Pilot study

Educational building. National report -Denmark

Wittchen, Kim Bjarne

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Energy Performance Assessment
of Existing Non-Residential Buildings

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

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Pilot study – Educational building

National report – Denmark

Author/s
Kim B. Wittchen
SBi
Hørsholm, Denmark
Telephone: +45-45 742 379
Email: kbw@SBi.dk

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www.epa-nr.org

Project coordinator
EBM-Consult, Arnhem,
The Netherlands

Mr. Bart Poel
bpoel@ebm-consult.nl

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 Education building, Stengård School

2.1 Project summary

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

Type of building: Education Location: Scattered urban environment of similar height *Owner:* Public *Year of construction:* 1950-52 *Total gross area (m²):* 12,995 m² *Total conditioned area (m²):* 7,702 m² *Building occupancy:* 80 hours week, except during summer holydays (late June – mid August) *Number of occupants:* About 560, 512 pupils, 35 teachers and misc. staff.	*Short description:* The scattered buildings at Stengård school consists 6 terraced buildings with most of the class rooms. The gymnasiums are located in an individual building. The school is owned by Gladsaxe municipality. The buildings are oriented along a North-West axis and the rooms are thus oriented either South-West or North-East. *Construction:* Facades are made of hollow core masonry with insulation. Roof is covered by roofing tiles. The glass in the windows is traditional double pane thermo windows though in continuous replacement to low energy glazing when broken. *Heating/cooling/ventilation/lighting:* Heating is via a local district heating plant running on natural gas. There are two boilers, a new condensing and an old traditional operating in cascade, with the new boiler as #

<table>
<tr>
<td></td>
<td>1. There is mechanical ventilation in gymnasiums and assembly hall while there is exhaust ventilation in the rest of the heated area.</td>
</tr>
<tr>
<td>
Energy management: An energy management system has been installed recently.

Energy consumption year 2005:
<table>
<tr><th></th><th>The building (According the bills)</th><th>National average (if known)</th></tr>
<tr><td>Fuel</td><td>147.4 kWh/m²</td><td>125.9 kWh/m²</td></tr>
<tr><td>Electricity</td><td>16.5 kWh/m²</td><td>22.3 kWh/m²</td></tr>
<tr><td>Water</td><td>0.18 m³/m²</td><td>0.24 m³/m²</td></tr>
</table>
</td>
<td>
Previous refurbishment: Almost all windows have been replaced with low energy windows. Old roof insulation (100 mm) has been replaced with new 125 mm mineral wool. Thermostat valves have been introduced in all rooms. New condensing natural gas boiler has replaced an old one. No further major refurbishments have been undertaken, but continuous, minor improvements of the energy performance are being made.

Planned refurbishment: Update of the heating system, installation of energy management system, new lighting system.
</td>
</tr>
</table>

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

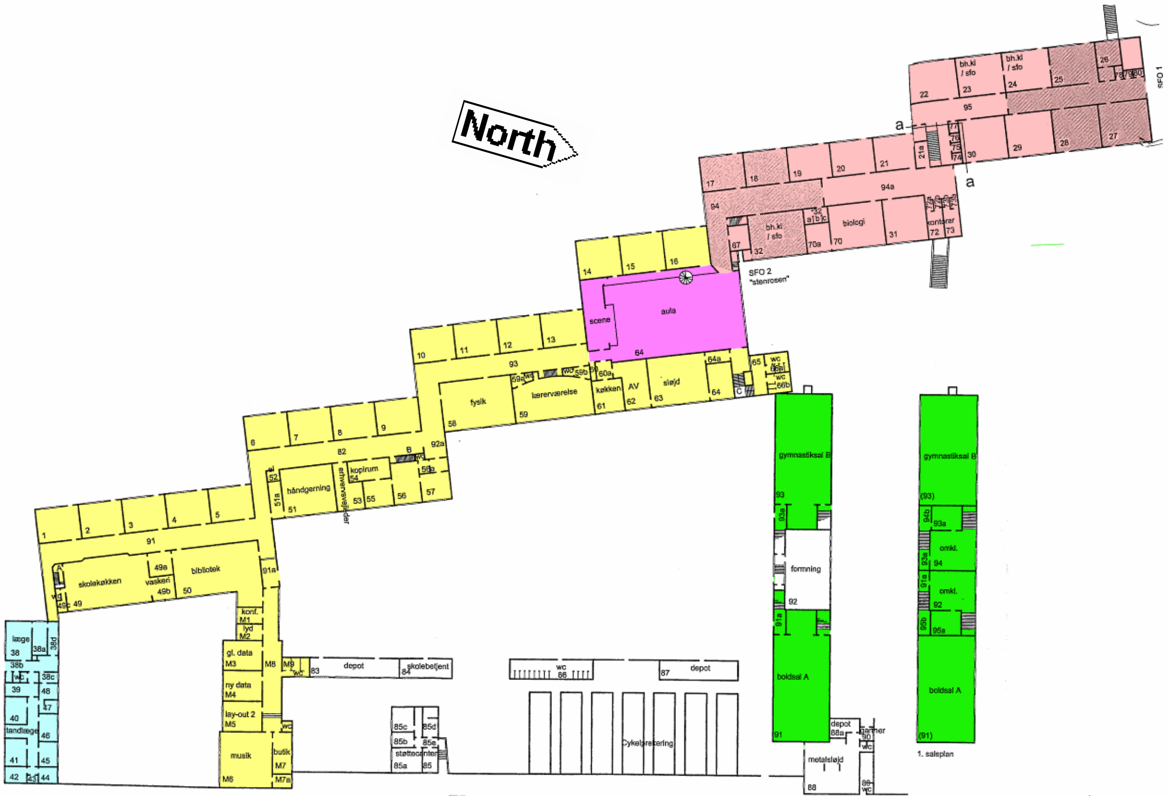


Figure 1. Plan of Stengård school. The colours indicate: Green – gymnasium (ground and 1st floor); Pink – after-school centre; Yellow – educational areas; Purple - assembly hall; Blue – School dentist and doctor; White – service areas, metal workshop, and arts class.

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

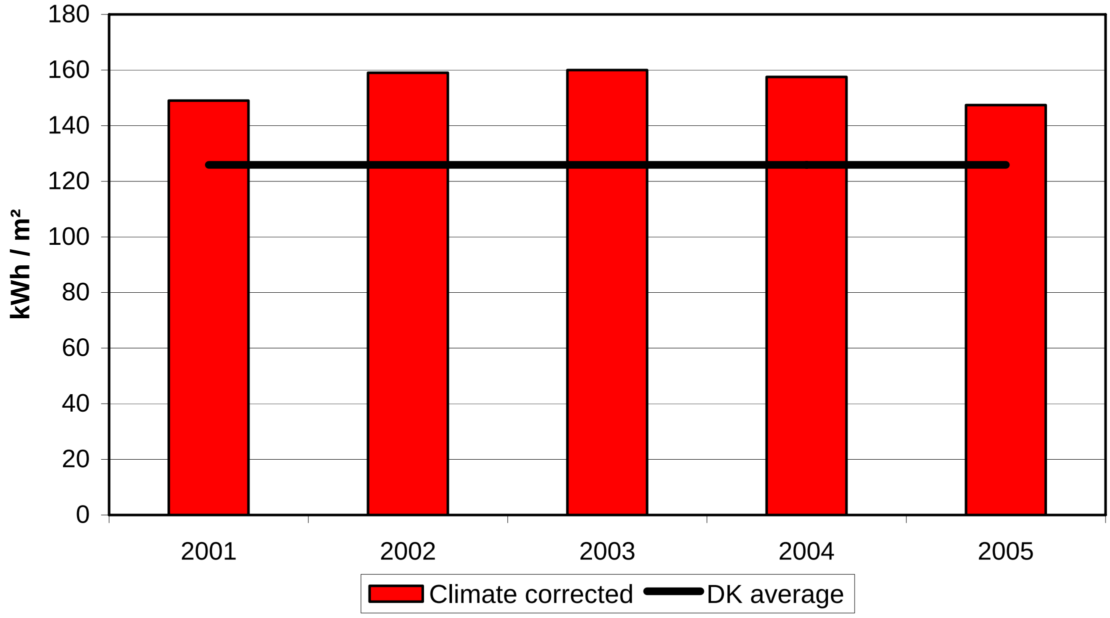


Figure 2. Climate adjusted heating consumption in kWh/m² and the average heating consumption in Danish natural gas heated schools. The degree-day independent heating consumption constitutes 3 %.

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

2.2.1.3 Electricity consumption

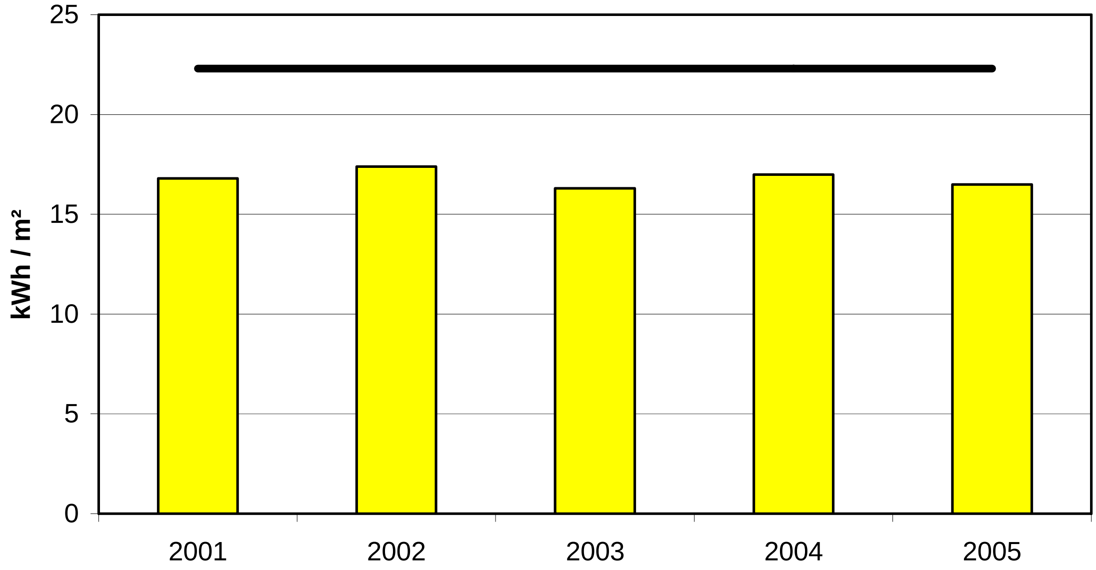


Figure 3. Actual electricity consumption in MWh and the average consumption in Danish schools.

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

2.2.1.4 Water consumption

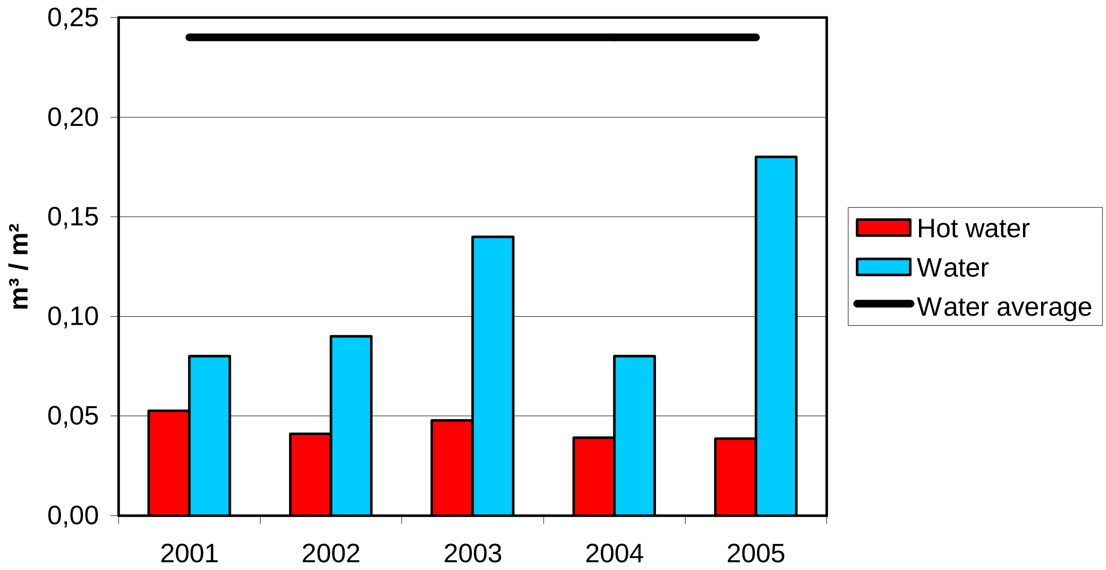


Figure 4. Water and hot water consumption at Stengård school in m³/m² and Danish average consumption in schools.

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

The large national water consumption is partly influenced by the presence of swimming baths in a number of the Danish schools. 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 m²),
2. Zone 2: Gymnasium (1240 m²),
3. Zone 3: After-school centre (1726 m²),
4. Zone 4: Assembly hall (450 m²).

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

5. Health clinic (290 m²),
6. Metal workshop (105 m²),
7. Support centre for pupils with special needs (108 m²).

List of energy uses:
Zone 1: heated and naturally ventilated,
Zone 2: heated and naturally ventilated,
Zone 3: heated and naturally ventilated,
Zone 4: heated and mechanically ventilated.

Operational parameters used for the calculation:

	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_2 emission of the building

Primary energy consumption of the building: kWh/m²/year	CO_2 emission of the building: kg/m²/year
203.98	25.7

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

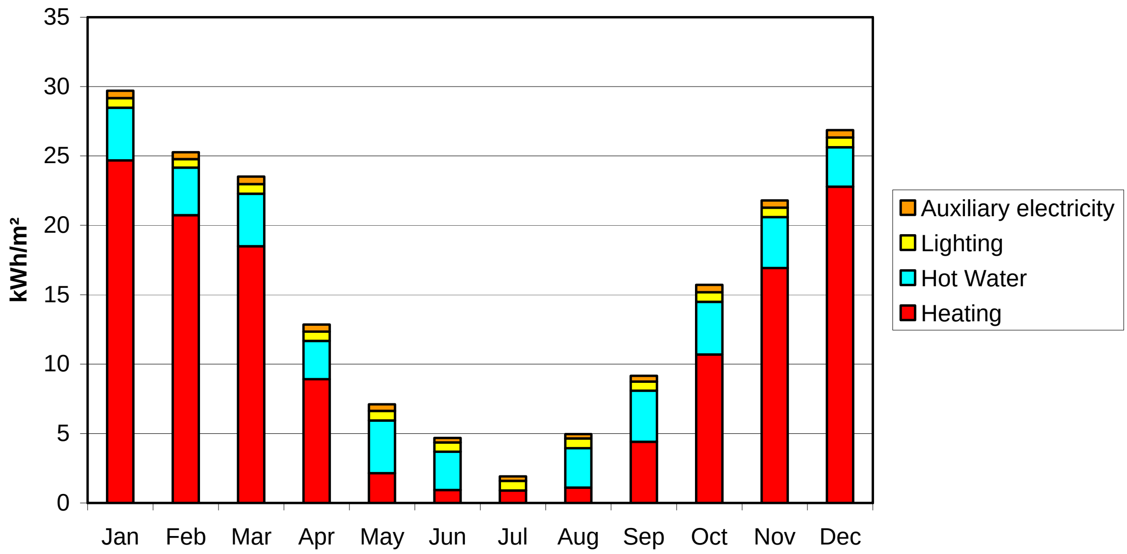
	Annual final energy consumption* of the building per fuel type:	Primary energy consumption of the building: kWh/m²/year	CO_2 emission of the building: kg/m²/year
Natural gas	1053,79 MWh/year	169.86	16.1
Electricity	211,72 MWh/year	13.65	9.6

** 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).

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

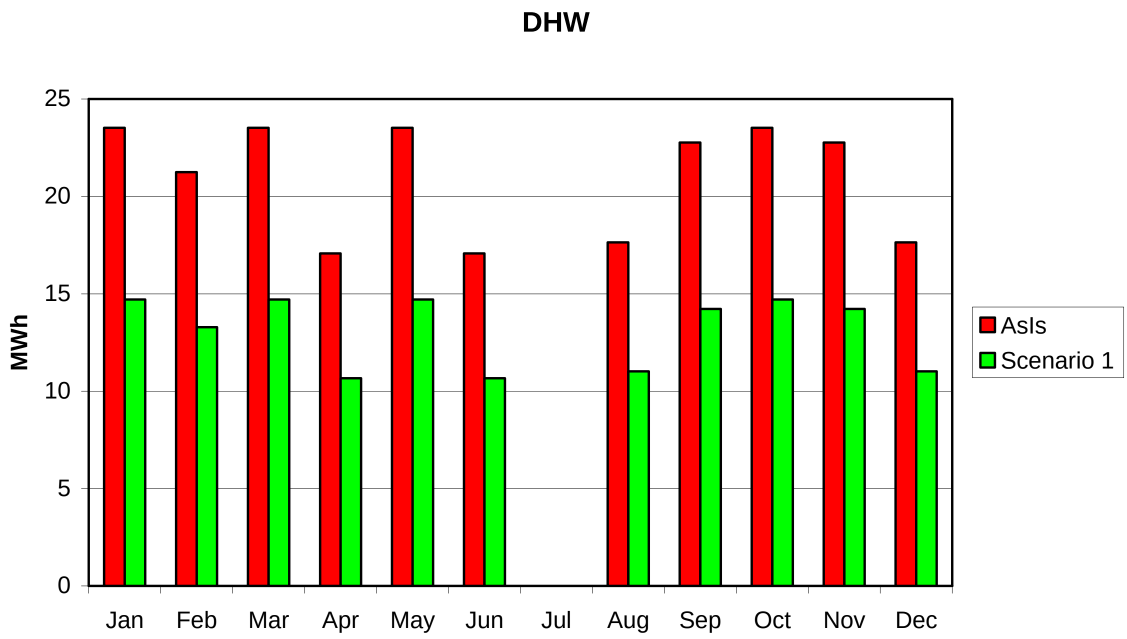
2.3 Calculation of energy savings : scenarios for improvement

2.3.1 Scenario 1 - Derease of DHW circulation temperature

2.3.1.1 Background and proposed solution

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

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



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

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

2.3.1.2 Recommendation

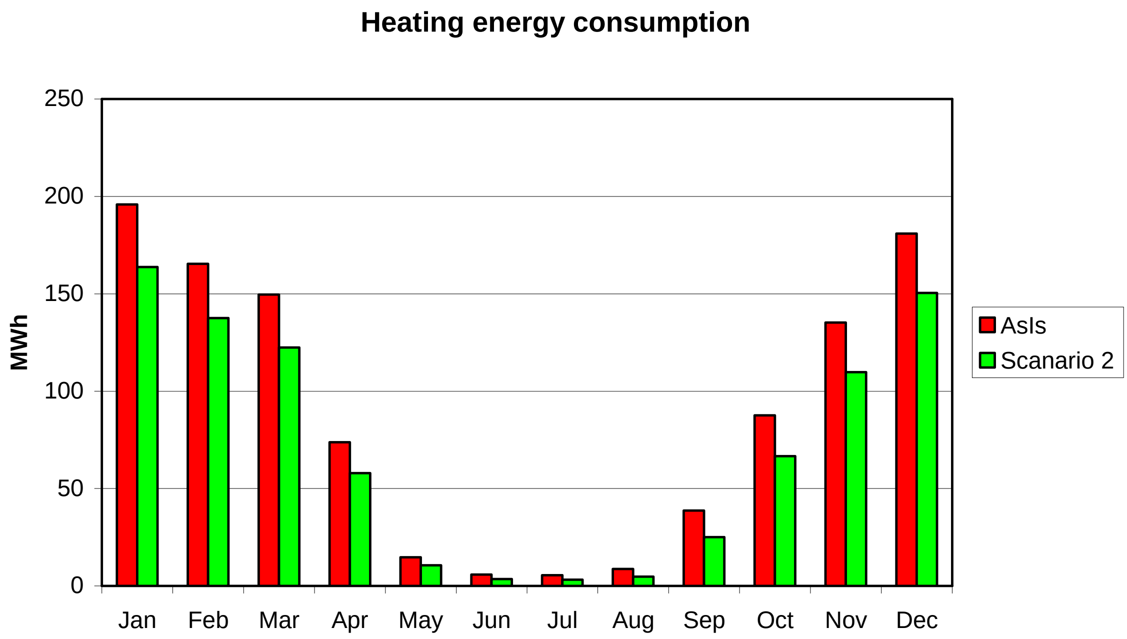
It is highly recommended to carry out this measure.

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

2.3.2.1 Background and proposed solution

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

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



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

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

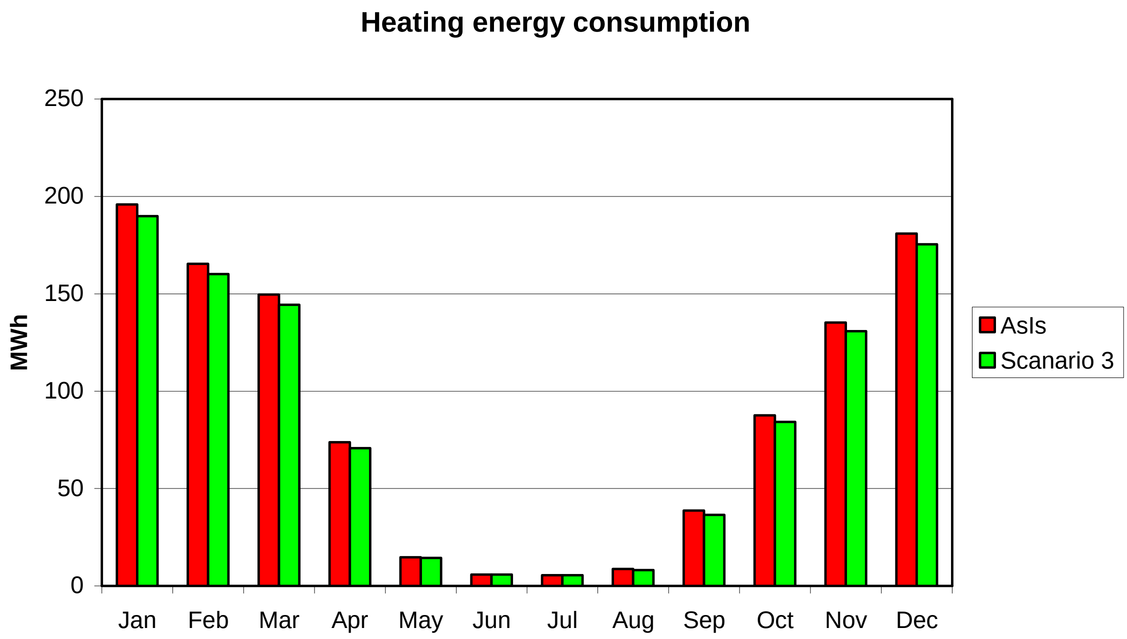
2.3.2.2 Recommendation

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

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

2.3.3.1 Background and proposed solution

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



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

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

2.3.3.2 Recommendation

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

3 Appendix 1: additional information about pilot projects

3.1 Educational building, Stengård school

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


View from the playground.


Connection building with media facilities.

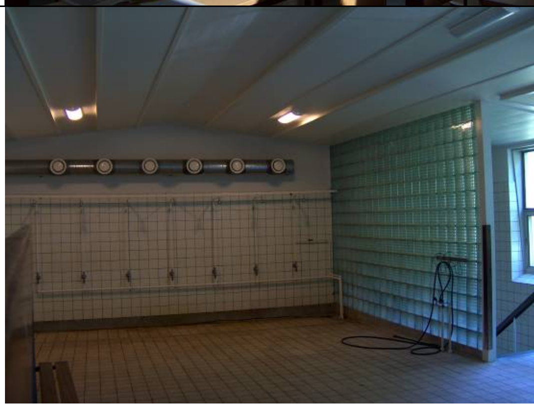

Exit from one of the corridors.


Assembly hall.


Corridor with class rooms on both sides.


Class room with sky lights.


Domestic hot water distribution network.


Bathing facilities in gymnasium.


Boilers, condensing and traditional.


New, un-insulated ventilation system.

Dis-placed and compressed roof insulation.

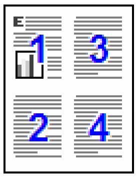
Heat exchanger and control system for domestic hot water distribution and circulation.

4 Appendix 2: inputs data for calculations

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

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

three or four pages:



4.1 Educational building, Stengård school

EnrModel: Stengård AsIs Created 15.06.2007 12.47

Building: Stengård school, AsIs	
Zone: Educational areas	
Gross area, m²	2788
Specific internal heat capacity, kJ/m² K	240
Specific internal coupling coefficient, W/m² K	9,2
Int Temp Heating, °C	22
Int Temp Cooling, °C	30
Lighting	
Total installed lighting power, W	22000
Daylight time usage per year for lighting, hours	875
Non-daylight time usage per year for lighting, hours	175
Daylight dependency factor for lighting, -	1
Occupance factor for lighting, -	1
Fraction not removed by exhaust ventilation, -	0
Emergency lighting charging energy	no
Lighting controls stand-by energy	no
Invest	0
Heat Production / Fraction of time	
Occupants, W/m²	16,8
Fraction Persons present, -	0,13
Appliances, W/m²	4
Fraction Appliances are on, -	0,4
Airflow rate	
Infiltration, m³/s	0,5
Natural vent, m³/s	0,6
Fraction Nat Vent is present, -	0,2
Domestic hot water	
Average DHW consumption, m³/m²/year	0,2
Boiler Temp, °C	72
Cold-water Temp., °C	8

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
Esat facades	293,5	90,0	90,0	0,600	0,80	0,04	0,850	0,850	1,000	0,00
West facades	373,5	270,0	90,0	0,600	0,80	0,04	0,900	0,850	0,800	0,00
South facades	312,5	180,0	90,0	0,600	0,80	0,04	0,900	0,900	0,700	0,00
North Facades	221,0	0,0	90,0	0,600	0,80	0,04	0,900	0,900	0,850	0,00
Roofs	2983,0	90,0	20,0	0,300	0,80	0,04	1,000	1,000	1,000	0,00
Dormers	19,5	90,0	90,0	0,300	0,20	0,04	1,000	1,000	1,000	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
East windows	122,4	90,0	90,0	1,800	1,800	0,680	0,68	0,000	0,000	0,800	0,850	0,950	0,00
East doors	34,0	90,0	90,0	2,000	2,000	0,700	0,70	0,000	0,000	0,800	0,750	0,950	0,00
West windows	158,4	270,0	90,0	1,800	1,800	0,680	0,68	0,000	0,000	0,900	0,850	0,950	0,00
South windows	45,5	180,0	90,0	1,800	1,800	0,680	0,68	0,000	0,000	0,900	0,950	0,800	0,00
South doors	39,0	180,0	90,0	2,000	2,000	0,600	0,60	0,000	0,000	0,900	0,950	0,800	0,00
North windows	48,2	0,0	90,0	1,800	1,800	0,680	0,68	0,000	0,000	0,900	0,500	0,900	0,00
Nort Doors	8,0	0,0	90,0	5,000	5,000	0,820	0,85	0,000	0,000	0,900	0,300	0,850	0,00

Ground construction

Name	Area, m²	U, W/m²K	B_g_h, -	B_g_c, -	Invest/m²
Floors	2788,0	0,600	0,30	0,30	0,00

School Ahu	
Fraction of time, -	1
Temp. rise by fans, °C	0
Invest	0
Heating part	
Active	false
Supply temp., °C	0
Mechanical ventilation, m³/s	0
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	0
Systems	
Heating	General Heating System
Dhw	General Dhw System

Assembly hall 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	1	0,75	0,1	0	0	0,5	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
Generator	1,04	1	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Heating distribution efficiency	0,7	0

Emission

Name	Efficiency, -	Invest
Heating coil in ventilation	0,85	0

General 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	1	0,75	0,1	0	0	0,5	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
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

Distribution

Name	Efficiency, -	Invest
Distribution system	0,8	0

Emission

Name	Efficiency, -	Invest
Radiators	0,9	0
Radiators	0,9	0

General 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
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

Distribution

Name	Efficiency, -	Invest
DHW distribution	0,5	0

Emission

Name	Efficiency, -	Invest
Water taps	1	0
Water taps	1	0
Taps and showers	1	0

Gymnasium 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: Gymnasium

Gross area, m^2	1240
Specific internal heat capacity, kJ/m^2 K	240
Specific internal coupling coefficient, W/m^2 K	9,2
Int Temp Heating, °C	22
Int Temp Cooling, °C	30
Lighting	
Total installed lighting power, W	6200
Daylight time usage per year for lighting, hours	875
Non-daylight time usage per year for lighting, hours	265
Daylight dependency factor for lighting, -	1
Occupance factor for lighting, -	1
Fraction not removed by exhaust ventilation, -	0
Emergency lighting charging energy	no
Lighting controls stand-by energy	no
Invest	0
Heat Production / Fraction of time	
Occupants, W/m^2	20
Fraction Persons present, -	0,1
Appliances, W/m^2	2
Fraction Appliances are on, -	0,2
Airflow rate	
Infiltration, m^3/s	0,5
Natural vent, m^3/s	0,6
Fraction Nat Vent is present, -	0,3
Domestic hot water	
Average DHW consumption, m^3/m^2/year	0,8
Boiler Temp, °C	72
Cold-water Temp., °C	8

Opaque Construction

Name	Area, m^2	Orientation, deg	Tilt, deg	U, W/m^{2}K	Alpha, -	R_se, m^{2}K/W	F_h, -	F_o, -	F_f, -	Invest/m^2
South facade	354,0	180,0	90,0	0,600	0,80	0,04	0,900	0,800	1,000	0,00
North facade	384,5	0,0	90,0	0,600	0,80	0,04	0,500	1,000	1,000	0,00
East facade	80,0	90,0	90,0	0,600	0,80	0,04	0,900	1,000	0,800	0,00
West facade	80,0	270,0	90,0	0,600	0,80	0,04	0,800	1,000	1,000	0,00
Roof, South	310,0	180,0	20,0	0,300	0,80	0,04	0,800	1,000	1,000	0,00
Roof, North	310,0	0,0	20,0	0,300	0,80	0,04	0,800	1,000	1,000	0,00

Transparent construction

Name	Area, m^2	Orientation, deg	Tilt, deg	U, W/m^{2}K	U_s, W/m^{2}K	G_g, -	G_g_s, -	F_s, -	F_with, -	F_h, -	F_o, -	F_f, -	Invest/m^2
South windows	65,6	180,0	90,0	3,000	3,000	0,400	0,40	0,000	0,000	0,950	1,000	0,950	0,00
South doors	14,0	180,0	90,0	5,000	5,000	0,500	0,50	0,000	0,000	0,950	0,600	0,950	0,00
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	0,00
North doors	4,0	0,0	90,0	5,000	5,000	0,500	0,50	0,000	0,000	0,500	0,700	0,950	0,00

Ground construction

Name	Area, m^2	U, W/m^{2}K	B_g_h, -	B_g_c, -	Invest/m^2
Floor	620,0	0,600	0,25	0,25	0,00

Gymnasium Ahu

Fraction of time, -	1
Temp. rise by fans, °C	0
Invest	0
Heating part	
Active	false
Supply temp., °C	0
Mechanical ventilation, m^3/s	0
Heat rec. eff, -	0
Recirc. factor, -	0
Cooling part	
Active	false
Supply temp., °C	0
Mechanical ventilation, m^3/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/m^3	0
Systems	
Heating	General Heating System
Dhw	General Dhw System

Assembly hall heating system

Factor on fuel consumption, -	1
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m^2	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0,3	1	1	1	1	1	0,75	0,1	0	0	0,5	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
Generator	1,04	1	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Heating distribution efficiency	0,7	0

Emission

Name	Efficiency, -	Invest
Heating coil in ventilation	0,85	0

General Heating System

Factor on fuel consumption, -	1
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m^2	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0,3	1	1	1	1	1	0,75	0,1	0	0	0,5	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
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

Distribution

Name	Efficiency, -	Invest
Distribution system	0,8	0

Emission

Name	Efficiency, -	Invest
Radiators	0,9	0
Radiators	0,9	0

General 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
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

Distribution

Name	Efficiency, -	Invest
DHW distribution	0,5	0

Emission

Name	Efficiency, -	Invest
Water taps	1	0
Water taps	1	0
Taps and showers	1	0

Gymnasium 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: After-school centre

Gross area, m²	1726
Specific internal heat capacity, kJ/m² K	240
Specific internal coupling coefficient, W/m² K	9,2
Int Temp Heating, °C	22
Int Temp Cooling, °C	30
Lighting	
Total installed lighting power, W	17260
Daylight time usage per year for lighting, hours	700
Non-daylight time usage per year for lighting, hours	0
Daylight dependency factor for lighting, -	1
Occupance factor for lighting, -	1
Fraction not removed by exhaust ventilation, -	0
Emergency lighting charging energy	no
Lighting controls stand-by energy	no
Invest	0
Heat Production / Fraction of time	
Occupants, W/m²	25
Fraction Persons present, -	0,14
Appliances, W/m²	2,2
Fraction Appliances are on, -	0,5
Airflow rate	
Infiltration, m³/s	0,5
Natural vent, m³/s	0,6
Fraction Nat Vent is present, -	0,17
Domestic hot water	
Average DHW consumption, m³/m²/year	0,02
Boiler Temp, °C	72
Cold-water Temp., °C	8

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
Facades, East	217,5	90,0	90,0	0,600	0,80	0,04	0,850	0,850	1,000	0,00
Facades, West	191,5	270,0	90,0	0,600	0,80	0,04	0,850	0,850	0,950	0,00
Gables, North	173,0	0,0	90,0	0,600	0,80	0,04	0,850	1,000	0,950	0,00
Gables, South	147,0	180,0	90,0	0,600	0,80	0,04	0,900	1,000	0,850	0,00
Roof, East	923,0	90,0	20,0	0,300	0,80	0,04	1,000	1,000	1,000	0,00
Roof West	923,0	270,0	20,0	0,300	0,80	0,04	1,000	1,000	1,000	0,00
Dormers East	15,0	90,0	90,0	0,300	0,20	0,04	1,000	1,000	1,000	0,00
Dromers West	15,0	270,0	90,0	0,300	0,20	0,04	1,000	1,000	1,000	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
East windows	72,0	90,0	90,0	1,800	1,800	0,680	0,68	0,000	0,000	0,850	0,850	0,950	0,00
East Doors	20,0	90,0	90,0	2,000	2,000	0,700	0,70	0,000	0,000	0,850	0,750	0,950	0,00
West Windows	79,2	270,0	90,0	1,800	1,800	0,680	0,68	0,000	0,000	0,900	0,850	0,950	0,00
West Doors	8,0	270,0	90,0	2,000	2,000	0,700	0,70	0,000	0,000	0,900	0,750	0,950	0,00
South doors	20,8	180,0	90,0	2,000	2,000	0,500	0,50	0,000	0,000	0,900	0,950	0,850	0,00
North Doors	10,4	0,0	90,0	2,000	2,000	0,500	0,50	0,000	0,000	0,900	0,950	0,950	0,00
East dormers	32,0	90,0	90,0	1,800	1,800	0,680	0,68	0,000	0,000	0,950	1,000	1,000	0,00
West dormers	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

Ground construction

Name	Area, m²	U, W/m²K	B_g_h, -	B_g_c, -	Invest/m²
Floor	1726,0	0,600	0,30	0,30	0,00

General AHU

Fraction of time, -	1
Temp. rise by fans, °C	0
Invest	0
Heating part	
Active	false
Supply temp., °C	0
Mechanical ventilation, m³/s	0
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	0
Systems	
Heating	General Heating System
Dhw	General Dhw System

Assembly hall 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	1	0,75	0,1	0	0	0,5	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
Generator	1,04	1	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Heating distribution efficiency	0,7	0

Emission

Name	Efficiency, -	Invest
Heating coil in ventilation	0,85	0

General 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	1	0,75	0,1	0	0	0,5	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
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

Distribution

Name	Efficiency, -	Invest
Distribution system	0,8	0

Emission

Name	Efficiency, -	Invest
Radiators	0,9	0
Radiators	0,9	0

General 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
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

Distribution

Name	Efficiency, -	Invest
DHW distribution	0,5	0

Emission

Name	Efficiency, -	Invest
Water taps	1	0
Water taps	1	0
Taps and showers	1	0

Gymnasium 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: Assembly hall

Gross area, m^2	450
Specific internal heat capacity, $kJ/m^2 K$	260
Specific internal coupling coefficient, $W/m^2 K$	9,2
Int Temp Heating, °C	22
Int Temp Cooling, °C	24

Lighting

Total installed lighting power, W	20000
Daylight time usage per year for lighting, hours	200
Non-daylight time usage per year for lighting, hours	200
Daylight dependency factor for lighting, -	1
Occupance factor for lighting, -	1
Fraction not removed by exhaust ventilation, -	0
Emergency lighting charging energy	no
Lighting controls stand-by energy	no
Invest	0

Heat Production / Fraction of time

Occupants, W/m^2	130
Fraction Persons present, -	0,05
Appliances, W/m^2	0
Fraction Appliances are on, -	0

Airflow rate

Infiltration, m^3/s	0,5
Natural vent, m^3/s	0
Fraction Nat Vent is present, -	0

Domestic hot water

Average DHW consumption, $m^3/m^2/year$	0,04
Boiler Temp, °C	72
Cold-water Temp., °C	8

Opaque Construction

Name	Area, m^2	Orientation, deg	Tilt, deg	U, W/m^2K	Alpha, -	R_se, m^2K/W	F_h, -	F_o, -	F_f, -	Invest/m^2
Ext walls, South	29,0	180,0	90,0	0,600	0,80	0,04	0,850	1,000	1,000	0,00
Roof, West	251,0	270,0	30,0	0,300	0,80	0,04	1,000	1,000	1,000	0,00
Roof, East	251,0	90,0	30,0	0,300	0,80	0,04	1,000	1,000	1,000	0,00

Transparent construction

Name	Area, m^2	Orientation, deg	Tilt, deg	U, W/m^2K	U_s, W/m^2K	G_g, -	G_g_s, -	F_s, -	F_with, -	F_h, -	F_o, -	F_f, -	Invest/m^2
Double facade	120,0	0,0	90,0	1,120	1,120	0,500	0,50	0,000	0,000	0,900	1,000	0,950	0,00

Ground construction

Name	Area, m^2	U, W/m^2K	B_g_h, -	B_g_c, -	Invest/m^2
Floor	450,0	0,600	0,30	0,30	0,00

Assembly hall ventilation

Fraction of time, -	0,48
Temp. rise by fans, °C	1,4
Invest	0

Heating part

Active	true
Supply temp., °C	18
Mechanical ventilation, m^3/s	2,2
Heat rec. eff, -	0,6
Recirc. factor, -	0

Cooling part

Active	false
Supply temp., °C	0
Mechanical ventilation, m^3/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/m^3	2500

Systems

Heating	Assembly hall heating system

Assembly hall heating system

Factor on fuel consumption, -	1
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m^2	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0,3	1	1	1	1	1	0,75	0,1	0	0	0,5	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
Generator	1,04	1	Natural gas, high energy	0	1	1	1	1	1	1	1	1	1	1	1	1

Distribution

Name	Efficiency, -	Invest
Heating distribution efficiency	0,7	0

Emission

Name	Efficiency, -	Invest
Heating coil in ventilation	0,85	0

General Heating System

Factor on fuel consumption, -	1
Use Solar Collector	No

Aux energy and operation time fraction

Name	p_pump, W/m^2	f_contr, -	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating Aux	0,3	1	1	1	1	1	0,75	0,1	0	0	0,5	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
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

Distribution

Name	Efficiency, -	Invest
Distribution system	0,8	0

Emission

Name	Efficiency, -	Invest
Radiators	0,9	0
Radiators	0,9	0

General 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
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

Distribution

Name	Efficiency, -	Invest
DHW distribution	0,5	0

Emission

Name	Efficiency, -	Invest
Water taps	1	0
Water taps	1	0
Taps and showers	1	0

Gymnasium 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

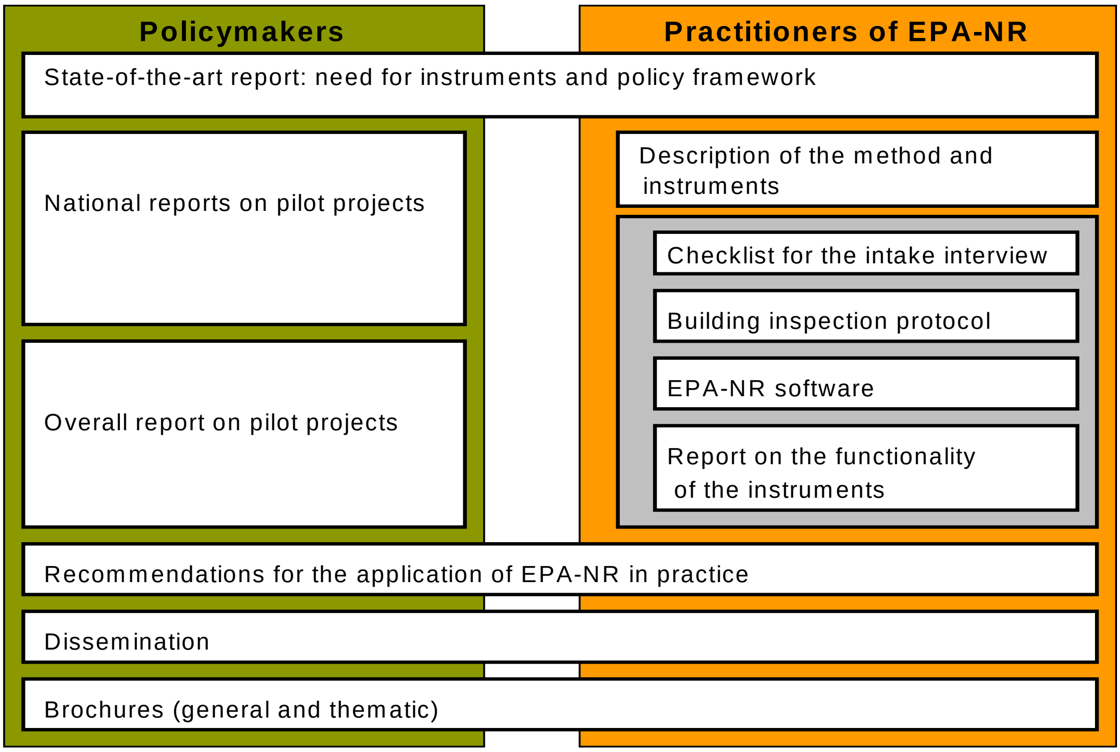
Emission

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

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-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