Final Technical Report - EGC

Project

European Green Cities

December 2001

Project Reference Number: BU-1001-96

Title of project: European Green Cities - European - Global Renewable Energy and Environmentally Responsible Neighbourhoods and Cities

4 OPERATION AND RESULTS

4.1 Operation History

4.1.1 Abruzzo, Italy

Manufacturing phase was completed on the 29.09.1999 and the conclusion of work was declared in February 2000 with all technical and administrative tests done.

Technological test of all plant systems and the maintenance manuals were completed in December 2000.

The set up of the monitoring system and of the remote unit of tele controlling was completed on the 06.09.2000.

From 15th of October 2000 started the energy metering and the monitoring phase according to the defined programme.

Important problems with the project interventions didn’t incurred during the project phases.

The works were carried on with a limited inconvenience for tenants.

4.1.2 Brescia, Italy

The construction phase started on 24/12/1998 but it at once stopped because of the winter season and because ALER of Brescia had some problems to obtain the building permission from the Municipality of Brescia as far as the closure of the loggias and the displacement of the thermal power plants concerns.

The works started on 01/03/1999 and were completed in march 2000.

End of work declared on 5/10/2000.

Technological test of all plant systems and the maintenance manuals were completed in December 2000.

The set up of the monitoring system and of the remote unit of tele-controlling was completed before the summer 2000.

From January 2000 started the energy metering and the monitoring phase.

First data about energy consumption and about solar energy contribution have been measured but the solar contribution appeared very different between the three building blocks. This required a check of the three solar plant systems.

Problems concerned the works inside the apartments as far as the ventilation system and the heat metering system concerns. Tenants were in fact very suspicious about the works and ALER of Brescia had some problems for tenants information and training.

For some old people crono-thermostat are very difficult to be used.

4.1.3 Copenhagen, Denmark

The tenants were offered other flats in the year where the blocks were renovated. They then moved back after all work had been finished. It has been a great change to the tenants to move from very old and defective flats to modern flats with all modern facilities.

In Tøndergade there have been problems with noise and vibrations from the ventilation system. The tenants have also complained of draught from the fresh air valves in the facade. The ventilation systems had not been adjusted sufficiently when the tenants moved into the flats. Therefore, the tenants complained of the noise from the system and even though these defects have been corrected, it has been difficult to change a negative attitude to a positive attitude.

In Tøndergade/Sundevedsgade the heating has not been sufficient during the first heating season. Many initiatives have been taken to solve the problems. The control of the buffer storage in the basement is modified to improve the cooling of the return of the local district heating network. Also the heating coil in the supply air ducts are modified to improve the heating system.

In Sundevedsgade 26-28 no considerable problems have arisen after the tenants have moved in.

4.1.4 Grenoble, France

This project was one of the first big solar projects. It has been presented towards a lot of meetings to convince tenants, financial partners, etc. It was the aim to do an exemplary project for all the energy saving partners network. The performances have been good monitored and the results have been communicated to a lot of professional partners.

4.1.5 Herning, Denmark

Tenants were from previous dwellings not used to draught and noise from the air inlets, why several users made their own adjustments of the inlets, and so broke the regulation.

Specific adjustments on tank for rain water (level for city water supply start and stop) were necessary along the way.

4.1.6 Hulshout, Belgium

The tenants went in 1 November 1999. Most of the technical installations were ok. Tenants hat room heating and hot sanitary water.

Because of the problems with the overpressure valve in the solar collector system a new overpressure valve (6 bar) was installed. The problem was solved.

Problems with the low efficiency of the collective solar collector system of building block 2 will be solved in March 2001.

Problems with the air tightness of the air ducts will be solved in July 2001. The solution is replacement of fittings.

4.1.7 Kuopio, Finland

The building was taken into use on 1.8.1998. Due to finishing and adjustment work the follow-up was started on 1.1.1999. The standard use of the building is based on the school timetable and ventilation operating time is also connected to it apart from the sports hall ventilation unit. The extractor equipment of the washing and toilet facilities are connected to the sports hall ventilation unit and the timing programme.

The Mechanical ventilation system operating times of the initial follow-up period are in appendix 1.

The use of energy in the building was studied by monitoring the consumption continuously for a year. The summary report is dated 20.2.2000.

The result was an analysis of the proportions of energy consumption of the building's mechanical ventilation system, radiator network and water usage. The consumption of heating energy was altogether 587.1 Mwh during the follow-up year. The proportion for mechanical ventilation system was 39.7%, for the radiator network 53.9% and for water usage (DHW) 6.5%.

The amount of solar-generated heat energy acquired from the sun wall was also studied. The sun wall was used for pre-heating. The acquired energy for the entire 12-month period was 38,1 Mwh. The amount of energy collected with the sun wall would be significantly higher if the position of the wall towards the sun were better. The amount of solar radiation onto the wall is at its greatest when school hours are over and mechanical ventilation system units have been stopped.

The efficiency ratio of the mechanical ventilation heat recovery system was followed up during the period.

A study was made of the energy consumption of traditional standard volume mechanical ventilation system and the innovative solution consisting of mechanical ventilation system according to need. The basic principle was that the standard air volume corresponded to the maximum air flow in the ventilation plant and usage times of the plant were the same during the follow-up period. There was a saving of 51,6%.

As the ventilation system works with half or less of its air volume capacity for most of the time there is no noise at all from the intake air equipment.

4.1.8 Portsmouth, GB

The project is not complete at the time of writing this report. As previously described the project start was severally delayed when structural problems were identified. Poor performance by the contractor has further delayed the project completion.

The LTHW heating and DHW systems including the CHP have been complete for operation since November 2000. The operation history of this part of the project can be summarised as follows:

- Initial problems with the communal boilers locking out was identified as being a problem with too high a gas pressure at the burner. Fitting new gas control governors rectified the problem.
- Lock out problems has since reoccurred with communal boiler no. 1. A control fault was initially thought to be the course but this appears not to be the case. The problem is still to be solved.
- Some residents have complained that the domestic hot water gets too hot. This is seen to be a combination of their individual valve being set too high and their unfamiliarity with this new system or the individual valve could be faulty. Each case is being assessed separately.
- The Building Energy Management System (BEMS) has not been commissioned for the collection of metering data. Manually monthly readings have been taken but they do not provide the same detailed information.

4.1.9 Radstadt, Austria

In the first winter (1998 to 1999) there were some difficulties with tubes in the heat installation and some meters didn´t work correct. This problems were solved very quickly.

In the years 1999 and 2000 there were some problems with the solar-collectors at house HA6a. So the collector had to be repaired and did not work for several weeks - we see this in the monitoring report, there was less energy because of this.

First the tenants were not used to live with a controlled air-ventilation and still opened the windows in winter for a longer time. This could be increased after a tenants information. Last winter it was better.

4.1.10 Vilanova, Spain

A total of 80 dwellings will have hot water requirements supplied by Low Temperature solar thermal collectors. At the moment only two stairs are supplied and a total of 32 panels are installed. The rest will be installed in the next months.

- the installation has already been carried out in two of the seven stairs, with 20 dwellings (stairs 6 and 7), but not all dwellings are occupied yet. Nevertheless, the hot water installation is already working and supplying the requirements of the buildings.
- the rest of the stairs to be constructed are expected to be finished and occupied by the end of the year 2001.

The Monitoring system was installed in two flats not occupied yet, for external not expected reasons. That obliged us to change the monitoring dwellings. Therefore the monitoring system is planned to be completed in the next weeks, and data will be finally acquired from the two model dwellings.

The operation history doesn’t exist until now because only eight families are living in the flats. In a few months more information will be provided about the operation.

At the present time the building is under construction and only one of the 20 dwelling’s phases has been handed in, in the first week of December 2000.

It is expected to hand over 20 more dwellings at the end of March, 25 dwellings in May, and the last 15 dwellings in July 2001.

Actually, since the 20 first dwellings were delivered a short time ago, only 8 families are at the moment living in the building. During the next three months full occupation of the dwellings in this phase is expected. However, 100% occupation of the dwellings is not expected until the end of 2001.

4.1.11 Volos, Greece

Finalising the project on time we faced problems of political and administrative nature. Between the years of constructing those two municipal buildings, we had elections (October 1998) and new municipal authority and in a sort while again, repeated elections (after resignation of mayor-May 1999) and again new authority. This had a time delay effect on the project. Considering that for about two years the municipality was not supporting financially the construction. Finally last year (2001) everything was resolved and the project went through.

4.2 Performance

The results of the monitoring programme are given in a separate report – *Final report on monitoring, December 2001*. This report includes all the results from the 11 EGC projects. In this report only the main figures are included.

The aim of the EGC projects is to make energy efficient buildings. The key figures are the energy consumption for space heating, domestic hot water and electrical appliance is monitored in the projects.

The energy consumption for heating is given in the Figure 4.1 for all the EGC projects. The results are given as kWh per treated floor area.

In all projects the heat consumption is much lower than what is normal practice in the countries. Especially in Hulshout, Portsmouth and Kuipio the predicted savings are higher than the norms and in Hulshout the monitored values is also very high.

The Copenhagen project is a renovation project where the buildings are changed from very low standard to modern standard with ficilities like bath, central heating and effective ventilation with improved indoor air quality.

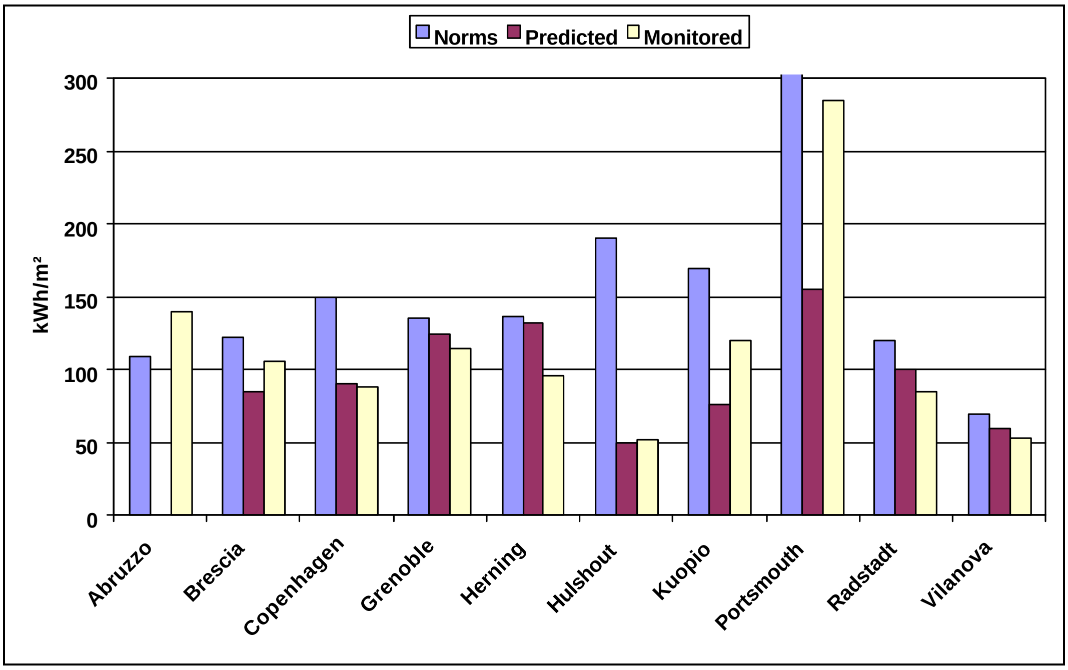

Figure 4.1: Yearly energy consumption for space heating and domestic hot water for the projects in EGC given as kWh/m² (treated floor).

The water consumption are shown in Figure 4.2.

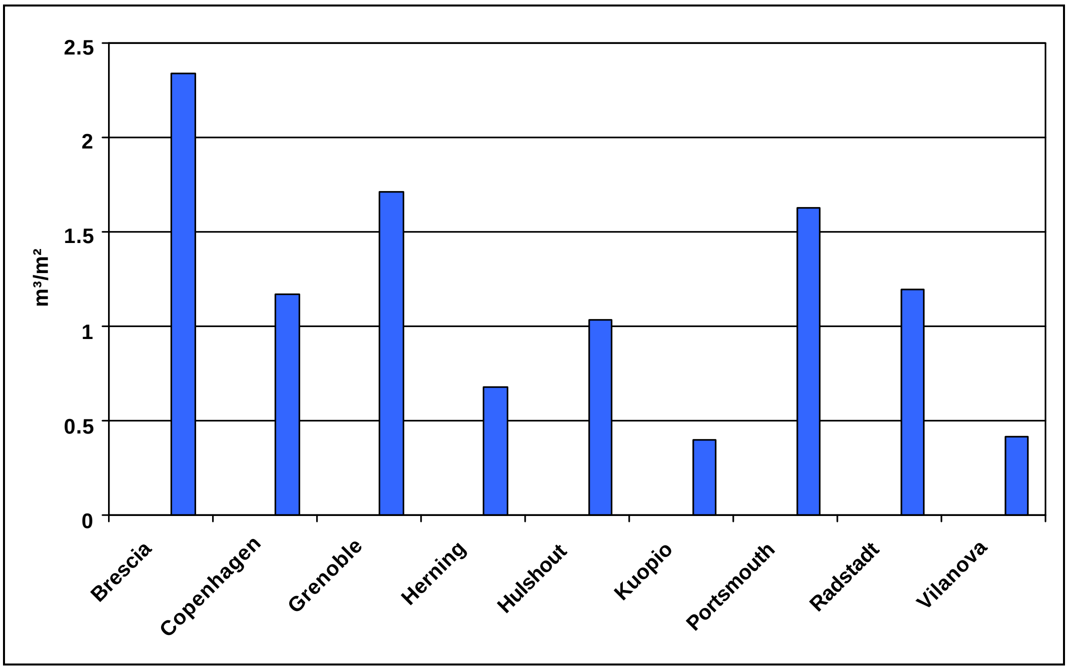

Figure 4.2: Yearly water consumption for EGC projects.

Abruzzo, 54 dwellings with total 5322 m² floor area.

	Before	Predicted	Monitored
Heat, kWh/m² (natural gas)	109.5	47.9	139.9
Electricity, kWh/m²	7.0	4.8	0.6
Water, m³/m²			na

Brescia, 72 dwellings with total 5750 m² floor area.

	Before renovation	Predicted	Monitored
Heat, kWh/m² (natural gas)	122.4	85	106
Electricity, kWh/m²	4.23		6.15
Hot water, m³/m²	0.74		0.844
Water, m³/m²			2.34

The electricity consumption refers only to the technological plants and the thermal central plant operation. Each user pays the consumed electricity and these data are unknown by ALER of Brescia.

The electricity consumption for the operation of the three thermal central plants has grown up of about 31,25% because of the realisation of the three solar central plants for DHW production and the implementation of the new central thermal plants.

Interventions to reduce electricity consumption have been not foreseen in the project.

Moreover, a local district heating network supplies energy for space heating and DHW and it provides high efficiency and good cost rates for heat supply. Comparing to this reality a solar system only for DHW production didn’t result cost-efficient.

The cold water is directly payed by each tenant and data on the water consumption before the Thermie actions are not available.

Moreover measures to reduce water consumption have been not foreseen.

Copenhagen

Tøndergade 3-3A, 20 dwellings with total 1040 m² floor area.

	Norms.	Predicted	Monitored
Heat, district heating (kWh/m²)	150.0		119.8
Electricity, kWh/m²	32		32
Water, m³/m²	1.1		1.37

Tøndergade/Sundevedsgade, 20 dwellings with total 1137 m² floor area.

	Norms.	Predicted	Monitored
Heat, district heating (kWh/m²)	150.0		162
Electricity, kWh/m²	32		32
Water, m³/m²	1.1		0.95

Sundevedsgade 26-28, 21 dwellings with total 1201 m² floor area.

	Norms.	Predicted	Monitored
Heat, kWh/m² (district heating)	150.0	90.0	88.3
Electricity, kWh/m²	32		32
Water, m³/m²	1.1		1.17

Rødekro, 53 houses with total 4500 m² floor area.

	Norms.	Predicted	Monitored
Heat, kWh/m² (district heating)	134.0	130.0	145.0
Electricity, kWh/m²	32	32	32
Water, m³/m²	1.08	1.08	1.00

The monitored heat consumption includes the losses in the district-heating network. This loss is approximately 20%. That means the heat consumption in the houses is 116kWh/m².

Grenoble, 505 dwellings with total 36,696 m² floor area.

	Before.	Predicted	Monitored
Heat, kWh/m²	135.0	125.0	115.0
Electricity, kWh/m²	12.5	12.3	11.9
Water, m³/m²	1.7	1.7	1.71

The average heat consumption for compatible building is 162 kWh/m²/year

Herning, 42 dwellings with total 1,699 m² floor area.

	Norms.	Reference	Monitored
Heat, kWh/m²	132		96.2
Electricity, kWh/m²	32		32
Water, m³/m²	1.10	0.84	0.68

The Herning project consists of two identical building blocks with 42 dwellings each. One block with standard specifications (Reference) and one with Thermie specifications (Monitored).

Hulshout, 23 dwellings with total 2202 m² floor area.

	Norms.	Predicted	Monitored
Heat, kWh/m² (space heating)	190	50.0	51.6
Electricity, kWh/m²	33	30	not monitored
Water, m³/m²	1.01	1.04	not monitored

Kuopio, School building with total 4900 m² floor area.

	Norms.	Predicted	Monitored
Heat, kWh/m²	169.5	76.0	119.8
Electricity, kWh/m²	49.9	28.0	45.0
Water, m³/m²	0.51	0.36	0.40

Portsmouth, 136 dwellings with total 7328 m² floor area.

Due to poor performance by the contractor the refurbishment work is still not complete, which means that some of the energy efficient measures to be implemented are not sufficiently complete for their performance to be monitored. The measures are:

- replacement double-glazed windows
- external insulated cladding
- PV modules
- solar domestic hot water

The outstanding measures are mainly affecting the performance of the heat consumption. Double-glazed windows and especially wall insulation in the form of external insulated cladding will reduce the heat demand. Considering the monitored performance to date, which reflects the affect of, improved heating controls and new plant there is no concern that the project ones complete will meet its performance target.

Eleven months of monitoring data is available at this stage to complete a full twelve months period one month of data has been interpolated.

Per Annum	Historic data	Predicted	Monitored
Heat, kWh/m²	533.2	155.4	284.5
Electricity, kWh/m²	105.3	60.6	33.3[1]
Water, m³/m²	n/a	3.25	1.63

The landlord electricity being stairwell lighting, boiler house electricity, lifts etc. is now mainly being generated on site by a small Combined Heat and Power (CHP) plant. Only when the CHP is not running or if demand exceeds that generated by the CHP, is electricity imported from the grid.

In addition to the above electricity saving there is a substantial amount of electricity saved on domestic supplies due to domestic hot water (DHW) electrical immersion heaters being replaced by DHW supplied via the community heating system. There is no monitoring of this saving but it is estimated to be at least 20 kWh/m2 per annum.

[1] Electricity imported from grid

Radstadt, 36 dwellings with total 2559 m² floor area.

	Norms.	Predicted	Monitored
Heat, kWh/m²	120	100	84.7
Electricity, kWh/m²	47		28
Water, m³/m²	2.0		1.2

Vilanova, 80 dwellings with total 6752 m² floor area.

	Norms.	Predicted	Monitored
Heat, kWh/m²	70	60	53
Electricity, kWh/m²	42	42	38
Water, m³/m²	0.7	0.57	0.42

Volos

	Norms.	Predicted	Monitored
Heat, kWh/m²	n/a	62.7	76.9
Electricity, kWh/m²	n/a	-	19.2
Water, m³/m²	n/a	n/a	n/a

The above refers to the energy center building

For a typical municipal building in Volos the annual consumption is around 200 – 250/ kWh/m².

	With no change predicted	Predicted	Monitored
Heat, kWh/m²	450	160	
Electricity, kWh/m²	180	47	
Water, m³/m²	n/a	n/a	n/a

The above refers to the Tsalapatas building. Knowing that the building had no insulation at all on the roof, ground and side walls, and with no openings for lighting. (it was an old industry)

4.3 Success of the Project

4.3.1 Abruzzo, Italy

Technological systems appear well done and they demonstrate a good operation.

Referring to the monitored data, an energy saving was not obtained. The heat consumption increased after the Thermie intervention, because of the new type of the heating system. Before the Thermie project the heating system consisted in an autonomous boiler for each apartment so that each tenant was responsible of the temperature in the apartment and payed on the base of proper consumption. Many tenants used to keep a low temperature in their apartment in order to save money.

Actually the centralised heating system doesn’t permit to keep the space heating not operating, so that global heat consumption increased, although tenants had an improvement of the idoor air quality and comfort of the apartments.

Moreover maintenance costs of the buildings plants also increased because of the new technologies installed.

An energy saving concerning the electricity consumption for common uses was obtained.

Monitored data of gas consumption in year 2000 and year 2001 show that a small reduction, between the two years, has been obtained, but the heat consuptiom is still higher than before the Thermie intervention.

Referring to the previous considerations, ATER L’AQUILA, that manages the buildings object of the intervention, has actually many technical, organization, administration, legal, economical problems, due to tenants relationship.

Public residential buildings are often occupied by families with economical problems and low culture.

Tenants are not available to pay energy consumption and the public housing association is obliged to anticipate the payment of the bills to the local utility. The problem of ATER L’AQUILA is that it generally can’t recover the anticipated money.

With autonomous heat systems ATER L’AQUILA was not responsible of the payment of the gas consumption of their tenants.

Tenants were directly responsible of their heating system: if they didn’t pay the energy bills, the local utility didn’t provide them with energy.

With a centralised heating plant, ATER L’AQUILA became responsible of the heat system and energy costs of the buildings.

4.3.2 Brescia, Italy

The project has been well accepted by the local public Institutions although ALER of Brescia had some problems to obtain the building permission from the Municipality of Brescia as far as the closure of the loggias and the displacement of the thermal power plants concern.

Energy saving was fairly good: energy consumption before the intervention was not so high comparing to other buildings owned by ALER of Brescia in the city of Brescia so a reduced energy saving has been obtained.

Energy saving for DHW production is lower than predicted also because a purification cycle for the water in the storage tanks has been foreseen every week: it consists in a high temperature purification system of the water in the solar tanks (at 70°C) lasting two hours.

Costs for maintenance and plant's conduction is actually quite high comparing to the costs before the intervention (from 2826 EURO/year to 6507.4 EURO/year). This is due to the increase of the technological systems after the project interventions.

Solar system for DHW production didn't result very cost-efficient in Brescia because of the presence of the local district heating network that is a high efficiency system and it provides good cost rates for heat supply.

Moreover, the technological systems have been implemented (solar system, heat metering system, EMS) and they actually consume more electricity than before the intervention.

4.3.3 Copenhagen, Denmark

The European Green Cities project in Copenhagen shows examples of use of energy saving measures in connection with renovation of old buildings. Many old buildings in Copenhagen are being renovated in these years and the European Green Cities projects appear as display windows of the use of alternative energy supply and are a great source of inspiration to architects and consultant engineers in similar renovation projects.

The buildings have been improved and fitted with modern facilities without a considerable rise of the water, heating and electricity consumption. All buildings have been provided with efficient ventilation systems that will secure a good indoor climate both for the tenants and also for the building constructions. The buildings show examples of how complicated duct systems can be integrated in small flats with good possibilities for service and without taking up too much of the small space.

Figure 4.3.: The ventilation system is installed outside the external wall.

The project with one-family houses shows examples of new installations that match the demand for small and efficient heating systems for low-energy building. The installations have been simplified combined with integration of measures that secure a good indoor climate with a minimum risk for indoor climate problems, e.g. mould fungus attack.

4.3.4 Grenoble, France

The aimed performances have been reached and the technical difficulties have been solved.

The complete action, with DHW solar panels, PV panels, windows replacement, insulation, has permitted an important maintenance costs reduction. The tenants are now satisfied.

An important aim was also to develop the tenants environmental consciousness. They seems to have now a good impression concerning energy saving and solar energy and it is possible now to treat other questions like energy saving in the dwellings, wastes, water saving, etc.

4.3.5 Herning, Denmark

Building a new building is not expected to cause problems of any unusual kind. The success of the project is primarily the interest we see in the community and among the young coming dwellers, for a green project, and who gets a chance to outlive their green dreams.

4.3.6 Hulshout, Belgium

Most people in social housing have a very low income. The share of the energy costs in the total family budget is rather high. People living in this project were very surprised about the very low energy billing compared to other social houses even with an equal or higher comfort level in this project.

The energy billing for room heating was very low because of the high insulation level, the very efficient condensing boiler and the recuperation of the heat in the extraction air. Because of the use of solar collectors the energy consumed for hot sanitary water is low compared to other social housing projects.

The project was visited by a lot of important persons and got a lot of media publicity:

An exhibition of the project was organised on 26 September 1997. The Flemish minister of Social Housing Mr. Leo Peeters participated in this exhibition. He was very interested and he was prepared to support the project.

The project got a number of times into the press. For instance, the project was proposed on the regional television RTV Kempen and different articles were published in the national newspapers.

In the energy month October 1998, the Flemish Minister of Energy Mr. Van Rompuy visited the project. An information program concerning energy efficient and sustainable building was made for the Flemish television (VRT). This project in Hulshout was shown as an example of energy efficient and sustainable building.

In December 1998, the project was visited professor Hens (construction and building physics of the Catholic University of Leuven).

The European project was officially opened on 24 March 2000 by the Minister – vice President, Minister of Mobility, Public Construction and Energy Mr. Steve Stevaert and by the Depute of the Province of Antwerp Mr. Ludo Helsen. A lot of interested people were present at the official opening.

The project was detailed described in newspapers and local Television Company RTV (Regional Television Vlaanderen). By this way information about the European Thermie project was disseminated to a broad public.

After the official opening a lot of interested people from inland and abroad (the Netherlands, Poland, …) have had a guided tour to the project.

Every two years the Flemish Government organises a "month of energy saving", mostly in October. In October 2000 the project was open to the public. Guided visits were organised to interested Flemish people.

The project was presented in the international conference "Sustainable building 2000", 22-25 October 2000 in Maastricht (NL).

4.3.7 Kuopio, Finland

It is of the utmost importance from the point of view of the success of the project that all components in every sub-section function faultlessly. An important part in this is played by the functionality of the LON data transfer network and its installment. The fact that individual components such as temperature sensors, lighting measurement sensors, and CO2 sensors have been manufactured for a longer period of time and are calibrated by the manufacturer guarantee that they function faultlessly. Problems arise in projects such as this when different components have to be fitted together, when somebody has to be found to take final responsibility when the plant does not work, when machines stop or when the locking system is inoperative. From the user's point of view, the biggest dilemma arises from a piece of equipment breaking and needing replacement. The user's maintenance organisation lacks the required expertise and training in new technology to carry out the repairs.

In exploiting new technology, the desired energy savings and savings in the cabling of the building were as expected: the amount of cabling required for the room controls and sensors is considerably smaller and brings savings for the builder. Measured in percentages, the energy savings are important. However, while the price of energy is low, in this case FIM 170/MWh for heat energy and FIM 300/MWh for electricity, the payback period of the equipment cannot function solely as the motive for installing them. When estimating the value of user comfort in various rooms, even the mentioned energy prices make a good case for using mechanical ventilation system according to need.

4.3.8 Portsmouth, GB

Working in a high rise building whilst a high number of residents remained in occupation is seen as a success.

- In meeting the resident's wishes an extensive reprogramming of the project was necessary to ensure that health and safety regulations were applied.
- Careful programming was essential whilst meeting the day to day challenges that occurred due to unavoidable issues arising within family life.
- Dedicated staff is key to successfully manage a project of this calliber. The actual works within each flat was scheduled with each family.

The installation of a CHP unit providing base load heat and electricity for landlord and boiler supply with excess electricity being exported to the grid has been a success. It has been running 17 hrs/day since November 2000. A contract has been set-up with the electricity board for Portsmouth City Council to receive an income from the excess electricity produced. However, it is to be considered to connect the Landlord Supply of Solihull House and thereby use all the CHP generated electricity locally. This will financially be more beneficial to the council.

4.3.9 Radstadt, Austria

The project itself is well accepted by the tenants and the local people. The living quality is very high because of the good architecture and the high energy-standard. The architecture is very good for this area: simple, modern...

The success of the project for other projects in Salzburg:

- The energy standard in social housing has increased a lot in the last years (because of demonstration-projects like Radstadt).
- Radstadt-West was the first social-housing project with a controlled air ventilation in Salzburg. Now a lot of new houses are planned with it.
- For the politic it was very important to demonstrate how research can have practical results and give an impulse to the building culture and the economy in the area.
- Radstadt was the first social project were the theme "ecology" was think of (study for ecology and economic results). Now in the most new project ecological themes have to be think of (material, rubbish...).
- Projects like Radstadt have shown, that solar-collectors for the domestic hot water are economical and good practical solutions for bigger houses. In the year 2000 nearly the half of the new social houses had a solar-collector.

4.3.10 Vilanova, Spain

At that moment the success of the project is guaranteed by:

- The building has been designed and constructed with bioclimatic criteria and environmental conditions.
- The solar system and the domestic installation are working and provide hot water and heating.
- Some of the owners are occupying the dwellings.
- The market acceptance has been greater than expected.

4.3.11 Volos, Greece

The energy center building has been designed and constructed with bioclimatic criteria.

As it is operate for about a year now we must point out that it is very rare that artificial lighting has been used, even in cloudy days there is no need for switching on the lights. The behavior of the building during summer time (August) was exceptional, with 38oC outside temperature the inside temp never passed the 32°C and with the natural forced ventilation through the design of the building it has an acceptable degree of comfort. We did not install any cooling machines because are not needed.

A very well behavior has in the winter as well. (oil consumption is 4000 lt for the whole winter).

Concerning the Tsalapatas building we will have results very soon this year.

4.4 Operation Costs

The total operation costs for the tenants include:

- heating
- water
- electricity
- maintanace

The heating costs in the EU-countries are different and for the 11 locations of the EGC projects are given in Figure 4.4. The heating cost is more than two times as high in Herning compared with Radstadt. Also big difference can be found in the costs of water and electricity.

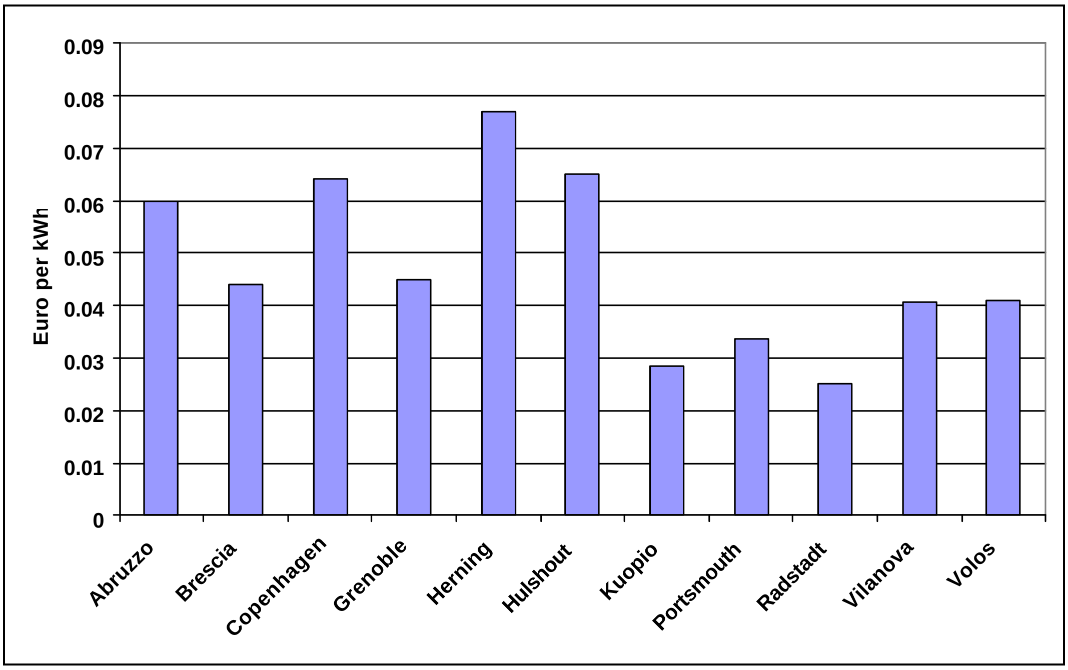

Figure 4.4: Costs of heating in the 11 EGC projects. The costs include VAT.

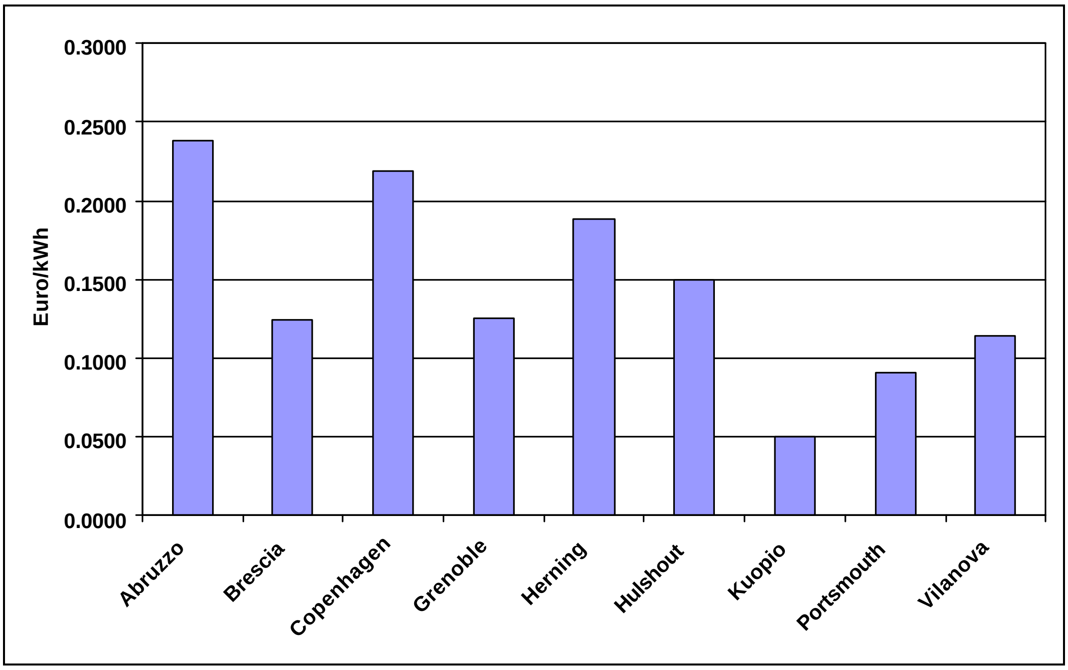

Figure 4.5: Costs of electricity in the EGC projects. The costs are the tenants costs including VAT.

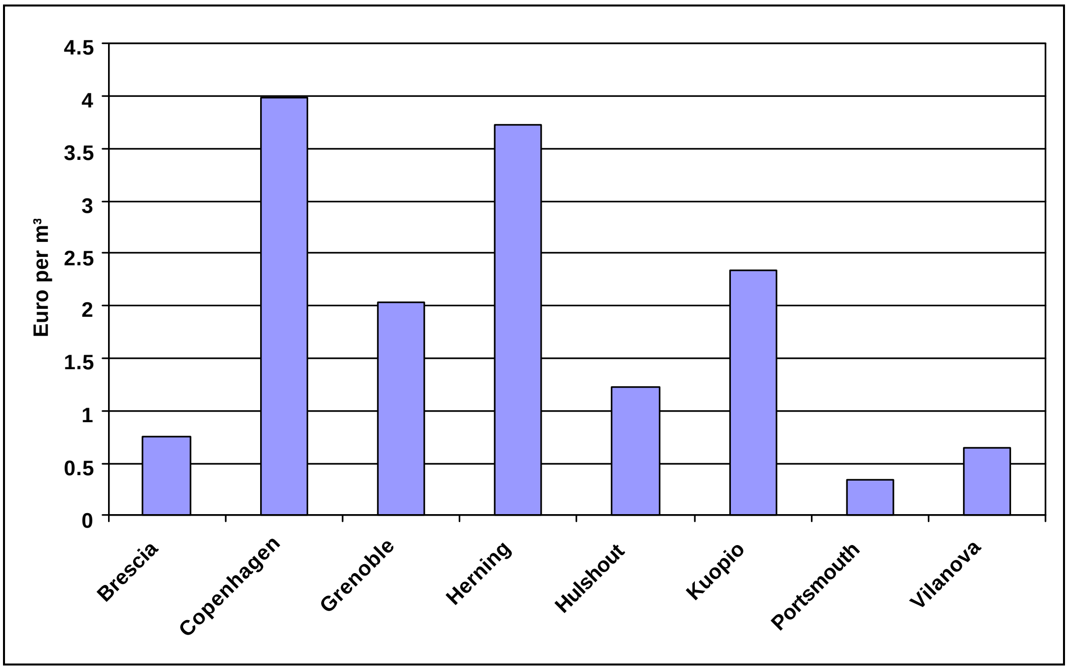

Figure 4.6: Costs of water in the EGC projects. The costs are the tenants costs including VAT.

The total operation costs are shown for the EGC projects with the low energy technologies and for what is norm for compatible building with traditional standards in the respective countries in Figure 4.7. The operation costs are shown per dwellings and the school project in Kuopio is not included this list. The operation costs of the EGC project (except Abruzzo) is lower compared with compatible building without any extra improvements. That means it is economic ettractive for the tenants to live in an energy efficient building. The operation costs in Houlshout is reduced from 1780Euro per year to 931 Euro.

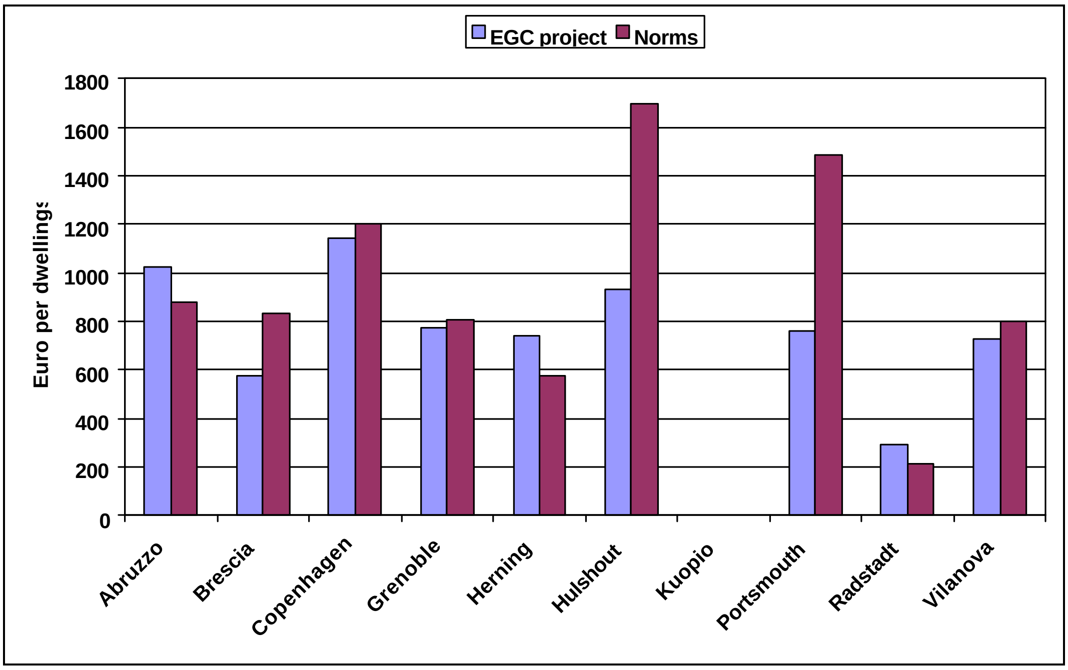

Figure 4.7. Yearly operation costs of the EGC projects per dwellings. The operation costs include energy, water and maintenance costs. The operation costs are shown for the EGC projects with the low energy technologies and for what is norm for compatible building with traditional standards in the respective countries. The operation costs of Radstadt only include heat.

4.4.1 Abruzzo, Italy

Table 4.1.: The energy and water costs of the Abruzzo project incl. VAT.

Costs per unit	**ITL**	**euro**
Heating, natural gas (kWh)	109.92	0.06
Electricity (kWh)	484.1	0.25
Water (m^3)		

Table 4.2.: Abruzzo (average floor area per dwellings = 99 m²)

Yearly operation costs, euro	**uses per m²**	**costs per m²**	**costs per dwell**
Heating, kWh	139.9	7.92	780.51
Electricity, kWh (common use).	0.06	0.15	14.17
Water, m³			-
Maintenance (euro/year)		2.33	229.54
Total costs EGC project		10.40	1024.22
Total costs norm		8.95	881.95

4.4.2 Brescia, Italy

Table 4.3.: The energy and water costs of the Brescia project incl. VAT.

Costs per unit	**ITL**	**euro**
Heating, natural gas (kWh), variable+fixed.	84.6+24,500,000	0.044+12,653.2
Electricity (kWh)	239.4+237,357	0.124+122.6
Water (m³)	1451	0.75

Table 4.4.: Brescia (average floor area per dwellings = 80 m²)

Yearly operation costs, euro	**uses per m²**	**costs per m²**	**costs per dwell**
Heating, kWh	106	7.55	603
Electricity, kWh	6.15	0.54	43
Hot water, m³	0.844	0.55	44
Maintenance			90
Total costs EGC project			748
Total costs norm			832

The difference between the operation costs for heat supply before and after the intervention is not quite high because of the energy tariff that includes a high fixed rate that it not depends on the energy consumed; this although an energy saving in kWh has been obtained.

In Brescia a local district heating network provides heat for space heating and DHW: the cost of the supply service consists in a fixed rate and a cost per unit. The fixed rate is quite high and there is no difference between before and after the intervention.

4.4.3 Copenhagen, Denmark

The costs of energy and water in the copenhagen projects are given in **Table 4.5**.

Table 4.5.: The energy and water costs of the Copenhagen project incl. VAT.

Costs per unit	**DKK**	**euro**
Heating, district heating (kWh)	0.478	0.0642
Electricity (kWh)	1.63	0.2188
Water (m^3)	29.75	3.99

The heating cost includes variable costs. The fix costs is 141.19 DKK/kW.

The yearly operation costs are calculated based on monitored consumption and the results are given in the Table 4.6. The monitored yearly use of district heating, electricity and water are listed in the second column in the table. The costs per floor area are given in the next column. The yearly costs of water and electricity are nearly the same and the costs of heat is twice as much. The average floor area of the dwellings is 52 m² and the yearly costs for the tenants are given in the last column of the table. The maintenance costs is calculated a percentage of the investment of extra energy savings technologies according to the figures in part 3.6. The actual yearly operation costs for the tenants is then 1226 euro per dwellings when living in the house with a low energy design and 1315 euro in a compatible dwellings with conventional installations. The operation costs of the dwellings in the other buildings are given in Table 4.7 and Table 4.8.

Table 4.6.: Tøndergade 3-3A (average floor area per dwellings = 52 m²)

Yearly operation costs, euro	**uses per m²**	**costs per m²**	**costs per dwell**
Heating, kWh	119.8	7.70	400
Electricity, kWh	32	7.00	364
Water, m³	1.2	5.46	284
Maintenance			47
Total costs EGC project			1095
Total costs norm			1093

Table 4.7.: Tøndergade/Sundevedsgade (average floor area per dwellings = 57 m²)

Operation costs, euro	**uses per m²**	**costs per m²**	**costs per dwell**
Heating, kWh	162.1	10.4	591
Electricity, kWh	32	7.0	398
Water, m³	0.95	3.8	215
Maintenance			112
Total costs EGC project			1316
Total costs norm			1195

Table 4.8.: Sundevedsgade 26-28 (average floor area per dwellings = 57 m²)

Operation costs, euro	**uses per m²**	**costs per m²**	**costs per dwell**
Heating, kWh	88.3	8.30	324
Electricity, kWh	32	5.60	400
Water, m³	1.0	4.30	267
Maintenance			152
Total costs EGC project			1143
Total costs norm			1202

4.4.4 Grenoble, France

Table 4.9.: The energy and water costs of the Grenoble project incl. VAT.

Costs per unit	**FRF**	**euro**
Heating, district heating (kWh)	0.294	0.045
Electricity (kWh)	0.82	0.125
Water (m³)	13.41	2.04

Table 4.10.: Grenoble (average floor area per dwellings = 72.7 m²)

Yearly operation costs, Euro	**uses per m²**	**costs per m²**	**costs per dwell**
Heating, kWh	115	5.18	376
Electricity, kWh	11.9	1.49	108
Water, m³	1.71	3.49	254
Maintenance		1.50	37
Total costs EGC project		11.66	774
Total costs norm		13.72	807

The operation costs without maintenance is reduced from 807 Euro to 738 Euro per dwellings. The maintenance costs is also reduced from 190 to 109 Euro per dwellings.

4.4.5 Herning, Denmark

Table 4.11.: The present expenses in Herning year 2001 incl. VAT.

Costs per unit	**Dkr**	**euro**
Heating (kWh)	0.57	0.077
Electricity (kWh)	1.40	0.188
Water (m³)	27.75	3.725

Electricity is accounted for to the local plant, why we're not involved, and do not know the actual consume. The electricity consumption is expected to be the same because the electricity consumption in the reference building uses the same amount of electricity as in the Thermie Building.

The maintenance costs is calculated as 2% of the investment costs of the extra energy savings technologies, that means the rain water system, solar heating system and the ventilation system with solar wall.

Table 4.12.: Herning (Total floor area for 84 app. is 3.398 m², which gives average floor area per dwelling = 40.4 m²).

Yearly operation costs, euro	**uses per m²**	**costs per m²**	**costs per dwell**
Heating, kWh	96.2	7.4	298
Electricity, kWh	32	6.01	243
Water, m³	0.62	2.52	102
Maintenance		2.4	97
Total costs EGC project			743
Total costs norm			577

4.4.6 Hulshout, Belgium

Table 4.13.: The energy and water costs of the Hulshout project incl. VAT.

Costs per unit	**BEF**	**euro**
Heating (kWh)	2.6	0.065
Electricity (kWh)	6.0	0.15
Water (m³)	49	1.23

Table 4.14.: Hulshout (average floor area per dwellings = 96 m²)

Yearly operation costs, euro	**uses per m²**	**costs per m²**	**costs per dwell**
Heating, kWh	51.6	3.4	322
Electricity, kWh	30	4.5	432
Water, m³	0.71	0.87	83
Maintenance			94
Total costs EGC project			931
Total costs norm			1697

4.4.7 Kuopio, Finland

Table 4.15.: The energy and water costs of the Kuopio project incl. VAT.

Costs per unit	FIM	euro
Heating, district heating (kWh)	0.170	0.0284
Electricity (kWh)	0.300	0.050
Water	14.01	2.34

Table 4.16.: Kuopio

Yearly operation costs, euro	uses per m²	costs per m²	whole school
Heating, kWh	119.8	3.4	16671
Electricity, kWh	45	2.3	11050
Water, m³	0.4	0.9	4587
Maintenance			7494
Total costs EGC project			39777
Total costs norm			41661

The functional costs of the mechanical ventilation systen are accrued from heating the intake air and from the electricity consumption of the blowers and pumps. The Mechanical ventilation system unit for the classrooms was equipped with necessary ventilation. In a standard solution, the consumption of the TK1 mechanical ventilation system equipment would be 74 MWh annually and in the solution used 35.9 MWh, thus bringing a 51 % saving in consumption. The greater than expected savings are due to the fact that the required volume of 9 l/s per person or 4.5 l/floor m2 is a fairly large figure and children's need for air and thus the load per room is much smaller than in the case of adults. With the central heating system pumps, there are no savings compared to the standard solution, but the savings in the energy consumption of the blowers are significant, about 85% of the electricity consumption.

Heating

In heating costs, savings are gained in the basic fee and energy charges of the heating plant according to the table below.

	Basic fee, FIM/a	Energy charge, FIM/a	Total cost, FIM/a
Reference solution	39.663	139.954	179.617
Innovative solution	23.644	98.985	122.629

The saving			56.988

Electricity

In electricity consumption, savings occur especially in the electricity consumption of the ventilation blowers.

Electricity consumption of HVAC-installations FIM

- Standard solution 35.600
- Experimental solution 25.600
- Total savings FIM/a 10.000

The entire electricity consumption of the building was 220.6 MWh/a in 2000. The consumption consists of the following:

- Lighting 72.9 Mwh/a
- Ventilation 64.1 Mwh/a
- Pumps and other heating-installations 4.7 Mwh/a
- Kitchen 56.4 Mwh/a
- Other consumption 22.5 MWh/a

Savings through innovative solutions in lighting:

- Reference level with standard lighting
- equipment and controls, total consumption 96.8 MWh/a
- Savings through innovative electronic equipment 12.6 MWh/a
- Savings through innovative movement detectors 4.9 MWh/a
- Savings through adjustment of standard lighting 6.4 MWh/a
- Total savings in innovative lighting (24.7%) 23.9 Mwh/a

In Finnish marks:

- Standard solution FIM 31.300
- Innovative solution FIM 23.600
- Savings FIM 7.700/a

Room spaces with innovative lighting controls are not used very intensively on an annual hourly basis. The annual usage time for basic school classroom lighting is 1,000 hours. The payback period of the controls would be reasonable if the rooms were used more intensively.

Savings in water consumption

Savings are gained in water consumption as follows (In Finnish basic schools, the average water consumption is 150 litres / m3.a, varying between 100 and 200 litres / m3.a), when compared to the lower limit of the consumption variation:

The price of water is FIM 14,01/m3

Water charges	FIM
Reference solution	29.400
Innovative solution	27.200
Saving	2.200/a

4.4.8 Portsmouth, GB

Table 4.17.: The energy and water costs of the Portsmouth project incl. VAT.

Costs per unit	GBP	euro
Heating, district heating (£/kWh)	0.0210	0.0338
Heat production, natural gas (£/kWh)	0.008425	0.0136
Electricity (£/kWh) – Landlord import	0.0564	0.0907
Water (£/m³)	0.219	0.349

The costs of district heating are based on fixed charge £6.20 per week per dwelling.

Table 4.18.: Portsmouth (average floor area per dwellings = 53.9 m²)

Yearly operation costs, euro	uses per m²	costs per m²	costs per dwell
Heating, kWh	284.5	9.61	518
Electricity, kWh	33.3	3.02	163
Water, m³	1.63	0.57	31
Maintenance		1.48	80
Total costs EGC project		14.69	792
Total costs norm			1547

In addition to the total costs for the EGC project, Portsmouth City Council is receiving an income from electricity exported to the grid. The charge received for this electricity is less than what is paid for electricity imported from the grid. The income in cost per m2 is approximately 2.29 euro and the income per dwelling is around 123.2 euro per dwelling per annum.

4.4.9 Radstadt, Austria

Table 4.19.: The energy and water costs of the Radstadt project incl. VAT.

Costs per unit	ATS	euro
Heating (kWh)	0.34	0.025
Electricity (kWh)		
Water (m³)		

The energy costs for heating and domestic hot water in the project Radstadt-West are between 2,4 and 2,9 ATS (0,174 and 0,211 ecu) per m² living area. To compare normally the energy costs are about 7 ATS (0,509 ecu).

The operation costs (inclusive energy, calculation, maintenance...) are between 5,2 and 7,5 ATS (0,378 and 0,545 ecu) - normally 10 to 15 ATS (0,727 and 1,090 ecu).

Table 4.20.: Radstadt (average floor area per dwellings = 71.1 m²)

Yearly operation costs, euro	uses per m²	costs per m²	costs per dwell
Heating kWh	84.7	2.09	151
Electricity, kWh			
Water, m³			
Maintenance			139
Total costs EGC project		2.09	290
Total costs norm		6.10	213

4.4.10 Vilanova, Spain

Table 4.21.: The energy and water costs of the Vilanova project incl. VAT.

Costs per unit	ESP	euro
Heating, natural gas (kWh)	6.76	0.0406
Electricity (kWh)	19	0.1141
Water (m³)	109	0.6546

Table 4.22.: Vilanova (average floor area per dwellings = 99 m²)

Yearly operation costs, euro	uses per m²	costs per m²	costs per dwell
Heating, kWh	53	2.2	213
Electricity, kWh	38	4.3	429
Water, m³	0.42	0.3	27
Maintenance			58
Total costs EGC project			727
Total costs norm			801

The maintenance costs is estimated as 2% of extra investment costs for the solar heating system and for the gas boilers.

4.4.11 Volos, Greece

Table 4.23.: The energy and water costs of the Volos project incl. VAT.

Costs per unit	**GRD**	**euro**
Heating, natural gas (kWh)	14	0.041
Electricity (kWh)	35	0.1
Water (m^3)		

Table 4.24.: Volos

Yearly operation costs, euro	**uses per m^2**	**costs per m^2**	**costs per dwell**
Heating, kWh	76.9	3.16	
Electricity, kWh	19.2	1.92	
Water, m^3			
Maintenance			
Total costs EGC project			
Total costs norm			

4.5 Future of the installation

4.5.1 Abruzzo, Italy

The Monitoring systems is actually operating and it provides energy consumption data of the apartments to ATER of L'AQUILA, the public Housing Association that manages part of Regione Abruzzo building property.

The future actions of the ATER of L'AQUILA will be focused on:

- tenants involvement and training, increasing their cosciousness towards the new heating plant operation
- optimisation of technological systems operation, by means of the annual maintenance contract with a specialised company.

The future actions of the Regione Abruzzo will be focused on:

- how to diffuse sustainable building intervention

- how to reach energy saving objectives
- which tools to apply energy saving technologies in building sector.

4.5.2 Brescia, Italy

Some problems concern the solar system of one building block that doesn't work very well. It's foreseen a check of this solar central plant.

The Monitoring systems is actually operating and it provides energy consumption data of the apartments to ALER of BRESCIA but ALER of Brescia is not sure that the heat meters work correctly. Some hot and cold water meters and heat meters register wrong data.

It's foreseen a check of the metering system.

The future intention is to maintain the plant systems operating and to improve the performance and efficiency of the installation in order to reduce electrical consumption and to improve the contribution for the solar systems.

4.5.3 Copenhagen, Denmark

The demonstration projects are completed and the occupants have been living in the dwellings more than one year. The problems are solved and there is no plan for changing the installation in the future.

4.5.4 Grenoble, France

The both solar installations will be monitored during 3 years with "solar result guarantee".

The site will be probably often visited by students and professionals. Some visits are yet scheduled.

4.5.5 Herning, Denmark

The plan is currently to optimise the various installations, to gain the most of the money invested.

4.5.6 Hulshout, Belgium

Problems with the low solar collector efficiency of building block will be solved in March 2001 by installer and producer of the solar collector system. Problems with the air tightness of the air ducts will be solved in 2001.

In 2001 the installation will be closely monitored by the research institute Vito. Because of management problems at the University of Leuven (KUL) part of the expected measurements can not take place (inside environment, efficiency of the mechanical ventilation with heat recovery, …).

Interested people can visit the project.

4.5.7 Kuopio, Finland

The technology in the school building is functioning well. The quality of air is excellent, classrooms are quiet with no drafts in the indoor air, and lighting is on when it is needed. Information is gained continuously on the status of the technical equipment of the building and what is more, situational changes in the rooms are flexible and easily made. There will be no need to change the selected equipment or the processes at least during the next few years. In the overall functioning of the plant, the programmes in the master PC have been updated during the one year guarantee period. Due to the active product development of the manufacturer, the control equipment will probably be the first to be changed. The operating life of the mechanical ventilation system machines of the building is at least 35-40 years. The operating lifetime of the building automation system is 20 years, that of the heating equipment network 50 years and of the exchangers about 25 years.

When considering the viability of the innovative solutions, the main factor is the mechanical ventilation according to need. As equipment manufacturers increase in number, unit costs will go down and payback periods will diminish to under ten years. Adjusted power currents will be weaker and the design efficiencies of heating plants will be lower, all of which will definitely lower the environmental load.

The use of data transfer networks will also become more common and has already done so to some extent during this project. The use of solar walls will probably be examined in some projects.

4.5.8 Portsmouth, GB

The main priority is obviously to get all the works completed.

Once the BEMS has been commissioned it is the intention to continue with the utility monitoring via this system.

It is to be considered to connect the CHP electricity generation to meet part of the Landlord Electricity Supply at Solihull House.

It is to be considered to replace the existing DHW system in Solihull House, which is by immersion heaters with hot water from the boiler house. This will enable the CHP to run its 17hrs a day during summer, at present there is not enough heat load during summer by supplying Leamington House only.

4.5.9 Radstadt, Austria

The construction is finished.

The monitoring runs since 1999 and shall be done at least three years. The gswb will do it five years for learning themselves.

The future of the installation will depend on the maintenance. The construction is partly concrete and bricks (the two leaf brick walls have a very long living time because the insulation is between) that will have a long living time with low maintenance necessary. The wooden facade-elements have to be painted. The maintenance of the house and all technical parts will be done from the gswb, who have a lot of experience. The construction is calculated for a life time of at least 70 years.

The solar collectors have a life time of 20 to 30 years.

4.5.10 Vilanova, Spain

The future prevision of the installation depends deeply on the maintenance of the building’s systems.

- The bioclimatic elements do not have life expectancy because the elements used are construction materials like bricks and windows. Therefore these parts will last as long as the building itself.
- The solar hot water equipment durability depends very much on its maintenance. Within a good periodical maintenance, it is expected to last about 20 years.

4.5.11 Volos, Greece

The bioclimatic elements introduced in both buildings do not have life expedancy because the elements used are construction materials.

The solar hot water equipment depends very much on its maintenance. Is expected to last about 20 years.

4.6 Economic Viability

The economic viability of the EGC projects is calculated by the Simple Payback Time method. For each project the total costs of the installation, excluding the costs associated with the demonstration, i.e. design, monitoring, and a part of the management and engineering costs is given. The yearly savings include annual amount of energy produced or saved. The annual maintenance costs is the difference between the maintenance costs of the extra energy savings technologies and that of a conventional installation.

4.6.1 Abruzzo, Italy

Calculations per dwellings (Euro per dwellings).

Total investment	16,481
Yearly savings	-19
Maintenance	124
The simple pay-back time	no sense

4.6.2 Brescia, Italy

Calculations per dwellings (Euro per dwellings).

Total investment, euro	11,850
Yearly savings, Euro/year	32
Maintenance	-225
The simple pay-back time	46 years

As shown in the above table, it seems that the project didn't demonstrate economic viability: the reason of this result is previous reported (see performance of the energy systems, operation costs, success of the project). The lessons learned are reported in the follow.

4.6.3 Copenhagen, Denmark

The economic data for the three projects in Copenhagen is given in the following table. The data are average values per dwellings. The total investment include total costs of the extra energy savings technologies, excluding the costs associated with the demonstration i.e. design, monitoring, and a part of the management and engineering costs. A yearly saving is based on monitored values of the operation costs se part 4.4. The maintenance costs is calculated as 2% of the investment costs, se also part 3.6.

Tøndergade 3-3A

Calculations per dwellings (Euro per dwellings).

Total investment	4,674 euro
Yearly savings	45 euro
Maintenance	47 euro
The simple pay-back time	no sense

Tøndergade/Sundevedsgade

Total investment	11,151
Yearly savings	-10
Maintenance	112
The simple pay-back time	no sense

Sundevedsgade 26-28

Total investment	15,185
Yearly savings	211
Maintenance	152
The simple pay-back time	no sense

4.6.4 Grenoble, France

The expected “direct pay back time” for the all project is not very good : it is estimated 20 years. The most important reason is the energy low price : the district heating prices are low. But the aim was to decrease the maintenance costs to reach an affordable maintenance cost level for the tenants. The total maintenance cost fall is about 80 euros per dwelling per year. It will contribute, with comfort improvement, to avoid tenants rotations and vacancies, and consequently, to avoid some costs.

The economic data per dwellings in Grenoble are given in the following table.

Calculations per dwellings (Euro per dwellings).

Total investment	3650 euro
Yearly savings	66.6 euro
Maintenance	37 euro
The simple pay-back time	no sense

The yearly saving are include the electricity from the PV cells and the lower heating demand from 135 kWh/m² to 115 kWh/m².

4.6.5 Herning, Denmark

The economic data for the project in Herning is given in the following table.

Calculations per dwellings (Euro per dwellings).

Total investment	9,716
Yearly savings	-69
Maintenance	97
The simple pay-back time	no sense

Once the installations has been adjusted and subsequently monitored over 1-2 years, it is possible to evaluate each single investment by itself. However we do at present have a supposition as to the outcome, where each small project has its own economy and various payback times.

The expectations were as follows:

	Payback time	Cost price	Savings/year
Collecting water from roof to toilet-flush	18 years	10.350	670
Solar Collector on roof	12 years	29.300	4.020
Ventilation system and solar wall	14 years	30.000	2.016

Low-flush toilets	0	2.000	0

4.6.6 Hulshout, Belgium

In order to evaluate the project on an economic basis, the investment cost are compared to the yearly energy savings and the extra maintenance cost of the project. In this project the total investment cost without solar collectors was EURO 215,785. The yearly energy saving is EURO 21,427. The extra maintenance cost is estimated to be 1% of the extra investment cost. The pay back time of the project (without solar collectors) is thus 11 years.

Calculations per dwellings (Euro per dwellings).

Total investment (without solar collectors), Euro	9,382
Yearly savings (wthout solar collectors), Euro/year	861
Maintenance (without solar collectors), Euro/year	94
The simple pay-back time (year	12.2 years

4.6.7 Kuopio, Finland

The basic concept in economic viability is the relationship between acquisition costs and saved costs, that is the payback period of the investment. During the project, the viability of the innnovative solutions regarding to the payback time were studied.

The following table describes the payback time of the innovative costs for the entire project.

Total investment	768,470 euro
Yearly savings	9378 euro
Maintenance	7494 euro
The simple pay-back time	no sense

When excluding the Thermie and national support, 2.400.000 FIM, the pay-back time is 27,5 years.

One reason to the long pay-back time is the small financial saving in energy consumption, which is due to the cheap prices of heating and electricity in Kuopio.

4.6.8 Portsmouth, GB

The economic data for the project in Portsmouth is given in the following table.

Calculations per dwellings (Euro per dwellings).

Total investment	8,030 euro
Yearly savings (the saving allows for an estimated saving of 5,070 euro due to domestic electricity saving).	805 euro
Maintenance	80 euro
The simple pay-back time	11.1 years

The total investment is the total cost of direct and indirect energy saving measures such as, Building Energy Management System, Combined Heat and Power, Solar collectors, Windows, Pitched Roof, Heat recovery, District heating works, Water savings, Lighting improvements and Extract ventilation fans. The cost does not allow for any contribution from THERMIE or any national grants received.

Not allowing for the investment in measures not complete and therefore not contributing to the saving would reduce the payback to 38.5 years.

4.6.9 Radstadt, Austria

In the economic and ecological study was done by Dr. Manfred Bruck and Dr. Harald Koch from Vienna in co-operation with the Architect Hanns Peter Köck. In this study they wanted to check which material and which technical equipment have an economic and ecological effect. The goals were:

- good quality standard and living comfort (observance all laws)
- limited costs for social dwellings
- minimise the disposition of environment

Therefor 10 different variants of construction and heating systems have been analysed relating to their ecological effects.

In the **economic part** the total lifecircle-costs of the project (raw material, construction, maintenance and demolition) have been calculated in two scenarios:

Scenario one: prices for energy will rise like all other costs

Scenario two: Prices for energy will rise higher than all other costs.

According to the results of this study it was possible to find the best combination of construction, material and heating system. By that combination it is possible to preserve the environment and to promote renewable sources of energy without a reduction of the users living comfort and keeping the rates low.

The committee decided the **construction and material** based upon this study to have low lifecircle-costs.

The payback time for the solar-panels shall be between 12 and 14 years.

4.6.10 Vilanova, Spain

- Since there is no extra cost for the construction, the bioclimatic installation does not have any pay back time
- The expected payback time of the solar hot water installation is between 8 and 10 years.

4.6.11 Volos, Greece

Total investment	1.024.982 euro
Yearly savings	50148 euro
maintenance	
The simple pay-back time	20,4 years

The above refers to the whole project

4.7 Environmental Impact

4.7.1 Abruzzo, Italy

Environmental improvements per year for the whole project of

	savings, %	Total savings	CO2 reduction
Heat		-159,660 kWh	+ 30,28 ton
Electricity	80%	34000 kWh	21.43 ton

1 TOE = 11600 kWh termici = 3490 kWh elettrici

1 TOE di metano = 2,2 ton di CO2

4.7.2 Brescia, Italy

Environmental improvements per year for the whole project of Brescia.

	savings, %	Total savings	CO2 reduction
Heat	15.4%	73,144 kWh	13.9 ton
Water	38.6%	145288 kWh	27.6 ton

4.7.3 Copenhagen, Denmark

Table 4.25.: Environmental improvements per year for the whole project of Copenhagen.

	savings, %	Total savings	CO2 reduction
Heat	18%	92000 kWh	11 ton

The CO2 calculation is based on 119 kg CO2 per MWh heat and 650 kg CO2 per MWh electricity.

The total reduction in the CO2 emission from heating and lighting is 11 ton for all 61 dwellings in the Copenhagen project.

4.7.4 Grenoble, France

The aim is to reduce the greenhouse effect gases emission.

The district heating system energy sources are:

– 25 % wastes
– 5 % wood
– about 70 % coke, fuel.

The average of greenhouse effect gases emission are :

Heating source (monitored)	District heating supplier: Compagnie de Chauffage
CO2 emission	286,329 kg/MWh
SO2 emission	7,25 kg/MWh
NOx emission	4,57 kg/MWh

So, the reduction which are aimed with the DHW solar panels are shown in the table below:

Greenhouse effect gases emission reduction	
CO2 emission reduction (July 1999 – June 2000)	128 016 Kg/year
SO2 emission reduction (July 1999 – June 2000)	471 Kg/year
NOx emission reduction (July 1999 – June 2000)	302 Kg/year

4.7.5 Herning, Denmark

Environmental improvements per year for the whole project of Herning is 23.3 ton CO2 per year.

4.7.6 Hulshout, Belgium

Because of the fact that lots of energy saving technologies are used in this project emissions of CO_2, SO_2, NO_x, soot, … are reduced. Super insulation of roofs, walls, floors and windows leads towards a low energy demand for heating. Mechanical ventilation with heat recovery reduces the ventilation losses. The remaining heat demand is covered by energy efficient boilers with condensation of flue gasses. Solar collectors are installed for hot sanitary water production. The primary energy demand for hot sanitary water production is of course reduced especially in summer, spring and autumn.

In order to keep tenants informed about their energy consumption, an energy management system is installed. This motivates individual users to reduce energy consumption. In order to save electricity the blocks are designed in order to use as much as possible daylight. Compact fluorescent lamps, high efficient pumps, fans with low energy use are used in the blocks. Tenants are informed about and stimulated to buy energy efficient equipment (cooking apparatus, washing machine, drying machine, ….).

Water conserving toilets and shower heads, recycling of rain water, separation of rain water and waste water are measures to save water consumption in the building blocks.

	savings, %	Total savings	CO2 reduction
Heat	73%	304,757kWh	60.3ton
Electricity	10%	8,050kWh	5.0ton
Water	30%	665m³	

4.7.7 Kuopio, Finland

The City of Kuopio has made the report of the greenhouse gas emissions and the balance of the carbondioxide and energy covering the whole city. The report was made first time in 1997, and the statistics has been checked in the year 1999. The city wanted to examine the impacts to the environment from the power plant that includes the communal heating and produce of electricity, traffic, industry, waste handling and other sources.

Table 4.26.: Environmental improvements per year for the whole project of Pirtti School

	savings, %	Total savings	CO2 reduction
Heat	32%	276,244 kWh	105 ton
Electricity	25%	73,500 kWh	28 ton
Water	25%	653 m³	

The total CO_2 reduction of the Pirtti School is 133 ton compared with conventional solutions.

4.7.8 Portsmouth, GB

The environmental impact for tenants is improvements to comfort levels resulting in improved internal environment and health benefits to occupants. The improvements are achieved whilst also seeing a reduction in heating and DHW costs.

Table 4.27.: Environmental improvements per year for the whole project of Portsmouth

	savings, %	Total savings	CO2 reduction
Heat/gas	-4.45	-269,726	-60.7 tonnes
Electricity	68.4	179,427	198.4 tonnes
Water	49.9	11,887 m^3	n/a

There is an increase in CO_2 emissions for heat production because there is an increase in gas consumption due to a CHP plant consuming more gas than an equivalent sized conventional boiler. However, the CHP has the added benefit of generating electricity so that overall the CO_2 emission saving is greater than when using a conventional CH heating system.

The CO_2 emission saving in the above table is due to the total on site electricity generation i.e. allowing for both on site electricity use and electricity exported to the grid. Electricity exported to the grid accounts for 96.1 tonnes per annum.

In addition there is a saving of at least 84.5 tonnes of CO_2 emitted per annum due to the saving in domestic electricity.

The total CO_2 emission saving for the Portsmouth project is therefore around 221.5 tonnes per annum.

4.7.9 Radstadt, Austria

In the **ecological analysis** in the study the environmental effects of the different variants have been investigated.

- the use of primary energy
- the contribution to the global warming potential
- the sour of ground

Ecological dates of the construction:

BUILDING:	*primary energy*	*PE* ______	*14063,0*	*kWh*
	Global warming potential	GWP _______	2788,0	kg CO²
	Acidification potential	AP _________	21,0	kg SO²
ELECTRICITY (20 years) = 128000 kWh		*PE* _____	*409984,0*	*kWh*
		GWP ______	85248,0	kg CO²
		AP ________	***115,3***	***kg SO²***
TOTAL (20 YEARS)		***PE*** _____	***424047,0***	*kWh*
		GWP ______	**88036,0**	kg CO²

Ecological savings:

IEAT IN 20 YEARS _________________________________2 263 900 kWh

Ecological amortisation of the controlled air-ventilation:

If you substitute gas:

PE	2557015,0	kWh	**0,13 years**
GWP	535722,0	kg CO²	**0,12**
AP	438,5	kg SO²	**1,30**

If you substitute wood (district heat):

PE	3438109,0	kWh	**0,09**
GWP	119474,0	kg CO²	**1,60**
AP	2244,0	kg SO²	**0,20**

If you substitute Oil (extra light):

PE	2844968,0	kWh	**0,11**

GWP	760449,0 kg CO^2	**0,08**
AP	1571,0 kg SO^2	**0,29**

4.7.10 Vilanova, Spain

Table 4.28.: Environmental improvements per year for the whole project of Vilanova (predicted values).

	savings, %	Total savings	CO2 reduction
Heat		285,480 kWh	103 ton
Electricity (cooling)		172,800 kWh	63 ton

The total energy saving expected for this building is 458.280kWh/year, which will cause a reduction of CO2 emissions of about 165.897kg/year. The energy saving expected that corresponds to heating is 211.200kWh/year, which avoids the emission of 76.454kgCO2/year. For cooling the quantities are of 172.800kWh/year saved, and 62.553kgCO2/year reduced, and for domestic heat water the energy saving is 74.280kWh/year and a reduction of emissions of 26.889kgCO2/year.

4.7.11 Volos, Greece

Table 4.29.: Environmental improvements per year for the whole project of Volos.

	savings, %	Total savings	CO2 reduction
Heat + Electricity	40%	529975kWh	191.213 kg/year