“Towards Industrialized Zero Energy Retrofit”
by a prefabricated FacadeModule
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GLOBAL PROBLEM

- CO2 Emissions Rising
- Buildings Biggest CO2 Consumers
- EU-GOAL 20-20-2020
- Building stock growth with 1%
- Focus on existing Building stock

--> ZERO ENERGY REFURBISHMENT
AMBITION ENERGY NEUTRAL - ‘0’ OP DE METER || PORTIEK homes from the PERIODE 1945-1970 || INDUSTRIALISED APPROACH
AMBITION ENERGY NEUTRAL - ‘0’ OP DE METER || PORTIEK homes from the PERIODE 1945-1970 || INDUSTRIALISED APPROACH

INNOVATIVE APPROACH:
OPTIMIZE THE PREFABRICATION & ASSEMBLY OF A INTEGRATED BUILDING ENVELOPE THAT CONTAINS PARTS OF THE BUILDING SERVICES, SUCH AS VENTILATION DUCTS.
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OPTIMIZE THE PREFABRICATION & ASSEMBLY OF A INTEGRATED BUILDING ENVELOPE THAT CONTAINS PARTS OF THE BUILDING SERVICES, SUCH AS VENTILATION DUCTS.

WHY?

- Minimize inconvenience to residents
- Efficiency on the building site
- Mass- implementation of concept
SCOPE

HEATING

1. GAS

VENTILATION

1. INSIDE SYSTEM

Don’t meets 2ndskin requirements

2. HR - GAS & ELECTRIC

CENTRAAL VENTILATION

Current 2ndSkin Design

3. ALL ELECTRIC

DECENTRAL VENTILATION

Next/future Design
Needs investigation

Ahmed Assad - PREFABRICATED FACADE MODULE -
SCOPE

1. GAS
   - INSIDE SYSTEM
   - Don’t meets 2ndskin requirements

2. HR - GAS & ELECTRIC
   - CENTRAAL VENTILATION
   - Current 2ndSkin Design

3. ALL ELECTRIC
   - DECENTRAL VENTILATION
   - Next/future Design Needs investigation

Ahmed Assad - PREFABRICATED FACADE MODULE -
- **HIGHER EPC --> 0 OR - 0.2**
  ENERGIE PRESENTATIE COEFFICIENT

- **HIGHER EPV**
  ENERGIE PRESENTATIE VEROEIDING

- **HIGHEST COP OF 5.3 (KIWA)**
  COEFFICIENT OF PERFORMANCE

- **LOWER CO₂ --> NO GAS**

- **Fits in Dutch climate**

- **SAFETY --> GAS = 30TH death**
**HYPOTHESIS**

“OPTIMIZE PREFABRICATION & ASSEMBLY TECHNIQUE OF INTEGRATED FACADE”

**TOPIC/PERSPECTIVE**

INTEGRATION OF DECENTRAL VENTILATION / VENTILATION DUCTS

**P1 PRESENTATION**

“How can all electric component get integrated in a prefabricated facade module, to upgrade the building envelop for Dutch post-war apartments to make them zero energy (EPC “0”)?”

**P2 PRESENTATION**

“How can ventilation system get integrated in a facade system?”

**P3/4 PRESENTATION**

“What facade and building services combination can be designed?”
ALL ELECTRIC EQUIPMENT ARE NOT DESIGN TO INTEGRATE IN THE FACADE. THEREFORE, THE CURRENT SOLUTIONS SPREAD THESE COMPONENTS ON THE ROOF AND STAIRCASE. THIS LEADS TO CUSTOMIZED PREFABRICATION AND ASSEMBLY TECHNIQUES.
**PROBLEM STATEMENT**

ALL ELECTRIC EQUIPMENT ARE NOT DESIGN TO INTEGRATE IN THE FACADE. THEREFORE, THE CURRENT SOLUTIONS SPREAD THESE COMPONENTS ON THE ROOF AND STAIRCASE. THIS LEADS TO CUSTOMIZED PREFABRICATION AND ASSEMBLY TECHNIQUES.
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METHOD

DESIGN STRATEGY

DESIGN DEVELOPMENT

FINAL DESIGN

EVALUATION-CONCLUSION-RECOMMENDATION

2ndSkin Project

Building typology

Facade/Installation requirements

Experience based NOM-Projects

Dutch Reference Projects

Supplair/Installation Expertise

EU-Projects Integrated Facades

INTERVIEWS

DESIGN REQUIREMENTS ACCORDING TO FACADE

DESIGN REQUIREMENTS ACCORDING TO SERVICES
**ASSEMBLY TECHNIQUE**

**LARGE SCALE FACADE ELEMENTS**
- Higher transport costs
- Fast assemblage méthode, if full prefabricated. Included window, new systems etc.
- Mostly in unhabited state

**SMALL SCALE FACADE ELEMENTS**
- Low transport cost
- Fast assemblage méthode, if full prefabricated. Included window, new systems etc.
- Mostly in occupied state
**ASSEMBLY STRATEGY**

**CONNECT**
- Difficult integration of technology
- Main difficulty are the windows, Mostly separate parts
- Because of duct integration

**INTEGRATE**
- Flexibility in design
- Easier to integrate technology
- Traditional retrofit process
• SPECIAL CRANE

• EXCEPTIONAL TRANSPORT OR MOUNTED TOGETHER ON BUILDING SITE --> SEMI PREFABRICATED
INTEGRATE

- TRADITIONAL ASSEMBLAGE WITH NEW TECHNOLOGY
- FLEXIBLE IMPLEMENTATION

Annex 51, 2013
CONCLUSION

VENTILATION SYSTEM
- CENTRAAL
- DECENTRAL
- DUCTS
- D-UNITS

HEATING SYSTEM
- HR KETEL
- ALL ELECTRIC
- BOILER
- HEAT PUMP

PV PANELS
- ROOF
- FACADE
- CLADDING

SMALL ELEMENTS
- WINDOW-PARAPET

LARGE ELEMENTS
- ISOLATION LAYER

Growing Green project, Delft
DHS roof unit
Small-sized prefabricated window elements provide **flexibility** and **multifunctionality** with a (as far as possible) traditional retrofitting process at the same time (Fraunhofer IRP, 2013).
NON-TRADITIONAL BUILDING METHODE

BUILDING TYPOLOGIES

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● Near the existing waterpipes-->plug’n play

● Kitchen is near the installation room

● Kitchen is not a living spaces -> Less Disturbancing

● Maintaince from outside is possible
• Need new water infra

• Less disturbance

• Maintaince is possible throw staircase

• One central zone--> Design freedom
DESIGN STRATEGY

Design

2ndSkin F-Assemblage
DESIGN STRATEGY

1. Design
2. 2ndSkin
3. FLEX
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WHAT TO INTEGRATE??

DESIGN DEVELOPMENT

HEAT PUMP

BOILER

PLATE EXCHANGER

Heat pump

plate heat exchanger

CPU

Boiler

Hot water output

Cold water input

LTV convector

Heat pump

Cold water input

Hot water output

LTV convector

Heat pump

Cold water input

Hot water output

LTV convector

Heat pump

Cold water input

Hot water output

LTV convector

Heat pump

Cold water input

Hot water output

LTV convector

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Heat pump

Cold water input

Hot water output

LTV convector

Heat pump

Cold water input

Hot water output

LTV convector
**CHALLENGE HEAT PUMP**

**AIR**
- 2100 M³/h
- In-out air separate

**Vibration**
- Vibration of compressor
- Design solution
- Supplair solution

**Sound**
- Sound = 35 dB according to Artikel 3.19
  5 dB too much
- Isolation on the compressor
CHALLENGE HEAT PUMP

- 2100 M³/h
- in-out air
- Design solution
- Isolation on the
- Sound = 35 dB according to Artikel 3.19

AIR  Vibration  Sound

- vibration of compressor
- Rubber feet supplair so-

>100mm
CHALLENGE BOILER

- CHANGE GEOMETRY LEADS TO:
  - BAD STRATIFICATION (Temperature)
  - STIFFNESS OF THE VESSEL
CHALLENGE BOILER

Heat pump → CV-Water → Shower

ΔT = lower

Heat pump → CV-Water → Shower

fresh water
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FINAL DESIGN

- Aluminium-frame
- Composite box 800x1750x450;
  Vacuum insulation rc=5.0
- SIPS - wood panel

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Ahmed Assad - PREFABRICATED FACADE MODULE -

**Final Design**

- Composite plate: 3 mm
- Vacuum insulation: 50 mm
- Aluminium frame
- Wooden Beam
- Rubber feet
- Floor anchor

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**Design evaluation:**

- Design requirements, according to 2ndSkin
- Interviews
  - Supplier --> Mitsubishi
  - Constructor --> BAM (nieuwegein)
  - Architect --> Bart spee architecten
### Design requirements, according 2ndSkin

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Description</th>
<th>Grade +/-</th>
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<tbody>
<tr>
<td>Structural adjustments</td>
<td>adding structural elements? changing structural elements Level of demolition.</td>
<td>+</td>
</tr>
<tr>
<td>Facade assemblage</td>
<td>Component or element facade? Assemblage technique complex? Prefabricated level?</td>
<td>+</td>
</tr>
<tr>
<td>Residents</td>
<td>Level of disturbance?</td>
<td>+/-</td>
</tr>
<tr>
<td>Integrate installation</td>
<td>level of prefabricate installation level of assemblage technique</td>
<td>+</td>
</tr>
<tr>
<td>Scaleability</td>
<td>level of customized design or Industriased solution? Fit other typologies?</td>
<td>+</td>
</tr>
</tbody>
</table>

#### Design requirements

- **Structural adjustments**
  - NO demolition existing facade intact
  - Full prefabricated incl. windows, installations
  - Temporary house.
  - Complex facade to many components

- **Facade assemblage**
  - Full prefabricated incl. windows, installations
  - Semi prefabricated without windows different components
  - Temporary house.
  - No integration with facade

- **Residents**
  - Remain home, little or no disturbance
  - Staying home, but experience lot of problems
  - No integration with facade

- **Integration of Installations**
  - Installation integrated in facade elements
  - Installation duct, pipes or other subcomponents

- **Scalability**
  - Suitable for different types
  - Only for certain types
  - Only for one type

#### Evaluation

- No structural adjus, Some typology --> remove parapet (brick)
- Traditionel assemblage methode
- Flexibel --> component or element
- Install waterpipes/elektra from inside
- Maintenaince from inside --> staircase?
- Full prefabricated but, Transport --> box
- High Scaleability --> according the dimensions of the box
• Interviews

ir. Linda van Leeuwen (Bam/stroomversnelling)

• Integrating heat pump in facade is potential ---> Roof is not always best option- slope/pv-panels
• Maintenance from outside ---> Expensive -> Staircase is very good option
• Integrate boiler in facade ---> Interesting topic --> needs investigation according installation time with current methode
• Install from inside ---> Bam research indicate work in kitchen is not disturbing

ir. Hugo Jansen (Mitsubishi/Growing green/stroomversnelling)

• Integrating heat pump in facade ---> Refurbishment & new building, wanted product
• Maintenance from outside
• Integrating boiler in facade
  airflow--> testing/monitoring
  --> Needs to be easier designed
  --> Needs investigation on costs and time

Architect --> Not yet interviewed
**RECOMMENDATION/ FURTHER RESEARCH**

• **ALL ELECTRIC SYSTEM**

- Testing/monitor heatpump --> Mitsubishi Lab
- Production technique Boiler, Stiffness --> Tema Techniek
- Boiler facade, staircase or inside --> Cost study -> Markt related
- Install from inside 2hr --> Inhabitants study

• Facade Module

- Transport full or semi --> Efficiency study --> design study
- Composite frame --> Design study --> constructive
- Box development --> P5 --> Material,Mounting, form
- Esthetically --> P5 --> Design option parapet
CONCLUSIONS

“How can all electric equipements get integrated in a prefabricated facade module, to upgrade the building envelope for Dutch post-war apartments to make them Zero energy?”

**How can we integrate 200L boiler, without changing the façade geometry?**
- Use “open source“ all electric system, with plate heat exchanger
- Design the boiler without
- The window/parapet are suitable area’s in post war apartements

**Is the heat pump suitable to integrate in the façade?**
- According --> airflow of the HP vs Facade, still unknow. Reference project showed it is possible
- According to weight and size the heat pump is not a obstacle,
- Maintenance is once year, low cost reachable from outside.
- Leads to a industriliased design, fits in refurbishment
“Towards Industrialized Zero Energy Retrofit”
by a prefabricated FacadeModule

THANK YOU!

1ste Dr. ir. T. Konstantinou
2de Dr. ir. T. Klein
3de Dr. ir. P. van den Engel
ext Dr. ir. Olindo Caso,