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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: Kim B. Wittchen Danish Building Research Institute, SBi Hørsholm, Denmark Telephone: +45-45-742 379 Email: kbw@SBi.dk





# Pilot study – Educational building

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Date: June 2007

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#### www.epa-nr.org

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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.



#### Education building, Stengård School 2

## 2.1 Project summary Stengård primary and lower secondary school, Gladsaxe Contractor: Gladsaxe Municipality. Type of building: Education Short description: The scattered buildings at Stengård school consists 6 terraced Location: Scattered urban environment of similar buildings with most of the class rooms. The height gymnasiums are located in an individual building. The school is owned by Gladsaxe Owner: Public municipality. The buildings are oriented Year of construction: 1950-52 along a North-West axis and the rooms are thus oriented either South-West or North-Total gross area (m<sup>2</sup>): 12,995 m<sup>2</sup>

Total conditioned area (m<sup>2</sup>): 7,702 m<sup>2</sup>

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.

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 gym- nasiums and assembly hall while there is exhaust ventilation in the rest of the heated area.
tem has bee	nagement: An energen installed recently. Insumption year 200		<i>Previous refurbishment:</i> Almost all windows have been replaced with low energy win- dows. Old roof insulation (100 mm) has been replaced with new 125 mm mineral
	The building (According the bills)	National average ( <i>if known</i> )	wool. Thermostat valves have been intro- duced in all rooms. New condensing natural
Fuel	147.4 kWh/m <sup>2</sup>	125.9 kWh/m <sup>2</sup>	gas boiler has replaced an old one.
Electricity	16.5 kWh/m²	22.3 kWh/m <sup>2</sup>	No further major refurbishments have
Water	0.18 m³/m²	0.24 m <sup>3</sup> /m <sup>2</sup>	been undertaken, but continuous, minor improvements of the energy performance
			are being made.
			<i>Planned refurbishment:</i> Update of the heat- ing system, installation of energy manage- ment system, new lighting system.

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

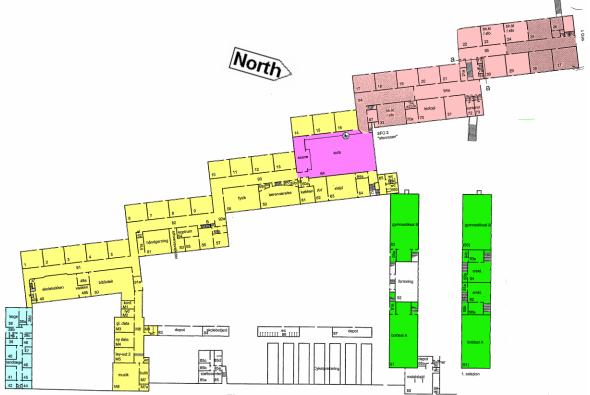


Figure 1. Plan of Stengård school. The colours indicate: Green – gymnasium (ground and 1<sup>st</sup> floor); Pink – after-school centre; Yellow – educational areas; Purple - assembly hall; Blue – School dentist and doctor; White – service areas, metal workshop, and arts class.

#### 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.

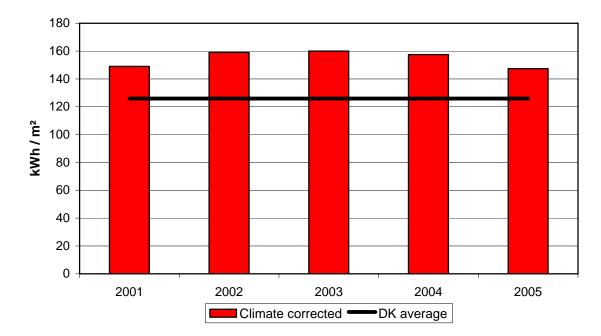
#### Light:

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.

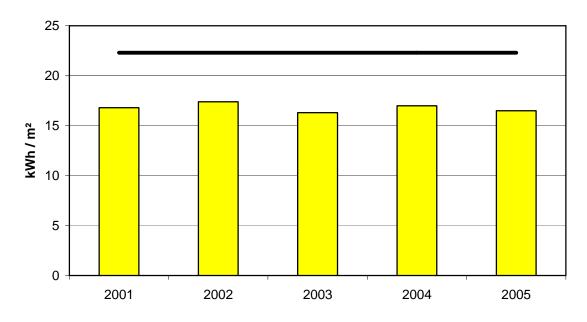




2.2.1.2 Heating consumption

Figure 2. Climate adjusted heating consumption in kWh/m<sup>2</sup> 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 %.

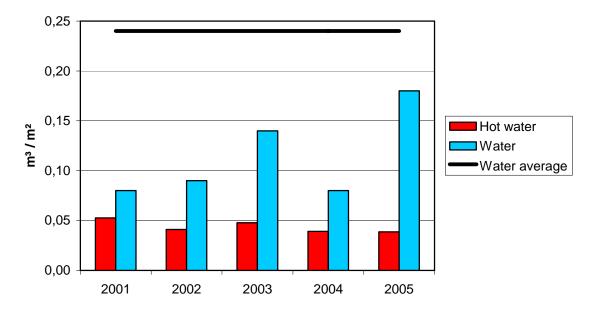


2.2.1.3 Electricity consumption

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 m<sup>3</sup>/m<sup>2</sup> 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 m<sup>3</sup> (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. Stengård 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 m<sup>2</sup>),
- 3. Zone 3: After-school centre (1726 m<sup>2</sup>),
- 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 m<sup>2</sup>),
- 7. Support centre for pupils with special needs (108 m<sup>2</sup>).



#### 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:

	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: kWh/m²/year	CO <sub>2</sub> emission of the building: kg/m <sup>2</sup> /year
203.98	25.7

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

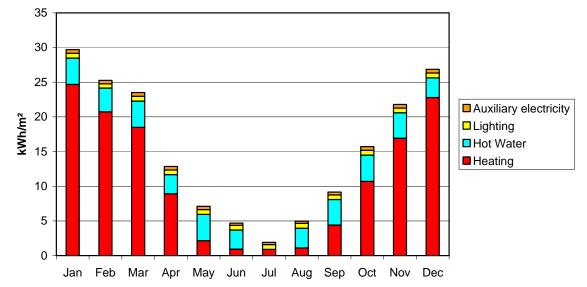
i intar ontor gy c	iomana, primary onorgy ac		
	Annual final energy con-	Primary energy con-	CO <sub>2</sub> emission of the
	sumption* of the building	sumption of the building:	building:
	per fuel type:	kWh/m²/year	kg/m²/year
Natural gas	1053,79 MWh/year	169.86	16.1
Electricity	211,72 MWh/year	13.65	9.6

\* 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).

	A	nnual losse	S	Annual gains										
Total heating kWh/m <sup>2</sup>	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 improvement2.3.1 Scenario 1 - Derease of DHW circulation temperature

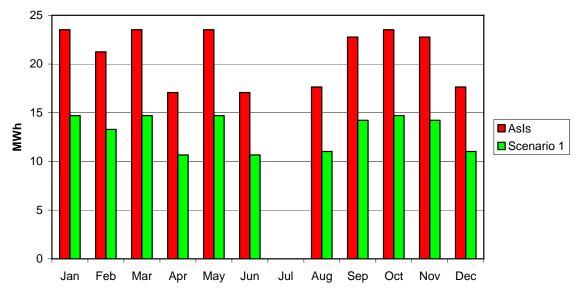
#### 2.3.1.1 Background and proposed solution

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.



#### DHW



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.

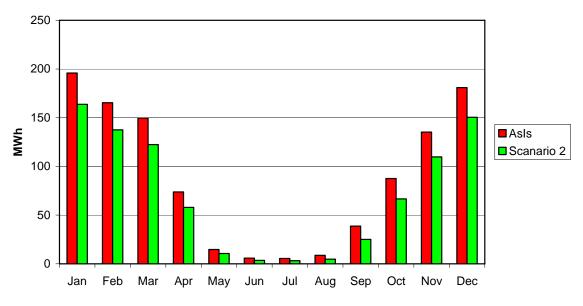
## 2.3.2 Scenario 2 – Upgrade of roof insulation to 300 mm incl. replacement of 10 % of the existing insulation

#### 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 m<sup>2</sup>, 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  $\leq$  26000. The corresponding investment accounts for about  $\leq$  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

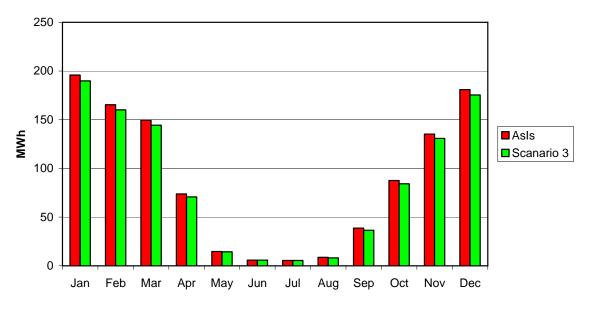
This energy saving measure is highly recommended from a total economy point of view.

### 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  $\in$  8700. The corresponding investment accounts for about  $\in$  83000. The simple pay-back time for this measure is calculated to be about 9 years.

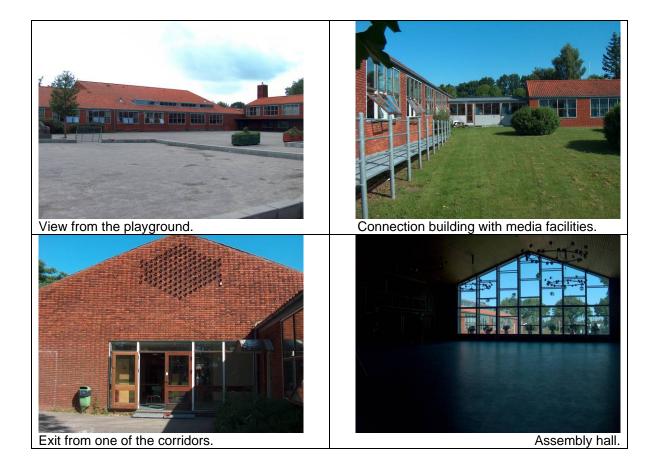
#### 2.3.3.2 Recommendation

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.













Dis-placed and compressed roof insulation.

Heat exchanger and control system for domes-tic 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:

1	3
2	4

## 4.1 Educational building, Stengård school

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Occupance fa	ctor for	lighting												1	Supply temp.																
Fraction not r	emoved	by exhaust ve	ntilation	a										0		ntilation, m <sup>3</sup> /s															
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Fraction Appl		re on												0.4		ty cons. for fan	Ws/m <sup>3</sup>			_		<u> </u>									0
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West facades	_	373,5			90,0	0,60		0,80	<u> </u>	_	0,900		_	0,00				_		⊢	+-	-	<u> </u>	-	+-	+	+-	+	+	+	+
South facades	<u> </u>	312,5		180,0	90,0	0,60	9	0,80	<u> </u>	0,04	0,900	0,900	0,700	0,00	Generator	1,04		ural gas,	0		4	1	1	ļ '	1	1	1	1	1	1	1
North Facades	1	221,0		0,0	90,0	0,60	•	0,80		0,04	0,900	0,900	0,850	0,00			hig	energy													
Roofs	+	2983.0		90,0	20,0	0,30		0,80	-	0.04	1,000	1.000	1.000	0,00	Distribution																
Dormers	+	19,5			90,0	0,30		0,20	-	_	1,000	_	_	0,00	Name								Eff	ficiency	_						Invest
	-						<u> </u>			.,					Heating distri	ution efficienc	y							(	0,7						0
Transparent	constru	ction													Emission																
Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m <sup>2</sup>	< w	U_s. G	.e. G_	8_5. F	- <u>`</u>	F_with, •	F_h.	F_0,	F_f	Invest/m <sup>2</sup>	Name Heating coil i	ventilation		_					Eff	ficiency 0	y, = .85						Invest
East windows	122,4	90,0	90,0	1,80	0	1,800 0,0	\$80 (	0,68 0,0	00	0,000	0,800	0,850	0,950	0,00						_				0,	~~	_	_	_	_		
East doors	34,0	90,0	90,0	2,00	0	2,000 0,7	700 (	0,70 0,0	00	0,000	0,800	0,750	0,950	0,00	General Hea							_									
West windows	158,4	270,0	90,0	1,80	0	1,800 0,0	580	0,68 0,0	00	0,000	-	0,850	-	0,00	Factor on fael Use Solar Col	consumption, - lector						$\vdash$									1 No
South	45.5	180,0	90,0	1.80	0	1.800 0,/	\$80 (	0,68 0,0	00	0,000	0,900	0.950	0,800	0.00		nd operation t	me fraction									_	_	_	_		
windows South doors	39,0	180,0	90,0	2,00		2,000 0,0	_	0,60 0,0	_		0,900			0,00	Name	p_pump W/m	f_con	a	lan	Feb	Mar	Apr	May	Ju	m	Jul	Aug	Sep	Oct	Nov	Dec
North windows	48,2	0,0	90,0	1,80	0	1,800 0,0	580	0,68 0,0	00	0,000	0,900	0,500	0,900	0,00	Heating Aux	0,3		1	1	1	1	1	0,75	0,	.1	0	0	0,5	1	1	1
Nort Doors	8,0	0,0	90,0	5,00	0	5,000 0,2	820	0,85 0,0	00	0,000	0,900	0,300	0,850	0,00		and load con				1	Feb	Me	4	<u>,</u>	-					t No	
Ground cons	tractice															ciency, -		Fuel In	est	Jan	140	Mar	Apr	May	768	Jul	I Aug	8 Se	p Oc		v Dec
Name			Arei	8, m <sup>2</sup>	U, 1	W/m²K		B_8	.h.•		B_8	_c, -		Invest/m <sup>2</sup>	Gas boiler	1,04	Natural high er		0	1	1	1	0,75	0,1	0	0	0,5	5	1	1	1 1
		1		1		-i														_											



Name				E.07	1			Transparent	_	dana dan											1 1	-	
				Efficiency,			Invest	Name	Area, C m <sup>2</sup>	rientation, deg	Tilt, deg	U, W/m²K	÷ ,	U_8, V/m <sup>2</sup> K	9_8_0	1.8.5	F_8,	F_	with, -	. F_h,	F_0,	· 3_3	Inv
Distribution system				0,	8		0	South					<u> </u>	-	+	-	-			1	+	-	
Emission								South windows	65,6	180,0	90,0	3,000	1	3,000	0,400	0,40	0,000		0,000	0,950	1,000	0,950	
Name		1		Efficiency,			Invest	South doors	14,0	180,0	90,0	5,000	<u> </u>	5,000	1 500	0,50	0.000		0,000	0.050	0,600	0,950	_
									24,0	19/0	30,0	5,000	-	2000		3,70	0,000		0,000	0,930	3,000	0,990	
Radiators				0,			0	North windows	45,5	0,0	90,0	3,000		3,000	0,400	0,40	0,000		0,000	0,600	1,000	0,950	
Radiators				0,	2		0							_	_	_	_			_		_	_
								North doors	4,0	0,0	90,0	5,000	2	5,000	0,500	0,50	0,000		0,000	0,500	0,700	0,950	
General Dhw System	n																						
Factor on fael consum	notion. •						1	Ground conv	truction														
	4		<u> </u>				No	Name			Area, r	12	U	$W/m^2K$		E	3_g_h	·		B_8	c		Inv
Use Solar Collector							NO	Floor			620	0		0,600	_		0,25	1			0,25		_
Generator eff. and lo	oad contribution											~						<u> </u>			1,87		
Name	Efficiency, - Fi	sel Invest Jan	Feb Mar	Apr May	Jun Jul	Aug Seg	Oct Nov Dec	Gymnasium	A here														
Gas	0.85 Natural g								_				_			_	_	_				_	
boiler+exchanger	0,85 Nation g high ener	8y 0 1		0,75 1	0,75 0	0,75	1 1 0,75	Fraction of ti	ne, •														
Distribution								Temp. rise by	fans, °C														
								Invest															
Name				Efficiency,	·		Invest						-	_	_	-	-	-				-	
DHW distribution				0,	5		0	Heating part							_								
Emission								Active															
Lantinou					-			Supply temp.	°C														
		1			1										_								
Name				Efficiency.	· [		Invest	Mechanical v		m <sup>1/s</sup>													
Water taps					1		0	Heat rec. eff.															
Water taps		1			1		0	Recirc. factor															
Taps and showers		1			1		0												_				_
s sha una anomera		1			· I		0	Cooling part															
C								Active															_
Gymnasium Dhw Sy	·							Supply temp.	°C														
Factor on fuel consum	uption, -						0	Mechanical v		m <sup>3</sup> /s													_
Use Solar Collector							No								-								_
Generator eff. and lo	and controller street		<u> </u>					Cool rec. eff,															
					_			Recirc. factor															
Name Eff	ficiency, - Fuel	Invest Jan	Feb Mar	Apr May	Jun Jul	Aug Sep	Oct Nov Dec	Humidificati											_				_
Distribution									- tear														
Name		1		Efficiency.			Invest	Active															
				Elikiency,			mvest	Hum. supply	ir, g/kg														
Emission								Eff. hum. rec	wery, -														
Name				Efficiency.			Invest												_				_
								Auxiliary fa															
Zone: Gymnasium								Spec. electric	ty cons. fe	e fans, Ws/	n'												
								Systems															
Gross area, m <sup>2</sup>			$\rightarrow$				1240														0	and M.	and and the
Specific internal heat	capacity, kJ/m <sup>2</sup> K						240	Heating							-							eral Hea	_
Specific internal coupl	pling coefficient, W/m2 K						9,2	Dhw								_					(	eneral I	Dhw S
			_																				_
Int Temp Heating, "C			i				22	Assembly ha															
			$\rightarrow$												_								
Int Temp Cooling, °C	2						30	Factor on fae	consumpt	ion, -													
Lighting								Use Solar Co	lector														
Total installed lighting	a romar W						6200	Aux energy	nd covered	ion time fr	ection												
			$\rightarrow$					Aux energy	T		Retton	_	_		_	_		_	_	_	_	_	_
	per year for lighting, hours						875	Name	19	W/m <sup>2</sup>	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	5	74 /	Aug	Sep (	201 2	Nov
Non-daylight time usa	age per year for lighting, h	otes					265			0.3					-+				+-	-		+	-+
Daylight dependency :	factor for lighting						1	Heating Aux			1	'	'	- 1	- 1	0,75	0,1		0	0	0,5	1	- 1
Occupance factor for I							1	Generator ef	f. and load	l contribut	ion												
			$\rightarrow$							COP.			Τ.						<u> </u>				
Fraction not removed	by exhaust ventilation, -						0	Name	Efficienc	y		oel Inve	st Ja	Feb	Mar	Apr	May	Jun	Jul	d Aug	Sep	Oct	Nov
							по						-	_					<u> </u>				_
	charging energy										Natural	235.			1	1	1	1	1	1	1	1	1
Emergency lighting ch							no	Generator	1	1,04 1	Natural high end	gas, rgy	0	1				_		-			_
Emergency lighting ch Lighting controls stan			$\rightarrow$				no	Generator	1	1,04 1	Natural high end	gas, rgy	0	1									
Emergency lighting ch Lighting controls stan Invest	nd-by energy							Distribution	1	1,04 1	Natural high en	gas, rgy	0	1		p.or		_				_	
Emergency lighting ch Lighting controls stan	nd-by energy						no	Distribution Name		_	Natural high en	gas, rgy	0	1		Effs	iency, -	·					
Emergency lighting ch Lighting controls stan Invest	nd-by energy		<u>+</u>				no	Distribution		_	Natural high end	gas, rgy	0	1		Effic	iency, - 0,7	-	_				_
Emergency lighting ch Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup>	nd-by energy 'raction of time						no 0 20	Distribution Name		_	Natural high end	gas, rgy	0	1 1		Effic		7	_				
Emergency lighting ch Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup> Fraction Persons prese	nd-by energy 'raction of time						no 0 20 0,1	Distribution Name Heating distri Emission		_	Natural high en	gas, rgy	0	1		_	0,7	· /					_
Emergency lighting ch Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup> Fraction Persons preso Appliances, W/m <sup>2</sup>	nd-by energy raction of time sent, -						no 0 20 0,1 2	Distribution Name Heating distri Emission Name	bution effi	ciency	Natural high end	gas, rgy	0	1		_	0,7	·					_
Emergency lighting ch Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup> Fraction Persons preso Appliances, W/m <sup>2</sup>	nd-by energy raction of time sent, -						no 0 20 0,1	Distribution Name Heating distri Emission	bution effi	ciency	Natural high end	gas, rgy	0	1		_	0,7	·					_
Emergency lighting ch Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup> Fraction Persons preso Appliances, W/m <sup>2</sup> Fraction Appliances at	nd-by energy raction of time sent, -						no 0 20 0,1 2	Distribution Name Heating distri Emission Name Heating coil i	bution effi	ciency m	Natural high eno	gas, rgy	0	1		_	0,7	·					_
Emergency lighting cl Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup> Fraction Persons press Appliances, W/m <sup>2</sup> Fraction Appliances at Airflow rate	nd-by energy raction of time sent, -						no 0 20 0,1 2 0,2	Distribution Name Heating distri Emission Name	bution effi	ciency m	Natural high en	gas, rgy	0	1		_	0,7	·					_
Emergency lighting of Lighting centrols stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup> Fraction Persons press Appliances, W/m <sup>2</sup> Fraction Appliances at Airflow rate	nd-by energy raction of time sent, -						no 0 20 0,1 2 0,2 0,2 0,5	Distribution Name Heating distri Emission Name Heating coil i	bution effi	ciency m	Natural high en	gas, rgy	0	1		_	0,7	·					_
Emergency lighting ch Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>3</sup> Fraction Persons press Appliances, W/m <sup>3</sup> Fraction Appliances an Airflow rate Infiltration, m <sup>3</sup> /s	nd-by energy raction of time sent, -						no 0 20 0,1 2 0,2	Distribution Name Heating distri Emission Name Heating coil i	bution effi a ventilatio ting System	ciency m	Natural high end	235, 1937	0			_	0,7	·					_
Emergency lighting cl Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup> Fraction Persons press Appliances, W/m <sup>2</sup> Encidon Persons press Appliances, W/m <sup>2</sup> Encidon Appliances and Airflow rate Infiltration, mV/s Natural vent, m <sup>3</sup> /s	nd-by energy raction of time ent, - are on, -						no 0 200 0,1 2 0,2 0,2 0,5 0,5	Distribution Name Heating distri Emission Name Heating coil i General Hea	bution effi a ventilatio ting System consumption	ciency m	Natural high end	235, 1937	0			_	0,7	·					_
Emergency lighting cl Lighting controls stan Invest Heat Production / Frr Occupants, W/m <sup>2</sup> Fraction Persons preses Appliances, W/m <sup>2</sup> Fraction Appliances at Altflow rate Infiltration, m/s Natural vent, m <sup>3</sup> /s Fraction Nat Vent is p	us-by energy raction of time went, - are on, -						no 0 20 0,1 2 0,2 0,2 0,5	Distribution Name Heating distri Emission Name Heating coll i General Hea Factor on fue Use Solar Col	bution effi a ventilatio ting System consumpt lector	ciency m m ion, -	high end	235, 1997	0			_	0,7	·					_
Emergency lighting cl Lighting controls stan Invest Heat Production / Far Occupants, W/m <sup>2</sup> Praction Persons preses Appliances, W/m <sup>2</sup> Praction Appliances as Appliances, W/m <sup>2</sup> Praction Appliances as Appliances, m <sup>3</sup> /s Infiltration, m <sup>3</sup> /s Natural vent, m <sup>2</sup> /s Fraction NAt Vent is p Denestic how water	nd-by energy raction of time ent, - ent, -						80 0 0.1 0.2 0.2 0.2 0.5 0.6 0.6	Distribution Name Heating distri Emission Name Heating coil i General Hea	bution effi a ventilation ing System consumpt lector and operation	ciency m ion, -	high end	235. 1937	0			_	0,7	·					_
Emergency lighting cl Lighting controls stan Invest Heat Production / Far Occupants, W/m <sup>2</sup> Praction Persons preses Appliances, W/m <sup>2</sup> Praction Appliances as Appliances, W/m <sup>2</sup> Praction Appliances as Appliances, m <sup>3</sup> /s Infiltration, m <sup>3</sup> /s Natural vent, m <sup>2</sup> /s Fraction NAt Vent is p Denestic how water	nd-by energy raction of time ent, - ent, -						no 0 200 0,1 2 0,2 0,2 0,5 0,5	Distribution Name Heating distri Emission Name Heating coll i General Hea Factor on fue Use Solar Col	bution effi a ventilation ing System consumpt lector and operation	ciency m ion, -	action		0 Feb	Mar	Apr	Effs	0,7	· •	24	Aug	Sep	× ,	_
Emergency lighting cl Lighting controls stan Invest Heat Production / Fr Occupants, W/m <sup>2</sup> Praction Appliances as Appliances, W/m <sup>2</sup> Praction Appliances as Airflow rate Infiltration, m <sup>3</sup> /s Natural event, m <sup>3</sup> /s Praction Appliances as Natural event, m <sup>3</sup> /s	nd-by energy raction of time ent, - ent, -						80 0 0.1 0.2 0.2 0.2 0.5 0.6 0.6	Distribution Name Hearing distri Emission Name Hearing coil i Factor on fine Use Solar Co Aux energy Name	bution effi a ventilation ing System consumpt lector and operation	ciency on m ion, - don time fr pump. W/m <sup>2</sup>	high end	ass, rgy	Feb	Mar	Apr	Effic	0,7 iency, - 0,85 Jun	· •				Det 2	
Emergency lighting ch Lighting controls stan Invest Heat Production / Frr Occupants, W/m <sup>2</sup> Fraction Appliances, W/m <sup>2</sup> Fraction Appliances Infiltration, m <sup>3</sup> /s Natural vent, m <sup>3</sup> /s Natural vent, m <sup>3</sup> /s Fraction Nat Vent is p Donestic hot water Donestic hot water Boiler Temp, "C	st-by energy raction of time ettl, - ettl, - are co., - prevent, - maption, m <sup>2</sup> /m <sup>2</sup> /yeer						80 0 20 0,1 2 0,2 0,2 0,5 0,6 0,5 0,6 0,3 0,6 0,3 7 2	Distribution Name Hearing distri Emission Name Hearing coil i Factor on fire Use Solar Co Aux energy i	bution effi a ventilation ing System consumpt lector and operation	ciency m ion, -	action		Feb	Mar 1	Apr	Effs	0,7 iency, - 0,85	· •			Sep 0	2xt 2	
Emergency lighting ch Lighting controls stan Invest Heat Production / Frr Occupants, W/m <sup>2</sup> Fraction Appliances, W/m <sup>2</sup> Fraction Appliances Infiltration, m <sup>3</sup> /s Natural vent, m <sup>3</sup> /s Natural vent, m <sup>3</sup> /s Fraction Nat Vent is p Donestic hot water Donestic hot water Boiler Temp, "C	st-by energy raction of time ettl, - ettl, - are co., - prevent, - maption, m <sup>2</sup> /m <sup>2</sup> /yeer						80 200 0,1 2 0,2 0,2 0,5 0,6 0,3 0,8 0,8	Distribution Name Heating distri Emission Name Heating coil i Factor on file Use Solar Coi Aux energy i Name Heating Aux	a ventilation effi ing System consumpt lector nd operat P_1	ciency m iion, - iion time fr pump, W/m <sup>2</sup> 0,3	netion f_contr, -		Feb 1	Mar 1	Apr	Effic	0,7 iency, - 0,85 Jun	· •				2et ?	
Emergency lighting ch Emergency lighting controls stan furest Heat Production / Fr Occupants, Wim <sup>1</sup> Fraction Person preson preson preson preson Appliances. Wim <sup>1</sup> Fraction Appliances. Wim <sup>1</sup> Fraction Appliances on Miflow rate Miflow rate Miflow rate Miflow rate Miflow rate Miflow rate Miflow rate Miflow rate Wim <sup>1</sup> South State South State	station of time vaction of time vent, - ere on, - prevent, - maption, m/hal/yeer						80 0 20 0,1 2 0,2 0,2 0,5 0,6 0,5 0,6 0,3 0,6 0,3 7 2	Distribution Name Hearing distri- Emission Name Hearing coil i Factor on first Use Solar Coi Aux energy a Name Hearing Aux	oution effi a ventilation consumpt lector nd operat P_J	ciency m ion, - ion time fr pump, W/m <sup>2</sup> 0,3 t contribut	netion f_contr, -		0 Feb 1		1	Effs May 0,75	0,7 iency, - 0,85 Jun 0,1	· •	0	0	0,5	1	
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Emergency lighting ed lighting controls state invol III and Peoduction. For Practice Persona prese Applicances. Wini' Praction Appliances. Wini' Praction Appliances. Wini' Praction Appliances. Wini' Statural vent, mi's Statural vent, mi's Statural vent, mi's Disasteric Edvarage Differences Disaster Edvarage Differences Biolier Temp, "C Clockl-nater Temp, "C	stady energy raction of time entl - entl	Tite U. Werk		Rát	F.h. (	F_0.+	80 0 0,1 0,2 0,2 0,2 0,2 0,2 0,2 0,5 0,6 0,3 0,3 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8	Distribution Name Hearing distri Hearing coli i Hearing coli i Hearing coli i General Hea Aux energy i Name Hearing Aux Generator eff Name Eff	a ventilation effi ing System consumpt lector nd operat P_J	ciency m ion, - ion, - 0.3 0.3 COP.	action f_contr, - 1 ion Fue	785	1		1 Mar	Efficiency May 0,75 Apr 3	0,7 0,85 Jun 0,1	· 5 ]	0	0 Aug		1	Nev 1
Itemprany: Yighting cli Lighting controls was arrived wave set wave set Heat Production : The Second Second Provide Second Second Second Second Applications, marks Applications, and applications, marks Applications, and applications, and Applications, and Applicat	stady energy raction of time entl - entl	Tili, deg U. Wurk	Alpha	R. sc. m·K/W	F_h.+	F_0.+	80 0 0,1 0,2 0,2 0,2 0,2 0,2 0,2 0,5 0,6 0,3 0,3 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8	Distribution Name Hearing distri- Emission Name Hearing coil i Factor on first Use Solar Coi Aux energy a Name Hearing Aux	oution effi a ventilation consumpt lector nd operat P_J	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Efficiency May 0,75 Apr 3	0,7 iency, - 0,85 Jun 0,1	· 5 ]	0	•	0,5	1	Nev 1
Emergency lighting cd Emergency lighting correls star atoms - U- Hata Production. The Coccupants. Ward Fraction Persona provide Appliances. Ward Fraction Appliances ward Natural vent, mily Natural vent, mily Natural vent, mily Natural vent, mily Natural vent, mily Natural vent, mily Natural vent, mily Coclod-nator Temp, - C Coclod-nator Temp, - C Coclod-nator Temp, - C Coppage Concernetion	stady energy raction of time entit, - entit, - entit	deg U, W/m-8			$\rightarrow$		80 0 0,1 0,2 0,2 0,2 0,2 0,2 0,5 0,6 0,3 0,3 0,8 0,8 72 8 72 8 F_f Investin'	Distribution Name Hening distri Emission Name Hening coli i factor on find factor on find factor on find factor on find Aux corregt of Name Hening Aux Generator et Same Efficient	a ventilation effi ing System consumpt lector nd operat P_J	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue	785	1		1 Mar	Efficiency May 0,75	0,7 0,85 Jun 0,1	· 5 ]	0	0 Aug	0,5	1	Nev 1
Itemprancy lighting cli inglipting controls was used inglipting controls was used Heat Production : The Second Heat Network Second Second Second Second Appliances, Ward Second Sec	stady energy raction of time entl - entl	Tih, U, Wim76 00.00		R_se. mKW 0,04	F_h. •	F_0.+	80 0 0,1 0,2 0,2 0,2 0,2 0,2 0,2 0,5 0,6 0,3 0,3 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8 0,8	Distribution Name Name Henning distribution Name Henning coll i General Hea Factor on fire Use Solar Co Aux energy a Name Henning Aux Generator et Name Efficient Same Efficient Distribution Distribution	a ventilation effi ing System consumpt lector nd operat P_J	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Efficiency May 0,75	0,7 0,85 Jun 0,1	· 5 ]	0	0 Aug	0,5	1	Nev 1
Emergency lighting of Emergency lighting corrects state wave set of the second	soldy energy raction of time entit	deg 0, w/m/s	0,80	0,04	0,900	0,800	0 20 0.1 0.2 0.2 0.2 0.2 0.5 0.6 0.3 0.8 72 8 F_f. Investin <sup>2</sup> 1.000 0.00	Distribution Name Hening distri Emission Name Hening coli i factor on find factor on find factor on find factor on find Aux corregt of Name Hening Aux Generator et Same Efficient	a ventilation effi ing System consumpt lector nd operat P_J	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Effs May 0,75 Apr 3 3,75	0,7 0,85 Jun 0,1	- 5 3m	0	0 Aug	0,5	1	Nov 1 Nov
Itempancy lighting cli inglipting controls sins inglipting controls sins Item Production : The Decempants, Wim / Tension Proceedings with Appliances with Papelineses, Wim / Tension Pay Control Stations Statistic and Controls and Name and Controls and December Temps, "Control Statistican December Temps, "Control Statistican	stably energy raction of time entit, - entit, - prevent, - maption, m/lus/year C sup to Ovientation, deg 18.0,0 18.0,0	deg         0, winns           90,0         0,600           90,0         0,600	0,80	0,04	0,500	0,800	80 0 0 0.1 0.2 0.2 0.2 0.5 0.6 0.3 0.8 72 8 F_f. Investin' 1.000 0.00 1.000 0.00	Distribution Same Hening distri- Ramission Hening coli i Hening coli i Factor on find Use show Col Use show Col Hening Aux Generator ef Same Hening Aux Generator ef Same Effecting Aux Generator ef Same Effecting Aux Generator ef Same Effecting Aux Col Col Col Col Col Col Col Col	a ventilatio ing System lector dependent f. and lose ceincy 1,04	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Effs May 0,75 Apr 3 3,75	0,7 0,85 Jun 0,1 0,1	- 5 Jun 0	0	0 Aug	0,5	1	New 1 New 1
Imergency Taphing cl Lighting contexts stars turned = United Stars Stars Heat Production : To Coccupants, Ward Transition Process present Appliances, Ward Transition Process present Infiltrations, m <sup>(1)</sup> Shafted verate Infiltrations, m <sup>(2)</sup> Shafted verate Demonstic hot water Demonstic hot water Demonstic hot water Demonstic hot water Cold-starts Temp, -C Cold-starts Temp, -C Cold-starts Temp, -C Copage Construction Numer Array, South	soldy energy raction of time entit	deg 0, w/m/s	0,80	0,04	0,900	0,800	0 20 0.1 0.2 0.2 0.2 0.2 0.5 0.6 0.3 0.8 72 8 F_f. Investin <sup>2</sup> 1.000 0.00	Distribution Name Hering distribution Name Hering coli i Factor on for General Hea Factor on for Usi Solar Col Usi Solar Col Name Hening Anx Generator ef Name Eff Col Distribution Name Distribution Name Distribution	a ventilatio ing System lector dependent f. and lose ceincy 1,04	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Effs May 0,75 Apr 3 3,75	0,7 0,85 Jun 0,1 0,1	- 5 Jun 0	0	0 Aug	0,5	1	Nov 1 Nov
Imergency lighting editions of the lighting control state state in the light of the	st-by energy raction of time entl	deg         U, wimes           90,0         0,600           90,0         0,600           90,0         0,600	0 0,80 0 0,80 0 0,80	0,04 0,04 0,04	0,900	0,800	80 0 0.1 0.2 0.2 0.5 0.6 0.6 0.3 0.6 0.8 72 8 F_f Investin' 1.000 0.000 1.000 0.000	Distribution Same Hening distri- Ramission Hening coli i Hening coli i Factor on find Use show Col Use show Col Hening Aux Generator ef Same Hening Aux Generator ef Same Effecting Aux Generator ef Same Effecting Aux Generator ef Same Effecting Aux Col Col Col Col Col Col Col Col	a ventilatio ing System lector dependent f. and lose ceincy 1,04	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Eff56 May 0,75 Apr 3,75 Eff56	0,7 iimcy, - 0,85 Jun 0,1 iimcy, - 0,8	30m	0	0 Aug	0,5	1	Nov 1 Nov
Imergency lighting el Ighting contexts vita Italifizio contexts vita Italifizio contexts vita Italifizio contexts vita Appliances, Warr Traction Appliances a Malfore rate Infiltration, m <sup>2</sup> /s Fraction Applications on Statistica Vita is p Domestica Iot vita Iot vita Iot Nonth Iot Statistica Iot vita Iot Nonth Iot Statistica Iot vita Iot Nonth Iot Statistica Iot vita Iot Nonth Iot Nonth Iot Nonth Iot Nonth Iot vita Iot Nonth Iot	stably energy raction of time entit, - entit, - prevent, - maption, m/lus/year C sup to Ovientation, deg 18.0,0 18.0,0	deg         0, winns           90,0         0,600           90,0         0,600	0 0,80 0 0,80 0 0,80	0,04	0,500	0,800	80 0 0 0.1 0.2 0.2 0.2 0.5 0.6 0.3 0.8 72 8 F_f. Investin' 1.000 0.00 1.000 0.00	Distribution Name Hering distribution Name Hering coli i Factor on for General Heat Factor on for Usi Solar Col Usi Solar Col Name Hening Anx Generator ef Name Eff Col Distribution Name Distribution Name Distribution	a ventilatio ing System lector dependent f. and lose ceincy 1,04	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Eff56 May 0,75 Apr 3,75 Eff56	0,7 0,85 Jun 0,1 0,1	30m	0	0 Aug	0,5	1	Nov 1 Nov
Imergency lighting cl Lighting contexts stars Interface of the second stars Interface of the sec	stady energy raction of time entit, - entit, - entit, - entitientity entity e	deg         U, Winn's           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600	) 0,80 0 0,80 0 0,80	0,04 0,04 0,04	0,900 0,500 0,900 0,800	0,800 1,000 1,000 1,000	80 0 0.1 0.2 0.2 0.5 0.6 0.3 0.6 0.3 1.000 0.000 1.000 0.000 1.000 0.000 1.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 00	Distribution Name Reming distribution Name Reming coll ri Resting coll ri Resting coll ri Resting coll ri Resting Aux Resting	a ventilatio ing System lector dependent f. and lose ceincy 1,04	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Eff56 May 0,75 Apr 3,75 Eff56	0,7 iimcy, - 0,85 Jun 0,1 iimcy, - 0,8	- 5 Jm - -	0	0 Aug	0,5	1	Nov 1 Nov
Emergency lighting ed Lighting contexts van Heat Forbaction / Fre Verstein Persons present Appliances, Warr Frestion Appliances a Million rate Infiltration, m <sup>2</sup> /s Frestion Appliances a Million rate Textion Appliances a Namal Vent is p Datasetic hot water Cold-outer Temp. °C Object Context Frestion Appliances a Appliances a South frestion Appliances a Appliances a Appliances a South frestion Appliances a Appliances a Appl	st-by energy raction of time entl	deg         U, wimes           90,0         0,600           90,0         0,600           90,0         0,600	) 0,80 0 0,80 0 0,80	0,04 0,04 0,04	0,900	0,800	80 0 0.1 0.2 0.2 0.5 0.6 0.6 0.3 0.6 0.8 72 8 F_f Investin' 1.000 0.000 1.000 0.000	Distribution Name Hering distribution Name Hering coli i General Hea Factor on for Usi Solar Col Factor on for Distribution Distribution Name Emission Name	a ventilatio ing System lector dependent f. and lose ceincy 1,04	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Eff56 May 0,75 Apr 3,75 Eff56	0,7 iency, 0,85 Jun 0,1 iency, 0,8 iency, 0,9 iency, 0,8 iency, 0,9 iency, 0,9 iency, 0,9 iency, 0,9 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,9	- 5 3m 3m 0	0	0 Aug	0,5	1	Nev 1
Imergency lighting cl Lighting contexts stars Interface and the second stars Interface and th	sk-by energy raction of time entit, - entit, - entit	deg         U, Wim's           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600	0         0,80           0         0,80           0         0,80           0         0,80           0         0,80           0         0,80           0         0,80	0,04 0,04 0,04 0,04	0,900 0,500 0,500 0,800 0,800	0,800 1,000 1,000 1,000 1,000	80 0 0 0.1 0.2 0.2 0.5 0.6 0.3 0.6 0.3 0.5 0.6 0.3 0.5 1.000 0.000 1.000 0.000 1.000 0.000 1.000 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 00	Distribution Same Hening dati Hening dati Hening coli I Hening coli I Factor on find Factor on find Uus Salare Col Uus Salare Col Uus Salare Col Same Hening Aux Generator ef Same Hening Aux Generator ef Same Colorential Same Name Distribution Name	a ventilatio ing System lector dependent f. and lose ceincy 1,04	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Eff56 May 0,75 Apr 3,75 Eff56	0,7 iency, - 0,85 Jun 0,1 (ay 0,1 iency, - 0,8 iency, -	- 5 3m 3m 0	0	0 Aug	0,5	1	Nov 1 Nov
Immergency lighting ed Indiregency lighting ed Indiregencies Anne Heat Production / Tar Heat Production / Tar Proxide National Indiregencies Anne Indiregencies	sk-by energy raction of time entit, - entit, - entit	deg         U, Winn's           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600           90,0         0,600	0         0,80           0         0,80           0         0,80           0         0,80           0         0,80           0         0,80           0         0,80	0,04 0,04 0,04	0,900 0,500 0,900 0,800	0,800 1,000 1,000 1,000	80 0 0.1 0.2 0.2 0.5 0.6 0.3 0.6 0.3 1.000 0.000 1.000 0.000 1.000 0.000 1.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 00	Distribution Name Hering distribution Name Hering coli i General Hea Factor on for Usi Solar Col Factor on for Distribution Distribution Name Emission Name	a ventilation effi ing System	ciency m ion, - ion time fr yomp, W/m <sup>2</sup> 0,3 <b>5 contribut</b>	action f_contr, - 1 ion Fue Natural gas	785	1		1 Mar	Eff56 May 0,75 Apr 3,75 Eff56	0,7 iency, 0,85 Jun 0,1 iency, 0,8 iency, 0,9 iency, 0,8 iency, 0,9 iency, 0,9 iency, 0,9 iency, 0,9 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,8 iency, 0,9	- 5 3m 3m 0	0	0 Aug	0,5	1	Nov 1 Nov



I						1							l			Local			l		L							
Factor on for Use Solar Ce		ion, -				+						1 No	West Doors South doors	8,0	270,0		2,000		0,700		0,000		_	900		0,950		0,00
												N0	North Doors	10,4	0,0		2,000	2,000		0,50			_	900 0	_	0,850	-	0,00
Generator e			· · · · ·			n							East	$\rightarrow$		<u> </u>	_		$\sim$		$\sim$		-	-	-	_	-	_
Name	E	fficiency, -	<u> </u>	Fuel Inve	ıst Jan	Feb Ma		May	Jun Jul		Sep Oc	+	dormers	32,0	90,0	90,0	1,800	1,800	0,680	0,68	0,000	0,	000	950	1,000	1,000		0,00
Gas boiler+excha	inger	0,85	Natural high er	i gas, nergy	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	,												dormers															
Name							Eff	ciency.	•			Invest	Ground con-	struction														_
DHW distrib	oution							0,	5			0	Name			Area, m		U, W/m <sup>2</sup>	к		B_g_h.	•		B_8_6			Inv	est/m
Emission													Floor		1	1726,0		0,60	0		0,3	0		0,	30			0,00
Name							Eff	ciency.				Invest			·				_			_			_			_
Water taps									1			0	General AH	U														
Water taps									1			0	Fraction of ti															1
Taps and sho	owers								1			0	Temp. rise by	y fans, °C														(
									·				Invest															(
Gymnasium	a Dhw Syste	m											Heating part	t														
Factor on fac	el consumpti	ion, -										0	Active															false
Use Solar Co	ollector											No	Supply temp.															(
Generator e	ff. and load	contribut	ion										Mechanical v	entilation	a, m¹/s													(
																			1									
Name	Effici	ency, - 1	lsel	Invest	Jan F	eb Mar	Apr	May	Jun Jul	Aug 5	Sep Oct	Nov Dec	Heat rec. eff,						+									(
Distribution	1												Recirc. factor	_														(
Name							Eff	ciency,	·			Invest	Cooling part	t					_									
Emission													Active						+									fals
Name							Eff	ciency,	·			Invest	Supply temp.						-									0
Zone: After	school er												Mechanical v		a, m <sup>1/</sup> s				+-									0
Gross area, n												1726	Cool rec. eff,						+-									0
		weite klie	J K			+						240	Recirc. factor															0
Specific inter Specific inter				ĸ		+						9,2	Humidificat	ion part					_									
Int Temp He		g comme	n, 10 m 1			+						22	Active						_									false
Int Temp Co												30	Hum. supply						_									0
Lighting	comp. c											50	Eff. hum. rec															0
Total installe	d Kabilana											17260	Auxiliary fa															
Daylight tim			hino ha			+						700	Spec. electric	ity cons.	for fans, Ws	/m³												0
Non-daylight						$\rightarrow$						0	Systems															
Daylight dep				, notes								1	Heating												Get	eral He	eating S	lysten
Occupance fa			ung. •			+						1	Dhw												(	Seneral	Dhw S	lysten
Fraction not:			ntilation			+						0	L															_
TIN DALINA	read/rea by	VALUE ON TH	umation,	-		+						0	Assembly ha	di beatin	g system				-									
Emergency l			y									по	Factor on fae		ption, -													1
Lighting con	itrols stand-b	y energy										по	Use Solar Co	diector														No
Invest												0	Aux energy	and oper	ation time f	raction												_
Heat Produc	ction / Frac	tion of tim	•										Name		_pump, W/m <sup>2</sup>	f_contr, -	Jan	Feb Mar	Apr	May	Jun	Jul	Au	s	10	Oct	Nov	Dec
Occupants, V	$N/m^2$											25		-	0.3	1	1	_		0,75		0			_	-	_	1
Fraction Pers	sons present											0,14	Heating Aux	_			- 1	1 1		0,75	0,1	0		0	3	1	1	_
Appliances,	$W/m^2$											2,2	Generator e			tion			_	_			_	_				_
Fraction App	pliances are	00, -										0,5	Name	Efficie	ncy, - COP	Ft	el Invest	Jan F	ib Ma	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dev
Airflow rate	,												Generator	i —	1.04	Natural g	15, 0			<u> </u>	1							_
Infiltration, r	m³/s											0,5			1,04	high ener	N N	<u>'</u>	<u> </u>	<u> </u>				-				
Natural vent,	, m <sup>a</sup> /s											0,6	Distribution															
Fraction Nat	Vent is pre-	ient, -										0,17	Name							Ef	ficiency,	<u> </u>						Inves
Domestic ho	ot water												Heating distri	ibution ef	ficiency						0,	7						(
Average DH	W consump	tion, m <sup>3</sup> /m <sup>2</sup>	year									0,02	Emission															
Boiler Temp	, °C											72	Name							Ef	ficiency,	•						Inves
Cold-water T	Temp., °C											8	Heating coil	in ventila	tion						0,8	5						0
													0															_
Opaque Cor	astruction						_					_	General Hea						_									
Name	Area, m	Orien	tation, de	g Tilt, deg	$\rm U, W/m^2K$	Alpha,	· m	t_se. K/W	F_h, •	F_0, •	F_1	- Invest/m <sup>2</sup>	Factor on fue	a cotistim	hann' .				+-									1
Facades,	217,5	ĺ.	90,	1 1	0,600	0,80	i	0,04	0,850	0,850	1.0	0.00	Use Solar Co	diector					i									No
East	217,5	1	90)	90,0	0,600	0,80	1	0,04	0,850	0,850	1,0	~ 0,00	Aux energy		ation time f	raction							_	-	-	-		_
Facades, West	191,5		270/	90,0	0,600	0,80	·	0,04	0,850	0,850	0,9	50 0,00		_			. [	F.A. 14										~
Gables.		1					1						Name		_pump, W/m <sup>2</sup>	f_contr, -	Jan	Feb Mar	Apr	May		Jul	Au		_	Oct	Nov	Des
North	173,0	<u>'</u>	0,	0 90,0	0,600	0,80	°	0,04	0,850	1,000	0,9	50 0,00	Heating Aux		0,3	1	1	1 1	1	0,75	0,1	0	- 0	0	5	1	1	1
Gables, South	147,0		180/	0 90,0	0,600	0,80		0,04	0,900	1,000	0,8	50 0,00	Generator e	ff. and lo	ad contribu	tion												_
Roof, East	923.0	1	90.	+	0.300	0.80	+	0.04	1.000	1.000	1.0		Name Eff	ficiency,	COP,	Fuel	Invest	Jan Feb	Mar	Apr	May	Jun	Jul J	lug	Sep	Oct	Nov	Des
Roof, East Roof West	923,0			0 20,0	0,300	0,80		0,04	1,000	1,000	1,0				+++	Natural gas.	$\rightarrow$		$\vdash$			+	+	-+-	-	-	_	-
Root West Dormers				+-+			+	-					Gas boiler	1,04	1	Natural gas, high energy	0	1 1	1	0,75	0,1	0	0	0,5	1	-1	1	- 1
East	15,0	1	90,	0 90,0	0,300	0,20	2	0,04	1,000	1,000	1,0	0,00	Distribution													-		_
Dromers West	15,0		270/	0 90,0	0,300	0,20		0,04	1,000	1,000	1,0	00,00	Name							Ef	ficiency.	·	_		_		_	Inves
West		1			5,000				.,	2,000			Distribution s	system							0,	<u> </u>						(
Transparen	t constructi	on											Emission										_	_	_	_	_	
Name			Tib.	U, W/m/9	, u	5. G.p.	G_8_s,	F_5,	<b>R</b> - 14	F_h, 1	F_0, F_E		Name							Ef	ficiency.	·						Inves
	m <sup>2</sup>	rientation, deg	Tilt, deg	0, Wimit	K U W/m	к .			F_with,	1.1	F_0, F_f,	<ul> <li>Invest/m<sup>2</sup></li> </ul>	Radiators								0,							(
East windows	72,0	90,0	90,0	1,80	0 1.8	00 0,680	0,68	0,000	0,000	0,850 0,	850 0,95	0,00	Radiators								0,		_	_	_	_	_	
East Doors	20.0	90.0	90,0	2.00	0 74	00 0,700	0,70	0.000	0.000	0.850 0.															_			_
West					<u> </u>			-			-		General Dhy															_
Windows	79,2	270,0	90,0	1,80	1,8	00 0,680	0,68	0,000	0,000	0,900 0,	850 0,95	0,00	Factor on fue	d consum	ption, -													1
					1														1									



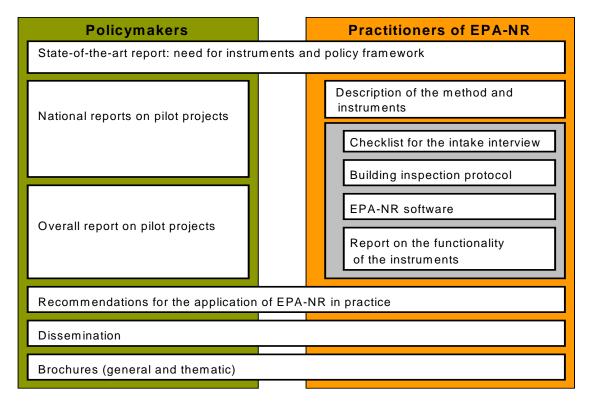
Use Solar Collector	No	Mechanical ventilation, m//s	2.2
Generator eff. and load contribution	100	Heat rec. eff	4,4
Name Efficiency, Fuel Invest Jan Feb	Mar Apr May Jun Jul Aug Sep Oct Nov Dec	Recirc. factor, -	0
Gas boiler+exchanger 0.85 Natural gas, high energy 0 1 1	1 0,75 1 0,75 0 0,75 1 1 1 0,75	Cooling part	
Distribution		Active	false 0
Name	Efficiency, • Invest	Supply temp., *C Mechanical ventilation, m <sup>1</sup> /s	0
DHW distribution	0,5 0	Cool rec. eff, -	0
Emission		Recirc. factor, -	0
Name	Efficiency, Invest	Humidification part	
Water taps Water taps	1 0	Active	false
Taps and showers	1 0	Hum, supply air, g/kg Eff. hum, recovery, -	0
Gymnasium Dhw System		Auxiliary fan energy	
Factor on fuel consumption, -	0	Spec. electricity cons. for fans, Ws/m3	2500
Use Solar Collector	No	Systems	
Generator eff. and load contribution		Hesting	Assembly hall heating system
Name Efficiency, Fuel Invest Jan Feb	Mar Apr May Jun Jul Aug Sep Oct Nov Dec	Assembly hall heating system	
Distribution		Factor on fuel consumption, -	1
Name	Efficiency, - Invest	Use Solar Collector	No
Emission		Aux energy and operation time fraction	
Name	Efficiency, - Invest	Name P_pump, f_contr, - Jan Feb Mar	Apr May Jun Jul Aug Sep Oct Nov Dec
Zone: Assembly hall		Heating Aux 0,3 1 1 1 1	1 0,75 0,1 0 0 0,5 1 1 1
Gross area, m <sup>2</sup>	450	Generator eff. and load contribution	
Specific internal heat capacity, kJ/m2 K	260	Name Efficiency, - COP, Fuel Invest Jan Feb	Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Specific internal coupling coefficient, W/m <sup>2</sup> K	9,2	Generator 1.04   Natural gas, 0 1 1	
Int Temp Heating, *C Int Temp Cooling, *C	22	Outstate 1,04 1 high energy 0 1 1	
Lighting		Distribution Name	Efficiency, - Invest
Total installed lighting power, W	20000	Heating distribution efficiency	0,7 0
Daylight time usage per year for lighting, hours	200	Emission	
Non-daylight time usage per year for lighting, hours	200	Name	Efficiency, - Invest
Daylight dependency factor for lighting. • Occupance factor for lighting. •	1	Heating coil in ventilation	0.85 0
Fraction not removed by exhaust ventilation, -	0	General Heating System	
Emergency lighting charging energy	no	Factor on fuel consumption, -	1
Lighting controls stand-by energy	по	Use Solar Collector	No
Invest	0	Aux energy and operation time fraction	10
Heat Production / Fraction of time		Name P_pump, Wmi f_contr. Jan Feb Mar	Apr May Jun Jul Aug Sep Oct Nov Dec
Occupants, W/m <sup>1</sup>	130	W/m²            Heating Aux         0.3         1         1         1	1 0.75 0.1 0 0 0.5 1 1 1
Fraction Persons present, -	0,05	Generator eff. and load contribution	
Appliances, W/m <sup>1</sup> Fraction Appliances are on, -	0		Mar Apr May Jan Jul Aug Sep Oct Nov Dec
Airflow rate			
Infiltration, m <sup>1</sup> /s	0,5	boiler 1,04 1 high energy 0 1 1	1 0,75 0,1 0 0 0,5 1 1 1 1
Natural vent, m <sup>2</sup> /s	0	Distribution	
Fraction Nat Vent is present, -	0	Name Distribution system	Efficiency, - Invest 0.8 0
Domestic hot water	0.04	Emission	0.0
Average DHW consumption, m³/m²/year Boiler Temp, "C	72	Name	Efficiency, - Invest
Cold-water Temp., °C	8	Radiators	0,9
Opaque Construction		Radiators	0.9 0
	has Rife to the test to the second	General Dhw System	
~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	lpha, - R_5e, F_h, - F_0, - F_f, - Investim <sup>2</sup>	Factor on fuel consumption, -	1
Ext walls, Seuth 29.0 180.0 90.0 0.600	0.80 0.04 0.850 1.000 1.000 0.00	Use Solar Collector	No
Roof, West 251,0 270,0 30,0 0,300	0,80 0,04 1,000 1,000 1,000 0,00	Generator eff. and load contribution	
Roof. East 251.0 90.0 30.0 0.300	0,80 0,04 1,000 1,000 1,000 0,00	Name Efficiency, Fuel Invest Jan Feb	Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Transparent construction		Gas boiler+exchanger 0.85 Natural gas, high energy 0 1 1	1 0,75 1 0,75 0 0,75 1 1 1 0,75
Name Area. Orientation, Tilt, H WimW H a WimW G	.s. G_s.s. F_s. F_with. F_h F_o, F_f. Investini	Distribution	
mi deg deg of the option		Name	Efficiency, - Invest
Double facade         120,0         0,0         90,0         1,120         1,120         0,0	500 0,50 0,000 0,000 0,900 1,000 0,950 0,00	DHW distribution	0,5 0
Ground construction		Emission	The local local
Name Area, m <sup>2</sup> U, W/m <sup>3</sup> K	B_g_h. • B_g_c. • Invest/m <sup>2</sup>	Name Water taps	Efficiency Invest 1 0
Floor 450.0 0.600	0,30 0,30 0,00	Water taps	1 0
Assembly hall ventilation		Taps and showers	1 0
Fraction of time, -	0.48	Constant Black Constant	
Temp. rise by fans, °C	1,4	Gymnasium Dhw System Factor on fuel consumption, -	0
Invest	0	Use Solar Collector	No
Heating part		Generator eff. and load contribution	
Active	true	Name Efficiency, - Fuel Invest Jan Feb	Mar Apr May Jun Jul Ang Sep Oct Nov Dec
Supply temp_ °C	18	Distribution	
		Distribution Name	Efficiency, - Invest
		Emission	
		Name	Efficiency, - Invest



## **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
- guarantees simple transfer to all EU Member States



## **Project Partners**



Project Co-ordinators: EBM-Consult (The Netherlands) bpoel@ebm-consult.nl



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 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