1. INTRODUCTION

Norwegian Tax Authority - Oslo Norway

PROJECT SUMMARY

Year of construction - 1980
No previous energy renovations

SPECIAL FEATURES

Main topics in the renovation are:

- *High insulated pre fabricated façades*
- *Airtightness 0,6 h-1*
- *Reduced surface to volumen ratio*
- *Energy recovery from data facility I basement of building*
- *High efficiency technical systems, COP cooling systems, efficient heat recovery, and low SFP*

ARCHITECT

LPO Achitects AS, Oslo

Project Management

Optimoprosjekt

Consultant

Sweco, Multiconsult, Hambra, Energeticadesign

Partners

ENOVA, Norway, Future built, Norway

OWNER

Entra Eiendom as

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

2. CONTEXT AND BACKGROUND

BACKGROUND

- *The building is situated in the center of Oslo, close to public transportation and to a highway with heavy traffic.*
- *The entire building has an area of 35.119 m^2 (internal area without outer walls including basement 6.670 m^2)*
- *The building is programmed for approximately 1300 person, which makes an average area of 27 m^2 pr. person.*
- *The organization have focus on low energy equipment, thin Client computers are used on all workplaces.*

OBJECTIVES OF THE RENOVATION

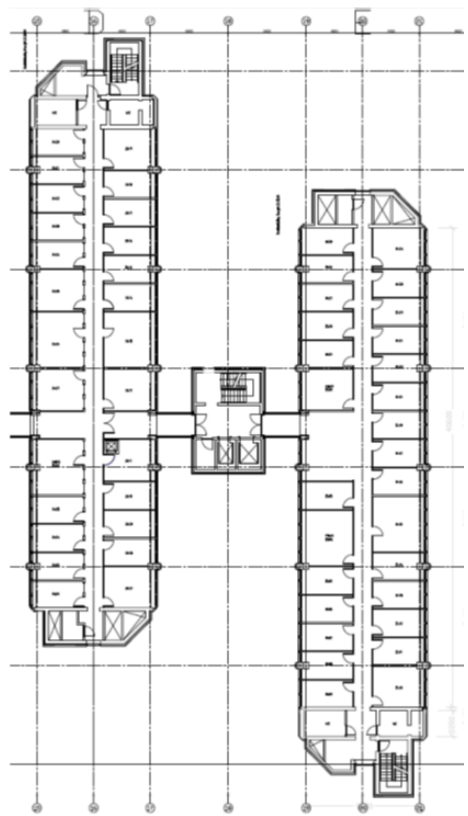
Overall goals for the project are:

- *Energy label A*
- *Passive house standard*

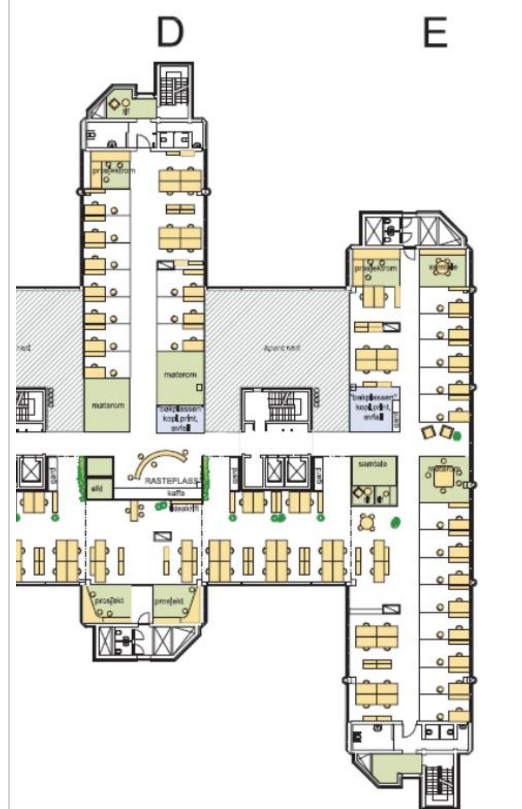
In addition to the overall goals:
Entra environmental policy, a specific Environmental Quality Assurance Program and a Quality Control Plan, where stated for the project.

Entra environmental policy states that all their projects should include environmental program and plans.

Typical floor plan before refurbishment



Typical floor plan after refurbishment



2. CONTEXT AND BACKGROUND

OBJECTIVES OF THE RENOVATION

The objectives and focus areas are:

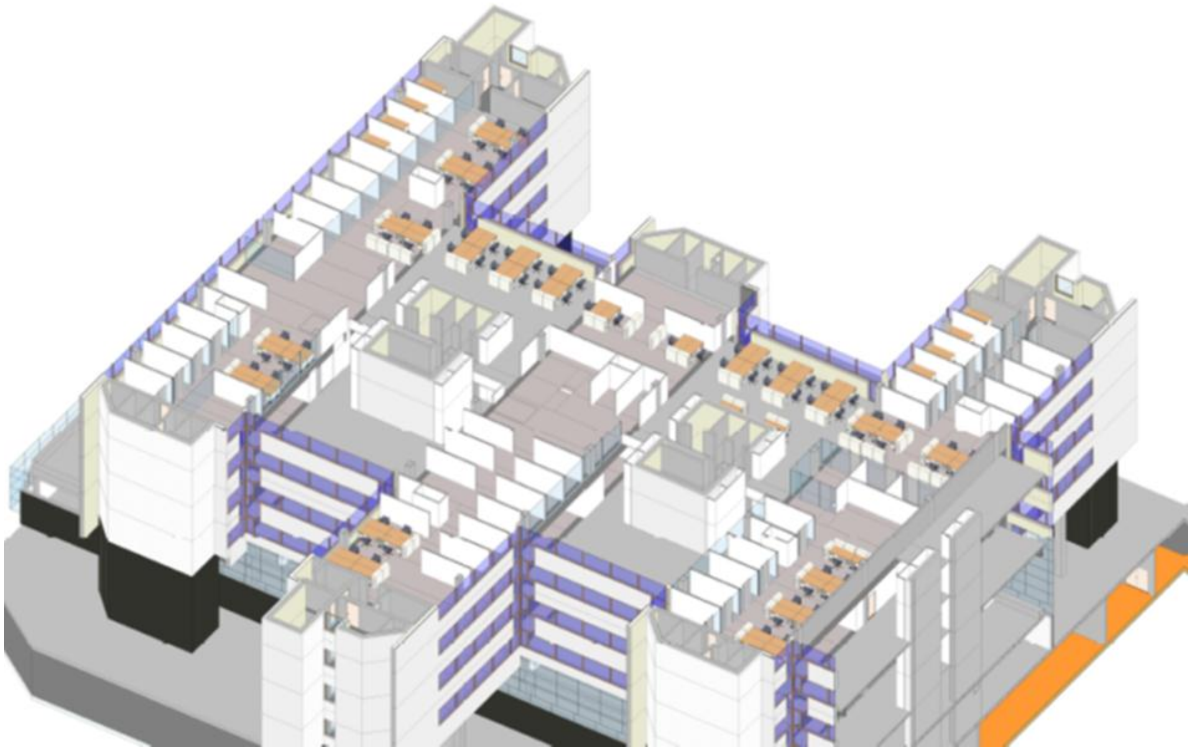
- *Energy objectives, 50% demands of Norwegian building codes.*
- *Indoor climate, in average level 1/2 according to EN 15251*
- *Low emission and sustainable materials*
- *Reduction on water use*
- *Building waste during entire life cycle*
- *Clean building processes*
- *Sustainable solution and materials with high durability*
- *Lowering energy for transportation in building construction stage, encourage public transportation and bicycling in maintaining stage*

Follow environmental quality control plan for following up and running assessments in all stages of the design process

SUMMARY OF THE RENOVATION

The overall expected percentage reduction in primary energy consumption is ~ 60%

3 D model of building after refurbishment



3. DECISION MAKING PROCESSES

The initial project objectives were to refurbish the interior of the building, and energy was not at the time the main objective. The energy goal was energy label B.

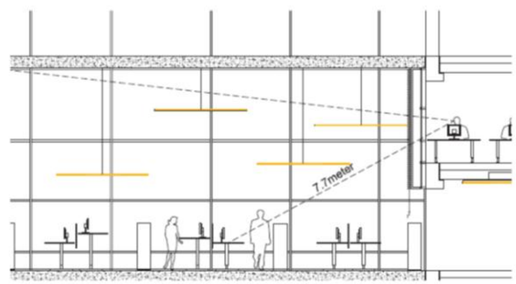
Through a process with building owner and users, the ambition was increased to energy label A / Passive house.

Public funding programs involved are granted for this project.

ENOVA, a Norwegian funding program, will be funding 50% of the extra Investment to improve the energy design from building codes minimum to a 50% below. Maximum funding is limited to ~69 Euro/m^2

The project has been granted a maximum funding of 2.400.000 Euro.

Reduced operation using calculated payback time has been made for the application to Enova.



Timeline for the decision making process

- **Idea was born** — **01.09.2009**
- **First brief project description completed** — **01.02.2010**
- **Detailed project description completed** — **01.03.2011**
- **Tendering process started** — **01.03.2011**
- **Signing of contract with main contractor** — **01.06.2011**
- **Start renovation** — **01.08.2011**
- **Renovation completed** — **Not completed**
- **Evaluation among occupants** — **Not completed**

4. BUILDING ENVELOPE

Roof construction :
U-value: < 0,12 W/m²K (average value)
(Roof construction over basement 0,5 - 0,8 below terrain have now insulation before refurbishment. Average U –value before refurbishment for roof 0,5 W/m²)

Wall construction :
U-value: < 0,14 (average value above ground)
U-value: < 0,47 (average value below ground)

Windows: :
U-value: < 0,72 (average value)

Thermal bridge avoidance*:*
Focus on thermal bridges in:

- *Mounting of windows*
- *Insulation thickness where concrete slabs meets the façade*
- *Wood facade construction with few thermal bridges., and 200 mm insualtion in front of slabs.*

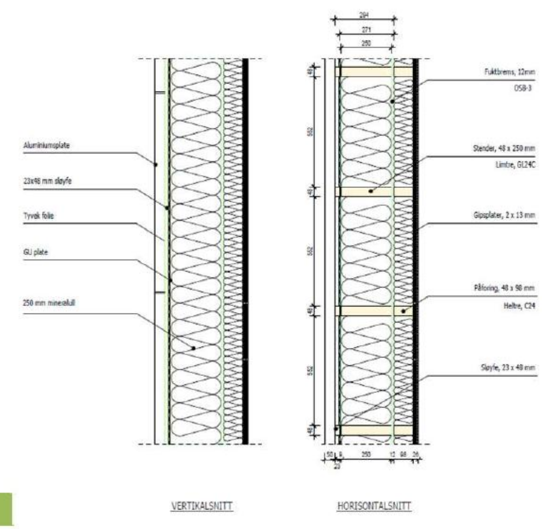
Overall demand to thermal bridges are:
< 0,04 W/m² K

Summary of U-values [W/m²K]

	Before	After
Roof/attic	~ 0,2 – 1,0 (average 0,5)	0,12
Floor/slab	~ 0,1	0,1
Walls	~ 0,2 – 0,4	0,17
Ceilings	~ 0,3	0,12
Windows	~1,8	0,72

Examples sections – for walls

RT'=	8,45 m²K/W
Nedre grense for varmemotstand RT"	
R1=	0,13 m²K/W
R2=	2,21 m²K/W
R3=	0,09 m²K/W
R4=	5,63 m²K/W
R5=	0,00 m²K/W
R6=	0,00 m²K/W
R7=	0,05 m²K/W
RT"=	8,31 m²K/W
Total varmemotstand for bygningsdelen, RT	
RT=	8,38 m²K/W
Varmegjennomgangskoeffisient	
U-verdi =	0,12 W/m²K



5. BUILDING SERVICES SYSTEM

OVERALL DESIGN STRATEGY

The overall design strategy based on:

- *Optimizing the building envelope*
- *Optimizing technical system*
- *Utilization / recovery of energy from data facility in the building*

LIGHTING SYSTEM

The existing lighting system is a traditional system with an estimated LENI number ~25 kWh/m^2 year

New lighting system has an estimated LENI number ~14 kWh/m^2 year

HEATING SYSTEM

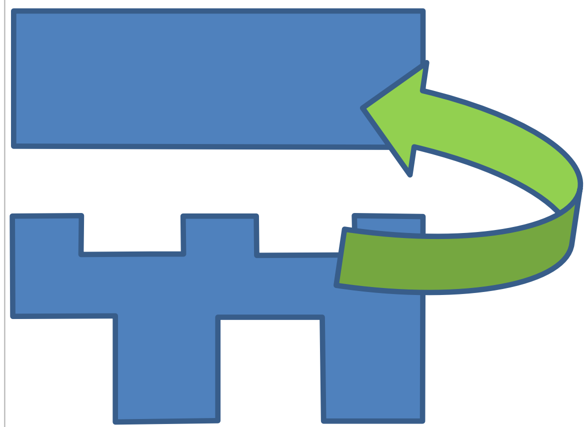
Before - Electrical heating
After - Water based heating systems

COOLING SYSTEM

Before – Central cooling of inlet air for mechanical ventilation

After – Cooling system will be based on:

- *Central AC – mechanical ventilation*
- *Cooled beams in areas with high internal loads (in area with high cooling demands, meeting rooms and office areas with high internal loads)*



5. BUILDING SERVICES SYSTEM

HEATING SYSTEM

Before - Electrical heating

After - Water based heating systems

VENTILATION

Before – CAV mechanical ventilation

After – VAV mechanical ventilation

HOT WATER PRODUCTION

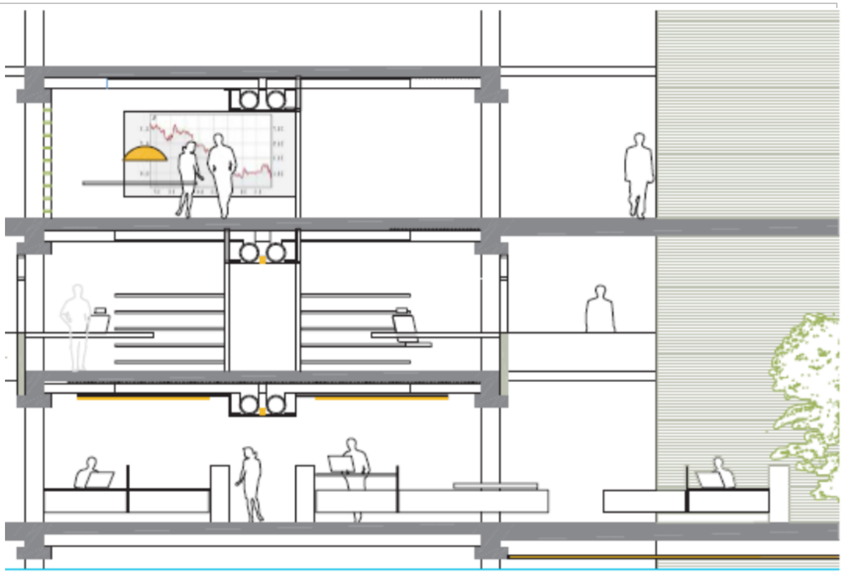
Before - Central electrical heated boiler

After - Central boiler heated with waste energy from data Facility in basement in combination with electricity/ district heating

RENEWABLE ENERGY SYSTEMS

Before – none, all energy consumption was based on electrical supply.

After - Reuse of waste energy from data facilities in basement in combination with district heating from public supply. Night cooling strategy for reduced cooling.



6. ENERGY PERFORMANCES

Energy performance (kWh/m^2)

Before:

~ 190 kWh/m^2 year (measured)

~ 174 kWh/m^2 year (estimated net energy consumption which is including sub consumptions according to Norwegian regulation, comparable with calculated consumption, see figure)

~170 kWh/m^2 year (estimated primary energy consumption which is including sub consumptions according to Norwegian regulation, comparable with calculated consumption, see figure)

After:

88 kWh/m^2 year (calculated net)

84 kWh/m^2 year (calculated primary)

Overall savings target :

From: 190 / 170 kWh/m2 year

To: 69 kWh/m2 year. Primary energy

Savings target ~ 65% / 60%

Energy budget - net energy/ space deliverable			
(calculated according to Norwegian Building codes)	After	Before	
Space heating	5,3		kWh/m²
Mechanical ventilation - heating	5,9		kWh/m²
Hot Water	5		kWh/m²
Energy fans for mechanical ventilation	11,2		kWh/m²
Energy pumps for heating, ventilation, cooling	1,8		kWh/m²
Lighting	13,8		kWh/m²
Technical equipmnet, PC, data etc.	34,5		kWh/m²
Coooling, cooled beams in office areas	3,3		kWh/m²
Cooling, central mechanical ventilation	6,9		kWh/m²
Total netto energy demand	**87,7**	**174**	**kWh/m²**
Energy deliverable (primary energy demand)			
Electricity	65	170	kWh/m²
District heating	4	0	kWh/m²
Heat recovery from data facility in building	15	0	kWh/m²
Total primary energy demand	**84**	**170**	**kWh/m²**
Conversion factors/ primary energy factors:			
Electricity	1		
Heating	0,87		
COP cooling	2,7		
COP Heating	3		

7 ENVIRONMENTAL PERFORMANCE

Environmental quality plan in addition to energy

Indoor Environment

The Best possible indoor air quality should be assured by appropriate design that meets:

- Flexible technical system
- Low emission materials
- Focus on operation and maintenance

Indoor thermal climate design criteria:

- 22 +/- 2 degree, minimum in winter
- Maximum 25 degrees C in summer, during business hours 8 am-4 pm
- On hot summer days , it is accepted that indoor temperature increases or decreases by 0.5 °C per °C outside increases above 25 °C

Indoor air quality

- CO_2 level not exceed 1000 ppm

Lighting

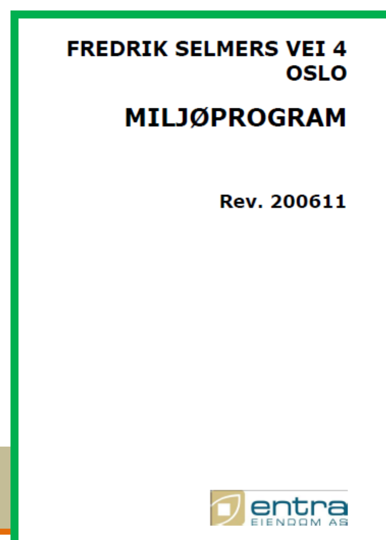
- LUX level general lighting – 300 LUX
- LUX level on desk / workplace – 500 LUX
- Average daylight factor in working areas – DF = 2.

Water management

- *water saving equipment, water saving toilets, nozzles and shower heads.*
- *Monitoring of water consumption*

Material Usage

- *Low emission materials for a good indoor environment*
- *Use of health-and environmentally hazardous substances should be reduced to a minimum*
- *Wood materials will come from sustainable forestry*
- *Materials that represents high greenhouse gas emissions should be avoided, target for green house emission are 50% below normal building standard in Norway (Future Built objectives*)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Waste Management

- *Health and environmentally hazardous substances in demolishing process has to be handled in an environmentally friendly way and in according to regulations.*
- *A minimum of 80% of the building and tearing waste should be sorted.*
- *Design should focus on efficient waste management in the operating stage.*

Transport

- *Restriction of transport to and from the construction site*
- *It should be made attractive to use environmentally-friendly means of transport such as bicycles, electric cars and public transport.*
- *It should be added to facilitate video conferences*

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Environmental monitoring in the execution phase of environment follow-up plan

Environmental follow-up plan to detail targets / objectives , and to provide accountability and to milestones.

8. MORE INFORMATION

RENOVATION COSTS

All investments cost are based on extra investment from Norwegian standard regulation level (TEK 10), to passive house standard / energy label A.

All extra cost will be subsidized with up to 60%

Overview on measured used, estimated investments cost (budget), and payback time are shown in figure.

Energy cost for calculating pay back time is:
0,125 Euro/ kWh

Energy result:

Annual consumption:

Before:	170 kWh/m²
Savings: TEK 10 level	27 kWh/m²
TEK 10 standard building	**143 kWh/m²**
Saving passive level	58 kWh/m²
Recovery:	16 kWh/m²
Passive house standard	**69 kWh/m²**

Payback time 5 – 11 years

Measure	Describtion	Amount	Unit	Extra investment (budget)	Energy saving (budget)	Energy saving saving	Energy saving	Payback time
				[Euro]	[kWh/ year]	[kWh/ m2 year]	[euro/ year]	[year]
Building envelope:								
Walls above ground	U- value improved from 0,22 in average to 0,14 W/m2 K	17.121	m²		105.357	3,0	13.170	
Cold bridges	Improved from 0,12 to 0,04 W/m2 K	35.119	m²	1.780.000	263.393	12,6	32.924	54
Roof	U- value improve from 0,18 in average to 0,1 W/m2 K	4.295	m²	130.000	31.607	0,9	3.951	33
Roof basement	Roof in basement belove ground level (facing ground), from 1,0 to 0,15 W/m2 K	2.833	m²	115.000	400.357	11,4	50.045	2
Air tight building	Air tightness improve from 1,5 to 0,6 h^{-1} (n_{50} value)	132.272 (volume building)	m³	125.000	287.976	8,2	35.997	3
Passive house windows	U-value improved from 1,2 i average to 0,72 W/m2 K	3.494	m²	265.000	161.547	4,6	20.193	13
Floor facing outside above the ground	U- value improved from 0,22 in average to 0,13 W/m2 K	450	m²	70.000	3.512	0,1	439	159
Technical system and energy supply								
Heat recovery and VAV mechanical vent.	Heat recovery on mechanical ventilation improved from 70% to 85% in average.	245.000	m³/h	310.000	677.797	24,1	84.725	4
SFP	Specific fanpower reduced from 2,0 to 1,5 kW/ m3/s in average	245.000	m³/h	155.000	98.333	2,8	12.292	13
Efficient lighting	Efficiency of lighting system improved from LENI 25 to 12,4 kWh/m2 year	35.119	m²	840.000	277.440	7,9	34.680	12
Energy supply	System for heatrecovery from data facility in basement (water based heat-ing system not included)	35.119	m²	100.000	561.904	16,0	70.238	1
All measurers together						**74,0**		
Process planing quality ensurance								
Extra project planning cost, quality planning etc., course workers on site.		35.000	m²	170.000	-	-	-	-
Overall budget investments cost				**4.060.000**	**2.869.222**	**74**	**358.653**	**11**
Subsidized				**2.400.000**				
Pay back time with subsidizing				**1.660.000**				**4,6**