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D19
8 reports on the realisation and validation analysis of the demonstration buildings in BRITA in PuBs

Chapter demonstration building Evonymos

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PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

D19
8 Reports on the realisation and validation analysis of the demonstration buildings in BRITA in PuBs

Chapter demonstration building Evonymos

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Disclaimer:

Bringing Retrofit Innovation to Application in Public Buildings – BRITA in PuBs has received funding from the EU 6th Framework Programme under the contract:
TREN/04/FP6EN/S07.31038/503135

8. Evonymos Ecological Library, Athens

Authors: Moissis Kourouzidis; Euphrosyne Triantis; Louizos Elias

8.1. General data

8.1.1. General information

Year of construction: 1890
Year of renovation (start): (i) 1955, (ii) 2006
Number of storeys: Three storeys plus one mezzanine

Heated volume (m^3): 3.780
Cubic contents volume (m^3): 3.180
Gross area (m^2): 1.000
Living area (m^2): 860
Total floor area (m^2): 1.000
S/V ratio: 0.55
Window/glass areas (m^2): 1.1

8.1.2. Site

Location
The building is located close to the central archaeological spaces in Athens, which are being united and enhanced by pedestrian roads. This location is ideal for dissemination purposes as the whole area is very popular and widely frequented by Athens citizens and visitors throughout the year.

Location

Geographic position

Latitude:	37° 58’
Longitude:	-23.43’
Altitude:	50 m.

Climate Conditions

Total Annual Sunshine hours	2818
Annual Heating Degree Days (18 °C)	1110
Temperature	
Winter Average	11.6
Winter av. min	7.6
Summer Average	25.1
Summer Av. max	29.7

8.1.3. Building type

It is a listed building of the 1890 ‘s used as a public library.

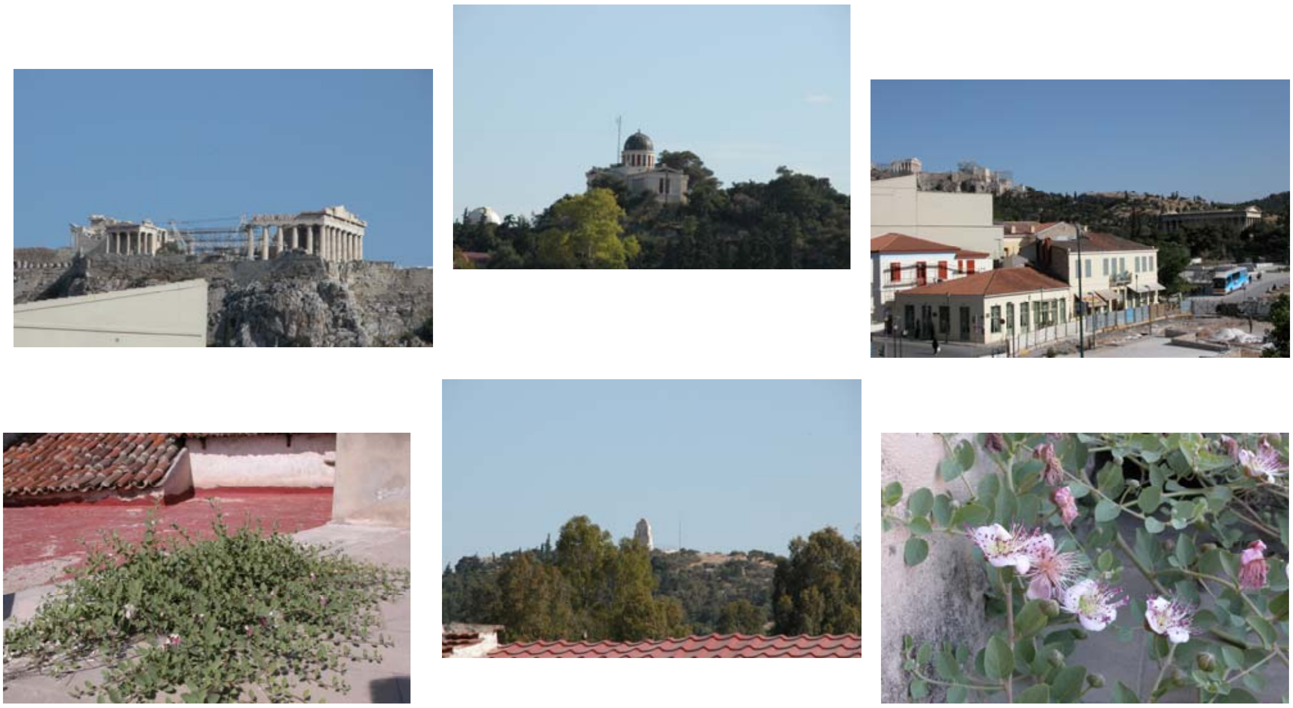
8.2. Before retrofit

8.2.1. Building construction

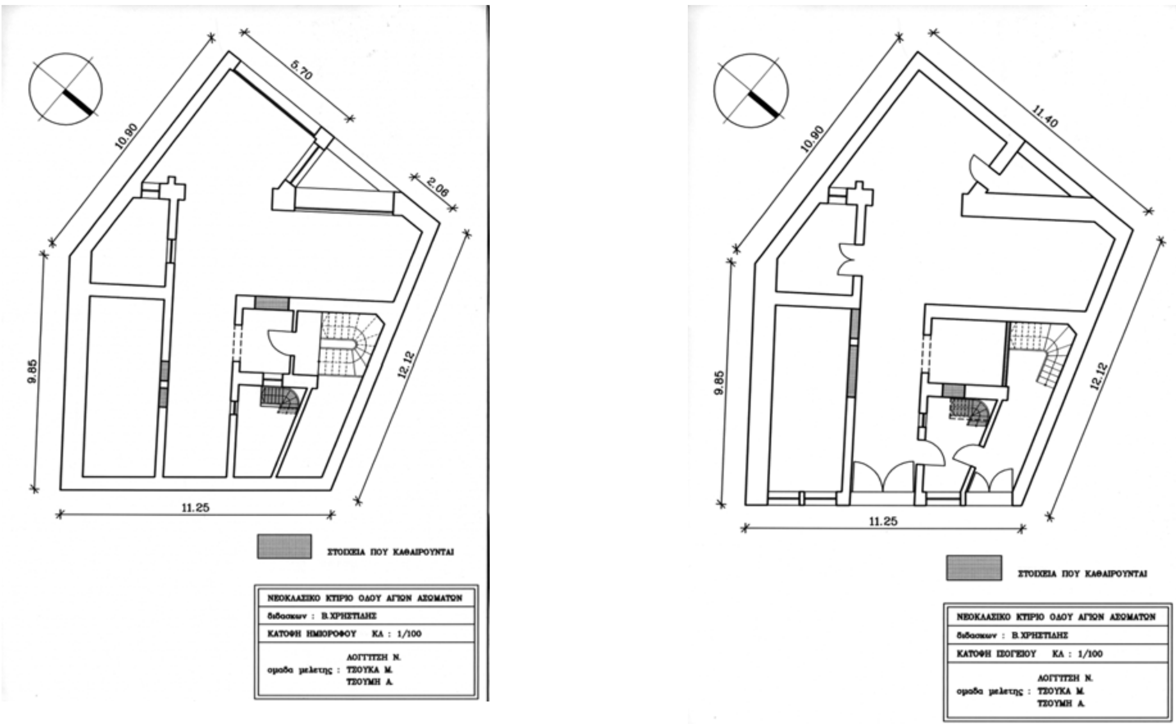
The building construction is characteristic of its era. It has 60 cm thick stone walls, and single pane 3,5 m high windows and balcony doors. At present there is no insulation on walls and roofs and there are serious humidity problems in the building. Currently it extends on three floors, a basement, and terrace. The ground floor housed commercial activities while the 1st floor originally a residence, is now used as a library.
The building has a total floor area of 910 m^2, to which two covered terraces will be added, bringing the total usable surface to 1000 m^2 approximately. Another serious problem is the building facade whites is gravely deteriorated and is in urgent need of renovation.

The building interior

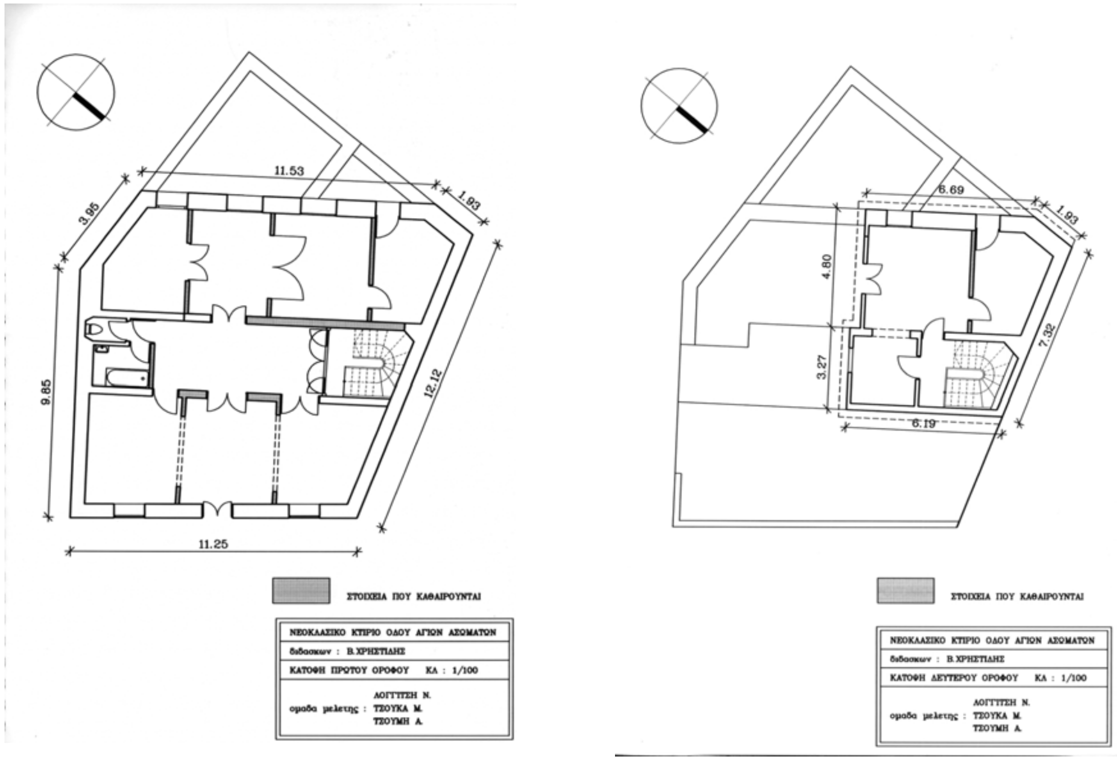
Characteristic details of the building



Main views from the building terrace



Existing plans of the building



Existing plans of the building

8.2.2. Existing heating, ventilation, cooling, lighting systems

Initially the building was heated locally with portable small stoves burning liquid gas. In order to reduce heating expenses, both in equipment and fuel, the stoves served only the places continuously occupied. The remaining building was quite cold, which gave rise to cold drafts and unpleasant cold zones that the users were exposed to when circulating to non-heated areas. Furthermore, the temperature regime was strongly fluctuating with room door opening. During very cold days the capacity of the stoves was not sufficient to keep the internal temperature within comfort levels. Overall the space had strong thermal asymmetries and quite often was under-heated.

Window opening provided ventilation, for both hygienic and cooling purposes. Although this may be in principle a sufficient mechanism for a high percentage of the building operating time, the cold drafts in winter and the street noise especially in summer, gave rise to uncomfortable conditions. Furthermore, the speed of the incoming air that often exceeded the comfort level and the lack of effective mechanisms to control it, gave rise to annoying conditions for the users. These problems resulted in reducing the potential of ventilation to provide cooling. Properly designed ventilation openings were needed in order to remove the warm air without causing any annoyance at the working level.
In summer, because the building remained closed during nighttime, for safety reasons, the heat absorbed by the high thermal mass during the day was not dissipated to the outside but remained in the building elements causing overheating. Thus night ventilation is very beneficial for cooling off the building mass.

Cooling was provided by portable and ceiling fans. This cooling type was quite sufficient for the limited activities and space in use.

Lighting was provided by fluorescent lamps as background lighting enhanced with task lights. The space housing the bookstands and the reading facilities was satisfactorily daylit. However, special daylight design was needed for the circulation space, and the new uses to be housed in the first floor and the mezzanine.

8.2.3. Energy and water use

The energy and water consumption tabulated in Table 1.2.3.1. is estimated based on national consumption levels. The actual consumption is reported in Table 1.2.3.2 but relates to the original limited use of the library. As mentioned in 1.2.2 above, the energy consumed did not suffice to provide comfort conditions to the library resulting in underheated spaces in winter and overheated ones in summer.

	Estimated year (2003)	Total for the whole building
Space heating	112 kWh/m^2 a	112000 kWh/a
DHW	3.2 kWh/m^2 a (included in electricity consumption)	3200 kWh/a
Electricity	140 kWh/m^2a	140000 kWh/a
Water	1.1 m^3/m^2a	1100 m^3/a

The above tabulated values are estimated based on typical consumption levels for offices and raised by 40% to account for longer working hours and different needs of certain uses for this building (such as material recycling labs, coffee shop etc.). Correspondingly the water consumption has been increased by 7%.

	Measured year (2003)	Total for the whole building
Space heating	82 kWh/m^2 a	14350 kWh/a
DHW	0 kWh/m^2 a	0 kWh/a
Electricity	3.1 kWh/m^2a	435 kWh/a
Water	0.8 m^3/m^2a	60 m^3/a

Measured data do not refer to the post retrofit situation of 1,000 m^2 but to the heated space of the original building (170 m^2 for heating and 140 m^2 for electricity) as above mentioned.

8.3. User satisfaction before retrofit

Due to the fact that there was no heating system for the whole building, and temperature differed at various zones depending on local heating sources, internal temperature was not homogeneous and many drafts were created between different spaces which were very disturbing for users, especially in the winter. In the summer, on the contrary, the building was overheated since it could not be sufficiently ventilated, even during the night, for security reasons.
The situation described above created many complaints reported by library users and personnel during questionnaires used before retrofitting started.

8.4. Energy saving concepts

The purpose of the project was to renovate the building and turn it into an ecological library devoted to demonstration, education, and dissemination of low energy and environment friendly technologies in building construction and renovation. This includes traditional and modern techniques of energy and water conservation, ecological building materials, renewable energy systems, and recycling of water, paper etc.

Besides the main function of the library, which includes open shelf reading spaces, new spaces are formed, including conference and seminar rooms as well as workshops on paper recycling, book making and photography, an electronic library and an internet cafe where information on ecological subjects can be obtained. A special open monitoring space is also created, where energy conservation technologies used in the building are demonstrated to the public.

The whole building is completely renovated in the interior. Key feature of the renovation is the addition of new useful spaces, that is:

a) a mezzanine between the ground and 1st floor, in order to take advantage of the double

height of the ground floor (nearly 6 m)
b) the conversion of an existing veranda on the first floor in to an open reading area,
c) the conversion of the terrace in to a sitting area. The outdoor spaces are designed to ensure high quality thermal and visual comfort for the users in all seasons.

All internal spaces are reformed and new spaces added to house diverse activities of the library such as laboratories of photography, CD and DVD production, book binding etc. Moreover an auditorium with a capacity of 80 people is created on the mezzanine, whilst the book stands and reading areas are located on the mezzanine and first floor.

First priority in the renovation curriculum is the minimisation of energy needs with the use of energy efficiency measures and integration of solar technology ensuring simultaneously thermal and visual comfort conditions both indoors and outdoors. Key feature of the renovation design is to accommodate energy efficiency and RES systems and techniques in an integrated design without altering the facades of the building. The energy refurbishment design follows the norms and restrictions foreseen by the General Building Code for listed buildings of this type.

8.4.1. Building construction

- Energy conservation:
- External insulation of walls and roofs
  (4 cm insulation thickness - all external architectural protrusions and balconies were dismounted for the placement of the insulation and then put back).
- Air tight low–e double glazing and night insulation
- Reduction of infiltration with window stripping and tight window frames
- Shading varying according to the orientation of openings
- Shading of the South and Southwest façades with wooden pergolas supporting PV modules
- Ecologically treated wood
- Insulation made of natural plant substances

	Pre-retrofit U-value [W/m^{2}K]	Post retrofit U-value [W/m^{2}K]
Walls	3,4	0,14
Roof	1,4	0,15
Windows	5,7	1,1
Doors	5,7	1,1

8.4.2. Heating

- **Renewable energy integration:**
  - Integration of two sunspaces on the verandas/terraces with openable vertical glazing to eliminate any increase of building cooling load.
  - Solar collectors for DHW (hybrid PV / thermal system for top floor and solar panels for the two lower floors).
- **Efficient energy supply**: Heating energy is supplied by a triple energy burner. The size of the water boiler is 82 kW and it will be shortly connected to the natural gas city network, which is currently renewed. A four-way distributor is used at the boiler outlet to significantly lower the water temperature to the level needed by fan coil units (~ 45-50°C).

8.4.3. Ventilation

- Hybrid efficient ventilation: ceiling fans and earth pipes.
- A centrifugal fan assists natural ventilation. It is installed at the top of the main stairs of the building to reject used air. Additional fans are used to regulate ventilation at each building level.

8.4.4. Cooling

Natural cooling

- Innovative solar chimney / light duct elements,
- Night hybrid ventilation for the warm months

Mechanical cooling

Auxiliary cooling unit. An auxiliary portable cooling unit of 1,5 KW is installed to assist natural cooling in extremely hot days. The unit mostly operates on off-peak low electricity tariffs.

Fan Coil Units (FCU) for the areas of the library. They are mostly placed on the floor of the rooms due to the big clear height (5m) of each space and most importantly of the wall frescoes. Each FCU contains two thermostats, one for air and one for water temperatures. It also carries a humidifier (water spray) downstream the heating-cooling element.

8.4.5. Lighting systems

Daylighting

- Light shelves to enhance daylighting in reading areas
- Light duct (as part of the ventilation chimney)
-

Artificial Lighting

General lighting in the library areas is provided by PL and T5 type eco-fluorescent light fixtures, which exhibit very low electricity consumption.
In areas close to openings the fixtures contain ecological electronic dimmable ballasts (High Frequency Regulated – HFR) and carry light sensors, so each fixture will adjust light output according to the incident light, using as criterion the maintenance of a preset light level on the working surface below it.
In special reading areas local user-operated table lights are used.

8.4.6. BEMS

An intranet with PCs is used for education and information purposes in order to present to students and visitors of the library the energy conservation and environmental systems used in the building and their operation.
Most of the systems installed in the building are controlled by a Building Management system (BMS). The BMS serves 3 distinct purposes:

- Control HVAC, lighting, passive cooling, RES and other systems installed in the building, optimizing their performance
- Collect system operation and energy consumption/production data for analysis and evaluation
- Demonstrate the usefulness of the system itself, as well as the entire energy conscious design of the building.

The BMS system receives input and/or controls the following:

System	Measurements & controls
Weather station	Temperature, solar radiation, humidity, lighting level, wind
PV	Recorders, display
Boiler	Thermostats / valves, time
FCU	Temperature, Time, humidification
Fans / Openings	CO_2 sensors, fans, openings, ambient conditions, Time
Lighting	Local dimmer sensors, occupancy sensors, Time
Sunspace	Openings, shading, ambient conditions
Glazing night thermal protection	Rollers (electric motors)
Fire protection and burglar alarm	Fire sensors, occupancy sensors alarms
-	Energy analysis

It is connected via LAN (Ethernet) to the computer system in the library and used for demonstration and teaching purposes.
The sections to follow, defines the details of operation for the BMS.

8.5. Predicted energy savings

Energy saving measures, heating, cooling, ventilation	[kWh/m^{2}a]	Total [kWh/a]
Heating	150	150.000
Ventilation	23	2.300
Solar hybrid cooling	22	2.200
Total heating energy savings	195	195.000

Energy saving measures, electricity	[kWh/m^{2}a]	Total [kWh/a]
Electrical lighting	2.5	2.500
BMS	1,0	1.000
Photovoltaic	0,7	700
Total Electricity energy savings	4,2	4.200

Water saving measures	[m^3/m^{2}a]	Total [kWh/a]
	0,17	175
Total heating energy savings		

8.5.1. Real costs and payback

Energy saving measure/investment	Area [m²]	Total costs [EUR]	Saving [EUR/a]	Pay-back periods [a]
Solar DHW	2,5	2.100	1.078	2 years
P.V. panels	22,24	16.120	673	23 years
Ventilation		6.500	1.186	5.5 years
Electrical lighting		22.500	2.750	8 years
BMS		30.000	1.370	21 years
Window replacement	45	12.500	836	15 years
Total		**89.720**	**7.893**	

8.6. Construction phase description

8.6.1. Building construction

A short description of work done during construction phase follows
The construction procedure described is based on weekly diaries forwarded via the coordinator to the Commission during construction.

	Work
1.	Reconstruction of the building shell
	Grindblasting scraping and cleaning of external surface of the building (including scrolls, marble parts and metallic surfaces
	Dismantling and removing major parts of the roof on the 1st and 2nd floors
	Scraping and removing veranda flooring (1st and 2nd floors)
	Scraping and removing points on railings shutters external metallic and wooden windows and doors
	External insulation and replastering of walls of bats the main and secondary facades
	Reconstruction and insulation of roof (1st, 2nd floors)
2	Reconstruction of windows (scraping, installation of low-e double glassing, tight dealing and repainting
3	Remodeling of the interior Construction of verandas as extension of reading rooms (1st and 2nd floors)
4	Integration of shading, daylighting

	and natural ventilation systems	
5	Integration of renewables (P.V. cells and solar collectors	
6	Installation of electrical and mechanical systems, including BEMS	

8.6.2. Heating

As described in 8.4.2.

8.6.3. Ventilation

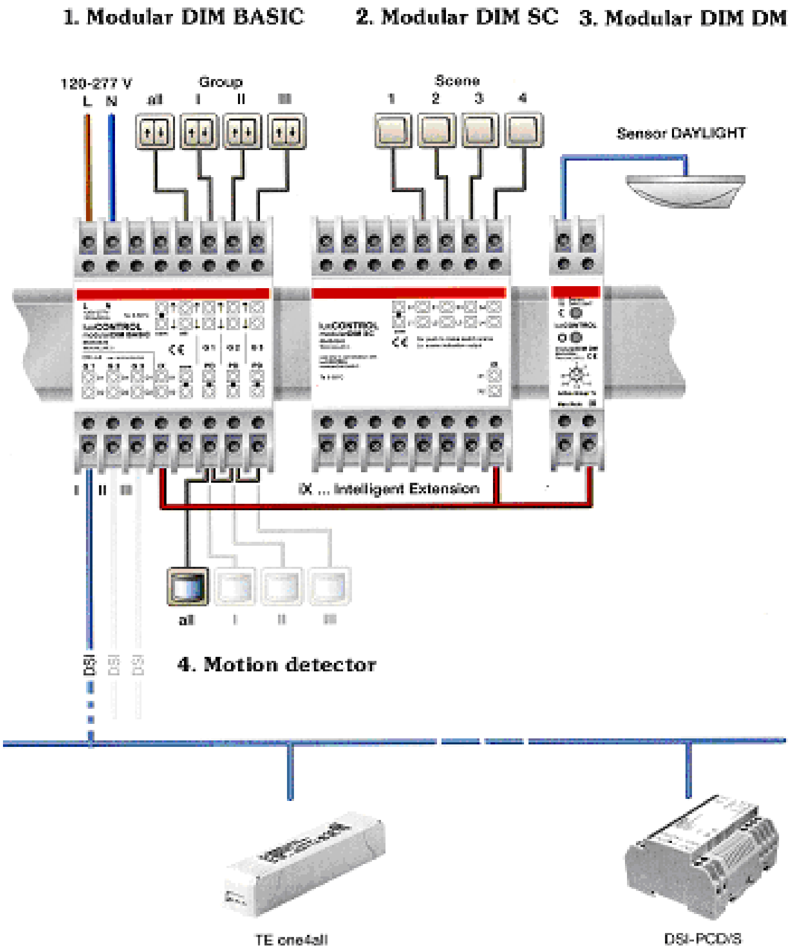
As described in 8.4.3.

8.6.4. Cooling

As described in 8.4.4.

8.6.5. Lighting systems

Lighting systems in the library reading spaces (1st floor) are portable, as there should be no interference with original listed ceiling paintings (see illustration).



Lighting quality and comfort as well as adaptability to a variety of functions and user requirements in addition to energy conservation considerations has led as to the choice of a digital lighting management system by Tridonic.Atco using a DALI protocol (Digital Addressable Lighting Interface) based on a user – friendly PC operation and programming. The description of the system as installed on different levels of the building follows.

8.6.6. Daylight Management System

1. Modular DIM BASIC
   Basic module for manual dimming and switching of 3 self contained DSI groups (all, I,II,III)
   Motion detector inputs for switching each group

2. Modular DIM Scene Control
   Expansion module for Scene Control
   4 light scenes programmed and recalled

3. Modular DIM manual dimming and switching

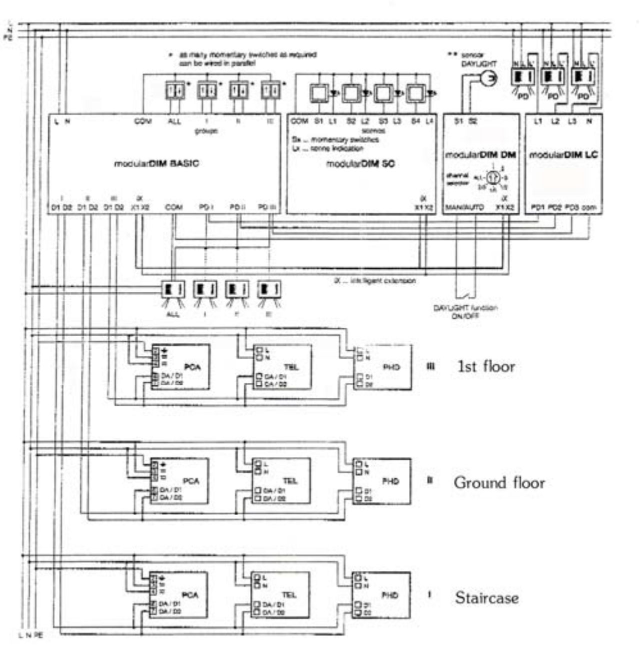
3.1 Expansion module for daylight control

8.6.6.1 DSI Technology

The daylight DSI signal is used for communication between DSI control module and digital dimmable DSI control devices.

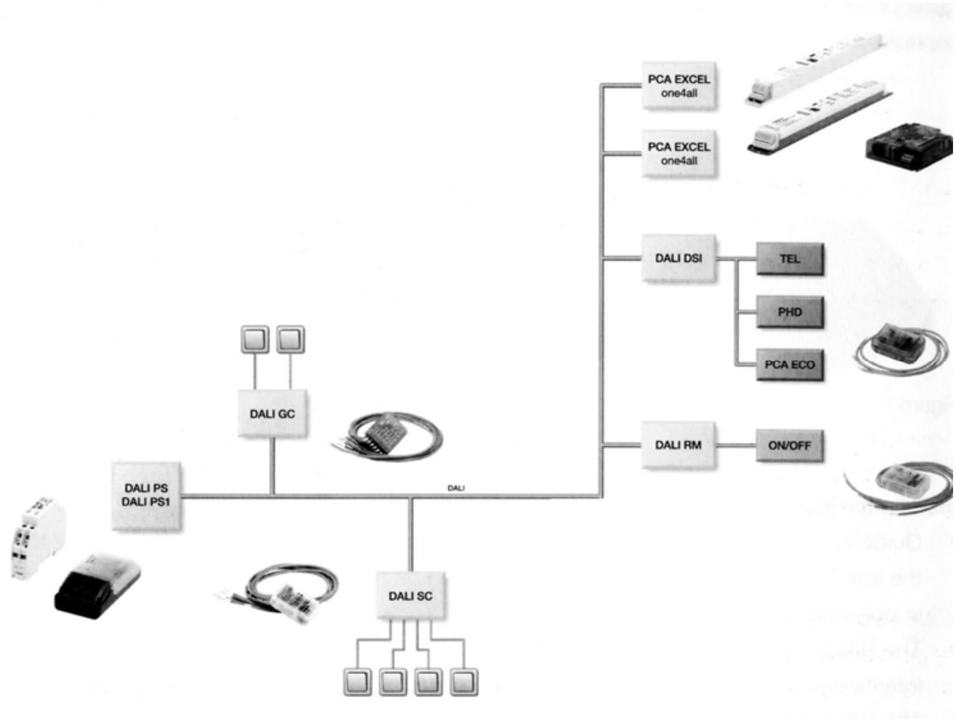
To enable several operating points switches are commented in parallel.
The DSI signal is transmitted by a functional low voltage from modular DIM Basic to electronic ballast.

8.6.6.2 Electric diagram of library (1st floor) and connections of digital devices



8.6.6.3 Management of 2nd floor lighting

An autonomous versalite management system allowing users to choose from all PC stations and positions and from simple wall switches to fully integrated digital building management system (BMS). It is the best solution for a dimmable light control system for the 2nd floor multi-purpose rooms which comprise multi-level luminal groups, requires several lighting scenes and have to mix different types of luminaries.
An operation diagram and port description of the system follows.



1. DALI parts description for 2nd floor Lighting System
Dimmable DALI electronic ballast
Power supply DALI PSI
DALI control system
TridonicATCO DALI GC
Functional description

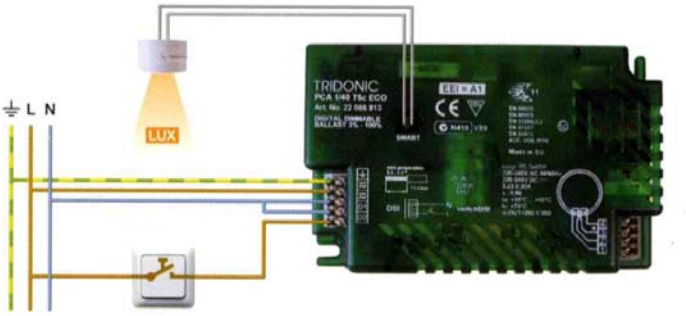
Ultra compact control module for dimming and switching of 2 DALI groups

DALI SCI PC1

The interface module DALI SCI is used to connect PC with WInDim S/W directly to the DALI network

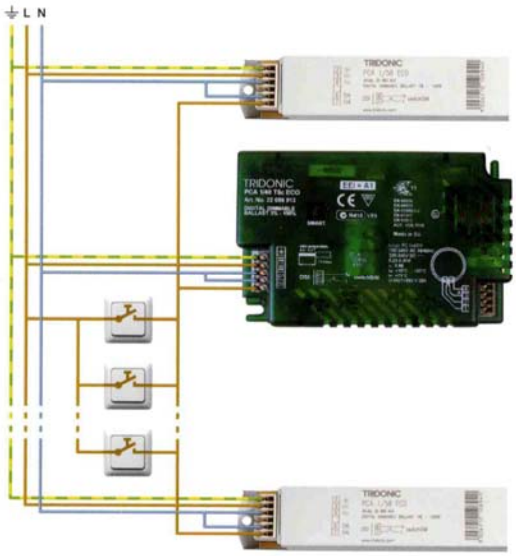
*DALI SC
Ulyta compact control module to set and recall light-scenes from DALI Ballasts with conventional momentary switches

Dimming system

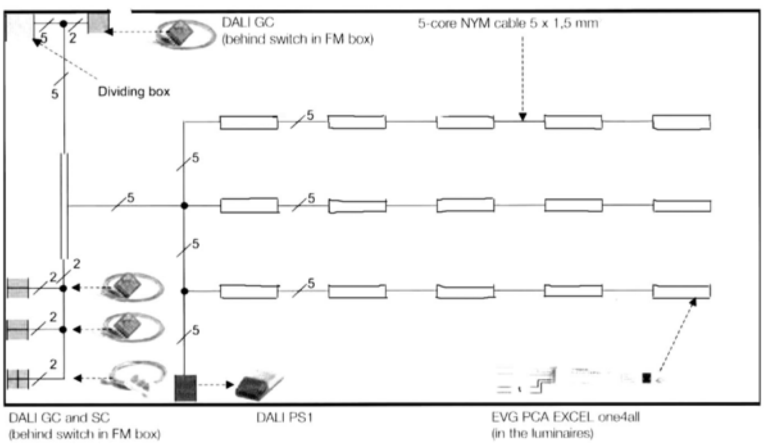


1. Manual dimming and switching
2. Control by natural light

Multi – point control system



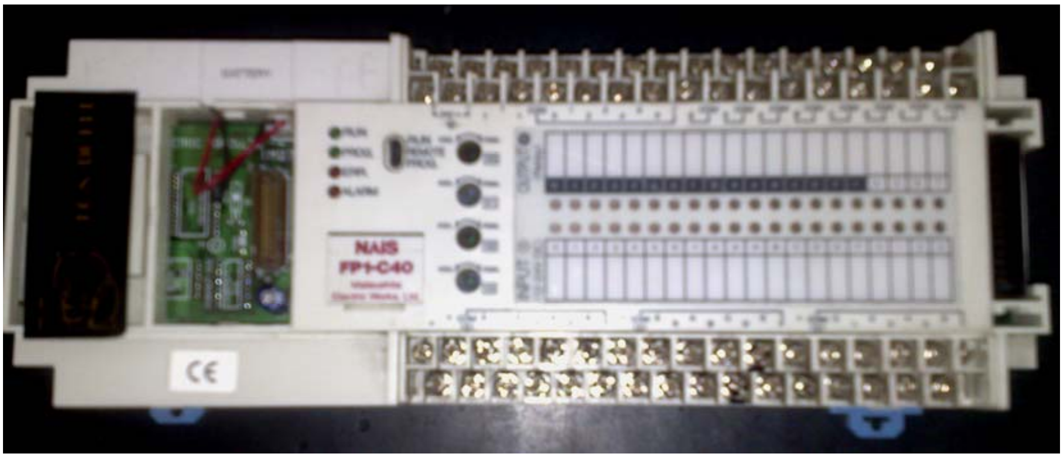
Multi point control



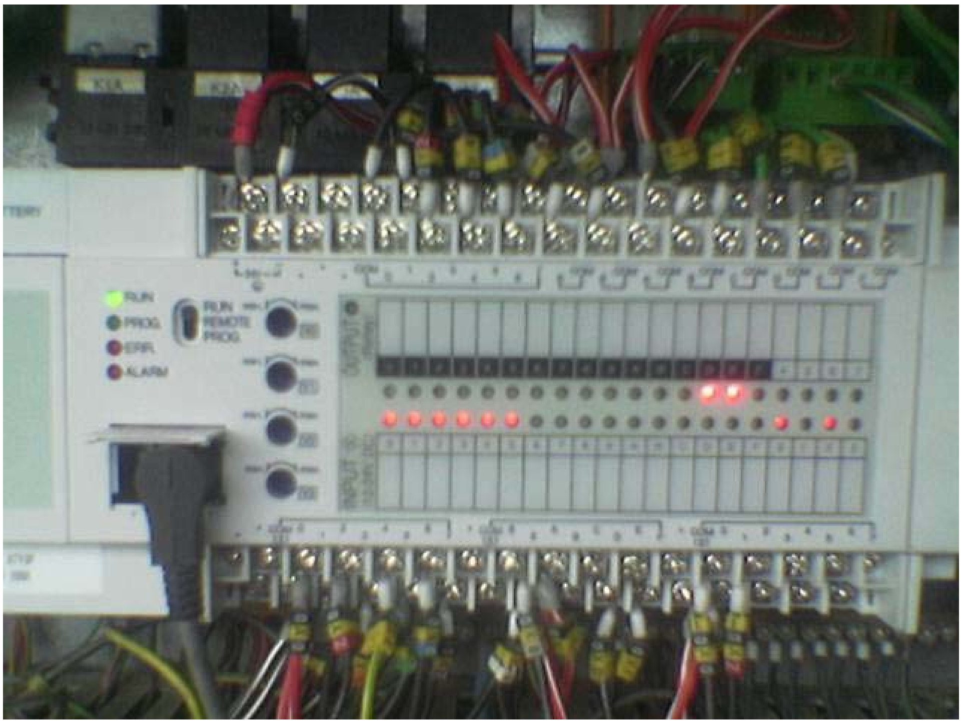
2nd floor electric lighting diagram

8.6.7. BEMS

Part of BMS as well as measurements and monitoring of energy savings is conducted by the light management system. In this project the majority of energy in consumed by electrical lighting. BMS is based on PLC FPI E40 control unit which can have an extension I/O and built-in RAM. Total of I/O points are 40. I/O 24 and O 16. Power supply: 120 VAC – 220 VAC and 12 to 24 V outputs. Miniature relays are TR NPN and TR PNP open collector. PLC used ROM and EEP ROM memory units. An FP1 master unit is used for copying programs.



PLC FPI E40



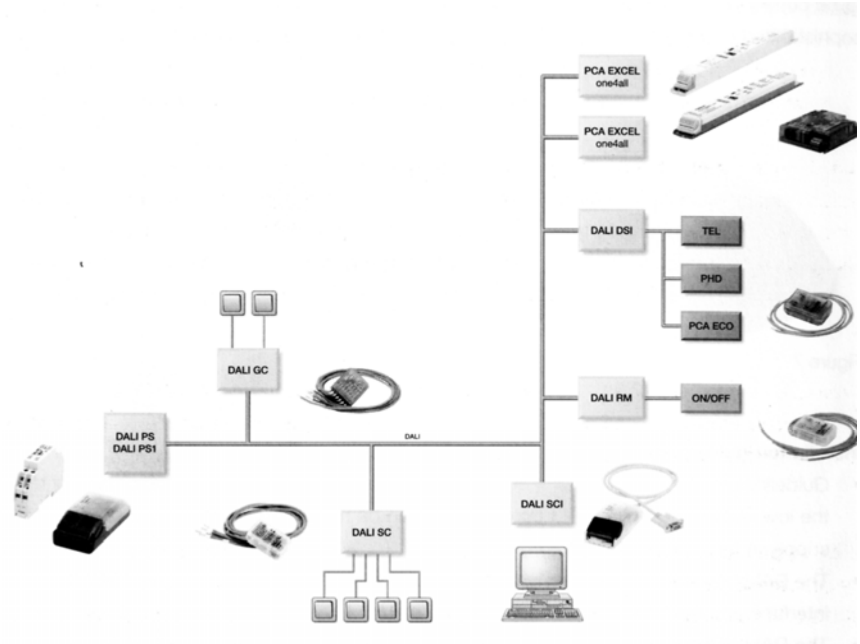
PLC FPI E40 with cabling connection

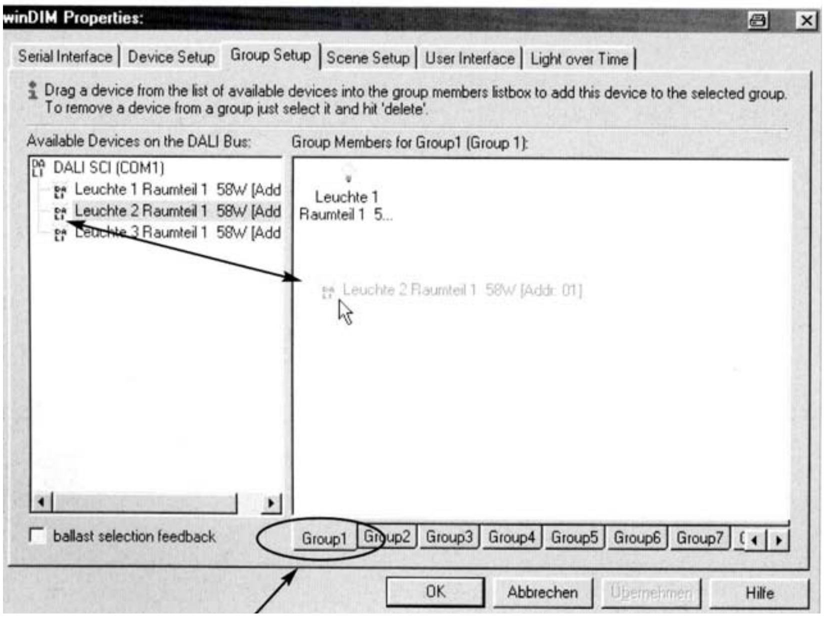
See attached file: POINTS ANALYSIS OF CENTRAL MANAGEMENT AND MONITORING SYSTEM (BMS)

8.7. Monitoring

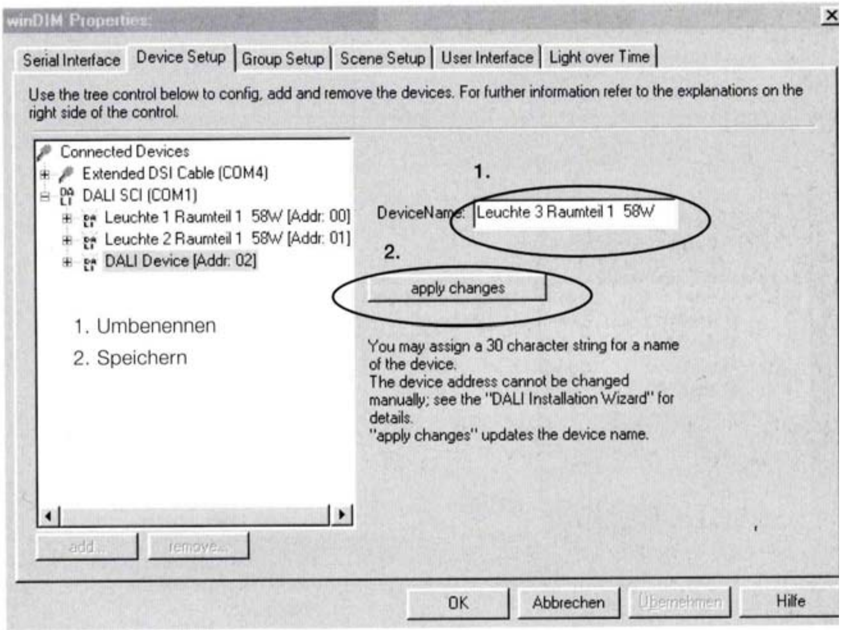
8.7.1. Monitoring plan

Monitoring plan of lighting management of 2nd floor

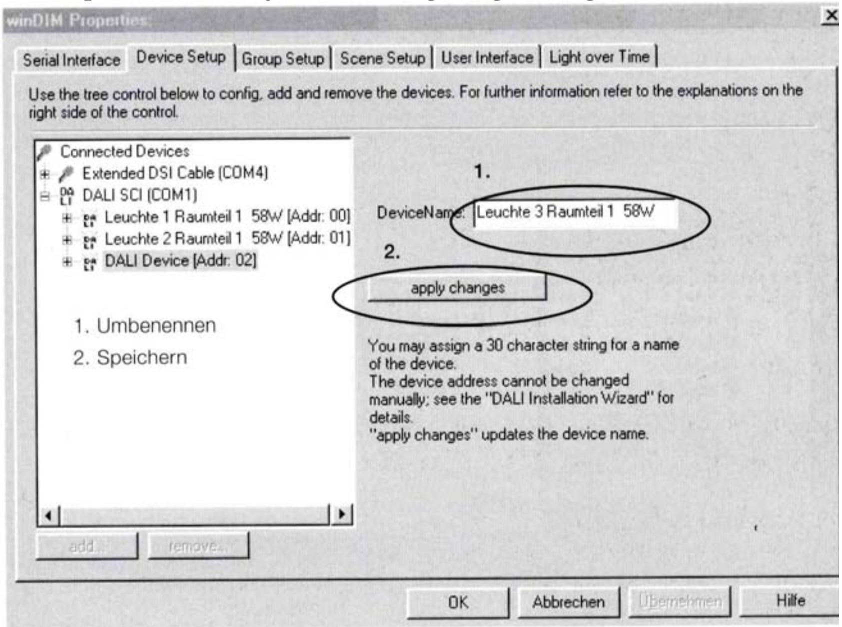




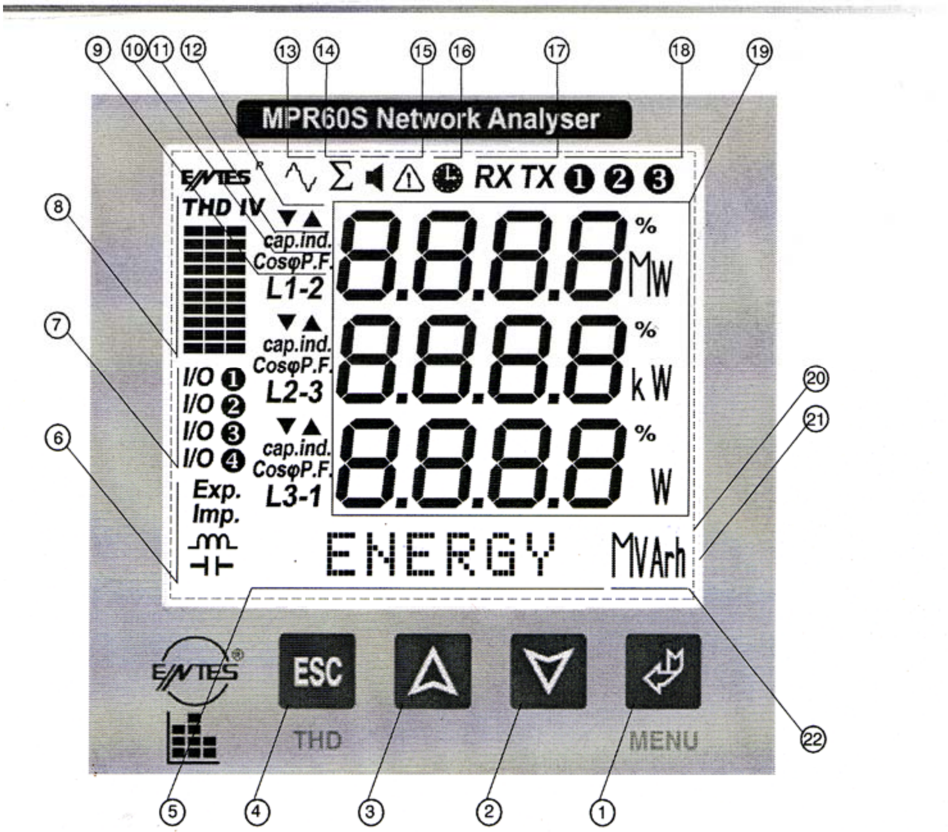
Programming groups with winDim S/W
WinDim is a S/W tool with used to control and program the TridonicATCO one4call electronic ECO ballasts and DALI network through the DALI SCI computer interface for windows.



DALI is a system with a standard protocol for digital DALI devices in the lighting equipment for room-orient light management.
DALI is a part of BMS components
DALI provides a very versatile lighting management solution

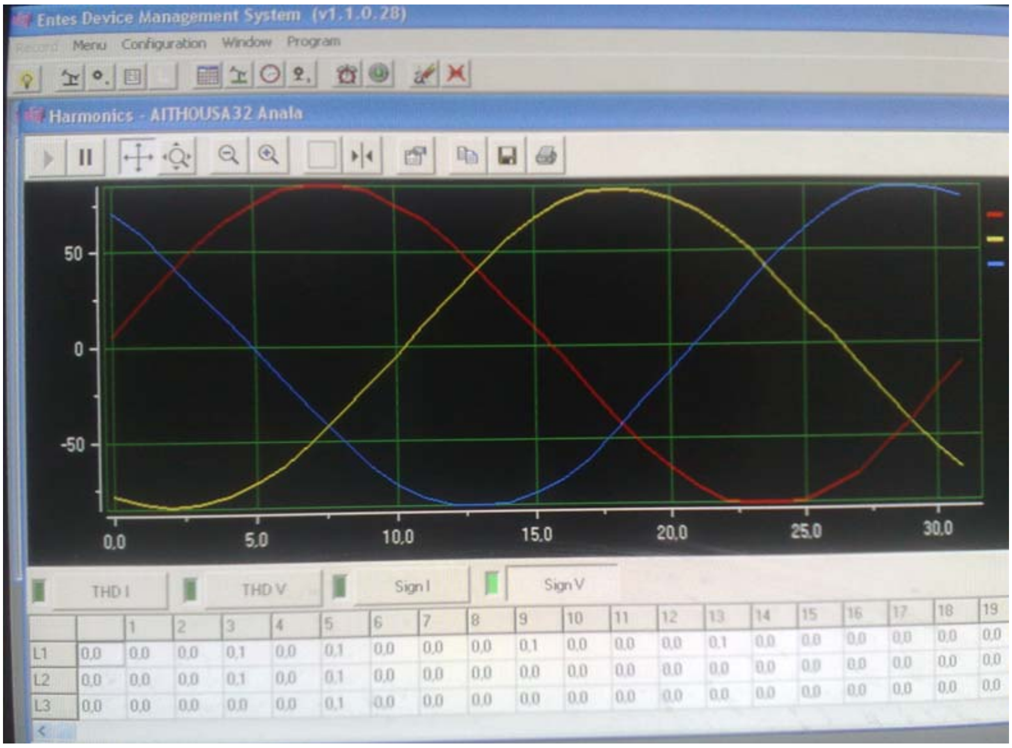


Start addressing
Addressing is mostly automatic. In Device Setup there is a button for “Start Dali Bms Addressing Wizard”

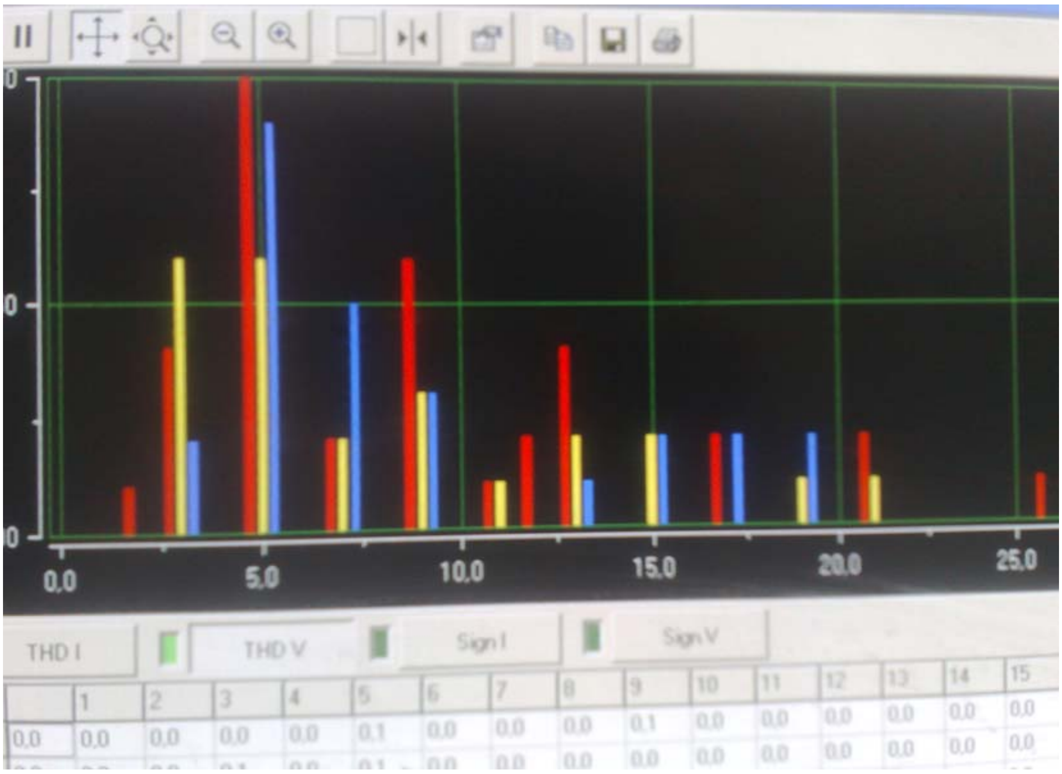


1 .... Menu (ENTER) button.
2 .... Down button.
3 .... Up button.
4 .... ESC button. Exits from a menu or settings at **any time.**
(THD I, THD V can also be displayed)
5 .... Menu / Energy line : Shows the present menu../ It also shows the energy values.
6 .... Shows whether the value in the Energy Menu is Export, Import, Inductive or capacitive.
7 .... Active output is indicated.
8 .... Harmonic bars: The total harmonics of the 3 phases are displayed in bar graphs. The columns represent L1, L2 and L3 phases. Each step indicate 10% increase / decrease V is for the voltages harmonics and I is for the currents harmonics.
9 .... Indicates if the measure is phase to phase or phase to neutral.
10.......... The Cosφ or PF (Power Factor) value of the related phase.
11 .... Indicates if the measurement is capacitive or inductive.
12 .... Min. and Max. symbols for the demand menu.
13 .... Indicates that the harmonics are displayed on the screen.
14 .... Total symbol. Shows the total value of the related measurement.
15 .... Phase sequence failure
16 .... Demand symbol. Shows the demand value of the related parameter.
17 .... PC Communication indicator.
18 .... Phase indication symbols.
19 .... Shows the following measurement values with units.
(V, kV, MV, A, kA, MA, W, kW, MW, VA, kVA, MVA, VAr, kVAr, MVAr %)
20 .... 3.6" LCD Display.
21 .... Backlight.
22 .... Shows the unit of energy values. (kWh, kVAh, kVArh)

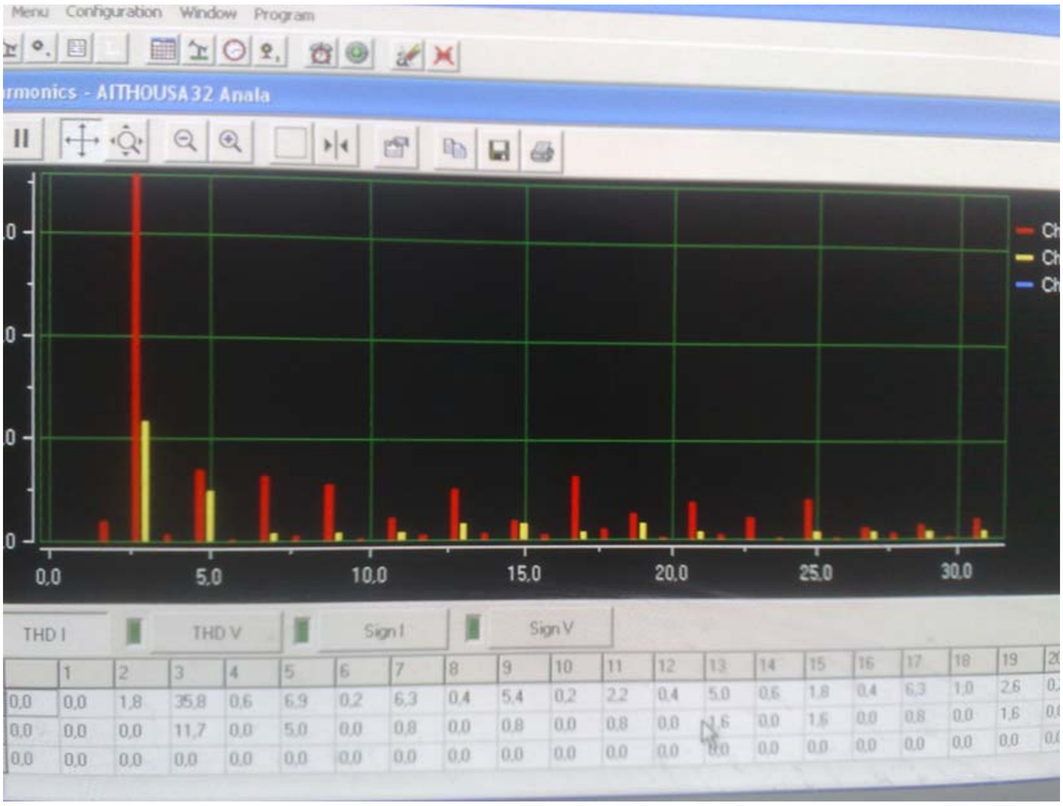
Electrical network parameters on PC via converter RS485 to USB



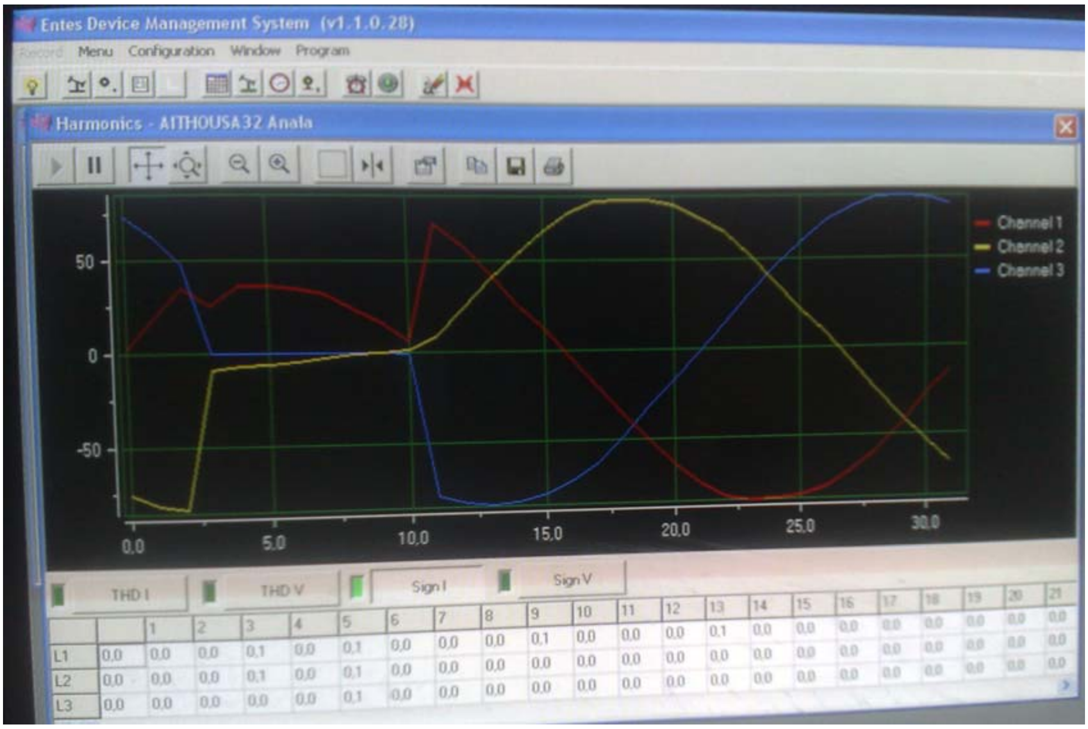
Recording parameters with monitoring software MPR-SW SERIES. Three phase indications from grid (PPC) AC power supply



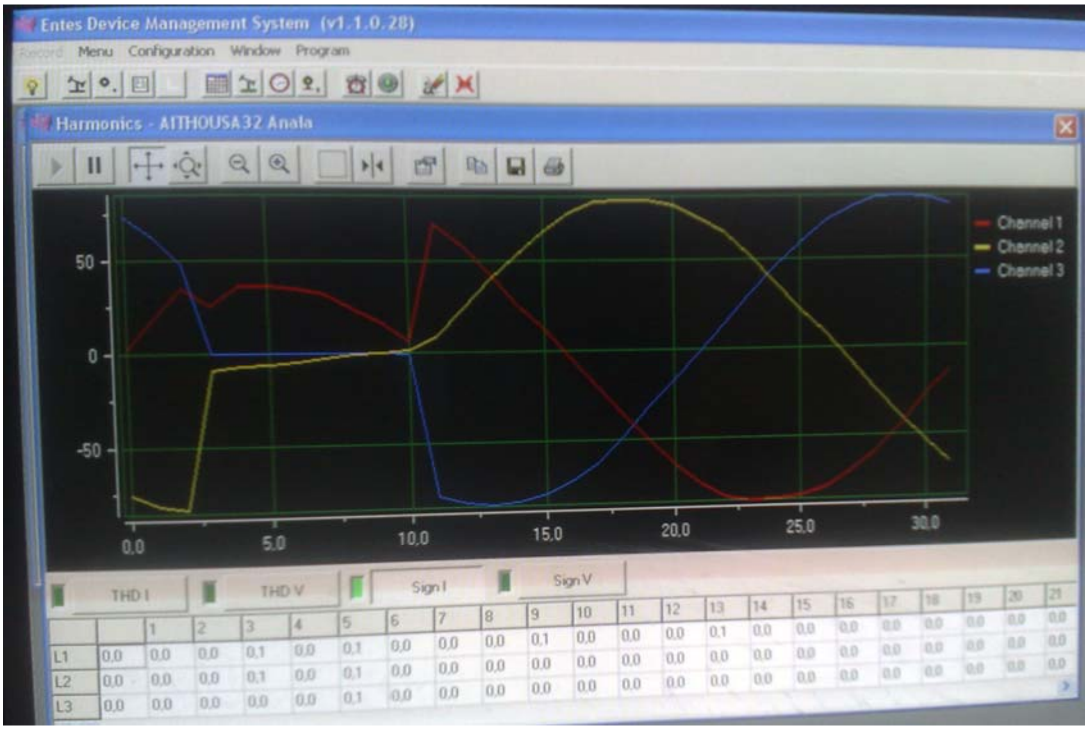
Data display in real time



Schematic diagram which represents the harmonic distortion with 90% light dimming



Schematic diagram which represents the harmonic distortion with 50% light dimming

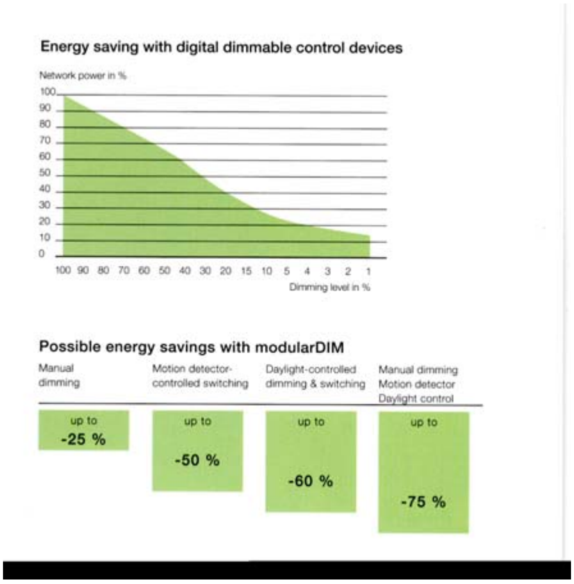


Current distortion at 90% light dimming

- Energy and Water Consumption
  - Temperature drop
  - Flows
  - Fuel
  - Electricity

With the modular DIM system energy savings of up to 75% are realized.

Savings are achieved as a result of both the increased operating efficiency of the lamps as well as the low power consumption of digital dimmable control devices such as the ECO PCA ballasts and TE one4all transformers. The addition of daylight control with presence detectors is a key factor in achieving such high-energy savings.



- Water

- o Renewable Contribution
  - Temperature drop
  - Flows
  - Electric Power

Photovoltaic Panels (PV)

PV has been installed on the sunspace roofs, on two verandahs, as shading devices. The direction of PV panels is south with a 30^0 inclination.

FitCraft Production s.r.o. — Photovoltaic panel FCP 170

FCP 170

The photovoltaic panel FCP 170 belongs to the new generation of panels that are manufactured on the basis of monocrystalline silicone cells with an efficiency of up to 15%. The maximum output of individual panels is ensured by a triple stage production inspection, where the first step is the careful selection of cells that have the same efficiency. Then follows a measuring of individual rows of solar cells (flash tester) and final measuring of the complete panel in the testing device Sun Simulator DO 01. (The simulator tests the panels by a flash of 1000W/m² in the spectrum AM 1.5 on the area of the surface panel) . The use of top quality basic components from renowned manufacturers guarantees high endurance, quality and long life expectancy of the final product. This product is designated for small and large applications for system voltage of up to 1000 V. The FCP panels are EZU certified.

Technical specification		
Weight	kg	19,3
Dimensions	(cm)	1878x800x35
Packing method	Modules	1 per carton
Number of cells	pcs	108
Max. output	W	170W
Module voltage	V	28
Max. system voltage	V	1000

- **Anodized frame**
- **12 x 9 cells**
- **Special hardened glass of panel**
- **Guarantee of material durability 5 years**
- **Guarantee of output 25 years**
- **Output tolerance ± 5 %**
- **Certification: EN 61215**

Example of use
Large area systems Photovoltaic power plants

Electrical properties FCP170	Mark	Unit	Value
Maximum output	Pmax	Wp	170
Tolerance	Ptol	%	+/-5
Maximum output voltage	Vmpp	V	28
Maximum output current	Impp	A	6,1
Open circuit voltage	Voc	V	31,8
Short circuit current	Isc	A	7,5
Maximum system voltage	Vmax	V	1000
Thermal coefficient	α = +2,1 mA/℃ ; β = -117 mV/℃ ; γ P/P = -0.39 %/℃		
Measuring conditions: Spectrum AM1.5 – 1000W/qm, T= 25℃			

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Specifications of PV panels (1)

FitCraft Production s.r.o. Photovoltaic panel FCP 145

FCP 145

The photovoltaic panel FCP 145 belongs to the new generation of panels that are manufactured on the basis of mono-crystalline silicone cells with an efficiency of up to 15%. The maximum output of individual panels is ensured by a triple stage production inspection, where the first step is the careful selection of cells that have the same efficiency. Then follows a measuring of individual rows of solar cells (flash tester) and final measuring of the complete panel in the testing device Sun Simulator DO 01. (The simulator tests the panels by a flash of 1000W/m² in the spectrum AM 1.5 on the area of the surface panel). The use of top quality basic components from renowned manufacturers guarantees high endurance, quality and long life expectancy of the final product. This product is designated for small and large applications for system voltage of up to 1000 V. The FCP panels are TUV and EZU certified.

Technical specification		
Weight	kg	18
Dimensions	(cm)	1575x800x35
Packing method	Modules	1 per carton
Number of cells	pcs	90
Max. output	W	145W
Module voltage	V	47
Max. system voltage	V	1000

- Anodized frame
- 9 x 10 cells (150 x 80)
- Special hardened glass of panel
- Guarantee of material durability 5 years
- Guarantee of output 25 years
- Output tolerance ± 5 %
- Certification: EN 61215

Example of use
Large area systems
Photovoltaic power plants
Water pumps
Telecommunications

Electrical properties FCP145	Mark	Unit	Value
Maximum output	Pmax	Wp	145
Tolerance	Ptol	%	+/-5
Maximum output voltage	Vmpp	V	46,8
Maximum output current	Impp	A	3,1
Open circuit voltage	Voc	V	55
Short circuit current	Isc	A	3,87
Maximum system voltage	Vmax	V	1000
Thermal coefficient	α = +1,29 mA/℃ ; β = -158 mV/℃ ; γ P/P = -0.43 %/℃		
Measuring conditions: Spectrum AM1.5 – 1000W/qm, T= 25℃			

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Specifications of PV panels (2)

8.7.2. <u>Details of PV installation</u>

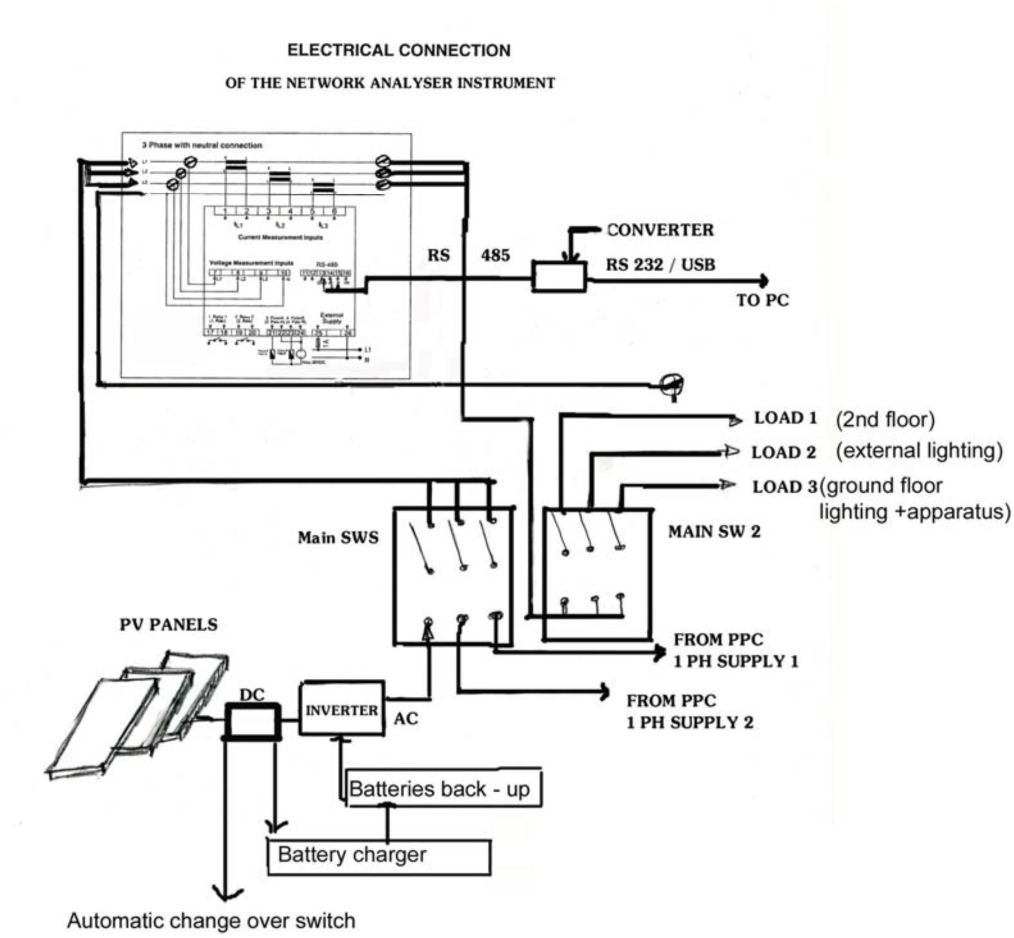
The system is composed of the following PV panels:
8 pcs X 170 W p ea = 1360 Wp
<u>8 pcs X 140 W p ea = 1120 Wp</u>
Total 16 pcs 2480 Wp

2.1.7.1. Dimensions of PV installation

140 Wp   1575 mm X 800 mm = 10,08 m^2
170 Wp   1878 mm X 800 mm = 12,16 m^2

Total effective area   22.24 m^2

Total installed power 2.48 KWp
Power factor of Athens area is 3.4
Electrical energy produced per KWp is 1400 KWh/a
Total solar energy production 3750 KWh/a



8.8. Data analysis

8.8.1. Energy consumption

1.1.8.1. Energy Demand: Electricity

	[kWh/m²a]	Total annual (kWh)
Total electricity	15.2	15.240 E1
Electricity consumed by ventilation	2.9	2.900 E2
Electricity consumed by heating	1.0	1.000 E3
Electricity consumed by cooling	1.5	1.520 E4
Electricity consumed by DHW	1.9	1.920 E5
Electricity of kitchen or special high-energy units	3.2	3.200 E6
Electricity consumed for lighting	4.7	4.700 E7
Primary Energy (Total electricity)	46,2	46.181 PE_E

1.1.8.2. Energy Demand: Thermal

	[kWh/m²a]	Total annual (kWh)
Total incoming heating energy (district heating/solar/gas/oil), measured from the main supply line (temperature drop/flow vs. oil/gas consumption*Heating value)	58.9 (diesel oil)	58.987 T1
Heating energy consumed by ventilation	-	- T2
DHW	2.9 (solar)	2.900 T3 (solar)
Primary Energy (Total thermal)	65	65.052 PE_T

1.8.1.3 Contribution from Renewables

	Total annual	Renewable fraction
Solar Thermal	2.900 R1	60%
PV	3.742 R2	25% R2/E1
Wind power	R3	

1.1.8.3. Water consumption

		Total for the whole building
Water	0.13 m³/m²a	143 m³/a

1.1.8.4. Primary energy calculation

		Total for the whole building
Space heating	65 kWh/m^2 a	65.052 kWh/a
DHW	5.8 kWh/m^2 a	5818 kWh/a
Electricity	40.4 kWh/m^2a	4363 kWh/a

1.9 Summary

1.9.1 Foreseen and Obtained Energy and water saving

	Predicted [kWh/m^2 a]	Obtained [kWh/m^2 a]	Predicted Total [kWh/a]	Obtained Total [kWh/a]
Energy saving measures, heating, cooling, ventilation	195	210	195.000	210.000

	Predicted [kWh/m^2 a]	Obtained [kWh/m^2 a]	Predicted Total [kWh/a]	Obtained Total [kWh/a]
Energy saving measures, electricity	4.2	14.6	4.200	14.670

	Predicted [m^3/m^2 a]	Obtained [m^3/m^2 a]	Predicted [m^3/a]	Obtained [m^3/a]
Water saving measures	0.16	0.13	170	143

1.9.2 Overall energy and water consumption and improving comfort evaluation

	Before retrofit (or average value of similar buildings, when applicable)	After Retrofit Foreseen	Saved foreseen	After Retrofit Measured	Saved measured
Primary Energy [kWh/m^2a]	703.8 (*)	362	341.8	111.2	592.6
Water [m^3/m^2a]	170				

(*) The conversion factors used for primary energy in these tables were based on Greek authorities calculations in which data before 2004 were used. According to new methodologies the conversion factors can in fact be changed to 0,33 for electricity and 0,9 for oil, based on 2007 data for Greece.

1.9.3 Overall Economic evaluation

Total extra costs (Foreseen) [EUR]	Total extra costs (Observed) [EUR]	Saving (Foreseen) [EUR/a]	Saving (Observed) [EUR/a]	Payback foreseen	Payback observed
124.050	206.000	14.500	18.682	8,5	11

Energy costs used for calculation (2008):
Thermal (€/kWh): 0,071
Electric (€/kWh): 0,178

1.10 Lessons learned

This project was a challenge not only on technical, but also on financial and management procedures. Thus, in addition to the technical challenge of integrating renewable and energy conservation systems to the traditional construction techniques of a listed building, it has been innovative in terms of the combination of private and public sponsors in the retrofitting of a public building

A major lesson learnt by our team was, therefore, that it is often difficult to combine public financing procedures for the restoration of public buildings with the prerogatives of a research project. In the case of Evonymos project, the construction process has been greatly delayed because of the lengthy procedures involved in building restoration financing through the Greek Ministry of Culture, to which the building belongs, as a listed building.

Finally, it should be noted that the introduction of innovative low energy components into the retrofitting of a listed building should not be treated in an inflexible way or as remedy for all types of problems. Each building should be considered individually and innovative features introduced into the overall design concept so that the best possible balance of thermal and visual comfort is achieved and the retrofitted building meets the occupants’ practical and aesthetic needs.