Design & Building Technology Report

Martijn Vos | 4289536 | 3 November 2020



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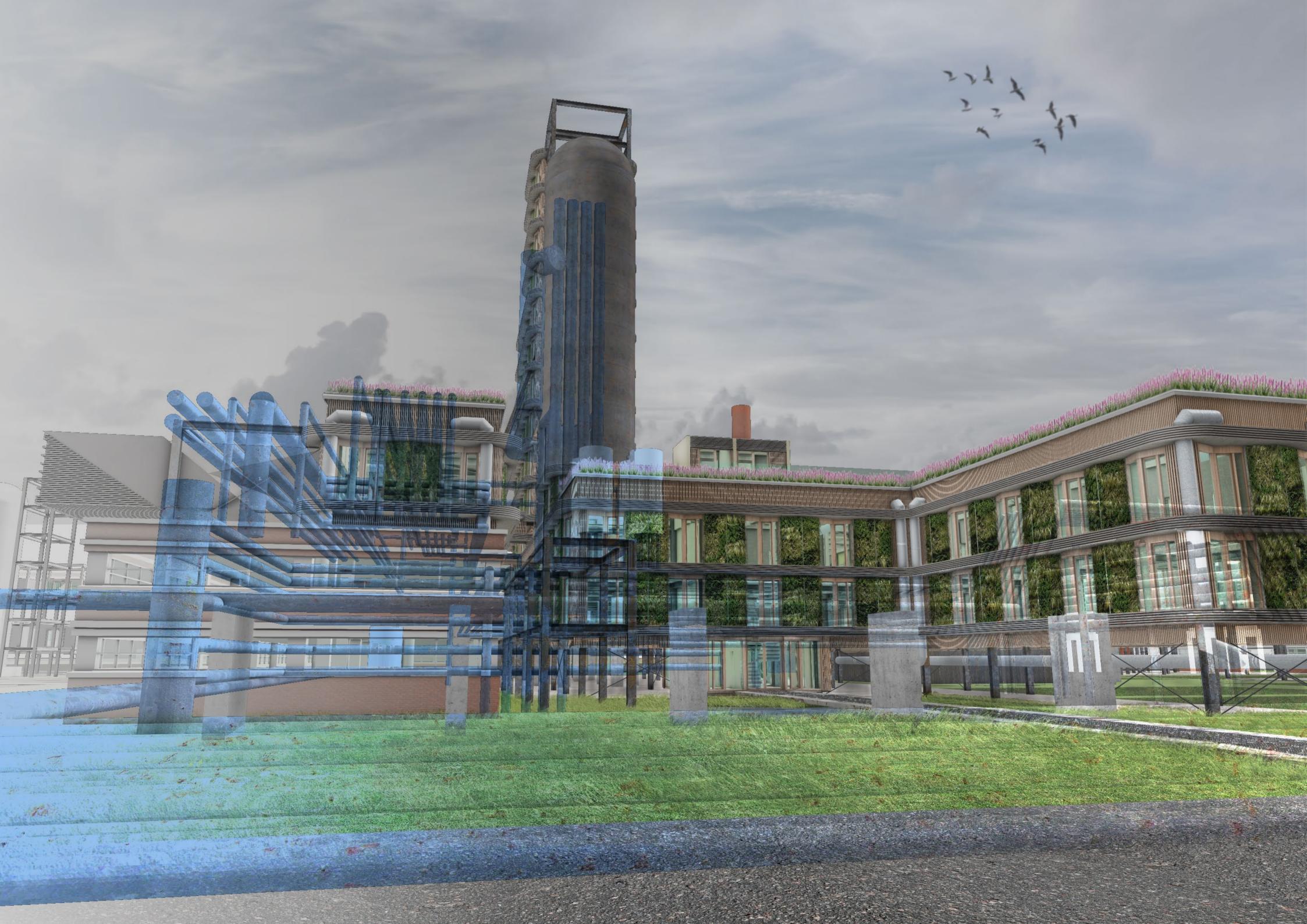
1. Introduction

The report that follows is a continuation of the research report of this thesis and shows how the research that was conducted during the first phase of the thesis is translated into a design. The research part of the thesis mainly dealt with the evolution of port-city interfaces and the oil and gas industry, and to some extent with soil pollution and phytoremediation. It also argued why the site of the project is chosen, which is a refinery in the city of Dunkerque. This document continues from the point of the introduction of the site. The report follows a structured explanation of all the aspect of the project starting with the large scale and going to the detailed scale.

The second chapter of the book deals with the cleanup of the site and the landscape design. It elaborates on the different phytotechnologies that are used to remediate and clean up the site. The third chapter continues from there and presents the program of the site, from the perspective of the users and buildings. The next chapter discusses the different flows on site that are created by the demolition of structures, the new building program and the phytotechnologies that are used on site. The last chapter before moving on to the explanation of the buildings contains the phasing of the project.

From the sixth chapter we continue with the buildings itself, where program and use of the buildings is described from a perspective of users. Chapter seven discusses the structural scheme of the building and chapter eight explains how this building structure can be clad with a modular building system, where there is also more elaboration about the materials that are used. The last chapter deals with the climate systems of the building that are implemented to create a comfortable working space for people and make sure the building program can function as it is intended. The references to literature in this report can be found at the end of the research report.

I hope you enjoy viewing and reading about this project!



2. Site Remediation

As described in the research report the main goal of the project is to remediate the pollutants on the site while providing new functions for the remaining structures in the meantime. The problem with the site in Dunkerque is the lack of financial incentives to clean up the site. Since phytoremediation of the site is a time consuming process, that will likely span several decades for this project, there needs to be an incentive to convince the owner that this site can be of use in the meantime, without it just being a long term, uncertain property investment. The remediation of the site of course also does not come for free. This is why the new site programs helps to finance the remediation process, while providing new functions for the city and its people.

As described by Kennen and Kirkwood (2015) there are several phytotechnologies that can be implemented to remediate soil, are and water. In this project all these will be used for several goals and functions, and relate to different aspects of the project. With the help of this book and some other literature, a soil and water remediation plan was made. Not all parts of the site are contaminated, as is shown in the map on the next page. However, also this space will function as productive space for the project, providing different types of remediation.

The largest part of the polluted soil (ca. 20 ha) will function as an extraction plot, where crops are planted to uptake the contamination from the soil, which is later harvested and used for different purposes. This organic matter provides the backbone for the project. This, in combination with the waste material from the demolition of the site functions as input materials for the construction of the buildings, energy generation and as resource for the building program.

The second largest implemented phytotechnology is based on water. There will be ca. 16 ha of surface flow wetland, that helps to remediate the polluted ground water from the site and the polluted water that flows from the buildings. This is situated in an area where there is not much soil contamination expected, due the fact that this is a former flood plain area and it didn't house any refinery buildings or silos.

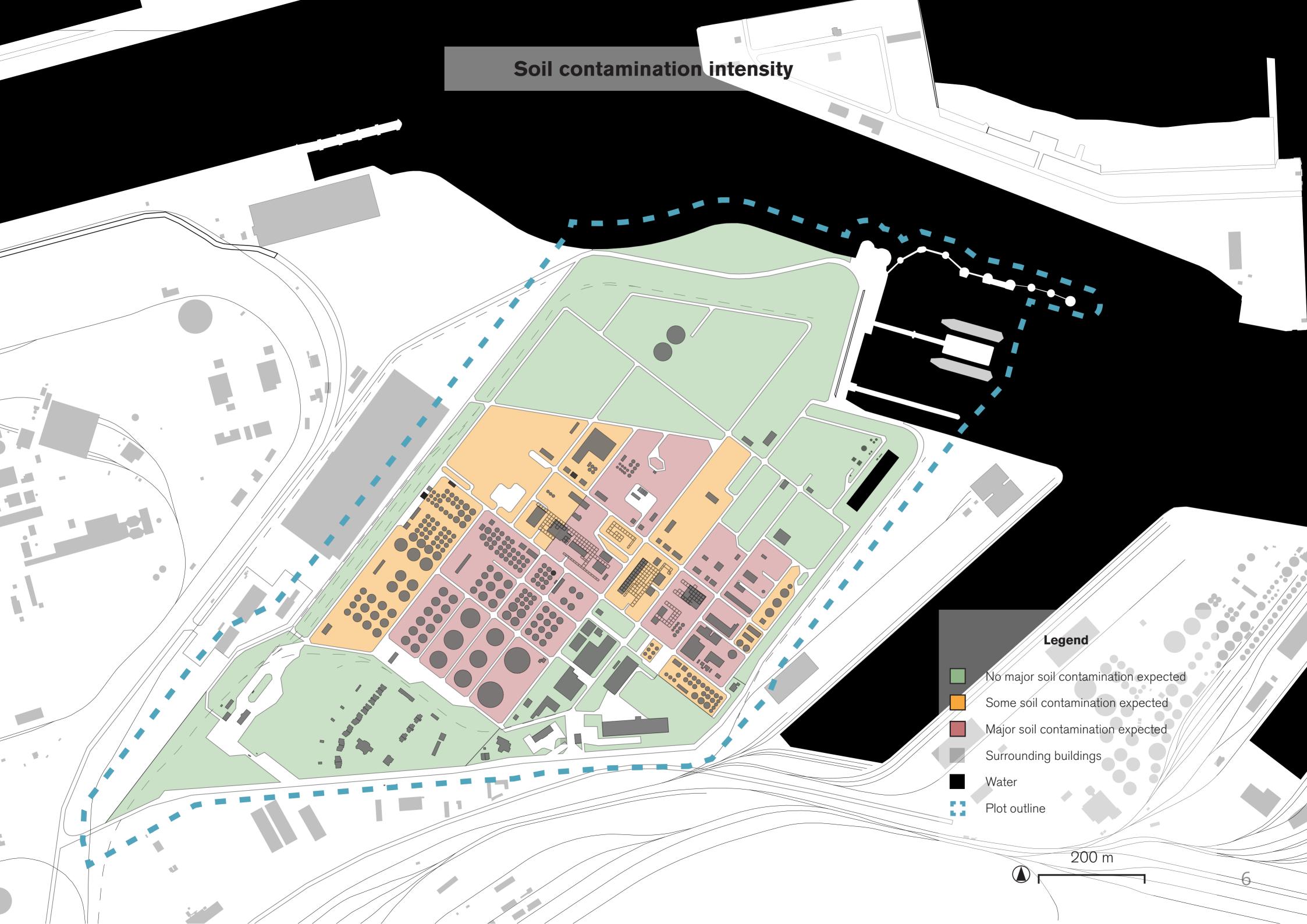
The third main phytotechnology is mycoremediation. The new buildings will be lifted from the ground to make space for remediation of the soil underneath. However, normal plants would need at least some sun to grow successfully. For this reason, fungi will be planted underneath that can be

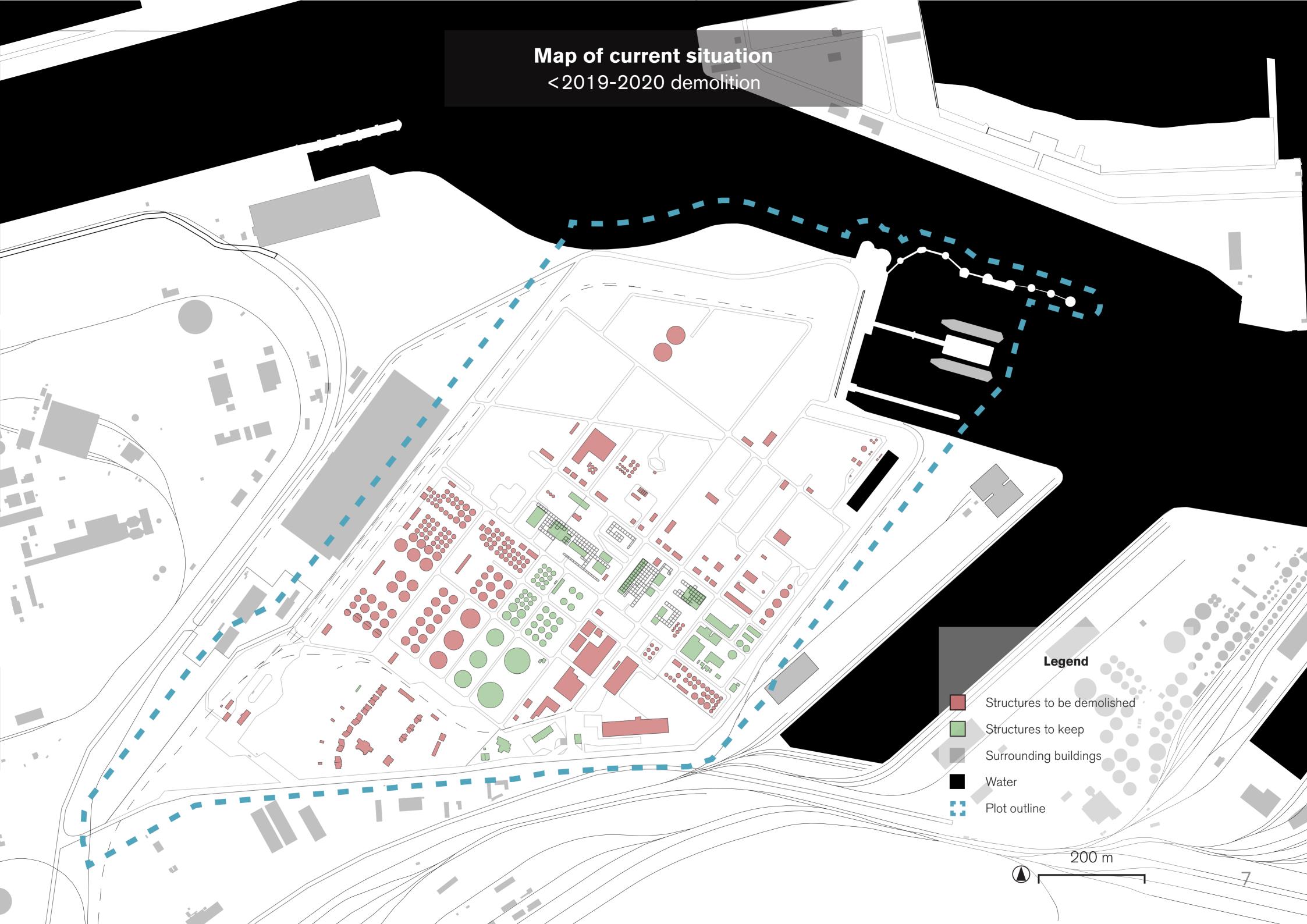
harvested and of which the mycelium can be used as input for the building sources.

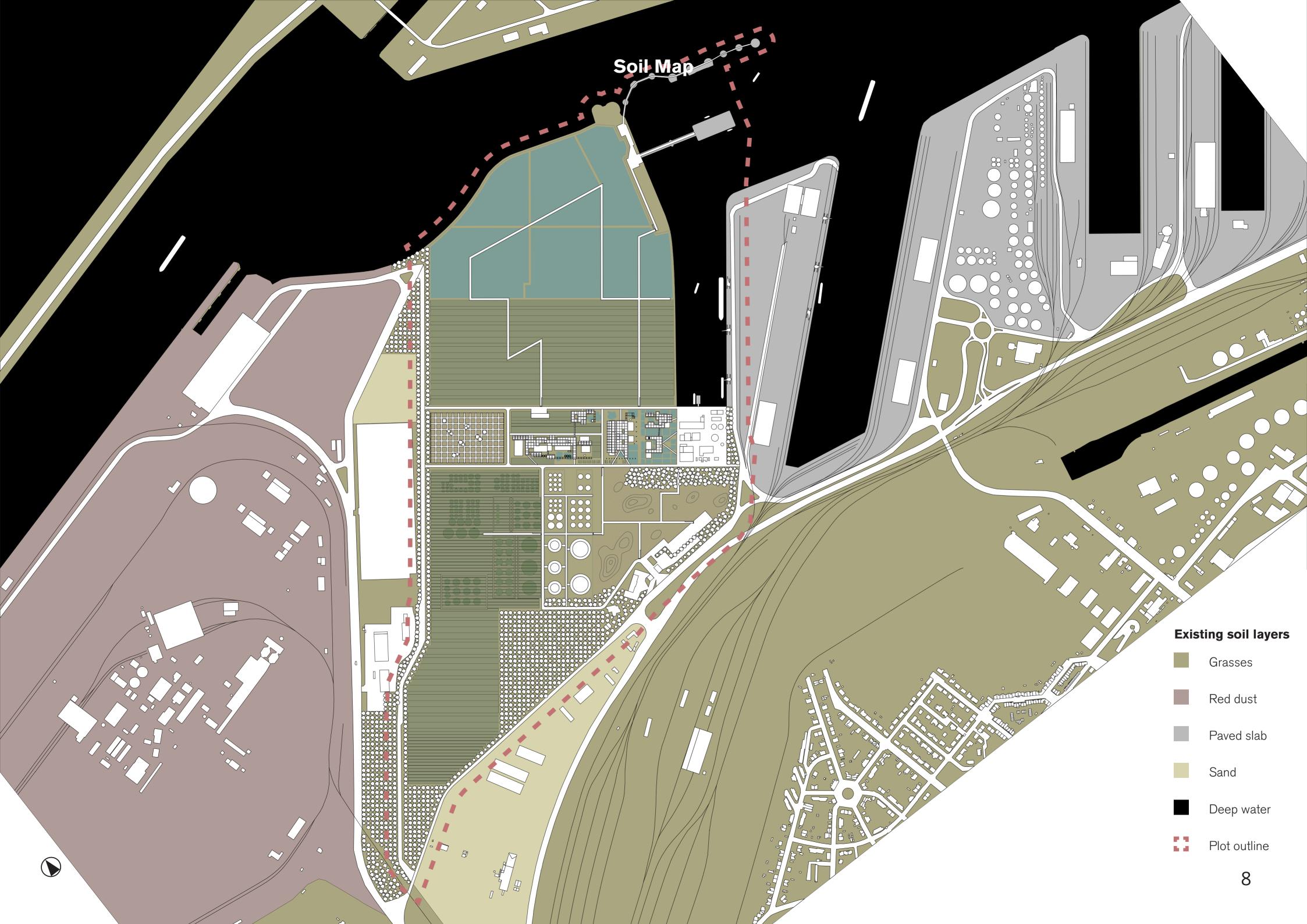
To make space for the logistics of the site a new dock, adjacent to the last mole of the port will be made. The main logistics of the site will be by boat and this way there is direct access to the main buildings and an easy way to unload the ships close to the site. To achieve this, a large portion of polluted soil will be dug from the site. This soil is moved to another part of site to form a hilly landscape which will be covered by plants, forming a degradation cover. Every couple of years the top layer of the hills can be removed, whereby the plants can be used as biomass and the soil can be moved somewhere else. The hills will shrink this way until they are completely gone towards the end of the lifespan of the project.

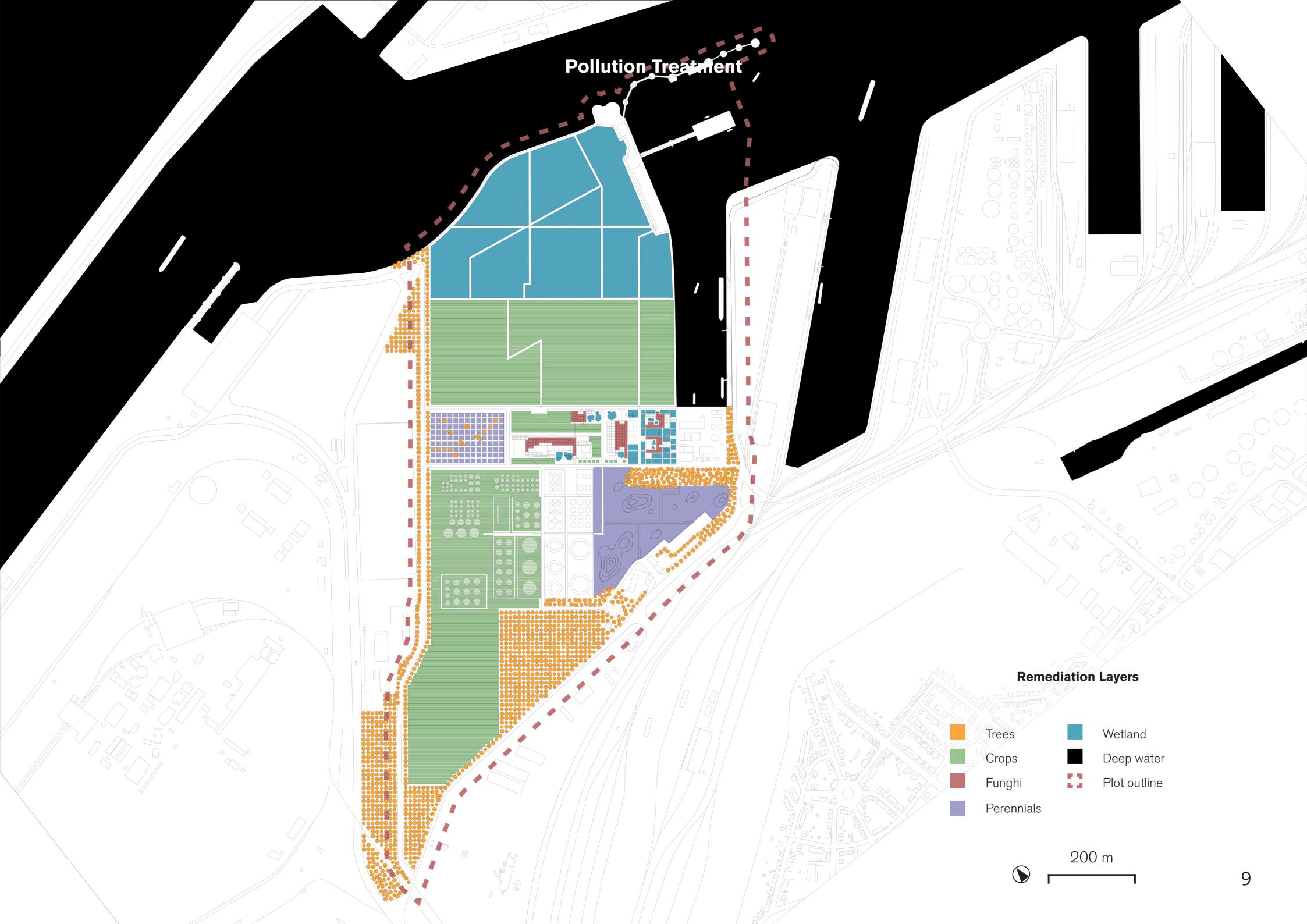
The last large phytotechnology is the use of trees, to form an edge around the site and isolating it (interception hedgerow/migration tree stand), to prevent the migration of groundwater away from the site and the migration of groundwater from adjacent polluted sites towards the project site. To compensate for the extensive use of timber in the construction of the building modules, the remaining free, non-polluted and very heavily polluted soil soil will be filled with trees that can be harvested for production after the completion of the project (or not). The planting of a forest for remediation is called a degradation bosque.

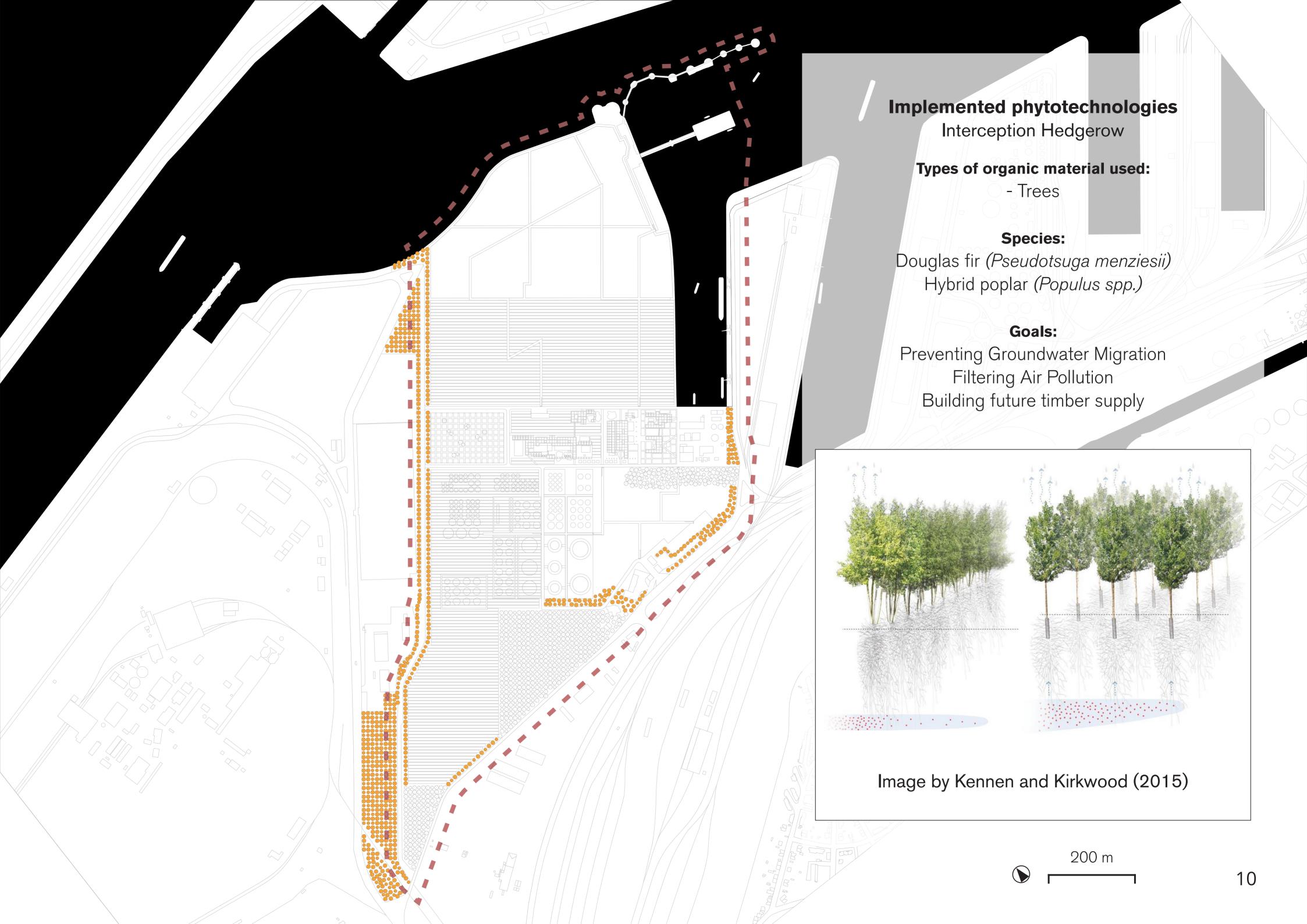
The maps and visuals on the following pages show the spatialisation and some more details of the technologies described above.

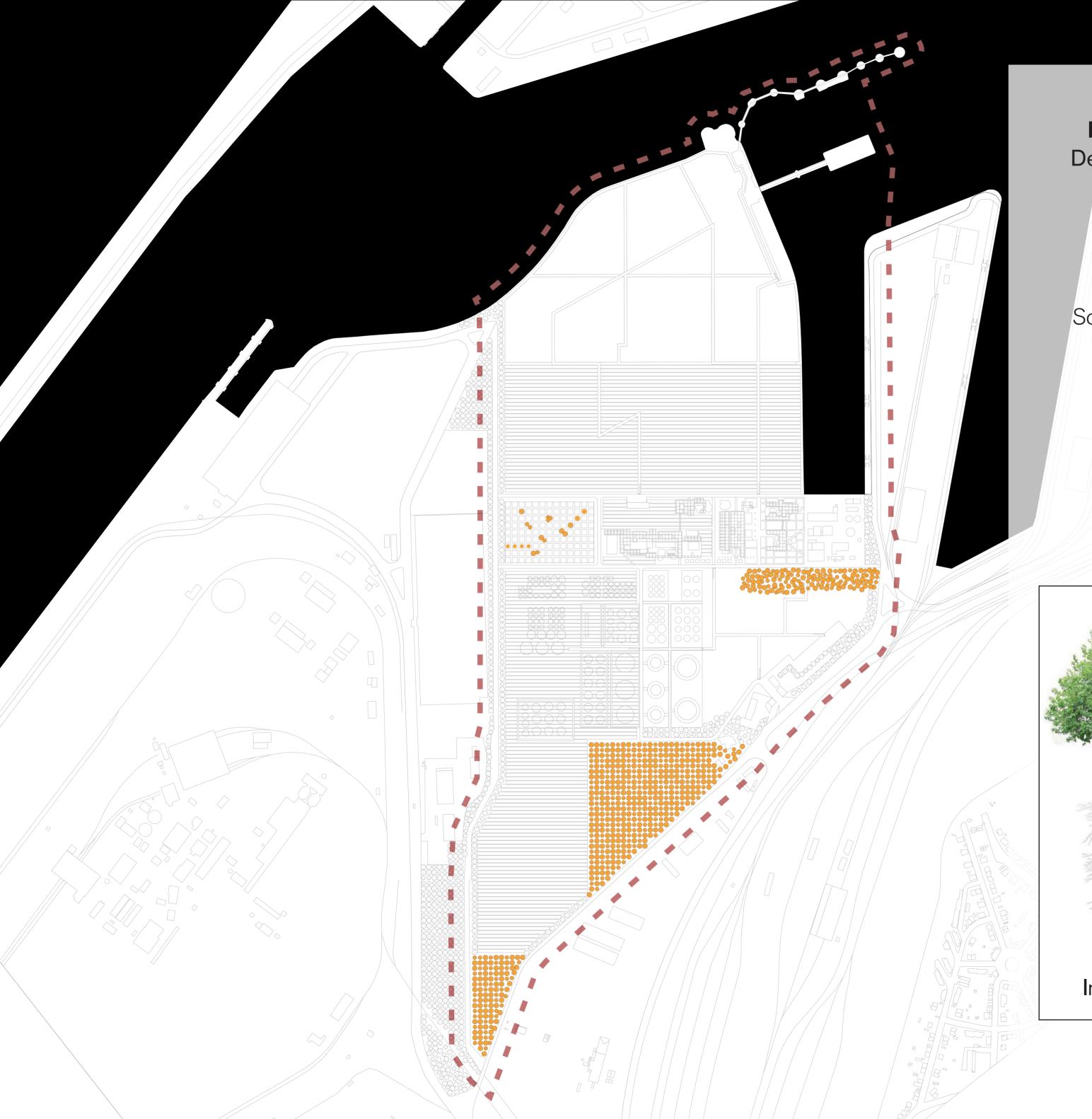












Implemented phytotechnologies

Degradation Bosque/ Production Forest

Types of organic material used:

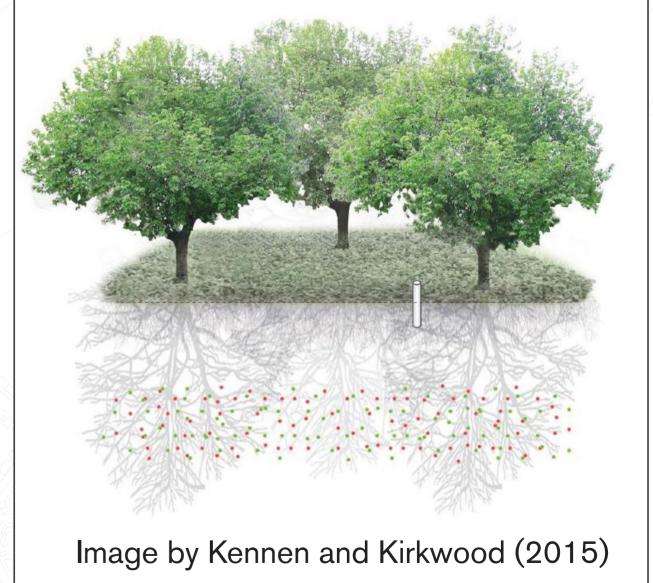
- Trees

Species:

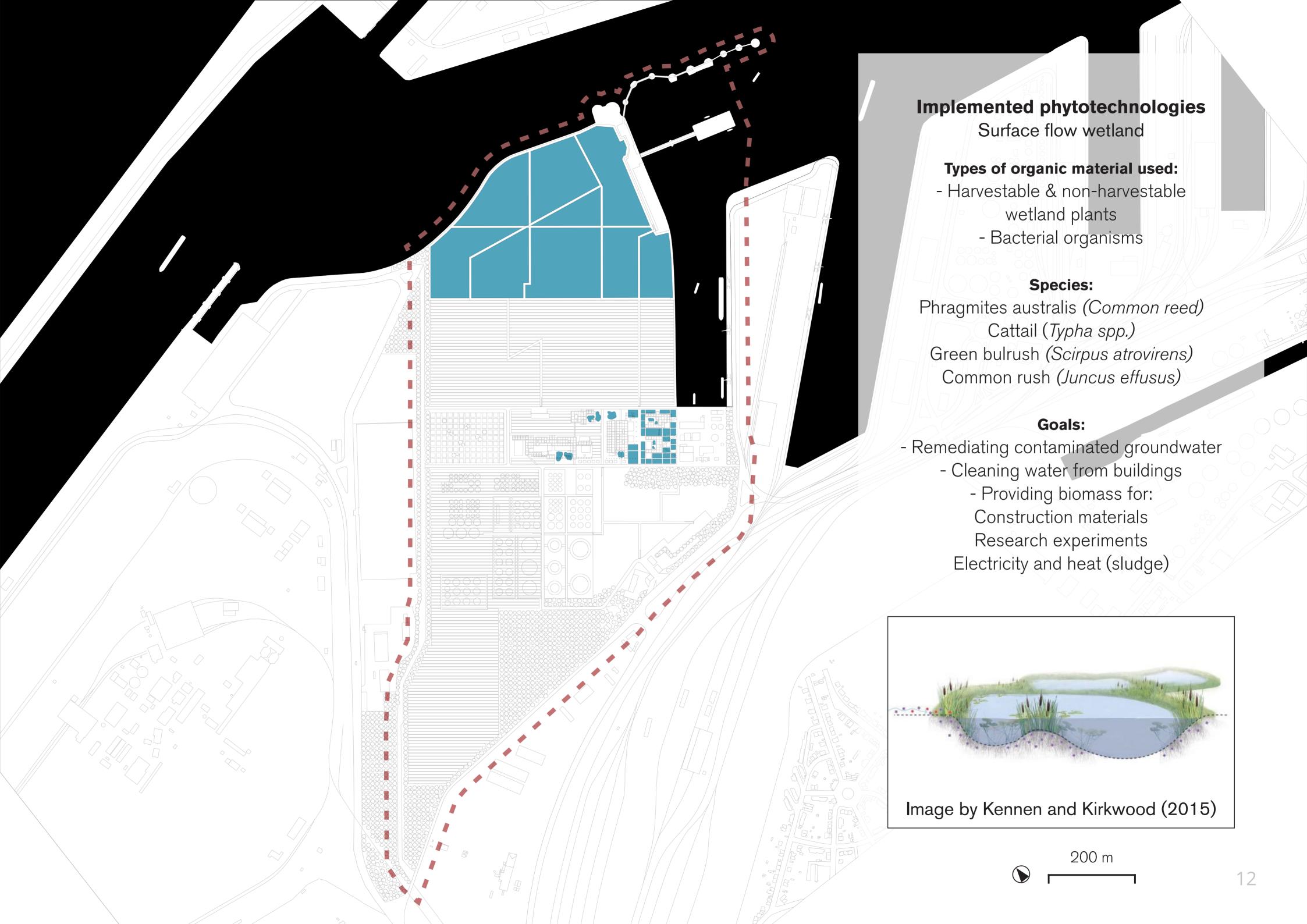
Scots pine for production (*Pinus sylvestris*)
European white birch (*Betula Pendula*)
Norway Maple (*Acer platanoides*)

Goals:

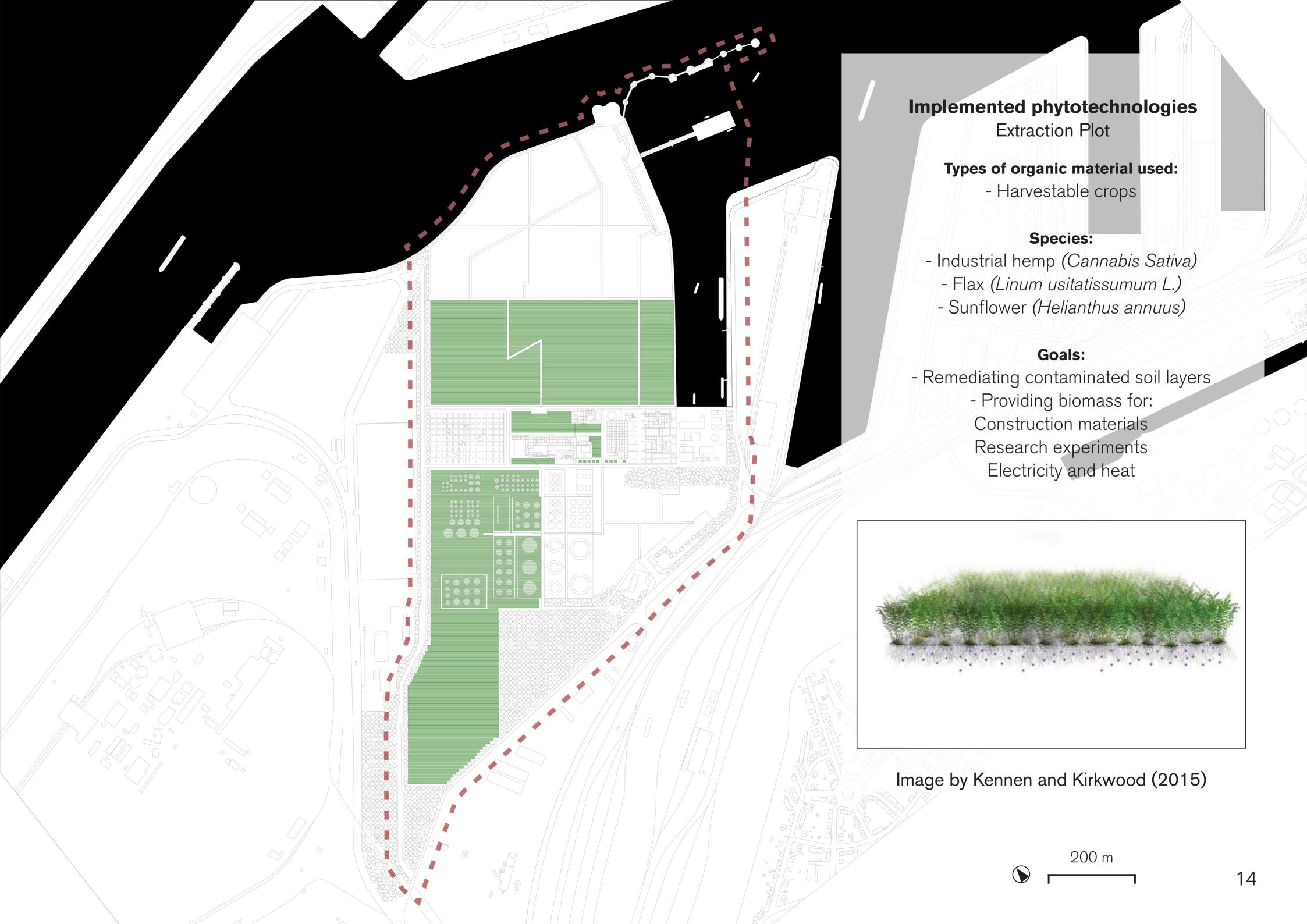
- Preventing Groundwater Migration
 - Filtering Air Pollution
 - Building future timber supply
 - Research Experiments



200 m

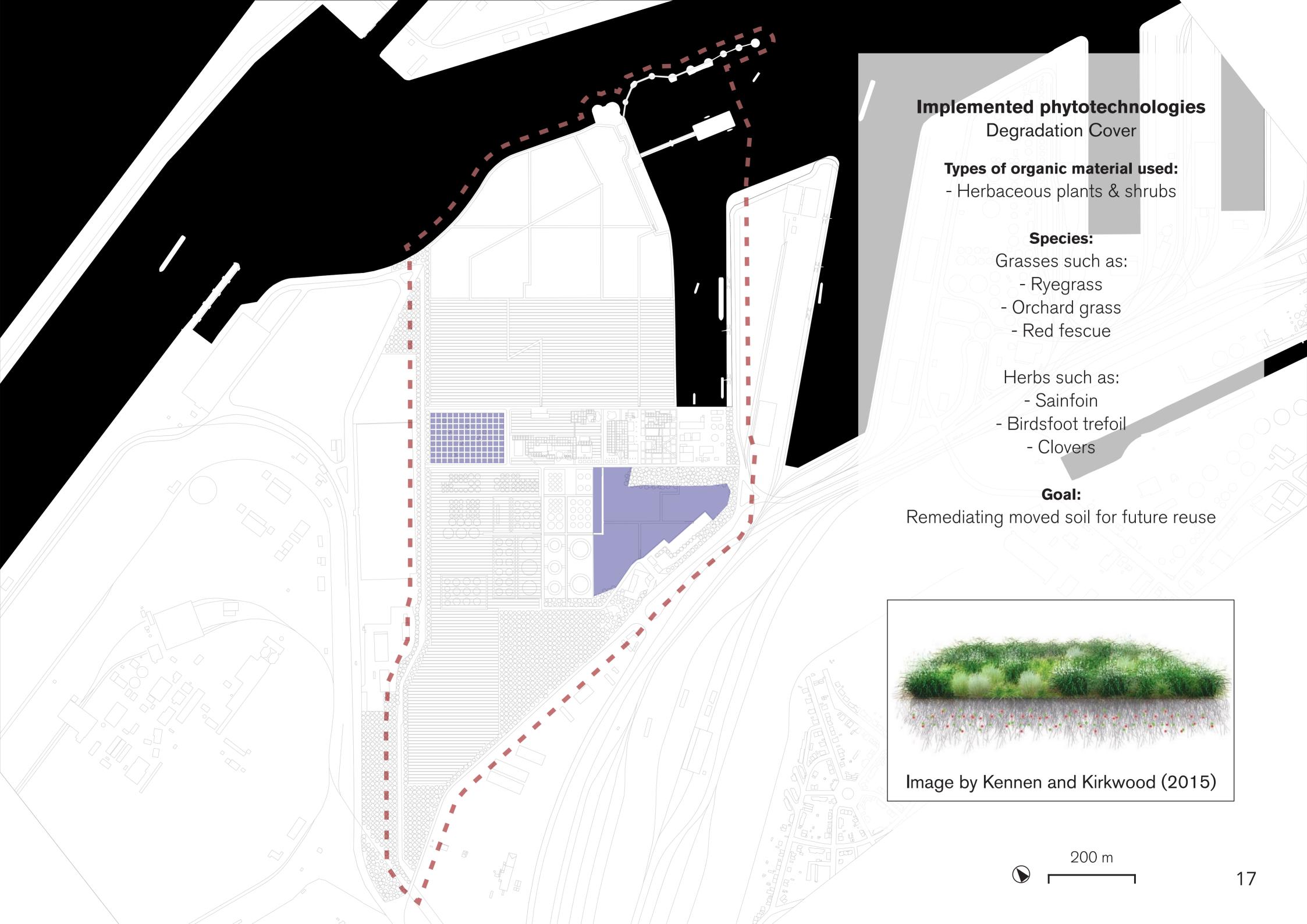


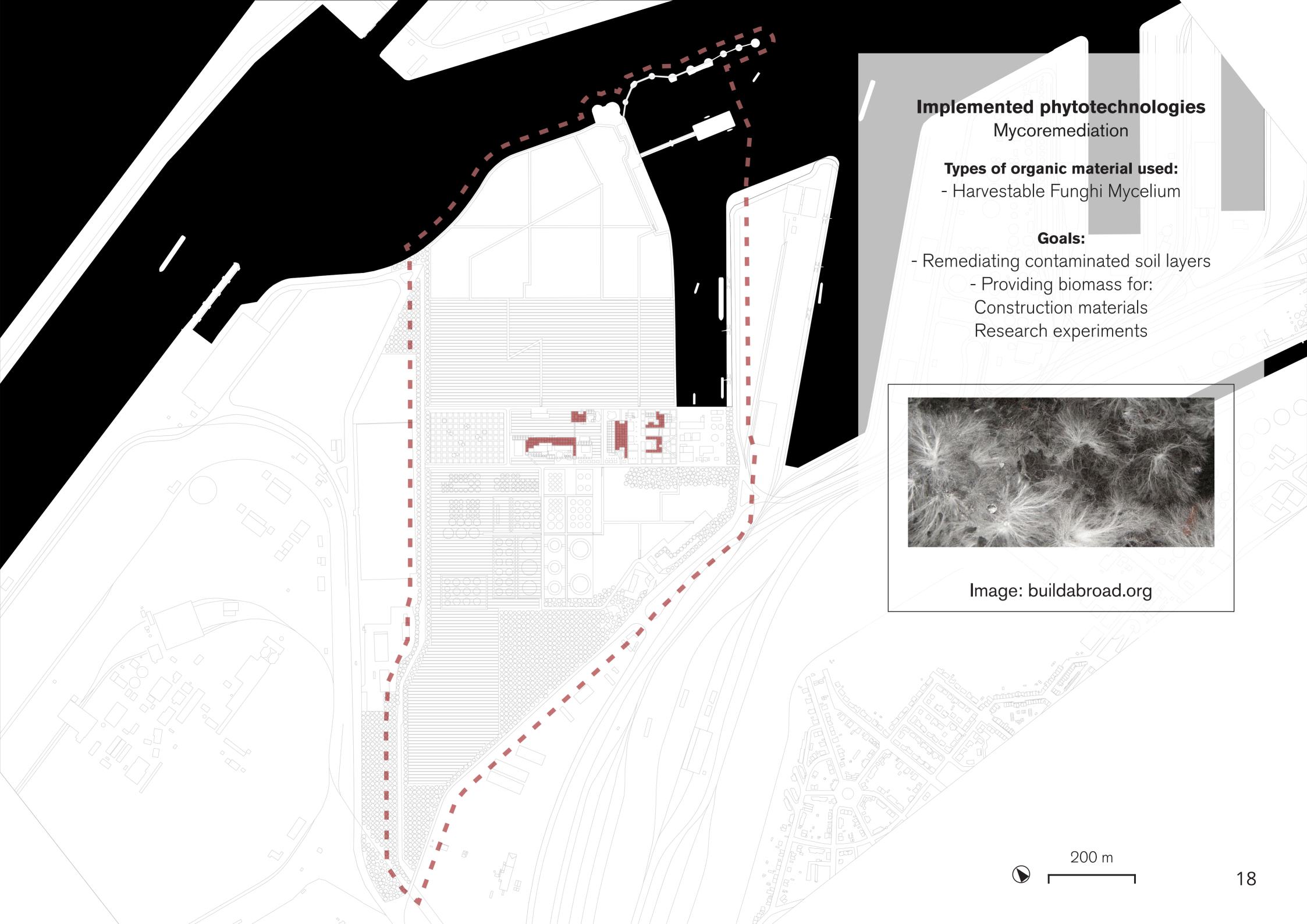












3. Site Program

To make most use of the phyremediation potential and scale of the size, the program of the site is adjusted to the remediation of the site, and really tries to follow a holistic approach. The program of the site not only comes from the remediation of the site, but it is also using there to create a place for the people of Dunkerque. One of the main design considerations was to really think of a way to create a program that fits the city. Dunkerque is not a city of high educated, knowledge based people, but is traditionally a city of industry, due to its extensive port. France experienced a big wave of deindustrialisation during the last decades of the 20^{th} century and Dunkerque was hit heavily by it. This means that many people lost their jobs at former industrial enterprises in the port. The new program of the site tries to bring some of this socio-economic factors back to the port, but with a different intention.

The main driver of the project is the series of buildings that will be created where the former refinery installations were. These buildings contain research laboratories and research offices that use the input that is generated from the biomass that is created by the implemented phytotechnologies. Between the buildings there are areas reserved for outdoor experiments with these different phytotechnologies, while other experiments take place inside the buildings. This series of buildings and plots together form the research & innovation axis of the project. To process all the biomass that is produced on site there is a district that consists of a series of manufacturing and processes buildings. The raw biomass an waste materials from the old refinery installations are here processed into refined products that can be used for the construction of the buildings or the generation of heat and electricity.

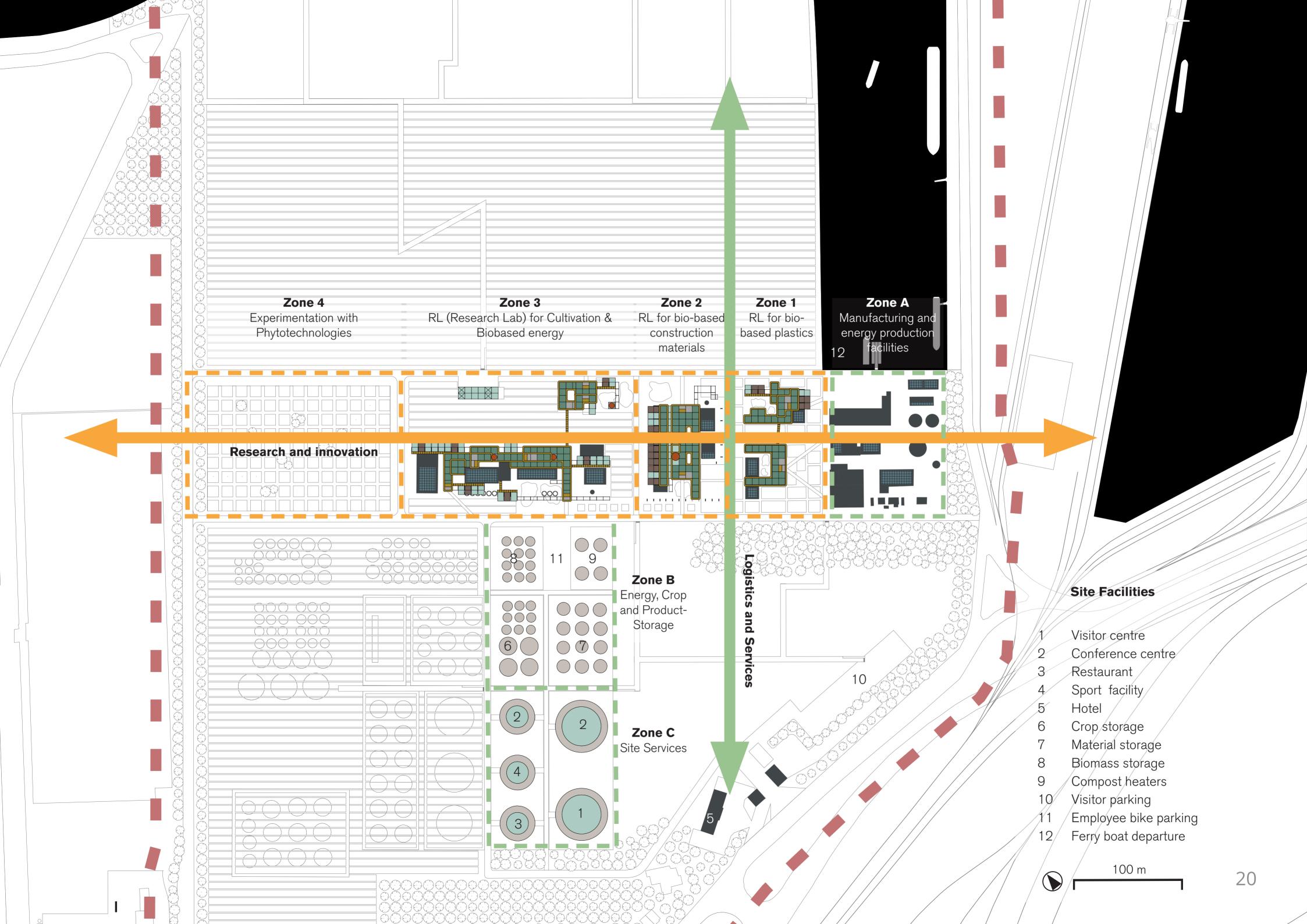
The largest part of the remaing storage silos of the refinery are used to store all this material and biomass for their different uses. However, a few of the silos are used to generate heat from the composting of biomass. The rest is used as storage facilities, except for the five largest silos.

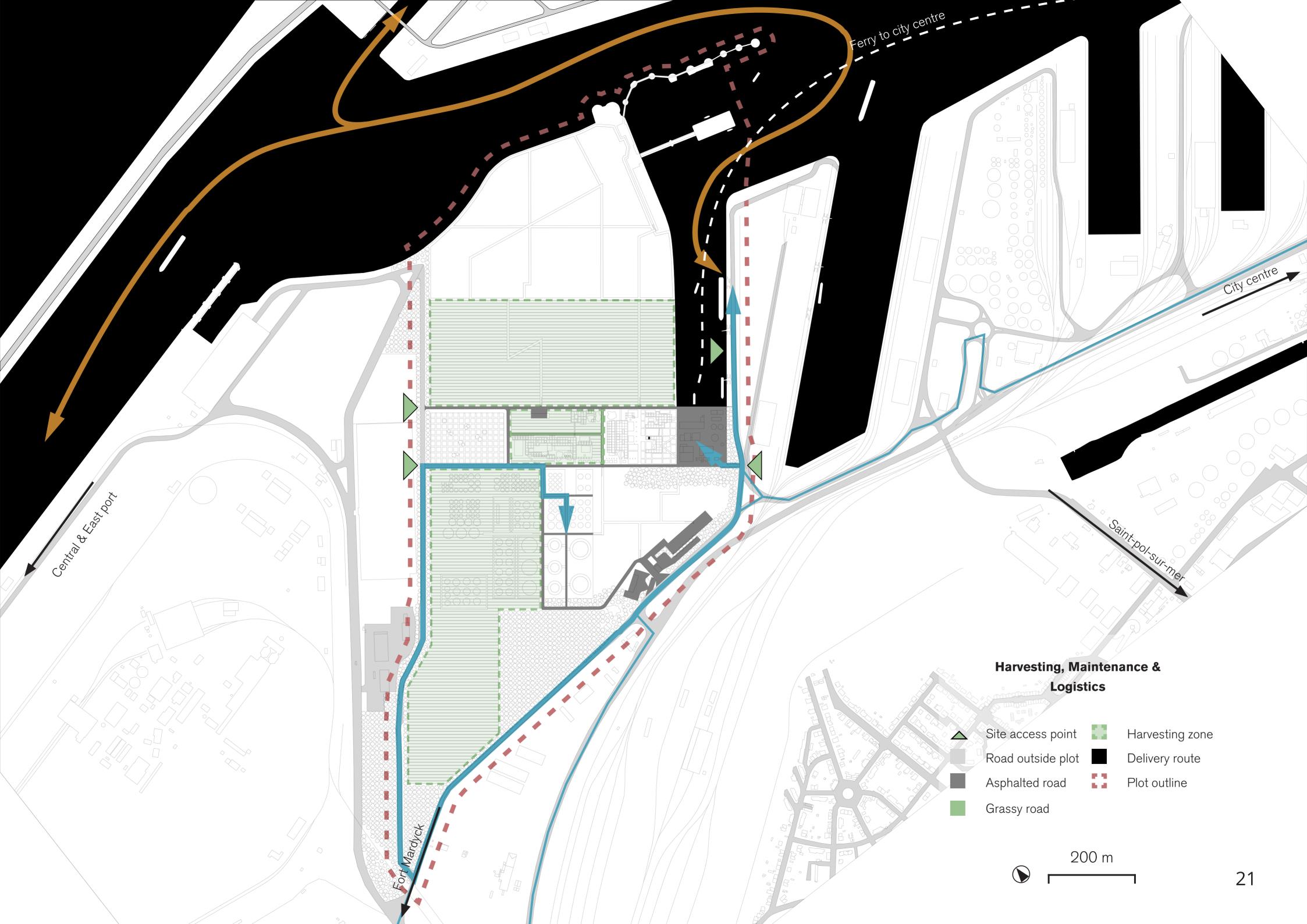
These five largest silos together form the public and valorisation part of the site. Even though most of the site will be accessible for public 24/7, most of the buildings have specific functions that do not involve constant engagement of an audience. This will take place in the five silos that

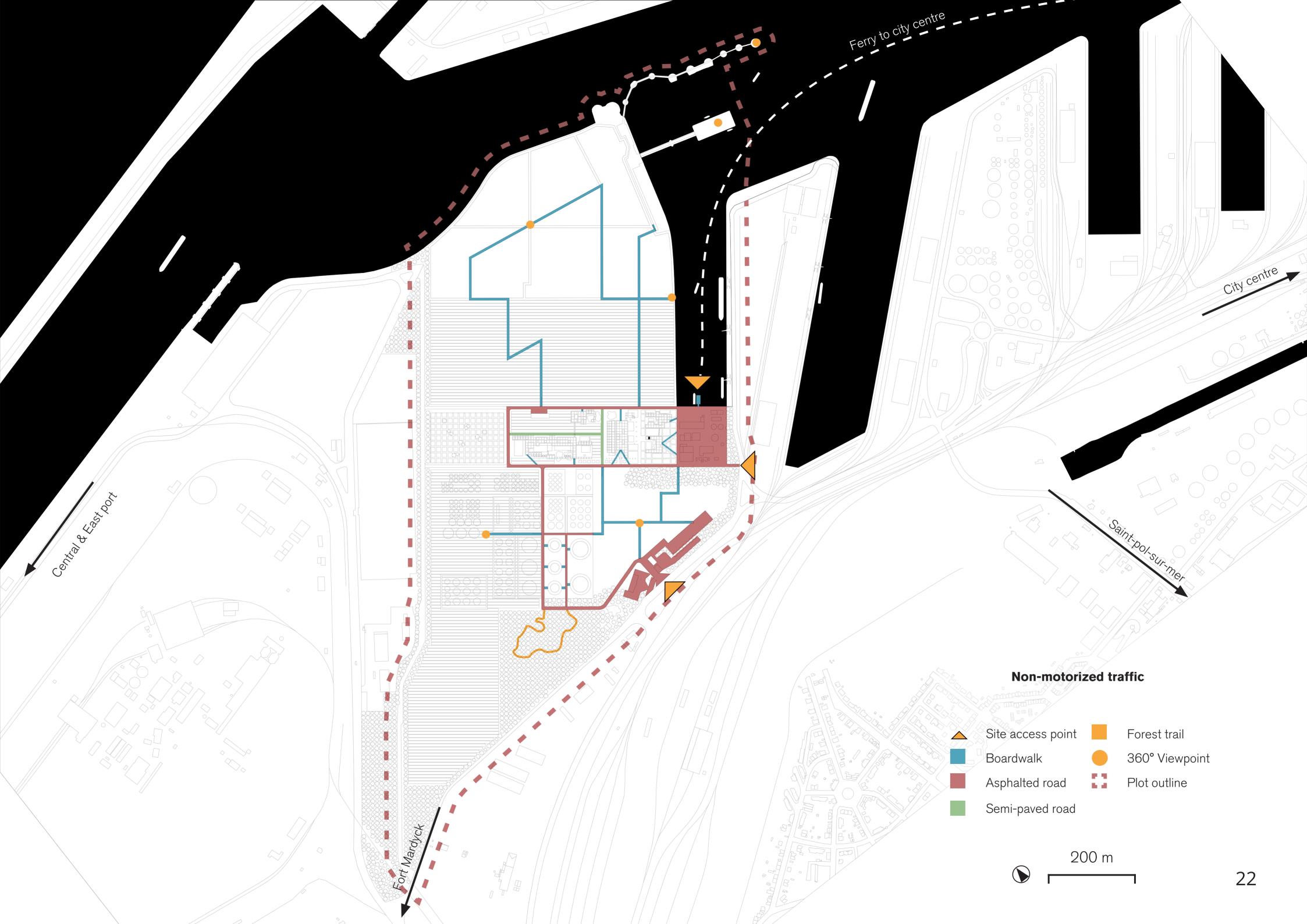
contain: A Conference center for valorisation of knowledge, A visitor centre that shows information of the project, phytotechnologies, reuse, exhibitions and provides guided tours around the site for interested people.

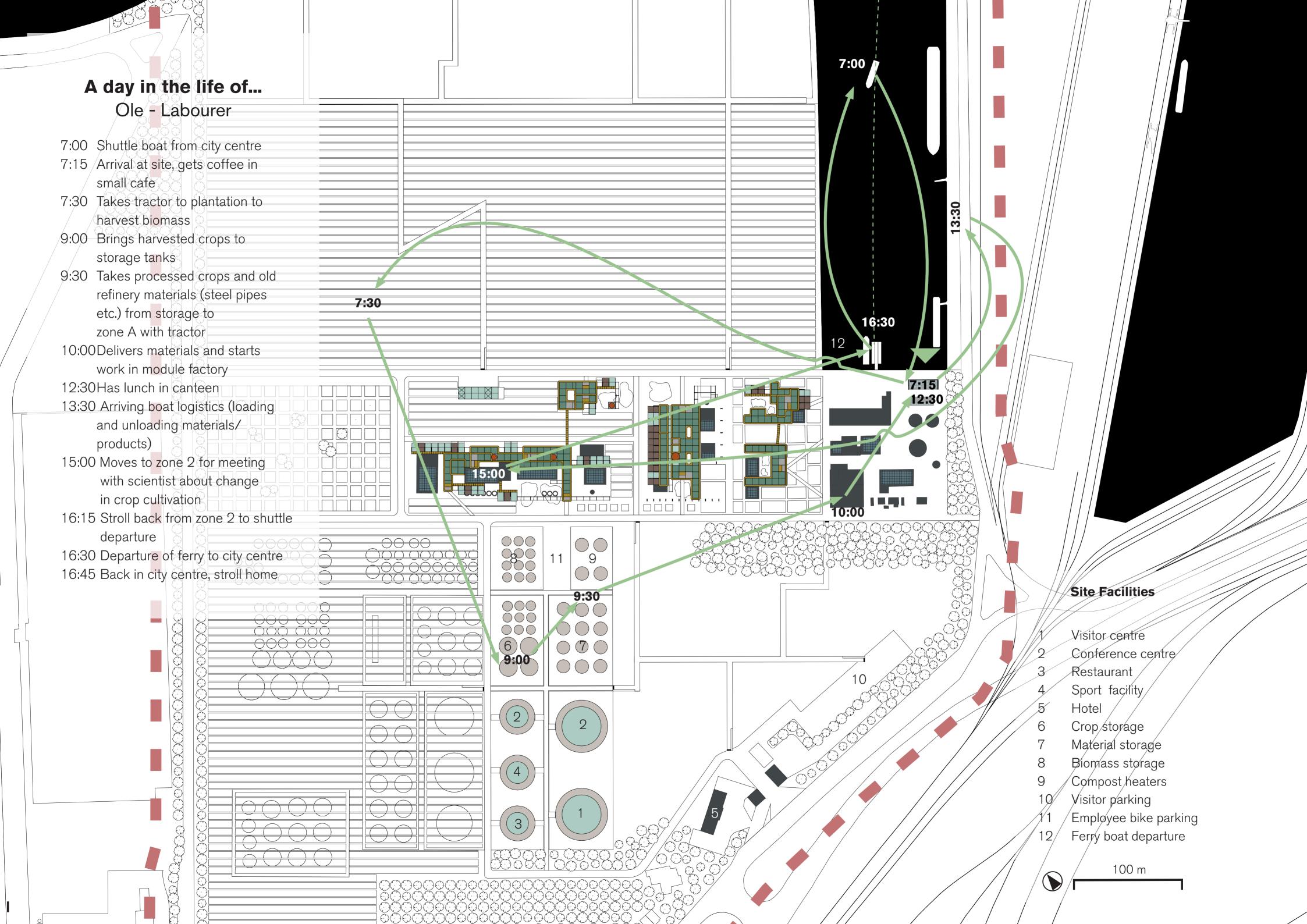
During the first phase of the project the research laboratories will have to be occupied for a larger part by employees that are attracted from abroad. There will be direct employment for people of the former industrial areas in Dunkerque, to make the phytoremediation process happen and to run the manufacturing and maintenance aspects of the site. The idea is that the project grows over time and knowledge is transferred from the external employees to local people and that it shifts the balance of employment towards more and more engagement from people from Dunkerque and the region around Dunkerque, thus providing a new opportunity for large scale employment in Dunkerque.

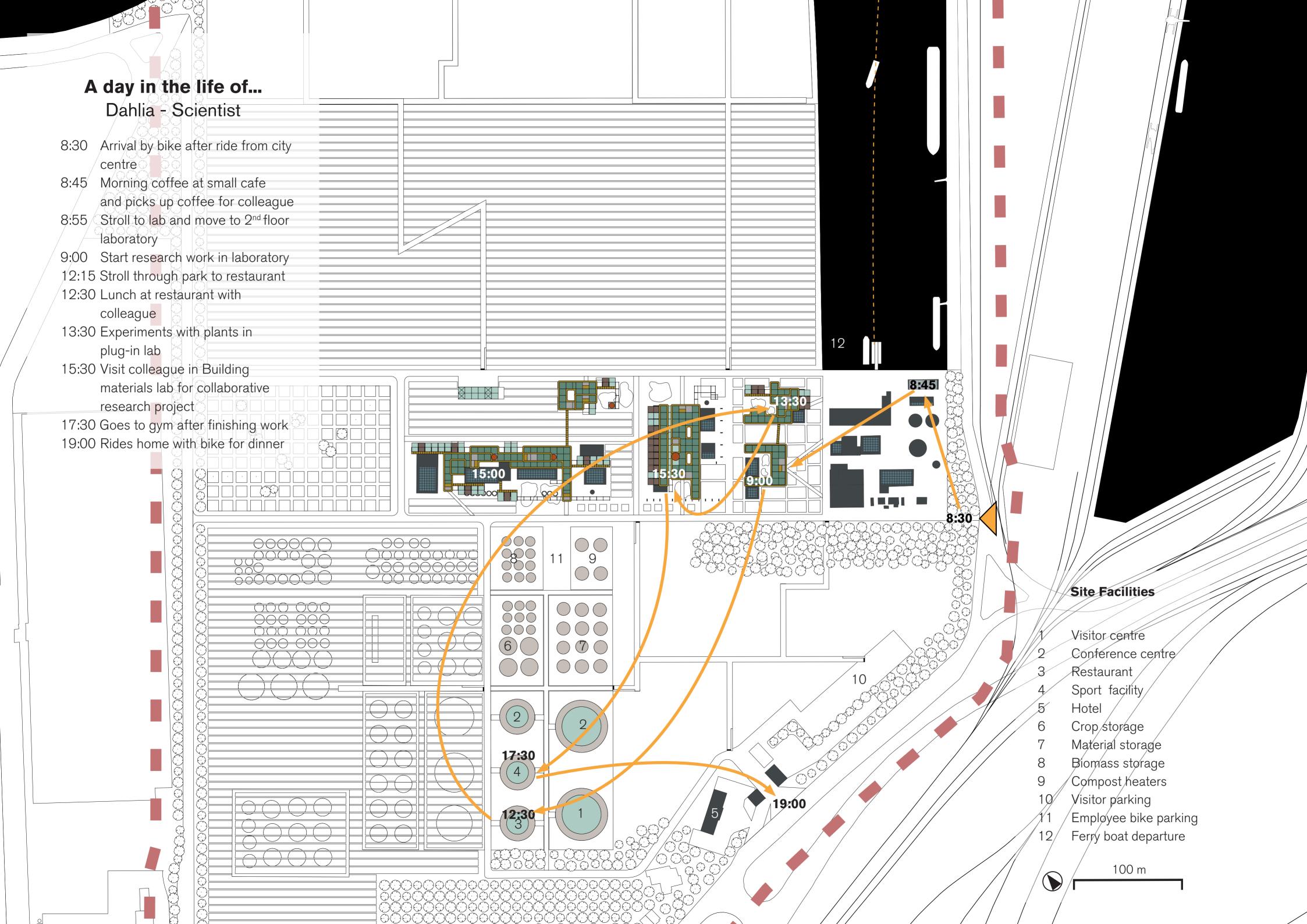
The next pages show this site program in some more detail and presents a few scenarios of different users of the site that visualize how the site would be used on a day-to-day basis.

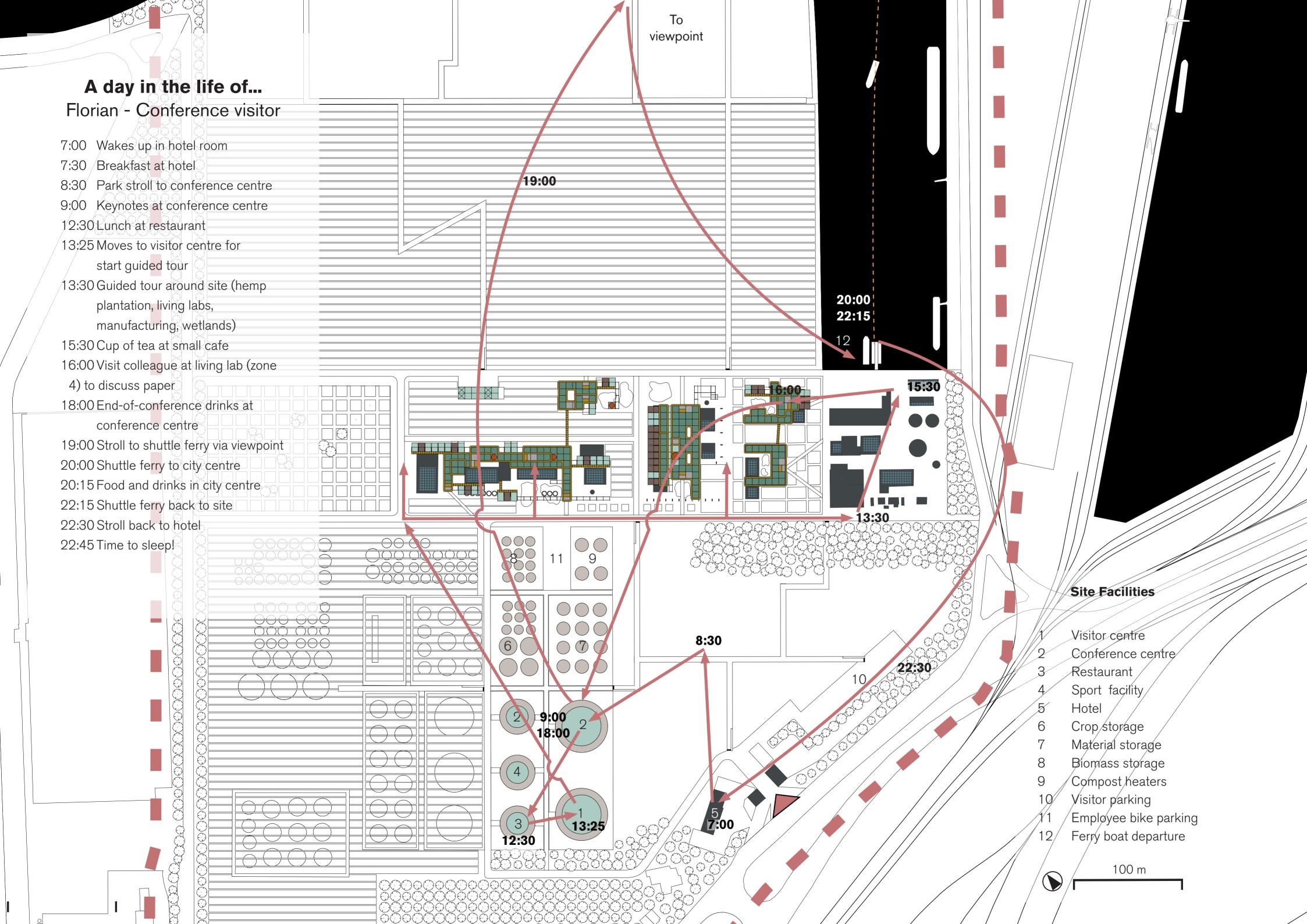






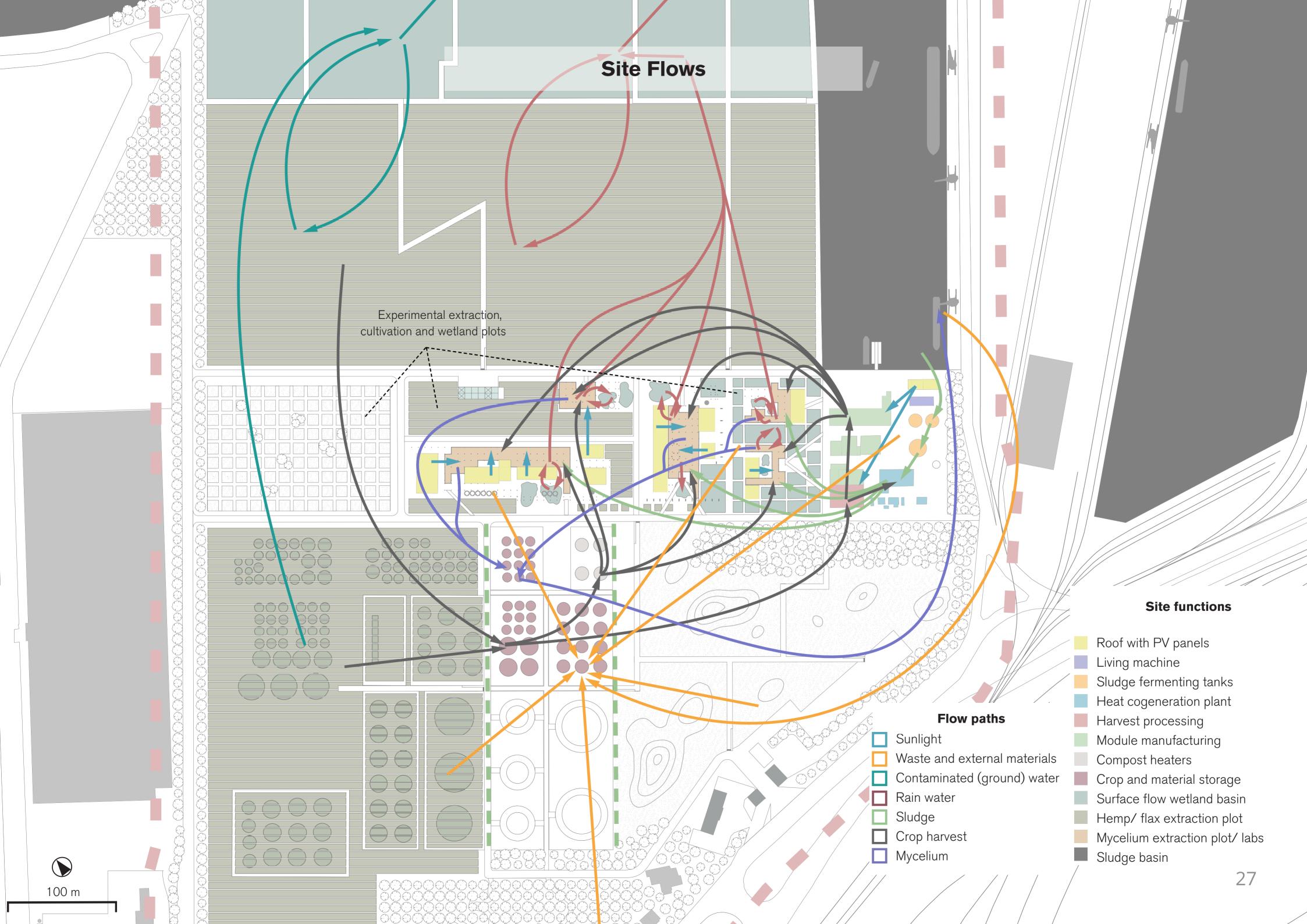




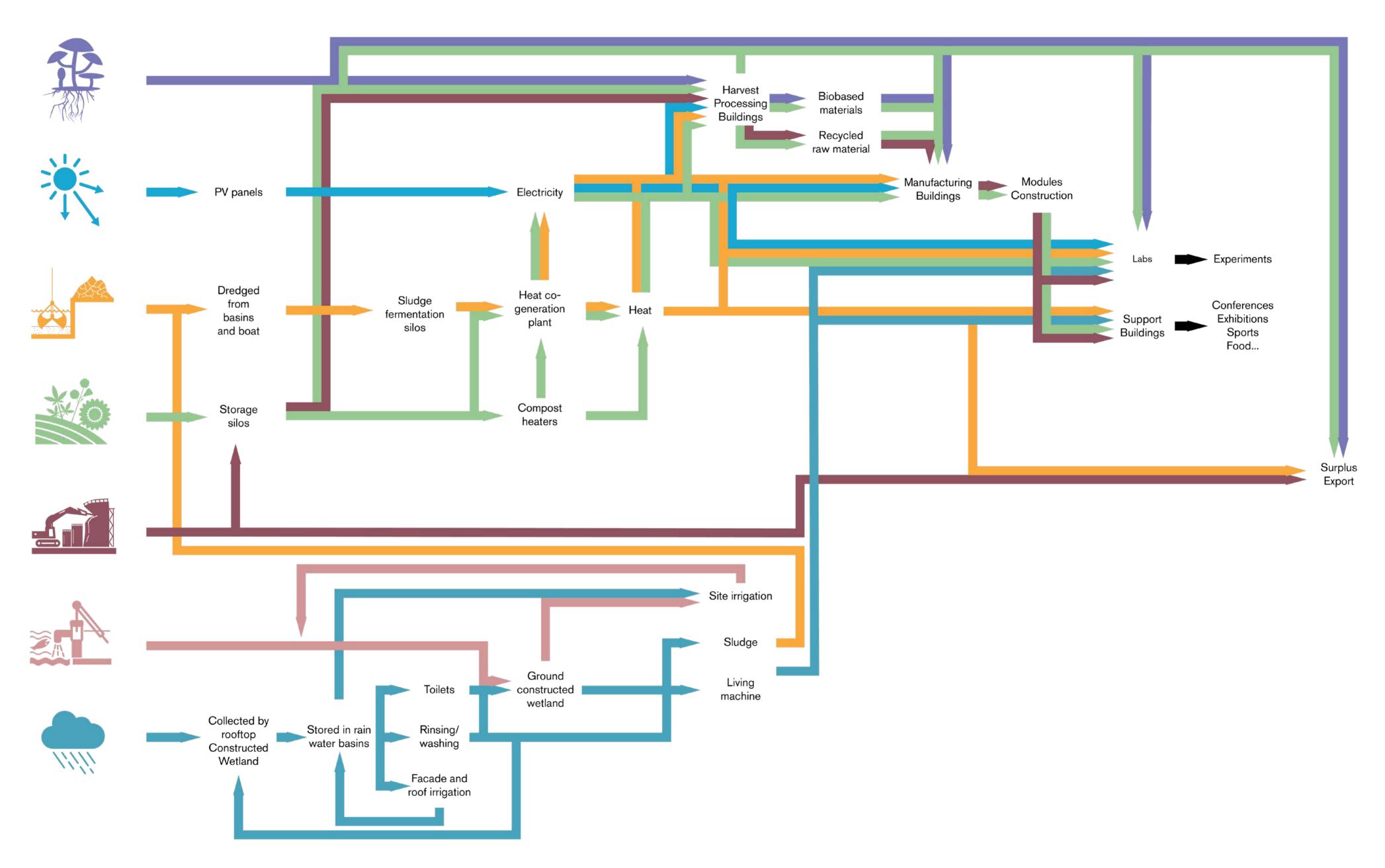


4. Site Flows

As became clear in the previous sections, there is deep-rooted interaction between the site, the buildings and its users. To get a better understanding of all these different processes on the site and the inputs and outputs that are generated from these processes, the next pages provide a diagram and map that make this more tangible. The main elements that flow on the site are different types of biomass, water, waste material and solar energy. The schemes make clear where different flows converge and diverge and meet, as well as the products that are created from them. These diagrams form the backbone of the program of the project and the argumentation of the main design choices of the project, both on site and building level. The design considerations that formed this flow diagram are mainly based on the circulation of flows on site as much as possible, and thus creating independency from external sources for electricity, materials, heat and water.



Site Flows





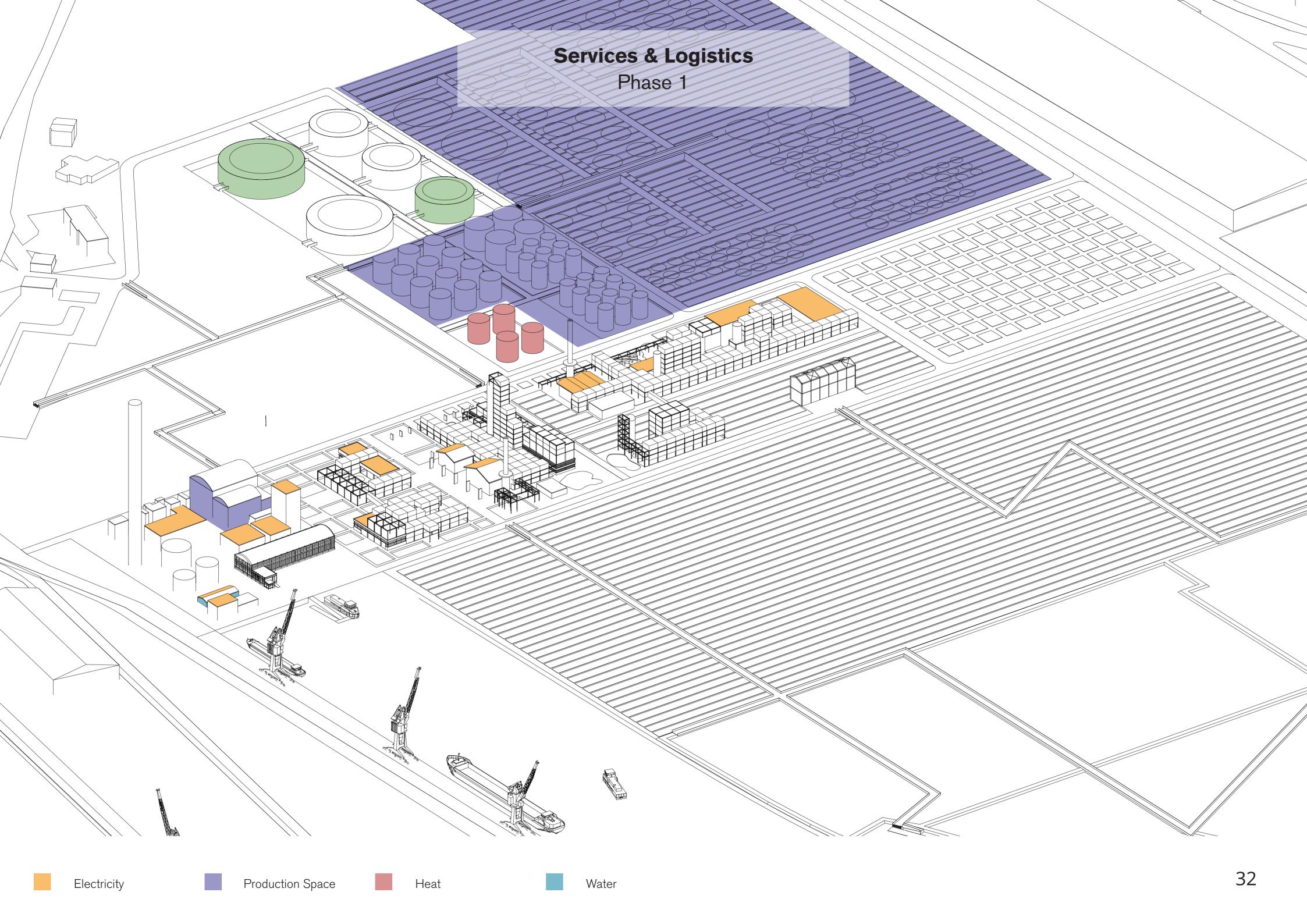


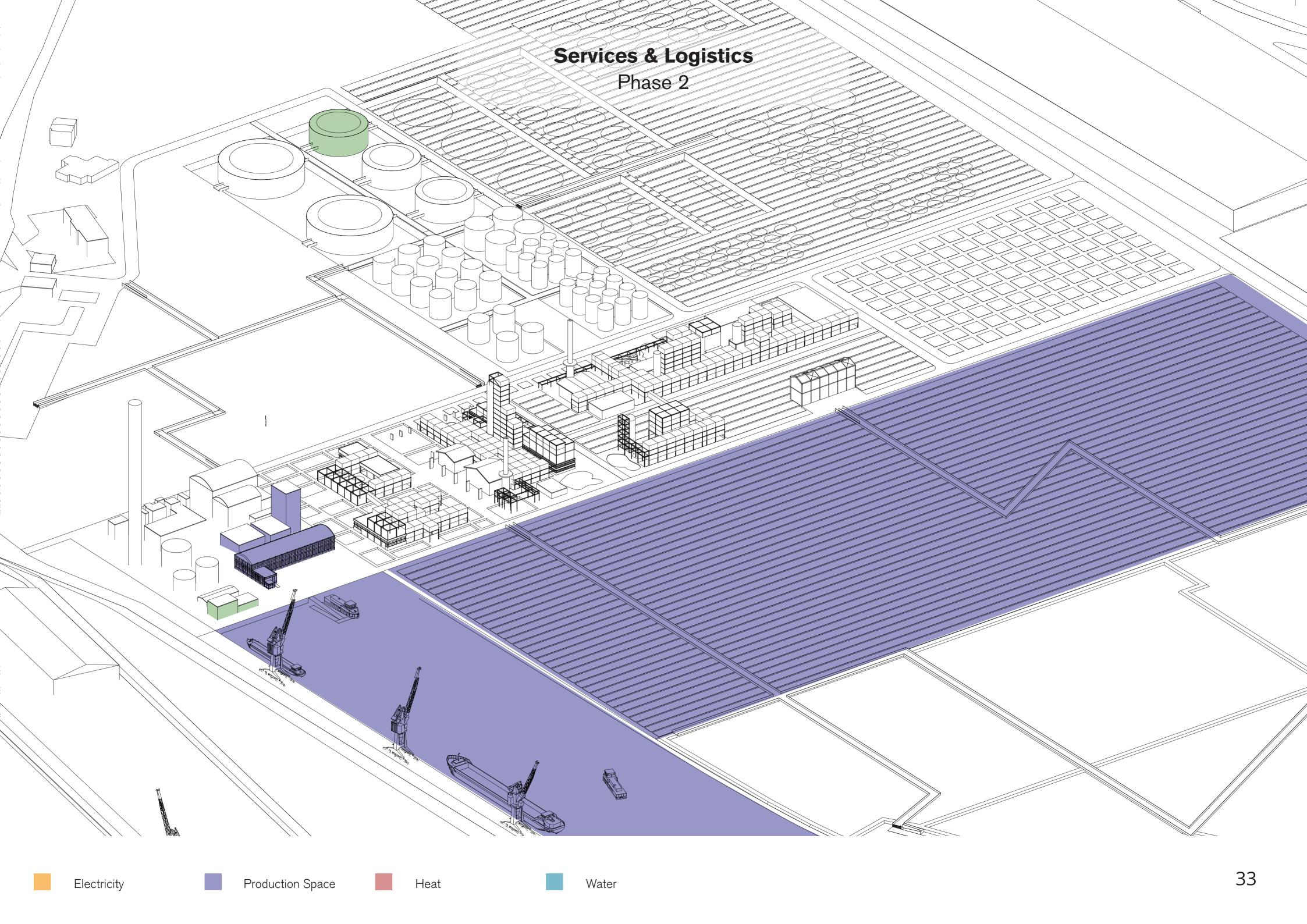
5. Project phasing

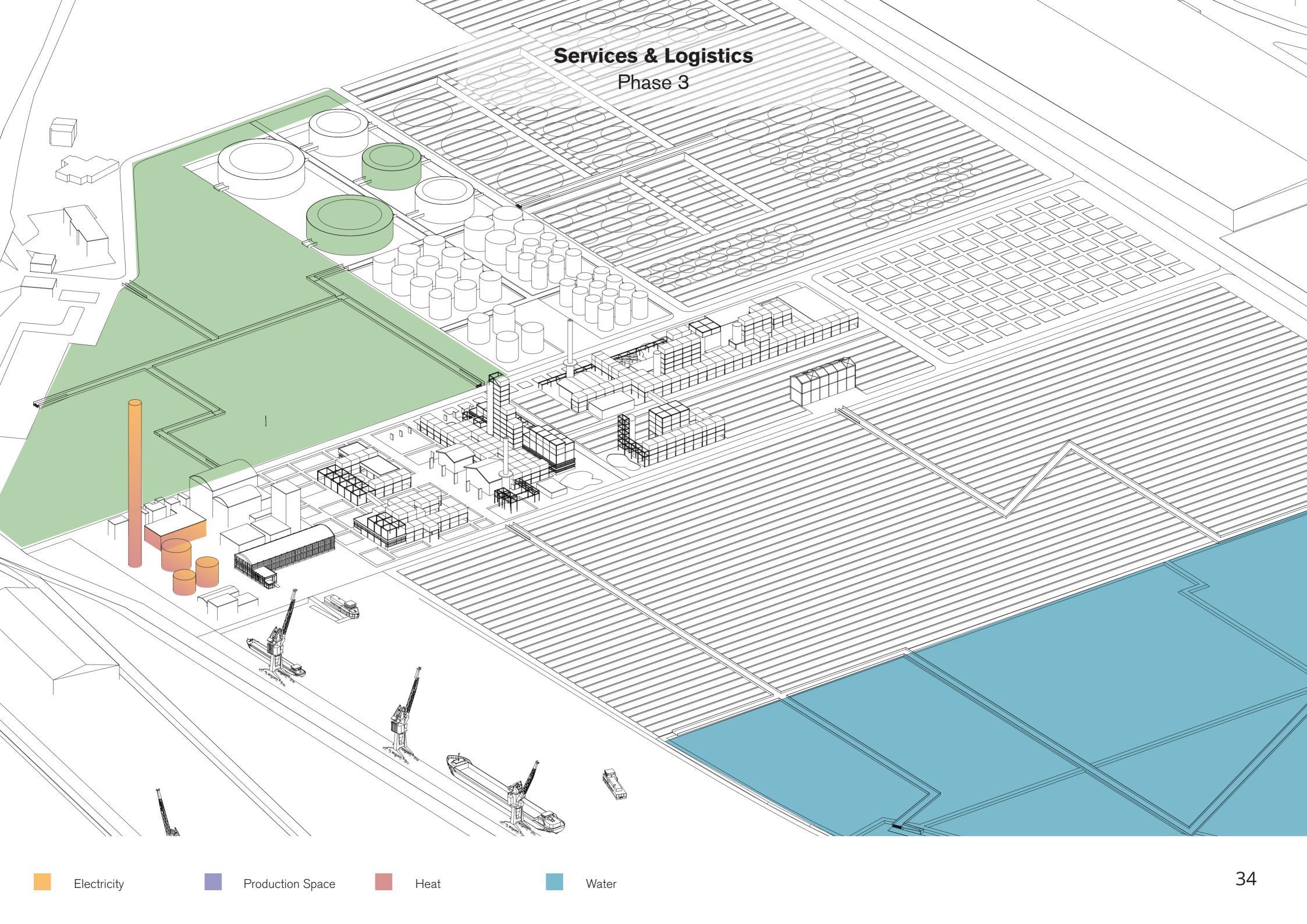
In the final stage of the project it would contain about 18000 m² of potential laboratory and office space. Of course it costs a lot of money to realize such a project, let alone the question whether there is need for this amount of space. The project is designed in such a way that both the site and the buildings can be phased out over a time span of ca. 35 years. The building system, that is discussed in a later section is also adjusted to this idea of growth. The buildings will be phased out over four phases, the site services over three. The idea is that the project site reaches maximum capacity before the end of the project. After some time, the first part of the site will be fully remediated, which decreases the input that is generated from the site. It is also likely that the remaining structures in these areas would already be demolished so that the cleanup process of this part of the site can be finished. The division of the buildings is made in such a way that with each phase one or more new wings are added to a project, opposed to extra floors. This approach results in very minor need for taking apart the building to add the next section. The growth of the research space will also lead to growth of amount of employees and the need for valorisation of knowledge to support the project. During the several phases new public facilities will be put into use in the silo district of the site.

Regarding the production part of the process the phasing is mainly based on the needs in time. With the growth of the project, the growth of consumption also increases. In the early stages the project is small, and the amount of floor space will be limited. During this phase electricity can be generated with solar panels on the roof of existing buildings, heat can be generated by means of compost heaters and the manufacturing and processing of buildings can be small, while water can be cleaned by means of some roof wetlands and a living machine for heavily polluted wastewater. During this phase the most contaminated of the parts will be made ready for remediation. In the next phase, the dock will be created and the surface flow wetlands system on the former floodplain. With this growing project, the demand for energy will be used and generated by the old heat cogeneration plant. The main input for this is sludge from the basins and the harbour, while in later stages surplus biomass from the degradation covers and extraction plots can be added. There is also room to expand the manufacturing facilities in some of the remaining old warehouses, and storage silos can be added on the fly.

The next pages show the growth model for the buildings and the phasing of the logistics and services part of the project.

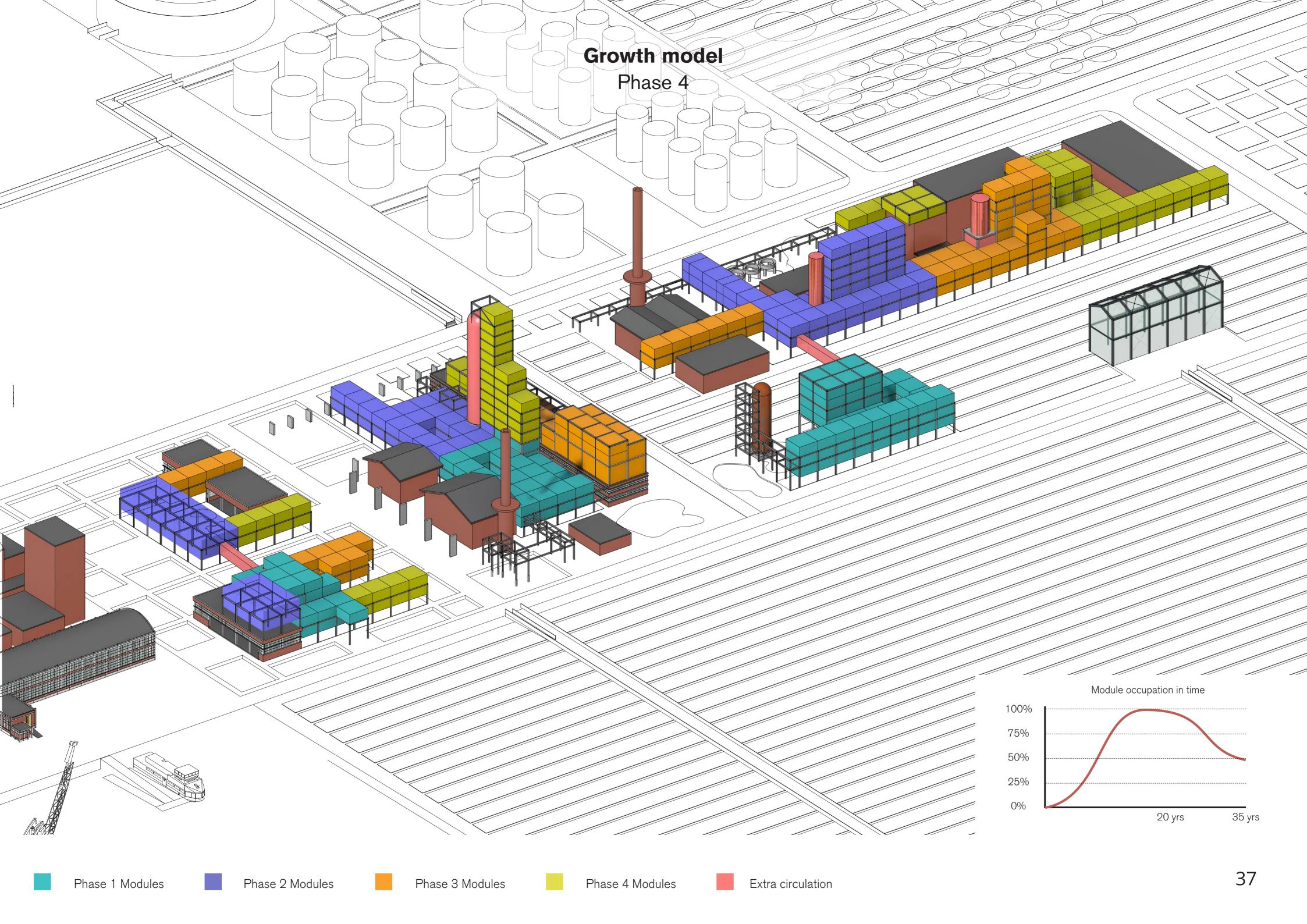


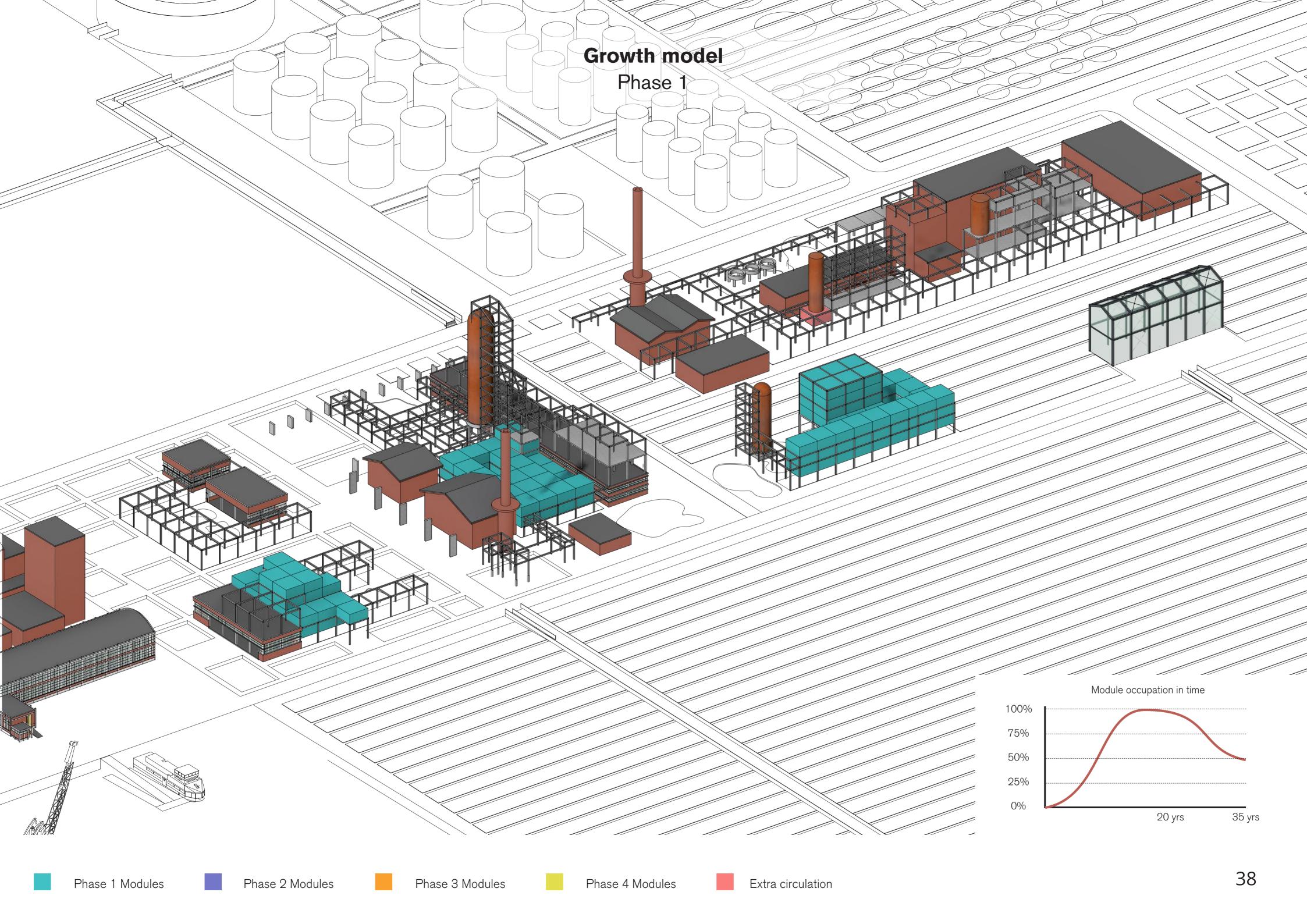


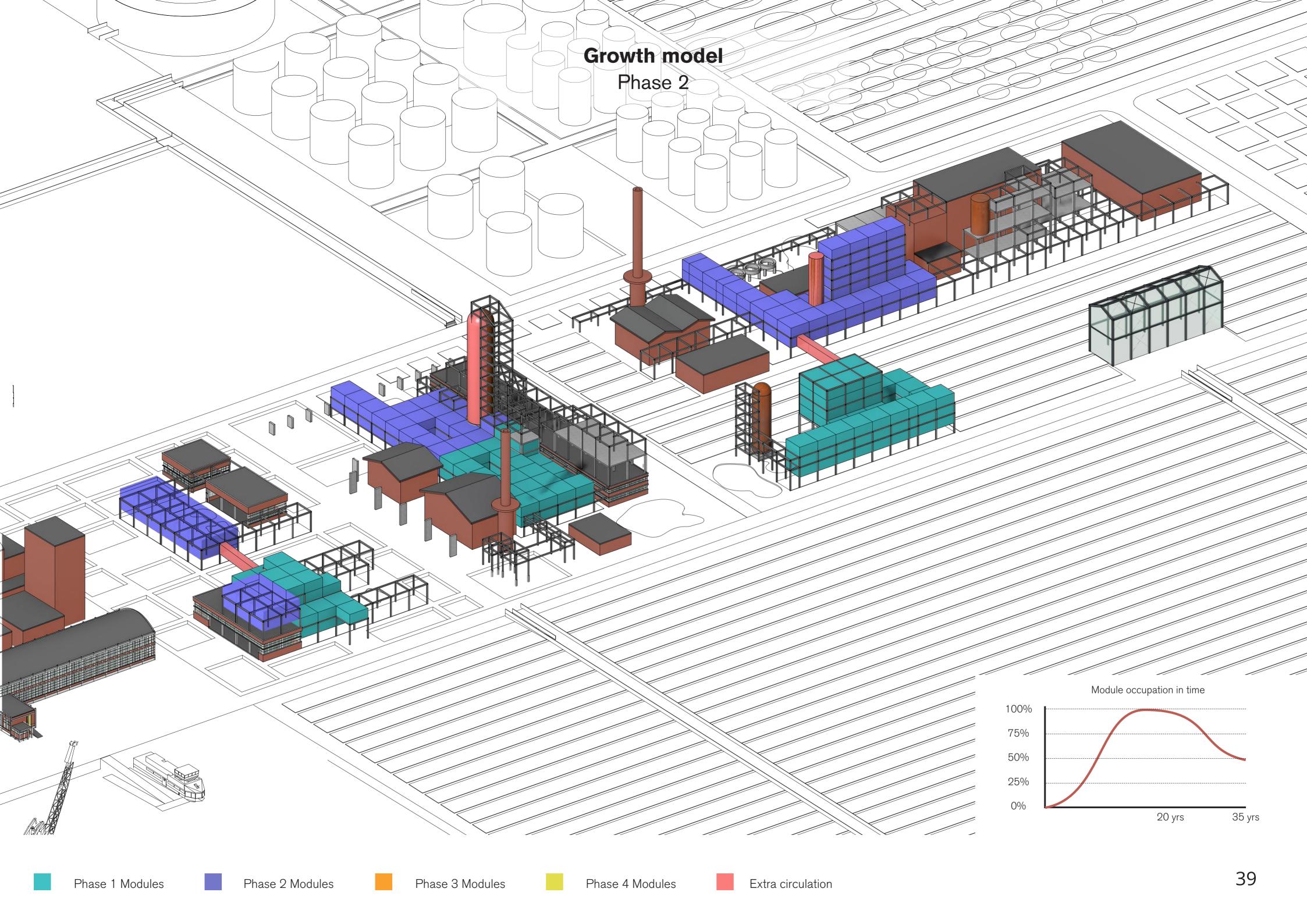


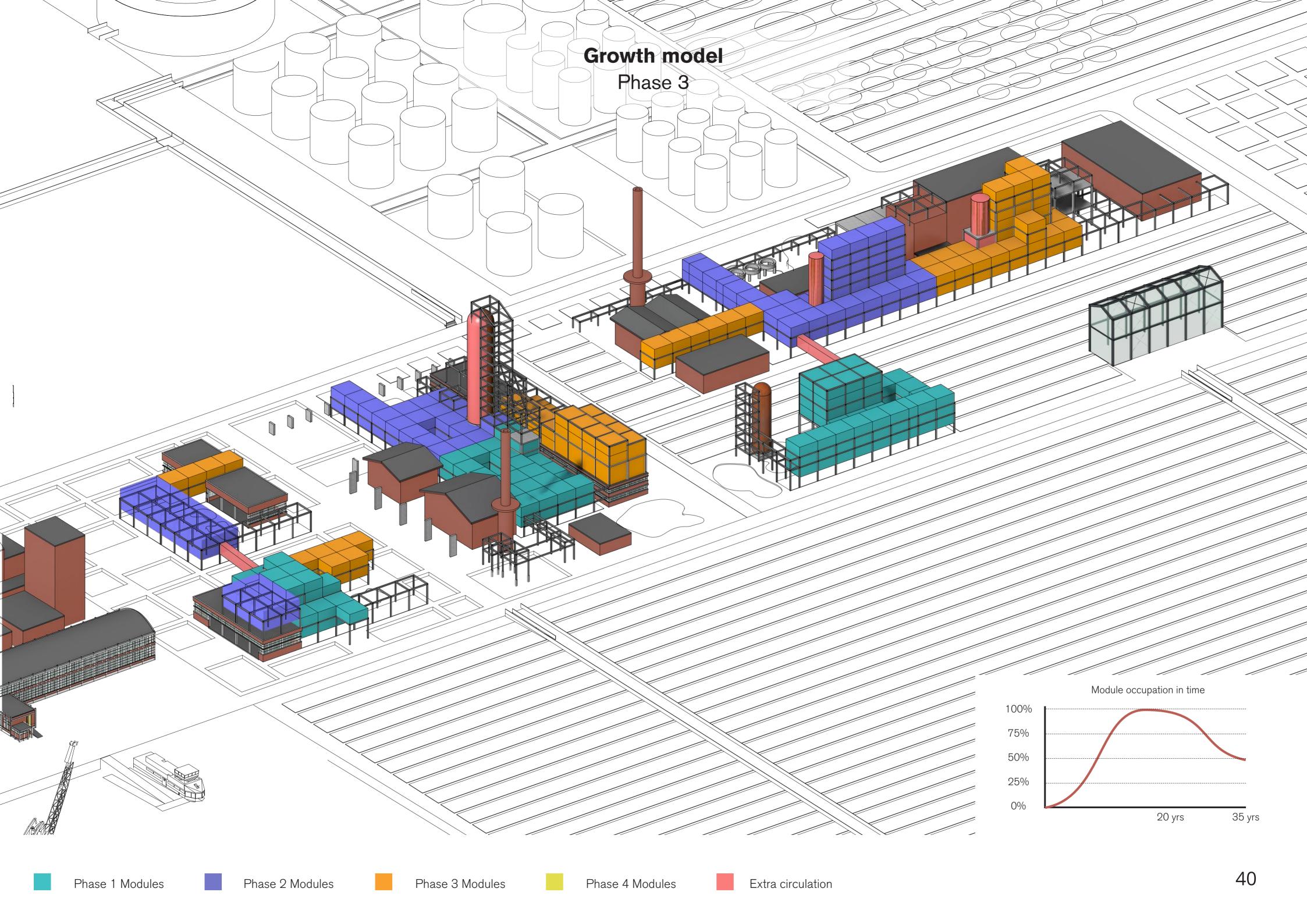












6. Program

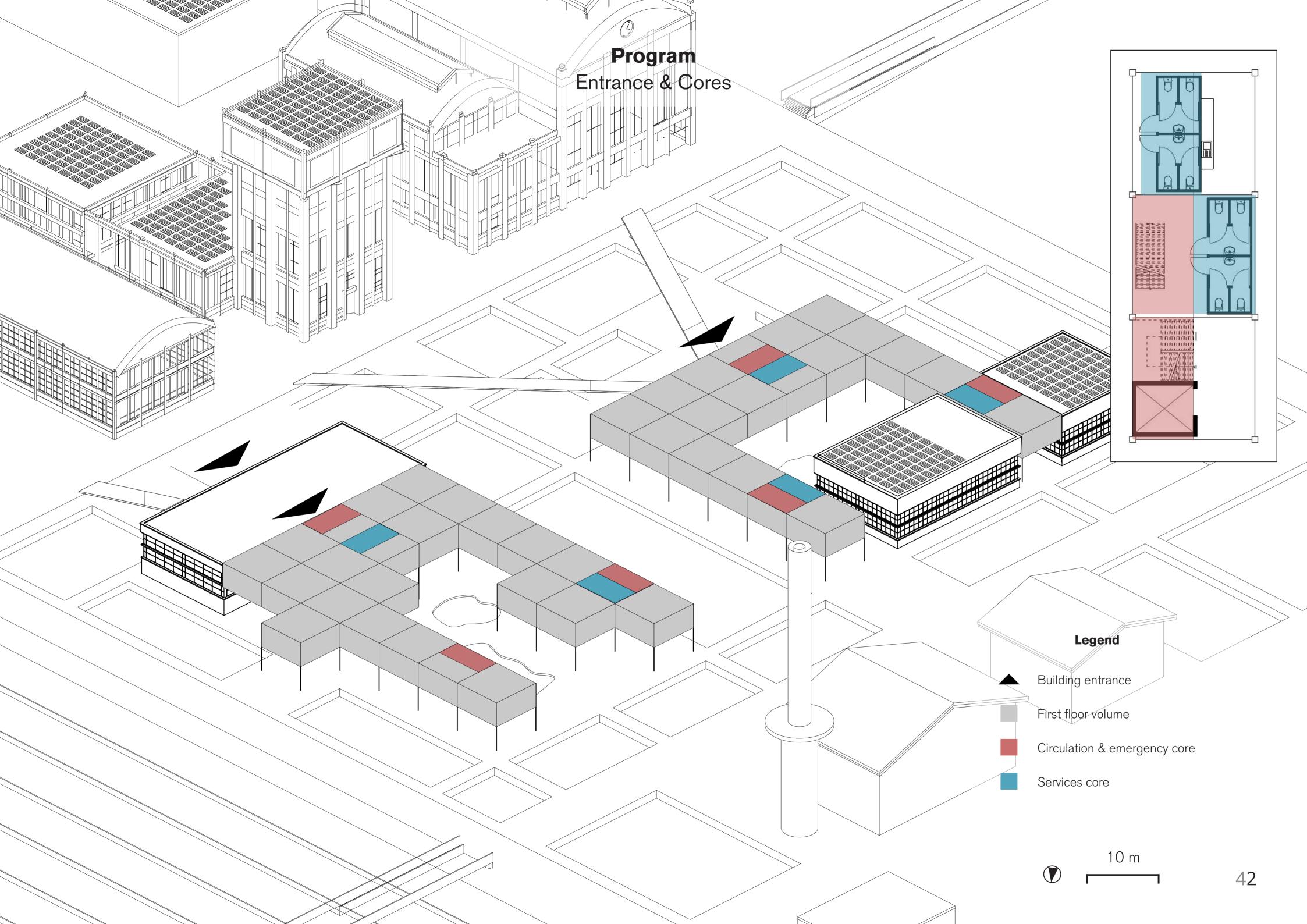
As mentioned before, the building program consists mainly of laboratories and offices. The new program is constructed in and on top of the old refinery installation steel grid, where the old pump and monitoring buildings act as spaces for the technical installations. The buildings are completely lifted from the ground, except for the builing entrances, which are reached from elevated boardwalks to make sure the users are not harmed by the contaminated plants growing. The boardwalks towards the entrances are made from old steel wire mesh from the stairs and boardwalks of the refinery installation, where the edges are made from the thick steel of the old silos. These edges provide access for emergency vehicles as well, so they can reach the entrances of the buildings.

The shape of the buildings is completely derived from the shape of the donor steel grid that the structures are built on. It follows the exact shape of the old refinery grid and wherever possible extra floors are added on top or within the steel grid. It was therefore necessary to create floor plans that are as empty as possible, to be able to tailor the sometimes strange shapes of the buildings to the needs of the users.

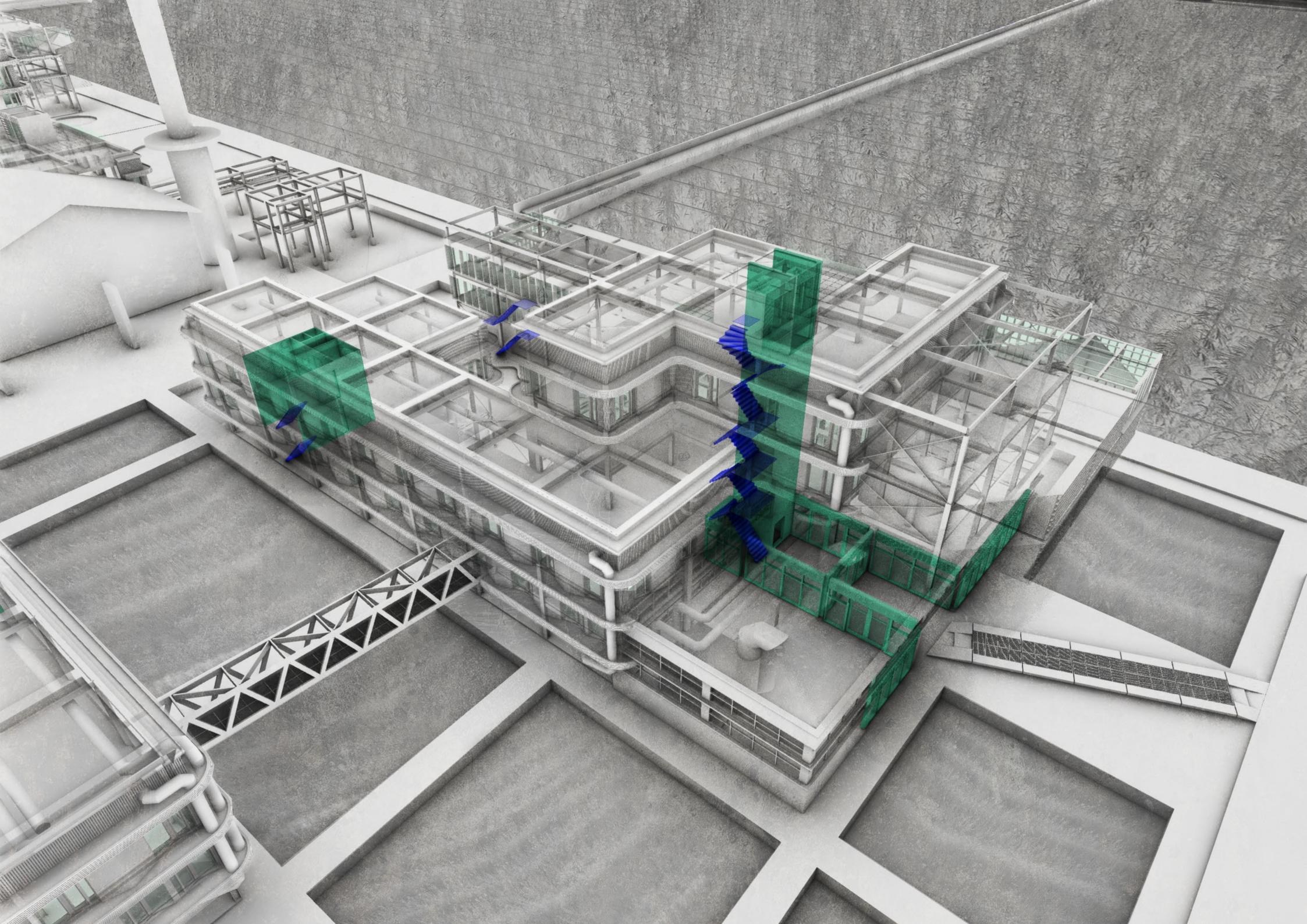
Inside the buildings are divided into wings by means of a central lobby in each building, which provides good lettability options. Every wing has a completely flexible layout except for the combined (emergency) circulation and sanitary cores. Due to the limited height of the steel grid (3 meters per floor) there is no possibility for making laboratories between the grid. That's why there is one floor added to the steel grid that provides extra ceiling height and thus space for the laboratories. Between two of the buildings that are close together and have the same laboratory type, there is an open timber bridge added to provide access to the different buildings for logistics and employees. The central cores in each building also provide access to the roofs for employees to take a break or for maintenance people to harvest plants or perform other maintenance to the buildings.

It is feasible that the laboratory conditions or research projects in the laboratories change over time, especially with the growth of the project. The buildings are designed in such a way that a whole new wing can be added relatively easy. However, that is not something that would be done on a regular basis, but once every 5 to 10 years. To still provide maximum

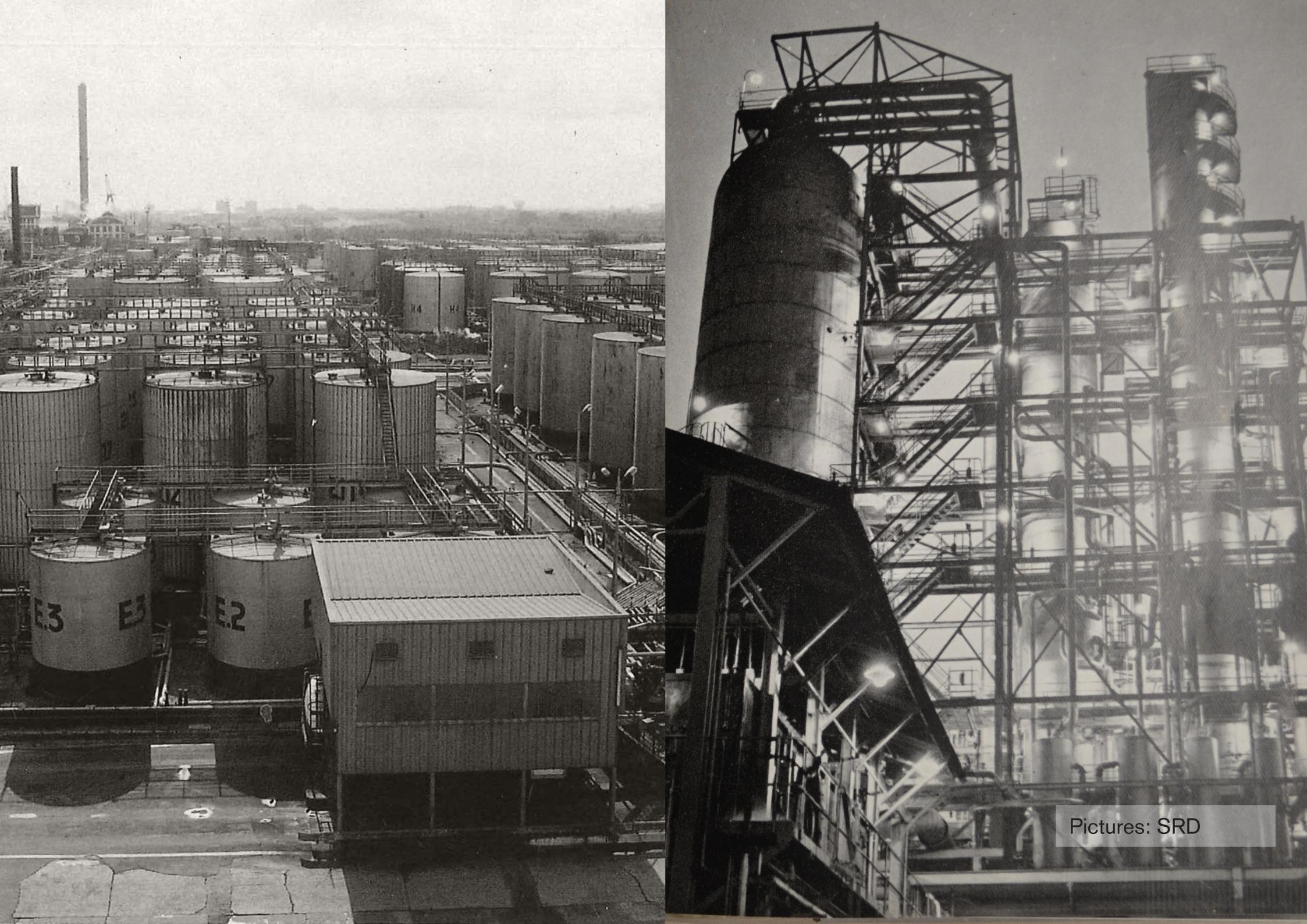
flexibility in the use of space, each laboratory has a few empty units inside the steel grid that provide space for a plug-in module. These modules are boxes with a length of 8 or 10 meters, that are self-contained units and can be plugged in and out of the building easily with a crane. Once connected they can make use of the extraction system of the laboratory, but they are designed in such a way that they could also as stand alone units on site somewhere. The modules can house specialist lab equipment that is needed for specific, temporary projects, or for experiments that require specific climates or growing conditions. The aim is that these plug-in units that can move around the site to anywhere they are needed for a while, these conditions can be easily met, without having to change the whole layout of the building. The visuals on the next pages provide more insight in the layout of the research program of the project.



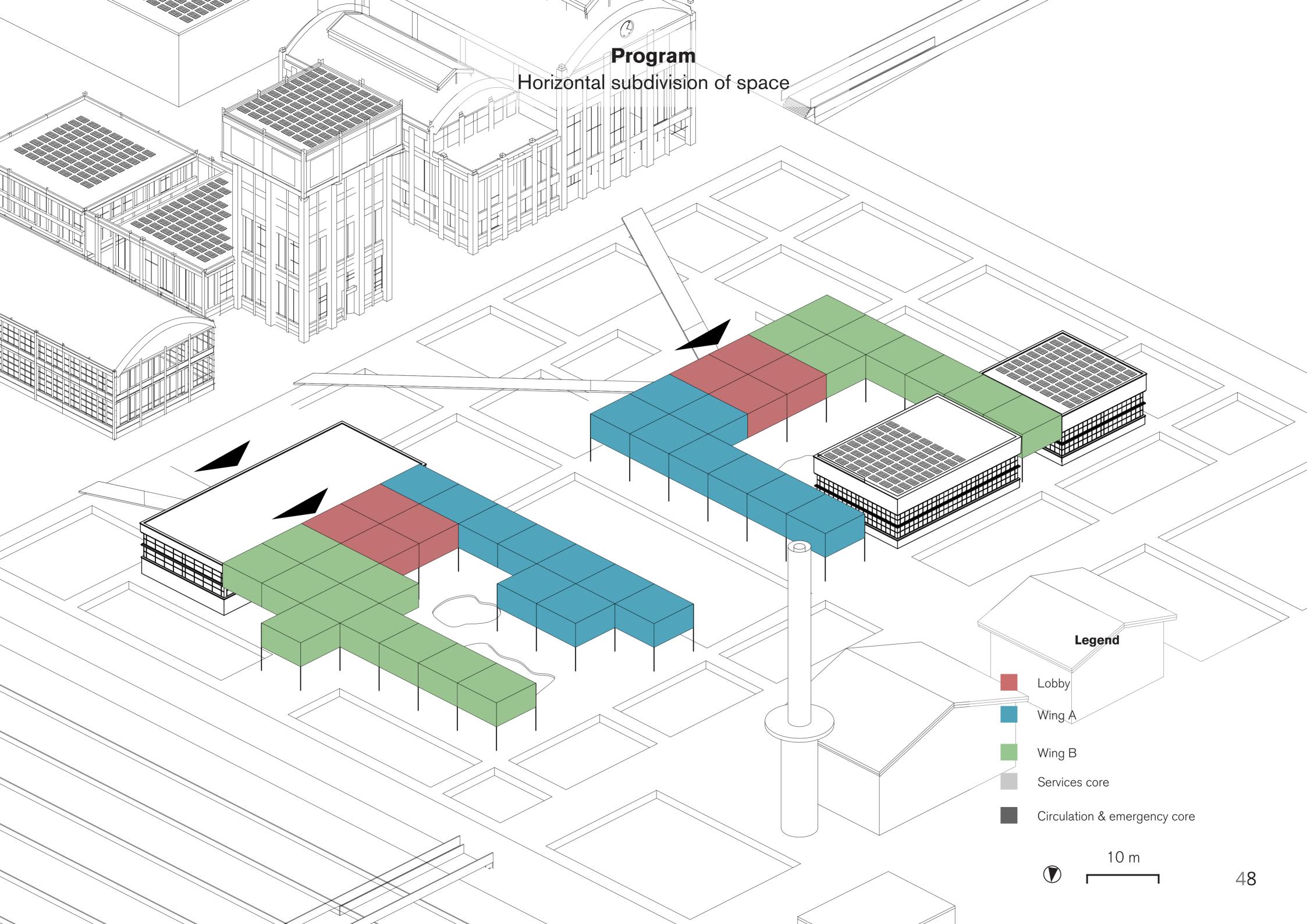


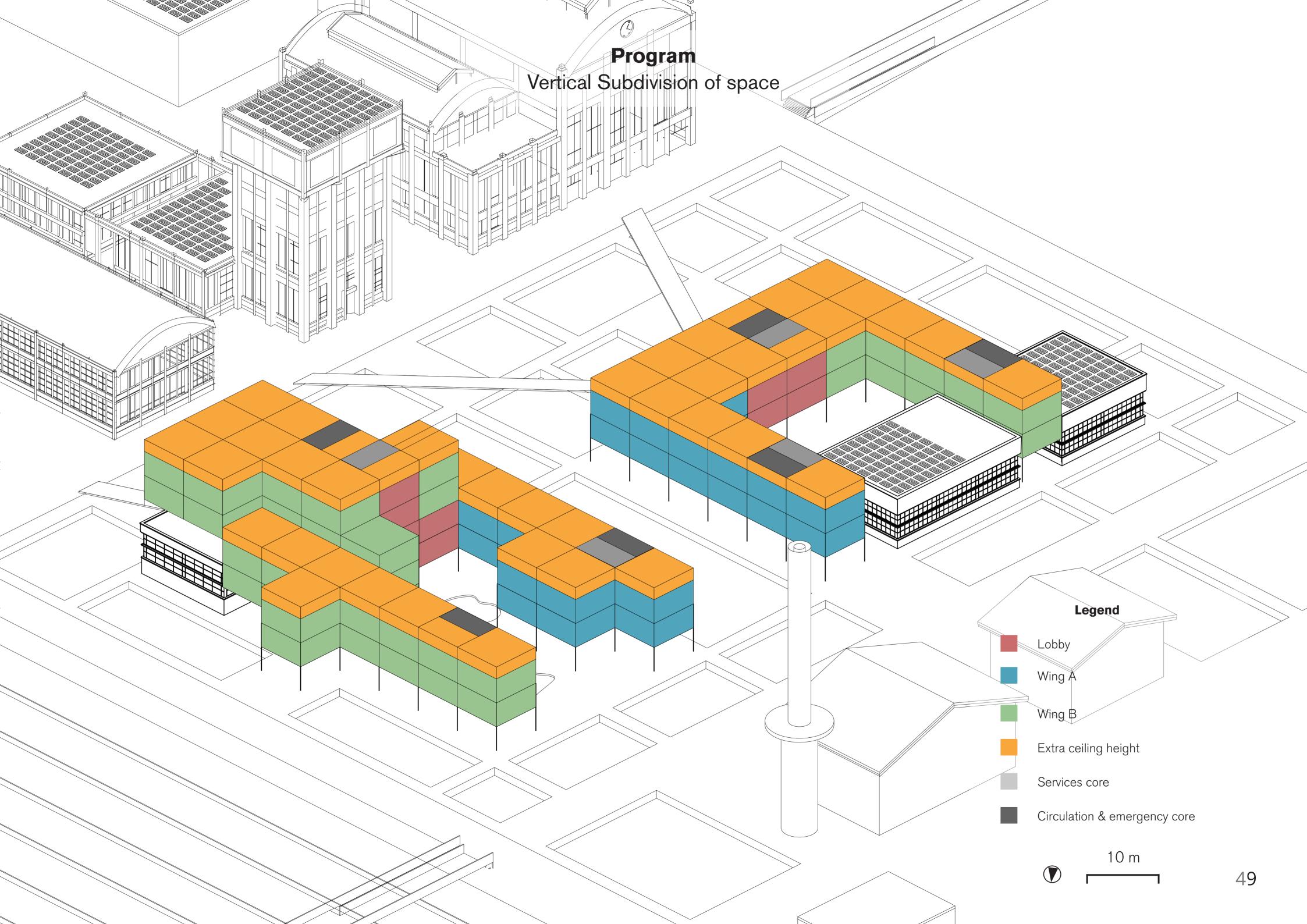


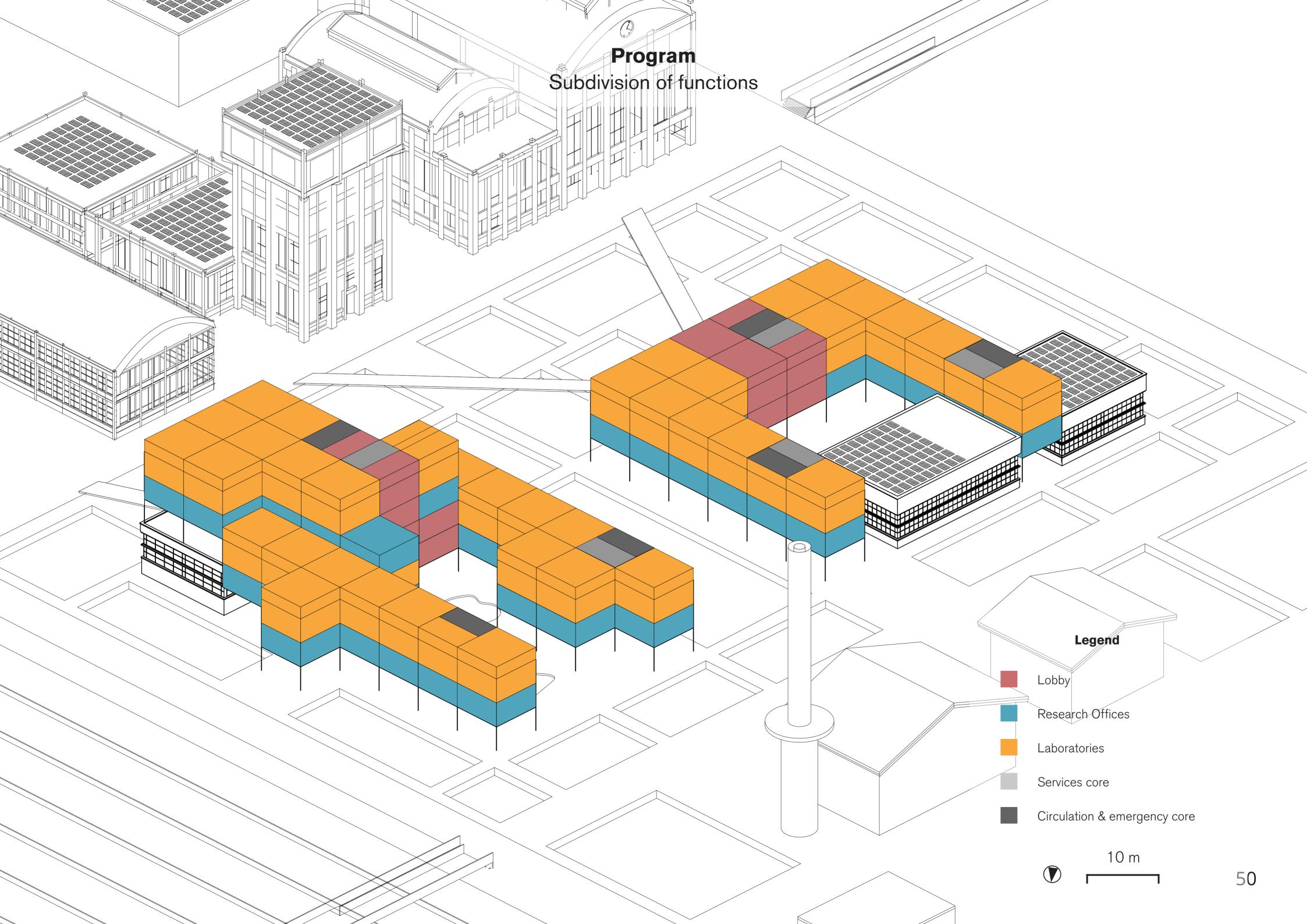


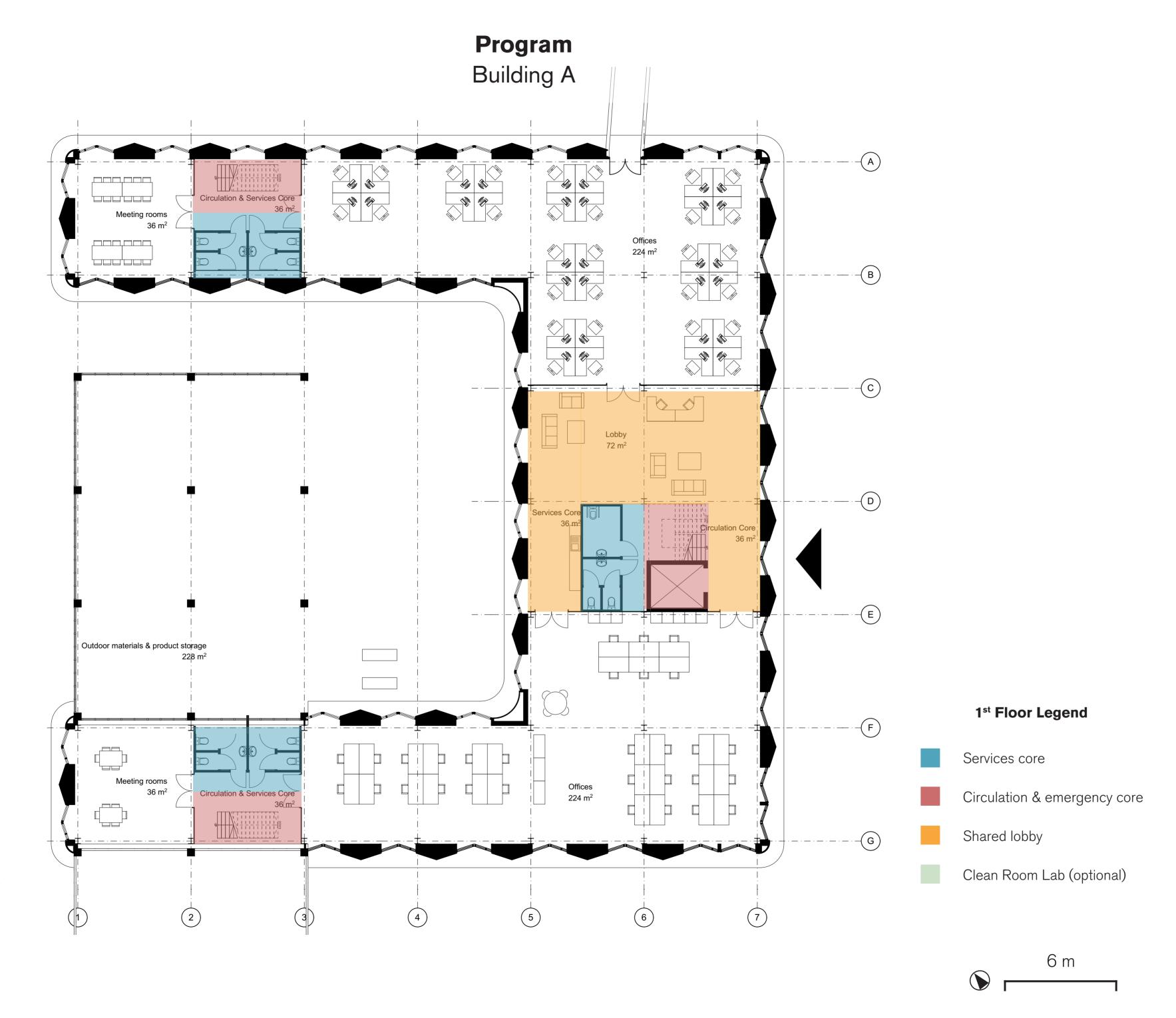




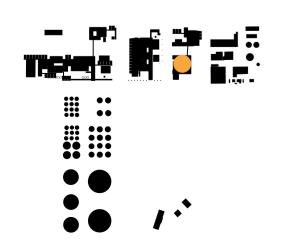




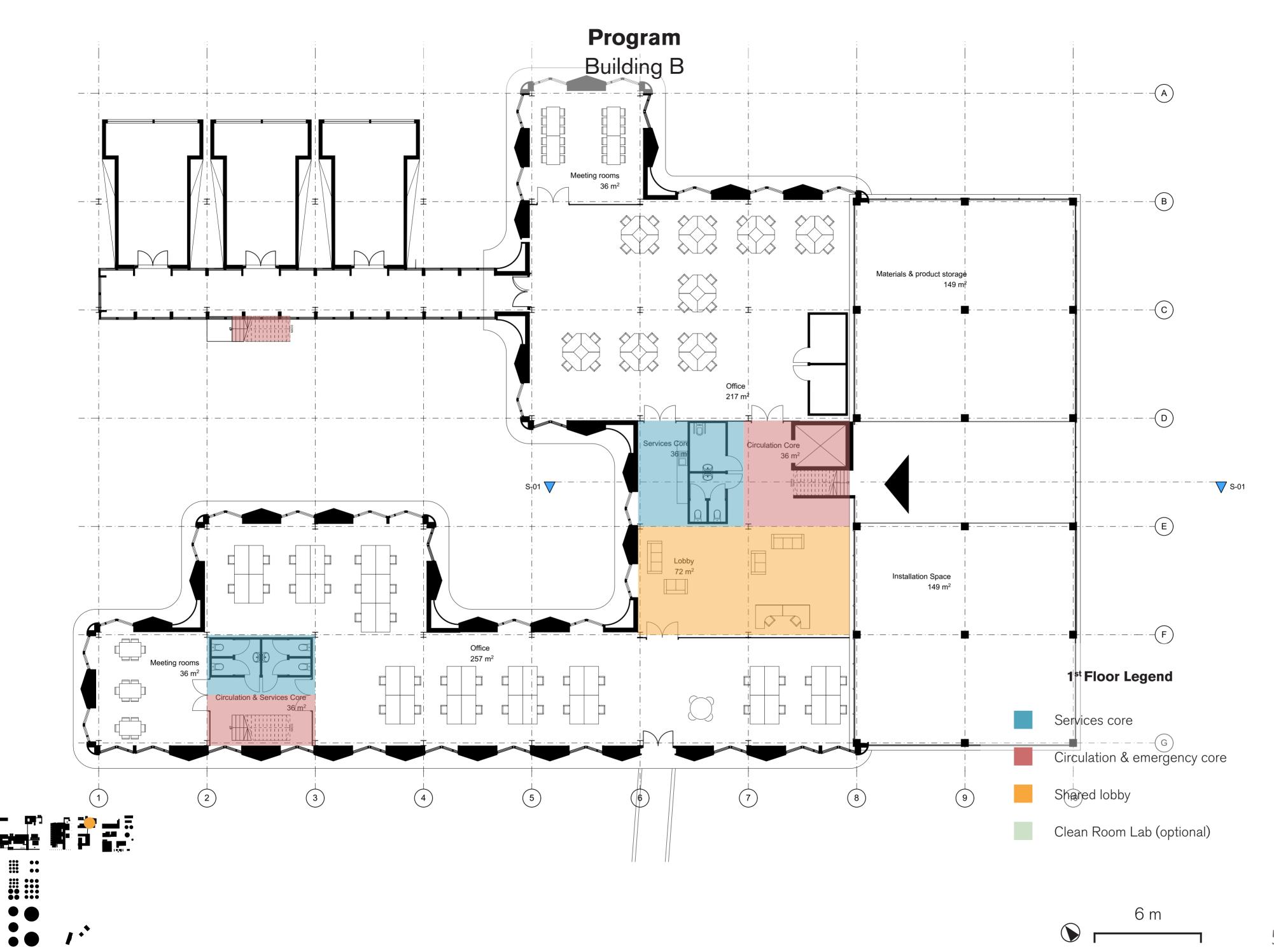








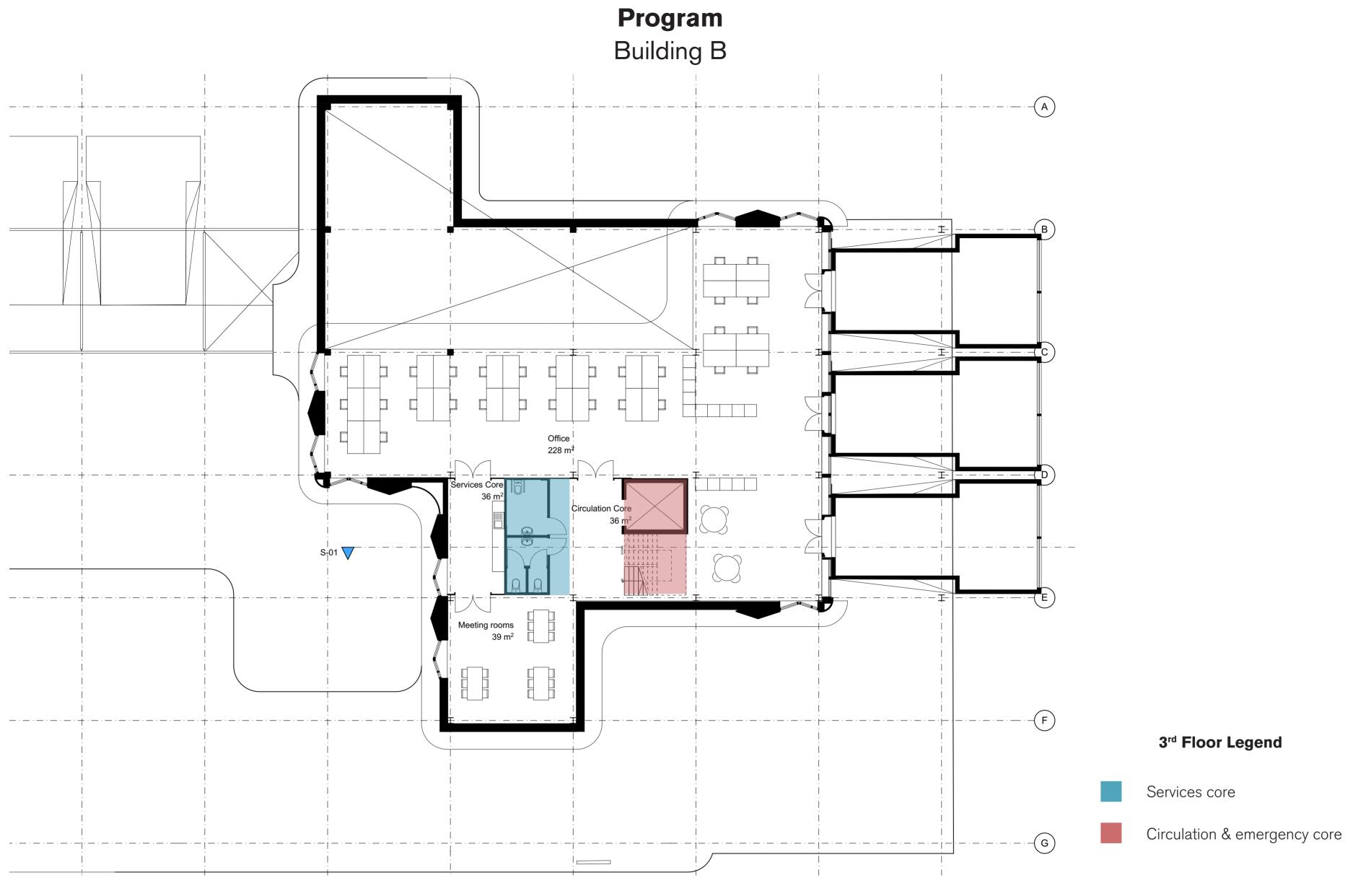


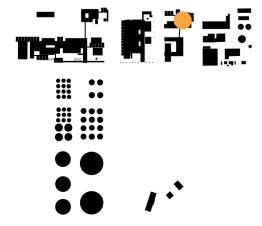


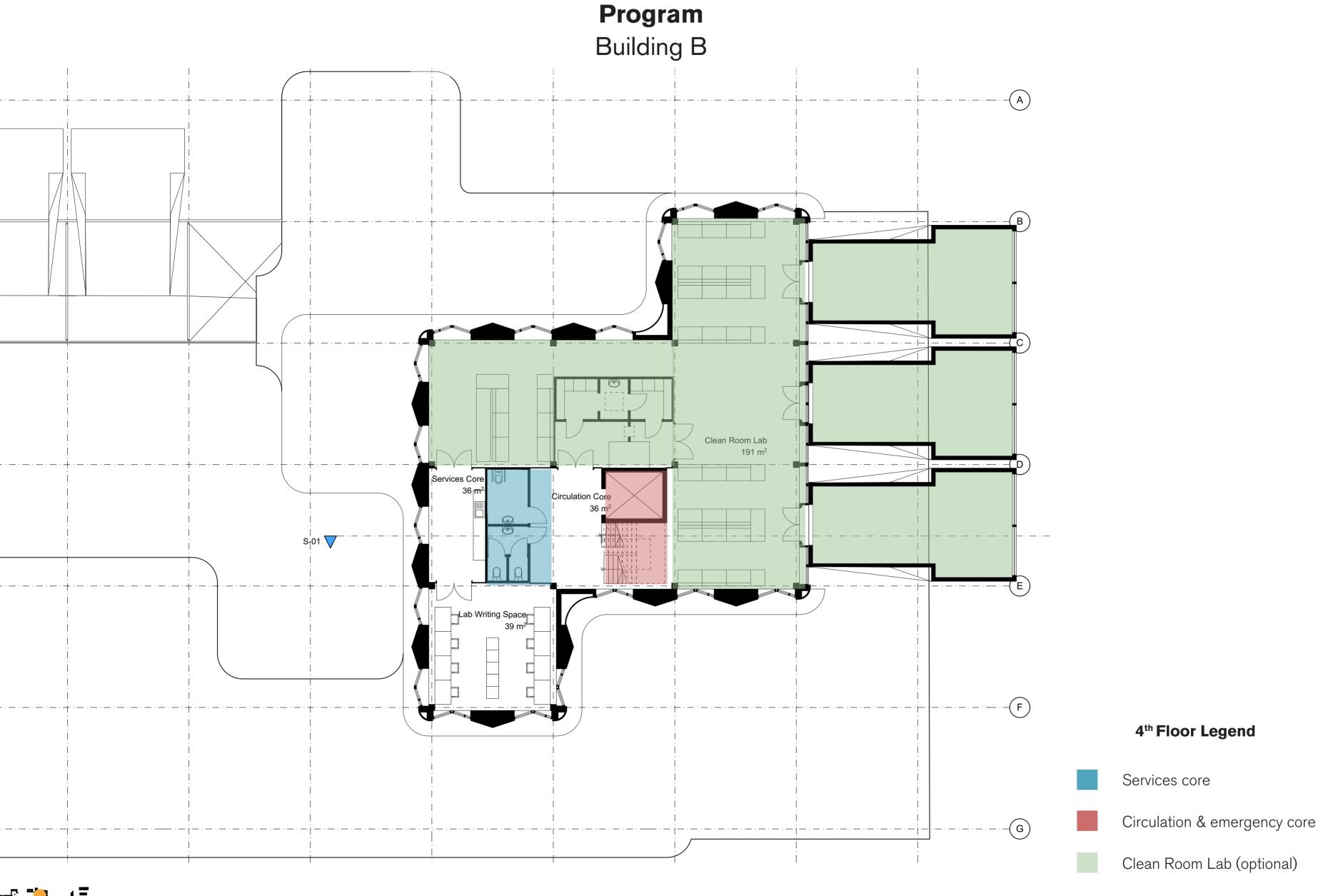


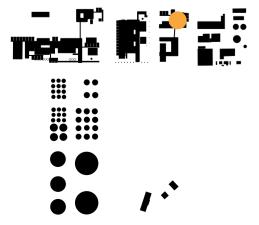






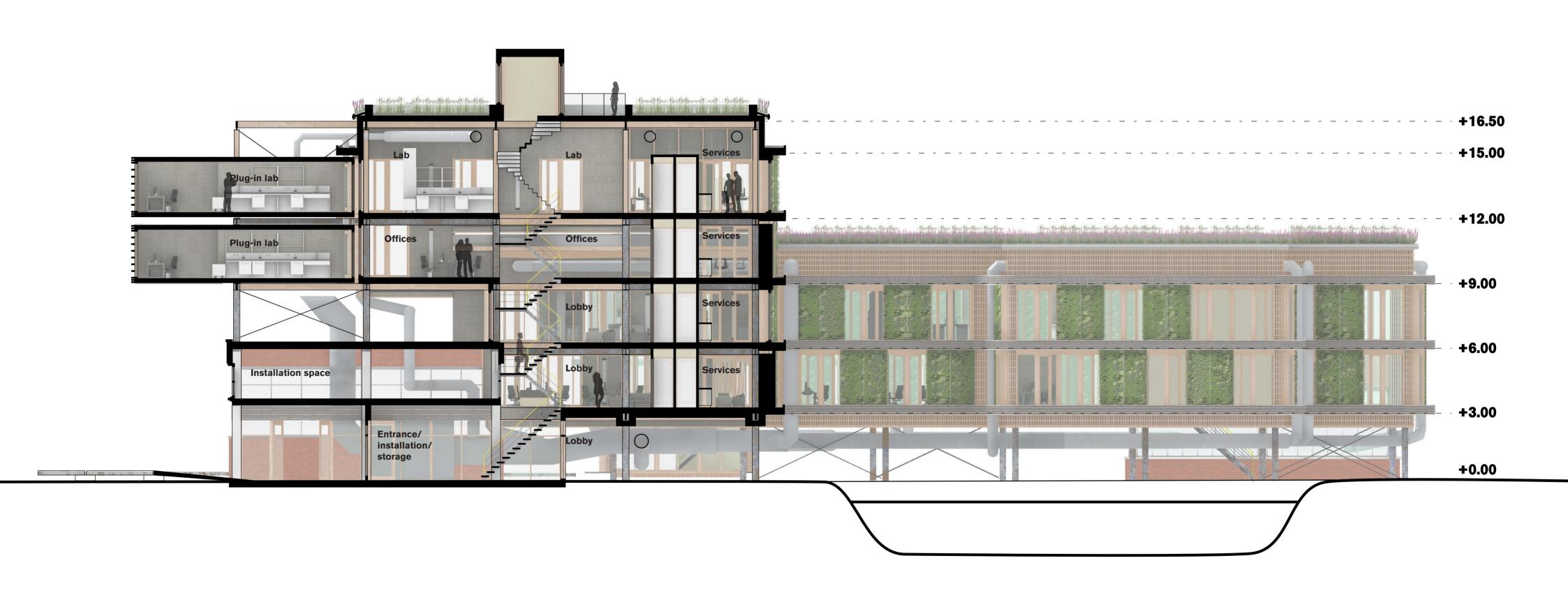






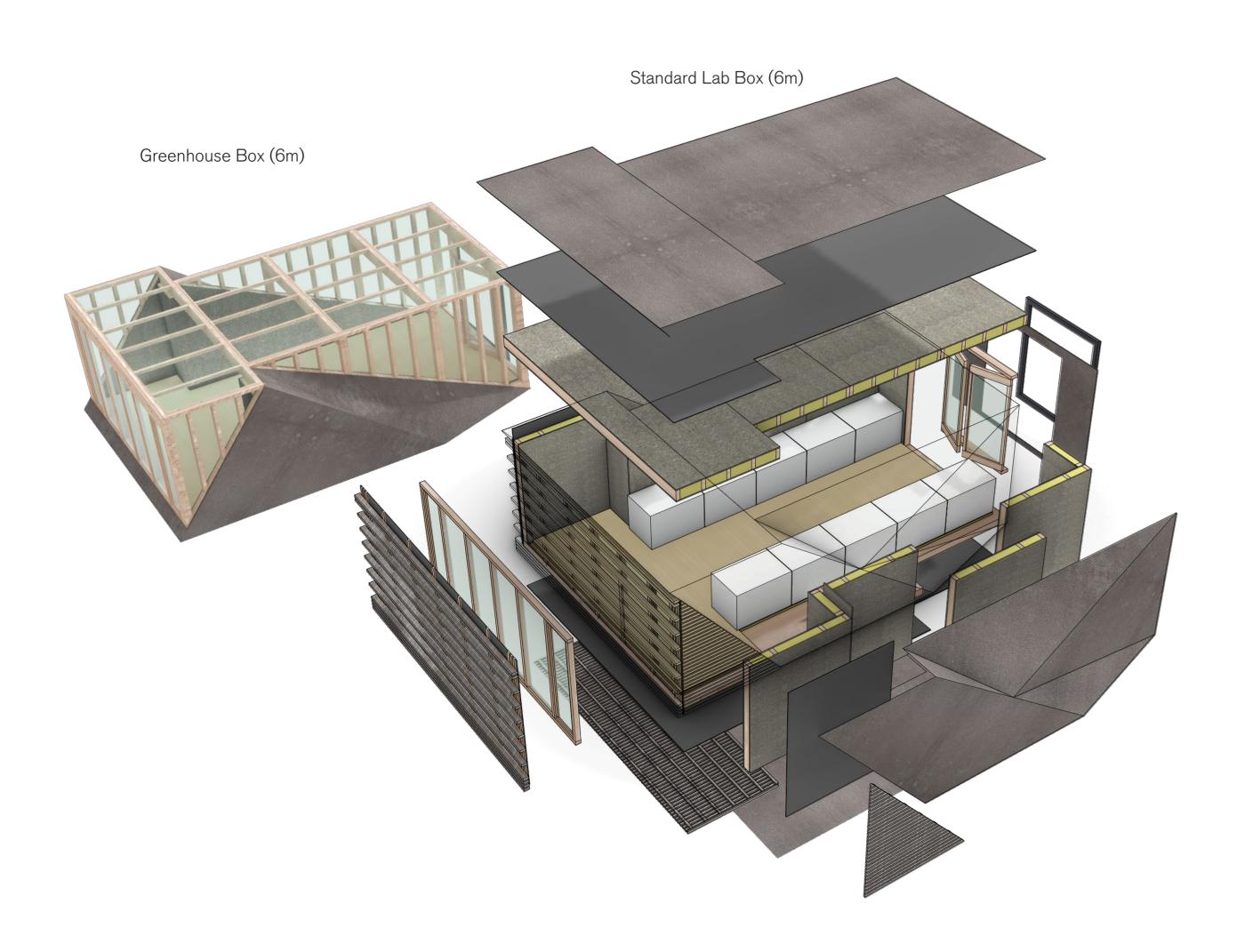
Program

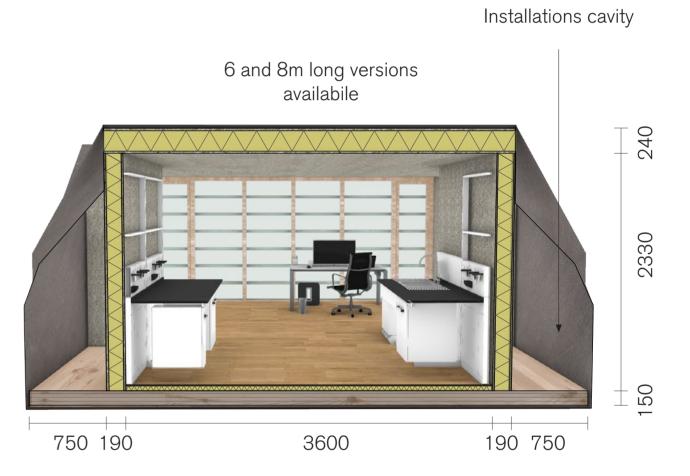
Building B



Program

Plug-in Module

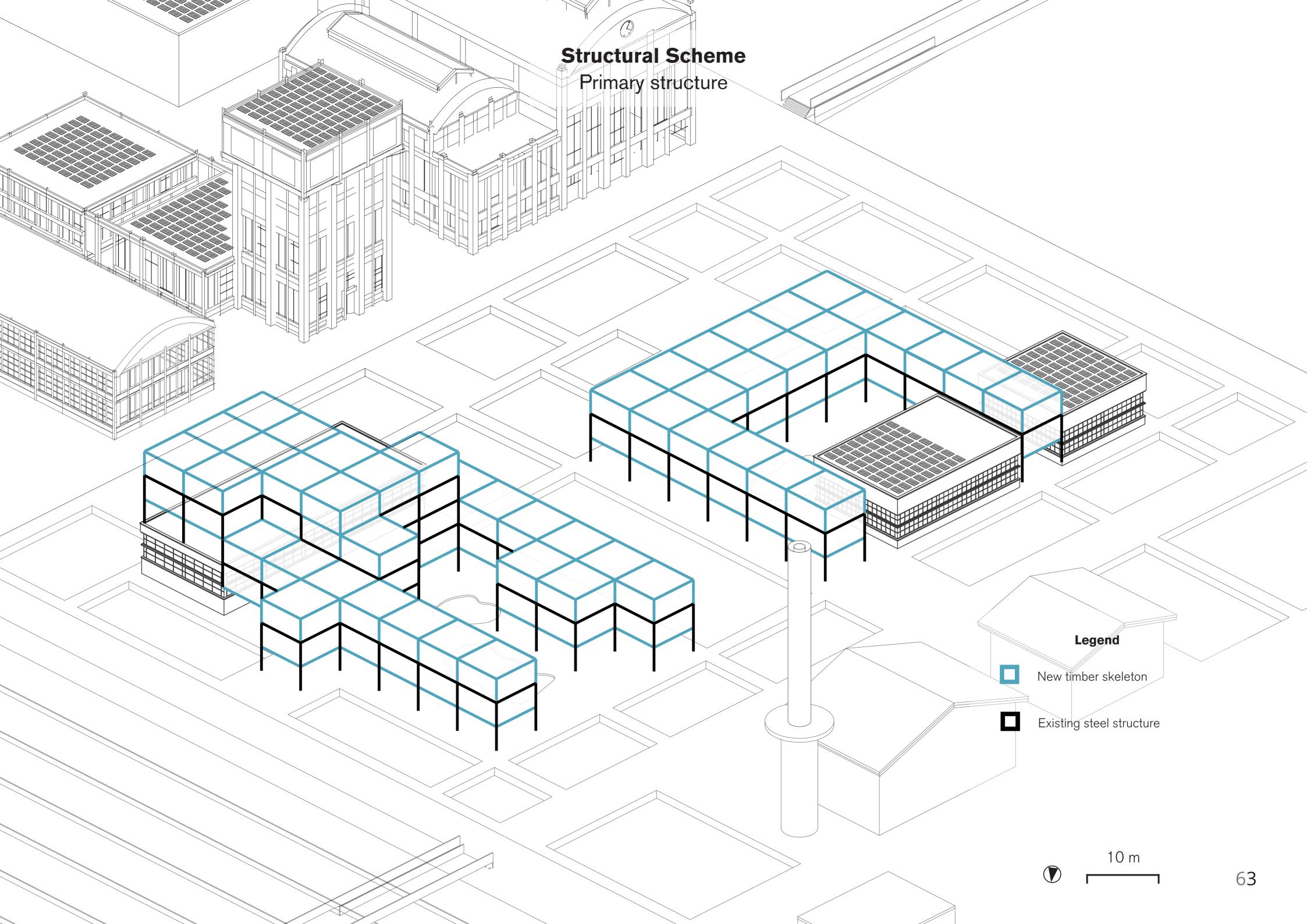


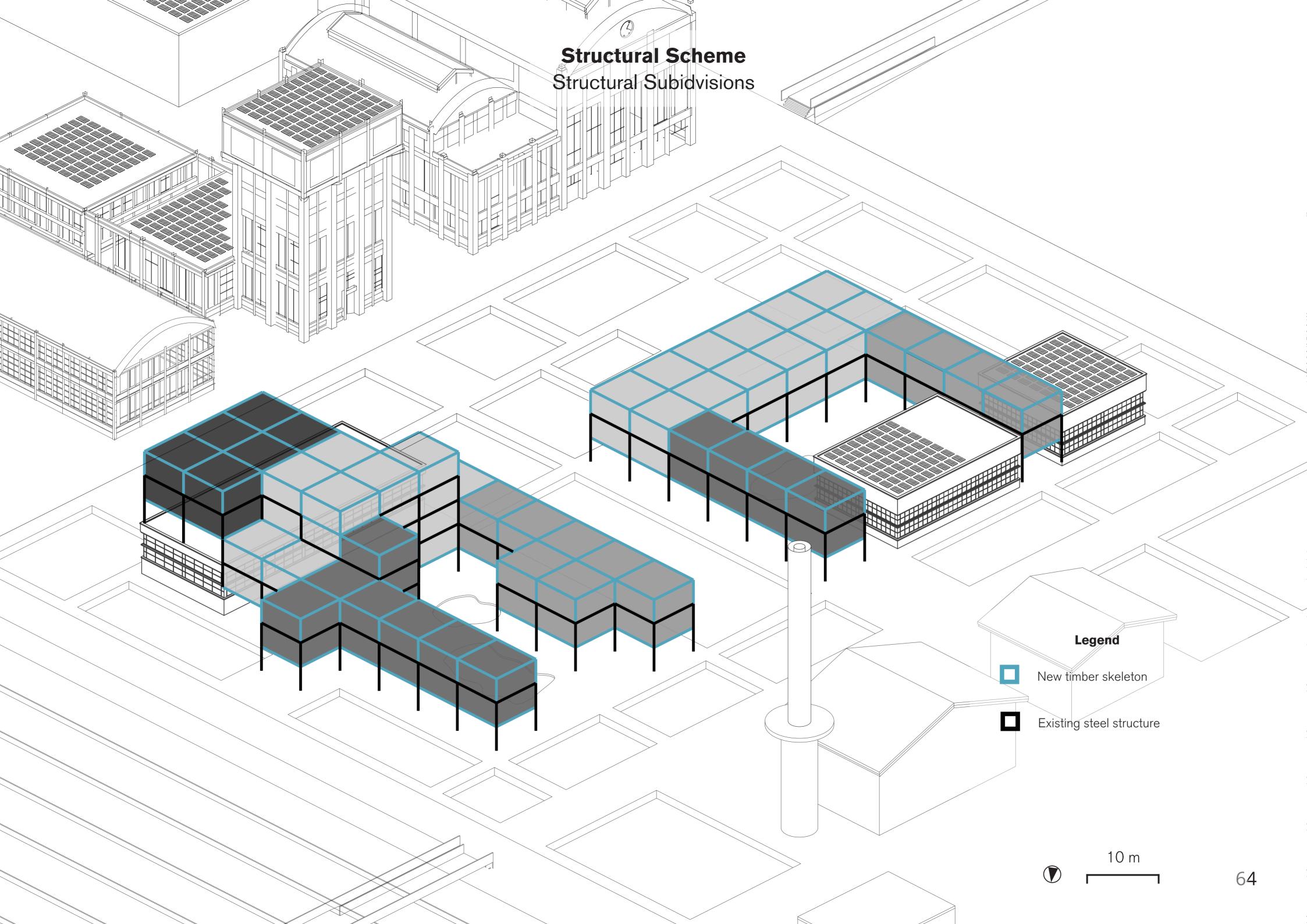


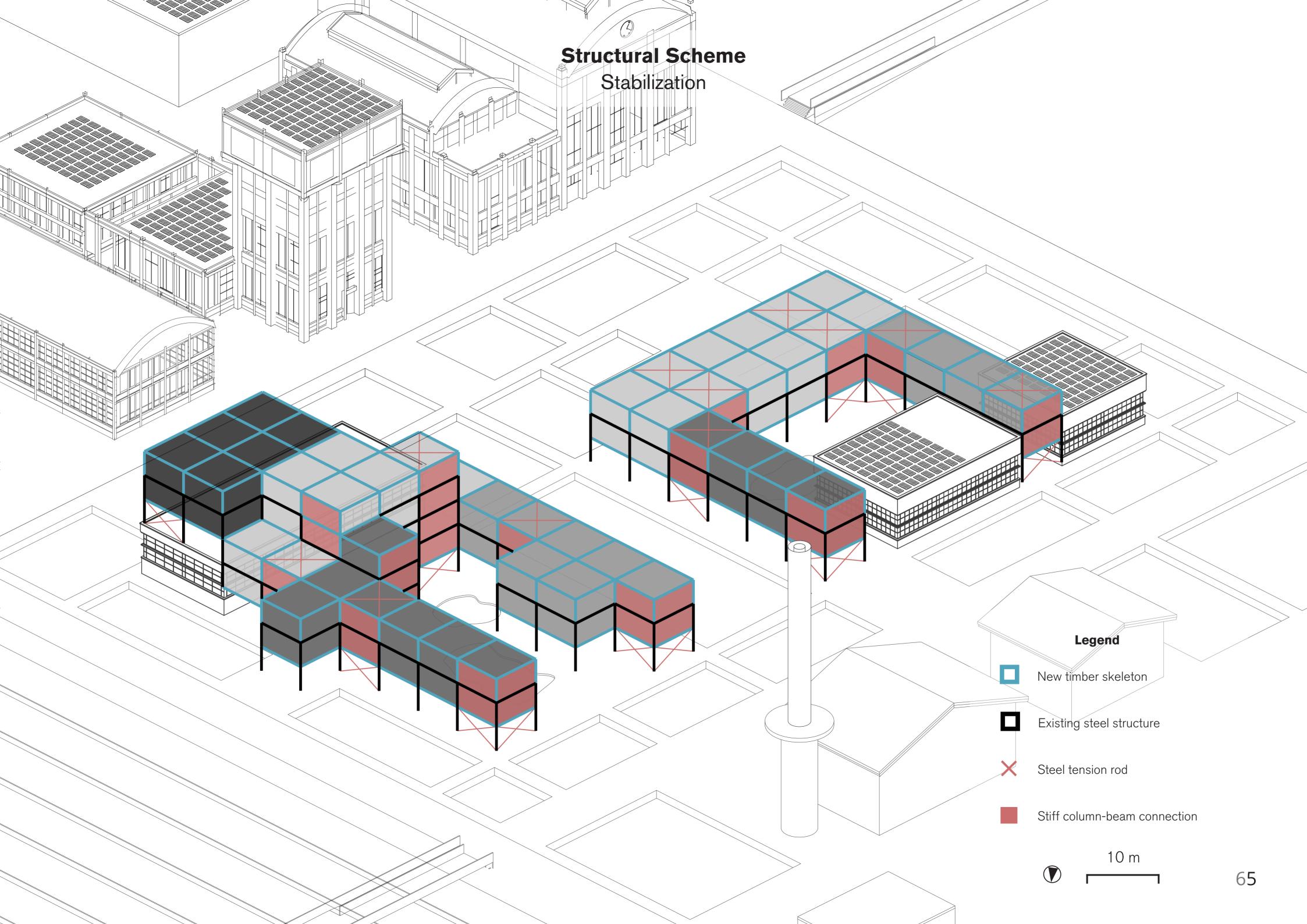
7. Structural Scheme

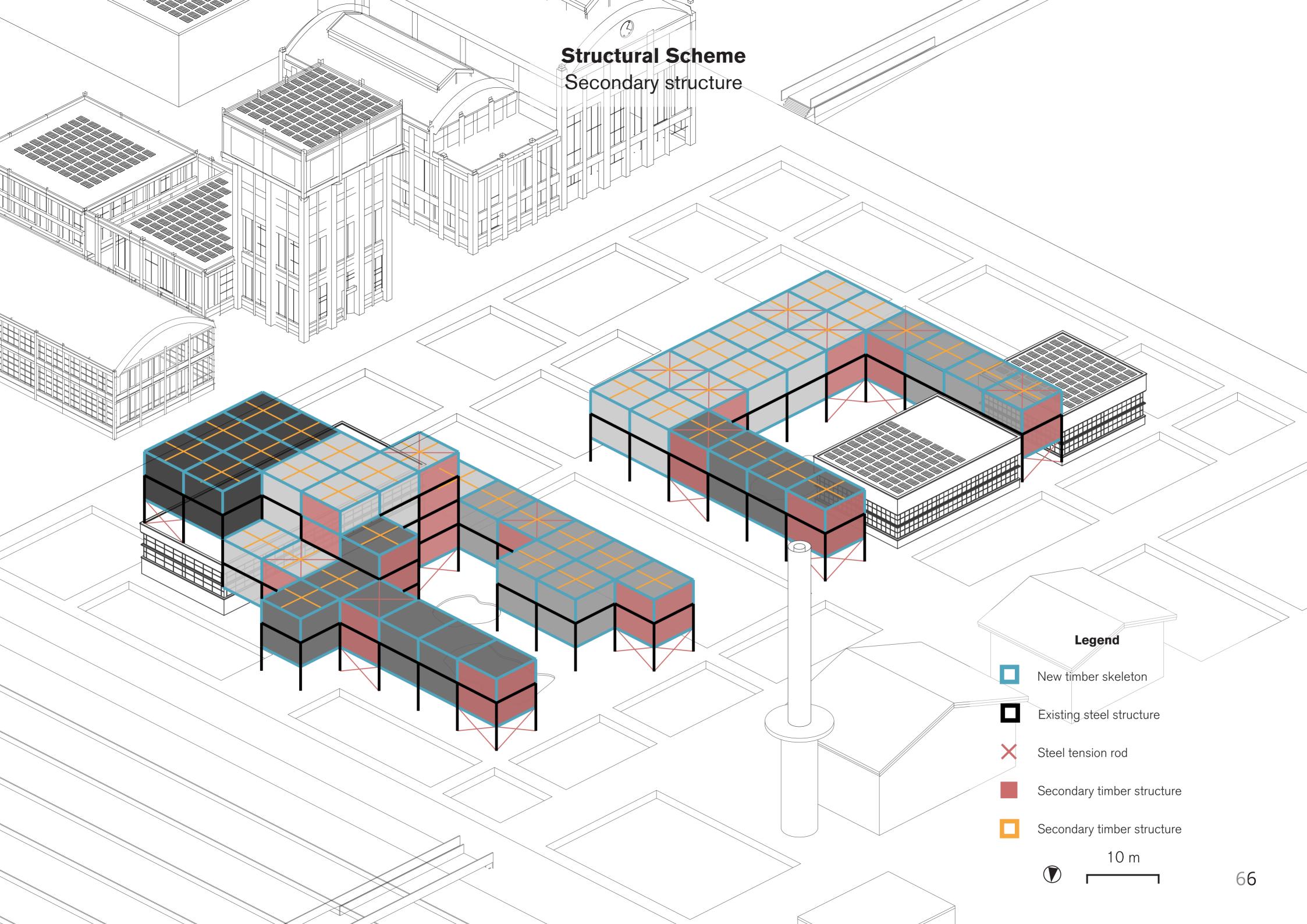
The structural scheme of the building relies heavily on the existing steel structure of the refinery installations. As mentioned in the previous section, the building shapes almost one-to-one follow the structure of the existing steel grid. To create a usable amount and concentration of spaces in each building, some extra floor space and height needed to be created. Besides that, the old structure that had a different purpose was stabilized in places that are not suitable for the new functions. To overcome these problems the following design considerations have been taken into account:

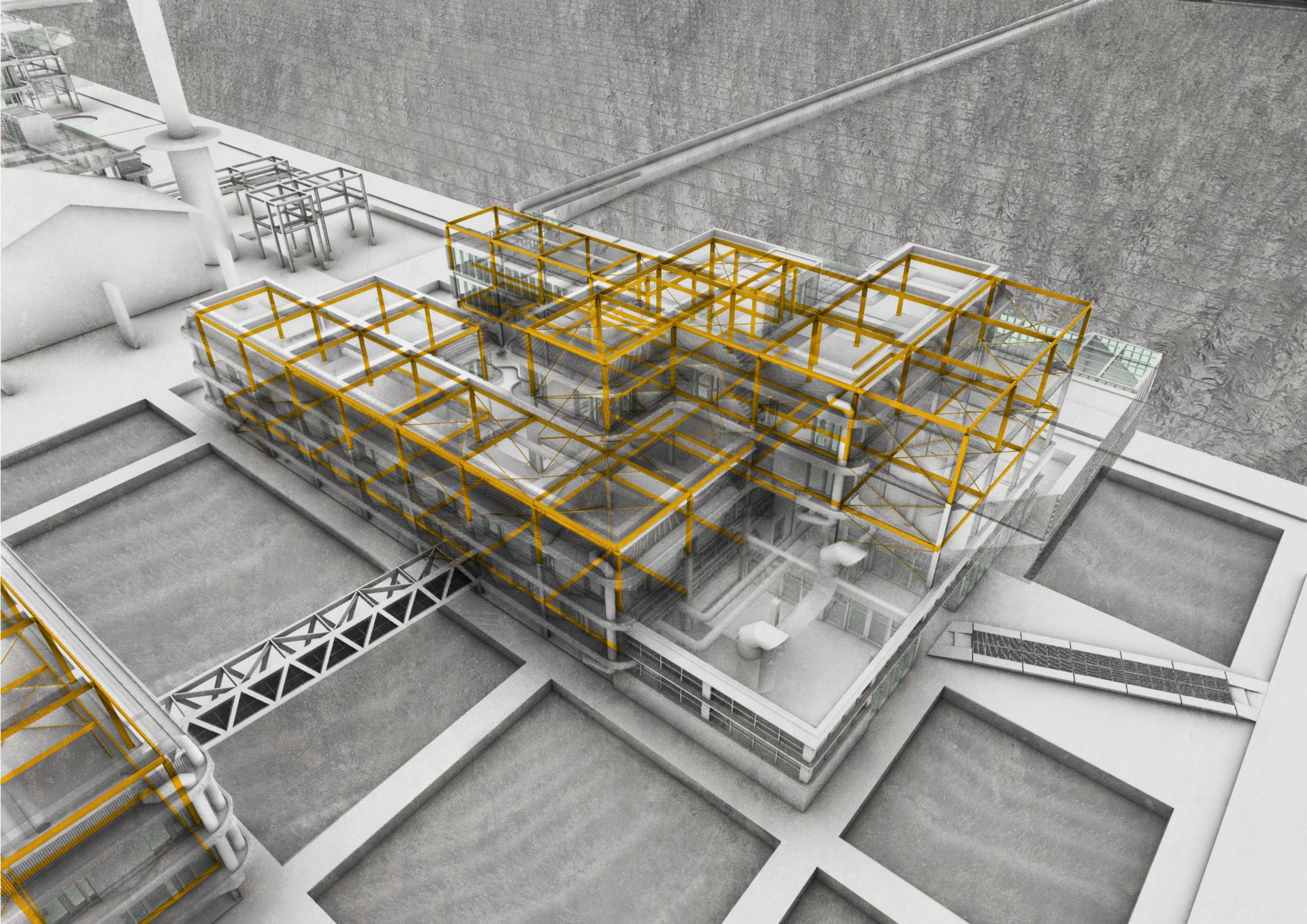
The structure is topped up and sometimes expanded in between the existing steel grid with a Cross Laminated Timber (CLT) grid of beams and columns, following the old structure. The stabilization of this structure is done by means of steel tension rods in the areas that are not occupied by facade, to not let this interfere with the skin that will be wrapped around the building. Here the connections between column and beam will be made stiff. The building level below the buildings and the roofs and floors that need stabilizing elements will be stabilized with the tension rods. The floor beams and grid will house massive CLT panels to provide the possibility of vibration-weak floors and placement of heavy equipment. Since this vibration requirement is not needed on the roof, there is a secondary timber structure added within the roof grid to decrease the span. By decreasing the span there is no need anymore for using CLT, but the usage of normal timber sandwich panels is made possible. This is good for the afterlife of the building. The big CLT slabs can be used somewhere else, but the timber sandwich panels can be taken apart and reused in a different way. This construction is also a lot lighter than the massive floor panels. The diagrams on the next pages visualize the structural diagrams for the new buildings.











8. The Building System

After the introduction of the building structure, the next step is to house a skin around the facade. This skin consists of a modular building system and forms the backbone of the architecture. The system of modules is designed in such a way that it provides maximum flexibily for the users and the possibility to use the system in different places. The system consists of one main closed element and one open element with a cantilevered roof on top. The closed elements house a decentral ventilation system and panels with vegetation.

The vertical part of the elements are folded towards the center of each module. They are folded for a couple of reasons. In the green elements they are folded to create space for a decentral ventilation and heating system that provides the basic ventilation and heating and cooling for the building. They are also angled to provide easier access to maintenance of the panel while standing on the gutter goes around the building, which brings us to the open modular elements. These elements are angled first of all for reasons of sun shading. In combination with the straight gutter roofs that form to the top of each modular element they form natural sun shading when they are folded inwards. These elements can be placed on the southeastern and southwestern facades. The outward folding elements on the other hand, provide extra daylight penetration on the other facades, where the amount of light is lower and maximum use of daylight is demanded.

The cantilevered roof-gutters are covered with sedum vegetation that help with the water run-off from the gutters. The folding of the modular elements provide the opportunity to create a workspace for maintenance on each elements without having to create a very large cantilever of the roof. On the bottom of each roof a safety rail is installed that provides the possibility of a safe working space for maintence of the vegetation panels. For the vegetation panels a plant selection is made that is based on its purifying potential, and the placement of the plants in relation to the daylight it receives.

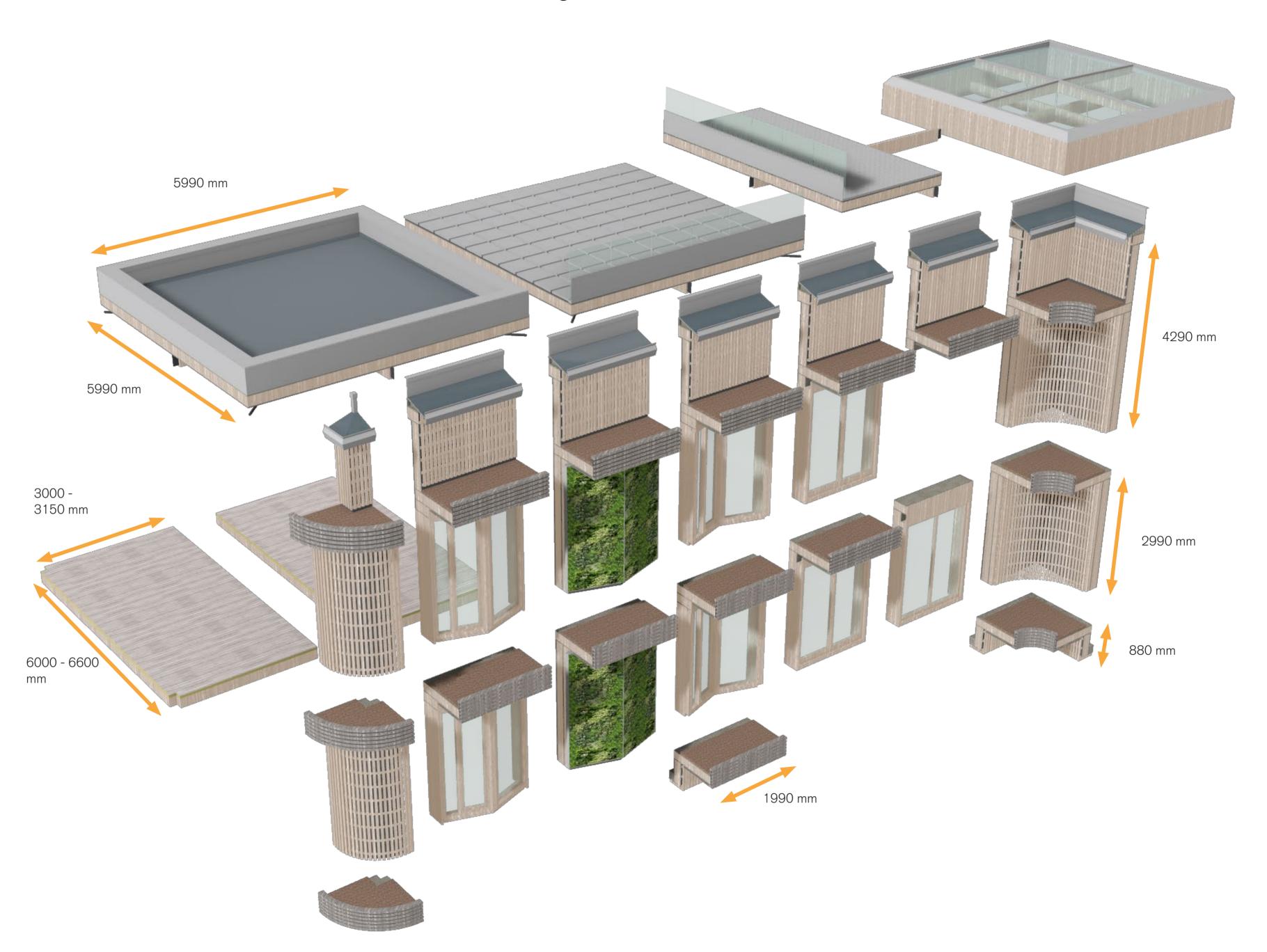
The building modules are created mainly from two materials: Timber for the main structure and framing, and hemp or flax for all the sheeting and insulation material. The hemp and flax can be harvested from the remediation plots on the site, but the timber needs to be imported from other places. For environmental reasons the choice of timber is Platowood, which is more durable than traditional wood and not treated with chemicals but with heat for strenghtening. However, there are innovations such as timber surrogates from hemp that are getting close to large scale implementation. The idea is that the research labs help accelerating these processes and these products can later be used to make the buildings and other systems on the site more and more independent from external sources.

The floor panels inside building are just plane Cross Laminated Timber (CLT) panels with a layer of insulation on top. The choice for this material comes from the demand for heavy equipment on the floors and the need for reduced vibrations in the floors. The problem however, is that CLT is not recyclable because of the glue. The panels are large though and could be reused in a different place. However, for the roof panels the requirements are less, and due to the secondary timber structure a more lightweight sandwich structure could be used.

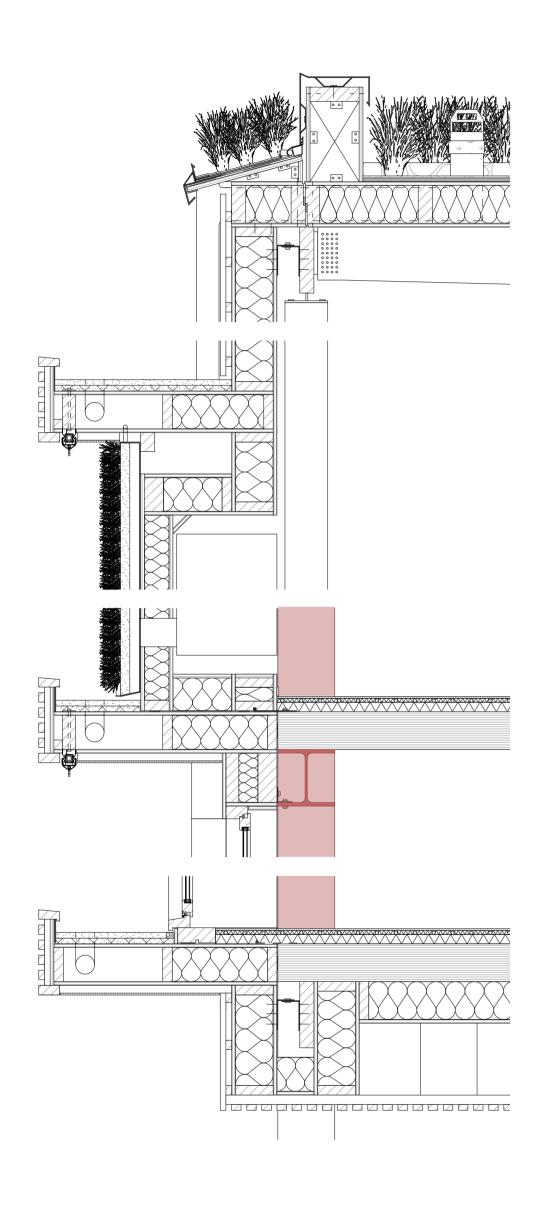
All the facade, floor and rooftop modules are bolted to the main and steel structure, and also the connections inside the modules are screwed and bolted, to maximize its reuse potential in case the modules need to be dismantled.

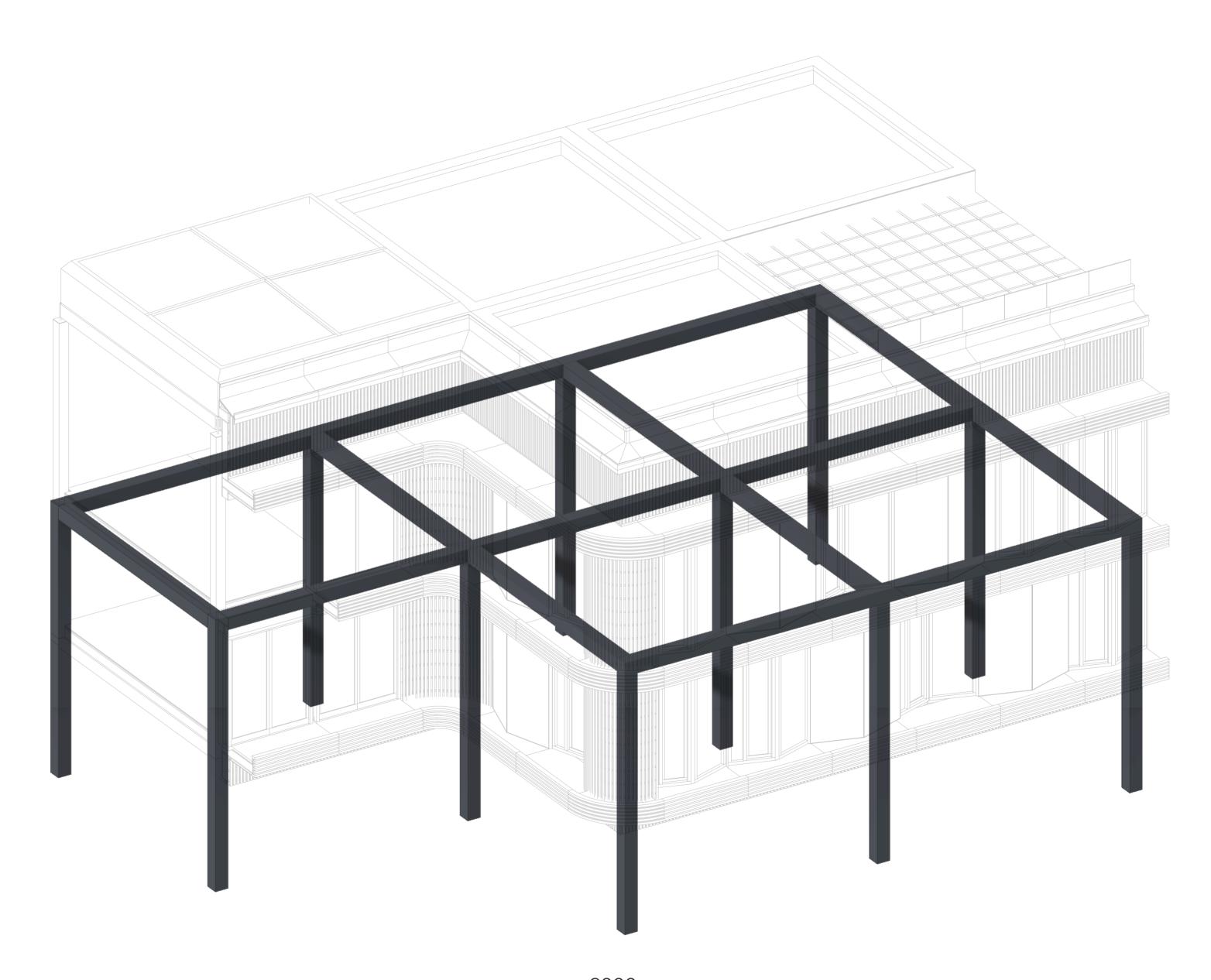
The next pages show a sequence of the how the building system is placed on the substructer, the different type of modules that are used to create the building system, some more information about the different materials and some details on how they are attached to the building structure and how the maintenance system works.

Catalogue of modules



Existing Structure

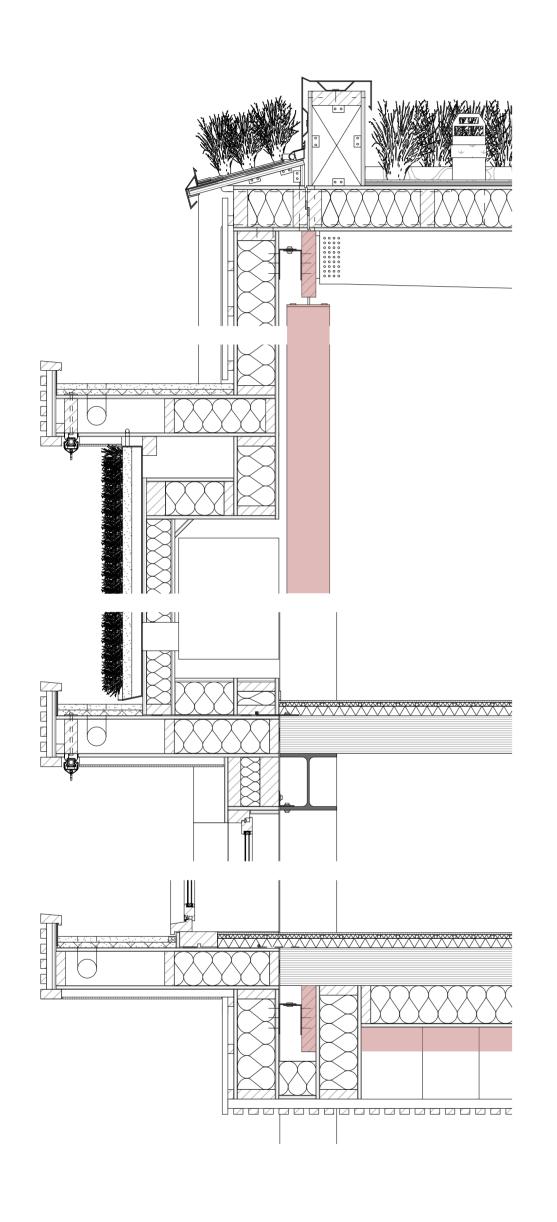


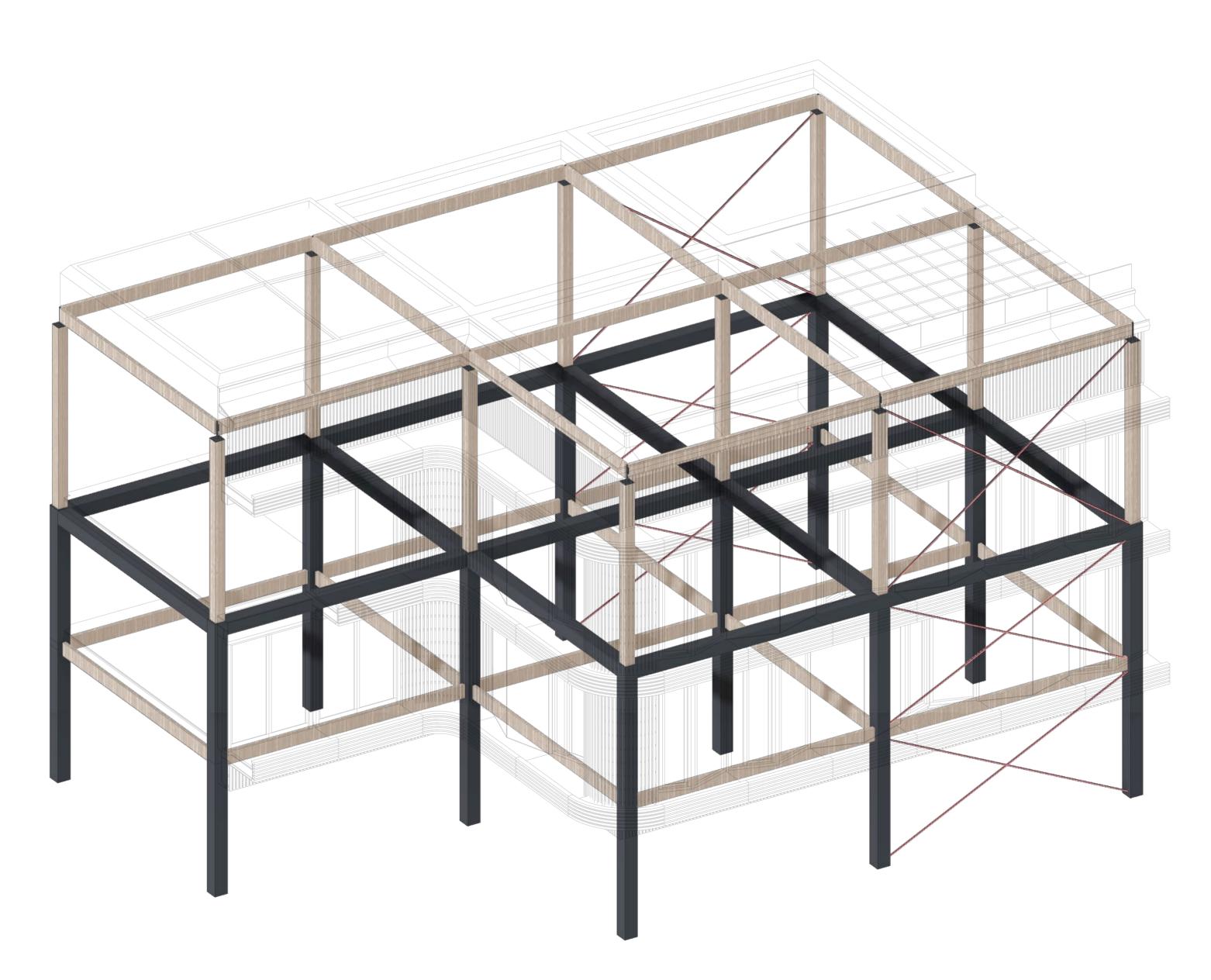


1000 mm

6000 mm

Additional Primary Structure





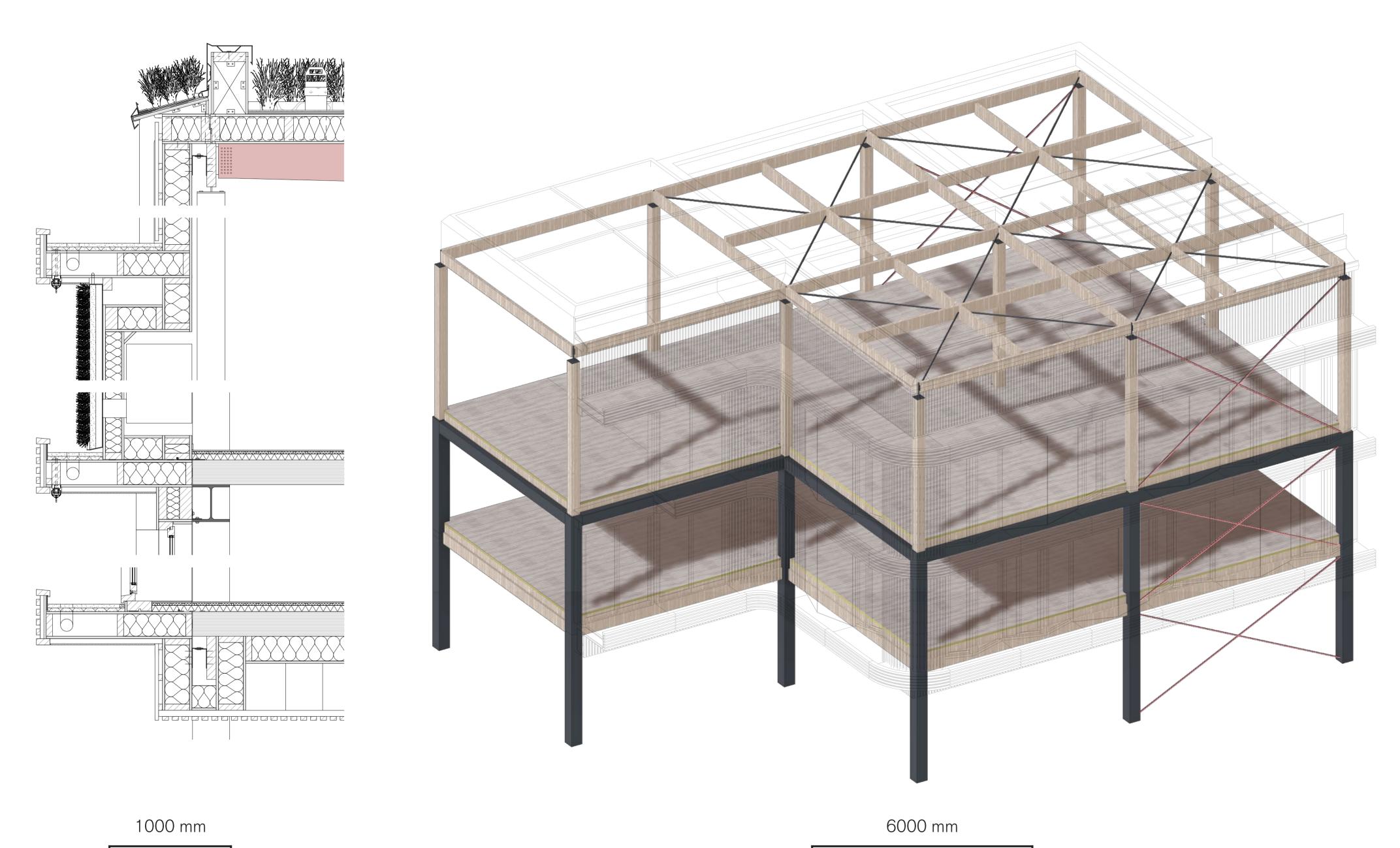
1000 mm

6000 mm

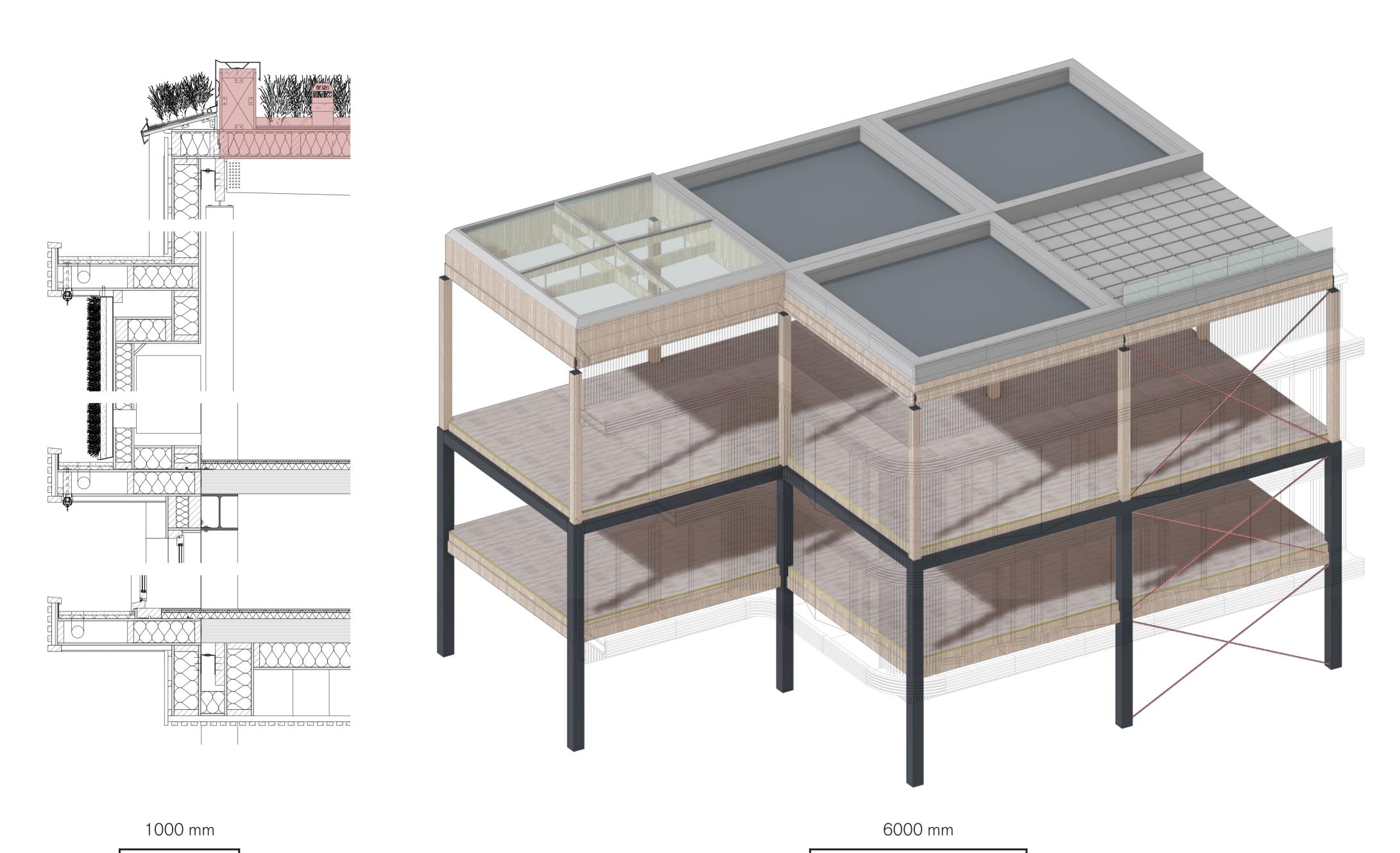
Floor Panels



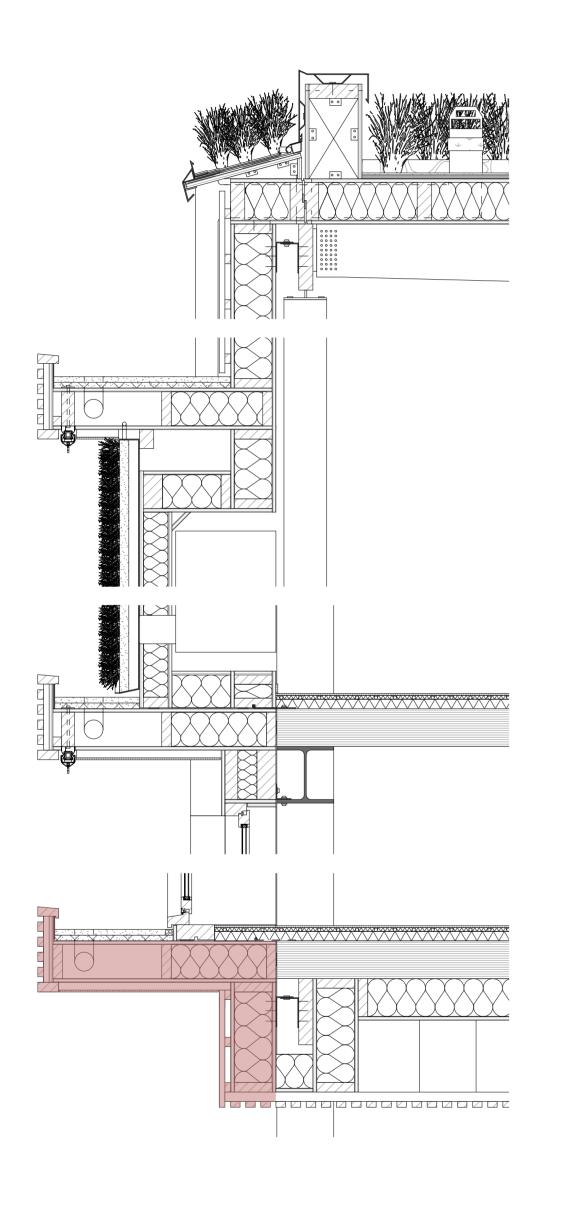
Secondary Structure & Bracing

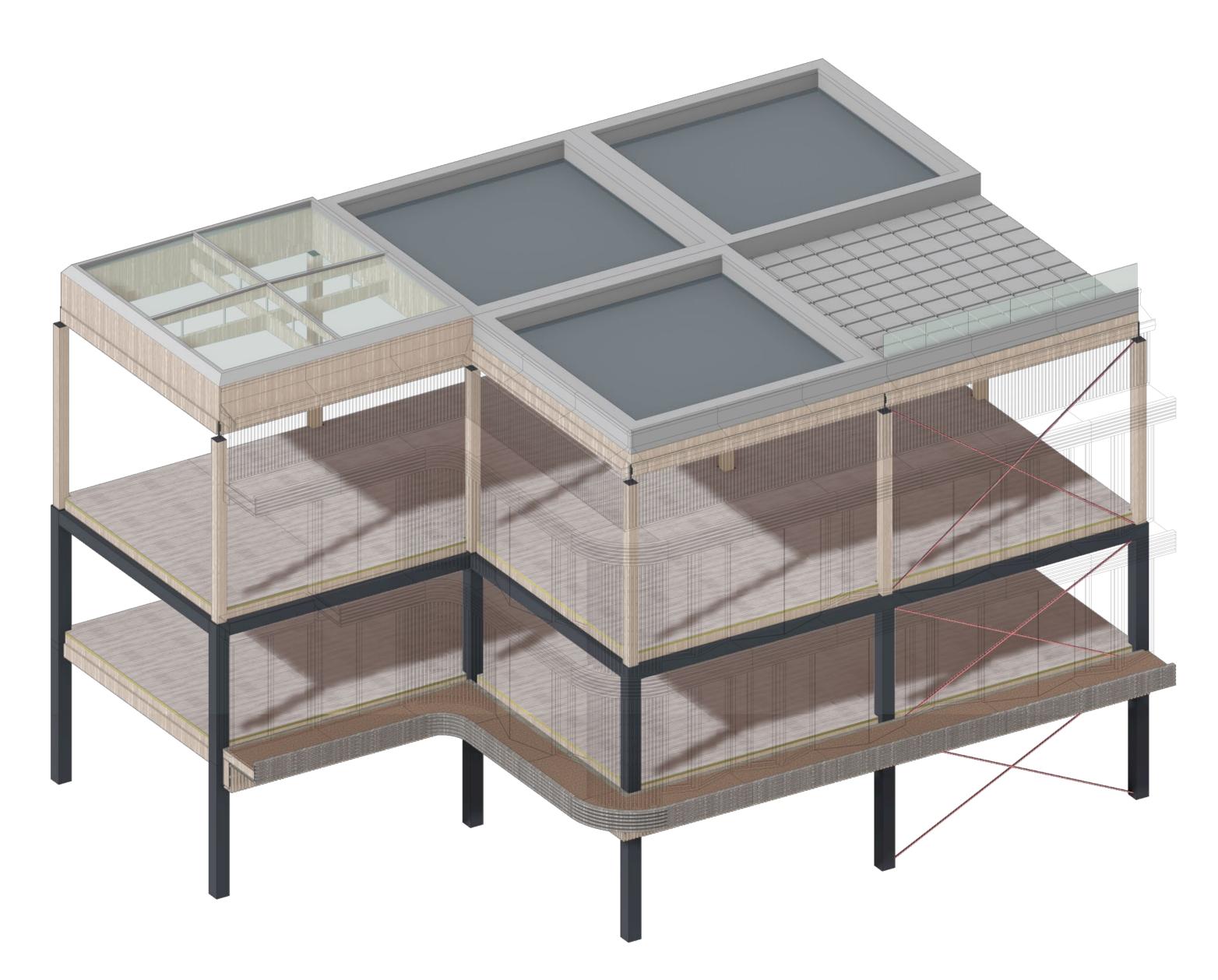


Roof Modules



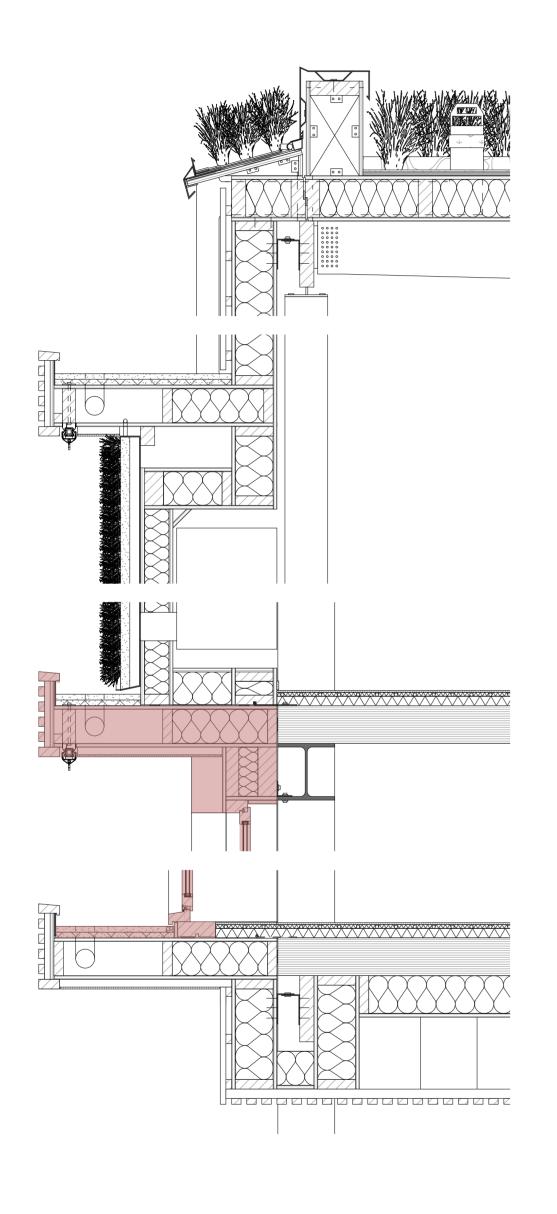
Bottom Gutter

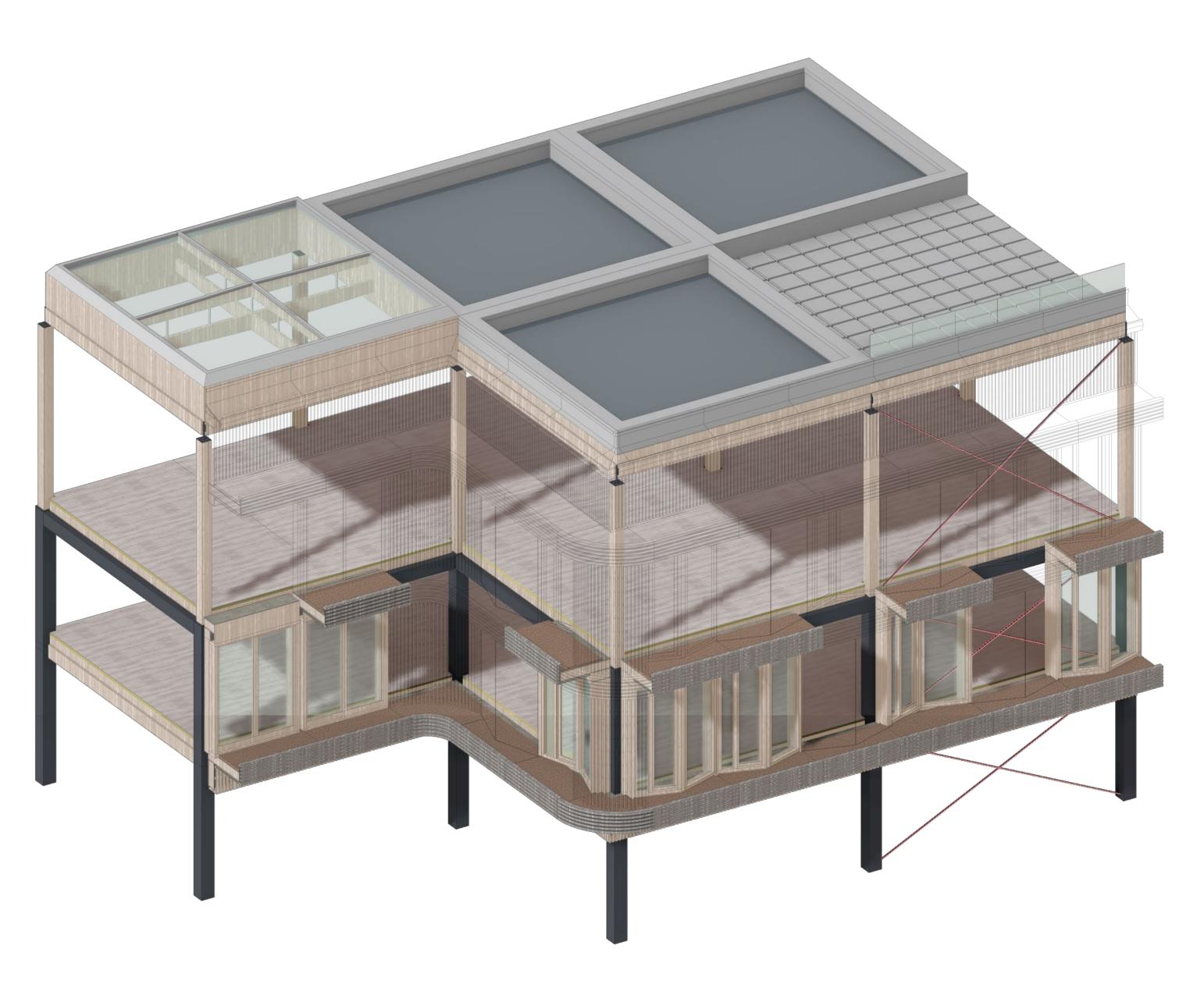




1000 mm 6000 mm

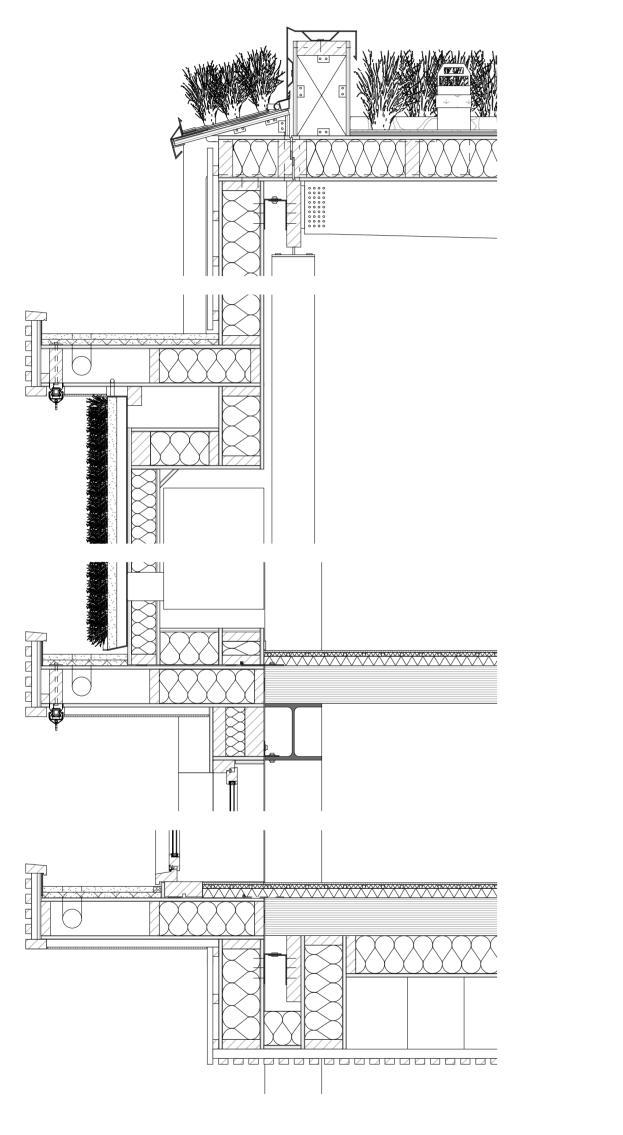
Window Modules





1000 mm 6000 mm

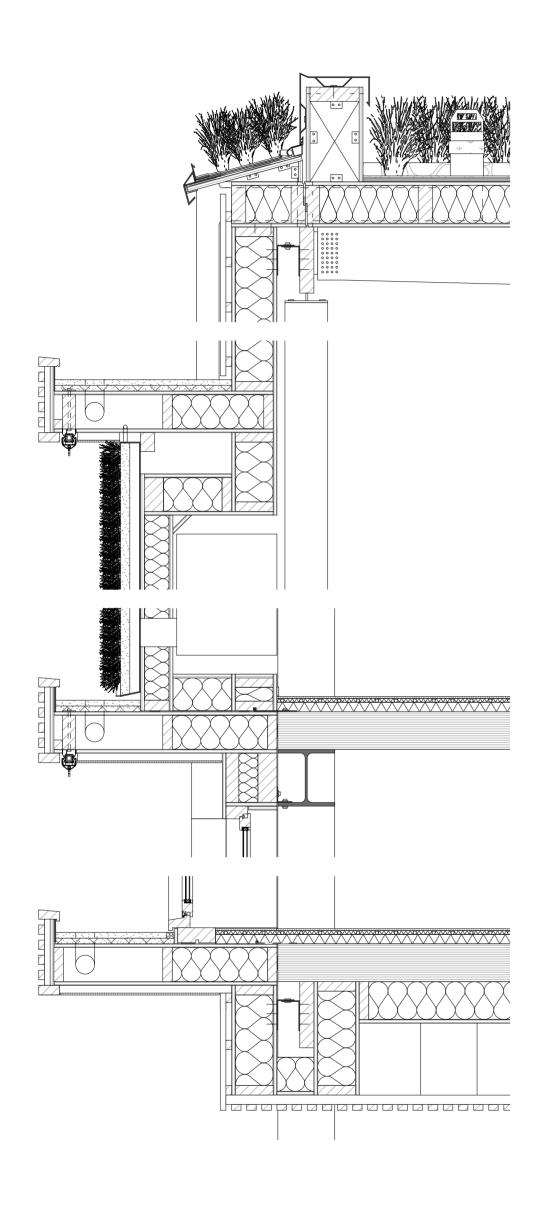
Vegetation Modules & Corners

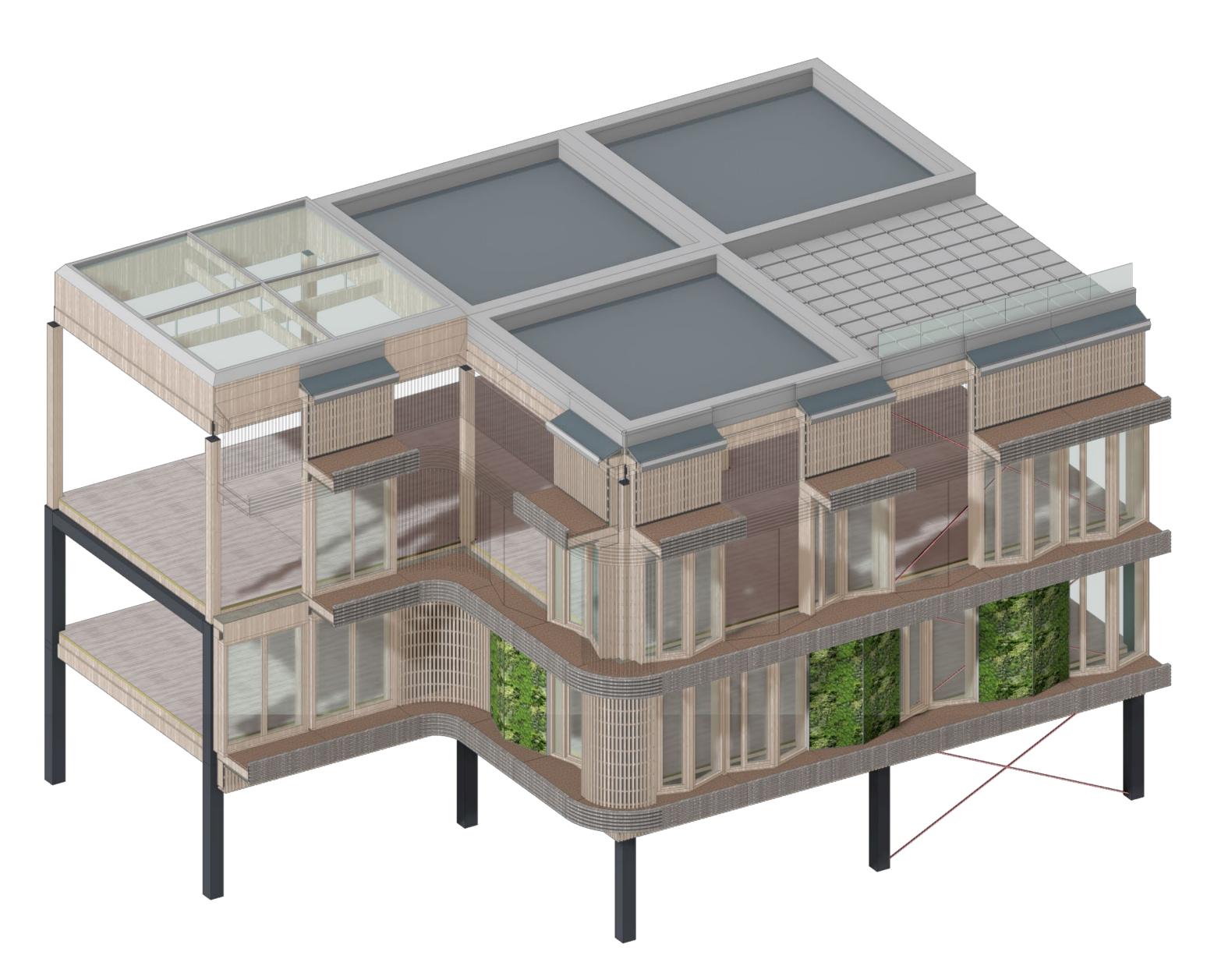




1000 mm

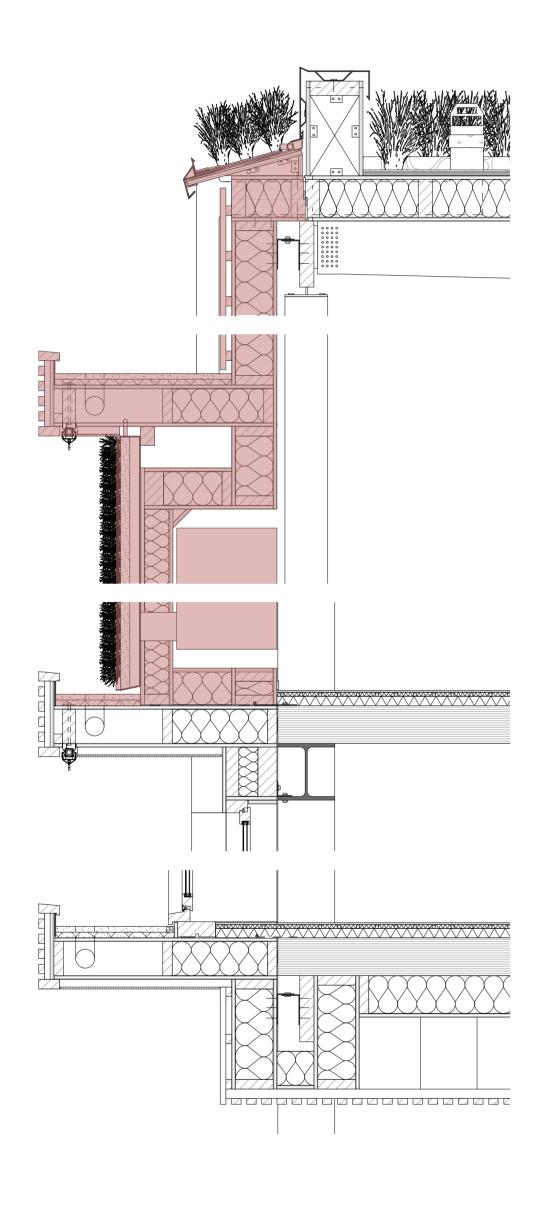
Repetition

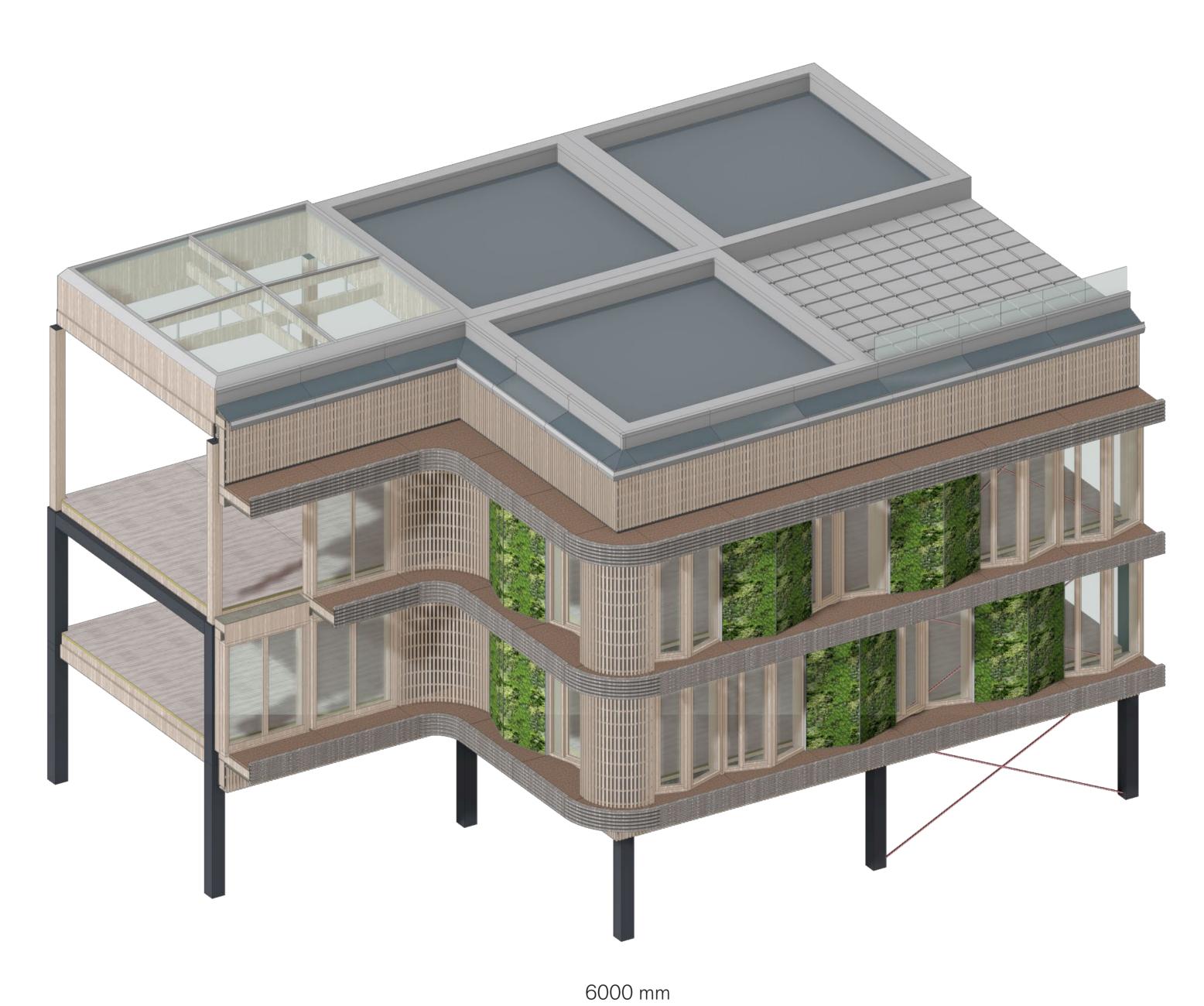




1000 mm

Repetition

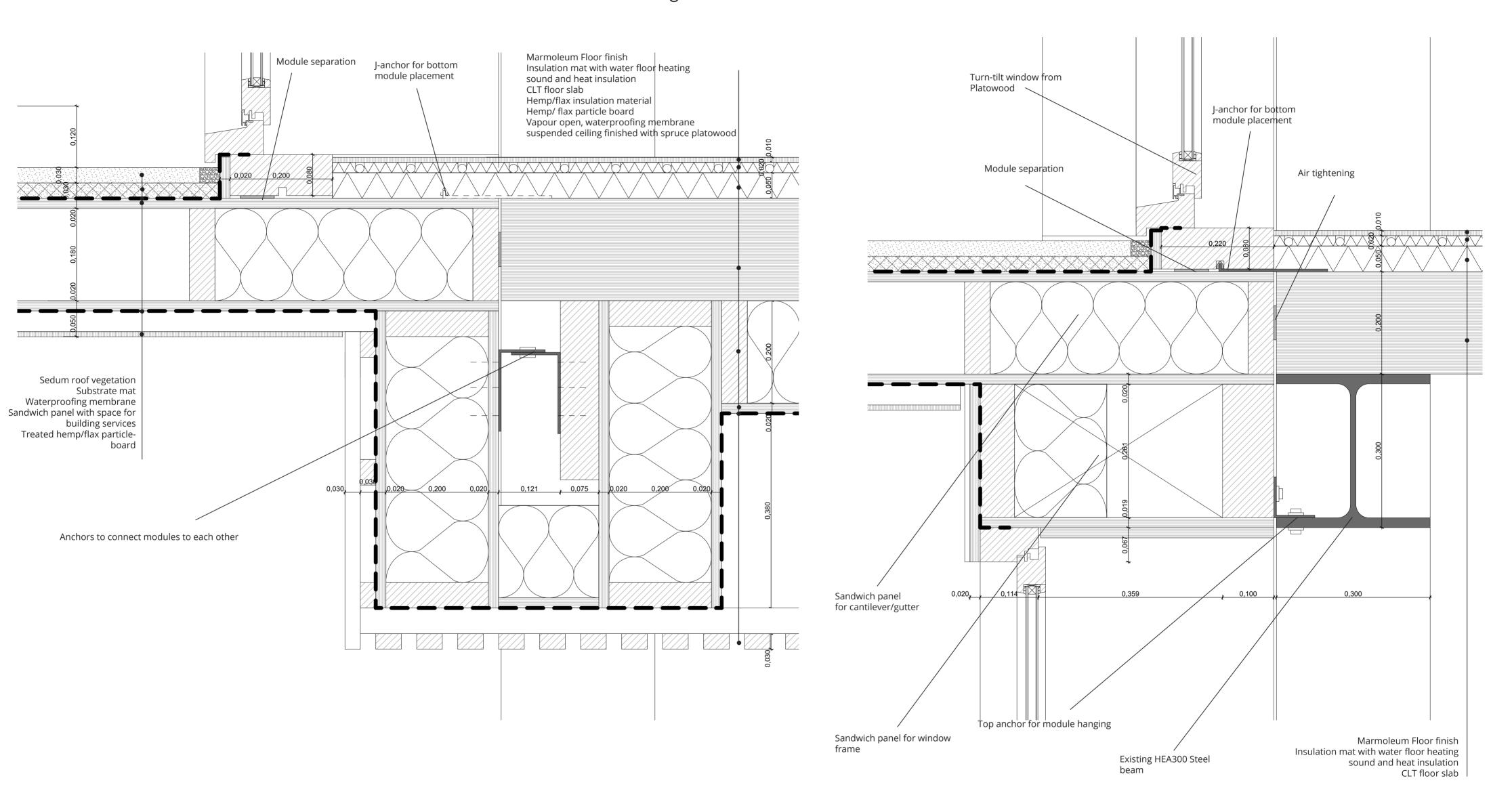




1000 mm

The building system

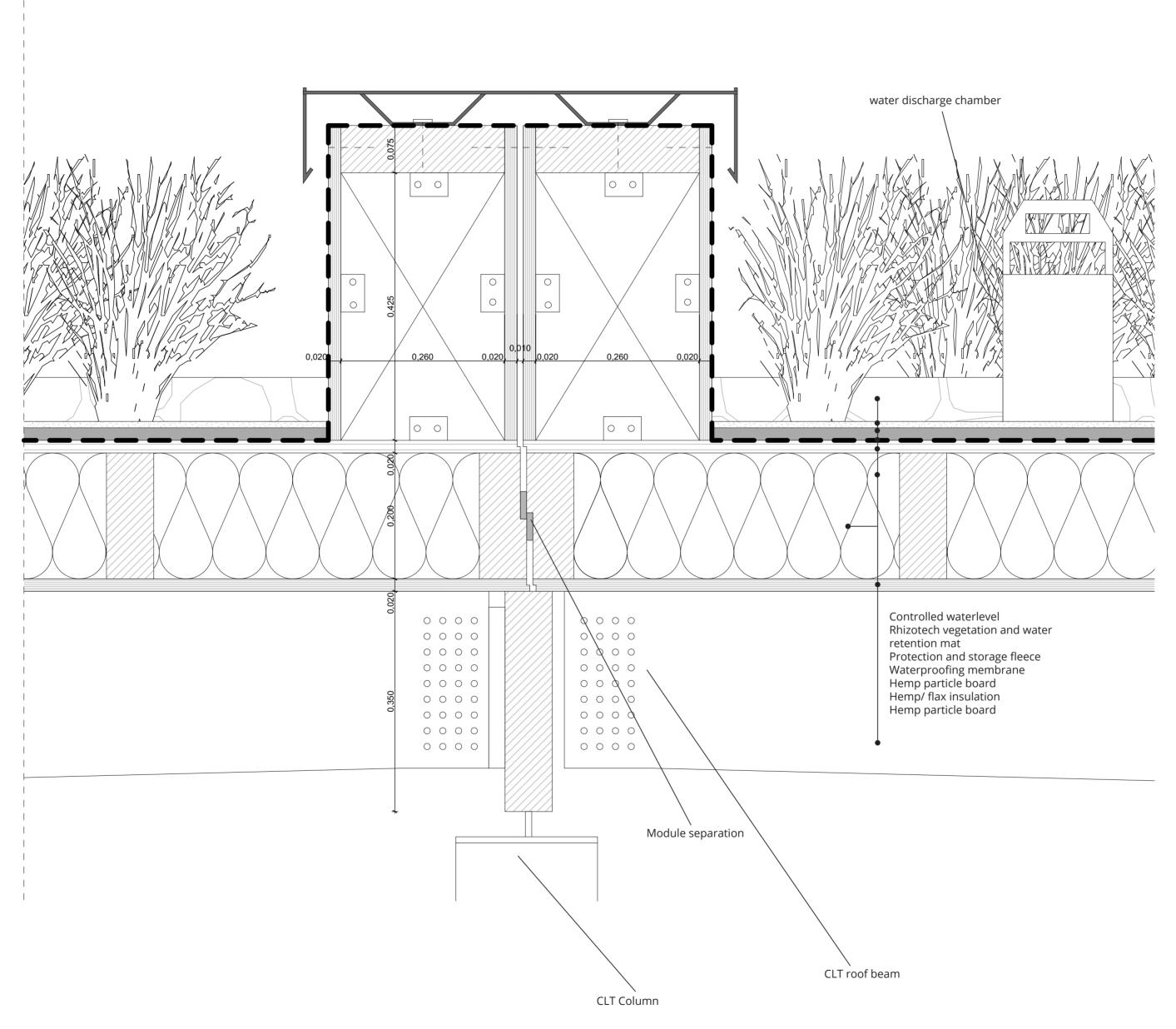
Installing facade modules on site



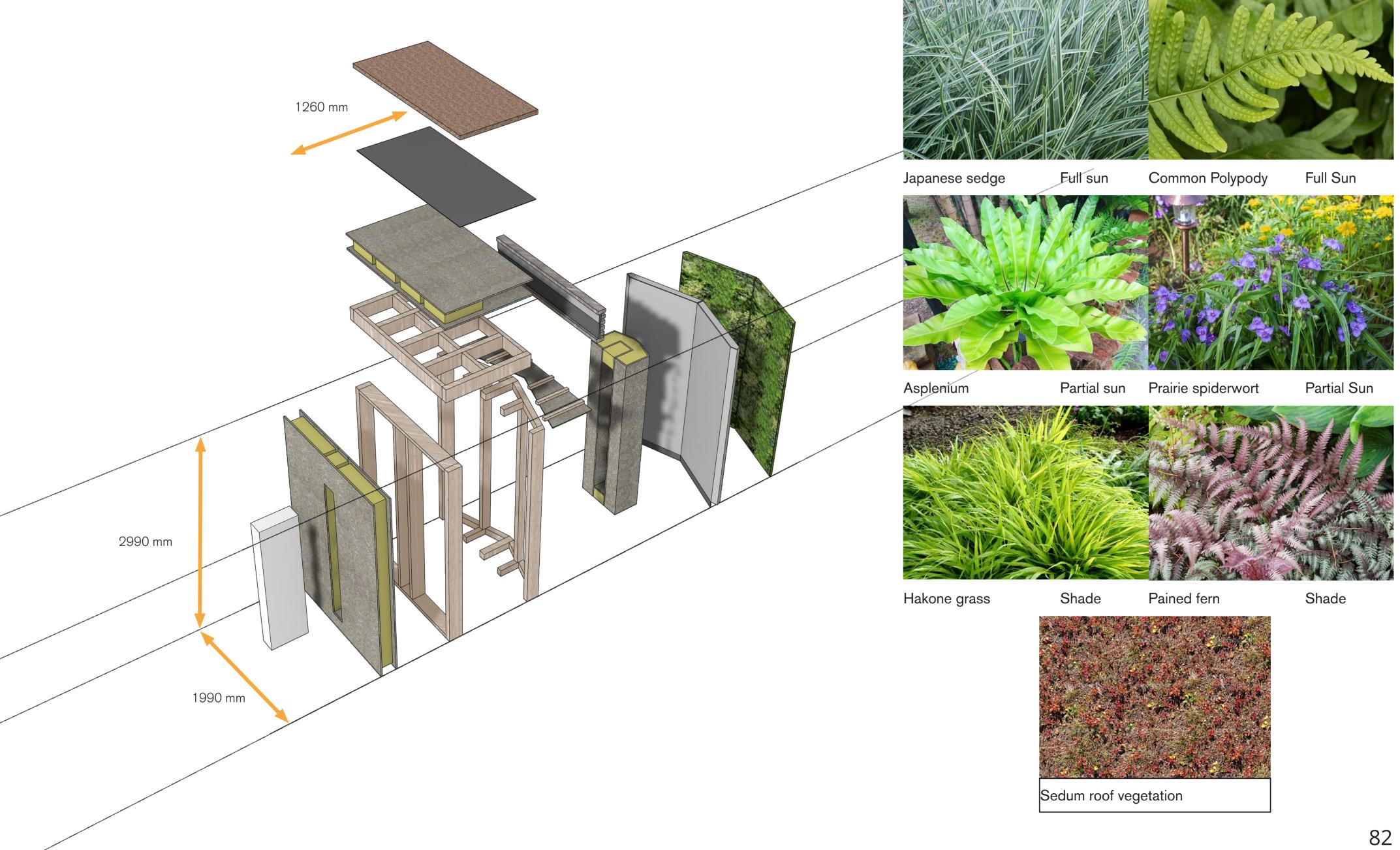
V1 V2

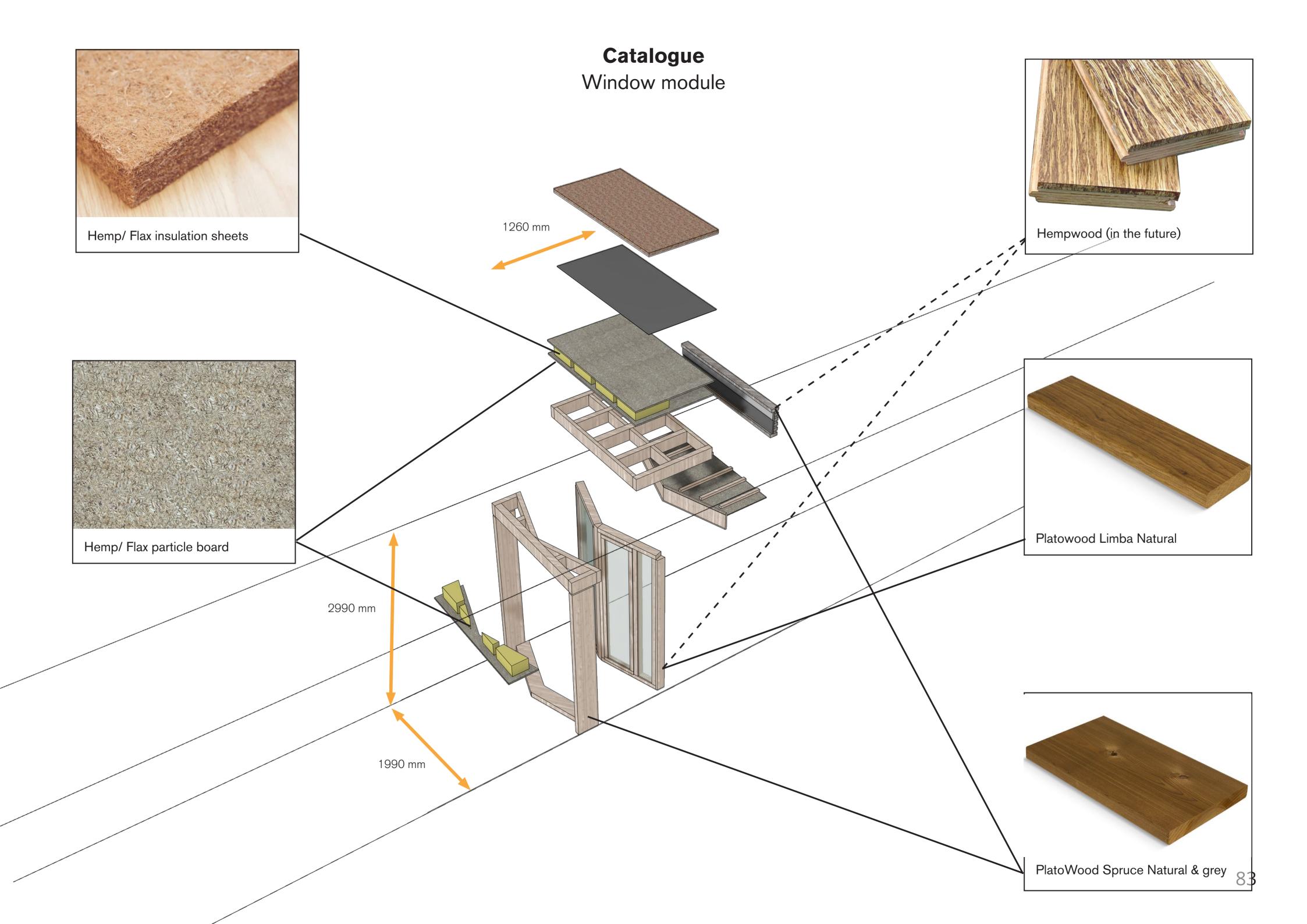
The building system

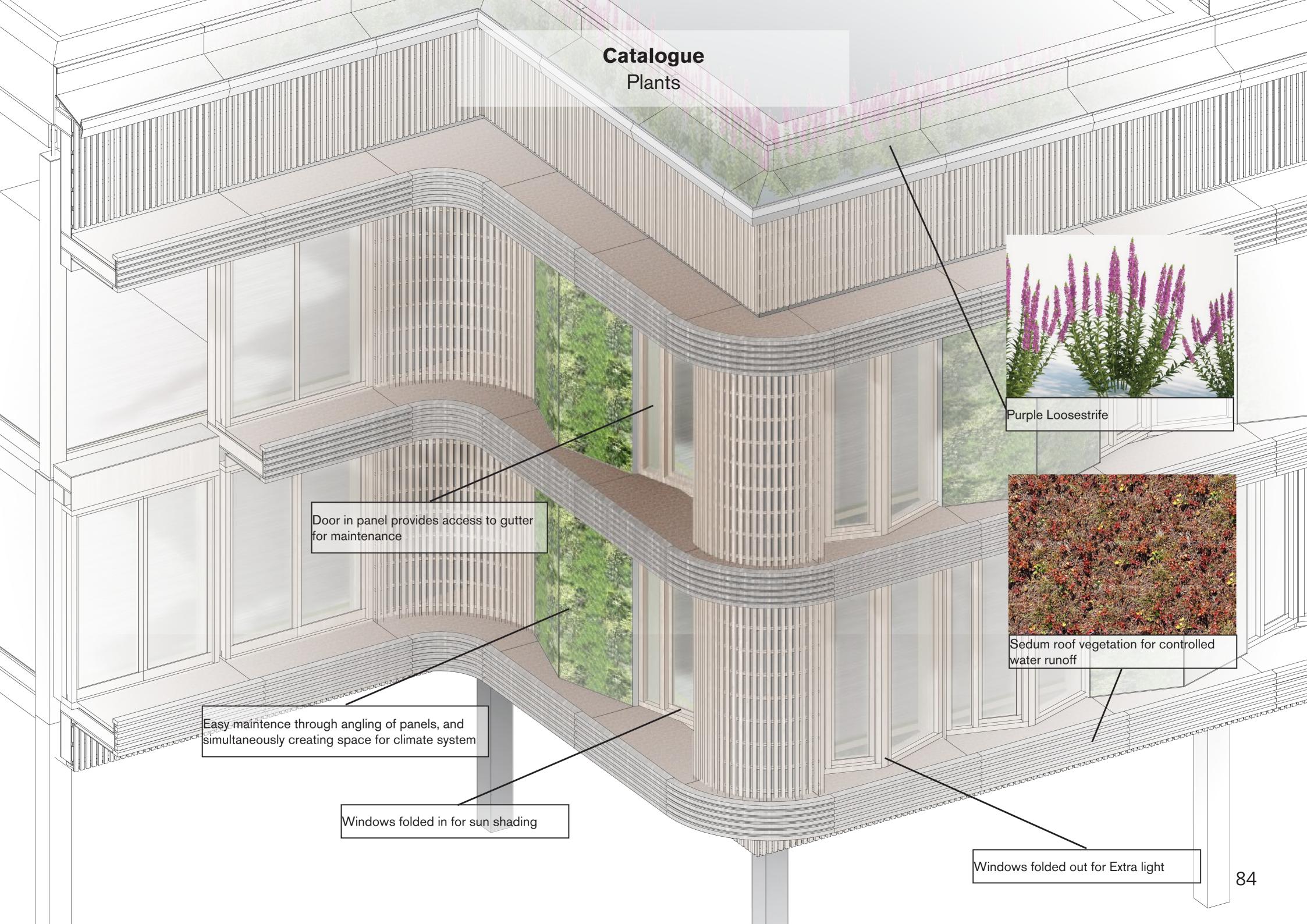
Installing Roof modules on site

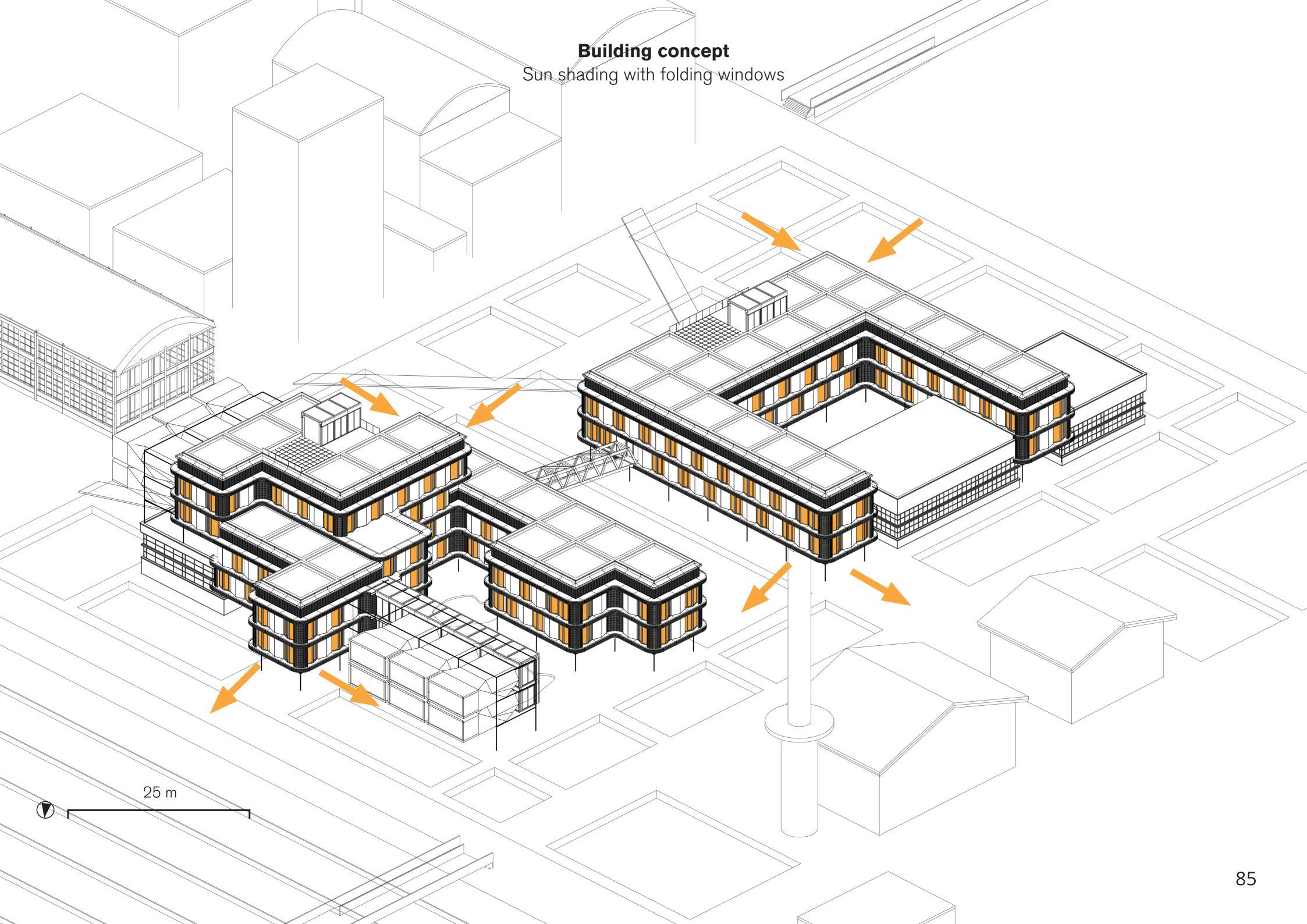


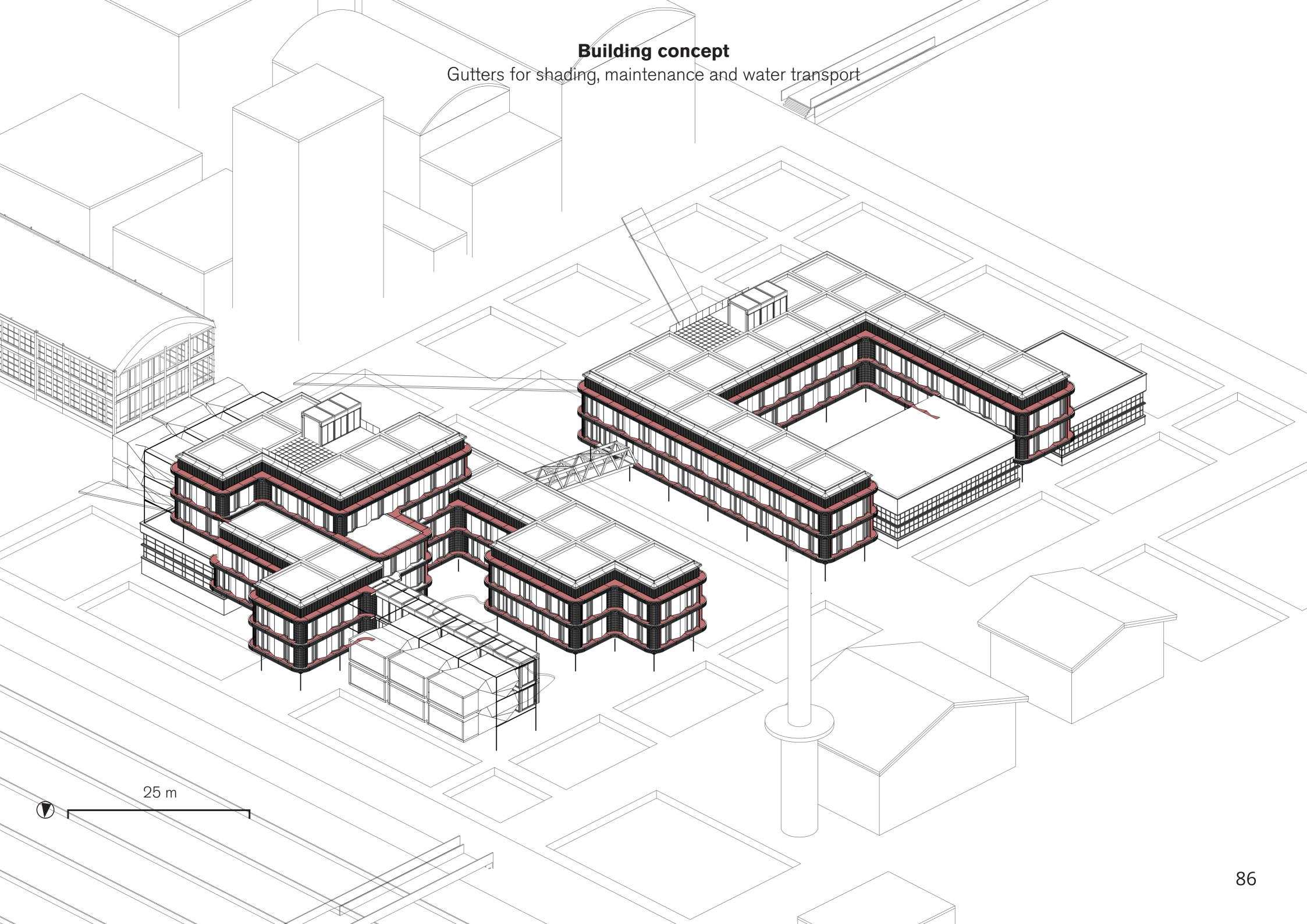
Catalogue Vegetation Module



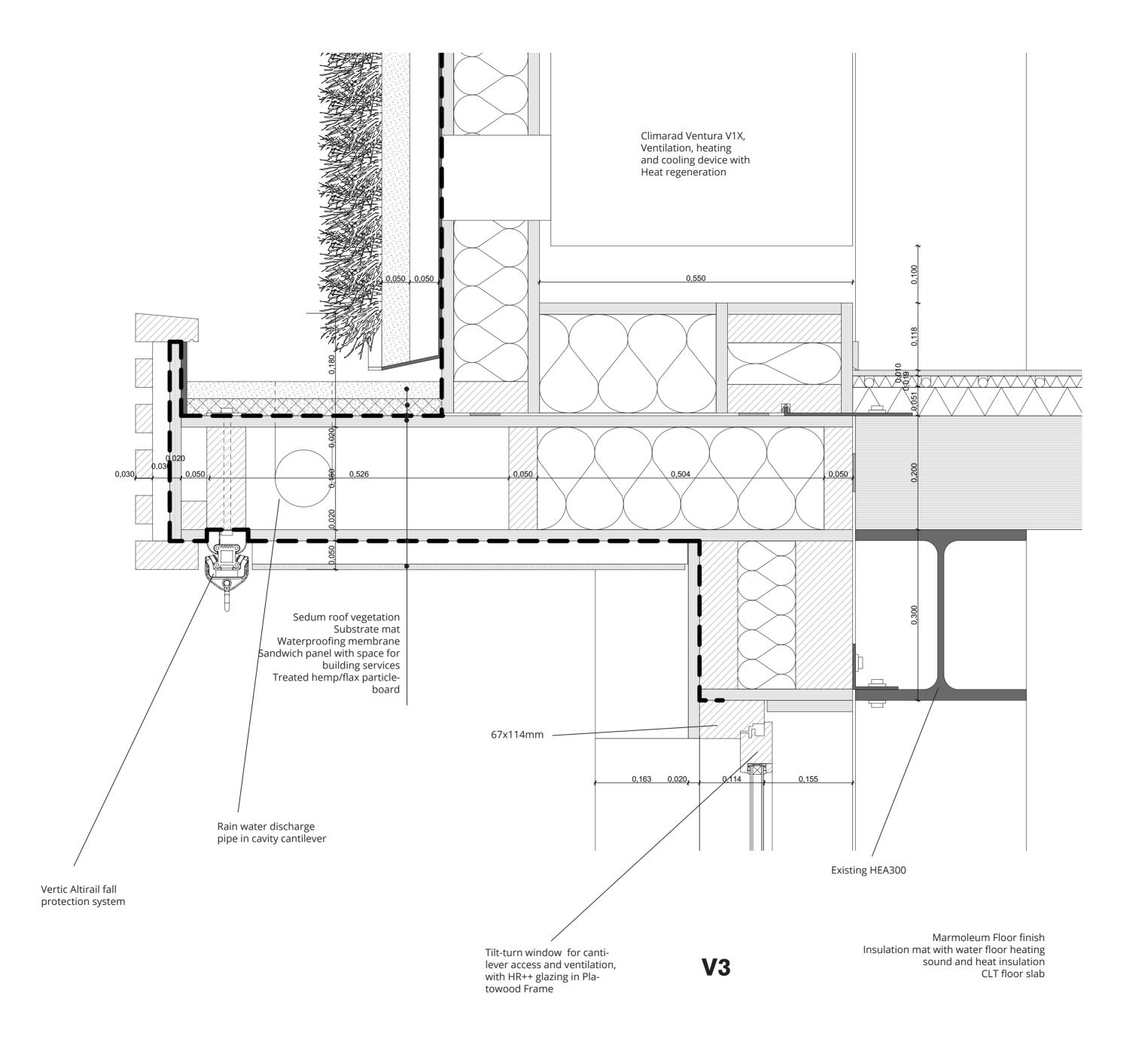








Folidng windows and maintenance





8. Climate

Χ

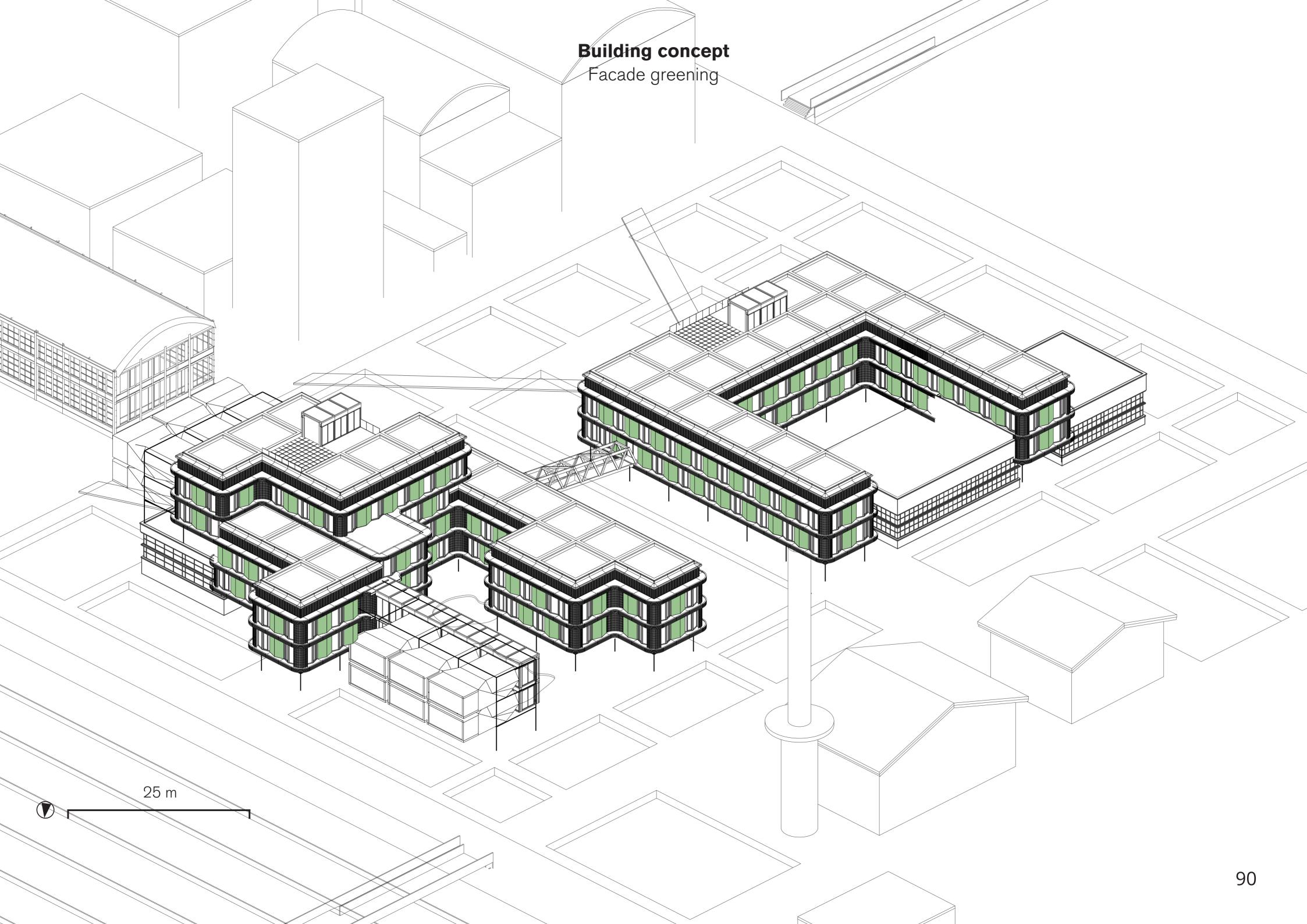
The buildings are loaded with technology that helps to make the building self-containing and provides the demand in heating, cooling and ventilation that is needed for the laboratories. There are three main systems: The decentral ventilation and heating/ cooling system, the water system and the laboratory ventilation and heating/ cooling system.

The ventilation of the building is divided into two parts. There is a decentral ventilation system via boxes in the vegetation modules. Each of these modules contains a box that drags air through the vegetation panels into the box. By dragging the air through the boxes a purified air flow is created. The next step is that this box preheats or precools the air and feeds it into the rooms behind.

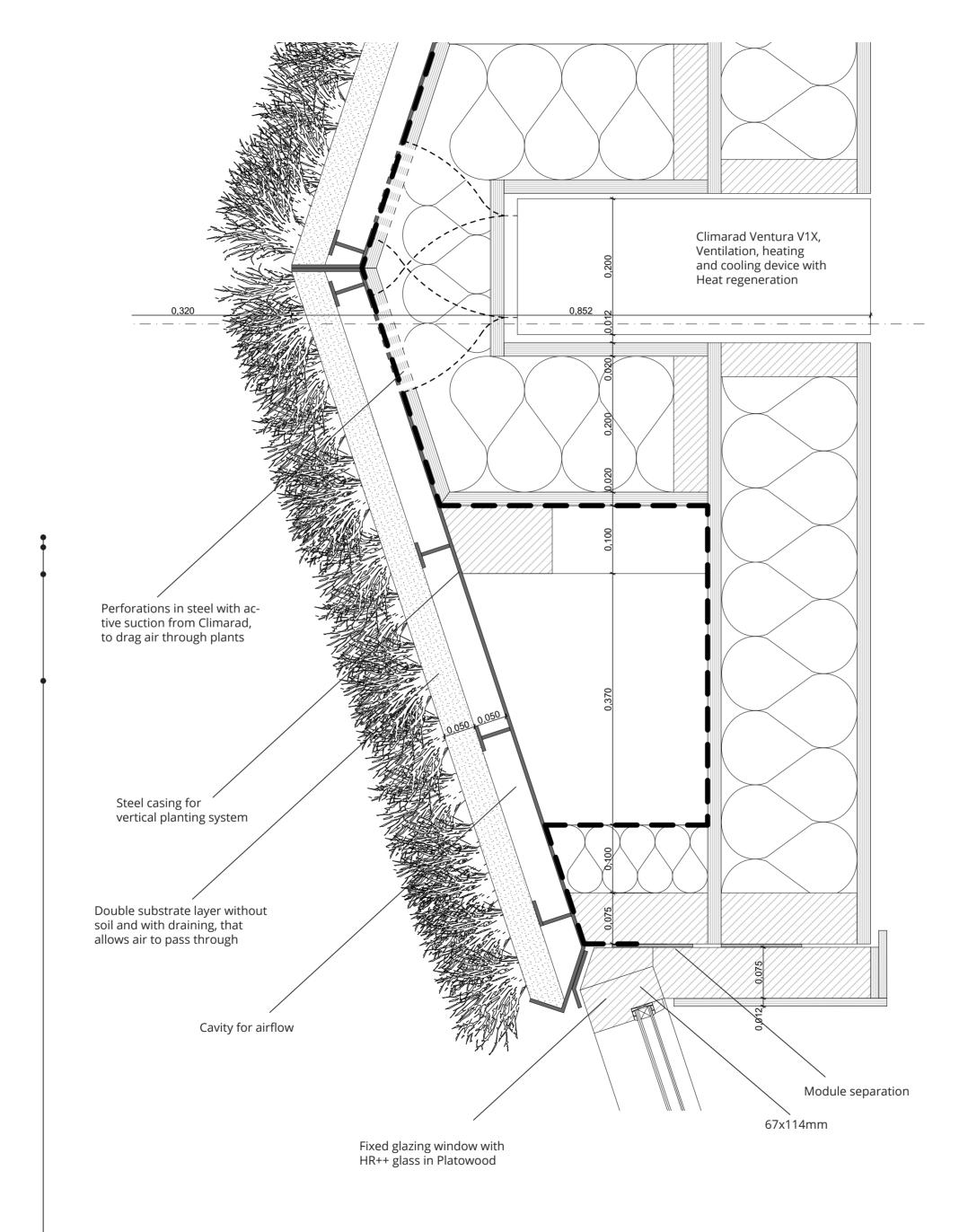
While this sytem may be sufficient for the offices, the demands of air flow for the labs are higher, and sterile air feed or strong air extraction may be needed. To achieve this, the old pump/monitoring buildings next to the architectural structures are used for the technical installations, and from these support buildings air is fed through pipes underneath the building and transported vertically via the corners of the building, after which it can be distributed in the laboratories. The extracted air makes use of heat regeneration and serves as input heat for the warm water buffer that is used for the floor heating system that provides the main heating of the laboratories and offices.

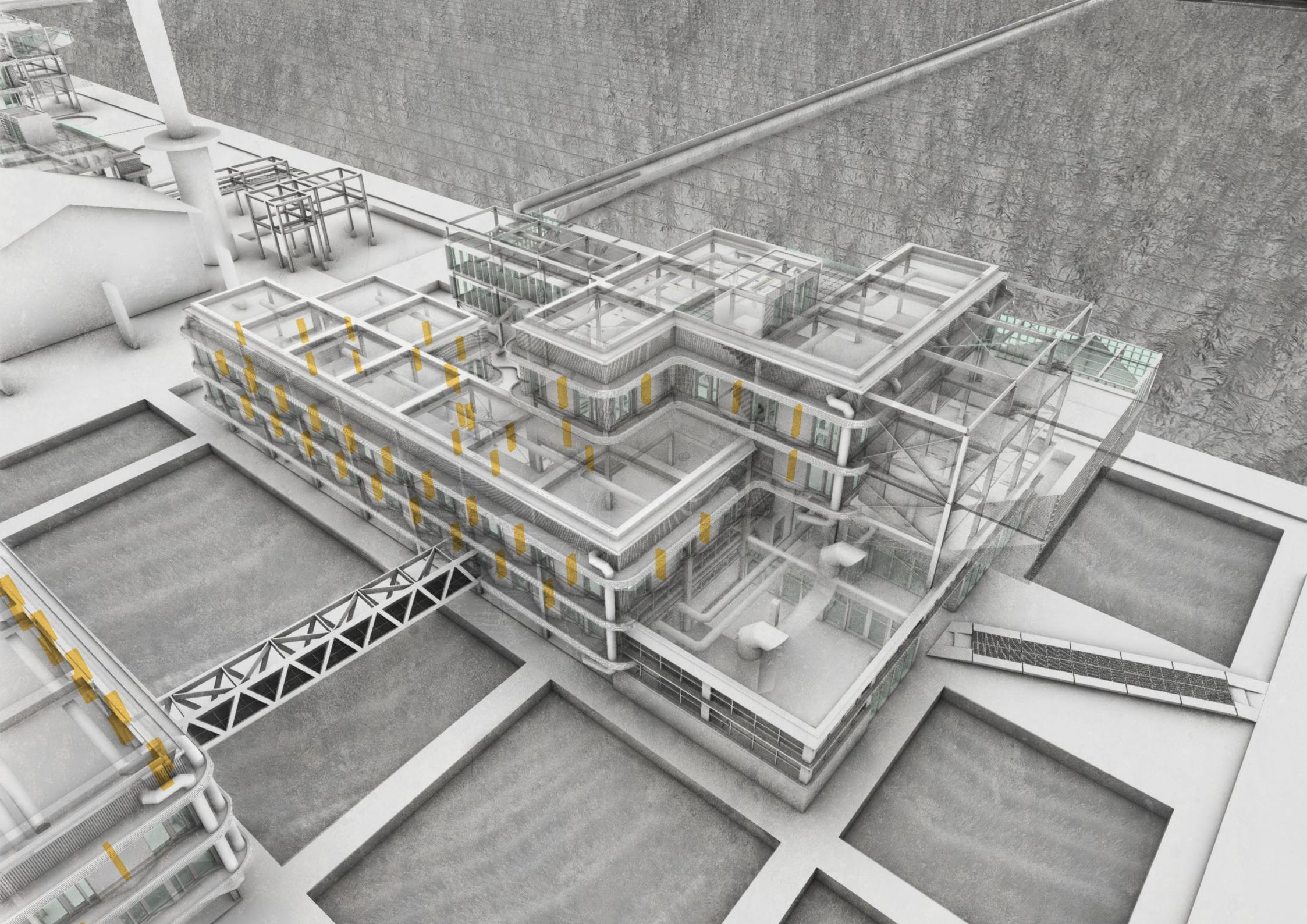
The third system encompasses a water reuse and cleaning system. The rooftop modules contain wetlands that collect rainwater and act as rainwater storage basins. At the same time the water in these wetlands is remediated by the microbes in the wetland system. This water can be used for the irrigation of the facade vegetation system, and the rest of the water is discharged into basins next to the buildings that provide the storage facility for water that can be used inside the buildings for the toilets and machines that don't need drinking water quality water. The water from these larger basins can also be used for the irrigation of the different remediation plots that are on the site.

The drawings on the following pages give visual explanations about the systems described above.

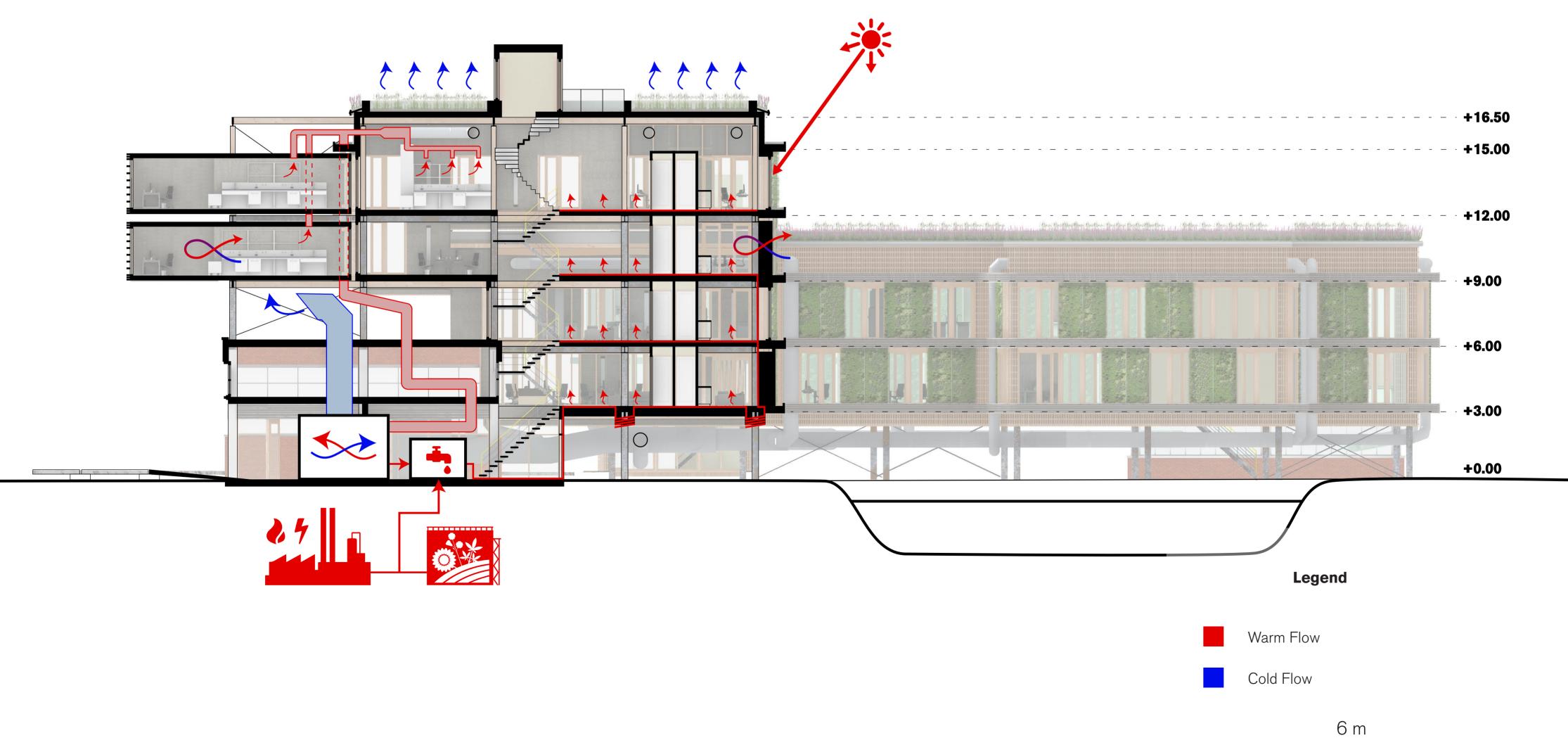


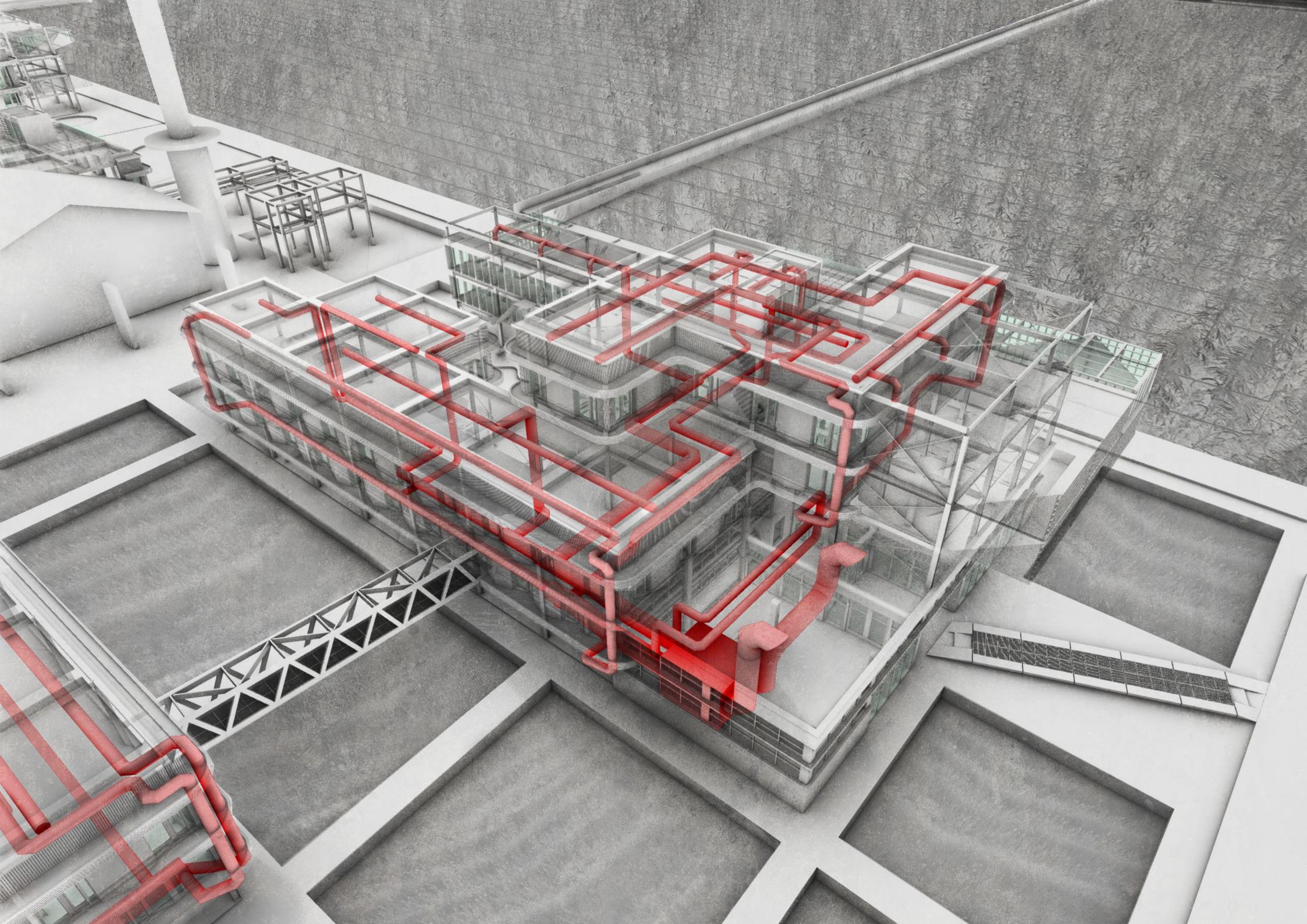
Folding windows and ventilation

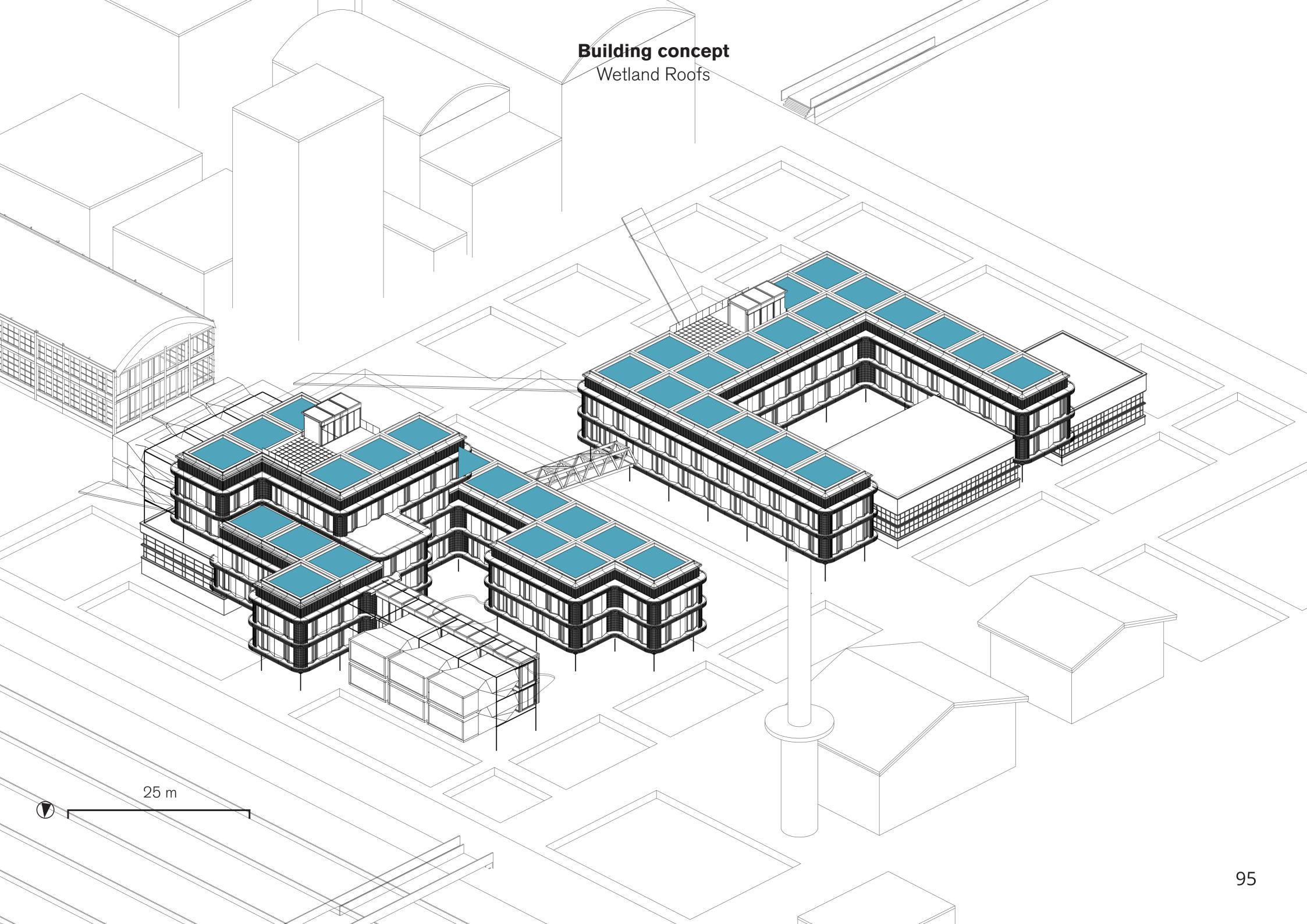




Climate

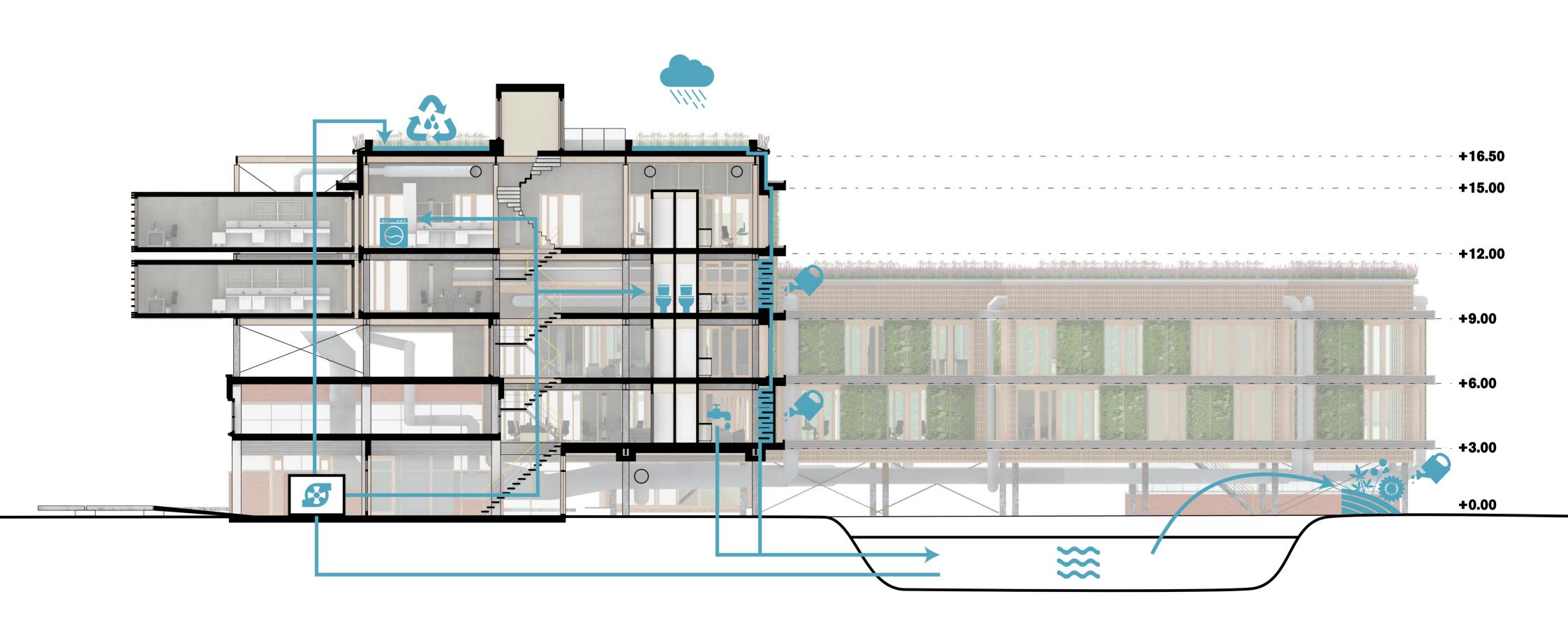


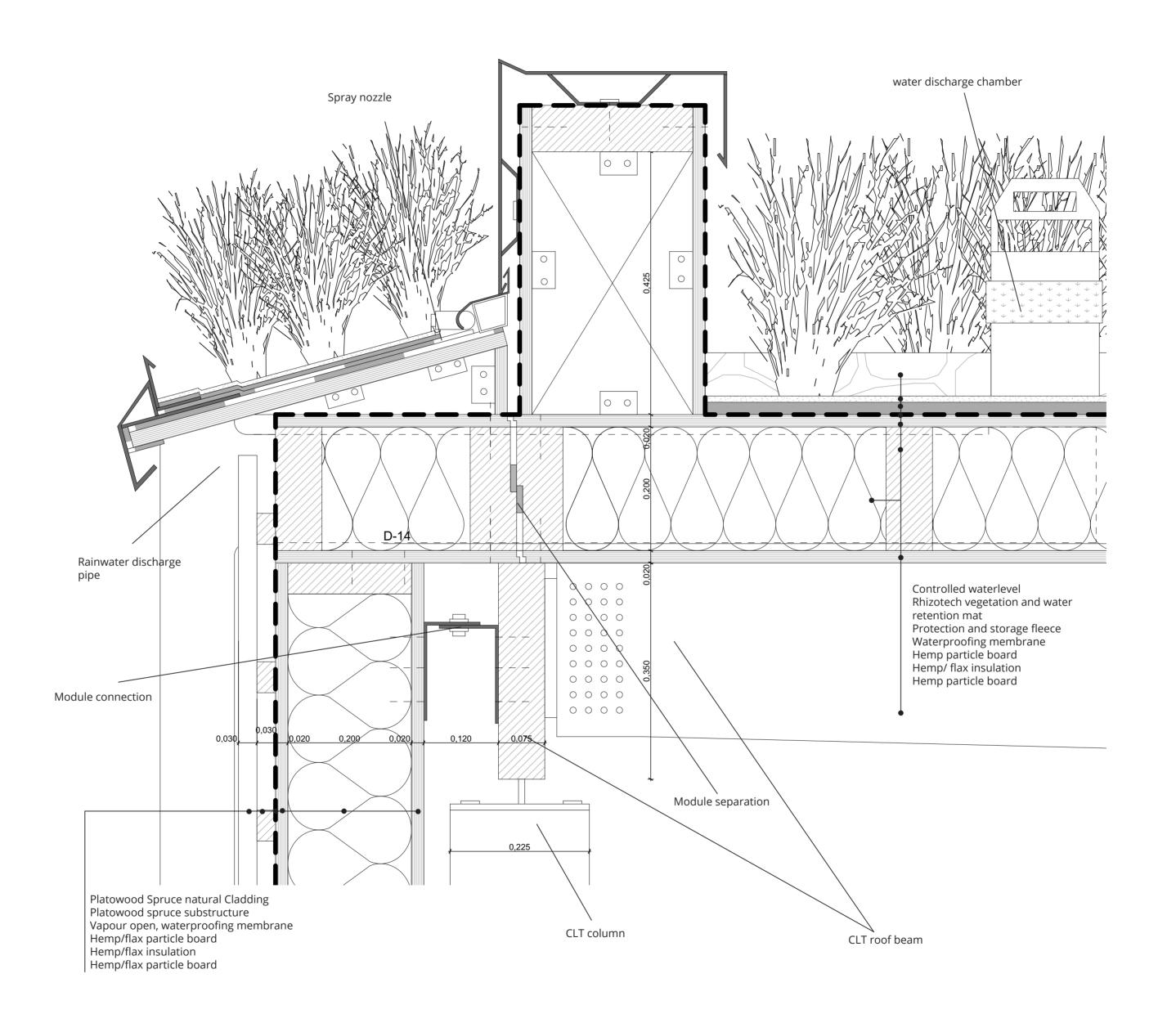


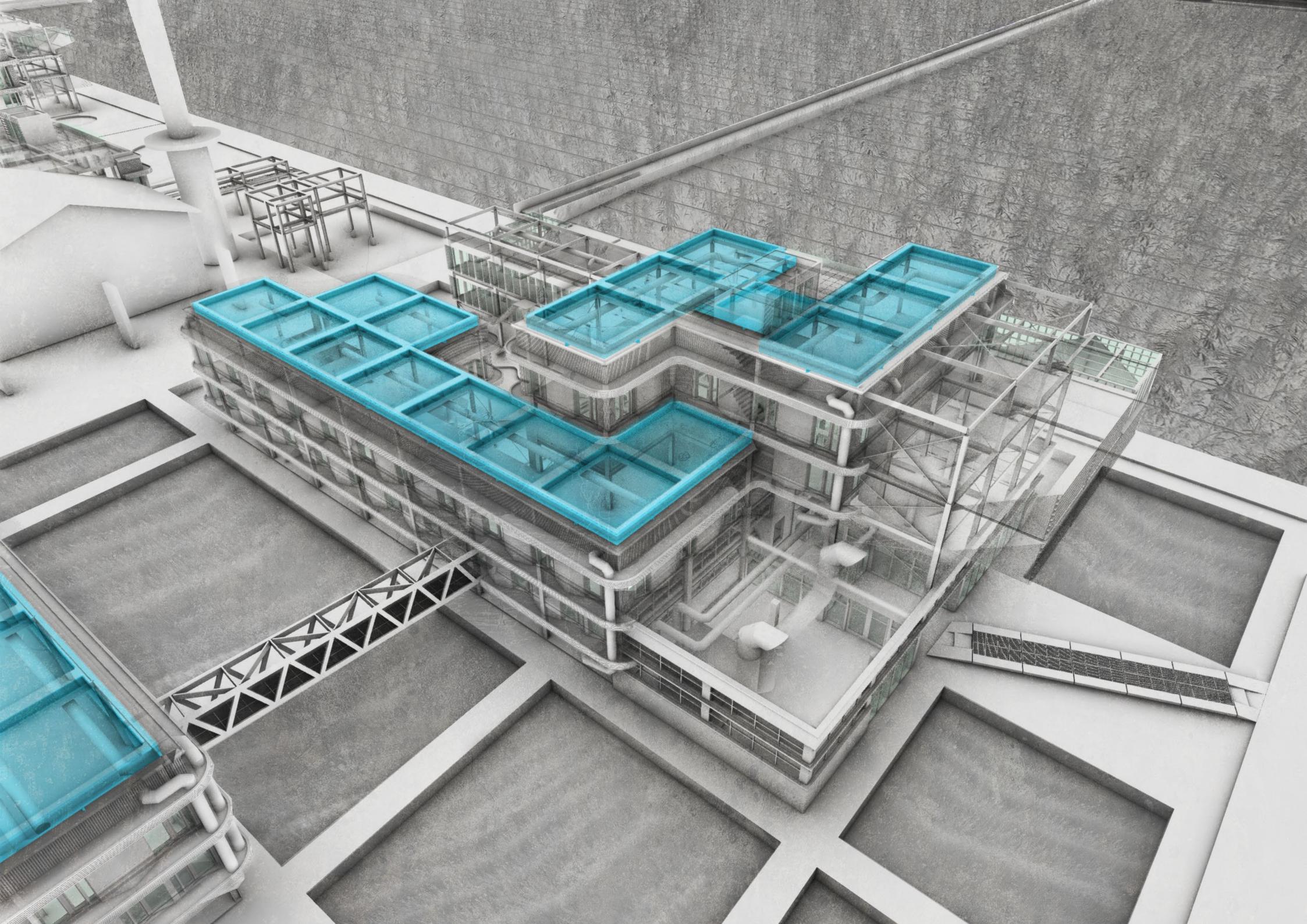


Water

Reuse and wetlands system



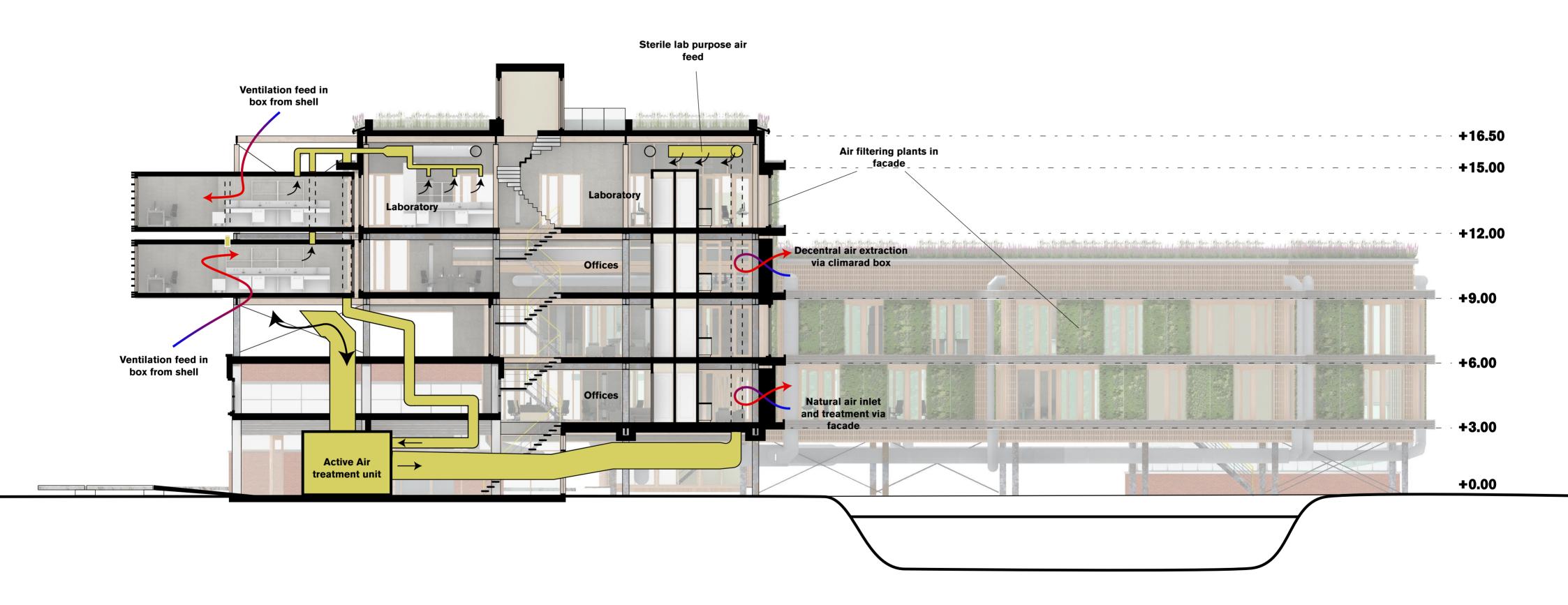






Ventilation

Laboratories and offices



Vertical Transport of air and water

