Lessons learned from exemplary projects

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Operating Agent SHC task 47

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Criteria for projects being task 47 exemplary buildings:

- **Building types:** Office buildings, Educational Buildings, Culture building and Hotels including historic / protected buildings
- **Energy:**
  - Goal: Towards a NZEB building
  - Optimized building envelope and technical installation using the best available technologies/products on the market
  - Within the given constraints of the individual building (e.g. for protected / historic buildings)
  - At least 60% reduction in the primary energy demand (heating, cooling, ventilation, lighting, DHW and pumps) (according to the calculation rules given by the EPBD standard or other similar standards)
  - The renovated standard should be better than the national standard building code for new buildings
  - Embodied energy strategies to be considered
- **Economics:** Marketable solutions
- **Market potential:** Replicable building concepts

Exemplary renovation projects from participating countries

Education buildings

- Kindergarten Veitofte in Høje Tåstrup (DK)
- School in Cesena (IT)
- School in Schwanenstadt (AT)
- Riva Bella School (BE)

Office buildings

- Norwegian Tax Authority Oslo (NO)
- Plus energy Kjørbo (NO)
- Office and Workshop Building Fraunhofer ISE Campus (GE)
- Printing Workshop and Office building (DE)
- TU Vienna Plus Energy (AT)
- Office Building, Roskilde (DK)
- Schüco Italia Headquarters (IT)
- Rockwool International Office Building “Center 2” (DK)
- Solbråveien office center, Asker (NO)
- Administration Building Bruck/Mur (AT)










Historic and listed buildings

- Norwegian Energy Authority (NO)
- Kampen School in Oslo (NO)
- Osram building (DK)
- Kaiserstraβe 7, Vienna (AT)

Task 47:
Renovation of Non-Residential Buildings towards Sustainable Standards

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Eighteen exemplary building brochures available on web-site

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

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

2. CONTEXT AND BACKGROUND

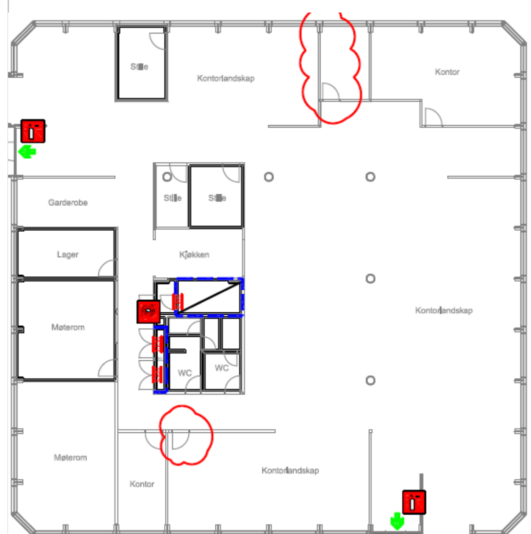
BACKGROUND

- *The building situated in Sandvika, close to the Oslofjord from the northeast to the southeast side, with a highway with heavy traffic on the northwest.*
- *The renovation includes two blocks out of a total of 9 of the entire site. (Map next page)*
- *The refurbish buildings have an area of 5.180 m^2 (internal area without outer walls)*
- *The buildings are programmed for approximately 240 person, which makes an average area of 22 m^2 per person*

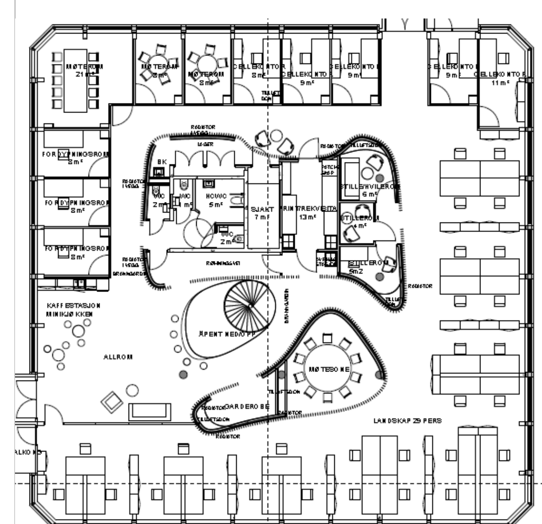
OBJECTIVES OF THE RENOVATION

- *Powerhouse is defined as a building that during its lifecycle produces more renewable energy than it consumes for the production of building materials, construction, operation and demolition of the building*
- *The building shall be built within commercial marketable conditions*
- *The energy production must be based on energy sources on site or nearby with access from the site*
- *Energy use for electrical appliances shall not be included in the energy balance account.*
- *BREEAM classification score: Outstanding*

Facade and typical floor plan before refurbishment



Facade and typical floor plan after refurbishment



3. DECISION MAKING PROCESSES

The Powerhouse Alliance

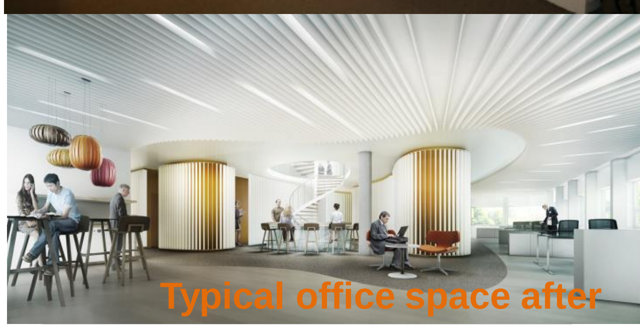
The Powerhouse Alliance includes the companies: Snøhetta Architects, Skanska, Hydro, Entra Eiendom and the NGO Zero. The Powerhouse concept was first launched in 2011. The proposal for the first Powerhouse project, a new office building in Trondheim, was presented in 2012. The Powerhouse Kjørbo is the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

Idea was born
2011

↓

First brief project description completed
01.07.2012

↓

Detailed project description completed
01.11.2012

↓

Tendering process started
01.11.2012

↓

Signing of contract with main contractor
18.03.2013

↓

Start renovation (demolishing)
01.02.2013

↓

Renovation completed
Q1.2014

↓

Evaluation among occupants
TBD

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 insualtion in front of slabs*

Overall demand to thermal bridges are: < 0,03 W/m² k

Window / to wall ratio: *40 / 60*

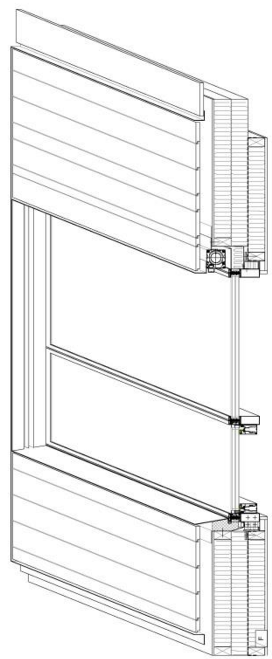
Light transmitting factor for windows: *68%*

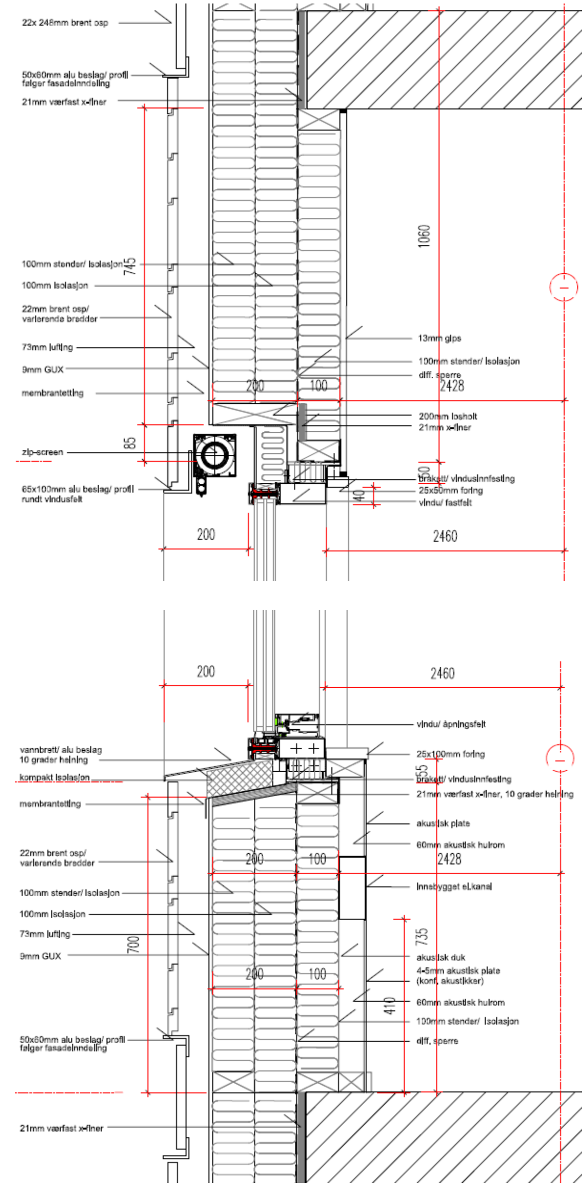
Daylight factor: *average on working areas 2,1*

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/m^2 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*

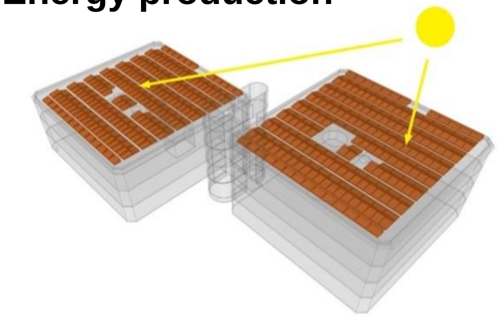
HOT WATER PRODUCTION

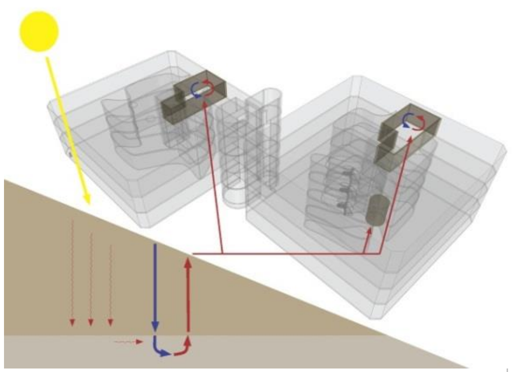
- *Heat pump and district heating*

RENEWABLE ENERGY SYSTEMS

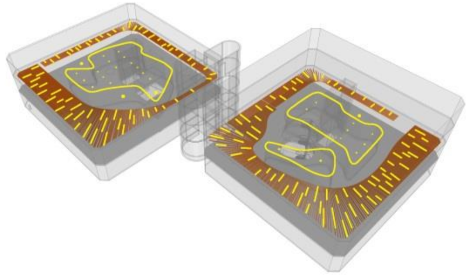
- *Before: District heating*
- *After:*
  - *preliminary ground based heat pump*
  - *310 kW PV system for electric generation to produce 230.000 kWh/year*

Energy production

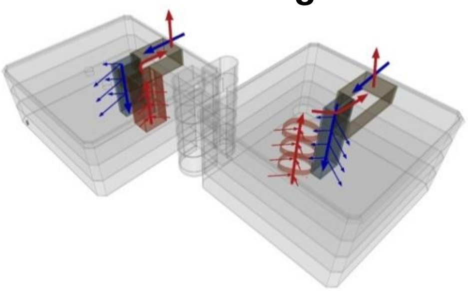




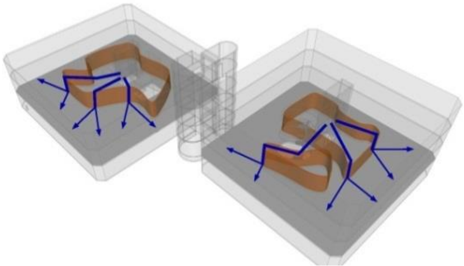
Daylight strategy – average DF > 2,1



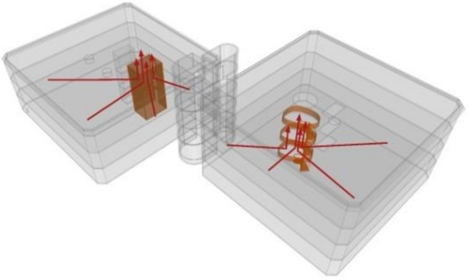
Ventilation and cooling
Reduced duct length



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

PRIMAY 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**
		Electicity	**District heating**	**Total**		
Space heating	15,4	4,6	0,9	5,5	kWh/m² year	Ground couples heatpump
Mechanical ventilation - heating	2,4	0,8	0,1	0,9	kWh/m² year	Ground couples heatpump
Hot Water	4,3	1,1	1	2,1	kWh/m² year	Ground couples heatpump
Energy fans for mechanical ventilation	2,1	2,1		2,1	kWh/m² year	
Energy pumps for heating, ventilation, cooling	0,8	0,8		0,8	kWh/m² year	
Lighting	7,7	7,7		7,7	kWh/m² year	
Technical equipmnet, PC, copymachines etc.	12	12		12	kWh/m² year	
Central data facilities - servers	16,9	16,9		16,9	kWh/m² year	
Coooling, cooled beams in office areas	0	0		0	kWh/m² year	
Cooling, central servers	16,9	1,1		1,1	kWh/m² year	Free cooling from ground
Cooling, central mechanical ventilation	3,5	0,2		0,2	kWh/m² 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/m² 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/m²
PV - production, last 30 years	60,1	0,93	55,9	kWh/m²
PV - production, average 60 years			68,7	kWh/m²
Operational energy use	-20,4	1,46	-29,8	kWh/m²
Embodied energy			-22,1	kWh/m²
Sum			**16,8**	**kWh/m²**

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

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/m² per year	kg CO_2-eq/m² 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.

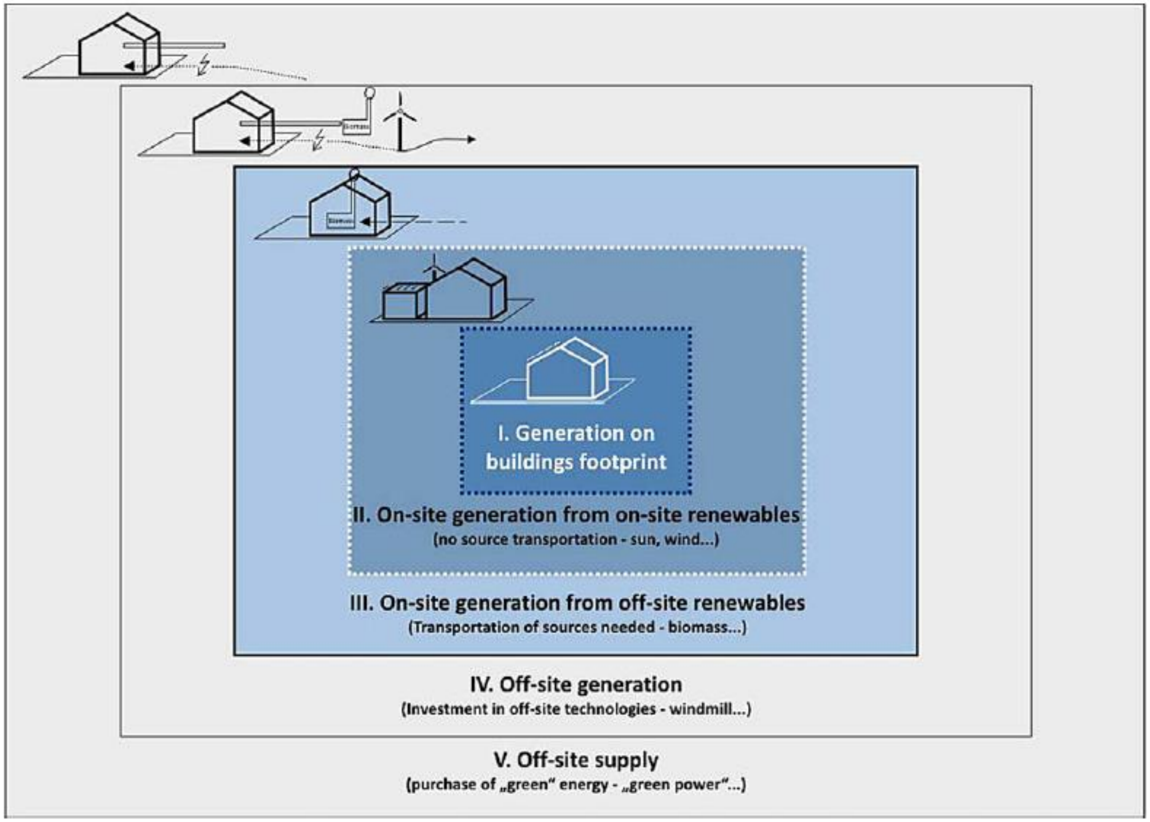
OTHER INTERESTING ASPECTS

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.

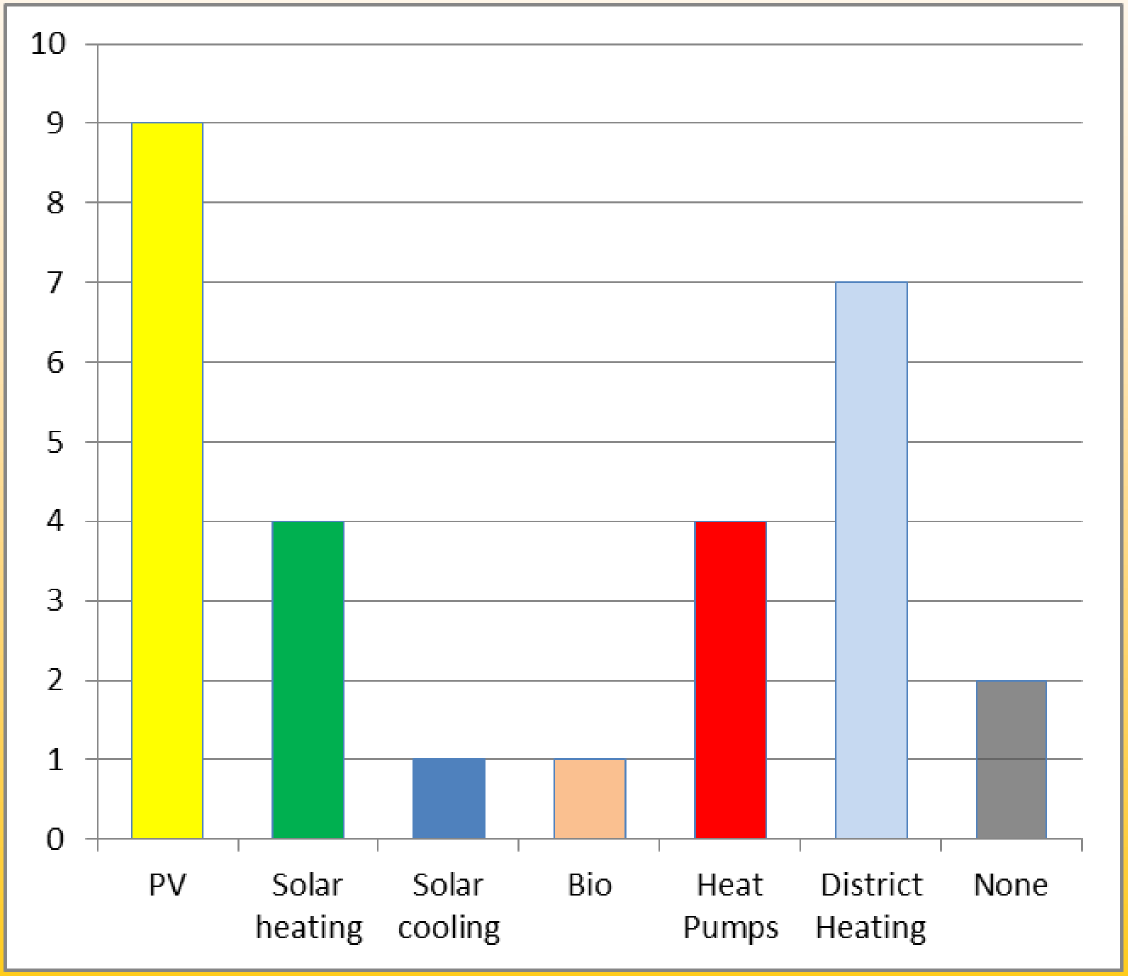
The energy goal must not be reached at the sacrifice of good architecture and indoor climate, or other central environmental qualities.

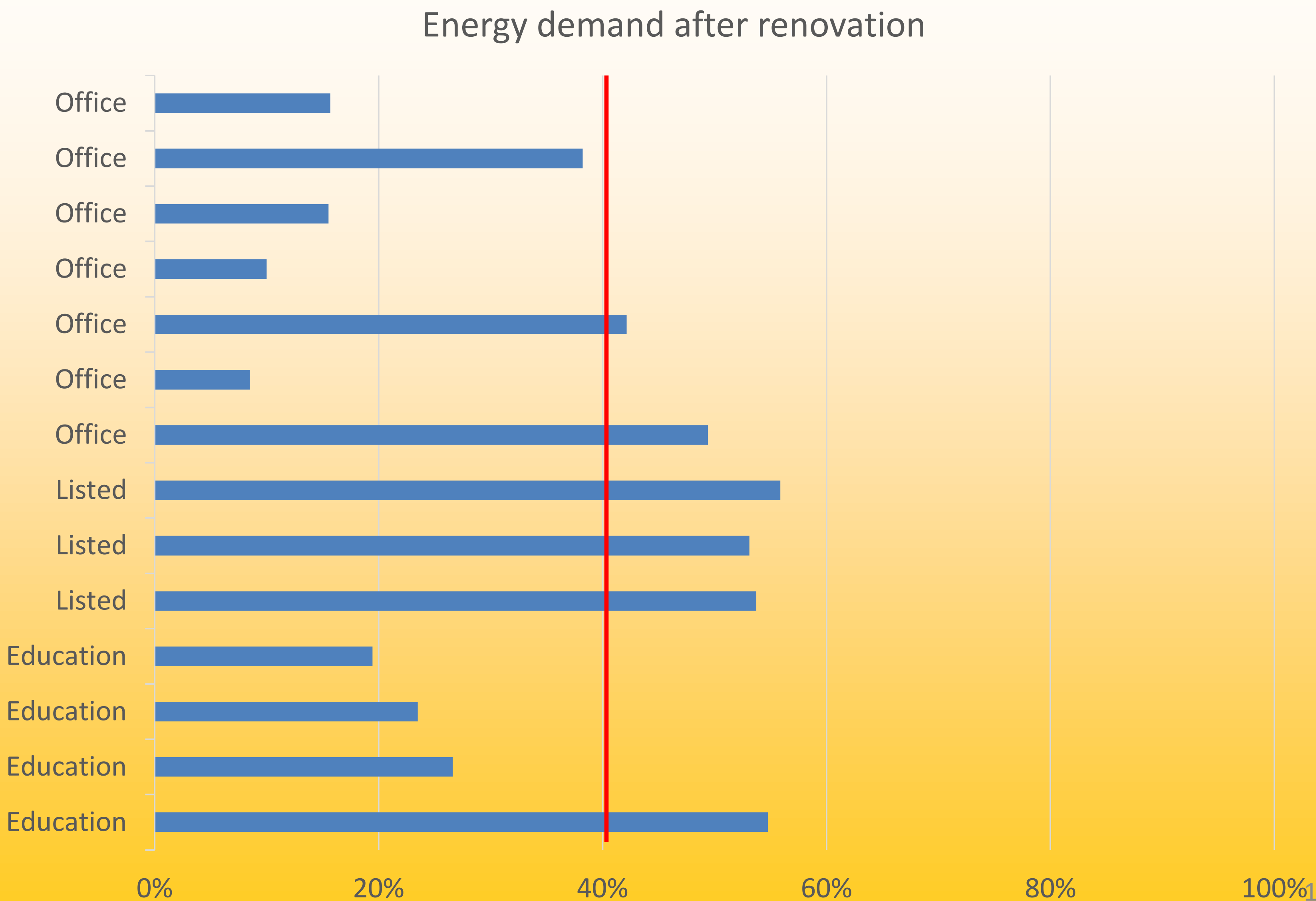
The Powerhouse boundary is similar to the Boundary II *(On site generation from on-site renewable)* as illustrated below



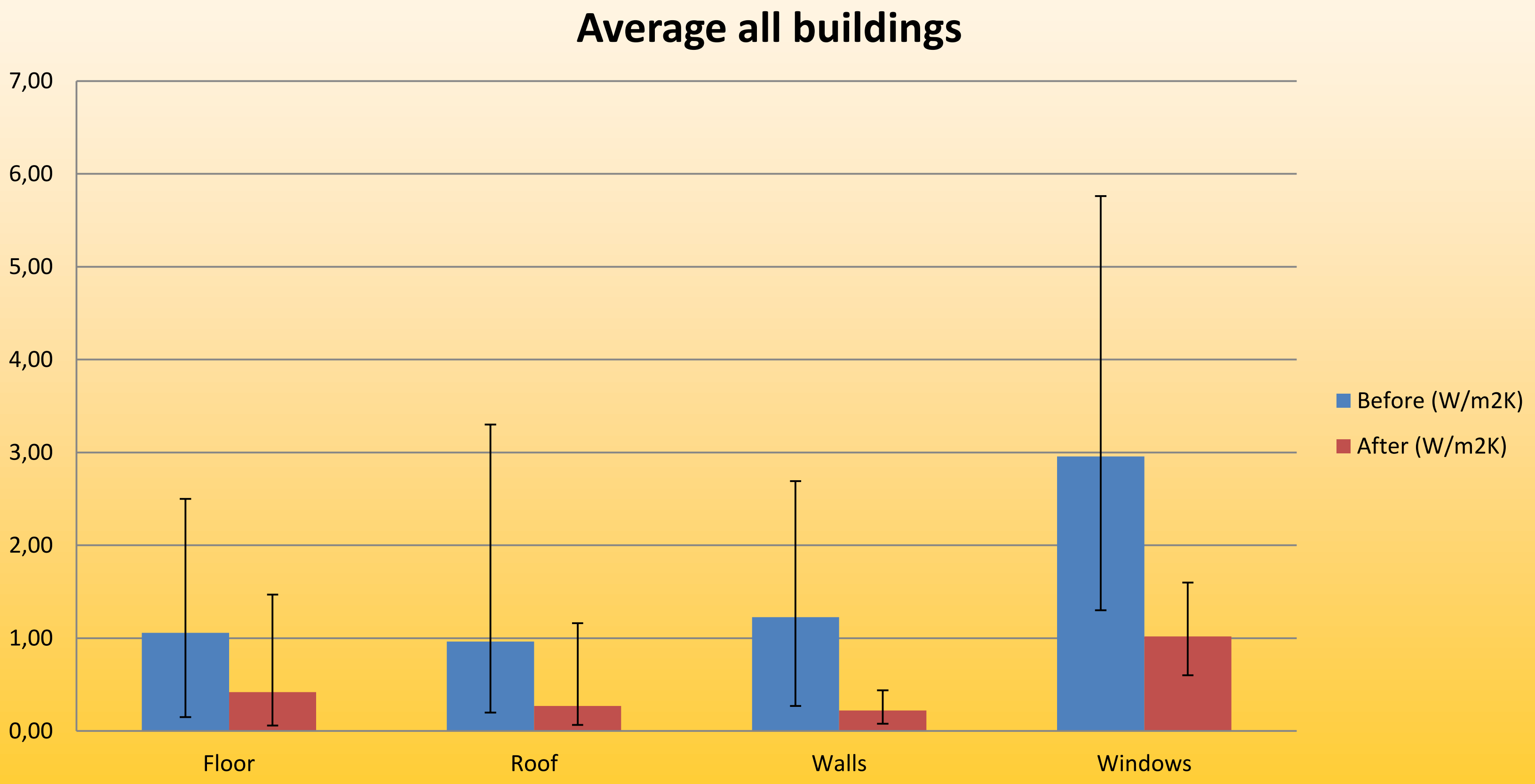
Source: A.J. Marszala,∗, P. Heiselberga, J.S. Bourrelleb, E. Musallc, K. Vossc, I. Sartori d, A. Napolitanoe. "Zero Energy Building – A review of definitions and calculation methodologies", Energy and Buildings 43 (2011) 971–979

Energy supply system in the 18 renovation projects




Energy demand after renovation
Office
Office
Office
Office
Office
Office
Office
Listed
Listed
Listed
Education
Education
Education
Education
0%
20%
40%
60%
80%
100%

U-values (W/m²K)



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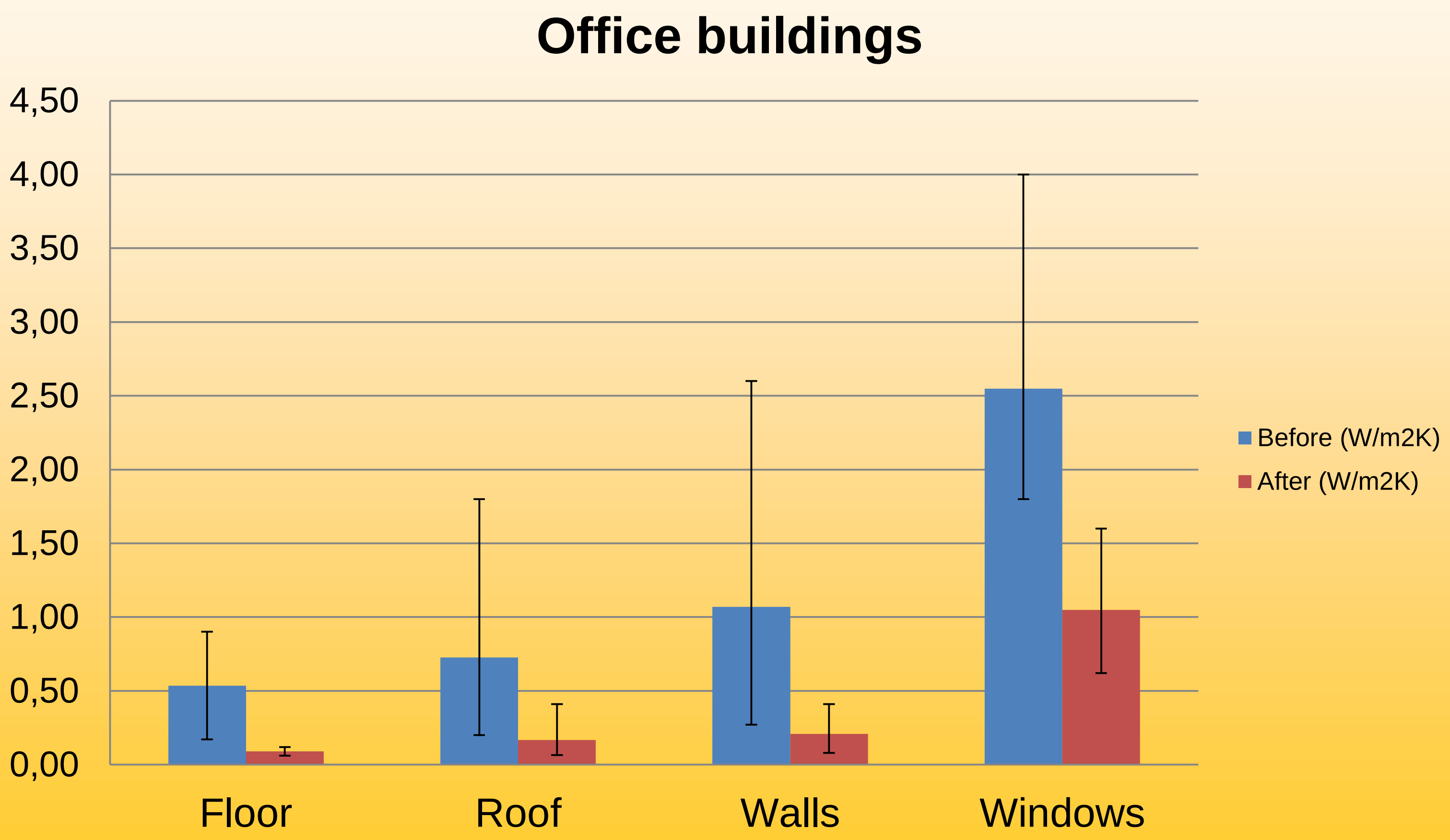
U-values (W/m²K)



Preliminary findings from 18 projects

- Windows upgraded to 0,6 - 1,2 W/m^{2}C
- Demand controlled mechanical ventilation system with heat recovery often in combination with controlled natural ventilation system during summer months
- Low air velocity in ducts important to reduce the fan power; one building shows a 90% decrease in demand for electricity
- Limited mechanical cooling needed, mostly covered by night–time ventilation
- Heat demand reduced 50 – 95%
- Efficient lamps with daylight control and/or movement sensors
- Renovation from 64 – 1100 €/m^2 for energy measures (listed buildings on the high end)

Preliminary findings; *cont.*

- Multidisciplinary team of experts is necessary in the early stage of planning to achieve a high standard renovation; architects, consultants, owner, tenant and contractor
  => integrated sustainable design
- Plus energy standard achieved with PV-system even in Norwegian climate, within acceptable economic conditions
- BREEAM outstanding achieved in at least one project
- It is documented that the pupils in school showed significant improvement in the concentration test scores and health and well-being questionnaires after a renovation which included an upgrade of the ventilation system.

More details to be available from the subtask A report «Lessons learned from exemplary renovation projects» which will be completed in the autumn 2014

Thank you for your attention

http://task47.iea-shc.org/

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