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Supervisors	**Peter Mandal Hansen** Architect MAA, Teaching Associate Professor at Department of Architecture, Design and Media Technology, Aalborg University **Peter Vilhelm Nielsen** M.Sc. Ph.D., Professor at Department of Civil Engineering, Aalborg University
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Camilla Grøn
stud.polyt.arch

Katrine Hove Schlosser
stud.polyt.arch

ABSTRACT

English

This Master Thesis treats the subject learning environments, in the design of a new Sønderbro School in Copenhagen, Denmark. This report contains a theoretical- and research part which sets the framework for the following design iterations that terminates in a design proposal.

With a point of departure in the new school reform, there is sought to reach an architectural design that encompasses longer schooldays, differentiated learning and movement as essential elements.

In order to creates a physical framework that accommodate modern pedagogical methods and encourages movement a common understanding of learning environments must be studied. Based on the theoretical reading about learning environments, it has been an important parameter to create a differentiated learning environment in children's scale. The teaching spaces requires a great variation, to accommodate the learning ability of the individual student, thus a focus on creating niches for absorption and spaced for negotiation and gathering both indoor and outdoor.

An important aspect of the new reform is to create a stronger connection between city and school, this creates a dynamic environment and facilitates a variety of offers to the citizens in the neighbourhood. We perceive the school as a unique learning environment and another offer on this list that will improve the social relations and facilities among others in this particular neighbourhood.

Danish

Dette afgangsprojekt omhandler læringsvmiljøer, og tager udgangspunkt i et design af en ny Sønderbro skole i København, Danmark.

Rapporten indbefatter en teoretisk- og research del, der danner ramme for de følgende design iterationer der ender ud i et design forslag. Med udgangspunkt i den nye skolereform, er det forsøgt at opnå et arkitektonisk design der imødekommer længere skoledage, differentieret læring og bevægelse som de essentielle elementer.

For at skabe de fysiske rammer der skal imødekomme moderne pædagogiske metoder og opfordre til bevægelse, har en fælles forståelse for læringsmiljøer været drivkraften igennem projekter. Baseret på teoretisk litteratur om læringsmiljøer, har det været en vigtig parameter at skabe et differentieret læringsmiljø i børnehøjde. Undervisnings rum forlanger en stor variation til at imødekomme lærings evnen ved den enkelte elev, således er et fokus på skabning af nicher til fordybelse, rum til forhandling og forsamling både indendørs og udendørs været afgørende.

Et vigtigt aspekt af den nye skole reform er at skabe en stærkere forbindelse imellem skole og by, og derved gøre skolen mindre institutionel. Skolen bliver en urban katalysator for at skabe et dynamisk miljø, der faciliteter et bredt udvalg af tilbud til befolkningen i nærområdet. Vi ser skolen som et unikt læringsmiljø der vil være endnu e tilbud på listen der kan forbedre sociale relationer og faciliteter blandt andet, i dette nabolag.

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MOTIVATION
.The underlying motifs for this Master Thesis

The public school is an institution of great importance, shaping us and our future children of the society - It is where we achieve the basic foundation of knowledge. We have more or less all been there through the journey developing us as individuals, and provide us the competencies that enables us to manage one self in the real society.
This project is a reaction upon the change in the Danish school reform, and seen as an opportunity towards creating a new environment that can accommodate the visions initiatives taken in the new school reform and todays building standards.

We believe there is a correlation between our surroundings, welfare and our ability to learn. "The Embodied memory is explained as; the space we live in has a long-term effect on our body" (Pallasma, Juhani, 2012) By having a greater ambition for the architecture, that should not only provide shelter, but favour spatial experiences that stores in our bodies, is of great meaning. Especially when you have the opportunity to store these experiences at an early stage of life.
A childhood is a delicate matter, the shaping of the individual. Our interest relies in the use of means in architecture to achieve the perfect foundation for personal development. The idea of a good childhood has been, and still is, mediated in school architecture, as well as social conditions and historical.
Through time different societal conditions that in retrospect has had a huge impact on architecture. In the 20's it was the hygiene movement, the 50's the division of functions by the implementation of subject rooms, the 70's group- and project work, and today it's movement.
By this mean that one parameter when designing is that the physical framework has to accommodate todays ways of dealing with knowledge and learning, a change in pedagogical ideals anno 2014 also has to be reflected in the built environment. (Coninck-Smith, N. 2011)

" It is a societal challenge, that we move to little. It will affect out health, but also our ability to learn. The causes of the missing movement are many, but one of the parameters to work with are the physical framework and their accessibility, and that matter the schools in the country contains a unexploited potential, both for the school seeking and the local associations "
(Realdania, Skoleplus, 2014)

THE NEW DANISH SCHOOL REFORM

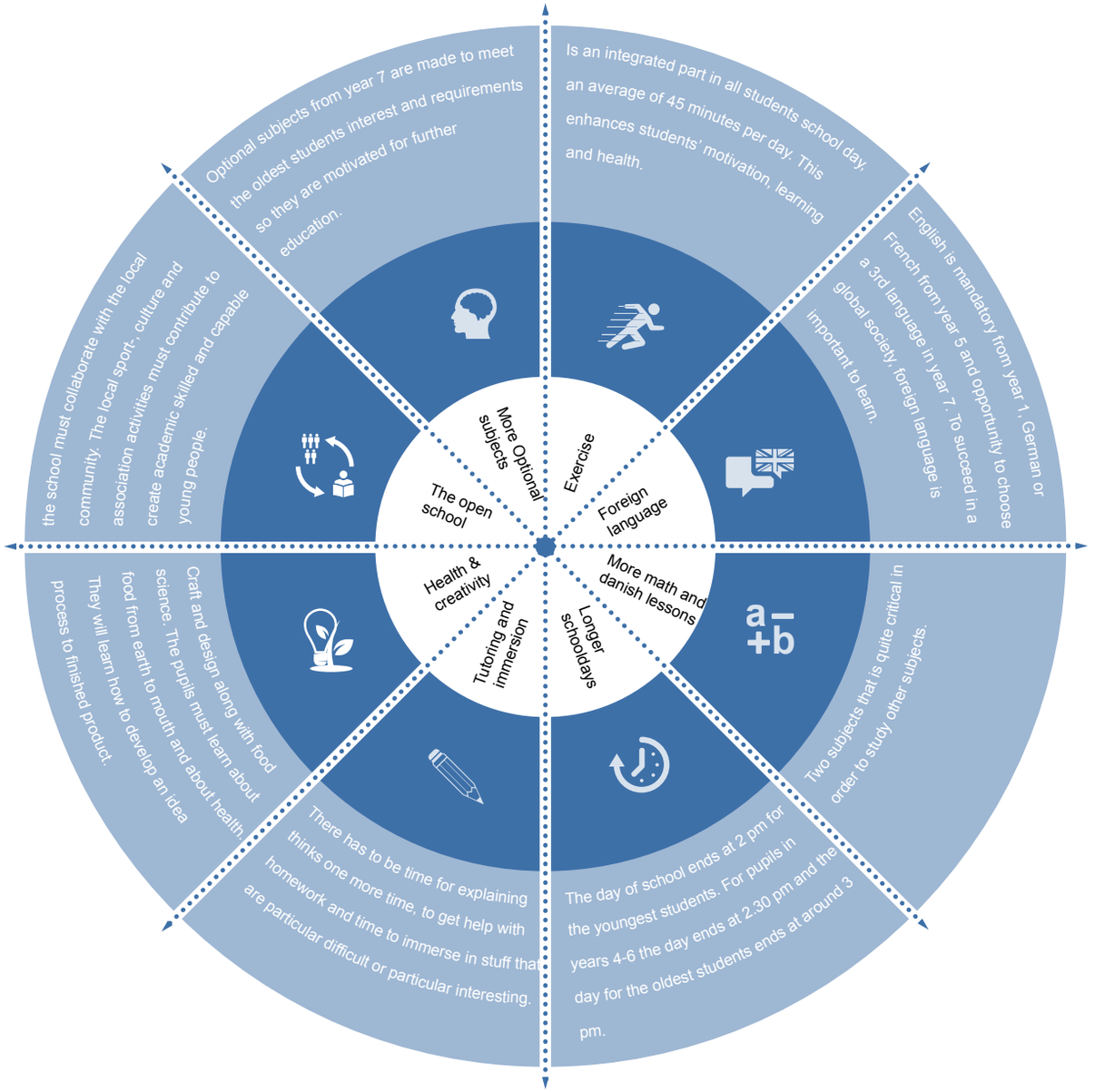
.The potential of a new school reform

"All students attending Danish public school should realise their full potential. Regardless of whether they are academically gifted or need a little help along the way. Regardless of their background, they must enjoy school. That is what the new public school aims to achieve." (umv.dk, 2004, s. 4)

To many children leave school without having achieved the skills to continue their out-of-school education. Other children do not receive enough academic challenge, and to many lack desire and motivation during the school period.
Thus a new school reform was initiated and implemented in August 2014. Improvements that ensures the public schools an academic boost by providing more time for learning, through a more varied school day, that enhances the focus on academic standards and well-being, was signed in June 2013 by the government and Venstre, Dansk folkeparti and Konservative.

To reach a common high level of ambition,
the new reform sets up three clear goals:

- *The new public school must challenge the children so they can reach their full potential*
- *The school must lower the influence of social backgrounds for the academics results*
- *Trust in school and the child's well-being must strengths though professional knowledge and practice.*



Map of new initiatives for the new school reform

More time means more time for learning. Time to immerse them selves in what motivates and is rewarding for the individual.

More time for movement and exercise every day. Time for tutoring and academic immersion. Time for the school to open up to the community, so the students experience how, what they learn in school, is used in reality.

The new public school is not just about more hours, but also about higher level of teaching. The teaching must increasingly meet the individual student, and must be handled by competent teachers and pedagogical staff.

The framework for teaching is critical in the new school, and a number of initiatives are taken to improve it.

- **Objective-oriented teaching:** *common goal for subjects will be clarified and simplified so it becomes learning goals and its clear what the student must learn.*
- **Enhanced classroom management and fewer disturbances in public schools:** *a national effort will be implemented to create a good learning environment and reduce the disturbance that disturbs the teaching in the Danish public school.*
- **Varied and realistic teaching:** *the longer day in school creates spaces for more varied teaching.*
- **Increased parental influence and involvement of students:** *the students and parents must be more involved in development of the new school.*
- **Competence development:** *all teachers must no later than 2020 have teaching competence, corresponding to the main subjects, in the subjects in witch they teach.*
- **Cooperation between teachers and other colleagues:** *teachers and pedagogical staff or colleagues with other relevant competences must on a higher level corporate for a higher degree on the students learning.*
- **Teaching consultants:** *a national corps of teaching consultants offers practice-based knowledge, inspiration and specifically guidance for the municipality and schools all over the country.*

The new school makes new demands for a visible school management that determines the direction for the school and takes responsibility for the goals to be achieved and how these goals are achieved. Regard to the school management and governance, following initiatives are taken:

• *Continuing education of principals: The school principal must be trained so they can establish goals and follow up the schools development.*
• *Objectives and follow-up: The quality report and the student plan will be simplified, and a common management information system is being established incorporating key data on the students and schools development.*
• *Rule simplifications: A number of rules has been simplified and introduced under the new reform in order to provide the municipality and school with greater freedom to plan the teaching and taking the local conditions into account.*

Together with the introduction of the new school reform in august 2014, the new working-time-regulations for teachers were also introduced.

The new rules means that the individual teacher must have more working hours on school, also the hours used on preparation. Before the new regulations for the teachers, there were an exact norm for how much preparation time the teacher has for each lesson; the time was the same for a Danish lesson in 1. grade and an English lesson in 9. grade. With the new rule the principal for the individual school will structure the working hours. This also means that there will be a bigger difference from school to school, it depends on the principal. Before the new regulations the teachers could structure their own workday. He could have a conversation with the parents in the evening or correct assignments in the weekends. After the 1st of august 2014, the teachers will only be available during the daytime and on the school. (dr.dk)

PROBLEM STATEMENT

With a point of departure in the new school reform implemented august 2014, the need for better facilities to accommodate todays pedagogic ideals and addressing the need for more physical activity is evident.

The implementation of longer schooldays blurs out the boundaries between spare time and school, thus a need for an attractive environment that creates the right setting for the students to spend longer in school is crucial.

The main spatial characteristics of the public school needs to be challenged and optimized to meet the demands for a differentiated learning environment.
The future school should reflect openness towards the immediate environment and invite the city indoor and the reverse. The potential in strengthen the students knowledge to the surroundings and the society should be explored.

Question

THE PUBLIC SCHOOL IS FACING A PARADIGM SHIFT, EFFECTING THE WAY WE SHOULD DESIGN LEARNING ENVIRONMENTS TODAY. HOW DO WE MEET THESE NEEDS THROUGH ARCHITECTURE?

Reasearch

The following chapter presents the theoretical- and research part of this Master Thesis, that seeks to explore the problems in modern school architecture and create a common understanding of learning environments in a historical light and due to the new school reform.

SOCIETY AND THE PUBLIC SCHOOL

.A survey of the alteration in school architecture, society & pedagogic ideals

Through time the architecture of public school have changed along with the pedagogic processes and the pedagogic ideals. The idea of a good childhood has been a mediator in school architecture, as well as the social conditions and the historical. (DRK, 2013)

In 1899, the public school law was effectuated and also the first time the school was referred to as the public school.
The school existed both in rural and urban areas. The different conditions of life were also reflected in the educational content, which was of less volume in the rural. (Coninck-Smith, N. 2011)

Hygine movement and pavillion schools (1900)"For the sake of contagion it is desirable, that the size of the school buildings are reduced to a minimum. If the circumstances allows it, a greater school etablissement should be built as a group of smaller buildings" (Haunstrup, A. 1902, p. 190, own translation)

The so-called hygiene movement characterized the schools in the city. To prevent the risk of contagion, the buzzword for a proper school was; light, air and hygiene. The design took its point of departure in this matter by introducing the Pavilion-schools where the separation of buildings should reduce the risk of contagion. It typically consisted of four to six independent one-storey pavilions and a common house with subject rooms and to ensure the hygiene, the children had access to showers and wash basin.
The hygienic visions were consistently performed in this period, the blackboards were painted on the walls and the corners were rounded to prevent dust and bacteria's to collect.
In this period, the furnishing of the classroom was for the first time developed to accommodate the height of the children and the expected position when seated. The tables were arranged in rows, with the teacher's table at the end on a pedestal to signalize authority. (Coninck-Smith, N. 2011)

Aula schools (1920)

During the First World War the first Aula-schools appeared to get grips with the old Pavilion-schools that until now had dominated the school building tradition. The aula space was in the center of the building, surrounded by classrooms on multiple floors. The space was used for school comedies, morning assembly and common happenings. The aula became “the people’s house” were children and adults could gather during school and after school. This type was an expensive estate, symbolizing the social political message about the working class children who also deserves an education. (DRK, 2013)

A bold design of this type was “Skolen ved sundet” (1938) by Kaj Gottlob, it caused a lot of discussion of how a school should look and how the playful look did not belong in this institution. (Coninck-Smith, N. 2011)

In 1937 the public school law was introduced, the whole country should be educated, it gave all children the opportunity to attend middle school and further education.

By centralizing the school system and gathering the children, the possibility for decreasing the expenses and grouping the children into year groups was a reality. The independent infant-wing was introduced and was seen as innovative on the pedagogic and architectural area, which later became more common. (Coninck-Smith, N. 2011)

Central schools (1950-60)
After Second World War, hundreds of new Central-Schools were established on the country because of the increasing amount of students. The subject rooms such as carpentry, a school kitchen and athletic facility had great significance, in order to appeal to a hands-on way of learning and by learning by experience. The athletic facility was now common in all the Central-schools in the country, for the first time they had the possibility to perform gymnastics indoor.
The new schools developed into congregation-lots where young and old could meet after school, for gymnastic, evening school or at the school library. In addition to the athletic facility a scene was integrated to accommodate the possibility for school play and extern use.
The heavy furnishing were replaced by lightweight wood and steel furniture that enables a rearrangement of tables and chairs, because the new education guide favors group work. However the classrooms was not designed to address this new way of teaching. (Coninck-Smith, N. 2011)

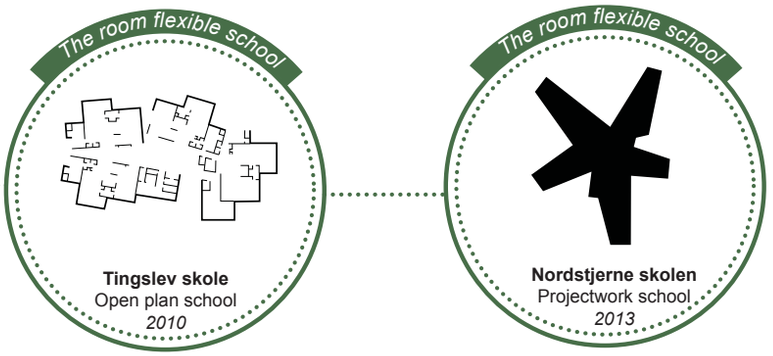
"A great number of rooms are designed to accommodate former ways of teaching, that could not succeed without a strong superiority from the teacher. The classroom was at that time first and foremost a place for examination, with students seated on their particular seat (...) several changes have been made since" (Lundahl, F. 1967, p. 265, own translation)

During the 70'ies the focus on group work and the opportunity to participate in decision-making through student council, changed the relationship between teacher and student. The democracy influences the school board, where the student parents operate half of the seats, this weakened the authority of the school board. (DRK, 2013)

Openplan schools (1970-)
" First came the buildings, later the pedagogic. That's how the course of development was several places in Denmark in the open-plan schools"
Harbo. T. (1976)

This meant that the future pedagogical ideals changed, as a reaction to a unknown future, and developed contrary to the function divided school which was the ideal in the 30', to a general architecture that could be used in multiple ways. The great interest in a flexibility of usage was a product of the expected changes in schooling the next long period, without knowing how it would be changed. The characteristics for the open-plan school was that the brick built wall was rarely seen. The exterior walls were bearing, and the interior walls were typically moveable. Most interior was moveable to accommodate different spatial needs for different teaching methods. (Kirkeby I. M. 2006)

After the Public school law in 1993, it was evident that the existing school building stock no longer was adequate, and needed renewal. School architecture is no longer what it used to be. In the start 90'ies the architecture became a part of the experience of attending school. The hierarchic order and the disciplined student that ruled the schools in 1950 and earlier are now replaced by a student who is self-taught, self disciplined and self managed. Thus today the schools are designed to offer opportunities for the individual student, whereas the collective values and the respect for school and society was what characterized the former school architecture. (Coninck-Smith, N. 2011)



LEARNING ENVIRONMENT

.Learning environment in an architectural perspective

Learning : Noun /ˈləːnɪŋ/
"Knowledge acquired through study, experience, or being taught"
[Oxford dictionary]

The learning environments have changed along with the change in the didactics. Today there is a focus upon flexible learning environments that accommodate differentiated learning. The way things are controlled today are different from earlier generations. The tendency has been going from predominantly outer control towards todays self control, which is reflected in the way we design learning environments. This means that the physical environment in a lesser degree needs to regulate behaviour, this makes demands on the child to administrate the "freedom" and fosters imagination (Kirkeby I. M. 2006),
The primary assumption is that there is a correlation between the physical framework and the daily life that takes place within the setting of a school, where learning and well-being emerges as a by-product of the built.

Winnie Rickens also describes in her research project (APOS) that design, arrangement and pedagogic initiatives needs to deal with learning scenarios.

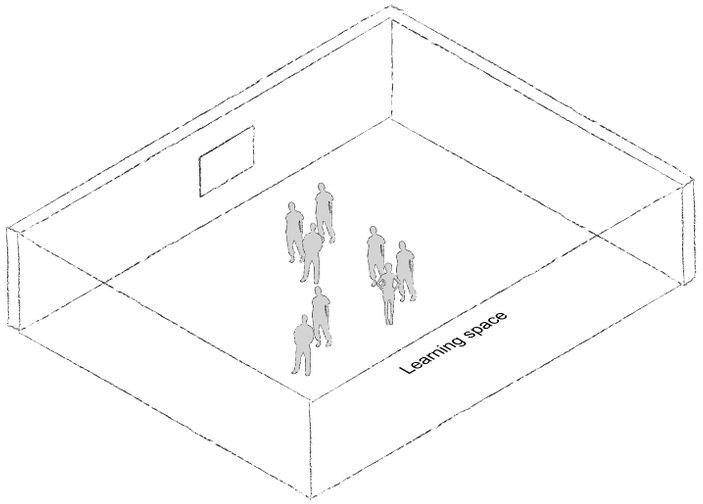
She states that each individual learns in different ways, hence a learning environment should embrace differentiated learning scenarios. However the space itself can not practise teaching, but will enable the teacher to facilitate several learning activities, to accomplish a differentiated teaching.

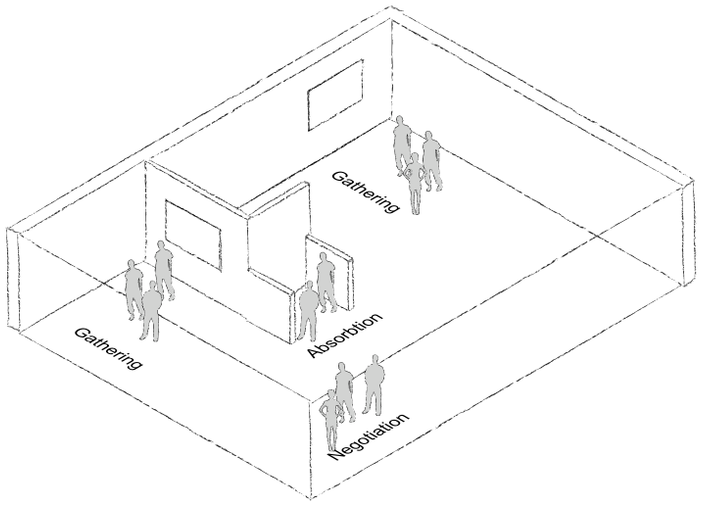
She specifies three spaces that are essential to create a good learning environment.
Space for gathering, Space for Absorbtion and Space for negotiation (Ricken, W. 2010).

"Gathering is defined as safe pedagogic common base, for initiating contemplated activities, knowledge presentation, teaching, recapitulation and evaluation" (Ricken, W. 2010 s. 45, own translation)

"Absorbtion is defined as individual studies" (Ricken, W. 2010 s. 45, own translation)

"Negotiation is represented as a 'void' between the learning scenarios Gathering and contemplation in the start-up phase before and the breaking up after" (Ricken, W. 2010 s. 45, own translation)



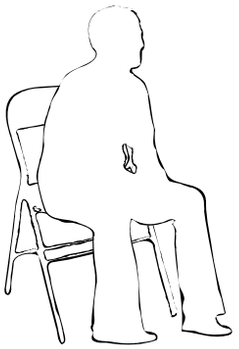


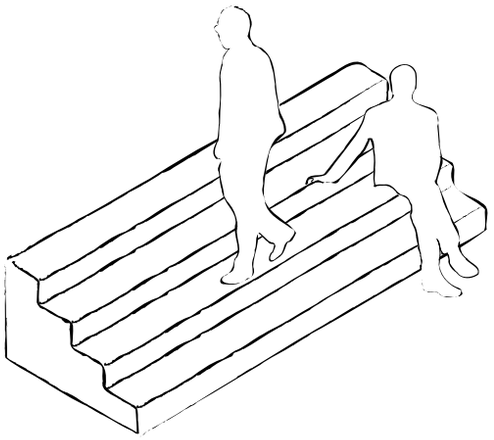
Diagraom of three learning scenarioes by Winnie Ricken

It is important to offer the students a palette of options to choose from, depending on which activity they will perform.
The ability to read the space is essential, to encourage a certain activity. It is important that the space identity is clear, so the child knows what to do and how to act within this setting. The younger children are more in need of spaces that talk clearly to them.
Mature children are able to be creative in spaces, because they have a higher developed imagination. Thus they can anticipate and imagine future actions within a space that does not contain a clear space identity. (Eva, 2014)
An objects utility can be more or less clear, and provide various potential for usage.
This is what Inge Mette Kirkeby refers to as soft and hard functionalism.
Hard functionalism is where architecture facilitate activities where the usage of space is pre-defined and easy to read or decode. Special subject rooms often imply a certain activity by the interiority or just the naming of the space itself.

Soft functionalism makes room for the creativity to emerge, hence the architecture amplifies different types of usage. A stair can be used in several ways and suits different occasions. It can encourage to sit, to walk on as a transit from one place to another; it can be a part of a children's game. (Kirkeby I. M. 2006)

A good learning environment is a complex matter, and seen as an interplay between child and the physical setting. There is a great importance in creating smaller spaces or corners where the student can reflect and larger spaces where the tempo and activity level can be raised. (Kirkeby I. M., 2005)
In longer schooldays, it will be important for the individual to create a personal space, where they can control permanent inputs and outputs, retract from the public space, where sounds, movements and smells are dominating.
(Larsen K., 2005)





Hard & Soft functionalism

THE CLASSROOM

.A survey of the two general rooms to accommondate courses

The basic classroom

Classrooms have been the principal building stone of schools. The classroom is designed on the basics of didactics where learning have been passed from teacher to student through the blackboard. It can be perceived as a series of autonomous spaces where the spatial conditions mainly serves to aid the concentration of the students, while being an explicit domain for the teacher to overview the class. The classroom as a sole is an obsolete idea and the teaching and learning territory is coming to occupy the entire school. (Hertzberger, H. 2008)

The articulated classroom

"The geometry of thought echoes the geometry of the room". Juhani Pallasmaa 2005

More articulated classrooms would create a potential space to differentiated learning, whereas the basic classroom lends itself to instruction. It enables different activities to simultaneously occur in a room without being distracted by each other, thus a greater palette of activities is an option here, there being several centers of attention rather than just one.

The articulation can also be found in the interior ornamentation and furnishing of a room. A presence of tools, instruments, posters and other subject related objects will inspire and motivate the students to learn within this space.The special subject room primary purpose is to accommodate one course only, contrary to the basic classroom. The typical subject teached in this type of room is chemistry, biology, physics, music ect. (Stolz, Kasper Kjeldgaard, 2012)

The classroom as a home base

Younger children have a greater need for a familiar environment as a refuge. The home base should be a place from which you leave, and keep returning to, there can be no adventure without a homebase to return to. The classroom as a basic facility is obsolete, but it does provide safety and security to children which they need when being away from home.

1957

"Few as possible shifts between classrooms (...) will create the best conditions for the execution of their work"

Earlier the children was perceived as noisy and troubled, hence there was a wish for clam well-fare, this was effectuated by the numerous courses in one room –the "Homeroom" This also prevented the children in causing noise in the common areas. The main purpose was to ensure a safe environment and a sense of belonging.

2003

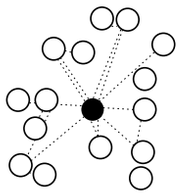
"The classroom is the most important room, since here the children experiences safety and familiarity"

It could be noticed that this room above all is not designed by the purpose of creating the ideal space for accommodating the academic aspect, but to create social bonds and a safety environment.

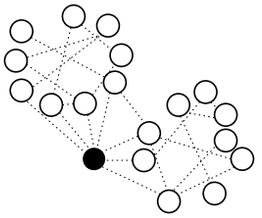
First and foremost it is the content of the course, the subject knowledge the student must learn, that determines how the physical framework should be designed and furnished"

2009

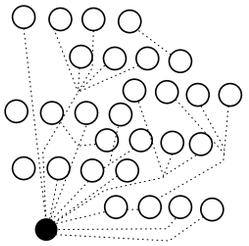
"the intention is to design subject specific rooms that inspires, motivates and facilitates the course being taught within this room, and to a lesser extend accommodates the social aspect."



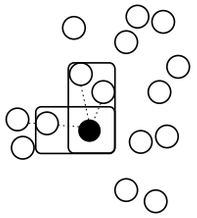
Small group



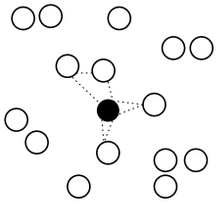
Large group



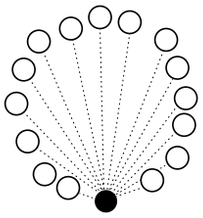
Teacher up-front teaching



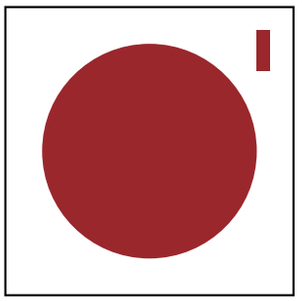
Individual work support



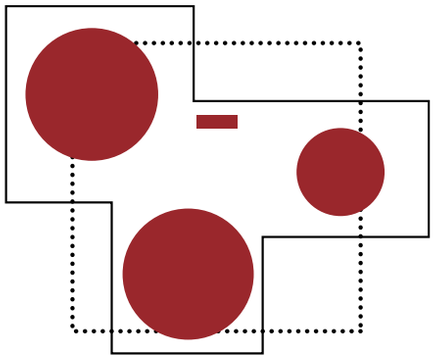
Individual work



Teacher up-front teaching



Basic classroom



Articulated classroom

THE NEED FOR EXERCISE

.How does movement affect our ability to learn

"We notice that the children are more motivated. They are more awake, and the concentration is better. In general. For the sports-weak children who are motor weak or overweighted and do not exercise regularly, have we in addition created a special team" (Karen Rasmussen, principal at Vibe School)

In the new school reform movement and exercise has become a more integrated part of all children's everyday life. More and more studies show that exercise and movement increases motivation, learning and health. The new initiative in the reform says that in all grades movement and exercise must to some extent be included, in approximately 45 minutes, during the longer and more varied school day. (uvm.dk)

In addition to the studies that show that movement and exercises increases the motivation and learning, it also shows that it strengthens the social competence and the brains development for the children's. The results from Vibe schools where they consequent work with movement in academic lessons, shows that students' self-respect raises and they becomes more outgoing. (Ritzau, 2013)

Movement and exercises can be included in the new public school in various ways. It can be in the subject divided learning where movement can be integrated with an eye to support the student's academic learning and training. (Uvm, 2014)

Nine different schools have for some years made a series of actions to integrated exercises and movement in all the students school day. Common to the schools is that they have experienced massive changes in the children's motivation to learn and go to school after they have taken the new initiatives. Several of the schools experience, like Vibe School, that the different focus areas also effectively contributes to the development of social fellowship and students' well-being. The schools works

with two different ways to get exercises and movement a part of the students day. Either by integrating physical activity in the classroom or by spreading movement at the school during the hours beyond the subject-specific teaching. (uvm.dk)

Exercises and movement can take place on the sports field, gym hall, local areas urban spaces and in the classroom. (uvm.dk)

According to Kasper Kjeldgaard Stoltz, Cand. Ped. in didactics and part-time teacher at N. Zahles seminary school, is it the rooms physical frames that dictate the way the teacher will teach. The traditional classroom appeals to sedentary work where the teacher speaks a lot. To get more movement and exercise into the school day, is it important that the physical environment supports that way of learning. (Schmeichel, K., 2013)

To strengthen the status for the subject Gym and increase the academic benefit of teaching, gym lesson have as a new initiative, become a subject for exam in year 9. (uvm.dk)

INDOOR CLIMATE & LEARNING

.A survey of indoor climate as a parameter for learning

It is well documented that children are particularly sensitive to indoor climates countless influences and that it may have effect on the students' well-being and learning if the indoor climate in the classroom is not acceptable. (Tofttum J., Wargocki P. and Clausen G., 2011)

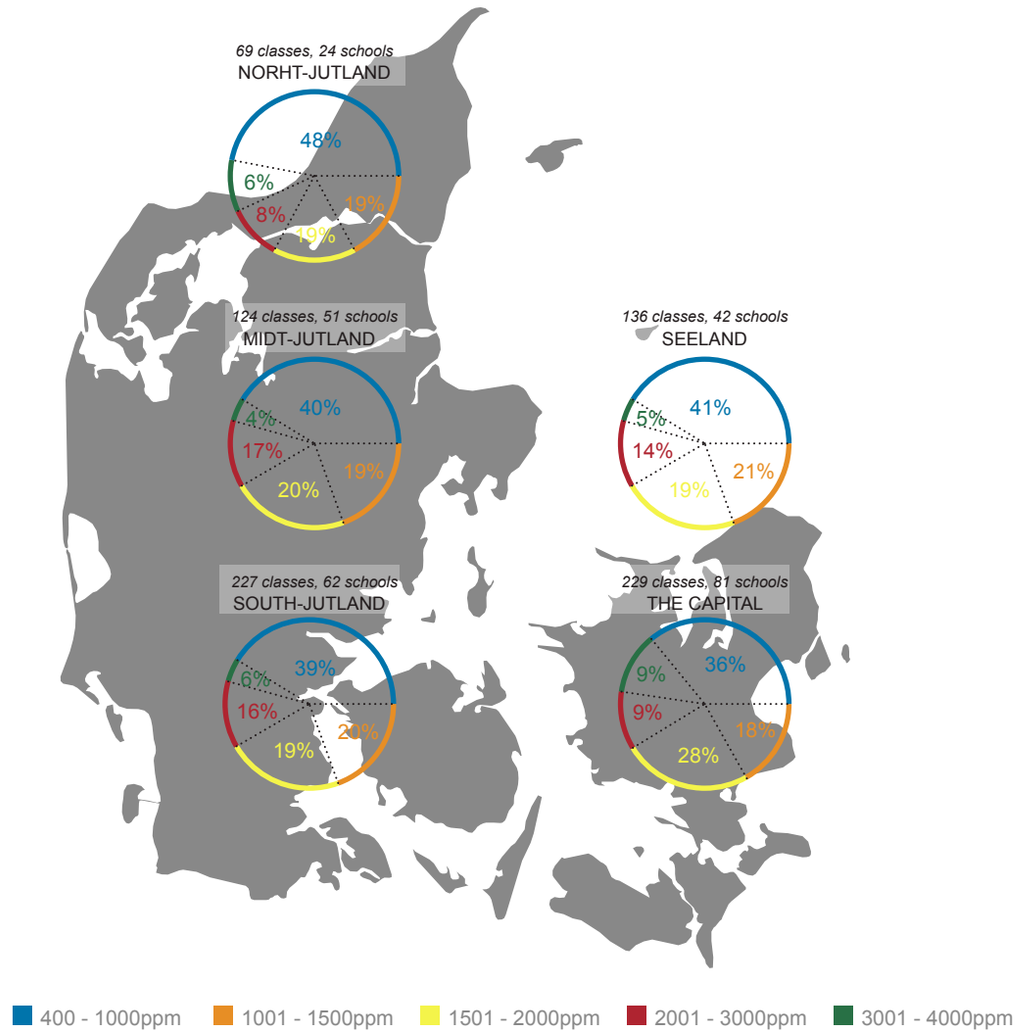
According to the Educational Environment Act (undervisningsmiljøloven), all students have the right to a good learning environment. This applies to mental, physical and aesthetic educational environment that individually and together has to ensure the students health, safety, well-being and learning. (Tofttum J., Wargocki P. and Clausen G., 2011)

The Danish building regulations say that all classrooms must have well lit rooms by daylight. However windows must be placed and dimensioned so overheating not will occur. Solar shading must be installed if necessary. (bygningsreglementet)

Indoor climate today

Newest research in the Danish public schools shows, that in 56 % of the schools, ventilation was not adequate and compared to Norway and Sweden the numbers were only 21 % and 16 %. When comparing schools with different ventilation types in all three countries, the tendencies were the same. Schools with mechanical ventilation were significant better than the schools with only natural ventilation. The majority of schools in Sweden and Norway have installed mechanical ventilation. (Tofttum J., Wargocki P. and Clausen G., 2011)

MasseEksperiment 2014 is developed by DTU and Danish science factory. The experiment is a result of the measured indoor climate in 785 classrooms from 262 schools and high schools in Denmark.
The same experiment was performed in 2009 and a comparison shows a similar distribution, which means that no improvement is seen within a four-year span.



Co2 concentration - MasseEksperiment 2014

The CO2 level is often higher in the middle-school since there is a higher activity, as children plays and moves more frequently. (Clausen G., Toftum J. and Andersen B., 2014)

"In Denmark schools must ventilate with a ventilation system that include injection, exhaust device and heat recovery. Injection and extraction in classrooms must be 5 l/s pr. person as a minimum, plus 0,35 l/s pr. build square meter. Furthermore must the CO2 concentration not exceed more than 900 ppm (parts per million) in longer periods of day." (Bygningsreglementet 2014, section 6.5.2, stk 1)

Many studies show that indoor climate has huge impact on childrens concentration and learning. Research from FOA shows that if the temperature in classrooms decreases from 25 to 21 degrees, the concentration of students will be improved, and students will perform 20 % better when solving assignments, if the temperature is constant around 20-21 degrees. (Tofttum J., Wargocki P. and Clausen G., 2011)

In the new school reform the goal is to make the students more academic skilled. To fulfil this it's important to make necessary investments according to the indoor climate. It will not only have the effects on the concentration and learning, but also have influences on the absences of students in school.

Indoor climate contains many different things. In this project we will focus on three aspects:

Light, air quality and thermal conditions

SCHOOL TENDENSIES

.A survey of the tendensies seen in modern school architecture

Through the latest years establish, renovation of already existing schools, has increased significantly. Among other things has the introduction of the new school reform made it a current subject, but also the fact that many of Danish public schools are in such poor condition, that a complete renovation is needed to create the best learning environment for the children in Denmark.

Tendencies in the new buildings are many, and more elements are repeated in new and renovated schools all over Denmark.
The schools are often seen with strong colours and odd angles that emphasises a place as inviting to learning.

Especially energy consumption in the building sets the agenda when new school are being built. This element is fundamental to create a school that meets the latest energy requirements, and in addition, it is also a good step in the right direction when tried to create a good indoor and learning environment.

More and more schools all over Denmark has a shoe-free area, it reduces the noise, and makes the schools cleaner and helps the cleaning staff, but furthermore is it also health sustainable.
The school buildings today are built in order to obtain spatial and functional flexibility. This is done by making fewer but larger classrooms often with large folding doors so you easily can teach across the classes. At the same time is it possible to include a part of the hallway into the room. Rooms in the new schools are large with high ceiling and often with open glass panels. This makes light penetrates both in and out of the rooms, and at the same time you can orientate and follow where the teaching is. Furthermore is it often seen that establishment of areas that allows students to contemplate has a great focus. This can happen in small niches where kids can immerse themselves in tasks or readings, or in areas for larger group work outside the classroom.

1. Christiansfeld skole, use of color 2. Nordstjerneskolen, central library 3. Ørestad skolen, shoefree area 4. Bagsværdskole, transperent classrooms 5. Dyveke Skole, working niches, 6. Hellerup skole, staircase 7. Vibeengskolen, energy 8. Frederiksbjerg Skole, division of glass 9. Søndervangskole, teacher facilities

A quite general thing for the new schools is openness. The corridors are wide so it is possible to get students out of the class, and often there is established a large open core in the middle of the school serving as the very centre. This centre is often seen as a large staircase, where spaces to stay and meet often is seen as the school library and located in this core of the building.

The different classes, preschool, middle school and High school school, are mostly divided in different sections. This is done to create comfort for the youngest students, as this is one of the keywords in the new reform. Furthermore is it also done to give the oldest kids more space without associating with younger students.

More and more schools have established SFO in connection with the school, and these are often placed in close contact with pre- or middle school.

The last part in the new school projects is the focus on the teachers and there working facilities. Over the last two years the amount of hours that the teachers has to work on the school has increased, and therefore is it necessary to create proper workspaces for the adults outside the classrooms.


Sønderbro Skole
20

SØNDERBRO SKOLE
.A story about a school

Sønderbro School is located on Amager, Copenhagen S. The school has around 450 students and 45 employees divided into teachers, pedagogue and other staffs. The goal for Sønderbro School is eventually to become a three-track school. The school is placed in a resource-weak area with many families of different ethnic origin.

This means that the majority of children are bilingual, which causes major challenges for the school. The ethnic Danish parents tend to take advantage of the free school choice and send their children to other schools in Copenhagen. Thus it is important for the school to have a strong profile to promote itself in the local area.

In school year 2008/2009 Sønderbro School became Copenhagen's Music-creative public school. This means that the schools uses diversity, subject knowledge and music-creative learning processes to strengthen the students self-confidence, competences and qualification.

As a profile school, Sønderbro School offers some different subjects that support their special profile, like KREA, craft and design, and other elective courses in connection to the preparation to the yearly musical week. To make this profile attractive and attract future students, it's important that the special subject rooms and conditions supports this profile.

The school today consists of four wings towards Lybækgade, these houses classrooms for year 0 to year 2. It is important for the school to divide the youngest classes from the rest, to create a good safe environment, as this is an important element to encourage students to stay in school during their education.
Besides the four wings, the schools also consist of a three-story high building witch houses the rest of the classrooms and the subject rooms. Behind the school there is a large green area that can be utilized in teaching purpose as well as during breaks or after school.

The school currently contains no KKFO, but uses instead the offers in the neighbourhood. The students will until 2. grade be assisted to the different leisure activities. For the school, it would be preferable if these offers were placed on the school. Not only because it would improve teachers' working conditions as they will only be associated with one place and not two, but also because the observations made in the school can be used in the KKFO.

To get more movement and exercise into the school day and to get the children outdoor, the schools makes use of the different facilities in the local area. Among other things, the nearby swimming pool is used for teaching in 5. grade, but also Prismen, Bredegrund and Kvarterhuset are used by the school. In addition, the school has also established playgroups, where students in middle school play with the youngest students to get more movement into the day. The framework of the schools does not meet the requirements for exercise or movement indoor, other than the movement area or gym.

The school also has facilities for EAT. EAT is the name of school meals in Copenhagen, and was launched in August 2009. The political message behind the concept was to create an ambitious school food concept both in terms of taste, health, sales and engagement in schools. The area associated EAT kitchen at Sønderbro School, is designed in cooperation with the children and the facilities are primarily intended as a dining area to the older students. Primary school and middle school are referred to the classroom, but in the future it would be better to establish dining areas also for the younger students, to get lunchboxes and students away from the classrooms during breaks.

The janitors at Sønderbro have done a lot of positive initiative for the school. Among other things created areas that can be used by other institutions in the area, here in the form of, for example, allotment gardens. It is important for the school to open up and invite people in. In that way the school has a better opportunity to promote itself.
Furthermore janitors will also establish a fire hut in connection with the outdoors facilities at EAT, and create space for chickens. In addition they have also applied for funding to create facilities for older students as they can make use of during breaks or after school.
(based on conversations with school employees)

PROFILE SCHOOLS IN COPENHAGEN

.A way to create the unique school

To create more well-being and better learning for all students in the Copenhagen school and to give the pedagogical competency a boost, an initiative has been taken in the municipality of Copenhagen. This initiative is called profile schools. A number of public schools in Copenhagen have a strong and specific academic profile.

With strong focus on the schools academic field and innovation work, new knowledge and experience about learning and well-being are being gained.

To make the school attractive and unique, each of them has its own clear academic profile.

The school must create development work, establish exciting learning environments linked to research, and work as professional knowledge and communication centre for both schools and others in the municipality.

The individual school must ensure new knowledge on the specific academic area, and further more the schools must establish close contact between the surroundings and the schools in Copenhagen.
(Københavns Kommune)

Profileschools Copenhagen

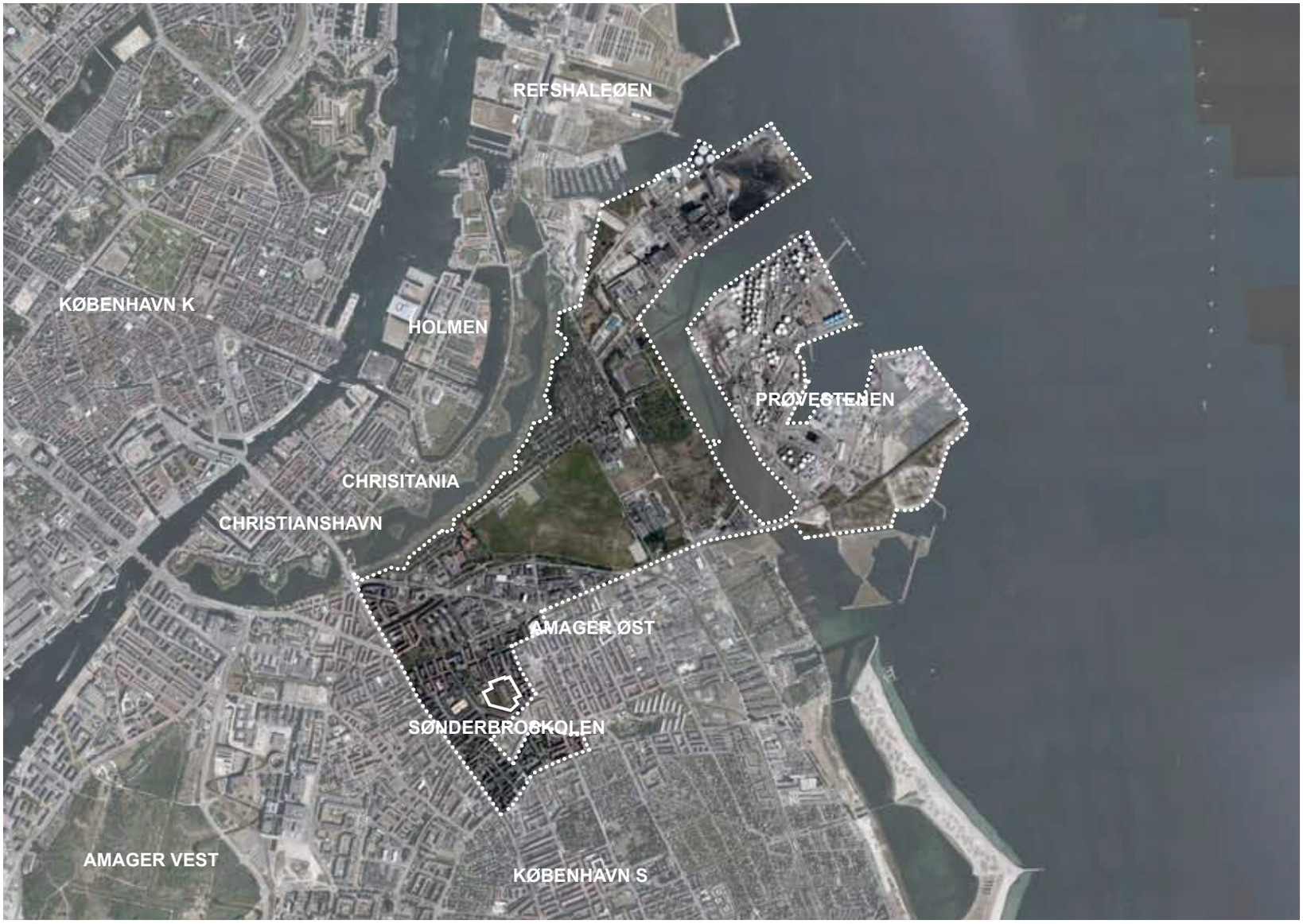
SUBCONCLUSION
.Conclusion upon research

The introduction of the new school reform has put a great focus upon the Danish public school. The new reform embraces, among other things, longer school days and more movement. Several studies show that more exercise and movement increases the student's motivation, learning capability and health. It is therefore important to create an environment that emphasises movement, and at the same time is inspiring for the longer days at school. Together with the introduction of the new school reform in august 2014, the new working-time-regulations for teachers were also published. This means that all preparation-time has to take place at the school. Many of the Danish schools today do not have the right facilities for the teachers to prepare at schools, and therefor is it important to design good workspaces for the teachers. The energy has a huge impact when designing new public schools.

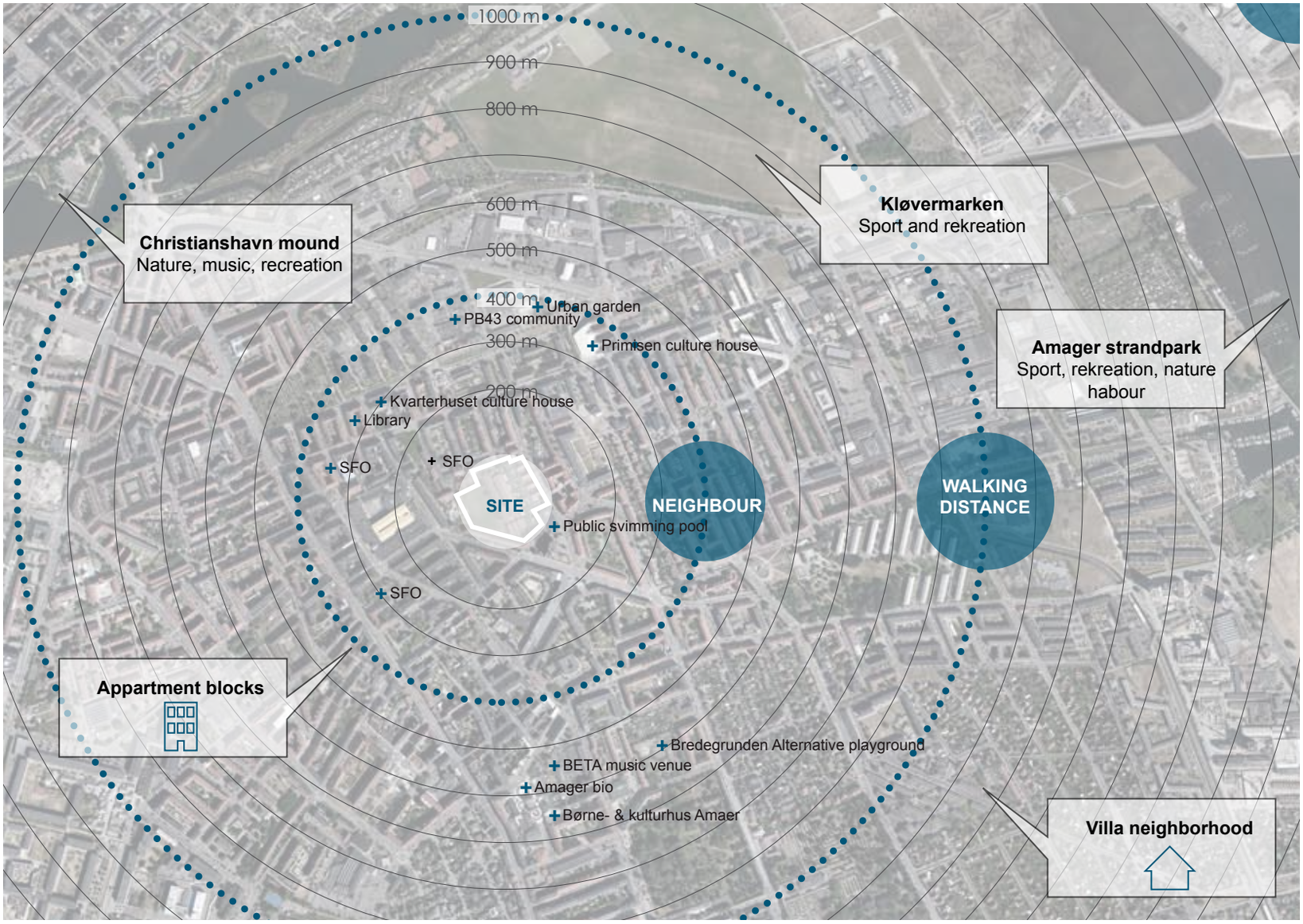
Many investigations conclude that the indoor climate in the public schools is not adequate. A focus upon good learning environments and optimal indoor climate, motivates students and keeps them engaged. Sønderbro School is an old school from the start the seventies, and located in a recourse-weak area. Most of the students are bilingual, and many of the ethnic Danish parents tend to send their children to other schools in the neighbourhood. This is a challenge for the schools, and it is therefore important to create attractive facilities to attract future students.

Analysis

The following chapter presents a site analysis at the project site Sønderbro School, Lybækgade 20. The site analysis is based on serial visions, mappings and climate conditions.

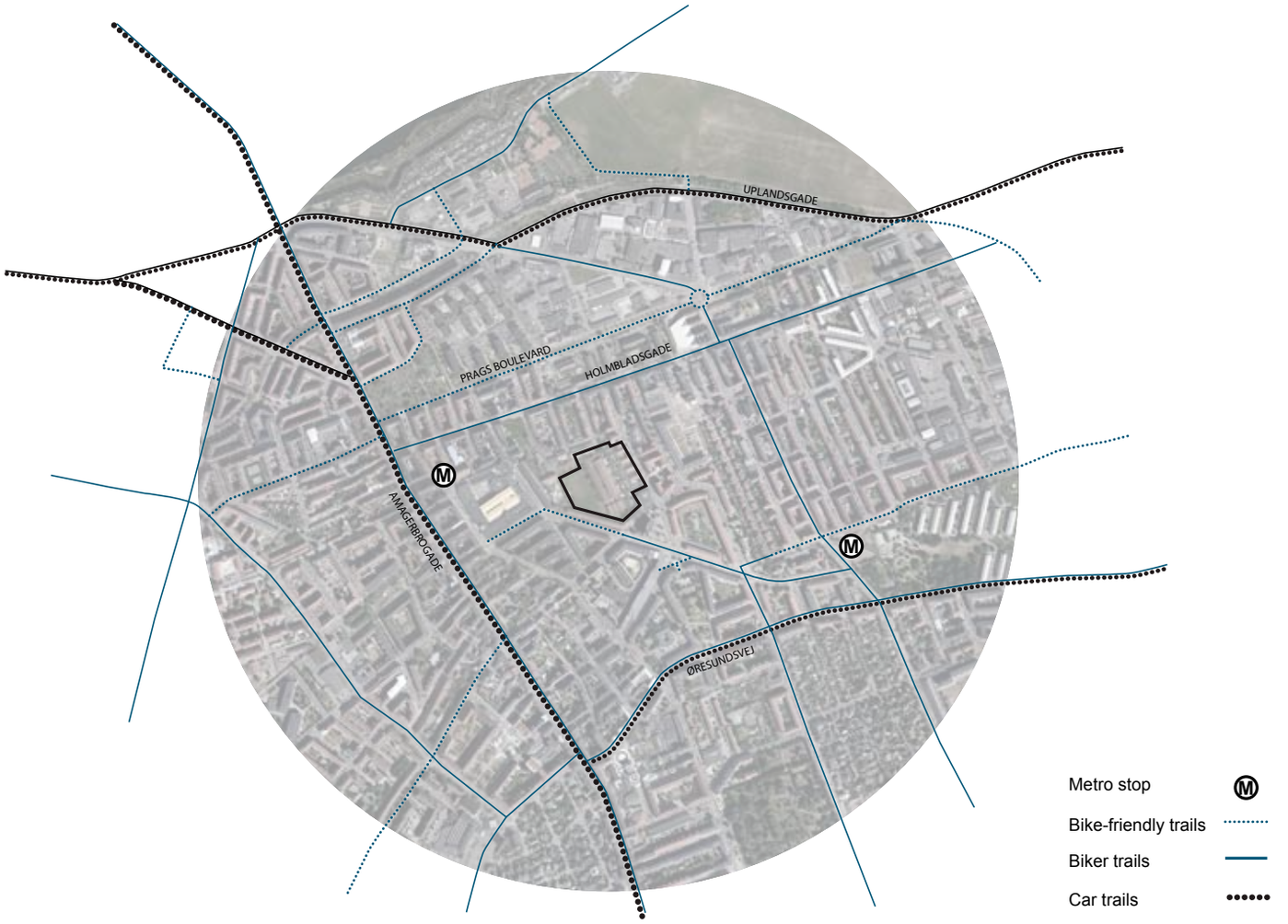


Location & School district



Neighbourhood

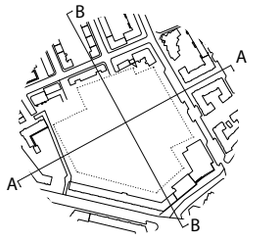
The site is located next to Holmbladsgade, which has gone through a urban regeneration from 1997 – 2003, that provided the area a facelift. [DAC, 2014]
The street is characterized by the many shops and cafees, that ensures a vibrant environment.
Amagerbrogade is the most common shopping street on Amager and is packed with shops and cafees. Since 2013 it has developed its commercial environment as a part of the overall plan “Ny Amagerbrogade”[Københavns commune, 2013]
The neighbourhood is also characterized by its many cultural offers, along the cityscape on Pragsboulevard different activities unfolds.

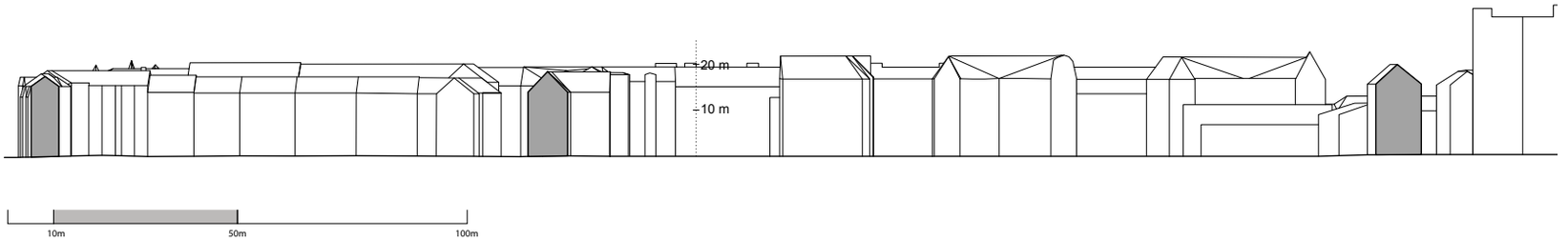


Infrastructure

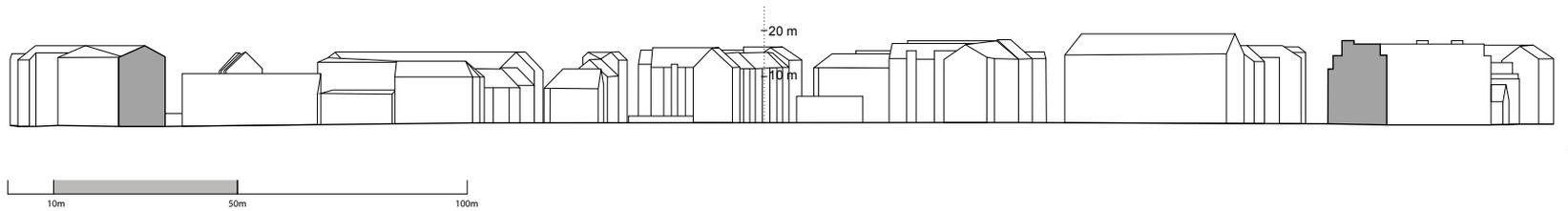
The site is connected do the bicycle network, that makes it easy to access the site from both North, South, East and West. The Local committee has launched a program for children traffic safety on Amager, that aims to secure the right setting for children in an early age to transport themselves. [ByX, 2012]
Within a short distance of 600m you can arrive by public transport from either Amagerbro (metrostop) or Lergravsparken (metrostop) supplemented by several bus stops. The Site is located in the centre of four larger roads, that connects the site to the rest of Amager. Amagerbrogade is the mainroad which serves the car transportation, running north south and connects Amager to the centre of Copenhagen. A new initiative from the municipality of Copenhagen should enrich Amagerbrogade as a shopping street and limit the car passage, to ensure better conditions for pedestrians, bicycles and public transport. [Københavns commune 2013]

SITE ANALYSIS
Sections of site



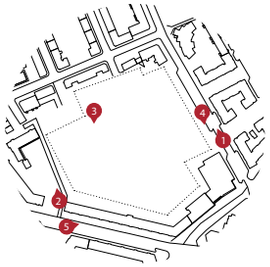


Section A



Section B

SITE ANALYSIS
Walking the site



1. Lybækgade

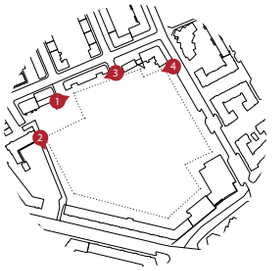
2. Folkets plads

3. Green space

4. Swimming facility

5. Frankrigs houses

SITE ANALYSIS
Small access ways



1. passage next to kindergarten

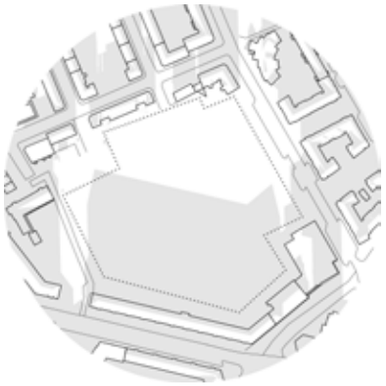
2. Bike passage south west of site

3. passage along the nord west edge of site

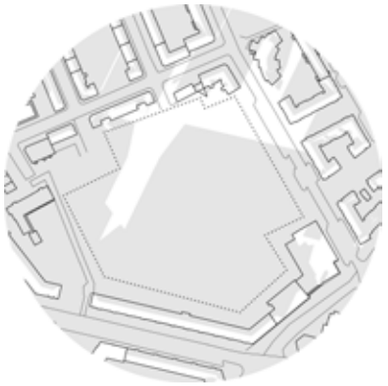
4. passage along kindergarten

To achieve an context based architecture we need to understand the colours and tactility of the place. With inspiration of Gordon Cullen's serial vision, we will us this as a way to understand the characteristics and infrastructure in the area that encloses the site. Excisting access ways that allows one to enter the site is photographed, and characteristic areas and elements when walking around.

SITE ANALYSIS
Sun conditions



Dec. 12.00 a.m



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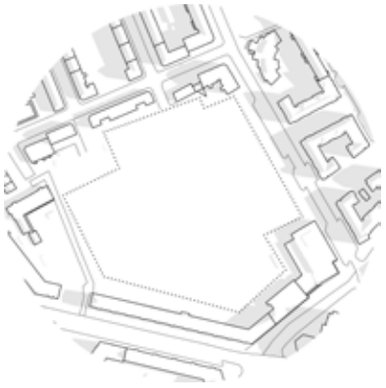
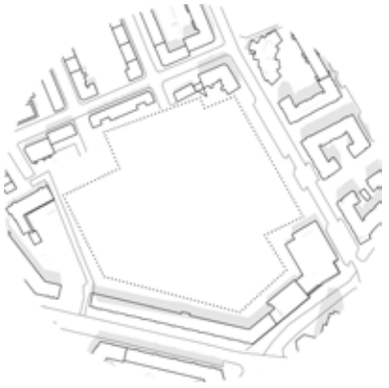
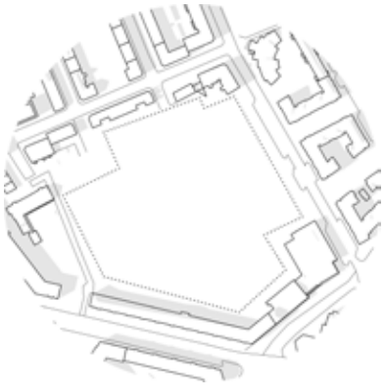


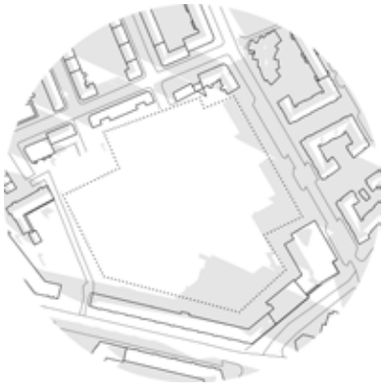
June 8 a.m



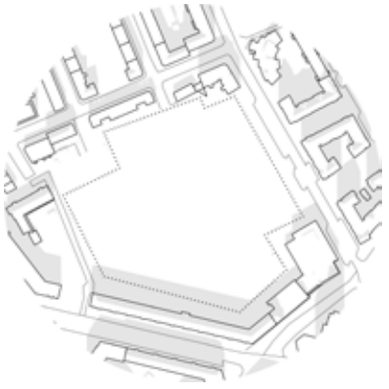
June 12 a.m



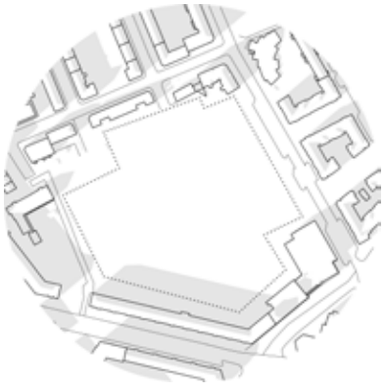
June 3 p.m



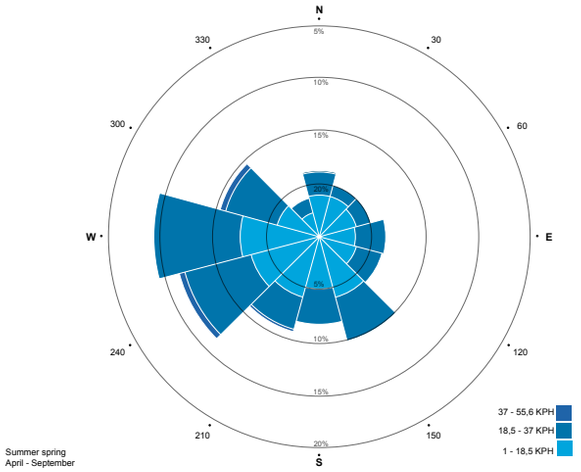
Sep. 8 a.m



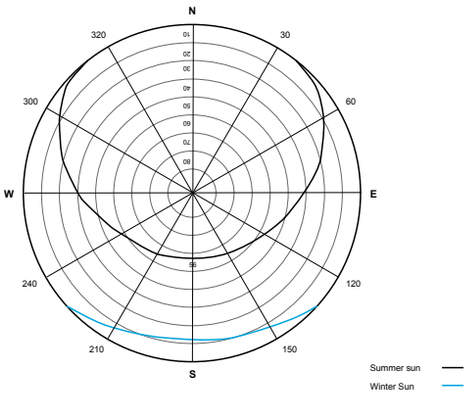
Sep. 12 a.m



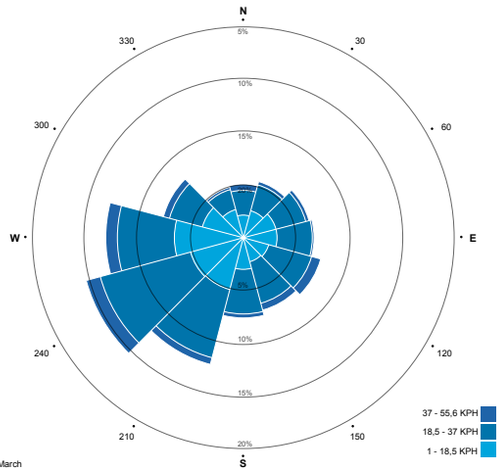
Sep. 15 p.m



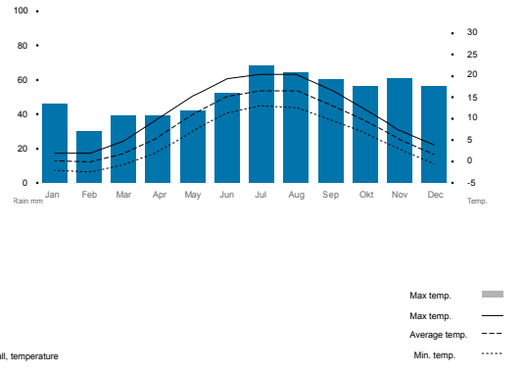
Summer spring
April - September



Sun path
Denmark



Winter fall
October - March



Year rainfall, temperature
Jan - Dec

Climate conditions

Wind: 25% of the wind enters from west, which makes it the predominant wind direction in Denmark. The wind varies in terms of how close to the coast you are situated. [dmi.dk] Within the dense city the high buildings will provide shelter from the wind compared to the open areas. However the buildings can cause turbulence and a more unpredictable wind conditions.

Rainfall: The climate in Denmark is generally temperate which can be described as having mild and windy winters and cool summers, without big oscillations. The temperature varies according to the season and time of day. During autum the rainfall dominates, falls continuously and varies from locations, the greatest rainfall is seen in Jutland. [Hansen. N, 2013]

Sun: In Denmark the sun hours varies according to the height of the sun on the sky. During the summer the height of the sun reaches 58,5° and decreases in winter to 11,5°. [Niels Bohr Institute, 2009]

SUSTANIABILITY
.In a greater perspective

Today sustainability is a common term one meet in the building sector. The evident need for a sustainable mindset when designing is increasing, if human beings keep consuming the way they do today. The term sustainability is defined in the Brundtland report as concerning three categories; social, economic and environmental sustainability, when these three aspects considered a holistic approach torch reaching a coherent and holistic sustainable architecture is more likely. (SBi, 2013, p.9)

Social sustainability can be addresses in several ways, but most commonly it covers the individual's possibility for maturity both in private but also a social context. This demands an understanding of the user requirements, both existing and in the future.
The environmental sustainability is described as a fulfilling the needs for humans, without descreasing the possibilities for future habitants to live on our planet.
The economic sustainability is ensuring economic growth, with a minimum impact on the environment. It should be as cheap as possible in the long term.

SUBCONCLUSION

.Conclusion and reflection upon siteanalysis and site registring

The natural environment affects our need for shelter, therefor the context in which we built, is of great importance. The passive strategies to optimize a building are found in our ambient surroundings and in renewable energy sources.
Wind is an important parameter that needs to be taken into consideration when designing a new building, natural ventilation being an important factor in saving energy, also the layouts and shape of the buildings and the vegetation on the site can diffuse and divert the harsh wind, creating lee in areas for stay.

The direct solar gain is one of the passive ways of using the sun energy to heat the buildings. Having cold weather into consideration, taking advantage of the solar heating is extremely important. The most needed time for heating is in wintertime when the sun has the shortest path and a lower altitude. In the summer when the path is longest and the sun is at a higher altitude the solar gains must be avoided to decrease the cooling cost. This is why sun is a challenging parameter when designing a new building.

The area is neighbouring several cultural venues, which can be used and are already used by the school. This opens an opportunity to utilize the city in a learning purpose, but also in the branding of the school. The great conditions for transporting oneself to school without the use of car, are to be considered as a parameter when planning a safe arrival to the school; where can the parents arrive or where the children's bike has to be placed during a school day.
The demography shows an increased an awareness upon the fact that the school should accommodate children of different cultural backgrounds. Outdoor areas safety should be taken into account, since the area is categorized as an exposed urban area in Copenhagen.

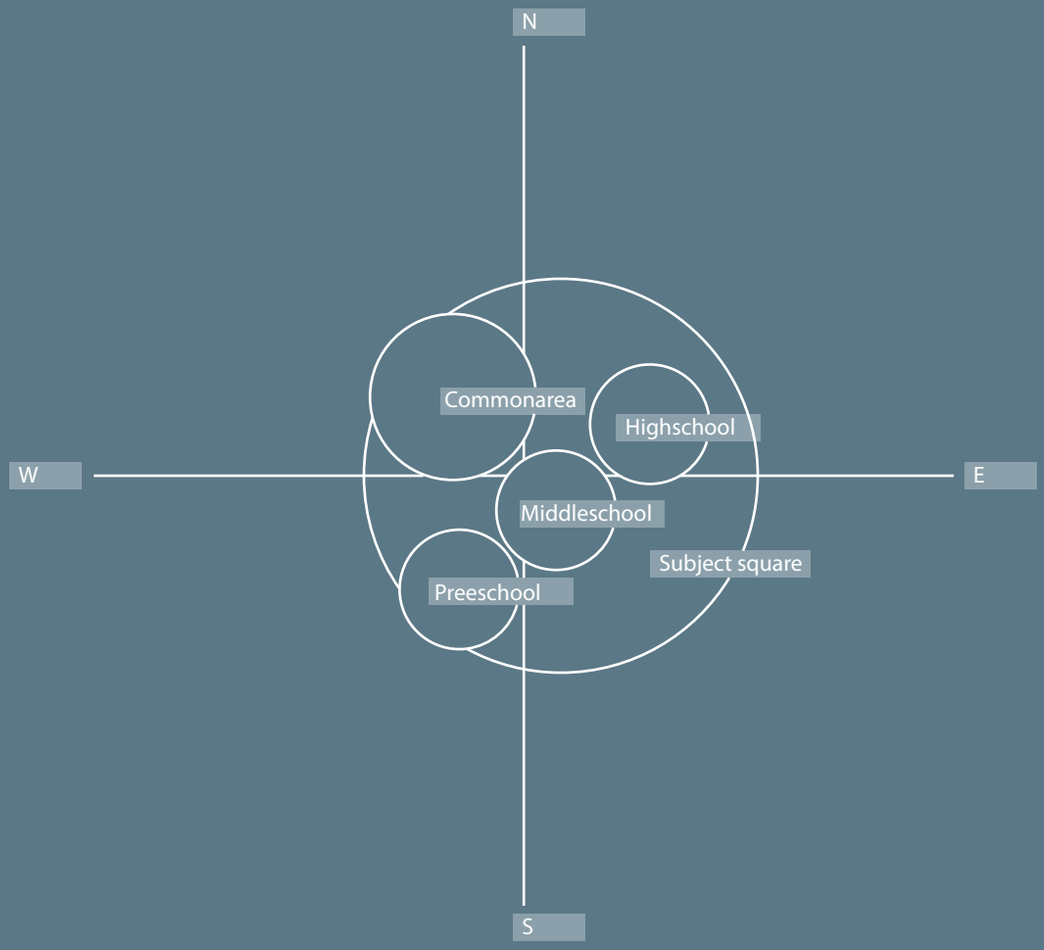
Vision

WE WANT TO DESIGN THE FUTURE PUBLIC SCHOOL OF TODAY, WITH AN ARCHITECTURE THAT EMBRACES INITIATIVES TAKEN IN THE NEW SCHOOL REFORM 2014.

Presentation

The following chapter presents our suggestion on a new Danish public school in Sønderbro, Copenhagen. Through visualisations, diagrams, plans and sections the project is explained in terms of functionality, aesthetics and technics.

FRAMEWORK
Spatial programme



The spatial programme encompasses an overview and an elaboration of functions in the school. The programme is divided into different functionalities of the spaces that clarifies the properties of the function such as size, numbers, occupants and level of activity that has been accounted for in the design process.

Function	no.	spm.	total	occupants	activities
Subjects rooms					
Music incl. depot	2	87	174		☐
Visual art incl. depot	1	100	100		☐
Handcraft and design incl. depot	1	132	132		☐
Food science incl. depot	1	149	149		☐
Natural science incl. depot	1	129	129		☐
Physic/bio. incl. depot	1	102	102		☐
Subject square	1	1187	1187		■
Total			1973		

Function	no.	spm.	total	occupants	activities
Home groups					
Classroom	28	59	1652	29	⬚
Common area	9	232,5	2092,5	87	☐
Wardrobe	28	4	112		⬚
Toilet	36	4	144		⬚
Depot	9	11	99		⬚
Total			4099,5		

■ High
☐ Medium
⬚ Low

Function	no.	spm.	total	occupants	activities
Teachers and adm.					
Office	2	23,5	47		⛶
Preparation area	4	46	184		⛶
Meeting room	2	22,5	45		⛶
Cantine incl. kitchenette	1	212	212		☐
Toilet	10	4.5	45		⛶
Depot	1	8	8		⛶
Open office	1	195	195		⛶
Admin. area	1	236	236		⛶
Total			972		

Function	no.	spm.	total	occupants	activities
After school care					
KKFO	1	233	233	336	■
Club	1	353	353	252	■
Youth club	1	203	203	252	■
Total			789	840	

■ High
☐ Medium
⛶ Low

Function	no.	spm.	total	occupants	activities
Sports facilities					
Multi hall incl. depot	1	523	523		■
Dance hall	1	152	152		■
Changing room	2	36	72		⛶
Total			747		

Function	no.	spm.	total	occupants	activities
Other					
Technique	1	67	67		⛶
Service facilities	2	5	10		⛶
EAT incl. depot	1	41	41		□
Healt care	1	73	73		⛶
Library	1	352	352		⛶
Toilet	12	3	36		⛶
Total			579		

Total	9159,5

■ High
□ Medium
⛶ Low

NEW SØNDERBRO SCHOOL

.A place for learning and activities

The new Sønderbro school is a replacement for the existing Sønderbro school. The new school consists of three trails that accommodate the 840 students, KKFO, youth club and library along with the staff and citizens that will be using the school every day.

The aim is to create a deliberate accentuation of the difference within learning spaces volume and size, hence activities and learning is ideal. In the school all rooms accommodate learning and encourage learning.

The new building interacts with the surrounding neighbourhood with a contemporary architectural expression, which matches the various scales present. The building manifests itself by its playful facade, providing depth and a play of colours. There appears a clear relation between function and architectural expression that emphasises that we are dealing with a house used for learning by children and teenagers. The colours of the façade emphasises the individual home group as “the small school within the large school”.

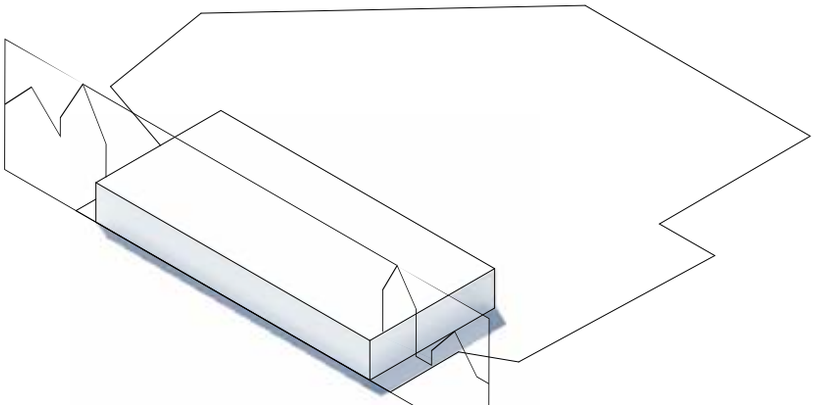
The school garden is a recreative area that invites for activities and learning through the whole day. There is consciously worked with creating differentiated outdoor environments, the spatial subdivision creates many different activities, both quite areas, the wild, motoric play and teamwork, that all are directed towards different age group and their needs.

Besides the creative and musical profile, the school encourage movement, and stimulates that one moves between different levels and along the building. The subject square is a dynamic space that gathers the whole school and the city, where food culture, creativity and activity unfolds and generates synergies.

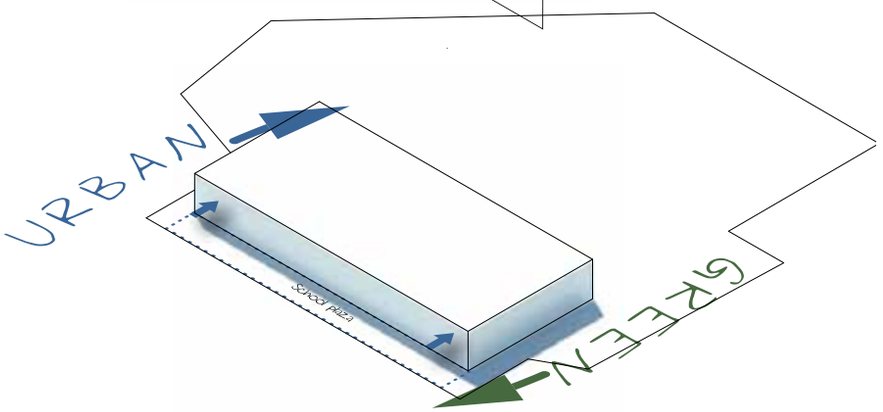
There is worked with a large degree of openness and transparency, which enables the functions and vibrancy to be exposed to the people who passes by on the street. This creates curiosity, and gives one the urge to explore what this house offers – and drop in.

PRESENTATION
Arrival at Lybækgade

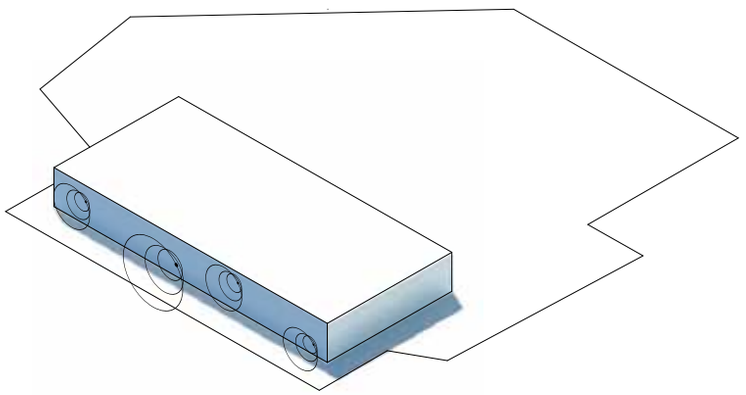
PRESENTATION
Placement on site



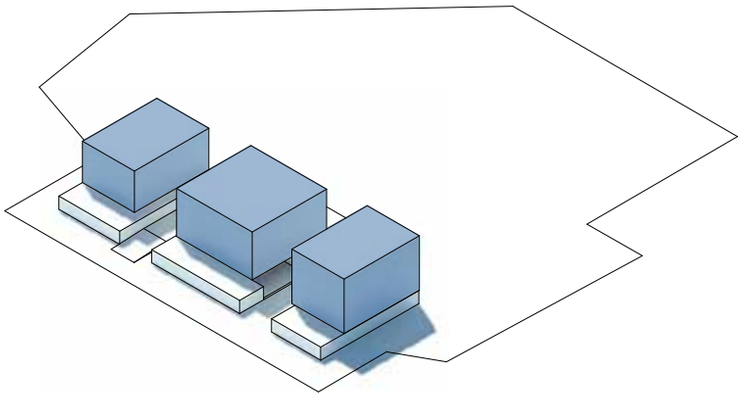
The site is located in the dense city within Amager east, The School is placed along the street of lybækgade to respect the urban fabric, but also to leave a large area for school yard behind the school building.



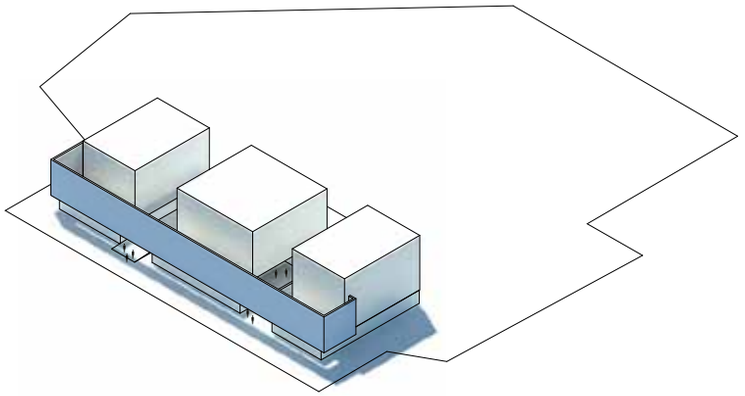
The urban characteristics from the city is dragged into the school yard and greens is dragged along the facade and towards the street.



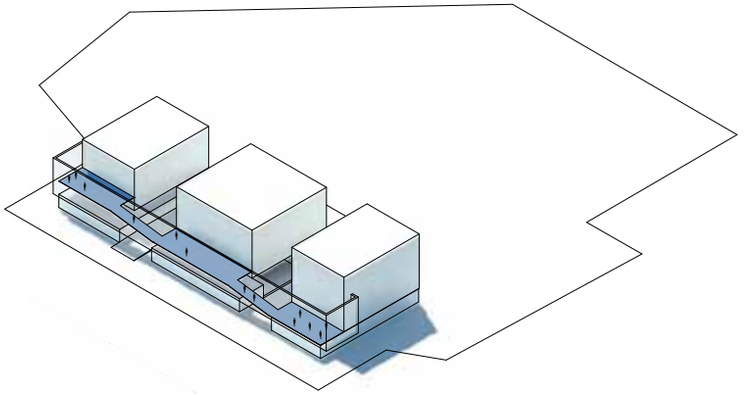
The long facade surface is facing Lybækgade to signal the profile of the school and invite the city inside.



The school is organized in three clusters, each featuring a common area with integrated KKFO, Youth club, Club and library. Each cluster uses niches to create an intimate framework for immersion, and larger areas for movement, play and activities.



The facade takes it point of departure in the idea of a stage cloth that wraps around and covers the school clusters. It will from the street have a clear distinction between citylevel and school level.

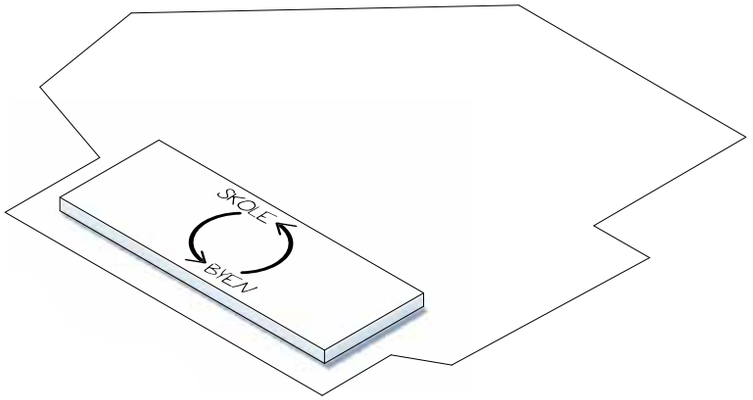


The gap is space that expands between the façade and the clusters. This space is transformed into a social gap that provides a common area within each cluster. A pathway is created along the façade and moving from preschool and upwards to high school.

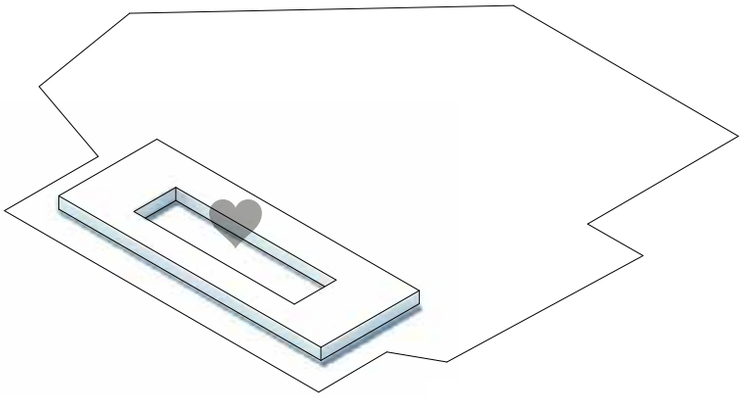
PRESENTATION
Subject square plan

1m 5m 10m

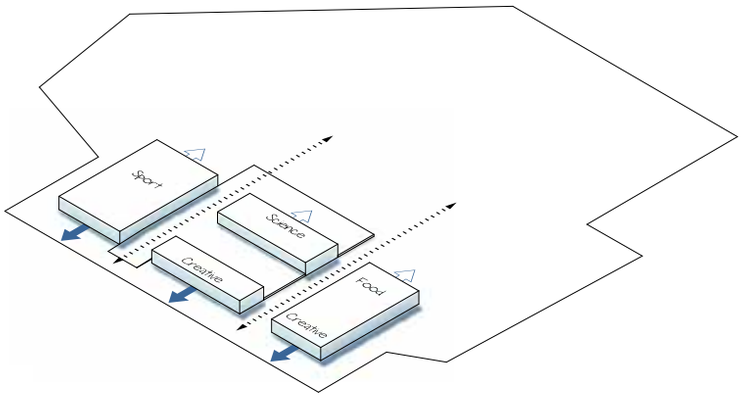
N



On city level, ground floor becomes the spatial glue between the city and the school. This space comprises afterschool for the citizens and the main common space for the students.



The subject square is the main common space and is enclosed by subject rooms, canteen and a multi hall. An interaction between these elements will produce synergies that will contribute to an atmosphere of learning, play and activity.



The profile subject rooms addresses the street to display its unique profile as creative and musical school. The scientific subject rooms addresses the school garden, and makes it easy and accessible to use the school garden as a learning environment for outdoor teaching.


Library
Music

SUBJECT SQUARE

.The connection between city and school

The new Sønderbro school should embrace the students as well as the local community, the subject square on ground level should comprise after schools for the citizens and function as the main common space for students. This multifunctional space will secure an active building during the day and evening. The home groups are raised on top of the subject square to maintain privacy for the students.

The spatial distribution ensures well lit rooms along the edge of the footprint and encloses a common space in the centre of the building for workshops and gatherings and generates a dynamic central plaza. The furnishing of the space creates opportunity for group work in niches, individual immersion among the tables and large presentations on the stairs.
The profile subject rooms addresses Lybækgade to display its unique profile as creative and musical school, the large glass facade ensures good daylight conditions and transparency to the life inside the building.

The scientific subject rooms addresses the school garden, and makes it easy and accessible to use the school garden as a learning environment for outdoor teaching. Example is the food science in close connection to the allotment gardens, outdoor kitchen and fireplace.

Sports facilities addresses the subject square, Lybækgade and the school garden. The large glass facade will mirror the high activity in the street scene.
The mirror room you can open up towards the school garden and be used as an outdoor scene where the audience are sitting on the amphitheatre.

The dinning area is located in connection to food science and placed on repos that decline towards the school garden and outdoor terraces, which can be used in the warmer month.
Within the dining area, a small lounge is provided mainly for high school students, to enjoy themselves undisturbed by the younger students.

The facilities for healthcare contains; a dentist and health visitors, and are also located on the ground floor close to the entrance.

PRESENTATION
Spatial programme

1m 5m 10m

[2 - 2,5] Floorplan

N

1m 5m 10m

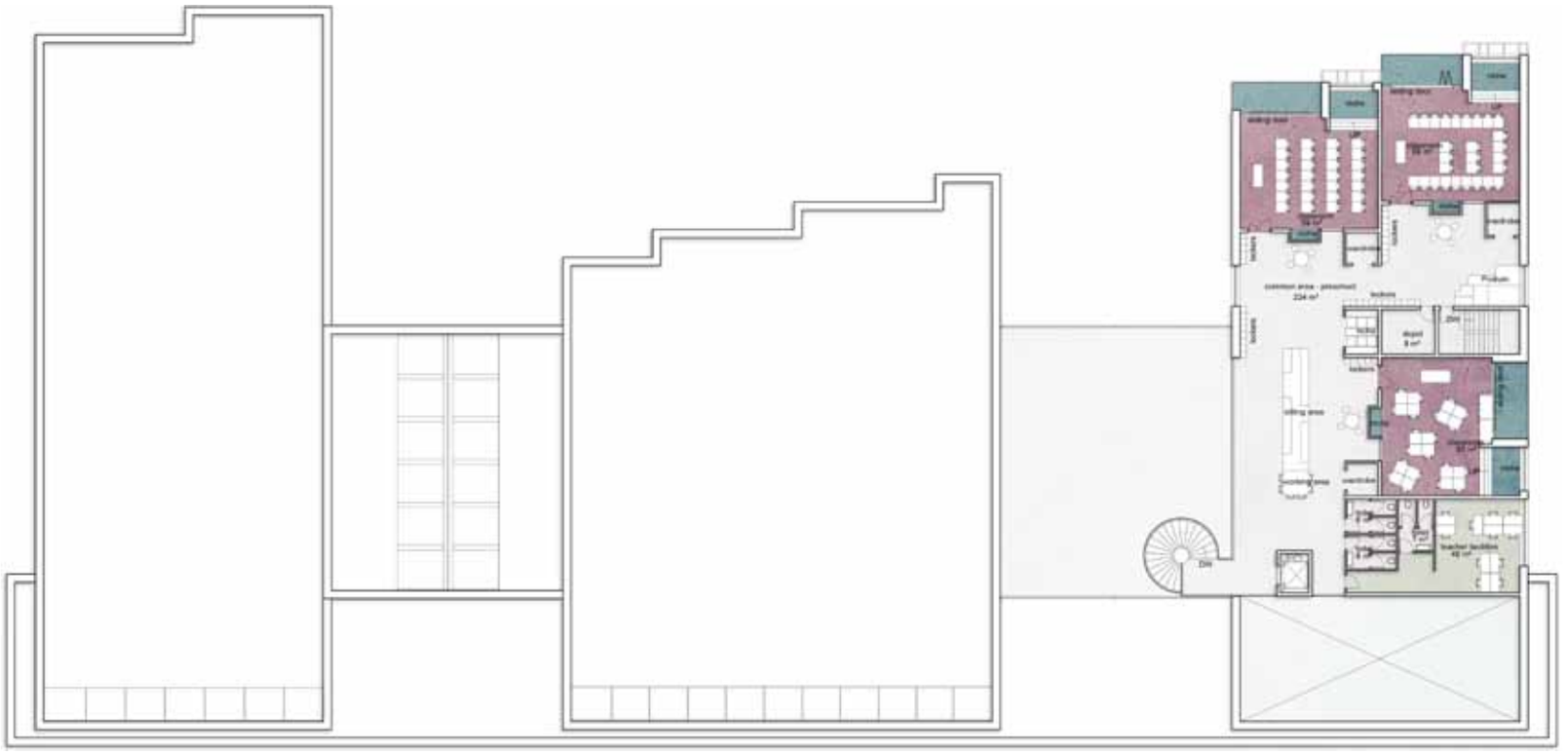
[3-3,5] Floorplan

N

1m 5m 10m

[4 - 4,5] Floorplan

N



1m 5m 10m

[5-5,5] Floorplan

N

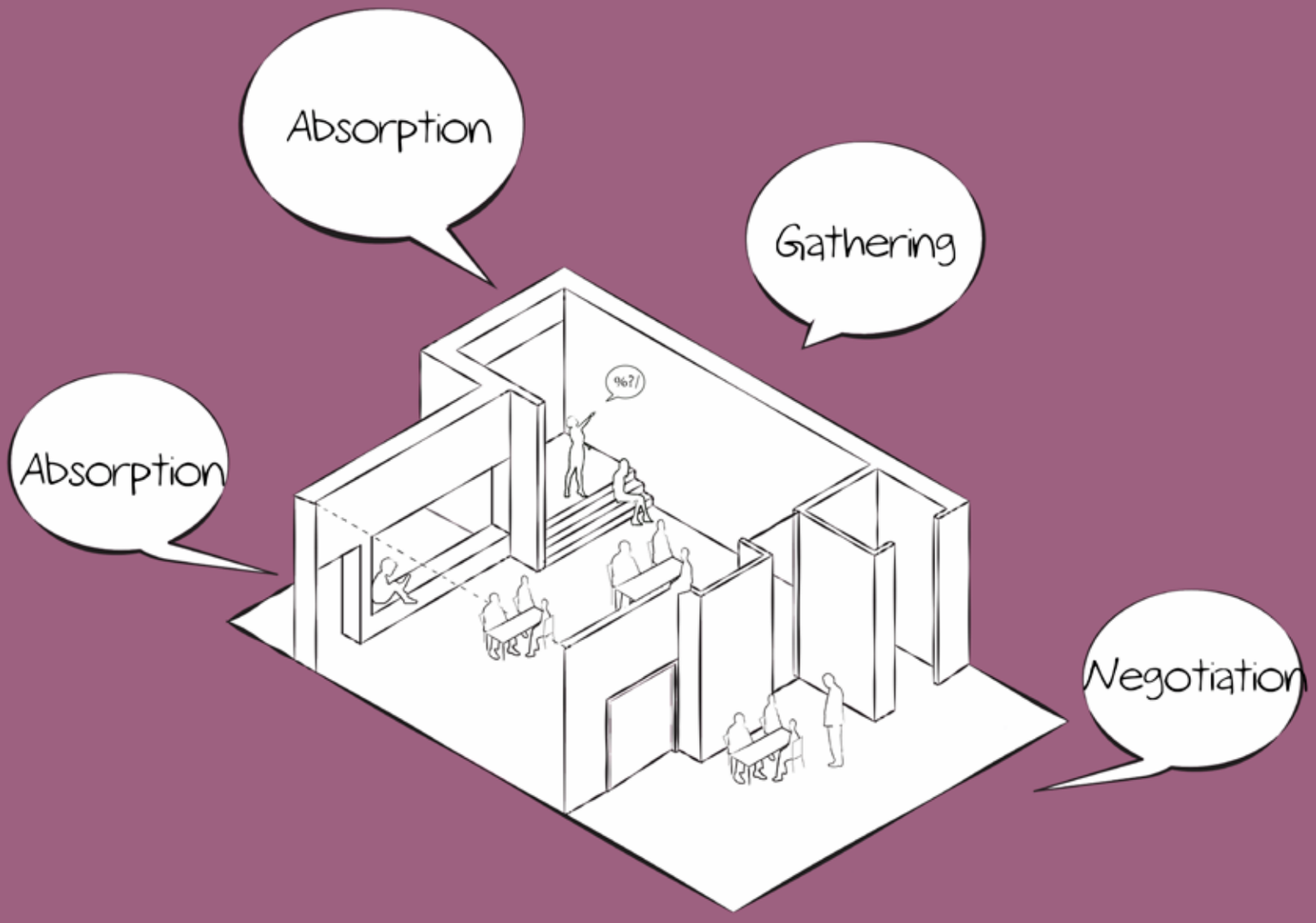
1m 5m 10m

Basement plan

N


MATH

PRESENTATION
Home groups



PRESENTATION
Home groups

1:200

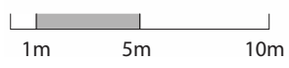
A learning environment demands various spaces, in size, expression and shape, particularly to accommodate the pedagogic accession to the individual students needs and the possibility to include everybody in the common teaching.
The classroom is a common teaching area, that supports differentiated learning.
The classrooms are designed upon the many student's different needs and strength. Stimulation by colours and spatial variation while still maintaining the focused attention is essential. The classrooms are all provided a small niche raised a couple of steps to create space for immersion, or a small stage to perform poems in front of the class. The space in front of the classroom will accommodate group work in close relation to the classroom, as you can watch the class through the windows.
The home group is a year group and consists three trails, it captures teaching elements within the space that connects the three classrooms, and accommodate each classroom with a small common area where facilities for group work outside the classrooms are present.

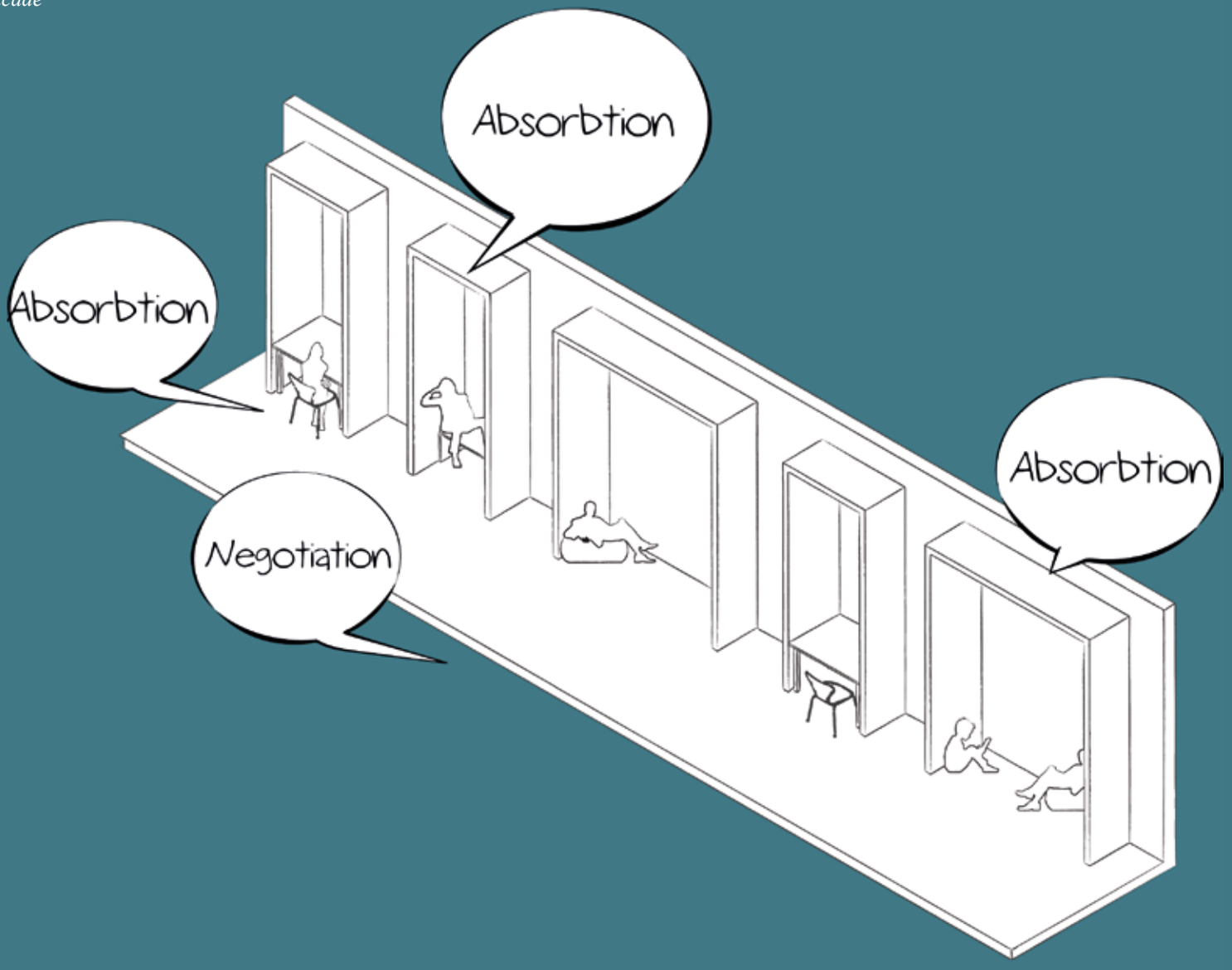
Section - Preeschool

1m 5m 10m

Section - Middel school

Section - High school





The facade seizes the potential in being a furniture, a stage and the transition from school towards the city. It will operate the opening, the translucent and the solid in such way that the city will get a glimpse at the school in different settings. The openings in the facade provides a variety of small niches for gathering in small groups and the possibility for absorption while looking into the cityscape.

The façade stages the activity behind the squared façade and can be perceived as a light cloth that wraps around the school. There is worked with a large degree of openness and transparency, which enables the functions and vibrancy to be exposed to the people who passes by on the street. This creates curiosity, and gives one the urge to explore what this house offers.
The play full coloured façade also expresses' lightness in its materiality n the use of U-glass, and a wood structure, that creates niches on the inside.

Elevation - North east

1:200

Elevation - South east

1:200

Elevation - North west

1:200

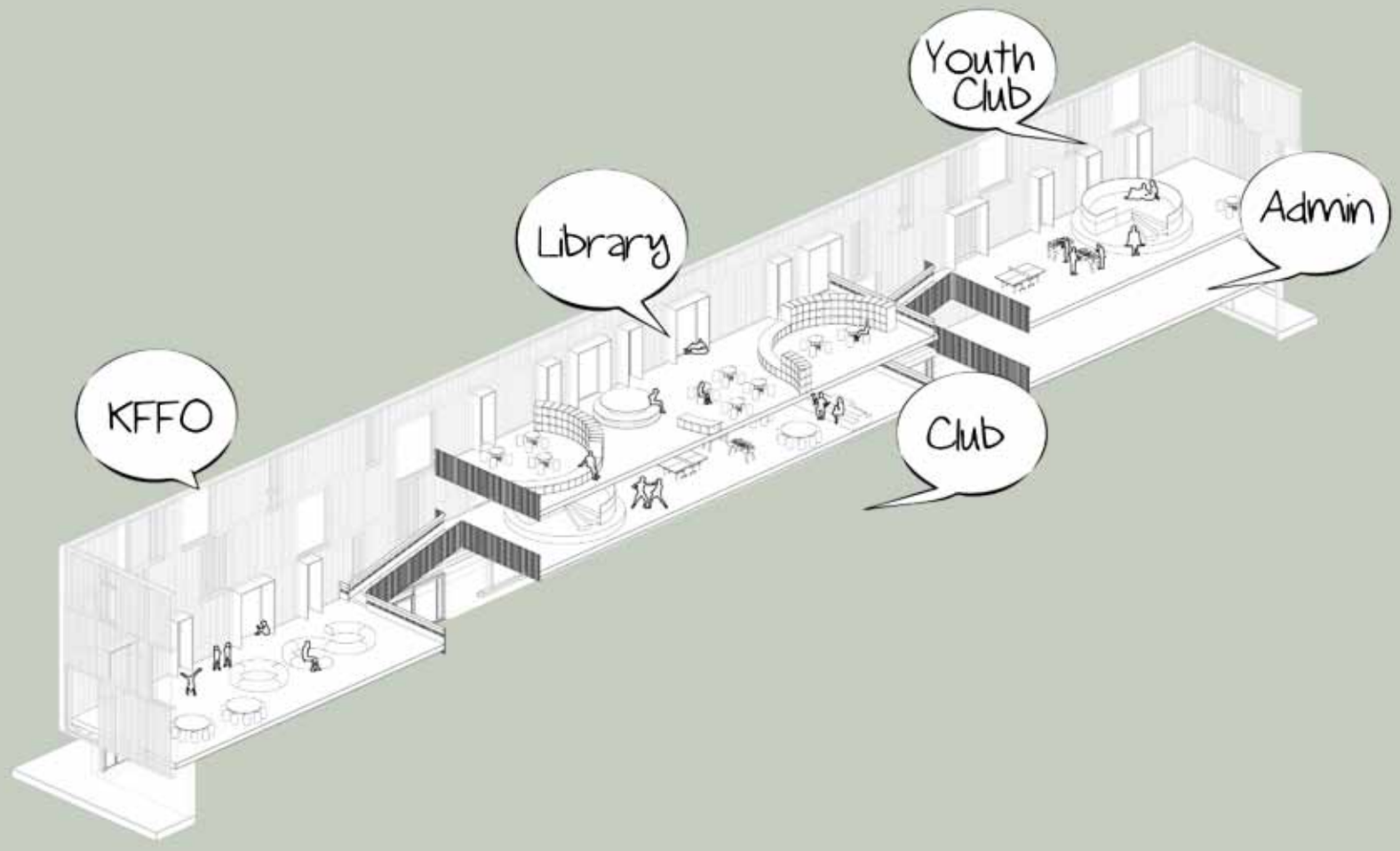
Elevation - South west

1:200

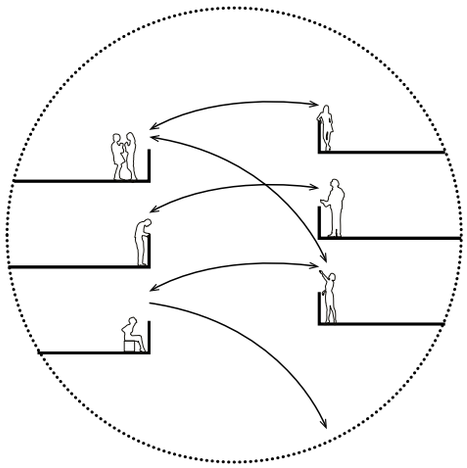
90.

The gap that expands between the facade and home groups, generates spaces for various activities. This space is transformed into a social gap that provides a common area within each homegroup and creates a horizontal pathway along the façade and moving from preschool and upwards to high school and thereby underlines a hierarchy.

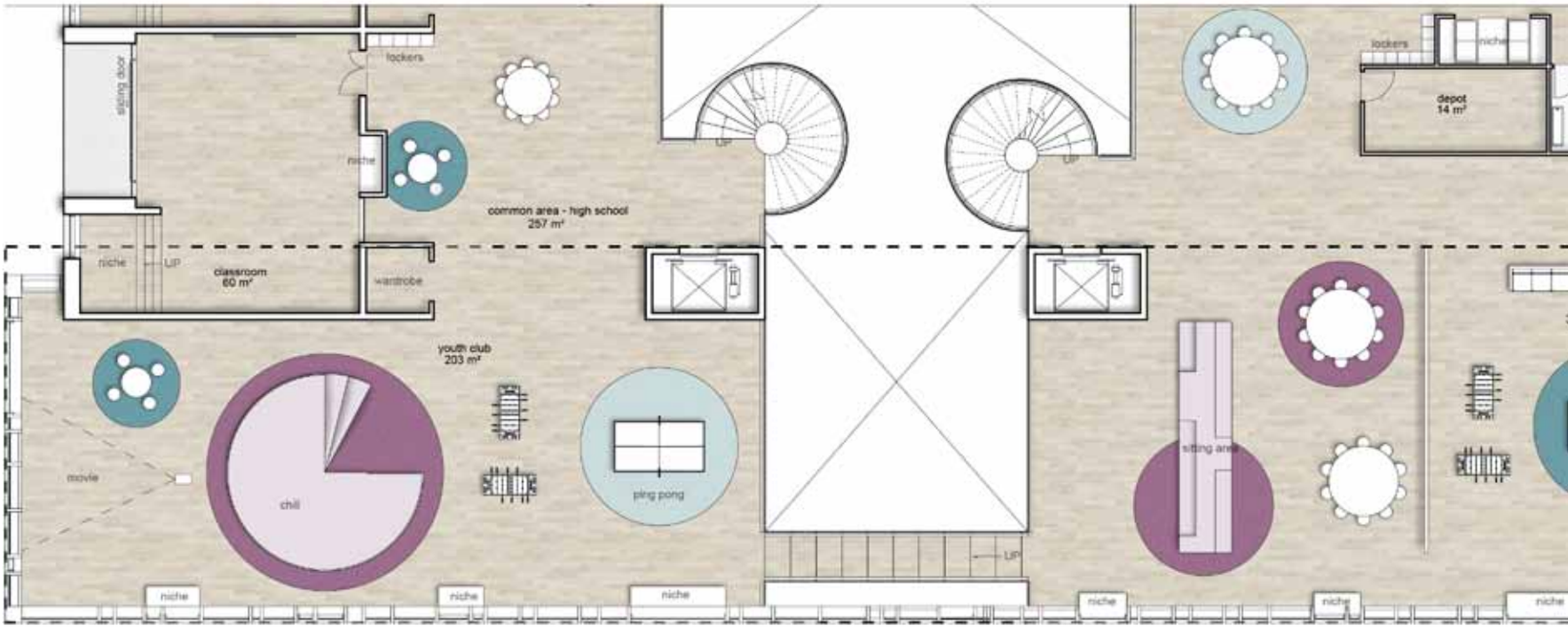
The activity level is higher than in the home groups, and the big draws on the different levels encourages the students to move around in the school building. The school library is placed on the highest level next to the middle school. Here is created niches for absorption and spaces for help to homework after school. The furnishing in the gap invites the teachers to drag out the teaching from the classroom, and to use the different spatial opportunities for workspaces. The facade towards Lybækgade has a large potential, where niches and spaces for different forms of absorption are created.


Youth Club
Admin
Library
KFFO
Club

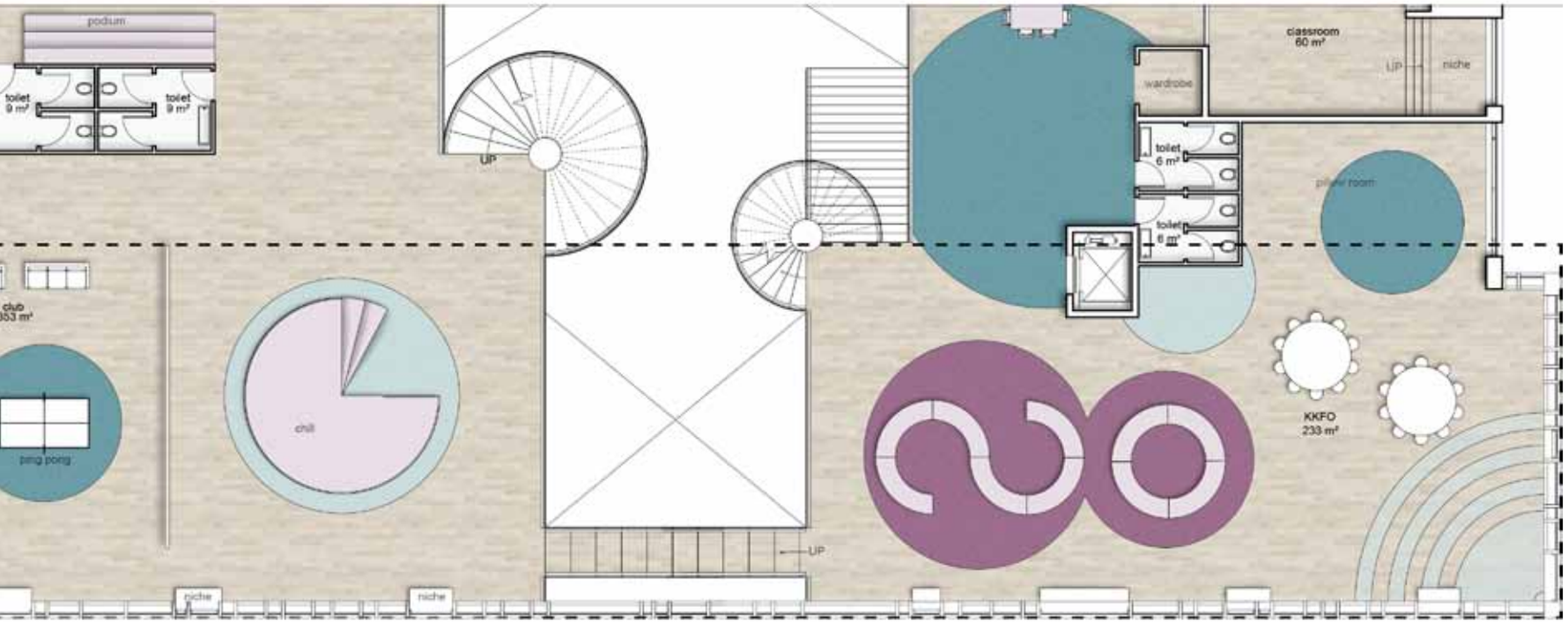
PRESENTATION
The Gap



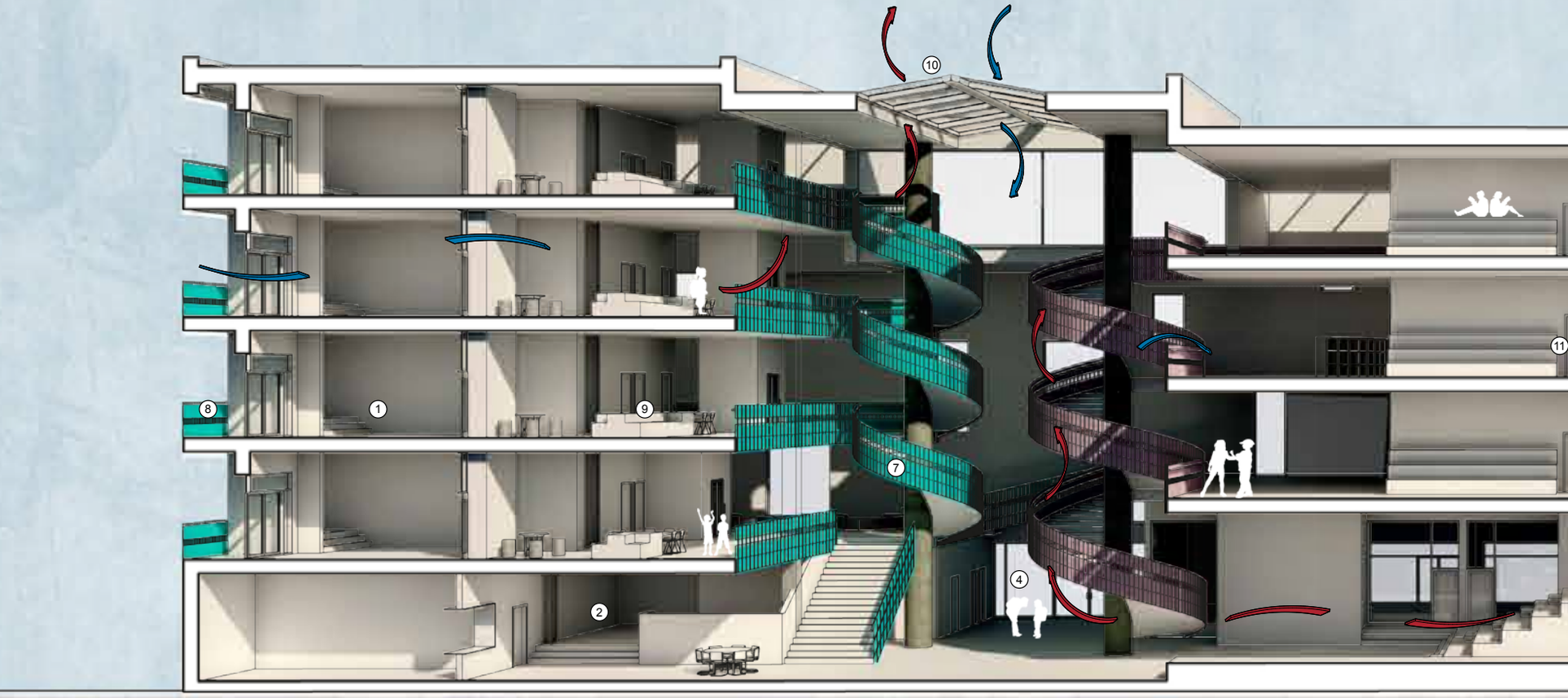
Shifted leveld to enchance visual connection



1:200


podium
toilet
9 m²
toilet
9 m²
UP
wardrobe
classroom
60 m²
UP
niche
toilet
6 m²
toilet
6 m²
pillow room
club
353 m²
ping pong
chill
KKFO
233 m²
UP
niche
niche

PRESENTATION
Longitude section



1: Classrooms: Large windows ensures an optimal daylight factor, and natural ventilation.

2 : EAT : EAT/dining area en close relation to outdoor eating areas, food science and alotmentgardens. Knowledge about “from earth to table” can flourish

3 : Subject square : The commonplaza, with possibilities for enjoying the sun all year.

4 : Entrance : Allows one to enter the building in two different areas of the building, creates an activity along the facede on Lybækgade.

5 : Multihall : Visualises movement as a central part of the building.

6 : Gennemlyst : Boligerne er kun 6 meter dybe og er samtidig gennemlyste, hvilket giver rigelige mængder dagslys.

7 : Administration : includes facilities for teachers to prepare their work and to socialize with their collegues.

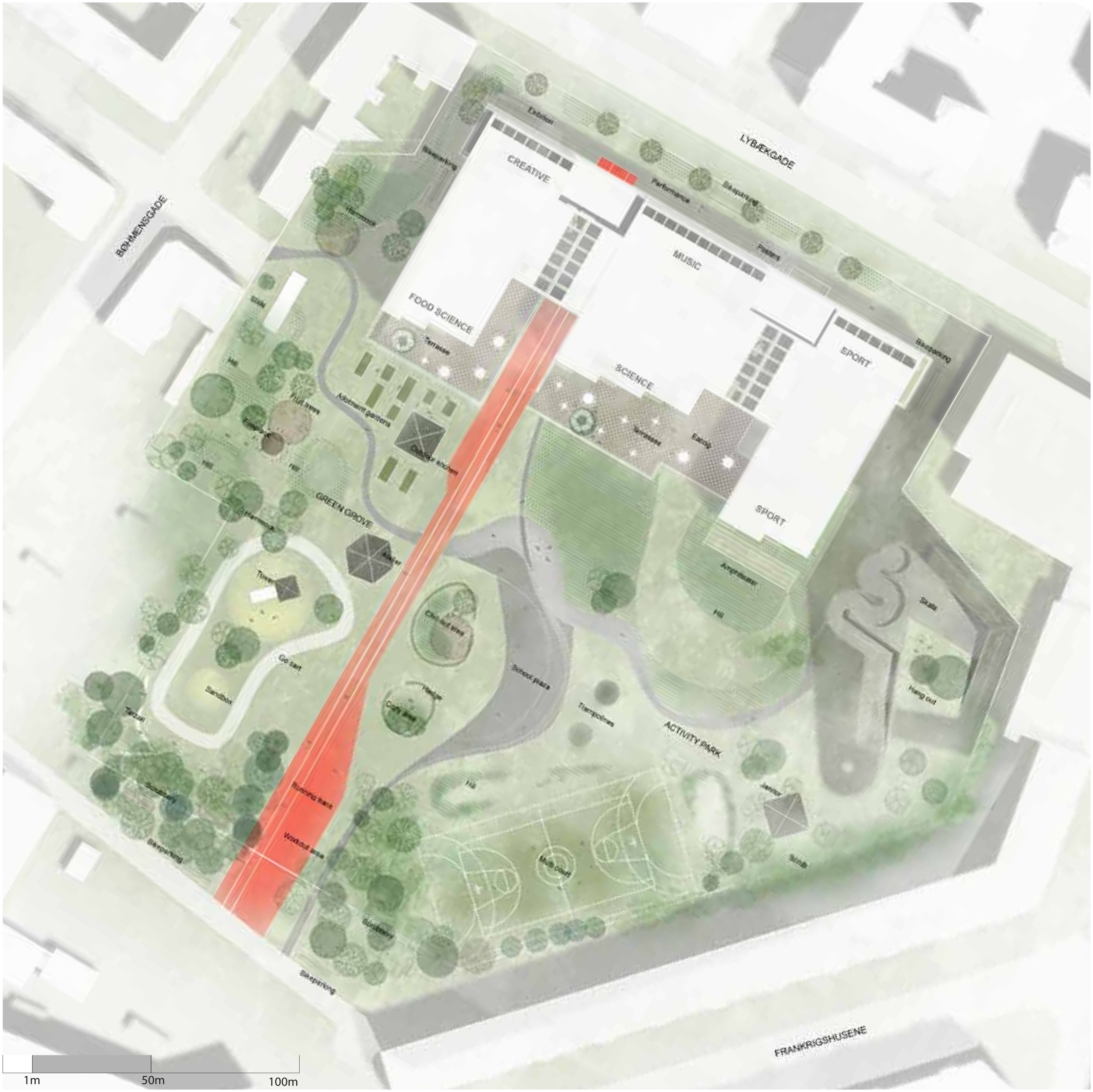
8 : Balconies : The students have acess to outdoor areas connected to the classrooms, with a view towards the school garden.

9 : Balconies : Home group areas, creates a place of belonging to the different groups where they can gather. this also provides spaces for group-work outside the classroom.

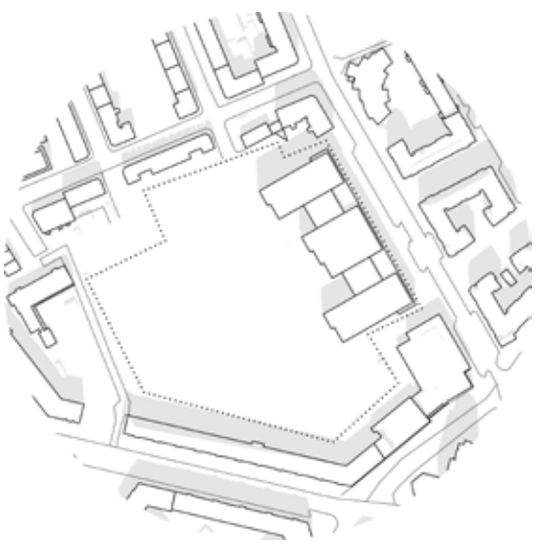
10 : Roof windows : Will provide a chimney effect and ventilate the large common space. During summer periods the glass windows in groundfloor and the roof windows can create chimney effect and ventilate the classrooms effectively. This decreases the need for mechanical ventilation and increases the thermal comfort.

11 : Integrated furniture : Furniture designed to accommondate group work og places for absorption.

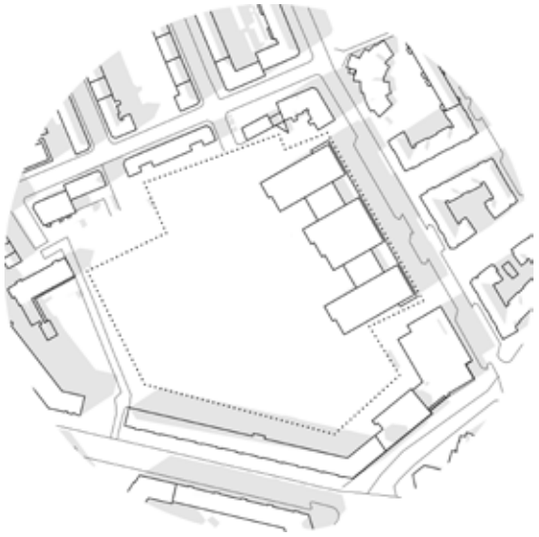

3
4
5
6


LYBÆKGADE
BOHMENSGADE
FRANKRIGSHUSENE
CREATIVE
MUSIC
FOOD SCIENCE
SCIENCE
SPORT
SPORT
GREEN GROVE
ACTIVITY PARK
1m
50m
100m

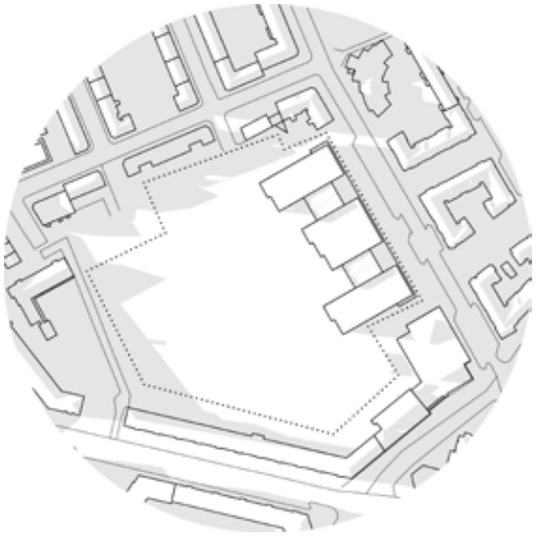
PRESENTATION
School garden



June 12.00 a.m



June 3 p.m



June 6.00 p.m

When I go for an evening run it is wonderful to be able to use the sports facilities in the schoolgarden

I like to play with my friends outside on a sunny day. The tarzan track in the schrubbery is good fun.

Me and my friends use the terrase in the lunchbreak, its nice to eat outside next to the garden

The schoolgarden

The landscape is designed to fit the creative and musical profile of the school with emphasis on exercise and activities and learning environments. It simultaneously adapts to the existing context, by utilizing the urban characteristics from the city and the greenery in the school garden.

The school garden is enclosed by the buildings and carries a reference to the surrounding courtyards within the dense city. The back facade evokes a backyard feeling by the strong reference to the apartment balconies. The school garden suggests the public to enter and use the facilities after school.

The outdoor areas are the children's oasis, and should provide other opportunities for development than indoor. To play outdoor should be eventful and challenging, invite for adventures, give space for fantasy and creativity. The school garden should provide children and adult the possibility to experiment and create their own surroundings – their own place.

The area is designed to support teaching, play, movement, outdoor kitchen. Workshops and areas for relaxing. Games occur spontaneously between the trees or on the small hills the spatial subdivision creates many different activities, both quite areas, the wild, motoric play and teamwork.

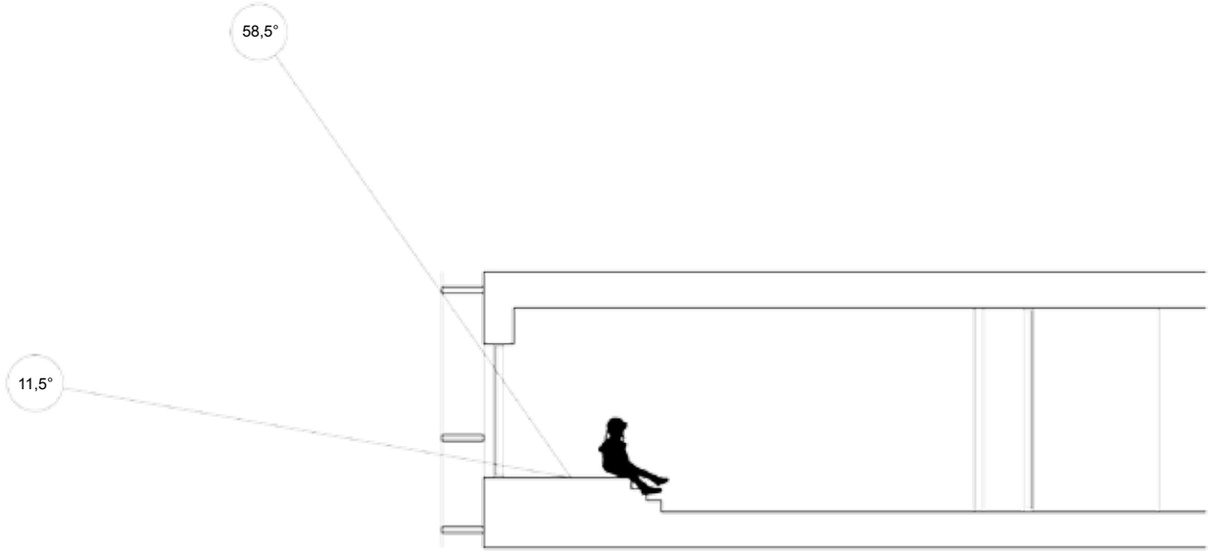
ATMOSPHERES LANDSCAPE
Creation of atmospheres in school garden

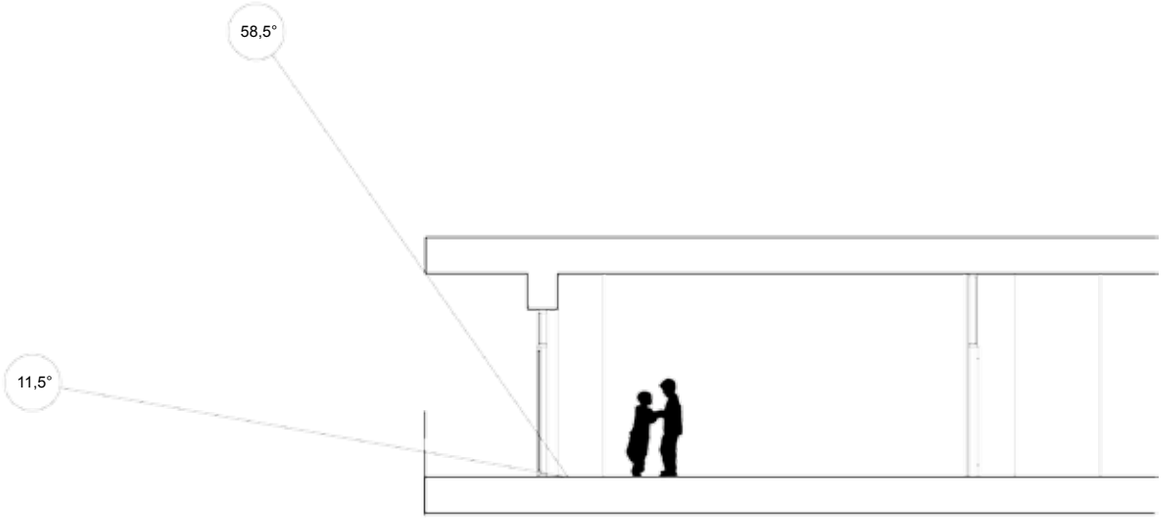
Chil out

Biodiversity

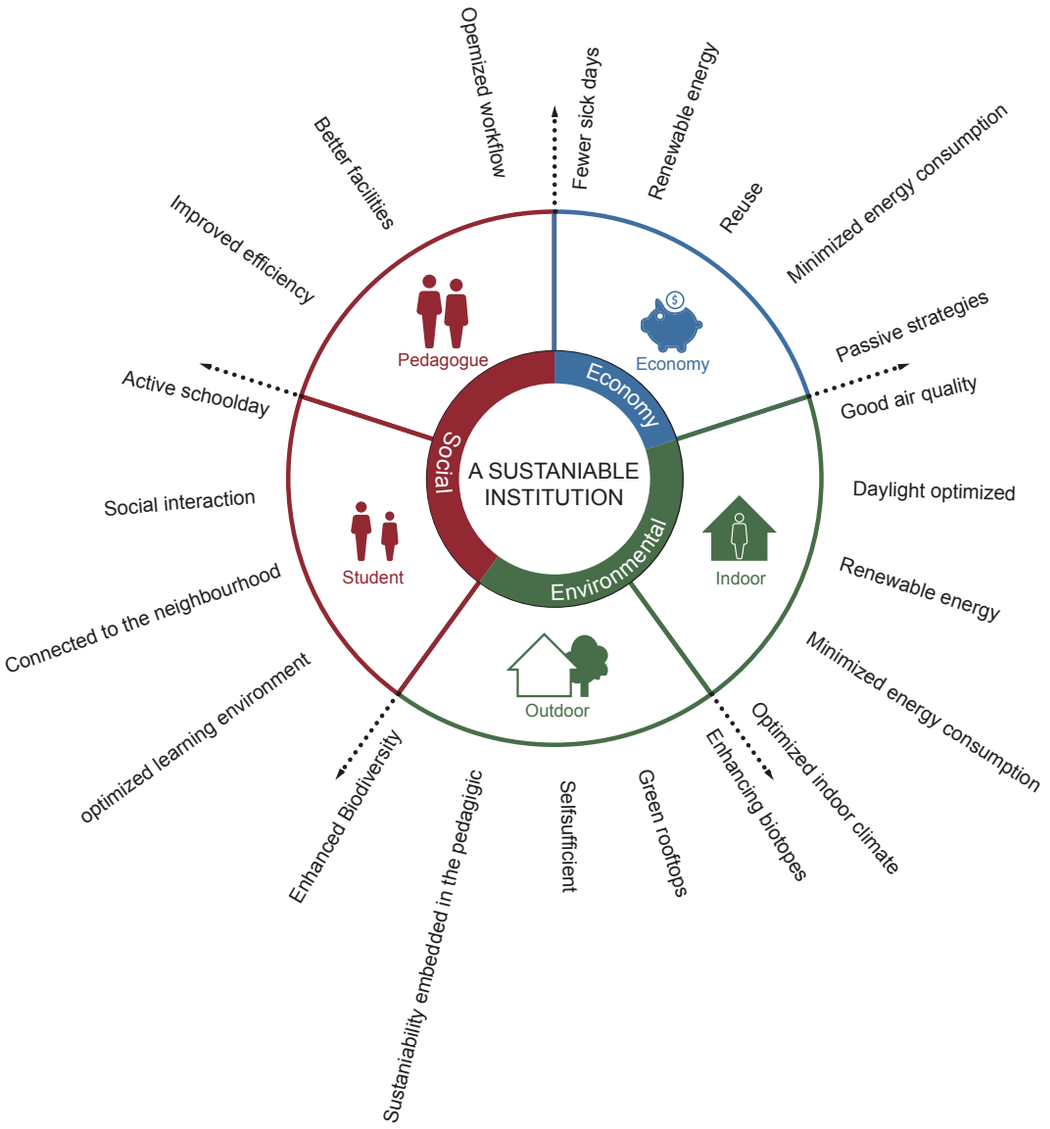
Sport

SOLAR SHADING
A passive strategy to prevent overheating

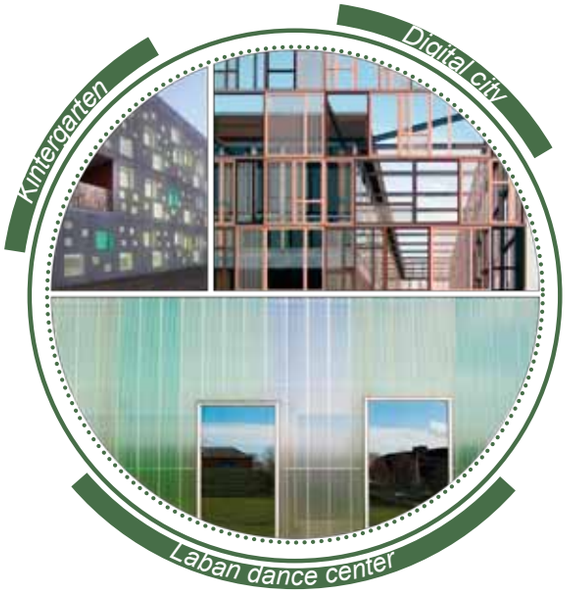




To prevent overheating in the S/W oriented classrooms, solar shading must be installed externally. A permanent solar shading solution is applied that carries reference to the façade pattern on the front, emphasizing the coherency in the architectural expression between both facades. The overhang and side fins the shading provides still ensures a great view towards the school garden that is painted as a picture in the window frame. The balconies also ensure shading properties to the large window in the classrooms, and at the same time enables students to stay outdoor or integrate the space within the teaching territory.



The vision for Sønderbro skole is to reach a coherent institution that is built upon a common sustainability for the future users. The school emerges from the idea of three part sustainability. This means that there has been put an emphasis on the social, environmental and the economical aspect of sustainability in the idea generation. This results in a balanced and realistic project, to the advantage of the users and the environment. The school sought to be a future inspiration among students, there during their school day gets an idea of the sustainable initiatives presence, that develops an awareness upon sustainability.



Facade
references

The gap
references

Subject Square
references

Primary Materials used

Indoor climate/ construction

The following chapter presents the technical investigations and results through BSim and Be10, made during the process and for the final proposal.

INDOOR CLIMATE & ENERGY PERFORMANCE

.Results and investigations of indoor climate

A good indoor climate within the school is proven to improve the concentration during learning, therefore the importance of this is unquestionable.

To achieve a good indoorclimate passive and active solutions are to be considered to meet the building regulations of BR20 concerning a low-energy building.

To evaluate the indoor climate DS/EN 15251 is used. We strive to fulfil the demands for a 2020 building class in terms of energy consumption.

(calculations and data can be found in appendix)

Atmospheric comfort

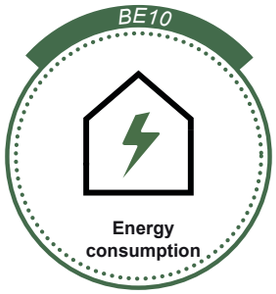
Corresponding to Class II – DS/EN 15251: 2007 standards and DS474 the operative temperatures should not exceed 26c. A maximum of 100 hours above 26c and 25 hours above 27c are allowed and can be avoided by natural and mechanical ventilation. During the winter period an operative temperature between 21-22c is preferable.

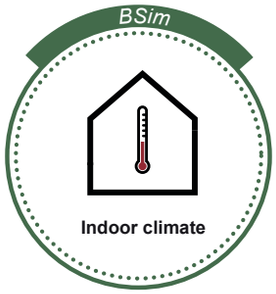
(Dansk Standard 1993; Dansk Standard 2007)

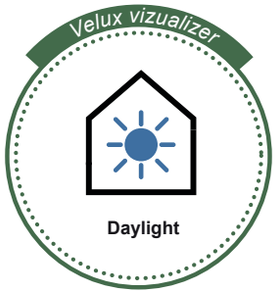
Energy consumption

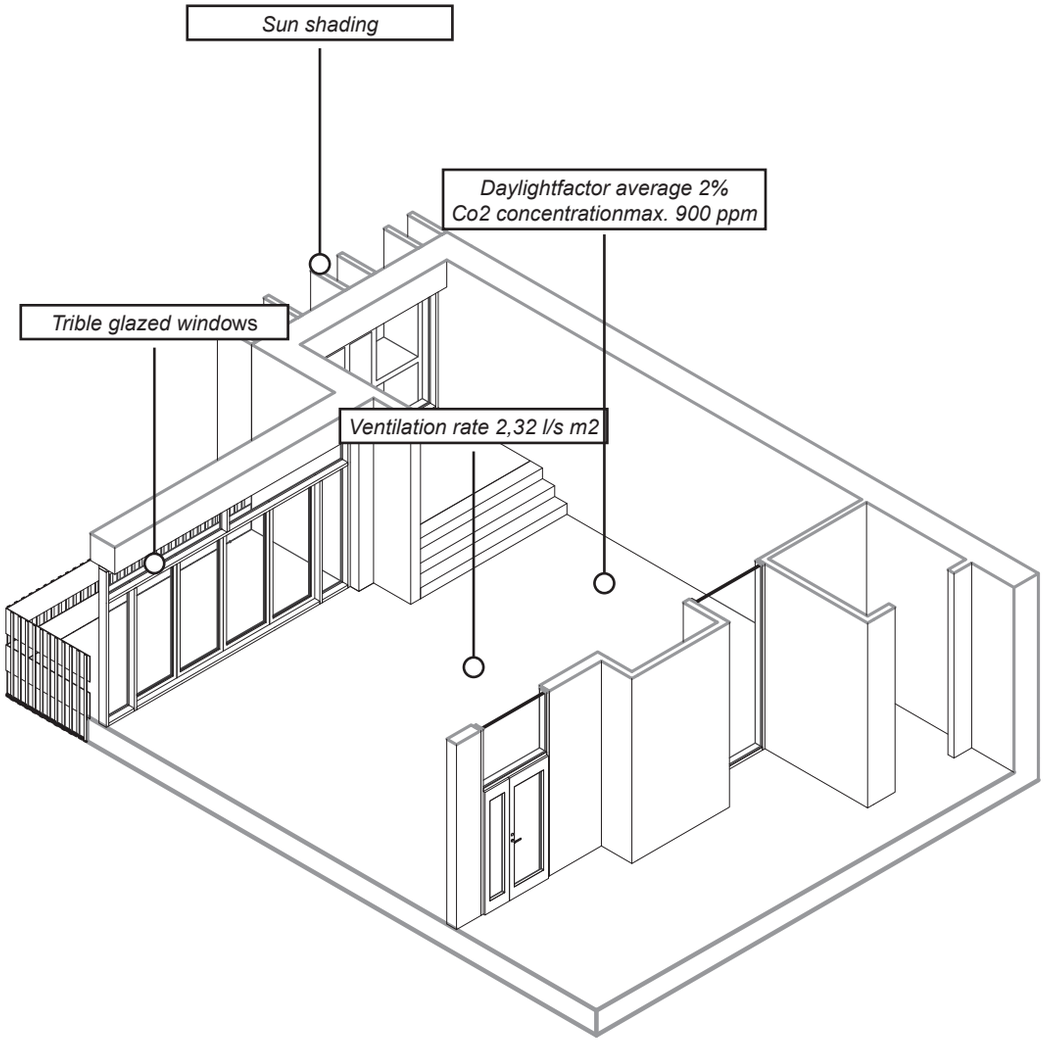
To achieve a BR20 the energy consumption cannot exceed 25 kWh/m2/year.

The energy frame is calculated by the energy supply from lightning, heating, domestic hot water, cooling and ventilation. (Energistyrelsen.dk)

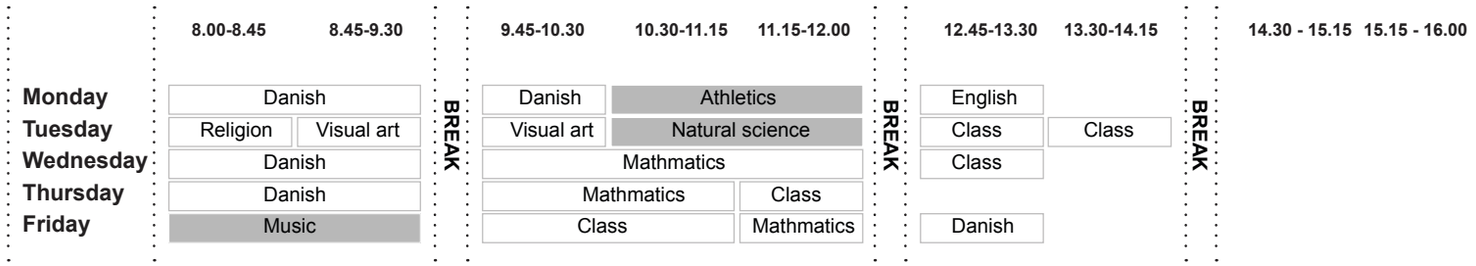

BE10
Energy
consumption


BSim
Indoor climate


Velux vizualizer
Daylight


Sun shading
Daylightfactor average 2%
Co2 concentrationmax. 900 ppm
Trible glazed windows
Ventilation rate 2,32 l/s m2

Schedule 2.a



Week table

Peopleloads

	Room	Area (m²)	Activity	Occupants
	Classroom	63	Sedantary activity	28

A school schedule from Sønderbro school 2.a is used to map the amount of hours the classroom is in use, In order to determine ventilation principles and solar shading.

INDOOR CLIMATE
Calculated air quality loads

Heat gain

	Person heat gain* (W)	Appliances heat gain** (W)	Lightning heat gain*** (W)	Solar heat gain S (W)	Total
	2646	630	441	18867	22584

*Person heat gain 7 W per person
**Classroom appliances 1 pc 10W/person, projector 350W
*** Lightning heat gain = 7W/m2

Classroom	Person heat gain* (W)	Requored ventilation rate (m3/s)	Requored ventilation rate (m3/h)	Airchange rate (h-1)
	4503	0,3	1403	6,1

Sensory load

	Activity level (met)	Sensory pers. load (olf/pers)	Sensory build. load (olf/m2)	Total sensory load (olf)	Required airflow rate (l/sxm2)	Required airflow rate (m3/h)	Airchange rate (h-1)
	1,2	1	0,3	2646	5,6	1226	5,3

Outdoor air quality = 0,3 (urban dense city)

Co2 load

	Maximum pollution (ppm)	Background pollution (ppm)	Person pollution (m3/h)	Total sensory load (olf)	Airchange rate (h-1)
	900	350	0,67	2646	3,42

Solar incidence

	Window orientation	G-Value	Angle factor (fg)	Shading factor (Fshade)	Shadow factor (Fshadow)	Glass area (fglas)	Solar incidence June (Wh/m2)
	South	0,48	0,9	0,9	0,7	25,7	4848

Window in question is a Velfac Energy one Helo 200i clear

Singleside

Cross

Stack

Drivingforce	Winter: Thermal bouyancy Summer : Wind turbulence	Wind pressure differntials between two openings	Thermal Bouyancy
Ventilation rate	Low	High	High
Applied	Classroom	Classroom	Commonarea

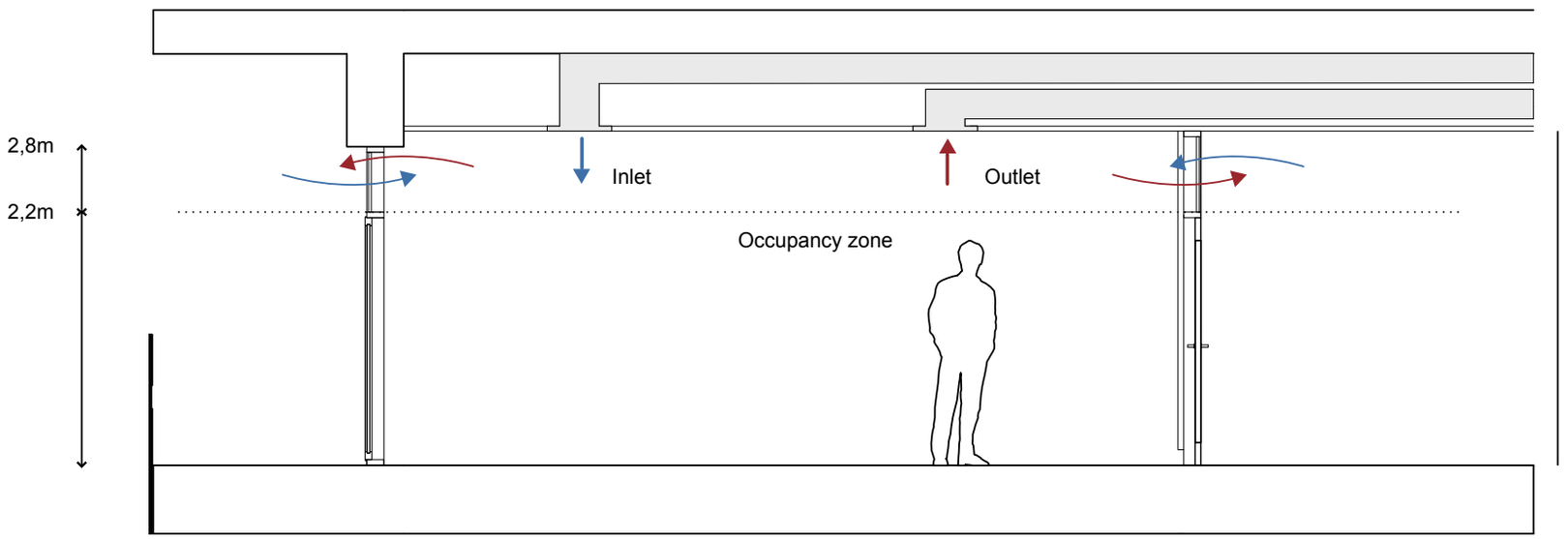
Natural ventilation

Mecanical ventilation

Hybrid ventilation

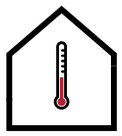
	1th December	**3th March**	**2th June**	**1th December**	**3th March**	**2th June**	**1th December**	**3th March**	**2th June**
Aver. T_{op} (°C)	20,1	21,8	27,8	20,1	21,5	20,8	20,1	20,4	20
CO_2level (ppm) min	350	350	350	350	350	350	350	350	350
mean	565	519	439	378	377	380	378	379	350
max	2475	1605	1250	573	573	572	580	578	577

As a result of the analysis of ventilation strategies the hybrid system is the system that provides the best conditions without consuming as much energy as a full mechanical ventilation system.
It is clear that a classroom only ventilated naturally is not sufficient enough, as the temperatures and the CO2 level is really high. the natural ventilation is only fully functional during the summer and this can also cause draught and a unstabil temperature. The hybrid system i further investigated in BSim.



Ventilation in classroom

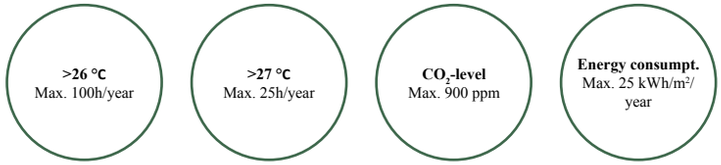
INDOOR CLIMATE
Bsim & Be10 Results



Indoorclimate

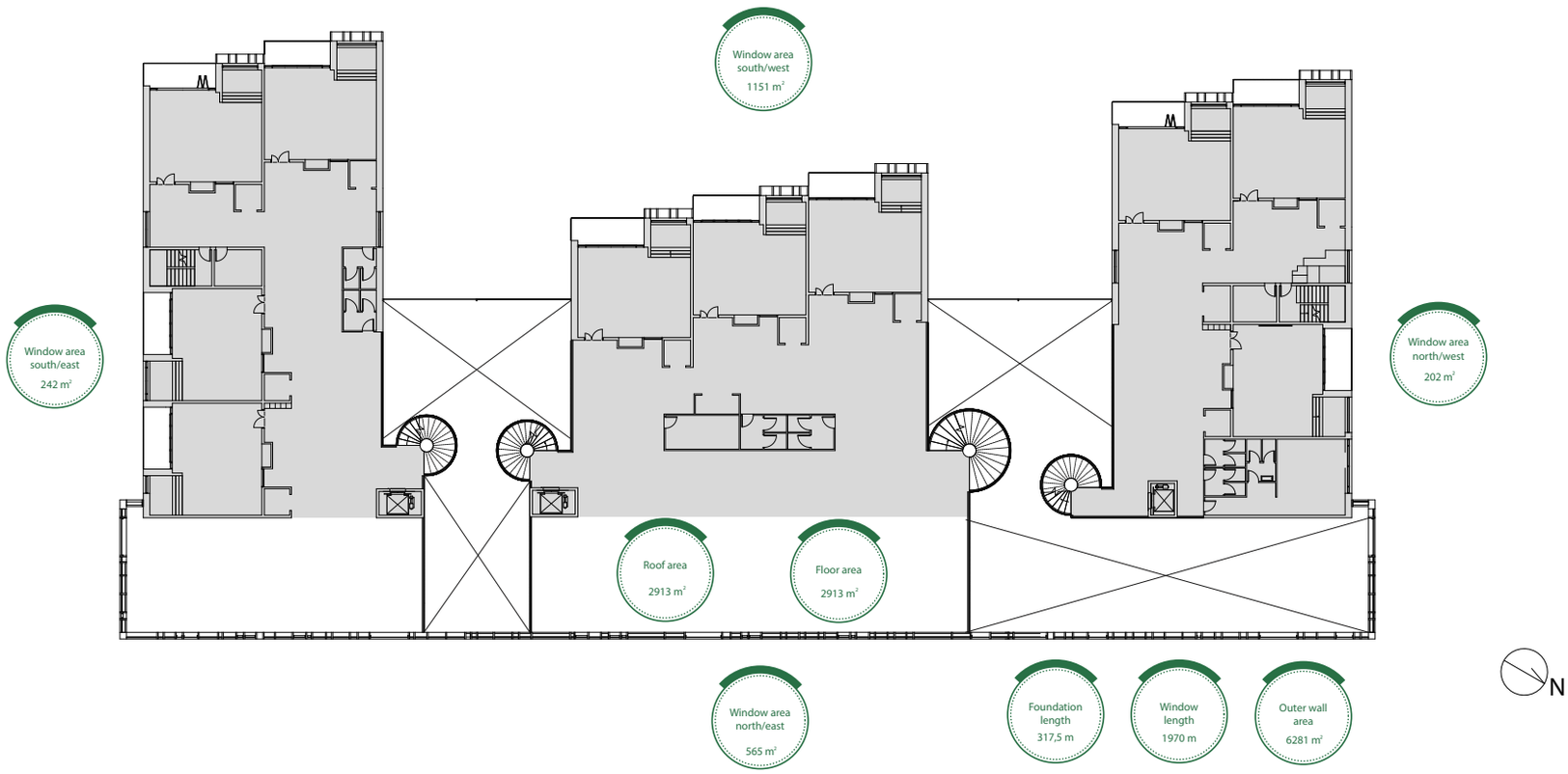
Energy consumption

BSim Results Classroom			Be10 Results School		
Hours/year > 26 °C	**Hours/year > 27 °C**	**Max CO_2level (ppm)**	**Be10 Consump. kWh/m²/year**	**PVs Contribut. kWh/m²/year**	**Supplement kWh/m²/year**
87	24	634,4	30	9,26	4,26
			Balance kWh/m²/year		
			5		



The building seeks to reach the BR20 with an energy consumption that does not exceed 25 kW/m2/year and a good indoor climate that fulfills category II buildings in DS/EN 15251 and DS474 to meet the requirements for the maximum hours overheating.
A result shows us that the building fulfills the energy frame for BR20 when active strategies as solar cells are implemented. The solar cells allows us to supplement with a small contribution on 4,26 kWh/m2/year.
The indoor climate is investigated in BSim where estimation of the thermal comfort and atmospheric comfort are made. The operative temperatures do not exceed the requirements, when solar shadings are implemented. The solar shading implemented is an integrated solution that cannot be controlled manually. The tool was used integrated to determine solar shading properties and design, and can be seen in the following pages. The atmospheric comfort is acceptable when mechanical ventilation is implemented in the calculations.

INDOOR CLIMATE
bE10



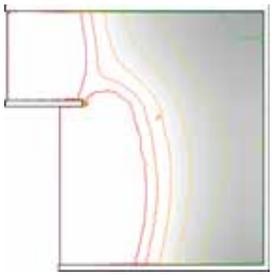
U-values used in Bsim and Be10	W/m^{2}k
Outer walls	0,12
Basment floor	0,18
Roof	0,12
Window	0,8

INDOOR CLIMATE
Optimation of window openings

The windows are Velfac energy one Helo 200i window with an improved U-value to prevent heatlosses. To make sure the daylight factor reaches the minimum of 2% in average large windows is investigated, and an implementation of external shading to prevent overheating. The placement of windows also improves possibilities for cross ventilation.

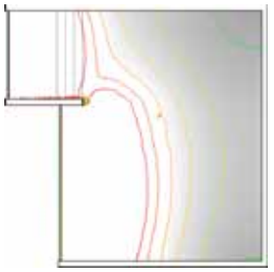
1

The first study is based upon a regular basic classroom, with floor to ceiling with a top offset of 500mm windows. This results in highly lit space, with good distribution of light.



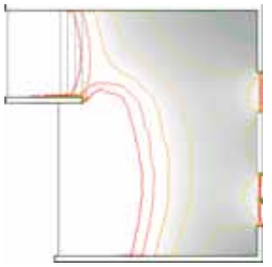
2

A niche is created to provide spaces for immersion, this result creates a variation of daylight within the classroom, and generates spaces with various atmospheres, and serves a good daylight factor.



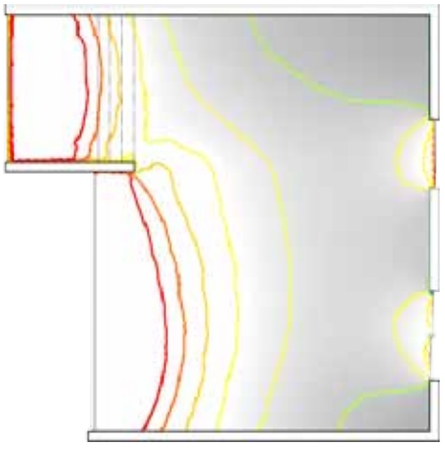
3

The niche is raised 500 mm to emphasise the space as a space within space, this does not affect the daylight factor.



4

Glazed areas are placed to provide visual contact to the group area within the cluster and also lets light into the room from the other side. This increases the light in the back of the classroom.



5

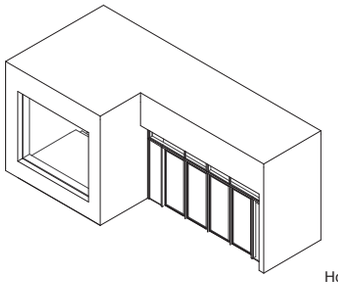
With shading the daylight factor is affected but it still shows a sufficient daylight factor.

1 2 3 4 5 6 7 8

INDOOR CLIMATE
Shading process

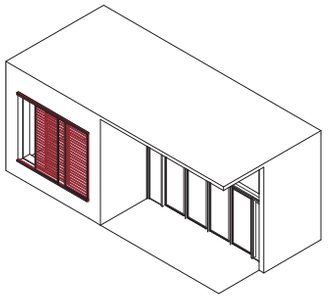
Good indoor climates are difficult to predict, as the human behaviour is an uncontrolled parameter. Corresponding to Class II - EN15251: 2007 standards and DS474 the operative temperatures should not exceed 26C.

100 hours above 26c
25 hours above 27 are allowed
In order to have an integrated process to achieve a good indoor climate, different design solution have been tested and evaluated in BSim.



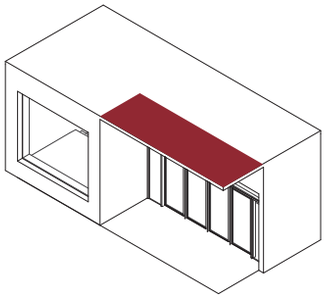
Hours > 26: 140t
Hours > 27: 60t

Without any shading the classroom is exposed for a large amount of hours overheating.



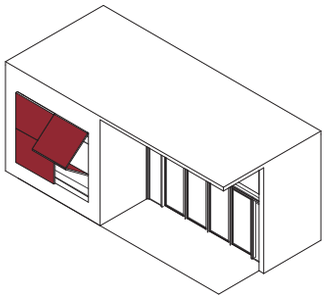
Hours > 26: 70t
Hours > 27: 20t

Movable venetians will allow a user manually to operate these when reaching to high temperatures, but will, when in use, block the view to the outside. The expression within these are not coherent with the architectural expression.



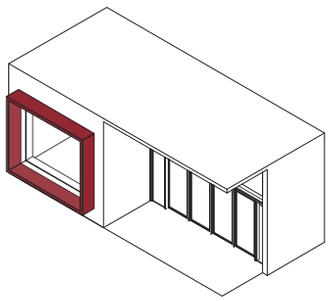
Hours > 26: 106t
Hours > 27: 40t

By integrating a balcony as an extension to the learning territory in the classroom, it will provide shading and lower the temperatures.



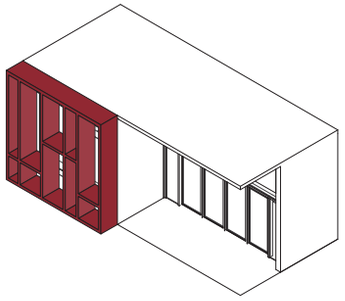
Hours > 26: 43t
Hours > 27: 9t

Solid plates, that opens upwards are really efficient and could emphasize a vertical expression of the façade. But when in use they block the view to the outside.



Hours > 26: 102t
Hours > 27: 38t

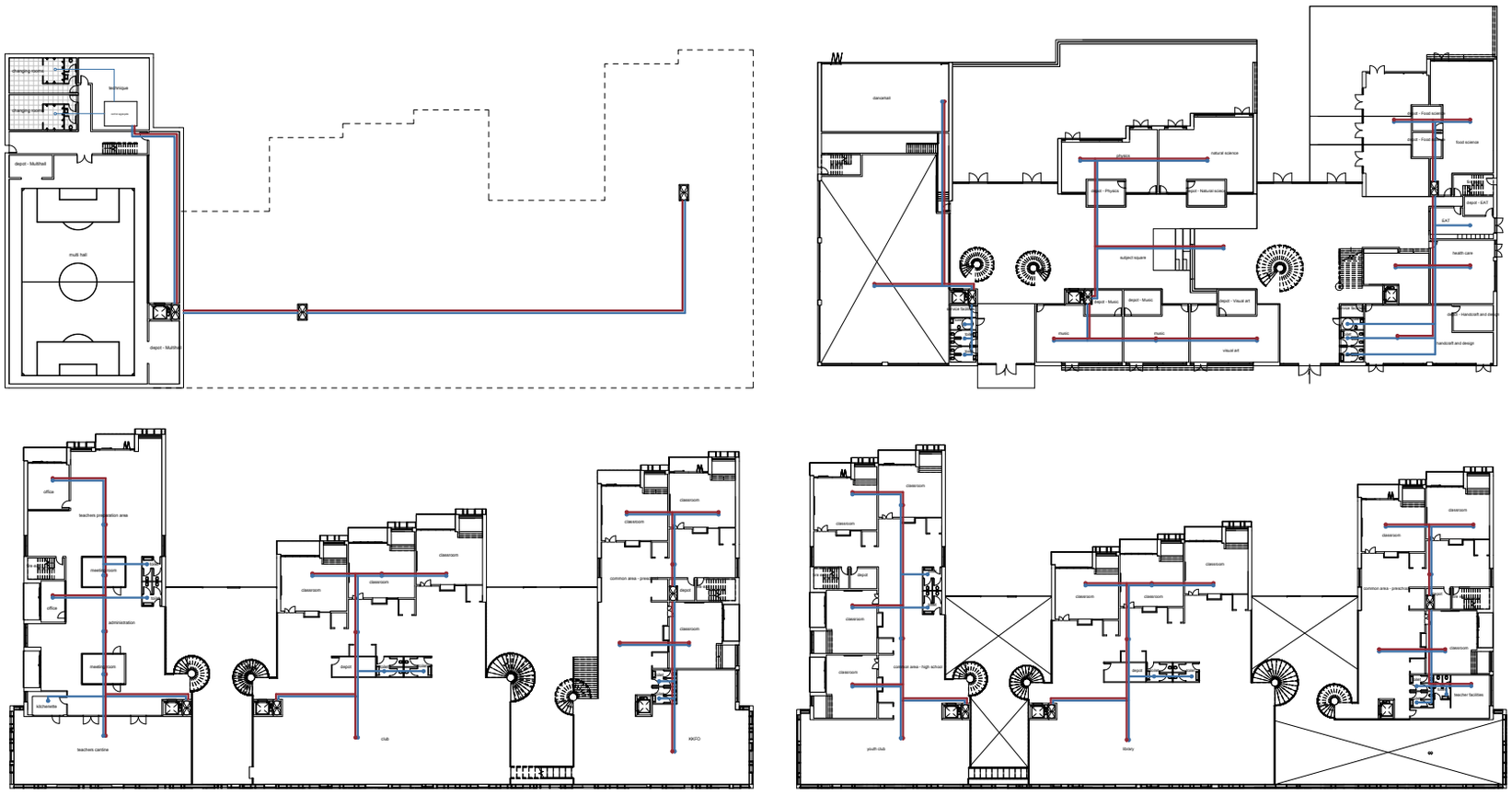
With 0,5 m sidefins and 0,5 m overhang around the niche window, the temperatures will only lower a small amount of hours, but still allow a view to the outside.



Hours > 26: 87t
Hours > 27: 24t

By taking elements from the front facade and extrude to a greater debth, it will provide shading to a larger amount of the window, and also carry reference to the front facade. The operative temperatures is acceptable and within the the allowed.

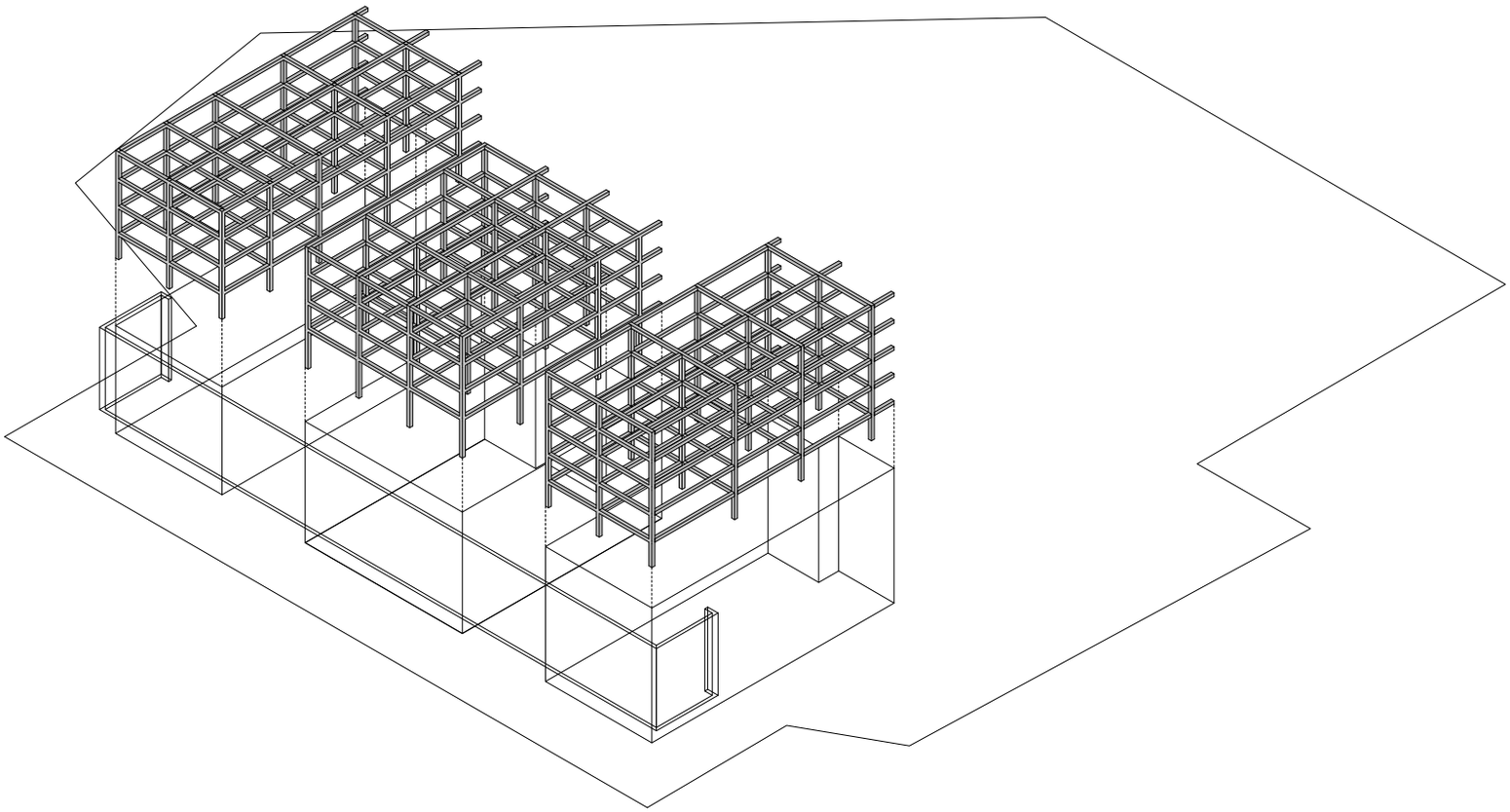
INDOOR CLIMATE
Ventilation plan



The school is ventilated with a hybrid system that combines natural and mechanical ventilation. Mixed-mode- and process ventilation are the two modes in question.
Mixed mode ventilation is the main ventilation system used, with the aim of distributing the heat and pollution equally.
In higher polluted areas process ventilation is utilized. The efficiency of this type will ensure a proper ventilation in subject rooms.

Mechanical ventilation is used during summer and winter, and supplemented by a heat recovery system during winter to keep the inlet air temperature down and decrease energy for heating up inlet air. During summer natural ventilation contributes to a good thermal and atmospheric indoor environment by the use of single sided, cross ventilation and stack ventilation in the school.
The central aggregate for mechanical ventilation is located in a technical room in the basement. The pipes are distributed vertical in connection with elevator shaft in the high- and middle school and in a depot in preschool. All rooms is supplied with an inlet and outlet air supply, except from the toilets where only outlet occurs.

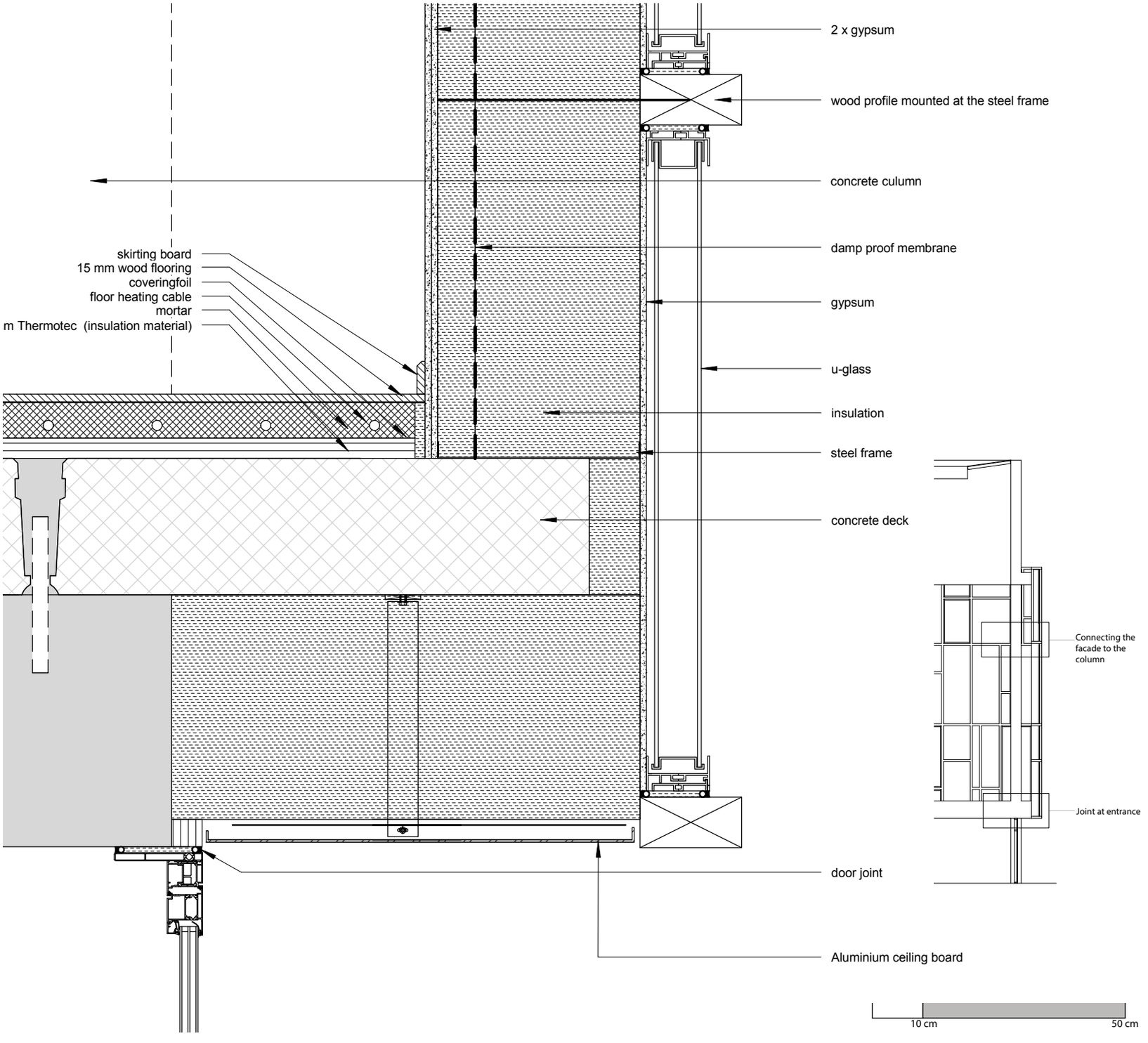
CONSTRUCTION
Construction principle



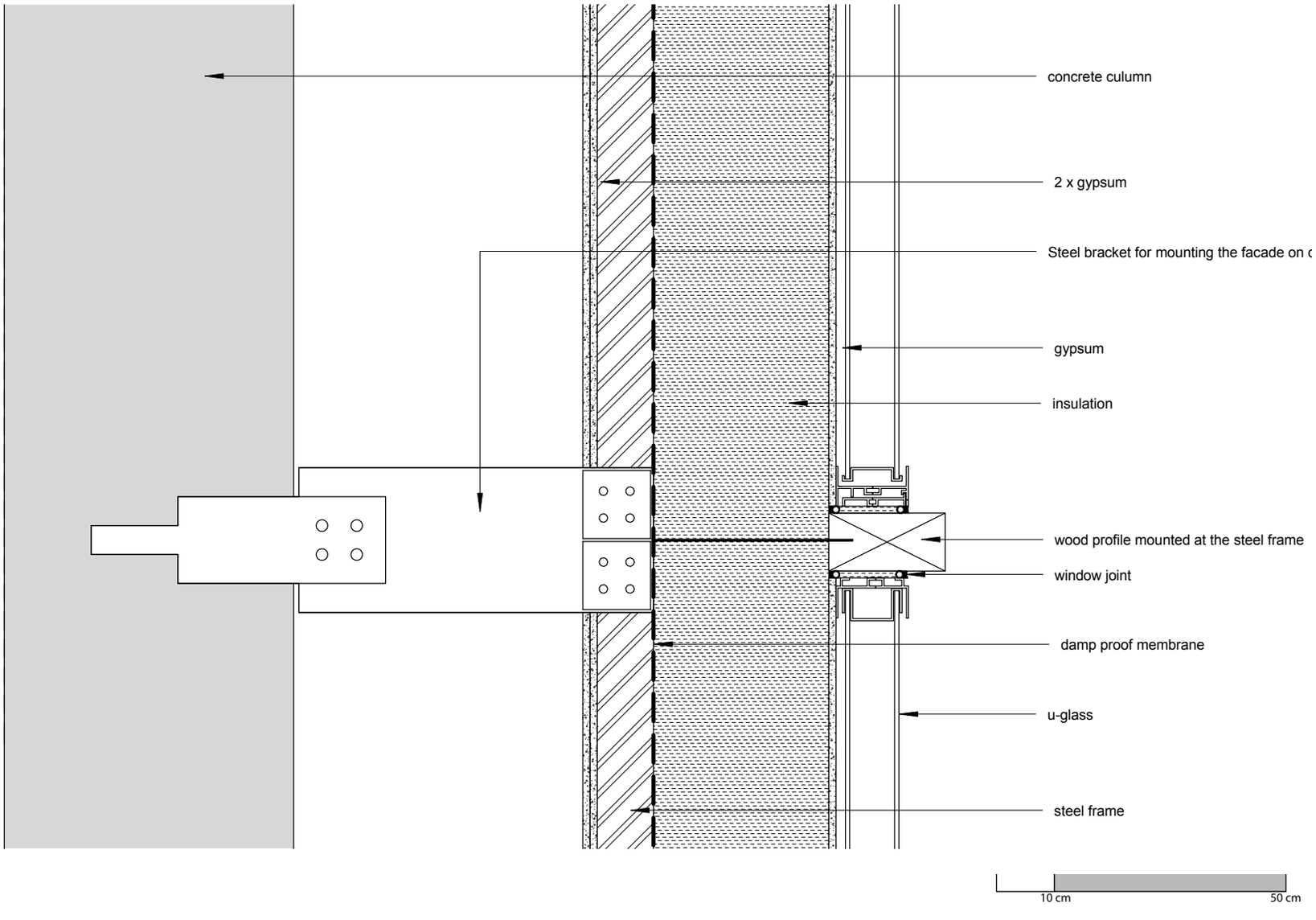
The construction principle is based on a concrete column-beam system, which provides a maximal flexibility in the interior layout.
The light and transparent expression on ground floor is best achieved by a column structure that supports the concrete slabs. In addition concrete is chosen as the construction material to meet the requirements in relation to fire.
The front façade towards Lybækgade is constructed around a steel frame fixed to the concrete column (see detail). The fillings in the front facade appears in three ways, the transparent that ensures well lit rooms, the translucent u-glass fixed to the steel frames, and the solid insulated panels that makes the building envelope.
The home groups appear more as massive boxes and are built with light outer wall covered with sprayed concrete.
(See drawing folder for details in 1:10)

CONSTRUCTION

Joint at entrance



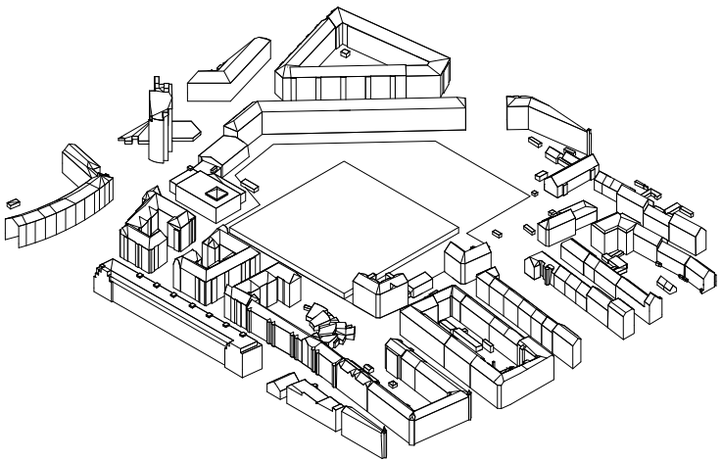
CONSTRUCTION
Connecting the facade to colum

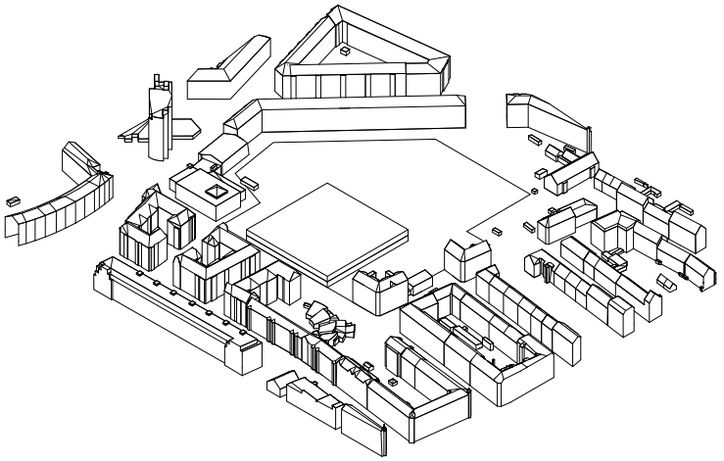


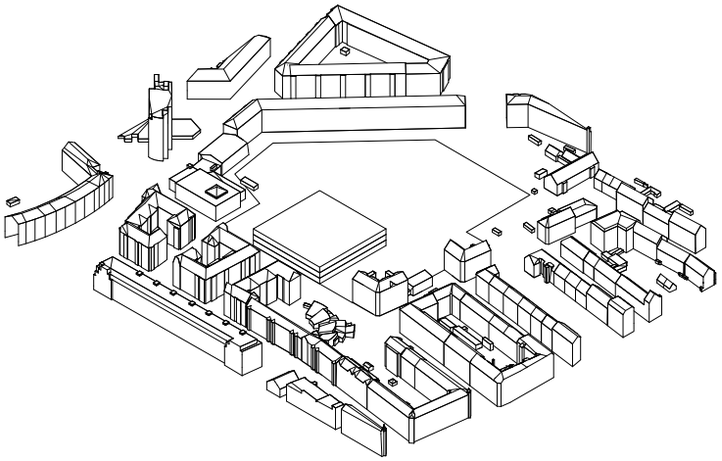
Ideation

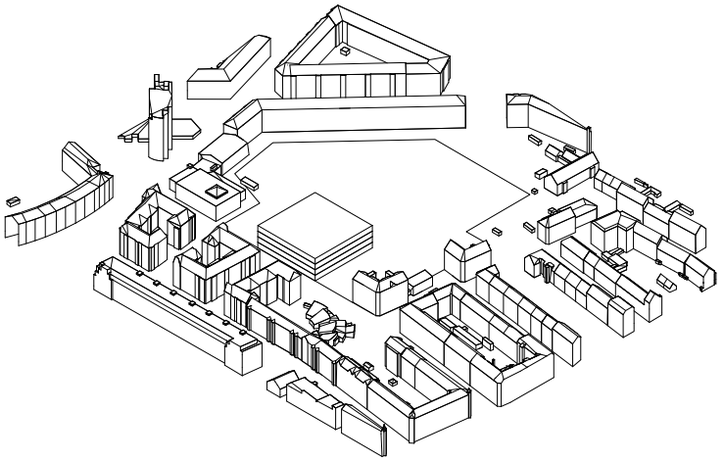
The following chapter presents the essential phases of the initial design process

IDEATION
Volume studies



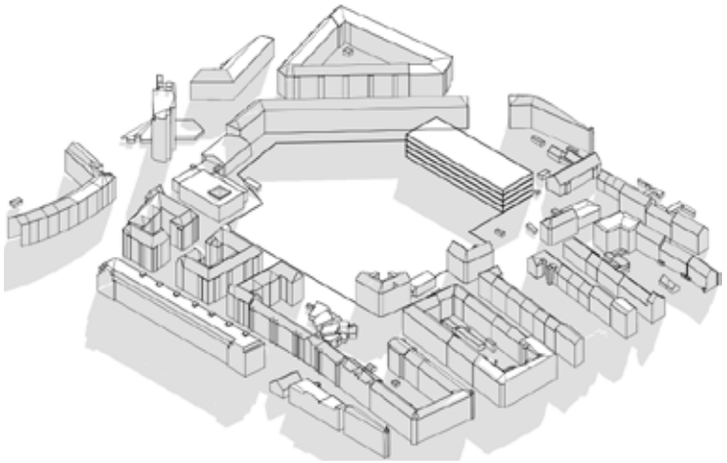


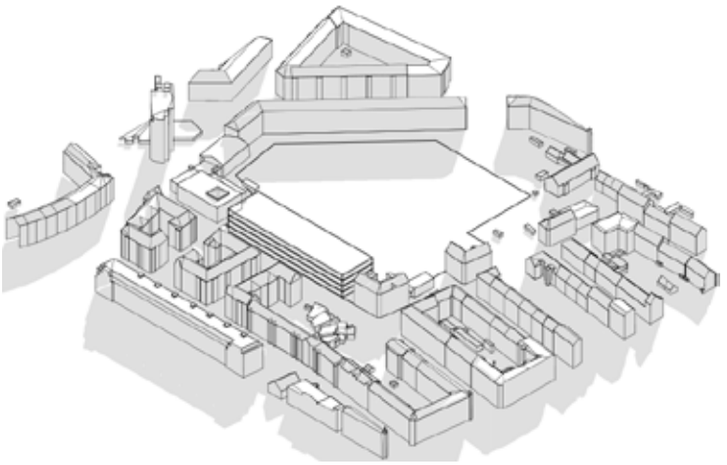


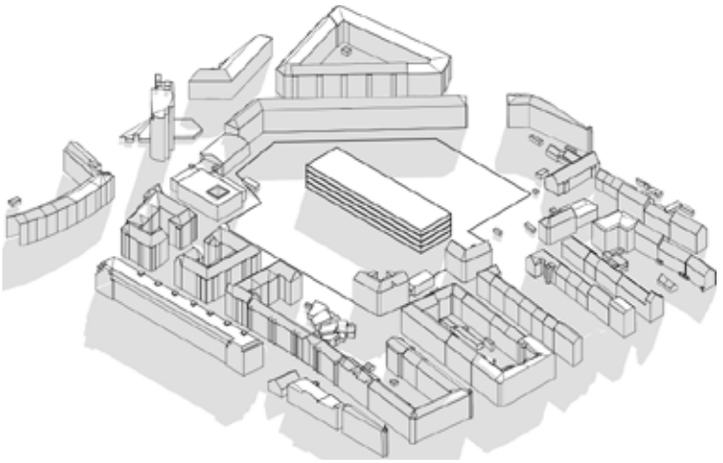


Studies of the building volume on site has been made to achieve an understanding of the building scale within its context. Diagrams exploits the use of space according to the number of levels. Green area for a school garden is important and the building scale should blends into its context. The squaremeters investigated is 10000 sqm.

IDEATION
Settlement

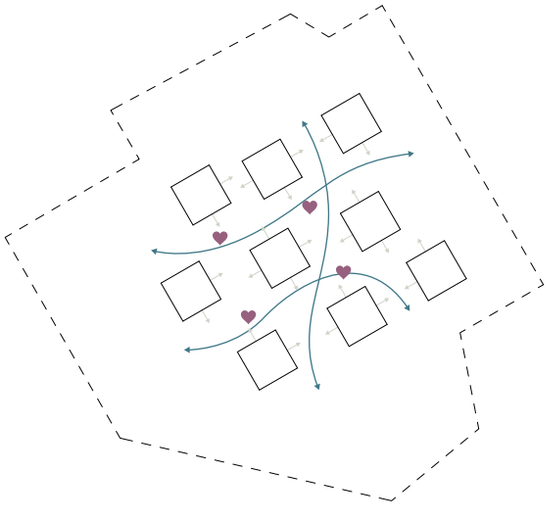


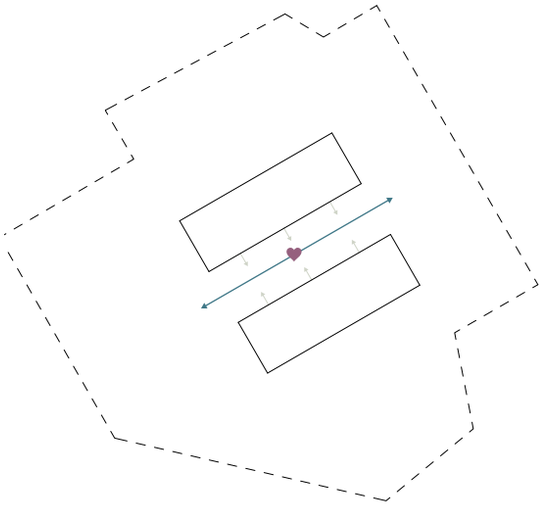


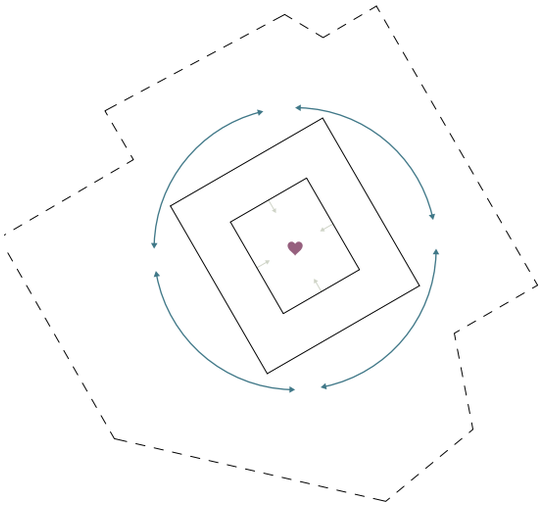


To achieve the best conditions for outdoor area, settlement of the building is investigated. Diagrams show three ways to address the site. Mostly important is the continuation of the street against Lybækgade and a large well connected outdoor area with good sun conditions.

IDEATION
Typologies

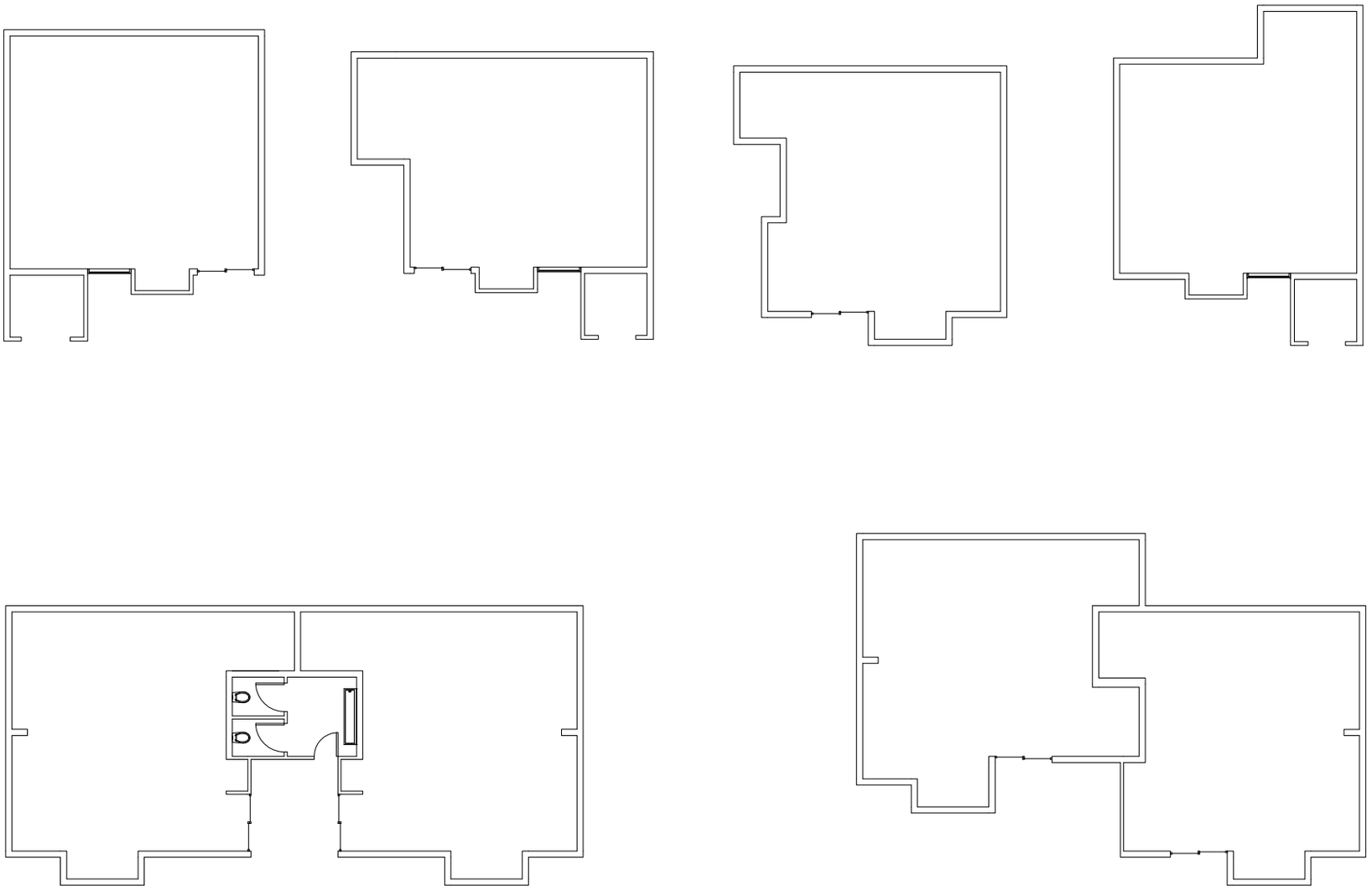






The different typologies are tested on site, to get an understanding of the area around the building, the visual connection between building volumes and the creation of meeting points.

IDEATION
Classrooms interiority

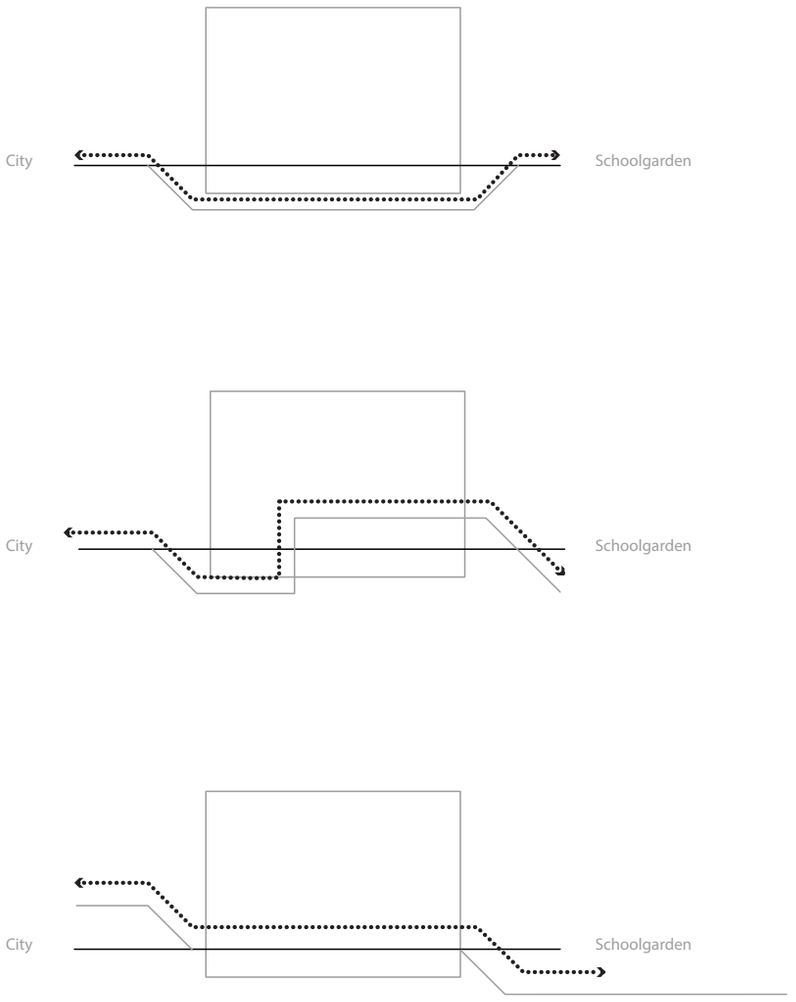


Different plan solutions investigate how to create niches for group work and absorption. The number and size of the niches are studied, and how it is connected to the main space in the classroom. Different areas outside the classroom generated private, semi-private and public areas that create possibility for a diverse learning territory.

IDEATION
Facade expression

Different design solutions for the expression on the facade towards Lybækgade have been made. It has been investigated how niches for activities can be integrated, and to get a play full façade on the schools is has been tested how to integrate colour in different ways. Furthermore are there in various ways tried to emphasize the shifted levels behind the facade.

IDEATION
Flow experiences from city to school garden



To get and understanding on how to enter the building and go from the city scale to the school garden, various flow scenarios are made. Depending on how you go from one space to another, the feeling will be different. Two ways of entering the building has been made in the school, and several ways of entering the school garden from the building volume are integrated in the final design solution. This creates different experiences depending on the situation.

CONCLUSION

The public school is an institution of great importance, shaping us, and our future children of society. As mentioned in the motivation, the public school plays a big role in society, as it educated Danish society, evolves our social competencies in the early years and develops us as individuals. This is covered in the research chapter, describing how the public school has developed through time to achieve a perfect foundation for a personal development.

The school reform reflects the changes in society, as accounted for in the chapter of society and the public school. Evidently, there is a correlation between the societal reactions and the architectural agenda. The interiority, educational content, social framework, authority are all mirrored in the architecture.
Due to our research and investigations we did, when visiting schools in Denmark, gave us an understanding of how the agenda of new school reform and teachers work schedule does not fit into these old school buildings, that were built during a different period to fit former pedagogic ideals. Furthermore the idea of an open school, that comprises the immediate neighbourhood, is not present to the extend the new reform requires.
The classrooms primarily support teacher's up-front teaching in an uninspiring environment, and does not accommodate facilities for teachers to prepare their work.
Both teachers and students are affected by this matter, that architecture simply does not embrace the new initiatives that encourages activity to this extend inside and outside the building, and does not facilitate a differentiated learning environment. The School reform comprises longer schooldays blurring out the boundary between school and spare time, this calls for a more varied and active school day.
Longer school days call for a more varied day, to be able to blur the boundary between school and spare time.
The spatial programme of the school is a complex matter that encompasses a great deal of spatial varieties, meeting architectural, technical and functional demands.

Learning environment
Learning environments both have to enable teachers to facilitate learning and students to receive it. Based on the theoretical reading about learning spaces, it has been an important parameter to create a differentiated learning environment in children's scale. The teaching spaces requires variation to accommodate learning ability of the individual student, thus a focus on creating niches for absorption and spaces for negotiation and gathering both indoor and outdoor.

Movement
Movement and activity should be embedded within the DNA of the architecture and have been an essential part of the project to highlight and visualize.

The placement of the multi hall as visual from the street, school garden and subject square signifies movement as a fundamental part of the school, and as a visible offer to the neighbourhood after school.
The easy access to outdoor activities is emphasised by the running track that penetrates the subject square from outdoor and encourage fast movement through the square and is a playful element.
Long narrow hall ways as we know it from the old schools are discarded to instead provide wide transit areas that mix activities and supports fast transit.
The vertical staircases are an optimal and clear transition from city to school that connects the two environments, hence the experience of the school as a whole is emphasized and staging school spirit.
The distribution of the spatial programme impacts the vertical a horizontal movement across the building. The big draws are the library, EAT, Multi hall, KKFO, Club and youth club.

Openness
The large amount of offers that lies within a short distance to the school already creates a dynamic environment and facilitates a variety of offers to the citizens in the neighbourhood. We perceive the school as a unique learning environment and another offer on this list that will improve the social relations and facilities among others in this particular neighbourhood.
School garden is accessible by the public and offers a green landscape for activity and play for the school and citizens. By introducing this informal breathing space as a pocket park for the public, it might provide a safe character to the area when activity is present during day, and not a desolated area.

Sustainability
We have sought to have a holistic approach to work within the social, environmental and economic sustainability, with focus on social and environmental. The school meets the demands for a BR20 energy frame and an optimal indoor climate that secures the best possible conditions for learning. Throughout the project there has been an integrated design process that loops back and forth between the technical demands and the architectural expression and optimization. The sustainability of the project is not only seen as the energy frame and the indoor climate but also in relation to create social sustainability that focuses on improving liveability and enhancing well-being of the human being.

This suggestion to a new Sønderbro School offers a broad variety of learning environments, a holistic approach towards sustainability that treats the softer values of social sustainability and spatial qualities, both in relation to the school itself but also the local environment.

REFLECTION

The choice of school has set the framework for how to change a school to fit the pedagogic ideal and usage of today. A school within the dense city differs from others. Normally a school within the dense city has little space to outdoor areas. This is not the case for Sønderbro School that holds a large area to utilize for school purpose. Sønderbro School is fortunate to have as large an area. The project is asking for a suggestion on a new school on an existing site, a draft for how a school could look within this context. To integrate the school as a part of the city, the school must offer something the immediate neighborhood does not, and by this mean the areas can melt together. It will create a bigger connection and the school will not seem as a closed institution.

The placement of functions is determined by its relation to context generating an interaction between these. This is achieved by exposing profile subject rooms towards the street, and the science and food subject rooms towards the garden, to utilize the areas during teaching. The placement of the subject square is also a convenient spot, in order to create division between private and more public areas, institution and community areas.

Outdoor teaching, differentiated learning and movement becomes a bigger part of the school day. This alteration is important to practice among teachers and student, and by this develop new ways of integrating these elements within teaching. Differentiated learning is facilitated by the spatial design, which encourages to be used differently in learning purpose from individual assignments to gatherings. It is important to facilitate the learning territory as a foreseeable project, so it would be seen as an opportunity to use the spaces in different ways and not a hurdle. It is a great opportunity to be able to shift between spaces that emphasize certain types of teaching.
A perfectly usage of the spaces demands a common practice and administration of the areas, engagement from teachers will be reflected in the usage of students.

By opening the school to neighborhood, the area could suffer a lot of wear, which calls for maintenance funds. This also means the area shouts for a pocket within the city like this, it could provide great value to citizens, to be able to use the place. Further this will trigger a redistribution of funds for maintenance. So by giving to the city, the city gives something back in return. Mostly important is that the school mainly is used by the school during school time to maintain

the experience of it as their common place. Many of the students' live in the neighborhood. This entails a utilization of the area after school time where they can meet up with friends. Through openness the possibility for an increased sense of belonging and safety on the school, vandalism on school property can be avoided.

The detailing and design process reflect that we are dealing with a large spatial programme which has to consider many different elements and functions, that all should be accommodated with the best conditions.

Time has been a limit in investigations that examines climatic conditions in common spaces, rules of thumps has been the guide for planning these spaces, in order to prevent overheating and optimize natural ventilation.
Further investigations on the acoustical conditions could also be used integrated in the shaping of the gap, where there is a high space, especially where the KKFO is situated. References show a choice of acoustical materials on the back of the front facade that will influence on reverberation time and be used to detail the large white surface.

LIST OF LITTERATURE:

Litterature:

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ILLUSTRATIONS

All illustrations not listed, are created by the authors

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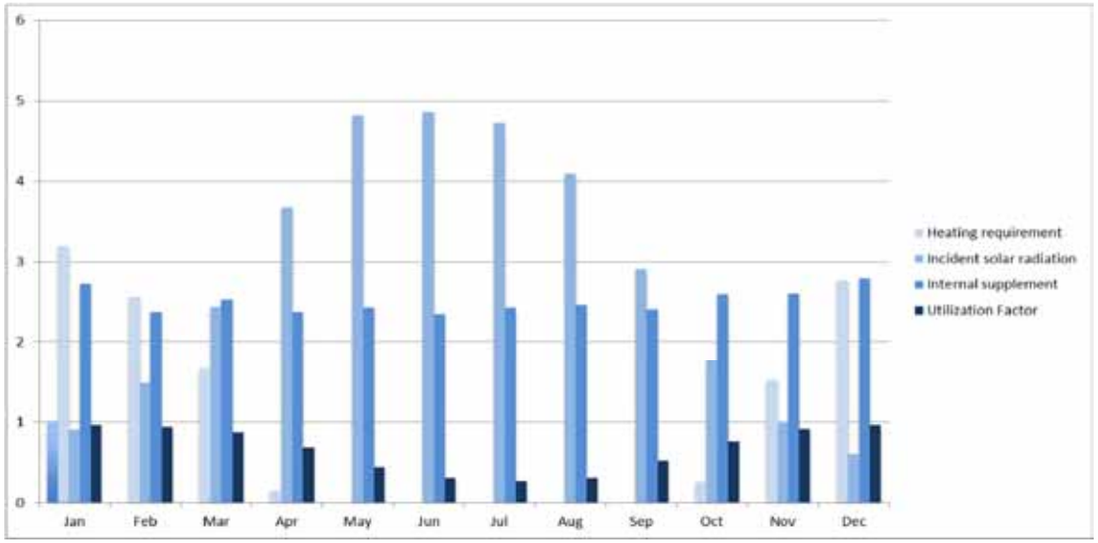
Appendix

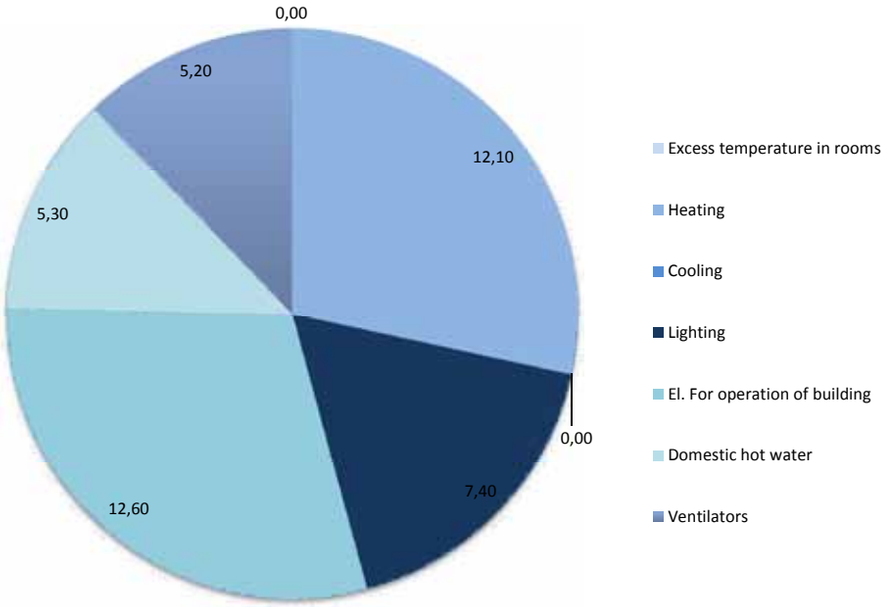
- *Be10 Data*
- *Be10 Results*
- *Solar cells calculations*
- *BSim Data*

COMPONENT	ASPECT	CHARACTERISTICS
Building	Heated floor area	13647 m2
	Heat capacity	120 Wh/K x m^2
	Time of use	70 h/week (from 8 to 22 five days a week)
	Rotation	150 deg.
Outer surface	Outer walls north-east	A = 1757 m^2, U = 0,12 W/m^2K, b = 1, H_t = 210,84 W/K, Heat loss = 6746,88 W
	Outer walls south-east	A = 1370 m^2, U = 0,12 W/m^2K, b = 1, H_t = 164,4 W/K, Heat loss = 5260,8 W
	Outer walls north-east	A = 1379 m^2, U = 0,12 W/m^2K, b = 1, H_t = 165,48 W/K, Heat loss = 5295,36 W
	Outer walls south-west	A = 1775 m^2, U = 0,12 W/m^2K, b = 1, H_t = 213 W/K, Heat loss = 6816 W
	Basement walls	A = 571,5 m^2, U = 0,12 W/m^2K, b = 1, H_t = 68,58 W/K, Heat loss = 2194,56 W
	Roof	A = 2913 m^2, U = 0,10 W/m^2K, b = 1, H_t = 350,5 W/K, Heat loss = 7474,2 W
	Floor	A = 2920 m^2, U = 0,10 W/m^2K, b = 1, H_t = 436,95 W/K, Heat loss = 6525,12 W
Foundations ect.	Outerwalls foundations	L = 317,5 m, Loss = 0,2 W/mK, b = 1, H_t = 63,5 W/K, Heat loss = 2032 W
	Windows	L = 1970 m, Loss = 0,06 W/mK, b = 1, H_t = 118,2 W/K, Heat loss = 3782,4 W
	Roof	L = 636 m, Loss = 0 W/mK, b = 1, H_t = 0 W/K, Heat loss = 0 W
Windows	Roof window	A = 197 m^2, U = 0,5 W/m^2K, H_t = 98,5 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 3152 W
	North-east facade	A = 265 m^2, U = 0,5 W/m^2K, H_t = 132 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 4240 W
	North-east groundfloor	A = 217 m^2, U = 0,5 W/m^2K, H_t = 108,5 W/K, F_f = 0,9, g = 0,5, F_c = 1 Heat loss = 3472 W
	North-east topwindow	A = 83 m^2, U = 0,53 W/m^2K, H_t = 41,5 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 1328 W
	North-west balcony	A = 53 m^2, U = 0,53 W/m^2K, H_t = 28,09 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 898,88 W
	North-west facde	A = 131 m^2, U = 0,53 W/m^2K, H_t = 69,43 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 2221,76 W
	North-west highschool	A = 18 m^2, U = 0,53 W/m^2K, H_t = 9,54 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 305,38 W
	South-east balcony	A = 79 m^2, U = 0,53 W/m^2K, H_t = 41,87 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 1339,84 W
	South-est facade	A = 121 m^2, U = 0,53 W/m^2K, H_t = 64,12 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 2052,16 W
	South-east under facade	A = 24 m^2, U = 0,53 W/m^2K, H_t = 12,72 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 407,04 W
	South-east preschool	A = 18 m^2, U = 0,53 W/m^2K, H_t = 9,54 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 305,28 W
	South-west niches	A = 143 m^2, U = 0,53 W/m^2K, H_t = 75,79 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 2425,38 W
	South-west balcony	A = 322 m^2, U = 0,53 W/m^2K, H_t = 170,66 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 5461,12 W
	South-east atrium	A = 505 m^2, U = 0,53 W/m^2K, H_t = 267,65 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss =8564,8 W
	South-west ground floor	A = 117 m^2, U = 0,53 W/m^2K, H_t = 62,01 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 1984,32 W
	South-west dancehall	A = 64 m^2, U = 0,53 W/m^2K, H_t = 33,92 W/K, F_f = 0,9, g = 0,5, F_c = 1, Heat loss = 1085,44 W
Ventilation	Classroom	A = 1660 m^2, q_m = 2,32 l/s m^2, n_{vgv} = 0,75, t_i = 18°C, $q_{i,n}$ = 0,3 l/s m^2, SEL 1 kJ/m^2, $q_{m,s}$ = 2,32 l/s m^2, $q_{n,s}$ = 5,6 l/s m^2
	Common area	A = 4453 m^2, q_m = 1,9 l/s m^2, n_{vgv} = 0,75, t_i = 18°C, $q_{i,n}$ = 0,3 l/s m^2, SEL 1 kJ/m^2, $q_{m,s}$ = 1,9 l/s m^2, $q_{n,s}$ = 3,6 l/s m^2
	Subject room	A = 1380 m^2, q_m = 4 l/s m^2, n_{vgv} = 0,75, t_i = 18°C, $q_{i,n}$ = 0,3 l/s m^2, SEL 1 kJ/m^2, $q_{m,s}$ = 4 l/s m^2, $q_{n,s}$ = 2,4 l/s m^2
	Toilet/bathroom	A = 315 m^2, q_m = 1,5 l/s m^2, n_{vgv} = 0,75, t_i = 18°C, $q_{i,n}$ = 0,3 l/s m^2, SEL 1 kJ/m^2, $q_{m,s}$ = 1,5 l/s m^2, $q_{n,s}$ = 2,3 l/s m^2
	Admin	A = 910 m^2, q_m = 1,3 l/s m^2, n_{vgv} = 0,75, t_i = 18°C, $q_{i,n}$ = 0,3 l/s m^2, SEL 1 kJ/m^2, $q_{m,s}$ = 1,3 l/s m^2, $q_{n,s}$ = 2,5 l/s m^2
Internal heat load	Heated area	A = 8479 m^2, Person load = 4 W/m^2, Appliance load 6 W/m^2, Appliance load night = 0 W/m^2
Lighting	Classroom	A = 1660 m^2, Min. Power = 3 W/m^2, Lighting level = 300 Lux, DF = 5 %, F_o = 0,8
	Common area	A = 4453 m^2, Min. Power = 3 W/m^2, Lighting level = 300 Lux, DF = 5 %, F_o = 0,8
	Subject room	A = 1380 m^2, Min. Power = 3 W/m^2, Lighting level = 300 Lux, DF = 5 %, F_o = 0,8
	Toilet/bath	A = 315 m^2, Min. Power = 3 W/m^2, Lighting level = 300 Lux, DF = 5 %, F_o = 0,8
	Admin	A = 910 m^2, Min. Power = 3 W/m^2, Lighting level = 300 Lux, DF = 5 %, F_o = 0,8
Domestic hot water	Building average	100 l/m^2/year
	Dom. Hot water temp.	55°C



kWh/m2 year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heating requirement	3,19	2,57	1,66	0,15	0,00	0,00	0,00	0,00	0,00	0,26	1,52	2,77
Incident solar radiation	0,90	1,49	2,43	3,67	4,82	4,86	4,73	4,09	2,90	1,76	0,99	0,61
Internal supplement	2,73	2,37	2,53	2,38	2,42	2,35	2,42	2,46	2,41	2,59	2,61	2,80
Utilization Factor	0,96	0,94	0,87	0,68	0,44	0,31	0,27	0,31	0,52	0,76	0,91	0,96

kWh/m2 year	Energy consumption
Excess temperature in rooms	0,00
Heating	12,10
Cooling	0,00
Lighting	7,40
El. For operation of building	12,60
Domestic hot water	5,30
Ventilators	5,20
Total	42,60



Calculation of solar cells

To meet the requirements for energy frame 2020 solar cells are establish on the roof.

- Energy balance: 5 kWh/m^2/year
- Delivered energy: $\frac{5\ \mathrm{kWh/m2/year}}{1{,}8}$ = 2,78 kWh/ m^2/year

Total energy for the entire building pr. year:

- 13647 * 2,78 = 37938,66 kWh/year

Annual energy production with solar cells:

P = C * D * E C = $\frac{A*B}{100}$ A = $\frac{P}{D*E*B}$ * 100 %

A = total area of solar cells

B = module efficiency (mono crystal, high efficiency) = 15 %

C = installed effect

D = system factor (free standing, high efficiency inventor) = 0,8

E = solar radiation (horizontal, south, 15°) = 1100

Total need of solar cells:

- A = $\frac{37938{,}66}{0{,}8*1100*15} * 100\ \%$ = 287,41 kWh/year

532,1 m^2 of solar cells are established on the roof above preschool and middle school.

Annual production with solar cells:

- C = $\frac{532{,}1*15}{100}$ = 79,8
- P = 79,8 * 0,8 * 1100 = 70237,2 kWh/year

Dilivered energy pr. m^2:

- $\frac{70237{,}2}{13647} = 5{,}15\ \mathrm{kWh/\ m2/year}$

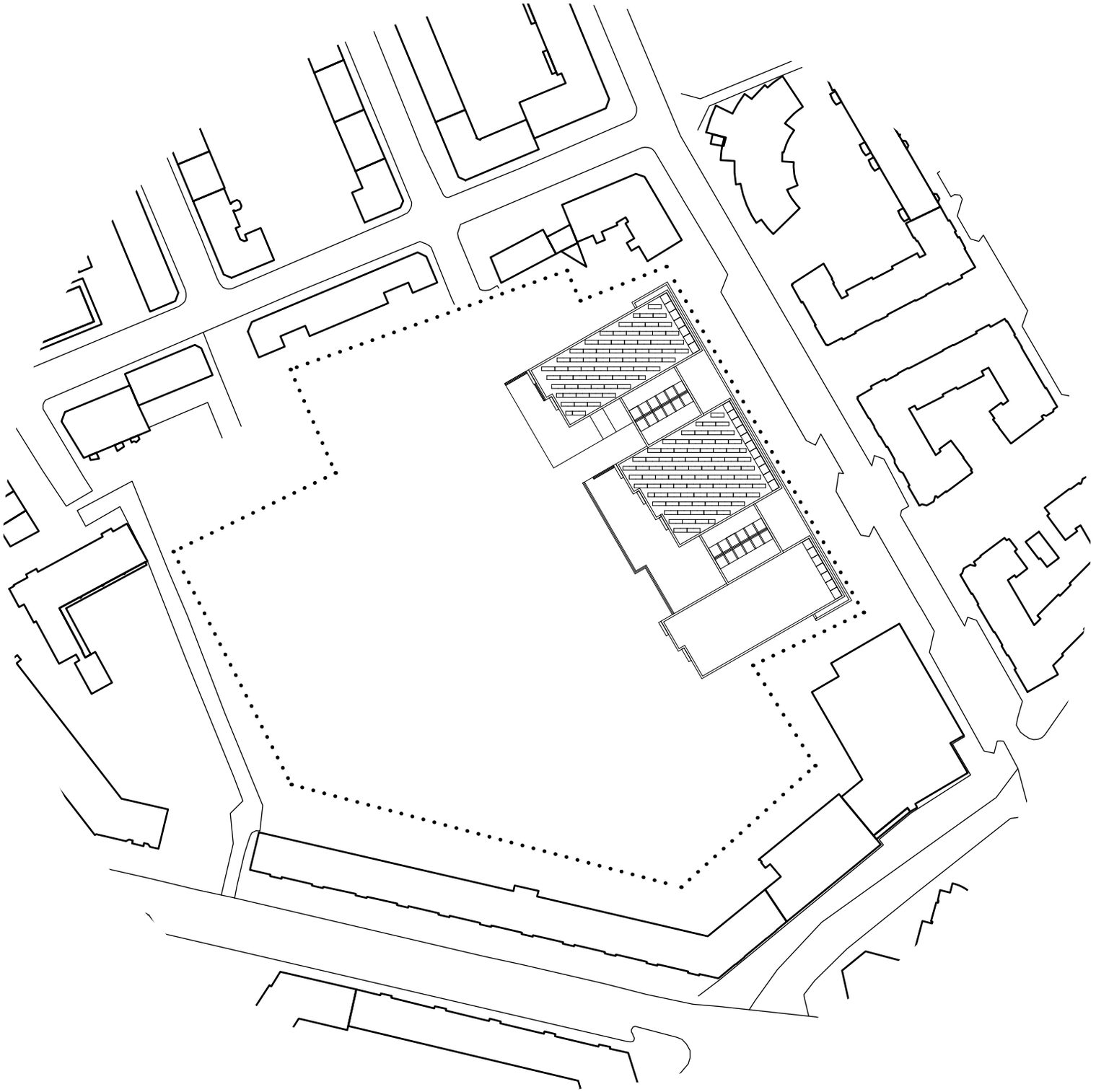
Primary enger produced:

- 5,15 * 1,8 = 9,26 kWh/ m^2/year

New energy frame:

- 30 – 9,26 = 20,75 kWh/ m^2/year

Energy frame 2020 < 25 kWh/ m^2/year



	System	Description	Control
	Equipment	Heat load = 0,9 kW Part to air = 0,9	08.00 - 16.00 (100%) 01.00 - 24.00 (25%)
	People load	**Number of people = 28**	**According to class schedule**
	Heating	Power (maximum and mimimun) = 5 kW Fixed part = 0 Part to air = 0,6 Factor = 1 Set point (day/night) = 20ºC / 17ºC Design temp. = -12^{0}C MinPow = 1 kW Te Min = 17^{0}C	08.00 - 16.00 (HeatCoolCtrl) 16.00 - 24.00 (HeatCoolCtrl Night)
	Infiltration	**Basic air change = 0,6 h^{-1}**	**01.00 - 24.00 (100%)**
	Ventilation	Supply (indput/output) = 0,6/0,05 m^3/s Pressure rise (input/output) =3/200 Pa Total effciency (input and output) =0,75 Part to air (input/output) = 1/0 Maximum heat heatrecovery =0,75 maximum cool recovery = 0 Heating coil max. Power = 0,65 kW VAV max factor = 2 Min inlet temperature = 17^{0}C Max. Inlet temperature = 25^{0}C Setpoint indoor air = 21^{0}C Setpoint cooling = 25^{0}C Setpoint CO_2 = 800 ppm Air humidity = 0,07 kg/kg	07.00 - 24.00 (VAVCtrl)
	Venting	**Air change (maximum single-sided)**	**07.00 - 16.99 (VentingCtrl Summer)**