# POWERHOUSE KJØRBO

## The world's first refurbished plus-energy office building

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# Content

- Definition Powerhouse
- Background and objective of the project
- Energy performance and embodied energy of the building
- Building envelope
- Technical systems
- Renovation costs

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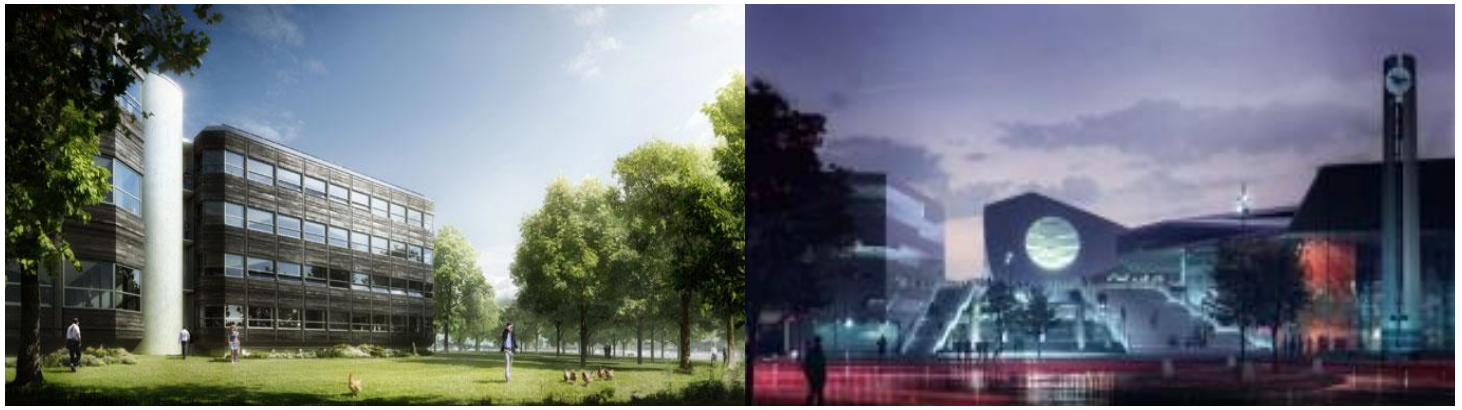
# What is a Powerhouse?

- A Powerhouse is a building which during its operational phase generates more renewable energy than what was used for the production of building materials, its construction, operation and disposal.
- The building is therefore transformed from being part of the energy problem to becoming part of the energy solution.



# Background

- Located in Sandvika outside Oslo in Norway
- Existing buildings from the 1980s
- Area: 5180 $m^2$.

# Objectives

- Keep the expression of the buildings
- Renovate to a plus- energy buildings (energy use for appliances not included in the energy budget)
- Build within commercial market conditions
- BREEAM outstanding

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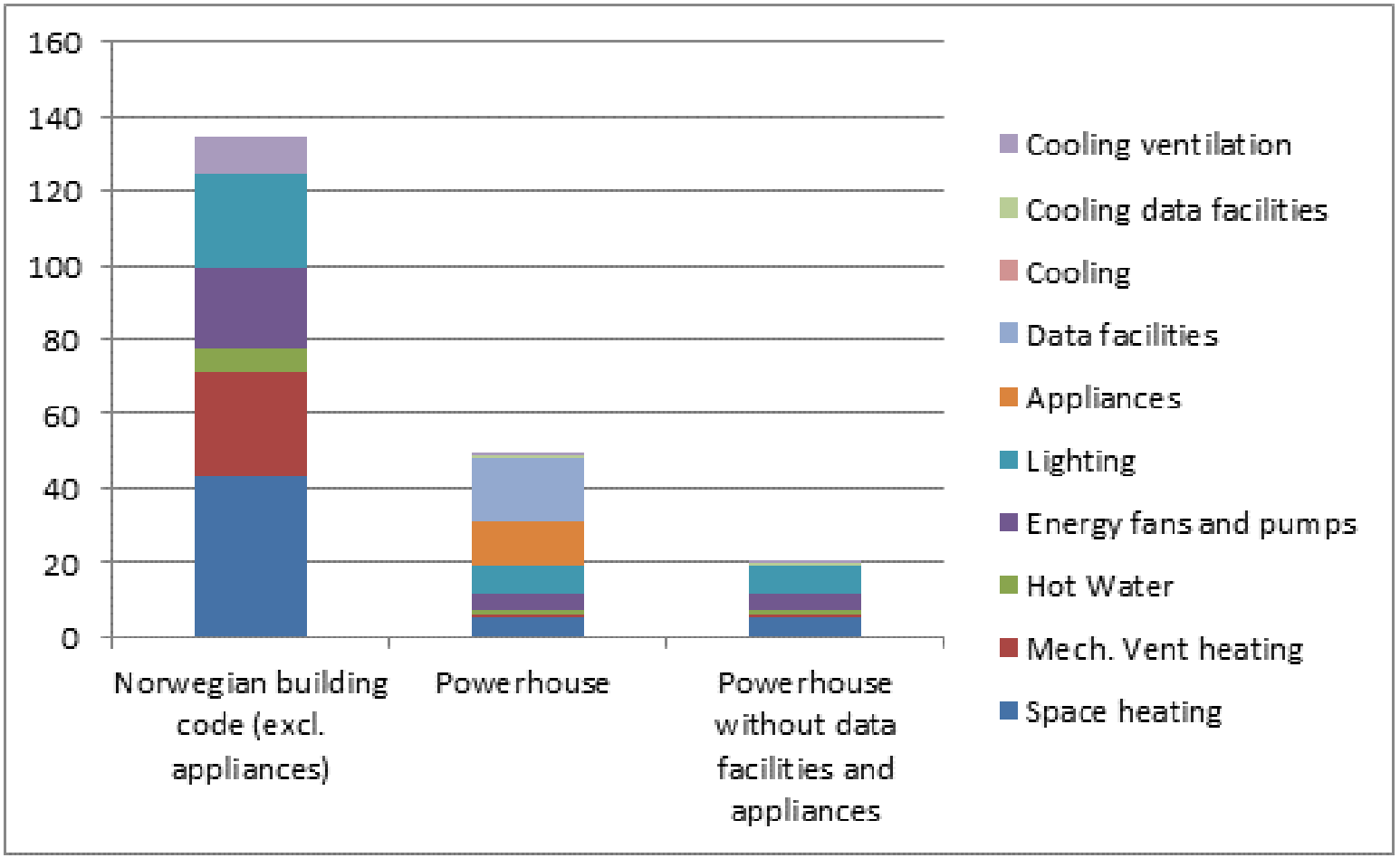
# Energy performance

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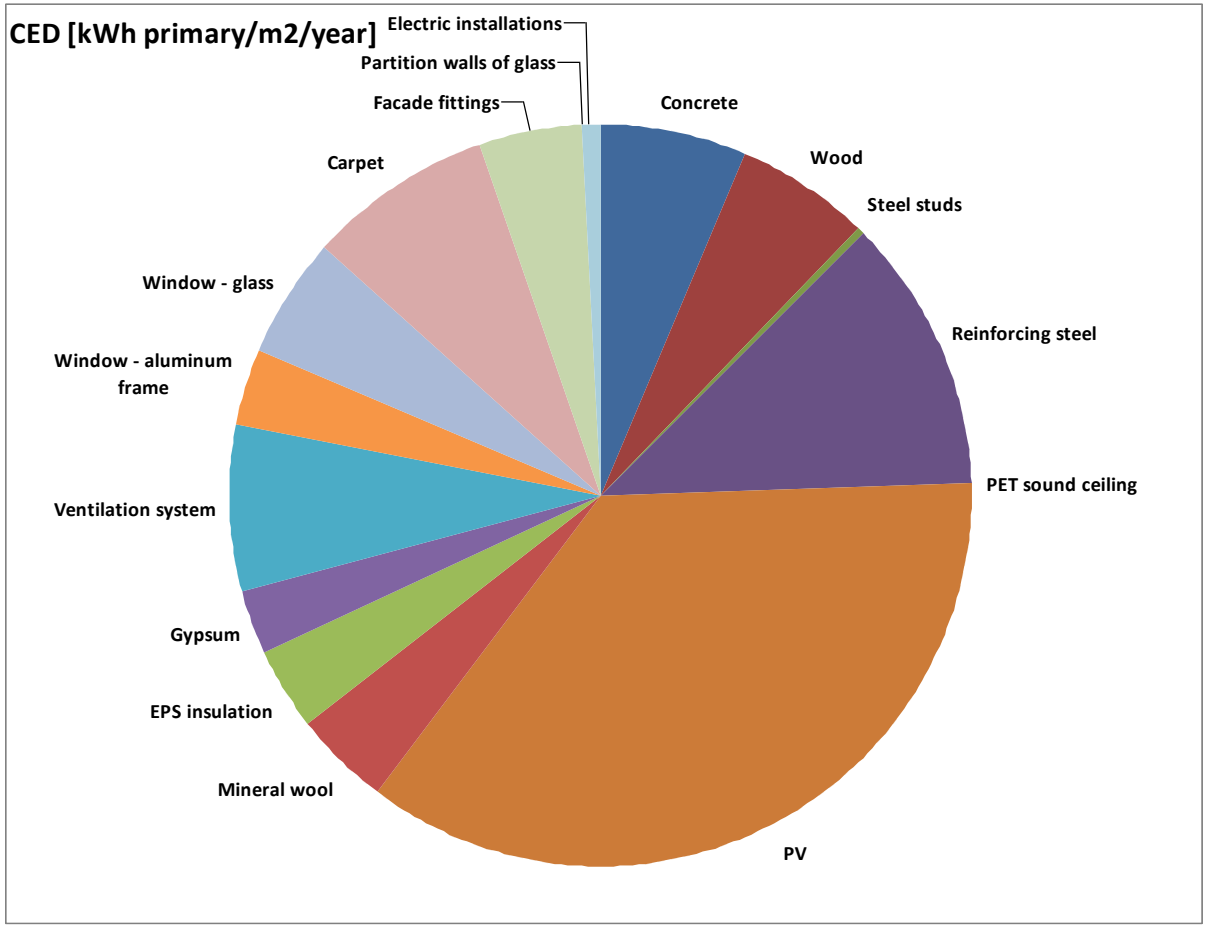
# Calculation of embodied primary energy




**Calculated average primary energy for materials per year for the entire lifespan: 16,3 kWh/m2/y**

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# Reuse of materials

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The old glass facade is reused in the indoor doors and windows for the offices.

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# Energy budget

| Energy demand/ production [kWh/m2] | Delivered/ produced energy | Primary energy factor | Primary energy demand |
|---|---|---|---|
| PV-production, first 30 years | 40,7 | 1,98 | 80,6 |
| PV- production last 30 years | 60,1 | 0,93 | 55,9 |
| **PV – production average 60 years** | | | **68,7** |
| **Operational energy use** | -20,4 | 1,46 | **-29,8** |
| **Embodied energy** | | 1,35 | **-22,1** |
| **Sum** | | | **16,8** |

The solar cells have to produce ~52 kWh/m2 for the building to be energy neutral. Because it produces ~69 kWh/m2, the building is energy positive -> fulfills the criteria for  Powerhouse

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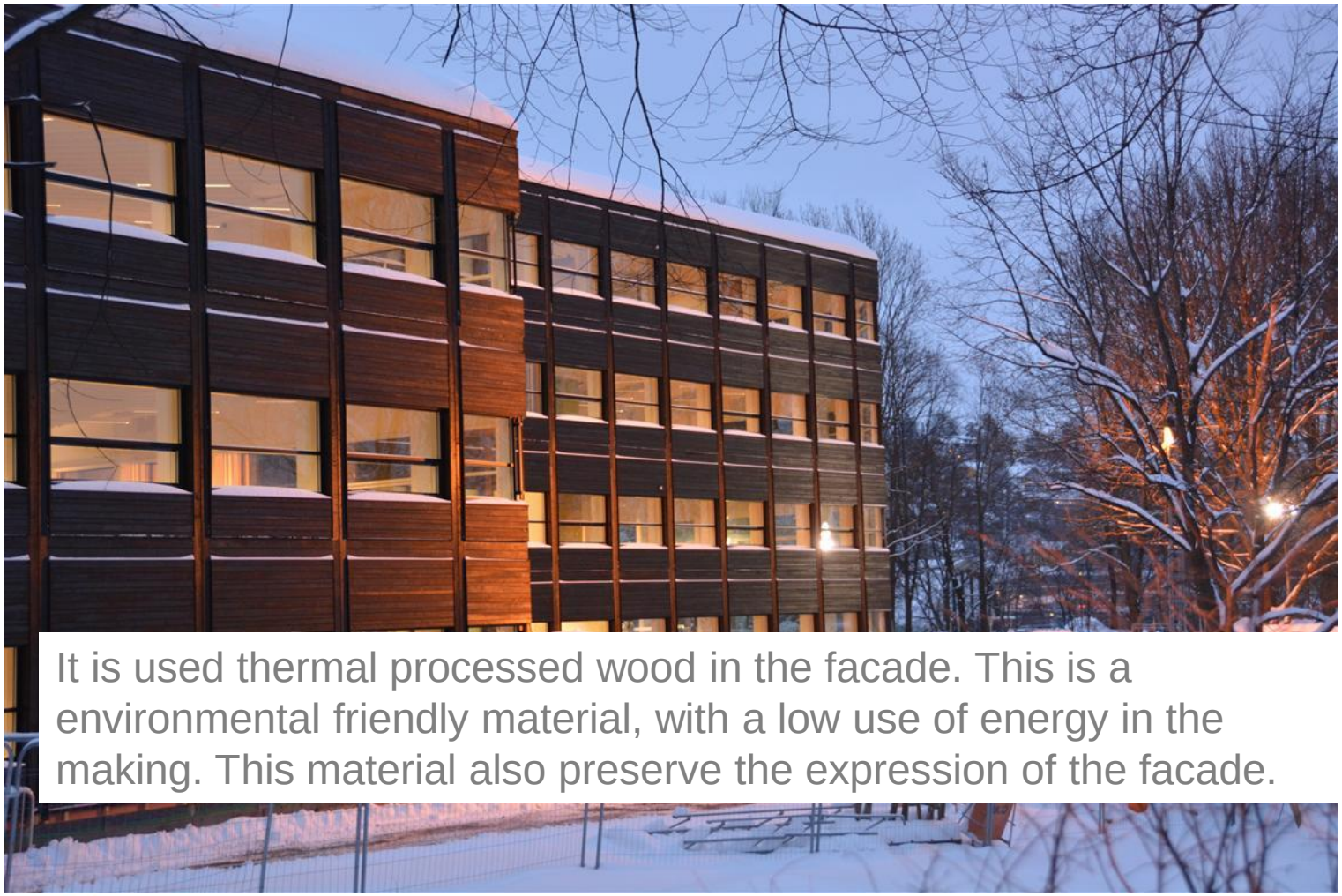
# Building envelope - facade



It is used thermal processed wood in the facade. This is a environmental friendly material, with a low use of energy in the making. This material also preserve the expression of the facade.

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# Building envelope

| 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 |

***Air thightness:***

| | |
|---|---|
| Norwegian regulations: | 1,5 1/h |
| Objective PH, less than: | 0,6 1/h |
| Measured: | 0,2 1/h |

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# Building envelope

- The construction of the building is better than passive house – level
- Focus on thermal bridge avoidance
- Good daylight factor
  - » Window to wall ratio: 40/60
  - » Light transmission for the windows: 68 %
  - » Daylight factor working areas: 2,1
- External sun shading integrated in the façade

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# Technical systems

- Energy efficient lighting
- Air heating delivered from ventilation combined with radiator in the wave wall in the center of the building
- Central air cooling
- Displacement ventilation (next slide)

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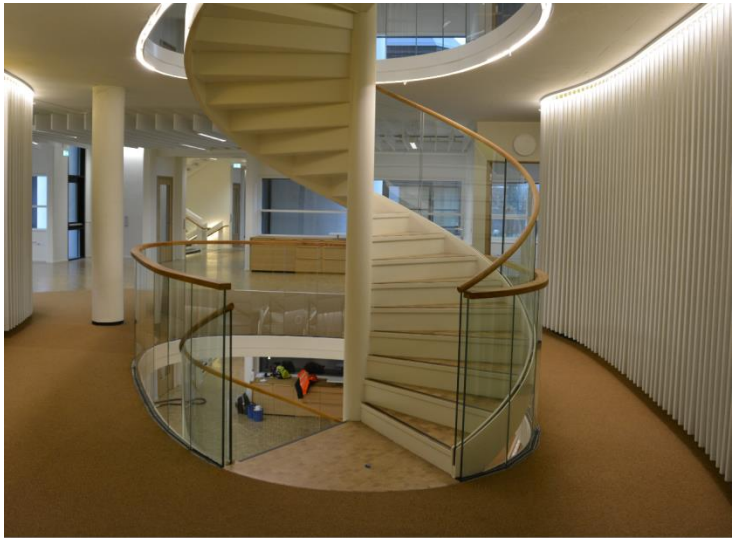
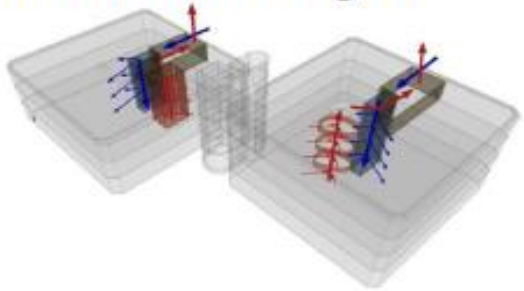
# Technical system - ventilation

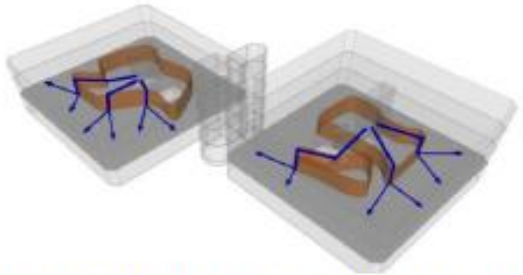


- Efficient heat recovery (85%)
- Displacement ventilation
- Use of the building, reduced duct lengths
- Demand control
- Windows that can be opened

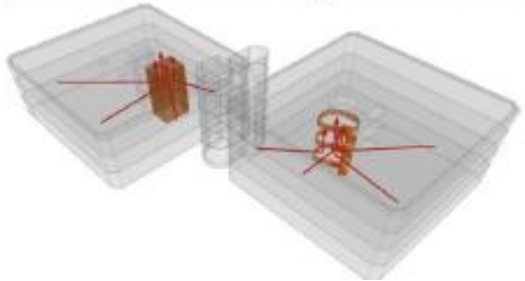
**Ventilation and cooling**
**Reduced duct length**



**Displacement ventilation**



**Exhaust air through staircase**



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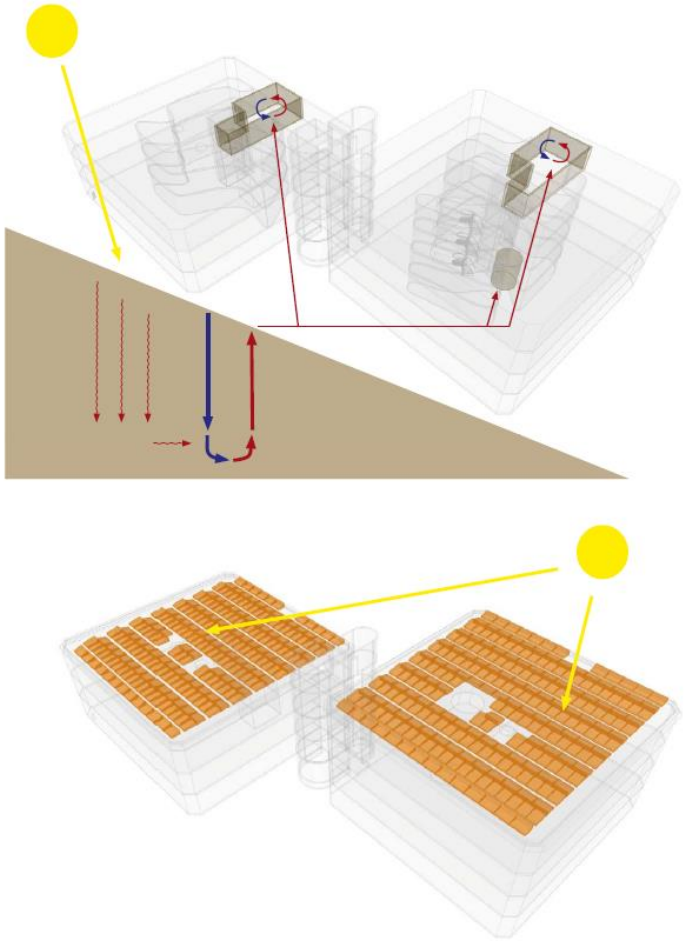
# Technical system - energy concept

- Reduction in the energy need by employing energy efficient solutions and a well insulated building structure.
- Heating and cooling from energy wells.
- Recycling of heat from computer servers.
- Two heat pumps running at different temperatures
- Local production of PV electricity



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# Solar power

- Norway's largest installation
- 1550 m2 on the roof of the two blocks and part of the garage
- Calculated energy production: 210 000 kWh/year (40 kWh/m2 BRA)
- Energy performance: 211 $kW_p$

Criterias PV – installation

1. Energy performance (yearly energy production)
2. Embodied energy
3. Price

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# Cost

- Built within commercial marked conditions
- The rent is higher than for a similar office building, but not when also considering reduced energy costs
- Total costs for the renovation: ~2650 €/m2

# Thank you for your attention!

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# Extra slides

| | Spesifikt behov for levert energi [kWh/m$^{2}$·år] | | |
|---|---|---|---|
| | Energimerke C kontorbygg | Powerhouse Kjørbo | Reduksjon vs energimerke C |
| **Romoppvarming** | 43,4 | 4,9 | 88,8 % |
| **Ventilasjonsvarme** | 27,6 | 1,0 | 96,5 % |
| **Tappevannsoppvarming** | 6,6 | 1,4 | 79,4 % |
| **Vifter og pumper** | 22,0 | 3,9 | 82,3 % |
| **Belysning** | 25,0 | 7,7 | 69,4 % |
| **Utstyr- generelt** | 34,0 | 12,0 | 64,8 % |
| **Utstyr - datarom (serveranlegg)** | Ikke medregnet | 16,9 | |
| **Romkjøling/komfortkjøling** | 0,0 | 0,0 | |
| **Dataromskjøling** | Ikke medregnet | 1,1 | |
| **Ventilasjonskjøling** | 9,6 | 0,2 | 97,6 % |
| **Totalt** | | 49,0 | |
| **Totalt eksklusive serveranlegg** | 171,5 | 32,0 | 81,3 % |
| **Totalt eksklusive serveranlegg og generelt utstyr** | 137,5 | 20,1 | 85,4 % |

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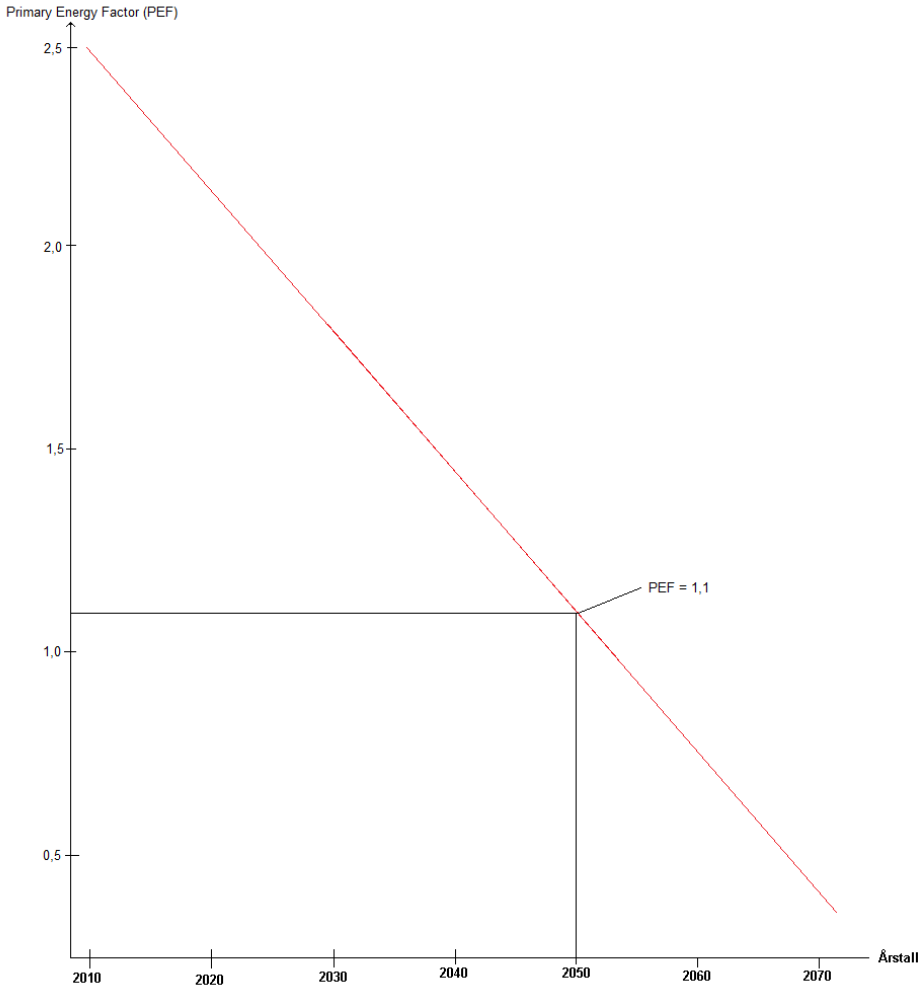
# Primary energy factor



# Definition Powerhouse

*Energy used in operation*

+

*Embodied energy (materials etc)*

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*The production of renewable energy*

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*Positive energy balance over the lifetime of the building*

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# The Powerhouse Alliance


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