Pilot study - Office building

National report - Denmark

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Final report, May 2007

Energy Performance Assessment
of Existing Non-Residential Buildings

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Contents

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 Office building, Rosenkæret 39

2.1 Project summary

Rosenkæret 39, Office building, Gladsaxe
Owner: private. User: Gladsaxe municipality.

Type of building : Office in old factory building Location : city area with surrounding buildings in similar height and relatively low density Owner (optional): Private Year of construction: 1952/1962 Total gross area (m²): 3622 m². Total conditioned area (m²): 3300 m². Building occupancy: from 8 am to 5 pm, 5 days/week all year. Number of occupants (approximately): 90.	Short description: The building is orientated South-East, surrounded by buildings of the same height and moderate density. The building can be considered being one zone, consisting of offices, reception, and meeting rooms. Construction: It is a typical Danish hollow core masonry building constructed in 1950'es. An extension building was constructed in the 60'es. There are two ordinary floors plus two floors in the attic and a full basement. At the West end of the building there is an extension with wooden facade covering. The 45 º sloping roof is covered by traditional red roofing tiles. Heating / cooling/ ventilation/ lighting systems: All systems in the building can be described as traditional systems for low tech Danish office buildings. Heating is made by a natural gas boiler located in the basement.

Energy management: The temperature of the heating system is controlled by an outdoor temperature sensor allowing for a lower temperature at high outdoor temperatures.

Energy consumption year 2005:

	The building	National average
Fuel	126 kWh/m²	105 kWh/m²
Electricity	39 kWh/m²	43 kWh/m²
Water	210 l/m²	250 l/m²

Previous refurbishment: Windows towards North at 3rd and 4th floor replaced with low energy glazing. Other windows replaced over time and are all less than 15 years old. Heating system updated in '93 and '95. Roof insulation at main (old) building decreased with 70 mm and roof construction made ventilated in 2003. Refurbishment of extension building and establishment of mechanical ventilation in 2005.

Planned refurbishment: No further refurbishment is planned.

Rosenkæret is located in an area with light industry in buildings of the same or lower height. The building was constructed in the early fifties and extended in the early sixties. Originally the building was used to light industry, but was later rebuild to meet the requirements of an office building.

The building is owned by a private company and rented to Gladsaxe municipality.

2.2 Audit of the building

2.2.1 Actual situation

The building has problems regarding air tightness at the two under-roof floors. These problems was introduced in 2003 when 70 mm of the roof insulation was removed to increase the ventilation in the roof construction and in this way eliminate a mould growth problem. The mould problem was introduced some years earlier in conjunction with additional insulation of the roof to save energy.

Some of the windows in the old part of the building are with traditional double pane glazing. These windows do also cause problems with cold draft.

The heating system is old and based on eight natural gas boilers operating in cascade. Occasionally it is not possible to produce sufficient heat for space heating, and it is thus not possible to operate the building with night set back of the indoor temperature.

The windows in the roof top are of many different sizes and shapes. This is because the building was used as demonstration site for the former owner. It gives a disorderly visual impression of the roof top. The many different sizes and shapes may also result in increased costs with respect to maintenance and replacement.

2.2.1.1 Heating consumption

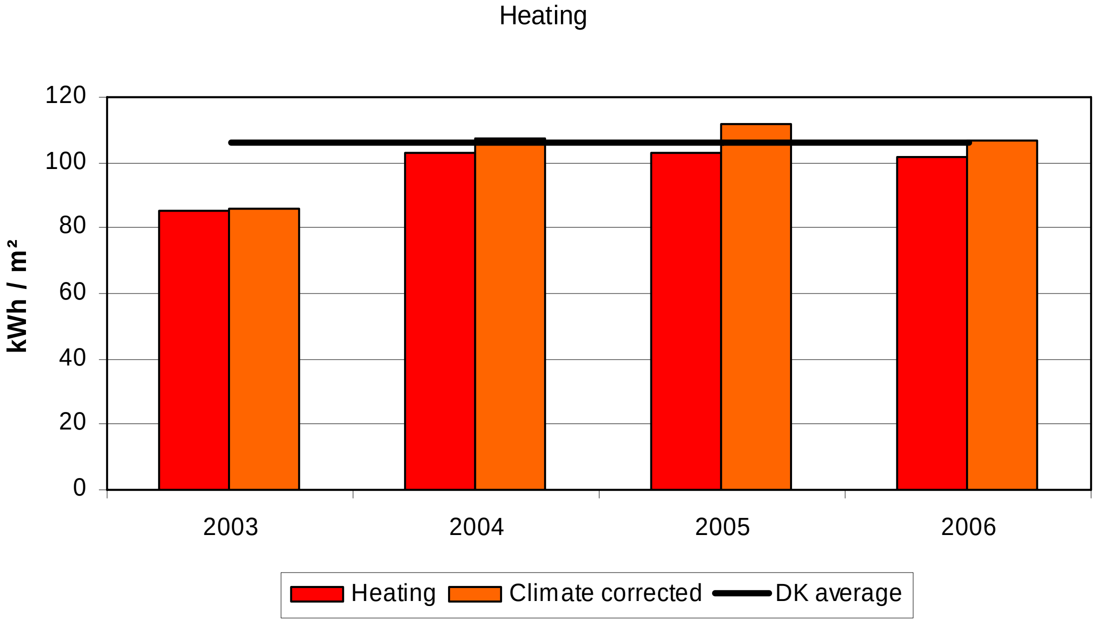


Figure 1. Recorded heating consumption in kWh/m² in 2003 - 2006 (meter reading and climate adjusted respectively) and the Danish average consumption in buildings used for similar purpose and size. The degree-day independent heating consumption constitutes about 20 % of the total heating consumption.

Energy consumption for space heating and domestic hot water has been stable since 2003 and around the Danish average for office buildings. Seventy millimetres of the insulation in the roof construction was removed in 2003 because of mould growth. This action have increased the ventilation over the insulation, eliminated the mould growth and increased the heating consumption.

2.2.1.2 Electricity consumption

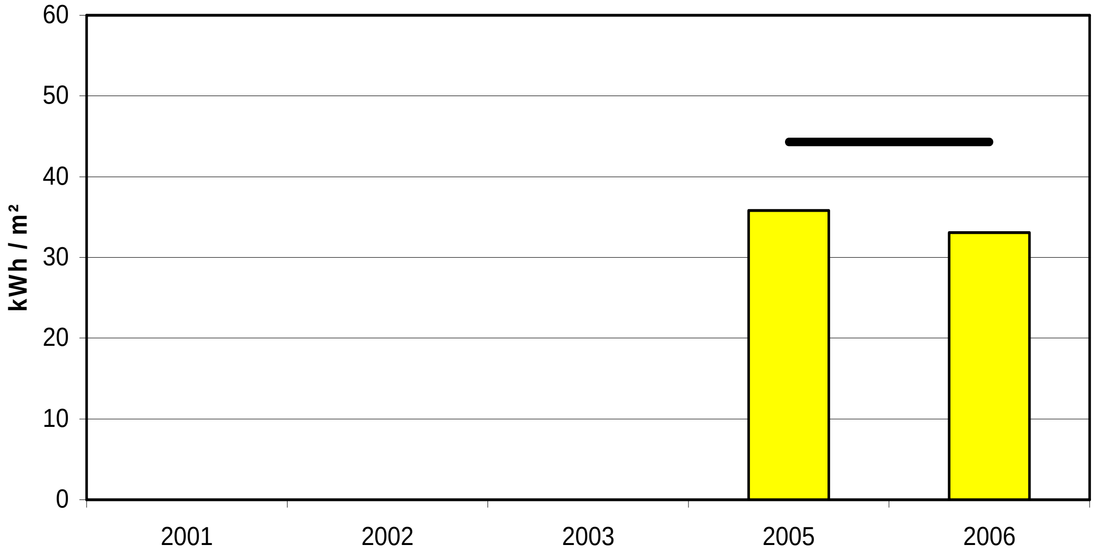


Figure 2. Recorded electricity consumption in kWh/m² in 2005 and 2006 and the Danish average consumption in buildings used for similar purpose and size.

The electricity consumption in Rosenkæret 39 is about 20 per cent lower than the Danish average for office buildings. There are several reasons for this, and among those are: the building is partly natural ventilated, there are almost no mechanical cooling, there is only four floors and the elevators are thus not being used intensive, at the two top floors there are many windows in the 45 ° ceiling contributing considerably with daylight in most of the office hours.

2.2.1.3 Water consumption

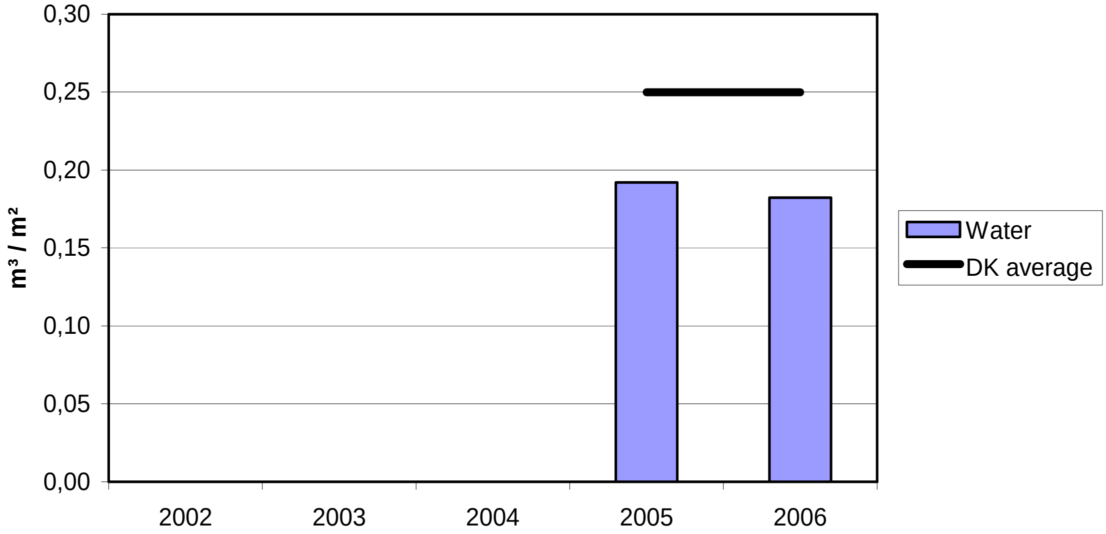


Figure 3. Registered water consumption at Rosenkæret 39 in 2004 and 2005 in m³/m² and the Danish average consumption in buildings used for similar purpose and size. The domestic hot water consumption is estimated to be 30 % of the total water consumption.

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

2.2.2.1 Energy characteristics of the building model

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. New extension building (430 m²),
2. Basement, 1st and 2nd floor of old building (1986 m²),
3. Offices under roof on 3rd and 4th floor (823 m²),
4. Canteen on 3rd floor (150 m²).

List of energy uses:

Zone 1: heated, mechanically ventilated with VAV control.
Zone 2: heated, naturally ventilated.
Zone 3: heated and naturally ventilated
Zone 4: heated, cooled and naturally ventilated
All zones have artificial lighting. Zones 2-4 have automatic window openers to control the indoor temperature by natural ventilation.

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	-	-	-	23 °C
Operation time for heating/year	5110 h/a	5110 h/a	5110 h/a	5110 h/a
Operation time for cooling/year	-	-	-	8760 h/a
Operation time for ventilation/year	2365 h/a	-	-	-
Operation time for lighting/year	2340 h/a	2340 h/a	2340 h/a	500 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 CO2 emission of the building

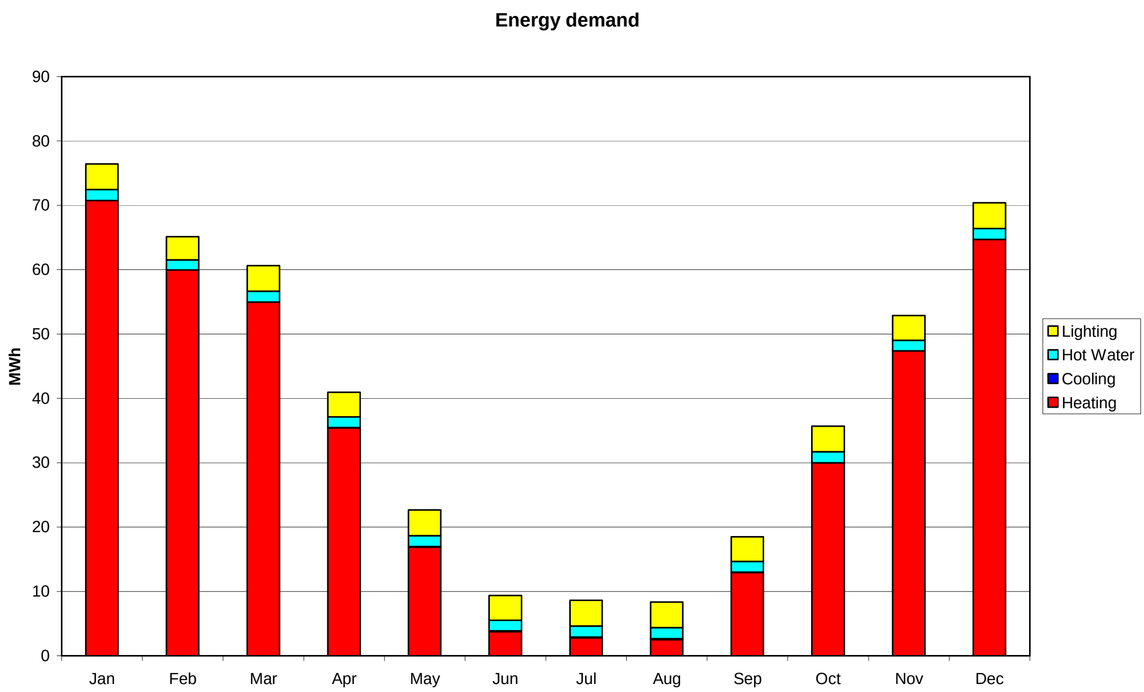
Primary energy consumption of the building: kWh/m²/year	CO_2 emission of the building: kg/m²/year
202.32	29.8

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

	Annual final energy consumption* of the building per fuel type:	Primary energy consumption of the building: kWh/m²/year	CO_2 emission of the building: kg/m²/year
Natural gas	507.95 MWh/year	149.88	14.2
Electricity	75.15 MWh/year	55.43	15.5

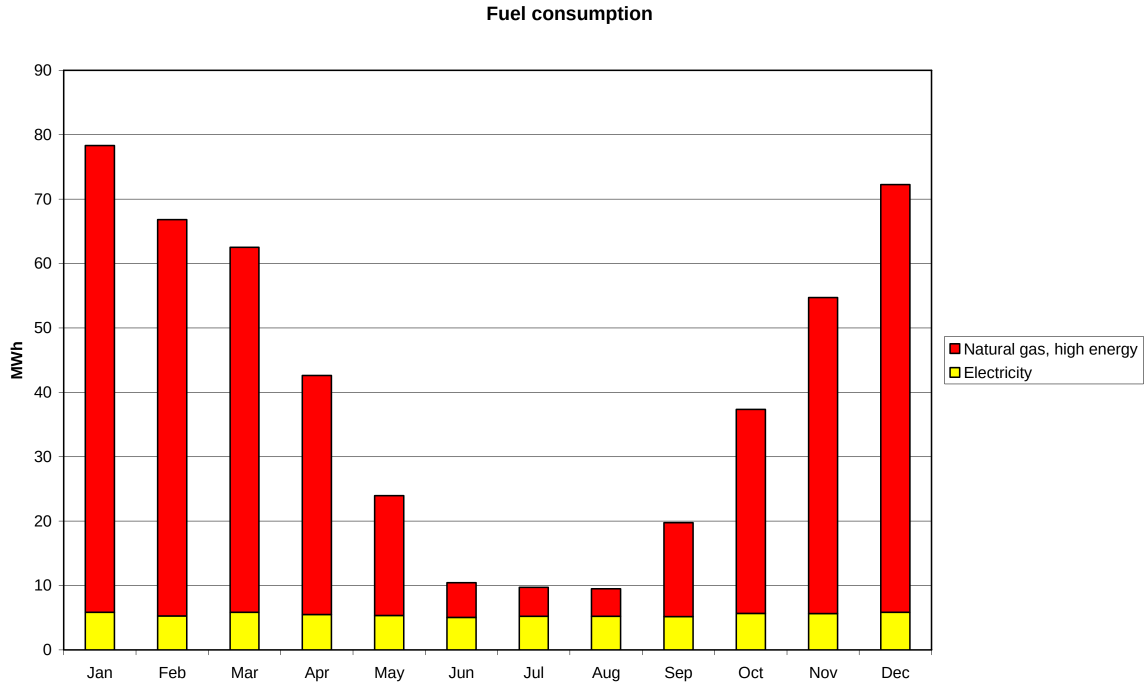
** Calculated under standard user pattern and outdoor conditions.*

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 Rosenkæret 39 is, as in most Danish office buildings dominated by the energy consumption for space heating (above).

The cooling energy consumption is reduced due to optimal possibilities for utilization of natural ventilation and manually controlled solar shading in the old part of the building, which is the part that has the highest potential solar loads during summer time (see table below).

	Annual losses			Annual gains			
Total	Total	Trans-mission	Ventila-tion	Total	Solar	Sun space	Internal heat
kWh/m² (heating)	136.21	50.09	86.12	54.65	23.64	0	31.01
kWh/m² (cooling)	329.21	130.42	198.79	58.06	27.05	0	31.01

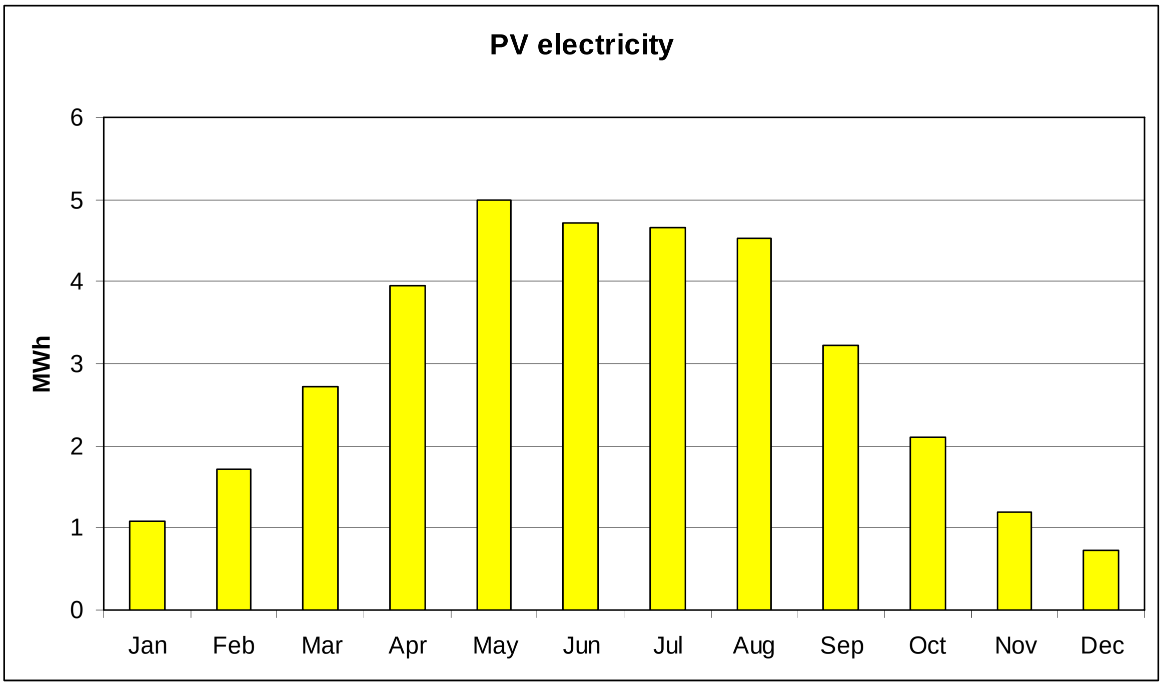
Old building	Annual losses			Annual gains			
Total cooling kWh/m²	Total	Trans-mission	Ventila-tion	Total	Solar	Sun space	Internal heat
0, 1 & 2 floor	281.85	111.08	170.77	53.39	19.0	0	34.39
3 and 4 floor	477.87	120.97	356.9	59.99	27.76	0	32.23
Canteen	58.39	36.9	21.49	46.68	24.02	0	22.66

2.3 Calculation of energy savings: scenarios for improvement

2.3.1 Scenario 1- PV system on South facing roof face

2.3.1.1 Background and proposed solution

Integration of a photo voltaic solar system in the South facing roof face with a 45 ° inclination was the initial idea to reduce energy consumption from the building. This action was suggested to create a more uniform appearance of the roof and minimise the visual impact of the many windows in the roof. It was thus suggested to apply PV solar cells to the entire opaque surface of the South facing roof (325 m²). With an overall efficiency factor of the PV system of 9 %, such a system will produce electricity as shown in the figure below.



The annual electrical output from the PV system is calculated to be 35.63 MWh giving a payback time of about 40 years when the cost for installing the system is 8000 DKK (1070 €) per m².

2.3.1.2 Conclusion

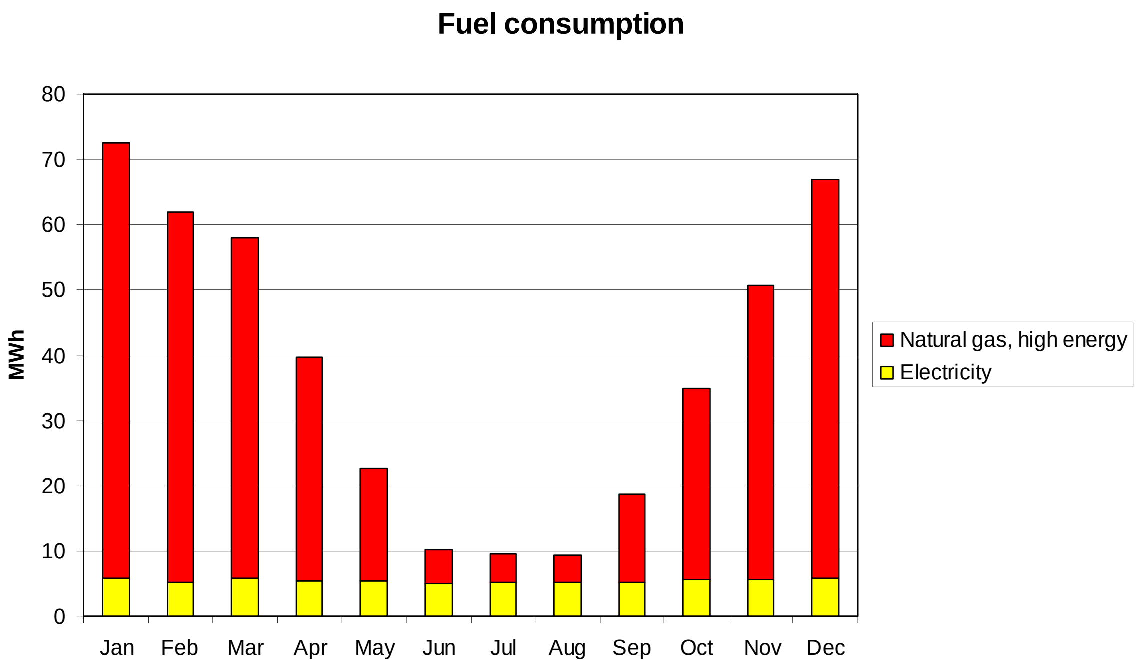
Installation of a PV system on the entire South facing roof face is not, as an energy saving measure, cost effective, but from an architectural point of view it could improve the visual impression of the building, creating a more uniform view of the roof-top. In addition to this, the South facing roof face is the one facing the main entrance of the building and the access road.

2.3.2 Scenario 2 – Replacement of boilers to natural gas condensing boilers

2.3.2.1 Background and proposed solution

The existing boilers (eight natural gas boilers in cascade) are old, inefficient and do not provide the necessary amount of heating at any given time. A new rack of boilers is suggested by the user of the building. The cost for installing new boilers in the building falls in the user, and cost analyses have not been performed yet.

2.3.2.2 Calculation results



The annual consumption of natural gas decreases from 422 MWh to 389 MWh, equal to a reduction of 8 per cent. With an investment of 40 000 DKK (5300 €) per gas boiler in the cascade of eight gas boilers, gives a simple pay-back time of 11.6 years.

2.3.2.3 Conclusion

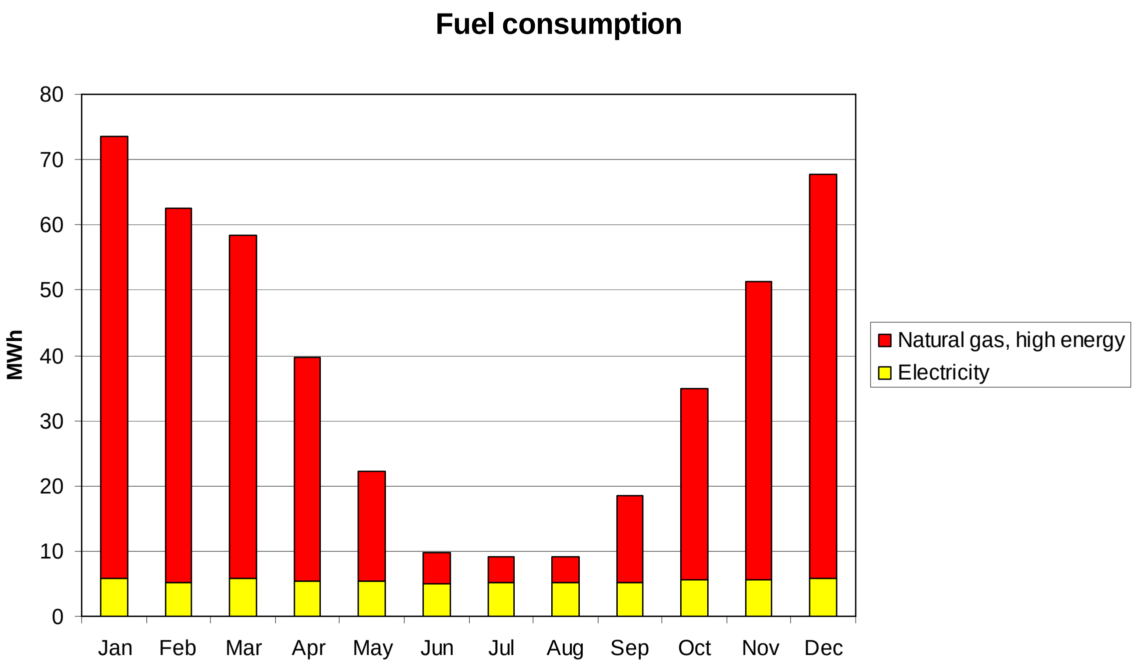
A pay-back time of about 12 years would normally be considered a good investment if the owner and the user of the building is the same entity. In this case however, the user and the owner is not the same. In addition to this is the cost of the boilers to the user of the building. To justify such an investment a long term rental contract or a buy-back obligation should be possible.

2.3.3 Scenario 2 – Replacement of windows in parts of the building

2.3.3.1 Background and proposed solution

The windows in the basement, first and second floor of the old building are traditional double pane windows with a U-value of 3 W/m²K. Replacement of these windows to today's standard with an overall U-value of 1.5 W/m²K would reduce the energy consumption for space heating and decrease the registered problems with draft near the windows.

2.3.3.2 Calculation results



The annual consumption of natural gas decreases from 422 MWh to 391 MWh, equal to a reduction of 7 per cent. With an investment of 1200 DKK (160 €) per m² windows, the calculated energy savings gives a simple pay-back time of less than 7 years.

2.3.3.3 Conclusion

Replacement of the glazing in the windows from traditional double pane thermo coupled glazing to a more energy efficient window of today's standard is an economical sound investment, especially if it is done in conjunction with a scheduled maintenance of the building.

Appendix 1: additional information

The office building at Rosenkæret 39 was established in 1993 in an old factory building originally constructed for light industry. The building is privately owned but the municipality of Gladsaxe rents the premises. Even though the size of the building has a size that made it mandatory to be in the ELO energy certification scheme (since 1997), it has never been labelled.

Landscaped office at Roenkæret at ground, 1st and 2nd floor.

Natural ventilation and internal solar shading in offices on ground, 1st and 2nd floor.

Canteen and kitchen at 3rd floor.

Windows with integrated balcony and solar shading in canteen area.

 Landscape offices at 3rd floor.	 Wall mounted condenser for cooling engine for canteen.
 Landscape offices at 4th floor	 Internal meeting rooms with replacement air from surrounding office landscape.
 Natural gas boilers operating in cascade. Domestic hot water storage.	

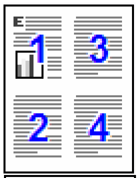
 Windows with integrated solar shading.	 Insulated heating distribution system in basement.

Appendix 2: Input data for calculations

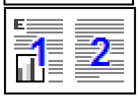
The following summary of inputs is taken directly from the EPA-NR calculation tool, exported into one pdf-file per pilot project.

The reproduction of the input summary should be read as indicated in the figures to the right, depending on the number of pages shown on one page of this report.

three or four pages:



one or two pages:



EnrModel: Rosenkæret

Created 9.05.2007 11.38

Project: Rosenkæret	
Climate Library	D:\Programmer\SBi\EnrTool\EnrClimateDk.xml
Constants Library	D:\Programmer\SBi\EnrTool\EnrConstDkdU0.xml
Fuel Library	D:\Programmer\SBi\EnrTool\EnrFuelDk.xml

Building: Rosenkæret Asls

Zone: New building	
Gross area, m²	430
Specific internal heat capacity, kJ/m² K	150
Specific internal coupling coefficient, W/m² K	9,2
Int Temp Heating, °C	20,5
Int Temp Cooling, °C	40
Lighting	
Total installed lighting power, W	4000
Daylight time usage per year for lighting, hours	1870
Non-daylight time usage per year for lighting, hours	470
Daylight dependency factor for lighting, -	1
Occupance factor for lighting, -	1
Fraction not removed by exhaust ventilation, -	1
Emergency lighting charging energy	no
Lighting controls stand-by energy	no
Invest	0
Heat Production / Fraction of time	
Occupants, W/m²	1,03
Fraction Persons present, -	0,06
Appliances, W/m²	1
Fraction Appliances are on, -	0,27
Airflow rate	
Infiltration, m³/s	0,11
Natural vent, m³/s	0
Fraction Nat Vent is present, -	0
Domestic hot water	
Average DHW consumption, m³/m²/year	0
Boiler Temp, °C	65
Cold-water Temp., °C	10

Opaque Construction

Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m²K	Alpha, -	R_se, m²K/W	F_h, -	F_o, -	F_f, -	Invest/m²
First floor, ext walls N	45,0	0,0	90,0	0,300	0,00	0,10	0,100	0,000	0,000	0,00
First floor, ext walls S	42,0	180,0	90,0	0,300	0,00	0,10	0,100	0,000	0,000	0,00
First floor, ext wall W	80,5	270,0	90,0	0,300	0,00	0,10	0,100	0,000	0,000	0,00
Roof	430,0	0,0	0,0	0,200	0,80	0,04	0,000	0,100	0,000	0,00
-	0,0	0,0	0,0	0,000	0,00	0,00	0,000	0,000	0,000	0,00
Basement walls	62,0	0,0	90,0	0,300	0,00	0,10	0,200	0,000	0,000	0,00
Basement walls, sub terrain	78,0	0,0	90,0	0,250	0,00	0,20	1,000	0,000	0,000	0,00

Transparent construction

Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m²K	U_s, W/m²K	G_g, -	G_g_s, -	F_s, -	F_with, -	F_h, -	F_o, -	F_f, -	Invest/m²
North	45,0	0,0	90,0	1,500	1,500	0,660	0,66	0,000	0,000	0,400	0,000	0,050	0,00
West	15,5	270,0	90,0	1,500	1,500	0,660	0,66	0,000	0,000	0,150	0,000	0,050	0,00
South	48,0	180,0	90,0	1,500	1,500	0,660	0,66	0,000	0,000	0,150	0,000	0,050	0,00
	0,0	0,0	90,0	0,000	0,000	0,000	0,00	0,000	0,000	0,000	0,000	0,000	0,00

Ground construction

Name	Area, m²	U, W/m²K	B_g_h, -	B_g_c, -	Invest/m²
Basement floor	430,0	0,250	0,70	0,70	0,00

Mechanical, balanced VAV ventilation	
Fraction of time, -	0,27
Temp. rise by fans, °C	0
Invest	0
Heating part	
Active	true
Supply temp., °C	18
Mechanical ventilation, m³/s	1,33
Heat rec. eff., -	0,8
Recirc. factor, -	0
Cooling part	
Active	false
Supply temp., °C	0
Mechanical ventilation, m³/s	0
Cool rec. eff., -	0
Recirc. factor, -	0
Humidification part	
Active	false

Hum. supply air, g/kg	0
Eff. hum. recovery, -	0
Auxiliary fan energy	
Spec. electricity cons. for fans, Ws/m³	2800
Systems	
Heating	Shared Heating System

Shared Heating System

Factor on fuel consumption, -	1
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0,3	1	1	1	1	0,75	0,25	0	0	0	0,25	0,75	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cascade gas boilers	0,89	1	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Heating distribution system, standard value	0,93	0

Emission

Name	Efficiency, -	Invest
Convectors	0,95	0
Old building, 0, 1 & 2 floor	0,95	0
Old building, 3 & 4 floor	0,95	0
Kanteen	0,95	0

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

Canteen Cooling System

Factor on fuel consumption, -	1

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling Aux	0,5	1	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling generation eff	1	3,5	Electricity	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Cooling distribution efficiency	0,9	0

Emission

Name	Efficiency, -	Invest
Kanteen	1	0

Shared Dhw System

Factor on fuel consumption, -	1
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DHW generated in heating system	0,89	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
DHW distribution	0,7	0

Emission

Name	Efficiency, -	Invest
Kanteen	1	0
Old building, 3 & 4 floor	1	0
Old building, 0, 1 & 2 floor	1	0

New Dhw System

Factor on fuel consumption, -	0
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Dhw System

Factor on fuel consumption, -	0
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

Zone: Old building, 0, 1 & 2 floor

Gross area, m²	1986
Specific internal heat capacity, kJ/m² K	124
Specific internal coupling coefficient, W/m² K	9,2
Int Temp Heating, °C	20,5
Int Temp Cooling, °C	40
Lighting	
Total installed lighting power, W	19860
Daylight time usage per year for lighting, hours	1870
Non-daylight time usage per year for lighting, hours	470
Daylight dependency factor for lighting, -	0,5
Occupance factor for lighting, -	1
Fraction not removed by exhaust ventilation, -	1
Emergency lighting charging energy	no
Lighting controls stand-by energy	no
Invest	0
Heat Production / Fraction of time	
Occupants, W/m²	2,83
Fraction Persons present, -	0,27
Appliances, W/m²	4,45
Fraction Appliances are on, -	0,35
Airflow rate	
Infiltration, m³/s	0,993
Natural vent, m³/s	0
Fraction Nat Vent is present, -	0
Domestic hot water	
Average DHW consumption, m³/m²/year	0,07
Boiler Temp, °C	65
Cold-water Temp., °C	10

Opaque Construction

Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m²K	Alpha, -	R_se, m²K/W	F_h, -	F_o, -	F_f, -	Invest/m²
0 walls	120,0	90,0	90,0	0,300	0,60	0,04	0,100	0,000	0,000	0,00
1 walls	188,0	90,0	90,0	0,300	0,60	0,04	0,100	0,000	0,000	0,00
2 walls	225,0	90,0	90,0	0,300	0,60	0,04	0,100	0,000	0,000	0,00

Transparent construction

Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m²K	U_s, W/m²K	G_g, -	G_g_s, -	F_s, -	F_with, -	F_h, -	F_o, -	F_f, -	Invest/m²
— Basement	0,0	0,0	0,0	0,000	0,000	0,000	0,00	0,000	0,000	0,000	0,000	0,000	0,00
8 North windows	7,8	0,0	90,0	3,000	3,000	0,100	0,10	0,000	0,000	0,300	0,050	0,050	0,00
6 South windows	5,9	180,0	90,0	3,000	3,000	0,100	0,10	0,000	0,000	0,200	0,050	0,050	0,00
2 North doors	11,0	0,0	90,0	3,000	3,000	0,000	0,00	0,000	0,000	0,300	0,050	0,050	0,00
— 1st floor	0,0	0,0	0,0	0,000	0,000	0,000	0,00	0,000	0,000	0,000	0,000	0,000	0,00
12 North windows	32,4	0,0	90,0	3,000	3,000	0,700	0,70	0,000	0,000	0,300	0,050	0,050	0,00
West door	2,4	90,0	90,0	3,000	3,000	0,500	0,50	0,000	0,000	0,250	0,050	0,050	0,00
West window	2,0	90,0	90,0	3,000	3,000	0,700	0,70	0,000	0,000	0,250	0,050	0,050	0,00
12 South windows	32,4	180,0	90,0	3,000	3,000	0,700	0,70	0,000	0,000	0,150	0,050	0,050	0,00
— 2nd floor	0,0	0,0	0,0	0,000	0,000	0,000	0,00	0,000	0,000	0,000	0,000	0,000	0,00
12 North windows	32,4	0,0	90,0	3,000	3,000	0,700	0,70	0,000	0,000	0,200	0,050	0,050	0,00
West Window	5,6	90,0	90,0	3,000	3,000	0,700	0,70	0,000	0,000	0,200	0,050	0,050	0,00
12 South windows	32,4	180,0	90,0	3,000	3,000	0,700	0,70	0,000	0,000	0,100	0,050	0,050	0,00

Ground construction

Name	Area, m²	U, W/m²K	B_g_h, -	B_g_c, -	Invest/m²
Basement floor	616,0	0,300	0,70	0,70	0,00

0, 1 & 2 floor ventilation

Fraction of time, -	0,27
Temp. rise by fans, °C	0
Invest	0
Heating part	
Active	true
Supply temp., °C	0
Mechanical ventilation, m³/s	0,61
Heat rec. eff, -	0
Recirc. factor, -	0
Cooling part	
Active	false
Supply temp., °C	0
Mechanical ventilation, m³/s	0
Cool rec. eff, -	0
Recirc. factor, -	0
Humidification part	
Active	false
Hum. supply air, g/kg	0
Eff. hum. recovery, -	0
Auxiliary fan energy	
Spec. electricity cons. for fans, Ws/m³	2300
Systems	
Heating	Shared Heating System
Dhw	Shared Dhw System

Shared Heating System

Factor on fuel consumption, -	1
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0,3	1	1	1	1	0,75	0,25	0	0	0	0,25	0,75	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cascade gas boilers	0,89	1	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Heating distribution system, standard value	0,93	0

Emission

Name	Efficiency, -	Invest
Convectors	0,95	0
Old building, 0, 1 & 2 floor	0,95	0
Old building, 3 & 4 floor	0,95	0
Kanteen	0,95	0

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

Canteen Cooling System

Factor on fuel consumption, -	1

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling Aux	0,5	1	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling generation eff	1	3,5	Electricity	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Cooling distribution efficiency	0,9	0

Emission

Name	Efficiency, -	Invest
Kanteen	1	0

Shared Dhw System

Factor on fuel consumption, -	1
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DHW generated in heating system	0,89	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
DHW distribution	0,7	0

Emission

Name	Efficiency, -	Invest
Kanteen	1	0
Old building, 3 & 4 floor	1	0
Old building, 0, 1 & 2 floor	1	0

New Dhw System

Factor on fuel consumption, -	0
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Dhw System

Factor on fuel consumption, -	0
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

Zone: Old building, 3 & 4 floor

Gross area, m²	823
Specific internal heat capacity, kJ/m² K	124
Specific internal coupling coefficient, W/m² K	9,2
Int Temp Heating, °C	20,5
Int Temp Cooling, °C	40

Lighting

Total installed lighting power, W	8235
Daylight time usage per year for lighting, hours	936
Non-daylight time usage per year for lighting, hours	1404
Daylight dependency factor for lighting, -	1
Occupance factor for lighting, -	1
Fraction not removed by exhaust ventilation, -	1
Emergency lighting charging energy	no
Lighting controls stand-by energy	no
Invest	0

Heat Production / Fraction of time

Occupants, W/m²	1,17
Fraction Persons present, -	0,26
Appliances, W/m²	4,45
Fraction Appliances are on, -	0,35

Airflow rate

Infiltration, m³/s	0,11
Natural vent, m³/s	2,5
Fraction Nat Vent is present, -	0,3

Domestic hot water

Average DHW consumption, m³/m²/year	0,07
Boiler Temp, °C	65
Cold-water Temp., °C	10

Opaque Construction

Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m²K	Alpha, -	R_se, m²K/W	F_h, -	F_o, -	F_f, -	Invest/m²
West Wall	71,0	270,0	90,0	0,300	0,70	0,04	0,050	0,000	0,000	0,00
East Wall	101,0	90,0	90,0	0,300	0,70	0,05	0,050	0,000	0,000	0,00
North Roof	414,0	0,0	45,0	0,200	0,80	0,04	0,000	0,000	0,000	0,00
South Roof	325,0	180,0	45,0	0,200	0,80	0,04	0,000	0,000	0,000	0,00

Transparent construction

Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m²K	U_s, W/m²K	G_g, -	G_g_s, -	F_s, -	F_with, -	F_h, -	F_o, -	F_f, -	Invest/m²
West windows	7,0	270,0	90,0	3,000	3,000	0,700	0,70	0,000	0,000	0,050	0,050	0,000	0,00
East Windows	7,0	90,0	90,0	3,000	3,000	0,700	0,70	0,000	0,000	0,050	0,050	0,000	0,00
North roof windows, 3	18,4	0,0	45,0	2,000	2,000	0,630	0,63	0,000	0,300	0,000	0,020	0,010	0,00
North roof windows, 4	17,6	0,0	45,0	2,000	2,000	0,630	0,63	0,000	0,300	0,000	0,020	0,010	0,00
South roof windows, 3	4,2	180,0	45,0	2,000	2,000	0,630	0,40	0,000	0,500	0,000	0,020	0,010	0,00
South roof windows, 4	15,6	180,0	45,0	2,000	2,000	0,630	0,40	0,000	0,500	0,000	0,020	0,010	0,00

Ground construction

Name	Area, m²	U, W/m²K	B_g_h, -	B_g_c, -	Invest/m²

Shared Heating System

Factor on fuel consumption, -	1
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0,3	1	1	1	1	0,75	0,25	0	0	0	0,25	0,75	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cascade gas boilers	0,89	1	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Heating distribution system, standard value	0,93	0

Emission

Name	Efficiency, -	Invest
Convectors	0,95	0
Old building, 0, 1 & 2 floor	0,95	0
Old building, 3 & 4 floor	0,95	0
Kanteen	0,95	0

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

Canteen Cooling System

Factor on fuel consumption, -	1

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling Aux	0,5	1	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling generation eff	1	3,5	Electricity	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Cooling distribution efficiency	0,9	0

Emission

Name	Efficiency, -	Invest
Kanteen	1	0

Shared Dhw System

Factor on fuel consumption, -	1
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DHW generated in heating system	0,89	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
DHW distribution	0,7	0

Emission

Name	Efficiency, -	Invest
Kanteen	1	0
Old building, 3 & 4 floor	1	0
Old building, 0, 1 & 2 floor	1	0

New Dhw System

Factor on fuel consumption, -	0
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Dhw System

Factor on fuel consumption, -	0
Use Solar Collector	No

Generator eff. and load contribution

Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

Zone: Kanteen

Gross area, m²	150
Specific internal heat capacity, kJ/m² K	124
Specific internal coupling coefficient, W/m² K	9,2
Int Temp Heating, °C	20,5
Int Temp Cooling, °C	23

Lighting

Total installed lighting power, W	1125
Daylight time usage per year for lighting, hours	52
Non-daylight time usage per year for lighting, hours	208
Daylight dependency factor for lighting, -	1
Occupance factor for lighting, -	1
Fraction not removed by exhaust ventilation, -	1
Emergency lighting charging energy	no
Lighting controls stand-by energy	no
Invest	0

Heat Production / Fraction of time

Occupants, W/m²	35
Fraction Persons present, -	0,03
Appliances, W/m²	5
Fraction Appliances are on, -	0,27

Airflow rate

Infiltration, m³/s	0,02
Natural vent, m³/s	0
Fraction Nat Vent is present, -	0

Domestic hot water

Average DHW consumption, m³/m²/year	0,07
Boiler Temp, °C	0,65
Cold-water Temp., °C	10

Opaque Construction

Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m²K	Alpha, -	R_se, m²K/W	F_h, -	F_o, -	F_f, -	Invest/m²
West gable	20,0	270,0	90,0	0,300	0,70	0,04	0,050	0,000	0,000	0,00
South roof	96,9	180,0	90,0	0,200	0,80	0,04	0,000	0,000	0,000	0,00

Transparent construction

Name	Area, m²	Orientation, deg	Tilt, deg	U, W/m²K	U_s, W/m²K	G_g, -	G_g_s, -	F_s, -	F_with, -	F_h, -	F_o, -	F_f, -	Invest/m²
South roof windows	8,1	180,0	45,0	2,000	2,000	0,630	0,40	0,000	0,500	0,000	0,050	0,050	0,00

Ground construction

Name	Area, m²	U, W/m²K	B_g_h, -	B_g_c, -	Invest/m²

Canteen Ahu

Fraction of time, -	0,03
Temp. rise by fans, °C	0
Invest	0

Heating part

Active	true
Supply temp., °C	18
Mechanical ventilation, m³/s	0,56
Heat rec. eff, -	0
Recirc. factor, -	0

Cooling part

Active	false
Supply temp., °C	0
Mechanical ventilation, m³/s	0
Cool rec. eff, -	0
Recirc. factor, -	0

Humidification part

Active	false
Hum. supply air, g/kg	0
Eff. hum. recovery, -	0

Auxiliary fan energy

Spec. electricity cons. for fans, Ws/m³	2300

Systems

Heating	Shared Heating System
Cooling	Canteen Cooling System
Dhw	Shared Dhw System

Shared Heating System

Factor on fuel consumption, -	1
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0,3	1	1	1	1	0,75	0,25	0	0	0	0,25	0,75	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cascade gas boilers	0,89	1	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Heating distribution system, standard value	0,93	0

Emission

Name	Efficiency, -	Invest
Convectors	0,95	0
Old building, 0, 1 & 2 floor	0,95	0
Old building, 3 & 4 floor	0,95	0
Kanteen	0,95	0

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

New Heating System

Factor on fuel consumption, -	0
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution

Name	Efficiency, -	Invest

Emission

Name	Efficiency, -	Invest

Canteen Cooling System

Factor on fuel consumption, -	1

Aux energy and operation time fraction

Name	p_pump, W/m²	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling Aux	0,5	1	1	1	1	1	1	1	1	1	1	1	1	1

Generator eff. and load contribution

Name	Efficiency, -	COP, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling generation eff	1	3,5	Electricity	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Cooling distribution efficiency	0,9	0

Emission

Name	Efficiency, -	Invest
Kanteen	1	0

Shared Dhw System	
Factor on fuel consumption, -	1
Use Solar Collector	No

Generator eff. and load contribution															
Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DHW generated in heating system	0,89	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution		
Name	Efficiency, -	Invest
DHW distribution	0,7	0

Emission		
Name	Efficiency, -	Invest
Kanteen	1	0
Old building, 3 & 4 floor	1	0
Old building, 0, 1 & 2 floor	1	0

New Dhw System	
Factor on fuel consumption, -	0
Use Solar Collector	No

Generator eff. and load contribution															
Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Distribution		
Name	Efficiency, -	Invest

Emission		
Name	Efficiency, -	Invest

New Dhw System	
Factor on fuel consumption, -	0
Use Solar Collector	No

Generator eff. and load contribution															
Name	Efficiency, -	Fuel	Invest	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

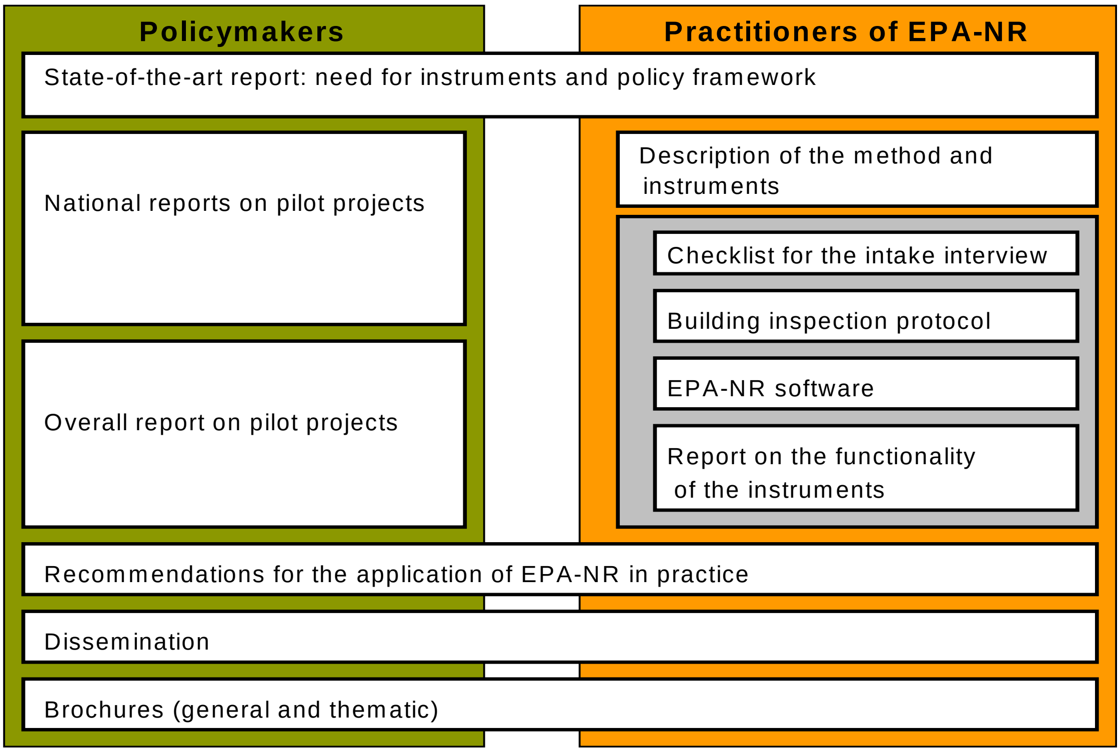
Distribution		
Name	Efficiency, -	Invest

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, design- and 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:
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ENEA (Italy)
National Agency for New Technology, Energy and the Environment

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