POST-WAR REFURBISHMENT
How to make your post-war house sustainable

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Content
Introduction
Methodology
Analysis row house
Refurbishment strategies
Other building types
Technical application
Conclusions
Content

Introduction
  Problem
  Research question
Methodology
Analysis row house
Refurbishment strategies
Other building types
Technical application
Conclusions
Problem

Climate change

Earthquakes in Groningen
Problem

Gasproduction

- Coming 4 years: 21 billion m$^3$ → 12 billion m$^3$
- Complete stop: 2030

Major changes
±20% built 1960-1974

1960-1974: 2500 m³

2000+: 1500 m³
Research question

Which **strategies** are possible to **improve energy consumption** in **different** levels for **multiple** building types built between **1960-1974**?
Research question

Which strategies are possible to improve energy consumption in different levels for multiple building types built between 1960-1974?

- Dutch houses
- Owner-occupied
- Late post-war
Research question

Which strategies are possible to improve energy consumption in different levels for multiple building types built between 1960-1974?

- Dutch houses
- Owner-occupied
- Late post-war
- Three strategies
  - Improvement
  - Budget
  - Versatile
Content

Introduction

Methodology
  Research-based design
  Simulations

Analysis row house

Refurbishment strategies

Other building types

Technical application

Conclusions
Research-based design

- Literature
- Analysis test house 1
- Theory
Research-based design

1. Literature
2. Theory
3. Analysis test house 1
4. Development strategies
5. Simulation
6. Final strategies

Flow: Literature → Theory → Analysis test house 1 → Development strategies → Simulation → Final strategies

Improve
Research-based design

- Literature
- Theory
- Analysis test house 1
- Development strategies
- Simulation
- Final strategies
- Improve
- Analysis test houses 2 & 3
- Application strategies
- Simulations
Simulations

Design Builder

Uniec 2.2
Simulations

Annual fuel consumption

Energy Performance Coefficient: EPC
- New houses: EPC ≤ 0.4
Situation

Orientation
Situation

Facades

North face

South face
Situation

Construction

Section A-A
Situation

Installation

HR combi boiler 2012

Electric boiler 10L 2008

Natural ventilation
Simulation

Programs
Simulation

Results

Electricity consumption [kWh/year]

Gas consumption [m³/year]

EPC = 1.13
Content

Introduction
Methodology
Analysis row house
Refurbishment strategies
  Basic insulation strategy (A)
  EPC ≤ 0.4 strategy (B)
  Net Zero Energy Building strategy (C)
Comparison
Other building types
Technical application
Conclusions
Basic insulation strategy (A)

Boundary conditions
- Simple techniques
- Improve ventilation
- Minimal disturbance
- Payback time: 10 years
Basic insulation strategy (A)

Insulation techniques

- Cavity wall insulation
- Crawl space insulation
- Internal insulation pitched roof
- External insulation flat roof
- Insulating dormers
- HR++ glazing
- Frames with thermal break

Indoor climate
Basic insulation strategy (A)

Thermal transmittance

U-value [W/(m²*K)]

<table>
<thead>
<tr>
<th>Component</th>
<th>Current</th>
<th>Strategy A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer wall</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Ground floor 1</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Ground floor 2</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Pitched roof</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Flat roof</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Dormer wall</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Dormer roof</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Doors</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Glazing</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Frames</td>
<td>1.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Basic insulation strategy (A)

Insulation techniques
- Cavity wall insulation
- Crawl space insulation
- Internal insulation pitched roof
- External insulation flat roof
- Insulating dormers
- HR++ glazing
- Frames with thermal break

Indoor climate
- Installations < 15 years
- New and extra ventilation grills
- LED lighting
Basic insulation strategy (A)

Results row house

Annual electricity consumption [kWh/year]

Current | Strategy A
---|---
0 | -3%
500 | 
1000 | 
1500 | 
2000 | 
2500 | 
3000 | 
3500 | 
4000 | 
4500 | 

Annual gas consumption [m$^3$/year]

Current | Strategy A
---|---
EPC = 0.77 | -56%
0 | 
500 | 
1000 | 
1500 | 
2000 | 
2500 | 
3000 | 
3500 | 
4000 | 
4500 |
Basic insulation strategy (A)

Visualisation

Current

Strategy A

Invest: €9,500,-
Payback time: 12 years
EPC ≤ 0,4 strategy (B)

Boundary conditions

- EPC ≤ 0,4
- Renewable energy
- Improve ventilation
- Medium disturbance
- Payback time: 10 - 25 years
<table>
<thead>
<tr>
<th>Insulation techniques</th>
<th>Indoor climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Cavity wall insulation</td>
<td></td>
</tr>
<tr>
<td>- Crawl space insulation</td>
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<tr>
<td>- Internal insulation pitched roof</td>
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</tr>
<tr>
<td>- External insulation flat roof</td>
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<tr>
<td>- Insulating dormers</td>
<td></td>
</tr>
<tr>
<td>- HR+++ glazing</td>
<td></td>
</tr>
<tr>
<td>- Frames with thermal break</td>
<td></td>
</tr>
</tbody>
</table>
EPC ≤ 0.4 strategy (B)

Thermal transmittance

U-value [W/(m²*K)]

- Outer wall
- Ground floor 1
- Ground floor 2
- Pitched roof
- Flat roof
- Dormer wall
- Dormer roof
- Doors
- Glazing
- Frames

Current Strategy A Strategy B
EPC ≤ 0,4 strategy

Insulation techniques
- Cavity wall insulation
- Crawl space insulation
- Internal insulation pitched roof
- External insulation flat roof
- Insulating dormers
- HR+++ glazing
- Frames with thermal break

Indoor climate
- HR combi boiler & solar collectors
- PV-panels
- New and extra ventilation grills
- LED lighting
EPC ≤ 0,4 strategy (B)

Results row house

<table>
<thead>
<tr>
<th>Annual electricity consumption [kWh/year]</th>
<th>EPC = 0,37</th>
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</thead>
<tbody>
<tr>
<td>Current</td>
<td>Strategy A</td>
</tr>
<tr>
<td>-3%</td>
<td>-48%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual gas consumption [m³/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
</tr>
<tr>
<td>-56%</td>
</tr>
</tbody>
</table>
EPC $\leq 0.4$ strategy (B)

Visualisation

Current

Strategy B

Invest: €23,000,-
Payback time: 15 years
Net Zero Energy Building strategy (C)

Boundary conditions

- NZEB
- Gas-free
- Renewable energy
- Improve ventilation
- Extreme electricity reduction
- Electric cooking
- Payback time: 25+ years
NZEB strategy (C)

**Insulation techniques**
- Cavity wall + external insulation
- Crawl space insulation
- External insulation pitched roof
- External insulation flat roof
- New dormers
- HR+++ glazing
- Frames with thermal break

**Indoor climate**

**Appliances**
NZEB strategy (C)

Thermal transmittance

U-value [W/(m²*K)]

- Outer wall
- Ground floor 1
- Ground floor 2
- Pitched roof
- Flat roof
- Dormer wall
- Dormer roof
- Doors
- Glazing
- Frames

- Current
- Strategy A
- Strategy B
- Strategy C
NZEB strategy (C)

Insulation techniques
- Cavity wall + external insulation
- Crawl space insulation
- External insulation pitched roof
- External insulation flat roof
- New dormers
- HR+++ glazing
- Frames with thermal break

Indoor climate
- Air heat pump & solar collectors
- Electric combi boiler
- PV-panels
- New and extra ventilation grills
- LED lighting

Appliances
## NZEB strategy (C)

### Insulation techniques
- Cavity wall + external insulation
- Crawl space insulation
- External insulation pitched roof
- External insulation flat roof
- New dormers
- HR+++ glazing
- Frames with thermal break

### Indoor climate
- Air heat pump & solar collectors
- Electric combi boiler
- PV-panels
- New and extra ventilation grills
- LED lighting

### Appliances
- Induction cooking
- New appliances A++/+++
NZEB strategy (C)

Results row house

Annual electricity consumption [m³/year]

Current  Strategy A  Strategy B  Strategy C

-3%  -48%  -39%

Annual gas consumption [m³/year]

Current  Strategy A  Strategy B  Strategy C

-56%  -84%  -100%

EPC = 0.15
NZEB strategy (C)

Visualisation

Current

Strategy C

Invest: €40,000,-
Payback time: 24 years
Comparison

Basic insulation (A)
Invest: €9.500,-
12 years

EPC ≤ 0,4 (B)
Invest: €23.000,-
15 years

NZEB (C)
Invest: €40.000,-
24 years
Content
Introduction
Methodology
Analysis row house
Refurbishment strategies
Other building types
  Free-standing house
  Semi-detached house
Technical application
Conclusions
Free-standing house

Situation
Free-standing house

Floorplans

Level 1

Level 2
Free-standing house

Facades
Free-standing house: strategy A

Insulation techniques
- Cavity wall insulation
- Crawl space insulation
- Internal insulation pitched roof
- HR++ glazing
- Frames with thermal break

Indoor climate
- HR combi boiler
- New and extra ventilation grills
- LED lighting
Free-standing house: strategy B

Insulation techniques
- Cavity wall insulation
- Crawl space insulation
- Internal insulation pitched roof
- HR+++ glazing
- Frames with thermal break

Indoor climate
- HR combi boiler & solar collectors
- PV-panels
- New and extra ventilation grills
- LED lighting
Free-standing house: strategy C

Insulation techniques

- Cavity wall + external insulation
- Crawl space insulation
- External insulation pitched roof
- HR+++ glazing
- Frames with thermal break

Indoor climate

- Air heat pump & solar collectors
- Electric combi boiler
- PV-panels
- New and extra ventilation grills
- LED lighting

Appliances

- Induction cooking
- New appliances A++/+++
Free-standing house

Results

Annual electricity consumption [kWh/year]

Annual gas consumption [m³/year]
Free-standing house

Basic insulation (A)
Invest: €25,000,-
15 years

EPC ≤ 0,4 (B)
Invest: €38,000,-
13 years

NZEB (C)
Invest: €69,000,-
17 years
Semi-detached house

Situation
Semi-detached house

Floorplans
Semi-detached house

Facades
Semi-detached house

Installations
- Hot air heating
- Stand-alone boiler

Natural ventilation
Semi-detached house: strategy A

Insulation techniques
- Cavity wall insulation
- Crawl space insulation
- Internal insulation pitched roof
- External insulation flat roof
- Insulating dormers
- HR++ glazing
- Frames with thermal break

Indoor climate
- Installations < 15 years
- New ventilation grills
- LED lighting
Semi-detached house: strategy B

Insulation techniques
- Cavity wall insulation
- Crawl space insulation
- Internal insulation pitched roof
- External insulation flat roof
- Insulating dormers
- HR+++ glazing
- Frames with thermal break

Indoor climate
- HR combi boiler & solar collectors
- PV panels
- New and extra ventilation grills
- LED lighting
Semi-detached house: strategy C

**Insulation techniques**
- Cavity wall + external insulation
- Crawl space insulation
- External insulation pitched roof
- External insulation flat roof
- New dormer
- HR+++ glazing
- Frames with thermal break

**Indoor climate**
- Air heat pump & solar collectors
- Electric combi boiler
- PV panels
- New grills
- LED lighting

**Appliances**
- Induction cooking
- New appliances A++/+++
Semi-detached house

Insulation techniques
- Complete internal insulation
- HR+++ glazing
- New frames with thermal break

Indoor climate
- LT floor heating
- Air heat pump
- Electric combi boiler
- Mechanical ventilation
- LED lighting

Appliances
- Induction cooking
- New appliances A++/+++
Content

Introduction
Methodology
Analysis row house
Refurbishment strategies
Other building types
Technical application
Conclusions
Technical application

Detail 1: current situation

- Masonry 100 mm
- Air gap 50 mm
- Masonry 120 mm
- Plywood underlayment 20 mm
- Beam 180 x 90 mm
- Cast-in-situ concrete foundation
Technical application

Detail 1: strategy A
Technical application

Detail 1: strategy B

- Vapor resistant barrier
- Water and vapor resistant layer
- Fixing batten 20 mm
- Crawl space ventilation pipe
- Cellulose insulation 50 mm
- Glass wool insulation 200 mm
- Fixing batten 20 mm
Technical application

Detail 1: strategy C

- Masonry strips 20 mm
- Reinforcement layer and adhesive mortar
- Insulation 80 mm $u < 0.035$ W/(m*K)
- Adhesive mortar
- Cellulose insulation 50 mm
- Crawl space ventilation pipe
- Vapor resistant barrier
- Water and vapor resistant layer
- Fixing batten 20 mm
- Glass wool insulation 200 mm
- Fixing batten 20 mm
Technical application

Detail 4: strategy A

- Clear glazing 3 mm
- Argon 13 mm
- Clear glazing low E 3 mm

- Glass wool insulation 130 mm
- Water and vapor resistant layer
- Gypsum board ceiling 10 mm
Technical application

Detail 4: strategy B

- Glass wool insulation 120 mm
- Water and vapor resistant layer
- Gypsum board ceiling 10 mm

- Glass wool insulation
- Water and vapor resistant layer

- Clear glazing low E 6 mm
- Argon 16 mm
- Clear glazing low E 6 mm

- Composite frame
  $u < 1.4 \text{ W/(m}^2\text{K)}$
Technical application

Detail 4: strategy C

- Clear glazing low E 6 mm
- Argon 16 mm
- Clear glazing low E 6 mm
- Argon 16 mm
- Clear glazing low E 6 mm

- Composite frame
  $u < 1.4 \text{ W/(m}^2\text{K)}$

- Gutter

- Gutter fascia
  - Fascia
  - Glass wool insulation 200 mm
  - Original side rafter
  - Water and vapor resistant layer
  - Original hanger

- Soffit board
  - Clear glazing low E 6 mm
  - Argon 16 mm
  - Clear glazing low E 6 mm
  - Argon 16 mm
  - Clear glazing low E 6 mm

- Clay tiles
- Wooden battens
- Water resistant, vapor open layer
- Glass wool insulation 190 mm
- Water and vapor resistant layer
- Plywood sheathing 20 mm
Technical application

Facades: strategy C

North face

South face
Content
Introduction
Methodology
Analysis row house
Refurbishment strategies
Other building types
Technical application
Conclusions
Conclusions

Which strategies are possible to improve energy consumption in different levels for multiple building types built between 1960-1974?

- Basic insulation strategy (A)
- EPC ≤ 0,4 strategy (B)
- NZEB strategy (C)

Unique situations
Conclusions

Advise

- Society
- Home-owner