

# Schaakwijk project in Utrecht, The Netherlands

## Passive ventilation strategy using a sun room

Evert Vrins, Els Oomens

W/E consultants sustainable building, P.O. box 256, 5000 AG Tilburg, The Netherlands

### **1 Synopsis**

An energy consumption of between 30 and 50 percent less than average is achieved in the 248 newly built dwellings in Schaakwijk, Utrecht. Through a combination of optimum use of the sun and a passive ventilation concept using sun rooms. This Thermie SUNH project also makes use of materials in an environmentally responsible way.

The house construction plan is part of the restructuring plan of the Zuilen district in Utrecht. Various blocks of dwellings are at the end of their useful life, in a technical and social sense. The old Schaakwijk district made way for an entirely renovated area.

36 Dwellings are designed with a passive solar concept. Part of the design is the passive ventilation concept combined with night cooling to prevent against overheating in summer. These dwellings consume 50% less energy compared with the Dutch building code. In this paper the passive ventilation and night cooling concept is described in detail. Results of calculations of the concept are presented, and conclusions for future projects are drawn.

### **2 Design features of the houses**

#### **2.1 Sun, light and shadow**

The challenge was to produce a urban planning approach in an existing district which makes optimum use of the sun. Almost all dwellings face either the south east or south west, with large windows to the south and small windows to the north. Major focal points in the design of the dwellings are optimising daylight to incorporate as much solar energy as possible and optimising the use of shade to prevent overheating in the summer. As a result of the chosen urban plan, a part of the dwellings have large windows facing the garden, where others have street-oriented floor plans. See *Figure 1*.



*Figure 1 View of dwellings, north facade*

All dwellings are connected to the district heating network and have a low-temperature heating system. Extensive energy conservation in the dwellings with sun rooms yield an energy saving of 50% compared to the Dutch building code.

## **2.2 Passive ventilation with sun rooms**

The 36 dwellings are equipped with a sun room over two floors, as can be seen in the figure below.



*Figure 2 View of the sunrooms*

The sun room is a pleasant outer area in the spring and autumn; it also plays an important role in the concept of passive ventilation.

The design features of the passive solar houses are:

- passive stack ventilation
- optimisation of the use of solar energy in the winter
- optimisation of the ventilation pattern in the house
- optimisation of the daylight in the dwellings
- night cooling in summer

The concept of passive ventilation and night cooling is described hereafter.

### **3 Passive ventilation concept**

The ventilation concept of these house is based on the use of air which is preheated in the sun room. The sun room is placed on the south side of the houses, covering two floors. The houses are relative airtight. Extra ventilation is possible by opening self-regulating vents (as shown in

Figure 3), most of which are placed between the sun room and the house.



*Figure 3 Self-regulating ventilation duct at bottom of sun room*

Therefore the percentage of preheated air flowing into the house is high. The vents preserve a constant flow of air from the sun room to the living room and to the bedrooms on the south side (see Figure 5).

The air flows through openings into the sun room. The openings are large, so that the air in the sun room has outside air quality. The vents regulate the airflow on a constant level in spite of the pressure difference. The air flows through the south rooms to the north rooms where the toilet, bathroom and kitchen have natural ducts. The outlets at the roof are shown in

*Figure 4.*



Figure 4 Outlets of natural ventilation channels.

The principle of the passive ventilation concept is presented in figure .

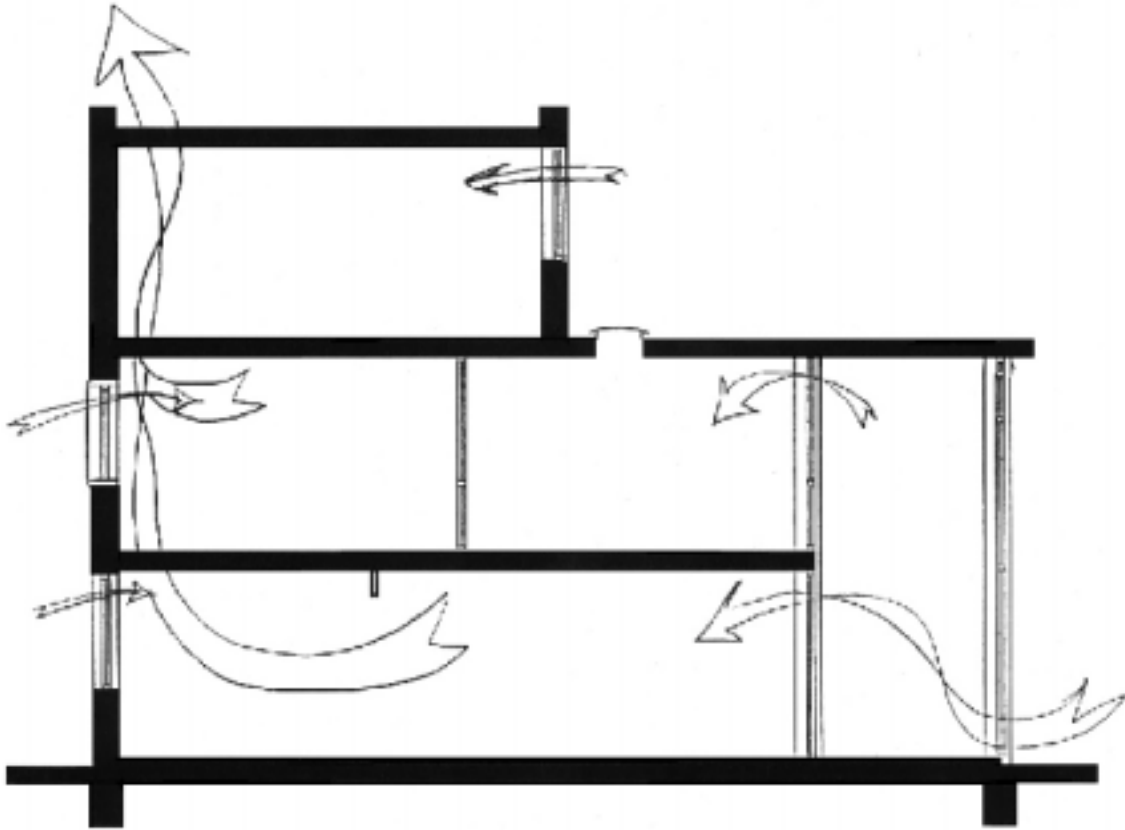


Figure 5: Passive ventilation strategy using preheated ventilation air.

#### 4 Night cooling design

Dwellings with a sun room as described above need protection against summer overheating. Therefore a shading device is installed on the inside of the sun room on the highest half of it's glazed area. The shading coefficient is 0.3. The vents and windows in the sun room can be opened during night time. Vents are used on the bottom of the facade and windows high in the facade. During night time the window in the roof of the sleeping room can be opened for extra ventilation capacity.

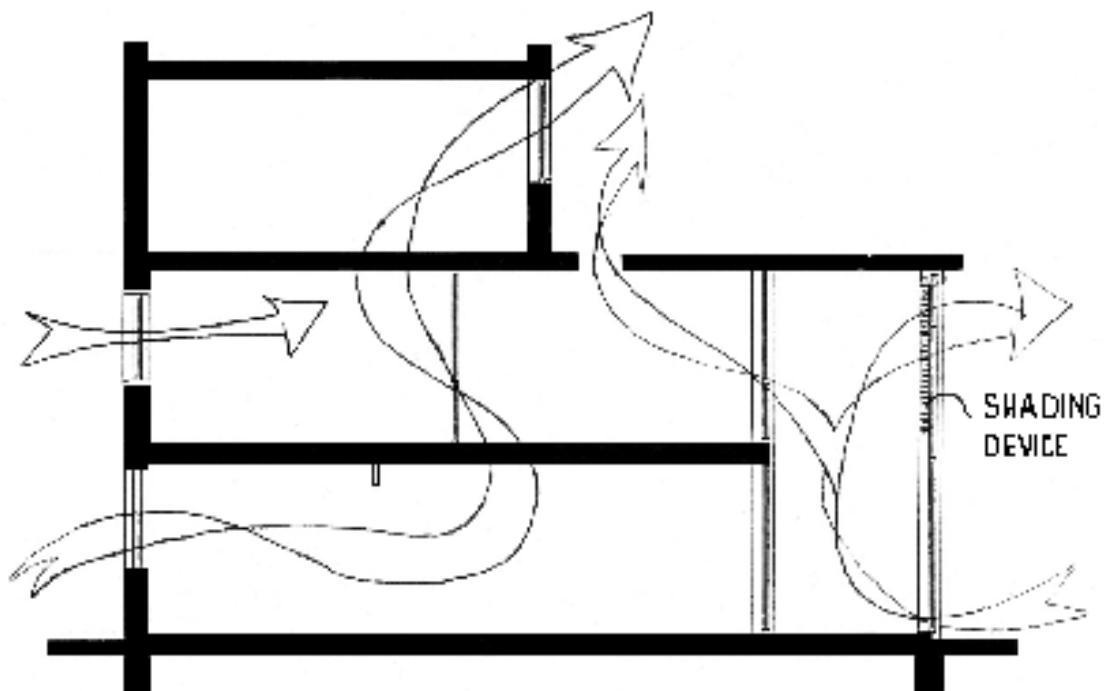
During day time the sleeping room roof window and the windows on the top floor are opened. The roof windows are depicted in Figure 6.



*Figure 6 Roof windows*

The inhabitants can ventilate by opening windows on the relative cold north side of the house or in the sun room.

The principle of measures against overheating is presented in Figure 7.



*Figure 7: Summer (night-) ventilation and shading of a dwelling house with a sun room.*



## **5 Calculations**

Calculations are made with the multi-zone ventilation calculation model MVRM 4.1 on the concept of natural ventilation of the dwellings using sun rooms. The aim was to see whether or not the chosen ventilation concept is working properly, as well as to optimise the concept.

In the appendix the calculated ventilation patterns are presented in figures.

The results of the calculations are:

- 1 There is hardly any cross ventilation in the houses. This is caused by the self-regulating ventilation vents. More vents will lead to cross ventilation.
- 2 The ventilation of the kitchen, bathroom and toilet in both alternatives is according to the Dutch regulations.
- 3 The ventilation of the sun room in winter is good. The air change rate in the first alternative is about 4 to 5 times per hour.

Next to this, calculations were made of summertime overheating, since overheating is becoming a issue to be regarded seriously in in the Netherlands as building insulation levels keep increasing. There is not much experience with overheating in Dutch dwellings. The calculations show that summer indoor temperatures are within set limits. Sometimes the indoor temperatures are lower than outside temperatures. This happens especially in the hot summer afternoons.

## **6 Conclusions**

Calculations showed it is possible to develop a naturally ventilated low energy house using a sun room. The self-regulating air inlet vents improve the flow pattern through the house.

There will be a substantial energy saving when using a good sun room concept.

Main conclusions are:

- 1 Natural ventilation is possible at the winter conditions.
- 2 The percentage of preheated infiltration air in the facade with the sun room is 67%. This is calculated for the concept using self-regulating inlet vents, at 5 m/s wind

velocity, 5°C outside temperature and at three wind directions: perpendicular to the sun room facade, on the north facade and parallel with the sun room facade.

- 3 The concept of natural ventilation using self-regulating air inlet vents performs much better than natural ventilation without self-regulating air inlet vents. This is valid for both the ventilation pattern and the energy demand.
- 4 Hardly any cross ventilation occurs in winter time.

## **7 Acknowledgements**

The project has been made possible with a subsidy by the Thermie programme of the European Commission, DG XVII. The SUNH (Solar Urban New Housing) project was approved within that programme. Ten housing construction projects from eight different European countries are participating.



## **Appendix**

### **Flow patterns through the house**

Flow patterns through the house according are calculated with the multi-zone ventilation calculation model MVRM 4.1.

The results of the calculations at three wind directions, windspeed 5 m/s, and outside temperature 5°C are presented in the next figures.

**Projectnaam:** Serrewoning Zuilen  
**Berekeningsnummer:** 1.8

Buitemtemperatuur [°C] 5 RV buiten 50%  
 Windsnelheid [m/s] 5  
 Windrichting noord  
 Aantal ruimtes 12

0.0

**Luchtstromen door connecties [m3/h]**

		in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
buiten gevel noord	Q uit	1	0	0	0	30	0	0	30	12	0	0	67	0	0	0	0	0	0	0	0	140
buiten gevel zuid	Q uit	2	0	0	0	0	0	101	4	0	0	0	0	0	0	0	0	0	0	0	0	105
buiten dak zuid schu	Q uit	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
buiten dak plat	Q uit	4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
woonkamer	Q uit	5	0	0	0	74	5	0	0	6	0	0	0	0	0	0	0	0	0	0	0	79
toilet	Q uit	6	0	0	0	19	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	19
serre	Q uit	7	0	9	0	0	50	0	7	0	0	20	22	0	0	0	0	0	0	0	0	101
trappenhuis	Q uit	8	4	0	0	0	0	20	0	8	29	28	26	0	0	0	0	0	0	0	0	106
badkamer	Q uit	9	0	0	0	40	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	40
slaapkamer 1 zuid	Q uit	10	0	0	47	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	47
slaapkamer 2 zuid	Q uit	11	0	0	47	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	47
slaapkamer 3 noord	Q uit	12	0	0	0	0	0	0	0	67	0	0	0	12	0	0	0	0	0	0	0	67
0	Q uit	13	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0
0	Q uit	14	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
0	Q uit	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
0	Q uit	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0
0	Q uit	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0
0	Q uit	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0
0	Q uit	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
0	Q uit	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
TOTAAL		4	9	94	133	80	20	101	107	41	48	48	67	0	0	0	0	0	0	0	0	0

Temperatuur [°C]	5.0	5.0	5.0	5.0	20.0	18.0	10.0	18.0	20.0	20.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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Vochtproductie [g/h]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vochtconcentratie [g/m3]	3.4	3.4	3.4	3.4	####	####	####	####	####	####	####	####	####	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RV	50%	50%	50%	50%	####	####	####	####	####	####	####	####	####	0%	0%	0%	0%	0%	0%	0%	0%

Gasproductie [-/h]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasconcentratie [-/m3]	0.0	0.0	0.0	0.0	####	####	####	####	####	####	####	####	####	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

afzuiging: kortsluiting

<b>Luchtstromen (selectie):</b>	wind	richt	T <sub>bu</sub>	in bu	in se	uit bu	uit se	via s	wk	keu	trap	serre	bad	stude	slk 2	slk 3	keu	bad	toilet	keuk	bad	
1.8	9	nat	5	noord	5	####	72	4	0	####	0	0	0	0	0	0	0	0	0	0	0%	0%

binnen - buiten	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
p' [N/m2]	872	872	872	872	2336	2062	1227	2062	2336	2336	2062	2062	611	611	611	611	611	611	611	611	611
rho' [g/m3]	6.8	6.8	6.8	6.8	17.3	15.3	9.4	15.3	17.3	17.3	15.3	15.3	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8

Totaal in vanuit buiten of serre:

- 5. Woonkamer 80
- 6. Toilet 20
- 9. Badkamer 41
- 10. Slaapkamer 1 20
- 11. Slaapkamer 2 22
- 12. Slaapkamer 3 67

**Project name:** Serrewoning Zuilen  
**Calculation number:** 1.8

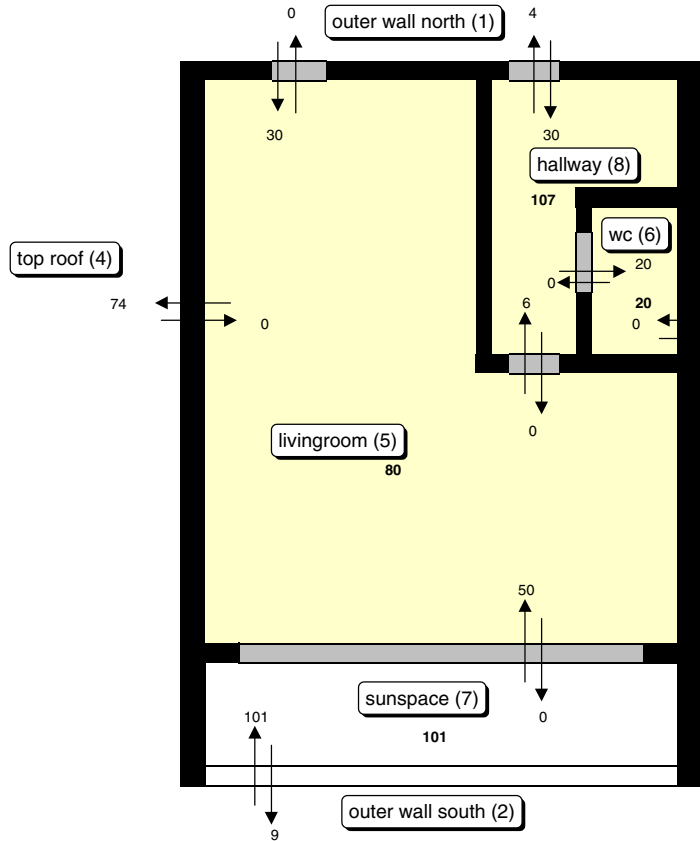
Outside temperature 5 °C  
 Wind velocity [m/s] 5 °C  
 Wind direction north  
 Ventilation type wet

Airtightness building envelope (qv(10)) [dm3/s]		30
Airtightness ventilation ducts dwelling (qv(10)) [dm3/s]		60
Airtightness sun room facade (qv(10)) [dm3/s]		100
Airtightness ventilation ducts sun room facade (qv(10)) [dm 200]		
kitchen shaft	A [m2] 0.0122 Z [-] 5 air flow [m3/h] 0	
bathroom shaft	A [m2] 0.0078 Z [-] 5 air flow [m3/h] 0	
toilet shaft	A [m2] 0.0035 Z [-] 5 air flow [m3/h] 0	

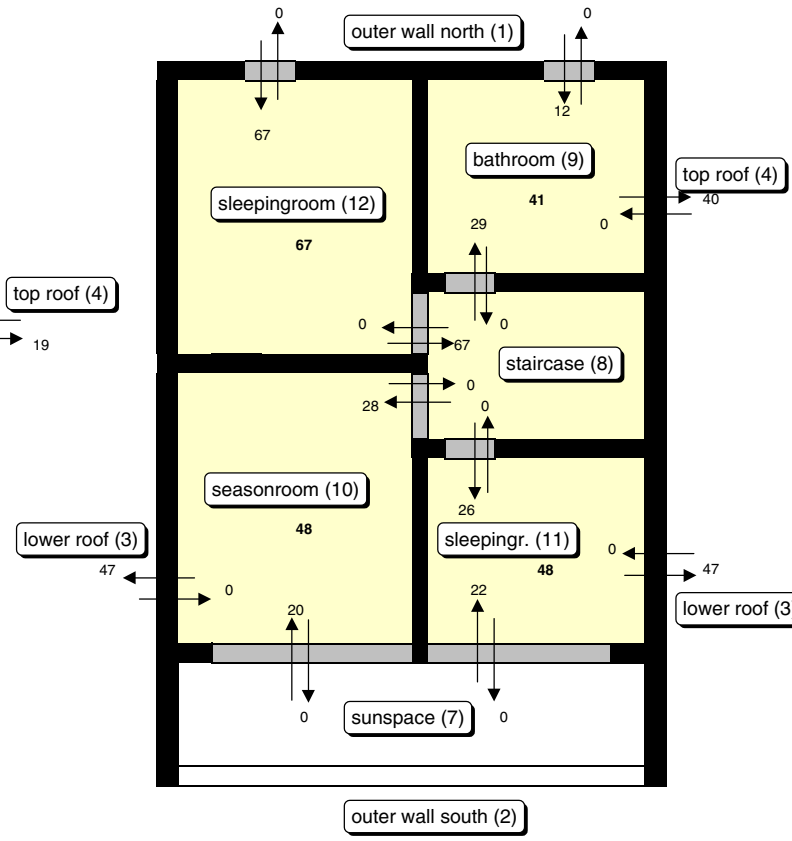
ventilation ducts to o	%	length [m]	height [m]
bed room 3	20%	0.30	5.60

ventilation ducts to suni	%	length [m]	height [m]
livingroom	50%	0.76	2.50
bed room 1	15%	0.23	5.60
bed room 2	15%	0.23	5.60

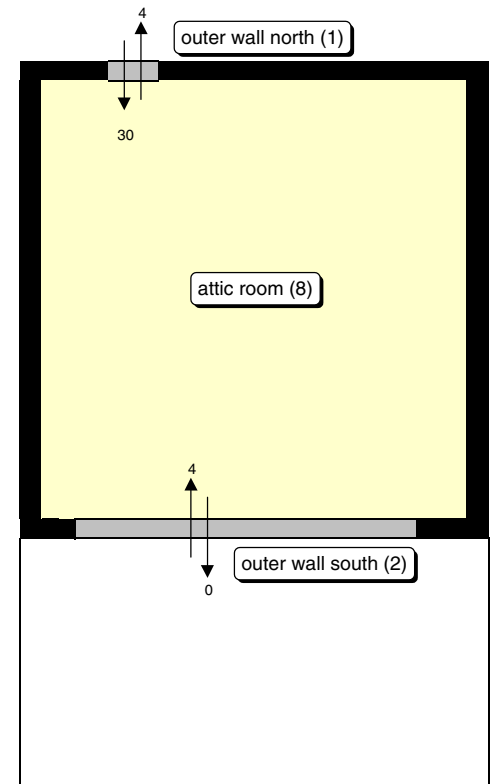
ducts sun room <-> outs	%	length [m]	height [m]
	50%	2.54	0.00
	50%	2.54	4.00



**GROUND FLOOR**



**1E FLOOR**



**2E FLOOR**

**Project name** Serrewoning Zuilen  
**Calculation number** 2.8

Outdoor temperature 5  
 Wind velocity (m/s) 5  
 Wind direction zuid  
 Number of rooms 12  
 Relative humidity outside 50%

**Luchtstromen door connecties [m3/h]**

	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
Q uit 1	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	
Q uit 2	0	2	0	0	0	0	186	17	0	0	0	0	0	0	0	0	0	0	0	0	203	
Q uit 3	0	0	3	0	0	0	0	0	0	94	94	0	0	0	0	0	0	0	0	0	188	
Q uit 4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Q uit 5	22	0	0	157	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	178	
Q uit 6	0	0	0	44	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44	
Q uit 7	0	0	0	0	90	0	7	0	0	48	48	0	0	0	0	0	0	0	0	0	186	
Q uit 8	23	0	0	0	89	45	0	8	107	0	0	38	0	0	0	0	0	0	0	0	302	
Q uit 9	9	0	0	97	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	106	
Q uit 10	0	0	0	0	0	0	0	141	0	10	0	0	0	0	0	0	0	0	0	0	141	
Q uit 11	0	0	0	0	0	0	0	141	0	0	11	0	0	0	0	0	0	0	0	0	141	
Q uit 12	37	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	37	
Q uit 13	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	
Q uit 14	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	
Q uit 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	
Q uit 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	
Q uit 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	
Q uit 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	
Q uit 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	
Q uit 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0
	92	0	0	298	179	45	186	303	107	142	142	38	0	0	0	0	0	0	0	0	0	0

5.0	5.0	5.0	5.0	20.0	18.0	10.0	18.0	20.0	20.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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i) [g/m3]

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.4	3.4	3.4	3.4	####	####	####	####	####	####	####	####	####	####	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	50%	50%	50%	####	####	####	####	####	####	####	####	####	####	0%	0%	0%	0%	0%	0%	0%	0%

m3]

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0.0	0.0	0.0	####	####	####	####	####	####	####	####	####	####	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

afzuiging: kortsluiting

lectie): wind richt T<sub>bu</sub> in bu in se uit bu uit se via s wk keu trap serre bad studicslk 2 slk 3 keu bad toilet keuk bad

14	nat	5	zuid	5	####	138	60	0	####	0	0	0	0	0	0	0	0	0	0	0	0	0%	0%
----	-----	---	------	---	------	-----	----	---	------	---	---	---	---	---	---	---	---	---	---	---	---	----	----

0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
872	872	872	872	2336	2062	1227	2062	2336	2336	2062	2062	611	611	611	611	611	611	611	611	611	611
6.8	6.8	6.8	6.8	17.3	15.3	9.4	15.3	17.3	17.3	15.3	15.3	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	

ten of serre:

##  
 45  
 ##  
 ##  
 ##  
 0



Projectnaam: Serrewoning Zuilen  
 Berekeningsnummer: 3.8

Buitemtemperatuur [°C] 5 RV buiten 50%  
 Windsnelheid [m/s] 5  
 Windrichting oost/west  
 Aantal ruimtes 12

0.0

Luchtstromen door connecties [m3/h]

		in																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
buiten gevel noord	Q uit 1	1	0	0	0	9	0	0	8	3	0	0	38	0	0	0	0	0	0	0	0	59
buiten gevel zuid	Q uit 2	0	2	0	0	0	0	138	8	0	0	0	0	0	0	0	0	0	0	0	0	146
buiten dak zuid sch	Q uit 3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
buiten dak plat	Q uit 4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
woonkamer	Q uit 5	0	0	0	92	5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	94
toilet	Q uit 6	0	0	0	25	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
serre	Q uit 7	0	0	0	0	74	0	7	0	0	32	33	0	0	0	0	0	0	0	0	0	139
trappenhuis	Q uit 8	1	0	0	0	11	24	0	8	50	0	0	0	0	0	0	0	0	0	0	0	86
badkamer	Q uit 9	0	0	0	53	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	53
slaapkamer 1 zuid	Q uit 10	0	0	26	0	0	0	0	6	0	10	0	0	0	0	0	0	0	0	0	0	33
slaapkamer 2 zuid	Q uit 11	0	0	12	0	0	0	0	22	0	0	11	0	0	0	0	0	0	0	0	0	33
slaapkamer 3 noord	Q uit 12	0	0	0	0	0	0	0	39	0	0	0	12	0	0	0	0	0	0	0	0	39
0	Q uit 13	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0
0	Q uit 14	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0
0	Q uit 15	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0
0	Q uit 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0
0	Q uit 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0
0	Q uit 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0
0	Q uit 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0
0	Q uit 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0
TOTAAL		1	0	38	170	94	24	138	85	53	32	33	38	0	0	0	0	0	0	0	0	

Temperatuur [°C]	5.0	5.0	5.0	5.0	20.0	18.0	10.0	18.0	20.0	20.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
------------------	-----	-----	-----	-----	------	------	------	------	------	------	------	------	-----	-----	-----	-----	-----	-----	-----	-----	-----

Vochtproductie [g/h]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vochtconcentratie [g/m3]	3.4	3.4	3.4	3.4	####	####	####	####	####	####	####	####	####	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RV	50%	50%	50%	50%	####	####	####	####	####	####	####	####	####	0%	0%	0%	0%	0%	0%	0%	0%

Gasproductie [-/h]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasconcentratie [-/m3]	0.0	0.0	0.0	0.0	####	####	####	####	####	####	####	####	####	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

afzuiging: kortsluiting

Luchtstromen (selectie):	wind richt	T,bu	in bu	in se	uit bu	uit se	via s	wk	keu	trap	serre	bad	stuc	slk 2	slk 3	keu	bad	toilet	keuk	bad
3.8	29 nat	5	ost/we	5	####	107	1	0	####	0	0	0	0	0	0	0	0	0	0%	0%

binnen - buiten	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
p' [N/m2]	872	872	872	872	2336	2062	1227	2062	2336	2336	2062	2062	611	611	611	611	611	611	611	611	611
rho' [g/m3]	6.8	6.8	6.8	6.8	17.3	15.3	9.4	15.3	17.3	17.3	15.3	15.3	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8

Totaal in vanuit buiten of serre:

5. Woonkamer	94
6. Toilet	24
9. Badkamer	53
10. Slaapkamer 1	32
11. Slaapkamer 2	33
12. Slaapkamer 3	38

**Project name:** Serrewoning Zuilen  
**Calculation number:** 3.8

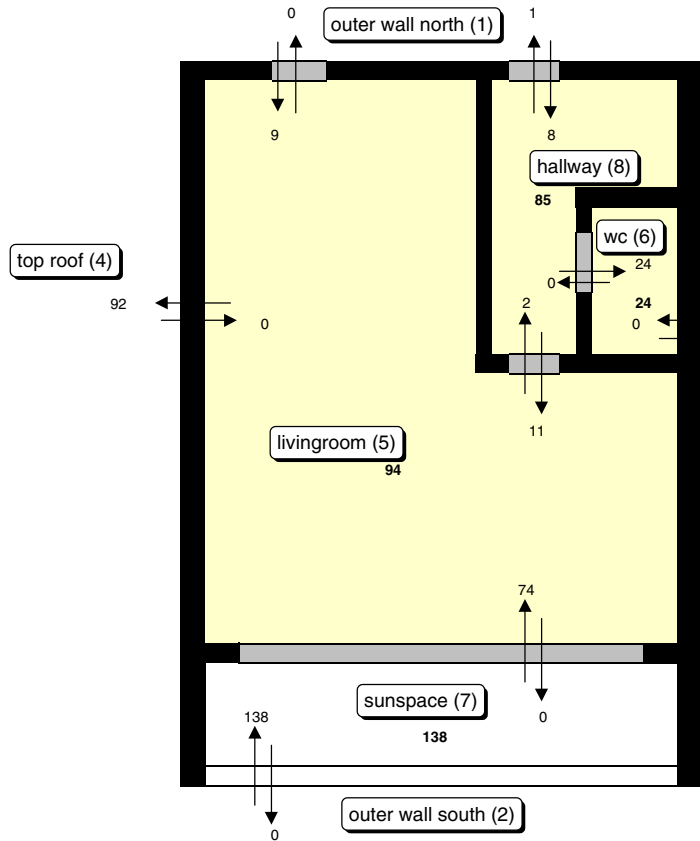
Outside temperature 5 °C  
 Wind velocity [m/s] 5 °C  
 Wind direction oost/west  
 Ventilation type nat

Airtightness building envelope (qv(10)) [dm3/s]	30
Airtightness ventilation ducts dwelling (qv(10)) [dm3/s]	60
Airtightness sun room facade (qv(10)) [dm3/s]	100
<b>Airtightness ventilation ducts sun room facade (qv(10)) [dm3/s]</b>	
kitchen shaft	A [m2] 0.0122 Z [-] 5 air flow [m3/h] 0
bathroom shaft	A [m2] 0.0078 Z [-] 5 air flow [m3/h] 0
toilet shaft	A [m2] 0.0035 Z [-] 5 air flow [m3/h] 0

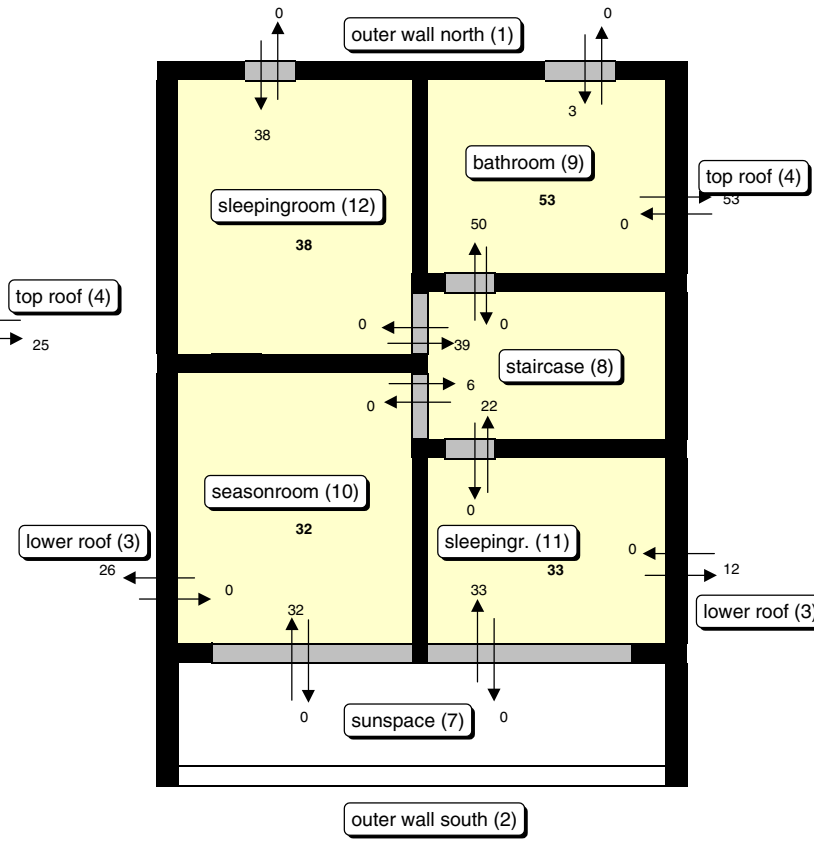
ventilation ducts to o	%	length [m]	height [m]
bed room 3	20%	0.30	5.60

ventilation ducts to sunr	%	length [m]	height [m]
livingroom	50%	0.76	2.50
bed room 1	15%	0.23	5.60
bed room 2	15%	0.23	5.60

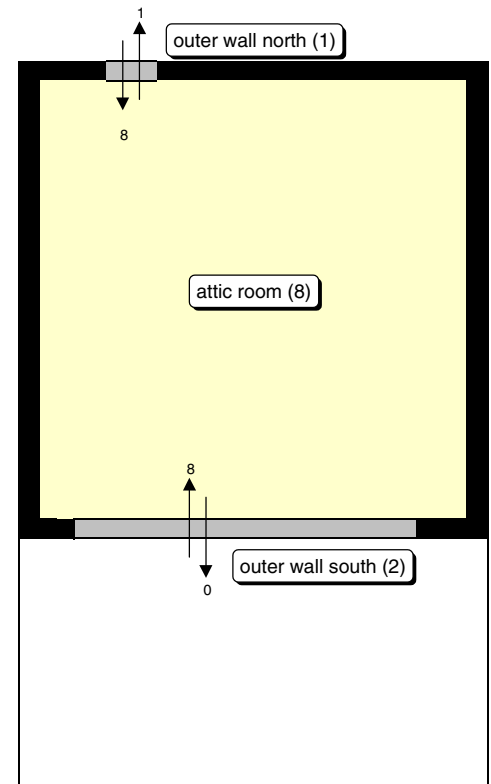
ducts sun room <-> outs	%	length [m]	height [m]
	50%	2.54	0.00
	50%	2.54	4.00



**GROUND FLOOR**



**1E FLOOR**



**2E FLOOR**