Energy efficient ventilation systems combined with solar systems.

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Abstract

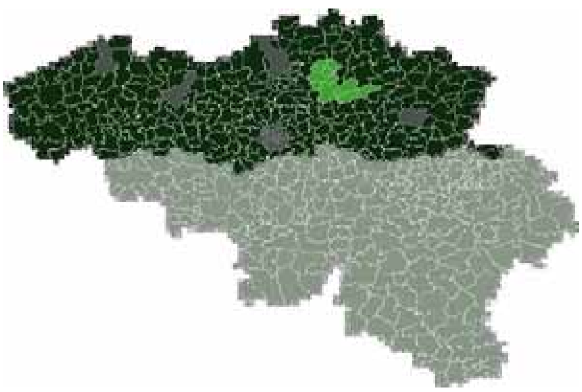
Zonnige Kempen, the youngest social housing company in Flanders, aims to contribute to sustainable development.
From the early nineties onwards various initiatives have been taken, both in new-construction and renovation projects. A few of these projects are highlighted and evaluated as for the applied ventilation technology.
A six-steps-plan is being used to test the realised additional value, both for the tenant and the housing company.
Some projects have been realised within a European context. Through Green Cities, Synpack and EGCN we could use European expertise and know-how to make great progress in regional development.
Experiences gained, not only by Zonnige Kempen but in the whole of Europe, can be a first step towards an energy-friendly application of the required ventilation.
The pilot function in this sector makes the reproductive effect even stronger.
Nevertheless, we should consider the remarks included in the conclusions.

A. Introduction

Situating the C.V. Zonnige Kempen within the framework of this seminar will not be easy for all persons present here. Therefore, this historical survey.

The social housing company 'Zonnige Kempen' is a co-operative society incorporated on 7 December 1963. Setting aside mergers between existing social housing companies 'Zonnige Kempen' is the youngest social housing company in Flanders. Its incorporation became fact when 11 small, rural municipalities around Westerlo joint forces and looked for co-operation in the field of social housing. The organisation was supported by social organisations, from which the ACW[1] took the lead. The latter put in part of the capital and assigned one employee for administrative support. The registered office of Zonnige Kempen was already located in Westerlo, but the offices were established in Turnhout. With the move in 1992 both registered office and administrative offices were brought together at the Grote Markt in Westerlo.

The capital of the Zonnige Kempen is for 60% in the hands of public administrations. The other 40% is put in by private partners. Zonnige Kempen is active in eleven municipalities: Berlaar, Nijlen, Heist-op-den-Berg, Vorselaar, Laakdal, Grobbendonk, Herenthout, Hulshout, Herselt, Westerlo and Zandhoven. These 11 municipalities own 40% of the shares of the Zonnige Kempen. The other 20% of publicly owned shares is put in by the Flemish Region and the province of Antwerp.



[1] Christian labour movement

The objective of the housing company is to provide in this region of some 150,000 inhabitants tenement and owner-occupied houses to people with a limited income.

At present, the company has built 1,764 houses, of which 321 have been sold, so that it has still 1,443 houses in its possession, another 112 houses are under construction.
Next to these houses the company also lets 599 garages and a library. It also has 7 houses under trust.

The story does not stop here. With a waiting list of more than 1,000 applicants, and the camping and weekend house occupants who are in urgent need of other accommodation, there is a great need for affordable housing facilities, to be created both by building new houses and through renovation projects.

To realise all this, several initiatives have been taken that cannot all be categorised under 'traditional' projects:

1. Architectural contests to show that social housing is also interested in new ideas.

2. Activities within the framework of article 94-95, rent subsidy, Domus Flandria, alternative financing.

3. Co-operation agreements with other partners such as:
    - province
    - municipalities
    - OCMW[2]
    - Associations without purpose of gain

Next to new-construction projects in residential extension areas, which remain necessary, C.V. Zonnige Kempen focuses on projects within existing residential areas.

All this and reshaping abandoned non-residential buildings such as former breweries, pubs and school buildings belong to the activities of the Zonnige Kempen.

We cannot go on leaving town centres, neighbourhoods and quarters in a vicious circle of ageing, dilapidation, demolition and maladjusted new housing facilities.
The extension of housing facilities must be turned inwards, ending the wasteful and uncontrolled use of land.
This goes further than merely the material renovation of the built-up environment. Social renovation of residential nuclei must also aim at a socially balanced development of society in villages or towns.
This was our first exercise in sustainable thinking.

[2] Public centres for social assistance

B. Sustainable and energy-efficient building in Belgium and the Netherlands

As from 1993 we began to become interested in this concept pursuant to a European project regarding sustainable and energy-efficient building in Belgium and the Netherlands. Our Dutch partner SRE (Co-operation Region of Eindhoven) looked into this issue on a macro-economic level (20,000 houses).
We in Belgium on the other went for a small-scale approach (about 20 houses) and we also focused on the social dimensions involved.
The Belgian component consisted of 3 phases and was carried out in co-operation with the Catholic University of Leuven (KUL), VITO[3] and VHM[4].

In a first phase the energy consumption in 250 social houses in Herenthout was examined.

Because the total patrimony of Herenthout was fitted with central heating on gas we could get a better insight in the influence of better insulation, double glazing, the use of window profiles with a better insulating value, a temperature-dependent control and inhabitant factors by using the annual gas and electricity consumption of the inhabitants.

This can be summarised in the following formula:

$$EV = 22{,}796.2 + 129.2 \times GC + 2{,}644.7 \times TOT$$

EV = energy consumption (MJ)
GC = building constant
TOT = number of inhabitants

For more recent houses we should take into account that energy savings are converted by the inhabitants in an increase in comfort by increasing the temperature of the thermostat and heating more rooms. This phenomenon is also called the "rebound effect of energy-saving measures".

For families with the strongest deviation we looked into the underlying reasons by way of an energy audit.

- The lowest values could in most cases be explained by a non-permanent occupation.
- Among the highest values there were some peculiar cases:
  a) Heating an aviary using an electric heater.
  b) Closing thermostatic valves in the evening without lowering the thermostat temperature, causing the boiler to keep its temperature during the entire night.
  c) An elderly couple that after every meal washed their cutlery using a dishwasher.

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[3] Flemish Institute for Technologic Research
[4] Flemish social housing association, co-ordinating the different social housing companies

Obviously, there is still much work in sensitising people and making them aware of this matter, this will definitely remain one of our main concerns for the future.

From the experiences gained a strategy was developed for working out future projects. The basis here was the six-steps-plan.

The first three steps are based on the "Trias Energetica".

In the first step we checked how energy consumption could be decreased, among others by calculating the optimal thickness of the insulation, investing in better glazing, etc.
The second step examines which available energy source is inexhaustible or gives the least environmental burden, for instance, for the preparation of hot water we can use solar energy by way of solar collectors. .
The third step establishes which techniques could be used to improve the return. After a study we opted in this project for a series of installation and condensation technology systems.

Next to respecting the above-indicated sequence, it is in my opinion also necessary to add another three steps.
The fourth step being the fine-tuning, measurement and evaluation of the measures taken.
Step 5: informing and assisting the user.
In the sixth step the findings, both positive and negative, must be spread.

It is in this context that my lecture should be regarded.

C. ENERGY AND VENTILATION

C.1. INTRODUCTION

Most people know that air pollution outdoors can have an influence on our health. Few, however, are aware of the fact that the air quality indoors is at least as important and often even more important for our health.

The negative health effects of polluting substances are often linked to the extent to which we are exposed to these substances. The combination of a concentration of polluting substances in the air and the time that we are staying in that environment are the most important parameters to determine this exposure, as are the activity level, the age and sex of the persons involved..

Already in the sixties of the previous century researchers showed that the concentration of polluting substances in houses is often higher than outside. Part of that pollution comes from the outside environment, but the characteristics of the house itself and the conduct of its inhabitants are also important determining factors for the concentration of polluting substances in the house. Then there is the time component of the exposure concept. We spend most of our time inside, about 60% in our house and another 20% in buildings where we work. And the most vulnerable of us, such as very young children, elderly people and young mothers, spend even more time indoors.

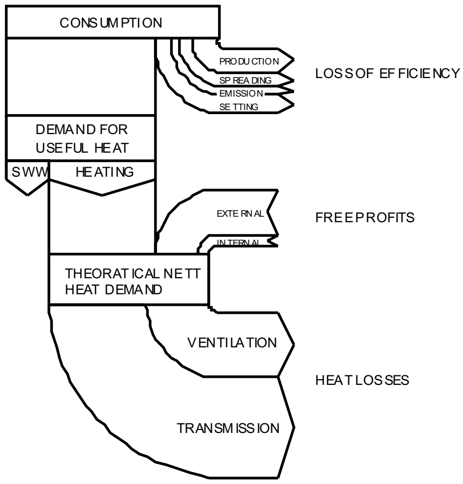
As a result of the energy crisis the heating costs increased and that combined with the growing awareness that we should be very careful in our use of energy sources lead to the fact that we tried harder to keep our energy inside. Double glazing made its appearance, we made our houses air-tight, we came into the habit to insulate the cavity walls, to avoid draught, etc. However, it also meant that the air pollution that has its origin inside is less diluted by the incoming air.

Besides, in the second half of the previous century many building materials were introduced that could release health-affecting by-products, for instance chipboards and, at the time, plaster boards. And then there were new cleaning products, products for personal hygiene and insecticides, … Next to the chemical indoor pollution there is also the biological and microbial contamination that can affect our health. The best known examples are the allergy to the glycyphagus and asthma. Inhabitants themselves can also be a source of pollution, ranging from hydrocarbons in body odour substances over the baking and roasting of food up to the spreading of chemicals from cigarette smoke.

The connection between insulation and ventilation is not that clear to everyone and often both concepts are mixed up.

The schematic depiction below clearly shows that these two concepts should be considered separately and that with better insulation the loss of energy through ventilation becomes more important. Heat recovery from this ventilation thus becomes a must.

THERMAL BALANCE OF A HOUSE



C2 How to ventilate?

C.2.1 As formerly,

Even now, many houses are but ventilated by the incidental infiltration of air through cracks and chinks, in other words by imperfections in the building shell, or by opening t doors and windows at regular intervals. Research showed that, on average, Belgian houses are not at all air-tight, but also that even in overall very 'air-open' houses some rooms are very air-tight, whereas others are suffering from a total lack of ventilation. Bedrooms, for instance, are "aired" during the day by opening the windows (whereas the air pollution occurs at night with the windows closed).

Such excessive ventilation results in unnecessary energy losses, a strong cooling-down of the whole house (risk of condensation), without protection against rain, burglary, etc.

The introduction of central heating also dispelled from our living rooms a natural way of increased ventilation, through the sucking in of combustion air for the stove and the discharge of pollution through the waste gases.

C. 2.2. Towards a controlled ventilation

A balanced ventilation strategy will ensure:

- an air-tight finishing of the building shell to avoid uncontrolled infiltration (draught and loss of energy). A proper air-tightness depends on a proper design and the correct execution of the construction details (connections, air guard, …). As to air-tightness, Belgium has not (yet) established any performance requirements.

- a set of facilities for controlled ventilation. "Controlled" means that the amount of air (or the air flow) is set according to the needs, without exaggerated loss of energy, and that the direction of the ventilation flows is fixed.

The standard NBN D 50-001 describes the requirements as to ventilation facilities in dwelling houses.
This standard forms the basis of the ventilation laws in the various regions.

C. 2.3. The standard NBN D 50-001

The Belgian standard NBN D50-001 "Ventilation facilities in dwelling houses" prescribes how to equip building(s) (parts) with residential function to enable a correct ventilation of the rooms.

The standard does not ensure that the building is ventilated correctly, that depends on the user and on how he/she deals with the incorporated facilities.

The ventilation is divided in three categories:

- Basic ventilation: this is the ventilation of the living areas in normal circumstances, with limited air flows, to keep the air quality and moisture content under control.
- Intensive ventilation: higher air flows to compensate for peak pollution or unusual circumstances: moisture and odours during cooking, cleaning, paint jobs, a party.

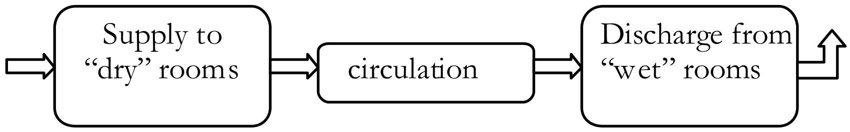
- Ventilation of special rooms: garage, cellar, attic, storage space, lift shaft, common hallways, heater rooms, … These are ventilated using separate facilities; interaction with the basic ventilation is to be avoided as much as possible.

C. 2.4. Basic ventilation: where?

The principles of basic ventilation must be applied in ordinary living areas:
- The so-called "dry" rooms: living rooms, bedrooms, studies, playrooms and hobby rooms.
- The so-called "wet" rooms: kitchen, bathroom, toilet, washroom;
- The circulation areas within one housing unit: corridors, hallway, staircase.

All other rooms are so-called "special" rooms.

C. 2.5. Basic ventilation: supply – circulation - discharge



To ensure control over the direction of the flow, the air flow must be guided:

- The supply of fresh air takes place in the "dry" rooms
- The discharge of polluted air is done where most of the pollution occurs, this is in the so-called "wet" rooms
- Between the areas with supply and those with discharge facilities the air circulates through circulation holes in inside doors or partition walls and through the corridors, hallway, staircase of the housing unit.

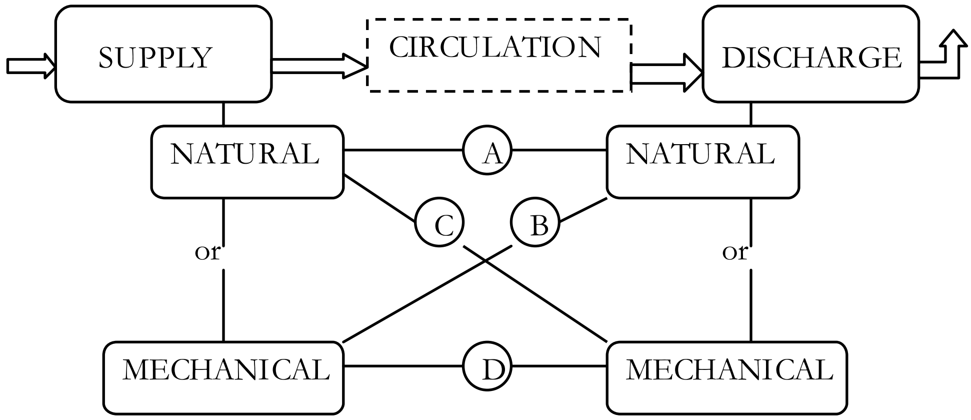
The pressure difference between the supply and discharge facilities ensures permanent air flow in the proper direction.
This prevents that unpleasant smells from e.g. kitchen or toilet are lead to the living room or bedroom.

C. 2.6. Possible methods

There are four combinations of natural and mechanical supply and discharge facilities, called the simplified systems A, B, C and D:

- system A: natural supply and natural discharge: applied in almost all social one-family houses and in about 3 out of 4 of the apartments
- system B: mechanical supply and natural (free) discharge: only applied under specific circumstances: among other in renovation projects
- system C: natural (free) supply and mechanical discharge: 1 out of 4 apartments
- system D: mechanical supply and mechanical discharge: a few projects in which energy control is essential (see examples).

Flow chart:

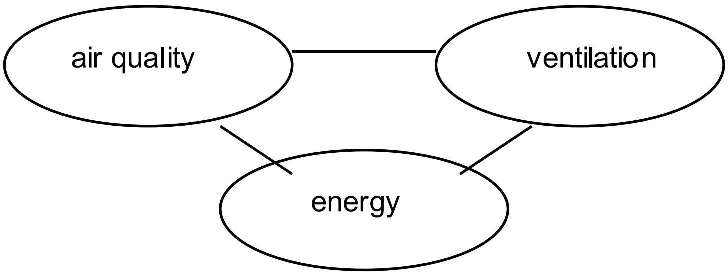


C. 2.7. Ventilation in 10 principles

1. Ensure a good air-tightness of the building shell: avoid cracks and chinks, take good care of the connections between building components and walls, integrate an air guard, where needed.
2. Incorporate the required facilities for the basic ventilation in the living areas according to the demands.
3. Fresh air is lead into the "dry" living areas: living room, bedrooms, playrooms, studies and hobby rooms. This can be done in a natural way (adjustable supply grids) or by mechanical ventilation (blast air nozzles).
4. The moist and polluted air is discharged in the "wet" areas, where most of the pollution occurs: kitchen, bathroom, toilet, washroom. This can be done through channels for natural discharge, fitted with adjustable discharge grids, or by mechanical exhaust.
5. Between the areas with supply and those with discharge facilities the air circulates through circulation holes in or near inside doors, in partition walls (grids or gaps below the door) and through corridors and circulation areas.
6. Various combinations of natural and mechanical facilities for the supply and discharge of air are possible. This corresponds to the systems A, B, C and D.
7. In your plan you must incorporate the required ventilation facilities and/or areas; provide for:
   - with a natural supply: supply openings (grids, etc.) in windows or outside walls;
   - with natural discharge: vertical discharge channels that open as close as possible to the ridge of the rood;
   - with mechanical supply and/or discharge: the necessary space for fans, channels and supply and discharge nozzles.
8. It must be possible to adjust the facilities for basic ventilation to the specific needs: either manually or automatically (fixed setting or self-regulating).
9. Opening windows and doors are meant for intensive ventilation. There are minimum dimensions, depending on the floor surface and on the position of the windows.

10. Special rooms such as attics and cellars, garages, heater rooms and storage rooms need ventilation as well. This is done independently from the basic ventilation.

It should be clear by now that proper balance must be sought between the three major pillars, being air quality, ventilation and energy.



In the next chapter the described possibilities are illustrated by way of a few projects.

D. EXAMPLES

D.1. Houtvenne-Waterstraat

For the land concerned an allotment permit for 6 lots with detached building has been issued.
It was situated in the centre of this village, "80 metres from church", all but a good example for the inward extension of residential areas.

Departing from another approach and taking into account an optimal orientation to the south, the necessary privacy and the provision of private outer space, 23 housing facilities could be implanted here.

As for the type, we opted for a mix of facilities for elderly and young people, for small and large families.

As for the energy source, we departed from the following objectives:

- 50% of the energy required for the hot-water consumption should be supplied by the sun.

- The required energy for heating should be reduced from 220 kWh/m^2/year to 50 kWh/m^2/year; to this purpose, we applied principles of compact building, proper orientation and extensive insulation (insulation level K24), condensing boilers and mechanical ventilation with heat recovery.

The project in the Waterstraat in Hulshout can be subdivided in three parts:
block 1 consists of 3 dwellings, block 2 has 12 dwellings and block 3 consists of 8 dwellings.
The architect of the houses is Mr. E. Maes from Westerlo, Mr. J. Daenen from Bertem was engaged as civil engineer.

All dwellings of blocks 1, 2 and 3 are ventilated according to the balanced mechanical ventilation principle (= mechanical supply and mechanical discharge of ventilating air) including heat recovery. In the Belgian standard NBN D 30-001 this ventilation system is classified as a ventilation system of type D.

In each of the houses of block 1 an individual solar boiler with return reservoir (make Izen) was placed. Figure 1 depicts a flow chart of the installation. On the roof oriented to the south of each house a solar collector with a surface of 2.75 m^2 was installed.

The solar heat is stored into a boiler of 100 litre. The circulation pump only runs if the temperature measured in the solar collector is 10° higher than the temperature in the solar boiler. If the temperature difference is less than 2° C, the circulation pump is switched off. In this case, the water in the solar collector automatically returns to the return tank. A multifunctional device on natural gas ensures the after-heating of the domestic hot water and radiators; the heating and the heating of the ventilating air is based on the condensation technique.

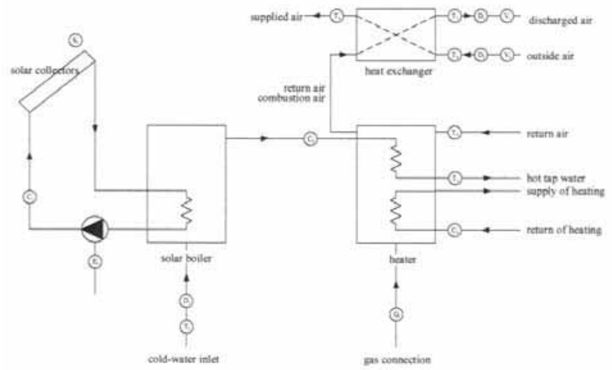
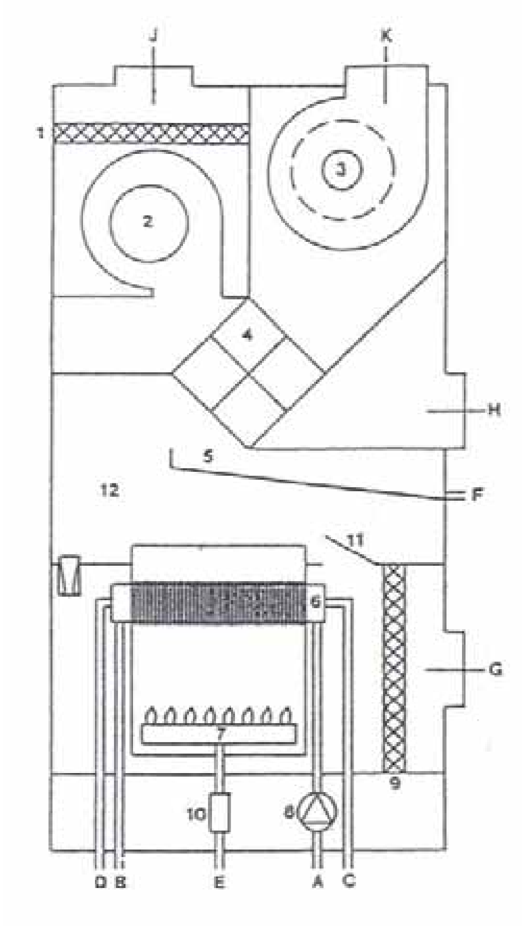


Figure 1: flow chart of the installation of block 1 at Zonnige Kempen, Hulshout.

Condensation occurs in that part of the device that is to recover heat from the combustion and ventilating air.
The device consists of a modulating natural gas boiler with flexible boiler water temperature, adjusted by way of a room thermostat (rated power of 8.4-24.0 kW). The boiler part is air-rinsed, thus limiting the radiation and convection losses. There is one integrated heat exchanger for both heating and domestic hot water, with priority control for the domestic hot water. The rated tap speed is 6l/minute at a constant temperature of 60° C. The balanced ventilation works in three positions for air supply and air discharge (boiling position, normal position and absence position). In the heat recovery battery the heat of the discharged ventilating air and of the waste gases is recovered, making returns of 60 to 70%. In the heat recovery part of the device condensation takes place. Electricity savings are realised through a discharge fan with limited power, by setting the pump speed according to the installed radiator power, through a pump with interrupted functioning, by using two in stead of three fans, made possible by the integrated solution, and by switching off the air supply fan upon a longer absence and in summertime.



A = return CH
B = supply CH
C = cold-water inlet
D = hot tap water outlet
E = gas connection
F = condensation connection
G = return air
H = supplied air
J = outside air
K = discharged air, also discharge of combustion gases

1 = outside air filter
2 = air supply fan
3 = air discharge fan
4 = heat recovery battery
5 = condensation discharge
6 = integrated heat exchanger for central heating (CH) and hot water
7 = burner bed
8 = circulation pump
9 = return air filter
10 = gas control block
11 = control valve
12 = header

Figure 2: schematic depiction of the functioning of the multifunctional device in blocks 1 and 3

The heating of the domestic hot water in block 2 is also ensured by solar boilers, but here a collective system of 24 flat-panel solar collectors of 1.7 m^2 each is used.

Figure 3 depicts a flow chart of the installation. The heat is stored in four boilers with a content of 500 litre each. One boiler also serves as peak boiler. To this boiler the condensation boiler is connected for additional heating in the transitional season and in wintertime. The circuit between the solar collectors and the four boilers is filled with a certain chemical product so that the pipes must not be drained in winter. The solar system was supplied by the company Viessmann.

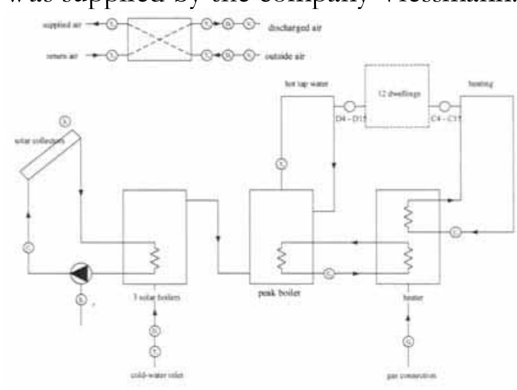


Figure 3: flow chart of the installation of block 2 at Zonnige Kempen, Hulshout

In the storage room of each dwelling a hydraulic aggregate with pulsion and exhaust fans, a filter, a heat exchanger with summer by-pass and a condensation receptacle are placed. A network of exhaust pipes discharges the air from the wet rooms (= kitchen, toilet, bathroom). The heat of the exhausted air is recovered through a heat exchanger with a return of 60 to 70%. A network of pulsion pipes conveys the heated air to the dry rooms (= living room, bedroom).
Induction valves mix the supplied air very efficiently with the inside air. This reduces the risk of draught problems. Therefore, after-heating is not provided for.

Table: natural gas savings through mechanical ventilation with heat recovery

VENTILATION	BLOCK 1	2	3	Total
Technique :	Mechanical ventilation with heat recovery			
Energy savings:				
Energy consumption per m^2				
• without heat recovery =	79	79	79	79 kWh/m²
• with heat recovery =	50	50	50	50 kWh/m²
Total energy consumption				
• without heat recovery =	27.729	97.249	48.980	173.958 kWh
• with heat recovery =	17.550	61.550	31.000	110.100 kWh
Savings in natural gas				
• consumption =	10.179	35.699	17.980	63.858 kWh
• costs =	11.854	41.573	20.938	74.365 BEF/yr
Investment:				
Surplus costs per dwelling =	55.000	55.000	55.000	55.000 BEF
Total surplus cost =	165.000	660.000	440.000	1.265.000 BEF
Time period to recover the costs:	13,9	15,9	21,0	17,0 year

Not only energy-efficiency, but also sustainability was an issue here, hence the use of rainwater and the specific choice of materials (using L.C.A.).

For the selection of materials the relevant maintenance requirements must be considered as well, for instance, when choosing wooden window frames, the required maintenance must also be considered.
In the project three water-based techniques, healthier for painters and environment, were used.

To enable the realisation of 23 houses in Houtvenne both financially and as to the necessary checks after its completion, the network of European Green Cities, part of the European Programme Thermie and involving 9 countries, was incorporated.

GREEN stands for	Global
	Renewable
	Energy
and	Environmentally
responsible	Neighbourhoods.

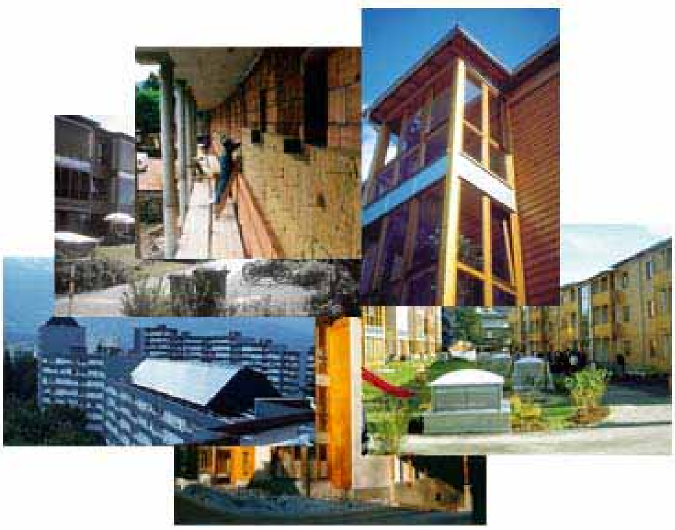
However, this was not the finishing point, it were but the first steps and the results can be consulted on www.europeangreencities.com.

European Green Cities Network

www.europeangreencities.com

Sustainable Urban Housing

Where partners and technologies of sustainable urban housing come together



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D.2. RENOVATION

Schransstraat Vorselaar

DESCRIPTION OF THE PROJECT

The project concerns five apartment blocks with 11 dwellings each. These blocks were built in 1971 and 2 apartments per block were added under the roof in 1992.

Walls are not insulated and windows are single- glazed. No ventilation system is currently installed. The current energy consumption for space heating and domestic hot water is shown in Table 9.

Table 9: Current (primary) energy consumption

Space heating energy consumption	210	kWh m-2 y-1
Hot water energy consumption	40	kWh m-2 y-1
Total heating consumption	250	kWh m-2 y-1

The objective of the Belgian project within the framework of Synpack is to reduce this energy consumption to 80 kWh m-2 y-1, which is about 30% of the current value.

Envisaged options and simulations
The impact of different insulation and ventilation scenarios was investigated using the simulation model of the building. Figure 20 shows the simulated heating load for the current situation and for 3 scenarios :

1. Insulation of external walls and garage ceiling with extra care to suppress cold bridges
Replacement of all external windows by insulating frames and 1.1Wm-2K-1 glazing
External terraces stay as they are
2. Same as 1 but terraces are transformed intto glazed balconies with 1.1Wm-2K-1 glazing. Cold bridges around terraces are suppressed since the external "skin" covers the whole building.
3. Same as 2 + full mechanical ventilation with heat recovery (90% efficiency) (VHR)

It can be seen that the "best case" leads to 80% energy savings compared to the present situation, and that heat recovery on ventilation is necessary to obtain a heating load lower than 40% of the initial one.

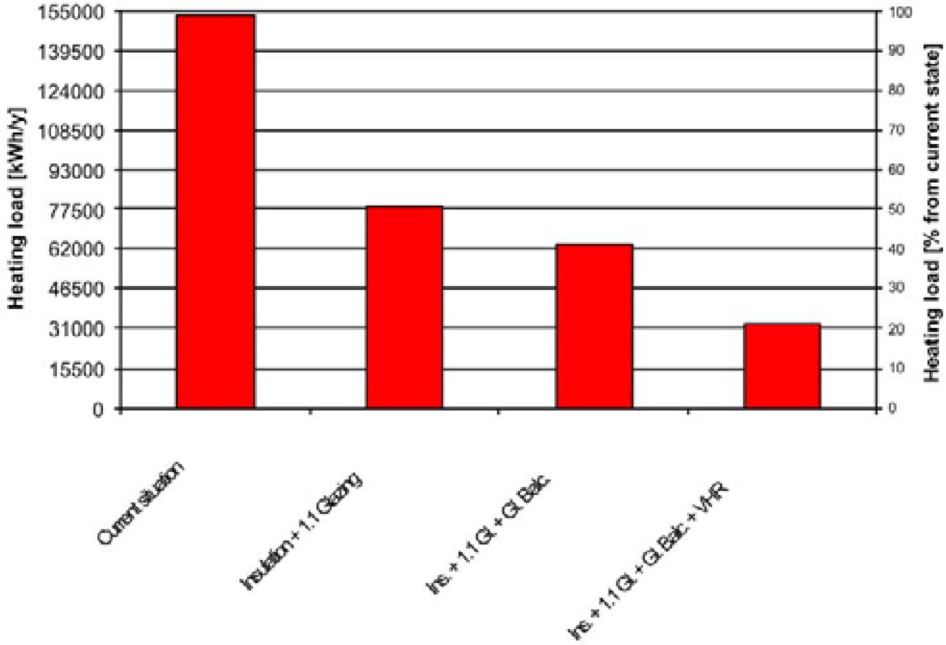


Figure 20: Space heating load for current situation and different scenarios

The social-housing company was willing to use only single glazing on the glazed balcony, for economical reasons and also to keep the "external character" of the terraces. Thermal simulations were made to investigate the effect of such measures for different user behaviours. First, it was assumed that the tenants would close the door between the balcony and the apartment during the winter, then it was assumed they would consider the balcony as an extra-room and heat it (by keeping the door open or installing an electric heater in the room).

Figure 21 shows the simulated heating load for different glazing scenarios for the balconies and different ventilation scenarios (note that it is supposed that the walls will be insulated and that other glazing will be "1.1 glazing" in all scenarios).

These results clearly show that the misuse of balconies could ruin all insulation efforts if they are equipped with single glazing. In the case of ventilation with heat recovery, heating the balconies could double the building's heating load.

In order to give an acceptable robustness to the renovation concept with respect to tenants' behaviour, it was decided to equip balconies with high-performance glazing and well-insulated frames.

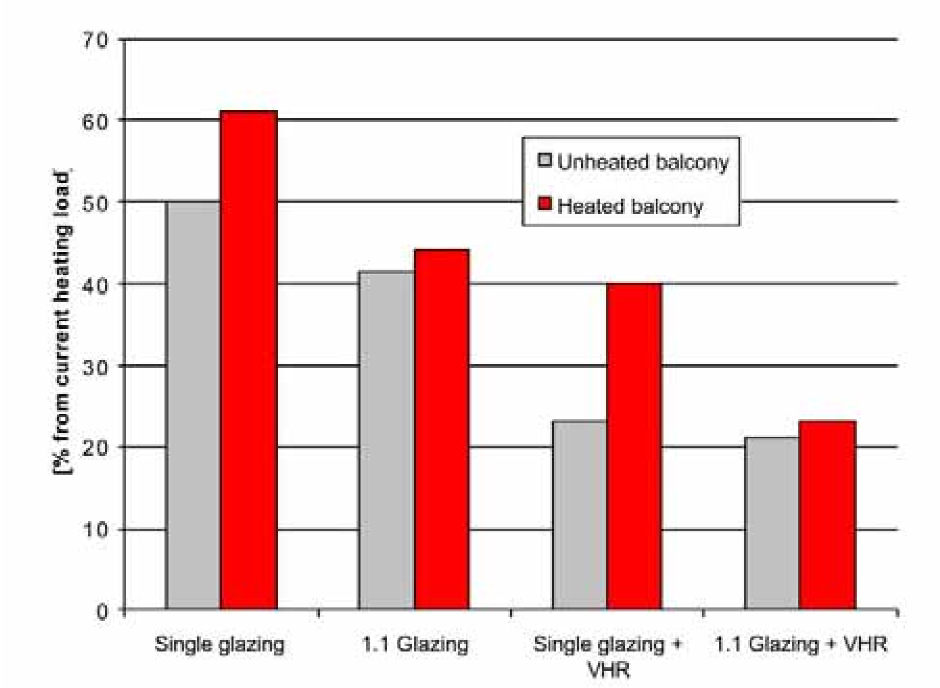


Figure 21: Space heating load for different balcony glazing and use

Energy concept : technical approach

The simulations show that different options were considered to decrease the heating load of the building. After the investigation, which included much more aspects of the renovation and technical solutions, decisions were made concerning the measures to be taken to fulfil the objective:

· Good thermal insulation of the building skin (U-value of 0.35 W m-2 K-2)

· Conversion of terraces into glazed atriums

· Use of high-performance double glazing (Centre U-value of 1.1 W m-2 K-2) with thermally broken aluminium frames. These windows will be used for the glazing of atriums as well.

· Installation of individual mechanical ventilation systems with heat recovery in all apartments

· Installation of a solar domestic hot water system with 25 m² of collectors to cover more than 40% of the domestic hot water load

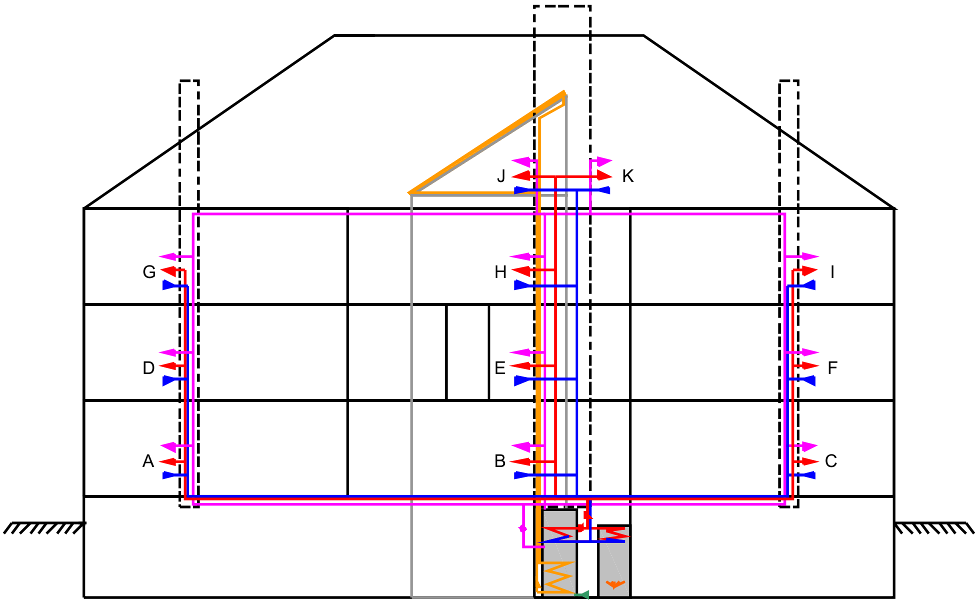
· Choice of high-performance condensing and modulating boilers (individual or collective), sized to meet the reduced thermal load. The total installed power will be reduced by a factor 3.5 in the case of collective installation.

· Implementation of simple but efficient control systems

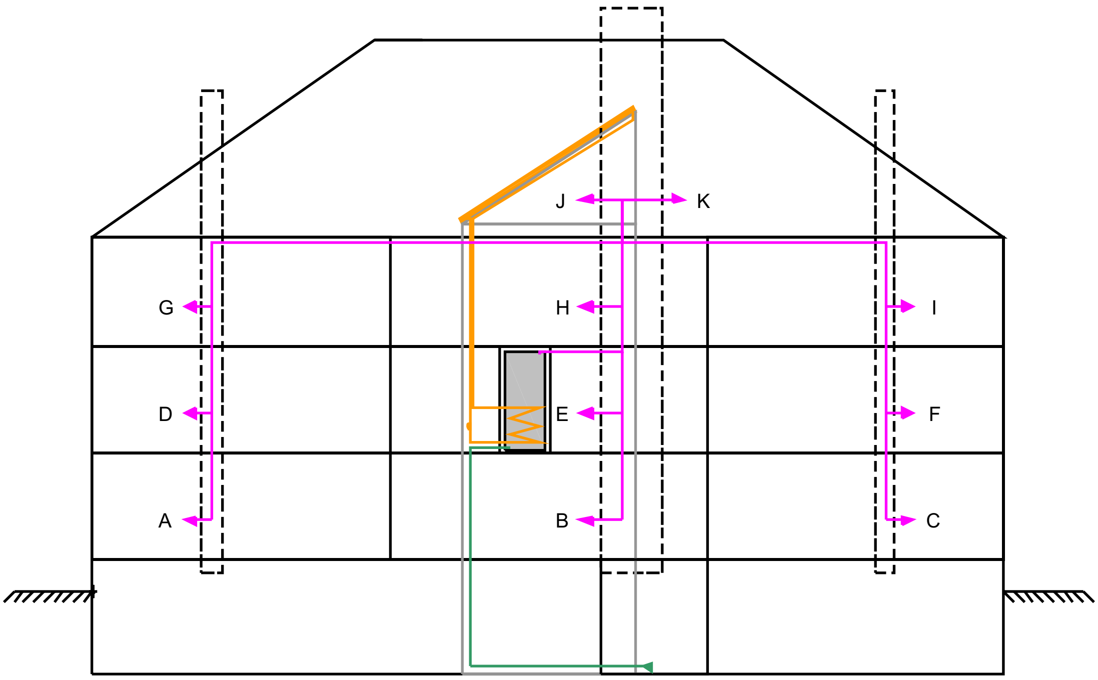
· Implementation of individual metering systems in order to raise the users' awareness of their energy consumption

· Information of the tenants and promotion of energy-conscious behaviour.

For each block solar collectors have been fitted on the new external lift shafts to be realised. These were concentrated in 4 blocks in a collective system (see figure).



For the fifth block a combination with individual heating was chosen (see figure). The main problem here was to find a low-power, high-efficiency heating boiler.



Performance after renovation

The estimated energy consumption is presented in Table 12. These figures include estimates of boiler efficiency for heating and hot water. Total energy savings compared with the current situation are in the range of 70%.

Table 12: Estimated energy consumption after renovation

Space heating energy consumption	60	kWh m-2 y-1
Hot water energy consumption	20	kWh m-2 y-1
Total heating consumption	80	kWh m-2 y-1

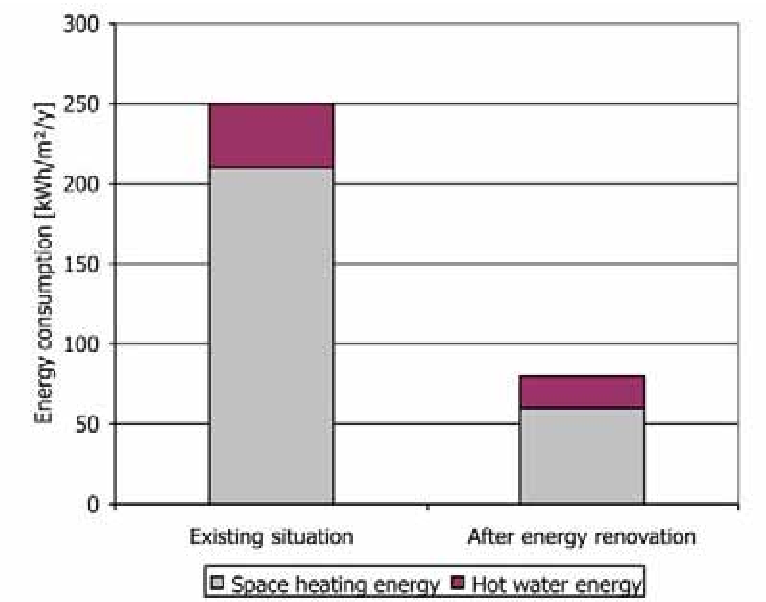
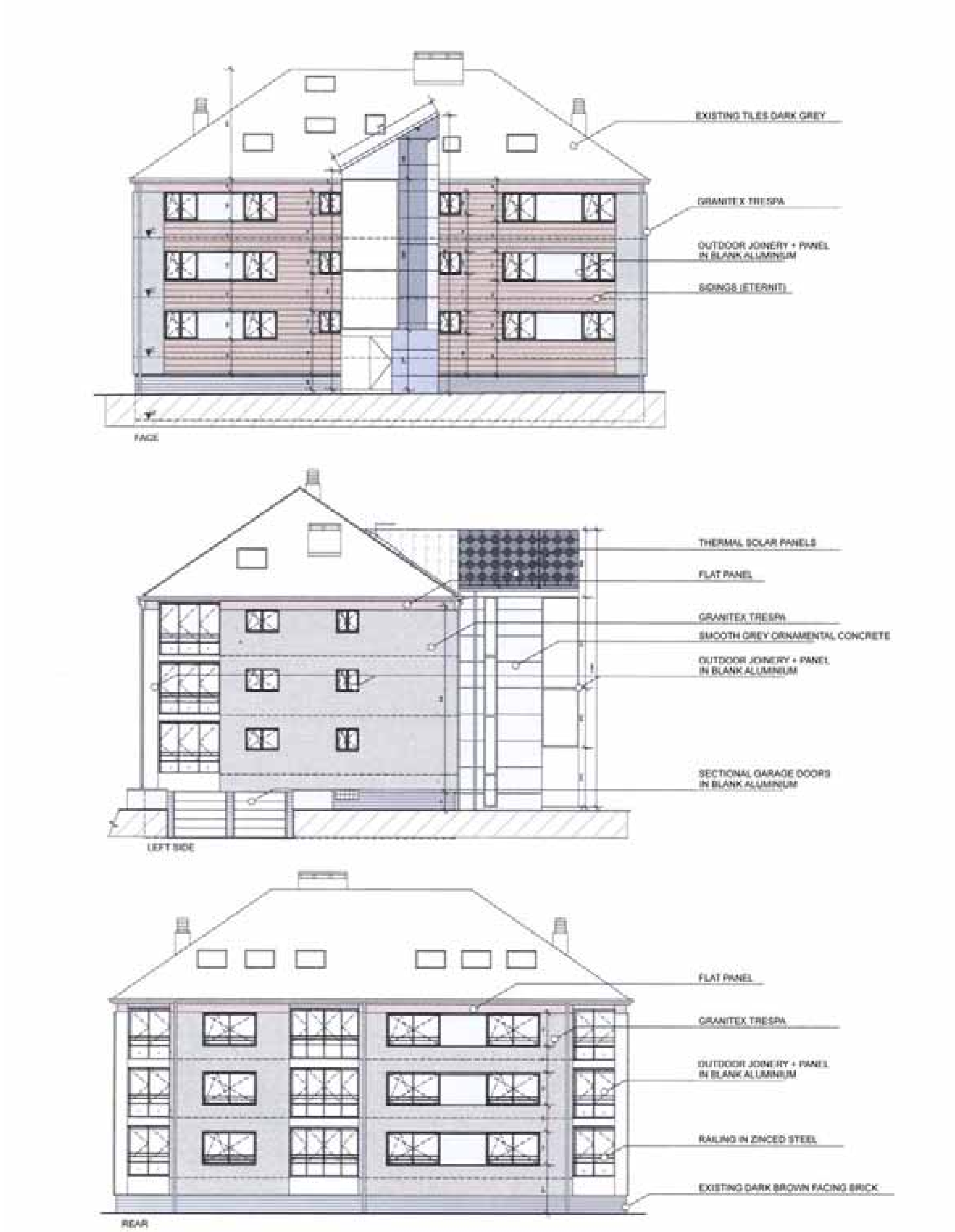


Figure 22: Estimated effect of the energy renovation

Below, you'll find an overview of the new outside walls.



PROJECT DATA Architect: Herman Bogaerts Engineer: 3[E] en Chris Ebinger Building year: 2002-2003

Synergy effects

A first synergy effect is the interaction between life quality improvement and energy performance. Proposed energy-savings measures concerning insulation will be realised together with esthetical and comfort building improvements, which will be realised at a lower cost :

- Improved comfort thanks to a direct connection between the garage and the staircase
- Easier access for disabled people thanks to the new entrance and the new staircase equipped with a lift
- Improvement of life quality inside the building through improved thermal comfort and indoor air quality (possibility to use the ventilation for free cooling in summer)
- Creation of a glazed balcony, which will hopefully become a comfortable place throughout the whole year

These comfort measures have no calculable payback time, but will be included in a global renovation with a positive economical impact thanks to the energy performance improvement. Furthermore, a synergy between different measures can be expected, reducing the global cost of renovation:

- The creation of glazed balconies will be part of the insulation process, which will create a new external skin surrounding the whole façade. The insulation of the façade without changing the terraces would have led to difficult problems to suppress cold bridges, while it would have been complex to create esthetical glazed balconies without changing the external side of the façade.
- The insulation and ventilation measures will allow to install a low-power heating system, hereby lowering the investment costs associated with the replacement of existing boilers. Furthermore, the choice of combined ventilation and heating systems could reinforce this interaction if individual systems are chosen.
- The placement of solar collectors on the roof of the new staircase will avoid difficult integration problems on the existing roof and suppress the problems linked to limited space availability. The construction of a new roof oriented towards south would not have been economically possible if it had not been used for the stair- (and lift-) case.

Finally, the realisation of all renovation works in the same time will minimise the disturbances for the tenants and simplify the practical implementation of some measures.

D.3. ANOTHER STEP FURTHER, THE SINT-ANTONIUSPLEIN: Zoerle-Parwijs-Westerlo

1. Situation

The social housing company Zonnige Kempen cv bought land in the centre of Zoerle-Parwijs for developing a new-construction project with tenement houses.

Early 2001 the 'Vlaamse Huisvestingsmaatschappij' selected this project as one of 3 demonstration projects regarding 'sustainable building'.

The re-mapping and the re-surfacing of the village centre of Zoerle-Parwijs that is planned simultaneously with the new-construction project, offers the unique possibility to integrate an asphalt collector in the paving at a limited additional cost, thus enabling to recover low-temperature solar energy.

Figure 1: picture of the replica of the building project

Besides, the various aspects of the energy concept, ranging from controlling the energy demand over ventilation concepts and recovering solar energy up to the heat pump cannot be considered separately from one another. Every aspect interacts with other ones, making that the efficiency of the energy concept largely depends on the synergy among these aspects.

Schematic depiction of the energy concept

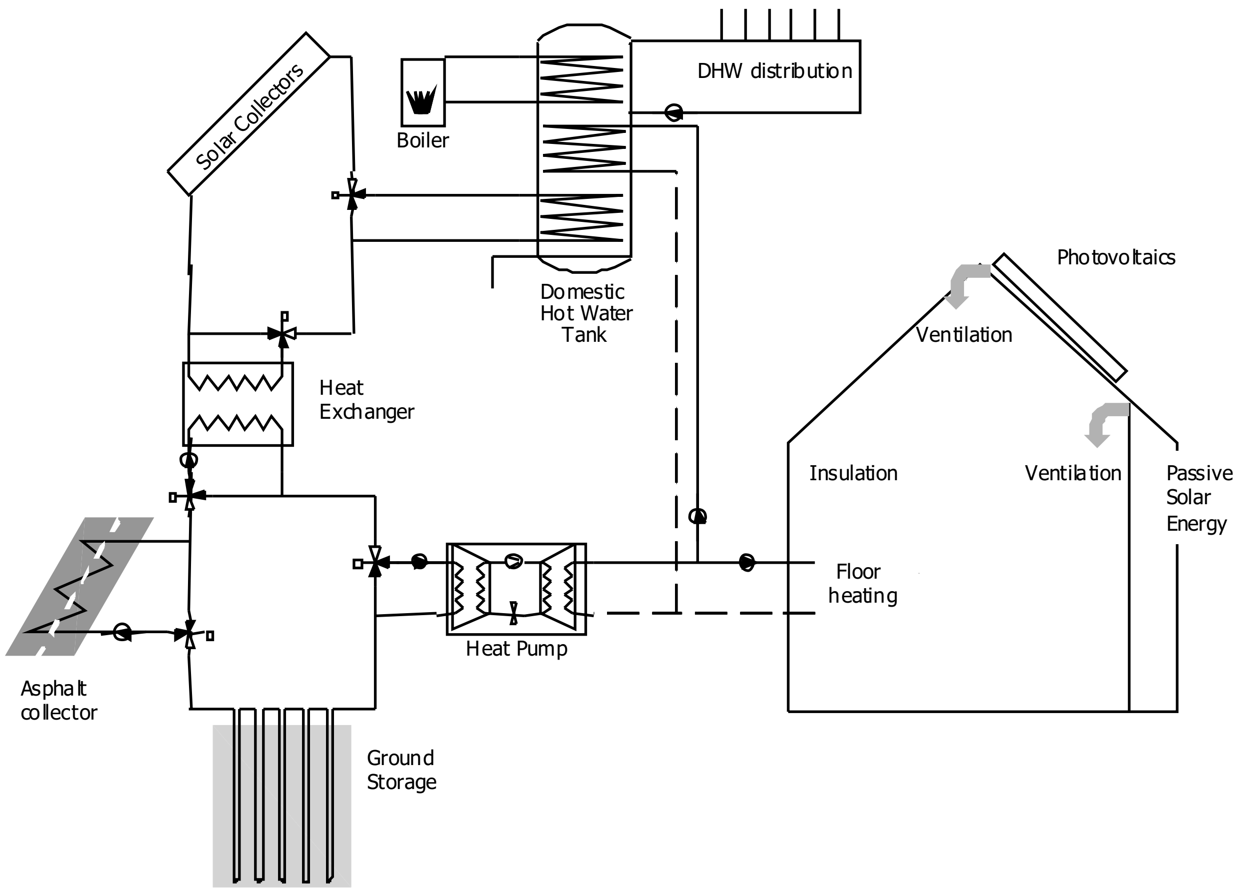
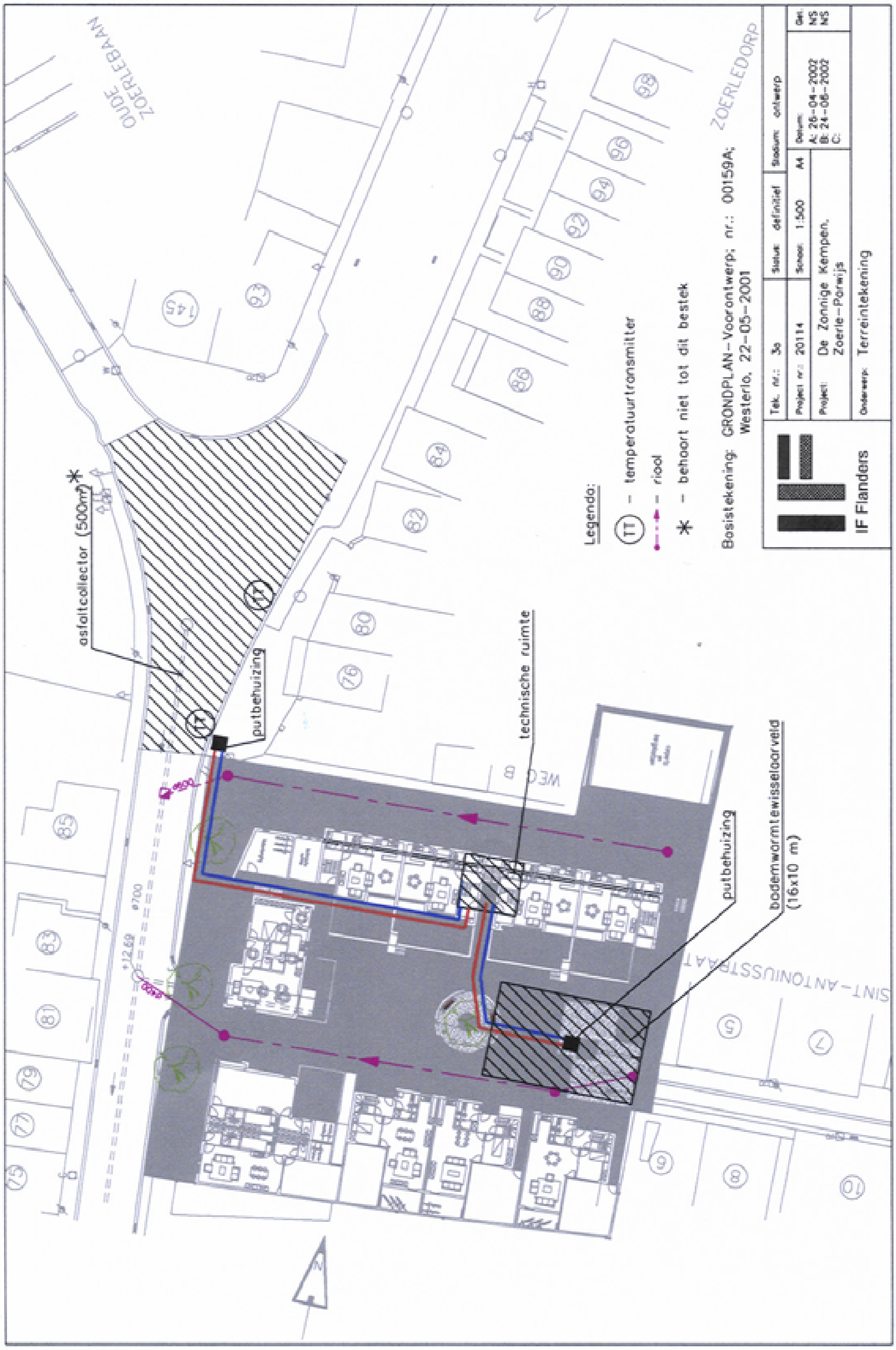


Figure 2: Schematic depiction of the energy concept

(basic drawing floor plan draft design no. 00159A)

asfaltcollector = asphalt collector
putbehuizing = well housing
technische ruimte = technical room
putbehuizing = well housing
bodemwarmtewisselaarveld = heat exchanger field in the bottom

Legend:
temperatuurtransmitter = temperature transmitter
riool = sewer
behoort niet tot dit bestek = not part of these specifications



Principle of asphalt collector and heat storage

2. Enumeration of the applied measures

Controlling the energy demand:

- Use of low-energy materials (LCA-analysis) and efficient organisation of construction site
- Extensive insulation
- Sun-oriented architecture
- Passive solar energy concepts: greenhouses
- Mechanical ventilation with heat recovery per dwelling (WTW)

Use of sustainable energy sources

- An asphalt collector generates low-temperature energy that is stored during summer months by way of vertical heat exchangers placed in the ground.
- Flat-panel solar collectors contribute considerably to heating the domestic hot water.
- Photovoltaic solar energy generates the electric energy needed annually to power the fans.
- The heat from the photovoltaic panels pre-heats the ventilating air.

Efficient energy generation

- The heat that is extracted from the ground supplies a low-temperature heating circuit using a heat pump.
- A high-efficiency boiler ensures the collective after-heating of the domestic hot water.

Some examples of synergies

- The surplus of solar energy from the solar collectors during summer months is stored using a heat exchanger in the ground storage.
- If no thermal energy is available in winter months, the heat pump will pre-heat the domestic hot water.
- The greenhouses or atria pre-heat the ventilating air.
- By drawing in the ventilating air below the photovoltaic panels the fresh air is pre-heated; simultaneously, the panels are cooled.
- The distribution channels for heating and hot water are running through the strongly insulated dwellings, recovering as such any distribution "losses".

3 Passive measures

Extensive insulation measures are applied: 10 cm of mineral wool in the traditional cavity walls, 12 cm in the wooden frame construction and 18 cm of insulation in the roof slope. The bottom is insulated with 8 cm of extruded polystyrene. The glazing has a k-value of 1.3.

Thus considered, heat recovery from the ventilating air means considerable energy-savings. To further increase the energy-efficiency a system of pre-heating the ventilating air has been worked out. To this purpose the advantages of ground pipes are combined with pre-heating in greenhouses (see figure 3). The ground pipes also offer the advantage that they protect the air heat exchangers against freezing.

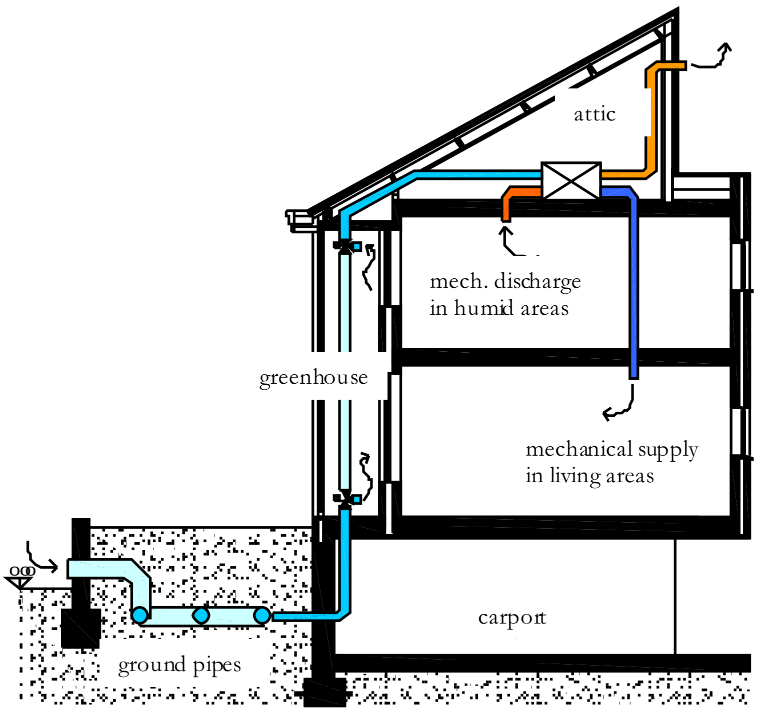


Figure 3: depiction of the ventilation with heat recovery and pre-heating of the ventilating air in ground pipes and the atrium

In the 3 apartments another system is used. Here, the ventilating air is pre-heated through circulation along the photovoltaic panels on the roof. Figure 4 shows the measured temperature curve on a day in January in a ventilated cavity between the photovoltaic panels and the roof. Figure 5 shows a cross-section of the intended construction.

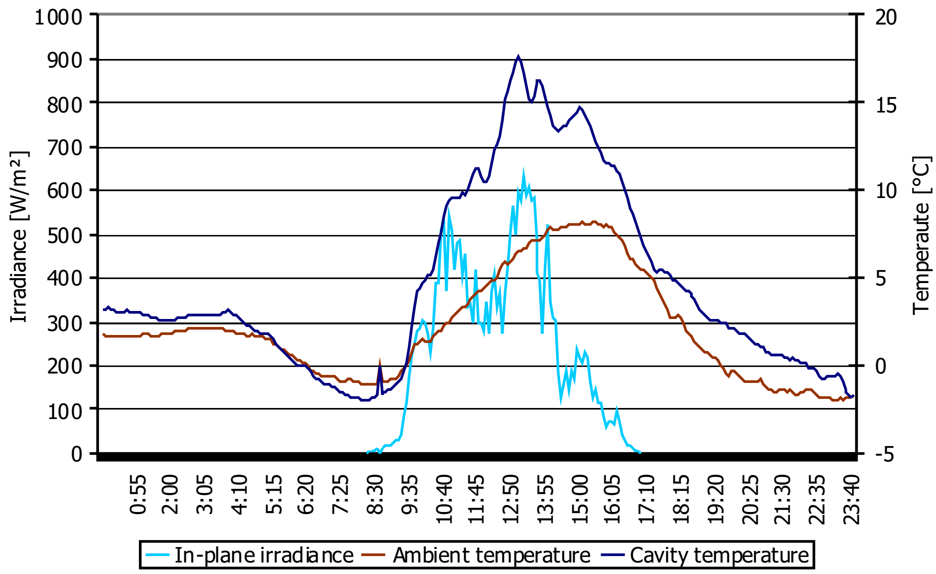


Figure 4: measurement of the cavity temperature between the photovoltaic panels and the roof when applying natural ventilation.

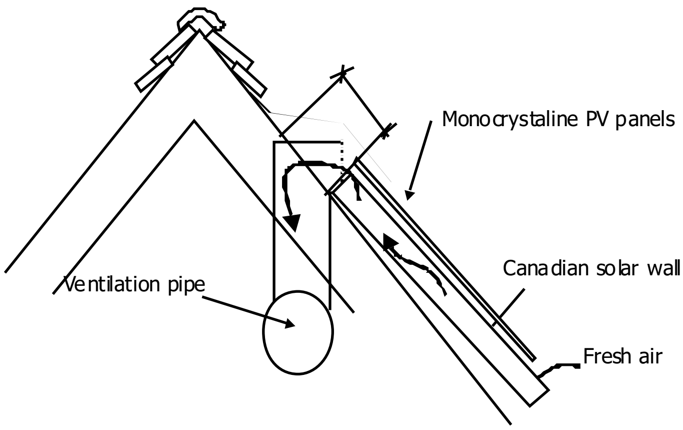


Figure 5: cross-section of the arrangement for pre-heating the ventilating air in the cavity between photovoltaic panel and roof

4. Addressing the heat demand

Because the time schedule of the new-construction project coincides with the re-paving of the centre of Zoerle-Parwijs, the possibility has been examined to extract the heat in the summer from the asphalt road surface and store it.
This technique offers various advantages:

- The heat exchanger below the road surface can be installed at a relatively low cost.
- Extracting the heat from the road surface during summer months extends the life span of the road surface considerably. Projects in Scandinavia have shown that the life span of the asphalt paving can be extended from 3 to 10 years by extracting the heat in summertime.
- In the winter the heat exchanger can be used to keep the road surface frost-free.

From simulations and comparisons with results of similar projects in the Netherlands it appears that an annual return of 150 kWh/m^2 can be expected. Based upon these simulations the asphalt collector is sized at about 500 m^2.

The energy that is extracted from the asphalt collector in summer months is stored in a vertical low-temperature heat exchanger placed below the new village square to be laid. As a collective solar collector is being installed for the domestic hot water, another heat exchanger is provided from this circuit to the ground storage (see figure 2) enabling to store this solar heat in the ground storage as well if it is not completely consumed during the summer months.

The ground storage will consist of about sixty drill holes of 40 m deep, divided over a surface of 15 by 15 m. Figure 6 shows the simulated temperature curve of the ground storage.

In winter months the heat extracted from the ground storage is used to power a heat pump that in turn feeds a low-temperature heating circuit. Figure 9 shows the simulated energy balance of the ground storage, indicating a ground storage return of 60%.

In winter periods in which the solar collector does not generate sufficient heat to pre-heat the domestic hot water the heat pump can be used to pre-heat the domestic hot water up to 40° C. To this purpose an extra heat exchanger is provided in the storage tank of the domestic hot water (see figure 2). Figure 10 shows the simulated energy balance of the heat pump and the monthly COP. The average COP of the heat pump amounts to 3.2.

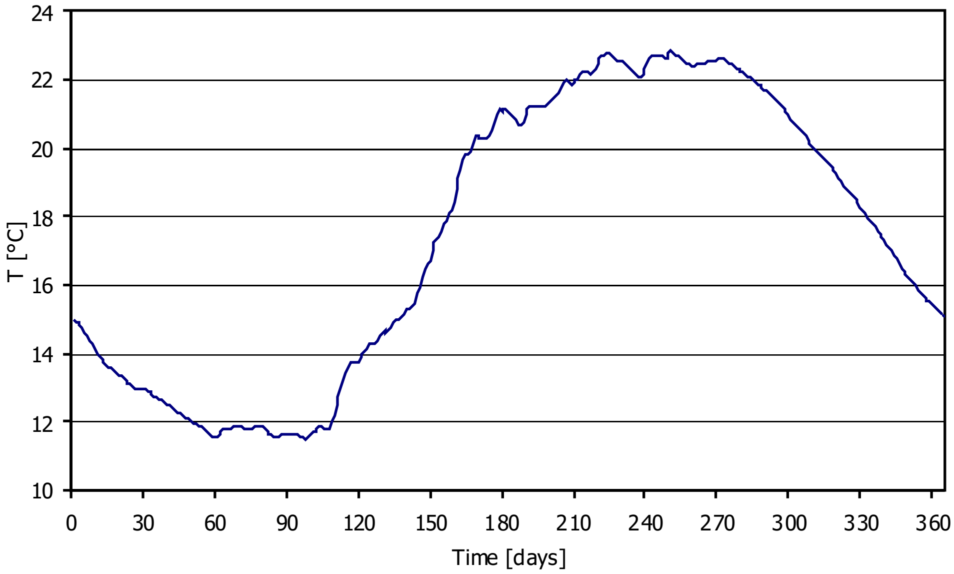


Figure 6: *Simulated temperature curve of the ground storage*

5. Photovoltaic solar energy

The photovoltaic panel field is sized to cover the annual consumption of the ventilation system. Based upon a consumption profile of the mechanical ventilation and the use of energy-efficient fans this is estimated at 8500 kWh/year. Departing from an energy recovery of 850 kWh/kWp/year for a photovoltaic system connected to the mains, the photovoltaic system is sized at 10 kWp.

6. Energy balance

For planning the energy concept of the buildings we used TRNSYS. TRNSYS is a software package allowing for the dynamic simulation of pre-defined models. TRNSYS has been developed at the University of Wisconsin and has been used for many years as the reference standard for the dynamic simulation of (solar) energy concepts in buildings. TRNSYS enables on the one hand the detailed simulation of the building shell based on the building physics; on the other hand, installations can be simulated using TRNSYS. The combination of these 2 components in 1 dynamic model enables to examine the synergy between various aspects and to make a rational and efficient design.

In the preliminary design phase of this project the energy concept is, as reflected in figure 2, optimised in TRNSYS. Below, the results of these simulations are shown by way of energy balances.

Ventilation with heat recovery

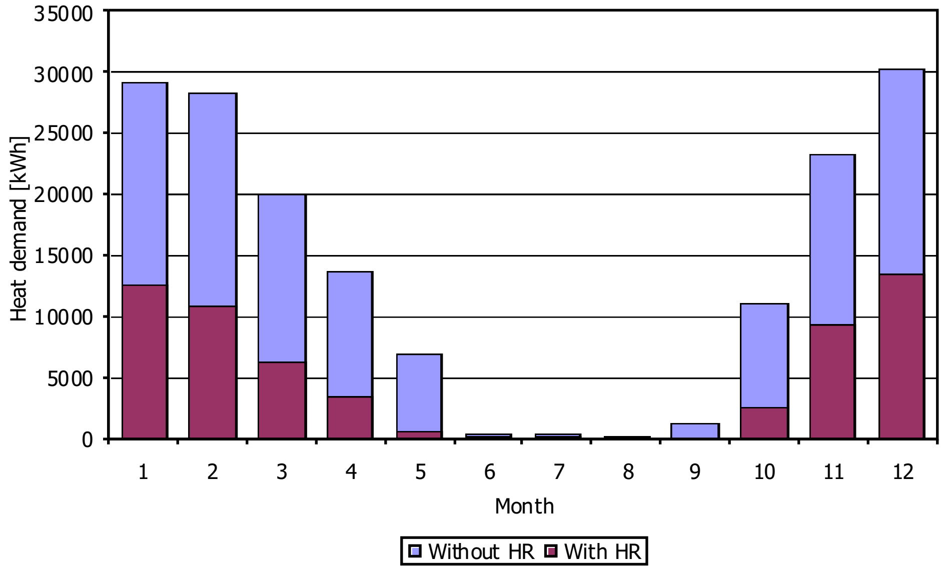


Figure 7: simulated total heat demand with and without ventilation with heat recovery.

Influence of passive solar gains

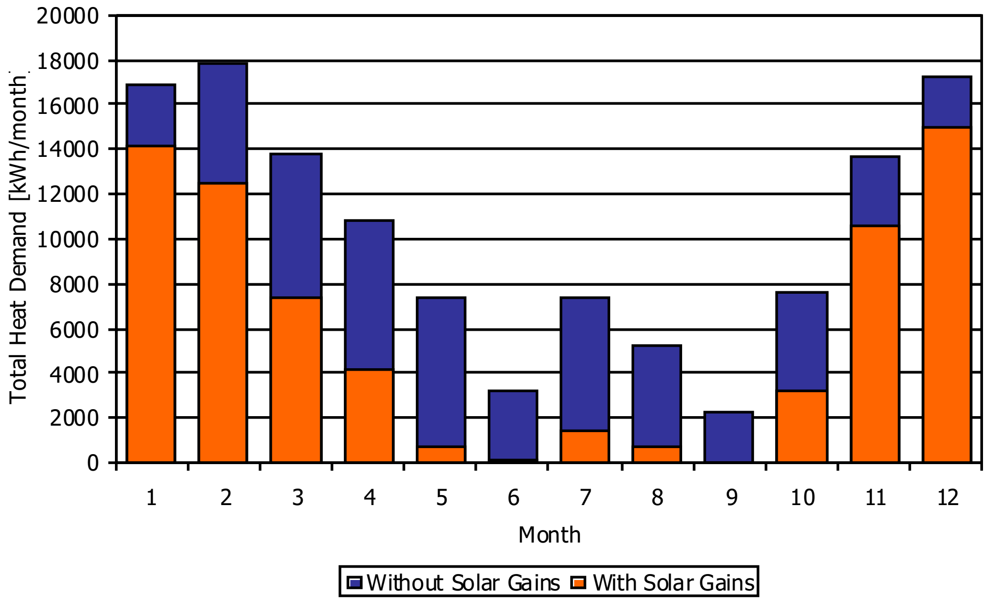


Figure 8: simulated total heat demand per month with (orange) and without (blue) passive solar gains.

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Ground storage

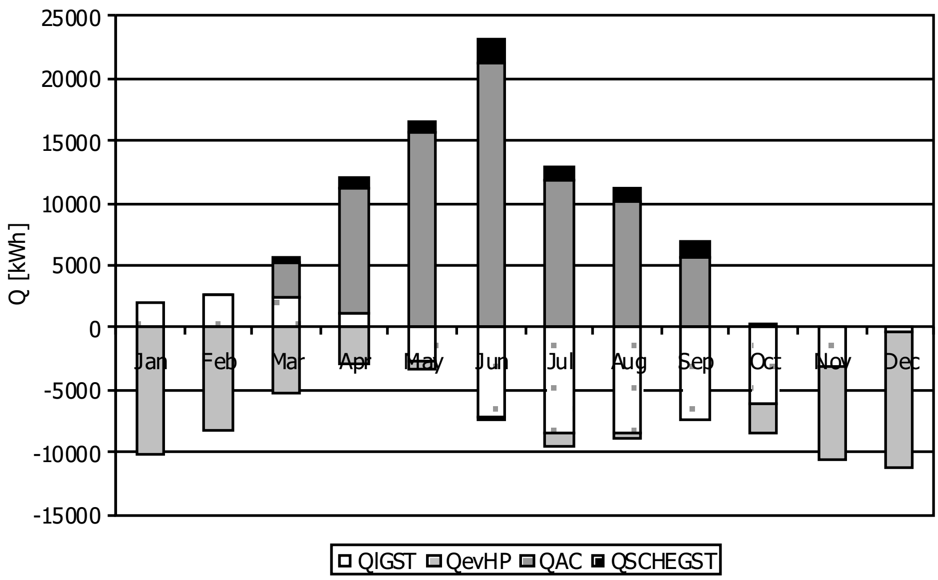

Figure 9: simulated energy balance of the ground storage: losses in the ground storage (QlGST), heat extraction by the heat pump (QevHP), heat from the asphalt collector (QAC), heat from the solar collector to the ground storage (GST).

Heat pump

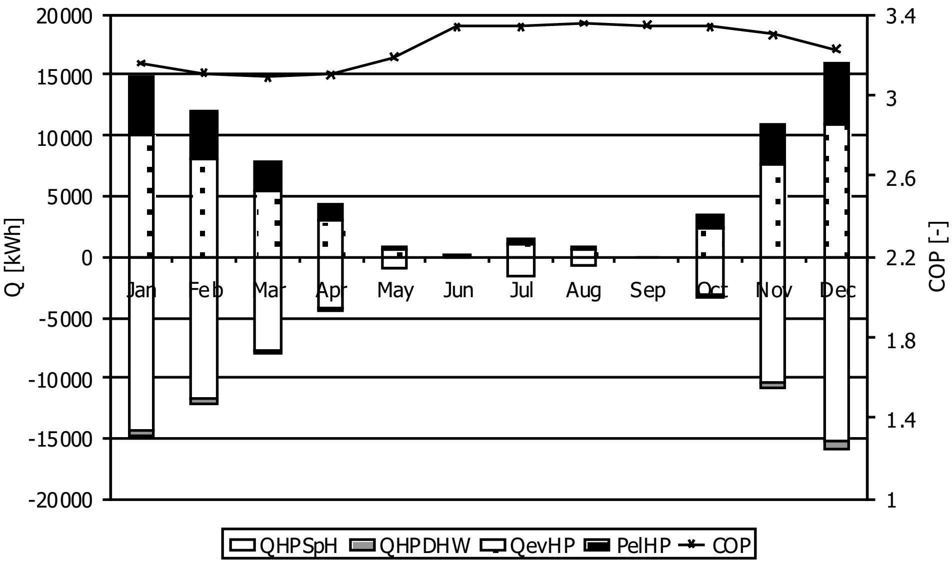

Figure 10: simulated energy balance of the heat pump: heat from the heat pump used for the heating circuit (QHPSpH), heat from the heat pump used for pre-heating the domestic hot water (QHPDHW), heat from ground storage to heat pump (QevHP), power consumption of heat pump (PelHP). Also, the monthly average COP of the heat pump is indicated.

Domestic hot water

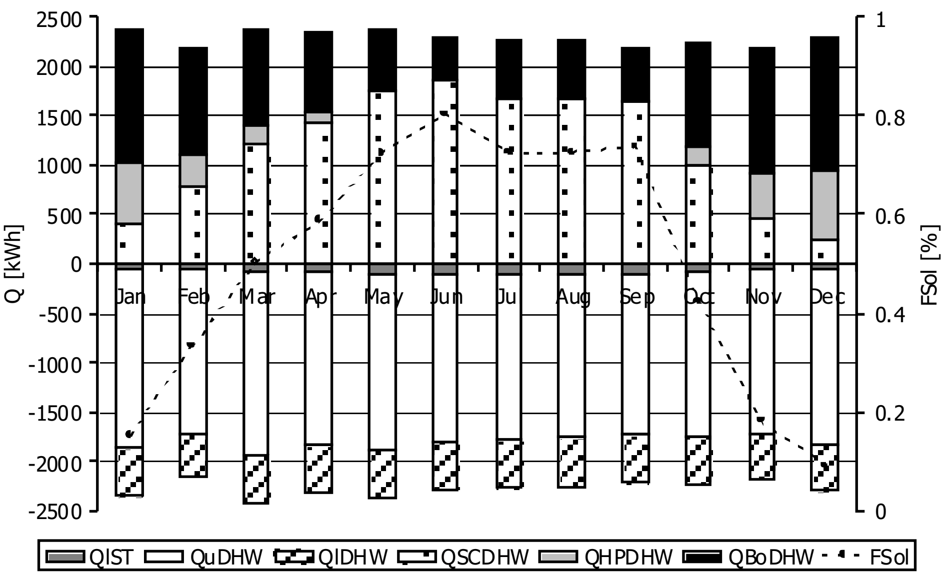

Figure 11: simulated energy balance of the hot-water supply: losses in the storage tank (QlST), useful heat from the domestic hot water (QuDHW), heat from the ring piping (QlDHW), heat supplied to the domestic water by solar collectors (QSCDHW), heat supplied to the domestic water by the heat pump (QHPDHW), heat supplied to the domestic water by the after-heating (QBoDHW), solar fraction (Fsol) defined as the fraction of heat supplied to the domestic water by solar collectors.

Overall energy balance

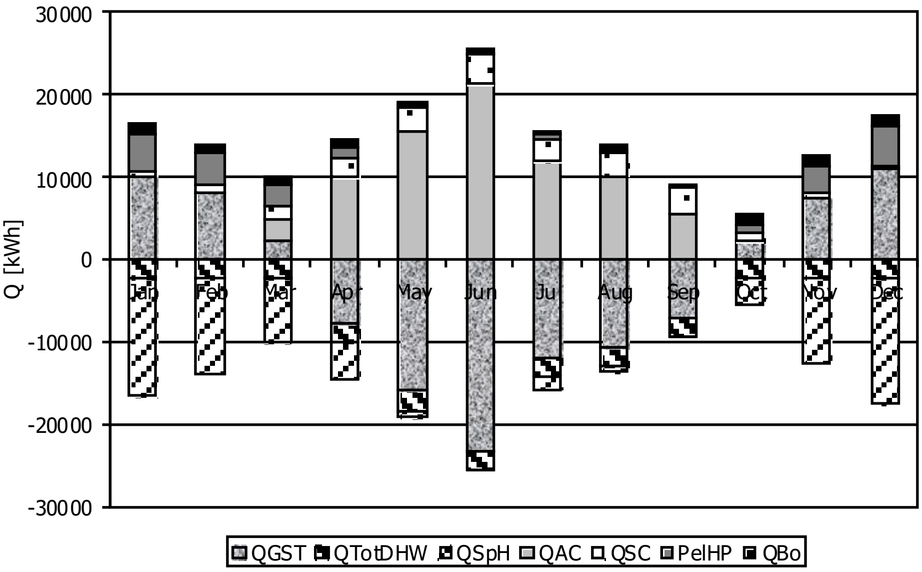

Figure 12: simulated monthly energy balance. The heat to and from the heat storage (QGST). The total heat demand for domestic hot water (QTotDHW), the heat demand for room heating (QSpH), heat from the asphalt collector (QAC), the electric energy supplied to the heat pump (PeIHP), heat supplied by the after-heating of domestic hot water (Qbo).

Table 1: annual energy balance for the simulated energy concept according to the parameters as defined in Figure 12.

Parameter		Energy	Perc.
QSC (solar collector)		22210 kWh	17%
QAC (asphalt collector)		76930 kWh	58%
PelHP (electric energy heat pump)		22750 kWh	17%
Qbo (after heating with gas)		10635 kWh	8%
QlGST (losses in ground storage)	-	35250 kWh	27%
QtotDHW (total demand hot tap water)	-	27345 kWh	21%
QSpH (room heating)	-	69930 kWh	53%
Balance QSC + QAC + PelHP + Qbo - QlGST - QTotDHW - QSpH		0 kWh	100%

Annual savings in €

7. Energy saving without photovoltaic electricity production

a) without photovoltaic electricity production

- The electric energy produced will be used locally, as will the generated and stored thermal solar energy.
- An overview of the savings is shown in table 2.
- Unit prices applied:
- Electricity: 12.79 Eurocent/kWh
- Natural gas: 2.91926 Eurocent/kWh (10,3046 kWh/m^2)

Table 2: annual savings compared to a similar project using standard techniques

Description	13 standard families		Estimate project Zoerle Parwijs	
	Consumption (kWh)	Cost (€)	Consumption (kWh)	Cost (€)
Natural gas consumption for heating	232050	6774.14	none	none
Natural gas consumption for hot tap water	50700	1480.06	10635 (after-heating)	310.46
Consumption of electricity	52000	6650.8	39000 (consumption after REG-applications) + 22 750 (consumption WP)	7897.83
Total	334750	14905.01	72385	8208.29

- Realised saving: E = 14,905.01 – 8,208.29 = € 6,696.72

b) Energy saving resulting from photovoltaic electricity production

- As for the photovoltaic energy, the objective is the total compensation of the annual electric consumption for the mechanical ventilation.
- Estimate of required power:
    - Electricity consumption of a WTW-unit (Stork WHR90): 25 W (100 m^3/h) – 125 W (250 m^3/h)
    - average flow per year: 175 m^3/h
    - average electric consumption per year: 75 W
- Total electric consumption per year: 8500 kWh
- Required photovoltaic power 10 kWp

- This results into an additional saving of € 1,275.00 (EP hours = 15 cent/kWh)

Total energy saving in €:

E= 6,696.72 + 1,275.00 = € 7,971.72

8. Milieuvoordelen

Reduction of emissions

Obviously, the use of renewable energy sources and sustainable energy techniques aims to reduce the emission of toxic substances and to spare fossil fuels.

The applied energy concept realises per year the following savings as compared to a standard reference project.

Description	Realised saving in kWh	Realised saving in kg CO_2	Realised saving in kg NO_x	Realised saving in kg SO_2
Natural gas consumption for heating	272115	54967,23	51,70185	0,54423
Consumption of electricity	-1250	-1233,75	-1,5875	-1,4
Balance		53733,48	50,11435	-0,85577

The applied indicators are for CO_2: 0.987 kg/kWh, for NO_2: 1.27 g/kWh and for SO_2: 1.12 g/kWh. These have been taken over from http://www.emis.vito.be/elektriciteit/index.htm. They are valid for the production of electricity in conventional thermal power stations. It departs from the hypothesis that REG and HE will result in the short term to a reduction of the consumption by fossil power stations only and into the related emission reduction.

By using heat pumps the total electric consumption is lower than in the reference project in spite of the use of photovoltaic panels. This gives a negative balance for SO_2.

E. Situating the initiative within the wider context of social housing

As can be deducted from this evolution our focus on energy-efficient and sustainable building did not come out of the blue and I can assure you that this attitude is going strong within the entire sector. I refer in this regard to the European subsidy rules for the integration of solar collectors in social housing in the years 2000 – 2001 and to the policy statement of the Flemish government.

It should be clear by now that Zonnige Kempen opted for a step-by-step approach in this matter for the obvious reason that if one step of many would not generate the desired or even the opposite result, one would throw out the baby with the bath-water.

The surplus value for the tenant is obvious: he benefits from the financial gain by decreasing the energy consumption. With the short depreciation terms (e.g. 7 years for the solar collector installation in Nijlen) it is no problem for the social housing company to integrate this in the whole. Besides, it should be noted that the tenant can but once spend a Euro. If the latter has already vanished through the chimney, he can no longer use it to pay for his rent.

He will also enjoy living in a healthier and more comfortable house and environment.

For the community the surplus value lies in the saving of energy and natural resources, the decreased CO_2-emission and the reduced use of land, not to mention the advantages of a satisfied tenant.

The result should even be improved by applying these principles in the entire sector of social housing with its more than 100 recognised companies. As the economic preconditions in social housing are even stricter than for the private house-construction, the conclusions can be passed on as role models to the market.

F. CONCLUSIONS

As already mentioned, the first lines have been drawn, the drawing, however, is far from ready and many details need to be outlined as yet.

For the further development of the ideas of energy-efficient and sustainable building it is useful to bring forward some considerations and necessary conditions.

- It is of essential importance that in the beginning of the project the preconditions are clearly established. These differ per project, making it impossible to set out unequivocal solutions.
- Departing from these preconditions one can start developing a plan; in doing so, the indicated sequence should be respected. The point of departure must be: both proper insulation and proper ventilation.
- An adequate level of transfer of knowledge must be organised, based on the practice, towards planners and contractors, for instance as to technology and air-tightness.
- Sustainable building solutions must be integrated in the design, they are an essential part of it and are not fitted in later.
- The user, in our case the social tenant, must be guided to obtain maximal results.
- We know from experience that an accurate setting and regular inspection of the system are necessary.
- One should take into account the initiatives that have been taken already and their results, both in Flanders and elsewhere. Proper feedback in the learning process makes that one need not reinvent time and again what has already been invented.
- Scientific support is also important.
- Within the social housing sector the ideas can but be developed further if the Board of Directors, the municipal counsellors and the administration are open to this approach and if the higher authorities create policy-supporting measures and financial stimuli. This will make it possible to reach the pre-set energetic and financial savings and to reduce the emission of toxic substances.