# AN INDUSTRIALIZED APPROACH FOR ZERO ENERGY REFURBISHMENT

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# INTRODUCTION

## BACKGROUND: INNOVATION TOWARDS SYSTEM INTEGRATION IN FACADES

The building environment is focussing on (near) zero energy principles of design, manufacturing and assemble buildings. An increasing number of energy efficient buildings in Europa is showing the growing interest in (near) zero energy buildings (sources). This development is not a trend, but a answer/ reaction on the 20-20-20 policy of the European commission. This policy is often called 20-20-20, because they set a target to reduce the greenhouse gas emissions by at least 20% , increasing the use of renewable energy by 20% and improve the energy efficiency by 20% compared to the correspoding levels in 1990[19].

On long term the European council set a target to reduce the carbonization emission by 80-95% by 2050[19]. The building sector is the biggest energy consumer, because of that the European commission mentioned the building sector as key sector in achieving the 2050 target. In response the building industry aimed at (near) zero energy buildings.
A (near) zero energy building is a building that produces on average as much energy as it consumes.  It draws power from the power grid and supplies it back to the grid. Over a year this needs to be in balance to reach a zero energy consumption.

However, a large portion of the building stock was built before the introduction of the zero energy  principle. In most European cities, the existed building stock is characterized by outdated buildings envelopes with limited insulation and ventilation systems that have reached their end of lives[13]. Therefore, refurbishment based on zero energy principle become an important task for Europe to achieve the target in 2050.

The quality of building envelops play an important role in energy consumption of heating, cooling, lighting and ventilation systems. Being the direct layer between the internal and external environments, building envelope is defined as the interface of energy loses.
To make an (near) Zero energy building we have to reduce energy consumption, increase the efficients use of installations and rely on sustainable energy. In this context zero energy retrofit of building envelope can be implemented with the improvement of thermal physical properties (passive system) of the envelope and the addition of active system elements which can be integrated into the envelope, such as HVAC systems

Ventilation systems are one of the energy hungry elements in buildings. Typically they account for 30% or more of the total energy consumption. So in order to reduce energy in buildings, this systems are been optimized to be energy efficient. An effective ventilation system is essential in Net Zero Energy buildings

A separate research direction aims at improving comfort and reducing living costs for the occupants by not relocating them during the refurbishment. This is possible by putting all systems in a second envelope called 2ndSkin.
The main goal of this project is to do all the necessary refurbishment from the outside. This thesis is part of the 2ndSkin research.
Several ongoing researchs and projects trying to minimize disturbance to the occupants along with reducing the construction time, costs and energy consumption by using methods such as prefabrication of building envelope and building installation components[12]. in these projects prefabricated building envelope system are attached to the existing envelope and prefabricated HVAC system are placed in the backyard. However, In the Netherlands there are several projects that implemented these methods, but only for single family houses.

Another important type of housing in the Netherlands are the post war apartments block (1951-1970). There are approximately 800.000 of these dwellings and are 1/3 of the existing building stock[17]. The majority of these dwellings have an energy label D or lower[16].
One of the major challenge is that post-war apartment has almost no space in the interior for new equipments that are necessary for a Zero Energy apartment, such as the ventilation system. Besides that, there will be too much disturbance to the occupants if the ventilation system is installed from the inside. That is where the facade introduces itself as an alternative.

The integration of ventilation system in a prefabricated facade module, is a serious need for zero energy refurbishing of the Dutch post war apartments blocks. Not only there is almost no space inside them, but also Zero Energy houses are isolated at least with Rc-value of 6,5 (roof 8,0). That means temperature losses through infiltration and transmission will be less.
As a consecuance of good insulation, heat produced by people and machines will be kept inside the building therefore, we will heat less. However, More ventilation is expected in zero energy buildings. Combining all reasons mentioned above over comfort refurbishment for zero energy buildings, we expect the integration of ventilation system in a prefabricated facade module have several advantages in terms of quality, costs, performance , safety for the construction workers and inhabitants, speed of retrofitting, efficient use of materials and of course less disturbance for the neighborhood and users[10]

## PROBLEM STATEMENT

Dutch post war apartment blocks are in need of a new 2ndSkin building envelope to achieve Zero Energy balance. However this requires space for new building service installation, this type of building are not design and build to adapt new equipment, such as the controlled ventilation systems.

## RESEARCH QUESTION

- How can ventilation system get integrated in a prefabricated facade module, to upgrade the building envelope for Dutch post-war apartments to make them Zero energy?

### SUB QUESTIONS

- How can the requirements and wishes be required and how can these values be translated to a concept and design?

1. *What is the current state of art in integrated prefabricated facade modules in Europe for refurbishment of residential post- war buildings?*
2. *Which material is used for high isolated (6,5 rc) prefabricated facade panels?*
3. *What are the EPC parameters that effect the dimensions of building envelope?*
4. *What are the recommendation for the ventilation systems regarding regulations of sound, fire and ventilation amount?*
5. *What type of ventilation systems are more suitable for integration in facade?*
6. *What are the possible position in the building envelop to integrate ventilation systems or components?*

## GENERAL OBJECTIVE

The objective of this integrated design is that it has to make a better use of energy neutral retrofit strategies, by integrating ventilation technologies in the building envelope, that can be manufactured in an industrialized process, to be suitable for mass-implementation in the Netherlands.

### FINAL PRODUCTS

The final product shall be an integrated prefabricated facade design which contains all the equipment that are necessary to provide ventilation. Other building service components are not excluded, however there is focus on ventilation systems.

### HYPOTHESES

I except that the integration of ventialtion systems in the facade will enable creation through industrilaized process, which makes it suitable for mass-implementation

### BOUNDRY CONDITIONS

- *The design has to be focused on the facade elements that would be used for zero energy refurbishment.*
- *The material used, will be first focused on wood frame for the facade elements and later to composite*
- *The product can be easily adjust for different type of Dutch post-war apartments that are built in 1951 till 1970*
- *The function of ventilation system is the main focus, however other potential building services are also allowed to be integrated.*
- *The requirements of the 2ndSkin research group are also requirement for this product.*

# METHODOLOGY

The research methodologies proposed for the graduation research are based on two books ‘Methodologie van technische-wetenschappelijk onderzoek’ and ‘Ways to stduy and research urban, architectural and technical design (Christiaans, Fraaij, Graaf, & Hendriks, 2004; T.de Jong & Voordt, 2002). The techniques that are used for this research are based on the book ‘Product development: The theory and its applicability in practice (Afshari, A., & Li, J.-T. 2012).

Each research question the goals, expected outcome and methodolgy are defined as follow. Each question is related to a phase in the structure of the thesis (see diagram 2):

## 1.

### Goal

- Exploring prefabricate facade module
- Exploring integrated components
- Exploring assemblage methods
- Exploring materials
- Comparing different retrofit strategies

### Expected outcomes

- Description of integrated prefabricated facade module
- Creating framework for literature assessment

### Methods, data and sources

- Annex 51: Retrofit strategy for prefabricated facades (handbook, 2012)
- Advanced Skin conference book/ articles
- Energiesprong platform
- Stroomversnelling platform

## 2.

### Goal

- Different material overview
- Mapping roduction techniques that are suitable to adapt ducts, pipes and othor building services components
- Selection facade element

### Expected outcomes

- Benefits and possibilties of each facade type, based on physical requirements and flexibelity in the production technique
- Current available companies that are willing to innovate in there production technique.

### Methods, data and sources

- Literature study by handbooks, articles and journals on manufacturing prefabricated facade elements
- Markt research by interviewing, collecting data and visite companies

## 3.

### Goal

- Understandig of Zero Energy calculation
- Mapping the parameters effecting the dimensions of the facade element

### Expected outcomes

- Creating framework of parameters that effect the dimensions of the facade
- Find potential components for integrating in the facade, such as pv panels or sunshading.

### Methods, data and sources

- Literature of EPC calculations
- Toolkit slecetiontool made by the rijksoverheid to understand the different factors

## 4.

### Goal

- Mapping the protentials of different ventialtion principels
- Develop framework of pros and cons of ventialtion system, based on the requirements

### Expected outcomes

- Problems needed to be solved in an integrated facade design
- Possibilties that are usually not used, but have potentials for further development (hybrid systems/ natural ventilation etcetc)

### Methods, data and sources

- Collect data from ventialtion companies, such as Brink, Stork, Bergschehoek etcetc
- Study the regulations(bouwbesluit)

## 5.

### Goal

- Turning information from sub questions 3,4 into design strategies for facade type selected from sub question 1,2
- Selection systems basd on the criterias set by the framework (outcomes)

### Expected outcomes

- Develop framework that shows possible design strategies with pros and cons of each varaiant
- Choose one potential design for futher development

### Methods, data and sources

- Usng data, information and othor sources from sub question 1,2,3
- Discuss the design strategies with Rollecate and othor proffesionals

## 6.

### Goal

- Designing and testing the chosen design from sub question 5
- Analyse the design by mockup

### Expected outcomes

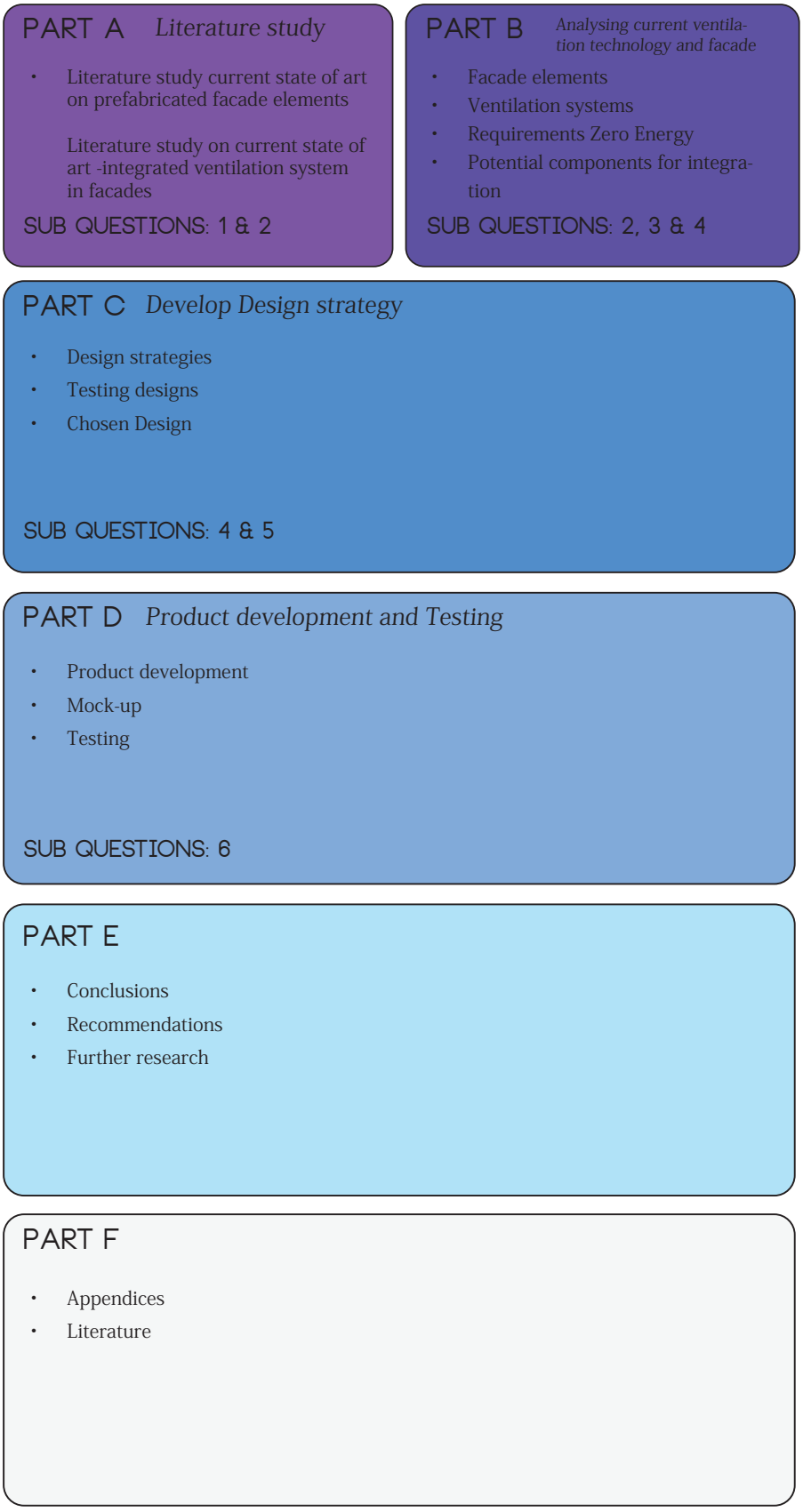
- Feed back on product from proffesionals
- Prototype/mockup
- Further potentials and optimizations
- Sell the product

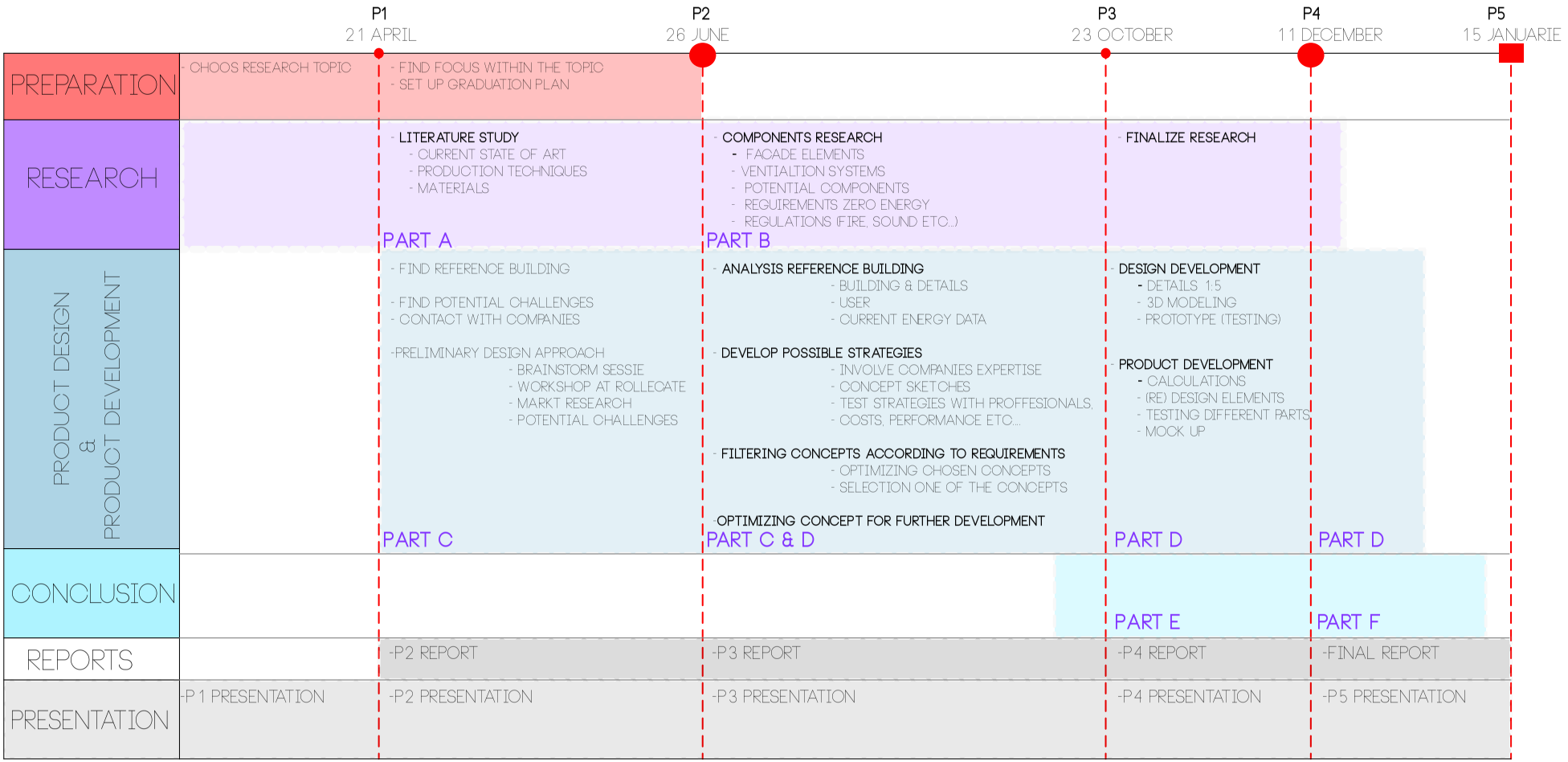
### Methods, data and sources

- Detailling, 3d modelling and 3D printing small elements
- Feedback sessies with Rollecate proffesionals
- Rollecate will provide materials and machine to build a prototype

## THESIS CONTENT DIAGRAM

The thesis content diagram shows how the structure will be build up. The structure is also linked to the time planning. The time planning shows the action pionts that need to be done, in order to develop a product, but also to answer the sub questions and finallly the main question.




P1
21 APRIL
P2
26 JUNE
P3
23 OCTOBER
P4
11 DECEMBER
P5
15 JANUARIE
PREPARATION
- CHOOS RESEARCH TOPIC
- FIND FOCUS WITHIN THE TOPIC
- SET UP GRADUATION PLAN
RESEARCH
- LITERATURE STUDY
- CURRENT STATE OF ART
- PRODUCTION TECHNIQUES
- MATERIALS
PART A
- COMPONENTS RESEARCH
- FACADE ELEMENTS
- VENTIALTION SYSTEMS
- POTENTIAL COMPONENTS
- REGUIREMENTS ZERO ENERGY
- REGULATIONS (FIRE, SOUND ETC..)
PART B
- FINALIZE RESEARCH
PRODUCT DESIGN & PRODUCT DEVELOPMENT
- FIND REFERENCE BUILDING
- FIND POTENTIAL CHALLENGES
- CONTACT WITH COMPANIES
-PRELIMINARY DESIGN APPROACH
- BRAINSTORM SESSIE
- WORKSHOP AT ROLLECATE
- MARKT RESEARCH
- POTENTIAL CHALLENGES
PART C
- ANALYSIS REFERENCE BUILDING
- BUILDING & DETAILS
- USER
- CURRENT ENERGY DATA
- DEVELOP POSSIBLE STRATEGIES
- INVOLVE COMPANIES EXPERTISE
- CONCEPT SKETCHES
- TEST STRATEGIES WITH PROFFESIONALS,
- COSTS, PERFORMANCE ETC....
- FILTERING CONCEPTS ACCORDING TO REQUIREMENTS
- OPTIMIZING CHOSEN CONCEPTS
- SELECTION ONE OF THE CONCEPTS
-OPTIMIZING CONCEPT FOR FURTHER DEVELOPMENT
PART C & D
- DESIGN DEVELOPMENT
- DETAILS 1:5
- 3D MODELING
- PROTOTYPE (TESTING)
- PRODUCT DEVELOPMENT
- CALCULATIONS
- (RE) DESIGN ELEMENTS
- TESTING DIFFERENT PARTS
- MOCK UP
PART D
PART D
CONCLUSION
PART E
PART F
REPORTS
-P2 REPORT
-P3 REPORT
-P4 REPORT
-FINAL REPORT
PRESENTATION
-P1 PRESENTATION
-P2 PRESENTATION
-P3 PRESENTATION
-P4 PRESENTATION
-P5 PRESENTATION

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