NET-ZERO ENERGY REFURBISHMENT WITH CIRCULAR BUILDING MATERIALS AT THE TU DELFT

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Master Building Technology
The posed problem is both global and local.

There are worldwide problems that are partially caused by the Built Environment.

- **Worldwide problems, including:**
  - Global warming
  - Depletion of natural resources

- **Built Environment is a large contributor,**
  - because it consumes large amounts of energy and materials

- **Focus on refurbishment,**
  - because there are far more existing buildings than new builds

- **TU Delft is a good starting point,**
  - because the university own 62 buildings and aims to decrease the consumption
DECREASE THE CONSUMPTION OF ENERGY AND MATERIALS

- Decrease
  - Energy consumption
  - Material consumption

- Increase
  - Reuse
  - Disassembly
  - Flexibility

Source: Minsterie van Infrastructuur en Milieu. (2017). From a linear to a circular economy
The graduation project result in an energy neutral refurbishment of the Low Speed Lab and provides the TU Delft with a method to refurbish its building portfolio.
METHOD

TU Delft analysis
- Planned projects
- Buildings
- Ambitions

Building choice
- Interviews
- Consumption
- Architecture
- Occupancy

Building analysis
- Flexibility
- Simplification
- Life extension
- Partial demolition

Strategy

Design
- Energy
- Architecture
- Circularity

Proposal

Requirements
- Size
- Energy consumption
- Plans

Problems and assets
THE LOW SPEED LAB IS LOCATED AT THE PERIMETER OF THE CAMPUS

Overview of mid-section of the campus

Source: Google Earth
THE LOW SPEED LAB IS LOCATED AT THE PERIMETER OF THE CAMPUS

Overview of mid-section of the campus

Source: Google Earth
Location of the Low Speed Lab at the campus of TU Delft
THE BUILDING HOUSES A THREE-STOREY HIGH WIND TUNNEL

Key information on the chosen building

- Low Speed Low Velocity wind tunnel
  - Built in 1952. Addition in 1977

- Increase of users groups to nine
  - Morphology does not suit many users

- High energy consumption
  - Lack of thermal insulation
  - Many machines

- Area is being redeveloped
  - New parking garage
  - New park
1. **Comfort**
   - Too cold/warm
   - Lack of thermal insulation
   - Lack of daylight

2. **Morphology**
   - Defect routing
   - Dead end routes
   - Chaotic
   - No focus point
   - Many materials, volumes, colours and routes
1. **Structure**
   - Large open spaces
   - High floors

2. **Architecture**
   - Wind tunnel
   - Open spaces

3. **Climate**
   - High thermal mass
   - Deciduous trees
STRATEGY

1. **Simplify**
   1. to decrease the current chaos

2. **Decrease consumption and increase reuse**
   1. of both materials and energy

3. **Increase flexibility**
   1. to make a future-proof building that can accommodate changes (e.g. users, functions)

4. **Strengthen relationship with urban context**
0. CURRENT BUILDING

Current volume (14000 m³)
Demolition of (uninsulated) machine hall (1110 m³)
Demolition of (uninsulated) top floor (338 m³)
The new design consists of an add-on and a new facade.

Addition of 4.5 m wide volume (2740 m³)
Total (15302 m³)
THE FLEXIBILITY IS IMPROVED BY DIVIDING THE BUILDING IN FOUR
Timber frame with wood fibre insulation (300-400mm)

Floor insulation (top)

Insulated shutters

North

South
VENTILATION

- Mechanical ventilation with heat recovery
- Night ventilation
- Earth tubes
- 12 °C
- South
- North

Ph: wind tunnel
- 21000
- 18800
- 16550
- 14650
- 12380

Ground floor
- 2985
- 3965
- 4985

Top wind tunnel
- 6
- 5

TU Delft
Deciduous trees that block the sun in summer

Vertical closed loop heat pump

Floor heating/cooling
What technical (re)design solutions should be used in the refurbishment of a TU Delft building to achieve net-zero energy whilst taking circular use of building materials into consideration?
RESULT AND CONCLUSION

REFURBISHMENT METHOD

TU Delft analysis
- Planned projects
- Buildings
- Ambitions

Building choice
- Requirements
  - Yes
  - No
  - Energy consumption
  - Flex

Building analysis
- Interviews
- Consumption
- Architecture
- Occupancy

Strategy
- Flexibility
- Simplification
- Life extension
- Partial demolition

Design
- Energy
  - Architecture
  - Circularity

Proposal