Recharge Center

An alternative design for a battery recycling plant in Skellefteå

Lisa Fransson
AAHM10: Degree Project in Architecture/ASBM01
LTH, Lund, Sweden 2020
Instructor: Andreea Marcu and Jesús Mateo
Examiner: Christer Malmström

Acknowledgment

Thank you for all the help and support, without you,
this would not have been possible.

Andreea Marcu
Jesús Mateo
Karin Frykholm
Hannes Frykholm
Clara Rodriguez Lorenzo
Johan Seger
Gustav Svanberg
Christer Malmström
Maria Rasmussen

I also want to thank Northvolt, especially Ingrid Karlsson, as well as Enar Nordvik at Skellefteå Kommun for providing me with information and maps that have been crucial for the design.

Table of Contents

Introduction

Acknowledgement 2
Table of Contents 3
Preface 5
Thesis Statement 6
Thesis Questions 7
Method 8

Part 1: Research

Li-Ion Battery Recycling 12
Mapping of processes 16
Geographic Context
- Regional 18
- Urban 20
- Local 22
Site Analysis
- Scale 26
- Development 28
- Site Conditions 30
- Site Visit 34

Part 2: Project Proposal

Site Strategy 40
Concept 42
Process 44
Site Plan 46
Isometric Site Drawing 48
Plans
- Ground plan 50
- Level 1 56
- Level 2 62
- Roof 68
Exterior Perspective 74
Exploded Isometric 76
Flows 78
Program 79
Longitudinal section
- AA 80
Cross sections
- BB 86
- CC 88
Interior perspective 1 90
Cross section
- DD 92
Interior perspective 2 94
- EE 96
- FF 98
- GG 100
Interior perspective 3 102

Part 3: Conclusion

Reflections 106
References 107

“The acceptance of certain realities doesn’t preclude idealism. It can lead to certain breakthroughs.”

- Rem Koolhaas

Preface

When starting on this thesis, my wish was to return to my hometown Skellefteå to reconnect with my background. I had heard of enormous developments in the city center but also changes lurking in its periphery. I was intrigued but not prepared for the groundbreaking transformations that were in the making: A giga-factory with all new technologies had cut into the forest and created a city within the city.

As contemporary industrial buildings are becoming less dependent on humans and instead cater to the machine, they often become hidden and treated as merely technical buildings. The new Skellefteå factory, which had landed as a UFO in the forest, was no different.

As I out of breath circulated the enormous factory site, I realized I wanted to engage with this vast territory formed by the new global industry. I was curious about what this new factory was containing, a large land holding a seemingly mundane and abstract function. What is happening in Skellefteå? How can I break the mystery of the industry of the future? I felt obligated to understand and meet with this strange global technology that existed in the familiar local context of my hometown.

Thesis Statement

This thesis seeks to explore the potential of extracting amusement from the utilitarian, and propose a design that aims to connect a vast industrial site with its immediate surroundings and the city. By investigating the design of a battery recycling plant that is to be built in Skellefteå, the thesis draws upon an actual situation to address a real world problem.

As the topic of climate change and the need for sustainable energy solutions is becoming urgent, there is a call for new and innovative solutions to prevent global warming. One industry in particular that is in rapid transformation is the car industry, where it is estimated that as many as 250 million cars will be electric in ten years, compared to around 5 million today. This revolution of the industry is made possible much thanks to the technique of Li-ion batteries, allowing longer distances between charging.

To accommodate the growing need of Li-ion batteries, a factory, Northvolt Ett, is currently under construction in Skellefteå, a municipality in the north of Sweden. As will be further developed in my research, the manufacturing of the Li-ion batteries comes with great consequences on multiple levels. A recycling plant for Li-ion batteries is hence to be built in Skellefteå on the same site as the battery production factory.

As Northvolt Ett is expected to provide over 3000 job opportunities, the site of the factory will be like a miniature city. The site of the new giga-factory in Skellefteå is representative of a new type of industrial territory that make too large an impact on the urban landscape to be ignored. The placement of the factory is difficult to detect unless you drive there intentionally, and in that sense has a traditional way of planning: placed at a cul de sac and difficult to approach. This thesis is an opportunity to explore how by rethinking the layout and the placement of the recycling plant there is possibility to bring value to the site and its surrounding context.

Thesis Questions

- How can an industrial process become a public space while also fulfilling its main function as a space dedicated to production?

- How can a site of large scale industrial production be integrated and part of the urban context?

- How can architecture add value to industrial projects that typically are considered mere technical?

Method

As there is no design yet for the recycling plant, the thesis project is an opportunity to investigate what such a facility could entail. The project aims to explore the possibility to intertwine industrial processes with public space, visualizing the recycling process to introduce new perspectives on waste and raw materials. The functional contamination is not intended to hide an ”ugly” process but rather the opposite- by inviting the public, a relationship between citizens and the industrial site is established.

To understand the actual situation, a travel to the site and the city of Skellefteå was made in February. A collaboration with the engineers of Northvolt has also been set in place in order to understand the process of the recycling plant, and the spatial needs of each step. A continuous contact with the engineers has been held throughout the process.

The intervention derives from an actual situation and answers to the formal demands of the site and program, yet it aims to challenge the scale by proposing spaces where the proportions relate to both human and machine dimensions. It will explore the relationship between labor and recreation to try to establish a complimentary flow between them.

By introducing a public function of a sports and education center that intertwines with the recycling program, an alternative way of access can be investigated. The recycling plant hence has the possibility to act as a spatial medium that connects the public with the site of the battery factory. The design intend to question the idea of technological and industrial buildings as separate from architecture and instead invite industry and architecture into a dialogue.

The project aims to propose an innovative design that acts as a medium between the industry and the city. The user groups are divided into three categories:

1. *The Worker* is the everyday user. The everyday user is both workers at the recycling plant and the workers at Northvolt who uses the facilities during breaks.

2. *The Visitor* is the public. People attending sports facilities as well as people visiting the restaurant, exhibition and students using the study area.

3. *The Passer By* are the local people experiencing the building by passing it. Cars, buses, skiers and runners pass by the site. An open outdoor program invites the passer by to stay a little longer.

1

2

3

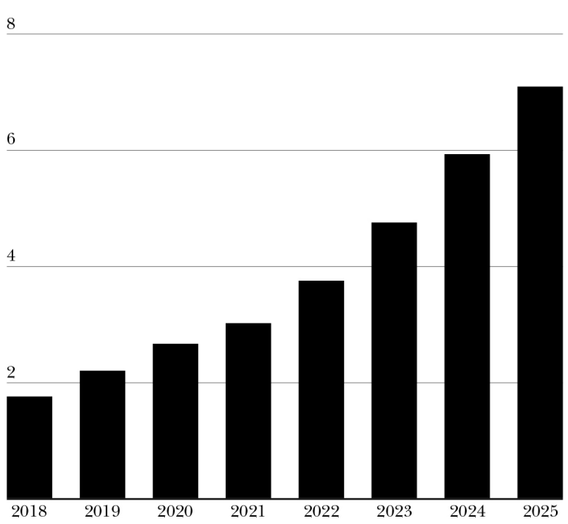
1. RESEARCH

Initial sketch collage: Approaching the hidden giga-factory in the forest.

Li-Ion Battery Recycling

A problem with the Li-ion batteries is that the manufacturing is dependent on the use of Earths resources such as lithium and cobalt, which creates consequences on societal, economical and environmental levels. The mining of cobalt, for instance, is often done in poor regions by hand, and besides being extremely dangerous, the environment is polluted by dust from the mines that creates a health hazard for everyone living near by.

The recycling capacity of Europe is around 33.000 tons per year. The existing capacity is however not very well suited for recovering the valuable materials of lithium-ion batteries, and it is not sufficient to handle the increasing amount of batteries reaching end of life which is expected to increase globally the coming years.



Predicted lithium-ion batteries reaching EOL globally 2018-2025 (100 000 tonnes)

Source: Circular Energy Storage

Because of the importance of finding sustainable approaches to the production of Li-ion batteries, Northvolt is in the process of developing a recycling program with the ambition to enable a circular production loop. In 2022, a full-scale recycling plant will be built at the Northvolt Ett giga-factory in Skellefteå. With the recycling plant, the giga-factory will be able to recover valuable materials from battery cells and return them directly back to manufacturing flows.

To be able to recover as much valuable material as possible, Northvolt has been developing the processes required for recycling lithium-ion batteries for over two years. A collaboration between Northvolt and researchers from Chalmers University of Technology has resulted in a hydro-metallurgical treatment process. This process, unlike traditional recycling processes where the material is burned in the final step, is more clean and safe and can recover finer material such as lithium, nickel, manganese and cobalt.

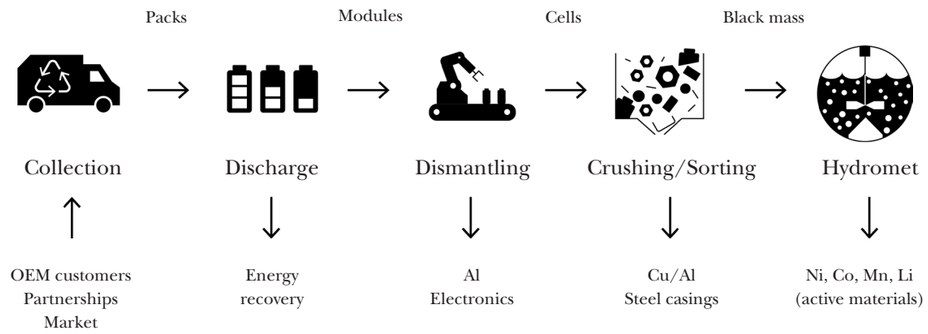
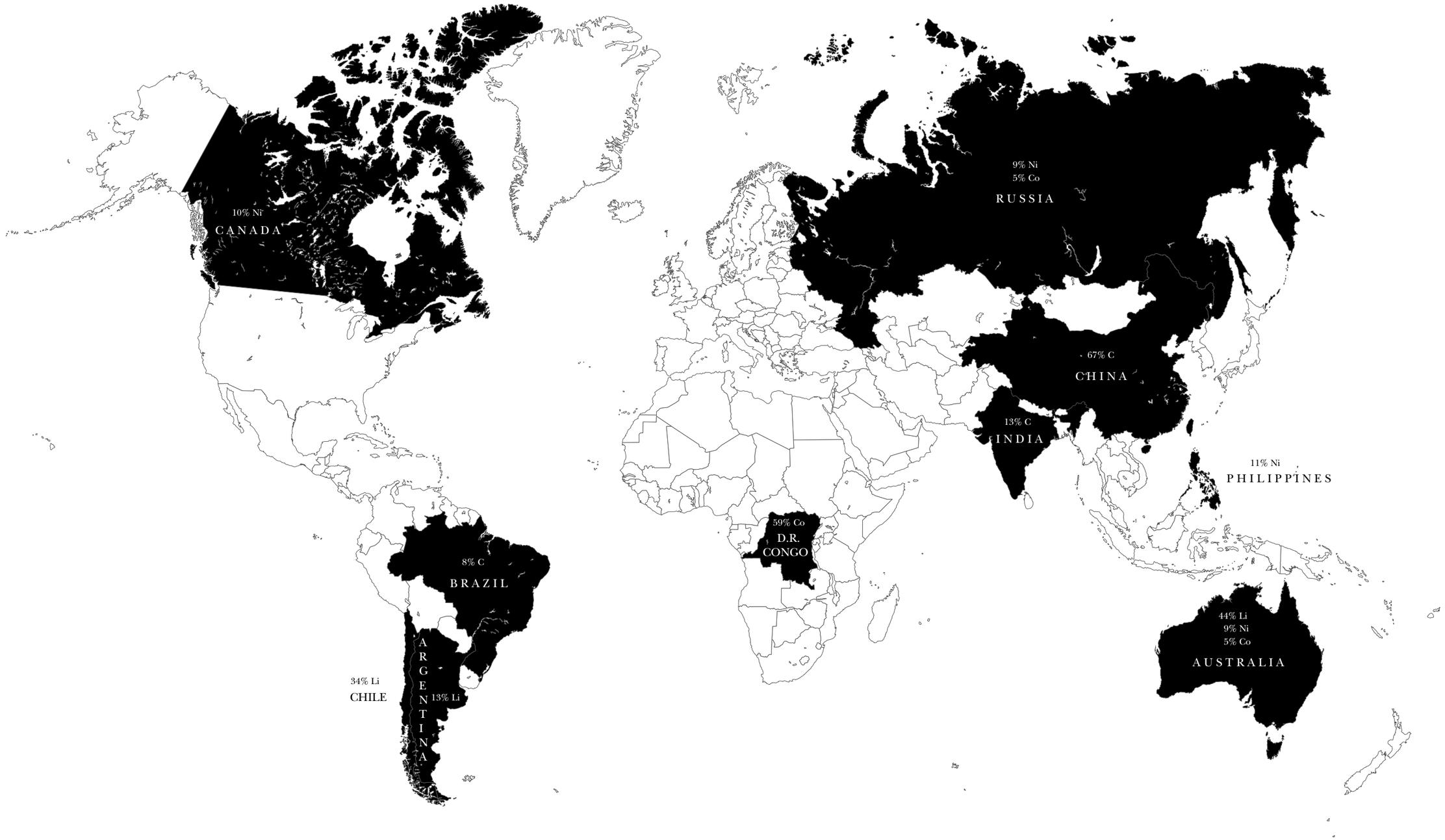


Diagram of recovery and recycling flow

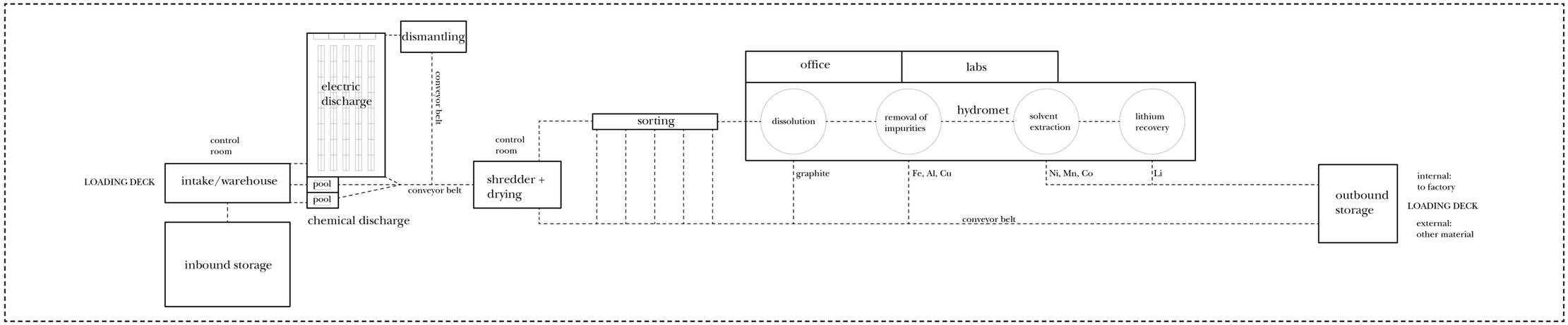


Distribution of mines: Global Production shares of selected Li-ion battery materials, 2017

Source: Clean Energy Manufacturing Analysis Center

Mapping of processes

Defining the different steps of recycling



Defining area requirements and connections between processes

1. Collection

Three types of used batteries will be delivered and stored in-house.

- Large cells
- Small batteries
- Production scrap

2. Discharge

Before dismantling the batteries they need to be discharged, which will be done in two ways:

- Electric: For intact batteries. The discharged energy can be used for powering processes or be sent back to the city.
- Chemical: For faulty or deformed batteries. Pools with chemical solution.

3. Dismantling

There will be no manual disassembly line but as it is still in research, there are 2 hypothetical scenarios:

- 1: Robots disassembling
- 2: Crushing of cells

4. Crushing and Sorting

Battery scraps are sent to the crushing machine for further demolition. This step is very noisy and not suitable for public. It should be kept apart from functions such as break room as the sounds can get very loud.

5. Chemical Separation

The hydromet is acid baths separating different minerals. This needs a lot of space as every step of purifying demands its own tank. There needs to be labs in connection that control the purity of each batch.

Geographic context: Regional

Map of the northern part of Norrlandskusten

The giga-factory and recycling plant will be located in Skellefteå, a municipality of ca 70 000 inhabitants in the north of Sweden. A reason for the choice of site was the municipality owned electric company *Skellefteå Kraft* which delivers 100% renewable energy. Skellefteå is also a part of a raw material and mining cluster in the north of Sweden and has a long history of process manufacturing and recycling.

There is currently no train traffic to Skellefteå, but a large project *Norrbotniabanan* is planned to connect the cities along the northern coast. There is a small airport with daily flights to Stockholm. The main transportation of goods goes through the harbor *Skelleftehamn*.

Located between Luleå and Umeå, Skellefteå has vicinity to the two big universities in Norrland. This increases possibilities to attract skilled labor to the factory.

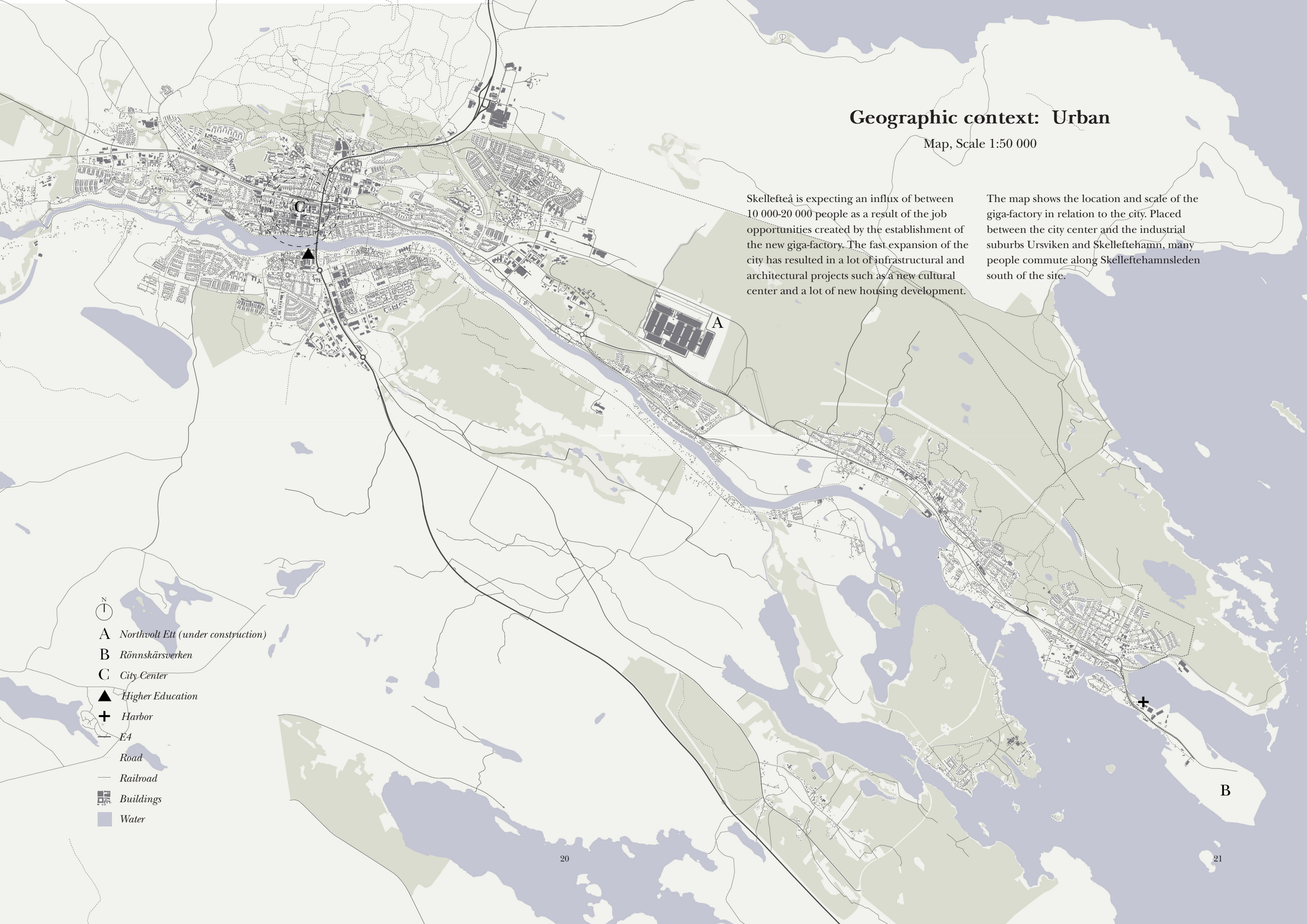
FACTS SKELLEFTEÅ
Inhabitants.....72 589
Area.....2 460 hectare
Density.....10,7 inhabitants/km2
Expected growth.....10 000 -20 000 people
Unemployment.....2,7%
Employers working in production.....ca 18%

Geographic context: Urban

Map, Scale 1:50 000

Skellefteå is expecting an influx of between 10 000-20 000 people as a result of the job opportunities created by the establishment of the new giga-factory. The fast expansion of the city has resulted in a lot of infrastructural and architectural projects such as a new cultural center and a lot of new housing development.

The map shows the location and scale of the giga-factory in relation to the city. Placed between the city center and the industrial suburbs Ursviken and Skelleftehamn, many people commute along Skelleftehamnsleden south of the site.

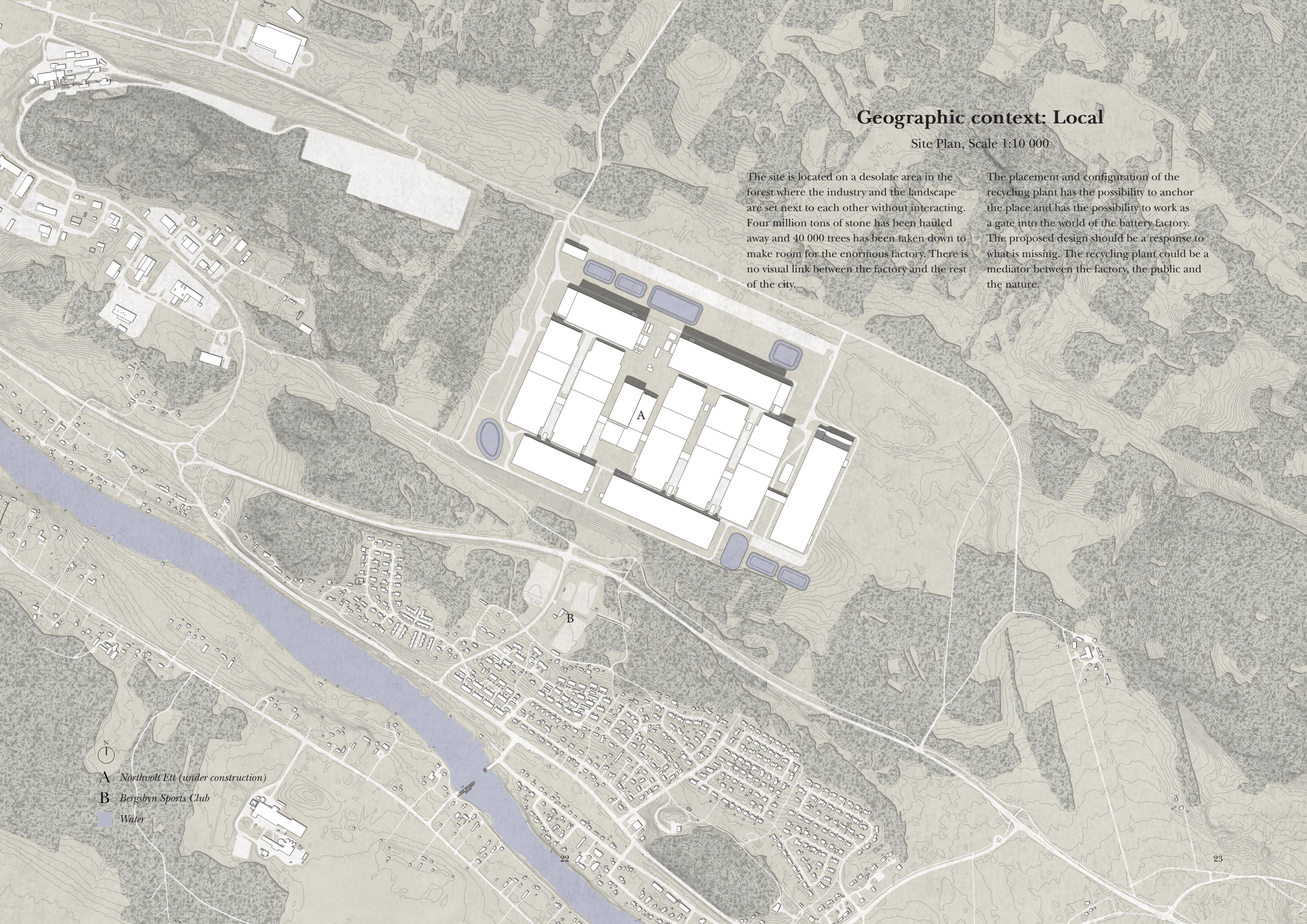


Geographic context: Local

Site Plan, Scale 1:10 000

The site is located on a desolate area in the forest where the industry and the landscape are set next to each other without interacting. Four million tons of stone has been hauled away and 40 000 trees has been taken down to make room for the enormous factory. There is no visual link between the factory and the rest of the city.

The placement and configuration of the recycling plant has the possibility to anchor the place and has the possibility to work as a gate into the world of the battery factory. The proposed design should be a response to what is missing. The recycling plant could be a mediator between the factory, the public and the nature.



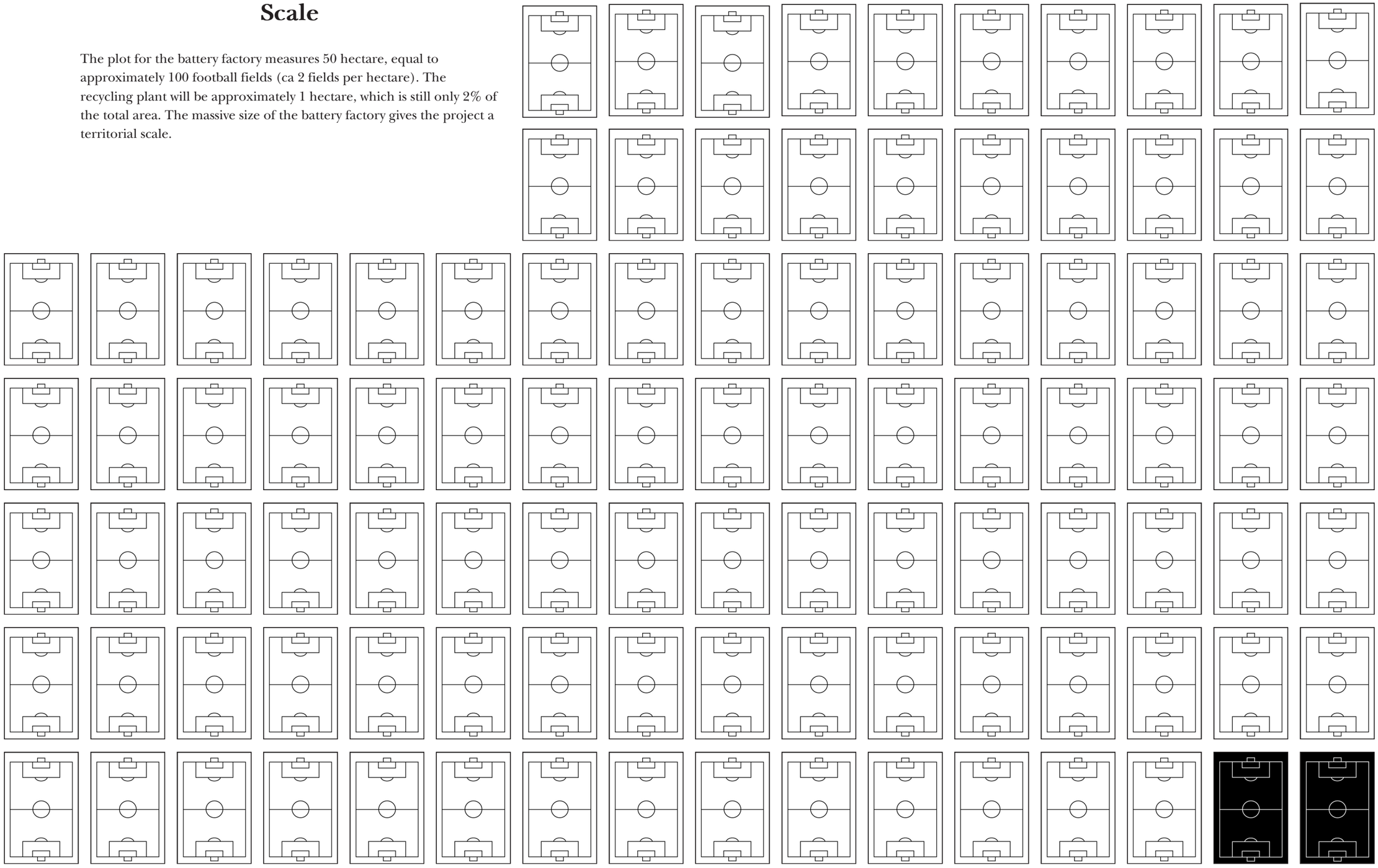
"A big box transforms the territory it inhabits, despite a complete ignorance towards its immediate surroundings."

- Kersten Geers

Drone photo by Filip Ershag:
Trees taken down at Northvolt Ett site

Scale

The plot for the battery factory measures 50 hectare, equal to approximately 100 football fields (ca 2 fields per hectare). The recycling plant will be approximately 1 hectare, which is still only 2% of the total area. The massive size of the battery factory gives the project a territorial scale.



Recycling plant

Geographic context

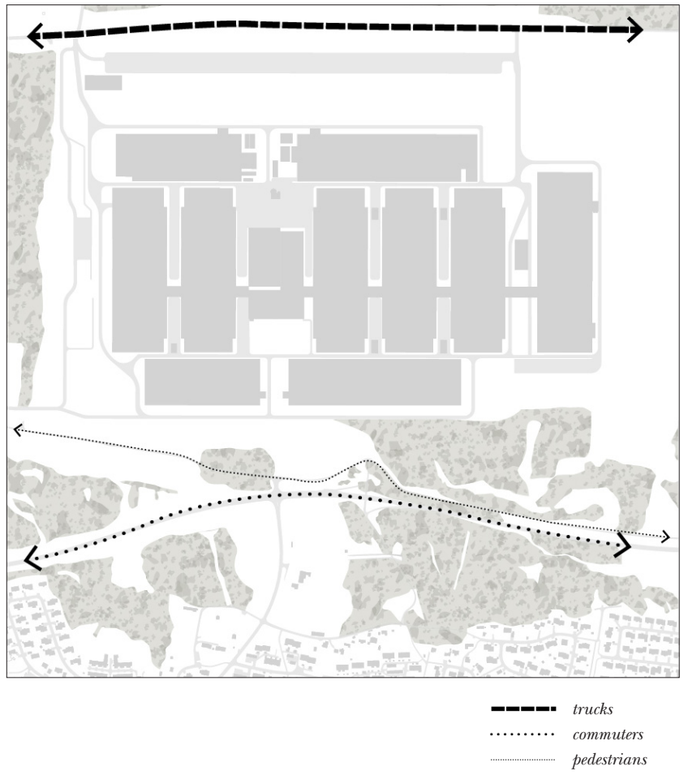
Rapid development

2018

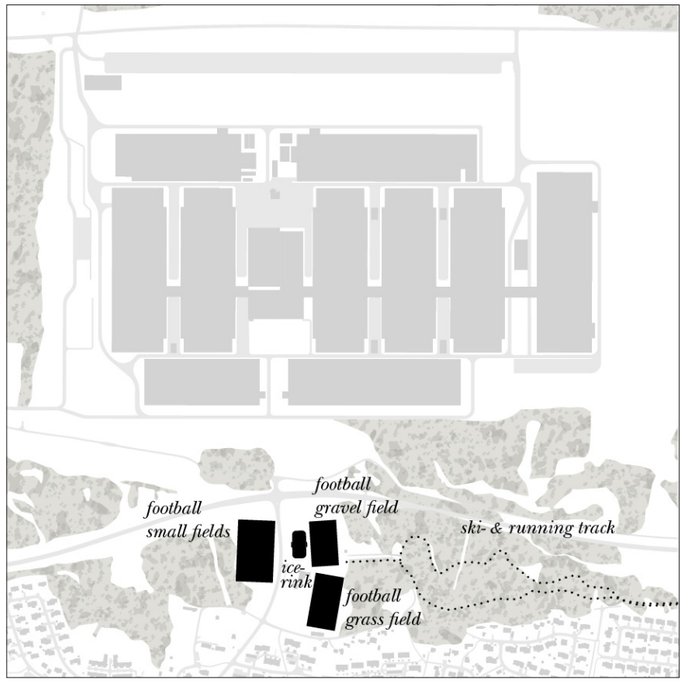
2019

Site Conditions

Connections



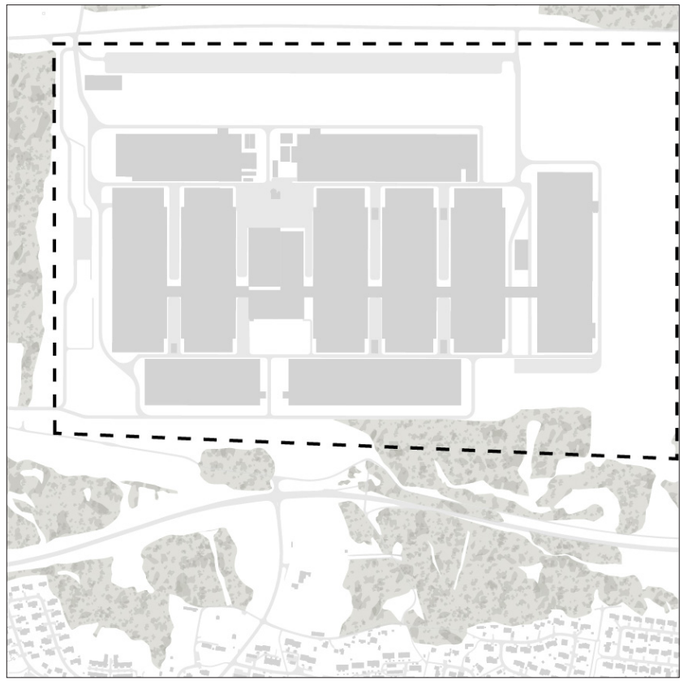
Main roads: On the north side, Torsgatan provides access for trucks leaving and picking up goods for the factory. On the south side, Skelleftehamnsleden is the main road for the general public commuting between the city and the main suburbs Bergsbyn, Ursviken, Skelleftehamn and Bureå. These are also connected through a bicycle and pedestrian path.



Adjacent sports fields: South of the site is Bergsbyn SK, a sports club with outdoor facilities open to the public.

Site Conditions

Plot configuration

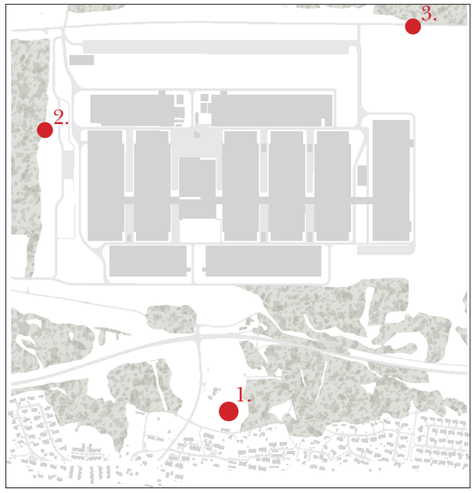


Plot boundary: The line shows the plot boundary and determines the limit of where the recycling plant can be placed.

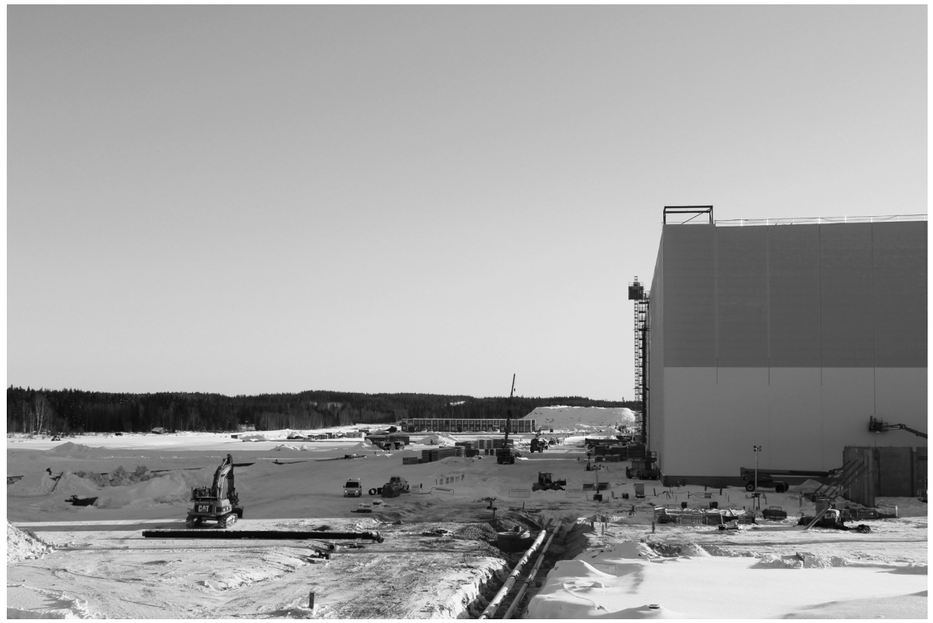
Current plan of placement: The current plan for the placement of the recycling plant in the north makes it invisible to the general public oriented to the south of the site. The proposed site is also located on land that used to be wetlands, and before testing of the ground is done, there is no fixed placement of the recycling plant.

Site Visit

Construction Site



1. View of site from soccer field. The first building under construction can already be seen.

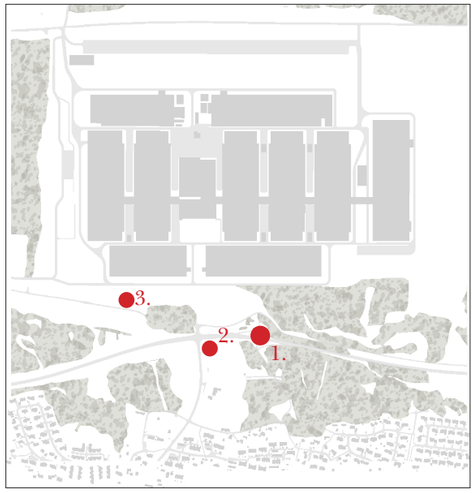


2. View of ongoing construction, the first building is being erected.

3. As the site is hard to see from the pedestrian street, curious locals are using skis to get a glimpse of the ongoing construction.

Site Visit

South Edge

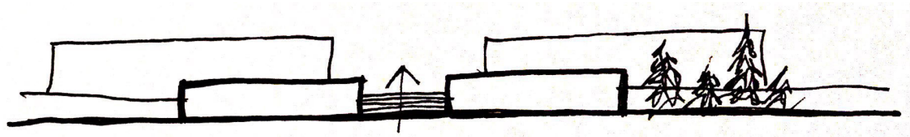


1. View from pedestrian bridge, the raised level for the industry can be seen to the right.

2. View of crossing in front of construction site. The level difference can clearly be seen.

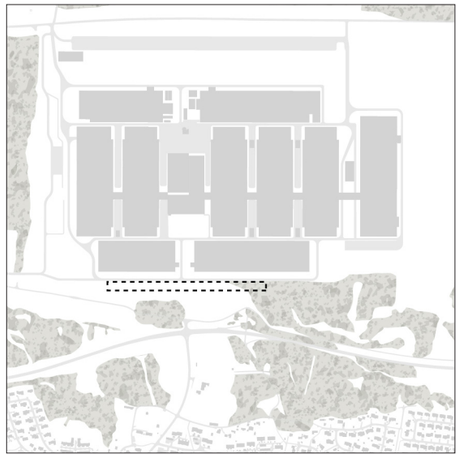
3. Pedestrian/Bicycle path west of site. The steep slope separating the level of the industry and the pedestrian level can be seen to the right.

2. PROJECT PROPOSAL

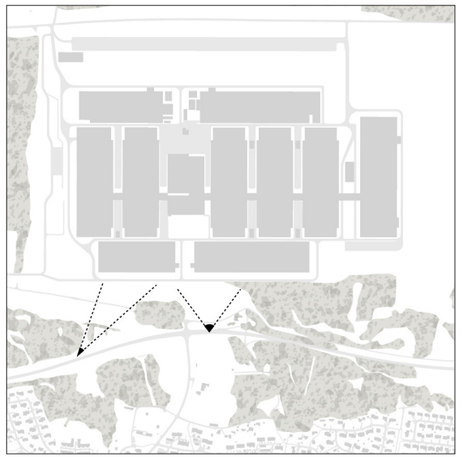


Early doodle of "gate"-concept

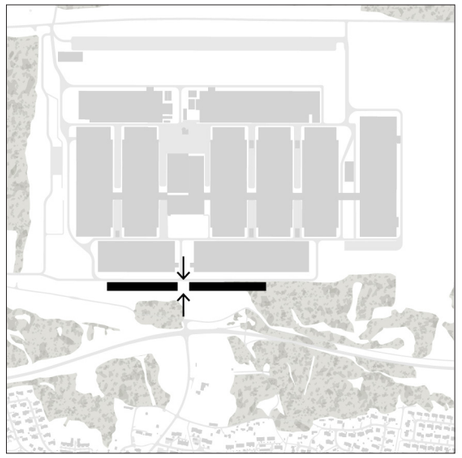
Site Strategy



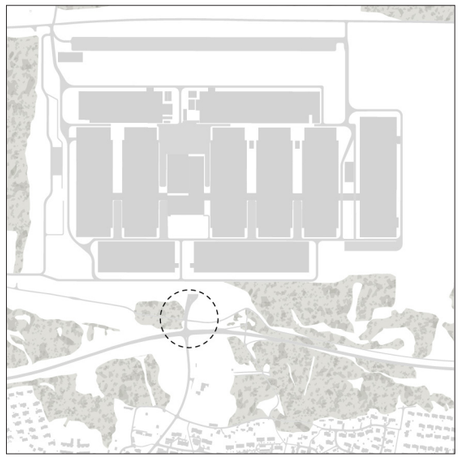
Placement: The intervention relates to the bicycle- and commuter paths, making it visible to the general public.



Visibility: The project proposal can be perceived from the road through forest clearings.

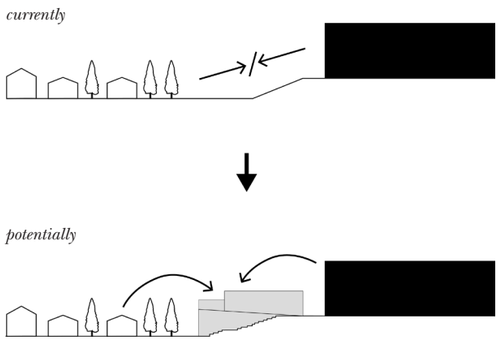


The Gate: The building is split in two by a large stair running south-north, the ‘gate’. The gate is the central access point which connects workers with people from the outside.



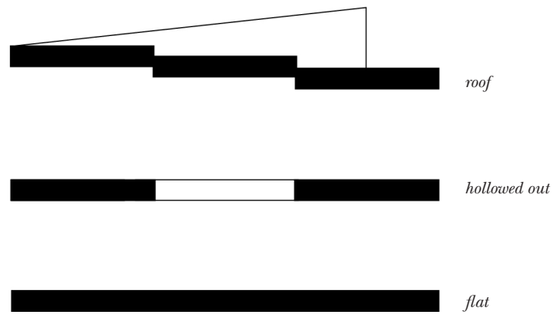
Connections: A new road connecting to Skelleftehamnsleden allows workers and visitors to drive into the parking garage underneath the intervention. A bus stop is also added to allow for public transportation.

Concept



The project aspires to transform the recycling plant into a mediator between the city, the factory and the landscape. The building needs to be placed half-buried, adapting to the topography and bridge the difference in level between the industry and the city.

The building performs as a hinge between employers and people outside both through its placement and program. The project proposes to add an everyday activity to the site: a sports center. Restaurant and sports facilities are provided for workers to avoid monotonous brakes and to get all employees at the factory to meet. The sports program thus provides a possibility to build community among the workers. The sports center is open to all Northvolt employees but residents of Skellefteå who are not employed by the company can also become members. It is a social meeting place for both workers and locals throughout the week.



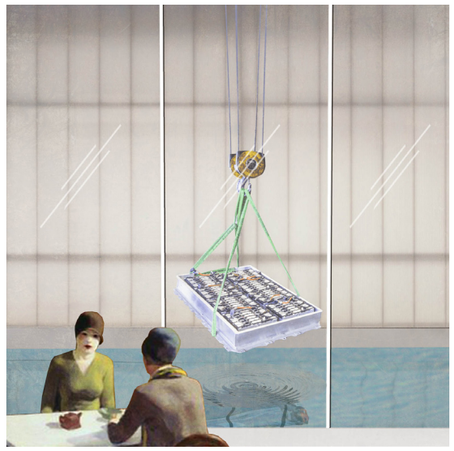
The building is split in two by a large stair running south-north, the ‘gate’. To the west of this split, the sports program and the mechanic process areas are located. The eastern side of the building houses restaurant, exhibition, study area, office spaces and labs as well as the chemical process area.

Although the Recharge Center is divided into two buildings: the Mechanical Process / Sports Center and the Chemical Process / Education Center, both buildings share the same logic of design which structures each building in three parts:
1.The flat landscape which contains the main functions of the recycling plant and the sports program in need of double height.
2.The hollowed out landscape as the open program.
3.The roof landscape as common free ground.

Additionally to the levels above ground, there is also a basement level where a large parking garage allows both visitors and workers to park and charge their cars with excess energy from the electric discharge process.

Design Process

A series of conceptual collages were used on an early stage to investigate the potential of cross programming the recycling plant with public functions. The collages where used to find what type of processes could be open or need to be closed, and what type of relation they could have with another program.



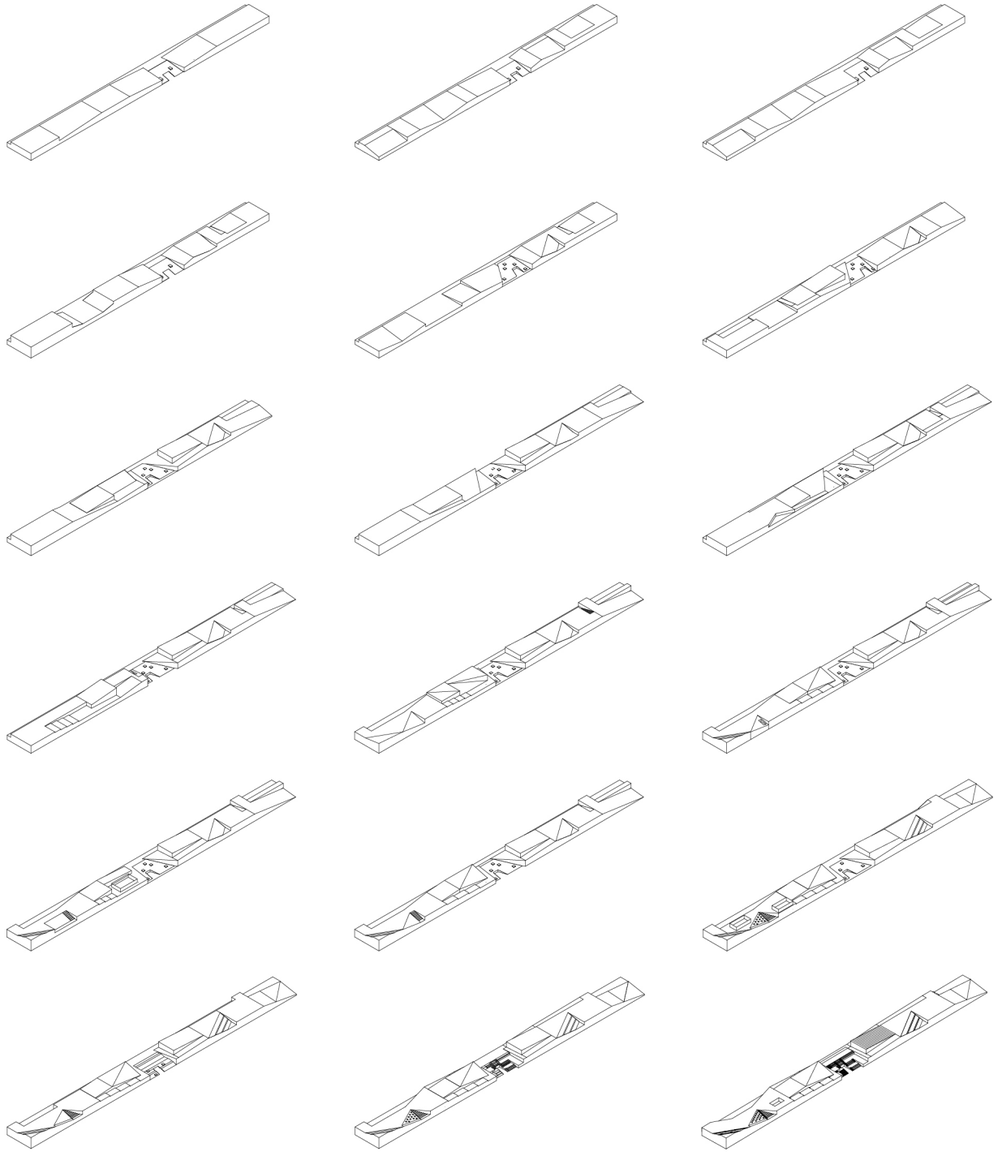
Collage investigating the chemical discharge as a spectacle. The process can be visually experienced even if separated from the public program.

Collage investigating the automated disassembly. This step can be open to the public and the robots become part of the interior.

Collage investigating the chemical separation process. As this step is quiet and concealed in tanks, it has good potentials for becoming a public space.

Collage investigating connection to outdoor program. This was later taken further and became its own landscape, the roof.

After defining the program and distribution of spaces a process of volumetric configuration followed. The sketches below show a selection of iterations leading up to the final roof landscape.



Iterations of roof-scape

Site Plan

Scale 1:5000

The site plan shows the location of the design project and its relation to the immediate surroundings. By placing the building on the south edge of the site, a visual link towards the road Skellefteå hamnsleden and the adjacent pedestrian street is made.

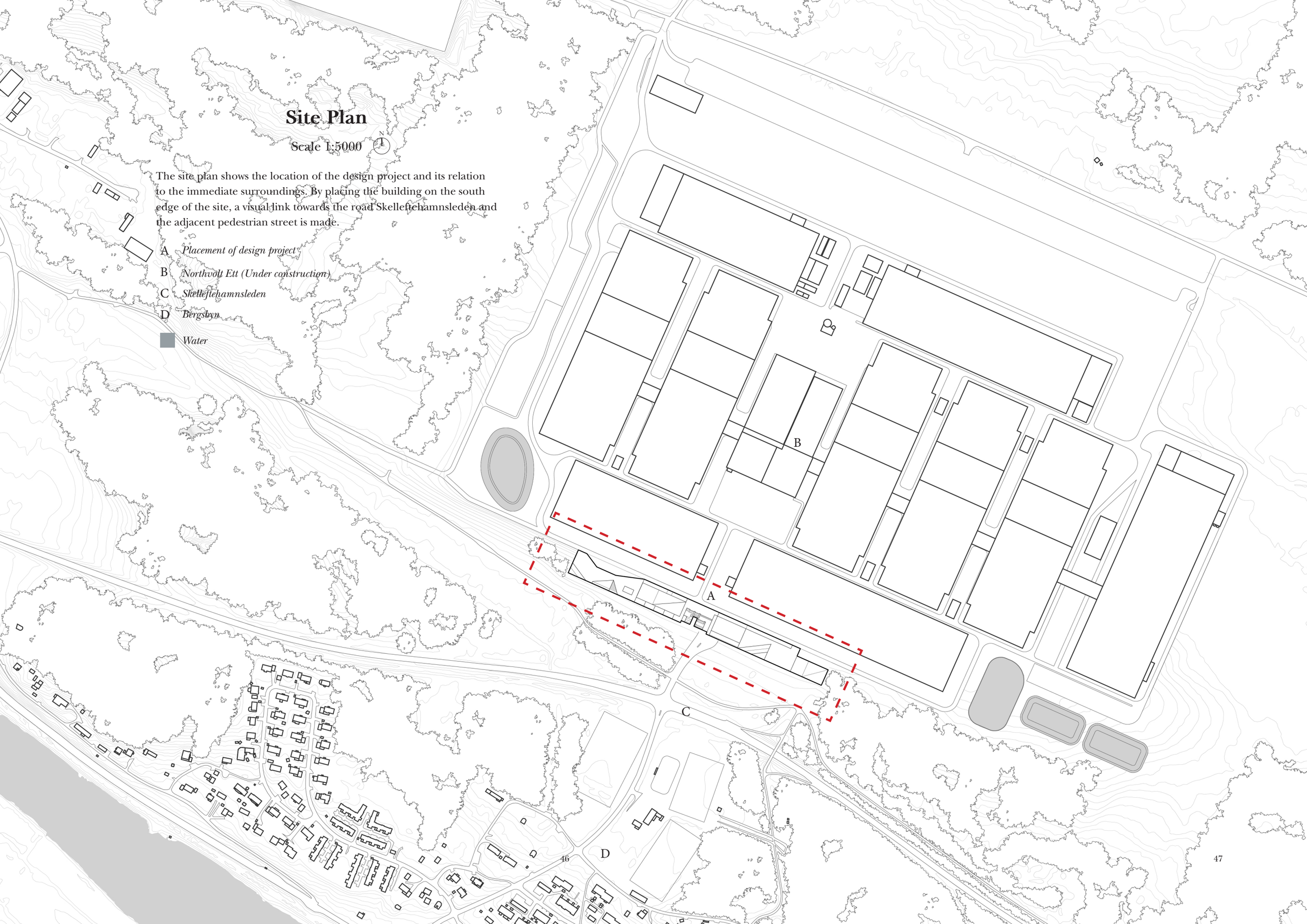
A *Placement of design project*

B *Northvolt Ett (Under construction)*

C *Skellefteå hamnsleden*

D *Bergsbyn*

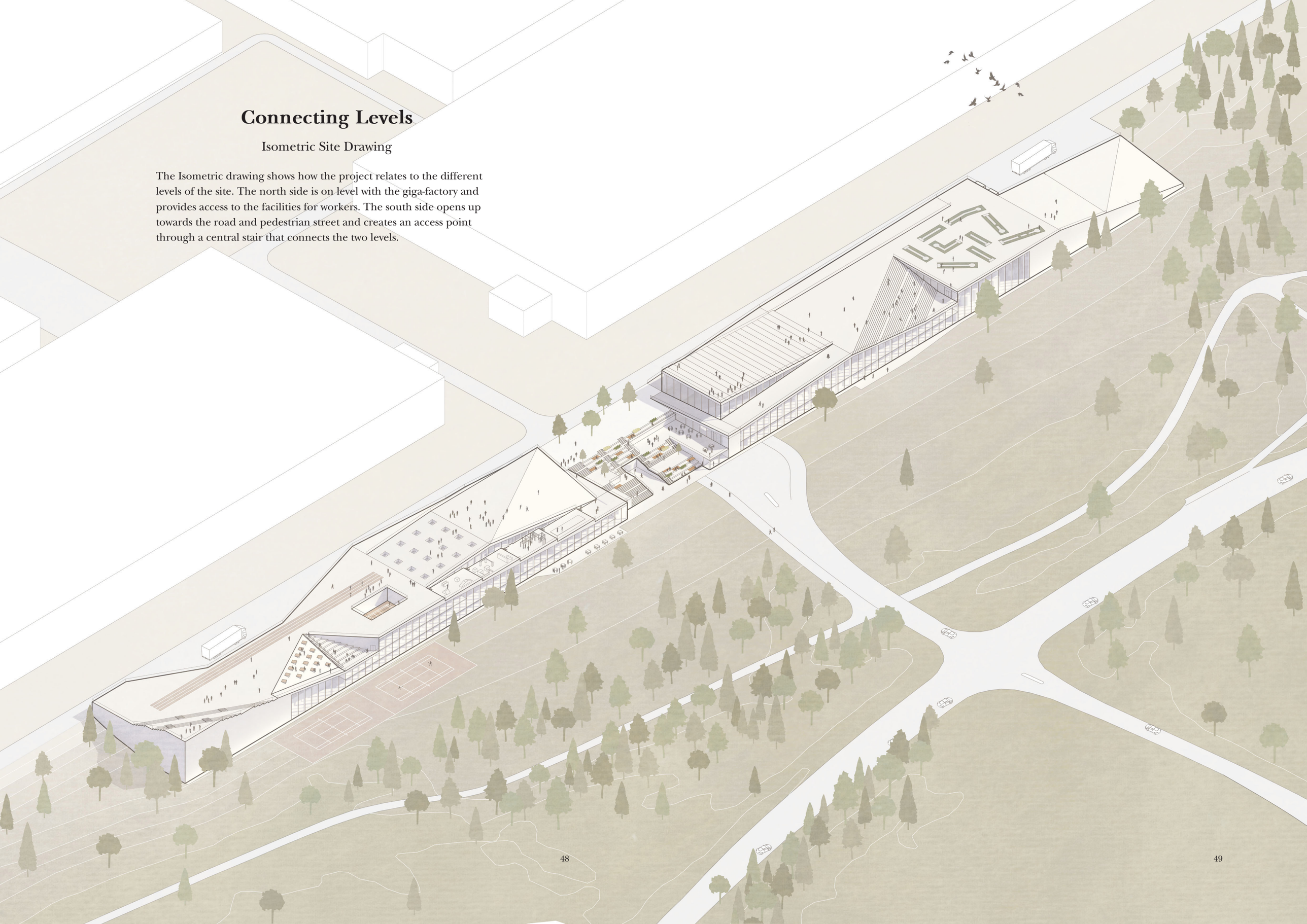
Water



Connecting Levels

Isometric Site Drawing

The Isometric drawing shows how the project relates to the different levels of the site. The north side is on level with the giga-factory and provides access to the facilities for workers. The south side opens up towards the road and pedestrian street and creates an access point through a central stair that connects the two levels.

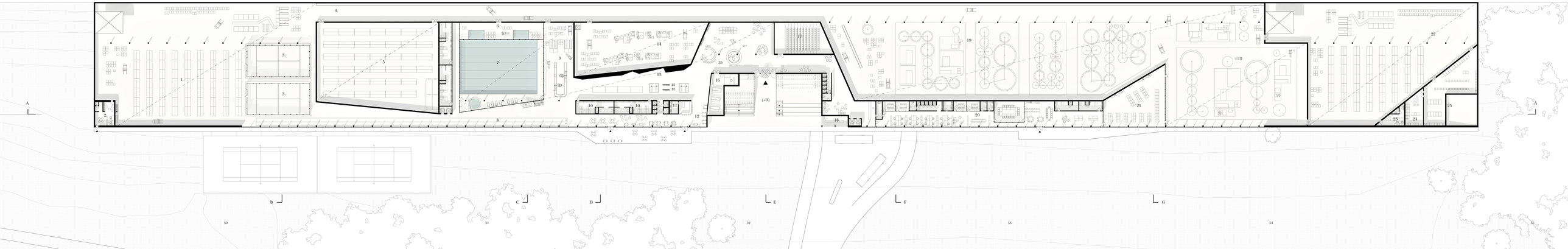


Ground-floor

Plan, Scale 1:400

0 5 10 20

1. Inbound Storage
2. Control Room
3. Padel Tennis
4. Forklift Lane
5. Electric Discharge
6. Chemical Discharge
7. Pool Area
8. 100 m Running Track
9. Automated Disassembly
10. Changing Room
11. Kitchen
12. Café
13. Climbing
14. Crushing and Sorting
15. Reception
16. Convenient Store
17. Auditorium
18. Bus Stop
19. Chemical Separation
20. Office
21. Labs
22. Outbound Storage
23. Control Room
24. Cold Garbage Room
25. Garbage Room

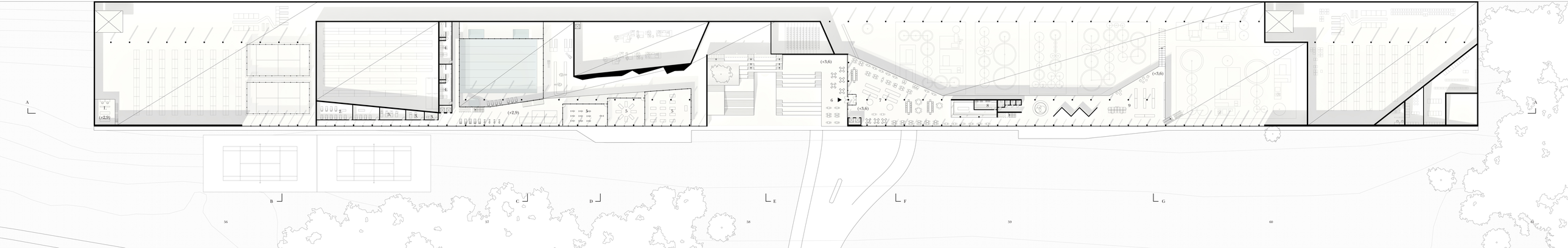


Level 1

Plan, Scale 1:400

0 5 10 20

1. Control Room
2. Light Therapy
3. Treatment
4. Changing Rooms
5. Group Training
6. Terrace
7. Restaurant
8. Kitchen
9. Exhibition Space

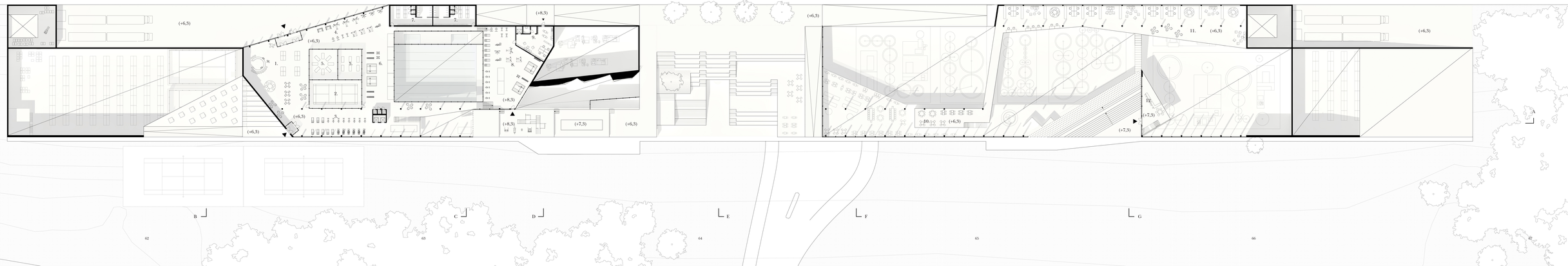


Level 2

Plan, Scale 1:400

0 5 10 20

1. Bar/Reception
2. Outdoor Badminton Court
3. Cardio
4. Training equipment
5. Group Training
6. Weights
7. Changing rooms
8. Training Equipment
9. Control Room
10. Restaurant
11. Study spaces
12. Bar

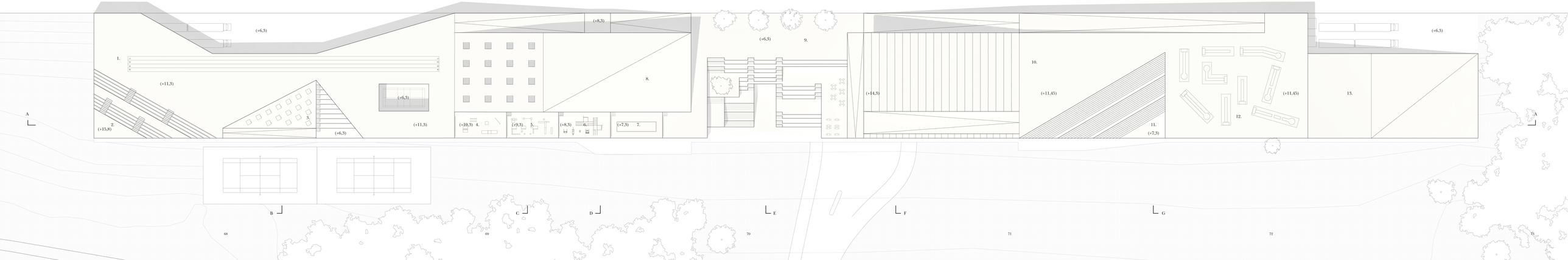


Roof

Plan, Scale 1:400

0 5 10 20

1. 100 m Running Track
2. Spectators
3. Sun stair
4. Skate
5. Parkour
6. Outdoor Gym
7. Boule
8. Rope Climbing
9. Food Trucks
10. Stage
11. Auditorium Stair
12. Mini Golf
13. Sledge Slope



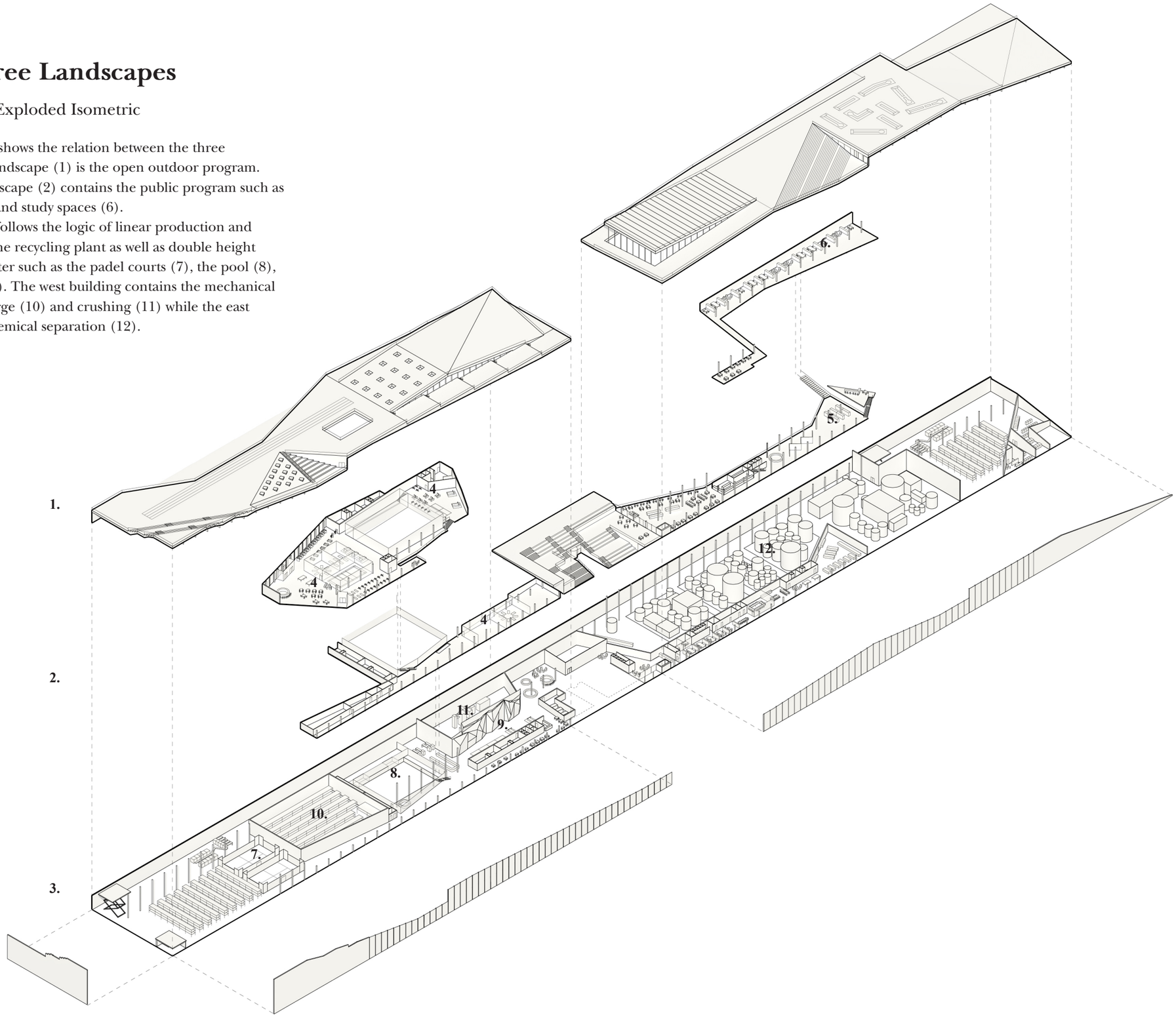
A large stair, the “gate”, splits the Recharge Center into two buildings. The image shows the gate as seen from the roof of the west building, looking towards the east building containing the chemical process and restaurant.

The roof makes big, folding movements, mimicking the snow dunes of Swedish winter. The different movements allow for a variation of urban spaces unfolding along the roof scape. Beneath the building, a bus stop provides access for both workers and visitors arriving at the giga-factory site.

Three Landscapes

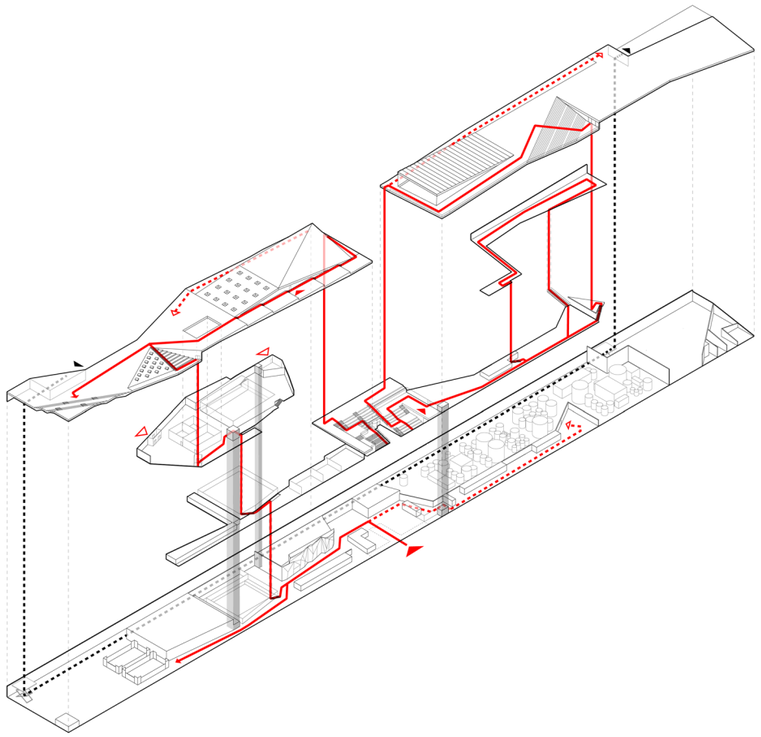
Exploded Isometric

The exploded isometric shows the relation between the three landscapes: The Roof Landscape (1) is the open outdoor program. The Hollowed Out Landscape (2) contains the public program such as gym (4), exhibition (5) and study spaces (6).
The Flat Landscape (3) follows the logic of linear production and contains the spaces for the recycling plant as well as double height spaces for the sports center such as the padel courts (7), the pool (8), and the climbing wall (9). The west building contains the mechanical processes such as discharge (10) and crushing (11) while the east building contains the chemical separation (12).



Flows

Connections and Movement

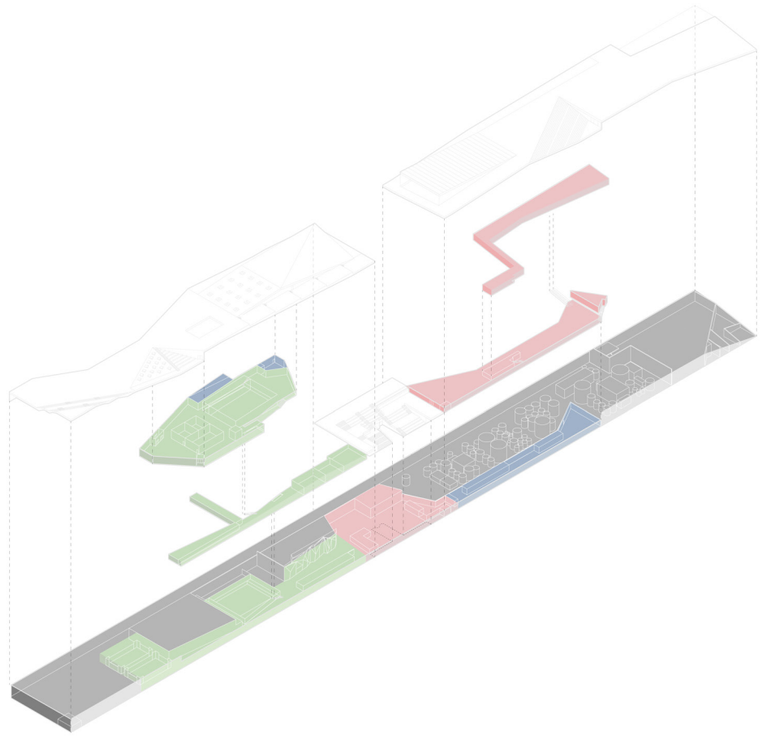


Production flow
Workers flow
Visitors flow

The flow-diagram explains the different entrance points and paths of access through the building. The production flow is located as a backbone that runs along the northern side of the building.

Program

Distribution of Functions



Recycling processes
Offices and labs
Restaurant, exhibition and education
Sports

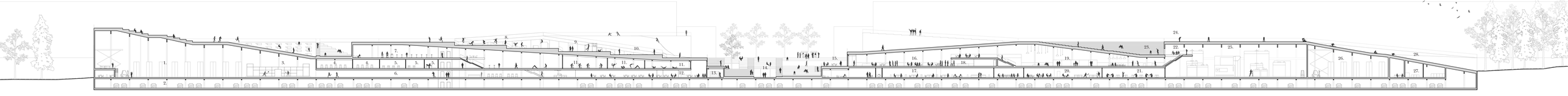
The program-diagram explains how the different functions are located in the building. The recycling processes form an unbroken line in the back of the building, with the public spaces making more or less deep cuts into the industry.

Section AA

Long Section, Scale 1:400

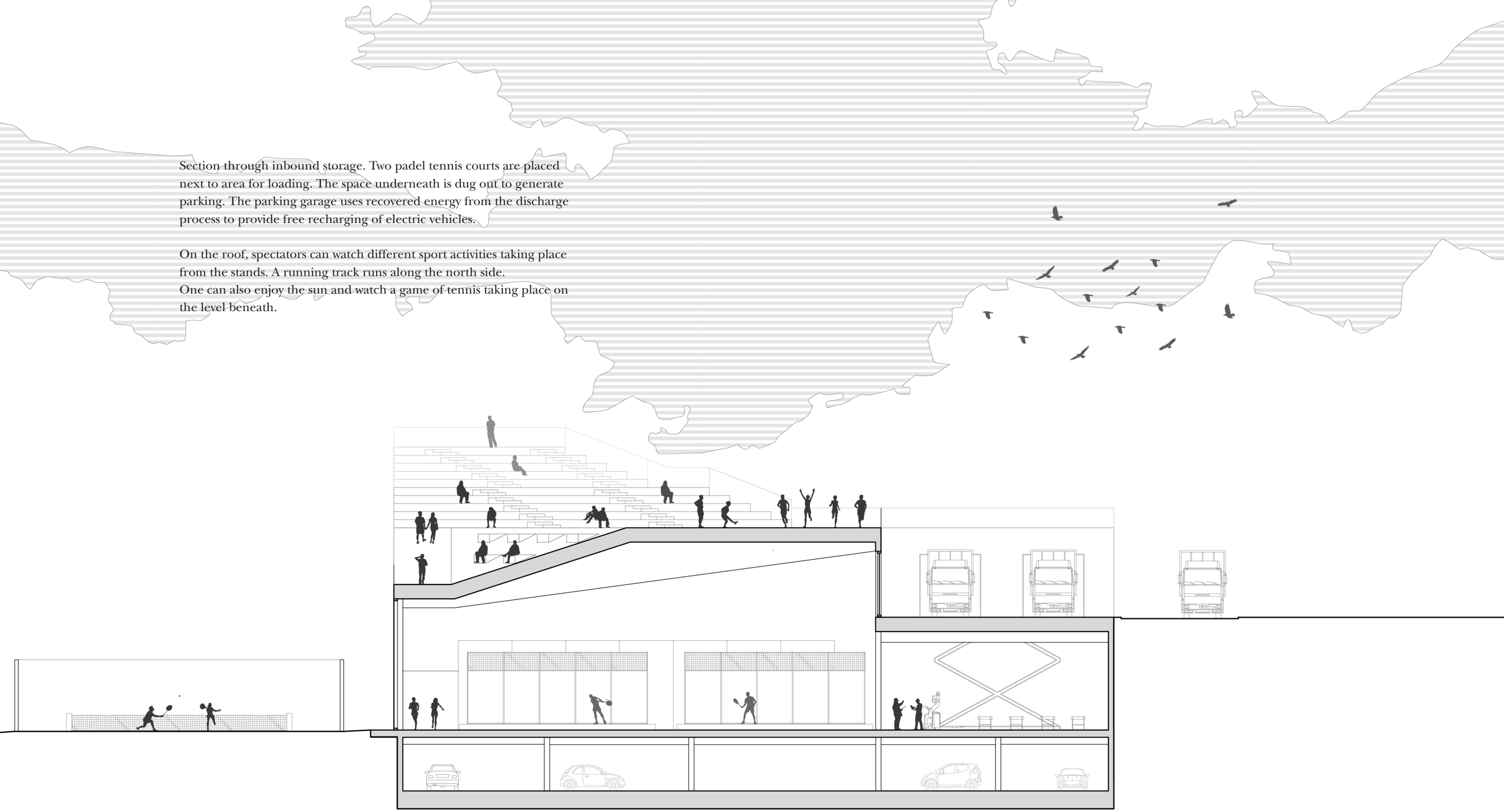
0 5 10 20

1. Inbound Storage
2. Parking Garage
3. Padel
4. Light Therapy
5. Massage/Treatment
6. Running track
7. Cardio
8. Skate and Parkour
9. Outdoor gym
10. Boule
11. Group Training
12. Cafe
13. Convenience Store
14. Entrance
15. Terrace
16. Restaurant
17. Office
18. Kitchen
19. Exhibition
20. Break Room
21. Labs
22. Bar
23. Amphitheater
24. Mini Golf
25. Chemical Separation
26. Outbound Storage
27. Garbage Room
28. Sledge Slope

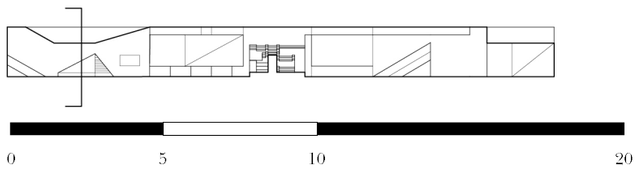


Section through inbound storage. Two padel tennis courts are placed next to area for loading. The space underneath is dug out to generate parking. The parking garage uses recovered energy from the discharge process to provide free recharging of electric vehicles.

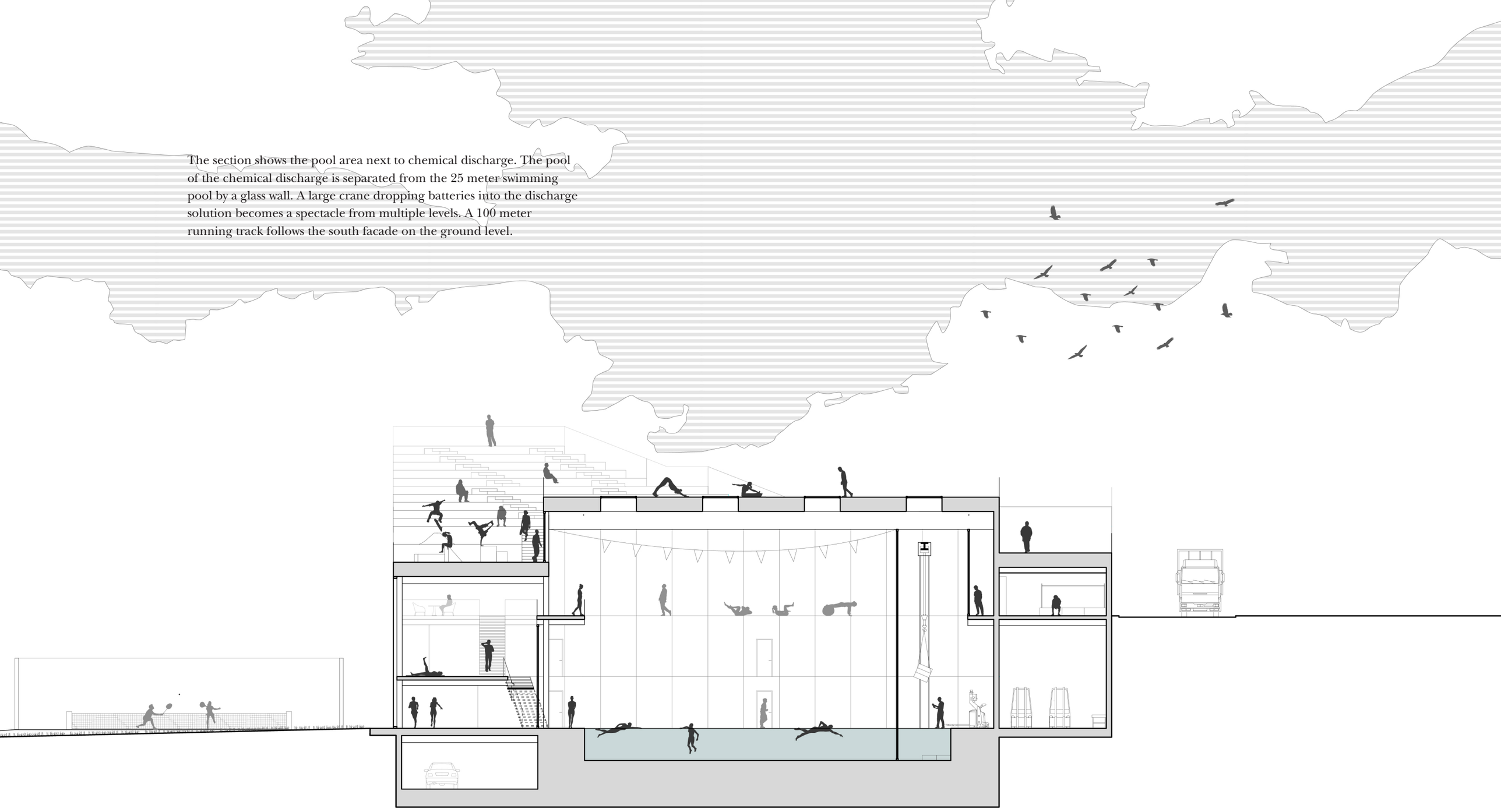
On the roof, spectators can watch different sport activities taking place from the stands. A running track runs along the north side.
One can also enjoy the sun and watch a game of tennis taking place on the level beneath.



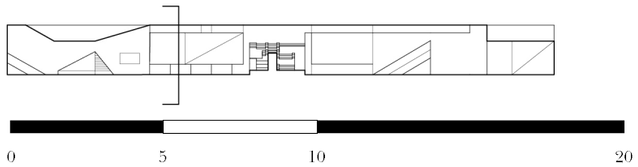
Section BB, Scale 1:200



The section shows the pool area next to chemical discharge. The pool of the chemical discharge is separated from the 25 meter swimming pool by a glass wall. A large crane dropping batteries into the discharge solution becomes a spectacle from multiple levels. A 100 meter running track follows the south facade on the ground level.



Section CC, Scale 1:200

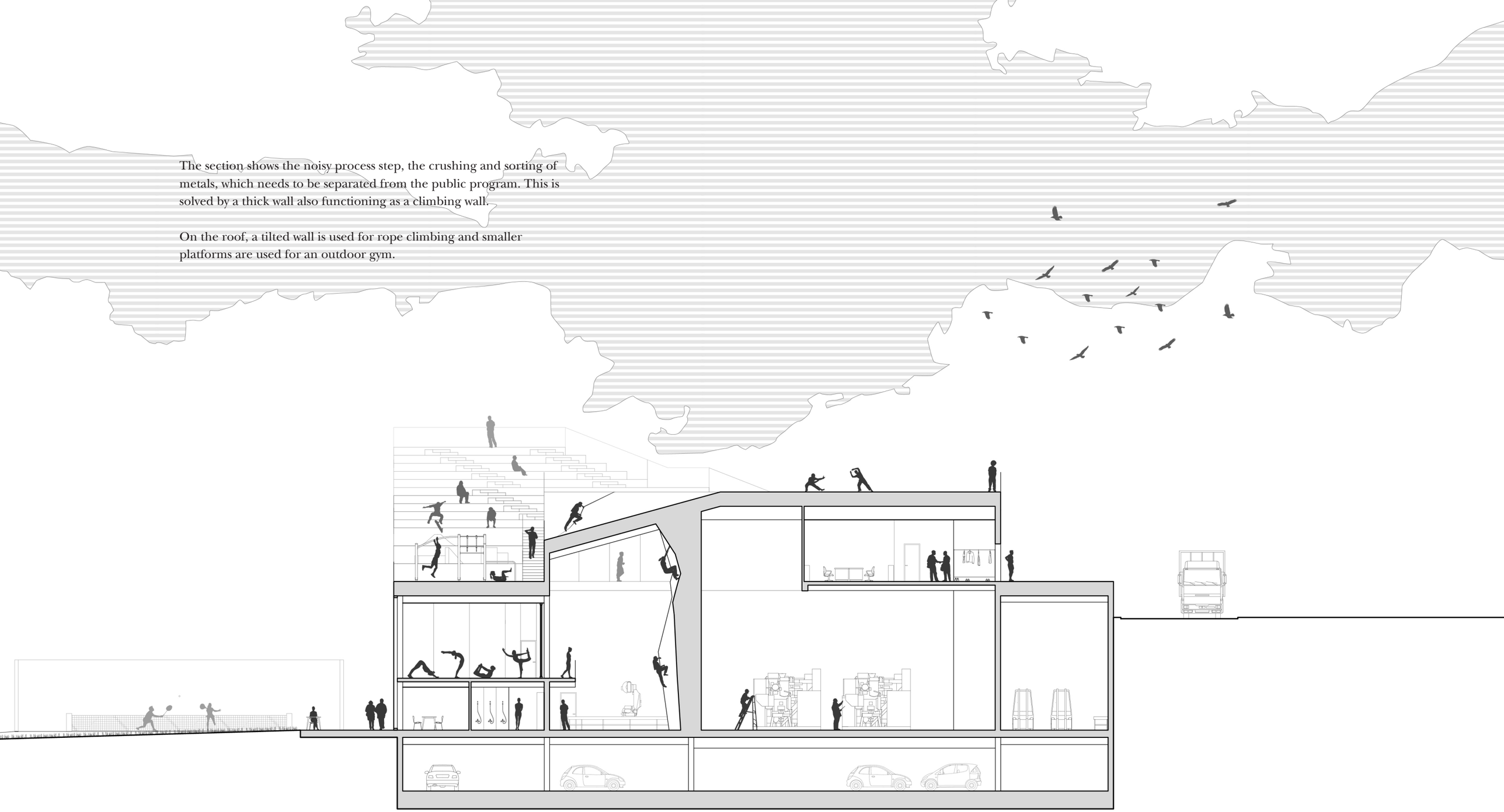


It is as if you have entered the eye of the storm when you dive into the public bath. Surrounded by industrial processes, overlooking balconies, as well as skylights providing the space with an ambient atmosphere, this is a space where all landscapes meet.

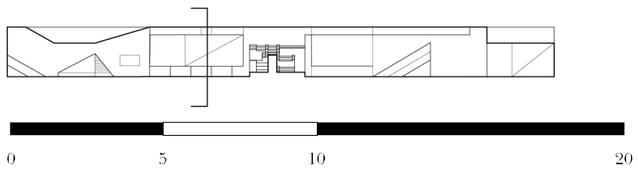
The link between the public and the industrial program is apparent. Next to the swimming pool, on the other side of the glass, two chemical pools for discharging batteries are placed. The image shows a gantry crane dropping a used car battery into the solution.

The section shows the noisy process step, the crushing and sorting of metals, which needs to be separated from the public program. This is solved by a thick wall also functioning as a climbing wall.

On the roof, a tilted wall is used for rope climbing and smaller platforms are used for an outdoor gym.



Section DD, Scale 1:200

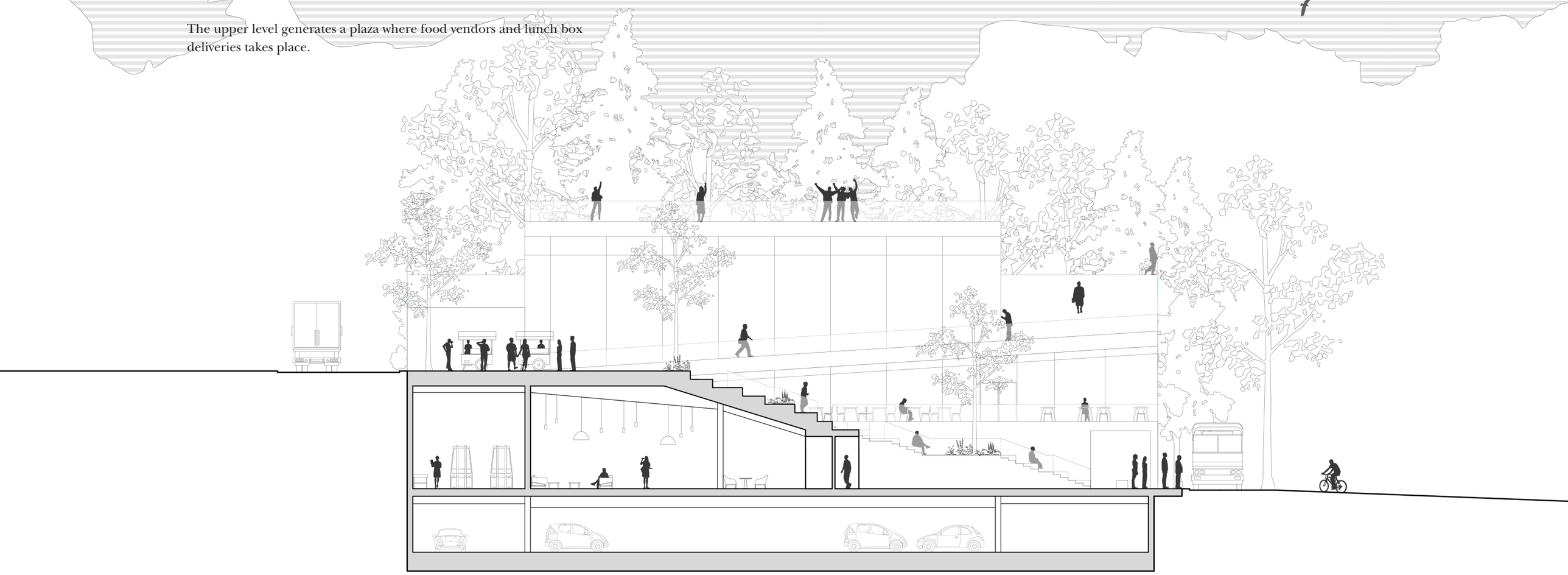


As one enters the sports center, the interior is animated by simultaneous views of different activities. Two levels unfold around the entrance atrium for the sports center and allows different view points of the space.

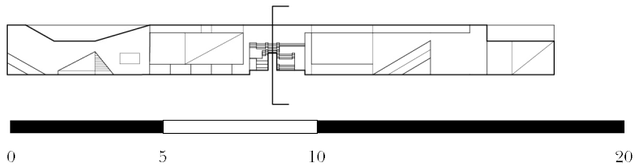
A large climbing wall stretches all the way to the roof and the swimming pool generates a soft blue light. Here, the industry is separated from the public space except for two large robots who dismantle battery packs in the end of the room.

The section shows the “gate”, the large stair that works both as an entrance to the building on the lower ground and to the factory site and roof scape on the upper level.
A bus stop is placed in front of the stair and is used by both workers commuting to the factory and the public going there to eat or do sports.

The upper level generates a plaza where food vendors and lunch box deliveries takes place.

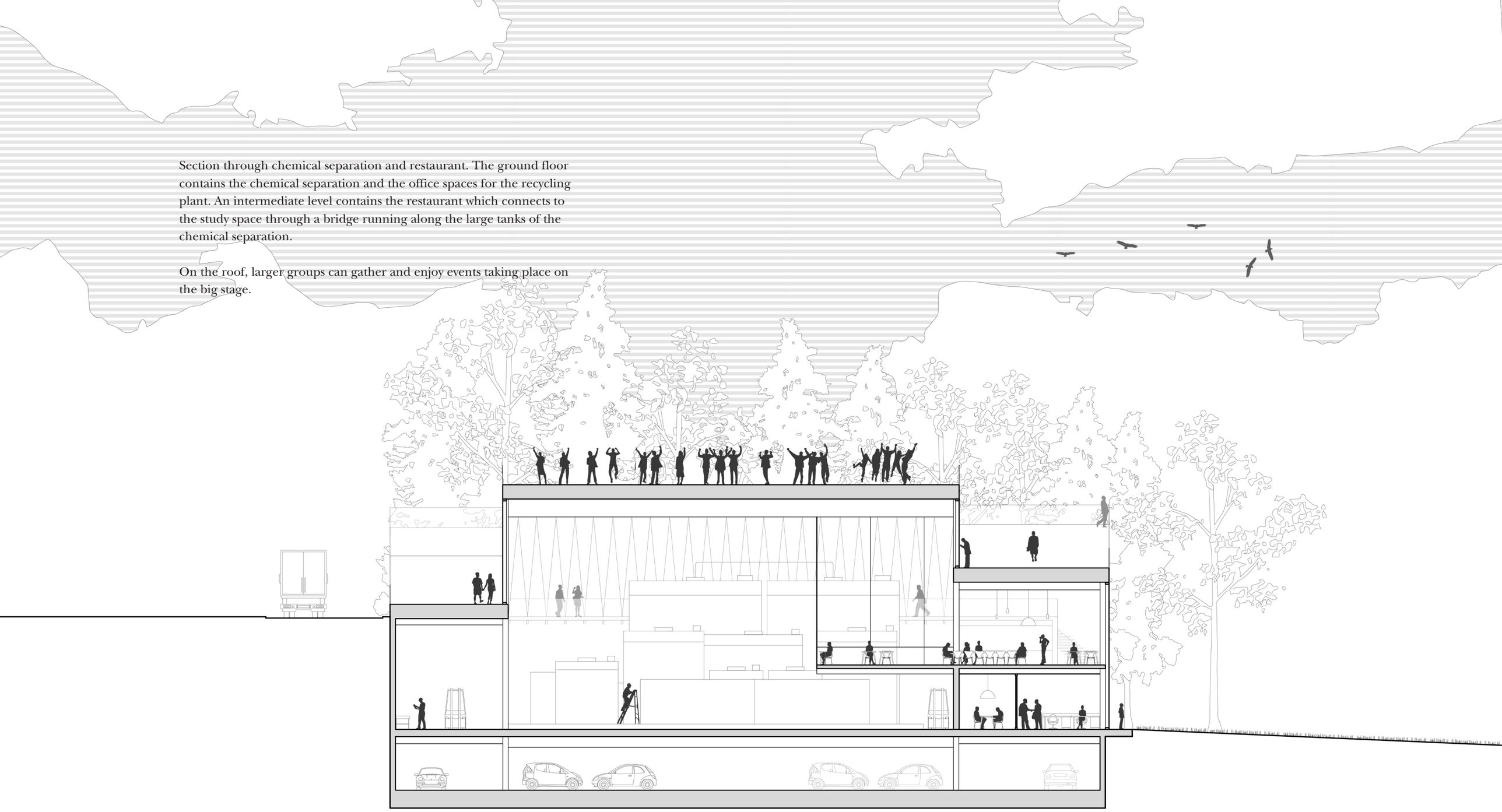


Section EE, Scale 1:200

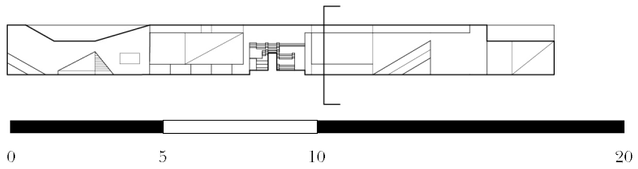


Section through chemical separation and restaurant. The ground floor contains the chemical separation and the office spaces for the recycling plant. An intermediate level contains the restaurant which connects to the study space through a bridge running along the large tanks of the chemical separation.

On the roof, larger groups can gather and enjoy events taking place on the big stage.

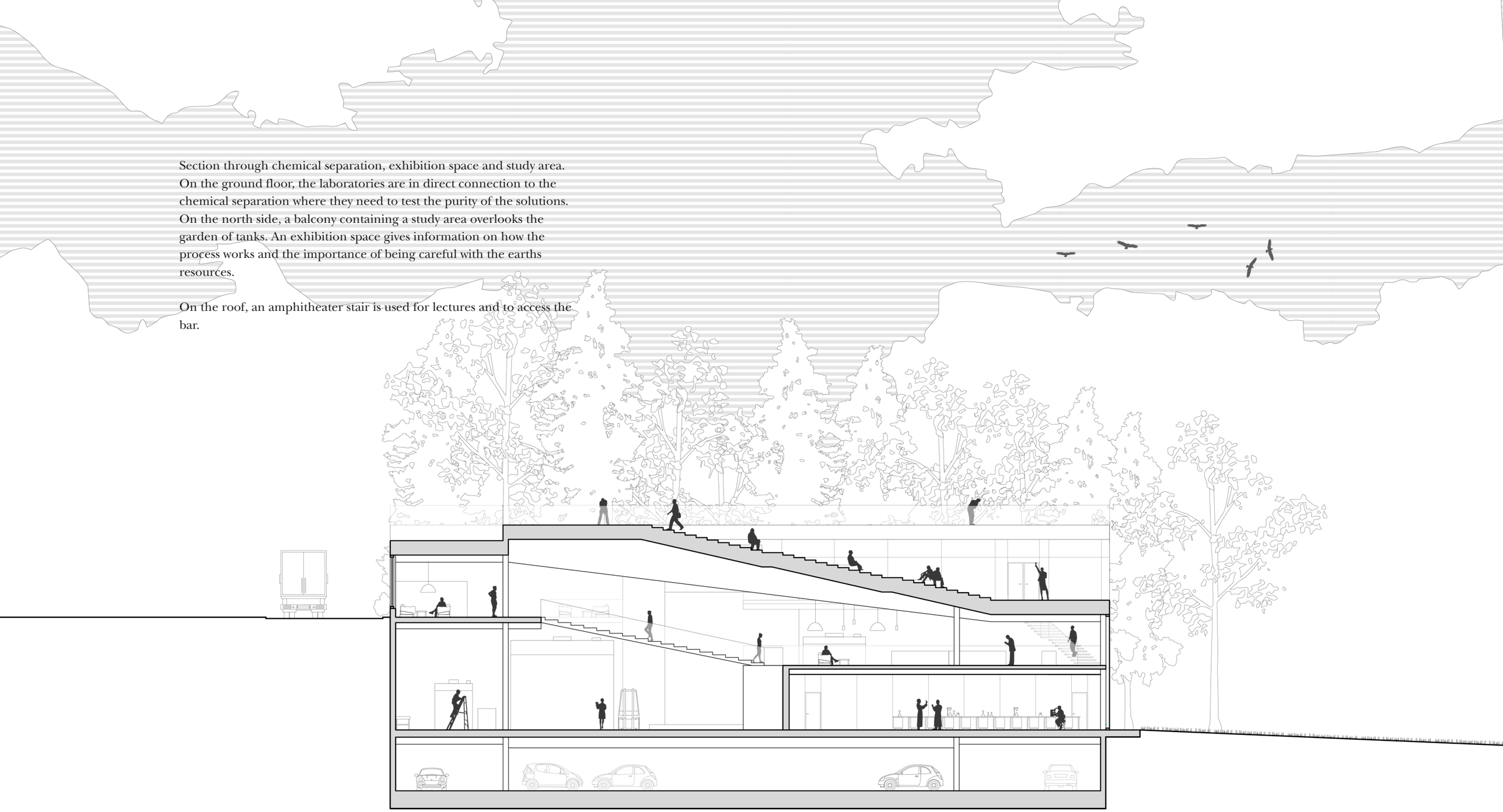


Section FF, Scale 1:200

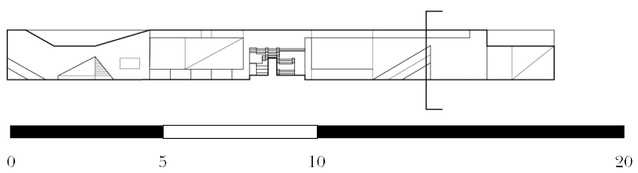


Section through chemical separation, exhibition space and study area. On the ground floor, the laboratories are in direct connection to the chemical separation where they need to test the purity of the solutions. On the north side, a balcony containing a study area overlooks the garden of tanks. An exhibition space gives information on how the process works and the importance of being careful with the earths resources.

On the roof, an amphitheater stair is used for lectures and to access the bar.



Section GG, Scale 1:200



The restaurant, exhibition and study space are wrapped around the chemical process, the “Hydromet”, which consists of large metal tanks containing different solutions for purification.

The perspective illustrates the meeting between raw and refined, and how the vast, rational atmosphere of the industrial space encounters the more human scale public sphere.

3. CONCLUSION

Sketch collage: Throwing an old iphone in the shredder. As this space is very noisy, the idea was disregarded.

Reflection

The thesis project has investigated a field of architecture where architects are seldom involved. By looking closer at an emerging territory outside of the city center, I want to relate to a larger discourse on where the future of architecture will take place. No definitive answers to the initial thesis questions will be given, instead will follow a discussion on the project as a whole.

The thesis started as a travel back home where the encounter with the factory site ignited my curiosity. By investigating the processes of recycling batteries, the mystery was slowly unveiling itself. As there were needs for rationality in each step of the recycling process, a pragmatic approach and acceptance towards the banality of the industrial layout made other aspects more important such as how the building relate to the ground and where it can be opened to the public.

There are several moments where the processes can be intertwined with a public program and through this enrich the space. By proposing to cross-program the recycling plant with a sports and education center, I have sought to broaden the field in which we as architects can operate, but also to open up and make visible this type of industrial space which today is hidden from general view. The massive scale and complexity of the project have at times been overwhelming, and yet, it is tiny in comparison to its surrounding factory neighbors. The fact that 3000 workers will use the site on an everyday basis brings a sense of legitimacy to the project. It might seem absurd to propose such a grand scheme, but when one understands the given context it is clear that it calls for a large gesture.

With my thesis I want to raise questions on how the current planning of these vast industrial complexes could be challenged and how the hidden program of recycling could be exposed by incorporating other factors such as the public. The thesis is an idea-driven project serving as a comment in the bigger debate of the productive city. In that sense, the thesis touches upon aspects that relate to both architecture and urbanism. The ideas put forward in the thesis can be linked to a contemporary debate on the emerging machine landscapes and landscape urbanism, with writers and architects such as Liam Young, Rem Koolhaas and Stan Allen. Finally, I also hope that some of the ideas are infused in the actual design of the recycling plant that will be built in two years.

References

The following literature has been important in regards of informing the approach to the thesis project as well as an inspiration for the design process in general:

Young, Liam, Machine Landscapes: Architectures of the Post Anthropocene, Architectural design vol. 89 (1), John Wiley & Sons, (London 2019)

Koolhas, Rem, Mau, Bruce, S-M-L-XL, The Monacelli Press (New York 2002)

Törnqvist, Anders, Ullmark, Peter. When people matter : [Nordic] industrial architecture & engineering design, Swedish Council for Building Research (Stockholm 1989)

Aureli, Pier Vittorio, The Possibility of an Absolute Architecture, MIT Press (Cambridge 2011)

Information on Lithium-Ion Batteries has been gathered from the article “State-of-the-art in reuse and recycling of lithium-ion batteries - A research review ” by Hans Eric Melin for Circular Energy storage that was retrieved through Energimyndigheten (https://www.energimyndigheten.se/globalassets/forskning–innovation/overgripande/state-of-the-art-in-reuse-and-recycling-of-lithium-ion-batteries-2019.pdf).