Kampen School, Norway

1. INTRODUCTION

PROJECT SUMMARY
Year of construction: 1888
Past energy renovations: 1978, windows 1998
Renovation: 2003

SPECIAL FEATURES
A demonstration project where new concepts for energy efficient ventilation and lighting are integrated, using the existing ducts and demand control sensors

Architect
Richard Engelbrektson

Consultant
Bakke, Søderblom og Tønsberg A/S
Norwegian Building Research Institute

Owner
Municipality of Oslo

Brochure authors: Mads Mysen and Anna Svensson, SINTEF Building & Infrastructure
Contact: Mads.mysen@sintef.no

IEA SHC Task 47
Renovation of Non-Residential Buildings towards Sustainable Standards

2. CONTEXT AND BACKGROUND

BACKGROUND

Kampen school is situated in the city of Oslo, The original building ~~is~~ was built in 1888, supplemented in 1902 with a new building, and a new floor added in 1921. Today, the school has around 400 pupils, divided in 30 classrooms with up to 28 pupils per class. The total floor area for the school is 4500 m².

OBJECTIVES OF THE RENOVATION

- *Listed building (historical value)*
- *Need for modernizing the school to today's standard, regarding i.e. accessibility, fire safety and ICT.*
- *Increased indoor air quality and reduced energy demand with limited changes on the building envelope.*

SUMMARY OF THE RENOVATION

- *Demonstrate that schools can be retrofitted with hybrid ventilation in an urban area and provide a comfortable indoor climate.*
- *Improve control of glare and thermal radiation without decreasing the daylight factor. Use of natural daylight.*
- *Evaluate the connection between indoor climate and human efficiency and optimize the ventilation and lighting in accordance with this.*
- *Demonstrate demand controlled ventilation and sensor based artificial lighting.*

3. DECISION MAKING PROCESSES

As part of the work in the IEA ECBCS Annex 35 HybVent , SINTEF agreed with Undervisningsbygg Oslo to use the Kampen Primary School as a demonstration project. The school was in an early retrofitting engineering phase.

The engineering group agreed to develop the project with R&D elements like hybrid ventilation.

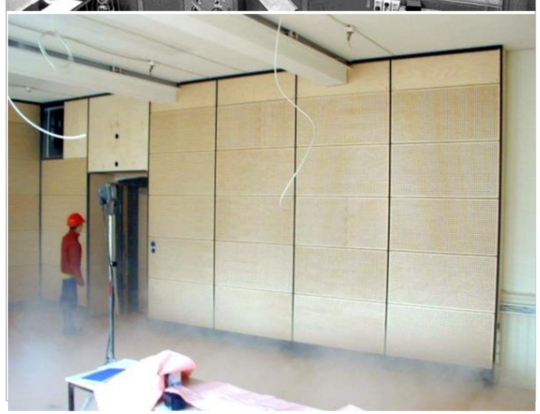
The project received a government grant of 600.000 NOK for R&D-activities.

Life Cycle Cost – analysis (LCC) showed that Hybrid ventilation was the most economical favorable alternative.

The contractor were chosen through an open tendering process.

Pictures (from the top):

1. *Ongoing construction work*
2. *Laboratory smoke test of supply air from a perforated wall*
3. *At site: Smoke test of supply air wall*



Timeline for the decision making process

Idea was born
2000

↓

First brief project description completed
20.07.2000

↓

Detailed project description completed
2002

↓

Tendering process started
2002

↓

Signing of contract with main contractor
2002

↓

Start renovation
2002

↓

Renovation completed
30.07.2003

↓

Evaluation among occupants
2001-2004

4. BUILDING ENVELOPE

The building envelope was kept as built, only the building services system was renovated. A new building was built between the two existing buildings.

Wall construction: *U-value: 1,3 W/m².K*
Solid masonry wall with plaster

Roof construction: *U-value: 0,96 W/m² K*
Swedish truss over a cold attic. Framed floor with clay filling.

Floor construction: *U-value. 0,96 W/m².K*
Double el. framed floor with clay filling to a cellar

Windows: *U-value. 2,4 W/m².K*
Most of the windows were switched in the 90s

Summary of U-values [W/m²K]

	Before	After
Roof/attic	0,96	0,96
Floor/slab	0,96	0,96
Walls	1,3	1,3
Windows	2,4	2,4

Pictures (from the top):
- *The Kampen School area*
- *New building intervening the existing buildings*

Cultural heritage

Kampen School was designed by architect Ove Ekmann. The front facade and courtyard facade have the same design. Symmetry is an important characteristic. The school is included in the Kampen Conservation Area and is listed as a property worthy of preservation. In the "Conservation Plan for Oslo schools“, the school is categorized with a Protection class 2. It is described as follow: "*The school has high environmental value and age value. The school was in its time model school for other schools in Oslo.*" The purpose of preservation is to keep a coherent school facility that includes the whole settlement structure of the school.

The Office of Cultural Heritage reviewed the renovation: *"From a conservation point of view an assembly of the two original buildings is preferable to be avoided, but the Office of Cultural Heritage has an understanding of the need for such an intervening building that facilitate communication within the school and utilize much needed space for teaching purposes. The new building is somewhat tucked in and embraces the existing building's heavy character but with a architectural expression of our time. The proposal also allows existing buildings to dominate the environment."*

Office of Cultural Heritage has no comments on changes to the interior, but this and the building services solutions were discussed in the meetings. This is common in cases of buildings registered as worthy of preservation.

5. BUILDING SERVICES SYSTEM

LIGHTING SYSTEM

Switched to more energy efficient lighting, with movement sensor. Use of shelf inside the window to throw sunlight further into the room.

HEATING SYSTEM

Before: *A conventional hot water radiator heating system with manual thermostatic valves provided perimeter heating in winter.*

After: *New hot water radiators with thermostatic valves to provide perimeter heating in winter with improved energy control and thereby reduced use of energy. Two new oil boilers and one electric boiler with a total of 1.200 kW.*

COOLING SYSTEM

No cooling system. Cooling achieved using night ventilation—ventilation and intake through the culverts as well as displacement ventilation.

VENTILATION

Before: *A mechanical balanced ventilation system that provided each classroom with approximately 120 liter/second of fresh air, half of what is recommend in the b0uilding code*

After: *Demand controlled displacement ventilation controlled by a combined CO_2 and temperature sensor.*

Lighting

Before:
Nine 2x65 W luminaires mounted on the ceiling, with manual on/off switches.
No blackboard lighting.

After:
Manual switch and an Infra Red (IR) movement detector control the suspended pendant luminaires. In order to switch the lights on, it is necessary to use the switch, but the IR detector may turn off the lights if there is no movement in the room. In this case it is necessary to turn them on again by the manual switch. The idea is that the lights will only be turned on if daylight seems insufficient. The lighting system is based on suspended pendants 2x 36W with high frequency ballasts. The light distribution ratio is 70% upwards and 30% downwards. The blackboard is lit with three luminaires of 1x 36W.

Ventilation

Based on the original building's integrated ventilation solution from 1888. Fan assisted natural ventilation, or hybrid ventilation. Because of traffic pollution, there is a new air intake on the top of the new intervening building. The air passes through a filter and a run-around heat recovery battery with low pressure drop, then passes via a concrete duct, under the building, finally through vertical shafts up to each classroom.
The rooms are ventilated with displacement ventilation through an integrated wall that will ensure no conflict between ventilation function, draft and the use of the rooms. The inlet for supply air is placed behind the new wall. A shelf under the air inlet is designed to spread the air equally along the long side of the classroom. The air is then distributed to the room through a perforated zone in the lowest meter of the wall.

Supply air temperature will increase about 2°C from the inlet behind the integrated wall to the air inlet in the room. This means that the new integrated wall also will serve as a cooling panel, making it possible to add some extra cooling to the ventilation air.

6. ENERGY PERFORMANCES

Energy performance (kWh/m^2)

- Net energy use (measured)

Before: ***281 kWh/m^{2}year.*** *- (2000-01)*

After: ***151 kWh/m^{2}year*** *- (2006-11)*

The energy savings are due to:

- *Improved control of radiator heating because of new thermostatic valves.*
- *Reduced fan power energy because of optimal use of natural driving forces.*
- *Demand controlled ventilation with heat recovery.*
- *Demand controlled artificial lighting which means maximum use of daylight and minimum use of artificial lighting.*

ÅRSRAPPORT

År	Periode	Temp	Fastkraft	Fyrhus	Sum energi	Budsjett	Spes.	Nåverdi	Tot. avvik	Tot. avvik	Spes.tmp.korr	Tmp.korr.	Vann
	Timer	°C	kWh	kWh	kWh	kWh	kWh/m²	kWh/m²	kWh	%	kWh/m²	kWh	m³
2000	8 736,0	6,9	1 477 448	665 492	2 142 940	1 791 246	296,6	230,4	477 795	28,7	314,0	2 269 041	3 317,0
2001	6 552,0	6,9	1 128 483	715 229	1 843 712	1 232 047	255,6	178,9	554 067	42,9	247,2	1 786 114	2 994,0
2002	0,0	0,0	0	0	0	0	0,0	0,0	0	0,0	0,0	0	0,0
2003	840,0	2,3	94 703	106 483	201 186	354 586	27,8	52,2	-176 199	-46,7	22,3	160 943	0,0
2004	8 903,0	6,3	767 323	23 968	791 291	1 865 801	109,5	246,8	-991 884	-55,6	121,8	880 081	0,0
2005	8 735,0	5,9	736 496	787 667	1 524 163	1 808 478	211,0	249,4	-278 003	-15,4	211,8	1 530 204	0,0
2006	8 721,0	6,1	526 232	910 270	1 436 502	1 662 738	149,6	172,6	-221 397	-13,3	147,1	1 413 840	0,0
2007	8 736,0	5,7	529 331	847 940	1 377 271	1 674 420	143,4	174,3	-296 151	-17,7	143,5	1 378 269	237,0
2008	8 736,0	6,6	397 457	746 652	1 144 109	1 674 420	119,2	162,1	-412 167	-26,5	132,2	1 269 499	632,0
2009	8 903,0	6,4	527 527	975 546	1 503 073	1 503 241	156,6	150,2	61 237	4,2	162,9	1 564 478	2 028,0
2010	8 735,0	4,6	583 962	1 176 796	1 760 758	1 502 355	183,4	178,4	47 401	2,8	162,0	1 555 469	1 330,0
2011	8 595,0	7,4	523 724	756 474	1 280 198	1 502 355	138,7	138,8	-1 199	-0,1	156,3	1 501 156	1 667,0
SUM	-	5,4	7 292 686	7 712 517	15 005 203	16 571 688	149,3	161,2	-1 236 500	-7,4	151,8	15 309 094	12 205

Energy report from Kampen School. The column *"Spes. Tmp. Korr"* shows temperature adjusted energy use per year.

CLARIFICATION: the energy calculations and given energy numbers will be according to the national standards which might vary between countries., i.e. numbers are not always comparable

7 ENVIRONMENTAL PERFORMANCE

INDOOR ENVIRONMENT QUALITY

Physical parameters like temperature, carbon dioxide-level, lux-level and relative humidity were measured. All measurements were done with calibrated equipment. CO_2- was measured in breathing height, app. 1 meter above floor.
Other measurements were done at desk level, app. 0.8 meter above floor.
In addition, the number of persons present, positions of the curtains and outdoor conditions were recorded.

Simultaneously with the performance tests, perceived health and well-being were mapped using a questionnaire with 45 simple yes and no questions. The pupils filled in the questionnaire three times during two weeks. The questionnaire is based on the Ørebro questionnaire, but all questions are related to the present moment and not for a period of three months. This makes the test suitable for primary school pupils.

To examine performance and IEQ effects of the energy measures, pupils at Kampen School and pupils at a control school were followed for up to four years. Findings for the pupils at Kampen School showed a significant improvement in the concentration test scores and health and well-being questionnaires.

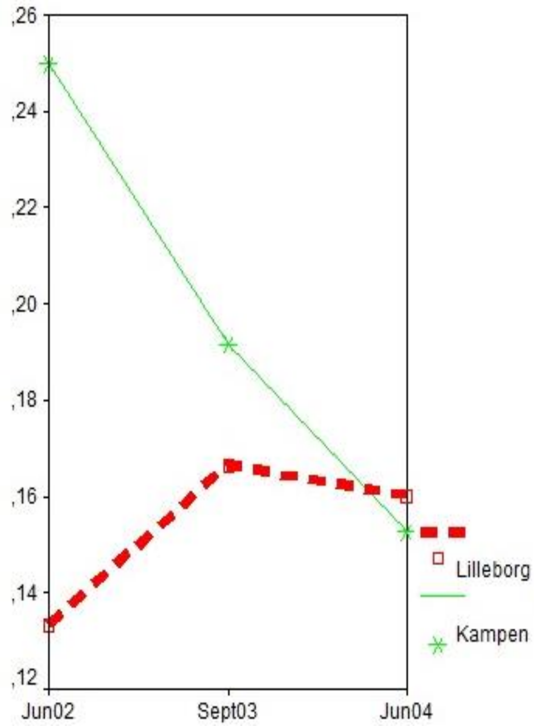


Figure: Result of a survey of Sick building syndrom-symptons before and after renovation on Kampen School. The symptoms are reduced after renovation of Kampen. Also shown result of the reference school Lilleborg

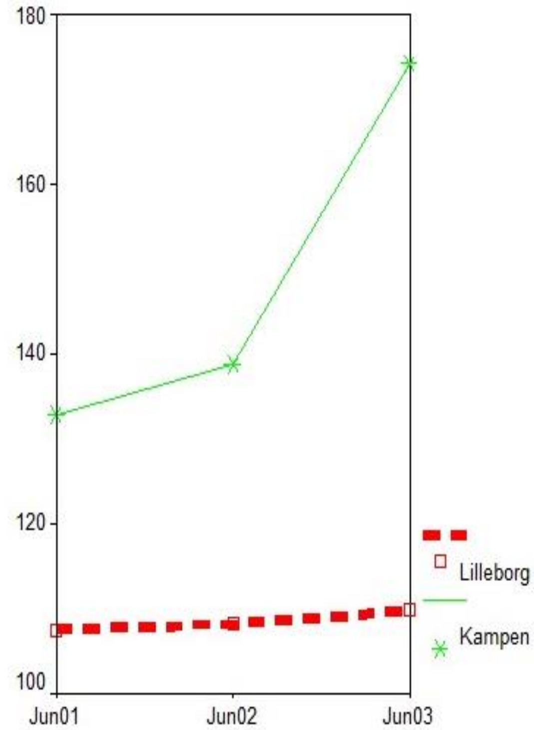


Figure: Scores of a concentration test before and after renovation of Kampen school. The power of concentration is increased in Kampen school . Also shown result of the reference school Lilleborg

Table: Indoor temperature, CO_2-level and lighting level before and after renovation in Kampen school

	Before renovation		After renovation	
Date	15.06.01	14.06.02	25.09.03	11.06.04
Temperature	22,7-23,7 °C	24,3-24,9 °C	21,7-22,7 °C	23,8-24,2 °C
CO2-level	1120 ppm	1040 ppm	440 ppm	350 ppm
Lighting level	896 lux	516 lux	810 lux	803 lux

8. MORE INFORMATIONS

RENOVATION COSTS

The hybrid ventilation (HV) solutions was compared to traditional mechanical balanced ventilation (MBV). Investment cost was about 10% higher for HV than MBV, but Life Cycle Costs (LCC) was about 15% lower for HV. HV was chosen based on this LCC analysis.

A serious accident made it impossible to compare real costs.

FINANCING MODEL

- *Public grant of 600.000 NOK for R&D-activities.*
- *The contractor were chosen through an open tendering process*

Referenses:

Mysen M, Nersveen J, Schild PG. Kampen School - Retrofitting of an historic school building with energy efficient ventilation and lighting system. Passivhus Norden 2012, Trondheim, ISBN/ISBN2 9788232101733, Tapir akademisk forlag.

Mysen M, Hammer HL, Nersveen J, Fostervold KI. Kampen School - Evaluation of pupils' performance and perceived health and well-being before and after school retrofitting10th int. Healthy Buildings Conference 8-12 July 2012. ISBN: 978-1-921897-40-5 | CRICOS No. 00213J Publisher: Queensland University of Technology