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
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 m².

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
Energy performance
Calculation of embodied primary energy

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

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

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

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.
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.
# Building envelope

<table>
<thead>
<tr>
<th>U – values [W/m2K]</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof/attic</td>
<td>~0,2</td>
<td>0,08</td>
</tr>
<tr>
<td>Floor/slab</td>
<td>-</td>
<td>0,12-0,16</td>
</tr>
<tr>
<td>Walls</td>
<td>~0,3</td>
<td>0,15</td>
</tr>
<tr>
<td>Ceilings</td>
<td>~0,3</td>
<td>0,3</td>
</tr>
<tr>
<td>Windows</td>
<td>~1,8</td>
<td>0,8</td>
</tr>
</tbody>
</table>

**Air tightness:**

- Norwegian regulations: 1,5 1/h
- Objective PH, less than: 0,6 1/h
- Measured: 0,2 1/h
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
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)
Technical system - ventilation

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

Criterias PV – installation
1. Energy performance (yearly energy production)
2. Embodied energy
3. Price
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!
### Spesifikt behov for levert energi [kWh/m²·år]

<table>
<thead>
<tr>
<th></th>
<th>Energimerke C kontorbygg</th>
<th>Powerhouse Kjørbo</th>
<th>Reduksjon vs energimerke C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romoppvarming</td>
<td>43,4</td>
<td>4,9</td>
<td>88,8 %</td>
</tr>
<tr>
<td>Ventilasjonsvarme</td>
<td>27,6</td>
<td>1,0</td>
<td>96,5 %</td>
</tr>
<tr>
<td>Tappevannsoppvarming</td>
<td>6,6</td>
<td>1,4</td>
<td>79,4 %</td>
</tr>
<tr>
<td>Vifter og pumper</td>
<td>22,0</td>
<td>3,9</td>
<td>82,3 %</td>
</tr>
<tr>
<td>Belysning</td>
<td>25,0</td>
<td>7,7</td>
<td>69,4 %</td>
</tr>
<tr>
<td>Utstyr- generelt</td>
<td>34,0</td>
<td>12,0</td>
<td>64,8 %</td>
</tr>
<tr>
<td>Utstyr - datarom (serveranlegg)</td>
<td>Ikke medregnet</td>
<td>16,9</td>
<td></td>
</tr>
<tr>
<td>Romkjøling/komfortkjøling</td>
<td>0,0</td>
<td>0,0</td>
<td></td>
</tr>
<tr>
<td>Dataromskjøling</td>
<td>Ikke medregnet</td>
<td>1,1</td>
<td></td>
</tr>
<tr>
<td>Ventilasjonskjøling</td>
<td>9,6</td>
<td>0,2</td>
<td>97,6 %</td>
</tr>
<tr>
<td><strong>Totalt</strong></td>
<td>49,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Totalt eksklusive serveranlegg</strong></td>
<td>171,5</td>
<td>32,0</td>
<td>81,3 %</td>
</tr>
<tr>
<td><strong>Totalt eksklusive serveranlegg og generelt utstyr</strong></td>
<td>137,5</td>
<td>20,1</td>
<td>85,4 %</td>
</tr>
</tbody>
</table>
Primary energy factor
Definition Powerhouse

Energy used in operation

+ 

Embodied energy (materials etc)

< 

The production of renewable energy

= 

Positive energy balance over the lifetime of the building
The Powerhouse Alliance