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# Pilot study – Educational building National report – Denmark

Final report, June 2007

**Energy Performance Assessment** of Existing Non-Residential Buildings

Report Number: EC Contract: EIE/04/125/S07.38651 www.epa-nr.org Title of contact:
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# Pilot study – Educational building National report – Denmark

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Date: June 2007

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EC Contract

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## 1 Introduction

This is the Pilot study National report performed in the frame of Work package 4 of the EPA-NR project.

The pilot Study consists of three Pilot projects for non residential buildings:

- Pilot project for one education building
- Pilot project for one offices building
- Pilot project for one health care building

Pilot projects are real buildings for which the EPA-NR method was applied.

## 1.1 Goal of pilot study

The goals of pilot study are:

- The evaluation of EPA-NR method, including the building diagnosis and the EPA-NR software
- The assessment of Energy Performance of the building and creating an useful Energy Performance Advice for the owner of the building

For the first objective, an evaluation procedure was defined and a questionnaire [1] was performed. The questionnaire was filled for each pilot project by the person who applies the EPA-NR method to the building.

The analysis of all the questionnaire answers was the basis of the evaluation of EPA-NR method and the recommendations of modifications.

The evaluation of EPA-NR method including recommendations for modifications are described in a specific (internal) report [2].

The assessment of Energy Performance of the building indicates the actual performance of the building and some proposed energy saving measures to reduce the energy consumption taking into account the indoor environment, investment costs, payback times and technical feasibility.

The assessment of Energy Performance of the pilot projects including a set of energy saving measures is described in this report.

The results of the pilot study will serve as demonstration for dissemination.

### 1.2 Structure of the report

The report is divided into three chapters:

- Chapter 2 concerns the pilot project for education sector
- Chapter 3 concerns the pilot project for offices sector
- Chapter 4 concerns the pilot project for health care sector

The characteristics of the building surveyed are described in paragraph 1 of the chapter.

The results of building diagnosis including a description of actual situation of the building and energy demand calculation using EPA-NR software are described in paragraph 2 of the chapter.

Paragraph 3 of the chapter presents a number of scenarios to improve the energy performance of the building, for each scenario, the energy saving, the investments and payback time are given and finally the most appropriate scenario as an advice to the owner is described.



## 2 Education building, Stengård School

2.1 Project summary



Stengård primary and lower secondary school, Gladsaxe Contractor: Gladsaxe Municipality.

Type of building: Education

Location: Scattered urban environment of similar

height

Owner: Public

Year of construction: 1950-52

Total gross area (m²): 12,995 m²

Total conditioned area (m²): 7,702 m²

Building occupancy: 80 hours week, except during

summer holydays (late June - mid August)

Number of occupants: About 560, 512 pupils, 35

teachers and misc. staff.

Short description: The scattered buildings at Stengård school consists 6 terraced buildings with most of the class rooms. The gymnasiums are located in an individual building. The school is owned by Gladsaxe municipality. The buildings are oriented along a North-West axis and the rooms are thus oriented either South-West or North-East.

Construction: Facades are made of hollow core masonry with insulation. Roof is covered by roofing tiles. The glass in the windows is traditional double pane thermo windows though in continuous replacement to low energy glazing when broken.

Heating/cooling/ventilation/lighting: Heating is via a local district heating plant running on natural gas. There are two boilers, a new condensing and an old traditional operating in cascade, with the new boiler as #



			1. There is mechanical ventilation in gymnasiums and assembly hall while there is exhaust ventilation in the rest of the heated area.
tem has bee	nagement: An energy en installed recently. Insumption year 200	, G	Previous refurbishment: Almost all windows have been replaced with low energy windows. Old roof insulation (100 mm) has been replaced with new 125 mm mineral
	The building (According the bills)	National average (if known)	wool. Thermostat valves have been intro- duced in all rooms. New condensing natural
Fuel	147.4 kWh/m²	125.9 kWh/m²	gas boiler has replaced an old one.
Electricity	16.5 kWh/m²	22.3 kWh/m²	No further major refurbishments have
Water	0.18 m <sup>3</sup> /m <sup>2</sup>	0.24 m <sup>3</sup> /m <sup>2</sup>	been undertaken, but continuous, minor improvements of the energy performance
			miprovements of the energy periorinance

*Planned refurbishment:* Update of the heating system, installation of energy management system, new lighting system.

are being made.

Stengård primary and lower secondary school is a single story school with detached buildings, the first of its kind in Denmark.

Further to ordinary class rooms, the school holds special subject rooms, four gymnasiums (two floors), and practical rooms such as computer rooms, needlework, educational kitchen, science labs, drama, media room, music room, drawing and arts room with an oven for ceramics, woodwork, metalwork, cinema, and school library. Further there is room for a school dentist and a doctor.

Underneath the entire school there is a basement for the distribution network, other technical facilities, and a limited number of storage rooms.



## 2.2 Audit of the building

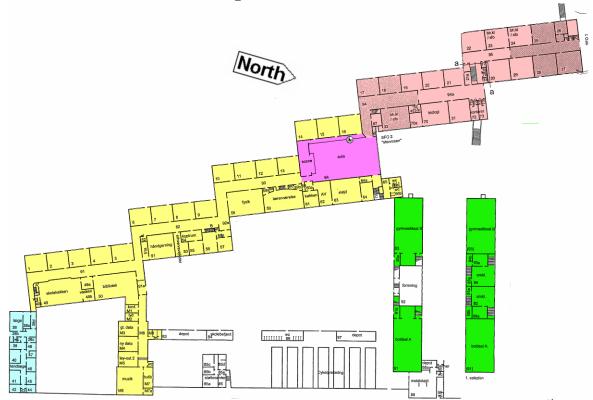


Figure 1. Plan of Stengård school. The colours indicate: Green – gymnasium (ground and 1<sup>st</sup> floor); Pink – after-school centre; Yellow – educational areas; Purple - assembly hall; Blue – School dentist and doctor; White – service areas, metal workshop, and arts class.

#### 2.2.1 Actual situation

A first time assessment in the Danish energy performance assessment scheme of a building as complex as Stengård school would take three to four days on the location for measuring and registering all relevant information related to making a building model. Additional 3-4 office days would be needed to convert the collected data to information needed for the calculation tool and quality checking the input data, and then about one to two days for making a report for the costumer. The total cost for a first time energy performance assessment would be around 7000 €, which is quite costly, but savings on the energy bill of the same magnitude should easily be harvested.

#### 2.2.1.1 Special findings

#### Windows:

Some of the windows are with single layer glazing and needs replacements to meet today's standard.

#### Doors:

Many doors are not airtight and needs replacement with new ones with better insulation and more hinges to prevent them from being wry and create leakages. Doors in a school do need to be of an extraordinary strength to withstand the daily wear.

#### **Connection building:**

The connection building, housing media facilities are constructed of light-weight constructions that need renovation. This is an ideal opportunity for making this part of the thermal envelope up to date and decrease future maintenance costs.



#### Roof insulation:

Insulation of the roof have been replaced and increased from 100 mm to 125 mm some years ago. The physical state of the insulation in some places is however so that a replacement should be considered again. The insulation have been stepped down and misplaced due to work carried out to the new ventilation system. In general there is plenty of room for placing additional insulation in the attic and it is recommended to increase the insulation thickness to at least 250 mm or 300 mm, covering the foot of the rafter. Loose filled insulation material could be blown in over the steel beams near the base of the roof.

#### Boiler room:

In the boiler room there are two natural gas boilers, one condensing boiler running as primary boiler and one traditional boiler as back up. Due to the low heat loss from the new condensing boiler, the room temperature is low, but the ventilation of the room is still dimensioned as if it was two traditional boilers that served the school. It is recommended to renovate the ventilation and insulation level of the boiler room to meet the demands of the new condensing boiler.

#### Boiler:

The set point of the boiler seems to be wrong as the boiler was running for 72 °C on a hot summer day where only hot water for the showers was needed. It recommended checking the BMS settings and the outdoor temperature sensor that controls these settings.

#### Domestic hot water distribution:

The temperature of the domestic hot water distribution, which covers all sections of the school, is unnecessary high -54 °C - and could without problems be decreased to around 40 °C. Domestic hot water is produced in a district heating heat exchanger near the boiler room of the school. The temperature here is that high that problems with Legionnaires' disease will not occur.

Many valves are not insulated and could be insulated to decrease waste of energy.

#### **Technical insulation:**

Insulation level of the technical installations is in general insufficient; about 10 mm. Replacement of the insulation to 30 mm insulation thickness will decrease the efficiency of the distribution systems and result in considerable energy savings.

There are some new ventilation systems installed different places in the school. These are however not insulated at all. It is recommended to add insulation to ducts, casings, exchangers, etc.

#### Pumps:

A large number of the pumps in the heating and domestic hot water distribution systems are old and can easily be replaced by new, electronic pumps with much lower electricity consumption.

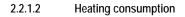
#### Light:

Many class rooms was found empty during breaks, but with the lights on. In the walk-ways the lighting level seemed too low in some placed and too high in other. Zoning of the lighting system in combination with PIR sensors and more efficient lighting systems would decrease the electricity consumption and increase the comfort level.

Lighting in the technical premises are both controlled by PIR sensors and by manual switches. It is recommended to install PIR sensors or timers in all these rooms.

In general the class rooms have good access to daylight, however it might be improved if the light-shafts were painted white and some of the trees near the building were cut.





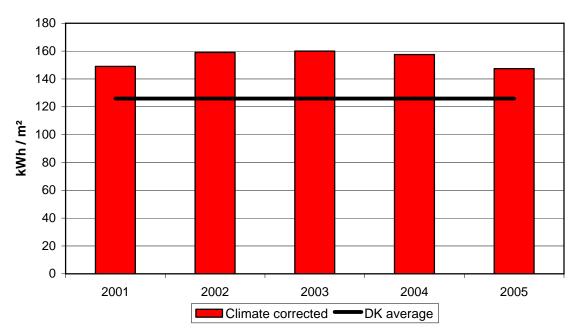


Figure 2. Climate adjusted heating consumption in kWh/m² and the average heating consumption in Danish natural gas heated schools. The degree-day independent heating consumption constitutes 3 %.

In 2004 one of the two boilers was replaced with a condensing natural gas boiler. The two boilers operate in cascade with the new boiler as # 1. It seems that the energy consumption for space heating was influenced by this replacement with about 6 %.

#### 2.2.1.3 Electricity consumption

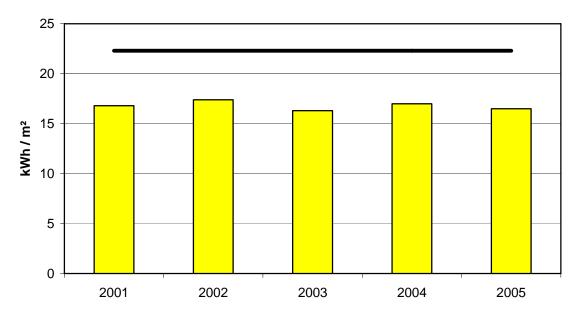


Figure 3. Actual electricity consumption in MWh and the average consumption in Danish schools.



Electricity consumption at Stengård school is clearly below the Danish average consumption in schools. This may be caused by the lay-out of the buildings and gradually introduction of PIR sensors to control artificial light in most rooms.

#### 2.2.1.4 Water consumption

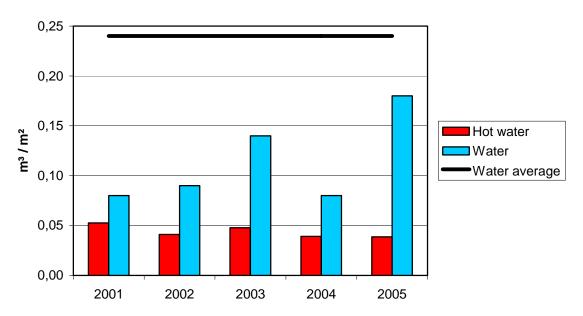


Figure 4. Water and hot water consumption at Stengård school in m³/m² and Danish average consumption in schools.

There are large variations in the registered total consumption, which partly can be explained by a defective main water meter that was replaced in 2004. There is though still a diversion between the development in the total water consumption and the hot water consumption. In 2005 the domestic hot water consumption constituted 1386 m³ (21.5 %) of the total water consumption.

The large national water consumption is partly influenced by the presence of swimming baths in a number of the Danish schools. Stengard school do not have a swimming bath.

# 2.2.2 Calculating energy 'demand' using EPA-NR software based on actual situation

#### 2.2.2.1 Energy characteristics of the building model (global)

The energy performance was calculated under standard conditions with the EPA-NR software. For the EPA-NR calculations, the building was divided into the following four zones:

- 1. Zone 1: Educational areas (2788 m<sup>2</sup>),
- 2. Zone 2: Gymnasium (1240 m²),
- 3. Zone 3: After-school centre (1726 m²),
- 4. Zone 4: Assembly hall (450 m<sup>2</sup>).

Some areas were not taken into account in the calculations, and these are:

- 5. Health clinic (290 m<sup>2</sup>),
- 6. Metal workshop (105 m²),
- 7. Support centre for pupils with special needs (108 m²).



#### List of energy uses:

Zone 1: heated and naturally ventilated,

Zone 2: heated and naturally ventilated,

Zone 3: heated and naturally ventilated,

Zone 4: heated and mechanically ventilated.

Operational parameters used for the calculation:

oporational parameters assarts the	oaioaiatioii.			
	Zone 1	Zone 2	Zone 3	Zone 4
Heating temperature set point	20 °C	20 °C	20 °C	20 °C
Cooling temperature set point	-	-	-	-
Operation time for heating/year	6075 h/a	6075 h/a	6075 h/a	6075 h/a
Operation time for cooling/year	-	-	-	-
Operation time for ventilation/year	-	-	-	4200 h/a
Operation time for lighting/year	1050 h/a	1140 h/a	700 h/a	400 h/a

Input data used for the calculation is found in Appendix 2 as documentation produced by the EPA-NR tool.

#### 2.2.2.2 Results

Primary energy demand and CO<sub>2</sub> emission of the building

Primary energy consumption of the building:	CO <sub>2</sub> emission of the building: kg/m²/year
kWh/m²/year	
203.98	25.7

Final energy demand, primary energy demand and CO2 emission by energy carrier

Annual final energy con-	Primary energy con-	CO <sub>2</sub> emission of the
sumption* of the building	sumption of the building:	building:
per fuel type:	kWh/m²/year	kg/m²/year
1053,79 MWh/year	169.86	16.1
211,72 MWh/year	13.65	9.6
	Annual final energy consumption* of the building per fuel type: 1053,79 MWh/year	Annual final energy consumption* of the building per fuel type:  1053,79 MWh/year  Primary energy consumption of the building: kWh/m²/year  169.86

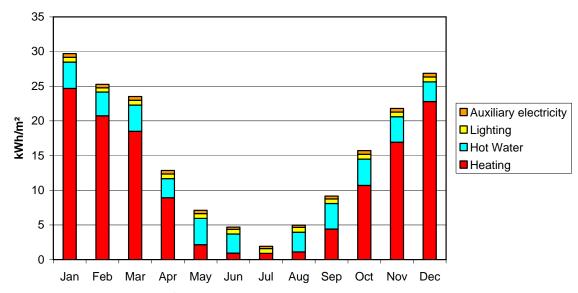
<sup>\*</sup> Calculated under standard user pattern and outdoor conditions.

#### **Energy demands by month**

Distribution of heating demand on different sources: Lighting; Domestic hot water; Cooling; and Heating.



#### **Energy demand by energy source**



Energy consumption at Stengård school is, as in most Danish buildings dominated by the energy consumption for space heating (above).

	А	nnual losse	S		Annua	l gains	
Total heating kWh/m²	Total	Trans- mission	Ventila- tion	Total	Solar	Sun space	Internal heat
Zone 1	167	133	33	80	47	0	33
Zone 2	207	124	83	46	25	0	21
Zone 3	183	131	53	91	51	0	40
Zone 4	373	106	267	95	38	0	57
Total	930	494	436	312	161	0	151

## 2.3 Calculation of energy savings: scenarios for improvement

### 2.3.1 Scenario 1 - Derease of DHW circulation temperature

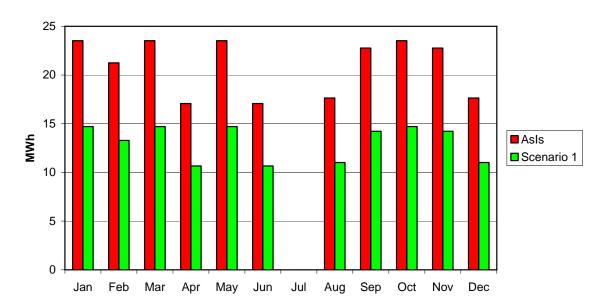
#### 2.3.1.1 Background and proposed solution

The set-point temperature for the domestic hot water circulation is at the moment about 52 °C and can easily be decreased without causing any Legionnaires' disease problems. The distribution network for domestic hot water is at least 700 meters of relatively poorly insulated pipes located in the technical galleries in the basement, which is unheated and heat losses in this part of the school do only influence the heating consumption indirectly as a decreased loss towards the basement.

As energy saving measure, this is a simple intervention that can be done by the technical staff of the school within about half an hour. The pay-back time does thus not exist.







Energy consumption for domestic hot water, before and after decreasing the water temperature in the distribution network. Estimated distribution efficiency changed from 0.5 to 0.8.

The annual saving is calculated to 86 MWh equal to a cost of about €19000 with an investment of one hour work or about €50.

#### 2.3.1.2 Recommendation

It is highly recommended to carry out this measure.

# 2.3.2 Scenario 2 – Upgrade of roof insulation to 300 mm incl. replacement of 10 % of the existing insulation

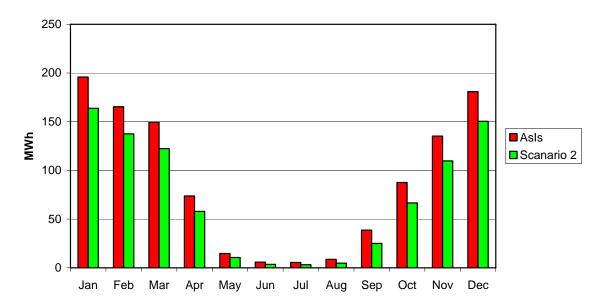
#### 2.3.2.1 Background and proposed solution

The general insulation level in the attic is below today's standard and is in some places de-located and/or compressed due to previous work on a new ventilation system and storage of various items on top of the insulation. In general there is easy access to the attic and additional insulation material can easily be laid out. Some areas are though more difficult to access with insulation slabs, but loose fill material can relatively simple be blown in. Increasing the insulation level from 125 mm to 300 mm will cut the heat loss through the roof by more than 50 %.

The average cost for this energy saving measure is estimated to be €27 per m², which includes removal of 10 % of the insulation (by area), laying out new insulation on these areas, laying out additional insulation un un-damaged areas, and blowing in loose fill material in some areas of the attic.



#### **Heating energy consumption**



Heating energy consumption before and after improvement of the roof insulation to 300 mm.

The annual energy saving of this energy saving measure is about 206 MWh or about €26000. The corresponding investment accounts for about €160000. The simple pay-back time for this measure is calculated to be as low as little more than 6 years.

#### 2.3.2.2 Recommendation

This energy saving measure is highly recommended from a total economy point of view.

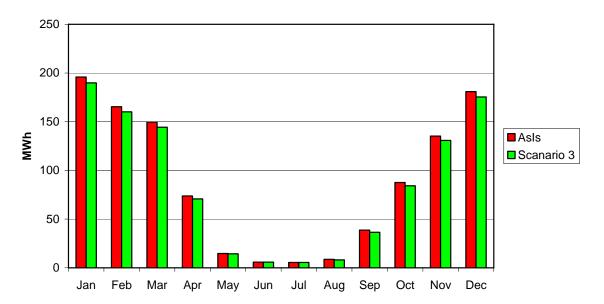
### 2.3.3 Scenario 3 – Replacement of windows and entrance doors in gymnasiym

#### 2.3.3.1 Background and proposed solution

The general physical condition of windows and entrance doors in the gymnasium is below the current standard, and a replacement will improve the energy performance. The windows to the gymnasium are frosted and thus more costly than normal glazing. The entrance doors are with single glazing and judged to contribute massively to the infiltration air change in that part of the buildings.



#### **Heating energy consumption**



Heating energy consumption before and after replacing the windows and entrance doors in the gymnasium.

The annual energy saving of this energy saving measure is about 69 MWh or about €8700. The corresponding investment accounts for about €83000. The simple pay-back time for this measure is calculated to be about 9 years.

#### 2.3.3.2 Recommendation

This energy saving measure is not a reasonable investment from an economical point of view. From an indoor climate point of view it might prove to be an even better investment, as cold draft in the gymnasium will be minimized at the same time. At least when the windows and entrance doors are to be replaced anyway, it should be to the current energy standard.



# 3 Appendix 1: additional information about pilot projects

3.1 Educational building, Stengård school
Stengård folk school teaches pupils from 0 to 9 class (6-16 years) and is the first single floor school in Denmark. The buildings and its installations have been constantly energy renovated over the past 10 years and is as such in a condition that is above what is to be expected for folk schools of the same age. The school is owned and managed by Gladsaxe municipality.



View from the playground.



Connection building with media facilities.



Assembly hall.





Corridor with class rooms on both sides.

Class room with sky lights.





Domestic hot water distribution network.



Bathing facilities in gymnasium.



Boilers, condensing and traditional.



New, un-insulated ventilation system.







Dis-placed and compressed roof insulation.

Heat exchanger and control system for domestic hot water distribution and circulation.



# 4 Appendix 2: inputs data for calculations

The following summary of inputs is taken directly from the EPA-NR calculation tool, exported into one pdf-file per pilot project.

The reproduction of the input summary should be read as indicated in the figures to the right. In this report up to eight pages with model data are shown on the same page.

three or four pages:



Educational building, Stengård school 4.1 Building: Stengård school, AsIs Zone: Educational areas Temp. rise by fans, Heating part Active Supply temp., °C Total installed lighting power, W -daylight time usage per year for light Heat Production / Fraction of time Auxiliary fan energy Fraction Nat Vent is pre Cold-water Temp., °C Area, m Alpha, 0,8 312,5 221,0 0,60 0,8 0,04 1.80 1.800 180,0 1,80 1.800 0.000 0,00



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	lighting chargi				-					по	-	$\rightarrow$		+	-	_	-		-	17.	7   1	-				
	strols stand-by				$\neg$					no	Genera	toe	1,0	04	1 Natura high e		0 1	1	1	1	1	1	1	1 1	1	1
Invest		-			$\neg$					0	Distrib	ution														
Heat Produ	ction / Fracti	on of time									Name									Efficie	ncy, •					Inv
Occupants,										20	Heating	distrib	ution effici	ency							0,7					
Fraction Per	sons present,									0,1	Emissi	on.														
Appliances,										2	Name									Efficie						Inv
_	pliances are or	l, -								0,2	Heating	coil in	ventilation								0,85					
Airflow rat											Genera	l Heati	ing System													
Infiltration,	m∜s									0,5								Т								
Natural vent										0,6	_		consumptio	n, -				_								
-	Vent is prese	nt, -								0,3	Use So															
Domestic h											Aux en	ergy ar	nd operatio	on time !	fraction				_			_				_
-		on, m/m/year			_					0,8	Name		p_po	imp.	f_contr,	- Jan	Feb	Mar	Apr !	May	Jun	Jul	Aug	Sep	Oct	Nov I
Boiler Temp					-					72	Heating	Aux	-	0,3		1 1	1	1	1	0,75	0,1	0	0	0,5	1	1
Cold-water	remp., °C									8	_		and load	_	ution		_		_	_	_	_			_	_
Opaque Co	nstruction										Name		$\overline{}$	OP.		el Invest	Jan	Feb M	r A	pr Ma	y Jon	Ju	I Aug	Sep	Oct	Nov I
Name	Area, m²	Orientation, deg	Tilt,	U, W/m²K	Alpha, -	R_se, m²K/W	F_h. •	F_0	F_f	Invest/m²	$\vdash$	_ mark	$\rightarrow$	-+		$\rightarrow$			+	-	+	Η"	-	-		
	$\vdash$		Oky	_			-			_	Gas boiler		1,04	1	Natural ga high ener	is, o	1	1	1 0,7	75 0,	1 0	9	0,5	1	_ 1	1
South facade	354,0	180,0	90,0	0,600	0,80	0,04	0,900	0,800	1,000	0,00	Distrib	ution														
North foods	384,5	0,0	90,0	0,600	0,80	0,04	0,500	1,000	1,000	0,00	Name									Efficie	ncy, •					Inv
facade East facade	80,0	90,0	_	0,600	0,80	0,04	0,900	1,000	0,800	0,00	Distrib	rtion sy	stem								0,8					
West											Emissi	on.														
facade	80,0	270,0	90,0	0,600	0,80	0,04	0,800	1,000	1,000	0,00	Name									Efficie						Inv
Roof, South	310,0	180;0	20,0	0,300	0,80	0,04	0,800	1,000	1,000	0,00	Radiate										0,9					
Roof, North	310.0		***	0,300	0,80	0,04	0,800	1,000	1.000	0.00	Radiate	es									0,9					
North	310,0	0,0	20,0	0,300	0,80	0,04	0,800	1,000	1,000	0,00	Genera	d Dhw	System													
																		Т								



Factor on find consumption.	
	2,000 0,700 0,70 0,000 0,000 0,900 0,750 0,950 0,00
	2,000 0,500 0,50 0,000 0,000 0,900 0,950 0,850 0,00
Generator eff. and load contribution         North Doors         10.4         0.0         90.0         2.000	2,000 0,500 0,50 0,000 0,000 0,900 0,950 0,950 0,00
Name Efficiency,- Fuel larvest Jam Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec East 0,000 90,0 1,000	1,800 0,680 0,68 0,000 0,000 0,950 1,000 1,000 0,00
Gas boiler-texchanger 0.85 Natural gas. 0 1 1 1 1 0.75 1 0.75 0 0.75 1 1 1 1 0.75 West 32.0 270.0 90.0 1.800	1,800 0,680 0,68 0,000 0,000 0,920 1,000 1,000 0,00
Distribution domers 92.0 20.0 90.0 1,000	1,800 0,800 0,80 0,000 0,000 1,000 1,000 1,000
Name Efficiency, - lavest Ground construction	
DHW distribution	U, W/m²K B_g_h, - B_g_c, - Invest/m²
Emission   Floor   1726.0	0,600 0,30 0,30 0,00
Name Efficiency, Invest	elana olta alta olta
Water taps 1 0 General AHU	
Water taps 1 0 Fractions of time, -	1
Tops and showers 1 0 Temp. rise by funs, *C	0
Invest	0
Gymnavium Dhw System Heating part	
Factor on fuel consumption 0 Active	false
Use Solar Collector No Supply temp *C	0
Generator eff, and load contribution Mechanical ventilation, m <sup>1</sup> /s	0
Name Efficiency, Foel Invest Jan Feb Mar Apr May Jun Jul Ang Sep Oct Nov Dec	0
Distribution Recirc factor, -	0
Name Efficiency, Invest Cooling part	
Emission Active	false
Name Efficiency. Invest Supply temp., *C	0
Mechanical ventilation, m <sup>1/3</sup>	0
Cool rec. etc.	0
Position in the desired best among in 1964 V	0
Specific internal condition and finish Wind V	
Active Active	false
In Torre Cooking 10	0
Libring Et. mill. recovery.	0
Lighting         Auxiliary fan energy           Total installed lighting power, W         17260	
Total installed lighting power, W 17260  Disylight time usage per year for lighting, hours 700	0
Non-ductible time mane not year for liabeling hours	
Declinit dependency factor for highing .	General Heating System
Lowyagan unpersonant protector for lighting.   Derw	General Dhw System
Fraction not removed by exhaust ventilation, - 0 Assembly hall heating system	
Emergency lighting charging energy no Eactor on field consumption.	1
Lighting controls stand-by energy no Use Solar Collector	No
Invest 0 Aux energy and operation time fraction	
Heat Freduction / Fraction of time   Name   P_Sump,   \( \xi_{\text{visit}} \) \( \xi_{v	Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Occupants, W/m <sup>2</sup> 25 Heating Ave. 0.3 1 1 1	1 1 1 0.75 0.1 0 0 0.5 1 1 1
Fraction Persons present, 0,14	1 1 1 1 1 1 1 1 1 1 1 1 1 1
Appances, w/m² 2.2	
Friction Appliances are on U.S Name Efficiency, - From invest	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Airflow rate  Generator 1,04 I Natural gas, high energy	1 1 1 1 1 1 1 1 1 1 1 1
Infiltration, m <sup>3</sup> /s 0,5	
Natural vent, m/s 0,6	
Fraction Nat Vent is present, - 0,17  Name Hearing distribution efficiency	Efficiency. Invest
Demestic not water	v./ 0
Average DHW consumption, m/m/year 0,02 Emission	Efficiency Invest
Boiler Temp. <sup>1</sup> C 72 Name  Having only in youNtsign	
Cold-water Temp, °C 8	0.85
Opaque Construction General Heating System	
- Parket State of the Control of the	1
Name Area, m' Orientation, deg deg U. W.mr. Algens, m'K/W F_n. F_o. F_s. Investim'	
Facedes, 217.5 90.0 90.0 0.600 0.80 0.04 0.850 0.850 1.000 0.00 Use Solar Collector	No
Aux energy and operation time fraction	
West Name P. grunp. G. contr Jan 1	Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Gables, 173.0 0.0 90.0 0.600 0.80 0.04 0.850 1.000 0.950 0.00 Heating Aux 0.3 1 1	1 1 1 0.75 0.1 0 0 0.5 1 1 1
	4 4 4 4 4 4 4 4 4 4 4 4
South 1470 1600 700 000 000 1000 1000 000	
Roof, Eist 923,0 90,0 20,0 0,300 0,80 0,04 1,000 1,000 0,00 Name Efficiency, COP. Fuel Invest	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Roof West 923.0 270.0 20.0 0.300 0.80 0.04 1.000 1.000 1.000 0.00 Gas 1.04 1 Natural gas, 0 light energy	1 1 1 0,75 0,1 0 0 0,5 1 1 1 1
Demers 44 000 000 000 000 000 000 1000 1000 000	1 1 1 2 2 1 2 1 3 1 4 4 4
Esst Distribution	
Dromers 15.0 270,0 90,0 0,300 0,20 0,04 1,000 1,000 0,00 Name	Efficiency, Invest
	0,8
Distribution system	
Transparent construction  Emission system  Emission system	
Transparent construction	Efficiency, Invest
Transparred construction	0.9
Transparent construction	
Transparent construction	0.9
Transparent construction	0,9
Transpared construction	0.9



Use Solar Collector					1					No	Mechanical venti	lation, m <sup>1</sup> /s				
Generator eff. and	load contr	ibution									Heat rec. eff, -					_
Name	Efficienc	y I	nel In	vest Jan	Feb M	ar Apr Ma	y Jun :	Jul Aug	Sep Oct	Nov Dec	Recirc. factor, -					
Gas		0.85 Natural	gas,	0 1	-,1	1 0.75	1 0.75	0 0.75	1 1	1 0.75	Cooling part					Т
boiler+exchanger	<u> </u>	high ene	rgy	<u> </u>		1 0,73	0,73	0 0,75	' '	1 0,73	Active					_
Distribution											Supply temp., °C					_
Name			$\perp$			Efficienc	y. •			Invest	Mechanical venti	lation, m <sup>1</sup> /s				
DHW distribution							0,5			0	Cool rec. eff, -					_
Emission											Recirc. factor, -			_		_
Name						Efficienc	y			Invest	Humidification	part		_		
Water taps							1			0	Active					_
Water taps			$\top$				1			0	Hum. supply air,	adea.				_
Taps and showers			$\top$				1			0	Eff. hum. recover					_
																_
Gymnasium Dhw											Auxiliary fan en					_
Factor on fuel const					$\perp$					0	Spec. electricity of	cons. for fans, Ws/m	1"			_
Use Solar Collector	r									No	Systems					
Generator eff. and	load contr	ibution									Heating					
Name 1	Efficiency, -	Fuel	Inve	st Jan I	eb Mar	Apr May	Jun J	nl Ang !	Sep Oct	Nov Dec	Assembly hall be					_
											Assembly hall h	eating system		_	_	_
Distribution											Factor on fael co	nsumption, -				
Name						Efficienc	y			Invest	Use Solar Collect	tor				
Emission											Aux energy and	operation time fra	ction			_
Name			Т			Efficienc	y			Invest	Name	p_pump. W/m²	f_contr, -	Jan	Feb	N
												$\rightarrow$	I_const, -	780	reo	
Zone: Assembly h:	ell .										Heating Aux	0,3	1	- 1	- 1	
Gross area, m <sup>2</sup>										450	Generator eff. a	nd load contributio	9B			
Specific internal he	at capacity.	kJ/m² K								260	Name E	fficiency, - COP.		nel Inve	est Jan	T
Specific internal co					$\neg$					9,2						1
Int Temp Heating.					$\neg$					22	Generator	1,04 1	Natural g high ener	as,	0 1	1
Int Temp Cooling.					$\neg$					24	Distribution		mga tare	87	_	-
Lighting					_									_		_
		n.			_					20000	Name			+		_
Total installed light					+						Heating distribut	ion efficiency				_
Daylight time usage					+					200	Emission					
Non-daylight time t			hours		+					200	Name			$\perp$		
Daylight dependent		lighting			+					1	Heating coil in ve	entilation				
Occupance factor fo					-					1						_
Fraction not remove					_					0	General Heating					_
Emergency lighting	charging er	nergy			$\rightarrow$					во	Factor on fuel co	nsumption, -				_
Lighting controls st	and has seen				- i						Use Solar Collect					
Invest	ana-oy ener	¥y			+					по						_
										- 0	Aux energy and	operation time fra	ction	_	_	_
Heat Production /	Fraction of	time			_						Name	p_pump, W/m <sup>2</sup>	f_contr, -	Jan	Feb	N
Occupants, W/m <sup>3</sup>					$\bot$					130	Heating Aux	0.3	1	1	1	_
Fraction Persons pr	esent, •				$\perp$					0,05		nd load contribution	_			_
Appliances, W/m <sup>2</sup>					_					0		COD				_
Fraction Appliance	s are on, •									0	Name Efficie	ncy, COP.	Fuel	Invest	Jan	F
Airflow rate											Gas	1,04 1 N	latoral gas,		1	_
Infiltration, m <sup>3</sup> /s					$\neg$					0,5	boiler	1,04 1 h	igh energy	L °	<u>''</u>	
Natural vent, m <sup>5</sup> /s					$\neg$					0	Distribution					
Fraction Nat Vent i	s present, -				$\neg$					0	Name					
Domestic hot water					_						Distribution syste	em		$\Box$		
Average DHW con		Man2/source			$\neg$					0,04	Emission					_
Boiler Temp, *C	mangaran, m	· · · · · · · · · · · · · · · · · · ·			+					72	Name			$\top$		_
Cold-water Temp.,	00				+					8	Radiators			+		_
Coto-water Femp.,											Radiators			+		_
Opaque Construct	tion													_		_
	$\overline{}$		Tilt,			R. se.					General Dhw Sy	stem				_
Name Are	ea, m² C	rientation, deg	deg	U, W/m/K	Alpha	R_se, m <sup>2</sup> K/W	F_h, •	F_0, -	F_f, •	Invest/m <sup>2</sup>	Factor on fael co	nsumption, -				_
Ext walls,																_
South	29,0	180,0	90,0	0,600	0,1	80 0,04	0,850	1,000	1,000	0,00	Use Solar Collect	tor				
Roof, West	251,0	270,0	30,0	0,300	0,1	80 0,04	1,000	1,000	1,000	0,00	Generator eff. a	nd load contributio	9 <b>0</b>			
Roof. East	251,0	90,0	30,0	0,300	0,1	80 0,04	1,000	1,000	1,000	0,00	Name	Efficiency, -	F	nel Inve	est Jan	Т
											Gas	0.04	Natural g	235,	$\neg$	.†
Transparent const	truction										boiler+exchanger	0,85	high ener	gy	0 1	1
	Orientation,	Tilt. deg U.	W/m³K	U_s, W/m <sup>2</sup>	G_g.	G_g_s, F_s,	F_with,	F_h, F	o. F_f	Invest/m²	Distribution					
DH.	deg	100	_	_	1			++	1		Name					_
Double facade 120,0	0,0	90,0	1,120	1,12	0,500	0,50 0,000	0,00	0,900 1,0	00 0,950	0,00	DHW distribution	n				_
					_						Emission			_		_
Ground constructi	ion										Name			$\top$		_
Name		Area, n	92	U, W	m²K	B_g_	h. •	B_g_c,		Invest/m²	Water taps			+		_
Floor		450,	.0	-	,600		,30	0,3	0	0,00	Water taps			+		_
			_											+		_
Assembly half ven	tilation										Taps and shower			_		_
Fraction of time, -										0,48	Gymnasium Dh	w System				_
Temp. rise by fans,	°C									1,4	Factor on fuel co			_		_
Invest										0	Use Solar Collect					_
Heating part																_
Active					Т					true		nd load contribution	_	1		-
Supply temp., °C					$\neg$					18	Name	Efficiency, - Fu	261	Invest	Jan	F
					$\rightarrow$						Pro					

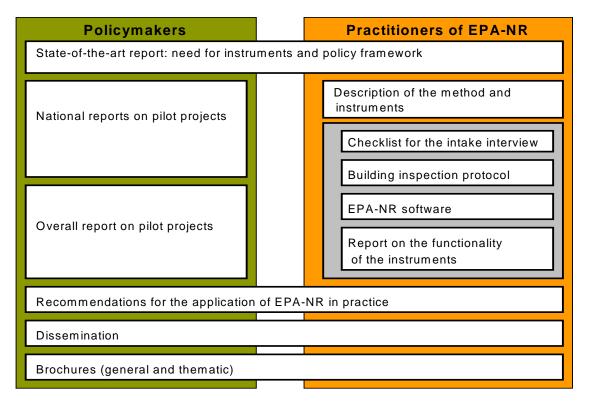
Mechanical ve	ennianon.																	
Heat rec. eff, -								$\perp$										-
Recirc. factor,																		
Cooling part																		
Active																		fal
Supply temp.,	°C																	
Mechanical ve	entilation,	m³/s																
Cool rec. eff,																		
Recirc. factor,																		
Iumidificatio	on part																	
Active			_					Т					_	_		_		fal
Hum. supply a	ir. s/ks							+						_				_
iff. hum. reco								+							_			
Auxiliary fan Spec. electrici			77.5					_						_	-			250
	iy cous. is	et tetts,	WSIII					_						_	-			
systems								_						_	-			_
Heating														Asse	mbl	y hall	heating	syste
Assembly hal	I heating	system	_											_	_			_
			_					-					_	_	_	_		_
Factor on fuel		tion, -						4										
Jse Solar Coll	lector																	
Aux energy a	nd operat	tion tin	ne fra	ction														
Name	P.J	pump, W/m²	-	_contr, -	Jan	Feb	Mar	Apr	Ma	y Ju	n ,	al /	lug	Sep	Г	Oct	Nov	De
	-		H	$\rightarrow$	_	-	—	-	-	_	-	_	-	_	⊢	_		_
Heating Aux		0,3	_	1	1	- 1	_		0,7	5 0,	1	0	0	0,5	_	1	1	_
Generator eff	f. and lose	$\overline{}$	$\overline{}$	a	_		_	_	_	_			_	_	_		_	_
Name	Efficienc	y	OP.	F	nel Inv	est J	on F	eb Ma	r Ap	r May	Jun	Jul	Au	s	iep	Oct	Nov	De
-	_	$\rightarrow$	-	Natural g	-	+	+	+	-	+	$\vdash$	$\vdash$	-	┰	⊣	_		$\vdash$
Generator	1	1,04	-1	high ener	зу	0	1	1	1	1 1	1	1		L	1	1	1	
Distribution																		
Name					Т				E	fficiency								Inve
Heating distrib	bution effi	ciency									.7							
Emission					_						_				_			
Same					_					fficiency					_			
	a vocazillazio	20			+				E						_			
Heating cost ii	a ventilatio	en.								0,								Inve
																		Inve
General Heat	ing Syste	m						_	Ε									Inve
General Heat	ing Syste	m						= T										Inve
General Heat Factor on fuel	ing System	m																
General Heat Factor on fuel Use Solar Coll	ing System consumpt lector	m tion, -	ne fra	ction					Ε									
General Heat Factor on fisel Use Solar Coll Aux energy a	ing System consumpt lector nd operat	m tion, -	$\overline{}$	$\neg$			T v.			0.	85							N
General Heat Factor on fisel Use Solar Coll Aux energy a Name	ing System consumpt lector nd operat	m tion, - tion tin pump. W/m²	$\overline{}$	_contr	Jan	Feb	Mai	_	Ma	у Ји	85 n J	_	Aug	Sep		Oct	Nov	N De
General Heat Factor on fisel Use Solar Coll Aux energy a	ing System consumpt lector nd operat	m tion, -	$\overline{}$	$\neg$	Jan 1	Feb 1	_	-	Ma	у Ји	85 n J	nd /	Aug 0	Sep 0,5		Oct 1	Nov 1	N De
General Heat Factor on fisel Use Solar Coll Aux energy a Name Heating Aux	ing System consumpt lector nd operat	m tion, - tion tin pump. W/m² 0,3	-	Contr		_	_	-	Ma	у Ји	85 n J	_	_	_	L	_		N De
General Heat Factor on fisel Use Solar Coll Aux energy a Name Heating Aux Generator eff	ing System consumpt lector nd operat P_1	m tion, - tion tin pump. W/m² 0,3	-	Contr		1		-	May 0,7	y Ju	85 n J	0	0	0,5		1		N De
General Heat Factor on fuel Use Solar Coll Aux energy a Name Heating Aux Generator eff Name Effi	ing System consumpt lector nd operat	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	1	_	_		Ma	у Ји	n J	_	_	_		_	1	N De
General Heat Factor on fuel Use Solar Coll Aux energy a Name Heating Aux Generator eff Gas	ing System consumpt lector nd operat P_1	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	1	1			May 0,7	y Ju	n J	0	0	0,5 Se		1	1	N De
General Heat Factor on fuel Use Solar Coll Aux energy a Name Heating Aux Generator eff Gas boiler	ing System consumpt lector nd operat P.J f. and loac ciency.	tion, - tion tin pump, W/m² 0,3	ibutio	Contr	Invest	Jan	Feb	Mar	May 0,7	y Ju 5 0,	n J	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	N De
General Heat Factor on fuel Use Solar Coll Aux energy a Name Heating Aux Generator eff Solar Solar Distribution	ing System consumpt lector nd operat P.J f. and loac ciency.	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	Invest	Jan	Feb	Mar	May 0,7.	y Ju 5 0, May 0,1	n J	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	N De
General Heat Factor on finel Use Solar Coll Use Sol	ling System consumpt lector nd operat P_3  L and loac ciency 1,04	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	Invest	Jan	Feb	Mar	May 0,7.	y Ju May 0,1	n J	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	De De
General Heat Factor on finel Use Solar Coll Use Solar Coll Aux energy a Name Heating Aux Generator eff Gas Local College Distribution Name Distribution sy	ling System consumpt lector nd operat P_3  L and loac ciency 1,04	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	Invest	Jan	Feb	Mar	May 0,7.	y Ju May 0,1	n J	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	De De
General Heat Factor on fuel Lise Solar Coll Aux energy a Name Heating Aux Generator eff Name Effi Soliter Distribution Name Distribution sy	ling System consumpt lector nd operat P_3  L and loac ciency 1,04	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	Invest	Jan	Feb	Mar	Ma; 0,7. Apr 0,75	y Ju May 0,1	Jen 0	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	Do Inve
General Heat Factor on fuel Use Solar Coll Aux energy a Name Heating Aux Generator eff Gas Doiler Doiler Distribution Name Emission Emission Name	ling System consumpt lector nd operat P_3  L and loac ciency 1,04	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	Invest	Jan	Feb	Mar	Ma; 0,7. Apr 0,75	y Ju y Ju May 0,1	Jun 0	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	De De Inve
General Heat Factor on fuel Use Solar Coll Aux energy a Name Heating Aux Generator eff Gas Foller Distribution Name Distribution sy Entitles Entitl	ling System consumpt lector nd operat P_3  L and loac ciency 1,04	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	Invest	Jan	Feb	Mar	Ma; 0,7. Apr 0,75	y Ju y Ju May 0,1	Jun 0	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	Do Inve
General Heat Factor on fuel Use Solar Coll Aux energy a Name Heating Aux Generator eff Gas Doiler Doiler Distribution Name Emission Emission Name	ling System consumpt lector nd operat P_3  L and loac ciency 1,04	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	Invest	Jan	Feb	Mar	Ma; 0,7. Apr 0,75	y Ju y Ju May 0,1	Jun 0	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	Do Inve
General Heat Factor on fisel Use Solar Coll Aux energy a Name Heating Aux Generator off Name Effs Gas boiler Distribution Name Emission Name Radiators Radiators	lector P.J. L. and lossos; 1,04	tion, - tion tin pump, W/m² 0,3	ibutio	Confr	Invest	Jan	Feb	Mar	Ma; 0,7. Apr 0,75	y Ju y Ju May 0,1	Jun 0	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	Do Inve
General Heat Factor on fisel Use Solar Col Aux energy a Name Heating Aux Generator eff Name Effi Solar Distribution Name Distribution Name Radiances Radiances Radiances	lector lector P.J. A. and load operation of the control of the control operation operation of the control operation opera	m tion, - tion tin pump, W/m² 0,3 d control 1	ibutio	Confr	Invest	Jan	Feb	Mar	Ma; 0,7. Apr 0,75	y Ju y Ju May 0,1	Jun 0	Jul	0 Ang	0,5 Se	EP	1 Oct	Nov	D
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## **Project Description**

EPA-NR is a project in the framework of the 'Intelligent Energy – Europe' Programme (IEE) of the European Commission. EPA-NR provides an assessment method for the Energy Performance Certificate according to the Energy Performance of Buildings Directive (EPBD) and offers additional advice for existing non residential buildings. The project, in which seven EU Member States are participating, is co-ordinated by EBM-consult, The Netherlands. It started in January 2005 and will last for two years.

The EPA-NR method consists of an energy calculation model and process supporting tools like inspection protocols, checklists and building component libraries. The EPA-NR method produces an Energy Performance Certificate for non-residential buildings with the possibility for additional advice. The two major target groups are policy makers and practitioners who are each addressed with a tailored set of deliverables.



#### The EPA-NR method:

- is in line with the EPBD and CEN-standards
- takes into account the local framework with respect to legislation, technical aspects, designand building maintenance processes and acceptance by actors in the market
- is modular and flexible and therefor easily adjustable to the national context, the diversity in the market and new or modified CEN-standards
- is tested through pilot projects in seven EU Member States
- can be further developed and maintained at low cost due to the joint efforts
- offers additionally policy recommendations addressing all levels of authorities in Europe
- quarantees simple transfer to all EU Member States



# **Project Partners**



Project Co-ordinators: EBM-Consult (The Netherlands)

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Ein Unternehmen der Austrian Research Centers.

#### arsenal (Austria)

Österreichisches Forschungs- und Prüfzentrum Arsenal Ges.m.b.H.



#### ÖÖI (Austria)

Österreichisches Ökologie Institut



#### SBi (Denmark)

Danish Building Research Institute



#### **CSTB** (France)

Centre Scientifique et Technique du Bâtiment



# Fraunhofer Institut

Institut Bauphysik

#### Fraunhofer-IBP (Germany)

Fraunhofer-Institut für Bauphysik



#### NOA (Greece)

GRoup Energy Conservation (GR.E.C.) Institute for Environmental Research & Sustainable Development (IERSD) National Observatory of Athens



#### **ENEA** (Italy)

National Agency for New Technology, Energy and the Environment



#### **TNO (The Netherlands)**

Netherlands Organisation for Applied Scientific Research