ARV

CLIMATE POSITIVE CIRCULAR COMMUNITIES

D4.1 DESIGN GUIDELINES FOR A CLIMATE POSITIVE CIRCULAR COMMUNITY IN OSLO

WP4 SUSTAINABLE BUILDING (RE) DESIGN

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[1] *ARV is a Norwegian word meaning "heritage" or "legacy". It reflects the emphasis on circularity, a key aspect in reaching the project's main goal of boosting the building renovation rate in Europe.*

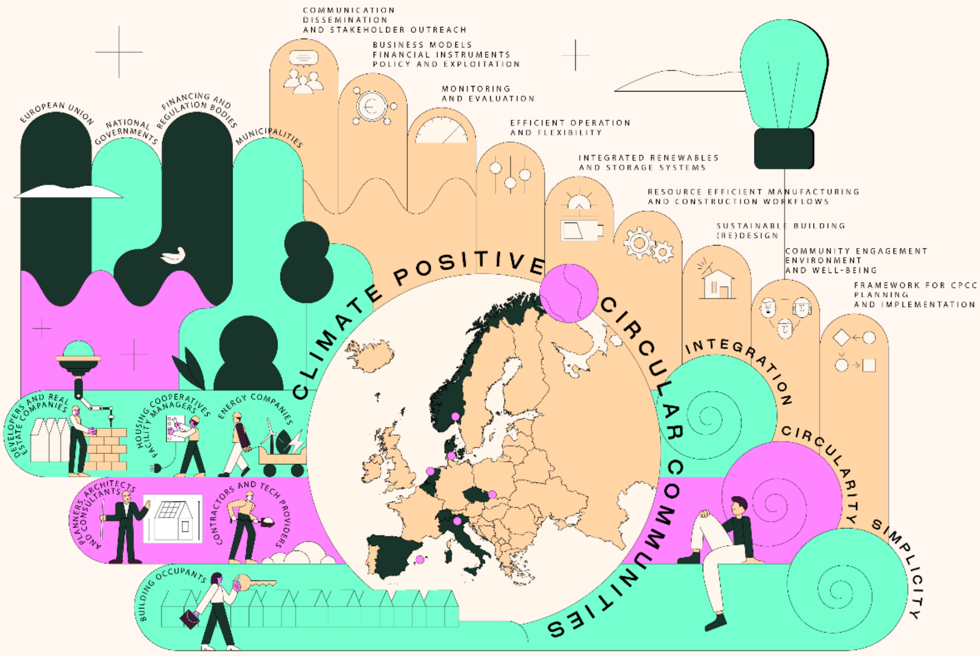
ABOUT THE ARV PROJECT

The vision of the ARV project is to contribute to speedy and wide scale implementation of Climate Positive Circular Communities (CPCC) where people can thrive and prosper for generations to come. The overall aim is to demonstrate and validate attractive, resilient, and affordable solutions for CPCC that will significantly speed up the deep energy renovations and the deployment of energy and climate measures in the construction and energy industries. To achieve this, the ARV project will employ a novel concept relying on a combination of 3 conceptual pillars, 6 demonstration projects, and 9 thematic focus areas.

The 3 conceptual pillars are integration, circularity, and simplicity. **Integration** in ARV means the coupling of people, buildings, and energy systems, through multi-stakeholder co-creation and use of innovative digital tools. **Circularity** in ARV means a systematic way of addressing circular economy through integrated use of Life Cycle Assessment, digital logbooks, and material banks. **Simplicity** in ARV means to make the solutions easy to understand and use for all stakeholders, from manufacturers to end-users.

The 6 demonstration projects are urban regeneration projects in 6 locations around Europe. They have been carefully selected to represent the different European climates and contexts, and due to their high ambitions in environmental, social, and economic sustainability. Renovation of social housing and public buildings are specifically focused. Together, they will demonstrate more than 50 innovations in more than 150,000 m^2 of buildings.

The 9 thematic focus areas are 1) Effective planning and implementation of CPCCs, 2) Enhancing citizen engagement, environment, and well-being, 3) Sustainable building re(design) 4) Resource efficient manufacturing and construction workflows, 5) Smart integration of renewables and storage systems, 6) Effective management of energy and flexibility, 7) Continuous monitoring and evaluation, 8) New business models and financial mechanisms, policy instruments and exploitation, and 9) Effective communication, dissemination, and stakeholder outreach.



The ARV project is an Innovation Action that has received funding under the Green Deal Call LC-GD-4-1-2020 - Building and renovating in an energy and resource efficient way. The project started in January 2022 and has a project period of 4 years, until December 2025. The project is coordinated by the Norwegian University of Science and Technology and involves 35 partners from 8 different European Countries.

EXECUTIVE SUMMARY

This is the first edition of the design guidelines of a climate positive circular community in Oslo.
The Norwegian demo project is the Voldsløkka School and Cultural area.

The main objective of this report is to describe the design process from the early urban planning stages to the detailed design and construction of the Voldsløkka project. The project includes the construction of new buildings and the renovation of an existing listed building. The area has high environmental ambitions and will be built as Oslo's first plus energy school, with a surplus of energy generated, covering all energy needs.

The report involves the main stakeholders and describes the decision-making process in the design phases by analysing qualitatively and quantitatively the most relevant aspects taking into account the spatial, technical, environmental, regulatory and social context of the district.

The fundamental goal is the integrated circular design, evaluation and implementation of Climate Positive Circular Communities (CPCCs). The CPCCs design includes concepts of flexibility, multi-use, quality of use, inclusive design, plus-energy and low emissions, as well as innovative storm water management and, moreover, renovation and adaptive reuse of a historical building. Chosen technical solutions aim to be robust, simple, environmentally friendly, and reasonably standardized. They should ensure cost-effective management, operation, and maintenance of the school facility.

As the design and construction of Voldsløkka project is already advanced, the future updates of the design guidelines will feature a scenario analysis on design alternatives for the school and cultural area ensemble. The energy consumption and GHG emissions calculations of the buildings as well as the alternative design scenarios will be refined and compared. The alternative solutions will showcase the use of digital support in design processes and extend the design space available for future projects.

The Design Guidelines report will be revised and supplemented annually to present the design practices and advancements of the climate positive circular community in Oslo.

TABLE OF CONTENTS

1. INTRODUCTION

The overarching aim of ARV WP4 is to address the design of new and retrofitting of existing buildings as zero-emission positive energy-buildings in sustainable climate positive circular communities (CPCC) to (i) reduce their embodied energy and emissions, (ii) increase their energy efficiency, and (iii) match sustainability with aesthetics and quality of life (in line with New European Bauhaus strategy). Each of the six ARV demonstration projects addresses these goals differently, due to the different demos' sizes, geographical locations and local climates, and buildings use.

The strategies adapted in the different demonstration projects include, among others: adaptation to local climate conditions, deep renovation with minimum disruption for buildings occupants, high energy efficiency with active & passive solutions, reuse and recycling of building materials, elements, and modules, and integration of renewables.

Task 4.2 addresses the goals specifically for the Norwegian ARV demonstration project, Voldsløkka project. Different scenarios of combinations of state-of-the-art materials, components, technologies, and smart control systems are analysed and tested against the ARV KPIs. The following design strategies will be analysed:

- BIM and Virtual scenarios will be used to document the performance of the design process.
- Climate adapted design using an innovative open surface water solution and green solutions for the outdoor area of the Voldsløkka project.
- The environmental benefit of implementing a circular renovation strategy, where most of the walls and windows in the old factory are reused and upgraded to new energy performance standards.
- Facade integrated BIPV system using novel, angular and coloured modules with high degree of standardized module sizes and fastening solutions.

The design and construction process of the Voldsløkka project is well ahead and as per July 2022 the planning and design stages have been already completed, and the construction and renovation activities are more than half-way to being completed.

Given the advanced stage of the Norwegian demo project, the current report has been adjusted to provide a thorough insight of the planning, designing, and construction activities of Voldsløkka project by focusing on the followings:

a. Which were the decisions taken in the critical steps of the urban planning and design processes.
b. Why these decisions and design choices were made.
c. Which was the decision-making process and who was involved.

The first issue of this report is dedicated to the documentation of the planning, designing, and construction activities of Voldsløkka project. Further revisions (December 2023 and December 2024) will describe and report the results of the scenarios analyses.

To proceed with the first issue of this report, documentation of the design processes of the Voldsløkka project needed to be obtained. To do so, information is retrieved from several sources, namely:

- Reporting of the urban planning and design processes produced by the Office of Urban Planning of Oslo Municipality, Oslobygg KF, and the Education Department of Oslo Municipality
- Interviews with key persons who were involved in the decision-making processes of the urban planning, design, and construction activities. These have been identified and summarized in Table 1.
- Results from the benchmarking of Voldsløkka project performance against the parameters described in the core ARV Key Performance Indicators (KPIs). The core ARV KPIs are described in Table 2.

An interview guide has been developed to be used for the different key persons. Interviews are based on a semi-structured framework, where a list of arguments is shared beforehand with the interviewees. The interviews cover the three main stages of the design process (early concept design, design development, detailed design). For each of these, three sets of arguments are discussed between the interviewer and the interviewees:

- Description of the procedure, by highlighting the vision, ambitions, and goals of the projects, key persons/authorities leading the process, limitations imposed from external authorities.
- Description of the used KPIs or Minimum Performance Requirements (MPRs) in the project, their quantification/calculation, compromises made in the design that did not meet the set KPI/MPR.
- Description of the occurred process, why and how decisions and compromises were made, what could have been done differently, and limitations.

Table 1. *List of the stakeholders interviewed.*

Stakeholder	Interviewees
Project developer: Oslobygg KF (OBF)	Bodil Motzke Øystein Johansen Marianne Vikene Eivind Bryne Retterstøl
Landscape design: Østengen & Kari Bergo	Marit Myklestad Kari Bergo
Architectural design: Kontur Arkitekter AS	Erik Brett Jacobsen
Architectural design: Spinn Arkitekter AS	Miriam Sivertsen

Benchmarking against the ARV KPIs and description of the analysis factors:

- Design and architectural qualities
- Social qualities
- Environmental sustainability (energy use, emissions, recyclability, circularity, etc)
- Economy (Life cycle costing and investment cost)

Table 2. *Overview of target values for new and renovated building in ARV CPCCs.*

Assessment criteria	New construction	Renovated buildings
Energy	**At least 50% reduction in energy needs** compared to current country building code. **Positive energy** level based on primary energy	**At least 50% reduction in energy needs** compared to pre-renovation levels. At least **nZEB** standard.
IEQ	High levels of indoor environment quality according to EU norms.	**At least 30% improvement** compared to pre-retrofitting levels according to EN 16798-1:2019
Noise and dust levels	According to the EU health, safety, and environment standards.	**At least 30 % reduction** in occupant disruption during retrofitting compared to local current practice
Embodied emissions	**At least 50% reduction** compared to local current practice	
Construction/retrofitting time	**At least 30% reduction** compared to local current practice	
Life Cycle Costs	**At least 20% reduction** for the community compared to local current practice	
Construction/retrofitting costs	**At least 30% reduction** compared to local current practice	

2. EXECUTIVE SUMMARY OF THE PROJECT– VOLDSLØKKA, OSLO, NORWAY

The Norwegian demo case is the Voldsløkka School and Cultural area. The project includes the construction of a secondary school for 810 students, a new culture hall, a dance hall, and rehearsal space. This involves the construction of new buildings and the renovation of an existing listed building, in total about 14000 m² floor area. The area has high environmental ambitions and will be built as Oslo's first plus energy school, with a surplus of energy generated, covering all energy needs included appliances/plug-loads. The total area of the PV-installation is 1556 m² and a yearly estimated production of 192 MWh. The new school facility will be integrated as part of the surrounding local area, which complements the area with new functions and activities and strengthens the area's green structure. The set of actions that will be undertaken by the ARV project will encompass resource efficient renovation processes, district energy analysis and operation, and highlighting social, educational, and digital aspects to enhance citizens involvement and generating Citizen Energy Communities.

Table 3. *Summary of the main characteristics of the Voldsløkka project.*

Name and Address	
Project type and ambition level	Plus-energy (S-building) + Class B (H-building)
Building types	School (S-building) and cultural centre (H-building)
Location	Voldsløkka, Oslo
Building owner	Oslobygg KF (OBF)
Design team	Østengen & Kari Bergo (Landscape design), Kontur Arkitekter AS and Spinn Arkitekter AS (Architectural design), Oslobygg KF (Project developer), Veidekke (Main contractor)
Number of occupants	810 pupils, teaching staff, 1 750 weekly users in the cultural centre
Mean average annual temperature	5.7 °C
Degree-days HDD/CDD	3587 (HDD)
Total annual horizontal solar radiation	876 kWh/m²
Design phase/construction phase/completion date	Design phase: 01.2018-03.2023 Construction phase: 04.2020 – 10.2023 Completion date: 08.08.2023
Plot area (m²)	12578
Conditioned/heated floor area (m²)	2331 (H-building) + 8888 (S-building) = 11219
Gross area (m²)	14000
Gross volume (m³)	11606 (H-building) + 38837 (S-building) = 50443

3. VISION AND GOALS

3.1. VISION

The project of Voldsløkka project envisioned the construction of a new school building and the energy retrofitting of an existing cement factory (the Heidenreich building) to host 8 parallel secondary school classes for 810 pupils. In addition to the school program, the project features in the above-mentioned buildings a cultural centre and a cultural hall. The cultural hall is used as a sport facility until the completion of the multi-purpose sport hall in the nearby plot of land. The school and cultural activities will cover an area of 11100 m^2 in the new construction and 2900 m^2 in the Heidenreich building. The school becomes operative in August 2023.

3.2. GOALS

The project's architectural goal, as set by the Oslo Education Department, is to provide a good school facility where the students should experience an inclusive learning environment adaptable to their specific needs. This implies the school to be planned and developed according to good functionality and quality of use. Chosen technical solutions, therefore, have to be robust, simple, environmentally friendly, and as much as possible based on the Oslo Municipality specified requirements for standardized solutions. Solutions adopted in the planning and designing should ensure cost-effective management, operation, and maintenance of the school facility. Part of the school premises should be shared with activities outside of the core school program, to be dedicated to different user groups and be used at different times of the day.

4. URBAN PLANNING

In this chapter, the Norwegian planning hierarchy is briefly explained. The following chapters give an overview of the various steps of the urban planning procedures followed for the Voldsløkka demo.

The Norwegian planning hierarchy is built upon three overarching master plan levels[2]:

- National plans
- Regional plans
- Municipal plans

The role and purpose of the National, Regional, and Municipal plans are mainly regulated by the Planning and Building Act chapter 3-5, chapter 3-4, and chapter 3-3, respectively[3].The National plans define the guidelines for the Regional plans, and the Regional plans provide guidance to the development and application of the Municipal plans. The National and Regional plans are not as legally binding as the Municipal plans, and provide only guidelines for which measures should be prioritised by the municipalities

[2] Det norske planhierarkiet. Https://9pdf.net/article/d-et-norske-planhierarkiet-brukermedvirkning-i-sosial-boligutvikling.zpnvxm8o Det norske planhierarkiet.
[3] https://www.regjeringen.no/en/dokumenter/planning-building-act/id570450/

MUNICIPAL PLANNING

At least one Municipal planning strategy must be adopted by the municipal council from the time of its election. As shown in Figure 1, the Municipal plan consists of a *Community part* which describes the needs of the local community, an *Action part* that details the development strategies, and an *Area part*, which details the areas of pertinence of the actions. The municipality must also prepare Municipal sub-plans (Regulatory Plans) for various areas, themes, and business areas. The A*ction part* in the Municipal plan must describe how the Regulatory Plans are to be followed up during their development (Regulatory process).

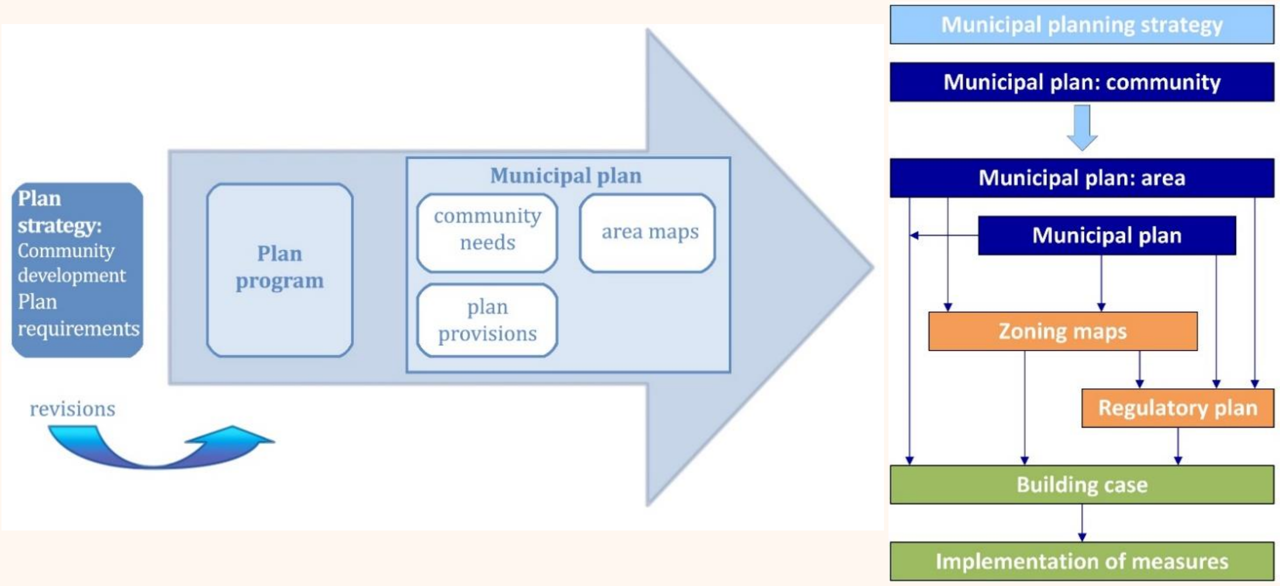


Figure 1*. Municipal planning strategy. Original image from https://distriktssenteret.no/artikkel/kommunal-plan-gjennomforing, edited by Nicola Lolli (SINTEF).*

The *Community part* of the municipal plan describes and details the overall municipal planning strategies through a holistic approach to community planning and business development. The *Community part* documents the conditions of the municipality and provides the common framework for a coherent development and adoption of all the sub-sequent municipal sub-plans, projects, and planning measures.

The *Area part* defines the area-related prerequisites for achieving the goals for the community development defined in the *Community part*, and these are implemented in the form of infrastructural development (e.g., roads, residential, commercial, recreational, and natural areas). More detailed description of land use is given in the *Regulatory Plans* (Områderegulering and Detaljeregulering)[4]. A Regulatory Plan consists of a detailed map with detailed land provisions and limitations to determine how the municipal areas are to be used and developed. The Regulatory Plan determines, among other things, the degree of utilization and building limits, land purpose and specifications of their use, and areas of protection. It is adopted by the municipal council as a single decision and it is legally binding, but it can be waived in certain cases by way of a dispensation. According to the Planning and Building Act, private actors are authorized to promote private planning initiatives. Before a private actor notifies the start of a Regulatory Plan development, it must submit proposals through a start-up meeting, to allow the municipality to give advice and assist in the planning process.

[4] *Saksgang ved kommunedelplan. Https://www.ha.no/_f/p1/id0d82c5c-2c3c-4a8d-af50-6cc503dc5de0/saksgang-ved-kommunedelplan_bogo-edit.pdf*

The procedure for the development of a Regulatory Plan (regulatory process) initiated by a private landowner/operator is as follows[5]:

- First, a kick-off meeting is held between the municipality and the initiative owner/proposer.
- Second, the start of planning work is publicly notified to allow the local community to be informed and participate in the process. The local community and affected parties have to right to give their remarks and feedback to the proposed plan.
- Third, a completed planning proposal is then submitted to the municipality, which proceeds to initial consideration by the planning committee. The planning proposal is evaluated for six weeks before it is taken forward for a second consideration. After the second round of consideration has been carried out, the proposal is adopted as a single administrative decision by the municipal council, and it is eventually announced with the right to appeal.

The procedural steps to be followed from the development of a Municipal plan to a Regulatory Plan are summarized below[6]:

- **Draft of the plan program**. The administration prepares a draft planning programme, which is presented to the municipal planning committee for consideration.
- **Amendment of the planning program and notification of commencement of work on the municipal sub-plan**. After the draft planning program has been approved and published for consultation by the municipal planning committee, the planning program is made available to the public to notify the start of planning work. The notification is sent to public bodies and interest organizations in the area. The work is also notified on the municipality's website and in local newspapers, with a hearing deadline of usually 6 weeks.
- **Approval of the planning program in the municipal council**. The municipal planning committee processes the input received, makes changes, and sends the matter to the municipal council for final processing.
- **Preparation of draft plans**. Based on the planning programme, the administration prepares working notes and explanations, and submits these to the municipal planning committee for consideration. Based on the individual notes and the treatment of these in the municipal planning committee, the administration draws up a draft municipal sub-plan with text/plan description and map. Drafts are presented to the municipal planning committee for consideration.
- **Public inspection**. The municipal planning committee publish a draft of the municipal sub-plan for public inspection and sends it to the relevant bodies for a statement. Notice period at least 6 weeks.
- **The municipal board**. The plan is adopted, or else the municipal council can decide to send the draft plan back to the administration to make changes. If the plan is adopted without any objections, the draft plan must be sent to the Ministry of Local Government and Modernization for final decision/clarification following a more detailed procedure.
- **Appeal against decisions**. The municipal board's decision on the municipal plan cannot be appealed.

4.1 VOLDSLØKKA SITE HISTORY

The Heidenreich building (H-building) is registered by the Office of Historical Preservation of the City of Oslo in the list of historical buildings worth being protected for its industrial and architectural value. Together with the worthy-of-conservation in Margarinfabrikken building, the Heidenreich gives historical legibility and identity to the area. The H-building was built and formerly used as a cement factory in 1918 and owned by Christiania Monier og Cementvarefabrikk AS. The company was specialized in producing reinforced concrete elements to be used especially for the building of energy production facilities and water sewage infrastructures[7]. At the time of construction, the factory building at Voldsløkka was one of the largest of its kind in Scandinavia and was an early example of the use of load-bearing structures in reinforced concrete. The building was located south of a planned railway

[5] *Reguleringsplanveileder. Https://www.regjeringen.no/no/dokumenter/reguleringsplanveileder/id2609532/?ch=4*
[6] *Saksgang ved kommunedelplan. Https://www.ha.no/_f/p1/id0d82c5c-2c3c-4a8d-af50-6cc503dc5de0/saksgang-ved-kommunedelplan_bogo-edit.pdf*
[7] *http://industrimuseum.no/bedrifter/oslomonier__cementvarefabrika_s*

route from Bestum to Grefsen. The track never came, but the plan prevented other development on Voldsløkka. The water pipe wholesaler Heidenreich took over the building in 1935 and operated there for over 70 years.

At the time of the project, two buildings were present on the plot, in addition to the Heidenreich building, named Building A and Building C. Both buildings, with a total area of 6 600 m² were rented out to two different companies as office use and storage. These two buildings, visible in the bottom right picture in Figure 2, were demolished to make place for the school building and the playground of the Voldsløkka project.

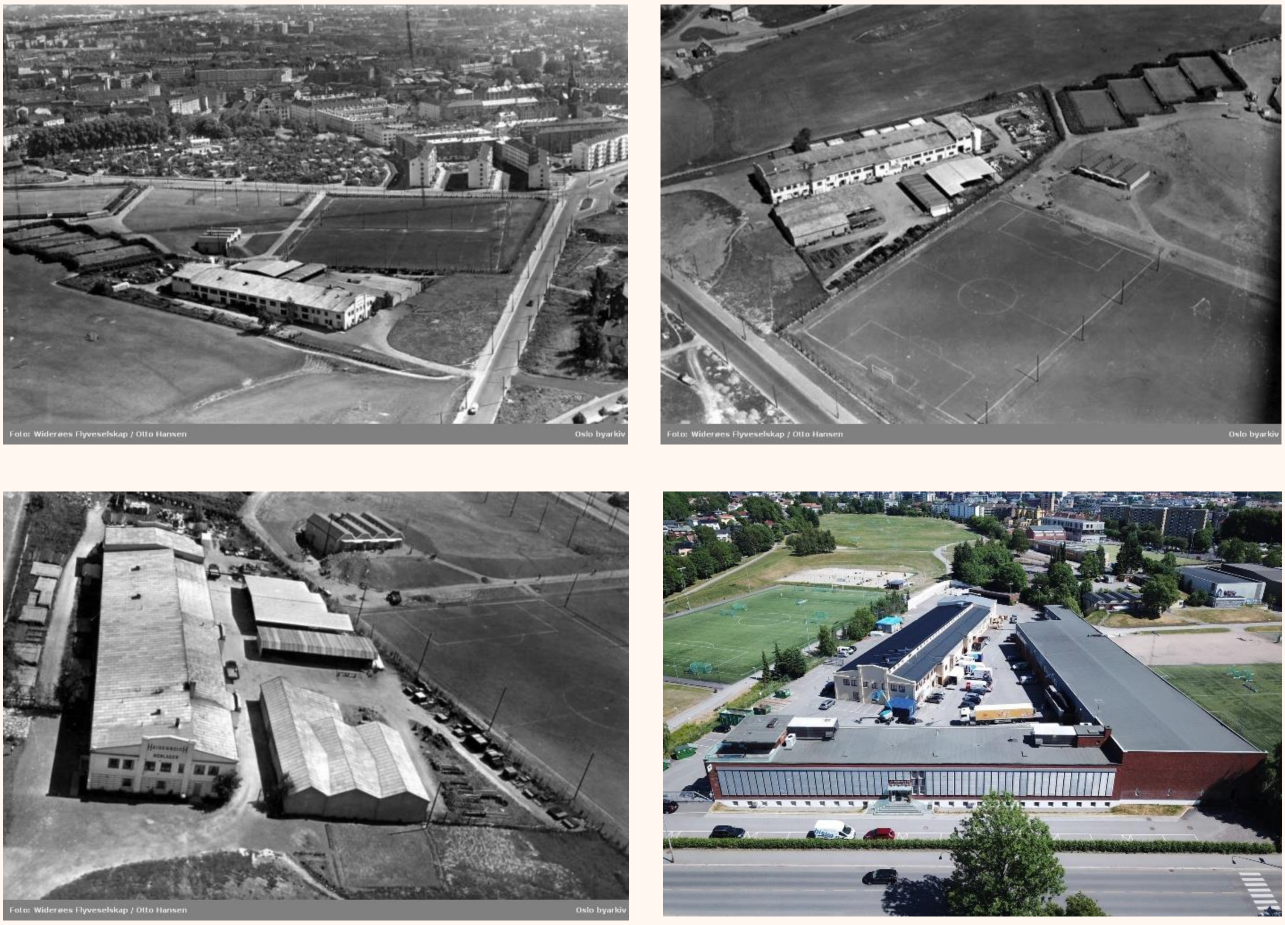


Figure 2. *Historical images of the Heidenreich Building taken in 1951 by Widerøes Flyveselskap / Otto Hansen. Source Oslo Byarkiv. Bottom right: image of the site taken in 2018, source Spinn/Kontur Arkitekter*

4.2 REGULATORY PLAN OF VOLDSLØKKA

In this chapter the main steps of the urban planning process of the Voldsløkka area are described.

STAKEHOLDERS IN THE REGULATORY PROCESS OF VOLDSLØKKA

The stakeholders involved in the Regulatory process of Voldsløkka are summarized in Table 4. Description of their function and role in the Regulatory process of Voldsløkka is given in Appendix A.

Table 4. *List of the stakeholders involved in the Regulatory process of the Voldsløkka project*

Stakeholder type	Stakeholder name	Abbreviation
Stakeholders directly involved in the Regulatory process of Voldsløkka		
Landowner (private company)	Uelands gate 85 AS	UG85AS
Process initiator	Uelands gate 85 AS	UG85AS
Administrative authority	Oslo City Planning and Building Agency	PBE
Administrative authority	Oslo City Council for Urban Development	BYU
Administrative authority	Oslo City Education Agency	UDE
Administrative authority	Oslo City Urban Environment Agency	BYM
Administrative authority	Oslo City Water and Sewerage Agency	VAV
Administrative authority	Oslobygg KF	OBF
External consultant	Dark Arkitekter AS	DAAS
External consultant	Asplan Viak AS	ASVAS
External consultant	COWI AS	COAS
External stakeholders who gave remarks during the public consultation		
Administrative authority	Sagene city district	BYSA
Administrative authority	Nordre Aker city district	BYNA
Administrative authority	Oslo City Property and Urban Renewal Agency	EBY
Administrative authority	Oslo City Fire and Rescue Service	BRE
Administrative authority	Oslo City Renovation and Recycling Agency	REG
Administrative authority	Oslo City Office for Building Preservation	BYA
Administrative authority	Oslo City Education Agency	UDE
Administrative authority	Oslo City Urban Environment Agency	BYM
Administrative authority	Oslo City Water and Sewerage Agency	VAV
Administrative authority	County Governor of Oslo and Akershus	FMOA
Administrative authority	Norwegian Water Resources and Energy Directorate	NVE

Public association	The Nature Conservation Association in Oslo and Akershus	NOA
Public association	Oslo Sports Circle	OIK
Public association	Skeid football club	SK
Public association	Sagene Sport Association	SAIF
Public association	Oslo and Akershus Corporate Sports Associations	OBIK
Private company	Ruter AS	RAS
Private company	Hafslund Nett AS	HNAS
Other	Private citizens	

THE REGULATORY PROCESS OF VOLDSLØKKA STEP-BY-STEP

The Regulatory process of Voldsløkka[8] (the area defined in Figure 3) was originally initiated by a private actor, the new-formed company Uelands gate 85 AS (UG85AS), which submitted a regulatory planning initiative to the Oslo City Planning and Building Agency (PBE) in November 2012. The planning proposal was to develop the area for residential purposes.

A meeting between UG85AS and PBE was held in February 2013, where PBE recommended UG85AS to wait for further planning work within Oslo municipality for receiving more clarifications on the intended use of the area to be developed. This was because PBE recommended to clarify within the Oslo Municipality whether the plot was to be used for public purposes or private residential. Furthermore, should the land to be developed for housing, further design and planning guidelines were needed. PBE stated that if these guidelines had been not followed up, PBE would commence an alternative Regulatory proposal for housing.

In a meeting between with the Oslo City Council for Urban Development (BYU) and UG85AS, the municipal interests in placing a school in the Voldsløkka area (Figure 3), and specifically in the land occupied by the Heidenreich building, was expressed.

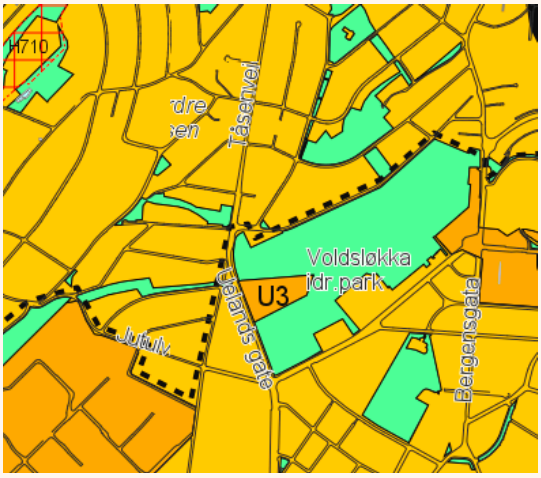


Figure 3. *Oslo Municipal plan 2015-2030 with identified the Voldsløkka area for school development (U3).*

[8] *https://innsyn.pbe.oslo.kommune.no/saksinnsyn/showregbest.asp?planid=201214524*

Figure 4. *Left: Alternative 1development of Voldsløkka with the apartment buildings proposed by UG85AS. Right: Alternative 2 development of Voldsløkka with the school proposed by UDE. The Heidenreich building is coloured in yellow. Original image by PBE, edited by Nicola Lolli (SINTEF).*

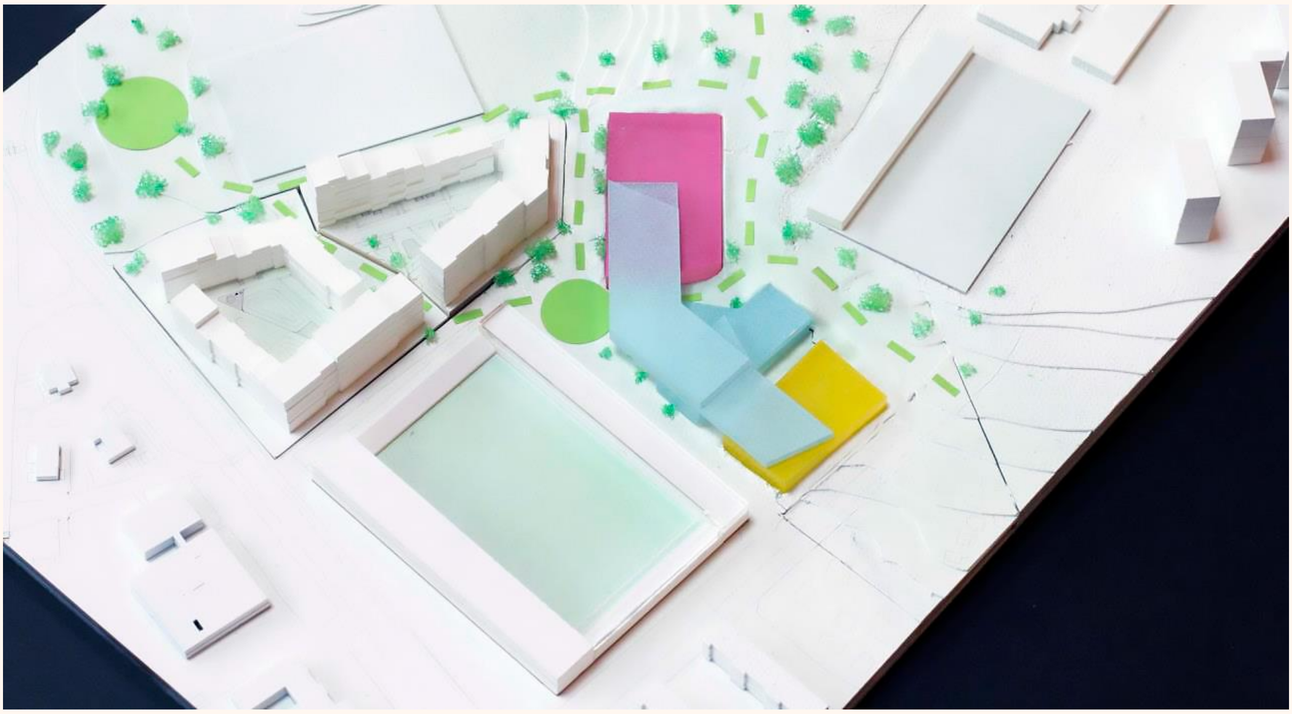


Figure 5. *Alternative solutions with the school (right in the figure) and the sports facilities (bottom in the figure) developed on the municipal land, and the apartment buildings (top in the figure) developed on UG85AS property. Image by PBE.*

In June 2013, the Oslo City Education Agency (UDE) was commissioned to propose an alternative Regulatory Plan for school purposes on the property of Uelands gate 85 AS (UG85AS). With this regard, UG85AS with the assistance of Dark Arkitekter AS prepared a feasibility study to show a future comprehensive study as input to the Regulatory Plan for Voldsløkka. This was proposed to include in the proposed Regulatory Plan for residential development the adjacent plot of land (Figure 5), which was regulated by the Oslo Municipality Urban Environment Agency (BYM) to be used for sports purposes. The feasibility study proposed an overall assessment of the area, where school, sports and housing uses were integrated.

The feasibility study resulted in August 2013 in the proposal of a Concept Selection Study (KVU) for Voldsløkka, to evaluate the possibility of adapting the area for different purposes and to assess the realism of placing the school among the sports facilities at Voldsløkka. The KVU was expected to be commenced by PBE in autumn 2013 and concluded by the end of 2013. However, by February 2014 there was no clarification weather the KVU had been started or not. UG85AS consequently decided to start in February 2014 a Regulatory Plan proposal for developing the Voldsløkka area for residential purposes and submitted their proposal in June 2014.

Between May and July 2014, the BYU requested PBE in collaboration with the BYM and UDE to investigate in more detail and outline a possible solution for the joint use of housing, multi-purpose hall, football field and school. The results of this investigation showed that placing the school above a buried triple sports hall would have been expensive and poorly functional. Since it was clear that it was difficult to satisfy the desire to place many building programs in the same area, BYU asked PBE to collaborated with UG85AS, UDE, and BYM, to find a third alternative that could satisfy the most important requests, including the housing development. In September 2014, UG85AS agreed to collaborate for finding a third alternative and in to have the regulatory process for housing development to be put on hold.

In autumn 2014 several workshops and meetings were carried out between UG85AS, BYM, PBE, and UDE, to find a third alternative that included housing, school, and sports facilities. PBE notified BYU the result of this process in February 2015, with a third development alternative for Voldsløkka. However, UG85AS withdrew from the cooperation on the basis that this alternative design implied a large reduction of the allocated volume for housing development and a replacement area was needed to be found for the remaining volumes to be developed.

In August 2015, PBE resumed the processing of the Regulatory Plan for Voldsløkka and decided to submit plans for both the school and the residential developments. Both the proposals were advertised for public feedback. Both Regulatory Plan proposals were subsequently (March 2016) merged in one case, as requested by BYU. Figures 6-9 show conceptual images of the two alternative developments.

Figure 6. *Alternative 1: apartment building development. View from Uelandsgate. Image by Dark Arkitekter.*

Figure 7. *Alternative 1: apartment building development. View from the football field. Image by Dark Arkitekter.*

Figure 8. *Alternative 2: school development. View from Uelandsgate. The Heidenreich building is coloured in yellow. Original image by Asplan Viak, edited by Nicola Lolli (SINTEF).*

Figure 9. *Alternative 2: school development. View from the football field. The Heidenreich building is coloured in yellow. Original image by Asplan Viak, edited by Nicola Lolli (SINTEF).*

Between April and June 2016 several meetings were held between PBE, Oslo City Water and Sewerage Agency (VAV), BYM, UDE, and Dark Arkitekter regarding different aspects of the two alternatives in the Regulatory Plan proposal, and revised planning proposals were submitted for a 2nd round of processing by PBE.

PBE in November 2016 recommended to develop a school on the Voldsløkka area and dismissed the residential development alternative. The school alternative was chosen because this proposal helped to ensure the needed school capacity in Voldsløkka and developed the area as a publicly accessible, green park by ensuring a coherent and large area for living, recreation, play and sports. The residential development alternative was not recommended because it would have added additional private residential volumes with a too-high density factor, and it was, therefore, considered to conflict with the Municipal Plan 2015 - Oslo towards 2030 (Figure 3). Moreover, most of the Heidenreich building was planned to be demolished in the residential development plan, whereas the preservation of its integrity was ensured in the school development. The Heidenreich building was considered an important part of the area's identity and by its demolition, the building's industrial history would have disappeared. Additional remarks on the residential development concerned the splitting of the existing landscape given by the new volumes, which would have hindered the plan of connecting the various parts of the sports park in Voldsløkka.

The Planning and Building Agency, therefore recommended to develop the Voldsløkka area by building a school with a possible multi-purpose hall is in line with the desired further development as a public area with a park, sports, kindergarten, and school. The school would strengthen Voldsløkka as a meeting place for children and young people. PBE also emphasized that population forecasts for the area showed a large and growing need for new school places in the school district and a lack of suitable areas for schools. Uelands gate 85 was therefore considered to be well suited for school purposes and recommended in a long-term urban development perspective.

Since Uelands gate 85 was owned and managed by Uelandsgate 85 AS, an agreement on the purchase of the property was needed to be found. The costs that followed due to the implementation and securing of the development of the infrastructural facilities and green structural elements outside the planning area, was decided in municipal agreements between the Oslo City Urban Environment Agency (BYM) and Undervisningsbygg Oslo KF (OBF) as project developer. The Regulatory Plan was adopted in December 2017.

PROJECT SPECIFICATIONS BASED ON THE REGULATORY PLAN OF VOLDSLØKKA

In this chapter the critical design and planning specifications that defined the regulatory process of the school alternative are described. These specifications were the result of the various meetings between PBE and the involved authorities and stakeholders (see list of stakeholders and their roles in previous chapters). The specifications defined for the housing development alternative are not discussed here since this alternative was not eventually chosen for the Voldsløkka area.

The overall development of the Voldsløkka area, as suggested by PBE, is summarized in Figure 10. PBE suggested a plan which aimed at developing a sustainable local community, where the residents had access to clean air, clean water and adequate recreational areas to pursue these goals the following areas were prioritized:

- Reduction of noise, air pollution and greenhouse gas emissions
- Development of a sustainable urban environment and environmentally friendly urban spaces.
- Preservation and strengthening of the blue-green structures.

The PBE plan defined the strategies and measures for reducing the inhabitants' noise load, facilitating non-motorized transportation routes, avoiding densification at the expense of green structure, prioritizing cultural heritage, and preserving older buildings, preserving and further developing the green structure with focus on coherence and quality, and reopening rivers and streams.

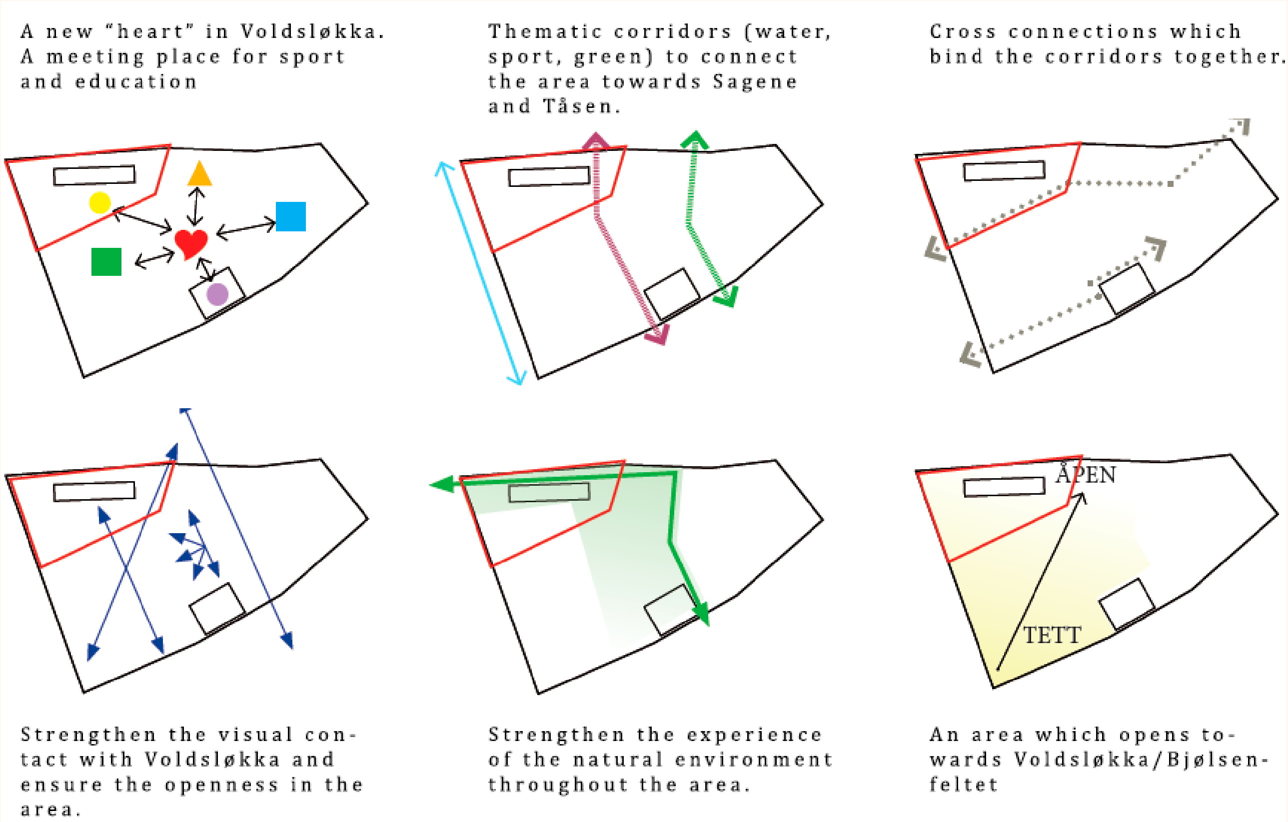


Figure 10. *PBE's site analysis. Edited by Nicola Lolli (SINTEF).*

From such a perspective, the choice of using the Voldsløkka area for school development aimed at making this area a gathering point for the local community by integrating educational, sport, and cultural activities in the local natural landscape. The initial concept envisaged the development of a multi-use hall (sport and cultural activities) by the school area to be used outside the school opening time. The Heidenreich building was proposed to be preserved while the other buildings on the site were to be demolished (Figures 11 and 12), as the Heidenreich building helped to define an identity of the area, by continuing the narration of the area's previous industrial history. To ensure high qualities of the school outdoor area, PBE included provisions regarding the prohibition of using artificial grass and ensuring the use of permeable and natural land cover. This was integrated in the local open surface water management plan, which followed the Oslo Municipality's environmental policy. Oslo Municipality promotes the use of open, local surface water management to contrast the damage to buildings and infrastructure produced by poor rainwater management. Such a problem is exacerbated by climate change, which in the Nordic will lead to more rain and sudden heavy rainfall. By opening closed streams and rivers and using green roofs and draining surfaces instead of asphalt, rainwater flows are slowed down and the risk of flooding reduced.

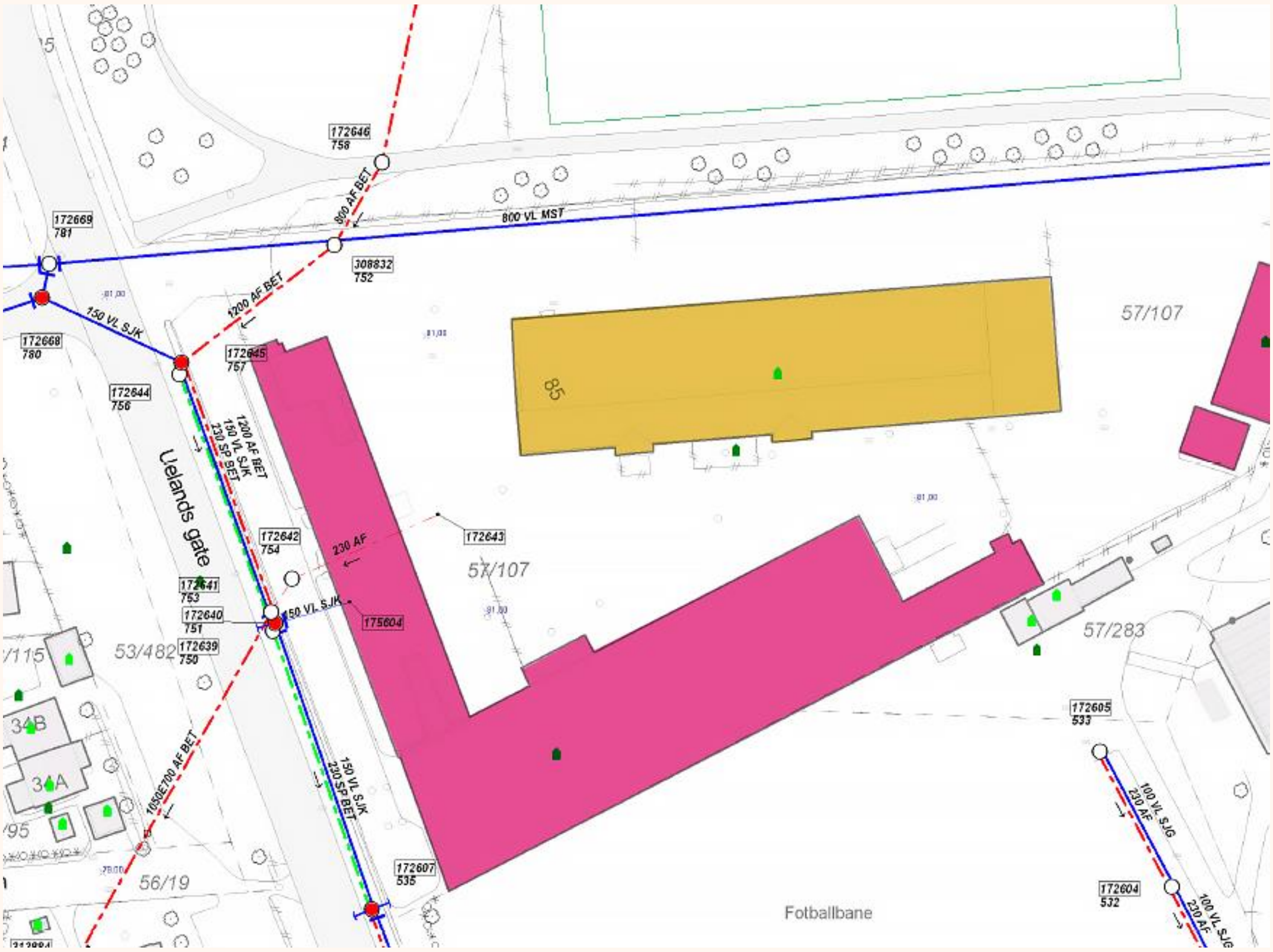


Figure 11. *Map of the main waste-water infrastructure near the Voldsløkka project. The Heidenreich building is coloured in yellow, the office-industrial buildings (Building A and C) which were demolished are coloured in pink. Original image by VAV, edited by Nicola Lolli (SINTEF).*

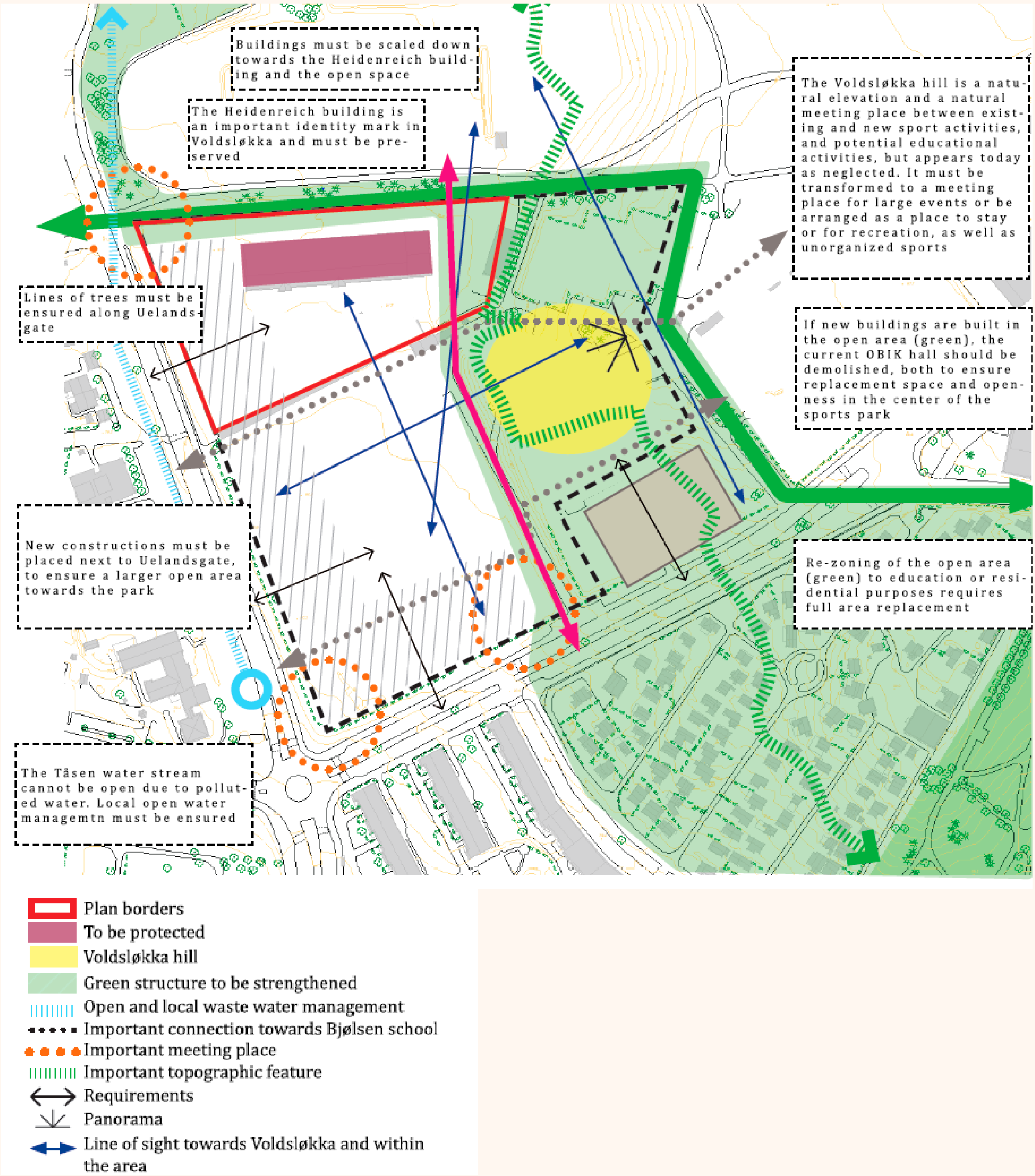


Figure 12. *Suggested plan development from PBE's site analysis. Original image by PBE, edited by Nicola Lolli (SINTEF)*

In the Regulatory Plan, PBE proposed the width of the new school building to be set to 22 m. this would have provided room for development of for various floor plan layouts, as shown in Figure 13. Such a building dimensioning provides well-proportioned classrooms with daylight on the long side, and a central zone with studio rooms and open student workspaces, or, with a double corridor layout, it provides teaching rooms combined with office workplaces and core functions. The 22-m-width dimensioning allows for the placement of the multi-purpose all within the building footprint, as shown in Figure 13. With this regard, two alternative placements of the multi-purpose hall were studied, and its placement was proposed to be either partially underground, or on the 3rd-4th floor of the building. By placing the multi-purpose hall within the new construction footprint, circa 1500 m^2 of floor area for education activities are to be moved in the Heidenreich building, as shown by the blue volume in Fig 14.

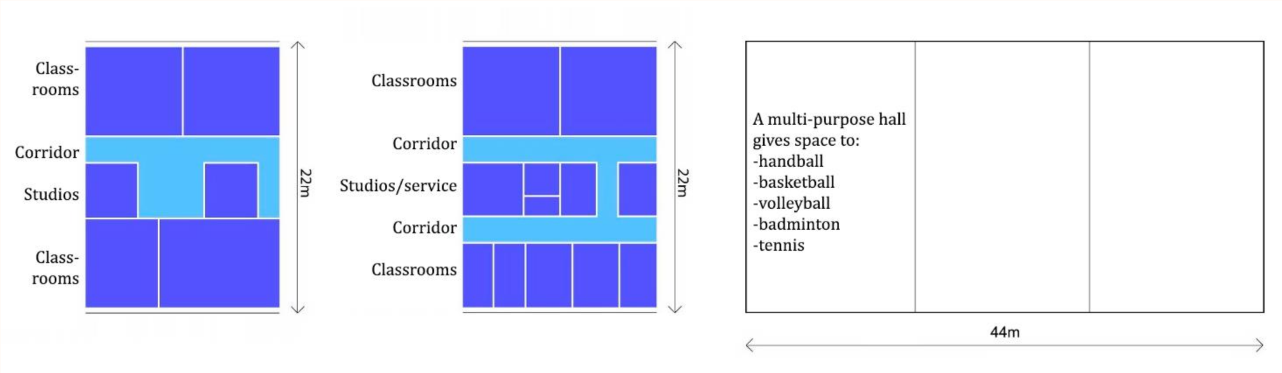


Figure 13. *Conceptual layouts given by defining the building width to 22 m. Original image by PBE, edited by Nicola Lolli (SINTEF)*

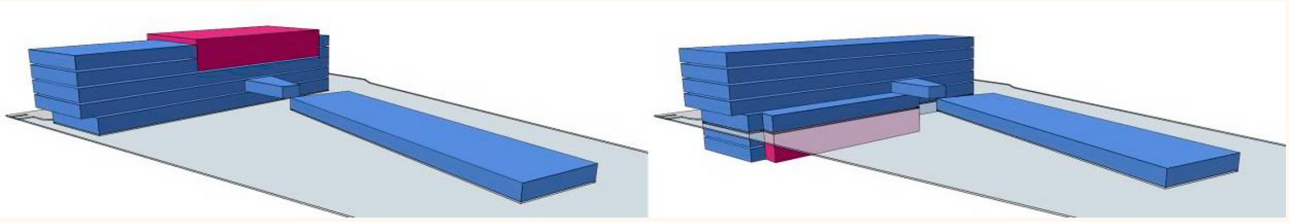


Figure 14. *Alternative A (left) and alternative B (right) placements of the multi-purpose hall. Source PBE.*

Upon request of BYA, PBE required the Heidenreich building to be preserved. The followings were defined in the Regulatory Plan:

- The building could not be demolished.
- The building could be improved, provided that the building's exterior with regard to scale, shape, detailing, use of materials and colours was maintained.

Therefore, the original exterior building parts had to be preserved to the greatest extent possible and reused in their proper context. The interior of the Heidenreich building was allowed to be changed in order to allocate the new education and cultural activities. Moreover, a connection (bridge) between the Heidenreich building and the new school construction was allowed, given this connection to be as much as transparent as possible and made in such a way to retain the original identity of the historical building. The bridge transparent feature ensured line of sight between the school courtyard and the open field lying north of the Heidenreich building, as shown in Figure 15.

Figure 15. *Concept of the bridge connecting the Heidenreich building (right in the image) to the new construction (right in the image). Source PBE.*

PBE proposed that the overall project of the outdoor area had to have a green feeling and being integrated in the Voldsløkka existing natural environment. This had to be ensured by implementing a smooth transition of the vegetation and type of ground covering between the surrounding park and the school area. Moreover, the use of fences had to be avoided to ensure the users experienced a continuous and park-like environment. Different types and heights of vegetations were to be used and a minimum of 30% of the outdoor areas had to be made of permeable and natural coverings (grass, gravel, sand, bark, paving stones, wooden coverings, etc). The use of artificial grass was not allowed. In such a perspective, local and open surface water management strategies were implemented in the area. This was to avoid the rainwater runoff damaging buildings, properties, and infrastructures and creating inconveniences to the local residents. The placement of the new construction was set in the area to ensure the surface water run-off was to be redirected to the existing waste-water infrastructure (shown in Figures 11 and 12). More specifically, VAV suggested PBE to place the new construction at enough distance from Uelandsgate to make room for local surface water management, given the wastewater main line was on the East side of Uelandsgate. VAV suggested to use infiltration and diversion strategies, the use of open waterways, and the use of local water recipients for handling the local surface water run-off.

A detailed strategy for ensuring an effective local water management was set by using the recommendations in the guide for the calculation of the Blue-Green Factor (BGF)[9] developed by PBE and Bærum Municipality, under the Framtidens Byer cooperation program.

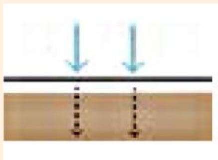
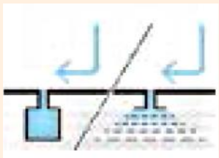
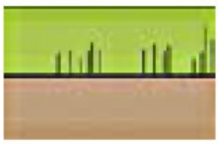
The guide recommends minimum BGFs based on the urban density of the area the project is placed on:

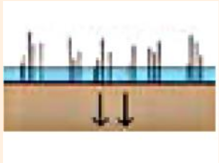
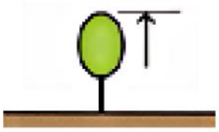
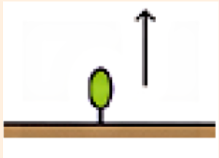
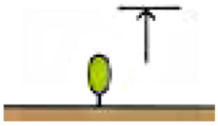
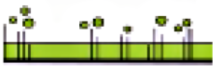
[9] *Blågrønn Faktor, Veileder byggesak. Framtidens Byer. 2014. https://www.regjeringen.no/no/tema/kommuner-og-regioner/by_stedsutvikling/Framtidens-byer-2008---2014/id752427/*

- Project in dense city/centre areas (incl. dense block housing): 0.7
- Project in outer city/small house development/terrace house/open block development: 0.8
- Public streets and squares: 0.3

The BGF is calculated by dividing the areas of "green-dedicated" surfaces by the total area of the project plot of land, and by adding eventual additional points for connection to existing blue-green infrastructures, as shown in Table 5. Education buildings and kindergartens were not specifically mentioned in the guideline, and there were no examples of such facilities in the sample collection. A school building with outdoor areas where requirements cannot compete on the BGF against a housing project. This is because the outdoor areas for a school building usually have a greater need for the placement of activity zones and a more intensive use. This leads to the use of more robust surfaces which, by being less permeable to water, give lower points in the BGF calculation. The BFG was therefore calculated in the Voldsløkka project by making sure the surface of the existing green areas was increased, to plant large new trees, to make sure the presence of large and continuous green areas, to plan a fairly high proportion of permeable surfaces, and plan the opening of a new open water stream for storm water management. Given the limitations due to use of outdoor areas for school activities, the proposed plan gives a BGF of 0.4, as shown in Table 5.

Table 5. *Calculation of the Blue-Green Factor (BGF) for the Voldsløkka project. Source PBE.*

BGF value	image	Description	Area m²	BGF
		total plot area	12578	
1		Permanently open water table to absorb rainwater	131	131
0.3		partially permeable surfaces such as gravel, shingles and grassy cover	2390	717
0.2		impermeable surfaces with runoff to vegetation areas or open drainage	635	127
0.1		impermeable surfaces with runoff to a local underground drainage system	4780	478
1		surfaces with vegetation associated with soil or natural rocks	1275	1275

0.3		rain bed or equivalent	160	48
0.6		existing small/medium-sized trees (5-10 m)	2	1.2
0.7		new planted trees which will grow more than 10 m tall	25	17.5
0.5		new planted trees which will grow between 5 m and 10 m tall.	35	17.5
0.4		hedges, shrubs and multi-stemmed trees	300	120
0.3		perennials and ground covers	425	127.5
0.1		connected green areas larger than 75 m2	1275	127.5
		total equivalent blue-green area		3888
		calculated BGF (total equivalent blue-green area/plot area)		**0.3**
0.05		connections to existing blue-green structures		0.05
		Final BGF		**0.4**

5. DESIGN

STAKEHOLDERS IN THE DESIGN PHASE OF VOLDSLØKKA PROJECT

The stakeholders involved in the design phase of Voldsløkka are summarized in Table 6. Description of their function and role in the design phase of Voldsløkka is given in Appendix A.

Table 6. *List of stakeholders involved in the design phase of the Voldsløkka project.*

Stakeholder type	Stakeholder name	Abbreviation
Project developer	Oslobygg KF	OBF
Project developer	Undervisningbygg	UBF
Client	Oslo City Education Agency	UDE
Client	Norwegian Education Union	UF
Client	Norwegian Student Organization	EO
External consultant	Spinn Arkitekter AS	SPAS
External consultant	Kontur AS	KOAS
External consultant	Østengen & Bergo AS	ØBAS
Builder	Veidekke AS	VEAS
Builder	Øyvind Moen AS	ØMAS
Technical consultant	Various	
External auditor	Various	
Subcontractor	Various	
Administrative authority	Norwegian Labour Inspection Authority	ARTY
Administrative authority	Sagene city district	BYSA
Administrative authority	Oslo City Urban Environment Agency	BYM
Administrative authority	Oslo City Office for Building Preservation	BYA
Administrative authority	Oslo City Water and Sewerage Agency	VAV
Administrative authority	Oslo City Planning and Building Agency	PBE

5.1 DESIGN DEVELOPMENT

THE DESIGN DEVELOPMENT PHASE OF VOLDSLØKKA STEP-BY-STEP

Summary of the Interviews

Several interviews were conducted to understand the design development procedure and stakeholders involved in Voldsløkka and the different goals in architectural, environmental, social, and economic areas. The list of interviewees is shown in Table 1.

Project initiation

The design development started in 2018 after the regulation was adopted in 2017. The regulatory procedures by the education authorities were based on the typical school's needs. There was not a complete start-up process apart from internal selection of roles, as the objectives related to the programme, functions, and use with a focus on cultural offers were clear. Moreover, there was an insight into limitations and considerations, under the condition of preservation of some existing facilities in combination with new developments.

Project development

Voldsløkka is a pilot project where several strategies were tested as a new plus-energy school facility and a cultural centre, that made it very special along the process. The project development and the different phases supported the objectives set by the Norwegian Education Agency Authority, with guidelines[10] that shaped the order of the development phases and framed the existing goals in something buildable that ensured user participation in the leadership of OBF.

During the **pre-project phase,** the FutureBuilt definition (2014)[11] of positive energy buildings and the technicalities necessary to achieve it, was discussed. However, the definition changed in 2018.

The **preliminary project** was divided into different themes: Energy and environment, Function, Building and outdoor spaces, with assigned responsibilities to experts in each area, as shown in Figure 16. In the preliminary phase, the BIM software was used to navigate between the design and the requirements, which later complemented the integrated energy design process.

During the **concept phase** the needs and requirements for user participation in the final solution, were facilitated through workshops based on cross-mapping their insights and technical design for consequences and solutions.

Guidelines and frameworks

Requirements were taken as a base for the further Concept Selection Study (KVU), with demands on all aspects of sustainability. OBF has framework agreements with different groups for working during the preliminary project where requirements about the experience, contributions for positive energy building and landscape were settled for example. However, for the design of the framework, Norconsult was the main actor.

Functionality

Given the defined placement and footprint of the school building, the architects and OBF had to work on working on flexible room placements and functions within the school building. The design solutions sought for space flexibility by enabling the classrooms' floor area to be increased or decreased by the use of movable partitions. The room scheme shows desired connections, which have to be prioritized when rooms are rearranged due to space limitations. The sharing of same spaces at different times of

[10] SKOK 2015. https://skok.no/skok-2015
[11] https://www.futurebuilt.no/content/download/28126/157914

the day was an additional strategy employed by the design team to "increase" the usable floor area. This strategy was implemented in the flexible use of the school and cultural centre throughout the day. In such a way, the complex, school and cultural centre, serves the needs of both the students and the local community. In order to achieve a good sharing concept, facilities are used longer time, which affects the school operating hours. This approach could seem to contradict the aim to reduce energy use, while at the same time the buildings are used for a larger share of the time. There are different areas in the project. The Culture Axis goes into much of the cultural building, so there are different functions for the students who are out in the schoolyard. The outdoors was specially focused on, creating islands for recreation and collecting water and decreasing pressure on the water drainage. More details on the design solutions are given in chapters 5.1 and 5.2.

Positive energy-building ambitions

The main goal set by OBF that influenced different aspects of the design, was Voldsløkka to be Oslo's first plus-energy building school with a 50% reduction of greenhouse gas (GHG) emissions. This goal was coupled to the ambition to adhere to passive house standards and to achieve an emission-free construction site. However, in a project that involved a combination of an existing culturally protected building and a new construction, it would have been extremely difficult to achieve this goal. Therefore, the focus was shifted to optimising the positive energy building concept for the new school building only through the installation of large PV surfaces, very low efficient thermal system, and very high energy performance of the building shell. The energy target was retrieved from the FutureBuilt 2014 plus-energy definition. During the process, it became clear that PV energy production was needed on the facades, as the production from roof PV would have not been sufficient. This was initially rejected by the contractor, but then changed because of the higher energy production on the facade all year round.

Several challenges were given to the design team and OBF in achieving the plus-energy target. Notably, the north-south orientation was not optimal for PV production, given that the shortest façade is facing south. The aesthetic requirements set in the Regulatory Plan did not envision large monotonous surfaces of black-coloured (and most efficient) PV panels. The PV technology in relation to their performance advanced more rapidly than the decisions on the design team, which is typical for any project of this type and magnitude. The existing building (Heidenreich building) was excluded from the plus-energy concept because, due to its conservation status, the energy retrofitting intervention allowed for reaching just a class B, and not PV systems could be installed on either its roof or facades. The school building was designed to rely mostly on a very efficient ground-source heath pump (GSHP) coupled with a low-temperature floor heating system, despite the having available the connection to the local district heating. This was done to ensure that the energy use (PV+GSHP) was cleaner than the district heating, to reach the GHG emissions goal. On the other hand, the Heidenreich building was designed to be connected to the district heating only.

Therefore, to answer the challenges given by this project, the team had to find technical and design solutions that ensured both the plus-energy target and the development of an aesthetically appealing school building. These are detailed in chapter 5.1, 5.2, and 7.

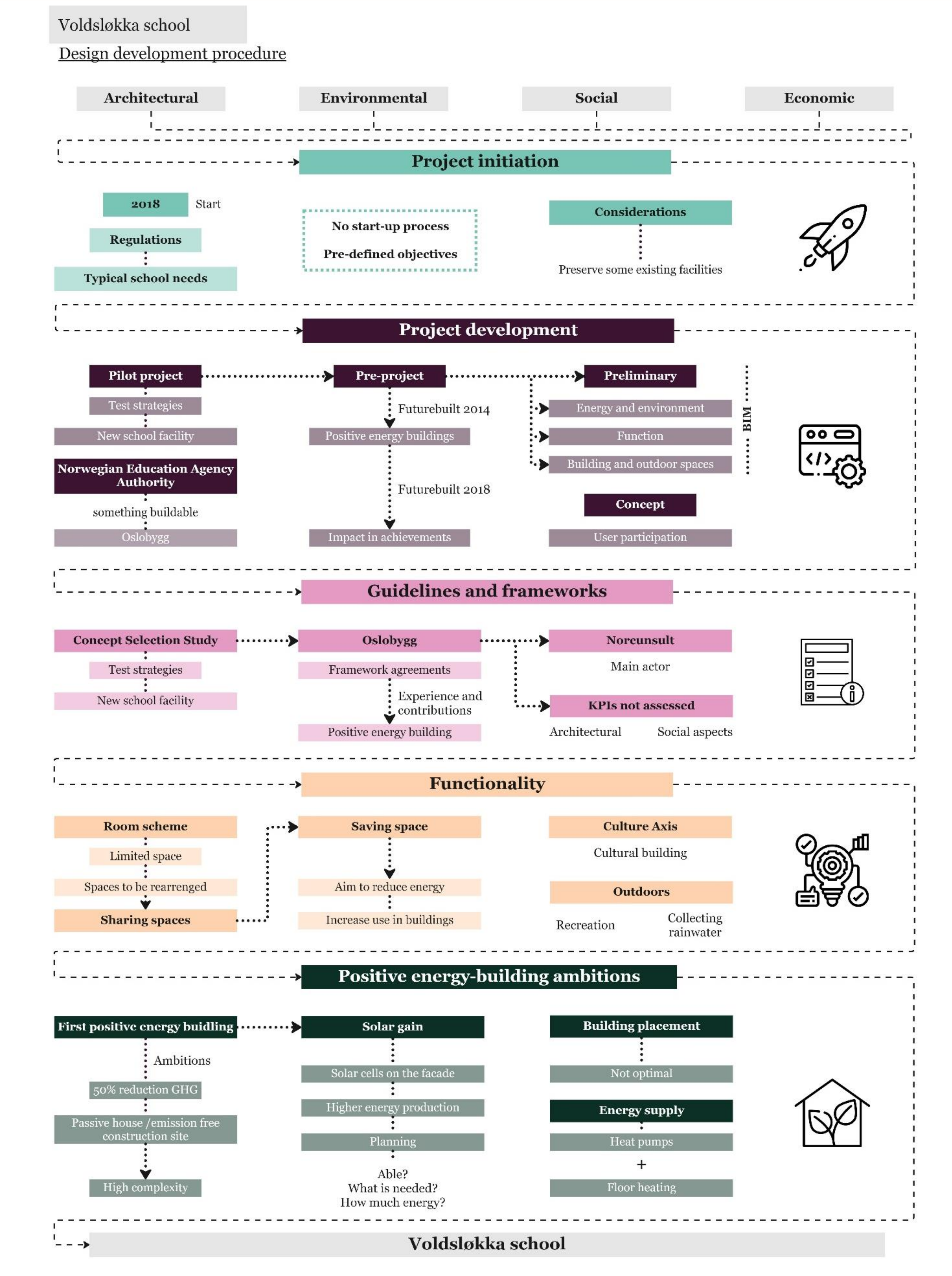


Figure 16. Design development procedure in the Voldsløkka project, by Jesus Daniel Garcia Melo (NTNU).

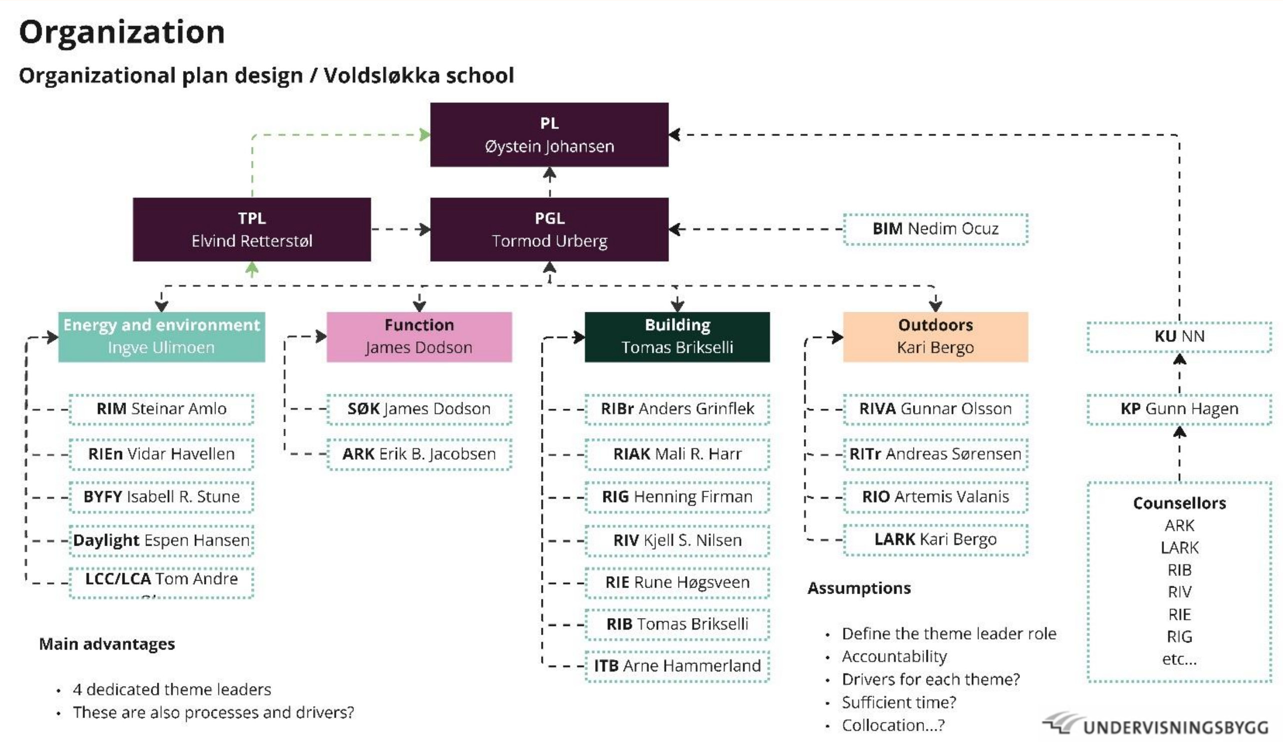


Figure 17. Original organizational scheme by OBF. Edited by Jesus Daniel Garcia Melo (NTNU).

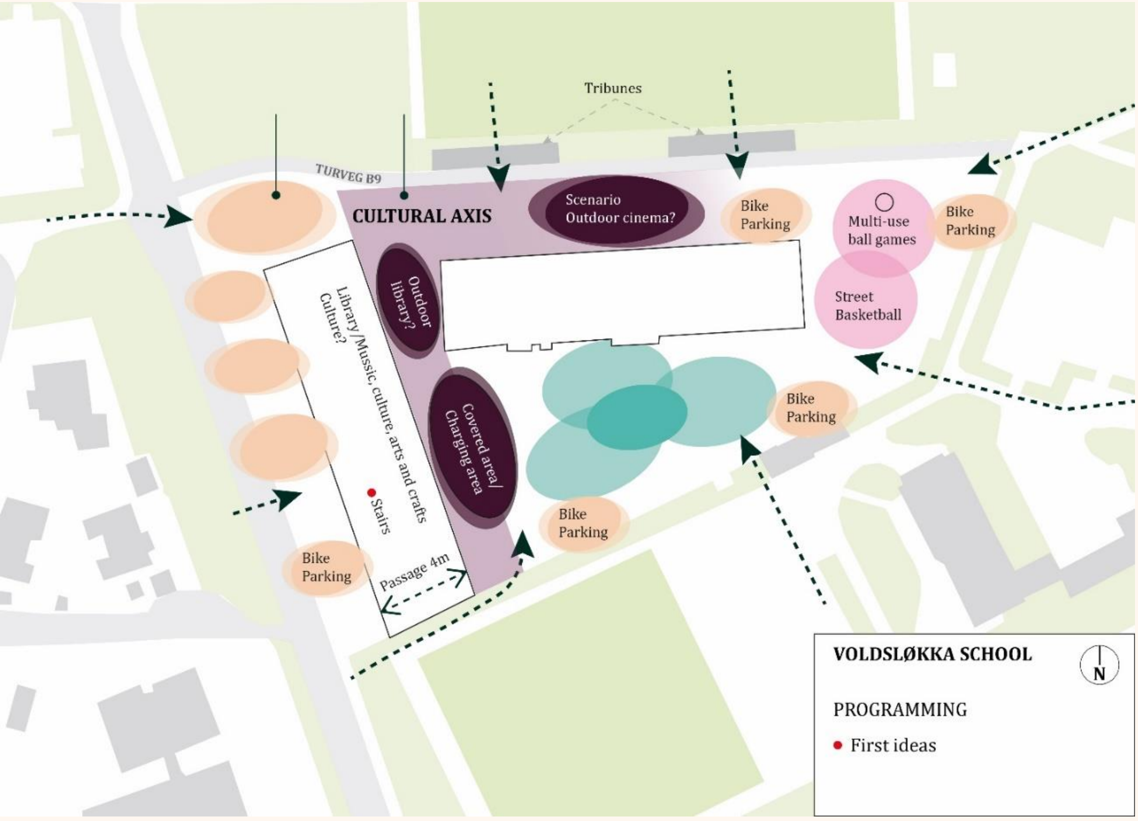


Figure 18. Initial sketch of the Voldsløkka School outdoor program. Original image by ØSTENGEN & BERGO AS. Edited by Jesus Daniel Garcia Melo (NTNU).

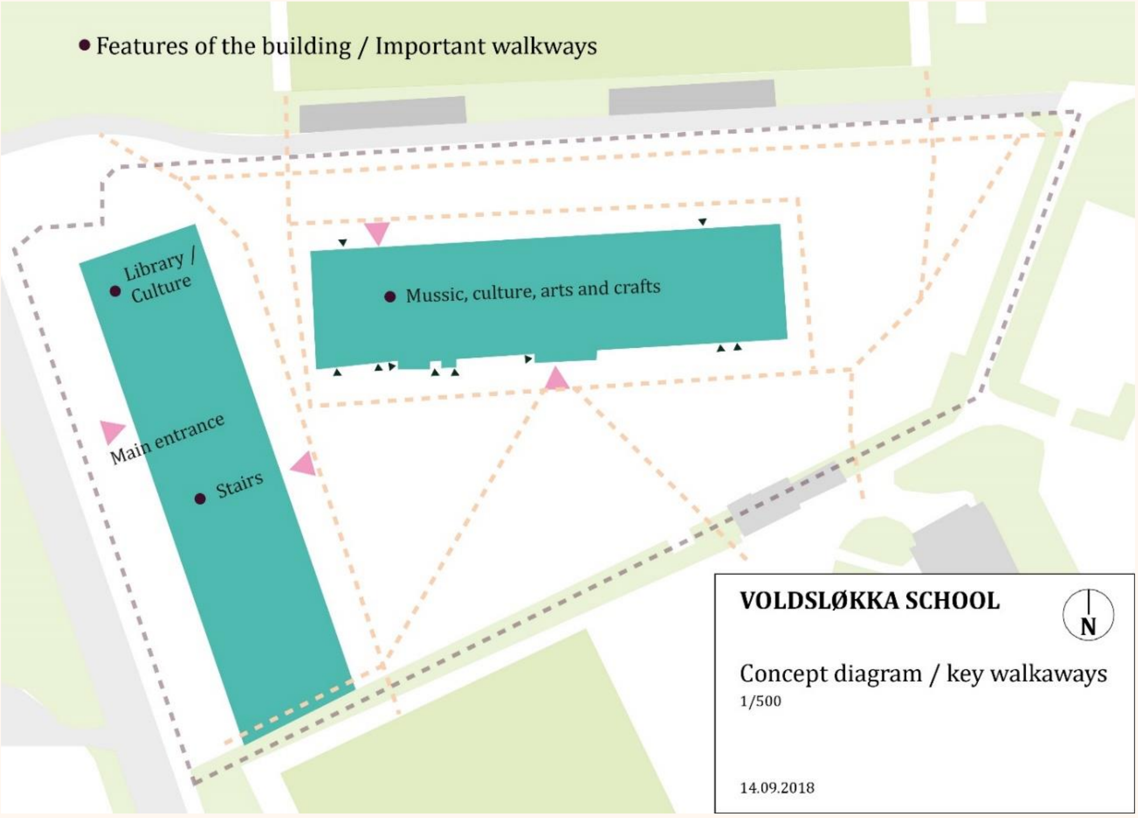


Figure 19. *Initial sketch of the Voldsløkka School indoor program. Original image by ØSTENGEN & BERGO AS. Edited by Jesus Daniel Garcia Melo (NTNU).*

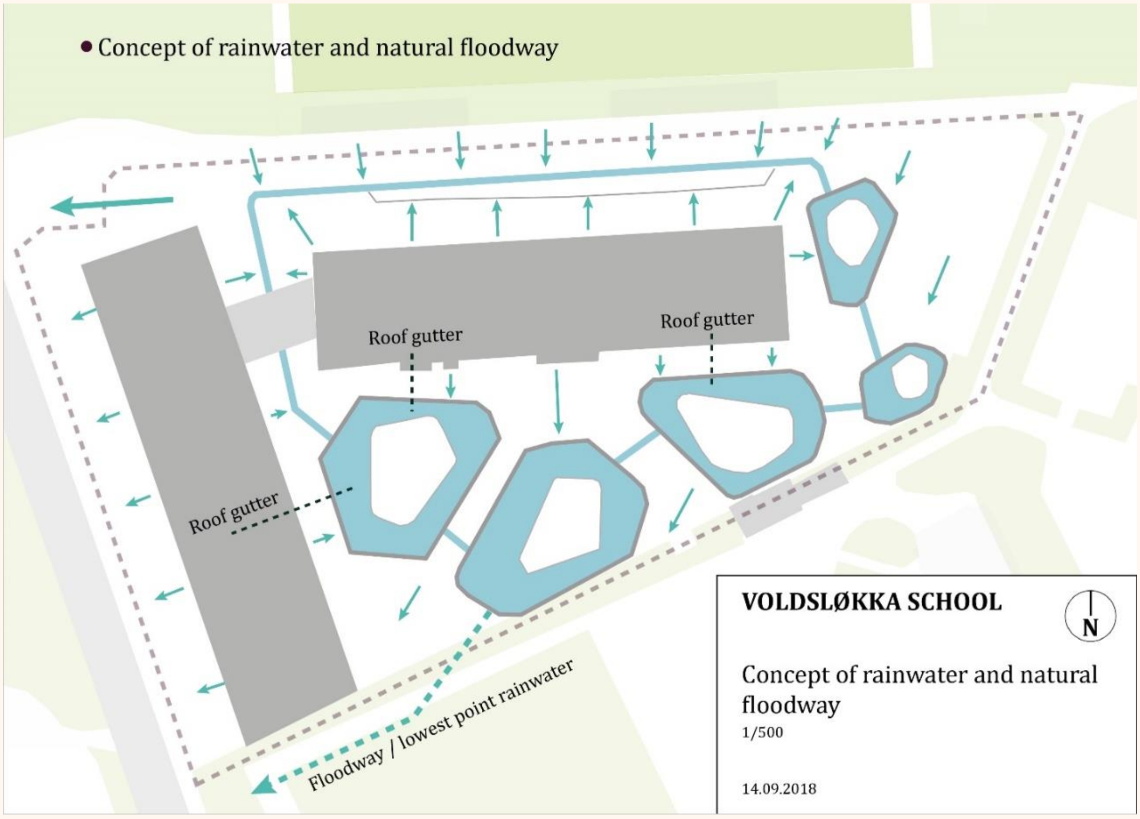


Figure 20. *Initial sketch of the Voldsløkka School stormwater management. Original image by ØSTENGEN & BERGO AS. Edited by Jesus Daniel Garcia Melo (NTNU).*

PROJECT SPECIFICATIONS OF THE DESIGN DEVELOPMENT PHASE

The Voldsløkka project consists of a Secondary School with a cultural hall and spaces for cultural activities. The collaboration between the education and the cultural activities is ensured by the mixed use of the building during and outside the normal school opening time. This is achieved by using the school building (S-building) and the Heidenreich building (H-building) either at the same or at different times of the day for various activities, as shown in Figure 21. The functional areas for education and culture are therefore distributed in the school building and the Heidenreich building, and the passage between these two is provided by a glazed bridge located at the floor 2, where the canteen, the kitchen, and the Food & Health department are located. Most of the education activities are located in the S-building, which is built over 5 floors, with the main access from Uelands gate. The distribution of the internal areas in both the buildings is planned so that those programs that require joint use and/or accessibility after regular school hours are located close to each other. The buildings' closing system is arranged so that the various user groups only have access to those rooms that can be reserved outside the school opening time.

The shared use and zoning of functions is planned so that the building can be easily divided into areas belonging to the school, those shared between the school and the cultural space, and those reserved to the cultural space. Such a zoning is the basis for defining the location of the rooms in the H-building and the S-building, as shown in Figure 21. The final arrangement of the building program and rooms placement is the result of a user participation process that has involved OBF, UDE, UF, and EO.

Figure 21. *Map of the different time-related uses of the Voldsløkka project. Original image by KONTUR and SPINN Arkitekter, edited by Nicola Lolli (SINTEF).*

The school building

The S-building is built over 5 floors and accommodates all the school activities. The northernmost part of the S-building is used for the auditorium, the main entrance, and the areas where the combined cultural/educational activities take place. This planning was made to ensure that those areas that are used jointly are placed next to each other. For this reason, the bridge connecting the S-building to the H-building is placed next to the auditorium, as shown in Figure 21. The distribution of the different rooms' programs in the S-building and in the H-building is done as such:

- The general learning areas (classrooms, teachers' and students' workspaces, reception rooms, teachers' meeting rooms) are placed together from level 2 to level 4.
- Some of the classrooms and administration are placed in the basement, level 1, and level 5 of the S-building, and in the bridge and in the H-building.
- The canteen and specialized learning areas are located in the part of the H-building closest to the S-building.
- The cultural area is located in the part of the H-building farther from the S-building.

The areas dedicated to cultural activities consist of various music and teaching rooms (rehearsal rooms), auditorium/black box, dance hall and associated warehouse. The auditorium/black box are located in the north of the S-building, closely linked to the building's main entrance (Figure 22).

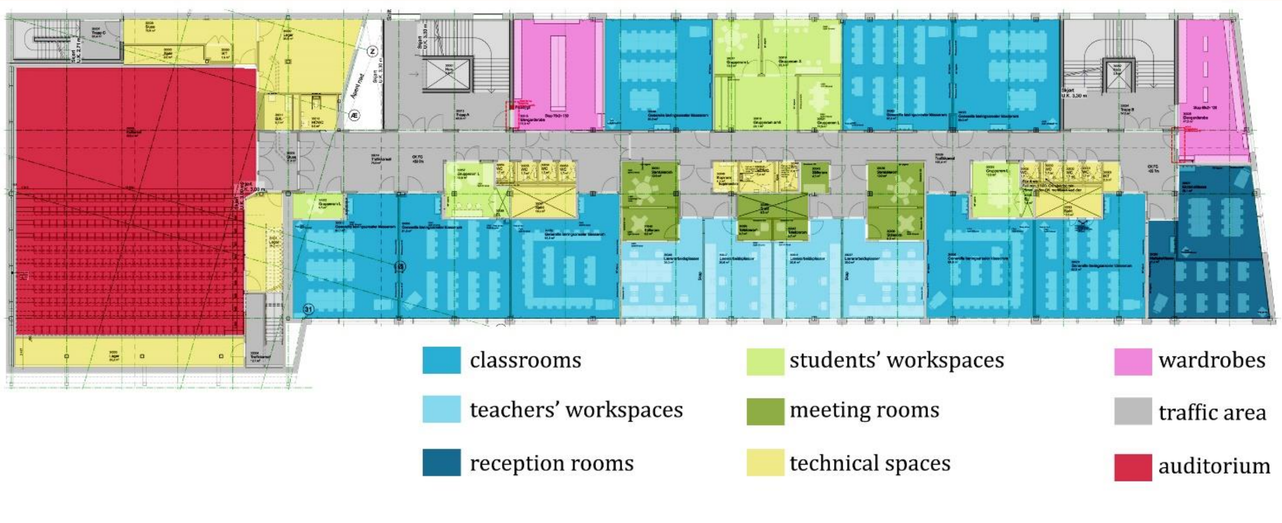


Figure 22. *Plan of the school building rooms program. Original image by KONTUR and SPINN Arkitekter, edited by Nicola Lolli (SINTEF).*

The general learning areas in the S-building are distributed over 3 floors, so that each learning grade is accommodated in each floor. Each area for general learning consists of rooms of different sizes and uses for the students:

- Classrooms and students' workspaces of different sizes
- Toilets and two separate areas for wardrobes directly connected to stairwells with direct access to the school yard.
- Teacher workplaces
- Flexible learning areas arranged for reception classes.
- Teachers/students meetings rooms

Each learning grade hosts 120 students, which are divided in two groups. Each group of students is associated to the learning areas placed on one of the two sides of the building, by the respective responsible teachers' workplaces. The students of each of the two group can access their own respective learning areas by a ramp of stairs and have their own wardrobe. This floor layout ensures the student flow to be controlled and the students can get directly to their own zone and avoid too much crossing traffic. Each group of 60 students is allocated in two classrooms of 30 students each. These classrooms are designed in such a way that they can be combined to form larger rooms. One of the classrooms of each group can, instead, be further divided to form two smaller classes of 15 students each. Finally, all classrooms belonging to each learning grade can be further arranged to form 4 classes of 20 students each, of which one classroom accommodates two separate groups of 10 students each, and, finally, one classroom which accommodates 40 students (Figure 22).

External facades cladding and PV modules

The school building at Voldsløkka school is built as a “plusshus” (plus-energy building) in accordance with FutureBuilt's definition from 20.08.2014[12]. This means that parts of the facades generate electricity which exceeds the total yearly energy use by 2 kWh/m^2 year. The plus-energy building goal also defines the guidelines for the building shell, which is built according to the minimum requirements set in NS3701 for low-energy buildings. The school building's shell is an insulated post and stud timber frame construction, finished with a non-ventilated system facade with photovoltaic panels and glass panels. The decisions for the cladding materials decided in the design development were based on the specifications given in the Regulatory Plan: "The building's facade material must be glass, a plastered surface, wood, brick, concrete, natural stone or facade panels. The facade panels must be of high aesthetic quality and the facade cladding between the new school building and the existing listed building must be made of glass so that the visual contact between the schoolyard in the south and park in the north is ensured". The facade cladding of the S-building consists of a curtain wall system outside the climate shell in the parts of the building where PV and glass panels are installed. A sufficient number of PV panels are installed on the curtain wall so to meet the requirements for a plus-energy building. The installation of a technical layer (PV panels) on top of a traditional insulated post-and-stud timber frame is planned to ensure a simple maintenance of the façade and simple operations for future replacement and inspection, without this conflicting with the school building's climate envelope. Two shades of green are chosen for the glass panels and PV panels, of which a part consist of standard black panels, as shown in Figure 23. Windows' installation is designed so they are installed and replaced from inside the building without the need to remove the outermost technical layer.

[12] *Kriterier for Futurebuilt Plusshus.* https://www.futurebuilt.no/content/download/5861/55365

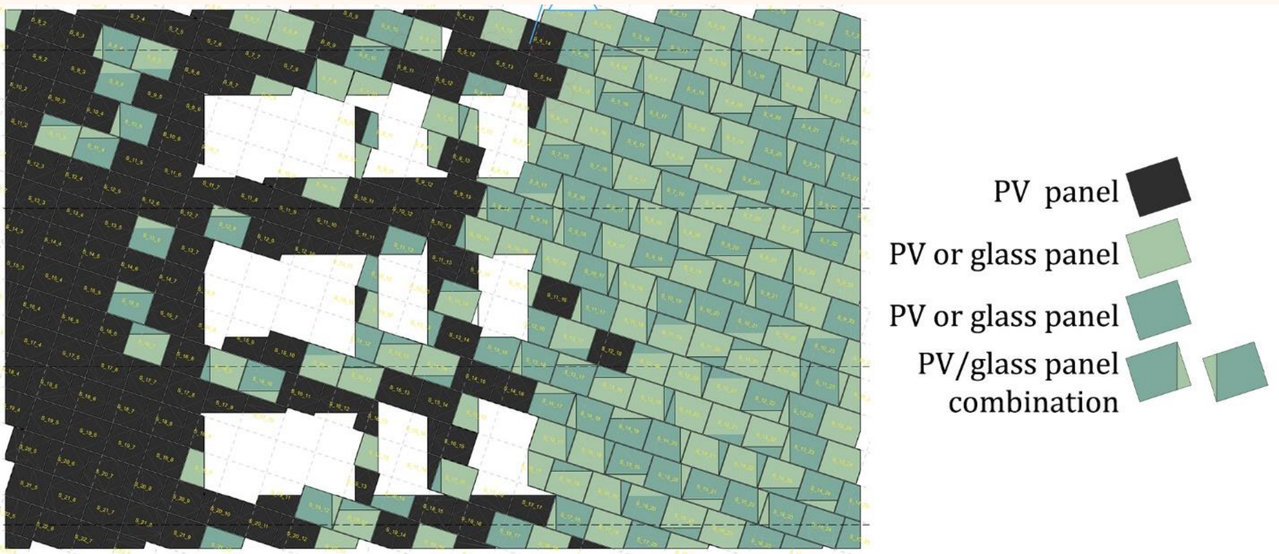


Figure 23. *Plan of PV panels installation on the south façade of the school building. Original image by KONTUR and SPINN Arkitekter, edited by Nicola Lolli (SINTEF).*

The Heidenreich building

During the project development phase several meetings with the Oslo City Office for Building Preservation (BYA) have been organised to discuss the guidelines for the renovation of the H-building. The following decisions were taken after BYA's recommendations. Given the specific requirement of preserving the architectural expression of the H-building decided in the Regulatory Plan, the facade appearance and design of the H-building from 1935 is used as a general guideline for their restoration, as the current window division originates from this period. In addition, the doorways on the ground floor shown in the original facade drawings from 1919 are re-established. To meet today's TEK 17 U-values requirements, the building facades are insulated from the inside to preserve as much as possible the outside appearance of the building. The roof of the H building is replaced in its entirety, but the original cornice details are preserved, so that the appearance of the facade is not changed. Four skylights are installed for the students' workplaces on the mezzanine. The skylights do not protrude over the roof surface to be visible as little as possible from the courtyard. The existing roofing made of corrugated steel sheets is preserved. In the meetings with Oslo City Office for Building Preservation (BYA), the prerequisite to maintain the same roof height after the post-insulation and technical upgrading was clearly expressed to make sure the roof surface meets the cornice. Other internal roof structures in the H building are to be demolished. Wood and concrete columns are preserved as visible non-load-bearing elements. In addition, the original water radiators are retrofitted and re-installed in the building as aesthetic elements. The façades are finished with plaster with the original colour and materiality.

Figure 24. *Demolition plan of the north façade of Heidenreich building. Original image by KONTUR and SPINN Arkitekter, edited by Nicola Lolli (SINTEF).*

Windows's retrofitting

As a general rule, the old windows are replaced with new windows, which are made with the same material use, detailing and dimensions as the existing original windows. However, some exceptions are considered. Four original inner windows are reused as outer windows and installed in the North façade, by following the 1935 façade appearance. The door openings in the South facade are re-established according to the 1919 drawings. The original windows in the South façade are retrofitted and the wooden windows replaced with new ones to match the 1935 appearance. Today's openings in the East façade are preserved as such since the original windows were lost and no information regarding their origin could be found. The opening sizes and positions are preserved but the windows are replaced with new ones. The windows opening in the West façade are maintained since they are shown in the 1935 drawings. However, a larger recess is planned in the bridge connection, to ensure accessibility between the S-Building and the H-building. Figures 24 and 25 shows the changes on the H-building facades.

Roof construction

The existing roof is demolished and a new ventilated roof that satisfies TEK 17 U-value requirements is installed with the same external appearance. The details of roof cornice are preserved and restored to maintain the original façade expression.

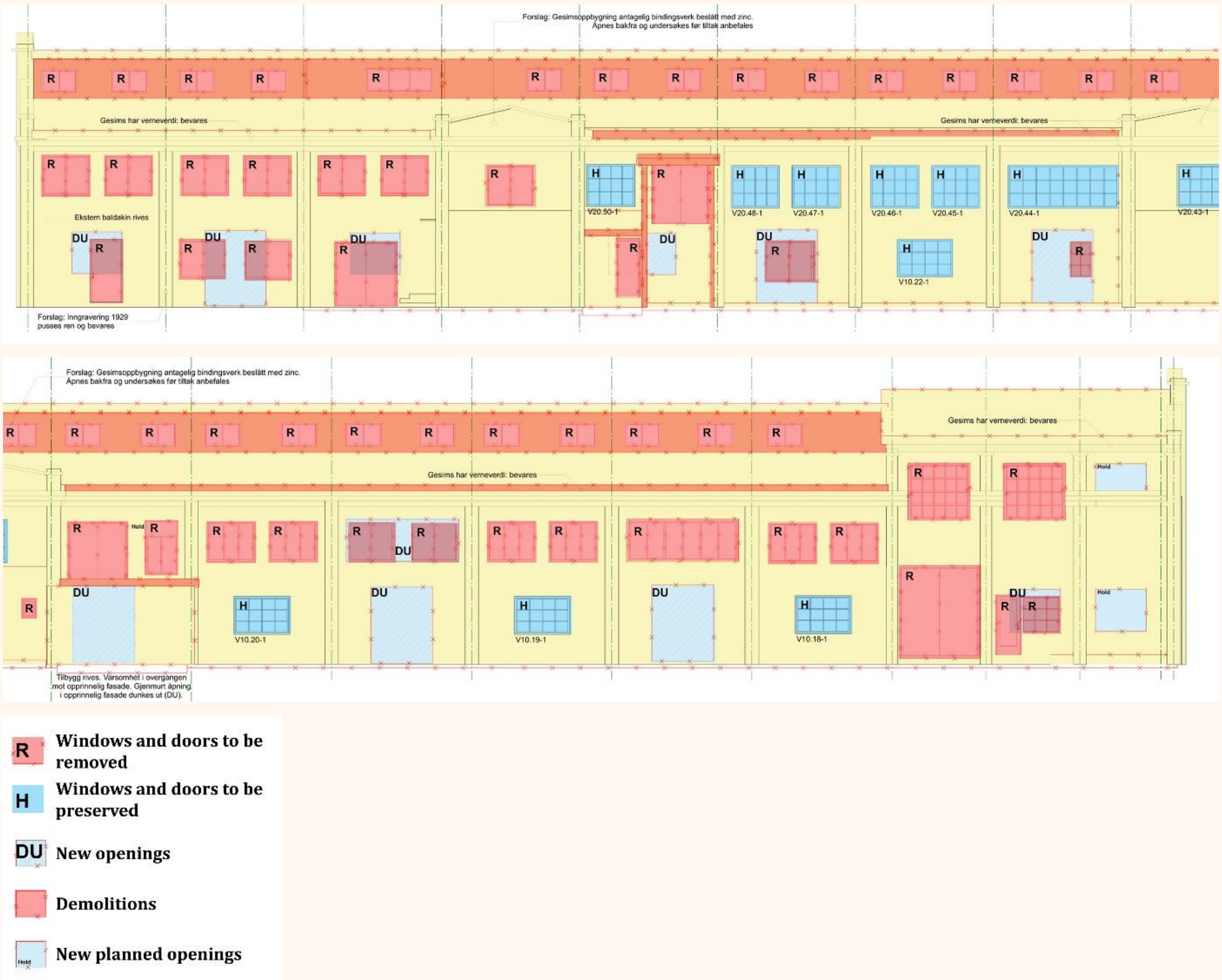


__Figure 25.__ Demolition plan of the south façade of Heidenreich building. Original image by KONTUR and SPINN Arkitekter, edited by Nicola Lolli (SINTEF).

The bridge between the H-building and the S-building

The bridge connecting the H-building and the S-building is designed according to the requirements defined in the Regulatory Plan, where a low and transparent volume was suggested, to ensure continuity of the line of sight between the school courtyard and the park on the north side of the H-building. UDE asked for this space to be used as a functional space, given its proximity to both the H-building and the S-building, the adopted joint use of both the buildings for educational and cultural activities, and the imposed limitations to its volume. The bridge allocates the kitchen of the school canteen and Food & Health Department, whereas the canteen dining and living area is placed in the mezzanine of the H-building. Given the large number of users, 810 secondary school students and 1 750 weekly external users of the cultural purposes, the canteen kitchen and its eating and living area are placed between the H-building and the S-building to provide a natural meeting point that integrates the functions of the two buildings together. In such a way, the canteen kitchen and the dining and living area can be accessible from both the students or the external users during the school daily activities and the cultural activities in the evenings.

BYA recommended to use cladding materials for the bridge roof and walls that matched both the H-building and the S-building. In such a way, the bridge should appear as part of the whole complex expression and not as a single independent element.

School courtyard and playground

The pathways and activities of the outdoor space were thought to work together with the surrounding area. Because the plot is rather small, the landscape architects in agreement with the municipality designed the school courtyard in such a way that it functions as a part of the greater area of Voldsløkka. In the area, there are a sports park and other fields for training and motion which supplements the school's direct outdoor spaces. The design of the school courtyard itself took as a starting point the water management solution the landscape architect designed. The Regulatory Plan requires that the school courtyard is to be developed as a park with a variety of vegetation at different heights and with permeable surfaces and natural surfaces covering at least 30% of the outdoor flooring. The school's green areas are organized and planned in two main groups with different designs, to facilitate natural protection of the vegetation, green areas at the plot edges, and green island in the middle, as shown in Figure 26.

Figure 26. *Landscape design of the Voldsløkka project. Original image by ØSTENGEN & BERGO AS, edited by Nicola Lolli (SINTEF).*

Green areas in the edge zones. The green areas are used to accommodate the difference in terrain height to surrounding areas. The marginal zones are established as sloping flower meadows with a varied density of trees and shrubs, as shown in Figure 26.

The green areas in the centre zones. The central green areas are developed as islands surrounded by "channels". These "channels" are the features that ensure an efficient stormwater management on the school grounds. The terrain around the channels is planned so that rainwater flows towards the islands, as shown in Figure 27. The channels are covered by metal grates below of which rain beds are placed. On the rain beds, a flower meadow with Norwegian, wild, perennial meadow plants is placed. When the plants get tall enough, they will stick up through the grates and will then be worn down by passers-by. The stormwater is collected by the channels and redirected to the islands, where it is absorbed and led deeper down towards the crushed stone reservoir below, as shown in Figure 28. In the islands, native bushes and multi-low-stemmed trees are planted densely, to achieve a nature-like feel, by using plant species that can withstand standing in water for shorter periods. The islands are surrounded with fences, edges, and benches, to make it difficult to walk in the islands and ruin the vegetation. Safe flood roads are ensured on the surface, out into Uelands gate, so that flood damage is avoided. The system islands-channels are designed in such a way to clearly show the water flows and the mechanism of storm water management employed in the school site.

Figure 27. *Scheme of storm water management in one of the project's "islands". Original image by ØSTENGEN & BERGO AS, edited by Nicola Lolli (SINTEF).*

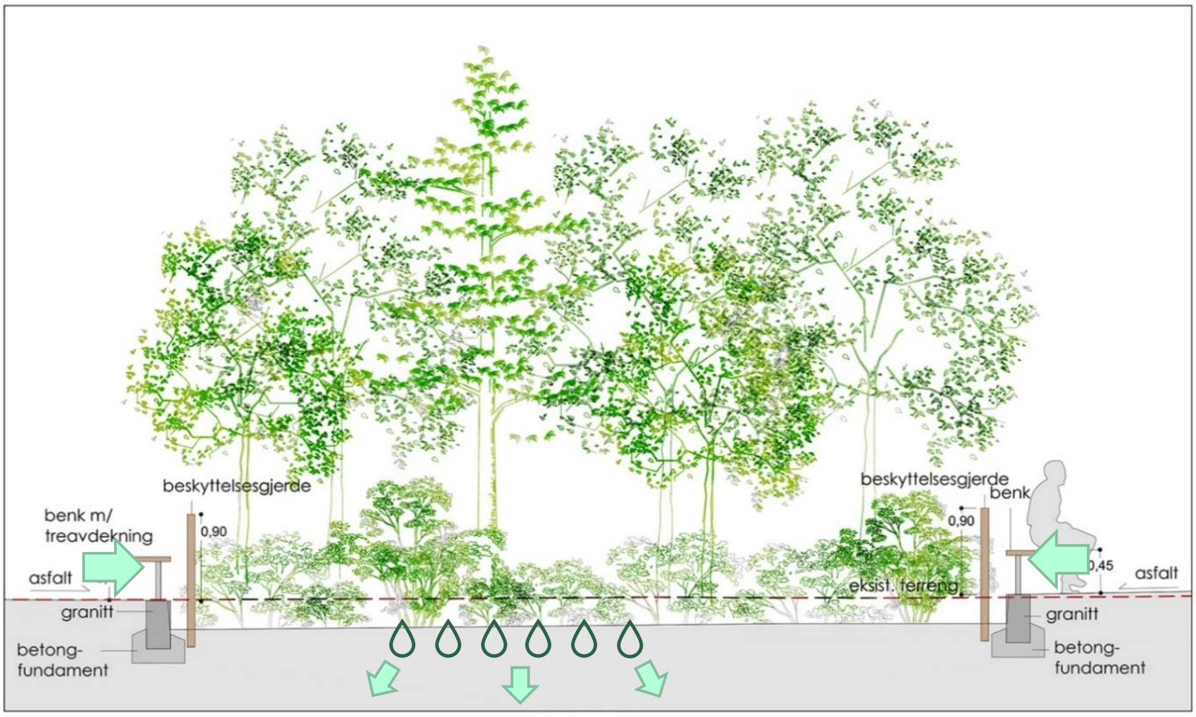


Figure 28. *Scheme of storm water management in one of the project's "islands". Original image by ØSTENGEN & BERGO AS, edited by Nicola Lolli (SINTEF).*

5.2 DETAILED DESIGN

THE DETAILED DESIGN PHASE OF VOLDSLØKKA STEP-BY-STEP

The detailed design phase of the project commenced once the selected architects (Spinn Arkitekter AS, Kontur AS, Østengen & Bergo AS) developed and completed the design concept, described in Chapter 5.1. The detailed design started by the end of March 2021 for a duration of 100 weeks (until March 2023). During this phase the construction permits for the following activities were processed:

- Demolition of the two existing buildings present on the project area (Building A and C).
- For the landscape: demolition of existing loading ramps (associated to the existing A-, C-, and H-buildings), digging and ground movements.
- For the H-building: demolition of the existing roof, installation of a new roof, demolition of the indoor partitions and installation of the new wood, concrete, and steel structural systems, opening of new voids in the façade, restoration of existing windows and façade outermost layer
- For the S-building: laying the foundations piles, glulam, concrete, and steel superstructures, weather proofing of the building.

Differently from the usual design development process, the architect team and the fire safety consultant were assigned to work on both the design development and detailed design phases. This was done to ensure that the overall environmental concept of the project (plus-energy building, storm water management, GHG gas reduction, etc) was developed with the same quality and characteristics in both the detailed design and in the design development phase. The normal process in detail designs is to assign the solution of the design concept to the builder, within a total enterprise contract. The builder is, therefore, responsible to develop technical solutions that fit the architectural concept. Since there may be more than one solution possible, is it up to the design team to agree on those that fit best their original ideas. By making the original design team following the detail design phase, it was easier to coordinate the work with the several subcontractors hired by Veidekke to make sure the implementation of the different part of the design was done in accordance with the original ideas.

Timeline for the design, building, completion, and test phase of the Voldsløkka project

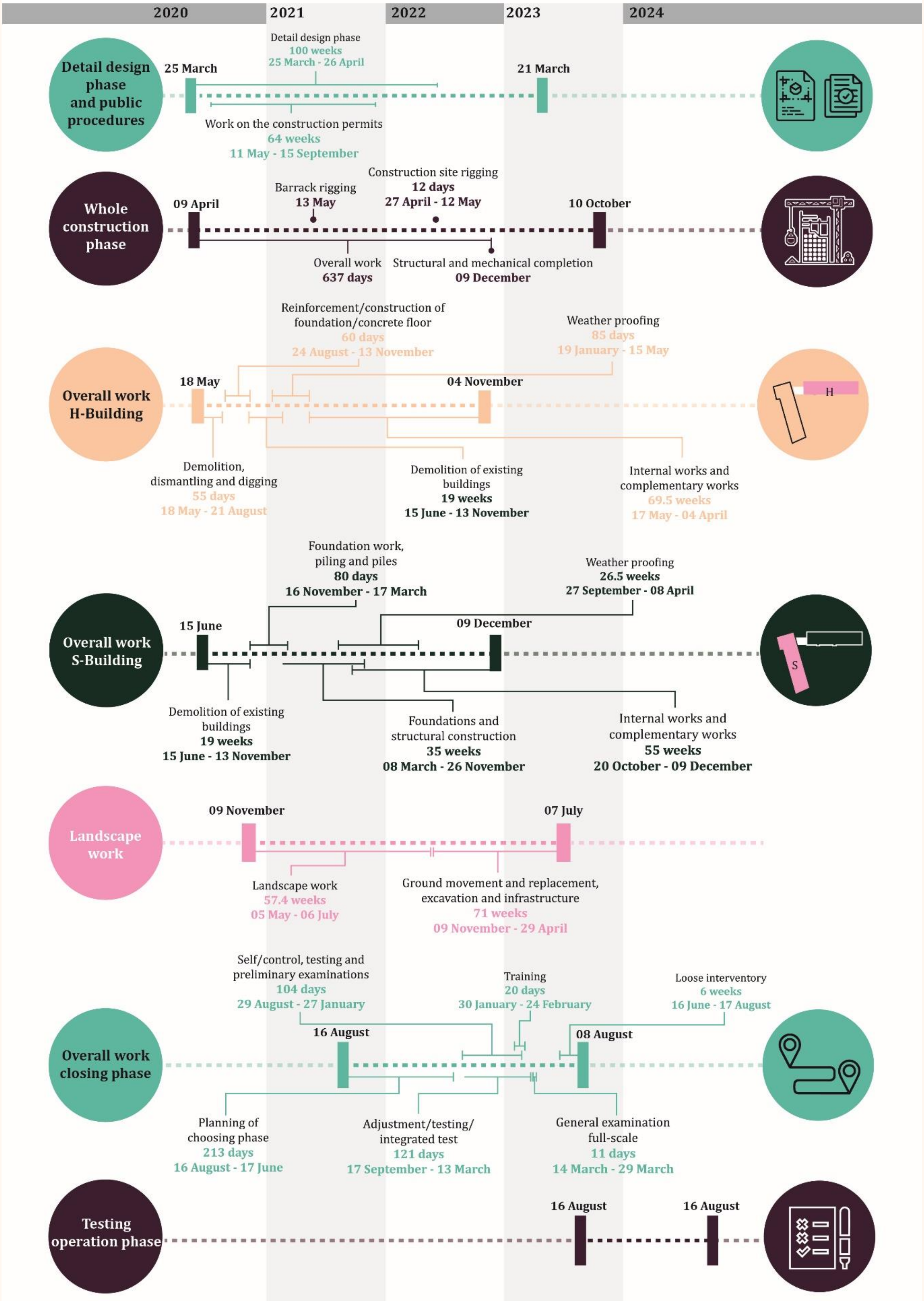


Figure 29. *Timeline of the Voldsløkka project, by Jesus Daniel Garcia Melo (NTNU).*

PROJECT SPECIFICATIONS OF THE DETAILED DESIGN PHASE

In this chapter the most interesting design solutions for the H-building and the S-building are described. Some of the challenges derived from the design process are described in Chapter 7.

The school building PV facade

The PV system is designed to produce circa 230 000 kWh per year. The design of the PV modules' layouts is defined by the PV modules' orientation in relation to the sky, the orientation of the school building's longest facades, and the regulatory provision regarding the look of the PV façade. The building's N-S orientation is not optimal for PV production, as the longest facades are facing either East or West, thus not taking advantage of the higher insolation on South-facing facades. In addition, the regulatory provision requested the school façade not to resemble that of an office building, meaning that solutions that entail large and monotonous surfaces with PV panels were possibly not accepted. On the other hand, the goal set by OBF for the school building is to produce 2 kWh/m^2 year of excess electricity. The challenge is therefore to combine the limitations given by the not-optimal building orientation, the need for variety of the façade appearance, and the highly ambitious energy goal for the building. The choice of using different shades of green and black for the PV panels, and the rotation of their vertical axis (as shown in Figure 31) is given by the necessity of avoiding a uniform and monotonous look of the façade. The overall principle of the façade design is therefore dictated by finding a balance between energy production and aesthetic appearance.

The rotation of the PV panel vertical axis determines the need of cutting the panels in triangular shapes. This reduces the space for allocating modules in each panel, and, depending on the rotation angle, higher or lower numbers of modules can be allocated, thus changing drastically the overall energy production of the façade. Given the plus-energy building target, the decision on the optimal angle for rotating the panels is taken by using a parametric design tool used by an external consultant[13]. The used tool allows the designers to test several panels orientations, calculate the panels cuts, the allowable modules placement, and the overall energy production. The choice of the green coloured PV modules lowers their potential efficiency at producing electricity, given the maximum efficiency is achieved by black modules. Tests of different shades of green are performed on the building site to evaluate which shades of green give the highest electricity outputs, as shown in Figure 31.

The PV panels are hung on an aluminium profile system with a backside minimum air gap depth of 100 mm. The vertical span between the profile system's vertical elements is 600 mm. The profiles are continuous and installed in front of the windows and they will be visible. Therefore, the placement of the vertical profiles and the vertical frames of the windows must match. A secondary profile system with a 20-degree angle is installed in front of the first profiles, to be used for hanging the PV panels at the designed rotation angle. Where the secondary profile system partially overlaps with the windows behind, glass panels are installed instead of PV panels. These glass panels match the colour variations used for the PV panels, as shown in Figure 30. This configuration of glass panels overlapping over the windows opening allows for a more dynamic and varying expression of the windows pattern, without incurring in the technical difficulty of installing non-rectangular windows. The number of total glass panels is circa 15% of the total number of PV panels. The PV panels installed on levels 2, 3 and 4 of the S-building are 850 mm by 1000 mm. The ratio of the green-coloured modules and black modules is as such: circa 25% of the modules on the west facade and circa 40% on the south façade are black. All other modules come with two different shades of green, in such a way each PV panel consists of two different,

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[13] Format Engineers Ltd. Https://formatengineers.com/

green-coloured parts. Two different combinations of the bi-coloured panels are used, as shown in Figure 31. These panels are installed either in an upright position or rotated by 180 degrees. This is to make the impression that 4 different panels are installed on the façade. An equal number of panels of each of these two-colour combinations is installed on the facades on level 5. Standard, black solar panels of 1700mm by 1000mm are installed on the east, west, and south facades.

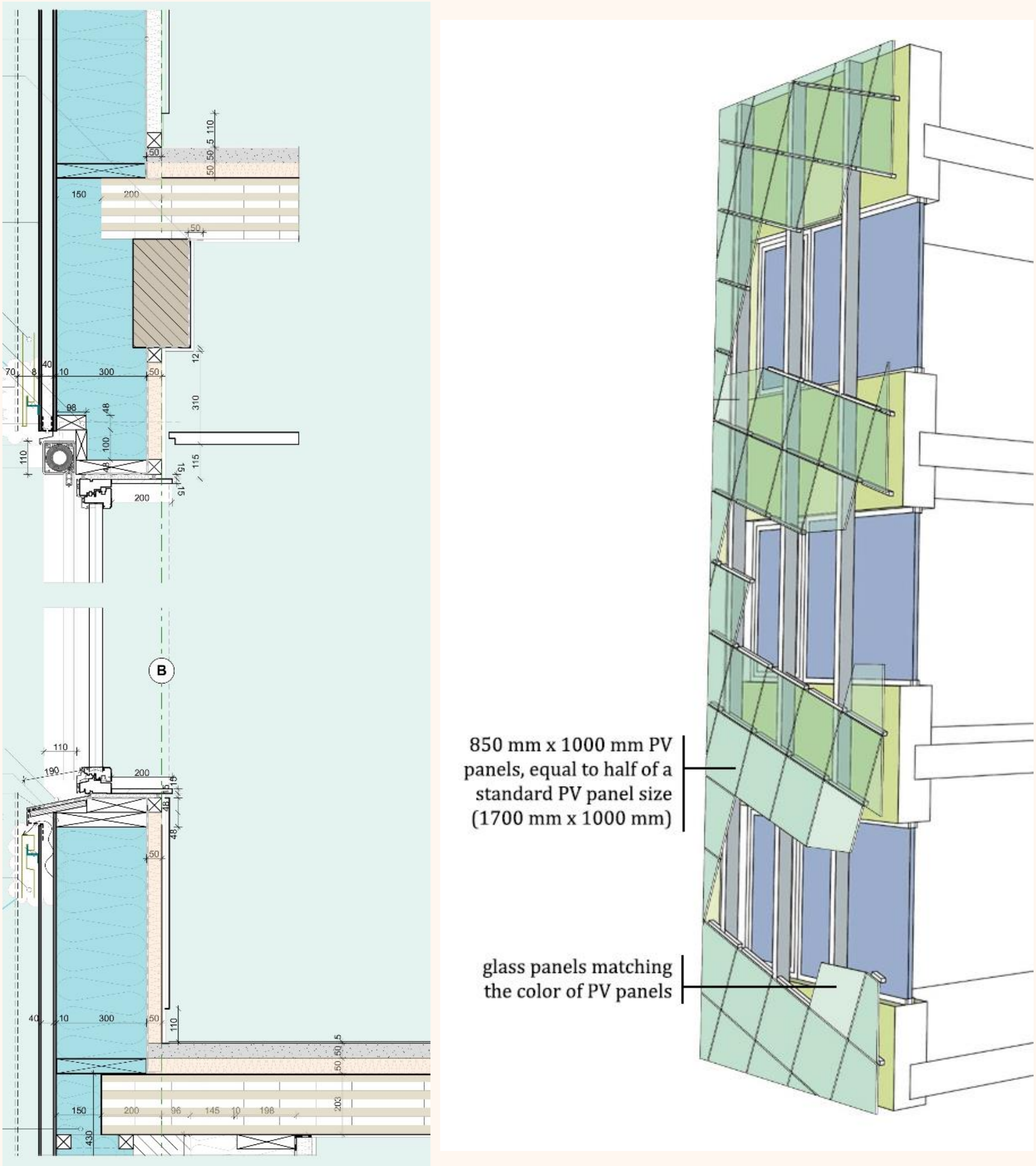

Figure 30. *Right: technical section of the school façade. Original image by KONTUR and SPINN Arkitekter, edited by Jesus Daniel Garcia Melo (NTNU). Left: Scheme of the installation of the PV panels on the school building facades. Original image by KONTUR and SPINN Arkitekter, edited by Nicola Lolli (SINTEF).*

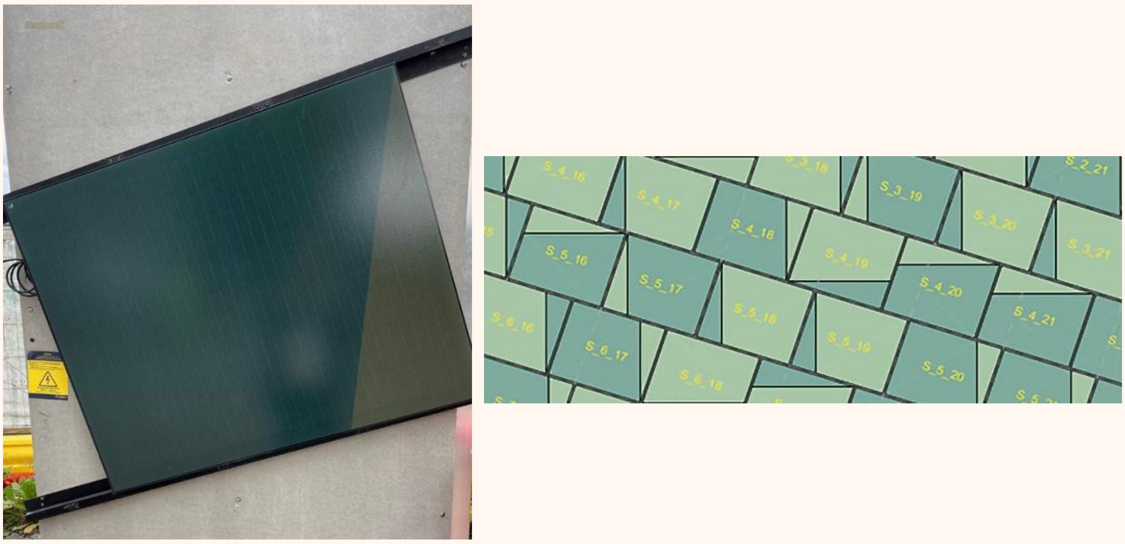

Figure 31. Left: image of one of the bi-coloured PV panels tested on the building site. Right: technical section of the school façade. Right: scheme of different installations of the two bi-colour PV panels. Original image by KONTUR and SPINN Arkitekter, edited by Nicola Lolli (SINTEF).

Technical solutions used in the H-building

The H-building was required to be preserved by BYA. The renovation is therefore focused on minimizing the impact on the parts of the building that are expected to be preserved while ensuring an improvement of its energy efficiency. The design of the energy retrofitting technical solutions covers two main areas of intervention: roof and façade. BYA agreed that the roof could be replaced entirely by a new lightweight ventilated roof construction by ensuring the preservation of the existing cornice height and design. This to preserve the building facades appearance. The roof insulation (210-mm-thick stone wool insulation) is placed between the structural frame to preserve the overall building height. The existing facades are insulated from the inside and the overall wall section consists of (from inside): gypsum boards anchored to a new wood structural system (shown in Figures 32-34), 50 mm air gap, moisture barrier, 100 mm stone wool insulation with metal studs, 40 mm air gap, existing wall construction (as detailed in the technical section, Figures 32 and 34).

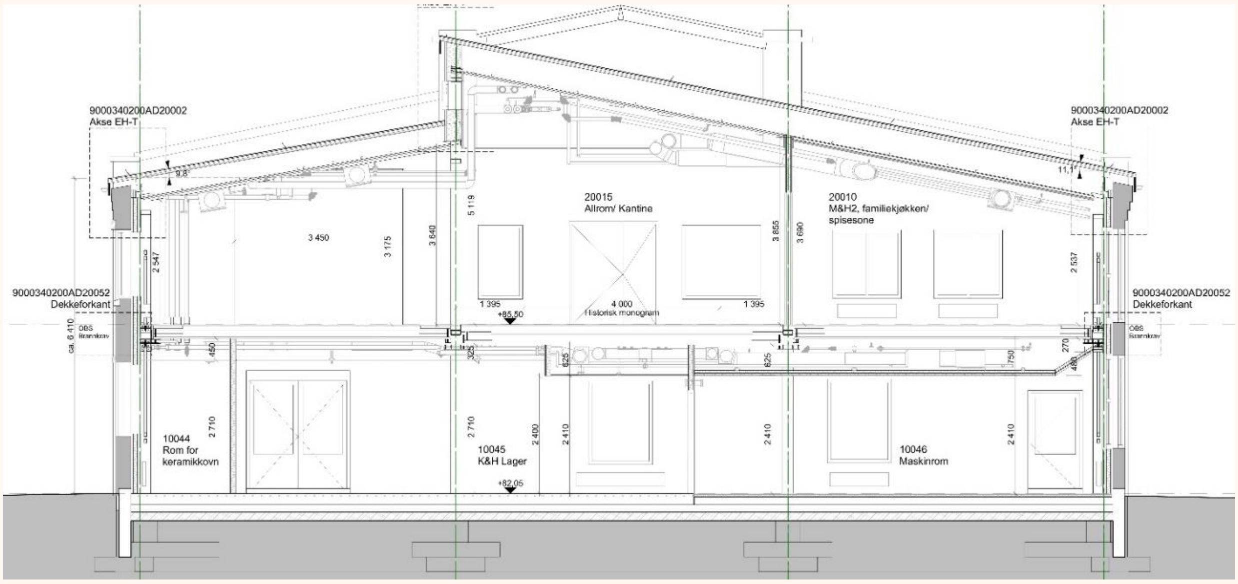

Figure 32. Technical cross section of the H-building. Original image by KONTUR and SPINN Arkitekter.

Figure 33. *Image of the internal insulation layer in the H-building. The new wood structural system is shown. The gypsum boards, not installed yet, are to be placed between the vertical and the horizonal wood frame. Photo by Nicola Lolli (SINTEF).*

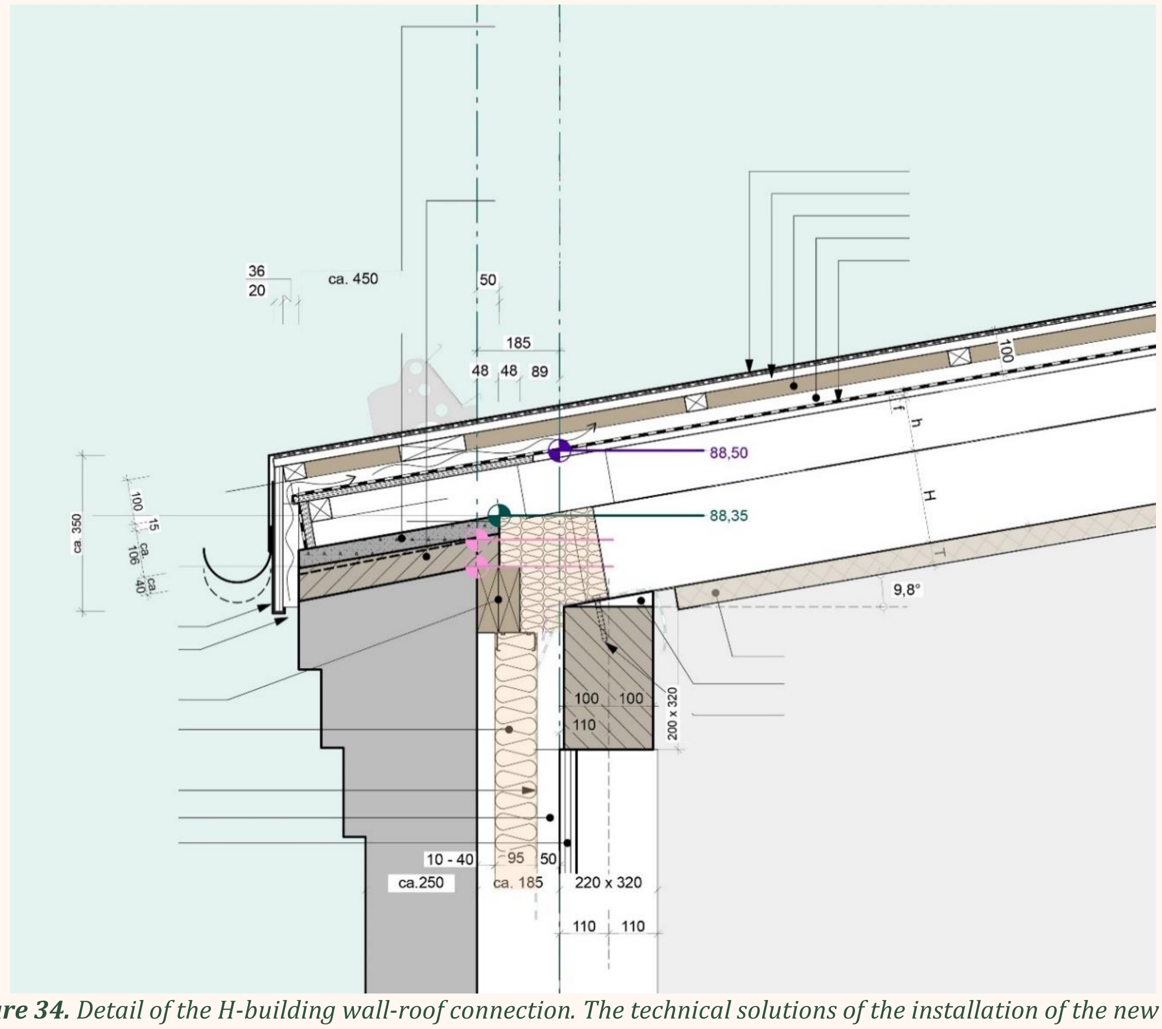

Figure 34. *Detail of the H-building wall-roof connection. The technical solutions of the installation of the new roof, the connection between the new roof and the existing façade, and the new added internal insulation layer are shown. Original image by KONTUR and SPINN Arkitekter, edited by Jesus Daniel Garcia Melo (NTNU).*

Technical solutions used in the school courtyard

The "islands" placed in the central outdoor area house vegetation, stormwater, and outdoor activity between central walkways. The activities allocated in each island are chosen based on being appealing to young people with different skills. The installed equipment is therefore chosen to be used in different ways and at several levels, depending on the student's individual skill. Biological diversity with greenery that is resistant and belongs to the local/regional species diversity is considered in the school landscape plan. To ensure a natural environment that can foster pollinating insects, part of the new vegetation consists of berry bushes and fruit trees.

Stormwater is handled according to the three-step principle: minor rainfall is handled locally, major rainfall events are delayed, and extreme rainfall is diverted into safe floodways. The rain bed facing Uelandsgate is planned without the steel grates (which are used in the central islands), as shown in Figure 35. This is because no student outdoor activities are planned in the plot facing the main road, due to traffic noise. Green lawns are planted on the outer edges of the east side of the plot, whereas the open areas in the north and south consist largely of gravel, and lawn areas with trees. Rainwater from the S-building roof is directed into underground drains and to a sump at the closest island in the school yard, where the water is distributed and later drained. Roof water from the H-building and the bridge is directed to the closest islands and there to the ground via external drainage. As shown in Figure 36, a stone draining mass is planned under the rain bed, in the islands. Between the draining masses, drainage lines are installed (between 110 mm and 200 mm diameter) to distribute storm water between the islands. In each island, a sand bed is installed for the distribution of stormwater to the draining mass.

The paving materials for the outdoor area varies depending on the intended use of each outdoor area. Permeable materials and greenery are used to ensure stormwater management, and rubber asphalt and concrete is used under the playground areas. Alternatives to rubber asphalt have been looked for (e.g., cork), however, their lifespan is not comparable due to their lower durability.

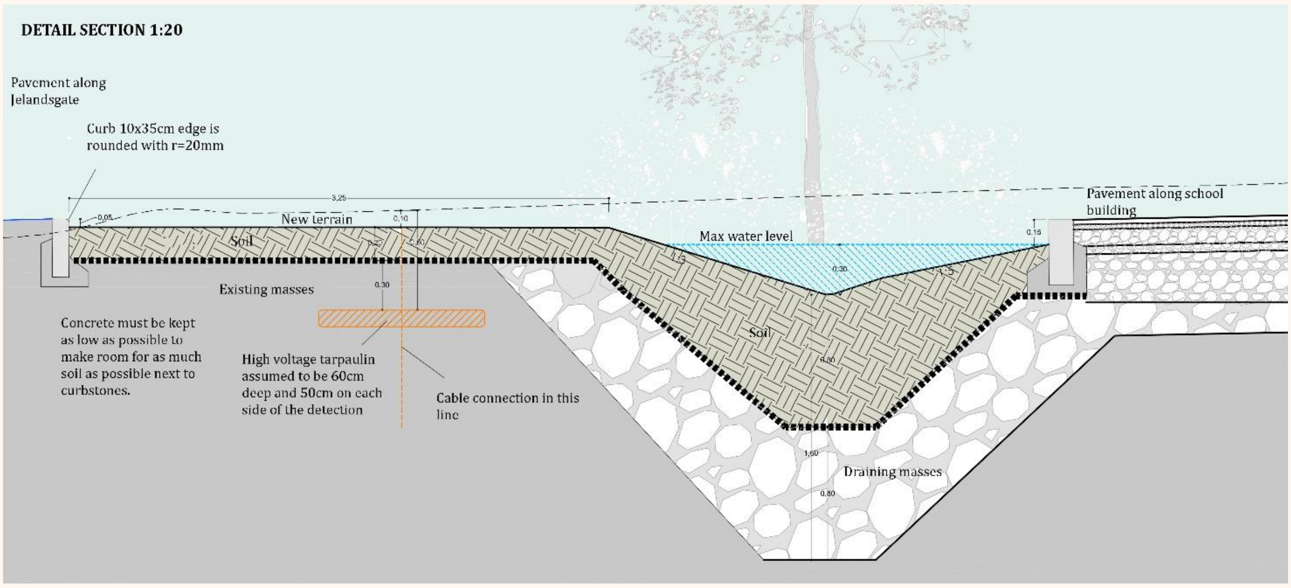

Figure 35. *Detail of the stormwater drainage system along Uelandsgate. Original image by ØSTENGEN & BERGO AS, edited by Jesus Daniel Garcia Melo (NTNU).*

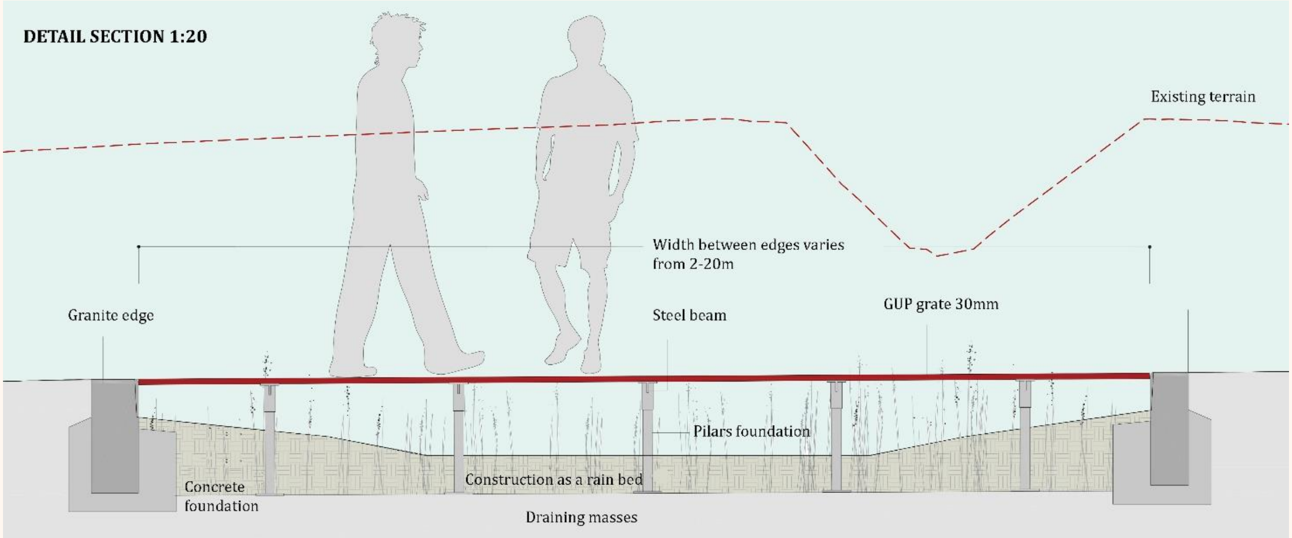

Figure 36. *Detail of the stormwater drainage system in one of the "islands" in the central part of the school courtyard. The rain bed and construction system of one of the channels is shown. Original image by ØSTENGEN & BERGO AS, edited by Jesus Daniel Garcia Melo (NTNU).*

5.3 BENCHMARK THE SOLUTIONS DECIDED AGAINST ARV KPIS

CPCCs in ARV should strive towards 50% reduction in life cycle embodied GHG emissions compared to ex-ante condition or current practice. In this report, the material use in final design of the new school building (the S-building) has been evaluated against that target. (Note that the Voldsløkka project also includes another building, the H-building, which is not part of this version of the report.) To be able to make such comparison, two steps were performed: (1) the life-cycle embodied GHG emissions were estimated through an LCA, and (2) a benchmark value was set for current domestic practice.

PERFORMING THE LCA

The LCA was performed by subcontractor Norconsult in two iterations: one for the early-phase design in February 2019 and another one for the detailed design in June 2022. Only the detailed design LCA is used in this benchmarking since it contains the most updated information. The material use for the bridge from the S-building to the H-building is included. The school has a support system made of solid wood, steel, and concrete. The calculation is a quantitative assessment of emissions of GHGs associated with materials over a lifetime of 60 years, and describes the project's impact on climate change, measured in CO2-equivalents. The GHG calculation was performed in accordance with the Norwegian standard *NS 3720 Methodology for greenhouse gas calculation for buildings*. The materials were organized into building elements according to the Norwegian standard *NS3451 Table of building elements*, and the lifecycle modules are organized according to the Norwegian and European standard *NS-EN 15978:2011*. Of the 134 materials included in the assessment, specific EPDs (Environmental Product Declarations) were used for 60 materials, while generic emission intensities were used for the remaining. Materials responsible for 5% or less of the weight in each building part were to some extent excluded. Technical installations were also excluded. The tool used for the calculations was OneClick LCA. The input data was gathered from various sources:

- Material quantities were extracted from an IFC file dated November 2021 and were supplemented with quantities for the structural materials from the structural engineers.

- Quantities of wastage from cut-off and surplus materials was based on project specific values from the contractor Veidekke for timber framing, wind barrier, CLT, and load-bearing steel (received in March 2022). For the remaining materials, the quantities of wastage were standard values in the software used.
- Material lifetimes are based on standard values in the software used. Maintenance and repairs are excluded from the assessment.
- Transport distances are using location of the specific supplier for concrete, reinforcement, steel and solid wood. For the remaining materials the transport distances were standard values in the software used. In all cases, the emission factors used for transport modes were standard in the software used.
- End-of-Life emissions are based on standard values from the software used.

MEASURES TAKEN TO REDUCE EMISSIONS

It appears, with the assumptions made, that total GHG emissions from materials are 2319 tonnes of CO_2e. The most impactful measures taken to curb emissions include:

- The concrete used is "low carbon class A"
- 100% recycled reinforcement in concrete structures
- A large amount of recycled steel in the beams
- A significant portion of the beams, columns, exterior walls, interior walls, slabs, were built with wooden materials (the remaining of low-carbon concrete with recycled reinforcement).
- The roof is a lightweight structure, which reduces the material use and the load on the building, furthermore, the roof structure is made of solid timber.

SETTING THE BENCHMARK VALUE

To set a target for current Norwegian practice, an evaluation was made of which target values are already available. Although there are multiple possible target values (statistics of OsloBygg's previous school projects, the FutureBuilt criteria) the most relevant and up-to-date target was judged to be the Norwegian governmental recommendations for public procurements made available from December 2020 by the Norwegian Government Agency for Financial Management (Direktoratet for forvaltning og økonomistyring)[14,15]. These reference values are intended to be representative of standard Norwegian practice for different typologies. The reference values do not include basements, rather, there are additional reference values for heated and unheated basements in addition to the typologies. The typology for school building and unheated basement were chosen. The system boundaries for the reference values include a subset of building elements (22 Load-bearing systems; 23 External Walls; 24 Internal walls; 25 Slabs; 26 Roof; 28 Stairs, balconies, etc.)[16] and lifecycle phases (A1 raw material supply, A2 transport (to manufacturer), A3 manufacturing, A4 transport (to the site), B4 replacement, B5refurbishment)[17]. The embodied carbon results from the Voldsløkka school building were recalculated to only include the same building elements and lifecycle phases as are in the reference values.

RESULTS AND COMPARISON WITH BENCHMARK

The results of the assessment are shown in Figures 37 and 38. Figure 37 shows the results for the Voldsløkka school and the reference values per building element and lifecycle phase. Figure 38 shows how those results compare to the reference, and the percentage reduction achieved. The current

14 https://anskaffelser.no/verktoy/analyseverktoy/klimagassutslipp-bygg
15 https://kriterieveiviseren.difi.no/nb/wizard-export/criteria/175_172/220_217#criteria-175
16 As defined in the NS 3451
17 As defined in the NS-EN 15978:2011

assessment shows that the Voldsløkka project has a significant reduction for all building elements and lifecycle phases, with a total reduction of 51% compared to the reference. The A-3 stages are contributing to most emissions among the lifecycle stages. Among the individual building element, the beams (due to steel profiles) and cantilevered slabs (due to cast-in-situ concrete) have the highest emissions. Among all material types, construction steel is causing most emissions, and is responsible for roughly one-fourth of total emissions in the building. The construction steel is followed closely by cast-in-situ concrete, and flooring is the third highest material category. Some emission culprits worth mentioning, where there are clear potentials for lowering the climate change impact, are: relatively large technical rooms, steel used for mounting façade elements and glass facades, aluminium framed as opposed to wooden frames windows, and vinyl flooring. Note that this analysis is of preliminary nature and will be updated before final conclusions can be made. Limitations of the current assessment are discussed below.

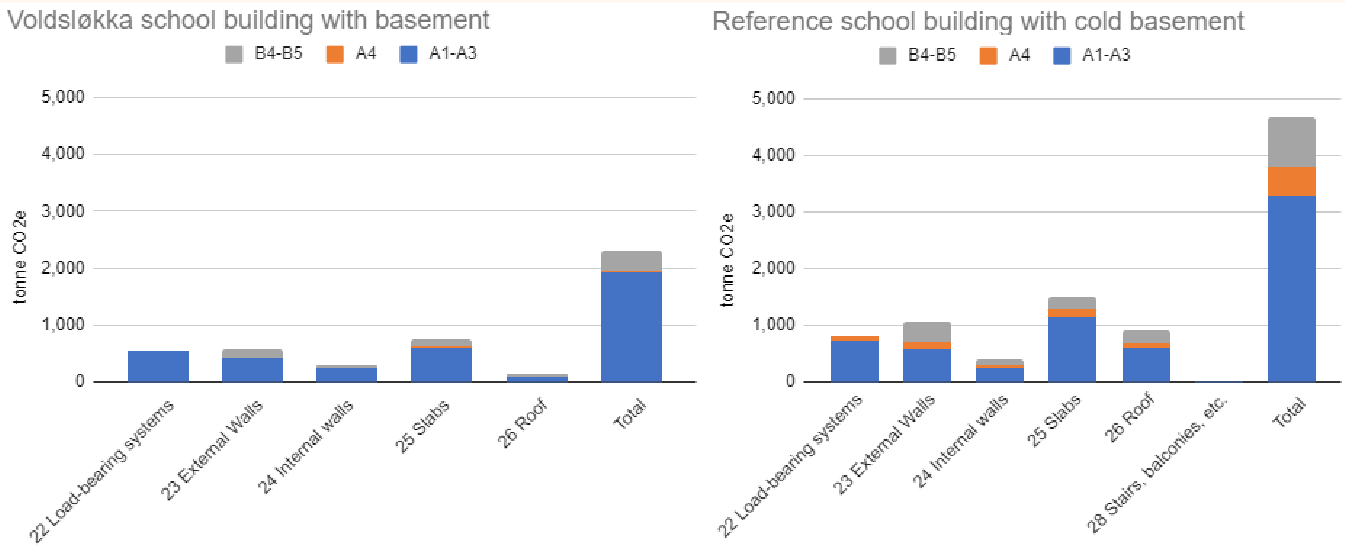

Figure 37. *The embodied carbon of the materials used in the Voldsløkka school building (left), and the reference values for standard Norwegian practice (right). The results are divided by building elements and lifecycle phases. Building element 28 Stairs, balconies, etc. is not included in the assessment due to data currently not being available.*

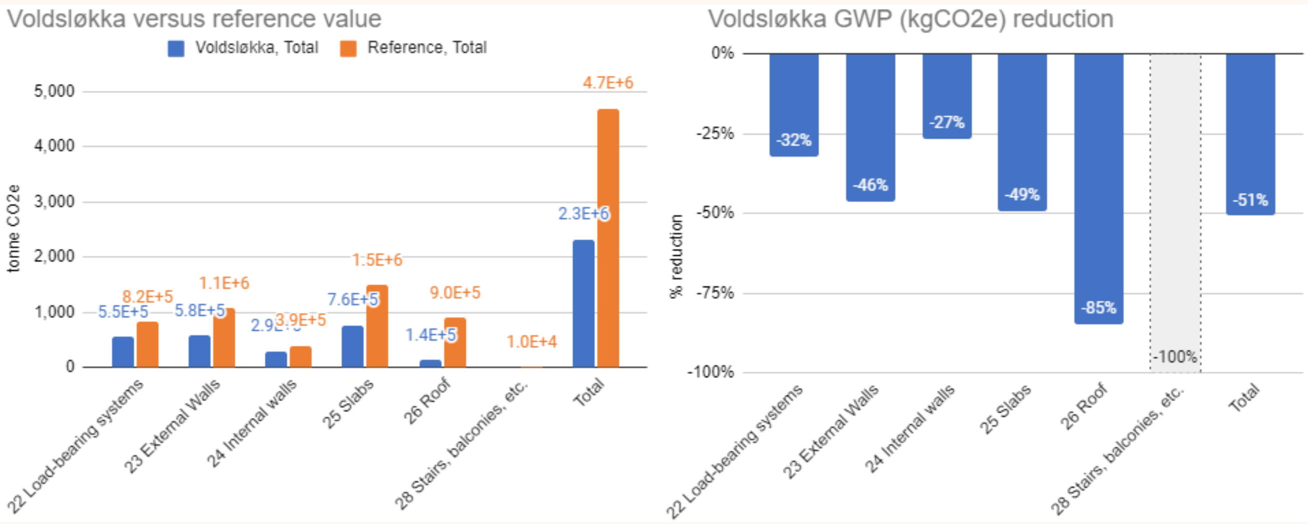

Figure 38. *The embodied carbon of the materials used in the Voldsløkka school building compared to the reference values for standard Norwegian practice (left), and the percentage reduction achieved (right). Results are shown per building element and for the total.*

LIMITATIONS OF THE LCA AND BENCHMARK COMPARISON

The result in this assessment is based on a material inventory of the *planned* construction. The actual materials used when construction is finished might differ from what was planned. For example, the material inventory did not include the building element no *28 Stairs, balconies, etc.,* however, this is not likely to influence the conclusions since that building element is quite insignificant in the reference values. More importantly, the reference values used for benchmarking the results do not include building element no *21 Groundwork and foundations,* which could be included for a more holistic comparison. There are currently no good benchmarks for this building part. The S-building has managed to achieve a low impact in this building part due to use of low-carbon concrete and recycled steel, a benefit that does not show in the current assessment. Other uncertainties include: the accuracy of the gross floor area of the building above ground and basement areas; some construction site wastage which is not included in the reference values is included in the Voldsløkka results for B4-5,; the emissions from transport, A4, are likely too low in the Voldsløkka results, since both the transport distances and the emission factor for the transport modes are unrealistically low compared to the assumptions made in the reference values; some production emissions, A1-3, may be too low in the Voldsløkka results due to an inaccurate method of "localization", i.e. applying a reduction factor to the emission factors of the products to make them country specific. These limitations should if possible be addressed when the data becomes available. In summary, the Voldsløkka school building fulfils the 50% reduction target in the current assessment.

ENERGY DEMAND

The energy simulations have been performed in the software SIMIEN[18] by the consultant at Norconsult. SIMIEN is an energy calculation software that is validated according to EN 15265 and were the calculations according to NS 3021:2014 "Calculation of energy performance of buildings — Method and data". The calculations have input data based on statistics of operating time and occupancy from Oslo Municipality. For energy use related to lighting, technical equipment, and heating of domestic hot water data from another school in Oslo (Brynseng Skole) was referred to. Of course, the current energy simulations are theoretical predictions, and the actual energy demand will probably change depending on the the actual use of the building and on actual weather conditions.

H-Building (Renovated building)

To check if the planned renovation leads to a reduction in the energy need compared to the pre-renovation level, it is necessary to find a suitable reference for comparison. As pointed out in chapter 5, the H-building is an old cement factory which is being transformed into a cultural building. This means that the pre-renovation reference should be a cultural building. Thus, we have used a reference energy which is based on average measured specific energy use in Norwegian cultural buildings[19]. The simulated energy demand, the representative energy demand, and the calculated difference (in kWh/m^2 & percent) can be found in Table 7. As we can see from the results, the renovated part of the building achieves the target of at least 50% reduction in energy needs compared to pre-renovation levels.

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[18]https://simien.no/?gclid=CjwKCAiAzKqdBhAnEiwAePEjkjP-0ThZcp7aTm_J_U0zYjPFIUWb8hfVvV5sn95zqrRQ5YINXl2GABoCK5kQAvD_BwE
[19] https://publikasjoner.nve.no/rapport/2016/rapport2016_24.pdf

Table 7. *Simulated annual energy demand of the H-building and of the representative similar building.*

Simulated energy demand H-bygget [kWh/m2]	Representative energy demand [kWh/m2]	Difference [kWh/m2]	Difference [%]
119	245	-126	-51 %

Due to the status as a listed building, there were limitations on changes to the façade of the building. The exterior appearance of the façade had to be preserved, and it had to be ensured that no further damages where to be done to it. This also meant that the amount of insulation was limited, as the consultant's (SINTEF) conclusion was that that thicker insulation layers on the interior side of the wall could damage the old brickwork. Therefore, the thickness of the mineral wool insulation was set to a maximum of 100 mm.

S-Building (New building)

A summary of the energy simulations can be found in Table 8. The simulations for the S-building were done to control the building against the plus-energy target according to a previous FutureBuilt definitions. This dictates that one is allowed to discount energy demand from technical equipment if a building has four stories or more. In addition, one can discount some of electrical energy demand from district heating. The amount of discountable Sustainable shares is calculated by using a weighting factor of 0.43. For the project it is assumed that the annul energy production from the PV system will be 229 848 kWh. It is important to note that numbers for the PV output are assumed, and not yet simulated. As shown in Table 8 this leads to a positive energy balance where the building produces 2.7kWh/m^2 year more than it uses. This is within the FutureBuilt definition that dictates that plus-energy buildings should deliver 2.0 kWh/m^2 or more back to grid on an annual basis.

Table 8. *Simulated annual energy demand of the S-building.*

	[kWh/m2]	[kWh]
Total energy demand	56,6	502989
Total electric energy delivered	37,1	329915
Technical equipment	13,3	117843
Sustainable shares from District Heating	0,68	6003,8
Assumed energy production PV	25,9	229848
Total energy delivered	2,7	23779,8

INDOOR ENVIRONMENTAL QUALITY - DAYLIGHTING

Daylighting simulations have been performed by external consultant in the project to control against the requirements in TEK 17 and SKOK (standard requirement specification Oslo municipality) and inform the design of the buildings. Daylight factor was used as the metric for assessing the indoor daylighting levels. Daylight factor is stated as a percentage of the daylight that hits an unshielded external surface. When calculating the daylight factor, the sky model (CIE Overcast Sky) is used as a starting point. Daylight factor is calculated at a point inside, measured 0.8 m above floor level and 0.5 m from adjacent inner and outer walls.

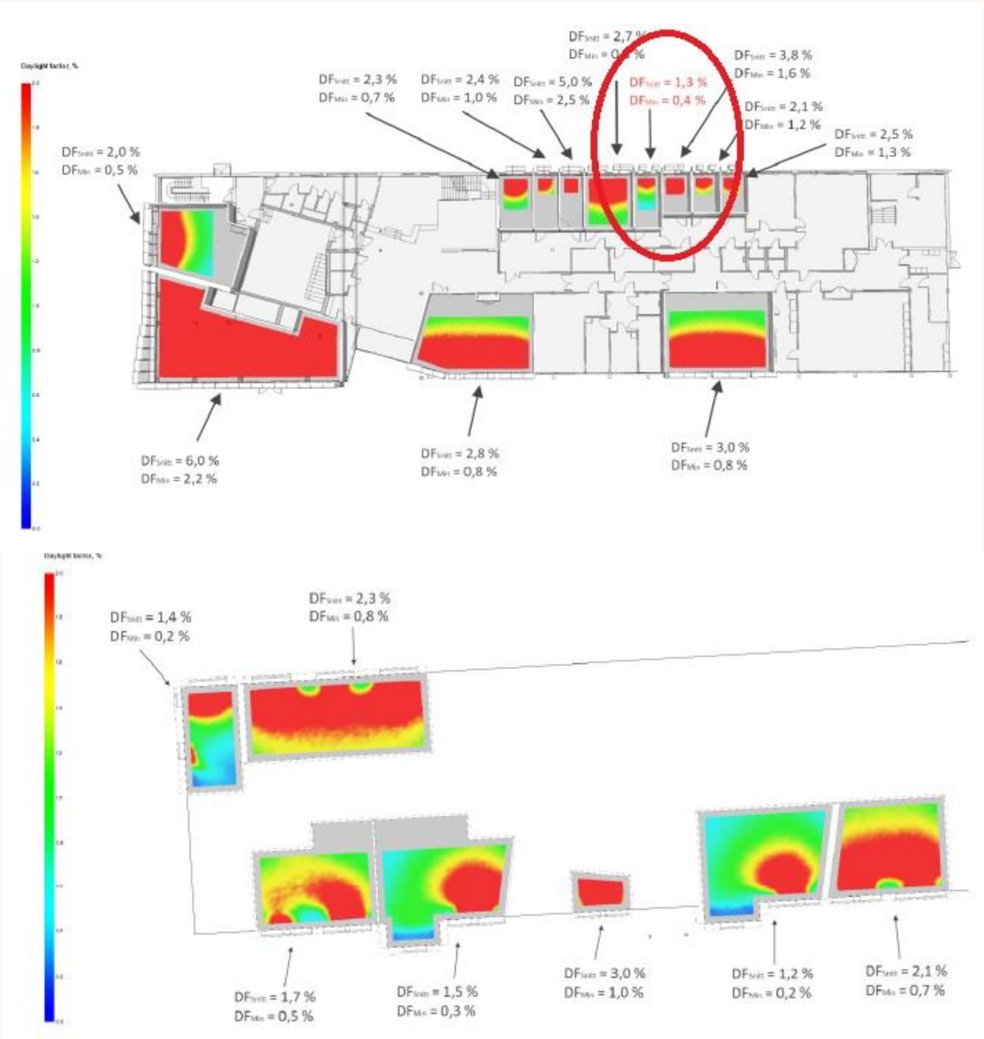

Figure 39. *Daylight simulations for (top) the S-building and (bottom) the H-building. The red circle highlights a room that was found to have insufficient daylighting.*

The simulations were done in the simulation's software IDA ICE[20], and performed for selected rooms deemed most critical. Examples of output from these simulations can be found in Figure 39 Where simulations revealed potential for insufficient daylighting, as shown, there has been a constant dialogue between the different building designers' groups to adjust according to the simulations results. Possible solutions were to change the size of the window, to change the functions of the room or to highlight specific ways the rooms should be furnished.

[20] *https://www.equa.se/en/ida-ice/validation-certifications*

5.4 SUMMARY

PROCESS

One of the most important decisions taken in the early urban planning process was the decision against privatization as residential development in favour of a public function as a school project. This not only ensured the needed school capacity for the area but made it possible to develop the site as a connector with the adjacent green areas and as a meeting point for the areas' children and youth. Moreover, the school is a pilot project, adding the function of cultural hub to the learning areas of the school. To achieve this, several alternative options for the development were proposed and evaluated. Finally, the site was purchased from the private developer who had proposed the residential development.

The further development of the plan included the decision to demolish two industrial buildings that were on the site which were not regarded as historically valuable. The school and cultural hub development allowed for the preservation of the Heidenreich building with historical value, which had been planned for demolition in the residential development. The preservation in turn triggered tight regulations on the possible alteration of the building. These were addressed in close dialogue with the building preservation authority.

The urban planning process also resulted in the placement of the new school building on the West side of the property to give a new façade to the road and keep connectivity with the park. At the point of this decision, the vision to develop the school as a plus-energy building had not been adopted and was consequently not considered.

The decision-making process in the planning phase involved as main actors the private entity initiating the process (Uelands gate 85 AS (UG85AS)), the Oslo City Planning and Building Agency (PBE), the Oslo City Council for Urban Development (BYU) and the Oslo City Education Agency (UDE). Later in the process, the Oslo City Water and Sewerage Agency (VAV) were involved and Dark Arkitekter AS prepared a feasibility study and a concept selection study.

For the later design development, the main client was the Oslo City Education Agency (UDE). For the guidelines on the renovation of the Heidenreich building, the Oslo City Office for Building Preservation (BYA) was instrumental. Oslobygg led the design phase with Norconsult and Spinn Arktitekter, amongst others, as consultants, and Veidekke as the main contractor.

After the design development phase, instead of the customary process of choosing a contractor who is solely responsible for the construction development and construction, the architect and fire consultant continued into the detailed design phase. This ensured continuation of the design in coordination with the contractor, who was expected to propose multiple solutions to the design team. Solutions were discussed and decisions were taken based on which solution best fitted the design concept.

ARCHITECTURAL QUALITIES

Goals

The project specifications from the Regulatory Plan aim at developing a sustainable local community. Areas of prioritization contain environmental criteria (reduction of noise, air pollution and GHG emissions), concrete development prescriptions (preservation and strengthening blue-green-structures), as well as qualitative goals (sustainable urban environment, environmentally friendly urban spaces). Amongst the measures, prioritizing architectural heritage plays an important role. The latter directly led to the preservation of the Heidenreich building. Because of its historic value, the building was kept and could only be transformed on the inside while maintaining the appearance of the building (scale, shape, detailing, use of materials and colours). For the new building, dimensioning considered a flexible floor plan layout. Two variants for a multi-purpose hall were considered in the Regulatory Plan (underground and integrated), but for its high cost and unpractical use in the school building (as mentioned by the Sagene Sports Association[21]), it was decided to plan the construction of a new separate sports hall in the nearby plot[22].

The design of the outdoor spaces uses an innovative open surface water solution. Goals for these areas included an integration with the existing natural environment to achieve a green feeling as well as making the area fit for increased rainfall by using natural and permeable surfaces. The rainwater management influenced the placement of the new building, as the distance from the street is to allow enough space for local water surface management. However, the Blue-Green factor was allowed to be lower than stipulated for residential projects, as the surface area is expected to be intensely used.

Programming and general appearance

The school has a multi-use concept, with spaces made available for cultural activities within and outside of school hours. This required for the spaces with more than educational use to be located close to each other with a flexible closing system that gives access to different user groups. The users were engaged in a user participation process to locate the different functions (school only, cultural only, both). Teaching areas are configured such that a flexible use of the spaces is possible with varying sizes of student groups. The bridge that connects both buildings is housing the kitchen for the adjacent school canteen that serves as a meeting point for the users of both buildings. The facade appearance of the new building (S-building) was strongly influenced by two factors. On the one hand, the Regulatory Plan specifies high aesthetic quality and a limited selection of materials, as well as transparency for the bridge between the S-building and the H-building. On the other hand, due to the plus-energy goal, the exterior wall had to be well insulated to low-energy building standard and PV production had to be located on the facade at the same time. In addition to these requirements, easy maintenance was considered in the façade design. These factors resulted in a timber frame curtain wall system, with a glass and PV cladding that can be replaced without damaging the exterior walls. The integrated PV system design uses novel, angular and coloured modules with high degree of standardized module sizes and fastening solutions, significantly reducing the time and costs of applying such a system.

For the historic building, the guiding principle was to safeguard the building's exterior appearance originating from 1935. Therefore, the building had to be insulated from the inside and the clear height under the roof was lowered to keep the original exterior height. Windows were replaced by new windows mimicking the original windows. On the interior, historic elements of the structure and installations were refurbished and reused.

The design of the outdoor spaces takes its starting point from the storm water management concept and aims to connect the schoolyard with the surrounding Voldsløkka area. This integrated design concept emphasizes the potential of vegetation and open surface water handling to create attractive outdoor spaces. This is achieved by introducing "green islands" and combining them with edge zones and circulation zones. All green areas were planted with native vegetation, with a focus on the potential benefits on local climate i.e., reduction of the heat island effect and the abatement of pollutants.

Detailed solutions

The façade design exemplifies the necessity to synthesize between requirements of a plus-energy building and the desire for a non-uniform colourful façade. Additionally, the building's orientation follows the urban design, enabling a larger green area towards Voldsløkka park, but offering larger East and West facades for PV production, which receive less insolation than a South façade. The design team's answer to these requirements is a multi-layered system which treats the cladding, PV panels, windows and insulated wall parts as technically independent units. For these units, the number of variations is limited, but design variation originates in the combination and overlapping of the layers. The design

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[21] *Uelands gate 85, Voldsløkka, bydel Sagene Planforslag til politisk behandling Detaljregulering, Saksnummer 201214524. https://innsyn.pbe.oslo.kommune.no/saksinnsyn/casedet.asp?caseno=201312704*

[22] *https://innsyn.pbe.oslo.kommune.no/saksinnsyn/showregbest.asp?planid=201214524*

strategy focuses on panel-to-panel and panel-to building-surface connections for easy installation and replacement of components. These can be easily replicated and varied for other buildings and contexts. For the refurbished building, an interior insulation system was installed, while the roof was replaced keeping its original appearance. The focus was to strike a balance between safeguarding the integrity of the historic building while making it as energy efficient as possible within the constraints.

SOCIAL QUALITIES

The school will serve as a HUB for involvement, engagement, and teaching pupils about energy transition technologies and sustainability. The building will include a demo-space for citizens' and children's education with a focus on new technologies like storage, electrical vehicles, renewables, etc. This will house and promote activities such as green ambassadors and influencers promoting energy efficient behaviour and circular solutions to their peers. Participatory methods where play, engage, inform, and educating young people and through them also their parents, are envisioned here. The decision to use the plot for a school rather than privatizing it contributes to the social qualities, especially because pupils will come from two neighbourhoods with differing demographics and social backgrounds. In the design process, user participation was engaged in design development, when the distribution of functions was developed.

ENVIRONMENTAL SUSTAINABILITY

The environmental goals of Voldsløkka school are ambitions: The school is to be the first plus-energy school with a 50% reduction in GHG emissions compared to a regular school. This decision was made in the concept phase of the building and pursued throughout the design and construction process. Additionally, the project features an emissions-free construction site. The project adheres to the 2014 definition of plus-energy buildings that allows to disregard the electricity use from technical equipment in the accounting of energy use. Per the 2018 definition, the school might not be plus-energy, but with user engagement and awareness it is to be seen if the monitoring might show a different picture.

The design process dealt with a trade-off between spatial (orientation) and aesthetic (no office-building-look) requirements and the goal of a plus-energy building, requiring a well-insulated building with large areas for electricity production. The compact design of the school building in combination with the façade system that was especially developed for this school answers to these requirements with an architecturally ambitious solution.

To achieve the envisioned reduction in GHG emissions for the new building, the use of "low carbon class A" concrete played an important role. This was combined with circular material strategies, with 100% recycled reinforcement in concrete structures and a large amount of recycled steel in the beams. Additionally, the use of wood helped to reduce GHG emissions, because large part of the load bearing structure as well as all the exterior and interior walls were built with wooden materials. The roof is a lightweight structure of solid timber, which reduces the material use and the load on the building.
In the historic building, circular renovation strategies were employed, where most of the walls and windows were reused and upgraded to new energy performance standards. The emissions from this have not been calculated and will be subject of the next report.

6. INNOVATIONS IN THE VOLDSLØKKA DEMO

A brief description of the innovations for the design phase of the Voldsløkka demo is presented in this chapter. Four innovations are identified on the different levels of the general progress of the development, ranging from the planning and design to the demonstration level. In the first year of the project implementation, several target groups were recognized as the final beneficiaries: architects, developers, city planners, consultants, and material producers.

(1) Climate adapted design using an innovative open surface water solution. The concept is a green and different schoolyard where vegetation and surface water management are used as a resource to create good and varied outdoor spaces. The design of the outdoor green area will ensure the use of vegetation to optimize water management and, at the same time, create a varied and appealing outdoor environment. Pollutant-absorbing plants have been proposed. This innovation is in the experimental phase.

(2) Effective application of low-carbon concrete with 40% lower embodied emissions than standard. This innovation is in the demonstration phase (Technological Readiness Level, TRL, 9).

(3) Digital design for optimum life cycle performance. BIM and AR technology are used to evaluate the performance of the building development from the environmental, architectural, and economic perspectives. The evaluation of the buildings and infrastructure is made by considering their lifecycle environmental impact, cost, and energy use, the inclusivity of the local community, the use of indoor and outdoor space, water management, noise and pollution, and aesthetic. This innovation is in the experimental phase.

(4) Circular renovation design strategies are developed by mapping of locally available building materials and components from existing and going-to-be demolished buildings. Most of the walls and windows in the old factory will be reused and upgraded to new energy performance standards to save embodied GHG emissions from building material use. This is part of the energy renovation design of cultural heritage building using a circular renovation strategy. This innovation is in the design phase.

An overview of the identified innovation types, their expected impacts call categories (EIC), and technological readiness levels for these innovations is given in Table 9.

Table 9. *ARV innovations for Norwegian DEMO linked with the design phase*

Innovation title	**(1) Climate adapted design using an innovative open surface water solution**	**(2) Effective application of low-carbon concrete**	**(3) Digital design for optimum life cycle performance**	**(4) Circular renovation design strategies**
Innovation Type	Product / Technical Solution, Guideline / Instruction	Product / Technical Solution	Product / Technical Solution, Method/System	Product / Technical Solution, Process, Method, Guideline / Instruction
Progress Phase	Testing / experimental	Demonstration	Testing / experimental	Design and development
Expected TRL	9	9	8	8
Expected Impacts	**C**ircular **E**conomy and **R**esiliency, **S**ocial-environmental qualities, **K**nowledge creation	**C**ircular **E**conomy and **R**esiliency	**C**ircular Economy and Resiliency, **S**ocial-environmental qualities, **E**nergy flexibility and security of supply, **K**nowledge creation **S**martness	**C**ircular Economy and Resiliency, **S**ocial-environmental qualities, **E**nergy flexibility and security of supply, **K**nowledge creation
Target groups	Architects Consultants City planners	Contractors, Consultants, Material producers	Architects Consultants City planners	Architects, City planners, Entrepreneurs, Developers

7. BEST DESIGN PRACTICES AND CHALLENGES

CONSIDERATIONS ON THE PRIVATE/PUBLIC PLANNING INITIATIVES

The regulatory process that preceded the design development of the Voldsløkka project was originally initiated by a private actor, Uelands gate 85 AS (UG85AS), which was the company owning of the plot of land in Voldsløkka. UG85AS proposed a Regulatory Plan for housing development, thus following its natural interest for commercial development for this area. As pointed out by Nordhal[23], the critical difference between the private and public planning proposals lies in the interests that drive the development process. For private actors, the interest of commencing a planning proposal is not based on the future land use of the area but mostly on being able to commence a private housing or commercial development. Moreover, the type of development is further influenced by market demand and cost assessment. On the other hand, publicly commenced planning initiatives are often driven by local population growth and needs for housing or public services.

According to Holsen[24], the planning system is built on two assumptions. The first deals with the public task to define and establish the planning activity and the second with the municipal task to overview the planning development. There are no restrictions on which actors have the right to participate in the planning process, since its aim is to present the plan that is best for the community. The municipality, as the central actor, is responsible for coordinating the process with the overall plans and to ensure the population has the right to participate and give opinions. Holsen highlights that the privately driven planning process deviates from the ideal process described in the Planning and Building Act. This is because a private actor does not have to abide to any formal obligations, such as the involvement of the municipality, until a regulatory proposal is advanced. This results in a difference perception of the steps that lead from the regulatory phase to the design development. From a private developer perspective, planning, designing, and building processes are experienced as one process, while the Planning and Building Act describes the planning and building process in two different sequential steps. This difference is reflected in the way the planning process is structured. The Planning and the Building Act illustrates an ideally vertical structure, with the municipality as the main driver, whereas today's reality with private initiators reflect a horizontal structure, with the private actor in central position. Since the municipality is no longer the driving actor, the degree of participation from the population is limited by the interest of the private actor to involve only those parties considered necessary.

[23] Berit Nordahl. Private development initiatives and the public planning authority - some reflections on collaboration and power relations. FUS, Tromsø 18.-19. June 2001.
[24] Terje Holsen. Negotiations Between Developers and Planning Authorities in Urban Development Projects. disP - The Planning Review. 2020.

CHALLENGES IN THE H-BUILDING

The regulations for the protected historical buildings set by the Office for Buildings Preservation (BYA) are rather strict. Facades of protected buildings cannot generally be changed since their appearance is worth being preserved. Most of the significant changes in the H-building could be implemented in the indoor spaces, where most of the existing non-load bearing structures were demolished to make the space for the new cultural functions.

Figure 40. Photo of the exposed façade (right in the picture) and cultural spaces (left in the picture) in the north side of the H-building. Photo by Nicola Lolli (SINTEF).

The limitations imposed to the façades made it impossible to use external insulation, thus limiting the energy performance of the building. The H-building was energy retrofitted to reach an energy class B by adding internal insulation, retrofitting the existing windows and installing new ones, and installing a new roof. PV panels were not allowed to be installed on either the south façade or the roof.

Despite the new indoor layout, some parts of the original concrete and wood structural elements were maintained. These elements were typical of the time when the building was built and showed its history as cement factory. The construction team from the contractor (Veidekke) was very helpful in identifying small details of the H-building construction (corner stones, inscriptions in some of the façade stones, traces of old openings that were closed, etc) that were then highlighted in the renovation process. The design team, therefore, chose to design large indoor spaces which can allocate different functions while maintaining the historical testimony of the building. As an example, the innermost layer of the original north façade was left exposed in some of its parts to show how the construction was made (Figure 40). It was challenging to incorporate the new programme in the H-building as the space layout had to consider the preservation of the original structural elements and the roof height. The roof height could not be changed because this would have changed the façade's appearance. This restriction made it complicated to fit the technical services in the building at a minimum free height from the mezzanine floor, as shown in the technical section (Figure 32).

CHALLENGES FOR ACHIEVING A PLUS-ENERGY TARGET

Three main challenges were faced by OBF and the design team to achieve a plus-energy building for the Voldsløkka project. These are described below.

Limitations given by the Regulatory Plan

The Regulatory Plan was quite detailed with regard to the location of the new school and its overall appearance. Most of all, the defined north-south alignment of the school, along Uelandsgate, that was made to ensure a continuous line of sight between the southern and northern parts of the Voldsløkka park, was a sub-optimal orientation with regard to the electricity production from façade-installed PV panels. At the time of the regulatory process, the plus-energy goal was not discussed nor decided for the project. The reasoning behind the decisions in the Regulatory Plan were mainly done to limit the visual impact of the new building, to define a new street front on Uelandsgate, and to shield the school courtyard from the road traffic. When the plus-energy goal was decided by OBF for the school building, the design team had to deal with a small south-facing façade and two long east- and west- facing façades, which is not the best condition for façade-installed PVs to maximise their electricity production. The design work on the PV façade started between the end of 2018 and the beginning of 2019. The building construction started in 2021, when the market-available PV technologies had already advanced in terms of performance and efficiency. Thus, the design of the PV system was based was not based on the most up-to-date technologies, and this had a strong impact on the overall design of the PV system. In addition, it was required that the appearance of the school facades should not be that of of large monotonous surfaces. The choice of the coloured palette for the PV modules and their rotated installation were solutions found to make the facades more dynamic and appealing, but had limitations with respect to the efficiency of the PV energy production.

FutureBuilt definition of plus-energy buildings

At the beginning of the preliminary project (described in Chapter 5.1), OBF and the design team decided to make the Voldsløkka project a pilot for the first plus-energy school in Norway. Therefore, they relied on the plus-energy definition given by FutureBuilt[25] in 2014:

> *"Energy use related to the operation of the building must be at least compensated over the year through the production of renewable energy. To be considered a plus house, surplus energy of 2 kWh/m² BRA per year must be produced [...]. For buildings over 4 storeys, it can therefore be permitted to deduct energy use for technical equipment, i.e., that the building must be considered as plus energy including the energy items heating, hot water, fans, pumps, lighting and cooling."*[26]

The definition of plus-energy building was thereafter updated in a new issue by FutureBuilt in 2018 by removing the above-mentioned exception for taller buildings.

> *"For some building categories, especially for hospitals and nursing homes, but also for multi-storey (over 3-4 floors) hotel buildings and commercial buildings, it will be very demanding or impossible to achieve plus house level with current technology and with standardized usage times and internal loads. For these building types, it may therefore be appropriate to use a lower level of ambition than FutureBuilt plus houses, e.g., something that lies between FutureBuilt nZEB and plus-energy building."*[27]

However, at the time of the updated definition, the preliminary design was already well ahead, including the design of the technical installations that would have made it a plus-energy building according to the initial FutureBuilt definition. OBF and the design team worked on possible alternative designs and solutions to evaluate the possibility of having the school building complying with the newly issued definition, but none of the alternatives produced satisfactory results with this regard. OBF and the design team therefore decided to keep the original design in compliance with the first FutureBuilt definition. As mentioned above, the plus-energy definition applies to the new school building and not to the renovated H-building. This is because the restrictions given by BYA on the building renovation did not allow for more energy-efficient solutions regarding wall insulations and installations of PV on the roof.

Ventilation requirements from the SKOK (standard requirement specification by Oslo Municipality)

The ventilation requirement given in the TEK17 standard requires a minimum of 23 m³ of fresh air per person per hour[28]. Considering the number of students and employees in the school, this amounts to about 13 m³/h per m² of floor area . To reduce the energy losses from the ventilation system, a demand-

[25] https://www.futurebuilt.no/English
[26] https://www.futurebuilt.no/content/download/5861/55365
[27] https://www.futurebuilt.no/content/download/28126/157914
[28] https://dibk.no/regelverk/byggteknisk-forskrift-tek17/13/i/13-3/

controlled system was installed, which provides 7.2 m^3/h of fresh air per m^2 of floor area when the rooms are occupied, and 3.0 m^3/h per m^2 when the rooms are not occupied. A demand-controlled system ensures that as soon the CO_2 concentration increases in the room, the amount of ventilation air flow and fresh air intake increase to deliver sufficient fresh air for the occupants. Moreover, OBF and the design team, in agreement with UDE, decided to make use of more efficient rotary heat exchangers than those recommended in the SKOK. The SKOK advises to use fixed-plate heat exchangers and to limit the use of rotary heat exchangers. This is to avoid the possible occurrence of extract air to recirculate in the intake and enter the rooms. However, the amount of extract air was calculated to be a maximum of 2.4% of the total fresh air intake. Since the amount was expected to be so small, UDE agreed on the use of rotary exchangers to allow its testing in this pilot building, for evaluating the feasibility of a large-scale implementation in future plus-energy school buildings.

Connection to the local district heating system

The Voldsløkka project is within the concession area of the local district heating system. This requires an obligation to establish the needed infrastructure for connection between new buildings and district heating network. According to the FutureBuilt definition of plus-energy buildings, the credit of renewable energy use from district heating to the delivered energy is given by multiplying the delivered energy by 0.43[29]. On the other hand, the energy saving given by using a ground source heat pump (GSHP) is in the range of 0.22 of delivered energy use, by assuming an GSHP performance factor of 4.5. The difference between 0.43 and 0.22 represent additional energy savings given by installing a GSHP instead of connecting to the district heating. Therefore, OBF and the design teams decided to have the energy and heating need of the school building covered by the GSHP. The GSHP covers between 80% and 95% of the heating load throughout the year, whereas the remaining 5%-20% is covered by the district heating during the coldest days of the year. For the H-building, it was decided to cover the heating demand by district heating only, as the use of a GSHP was not considered to be cost-effective.

8. FUTURE UPDATES

Following this analysis of the design process, we will analyse different scenarios with combinations of state-of-the-art materials, components, technologies, and smart control systems with regards to the ARV KPIs as defined in the ARV assessment framework. At the beginning of 2023, a group of students from NTNU's international Master program in sustainable architecture will develop alternative design scenarios with the goal to minimize GHG emissions while aiming for high architectural quality. To this end, students will receive a looser requirement framework than the actual project. For example, the potential of renovating all existing buildings on site or reusing the materials of the existing buildings can be considered as well as alternative placements for the school building. The alternative scenarios will be compared regarding their life-cycle emissions and architectural and urban qualities they generate. In this process, digital design aids (BIM, LCA tools) will be used to generate and assess different solutions and support the design process. Challenges will also include the consideration of locally available building materials and components from existing and going-to-be demolished buildings. The alternative scenarios will include design strategies for use of reused materials and components. The benefit of such solutions will be assessed in relation to technical and aesthetical constraints.

It has also been decided to include a planned sports hall at Voldsløkka in the ARV demonstration project. The design and construction of this sports hall will be included in the next update of the report.

[29] https://www.futurebuilt.no/content/download/5861/55365

9. APPENDIX A

FUNCTION AND ROLES OF THE DIFFERENT STAKEHOLDERS INVOLVED IN THE REGULATORY PROCESS OF VOLDSLØKKA

***Landowner** and promoter of the first regulatory process*
Uelands gate 85 AS (UG85AS): Company owner of the plot of land in Voldsløkka and proponent for a regulatory process for housing development.

***Administrative authorities involved in the** regulatory process*
Oslo City Planning and Building Agency (PBE): The Planning and Building Agency is responsible for the municipality's overall spatial planning, planning and building case processing, map management, and map and division business. PBE Led the regulatory process for Voldsløkka, and it was the reference authority for UG85AS.

Oslo City Council for Urban Development (BYU): the city council leads the Oslo Municipality's administration, and it is responsible for implementing the political decisions made in the city council. The city council and the individual city council members implement such decisions via the subordinated Agencies. Under the BYU the following Agencies are placed: Oslo City Property and Urban Renewal Agency (EBE), Oslo City Planning and Building Agency (PBE), Oslo City Office for Building Preservation (BYA). Gave directive/inputs to PBE regarding the development of the Voldsløkka area and the regulatory process.

Oslo City Education Agency (UDE): the Agency is responsible for the operation, development, follow-up and guidance of educational activities within the laws, frameworks and guidelines laid down by national and municipal authorities. UDE was involved by PBE in meetings and workshops to give inputs on the two alternative designs in Voldsløkka.

Oslo City Urban Environment Agency (BYM): the Agency is responsible for the management of common areas such as streets, squares, parks, open spaces, sports facilities, fields and the inner Oslo fjord. BYM is also responsible for monitoring the air, water and soil quality, and noise level withing the recommended values. BYM was involved by PBE in meetings and workshops to give inputs on the tow alternative designs in Voldsløkka.

Oslo City Water and Sewerage Agency (VAV): the Agency supplies Oslo's population with drinking water and handles the wastewater. The Agency is responsible for the operation, maintenance, and renewal of the city's treatment plants, pipelines and pumping stations for both drinking water and wastewater. Other important tasks are management of water source areas, supervision of the waterways in the city, guidance and information to customers. VAV was involved in meetings and workshops by PBE to give inputs on the two alternative designs in Voldsløkka.

Oslobygg KF (OBF): Oslobygg KF is Oslo municipality's real estate company. OBF owns, develops, builds public buildings in Oslo (such as kindergartens, schools, care homes, nursing homes, cultural buildings, sports facilities, fire stations and national facilities), and it is responsible for their management throughout their life span. Oslobygg KF is under the Oslo City Council for Industry and Ownership. OBF was not directly involved in the regulatory process but mentioned as the developer of the area.

External consultants
Dark Arkitekter AS (DAAS): Architect office hired by UG85AS for the Regulatory Plan development. DAAS was involved by PBE in meetings and workshops to receive inputs and propose alternatives on the residential development design in Voldsløkka.

Asplan Viak AS (ASVAS): consulting company hired by PBE for evaluating the traffic noise levels and storm water management in the two Regulatory Plan proposals.
COWI AS (COAS): consulting company hired by PBE for carrying out geotechnical analyses of the area ground stability, and damage assessment to the Heidenreich building in the residential development alternative.

External actors that submitted remarks to the two alternative development designs during the public review of the Regulatory Plan of Voldsløkka

Administrative authorities
Sagene city district (BYSA): one of the 15 administrative districts of Oslo City.

Nordre Aker city district (BYNA): one of the 15 administrative districts of Oslo City.

Oslo City Property and Urban Renewal Agency (EBY): the Agency is the Oslo Municipality's landowner and promoter of the development of the city. The Agency's activities are as such:

- To develop areas for the construction of housing, industry and other public purposes
- To enter into development agreements and coordinate urban development projects
- To clean up contaminated land and carry out various environmental measures
- To buy and sell property
- To manage and rent properties

Oslo City Fire and Rescue Service (BRE): the Service works to ensure fire safety and fire prevention throughout Oslo city. It provides an emergency response systems to handle large-scale fires and accidents.

Oslo City Renovation and Recycling Agency (REG): the Agency is responsible for collecting and managing household waste in Oslo. The waste is sorted out and sent to the different waste processing facilities (biogas processing for food waste, plastic recycling, burning for energy recovery). REG is under The City Council's Department for the Environment and Transport.

Oslo City Office for Building Preservation (BYA): Byantikvaren is Oslo municipality's professional advisor in all matters relating to the preservation of architecturally and culturally-historically valuable buildings, facilities and environments and archaeological cultural monuments.

Oslo City Education Agency (UDE)

Oslo City Urban Environment Agency (BYM)

Oslo City Water and Sewerage Agency (VAV)

County Governor of Oslo and Akershus (FMOA): The County Governor is the chief representative of King and Government in the county, and works for the implementation of Storting (Parliament) and central government decisions. The County Governor explains central policy documents in the local context, being aware of each municipality's ability to provide. Experts from the County Governor 's office supervise local activities, advise and instruct – with due respect to the political judgement of the local government. The County Governor may look into local decisions regarding the rights of any individual in the fields of health and social care, education, building and planning, and may change the decision to the benefit of the individual. Other important fields of action are environment protection, agriculture, emergency planning, local government finances and family matters.

Norwegian Water Resources and Energy Directorate (NVE): NVE is a directorate under the Ministry of Petroleum and Energy and is responsible for the management of Norway's water and energy resources. NVE works to reduce the risk of damages associated with landslides and flooding. The directorate aims to ensure an integrated and environmentally sound management of the country's water systems, promote efficient energy markets and cost-effective energy systems, and contribute to efficient energy use. NVE bears the overall responsibility for maintaining national power supplies.

Public associations

The Nature Conservation Association in Oslo and Akershus (NOA): is a democratic member organisation which works for protecting the nature and the environment in its region. NOA contributes to develop solutions that safeguard nature, through spreading knowledge about nature and contributing to the enjoyment of nature by the residents of Oslo and Akershus.

Oslo Sports Circle (OIK): OIK is an organizational link in the Norwegian Sports Confederation and Olympic and Paralympic Committee (NIF) and organizes all sports teams in Oslo.

Skeid (SK): Skeid is a Norwegian football club from Oslo.

Sagene Sport Association (SAIF): SAIF is the sport association of Sagene District.

Oslo and Akershus Corporate Sports Associations (OBIK): OBIK is a member of Norwegian Sports Confederation, and it provides companies and families with a social arena where to get involved into physical activities.

Private companies

Ruter AS (RAS): plans, coordinates, and orders public transport in Oslo and former Akershus (now part of Viken county). All transport services are performed by various operating companies on behalf of Ruter AS.
Hafslund Nett AS (HNAS): energy provider company.

Others

Private citizens

FUNCTION AND ROLES OF THE DIFFERENT STAKEHOLDERS INVOLVED IN THE DESIGN PHASE OF VOLDSLØKKA

Project developer

Oslobygg KF (OBF): Oslobygg KF is Oslo municipality's real estate company. OBF owns, develops, builds public buildings in Oslo (such as kindergartens, schools, care homes, nursing homes, cultural buildings, sports facilities, fire stations and national facilities), and it is responsible for their management throughout their life span. Oslobygg KF is under the Oslo City Council for Industry and Ownership. OBF led the design phase of the Voldsløkka project development.

Undervisningbygg (UBF): UBF is the group under OBF leading the development and management of education buildings.

Client

Oslo City Education Agency (UDE): the Agency is responsible for the operation, development, follow-up and guidance of educational activities within the laws, frameworks and guidelines laid down by national and municipal authorities. UDE was involved in meetings with OBF to provide guidelines and suggestions on the design choices.

Norwegian Education Union (UF): UF is one of the largest unions for educators and teaching professionals. UF, on behalf of the teaching staff, was involved in meetings with OBF to provide guidelines regarding the physical environment conditions.

Norwegian Student Organization (EO): EO represents and advocates for all pupils and apprentices to the politicians, the media and the rest of society. EO trains and educates students and student councils in speaking up for themselves at their school.

Designers

Spinn Arkitekter AS (SPAS) and Kontur AS (KOAS): design consultants for the new school construction and renovation of Heidenreich building.

Østengen og Bergo AS (ØBAS): design consultant for the school landscape and outdoor garden.

Technical consultants

Dr. Tech Olav Olsen (DROO), Ny Struktur AS (NSAS), Norconsult AS (NCAS), Heiberg & Tveter AS (HTAS), Erichsen & Horgen AS (EHAS), Brekke & Strand Akustikk AS (BSAS), COWI AS (COAS)

External auditors

Verkis AS (VAS), Afry AS (AFAS)

Contractors

Veidekke AS (VEAS): the main construction company.
Øyvind Moen AS (ØMAS)
Several subcontractors

External public authorities

Norwegian Labour Inspection Authority (ARTY): the Norwegian Labour Inspection Authority is a governmental agency under the Ministry of Labour and Social Affairs. It has administrative, supervisory, and information responsibilities in connection with working conditions and occupational safety and health. It is audited by KOAS/SPAS on behalf of OBF to request the authorization for the new construction of the school and renovation of the Heidenreich building.

Sagene city district (BYSA): BYSA is audited by KOAS/SPAS on behalf of OBF for the assessment of plans for local and outdoor areas in accordance with regulations on environmental health protection in kindergartens and schools, in connection with the establishment of Voldsløkka school in Uelands gate 85.

Oslo City Urban Environment Agency (BYM): BYM is audited by OBF for approval of the landscape design and storm water management strategy and planning.

Oslo City Office for Building Preservation (BYA): BYA is audited by OBF for approval of the renovation design of the Heidenreich building.

Oslo City Water and Sewerage Agency (VAV):
VAV is audited by NCAS for receiving advice and evaluation of the wastewater and water management plan in the Voldsløkka project.
VAV is audited by VEAS for approval of wastewater management during the construction activities of the Voldsløkka project.
VAV is audited by Båsum Boring AS for approval of drilling of 14 boreholes for the energy system of the Voldsløkka project.

Oslo City Planning and Building Agency (PBE):
PBE is audited by KOAS/SPAS on behalf of OBF to give approval of the Voldsløkka project and to start the project (building permit).
PBE is audited by KOAS/SPAS on behalf of OBF to give approval for drilling 14 boreholes for the energy system of the Voldsløkka project.

PBE is notified by KOAS/SPAS on behalf of OBF of the Voldsløkka project activities. This documentation is used to notify the neighbourhood of the commencement of the project. With this regard, HNAS and Tåsen Housing Association provided feedback and remarks to KOAS/SPAS on the project activities. BYM provided an assessment regarding the possible conflict of the project with the neighbouring plots BYM was managing.
PBE is audited by KOAS/SPAS on behalf of OBF to ask dispensations on the regulatory provisions defined for dimensioning (height and footprint) of the multi-purpose hall, the new school building, the bridge connecting the new school building and the Heidenreich building, location of parking spaces, and the daylight level in some of the school classrooms.

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