20.3	18.9	18.9	19.1	20.8	19.7	11.2	22.8	21.0
B2	Reference		20.9	19.6	19.5	19.8	21.0	20.9	11.3	21.2	?? 20.5 ??
	Basic		20.9	19.5	19.5	19.4	21.0	21.0	11.2	21.2	20.5
	Simple		This method is not recommended for surface temperatures							21.1	
	ICE 4		21.4	20.1	20.0	20.2	21.5	21.3	11.4	21.6	20.9
	ICE 4*		20.9	19.6	19.5	19.7	21.0	20.9	11.1	21.1	20.4

Table 6: Test G6: Predicted temperatures. ICE4\*: Adapted T<sub>Op</sub> (A2:20.7; B2:20.5).

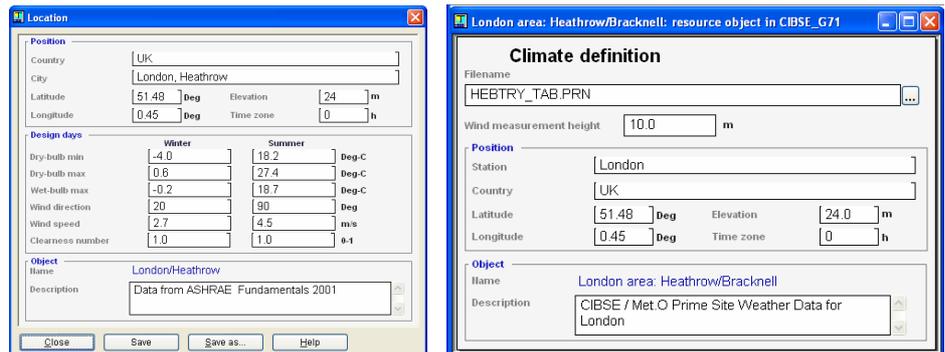
Test	Model	Heat loss / W			Test	Model	Heat loss / W		
		Fabric	Infiltration	Total			Fabric	Infiltration	Total
A1	Reference	542	121	663	B1	Reference	831	496	1327
	Basic	541	121	662		Basic	830	496	1326
	Simple	568	120	668		Simple	860	491	1352
	ICE 4	523	122	645		ICE 4	820	499	1319
A2	Reference	556	117	673	B2	Reference	862	465	1327
	Basic	554	117	671		Basic	859	465	1324
	Simple	574	117	690		Simple	877	464	1342
	ICE 4	528	118	646		ICE 4	837	468	1305

Table 7: Test G6: Predicted heat loss. ICE 4 with CeDetZon and CeWind model and adapted T<sub>Sky</sub> (-17 °C).

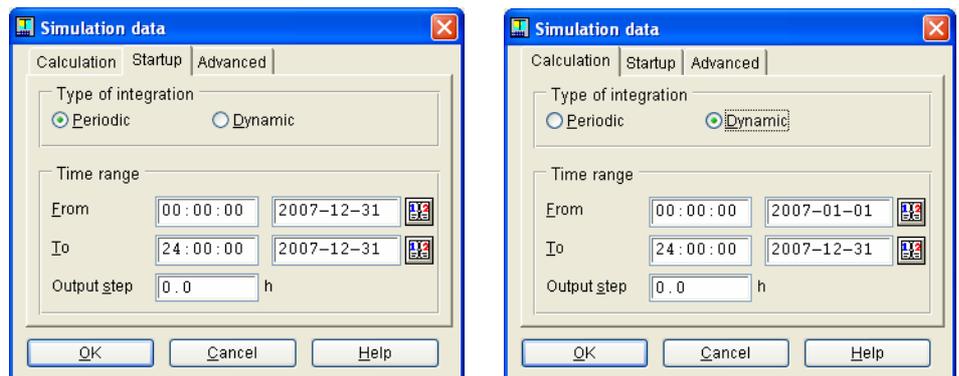
## 7. Test G7: Annual cooling and heating demand

### 7.1 Implementation in IDA ICE

Location / Climatic file: TRY-Weatherfile for London (HEBTRY\_TAB.PRN)

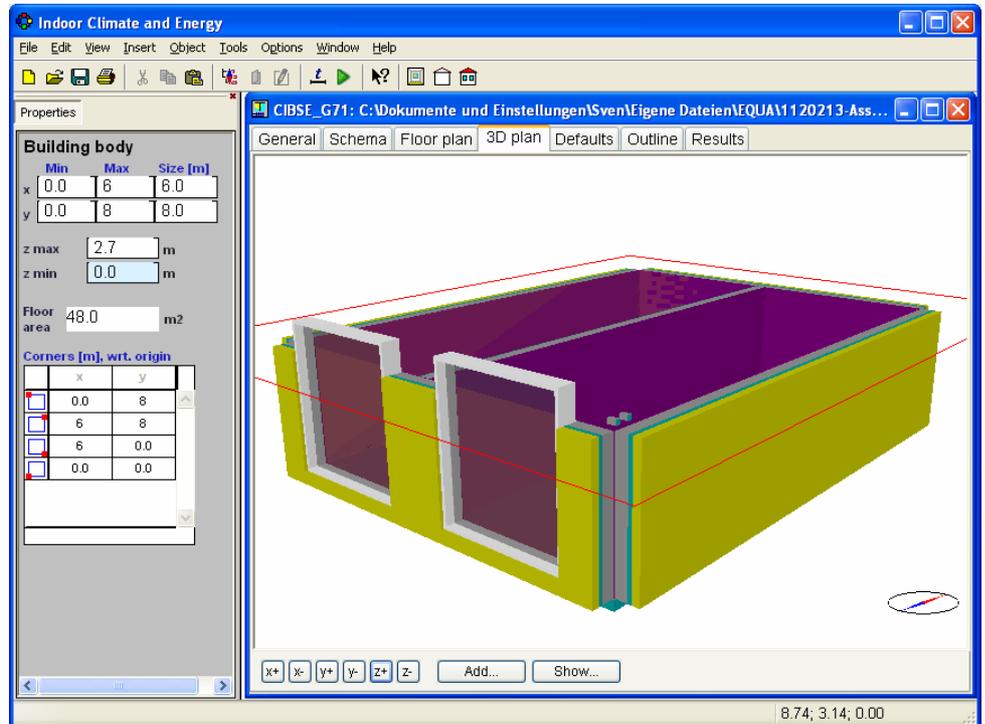


Simulation data:

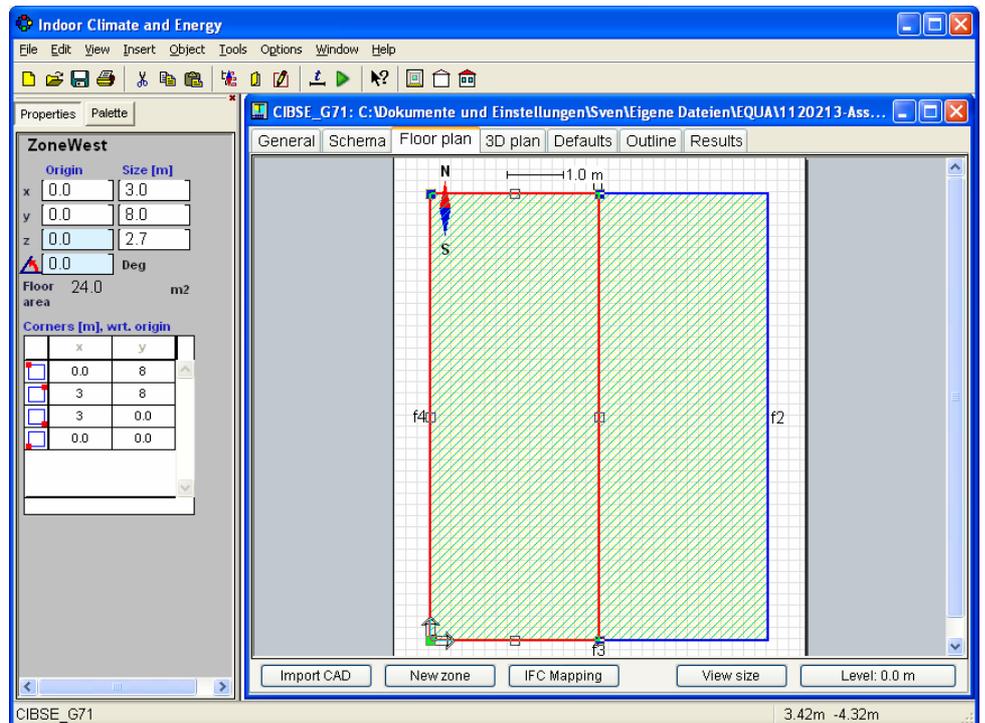


Building: 6 m x 8 m x 2.7 m

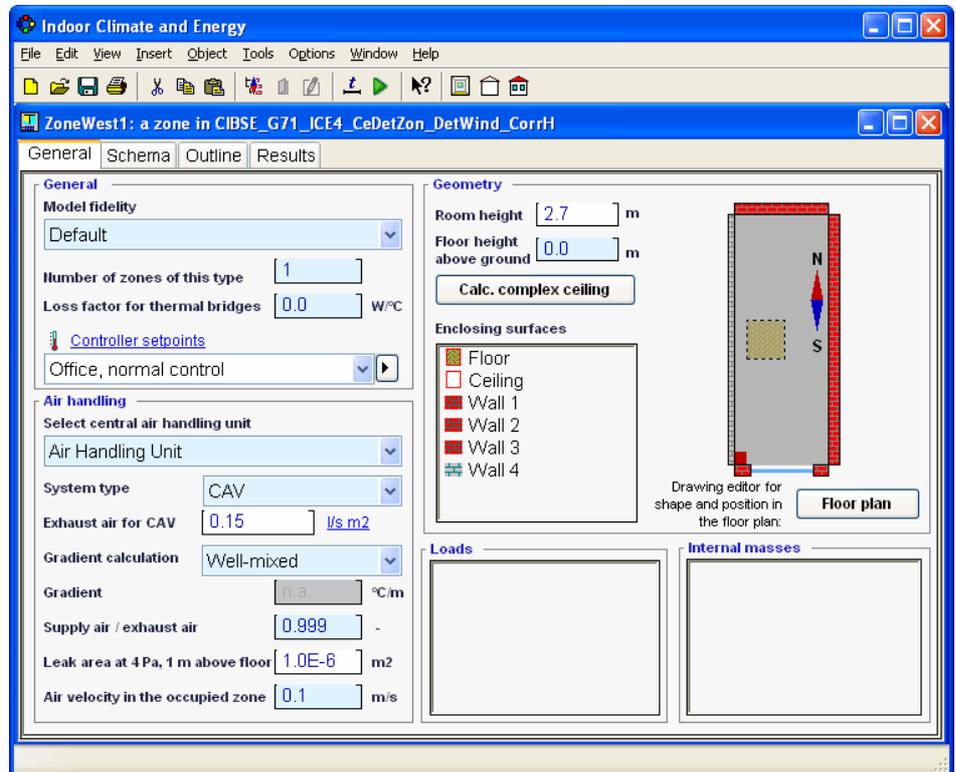
3D plan:



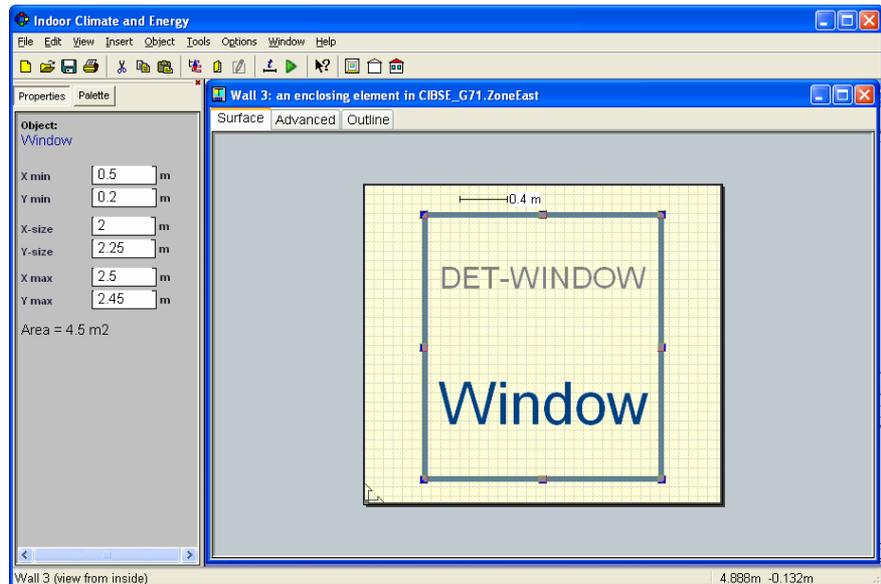
Floor plan:



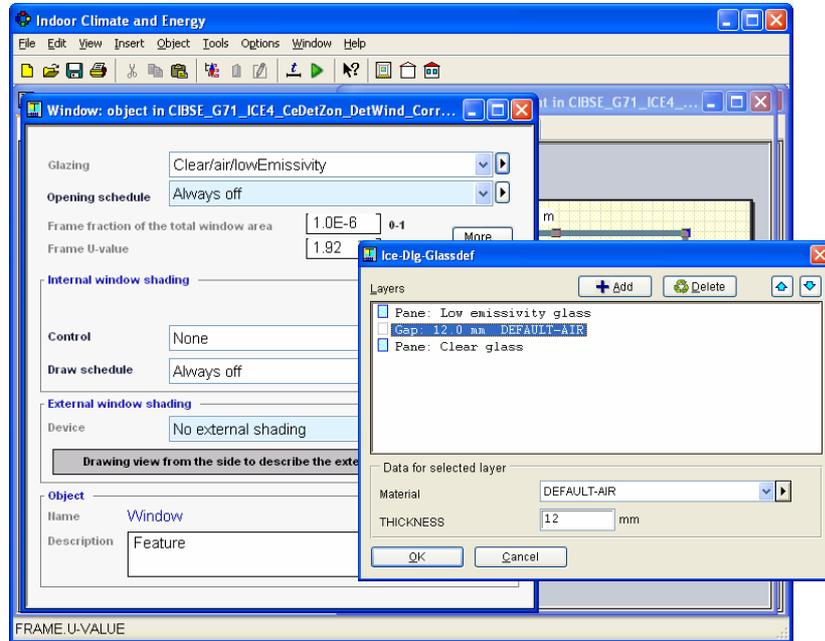
Zone East (equal West): 3 m x 8 m x 2.7 m



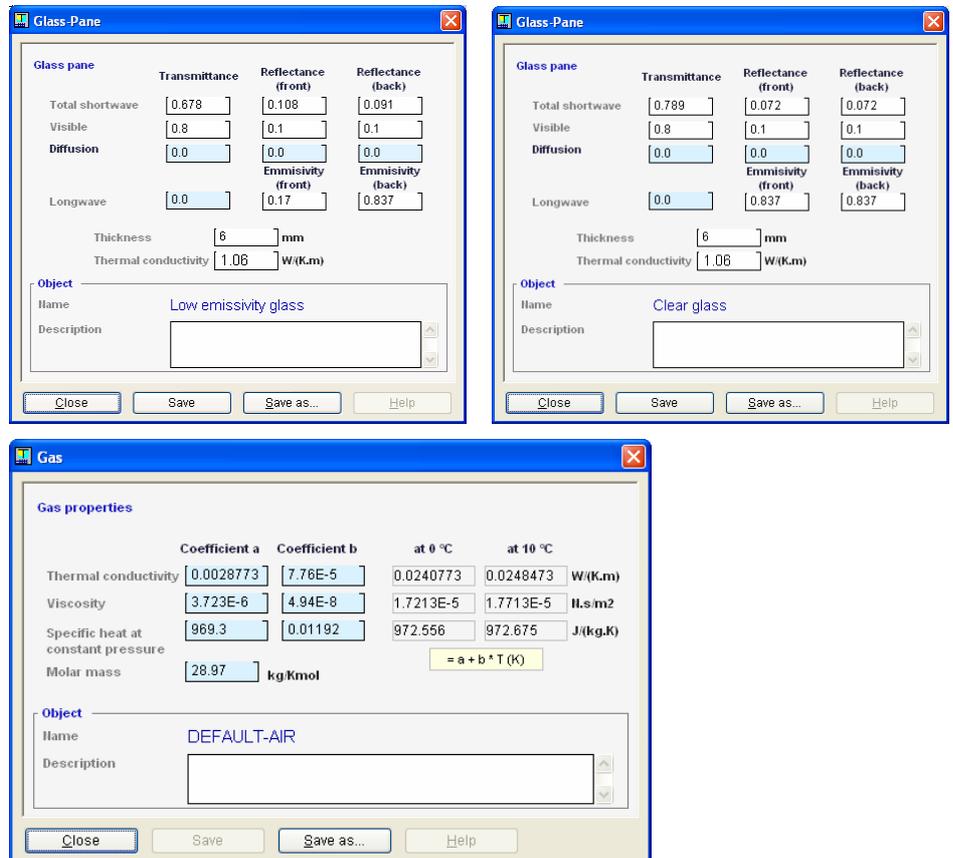
Window:



Window:



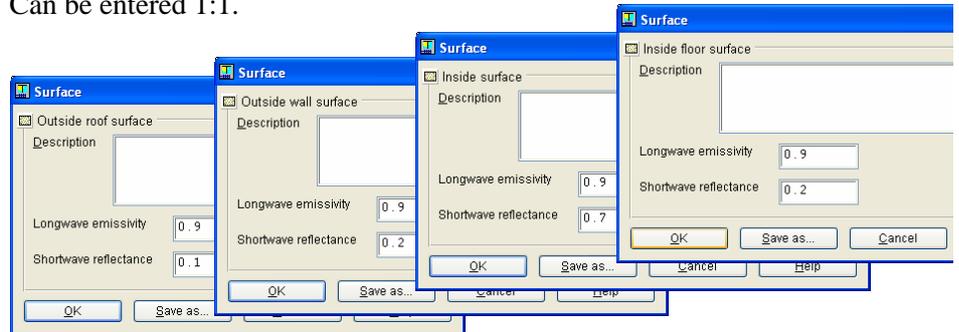
Glazing layers:



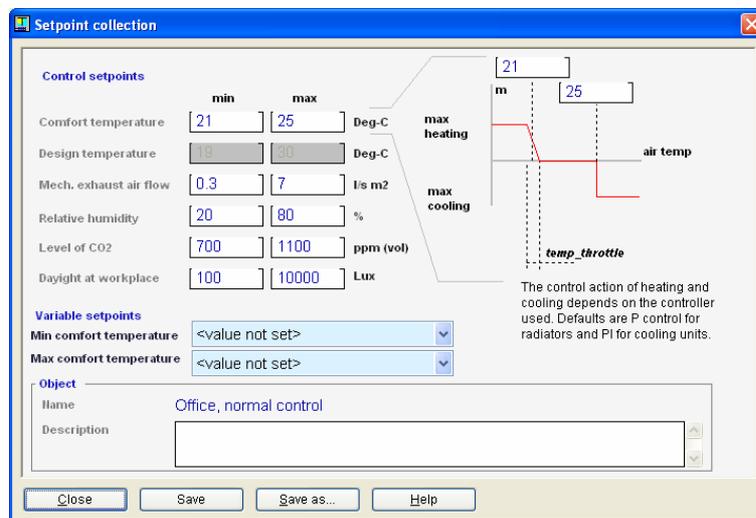
Wall constructions:

Wall surfaces:

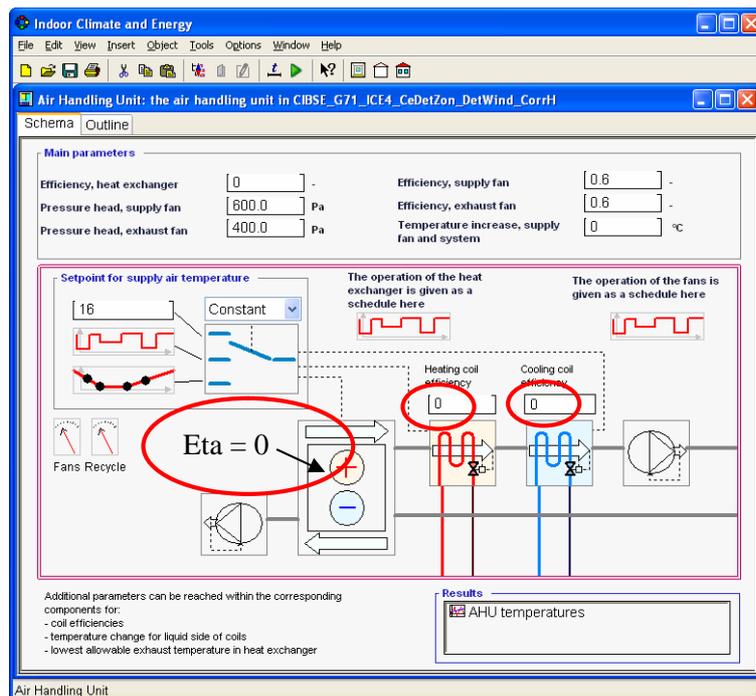
Can be entered 1:1.



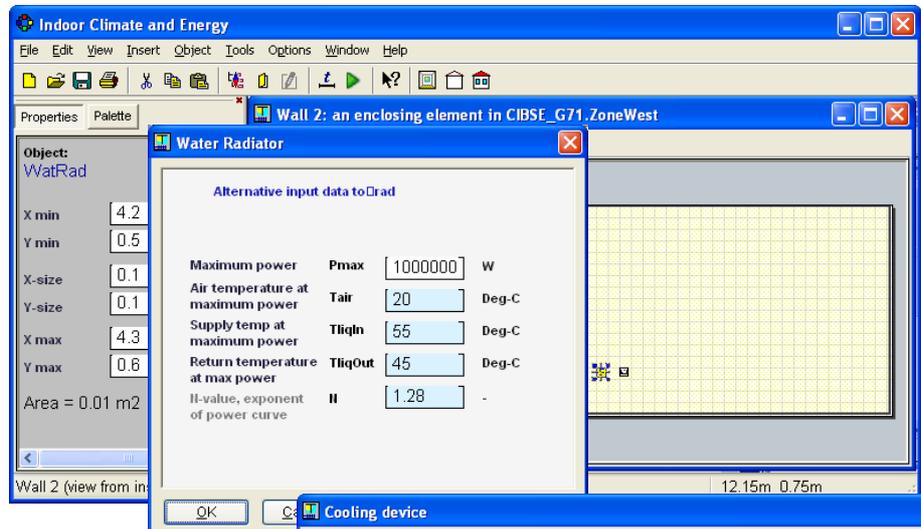
Controller setpoints:



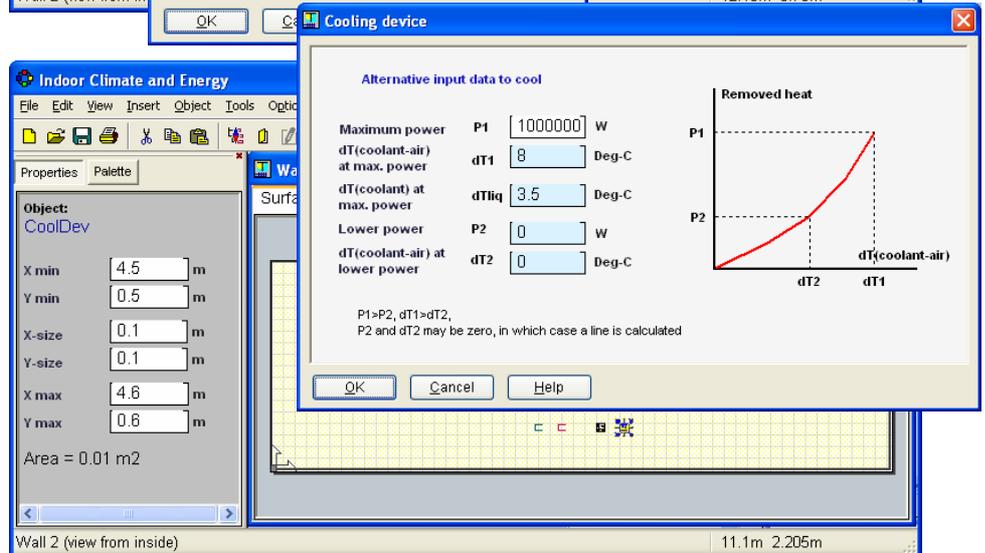
AHU:



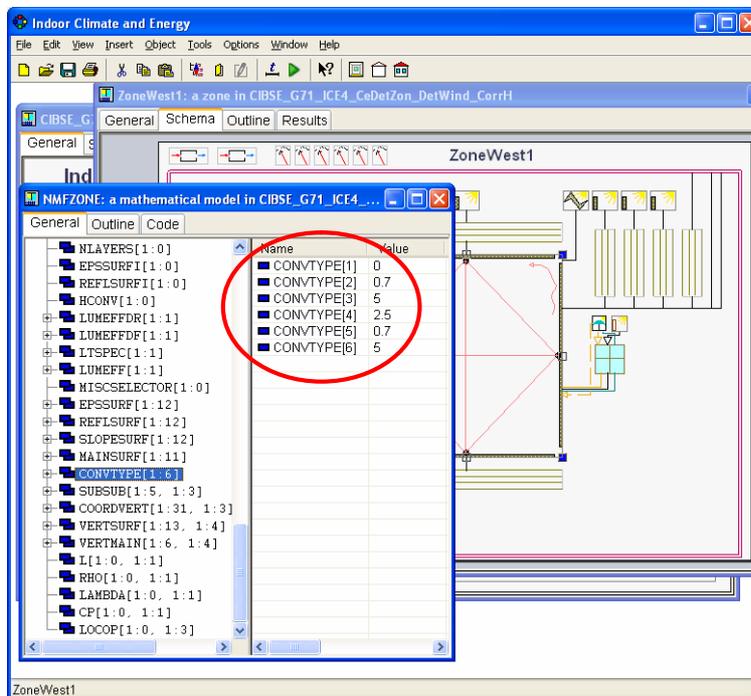
Heating unit:



Cooling unit:



Advanced level:



## 7.2 Results

Test	Heating demand / kWh		Cooling demand / kWh	
	CIBSE TM33	ICE 4 Detwind Perez	CIBSE TM33	ICE 4 Detwind Perez
G7.1	2'592	2'569	1'025	1'007
G7.2	3'257	3'458	449	398
G7.3	2'653	2'694	1'236	1'328
G7.4	3'155	3'332	474	466

Table 8: Test G7: Predicted heating and cooling loads.

## 8. Test G8: Overheating risk

### 8.1 Implementation in IDA ICE

*Changes from Test 7:*

- Change climate file to HEBDSY89\_TAB.prn
- Take out water radiators and cooling devices
- Change exhaust air for CAV to 0.7501 l/s m<sup>2</sup>
- Rebuild model and redo the advanced level changes (ConvType)
- Output Step = 1 hour

*Longwave radiation model simplification:* CIBSE TM33 calculates with a constant radiative heat transfer coefficient 5.7 W/m<sup>2</sup>K. To take this model simplification in account, the parameters of the room model are set as followed:

- ? EPSSURF [1...8] = 10<sup>-6</sup>, 10<sup>-6</sup>, 0.063, 0.063, 0.063, 0.063, 10<sup>-6</sup>, 10<sup>-6</sup>
- ? CONVTYPE [1...6] = 0, 6.856, 11.156, 8.22508, 6.856, 11.156

## 8.2 Results

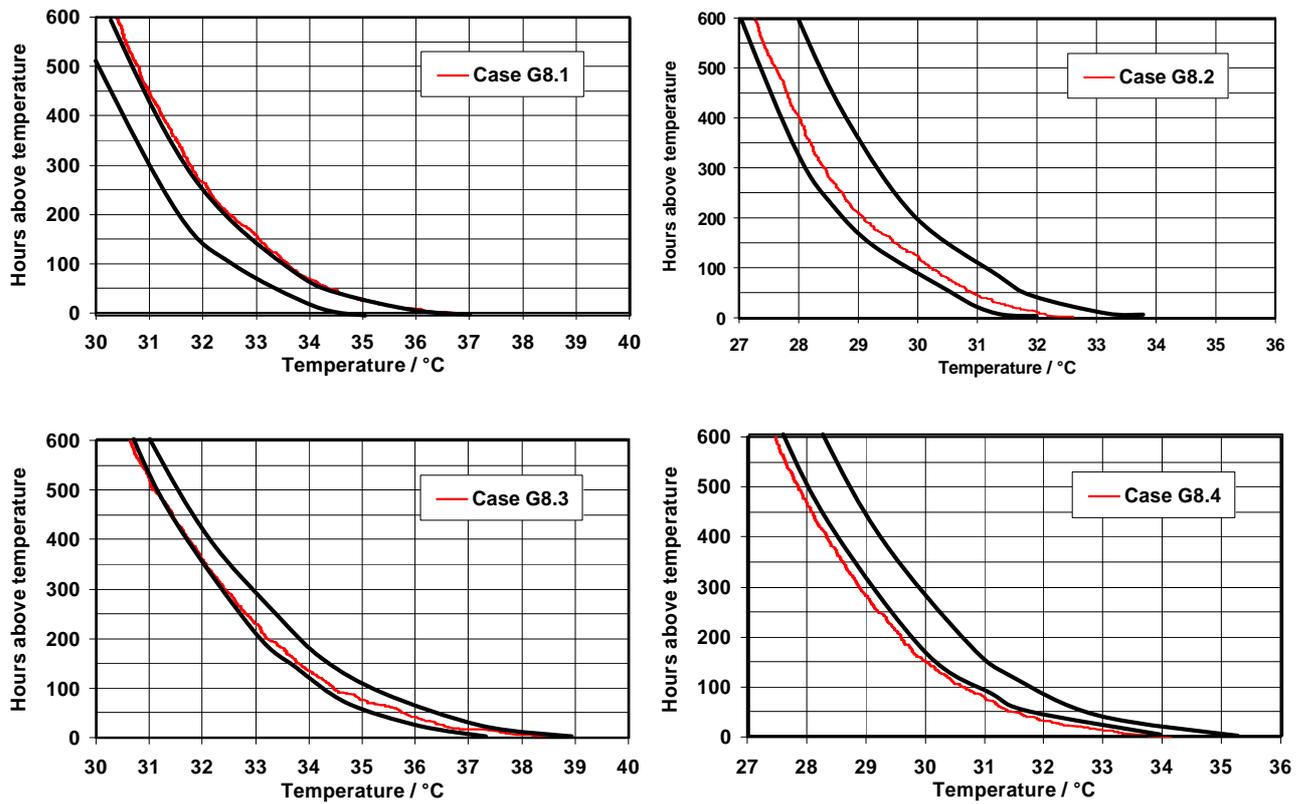


Figure 15: Test G8, Results by ICE 4 (red) compared to the tolerance given in TM 33 (black) (simplified long wave irradiation model).

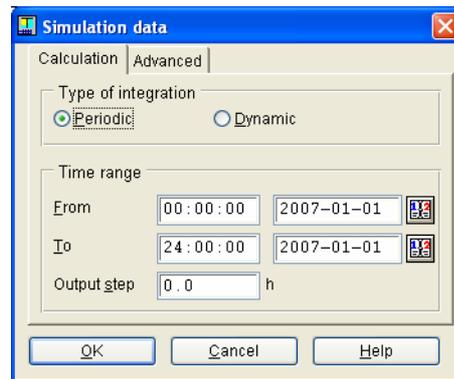
## 9. Test G9: Infiltration and ventilation

### 9.1 Implementation in IDA ICE

Weather file:

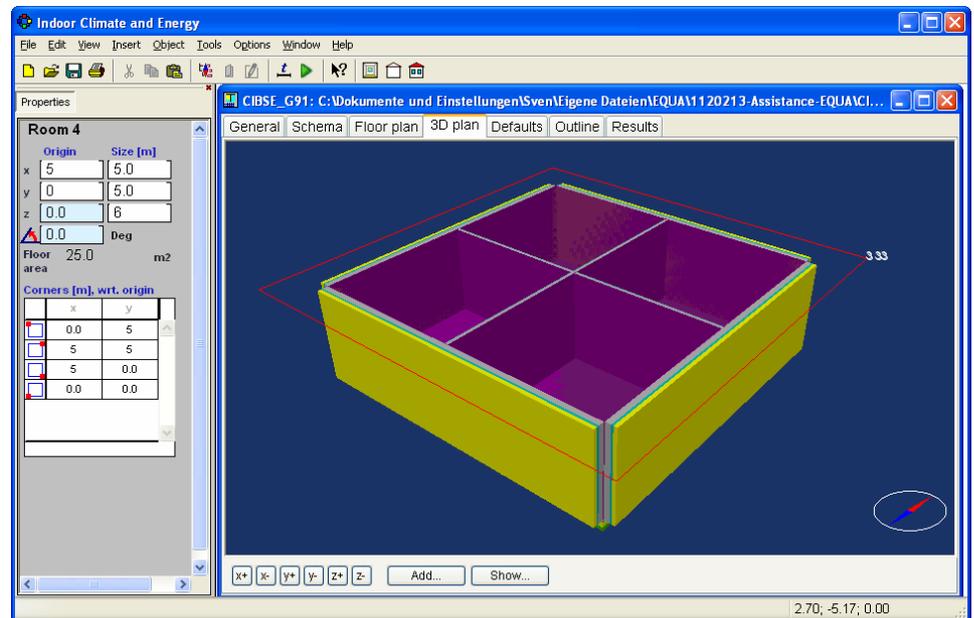
1	12.10	50.00	90.00	2.00	0.00	0.00
8760	12.10	50.00	90.00	2.00	0.00	0.00

Simulation data:

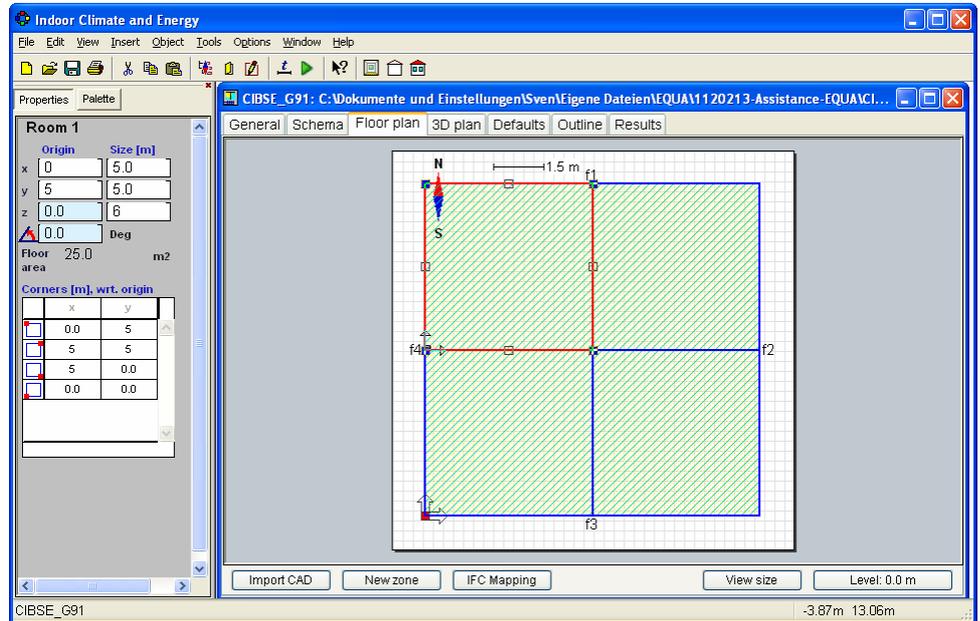


Building: 10 m x 10m x 6 m

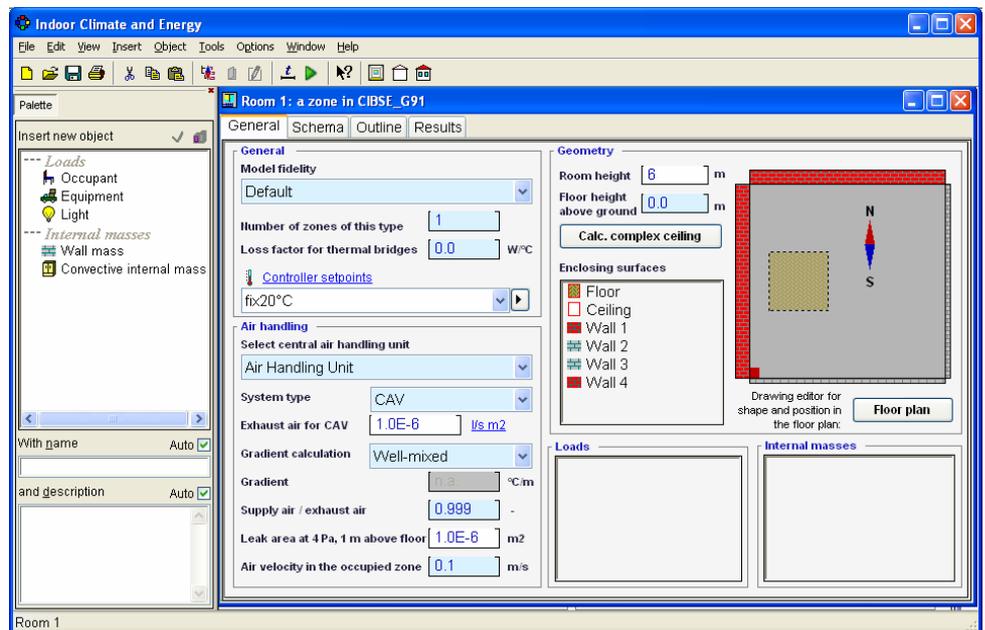
3D plan:



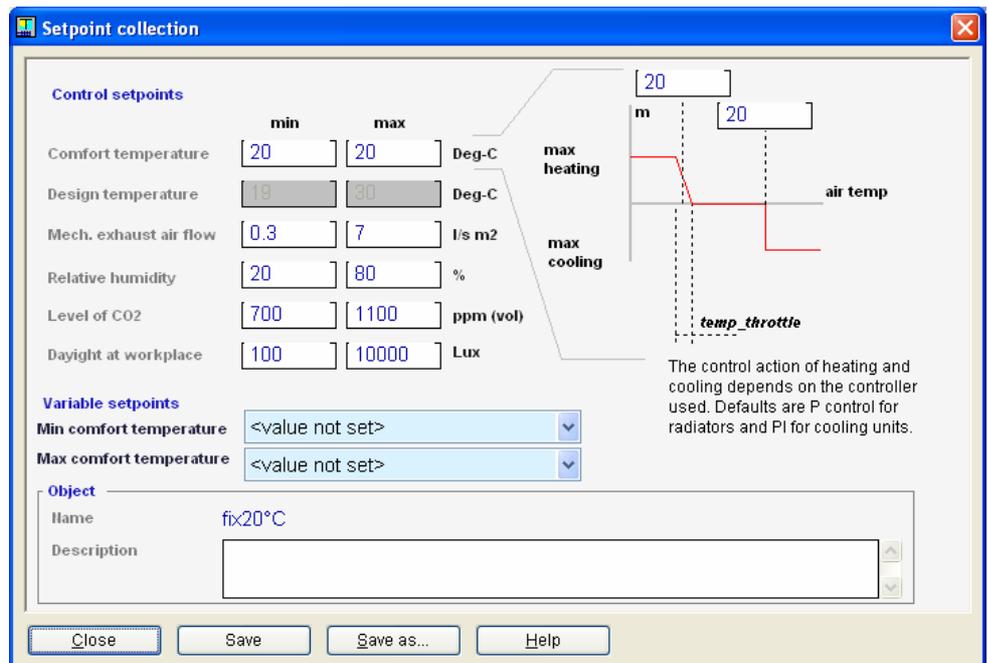
Floor plan:



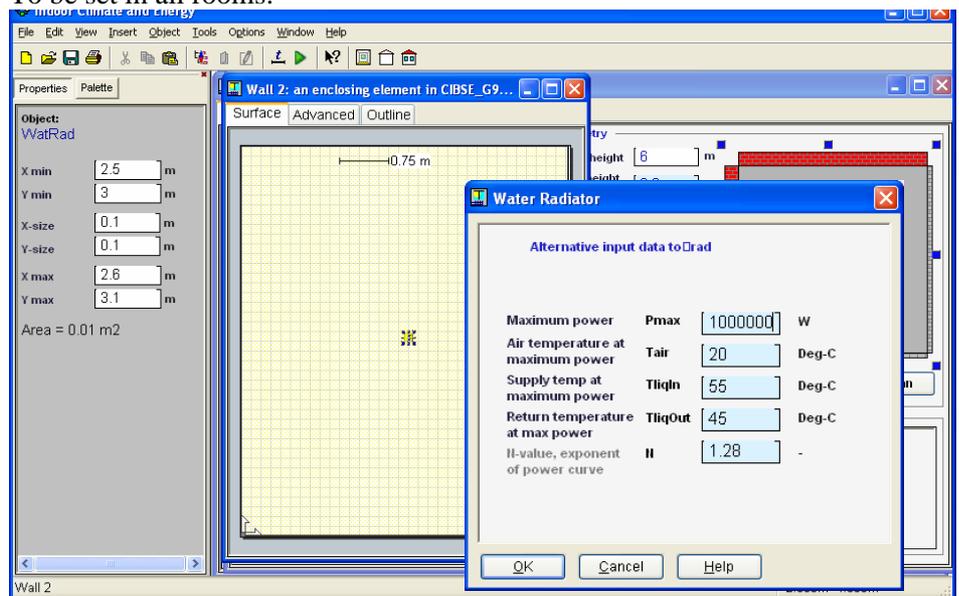
Zones Room 1 - Room 4: 5 m x 5 m x 6 m



- Wall constructions:* Not important.
- Wall surfaces:* Default
- Controller setpoints:* Fixed temperature (20 °C for Room 1 and 4, 22 °C for Room 2 and 3)

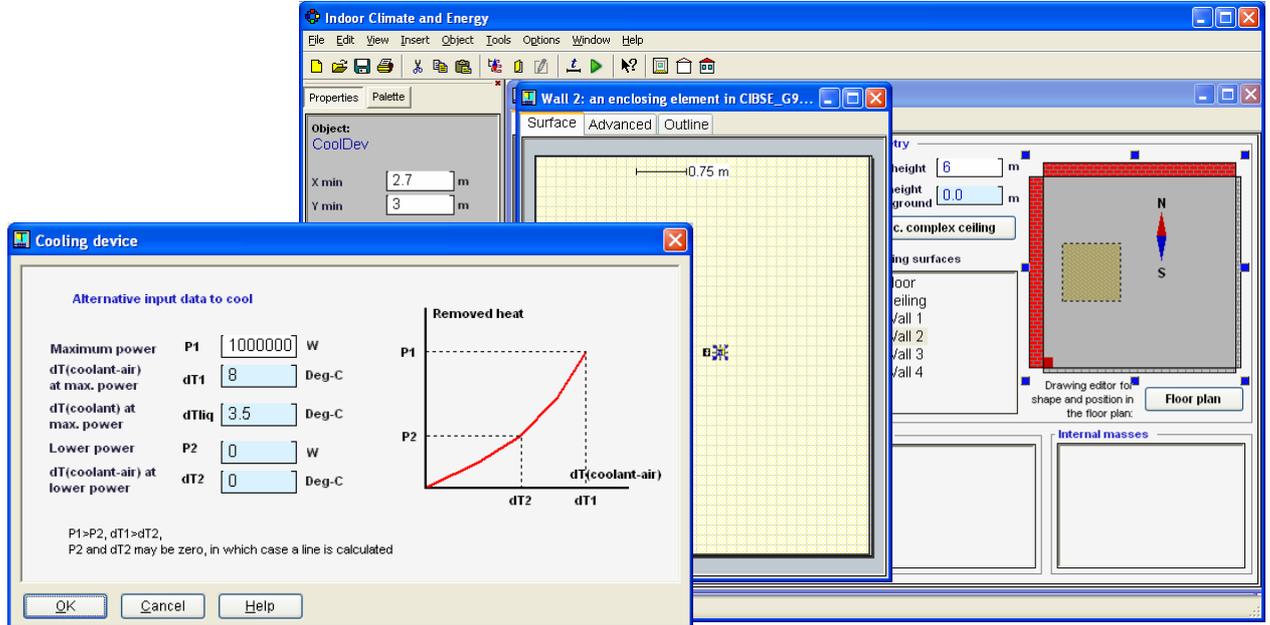


- AHU:* Not important (no AHU)
- Heating unit:* To be set in all rooms:



Cooling unit:

To be set in all rooms:



Leaks:

All 10 Leaks can be set in standard level. The flow coefficients have to be multiplied by temperature dependant air density to get  $\text{kg}/(\text{s Pa}^{**}\text{n})$  instead of  $\text{m}^3/(\text{s Pa}^{**}\text{n})$ :

	$\text{m}^3/(\text{sPa}^{**}0.5)$	$^{\circ}\text{C}$	$\text{kg}/\text{m}^3$	$\text{kg}/(\text{sPa}^{**}0.5)$
B1	0.01667	20	1.2041	0.02007235
B2	0.03333	12.1	1.2378	0.04125587
B3	0.01667	12.1	1.2378	0.02063413
B4	0.03333	22	1.1959	0.03985935
B5	0.01667	12.1	1.2378	0.02063413
B6	0.01667	12.1	1.2378	0.02063413
R1	0.01667	22	1.1959	0.01993565
R2	0.01667	20	1.2041	0.02007235
D1	0.00833	20	1.2041	0.01003015
D2	0.025	22	1.1959	0.0298975

Table 9: G9.1 flow coefficients.

	$\text{m}^3/(\text{sPa}^{**}0.5)$	$^{\circ}\text{C}$	$\text{kg}/\text{m}^3$	$\text{kg}/(\text{sPa}^{**}0.5)$
B1	0.01667	20	1.2041	0.02007235
B2	0.03333	12.1	1.2378	0.04125587
B3	0.01667	12.1	1.2378	0.02063413
B4	0.03333	12.1	1.2378	0.04125587
B5	0.01667	12.1	1.2378	0.02063413
B6	0.01667	12.1	1.2378	0.02063413
R1	0.01667	22	1.1959	0.01993565
R2	0.01667	20	1.2041	0.02007235
D1	0.00833	22	1.1959	0.009961847
D2	0.025	22	1.1959	0.0298975

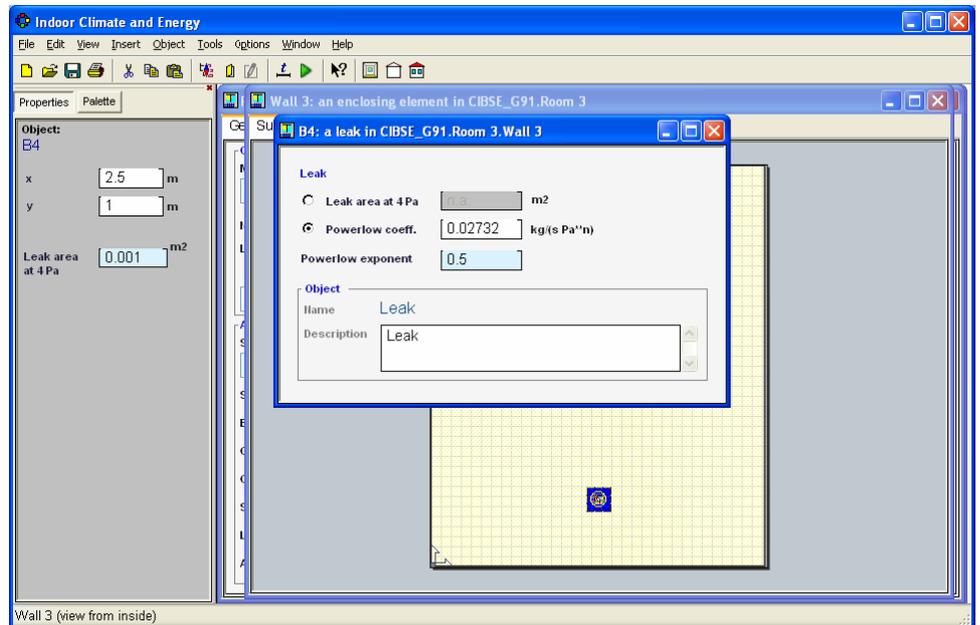
Table 10: G9.2 flow coefficients.

	$\text{m}^3/(\text{sPa}^{**}0.5)$	$^{\circ}\text{C}$	$\text{kg}/\text{m}^3$	$\text{kg}/(\text{sPa}^{**}0.5)$
B1	0.01667	20	1.2041	0.02007235
B2	0.03333	12.1	1.2378	0.04125587
B3	0.01667	12.1	1.2378	0.02063413
B4	0.03333	12.1	1.2378	0.04125587
B5	0.01667	12.1	1.2378	0.02063413
B6	0.01667	12.1	1.2378	0.02063413
R1	0.01667	22	1.1959	0.01993565
R2	0.01667	12.1	1.2378	0.02063413
D1	0.00833	22	1.1959	0.009961847
D2	0.025	22	1.1959	0.0298975

Table 11: G9.3 flow coefficients.

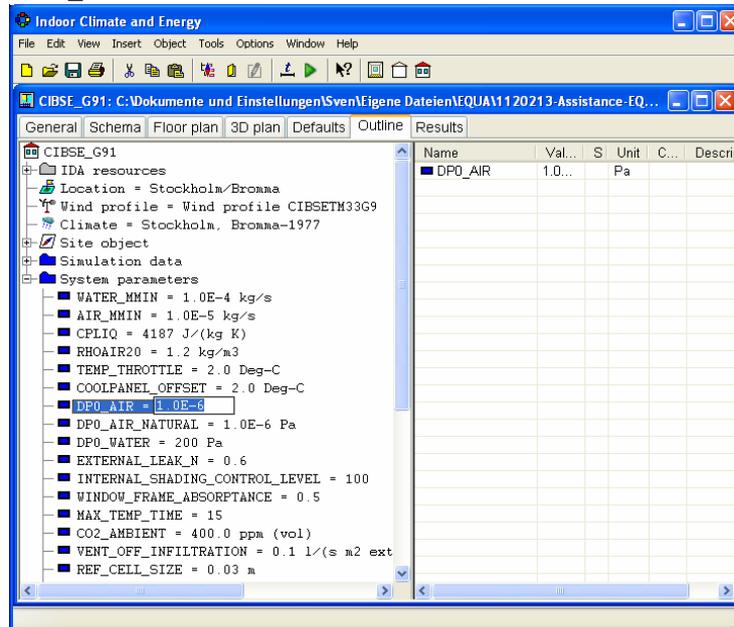
	$\text{m}^3/(\text{sPa}^{**}0.5)$	$^{\circ}\text{C}$	$\text{kg}/\text{m}^3$	$\text{kg}/(\text{sPa}^{**}0.5)$
B1	0.01667	20	1.2041	0.02007235
B2	0.03333	12.1	1.2378	0.04125587
B3	0.01667	12.1	1.2378	0.02063413
B4	0.03333	22	1.1959	0.03985935
B5	0.01667	12.1	1.2378	0.02063413
B6	0.01667	12.1	1.2378	0.02063413
R1	0.01667	22	1.1959	0.01993565
R2	0.01667	20	1.2041	0.02007235
D1	0.00833	20	1.2041	0.01003015
D2	0.025	22	1.1959	0.0298975

Table 12: G9.4 flow coefficients.



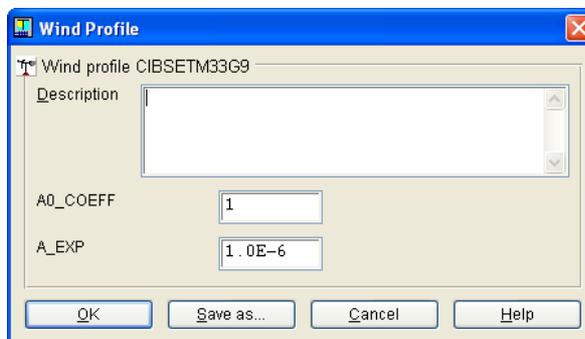
System parameters:

### DPO\_AIR



Wind profile:

Wind speed should not vary with height:



Pressure coefficients:

Face ->	Building body					
	f1	f2	f3	f4	Crawl space	Roof
0.0	0.7	-0.5	-0.2	-0.5	0.0	-0.8
45.0	0.35	0.35	-0.4	-0.4	0.0	-0.7
90.0	-0.5	0.7	-0.5	-0.2	0.0	-0.6
135.0	-0.4	0.35	0.35	-0.4	0.0	-0.5
180.0	-0.2	-0.5	0.7	-0.5	0.0	-0.4
225.0	-0.4	-0.4	0.35	0.35	0.0	-0.5
270.0	-0.5	-0.2	-0.5	0.7	0.0	-0.6
315.0	0.35	-0.4	-0.4	0.35	0.0	-0.7

## 9.2 Results

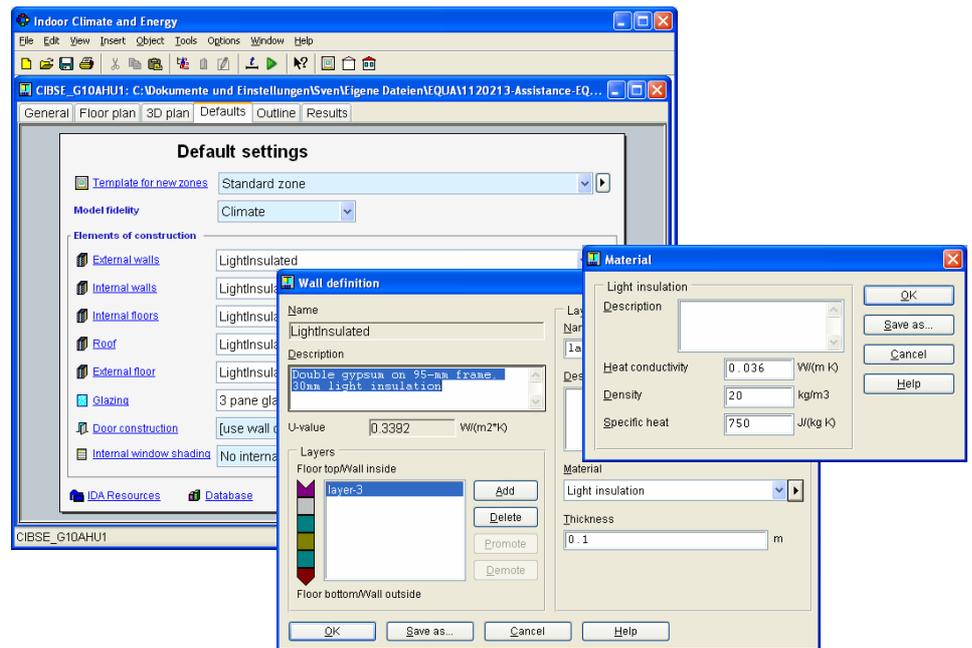
Connection	Air flow rate / L/s							
	Test 1		Test 2		Test 3		Test 4	
	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4
Entering room 1 via B1	-11.6	-11.7	-20.6	-20.8	-36.0	-36.5	-20.4	-20.5
Entering room 1 via B2	16.6	16.8	17.1	17.4	29.9	30.5	28.7	29.1
Entering room 1 via D1	-5.5	-5.6	3.4	3.4	6.0	5.9	-9.2	-9.3
Entering room 2 via B6	26.4	26.7	11.6	11.6	13.6	13.2	39.4	39.8
Entering room 2 via R1	-27.3	-27.5	-11.7	-11.7	-14.0	-13.4	-40.7	-41.1
Entering room 3 via B3	13.8	13.8	5.3	5.3	9.0	9.3	23.4	23.7
Entering room 3 via B4	-7.2	-6.9	10.5	10.7	18.0	18.5	-17.4	-17.4
Entering room 3 via D2	-12.7	-12.8	-12.8	-12.9	-21.4	-22.1	-16.2	-16.4
Entering room 4 via R2	-21.1	-21.3	-23.4	-23.7	38.7	40.0	-23.7	-23.9
Entering room 4 via B5	8.3	8.4	10.6	10.8	17.2	17.9	7.2	7.4

Table 13: Test G9 Air flow rate results.

## 10. Test G10: Air handling unit test

### 10.1 Implementation in IDA ICE

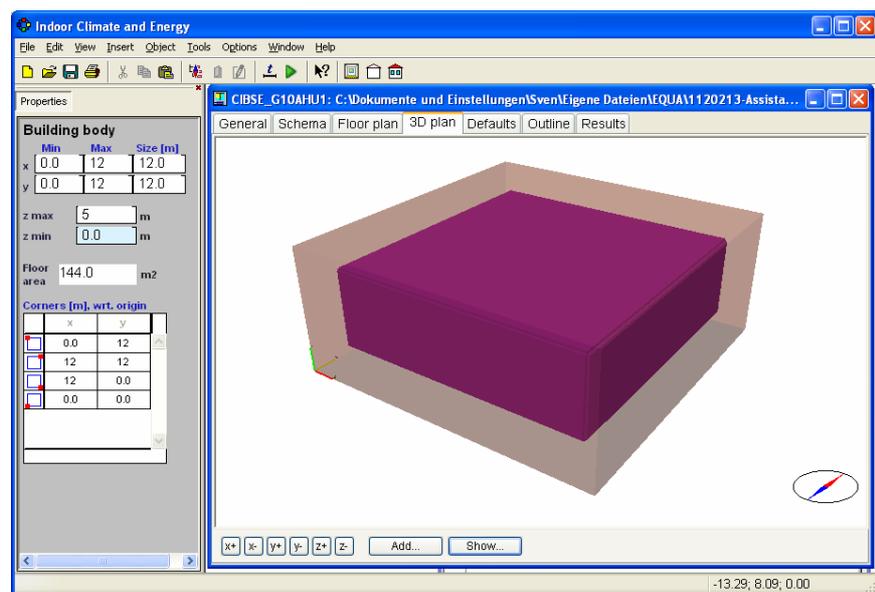
Walls:



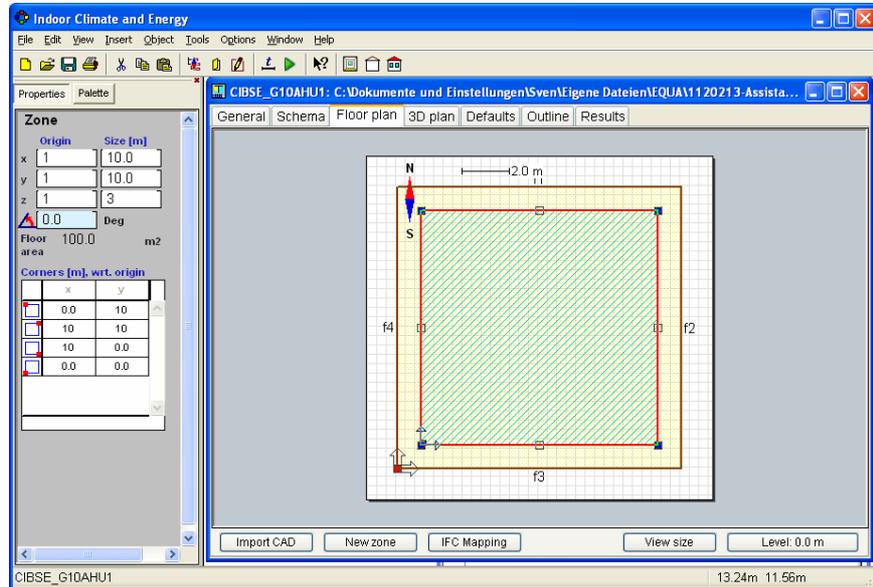
Building: 12 m x 12 m x 5 m

Zone: 10 m x 10 m x 3 m

3D plan:

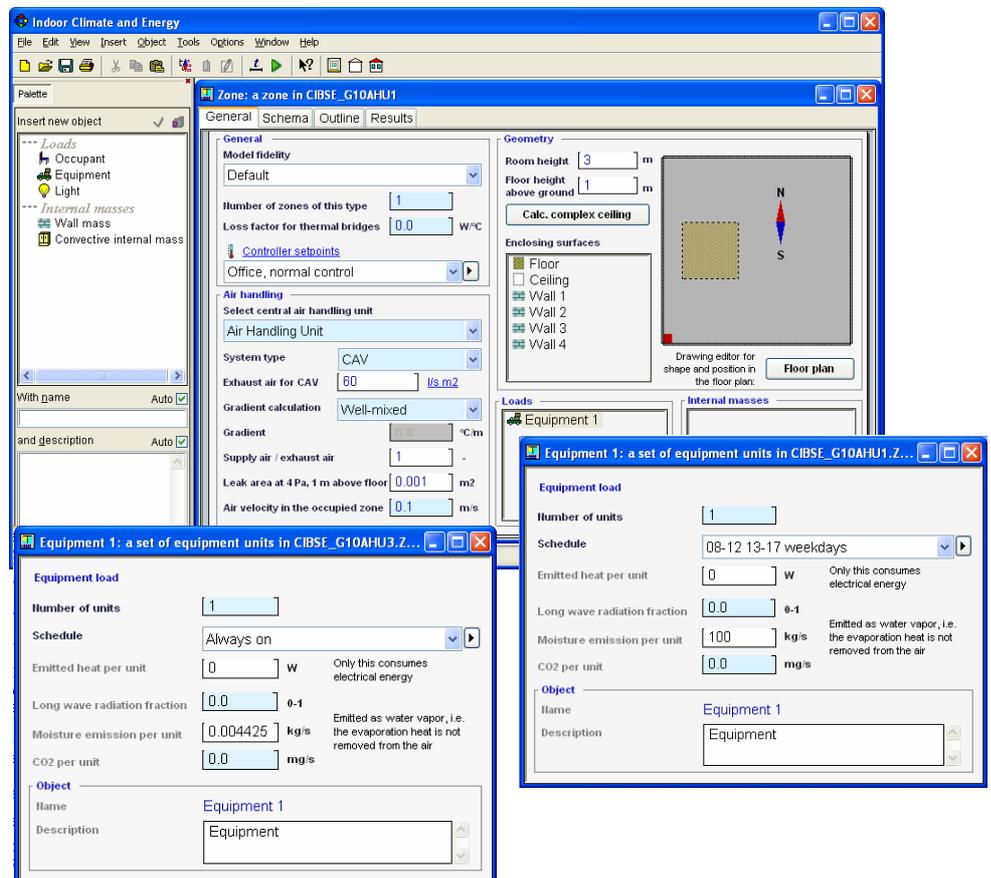


Floor plan:



Zone:

AHU2: Equipment is used for humidity control (see later: Advanced level)  
 AHU3: Equipment is used for latent gain



Controller setpoints:

Fixed temperature (23 °C):

AHU1:

AHU2:

**Main parameters**

Efficiency, heat exchanger	<undefinec	Efficiency, supply fan	0.7125
Pressure head, supply fan	800 Pa	Efficiency, exhaust fan	0.7125
Pressure head, exhaust fan	400.0 Pa	Temperature increase, supply fan and system	1.75 °C

**Setpoint for supply air temperature**

16.0 Constant

**Mode = 6**

**coeff[1] = 0.8**  
**coeff[2] = 0.2**

**TRise = 0.875**

**cc: a mathematical model in CIBSE\_G10AHU2.Air Handling Unit**

Object name: cc Object type: CCSIMCTR

**Variables**

TAIROUT	11.51	Deg-C	Temp of leaving air
TAIRIN	16.2	Deg-C	Temp of entering air
TLIQOUT	16.2	Deg-C	Temp of leaving liquid
TLIQIN	5.0	Deg-C	Temp of entering liquid

**Parameters**

ETA	0.94	dimless	Air side effectiveness at capacity
DTLIQ	11.85	Deg-C	Liq side temp rise

**Interfaces**

AIRFLOWIN <--> MixBox.SUPOUT  
 AIRFLOWOUT <--> hc.AIRFLOWIN  
 LIQFLOWIN <--> AHU\_Sup\_Cold  
 LIQFLOWOUT <--> AHU\_Rtn\_Cold  
 TEMPSETPOINT

AHU3:

**Main parameters**

Efficiency, heat exchanger	<undefinec	Efficiency, supply fan	0.7125
Pressure head, supply fan	800 Pa	Efficiency, exhaust fan	0.7125
Pressure head, exhaust fan	400.0 Pa	Temperature increase, supply fan and system	0.9 °C

**Setpoint for supply air temperature**

100 Constant

**Mode = 7**

**Setpoint <== 0.00854**  
**N = 1**  
**K = 0.3**  
**TI = 0.1**  
**TT = 0.1**  
**MODE = 0**  
**HILIMIT = 1**  
**LOLIMIT = 0**

**TSteam <== 100**  
**TWat <== 10**  
**PWat <== 50000**  
**RHMax <== 1**

**EtaQ = 0.66**  
**EtaW = 0.6**

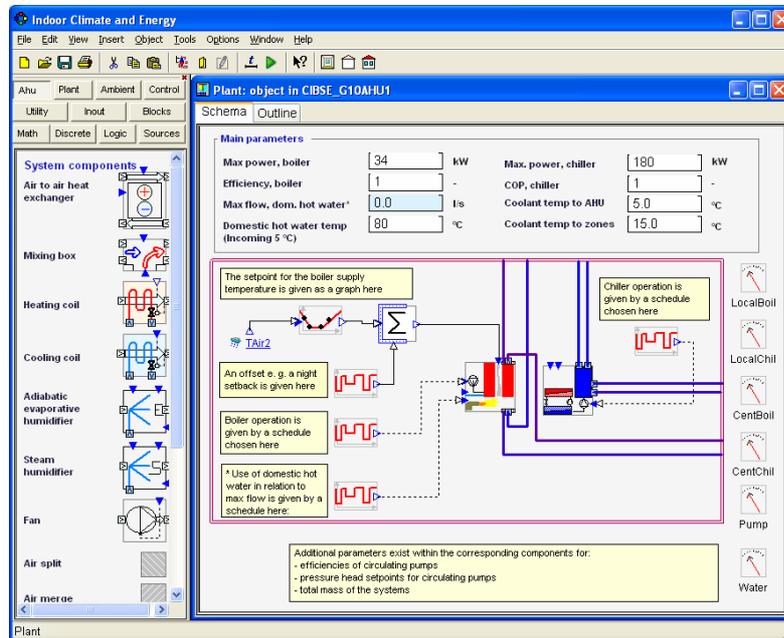
**TSet <== 25**

**TRise = 0.5**

**Results**

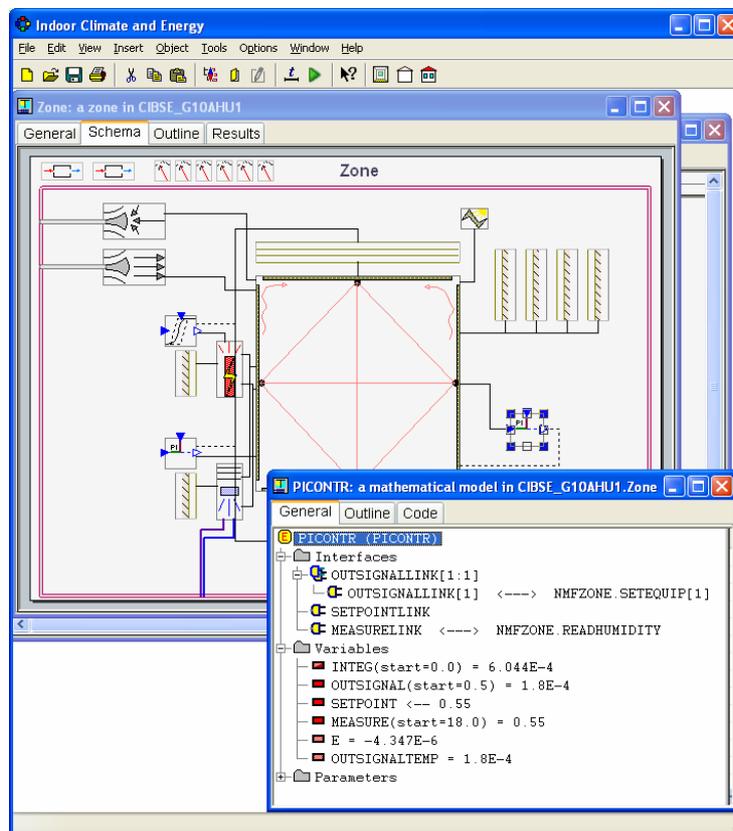
AHU temperatures

Plant:



Advanced level:

Humidity control for AHU2:



## 10.2 Results

Component	Energy demand / kWh					
	AHU1		AHU2		AHU3	
	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4
Cooling coil	12'348	12'565	11'744	11'952	0	0
Heating coil	5'461	5'383	5'579	5'473	10'914	10'786
Fan motor(s)	1'132	1'127	1'698	1'705	1'698	1'735
Humidifier	0	0	0	0	3'925	3'996

Table 14: Test G10: Energy demands.

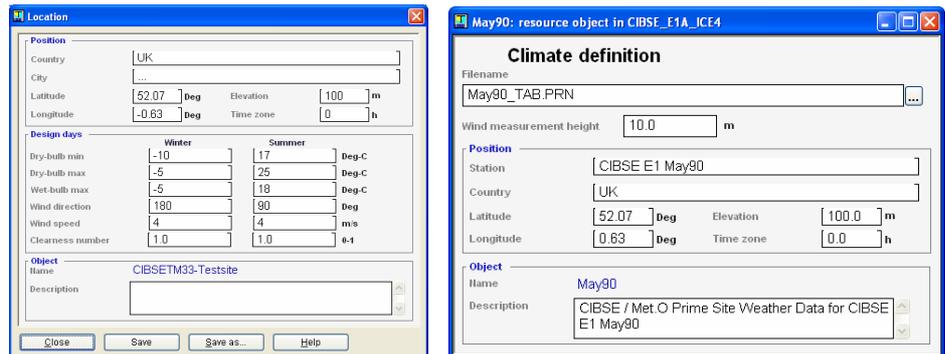
Node	2 Jan. 06:00				4 Jan. 04:00				7 Jan. 14:00			
	Dry bulb / °C		Humidity / g/kg		Dry bulb / °C		Humidity / g/kg		Dry bulb / °C		Humidity / g/kg	
	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4	CIBSE TM33	ICE 4
1	-2.1	-2.0	3.1	3.0	6.2	6.2	5.1	5.1	3.3	3.3	4.1	4.2
3	14.4	14.5	6.7	6.7	16.9	16.9	7.5	7.5	16.0	16.1	7.1	7.2
7	25.9	25.9	6.7	6.7	25.9	25.9	7.5	7.5	25.9	25.9	7.1	7.2
8	25.9	26.1	8.5	8.5	25.9	26.0	8.5	8.5	25.9	26.1	8.5	8.5
10	21.5	21.5	9.1	9.2	21.5	21.5	9.1	9.2	21.5	21.5	9.1	9.2
11	5.0	5.1	5.5	5.4	10.8	10.8	6.7	6.7	8.7	8.8	6.1	6.2

Table 15: Test G10 AHU3: Conditions at selected nodes.

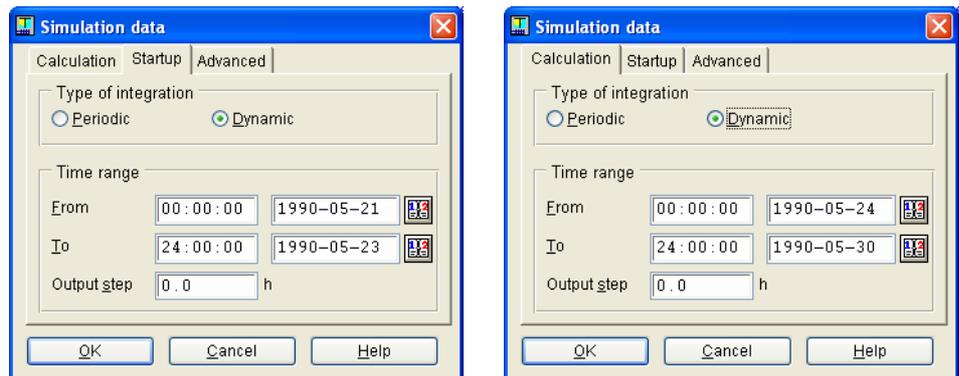
# 11. Test E1: Empirical validation

## 11.1 Implementation in IDA ICE

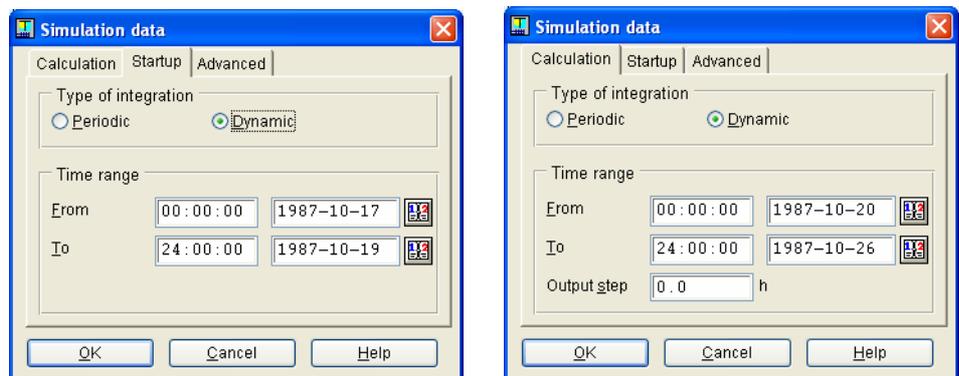
Location / Climatic file: Measured data (E1A-E1C: MAY90\_TAB.PRN; E1D-E1F: OCT87\_TAB\_PRN)



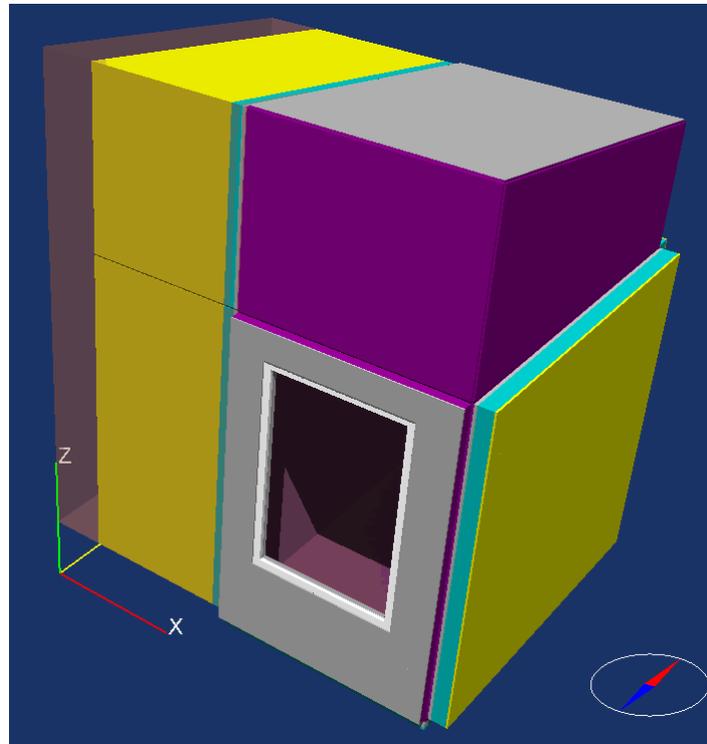
Simulation data E1A-E1C:



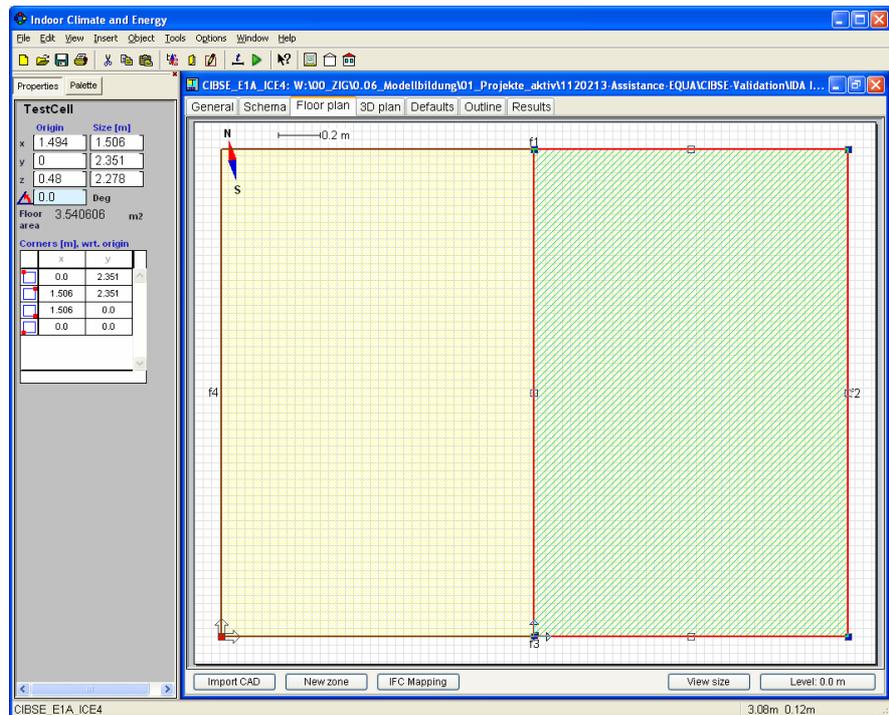
Simulation data E1D-E1F:



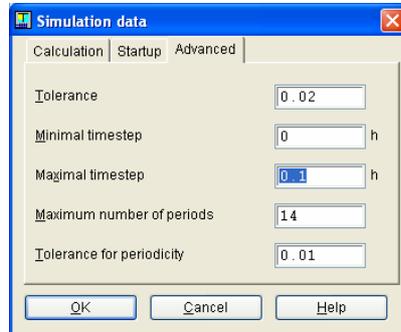
*Building:* 1.506 m x 2.351 m x 3.33 m  
*3D plan:*



*Floor plan:*

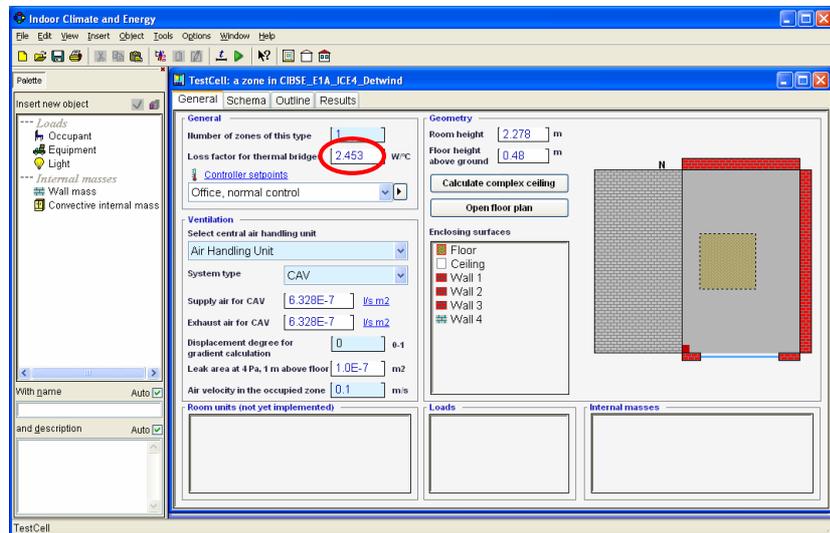


*Timestep:*



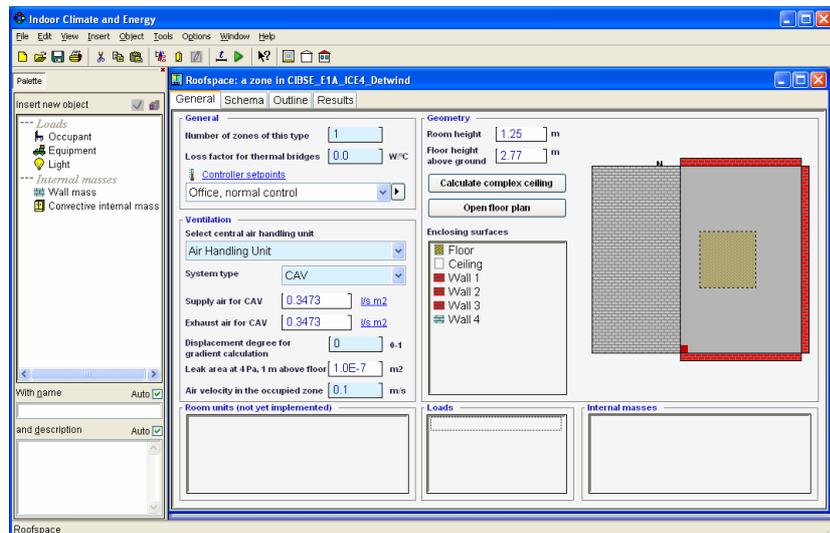
*TestCell:*

1.506 m x 2.351 m x 2.278 m

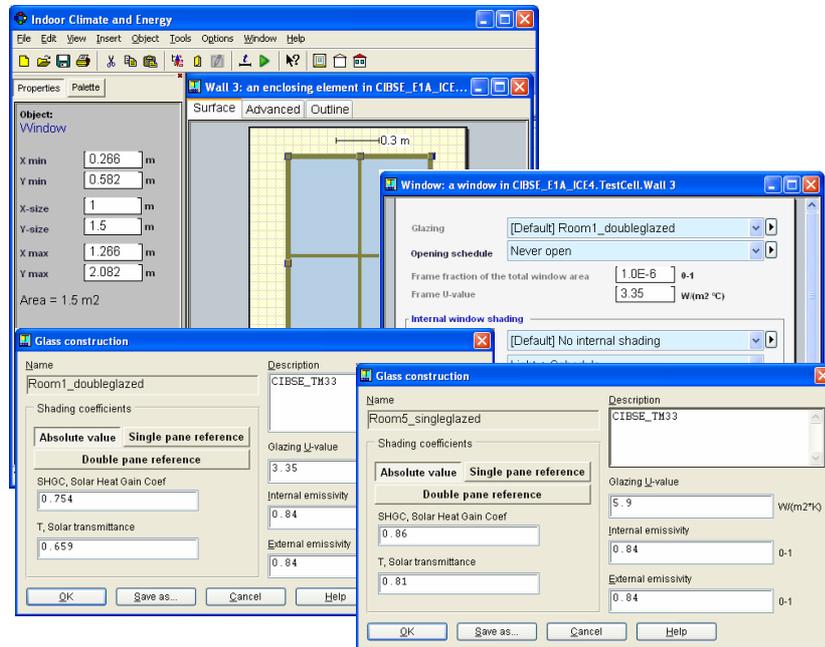


*RoofSpace:*

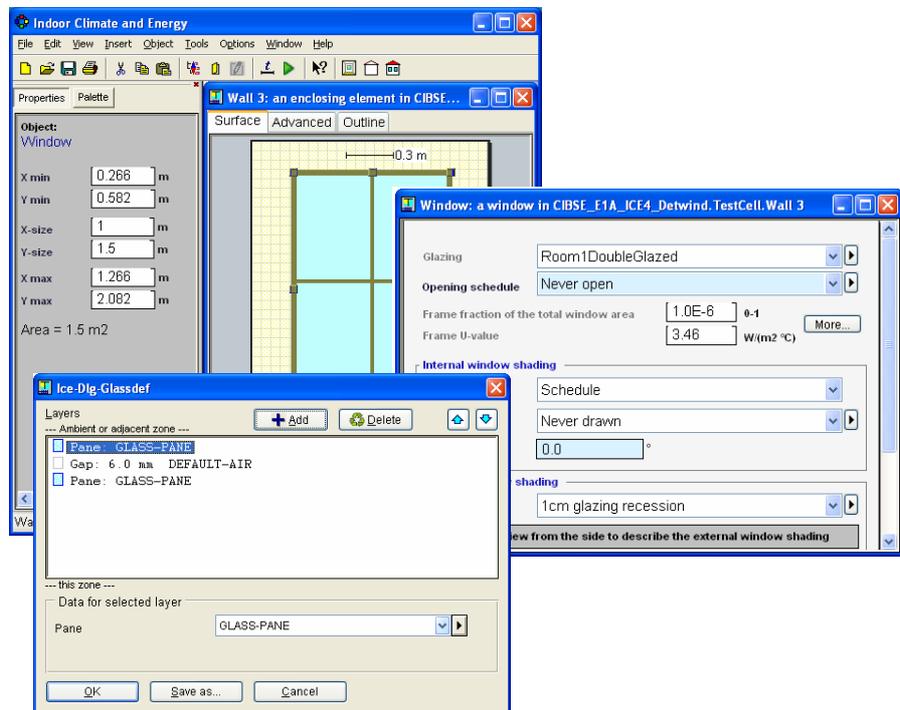
1.506 m x 2.351 m x 1.040 m



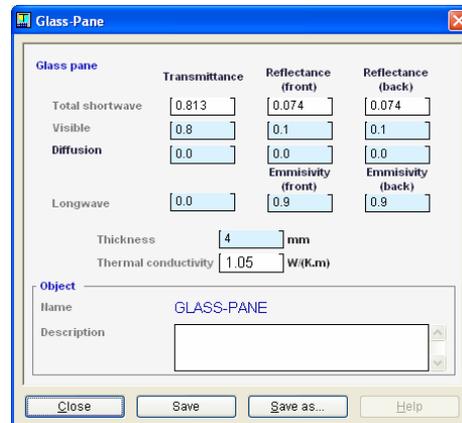
Window (Cewind):



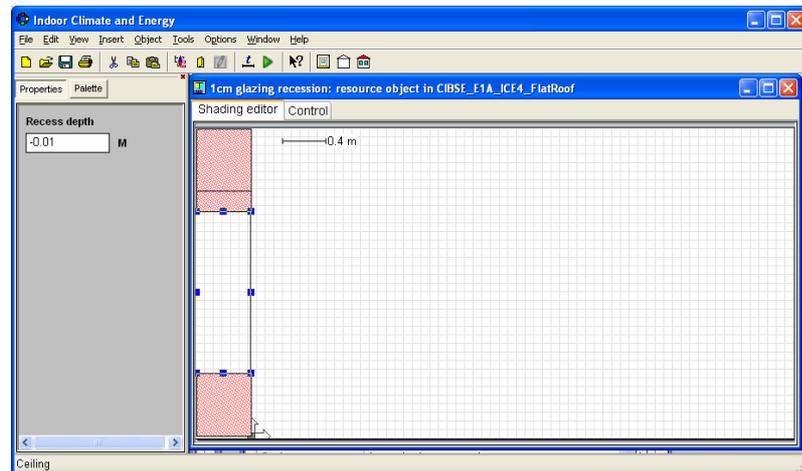
Window (Detwind):



*Glazing layers:*



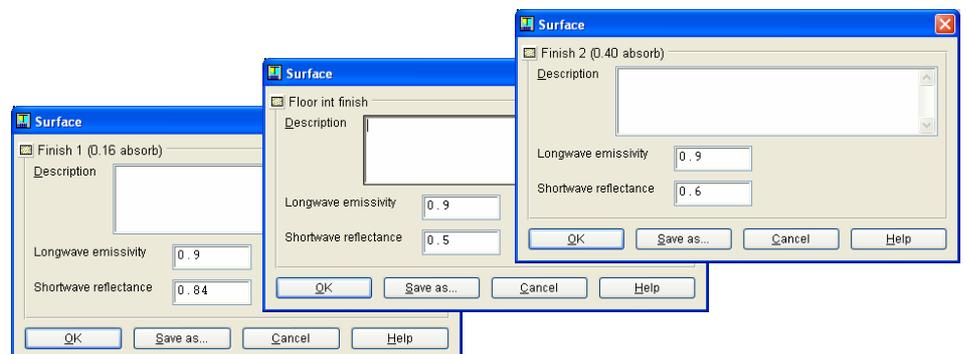
*Window recession:*



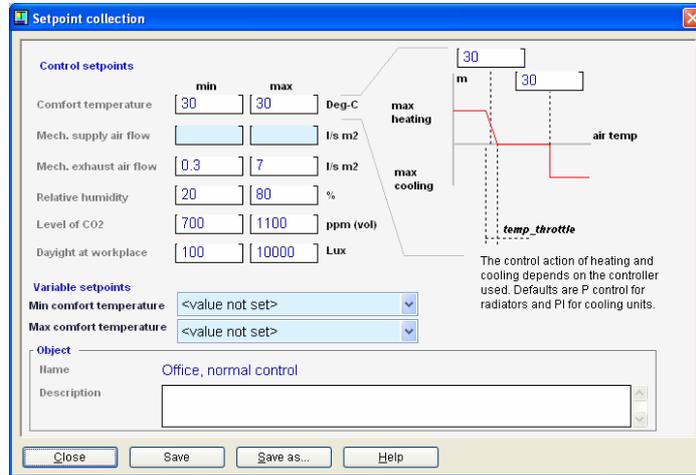
*Wall constructions:*

The specifications in TM33 include some, but not all cold bridges. In the IDA ICE model, all cold bridges (2.453 for the test cell) are taken into account. Therefore the conductivity for all wood layers is set to 0.125 W/mK, as it is in reality.

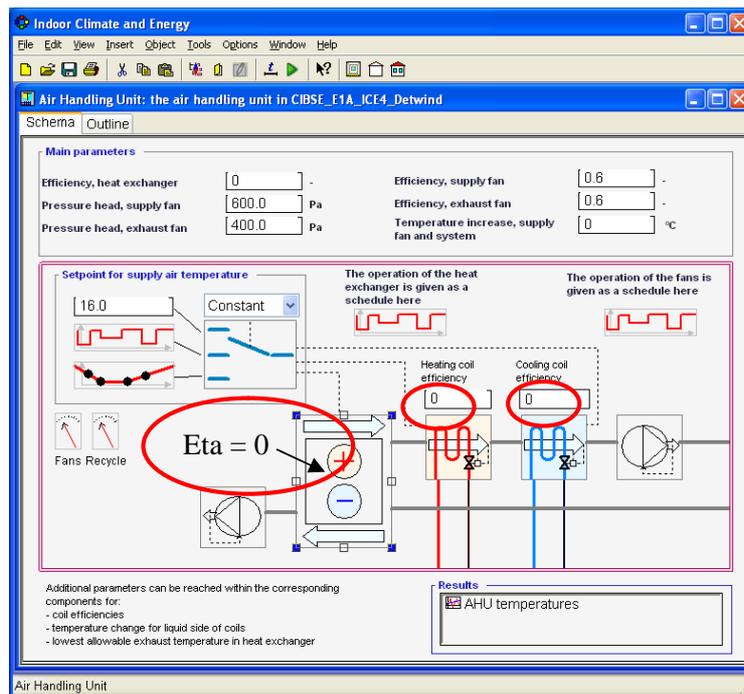
*Wall surfaces:*



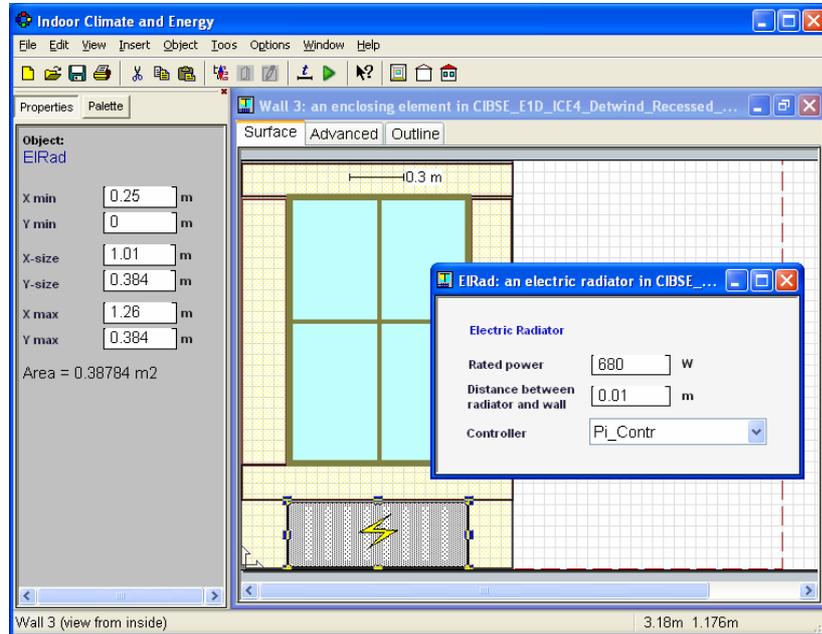
Controller setpoints:



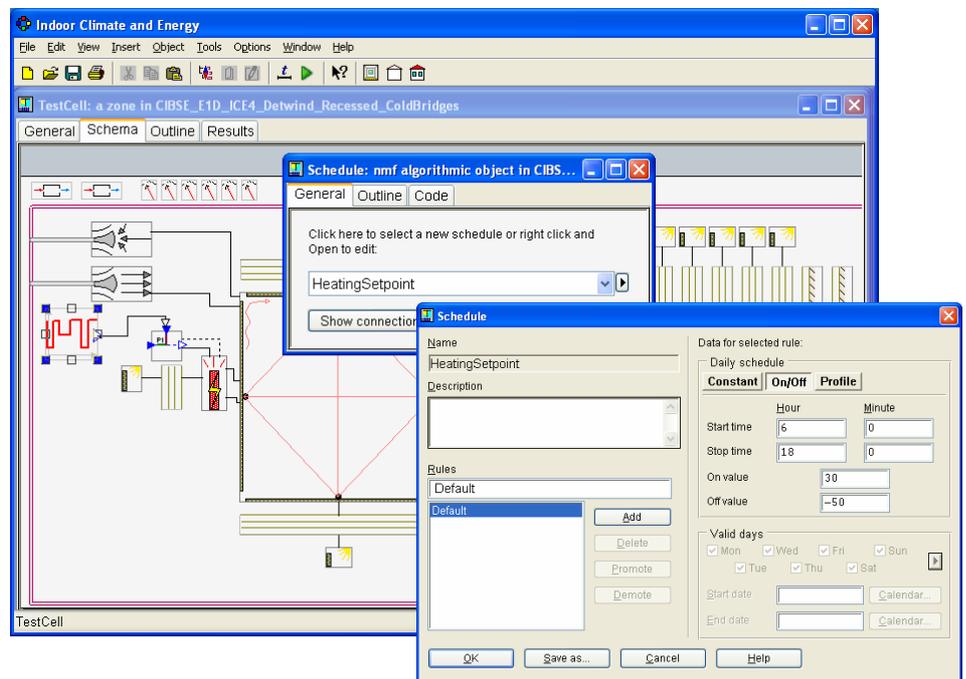
AHU:



*Heating unit (EID-EIF):*



*Advanced level:*



## 11.2 Results

Test	Parameter	Measured value	ICE 3 CeWind Flat Roof	ICE 4 CeWind Flat Roof	ICE 4 CeWind Sloped R.	ICE 4 DetWind Sloped R.	Tolerance
Case E1A	Energy (kWh)	0.0	0.0	0.0	0.0	0.0	0.0
	Max. temp. (°C)	31.0	29.9	30.5	30.4	29.6	2.5
	Min. temp. (°C)	12.2	11.5	11.8	11.6	12.4	2.5
Case E1B	Energy (kWh)	0.0	0.0	0.0	0.0	-	0.0
	Max. temp. (°C)	16.8	17.0	16.9	16.5	-	1.5
	Min. temp. (°C)	9.2	8.7	8.7	8.5	-	1.5
Case E1C	Energy (kWh)	0.0	0.0	0.0	0.0		0.0
	Max. temp. (°C)	32.6	30.1	30.3	30.1		2.5
	Min. temp. (°C)	12.1	10.4	10.4	10.4		2.5
Case E1D	Energy (kWh)	24.8	24.4	23.6	23.8	22.0	15 %
	Max. temp. (°C)	37.8	39.2	40.1	39.9	39.9	2.5
	Min. temp. (°C)	11.9	10.9	11.2	11.0	12.7	2.5
Case E1E	Energy (kWh)	32.5	31.8	31.5	31.6	-	15 %
	Max. temp. (°C)	29.8	30.1	30.1	30.1	-	1.0
	Min. temp. (°C)	14.6	10.6	10.5	10.5	-	2.5
Case E1F	Energy (kWh)	25.0*	27.7	27.2	27.3		15 %
	Max. temp. (°C)	37.0*	38.8	38.9	38.8		2.5
	Min. temp. (°C)	9.1*	8.9	8.9	8.7		2.5

Table 16: Test E1 results.