

# Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences



## Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners ([Examencommissie-BK@tudelft.nl](mailto:Examencommissie-BK@tudelft.nl)), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Koen Verbraeken
Student number	4839331

Studio		
Name / Theme	Reuse of existing structures	
Main mentor	Ir. A.C. Bergsma	Architectural Engineering & Technology, and Architectural Technology
Second mentor	Dr. A.J. (Andy) Jenkins	Architectural Engineering & Technology, and Environmental & Climate Design
Argumentation of choice of the studio	The student has a lifelong interest in agriculture and developed an interest in steel structures during his bachelor and master courses at TU Delft. The studio offers research on reusing greenhouse construction to repurpose it in urban agriculture modules. The studio thus combines two interests, each supported by a mentor.	

Graduation project	
Title of the graduation project	Hybrid Urban Vertical Farming
Goal	
Location:	Worldwide, case study from Illinois, USA
The posed problem,	<p>If existing agricultural practices were to feed the world by 2050 when there will be 10 billion people on Earth, they require an increase in farmland the size of Brazil – this is not available.</p> <p>Existing vertical farms can produce the required food demand on small areas, but they use too much energy to be a sustainable solution. Also, the investments costs are too high.</p> <p>Thus, this thesis researched how componentry of demolished greenhouses (steel structure, glass shell) can be reused to construct modules in which vertical farm systems can be used.</p> <p>This is a hybrid solution: using daylight as well to decrease the energy need of artificial lighting, using recycled materials to bring down investment costs.</p> <p>Challenge: to come close to the yield and quality control of vertical farms, with something as</p>

	varying as day-to-day natural light levels; <i>to save energy without harming quality to much.</i>
Research questions and	How can a high yield, circular and sustainable, economically feasible, expandable and stackable hybrid urban vertical farming module be constructed by reusing componentry from demolished greenhouses?
Design assignment in which these result.	<p><i>Main:</i> an example of a configuration of a few connected (if possible, some stacked) hybrid urban vertical farm modules, architecturally embedded in the urban infrastructure.</p> <p>That includes the module (construction; Bergsma) and farm system (urban agriculture; Jenkins). Of course, calculations will be made to proof that such a farm is structurally sound.</p> <p><i>Sub:</i> a reuse methodology; theoretical and designed like a guidebook of what to do when a greenhouse is demolished, and a hybrid urban vertical farm is to be built elsewhere close by.</p> <p><i>Sub:</i> an urban integration guidebook, which analysis which waste streams can be (re)used as resources, functions to cooperate with, and possible social interaction/education in the farm.</p> <p><i>Proof:</i> comparing calculations to material use, resource use, carbon footprint, etc. to determine whether a hybrid urban vertical farm is a viable sustainable source of food for 2050.</p> <p>All are built up in the thesis structure: reuse, system, module, urban integration, calculations.</p>

[This should be formulated in such a way that the graduation project can answer these questions. The definition of the problem has to be significant to a clearly defined area of research and design.]

## Process

### Method description

Scientific research and practical knowledge are combined in this thesis to ensure that the technology in the resulting hybrid urban vertical farm design is both scientifically proven and approved by people with tons of practical experience in agriculture, by having the design process tested against real-world practice at every step and incorporating and improving the feedback received.

Therefore, a partnership has been established with VB (design and project management of greenhouse construction, Naaldwijk, Netherlands). This collaboration provides access to a broad network of specialized horticultural companies in the Atrium Agri consortium, of which VB is a member, across the entire breadth of greenhouse construction.

T collaboration with VB includes a case study of a greenhouse in Chicago, Illinois, USA. VB managed that project and is able to supply order lists of all the steel, aluminum and glass used for construction. This case is used to establish a general reuse methodology. This thesis' hybrid urban vertical farm design will reuse parts available from the Chicago greenhouse.

The thesis is set up as a research by design project; up to P2, mainly literature review is done to define the problem and design boundaries, and a first design is sketched. After P2, design and specific research are carried out simultaneously to develop step by step an integrated module and farm system design, integrating recent research, improving existing vertical business systems.

Furthermore, the aim is obviously to make use of the knowledge and networks of the first and second mentors, Arie Bergsma and Andy Jenkins, respectively.

### Literature and general practical preference

- United Nations reports for the problem statement;
- The United States Department of Agriculture reports for the problem statement;
- Despommier's book on vertical farming and its benefits/challenges for the solution proposal;
- Atrium Agri consortium (VB network) for module design discussions;
- Artechno (vertical farm manufacturer) for farming system design discussions;
- VB geothermal department for urban integration design discussions;
- "*The embodied carbon emissions of lettuce production in vertical farming, greenhouse horticulture, and open-field farming in the Netherlands*", research by Andy Jenkins and others, to compare the carbon footprint of my design to existing farming practices and have predefined comparison limits;
- "*European recommendations for reuse of steel products in single-storey buildings*" for structural calculations with reused steel greenhouse structure elements;
- Various scientific research on reusability of materials, plant needs, and urban integration;
- Various manufacturer information on reusability of materials, plant needs, and urban integration.

### Reflection

- Q. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?
- A. The proposed hybrid urban vertical farm (*graduation topic*) aims to increase the circularity of the horticultural sector by reusing greenhouse componentry (*studio topic*), in order to do so structural verification of the construction is required and several surfaces and connections between those have to be designed (*master track BT*). The construction is embedded in the *urban* environment in a way that it *architecturally* fits in the existing infrastructure, possible by rearranging the configuration of several modules other (*MSc AUBS*).
- Q. What is the relevance of your graduation work in the larger social, professional and scientific framework?
- A. The proposed hybrid urban vertical farm aims to be a farming system that is about as sustainable as existing hydroponics, but with a higher yield per square meter of land area used by applying vertical farming principles. By optimizing daylight use, the goal is to minimize artificial lighting and thus minimize the farm's energy consumption. If this works, such a system is a sustainable solution to save the world from hunger by 2050 (social).

Even if the hybrid urban vertical farming system proves to be unsustainable after performing comparative calculations, the research is relevant for other designers of such systems to avoid making the same mistakes that ultimately make a design unsustainable, so in any scenario, this dissertation will help the scientific community to ultimately arrive at a viable sustainable farming system alternative (scientific).

*\* I do not understand what is meant with a professional framework, but I am sure I can answer the relevancy after my P2 presentation when the concept is explained.*