RENOVATION FOR DIFFERENT ENERGY SYSTEMS

Prefabrcicated renovation approach for post-war walk-up apartments that is applicable to different energy systems

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Dr. Marcin Dąbrowski
RESEARCH FRAMEWORK
GLOBAL ENERGY RELATED CO2 EMISSIONS - 2015

- Buildings: 28%
- Building construction: 11%
- Other: 24%
- Other industry: 22%
- Transport: 13%

Adapted from (UN Environment and International Energy Agency, 2017)
INTRODUCTION

RESIDENTIAL BUILDING STOCK EU

- Energy and CO2 emission targets of 2050
- Reduction needed up to 90%
- New buildings only add 1%
- Remaining 99% is already built

Reprinted from (Hiveminer, n.d.)
INTRODUCTION

POST-WAR WALK-UP APARTMENTS
(Naoorlogse portiekwoningen)

- Post-war walk-up is 8% of total building stock in the Netherlands
- 70% of which is social housing
- In 2020 all rental dwellings with energy label B

Reprinted from (Delft University of Technology, n.d.)
ENERGY SYSTEMS

- Reuse sources
A.- District heating
B.- Aquifer
C.- Heat pump with outdoor air
D.- Heat pump with PVT panels
RESEARCH QUESTION

‘What prefabricated renovation approach for post-war walk-up apartments is applicable to accommodate energy saving measures, depending on different energy systems?’
METHODOLOGY

INTRO

Introduction of research and graduation plan

PHASE 1: INVENTORY

Walk-up apartments
Prefabricated renovation approaches
Energy systems

Categorized energy systems

PHASE 2: CONTEXT

Construction type
Building services
Lay-out
Energy demand

Existing building

PHASE 3: SIMULATION

Existing building
Concept A-D
±6 Different parameters
Building services

Simulation

PHASE 4: DESIGN

Prefabricated renovation approaches
Walk-up apartments
Energy systems

Conclusion
Recommendaion
Evaluation
Design criteria
Categorized energy systems

INTRO

PHASE 1: INVENTORY

PHASE 2: CONTEXT

PHASE 3: SIMULATION

PHASE 4: DESIGN

CONCLUSION
METHODOLOGY

INTRO

PHASE 1: INVENTORY

PHASE 2: CONTEXT

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PHASE 4: DESIGN

EXISTING BUILDING

SIMULATION

DESIGN

Fixed Variables

Construction type

Building services

Lay-out

Energy demand

Walk-up apartments

Prefabricated renovation approaches

Energy systems

Concept A-D

±6 Different parameters

Building services

Existing building

Simulation

Design criteria

Design

Variables

Energy system

Categorized energy systems

Prefabricated renovation approaches

Walk-up apartments

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METHODOLOGY

PHASE 1: INVENTORY

PHASE 2: CONTEXT

PHASE 3: SIMULATION

PHASE 4: DESIGN

CONCLUSION

Existing building
Construction type
Building services
Lay-out
Energy demand

Simulation
Existing building
Concept A-D
±6 Different parameters
Building services

Design criteria

Fixed
Variable

Design

Template design
Energy system incl. building services

Conclusions
Recommendation
Evaluation
METHODOLOGY

INTRODUCTION

PHASE 1: INVENTORY

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Existing building

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Energy system incl. building services

Conclusions

Recommendation

Evaluation
PHASE 2: CONTEXT
SOENDALAAN
VLAARDINGEN

- Building constructed in 1952
- 12 apartments
- Three stories high
- Central staircase, characteristic for walk-up apartment building
CASE-STUDY

SOENDALAAN VLAARDINGEN

- Unoccupied attic
- Symmetric facade lay-out
- Balconies are cold connected
- Kitchen and bathroom located at balcony side

Reprinted from (Climate-KIC, n.d.)
CONSTRUCTION

- Prefabricated concrete elements

- Not possible to remove parts of facade

- Simplex - Aircavity - Masonry
PHASE 3 : SIMULATION
## ENERGY SYSTEM

<table>
<thead>
<tr>
<th>COLLECTIVE SYSTEMS</th>
<th>HIGH TEMPERATURE</th>
<th>LOW TEMPERATURE</th>
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<tbody>
<tr>
<td>A</td>
<td>$&gt;70^\circ C$</td>
<td>$=20^\circ C$</td>
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<tr>
<td>D</td>
<td>PVT</td>
<td></td>
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<tr>
<td>INDIVIDUAL SYSTEMS</td>
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</table>
CONCEPT A
DISTRICT HEATING
(Stadsverwarming)
CONCEPT A
HIGH TEMPERATURE THERMAL GRID

PV

Heat exchanger

>70°C

>90°C

70°C
ENERGY SYSTEM

CONCEPT B
AQUIFER

≈20°C

WINTER

SUMMER
CONCEPT B
LOW TEMPERATURE THERMAL GRID

≈20°C

≈20°C
≈10°C
CONCEPT C - D
HEAT PUMP

PVT

External heat source

Heat pump
CONCEPT C
OUTDOOR AIR

ENERGY SYSTEM

Heat pump A/W

Outdoor air

PV

Outdoor air
CONCEPT D
PVT PANELS

ENERGY SYSTEM
Post-war walk-up apartments at Soendalaan in Vlaardingen

Simulation

Concept A
Concept B
Concept C
Concept D

PHASE 3: SIMULATION

Low impact
CO2 regulated mechanical exhaust
Rc-values U-value
Heat recovery system
Rc-values U-value

High impact

RESULTS

Primary energy consumption
Final energy consumption
Energy demand

CONCLUSION

Conclusion
Low impact
BENG 2-3
High impact
BENG 1-2-3
### EAST FACADE

<table>
<thead>
<tr>
<th>Openings</th>
<th>Facade openings [m²]</th>
<th>Glazing [m²]</th>
<th>Window frames [m²]</th>
<th>Pieces [#]</th>
<th>All facade openings [m²]</th>
<th>All glazing [m²]</th>
<th>All window frames [m²]</th>
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</thead>
<tbody>
<tr>
<td>Window 1</td>
<td>2.0</td>
<td>1.7</td>
<td>0.3</td>
<td>2</td>
<td>4.0</td>
<td>3.4</td>
<td>0.6</td>
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<tr>
<td>Window 2</td>
<td>2.0</td>
<td>1.5</td>
<td>0.5</td>
<td>4</td>
<td>8.0</td>
<td>6.0</td>
<td>2.0</td>
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<td><strong>TOTAL OPENINGS AREA [m²]</strong></td>
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## INPUT MEASURES

### OVERVIEW

**Measures in Uniec**

#### Concept A

**External heat supply >70°C**

<table>
<thead>
<tr>
<th>Building envelope</th>
<th>A. Low</th>
<th>A. High</th>
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</thead>
<tbody>
<tr>
<td>Rc-value Floor</td>
<td>2.6</td>
<td>3.7</td>
</tr>
<tr>
<td>Rc-value Facade</td>
<td>2.1</td>
<td>4.6</td>
</tr>
<tr>
<td>Rc-value Roof</td>
<td>6.1</td>
<td>6.1</td>
</tr>
<tr>
<td>Rc-value internal wall</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>U-value glazing</td>
<td>1.2</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Heating systems**

<table>
<thead>
<tr>
<th>External heat supply</th>
<th>City grid Amsterdam Zuid-Oost - primary grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery temperature</td>
<td>&gt;50°C</td>
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</table>

**Ventilation**

<table>
<thead>
<tr>
<th>System</th>
<th>Inlet: Natural Exhaust: Mechanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Itho Daalderop CO2 Optima NGG</td>
</tr>
</tbody>
</table>

**PV panels**

<table>
<thead>
<tr>
<th>Peak power</th>
<th>180 Wp/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFpv</td>
<td>Z=1.00 N=0.70</td>
</tr>
<tr>
<td>Number/orientation</td>
<td>150m² 29°</td>
</tr>
</tbody>
</table>

#### Concept B

**External heat supply >20°C**

<table>
<thead>
<tr>
<th>Building envelope</th>
<th>B. Low</th>
<th>B. High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rc-value Floor</td>
<td>2.6</td>
<td>3.7</td>
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<td>0.7</td>
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**Heating systems**

<table>
<thead>
<tr>
<th>System</th>
<th>Combi-heat pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Groundwater</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product</th>
<th>Itho Daalderop WPU 25 5G + buffertank WPV150</th>
</tr>
</thead>
<tbody>
<tr>
<td>COp heating</td>
<td>4.85 5.70</td>
</tr>
<tr>
<td>COp DHW</td>
<td>3.45 3.70</td>
</tr>
<tr>
<td>COp additional heating</td>
<td>1.00 1.00</td>
</tr>
<tr>
<td>Supply temperature</td>
<td>50°C ≤ θsup ≤ 55°C 35°C ≤ θsup ≤ 40°C</td>
</tr>
<tr>
<td>Delivery temperature</td>
<td>&gt;50°C ≤ 50°C</td>
</tr>
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**Ventilation**

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<td>Concept A</td>
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<td>A. Low</td>
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<td></td>
</tr>
<tr>
<td>Source</td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>Itho Daalderop HP-S 55 + buffertank SVV 200l</td>
</tr>
<tr>
<td>COp heating</td>
<td>3,80</td>
</tr>
<tr>
<td>COp DHW</td>
<td>1,75</td>
</tr>
<tr>
<td>COp additional heating</td>
<td>1,00</td>
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<tr>
<td>Supply temperature</td>
<td>50˚ &lt; (\theta_{\text{sup}}) ≤ 55˚</td>
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</tbody>
</table>
# RESULTS

## Final energy consumption all concepts

<table>
<thead>
<tr>
<th>A. Low</th>
<th>A. High</th>
<th>B. Low</th>
<th>B. High</th>
<th>C. Low</th>
<th>C. High</th>
<th>D. Low</th>
<th>D. High</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.123</td>
<td>2.079</td>
<td>3.181</td>
<td>2.752</td>
<td>4.016</td>
<td>3.418</td>
<td>3.110</td>
<td>2.743</td>
</tr>
</tbody>
</table>

**User related electricity [kWh]**
- A. Low: 1.506
- A. High: 1.506
- B. Low: 1.506
- B. High: 1.506
- C. Low: 1.506
- C. High: 1.506
- D. Low: 1.506
- D. High: 1.506

**Building related electricity [kWh]**
- A. Low: 617
- A. High: 572
- B. Low: 1.675
- B. High: 1.245
- C. Low: 2.510
- C. High: 1.912
- D. Low: 1.604
- D. High: 1.237

**External heat supply [kWh]** (converted from MJ)
- A. Low: 2.685
- A. High: 1.759
- B. Low: 0
- B. High: 0
- C. Low: 0
- C. High: 0
- D. Low: 0
- D. High: 0

**Produced electricity [kWh]**
- A. Low: 3.798
- A. High: 3.798
- B. Low: 3.798
- B. High: 3.798
- C. Low: 3.798
- C. High: 3.798
- D. Low: 3.541
- D. High: 3.541
RESULTS

Final energy consumption all concepts

<table>
<thead>
<tr>
<th></th>
<th>A. Low</th>
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-70°C  -20°C  PVT

Final energy year / apartment [kWh]
RESULTS

Final energy consumption all concepts

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<thead>
<tr>
<th>Final energy/year/apartment [kWh]</th>
<th>A. Low</th>
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-70°C
+20°C
PVT
RESULTS

Final energy consumption all concepts

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<th>D. Low</th>
<th>D. High</th>
</tr>
</thead>
<tbody>
<tr>
<td>User related electricity [kWh]</td>
<td>1.506</td>
<td>1.506</td>
<td>1.506</td>
<td>1.506</td>
<td>1.506</td>
<td>1.506</td>
<td>1.506</td>
<td>1.506</td>
</tr>
<tr>
<td>Building related electricity [kWh]</td>
<td>617</td>
<td>572</td>
<td>1.675</td>
<td>1.245</td>
<td>2.510</td>
<td>1.912</td>
<td>1.604</td>
<td>1.237</td>
</tr>
<tr>
<td>External heat supply [kWh] (converted from MJ)</td>
<td>2.685</td>
<td>1.759</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
# RESULTS

![Graph showing final energy consumption for all concepts](image)

### Final energy consumption all concepts

<table>
<thead>
<tr>
<th>A. Low</th>
<th>A. High</th>
<th>B. Low</th>
<th>B. High</th>
<th>C. Low</th>
<th>C. High</th>
<th>D. Low</th>
<th>D. High</th>
</tr>
</thead>
<tbody>
<tr>
<td>User related electricity [kWh]</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
## RESULTS

### Final energy consumption all concepts

![Graph showing final energy consumption for different concepts and temperatures.]

<table>
<thead>
<tr>
<th>Concept</th>
<th>User related electricity [kWh]</th>
<th>Building related electricity [kWh]</th>
<th>External heat supply [kWh] (converted from MJ)</th>
<th>Produced electricity [kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Low</td>
<td>1.506</td>
<td>617</td>
<td>2.685</td>
<td>3.798</td>
</tr>
<tr>
<td>A. High</td>
<td>1.506</td>
<td>572</td>
<td>1.759</td>
<td>3.798</td>
</tr>
<tr>
<td>B. Low</td>
<td>1.506</td>
<td>1.675</td>
<td>0</td>
<td>2.792</td>
</tr>
<tr>
<td>B. High</td>
<td>1.506</td>
<td>1.245</td>
<td>0</td>
<td>3.798</td>
</tr>
<tr>
<td>C. Low</td>
<td>1.506</td>
<td>2.510</td>
<td>1.912</td>
<td>3.798</td>
</tr>
<tr>
<td>C. High</td>
<td>1.506</td>
<td>1.912</td>
<td>1.604</td>
<td>3.798</td>
</tr>
<tr>
<td>D. Low</td>
<td>1.506</td>
<td>1.237</td>
<td>1.237</td>
<td>3.798</td>
</tr>
<tr>
<td>D. High</td>
<td>1.506</td>
<td>1.237</td>
<td>1.237</td>
<td>3.541</td>
</tr>
</tbody>
</table>

### User-related electricity [kWh] and Build-in energy [kWh]
- User-related electricity: 1.506 kWh for all concepts.
- Build-in energy: 617 kWh for A. Low, 572 kWh for A. High, 1.675 kWh for B. Low, 1.245 kWh for B. High, 2.510 kWh for C. Low, 1.912 kWh for C. High, 1.604 kWh for D. Low, 1.237 kWh for D. High.

### External heat supply [kWh] (converted from MJ)
- External heat supply: 2.685 MJ for A. Low, 1.759 MJ for A. High, 0 MJ for B. Low, 0 MJ for B. High, 0 MJ for C. Low, 0 MJ for C. High, 0 MJ for D. Low, 0 MJ for D. High.

### Produced electricity [kWh]
- Produced electricity: 3.798 kWh for A. Low, 3.798 kWh for A. High, 3.798 kWh for B. Low, 3.798 kWh for B. High, 3.798 kWh for C. Low, 3.798 kWh for C. High, 3.541 kWh for D. Low, 3.541 kWh for D. High.

### Temperature Conditions
- **-70°C**
- **-20°C**
- **PVT**
## RESULTS

### Final energy consumption all concepts

<table>
<thead>
<tr>
<th></th>
<th>A. Low</th>
<th>A. High</th>
<th>B. Low</th>
<th>B. High</th>
<th>C. Low</th>
<th>C. High</th>
<th>D. Low</th>
<th>D. High</th>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

![Chart showing final energy consumption for different concepts]
DESIGN CRITERIA
BUILDING ENVELOPE

Façade

Cavity insulation
$R_c$-value = 2.1 m$^2$·K/W

Roof

Attic insulation
$R_c$-value = 3.4 m$^2$·K/W

Floor

Ground insulation
$R_c$-value = 4.0 m$^2$·K/W

LOW IMPACT
BUILDING ENVELOPE

Façade
Outside insulation
$R_c$-value = 3.4 m²·K/W

Façade openings
U-value = 0.93 W/m²·K

Roof
Outside insulation
$R_c$-value = 6.2 m²·K/W

Floor
Ground insulation
$R_c$-value = 5.6 m²·K/W

HIGH IMPACT
## Concept A: External heat supply >70°C

<table>
<thead>
<tr>
<th>Requirements estimation</th>
<th>Dimensions [mm] L x W x H</th>
<th>Weight [kg]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet – outlet city grid</td>
<td>588 x 258 x 493</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Electricity, air outlet</td>
<td>355 x 294 x 350</td>
<td>3,5</td>
<td></td>
</tr>
<tr>
<td>Electricity, air outlet, air inlet, condensation drain</td>
<td>597 x 290 x 916</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>990 x 35 x 1640</td>
<td>18,3</td>
<td></td>
</tr>
</tbody>
</table>

1. Sub-station EcoMechanic
2a. CO2 regulated Itho Daalderop Optima Flow system
2b. WTW Itho Daalderop HRU ECO 200 E
3. PV CSUN 255-60P 1 panel
## BUILDING SERVICES

<table>
<thead>
<tr>
<th>Concept B: External heat supply ≈20°C</th>
<th>Dimensions [mm] L x W x H</th>
<th>Weight [kg]</th>
<th>Requirements estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Sub-station</strong>&lt;br&gt;EcoMechanic</td>
<td>588 x 258 x 493</td>
<td>9</td>
<td>Inlet – outlet city grid</td>
</tr>
<tr>
<td><strong>2. Heat pump Itho Daalderop WPU 5G</strong>&lt;br&gt;2a. Heat pump only</td>
<td>600 x 600 x 830</td>
<td>85</td>
<td>Electricity, water inlet, water outlet</td>
</tr>
<tr>
<td><strong>2b. Optional: Buffer tank Itho Daalderop I-SVV 200l</strong></td>
<td>1486,5 x Ø595</td>
<td>56 (empty)</td>
<td>Electricity, water inlet, CV supply, CV outlet</td>
</tr>
<tr>
<td><strong>2c. In combination with buffer tank 200l</strong></td>
<td>600 x 600 x 2103</td>
<td></td>
<td>Electricity, water inlet, CV supply, CV outlet</td>
</tr>
<tr>
<td><strong>3. Ventilation</strong>&lt;br&gt;3a. CO2 regulated Itho Daalderop Optima Flow system</td>
<td>355 x 294 x 350</td>
<td>3,5</td>
<td>Electricity, air outlet</td>
</tr>
<tr>
<td><strong>3b. WTW Itho Daalderop HRU ECO 200 E</strong></td>
<td>597 x 290 x 916</td>
<td>12</td>
<td>Electricity, air outlet, air inlet, condensation drain</td>
</tr>
<tr>
<td><strong>3. PV CSUN 255-60P</strong>&lt;br&gt;1 panel</td>
<td>990 x 35 x 1640</td>
<td>18,3</td>
<td>Electricity</td>
</tr>
</tbody>
</table>
## BUILDING SERVICES

### Concept C: Outdoor air

<table>
<thead>
<tr>
<th></th>
<th>Dimensions [mm]</th>
<th>Weight [kg]</th>
<th>Requirements estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heat pump Itho Daalderop HP-s 55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a. Indoor unit</td>
<td>L x W x H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>505 x 288 x 790</td>
<td>45</td>
<td>Electricity, outdoor air, CV supply, CV outlet</td>
</tr>
<tr>
<td>1b. Outdoor unit</td>
<td>L x W x H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>934 x 354 x 753</td>
<td>62.5</td>
<td>Electricity, outdoor air, air outlet</td>
</tr>
<tr>
<td>2. Buffer tank Itho Daalderop I-SVV 200l</td>
<td>L x W x H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1486,5 x Ø595</td>
<td>56 (empty)</td>
<td>Electricity, water inlet, CV supply, CV outlet</td>
</tr>
<tr>
<td>3. Ventilation</td>
<td>L x W x H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3a. CO2 regulated Itho Daalderop Optima Flow system</td>
<td></td>
<td>3.5</td>
<td>Electricity, air outlet</td>
</tr>
<tr>
<td>3b. WTW Itho Daalderop HRU ECO 200 E</td>
<td>L x W x H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>597 x 290 x 916</td>
<td>12</td>
<td>Electricity, air outlet, air inlet, condensation drain</td>
</tr>
<tr>
<td>4. PV CSUN 255-60P</td>
<td>L x W x H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>990 x 35 x 1640</td>
<td>18.3</td>
<td>Electricity</td>
</tr>
</tbody>
</table>
# BUILDING SERVICES

## Concept D: PVT

<table>
<thead>
<tr>
<th>Component</th>
<th>Dimensions [mm]</th>
<th>Weight [kg]</th>
<th>Requirements estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Heat pump</strong>&lt;br&gt;NIBE-F1255-6&lt;br&gt;In combination with buffer tank 180l</td>
<td>600 x 620 x 1800</td>
<td>240</td>
<td>Electricity, water inlet, water outlet, CV supply, CV outlet</td>
</tr>
<tr>
<td><strong>2. Ventilation</strong>&lt;br&gt;2a. CO2 regulated Itho Daalderop Optima Flow system</td>
<td>355 x 294 x 350</td>
<td>3.5</td>
<td>Electricity, air outlet</td>
</tr>
<tr>
<td>2b. WTW Itho Daalderop HRU ECO 200 E</td>
<td>597 x 290 x 916</td>
<td>12</td>
<td>Electricity, air outlet, air inlet, condensation drain</td>
</tr>
<tr>
<td><strong>3. PVT Triple Solar M2 285 165</strong></td>
<td>1 panel&lt;br&gt;995 x 65 x 1668</td>
<td>27</td>
<td>Electricity, water inlet, water outlet</td>
</tr>
</tbody>
</table>

![Diagram of Concept D: PVT](image)
PHASE 4: DESIGN
CONCEPT B

≈20°C

Substation

Buffer tank

Heat pump
CONCEPT A

>70°C

Substation
LOW IMPACT
LOW IMPACT

FLOOR PLAN

apartment 1

apartment 2

apartment 3

apartment 4
LOW IMPACT

SUBSTRUCTURE
1. Fill crawl space with insulation

2. Fill cavity with insulation

3. Add insulation on attic

4. Add PV/PVT panels

5. Place window frame
LOW IMPACT

1. Pour extra foundation beam

2. Fill crawl space with insulation

3. Fill cavity with insulation

4. Add insulation on attic

6. Install building services unit
LOW IMPACT

FLOOR PLAN
HIGH IMPACT
FULLY PREFABRICATED ELEMENTS
HIGH IMPACT

0. Total prefabricated element

1. Insulation layer 20mm

2. Wooden framework

3. Ventilation duct

4. Soft insulation 140mm

5. Wooden plate 12mm

6. Window frames

7. Brick strips cladding
1. Pour extra foundation beam

2. Fill crawl space with insulation

3. Remove roof cladding

4. Remove window frames

5. Drill holes for ventilation ducts

6. Add insulation panels

7. Add roof cladding

8. Add PV/PVT panels

9. Place prefabricated facade elements

HIGH IMPACT
DIFFERENCES IN DETAIL
CONCLUSION
‘What prefabricated renovation approach for post-war walk-up apartments is applicable to accommodate energy saving measures, depending on different energy systems?’
CONCLUSION

TEMPLATE DESIGN

ENERGY SYSTEMS

A

B

C

D

PVT

Low impact

High impact

>70°C

≈20°C

A

B

C

D

PVT
DECISION-MAKING
DECISION-MAKING

HOUSING CORPORATION OR HOMEOWNER ASSOCIATION

Choose goal
- Low level of intervention
- Cost efficient
- Most sustainable

District heating in the neighborhood? Or plans?
- Yes
- No

Refurbishment for more than 10 years?
- Yes
- No

Excess heat and need for heating and cooling? Or plans?
- Yes
- No

Possible to make a network?
- Yes
- No

Energy system
- A. Connect to district heating
- B. ATEs
- C. Heat pump outdoor air
- D. Heat pump PVT panels

Roof suitable for PVT panels? (orientation South)
- Yes
- No

Consider
- Building characteristics
- Budget
- Big maintenance projects coming up
- Energy Performance Compensation
- Added value
- Improve esthetical quality

Legend
- Main goal
- Question building owner
- Context
- Answer Options
- Design

Building envelope
- Low impact
- High impact
DECISION-MAKING

HOUSING CORPORATION OR HOMEOWNER ASSOCIATION

Choose goal

Low level of intervention

Cost efficient

Most sustainable

District heating in the neighborhood? Or plans?

Yes

No

Refurbishment for more than 10 years?

Yes

No

Excess heat and need for heating and cooling? Or plans?

Yes

No

Possible to make a network?

Yes

No

Roof suitable for PVT panels? (orientation South)

Yes

No

Energy system

A. Connect to district heating

B. ATES

C. Heat pump outdoor air

D. Heat pump PVT panels

Legend

Main goal

Question building owner

Context

Answer Options

Design

Building envelope

Low impact

High impact

Consider

Building characteristics

Budget

Big maintenance projects coming up

Energy Performance Compensation

Added value

Improve esthetical quality
‘INDISCHE BUURT’ VLAARDINGEN

- 195 walk-up apartments
- 129 East-West orientation
- 66 North-South orientation
SCENARIO 1

Choose goal

Low level of intervention

Cost efficient

Most sustainable

District heating in the neighborhood? Or plans?

No

Refurbishment for more than 10 years?

Excess heat and need for heating and cooling? Or plans?

Yes

Possible to make a network?

Yes

Energy system

A. Connect to district heating

No

Roof suitable for PVT panels? (orientation South)

No

Yes

B. ATES

C. Heat pump outdoor air

D. Heat pump PVT panels

Consider

Building characteristics
Budget
Big maintenance projects coming up
Energy Performance Compensation
Added value
Improve esthetical quality

Building envelope

Low impact

High impact

Legend

Main goal Question building owner Context Answer Options Design
DECISION-MAKING

SCENARIO 2

Choose goal

- Low level of intervention
- Cost efficient
- Most sustainable

Excess heat and need for heating and cooling? Or plans?

- Yes
  - Refurbishment for more than 10 years?
    - Yes
      - Energy system
        - A. Connect to district heating
    - No
      - Roof suitable for PVT panels? (orientation South)
        - Yes
          - Design
        - No
          - Heat pump outdoor air
            - Consider
              - Building characteristics
              - Budget
              - Big maintenance projects coming up
              - Energy Performance Compensation
              - Added value
              - Improve esthetical quality
            - Heat pump PVT panels
              - Design

- No
  - District heating in the neighborhood? Or plans?
    - Yes
      - Possible to make a network?
        - Yes
          - Design
        - No
          - High impact
    - No
      - Low impact

Legend

- Main goal
- Question building owner
- Context
- Answer Options
- Design
SCENARIO 3: NORTH-SOUTH ORIENTATION

1. Choose goal
   - Low level of intervention
   - Cost efficient
   - Most sustainable

2. District heating in the neighborhood? Or plans?
   - Yes
   - No
   - Refurbishment for more than 10 years?
     - Yes
     - No
     - Excess heat and need for heating and cooling? Or plans?
       - Yes
       - No
       - Possible to make a network?
         - Yes
         - No
       - Roof suitable for PVT panels? (orientation South)
         - Yes
         - No
         - Heat pump outdoor air
         - Heat pump PVT panels

3. Energy system
   - A. Connect to district heating
   - B. ATES
   - C. Heat pump outdoor air
   - D. Heat pump PVT panels

4. Building envelope
   - Consider
     - Building characteristics
     - Budget
     - Big maintenance projects coming up
     - Energy Performance Compensation
     - Added value
     - Improve esthetical quality

Legend:
- Main goal
- Question building owner
- Context
- Answer Options
- Design

Low impact

High impact
COMPARISON WITH EXISTING SITUATION

**SCENARIO 1**
- Low level of intervention
- Greater than 70°C
- 2,9 times less energy

**SCENARIO 2**
- Cost efficient
- Greater than 20°C
- 5,0 times less energy

**SCENARIO 3**
- Most sustainable
- PVT
- 4,4 times less energy
COMPARISON WITH EXISTING SITUATION

SCENARIO 1
- Low level of intervention
- \( >70^\circ C \)
- \( 2.9 \times \) Less Energy

SCENARIO 2
- Cost efficient
- \( \approx 20^\circ C \)
- \( 5.0 \times \) Less Energy

SCENARIO 3
- Most sustainable
- PVT
- \( 4.4 \times \) Less energy
DECISION-MAKING

COMPARISON WITH EXISTING SITUATION

**SCENARIO 1**
- Low level of intervention
- Temperature: >70°C
- 2.9 TIMES Less Energy

**SCENARIO 2**
- Cost efficient
- Temperature: ~20°C
- 5.0 TIMES Less Energy

**SCENARIO 3**
- Most sustainable
- PVT
- 4.4 TIMES Less Energy
RECOMMENDATIONS
RECOMMENDATIONS

COST ASSESSMENT OF DIFFERENT ENERGY CONCEPTS

UPSCALING TO DIFFERENT BUILDING TYPES

CIRCULARITY OF THE APPROACH
THANK YOU!