Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences
Graduation Plan: Architectural Engineering + Technology

### Personal information

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### Studio

<table>
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<tr>
<th>Name / Theme</th>
<th>Architectural Engineering + Technology</th>
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<tr>
<td>Teachers / tutors</td>
<td>Andy van den Dobbelsteen &amp; Marc Ottelé</td>
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#### Argumentation of choice of the studio

It is one of the most sustainable tracks in the Architecture Faculty, as it automatically includes most of the classes to get the sustainable annotation. In addition I have a fascination for mechanisms which could reduce overall building consumption (water, gas, electricity), this studio provides the possibility to explore this interest.

### Graduation project

| Title of the graduation project | Designing a water filtering LWS for Utility buildings in the Netherlands |

### Goal

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<th>Location:</th>
<th>The Netherlands</th>
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#### The posed problem,

There is a lack of vegetation in cities for which outdoor Living Wall Systems could provide a solution. But Living Wall Systems existing today are not yet largely implemented as they are not cost-effective. Living Wall Systems could incorporate more functionality however, which might increase economic benefits, but this potential is still underdeveloped. On the other hand valuable water resources are wasted, as all wastewater streams are merged in the Netherlands. This is unfortunate from a sustainable perspective.

#### research questions and

How to design a Living Wall System that is able to filter and separate reusable wastewater streams exiting a utility building, while reducing the total water demand and increasing overall economic benefits?
design assignment in which these result.

1. Mock-up 1:1 which proofs the concept of vertical water filtering.
2. Cost-benefit analysis (indicative)
3. Design of the water filtering façade (exploded view, front view 1:20, side view 1:20, sections 1:20, details 1:5)
4. Visualization of the façade implemented in a utility building

**Process**

**Method description**

**Research Approach**

**Research Question**
How to design a Living Wall System that is able to filter and separate re usable wastewater streams exiting a utility building, while reducing the total water demand and increasing overall economic benefits?

**Context**

**Research**

- Water demand & availability
- Water reusability
- Constructed Wetlands
- LWS

**Design conditions**
Type of building - Reusable water volume - Water treatment method - LWS system - Circular materials

**Conceptualization**

**Design**

- Preliminary design
- Analysis of circular materials
- Reusable & Recyclable/Compostable
- Water filtering technique
- Proof of concept

**Final design**

- Proof of concept (water filtering technique)
- Visualization design implementation
- Cost-benefit analysis

**Result**

- Conclusion
- Recommendations
Data Collection
For this research different data collection methods are used:

Literature Study
For the research phase, desk research is done to obtain the majority of the information. Online databases are consulted (e.g. CBS and Milieubarometer) for quantitative data. To find qualitative data digital scientific search engines are used (e.g. ScienceDirect, Scopus and Google Scholar). In addition qualitative and quantitative data is searched by visiting websites from relevant companies in the field (e.g. water treatment, water filtering and Living Wall Systems, government). If information is unclear or unavailable relevant companies are consulted for extra information (e.g. VEWIN, Union of Water boards, KWR, CBS & Milieubarometer). Also in the TU Delft Library books on the topic were advised.

Case Study
For the chapter “Water Reusability” three case studies are examined to find out which water streams can be reused in the Netherlands and for what purposes. It gives an indication of what is already possible with the current techniques of constructed wetlands, thereby assuring certain streams can be reused without difficulty in the Netherlands.

Field Research
For three chapters field research is required. These chapters are “Constructed Wetlands”, “Living Wall Systems” and “Preliminary Design” (regarding plant selection & material selection). Experts are visited and interviewed to gain in-depth information as some information cannot be found online or in books. It is also used as means of getting answers to sub questions faster and to see the difference between literature and practice.

Design for Circularity as Method
According to Geldermans and Rosen Jacobson (2015, p. 15), circularity implies that a material or product should be:

- Of high quality (functional performance)
- Of sustainable origin (mining method, mining close to use, production method)
- Non-harmful (healthy for people and the environment)
- Recyclable and/or biodegradable.

The above mentioned conditions are the intrinsic properties of the material or product (Geldermans & Rosen Jacobson, 2015, p. 15). Beside this one can separate three relational properties, which indicate the relation between the products/materials. And affect the serviceability and reusability of the material/product.
According to Geldermans and Rosen Jacobson (2015, p. 15) these relational properties are:

- Dimensions (possibilities of customization)
- Connections (demountability & separatability)
- Performance time (lifespan)

From the literature a few deviations will be made in this report:

1. The quality of the materials is only considered in the design part. As it is assumed that for products on the market, the quality of the materials/products already fulfill the requirements needed for its function. For now the lifespan communicated by the supplier will be used as an indication of the products serviceability and thus overall material endurance and functional performance. In the design phase the material/product quality will be examined further, as the chosen quality depends among others on the dimensions, functional properties and styling of the final design.

2. The materials/products sustainable origin is omitted, although it is an important property, it would be a project in itself to identify materials of a sustainable origin. In the further developments this should be addressed.

3. The performance time (lifespan) discussed in this report will only be related to the product on elemental level, as this is often mentioned by the supplier as a certain guarantee of life expectancy. The lifespan on material level and therefore component level are dependent on different factors such as the exposure to different media in relation to the location and fatigue. Even within the Netherlands the environmental circumstances vary a lot. Therefore lifespan on material/component level could only be taken into account if a case study is used, but this does fall within the context of this report.

The information about materials properties (recyclable/compostable) is retrieved by using the tool CES EduPack (a database with i.a. material properties). In addition the Material Safety Data Sheet (MSDS) of the material is consulted in which, among others, health risks are described. Hereby the risk for the environment and on people’s health could be determined.

**Research by Design**

The concept for the water filtering technique will be developed by means of Research by Design. Tests will be made of different vertical constructed wetlands and the quality of the effluent will be evaluated. From these, new concepts of vertical water filtering principles are designed. The filter systems will be made in 1:1 scale, but the overall size of the models depends on the working principle explored, not on the preliminary design.
Literature and general practical preference

Report


Books


Reflection
Relevance

By finding methods to increase the amount of vertical green systems in cities automatically the amount of urban green rises. By this healthier living are created as green alleviates people’s stress (van den Berg, Maas, Verheij, & Groenewegen, 2010, p. 1203). And vegetation has more environmental and social benefits for both city and building, such as cooling (by evaporation) and the reduction of the heat island effect (Sheweka & Mohamed, 2012, p. 507 & 508).

In addition worldwide water supplies becoming more and more stressed, reusing water would only be one of the logical steps to reduce this stress by lowering overall water demand (Cisneros, 2014, p. 431). While rainwater cannot deliver a constant flow of water, wastewater can. This makes wastewater a reliable source for reuse. A water filtering façade can thereby be a solution to reduce the overall water consumption of a building in areas where there is no connection to the grid possible and where little space is available to apply a normal constructed wetland. However the water filtering façade in this report is designed for the Netherlands where plenty of water is available and water is cheap, but it could be extrapolated to countries where water is more scarce / expensive and . In the future it might be even possible to use the plants/biomass for other purposes as well.
Time planning

**Q2**
- P1: Week 1.10
  - Individual
  - Quantifying water flows
  - Water quality per flow
  - Case study analysis
  - How is water reused in NL
  - Visiting constructed wetland companies
  - Visiting horticulturist
  - Analyzing constructed wetlands
  - Plant selection
  - Visiting companies LWS
  - Analyzing LWS
  - Draft 1: Graduation report

**Q3**
- P2: Week 2.9
  - Individual Design & Research Module
  - Final prototype water filtering technique
  - Testing vertical water filtering concepts (proof of concept)
  - Determining boundary conditions
  - Conceptualization
  - Preliminary design (including material selection)

**Q4**
- P3: Week 3.8
  - Individual Research Project (Phase conclusion from P2)
  - Final design
  - Graduation plan P2

**Q5**
- P4: Week 4.4
  - Individual Design & Research Module
  - Final report
  - Draft 2: Graduation report