Interventions for the Sustainable Development of Architectural Heritage

The Example of the Soda Fabriek in Schiedam, NL
Problem Statement

Buildings contribute \(~30\%\) of total global greenhouse emissions [UN Environment Program]

Buildings consume \(~35\%\) of total world energy [IEA]

\(~65\%\) of existing buildings are more than 40 years old [CBS]
62.000 + Rijksmonumenten in the NL
“Which are the more appropriate technical interventions on the envelope of the Soda Fabriek in Schiedam in order to reduce the energy needed to condition the building”

- What is the definition of sustainable interventions on architectural heritage?
- What is the framework in which architectural heritage can be dealt with?
- What is the general context of the Soda Fabriek?
- What are the building's essential characteristics?
- What is the historical significance of the Soda Fabriek and how does it define the intervention possibilities?
- What is the current state of the building?
- Is it possible to upgrade the Soda Fabriek's energy performance without insulating the walls? To what degree?
- How do the different interventions affect energy distribution in the building and ultimately the energy consumption to condition the building?
- What other impacts do these interventions have for the building?
- What other factors affect energy consumption in the building?

Passive Strategies for the improvement of the Soda Fabrieks Envelope.

Different Envelope Configurations
- Systems Constant
- Functions & Activities Constant

Indicators to be evaluated
- Heat Loss through the Envelope
- Heat Gains
- Energy Consumption for Space Conditioning
The Soda Fabriek

Exposed Brick Masonry

Wooden Floor & Roof Construction

Wooden, Single Glazed, Fixed Windows

Corrugated Asbestos Sheets Roof
Current Condition

~70% of interior needs to be replaced
Conservation best practice

- Historic Preservation is a multidisciplinary field bringing together historians, archeologists, architects, planners, engineers, governments.
- Permanent maintenance of historic buildings is essential to their preservation.
- Minimize the amount of intervention as much as possible. Do as little as possible but also as much as is necessary.
- Respect the history of the building or site in question, its periods and previous interventions as they are essential to its value.
- All interventions should be reversible.
- All replacements or additions should be distinct from the original and/or bare a contemporary stamp.
- Any action should lead and/or derive from a site’s reuse. Therefore uses other than the original can be considered [with all its implications].
- Documentation at every step of the intervention process is paramount to ensure no loss of valuable information and to expand and distribute knowledge on this otherwise empirical field.
<table>
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<th>Case</th>
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<th>Insulation</th>
<th>Openings</th>
<th>Instalations</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>De Tempel, The Hague</td>
<td>Energy Label C</td>
<td>minimal insulation 25mm</td>
<td>frames maintained - glazing replaced</td>
<td>Heat Pump Floor and Wall Heating Natural Ventilation Backup system with Heat Recovery</td>
<td>Energy Label A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Conditioning 27.7 kWh/m² System Tot 39.9 kWh/m²</td>
<td></td>
</tr>
<tr>
<td>Huis de Witte Roos, Delft</td>
<td>Lower Carbon Emissions</td>
<td>thorough internal insulation</td>
<td>frames and glazing maintained</td>
<td>Heat Pump Wall Heating Decentralized Ventilation system with Heat Recovery</td>
<td>90% Carbon Emissions reduction</td>
</tr>
<tr>
<td></td>
<td>Energy Neutrality</td>
<td></td>
<td></td>
<td>System Tot 45.7 kWh/m²</td>
<td></td>
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<tr>
<td>Latijnse School, Middelburg</td>
<td>Renovation with Passive</td>
<td>Extreme internal and external insulation</td>
<td>frames and glazing maintained - triple glazed window added to the inside</td>
<td>Heat Pump Floor Heating Centralized Ventilation system with Heat Recovery</td>
<td>Heating 13 kWh/m²</td>
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<td></td>
<td>House Standards 15 kWh/m²</td>
<td></td>
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<td>per year</td>
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</table>
Interventions

- Existing Situation
- Wall Insulation
- Roof & Ground Insulation
- Window Replacement
- Trombe Wall
- Glass Roof
Proposed Reuse

- Bed & breakfast
- Horeca
- Office space
- Wellness center/yoga
- Exhibition space
- Workshops
Proposed Installations

Air Handling Unit [Mechanical Fresh Air Supply with Heat Recovery system - HR COP 0.7]

ground source heat pump [COP ~4]

Zones smaller than 30m² use water radiators [water temperature inside radiator 45°C]

Zones bigger than 30m² use underfloor heating [water temperature inside in-floor tubes between 30 and 50 °C]

ground heat source

Glass Roof System Variation
Model #1 - Existing Situation  [Control] - Winter

Electricity for Heating - kWh/m²

- 39,70

21,21

39,60

Auxiliary System Energy - kWh/m²

Heat Recovered - kWh/m²
Model #1 - Existing Situation [Control] - Summer

Zone Cooling - kWh/m²
Setpoint not met during Cooling - Hours
Setpoint not met during Heating

67.78  
1.343.00  
6.209.50
Model #2 - Wall Insulation - Winter

Asbestos sheet
Timber sheathing
Timber roof structure
Timber floor boards
Timber floor structure
Fixed wooden window [single glazing]
Solid brick wall [external]
XPS insulation 100mm
Concrete ground floor slab

Electricity for Heating - kWh/m²: 39,70
Auxiliary System Energy - kWh/m²: 21,21
Heat Recovered - kWh/m²: 39,60

Asbestos sheet
Timber sheathing
Timber roof structure
Timber floor boards
Timber floor structure
Fixed wooden window [single glazing]
Solid brick wall [external]
XPS insulation 100mm
Concrete ground floor slab

Electricity for Heating - kWh/m²: 39,18
Auxiliary System Energy - kWh/m²: 19,34
Heat Recovered - kWh/m²: 52,06
Model #2 - Wall Insulation - Summer

[Diagram showing energy flow and calculations]

Zone Cooling - kWh/m²

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>67.78</td>
</tr>
<tr>
<td>74.78</td>
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</table>

Setpoint not met during Cooling - Hours

<table>
<thead>
<tr>
<th>Value</th>
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<tbody>
<tr>
<td>1.343,00</td>
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<tr>
<td>1.708,50</td>
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</table>

Setpoint not met during Heating

<table>
<thead>
<tr>
<th>Value</th>
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<tbody>
<tr>
<td>6.209,50</td>
</tr>
<tr>
<td>6.001,50</td>
</tr>
</tbody>
</table>
Model #3 - Roof, Ground & Window Insulation - winter

- Electricity for Heating - kWh/m²
- Auxiliary System Energy - kWh/m²
- Heat Recovered - kWh/m²

- Solid brick wall [external]
- Sand-cement finishing screed
- XPS insulation 200mm
- Concrete ground floor slab
- Operable wooden window
double glazing 6-13-6 mm filled with air
- Timber roof structure
- Prefab roof panel with 200 mm of XPS insulation and waterproofing layer
- Timber floor boards
- Timber floor structure
- Zinc coated steel sheet cladding
Model #3 - Roof, Ground & Window Insulation - summer

-0.2 kW
-3.1 kW
1 kW
-1.4 kW
2 kW
24.5 kW
11.3 kW
-15.7 kW
-4.5 kW
-10 kW
-7.5 kW
5.7 kW
4.7 kW
6.4 kW
-7.6 kW
4 kW
-0.8 kW
0.5 kW

67.78
75.07
1.343,00
1.682,50
6.209,50
5.162,50
1.682,50
5.162,50

Zone Cooling - kWh/m²
Setpoint not met during Cooling - Hours
Setpoint not met during Heating
Model #4 - Trombe Wall - Winter

-asbestos sheet
-timber sheathing
-timber roof structure
-solid brick wall [external]
-concrete ground floor slab
-single glazing curtain wall with aluminum structure
-solid brick wall [external]
-concrete ground floor slab
-curtain wall reinforced concrete foundation
Model #4 - Trombe Wall - Winter

Electricity for Heating - kWh/m²
- 39,70
- 42,72

 Auxiliary System Energy - kWh/m²
- 21,21
- 60,80

Heat Recovered - kWh/m²
- 39,60
- 0,00

-14.3 kW
-46.3 kW
-18.2 kW
-15.3 kW
-24.5 kW
1.8 kW
314.3 kW
-198.3 kW
-3 kW
0.5 kW

asbestos sheet
timber sheathing
timber roof structure

sic single glazing curtain wall with aluminum structure
solid brick wall [external]
concrete ground floor slab
curtain wall reinforced concrete foundation

cement foundation
Model #4 - Trombe Wall - Summer

NE  57.486.57 kWh
    263.70 kWh/m²

SE  113.240.04 kWh
    471.83 kWh/m²

SW  76.496.95 kWh
    380.58 kWh/m²

Zone Cooling - kWh/m²
142,83
67,78
6.209,50
6.209,50

Setpoint not met during Cooling - Hours
1.343,00
1.343,00
725,00
7.582,00

Setpoint not met during Heating
725,00
725,00
7.582,00
7.582,00
Model #5 - Glass Roof - Winter

-14.15 kW
-25.4 kW
-33.7 kW
-15.5 kW
-60.5 kW
5.3 kW
3.3 kW
328.7 kW
-208 kW
-19.6 kW

- Single glazed aluminum gables
- Steel roof structure
- Timber floor boards
- Timber floor structure
- Fixed wooden window [single glazing]
- Solid brick wall [external]
- Concrete ground floor slab

Electricity for Heating - kWh/m²
21.21
39.70
33.20

Auxiliary System Energy - kWh/m²
39.60

Heat Recovered - kWh/m²
39.63
277.23
Model #5 - Glass Roof - Summer

**Lijfland**
132,168,00 kWh
349.4 kWh/m³

**Coerland**
97,715,82 kWh
164.20 kWh/m³

<table>
<thead>
<tr>
<th>Zone Cooling - kWh/m²</th>
<th>Setpoint not met during Cooling - Hours</th>
<th>Setpoint not met during Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>67,78</td>
<td>1.343,00</td>
<td>6.209,50</td>
</tr>
<tr>
<td>68,13</td>
<td>2.553,50</td>
<td>5.661,50</td>
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<tr>
<td></td>
<td>Model #1</td>
<td>Model #2</td>
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<tr>
<td>---------------------</td>
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</tr>
<tr>
<td>Electricity for Heating - kWh/m²</td>
<td>39.70</td>
<td>39.18</td>
</tr>
<tr>
<td>Auxiliary System Energy - kWh/m²</td>
<td>21.21</td>
<td>19.34</td>
</tr>
<tr>
<td>Heat Recovered - kWh/m²</td>
<td>39.60</td>
<td>52.06</td>
</tr>
<tr>
<td>Zone Cooling - kWh/m²</td>
<td>-67.78</td>
<td>-74.78</td>
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<tr>
<td>Discomfort - Hours</td>
<td>2641</td>
<td>2343</td>
</tr>
<tr>
<td>Improvement - %</td>
<td>1.3%</td>
<td>12.8%</td>
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</tbody>
</table>
Conclusion - Installations

Building Area
1900 m²
System Total Energy
39.9 kWh/m²

Building Area
2100 m²
System Total Energy
52.3 kWh/m²

Source of Heat Gains [kWh/m²]

Ventilation Requirement

Design Heat Load

Variation in the sizing parameter of the Ventilation System
Conclusion - Combination necessary - Comfort

Discomfort Hours
Reflections & Further Research
The Bigger Picture

Greenhouse Gass Emmissions: -20%
Renewable Energy Use: 20%
Energy Efficiency: 20%

Europe 2020

2013 Progress

Toledo Declaration of EU Member States [2010]
EU Urban Agenda [still under development]

All stress the importance of energy upgrading the existing building stock as well as the sustainability of Architectural Heritage

2014 - € 2.4 mil on building conservation subsidies
Thank You