

Powerhouse Kjørbo – Norway

1. INTRODUCTION

PROJECT SUMMARY

- Year of construction: 1980
- None past energy renovations

MAIN RENOVATION TOPICS

- High insulated facades
- Airtightness 0,6 h-1
- High efficiency technical systems, ground coupled heat pump, COP = 15 for cooling , COP = 3,5 for heating, efficient heat recovery, and low SFP
- PV electricity production on site

Architect

Snøhetta Architects AS, Oslo

Consultants

Skanska Norway, Hydro, Zero, ZEB and Asplan Viak

Owner

Entra Eiendom AS



IEA SHC Task 47

Renovation of Non-Residential Buildings towards Sustainable Standards

3. DECISION MAKING PROCESSES

The Powerhouse Alliance

The Powerhouse Alliance includes the companies: Snøhetta Architects, Skanska, Hydro, Entra Eiendom and the NGO Zero. The Powerhouse concept was first launched in 2011. The proposal for the first Powerhouse project, a new office building in Trondheim, was presented in 2012. The Powerhouse Kjørbo is the first renovation project of the Alliance.

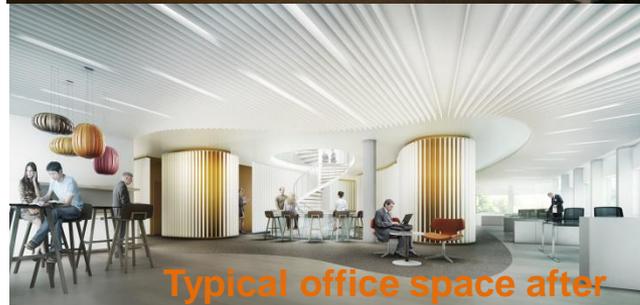
Powerhouse, criteria of the energy goal

In order to fulfill the declared goal of the PowerHouse (given in a press release from the Alliance): The Powerhouse alliance will:

- challenge existing building conventions
- develop cutting-edge concepts
- promote new national and international standards for energy efficiency and energy positive buildings
- be technological path-breaking

The main definition of PowerHouse:

Powerhouse shall during its lifetime produce more energy than it uses for materials, production, operation, renovation and demolition



Timeline for the decision making process



4. BUILDING ENVELOPE

Roof construction :

U-value: 0,08 W/m²K (average value)

Wall construction :

U-value: 0,15 W/m²K (average value above and below ground)

Floor facing ground (basement) equivalent value in average :

U-value: 0,16 W/m²K

Windows :

U-value: < 0,8 W/m²K (average value)

Floor on ground

U-value: 0,12 W/m²K

Floor in basement

U-value: 0,16 W/m²K

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 insulation in front of slabs

Overall demand to thermal bridges are:

< 0,03 W/m² k

Window / to wall ratio: 40 / 60

Light transmitting factor for windows: 68%

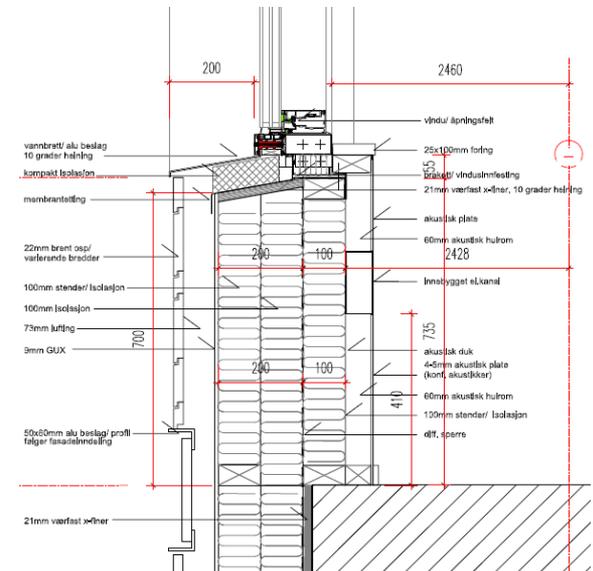
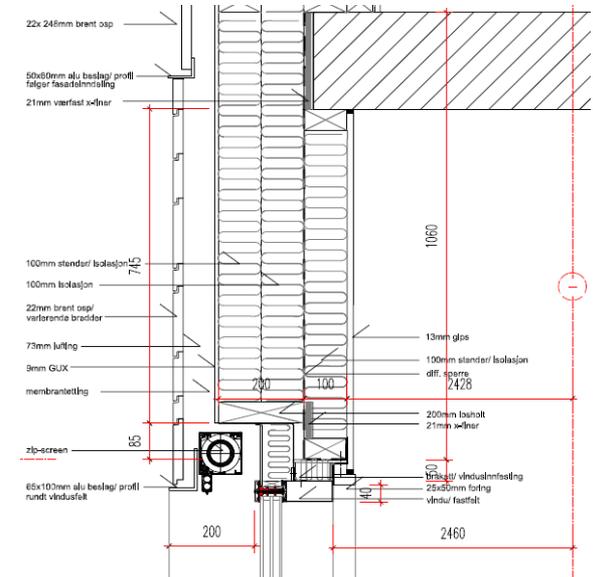
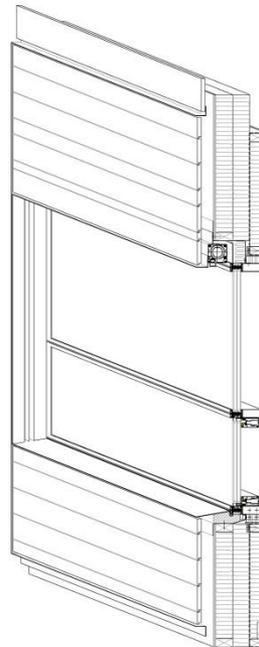
Daylight factor: average on working areas 2,1

Sun shading

External sun shading integrated in facade

Summary of U-values [W/m²K]

	Before	After
Roof/attic	~0,2	0,08
Floor/slab	-	0,12 – 0,16
Walls	~0,3	0,15
Ceilings	~0,3	~0,3
Windows	~1,8	0,8



5. BUILDING SERVICES SYSTEM

OVERALL DESIGN STRATEGY

The overall design strategy based on:

- Optimizing the building envelope
- Optimizing technical system
- Utilization renewable energy

LIGHTING SYSTEM

New lighting system have planned LENI number
~9 kWh/m² year

HEATING SYSTEM

Before – Water based heating system

After – Air heating delivered from ventilation system combined with radiators in the wave wall in the center of the building

COOLING SYSTEM

Before:

- central cooling of inlet air for mechanical ventilation in combination with cooled beams.

After:

- Central air cooling – mechanical and displacement ventilation

HOT WATER PRODUCTION

- Heat pump and district heating

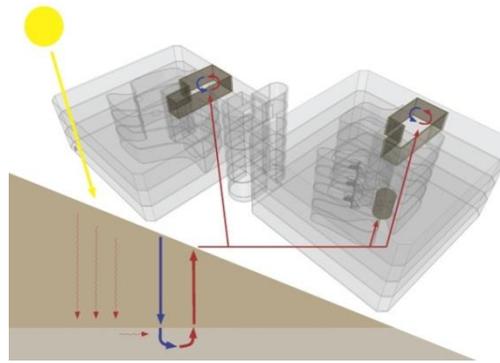
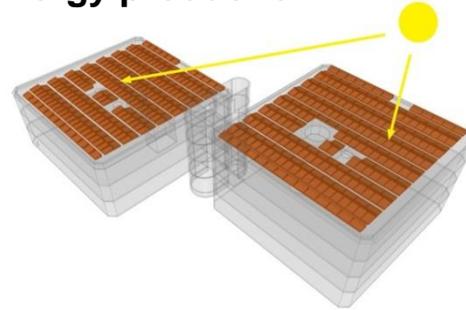
RENEWABLE ENERGY SYSTEMS

- Before: District heating

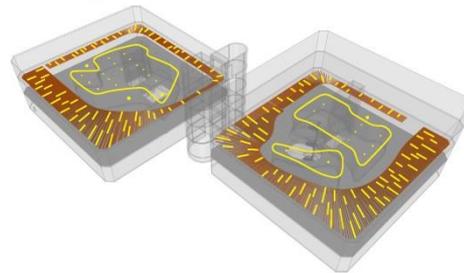
• After:

- preliminary ground based heat pump
- 310 kW PV system for electric generation to produce 230.000 kWh/year

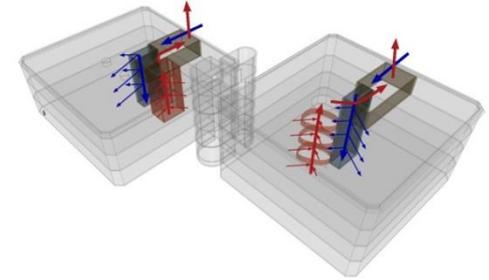
Energy production



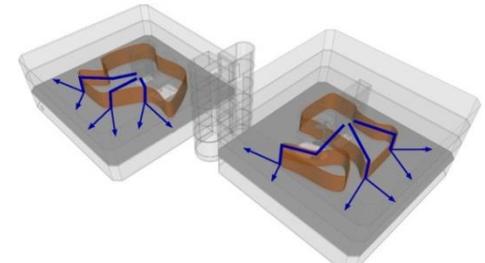
Daylight strategy – average DF > 2,1



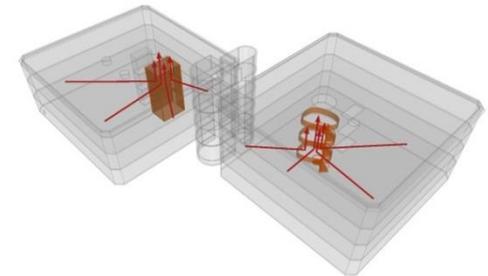
Ventilation and cooling Reduced duct length



Displacement ventilation



Exhaust air through staircase



6. ENERGY PERFORMANCES

ENERGY PERFORMANCE

Annual delivered before
~ 240 kWh/m² (including data facilities.)

Annual delivered after:
~20,4 kWh/m² (without data and technical equipment)
~50 kWh/m² year (including data facilities)

RENEWABLE ENERGY USE

Annual delivered before:
Electricity ~ 125 kWh/m²
District heating ~ 75 kWh/m²
District cooling ~ 40 kWh/m²

Annual delivered after:
Electricity ~ 18,4 kWh/m²
District heating ~ 2 kWh/m²

PRIMARY ENERGY CONSUMPTION

Primary energy consumption is defined as delivered energy multiplied with primary energy factors, as primary factor for conversion of electrical consumption calculated for a 60 year life time /Source ZEB and Powerhouse project report – 2012/

Energy budget - net energy/ space deliverable	Netto energy	Delivert energy				Remarks
		Electricity	District heating	Total		
Space heating	15,4	4,6	0,9	5,5	kWh/m ² year	Ground couples heatpump
Mechanical ventilation - heating	2,4	0,8	0,1	0,9	kWh/m ² year	Ground couples heatpump
Hot Water	4,3	1,1	1	2,1	kWh/m ² year	Ground couples heatpump
Energy fans for mechanical ventilation	2,1	2,1		2,1	kWh/m ² year	
Energy pumps for heating, ventilation, cooling	0,8	0,8		0,8	kWh/m ² year	
Lighting	7,7	7,7		7,7	kWh/m ² year	
Technical equipmnet, PC, copymachines etc.	12	12		12	kWh/m ² year	
Central data facilities - servers	16,9	16,9		16,9	kWh/m ² year	
Cooling, cooled beams in office areas	0	0		0	kWh/m ² year	
Cooling, central servers	16,9	1,1		1,1	kWh/m ² year	Free cooling from ground
Cooling, central mechanical ventilation	3,5	0,2		0,2	kWh/m ² year	Free cooling from ground
Sum energy demand	82	47,3	2	49,3	kWh/m² year	
Sum exclusive central data facilities	65	30,4	2	32,4	kWh/m ² year	
Sum exclusive central data facilities and technical equipment	53	18,4	2	20,4	kWh/m² year	

Energy demand / production	Delivered/ produced energy	Primary energy factor	Primary energy demand	
PV - production, first 30 years	40,7	1,98	80,6	kWh/m ²
PV - production, last 30 years	60,1	0,93	55,9	kWh/m ²
PV - production, average 60 years			68,7	kWh/m ²
Operational energy use	-20,4	1,46	-29,8	kWh/m ²
Embodied energy			-22,1	kWh/m ²
Sum			16,8	kWh/m²

7 ENVIRONMENTAL PERFORMANCE

Waste management

- More than 90% of waste from construction phase is recycled and / or reused

Ecological materials/ indoor AQ

- Building materials with lowest possible embodied energy
- Burned wood for façade cladding
- Labeling materials or materials with low polluting according to EN 15251
- All product categories listed in BREEAM have been tested against and documented to meet the relevant standards Volatile Organic Compound (VOC) emissions.
- The climate gas emissions from new materials in the building comprise 50% of the emissions in a new reference building. (Ref definition se /Klimagassutslipp.no/
- EPDs (Environmental Product Declarations according to ISO 14025/EN-NS15804) have been procured for at least 10 different building products used to a large extent

Certification / Labels

- BREEAM-NOR, planned for certification label outstanding



Building table element	kWh/m ² per year	kg CO ₂ -eq/m ² per year
22 Superstructure	0,07	0,04
23 Outer walls	3,81	1,75
24 Inner walls	1,50	1,49
25 Structural deck	6,09	1,27
26 Outer roof	2,20	0,78
28 Stairs, balconies etc.	0,03	0,01
36 Ventilation and aircondition	1,99	0,30
43 Low voltage supply	0,23	0,11
49 Other electric power installations (PV)	9,57	1,78
62 Person and product transport	0,08	0,02
69 Other technical installations	0,33	0,07
Energy consumption in construction phase	1,21	0,06
Total with reinforcing steel and concrete	27,2	5,7
Total without reinforcing steel and concrete	22,1	4,5

8. MORE INFORMATIONS

RENOVATION COSTS

The building shall be renovated within commercial market conditions.

The specific cost of the project are not public for the time being. The tenant Asplan Viak has signed a 10 year renting contract. The rent is higher than for a similar office building with an average energy standard. However, when the reduced energy costs are included, the total cost for the tenant is at the same level as for a standard office building.

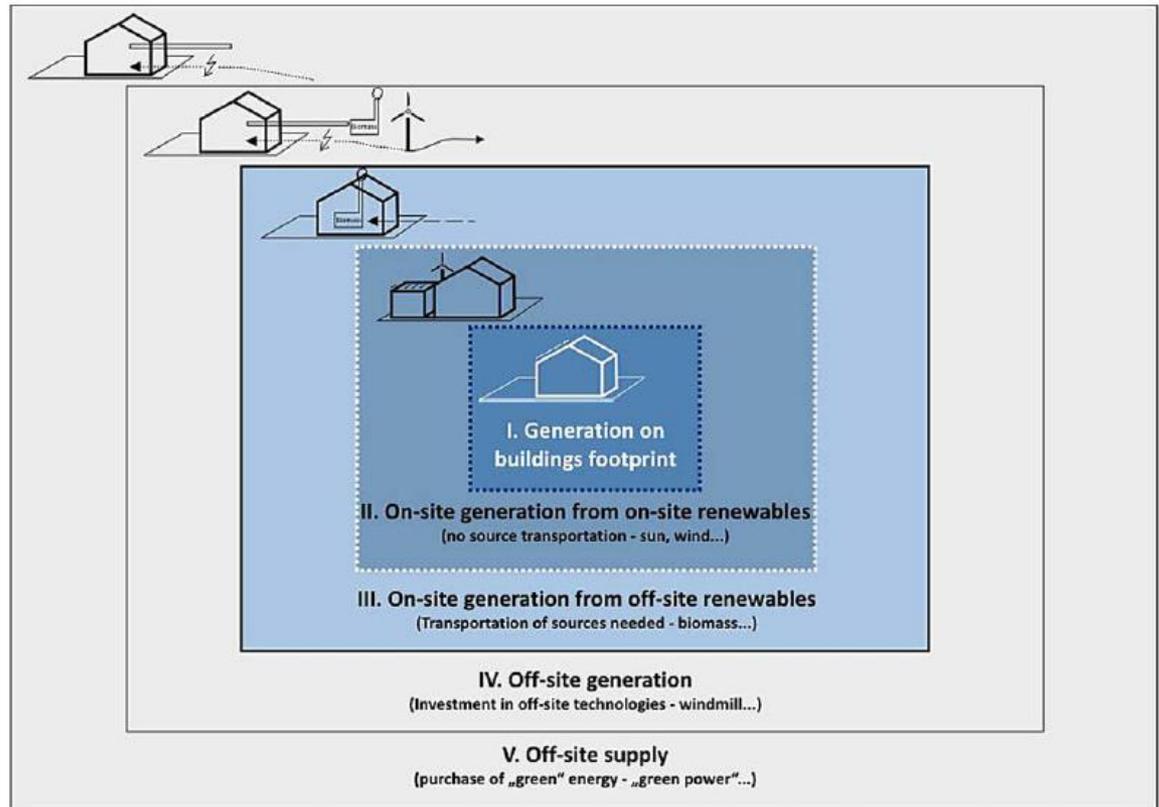
OTHER INTERESTING ASPECTS

Measured/delivered energy shall in net be counted to zero or be negative, and shall be calculated according to method/principles given in the Norwegian Standard 3031. Real operation conditions shall be used in the calculations, and technical equipment shall not be included.

The boundary of the plus energy building/Powerhouse is the site on which the building is located.

The energy goal must not be reached at the sacrifice of good architecture and indoor climate, or other central environmental qualities.

The Powerhouse boundary is similar to the Boundary II (*On site generation from on-site renewable*) as illustrated below



Source: A.J. Marszala, *, P. Heiselberga, J.S. Bourrelleb, E. Musallc, K. Voss, I. Sartori d, A. Napolitanoe. "Zero Energy Building – A review of definitions and calculation methodologies", *Energy and Buildings* 43 (2011) 971–979