“Stjärnhus” Stacken: Step-by-step deep retrofit and building integrated façade/roof on a ‘million program’ house

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Reducing barriers

Step by step vs. one shot retrofit:
step by step minimises challenges

Building stock

NZEB

Retrofitting challenges
• competence
• motivation
• financing
• life cycle of existing components
• disturbance of inhabitants
Many “million program” buildings need to be renovated.

Sweden has an ambitious political goal to be net zero greenhouse gas emissions by 2045.

A cost effective way to reduce energy consumption and generate renewable energy could be:
  ○ to cover most/all of the buildings energy needs with solar PV
  ○ that functions at the same time as a protective facade and roof for externally applied insulation.
construction drawings - solar modules
solar electricity vs. bought electricity

The graph compares solar electricity production and total building consumption over the course of a year. The bar chart shows the following:

- **Total building consumption** (blue bars)
- **Total roof PV production** (red bars)
- **Total facade PV production** (green bars)
- **Total PV production** (orange bars)

The data is represented on the vertical axis (kWh) and the horizontal axis (months from Jan to Dec). The graph highlights the variations in energy consumption and production throughout the year.
$\theta_{\text{si min}}_{\text{A,B}} = 15,00 ^{\circ} \text{C}$

$f_{\text{Rsi}} = 0.833$

$\varphi_{\text{33(50%)}} = 69\%$

$\varphi_{\text{100\%}} = 73\%$

$\varphi_{\text{80\%}} = 58\%$

$\Psi(\text{install}) = 0.016 \text{ W/(m}^2\text{K)}$
### Built in 1968, a (simple) triple-glazed window upgrade has been implemented

#### Step 1
Add a heat recovery ventilation (MVHR) unit; that since then has been PHI-certified, with 85% heat recovery efficiency

#### Step 2
Insulate attic – 500mm cellulose insulation, resulting in a U-value of 0.079 W/(m²·K)

#### Step 3
Install new PHI-certified windows [Uw-value ~ 0.7 W/(m²·K)] & sort out air tightness, upgrade MVHR control.

#### Step 4
Insulate façade and include balconies into thermal envelope (adding 134m² TFA and reducing thermal bridges); resulting U-value of external wall 0.102 W/(m²·K). Add BIPV to façade and roof

<table>
<thead>
<tr>
<th>145 kWh/(m²·a) specific heating demand, 53W/m² specific heating load</th>
<th>75 kWh/(m²·a) specific heating demand, 33W/m² specific heating load</th>
<th>15 kWh/(m²·a) specific heating demand, 11 W/m² specific heating load</th>
</tr>
</thead>
<tbody>
<tr>
<td>46,600 €</td>
<td>9,620 €</td>
<td>~350 000 €</td>
</tr>
<tr>
<td>Done</td>
<td>Done</td>
<td>Planned</td>
</tr>
<tr>
<td>~500 000 €</td>
<td>~500 000 €</td>
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