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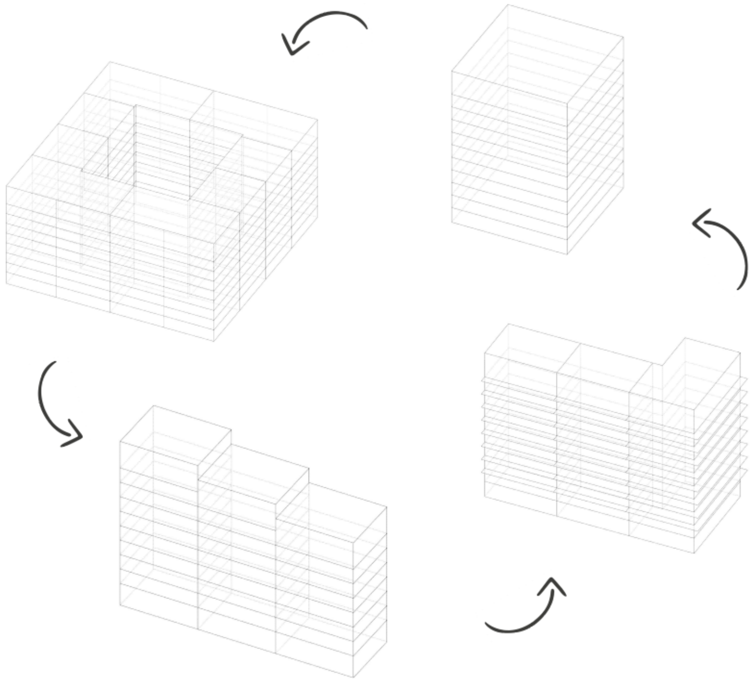

Implementation of Building Performance Simulations (BPS) in the Swedish detailed development plan process

Master's thesis in Master Program Structural Engineering and Building Technology

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Master's thesis ACEX30
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Cover: The figure shows different design options from the case study. The illustrations are done by Amanda Markgren.

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Abstract

It has in previous research been shown that by performing energy and indoor climate analyses in early-stage design, it may result in better performance of the building in terms of energy use and indoor climate as well as resource efficiency.

A case study have been performed with a detailed development plan (DDP) of an area in Gothenburg with an almost equal mix of residences and premises as the reference case. Alternative design options of the site plan were considered such as different type buildings, Window-to-Wall ratios (WWR) and the option of having external corridors or not while maintaining similar total floor area.

The study showed a good correlation between the shape factor (SF) of the building and the transmission losses, where a low SF is advised to minimize the energy use for heating.

The purpose and goal of this Master's thesis have been to investigate whether implementation of Building Performance Simulations (BPS) could contribute in even earlier stages than been studied before. In addition, it has been investigated if studies of energy and daylight could be a positive supplement to current studies in the DDP process.

Even though energy assessment could be challenging in early stage due to lack of details, results from the case study in this master thesis shows that studying the two aspects building shape (SF) and proportion of window in comparison to wall area (WWR) could be a positive contribution when comparing different options in the initial stage of building design. DDP:s shouldn't encourage to building shapes that in later stage can't be implemented is a step against a more efficient building design process. BPS in early stage could be one way towards reaching the European Union (EU) goal; that all building constructed after 2020 shall be near zero energy buildings.

Keywords: early-stage building design, shape factor, Window-to-Wall ratio, Vertical Sky Component, daylight, energy, BeDOT, Building Performance Simulations, BPS, Detailed Development Plan

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Sammanfattning

Det har i tidigare studier visats att genomförande av energi- och inomhusklimatssimuleringar i tidigt skede kan resultera i bättre byggnadsprestanda avseende energianvändning, inomhusklimat och resurseffektivitet.

En fallstudie har genomförts på en detaljplan i Göteborg där hälften av golvarean är bostäder och den andra hälften består av lokaler, vilken har använts som referensfall. Alternativ design av detaljplansområdet har tagits fram i form av olika typbyggnader, varierande fönsterandel samt med loftgångar som alternativ samtidigt som en total lika stor golvarea har eftersträvats.

Studien visade en god korrelation mellan formfaktor och transmissionsförluster för byggnaden, där en låg formfaktor är att föredra för att minimera energianvändning för uppvärmning.

Syfte och mål med studien har varit att undersöka huruvida implementering av simulering rörande byggnaders prestanda skulle kunna vara ett bidrag i tidigare skeden än vad som tidigare studerats. Dessutom har det undersökts om studier av energi och dagsljus kan vara ett positivt tillägg till nuvarande studier i detaljeplaneprocessen.

Trots att det kan vara en utmaning att bedöma energiprestandan i tidigt designskede med tanke på bristen på detaljer så visar den genomförda fallstudien att studier av de två aspekterna formfaktor och fönsterandel kan vara ett positivt bidrag i jämförelsen av olika alternativ i det initiella designskedet. Att detaljplaner inte skall uppmuntra till byggnadsformer som senare inte är möjliga att implementera är ett steg mot en mer effektiv byggdesignprocess. Simulering av byggnadens prestanda rörande energi och dagsljus i tidigt skede skulle kunna vara ett steg i rätt rikting mot att nå EU:s mål om att alla byggnader byggda efter 2020 skall vara nära-nollenergibyggnader.

Nyckelord: tidigt skede, formfaktor, fönsterandel, VSC, dagsljus, energi, BeDOT, BPS, byggnadsprestanda, detaljplan

Acknowledgements

This Master's thesis has been carried out in a collaboration with Chalmers University of Technology, Bengt Dahlgren AB and Skanska AB from January to June 2020.

We would like to address a special thanks to our supervisors at Chalmers University of Technology, Bengt Dahlgren AB and Skanska AB; Angela Sasic Kalagasidis, Max Tillberg and Nicklas Karlsson. Your help, guidance, insight and supervision helped us carry out this Master's thesis to its final form.

In addition, we would like to address our gratitude to the interviewed at The Urban Planning Department of Gothenburg as well towards Skanska for your answers and perceptive knowledge.

Julia Andersson & Sara Jonsson, Gothenburg, June 2020

Contents

List of terms and abbreviations

AF-method	The Area-Window Method
BDAB	Abbrevation of the company Bengt Dahlgren AB
BeDOT	The Building Early-stage Design Optimization Tool
BBR	Boverket's Building Regulations
BPS	Building Performance Simulation
BTA	Building gross area
CAD	Computer-aided design
DDP	Detailed Development Plan
DF	The Daylight Factor
e	Exploitation number
EPBD	The European Performance Building Directive
EU	European Union
IEQ	Indoor Environmental Quality
PBL	Planning and building act
RSF	Relative Shape Factor
SVF	Sky View Factor
SF	Shape Factor
SSNC	The Swedish Society for Nature Conservation
U-value	Thermal transmittance
VPL	Visual Programming Language
VSC	Vertical Sky Component
WFR	Window-to-Floor Ratio
WWR	Window-to-Wall Ratio
2D	Two-dimensional
3D	Three-dimensional

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1
INTRODUCTION

This chapter presents the purpose, background, aim, limitations and method for the thesis. Two research question that the master thesis shall answer is also presented. The introduction aims to help the reader understand the context of the master thesis work.

1.1 Background

The construction industry is continuously aiming for high performing buildings in terms of energy and indoor environmental quality (IEQ) as the requirements regarding these have raised throughout the years. Conventionally, energy assessments through building performance simulations (BPS) are usually not implemented in the early stage of the building process which may result in conflicts with the goal of optimized buildings as the design may be limited by already locked parameters defined in the early stages.

The development of the Building Early-stage Design Optimization Tool (BeDOT) was carried out in 2018 by Giovana Fantin do Amaral Silva and Ramón Bergel Gómez during a master thesis in cooperation with Chalmers University of Technology and Bengt Dahlgren AB. In 2019, Linda Wäppling and Ona Forss continued to develop the tool, also within a master theses that aimed to integrate building performance with architectural modelling. BeDOT is a BPS-tool intended for early stages and is today embedded within the three-dimensional (3D) modelling environment Rhinoceros. It aims to enable collaboration between energy engineers and architects, even though it is also striving to be used without the need of engineers involved.

Bengt Dahlgren AB have used BeDOT for detailed analyses in early stage, when the detailed development plan (DDP) is already defined, together with architects and the developer. It was estimated that the theoretical cooling and heating energy could be reduced by 15-20% compared to initial proposals without having any negative effects on the thermal comfort and daylight condition. There is therefore a need to validate this hypothesis by study representative design cases.

This master thesis is carried out in collaboration with the master thesis of Amanda Markgren. Markgren is doing a master thesis within the field of architecture and project management and will investigate on a wider scale how the architecture's role may be affected by an implementation of BeDOT at even earlier stage than what have been studied before. Markgren will also investigate how BPS in early stage can contribute to new perspectives to the construction industry.

1.2 Purpose and aim

The purpose with this master thesis is to validate if the energy use can be reduced when energy assessments are implemented earlier than what is usual to do today. If so, the level of impact will be investigated with a number of case studies where the building types and conditions vary. The purpose is also to investigate if daylight conditions could be improved if performing BPS early.

To be able to perform the case study, further development of BeDOT is required where one of the main tasks is to be able to include multiple buildings in the same simulation. Therefore, a continuation of developing the tool is also part of the purpose with the master thesis work.

In addition, the master thesis aims to contribute with knowledge about choices that affect energy use for city planners, property developers, architects and energy engineers. It also aims to conclude the different stakeholders perspective within the subject.

Two research question that the master thesis work wants to answer is presented below.

1.3 Research questions

- Can implementation of BPS regarding energy and daylight be advantageous in the earliest stage of building design?
- Can studies of energy and daylight be a positive supplement to the current studies in the DDP process?

1.4 Method

The practice of the master thesis work is decomposed and described in the sections below. The master thesis included a literature study, interviews, development of BeDOT and a case study. The outcome of these were then summarized and analyzed.

1.4.1 Literature study

This literature study begun with a study of previous master thesis work within the field of BeDOT. This to get an understanding of the tool and get an idea of have been done earlier. Information about the Swedish building process and the DDP process were studied as well as the early stage design process. Keywords when searching for relevant information were for instance *BPS*, *Building Performance Simulation*, *early stage design*, *Swedish building process*, *Detailed Development Plan* and *energy performance buildings*.

1.4.2 Interviews

The literature gathered necessary information that helped assemble relevant questions to include in the interview study and also to state stakeholders of interest. A number of these were contacted and handed an inquiry. Conversations with the participants were also included in addition to the inquiry.

1.4.3 Development of BeDOT

The development of BeDOT included a reorganization of the program that enables simulations of multiple buildings where the results are presented per building. Furthermore, calculation of linear thermal bridges and a rough ground model were implemented.

1.4.4 Case study

A case study was performed based on the theory gathered during the literature study and the interviews. The case study was carried out in order to help answer the research questions stated.

1.4.5 Analysis and parameter study

The results from the case study was gathered and the final results summarized. Based on this, conclusion were drawn based on the knowledge gained from the theory, interviews and case study.

1.5 Limitations

The study is concentrated to Sweden with the city of Gothenburg as main focus. Other climates than the one belonging to the mentioned is not part of the master thesis.

The master thesis focus on environmental sustainability and the impact on economical and social sustainability will not be studied in detail.

2
INVENTORY OF AREA

This chapter presents the result of the literature study in order to explain the building- and early design process today. Parameters influences the daylight condition and energy performance is also summarized.

2.1 The building process

According to the Planning and Building Act (PBL), the building process through the public law perspective begins when permission to build has been granted or after an application to build have been submitted (Boverket, 2019c). From a property developer perspective it begins earlier; at the point when the developer establish an idea to build. The building process could differ from case to case but generally the stages included in the Swedish building process are:

- **Pre study:** identification and specification of goals, risks and challenges within the specific project to be able to decide whether to go further with the project or not. The different disciplines needed for the specific project are identified whom will investigate and highlight relevant information about the different areas of interest
- **Program:** if the project is worth investing in, further investigations about the building, for instance geometry and technical details, are stated
- **Detail design development:** different disciplines within engineering together with architects work together to develop drawings for floor plans and solutions for technical systems
- **Construction:** the building is constructed
- **Administration:** maintenance and operation of the building

To be able to build, the developer needs a building permit which only can be applied for if there is an existing DDP for the specific site (Boverket, 2014a). If there is not, the developer must apply for a planning notification by handing in documents presenting which kind of building the developer have in mind. This could be presented in sketches showing intended volume and positions (Göteborg Stad, 2019). The municipality do an investigation whether the planned building is feasible or not and if it is; put together a DDP that the developer must adjust to. A more detailed description of the DDP can be found in the upcoming section regarding the DDP process. If there is already a DDP on a site, the developer can apply for building permit directly by handing in building permit documents.

2.2 The detailed development plan (DDP)

The developer needs permission for new housing estate in Sweden according to the Planning and Building Act (PBL) determined and accepted by the municipality (Sveriges Riksdag, 2020). If the developer decides to go further with a project after investigating what to build, the position the building and for which target group the building is meant for, there is either a DDP to adapt to or if not; the developer hands in an application to the municipality to establish a DDP. This is called applying for planning notification. The DDP contains three main parts:

- Planning description
- Implementation description
- Plan map with description

The purpose of the content in the DDP is to clarify what and how to build on the site and the municipality regulates the use of land and water through it (Sveriges Riksdag, 2020). The DDP must consist a map of the planned area and the regulations to which it is subject of. Height and property boundary are two of the regulations.

The DDP process differs depending on whether the municipality initiate a DDP without any developers involved or the developer owning the site and want to build on it (Boverket, 2014a). In those cases the developer have an idea and have gone through the pre study phase and stated that the idea is worth go further with, a program containing brief information about what to build are put together by the developer. The developer then applies for planning notification at the municipality, who investigate and evaluate whether the proposal is consistent with the comprehensive plan. The comprehensive plan is the municipalities overall plan that refer to the the whole area owned by the municipality. If the planning notification is approved, the process of producing a DDP for the site begins. This process contains different investigations related to the specific site and when a final proposal for a DDP is completed, the DDP is exhibited for feedback from different stakeholders. The developers further proposal, which will be handed in when applying for building permit, have to adapt to the DDP. Either the first proposal or an adapted one after feedback. If the municipality initiate a DDP, the process is similar but their is no application for planning notification.

2.2.1 Supplementary programs

When major parts of a city are up for development, or many stakeholders are affected, it can be advantageously with a program complementing the DDP (Boverket, 2014b). The programs could for example contains illustrations and details that help strengthen the municipalities visions.

The supplementary programs could for example be a quality program or an aesthetic design program (Rönn, 2019). The purpose of a quality program is to investigate the qualities of a site and how to strengthen these (Boverket, 2017). The aesthetic design program aim to encourage well thought architecture and could be common for many different DDPs.

2.3 Regulations and demands

There are several laws and regulations to adapt to regarding buildings in Sweden. Some of these are described below.

2.3.1 Building demands due to the Planning and Building Act (PBL)

The Planning and Building Act (PBL) regulates use of water, land and also how to build in Sweden (Sveriges Riksdag, 2020). The puropse of the law is to promote a well working build environment that takes into consideration not only the society and environment today, but also the future ones. There is many technical characteristics that a building need to address according to PBL. The properly shall for instance be compatible with its purpose and some of the technical demands are stated below:

- Bearing capacity, steadiness and durability
- Safety in case of fire
- Safety in use
- Protection against noise
- Energy conservation and thermal insulation
- Suitability for the intended purpose
- Accessibility and usability for people with reduced mobility or orientation
- Husbandry with water and waste
- Broadband connection

The property shall not only meet all the technical demands and be suitable with regard to its purpose. Appropriate and good shape together with colour and material choices is also mentioned as requirements. These aspects among others are evaluated when a developer applies for building permit.

2.3.2 The European Performance Building Directive (EPBD)

The European Union (EU), which Sweden is a member of, has put together a directive called European Performance Building Directive (EPBD) that aims to contribute towards the goal of all building constructed after 2020 being near zero energy buildings (NZEB) (European Union, 2018). This is one step in right direction against energy efficiency in the construction industry.

All members of the EU have their own national directions on how to reach the goal for NZEB and also their own national definitions of the term. EPBD defines a NZEB as a very high energy performing building using energy provided in high extend from renewable sources produced on site or nearby.

NZEB is one step against a more sustainable building stock. Sustainability is complex and is not only about the environment but about economical and social sustainability as well (Akadiri, Chinyio, & Olomolaiye, 2012). A sustainable project considers all these three and improve building design to achieve energy efficiency is an opportunity to decrease the environmental impact and at the same time save money which is relevant as the economy is always present in a project.

2.3.3 Energy demands in Sweden

Laws and recommendations regarding building performance in Sweden aim to limit energy use and the requirements regarding energy have increased with the awareness of the negative environmental impact from the construction industry (Naturvårdsverket, 2019). Due to Boverket's mandatory provision (BBR), new buildings have to fulfill demands regarding (Boverket, 2018):

- The building's primary energy number (EP_{pet}): Describes the building's energy performance. the primary energy number is comprised of the building's energy use where energy for space heating has been corrected with a geographical adjustment factor (F_{geo}), multiplied by a primary energy factor for energy carriers (PE_i) and distributed over the A_{temp}
- Installed electric input for heating: the total electric input power that is needed for heating to maintain the intended indoor climate, hot tap water production and ventilation when the building's maximum heat demand exists
- Average thermal transmittance (U_m): the average heat transfer coefficient for building components and thermal bridges
- Average air leakage rate: the air leakage of the thermal envelope

2.3.4 Daylight demands due to Boverket's mandatory provision (BBR)

When calculating the daylight factor (DF), the DF has to be at least 1.0% due to BBR28 for spaces where people are present more than just temporary (Eriksson & Waldenström, 2016). This demand considered both residences and premises. When study a room, a point positioned 0.8 m above the floor level with a distance on 1.0 m from the darkest wall is calculated. The daylight conditions could also be determine by hand using the AF-method. Regarding the AF-method, figure 2.1 states what is written in BBR28.

6:322 Daylight

Rooms or separable parts of rooms where people are present other than occasionally shall be designed and oriented to ensure adequate access to direct daylight is possible, if this does not compromise the room's intended use.

However, in common spaces according to Section 3:227, access to indirect daylight is sufficient. *(BFS 2016:6)*

General recommendation
For calculation of the area of the window glazing, a simplified method according to SS 91 42 01 can be used. The method applies for room sizes, window glazing, window placement and shielding angles according to the standard. When used, a general figure for the window glazing area in the room should be at least 10 % of the floor area. It entails a daylight factor of approximately 1 % if the conditions of the standard is met. For rooms with other conditions than those specified in the standard, the window glazing area can be calculated for the daylight factor 1.0 % according to the standard's annex. *(BFS 2014:3)*.

Figure 2.1: Demands regarding the AF-method, BBR28 (Boverket, 2019b)

2.4 Energy

This section presents a summary of why energy is relevant to consider together with a summery on which way energy is used in buildings.

2.4.1 Environmental impact

Energy is not only a matter of cost but also about use of nature resources (Naturskyddsföreningen, 2019). Use of energy is one of the most relevant issues when it comes to limit the impact on earth and the ongoing critical climate changes (Naturvårdsverket, 2019). Of the total greenhouse emissions globally, around 25% are result from the heat and electricity production if looking at the total use and not just the construction industry. In Sweden, the construction industry contributes to 40% of the total energy use and stands for 20% of the total greenhouse emissions. Looking at the EU, the contribution from buildings are 36% of the total carbon dioxide emissions and 40% of the total energy use (European Union, 2020). Depending on energy carrier, the environmental impact varies where renewable energy have less impact compared to fossil fuels. But important to have in mind is that not all renewable energy is sustainable and today, almost all energy produced have a negative impact in one way or another (Naturskyddsföreningen, 2019).

The Swedish Society for Nature Conservation (SSNC) argue for that there is a distinction between renewable and sustainable. Renewable energy must not necessary be sustainable and because of this, SSNC recommend that all energy produced in the future shall be 100% sustainable (Naturskyddsföreningen, 2019).

2.4.2 Energy use of buildings

All buildings consumes energy where the amount depends on a number of different aspects (Boverket, 2018). Some of these are:

- Transmission losses through the thermal envelope
- Heat losses due to thermal bridges
- Ventilation losses
- Hot tap water use
- Weathering losses
- Air leakage through the thermal envelope
- Distribution losses of heating and cooling
- Warm water circulation (VVC) losses
- Electricity for running fans in the ventilation system
- Facility energy for running elevators and outdoor lightning other for instance

Among the mentioned above, some of these are geometric dependent and inhere to the size and type of thermal envelope and some of these are activity based and depends on type of activity and position of these.

2.5 Daylight

A summary of aspect influencing daylight and why daylight is important to consider are presented in this section together with the daylight demands in Sweden today due to BBR28.

2.5.1 Health impact

Research indicates that people may experience negative impacts on their mental health in case of lack of daylight (Folkhälsomyndigheten, 2017). In parts of Sweden, access to daylight is restricted during winter time and studies shows that depression related to this is an issue. As mental and behavioral variations is connected to the daily cycle of dark and light hours, daylight issues may have negative impact on human well being.

2.5.2 Aspects affecting the daylight

Daylight is non geographic depending, independent of the level of cloudy sky and takes into consideration both the direct and indirect daylight (Boverket, 2018). Aspects affecting the amount of daylight hitting the facade are surrounding topology, distance to buildings around and the height and width of these (Eriksson, Waldenström, Tillberg, Österbring, & Kalagasidis, 2019). When it comes to daylight indoors, amount, size and form, position and characteristics of windows have impact. The shape of the room also influence where deep rooms with low reflective interior finishes will have difficulties to achieve good daylight compared to rooms with thinner volumes and high reflecting surfaces.

2.5.3 Methods for examine daylight

There are several different methods to evaluate the daylight. Some of these are described below.

2.5.3.1 The Area-Window method (AF-method)

The area-window method (the AF-method) is a hand calculation method possible to use when the angle between the top of the nearby building and the middle of the window studied, called the obstruction angle, is less than 30° (Eriksson & Waldenström, 2016). The AF-method have been evaluated and stated as less suitable for dense cities.

2.5.3.2 Sky View Factor (SVF)

The sky view factor (SVF) is the ratio of the amount of sky incident from a perspective on a surface and the amount that would be viewed from the whole hemispheric environment around that point (Jacobsson & Eriksson, 2017). The method is cosine weighted and based on a uniform sky.

2.5.3.3 Vertical Sky Component (VSC)

The vertical sky component (VSC) is a measure of the amount of sky visible from a given point on a vertical surface and is expressed in percentage (Jacobsson & Eriksson, 2017). It is simulated using an CIE overcast sky.

2.5.3.4 The daylight factor (DF)

The daylight factor (DF) is the difference between the illuminance on a point inside compared to the illuminance available simultaneously outdoor (Eriksson & Waldenström, 2016). The results is presented in percent, meaning that if the DF is 2.0 %, the illuminance indoor is 200 and outdoor 10,000. The DF takes into account reflected daylight, which isn't the case with SVF and VSC. When calculating the DF, an CIE Overcast sky is used and important to mention is that DF is independent of time and position in the world. The room geometry must be known to be able to determine the DF. Eq.2.1 below is used to calculate the DF.

$$DF = \frac{Illuminance_{indoors}}{Illuminance_{outdoors}} \times 100 \qquad [\%] \qquad (2.1)$$

2.6 Building design

This section presents building design in early stage and which design strategies cold be implemented to improve the energy performance.

2.6.1 Sustainable building design in Gothenburg

"Building shape shall promote low energy consumption" is stated as a quality demand in the built city of Gothenburg and it is related to the impact buildings have on the environment (Göteborg Stad, 2008). Achieve a high exploitation number (e) by high density and high buildings must be evaluated and weighted against the impact on the existing buildings when continuing develop the city. The same level of exploitation can be achieved by combining different building shape. The city scale is an outcome of the combination of building heights, size of blocks, width of streets etc. and the city density is related to degree of exploitation and in which way the site is exploited.

2.6.2 The energy efficiency stair

There are different design strategies when design for energy efficiency. One of these is the energy efficiency stair called the Kyoto pyramid which could be adapted in Nordic climates. The Kyoto pyramid is illustrated in figure 2.2.

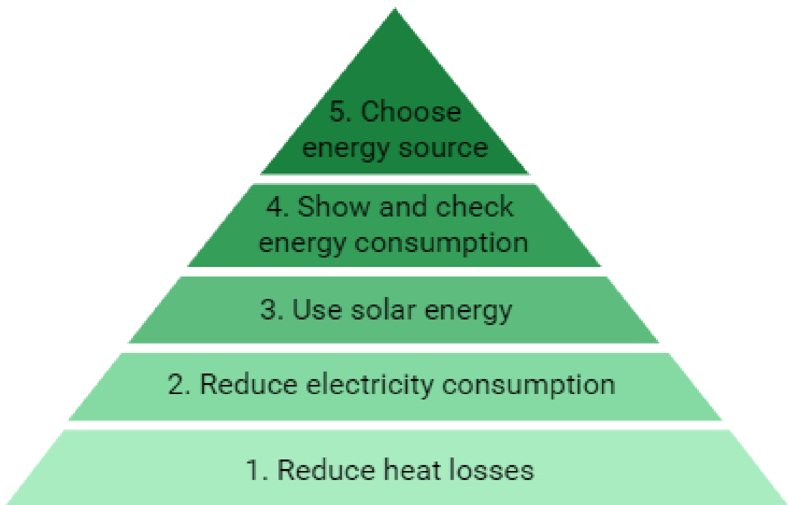


Figure 2.2: The energy efficiency stair, adapted from (Danebjer, 2012)

Strategies to reduce space heating is to build air tight buildings with well insulated thermal envelope, minimized level of thermal bridges and complement this with high performing installations such as heat recovery system (Berggren & Wall, 2013). Reduce transmission losses is also of great importance. More details regarding energy use reduction are presented in more detail below.

2.6.3 Early stage design

The final performance of a building is affected by the initial choices regarding design that are affected by restrictions in the DDP (Wäppling, 2019). If aiming to certify a building, studies indicate that the most early design choices will determine if it is possible or not (Han, Huang, Zhang, & Zhang, 2018).

Involved in early stage design is many different disciplines and for a successful result, they need to collaborate (Wäppling, 2019). Interviews shows that time and economy are two important aspects when it comes to the developers decision about including a engineer in early stages of the design process or not. In cases where a engineer were involved there are many examples with positive outcome due to performing and presenting analyses of matters like daylight and risk for overheating.

In 2019, work load for energy and daylight assessment at different design stages were studied at the company Bengt Dahlgren AB (Wäppling, 2019). In general, when not implementing simulations in early stages, the workload increase in later stages and consequences could be difficulties to fulfill requirements set in the project related to laws, environmental certification systems or the developer. By involve BPS more frequency in the early stage, the overall expression is an opportunity to create better performing buildings from the start which could increase time efficiency and reduce costs.

2.6.4 Design strategies

Decisions about building shape, orientation, construction materials and proportion of glazing on each façade can be taken very early in the design process (Elbeltagi, Wefki, Abdrabou, Dawood, & Ramzy, 2017a). In early stage design, big measures for energy reduction can be accomplished and it is therefore convenient to include energy assessments at this stage. At the early conceptual design phase, little may be known and the model and simulation process should therefore be as simplified as possible. As the detail level at this stage often is low, one simple thermal mass model may be sufficient. A parametric study at the early conceptual design phase should include orientation, building shape, building envelope, glass properties and HVAC options.

Passive strategies are of important consideration when planning building design (Fitzgeralg, McNicholl, Alcock, & Lewis, 2001). For residential buildings in northern latitudes, large glazing areas on the southern façade and small glazing areas in the north may reduce the heating load during winter-time considerably. By optimizing the shape and orientation of the building, the energy demand may be reduced by up to a half in such climates compared to the initial design. For non-residential buildings there may instead be a risk for overheating with large glazing areas. Solar shading may help to prevent these issues on south façades but may be more difficult to do effectively on east and west façades. However, overshadowing should be reduced during the most important hours of the heating season and therefore the position of buildings shall be chosen wisely. To avoid unfavourable overshadowing, taller buildings should be placed to the north to avoid overshadowing of the lower buildings.

The following subsections refer to three important parameters that have impact on the energy demand and are also usually set early in the design process; the building shape, window area and orientation of windows and the building itself. As the case study is concentrated to Gothenburg, the information has to a large extent been obtained from studies based on simile climates. Gothenburg is according to the Köppen climate classification of humid continental climate (Dfb) (Arnfield, 2020).

2.6.4.1 Building shape

Depecker, Menezo, Virgone, and Lepers (2001) qualified the shape of a building as the shape coefficient or shape factor (SF) which depicts the compactness of a building. The SF is described as the ratio between the total external surface (S_i) and the building's internal volume (V), as shown in Eq.(2.2) below. The smaller the ratio, the more compact building shape there is.

$$SF = \sum \frac{S_i}{V} \qquad [m^2/m^3] \qquad (2.2)$$

A large shape coefficient implies that the shape has a relatively large surface exposed to the exterior environment. For a residential building, where the outdoor temperature can be seen as directly correlated to the energy demand, the exterior surface should be as low as possible. Consequently, a low shape coefficient is preferable for such cases (Granadeiro, Correia, Leal, & Duarte, 2013).

Depecker et al. (2001) found that the shape coefficient has a good correlation to the energy demand when it comes to cold climates. However, in mild and sunny climates it is a rather unsuitable measure due to the fact that the solar gains in winter can make up for the heat losses through windows.

Danielski, Fröling, and Joelsson (2012) investigated the influence of the SF on the specific heat demand for residential buildings for four cities in Sweden. It was found that the thermal envelope properties and climate conditions have a large varying impact. In areas with higher average wind speed, the impact of an increasing shape coefficient have a larger impact compared to areas with a lower average wind speed. It was also found that a lower annual temperature and increasing U_m have a larger impact of the SF and on the specific heat demand.

Rodrigues, Amaral, Rodrigues Gaspar, and Gomes (2015) investigated how well a number of geometry-based indices correlates to energy consumption for different representative climates in Europe. One of the indices is the Relative Shape Factor (RSF) which is described as the fraction between the fraction of the volume (V) of the building and the surface area (S) and the fraction of a reference volume (V_r) and reference surface area (S_r), as shown in Eq.(2.3) below.

$$RSF = \frac{V/S}{V_r/S_r} \quad [-] \quad (2.3)$$

As the cube is the most dense and orthogonal shape conceivable, it is suitable to use as the reference shape. Eq.(2.3) can then be elaborated as Eq.(2.4) seen below.

$$RSF = \frac{6V^{2/3}}{S} \quad [-] \quad (2.4)$$

One benefit of the RSF index is that it is only dependent to the shape and is not influenced by the size of the building. The case study of a residential building in Helsinki, which has a Dfb Köppen climate classification, showed that it has a very strong negative correlation to two- and three-storey buildings and a weak negative correlation to single-storey buildings. This indicate that the number of degree-hours of thermal discomfort in the building will decrease with increasing RSF index. Both the SF and RSF index relates to the building volume, but do not consider window openings (Rodrigues et al., 2015). This will be further elaborated in the next subsection.

2.6.4.2 Proportion of window area

Glazing areas have themselves a large impact on the energy balance. Windows enable solar gains which in turn affects the heating and cooling energy use. In general, glazing areas have larger heat losses compared to walls which impacts mostly the heating use in a negative way. But why we implement windows at all is probably above all to provide views and daylight for the building which also can reduce the energy use for artificial lightning (Goia, 2016).

There are multiple ways to express the amount or proportion of windows in a building. A general guideline regarding window area according to Boverket (2019a), the Swedish National Board of Housing, Building and Planning, is that it should be around 10% of the floor area to meet the requirement of 1% DF. The Window-to-floor ratio (WFR) is expressed by Eq.(2.5) below.

$$WFR = \frac{A_{windows}}{A_{floors}} \quad [-] \quad (2.5)$$

The WFR index is somehow related indirectly to the building's volume, if the height of each building is identical. However, the WFR is only related to the window area and the heat exchange of the exterior wall, roof, slab etc. is not taken into account (Rodrigues et al., 2015).

Another common way to express the proportion of windows is the window-to-wall ratio (WWR), as can be seen in Eq.(2.6) below. It is often denoted for each orientation of the building. However, the WWR index does not consider the building shape as it is only surface dependent (Rodrigues et al., 2015).

$$WWR = \frac{A_{windows}}{A_{walls}} \qquad [-] \qquad (2.6)$$

For the case building in Helsinki within the research of Rodrigues et al. (2015), it was found that the WWR had a weak negative correlation to a single-storey building. Méndez Echenagucia et al. (2015) did a multi-objective search for early-stage design approaches with the aim to minimize energy need for heating, cooling and artificial light. The study strived to find optimized WWR for an open space office, positioned on the first floor of a five-storey building for different climates in an urban and sub-urban context. The number of windows, the position of these, shape and type and thickness of the walls were varied without changing the U-value. The study investigated the cities Palermo, Torino, Frankfurt and Oslo in order to cover typical European climate types. Oslo has, like Gothenburg, the Köppen climate classification Dfb.

The results from the parameter study of the WWR for reducing energy use were visualized by a box plot. The readings from it regarding the case of Oslo are presented below in table 2.1 and 2.2.

Table 2.1: Oslo sub-urban context, WWR design variables and box plot results retrieved from Méndez Echenagucia et al. (2015)

Orientation	Range between the 1st-3rd quartiles	Median of distribution
South	0.07 – 0.48	0.3
East	0.05 – 0.29	0.11
North	0.05 – 0.27	0.12
West	0.05 – 0.25	0.10
Total	0.06 – 0.29	0.19

Table 2.2: Oslo urban context, WWR design variables and box plot results retrieved from Méndez Echenagucia et al. (2015)

Orientation	Range between the 1st-3rd quartiles	Median of distribution
South	0.18 – 0.53	0.33
East	0.05 – 0.16	0.10
North	0.04 – 0.13	0.08
West	0.05 – 0.25	0.10
Total	0.10 – 0.25	0.15

Some of the key-findings from Méndez Echenagucia et al. (2015) are the following:

- When comparing the urban and sub-urban context, adjacent buildings do not affect daylight significantly but solar gains from direct solar radiation would decrease
- The total window area decreased for Oslo for the urban context compared to the sub-urban, while it tended to increase for the other cities
- The urban and sub-urban context have a resembling spread but the median of the WWR of the south facing wall increased a little for the Oslo case, this was not the case for the other cities
- It is more changing to shade with overhangs in cities at high latitudes as the sun-path is lower, resulting in that the optimized case for cooling has no windows facing south
- Walls with low U-values have a lower optimal WWR, compared to walls with higher U-values
- The range of the WWR on the south oriented wall is large for all cities which indicates that it is not critical

Goia (2016) did a similar early-stage study by investigating low-energy office buildings that has high performing HVAC-systems, integrated solar shading and lightning equipment to find optimal WWR values for four representative case studies with different climate classifications in Europe. The considered cities were Oslo, Frankfurt, Rome and Athens. The resulting optimized WWR regarding energy use for heating, cooling and artificial lightning are presented in table 2.3 below.

Table 2.3: Optimized WWR with respect to energy use. Values are retrieved from Goia (2016)

Orientation	Optimal WWR
South	0.56
North	0.40
West	0.40
East	0.41

Some of the key-findings from Goia (2016) are:

- For the south facing façade for the Oslo case, WWR values between 0.50-0.60 give similar total energy use
- The resulting optimized values for the Oslo case give satisfactory daylight. The largest increase in daylight lies between WWR values of 0.20-0.35
- For buildings located in colder climates (Dfb and Cfb), an inappropriate value for WWR are not as critical compared to warm climates
- By integrating solar shading systems, the WWR are more evenly distributed over the different oriented façades which contradicts the traditional rule-of-thumb of placing small windows towards north and larger windows towards south

- HVAC efficiency for the heating and especially regarding the cooling system can have a meaningful impact on the optimal WWR value. Different HVAC solutions may then be important to evaluate as it is not always determined at an early-stage design
- Energy use for cooling increases the more compact building there is and a lower value of WWR should then be used

2.6.4.3 Building orientation

Vasov, Stevanović, Bogdanović, Ignjatović, and Randjelović (2018) did a parametric analysis to investigate the impact of the orientation and building envelope for a three-storey office building in Serbia. The Köppen climate classification for the area is Cfb. The considered parameters were building orientation, U-values for windows, walls and roof and the parapet height of ground floor windows. The WWR were 0.68.

Results shows that optimized choice of parameters could reduce the heating demand by 52.18% and cooling demand by 62.19%. By having the largest area of windows towards south, the largest reduction of heating energy can be achieved. For the cooling energy demand, the best measures comprise raising the parapet of the windows as well as avoiding exposure of direct solar radiation by considering the building orientation. For the combined energy use, including both heating and cooling, a rotation of ±15 % towards southeast or southwest from a south orientation can decrease the heating demand by 13.73% and cooling demand by 13.26%.

2.7 Building Performance Simulations (BPS)

Using simulation tools for building performance during design could contribute to a more iterative process (Elbeltagi, Wefki, Abdrabou, Dawood, & Ramzy, 2017b). BPS tools can help in the decision making process to find the most suited design and building shape that takes into consideration energy, daylight and other properties within the specific project. Today there are many tools available on the market with a range of different opportunities for the users and which varies in degree of advancement (Ursula Eicker, 2019). Which simulation tool appropriate for a project is depended on level of detail for instance.

2.7.1 Black-, white- and grey box modelling

When performing energy assessment, the white-, gray- and black box are often mentioned (Fantin et al., 2018). These three terms are test methods and classified with regard to variation in simulation time, transparency of source code and degree of knowledge of the user (Infosec, 2019).

The methodologies differ in time consumption where black box often is the least time consuming method and white box the most (Mohd. Ehmer & Farmeena, 2012). But when it comes to the transparency of source code, the white box is the method with the highest transparency and the black the least.

In white box modelling, the user have full access to the source code which demands a certain level of knowledge (Mohd. Ehmer & Farmeena, 2012). The method is time-consuming but one advantage is that it provides opportunities to review the code and discover errors. The method demands high level of detailing though which can be challenging. Opposite to white box where user have access to the code, the black box model do not provide access to code and the programmer and tester is often independent of each other (Fantin et al., 2018). Grey box could be described as a combination with the advantaged from both the white and black box technique (Mohd. Ehmer & Farmeena, 2012).

2.7.2 BeDOT

The Building Early-stage Design Optimization Tool (BeDOT) were developed in 2018 by Giovana Fantin do Amaral Silva and Ramón Bergel Gómez during their master thesis in cooperation with Chalmers University of Technology and Bengt Dahlgren AB (Fantin et al., 2018). In 2019, Linda Wäppling and Ona Forss continued to develop the tool within their master theses to integrate building performance with architectural modelling (Wäppling, 2019). BeDOT is a BPS-tool that is intended for early stages and aims to enable collaboration between energy engineers and architects, even though it is also striving to be used without the need of engineers involved. The tool is based on a thermal network dynamic simulation in ISO 13790:2008, which is a Swedish standard for calculation of the energy performance of buildings.

BeDOT is today embedded in the Visual Programming Language (VPL) Grasshopper and the components are written in Python. Grasshopper is a plugin to Rhinoceros, a 3D CAD tool and in Grasshopper there are other plugins within the field building simulations, like Daysim which is used for daylight analysis, Honeybee that helps create zones and assign characteristics to the building so that for instance which surfaces are roof, external walls etc. are identified. There is also something called Ladybug that processes the weather data.

BeDOT is developed based on 5 main principles illustrated in figure 2.3 (Fantin et al., 2018):

Figure 2.3: Principles of BeDOT (Fantin et al., 2018)

The main principles are described in more detail below.

- Time & Simplicity: simplified physical calculations contributes to shorter simulation time
- Modularity: modularity enables combination and replacement of components
- Post-processing: possibility to visualise indata and result
- Accuracy: the developer aimed to reach a 15 % error margin as maximum value. This value is if comparing BeDOT with simulation tool IDA ICE
- Collaboration: enable collaboration between disciplines like architects and engineers during early stage design

3
INTERVIEWS AND INQUIRIES

This chapter presents the outcome from the interview study. The interviews have been carried out with the municipality of Gothenburg and Skanska. Participating disciplines in the study are:

- The department of building permit at the Urban Planning Department Gothenburg of City
- The department of municipality planning at the Urban Planning Department of Gothenburg City
- The department of project development at Skanska AB
- The department of business development at Skanska AB

The study focus on the different disciplines point of view on the DDP planning work and early stage design. Due to the fact that the municipality and Skanska are two completely different stakeholders, there have been some difference in question of interest. Regarding Skanska who's participating from the developers point of view, main focus is to state how energy and daylight is implemented in the earliest stage of building design. When it comes to the municipality, information about how daylight and energy is implemented today and if and in that case how to implement these aspects at best practise forwards are main focus.

The outcome from the interviews have been divided into two sections, one for the municipality of Gothenburg and one for Skanska.

3.1 Interview with the municipality of Gothenburg

Participating from the municipality is two DDP architects which one them also works as project leader, an administrator at the department of building permit and an administrator at the department of municipality planning. Questions asked in the inquire and the answers are presented in appendix A.

During the spring 2020, The Urban Planning Department of Gothenburg have put together guidelines for handling daylight in the DDP process. A summery of these guidelines are presented as it is a contribution to the interview study.

The content of the interviews and The Urban Planning Department of Gothenburgs guidelines for handling daylight will be presented using sections stated below.

- The DDP process
- Early stage building design
- Studies and BPS
- Level of detail
- The Urban Planning Department of Gothenburgs guidelines for handling daylight

3.1.1 The DDP process

It is unusual that the municipality initiate a DDP without request from a developer. In most cases, the developer hands in an application for planning notification which contains information about aspects like building volumes together with sections- and situation plans that describes the building.

The differences between when a developer asks the municipality to begin a DDP versus when the municipality initiate one are that the municipality often evaluate the condition on the site before looking at the building design and that the developers often wants to exploit in higher degree than the municipality may want. Developers have also often already made a decision about building design, which makes it more difficult for the municipality to come up with a completely other solution than the suggested one. As the economy is strictly related to the proposal, it means that if the municipality completely change a proposal, it affects the developers profitability. Important to mention is that an approved planning notification do not automatically mean that the suggestion handed in is the one that the DDP will adapt to. The proposals are investigated with respect to many different aspects. Regulation due to the law and the public opinion being two of these aspects.

The DDP planning work is a changeable process. Which aspects to focus on is varying, but a more holistic point of view when it comes to city planning in total is requested mentioned one of the respondents. The municipality also expresses that there are aspects that have to be considered in the DDP to avoid causing issues difficult to solve later in the building process. One example is daylight which will be described in more detail later in this chapter.

DDP can be complemented with different kind of programs. It it is quite common to frame a "quality program" or "aesthetic design program" which do not have any legal force but can be used in the building permit process to deal with details related to the planned area. An aspect mentioned related to these documents not being legally bounded is that aspects are not investigated in later stages. The final outcome for the building design could therefore be something completely different than what was presented in the program. This do not necessary have to be negative though expressed one of the interviewed. Regarding having programs, it is an opportunity to take into account aspects that may not be suitable to regulate in the actual DDP as well as it facilitate in those cases where there is many stakeholders included or when the DDP refers to larger areas. One risk though with programs is the aspect of being suitable and valid over time as the city planning is a constant and complex ongoing process. Producing a program is also time consuming.

3.1.2 Early stage building design

A DDP have to consider many different aspects. Some of the aspects due to the municipality are noise, air quality, communications, cultural values and national interests. Regarding building size and shape, a factor that besides the mentioned above have large influence is the economy. The building type is one aspect affecting the economy. For residential buildings, number of apartments, gross area (BTA) and share of dark BTA are three indicators which relates to the economy. To add is that the city of Gothenburg is currently working on a strategy that aims to contribute in the DDP process by clarify which indicators to take into account in the city development.

3.1.3 Studies and BPS

Studies carried out in the DDP process are site dependent. These studies are related to example noise, sun and air quality. Studies are valuable due to the architects opinion as it helps evaluate the building proposal suitability on the specific site. Responsible for the studies could be both the municipality and the developer. None of the interviewed persons have performed any BPS but one of the architect expresses that access to indicators and an iterative design process in early stages is valuable through a sustainable perspective.

When a developer applies for planning notification, there is no requirement on handing in results of studies regarding daylight condition or energy demand but one of the architect expresses that the municipality have begin to request studies of daylight conditions in some cases, even though it does not happen that often so far this early in the building process. Further information about studies is described below.

3.1.3.1 Energy

When it comes to studies of energy, solar studies are mentioned as a parameter related to energy, but nothing else. Regarding consider energy as a parameter important or not to take into account in the DDP, the opinion differ among the interviewed. One expresses that energy is important due to the fact that "position, height etc. have big influence on the forthcoming conditions", but do not have any suggestion on how to consider energy. One of the architects expresses that it is important to consider resources in early stages of the process due to the aspect of creating a sustainable society, but do not necessary think that it has to be a part of the DDP process.

One of the interviewed adds that regulate energy in the DDP may not be suitable or efficient for that matter either, as energy demands and aspects like example energy supply is under constant development. "A solution regarding energy may be up-to-date during the first year but not year 50 but you still have to adapt to it as the DDP is legally binding" is expressed by one of the architects. The second architect agrees and adds that "regulate details regarding building design, material choice or specific energy system means lock of details from an authority perspective with a tool (the DDP) that only is designed to be necessary limited".

3.1.3.2 Daylight

Daylight studies are, unlike energy, considered far more interesting at the municipality as the city of Gothenborg becomes more and more dense. One of the architects expresses that "overall control of daylight and investigate opportunities/challenges with the planned building volumes provides opportunities to early regulate the built environment so that good access to daylight are cater for". One of the interviewed adds thought that which surfaces requires daylight or not could be open for interpretation due to vague descriptions in the regulations. One challenge is also the level of detail in this early stage. It is often low and position of toilets and meeting rooms and other spaces that do not have daylight demands may be unknown which makes it tricky to evaluate if the daylight conditions is good enough. In cases with deep buildings, the municipality tries to evaluate how and how often these spaces will be used to get a perception if the suggested building geometry is suitable.

3.1.4 Level of detail

Level of detail in the DDP and the complementing programs differs from case to case. Programs shall be on a more brief level due to the PBL but if there are special conditions, like cultural values, the program can contain details about facade design, window positions, volumes and colours.

It is expressed by the municipality that it is important that the level of detail is reasonable to make sure that the DDP will be valid overtime and also, to high level of detail in the DDP is prohibit due to regulations. One of the architects expresses that it is important with sustainable regulations and not adapt the DDP to design standards applied and popular only at the moment as it may take many years between producing a DDP and the construction start. The level of detail must be suitable to avoid inappropriate and outdated DDPs.

3.1.5 The Urban Planning Department of Gothenburgs guidelines for handling daylight

The city of Gothenburg is growing with an increasing number of citizens at the same time as the city becomes more and more dense due to desire to build on already established popular locations (Göteborg Stad, 2020b). Consequences of this are a decreasing distance to near by buildings and reduced amount of visible sky which cause issues with access to daylight. The municipality have during the recent years experience an increase in building permit denial related to not fulfilling the daylight demands and The Urban Planning Department have come to realize that there is a need to investigate daylight earlier. As it is today, daylight condition is often not investigated until the developer applies for starting clearance.

"Detail development plans shall not result in expectations on building volumes and associated incomes that are not possible to implement in later stages" are stated as a reason to implement daylight studies earlier than it is implemented today (Göteborg Stad, 2020b). The citation is from The Urban Planning Department of Gothenburgs guidelines for handling daylight in the planning and building permit process that were put together during the spring of 2020.

For early investigation of daylight conditions, The Urban Planning Department of Gothenburg suggest that the obstruction angle for the bottom plan shall be studied in the planning notification process (Stadsbyggnadskontoret Göteborg Stad, 2020). If the obstruction angle is below 30 degrees, daylight conditions assumed to be good enough and do not have to be investigated further. If the obstruction angle is above 45 degrees, there is a risk that the daylight demands will not be met and further investigation of daylight conditions have to be carried out in the DDP process. If the obstruction angle is between 30 and 45 degrees, access to daylight should also be investigated in the DDP. Implementing daylight studies in the DDP:s complementing program are mentioned as a possible measure if expecting difficulties with daylight on a site.

When performing daylight studies, it is not only new buildings that has to be taken into consideration (Stadsbyggnadskontoret Göteborg Stad, 2020). If there is a possibility that already existing buildings around are affected in a negative way, the daylight condition of these have to be studied as well.

The Urban Planning Department of Gothenburg recommend using the VSC in early stage studies (Stadsbyggnadskontoret Göteborg Stad, 2020). The results should be presented in such way that it is clear which parts of the facade are within the level <10%, 10-12% , 12-15% , 15-25% and >25%.

The level of VSC for achieving enough daylight according to the guidelines >25%, given that the building depth isn't greater than 14 m (Stadsbyggnadskontoret Göteborg Stad, 2020). If the VSC is between 15% and 25%, the geometry have to be studied in more detail and size of windows, possibility to have balconies and position of these shall be evaluated to make the developer aware of potential restrictions on the site (Stadsbyggnadskontoret Göteborg Stad, 2020). The goal is to avoid building designs that can't be approved when applying for building permit.

In cases with a VSC less than 15%, modification on the building design is often necessary depending on if the building is planned to contain spaces occupied more than temporary (Stadsbyggnadskontoret Göteborg Stad, 2020). Modifications that The Urban Planning Department of Gothenburg expresses could improve the daylight conditions could be in form of (Stadsbyggnadskontoret Göteborg Stad, 2020):

- Geometrical changes of the building body
- Geometrical changes of the surrounding elements like example streets
- Changes in the block structure
- Changes in use of parts of or the total building

In cases where there are already existing buildings which daylight condition might be affected negative by the new property, these have to be investigated not only by looking at the VSC but also by study the daylight conditions inside the affected rooms.

3.2 Interview with Skanska

A project- and a business developer at Skanska working in early stage of the building process have participate in the interview study representing Skanska from the developers perspective. Questions asked in the inquire and the answers are presented in appendix A.

The result from the interview study have been divided into the following sections:

- The DDP and building permit
- Early stage building design
- Studies and BPS
- Level of detail

To mention is that Skanska is refereed as "the developer" in this chapter but must not necessary represent all developers point of view in the construction industry.

3.2.1 The DDP and building permit

Usually it is the developer that inquire a DDP. One difference regarding energy and daylight when it comes to whether the developer initiate a DDP or if it is the municipality is that the developer have bigger opportunity to consider these aspects compared to the municipality. The developer adds though that focus usually this early is on target group analysis and financial parameters rather than daylight and energy.

When applying for planning notification there is no demand on handing in information related to energy and daylight but the developer often informs the municipality if the building will be certified according to "Svanen", a Swedish certification program, in those cases it is relevant. The developer experience the planning notification process as similar as it has been the recent years but the building permit process as partly changed. There is more focus on energy and daylight today compared to previously even though that those questions still has less importance than other parameters. Skanska also adds that the County Administrative Board and other authorities focus significantly more on air-, noise- and traffic issues.

The developer finds having a program as complement to the DDP as helpful in the interpretation. A program can also help if it presents what may work and not on a site which facilitate produce a building design that will be approved when later applying for building permit.When it comes to application for building permit and denials, it is often related to interpretation issues of building shape allowed in the DDP or that the design do not adjust to the one specified.

"I feel that the municipality focuses very little on energy and daylight when it comes to the preparation of detailed development plans. Main focus on these aspects is instead at building permit and starting clearance, which means that it is us developers that takes a big risk. If awareness of these issues could be raised earlier and contribute to choices made in the detailed development planning process it would be better for us".

The citation above is the developers requests to the municipality when it comes to the DDP work and building permit. The developer expresss that if the administrators at building permit could accept certain deviation if it is stated in the DDP, it would be significantly better if these were clearly stated from the beginning.

3.2.2 Early stage building design

Building height, width and length have to adapt to the regulations stated in the DDP and the developer together with architects design the building based on the given conditions. When determine building shape, it is a result of studies of daylight and energy, but also aspects related to the surrounding conditions like noise, safety and greenery. There is also interior demands like fire demands and accessibility. The building shape is also a result based on the target group. Skanska have internal guidelines that can help in the building design process.

Regarding aspects that may be in conflict with each other, window area that is positive through a daylight perspective but negative through a energy perspective is mentioned as one example. Aspects in conflicts needs to be balanced against each other expresses the developer.

The economical aspect affects the building design in high degree. Minimize amount of corners and expand the building height instead of floor area on ground is mentioned as two measures positive through a economical aspect. If a site contains multiple building, it is advantageously to repeat similar building shapes. Rotate or move a building parallel is more economic favorable than mirror the next by building. Avoid complicated geometries is important and in those cases a complicated building design results in increasing floor area it has to be evaluated economical. If only take into account the economical aspect, buildings without internal stairwells that instead have external corridors is positive as the share BOA in relation to BTA increases and resulting in lower construction cost. The mentioned solution can therefore be suitable in areas where the economical ability is lower expressed the developer.

The interviewed mention that it might become more difficult to meet all requirements related to buildings in the future if continuing evolve a dense city. Develop buildings that fulfill all demands today is expensive, and there is a risk that these building will only be available to residents in Gothenburg with economical strength. Peoples ability to pay is therefore an aspect to take into consideration in early stage design.

"Through a long perspective it is about being able to understand problems and base decisions on them and the more possible aspects that could be simulated at an early stage, the better". The citation is related to all demands put on buildings today and the difficulty to value which aspects is more important than others.

3.2.3 Studies and BPS

The department of business and project development do not perform simulation of daylight and energy butdo have some knowledge about this which is presented in the upcoming section.

3.2.3.1 Energy

When it comes to energy, the developer have a department that perform energy studies, not only when applying for building permit but before this. This is important to ensure that the initial idea is possible to follow through. When it comes to energy simulations, it is today not consider to be equally important as doing daylight studies i early stage at the municipality expressed the developer. Challenges regarding energy can often be solved in later stages contra daylight but the developer adds that as the energy demands are getting stricter, the need of performing energy calculation in the DDP can come to be necessary in the future.

3.2.3.2 Daylight

Studies of daylight are often made by the developer before buying land to ensure that the desired planned buildings can fit on the site.

The developers perception of studies at the municipality is that solar studies is more common than daylight studies. The municipality investigates how the new building affects the already existing buildings around regarding solar radiation condition. Performing daylight studies could help the municipality investigate whether the DDP is possible to carry out or not expressed the developer, resulting in DDP:s that are realistic and can be followed through without daylight issues.

An aspect that the interviewed wants to add is if the existing demands is reasonable if wanting to continue densify the city and whether daylight always shall be dimensioning compared to other aspects. A citation from the interview is "these are no simple questions and human health is more important than anything else, but in the long run it is a lot about being able to understand the problem and make conscious choices based on it".

3.2.4 Level of detail

When applying for planning notification the level of detail is, like already mentioned, quite low but increases when handing in application for building permit. The level is also depended on which DDP the application refer to.

Most part of the document handed in when applying for building permit is architectural drawings, summery of material- and colour choices and a description of which type of surfaces the building will contain like for instance type of apartments and how these are composite together. Besides the already mentioned, there could be documents concerning example fire and noise handed in. The developer expresses that the feeling is that there is more focus on the issues mentioned above than on energy and daylight but that these aspects have begun to get more and more attention.

Regarding level of detail when it comes to the programs complementing the DDP, the developer expresses that the level of detail should not be to specific due to the fact that for example energy demands can change. The developer appreciate if aspects specified in the program is quantifiable.

4

FURTHER DEVELOPMENT OF BEDOT

To be able to perform the case study, BeDOT had to be further developed. The previously version of BeDOT were able to handle one property at a time but as the case study are concentrated on a large site it is important to be able to deal with multiple building at the same time. It is also important to be able to deal with thermal bridges and heat losses to the ground as the case study aim to study different building shape and geometry which in high degree the thermal bridges and area against ground is related to. To sum up what have been developed during this master thesis:

- Results of simulated zones are sorted into the building to which they belong
- Thermal bridges model is implemented related to the geometry
- A ground model is implemented

4.1 Thermal Bridges

Thermal bridges can be described as parts of the building structure where the thermal conductivity is higher than surrounding elements (Nagy, 2014). As the industry aim to decrease the energy use of buildings, the thermal performance of the envelope has improved over the years by decreasing transmission losses (Danebjer, 2012). However, the proportion of thermal bridges may increase with decreasing transmission losses and thus becomes more important to take into account for low-energy buildings.

There is no common value for the different type of thermal bridges, as these are material, structural and geometric depended (Nagy, 2014). To get a more theoretically correct value, thermal bridges can be simulated using 2D or 3D simulation tools like THERM and HEAT.

It is quite common in Sweden today to use a predefined percentage factor in early-stage design that increases the calculated transmission heat transfer through building elements with 20%, but this might be unsuitable (Berggren & Wall, 2013). Also, studies shows that the relative affect from thermal bridges vary a lot between different buildings.

Calculating thermal bridges in detail is not the main focus in this master thesis but instead of using a predefined percentage factor, the impact of thermal bridges will be accounted for by using values for linear thermal bridges for external dimensions. Thermal bridges accounted for and the values used for these are presented in table 4.1. Values are provided by B.Berggren (personal communication, 23 of April, 2020). External corridors assumes to have the same value as balcony attachments.

Table 4.1: Values for thermal bridges

Thermal Bridge	Type	Value	Unit
Windows	Linear	0.14	W/m,K
Balconies and external corridors	Linear	0.20	W/m,K
Slab edge in exterior wall	Linear	0.008	W/m,K
Connection ground slab and external wall	Linear	0.221	W/m,K
Connection roof and external wall	Linear	0.265	W/m,K

4.1.1 External corridors

The impact of having external corridors instead of staircases is investigated as it have an impact on both the energy and daylight conditions. External corridors results in, similar to balconies, thermal bridges in varying degrees depending on how the external corridor is attached to the building. The fact that is positioned outside the building also have negative impact on access to daylight. The depth of the external corridors have been assumed to 1.5 m, which is related to demands for evacuation due to BBR (Boverket, 2011).

4.2 Heat losses to ground

When dealing with heat losses to the ground, simplified or more complex models can be used. A semi-analytical method is the one of Kusuda, which is a method that uses the Green function where the floor heat flux can be calculated using Eq.(4.1) (Adjalit, 1998).

$$Q = (T_r - T_z)\left(\frac{\lambda}{l}\right) \qquad [\mathrm{W/m^2}] \quad (4.1)$$

l: The thickness of the earth layer [m]
λ: The thermal conductivity of the soil [W/m^2,K]
T_r: The mean temperature of the slab [°C]
T_z: The monthly average subfloor temperature at a given depth (z) [°C]

Other more complex methods for heat losses to ground is example using a method developed by Claesson and Hagentoft which takes into consideration heat transfer by superposition using both steady-state and periodic heat loss plus a step variation of the outdoor temperature (Adjalit, 1998).

For this master thesis, the simplified method that uses Eq.(4.1) is considered as sufficiently. To take into account the heat pillow effect, the model may be discretized by using different subfloor temperatures at given points of the floor. This is done by using an inner layer and outer layer of the floor zone, which is illustrated in figure 4.1. For the inner layer, the depth used for calculating T_z is the periodic penetration depth, d_p, which is the length from the ground surface where considerable variations of the ground temperature are present. In the same manner, half of the periodic penetration depth is used for calculating T_z for the outer layer.

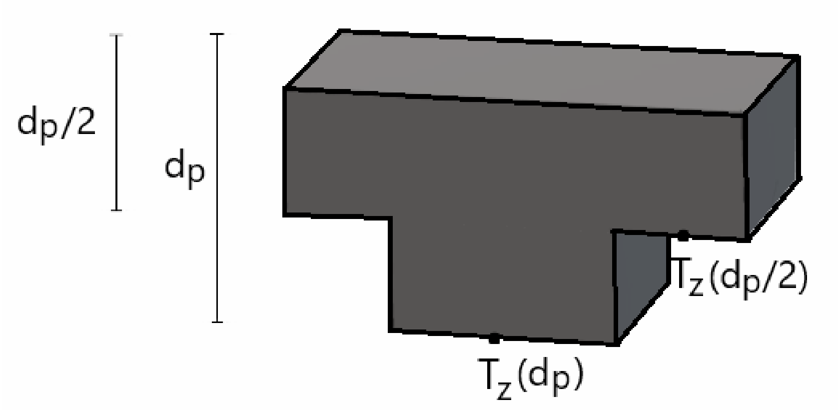


Figure 4.1: Illustration of the discretized ground model.

4.3 Recommendation for further development

The main benefits of BeDOT itself is that it the results responsive can be fast responsive and it can handle many zones. However, some calculations could take up to eight hours due to the radiance component that is used to calculate the incident solar gains through the windows. It took a lot of time as it calculates each node within the mesh for every time step. This is the main barrier for making fast calculations. However, as solar gains was an important measure to include and be simulated it was considered to be insufficient to use an estimated value.

Furthermore, relations between indoor and exterior would be positive and interesting to investigated and implemented in BeDOT. To add though is the awareness of the difficulty in early stage as room geometry may be undecided. But general measures could be applied and studied.

So to sum up, recommended measures for further development of BeDOT could be:

- Examine ways to speed up the calculations
- Implement relations between interior and exterior measures

- Develop a simulation environment which do not demands knowledge within coding

5
CASE STUDY

This chapter presents the cases studied within the master thesis. The chapter also contains presentation of the considered evaluated aspects, indata, simplifications and modelling methods.

5.1 Evaluation aspects

Evaluation of energy and daylight are main focus in this master thesis. Awareness about additional aspects besides daylight and energy are taken into consideration by collaborating with Amanda Markgren who contributes with knowledge about architecture and project management. Markgren produced the design proposals and made sure that the buildings are adapted to reasonable dimensions that also takes into consideration aspects like for example access to greenery and walkways.

When analyzing energy, the main focus for premises is heating and cooling and heating for the residences.

To determine which method to use when examine daylight, a comparison of suitability for the different methods mentioned in the literature study were carried out. Due to importance of not being limited by the obstruction angle, the AF-method is not suitable. DF requires a room structure, which often is unknown in this early stage. Between SVF and VSC, only VSC uses CIE overcast as sky type and is therefore the method chosen. When investigating the VSC, it is important to remember that there is a limited room depth if wanting to reach good daylight condition inside the building.

The results for VSC will be visualized and presented using diagrams. When visualizing, the results will be illustrated using colours representing which parts of the buildings are within the level <10%, 10-12% , 12-15% , 15-25% and >25%. The five intervals have been summarized into three levels when presenting the results; <15%, 15-25% and >25%. Levels chosen for VSC is due to The Urban Planning Department of Gothenburgs guidelines for handling daylight.

5.2 Input data and locked parameters

The input data used in the case study are presented in appendix B.1. Degrees of freedom have been limited to ensure a fair comparison between different cases.

Locked parameters is for instance the U-value for the different construction parts.

5.3 Zone division

When performing energy calculations, zone division is important as it affects the results (ISO 13790:2008, 2008). Generally, the more zones the more accurate results. But increasing amount of zones increases the simulation time. Different spaces could be merged to one zone if:

- All spaces have the same heating- and cooling system
- Set point temperature regulation for different spaces vary with less than 4 K
- At least 80% of the floor area have the same ventilation system
- The air flow vary with a factor less than 4 for at least 80% of the floor area

Based on the above and the fact that the level of detail in this early stage is low due to room geometry and position of staircases for example often is unknown, it was determined to model each floor as one zone. Given that the floor do not contain both residences and premises, which are always divided into separate zones due to having different need for cooling etc.

5.4 Simplification and limitations

Performing this case study, some simplification have been carried out due to lack of details and simulation limitations. These are:

- Buildings do not contain any basements, garages or attics
- Buildings are situated directly on the ground
- Offices and stores are modelled together, named *premises*
- Buildings are modelled without balconies
- Spaces like for instance internal staircases and corridors are included in the *residences* and *premises* zones

Comparison with requirements due to BBR is limited to EP_{pet}. Installed electric input for heating, U_m and average air leakage rate will not be analyzed.

5.5 Cases

The case study is carried out by comparing different design options for a site with a reference case which is the existing DDP. The cases will use the same input data, which can be read in appendix B.1. All cases will have WWR of 30% as a basis, except from one case where a higher WWR is studied.

5.5.1 The reference case

The site studied is located in the city of Gothenburg and the DDP map is presented in figure 5.1 below. The area consists of six planned properties, of them 49.8% are residences and 50.2% are premises. The total floor area is measured to 71 590 m^2. The average number of floors per property is 7.04, while the maximum number of floors is 12. On the right hand side of the site there is a high traffic road. There is also K-marked, listed buildings, which will be kept in existing condition.

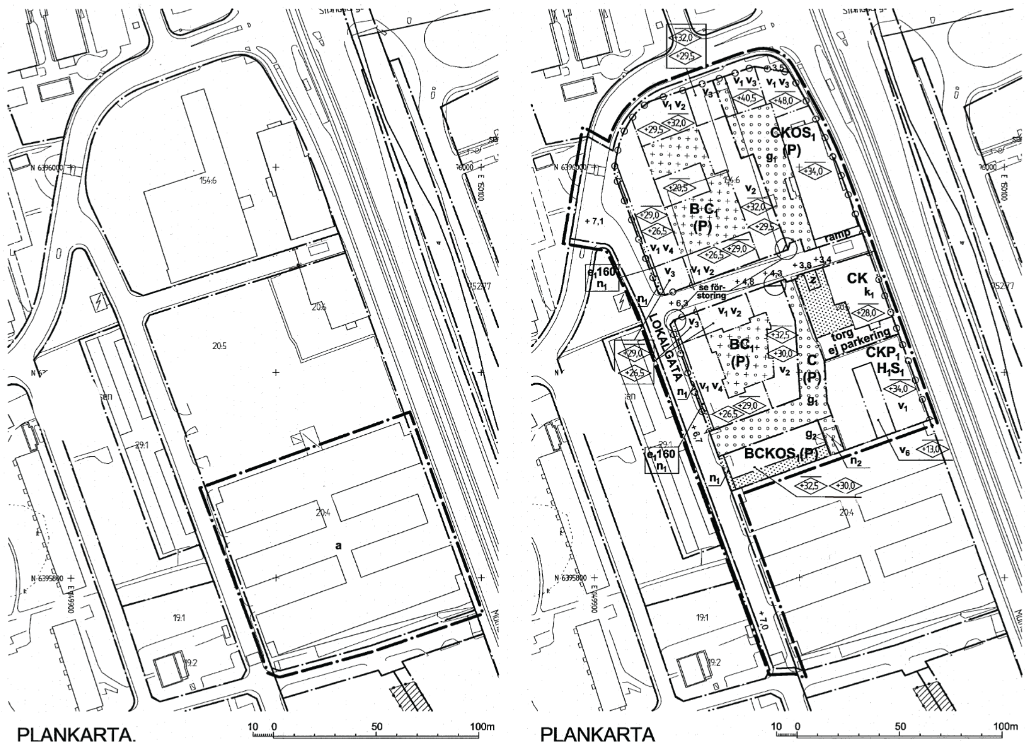


Figure 5.1: The DDP (Göteborg Stad, 2020a)

The interpretation of the plan map is shown in figure 5.2. The properties marked with **R** are residences and **O** premises, while **RO** are a mix of both with premises positioned on the ground floors. The property number of each is as well marked in the figure.

Figure 5.2: Reference0, illustration by A.Markgren

The floor area and share of residences and premises of each property, as well as the SF and the WFR are presented in table 5.1 below.

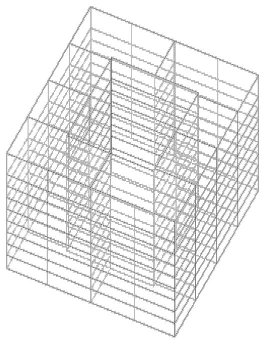
Table 5.1: Floor area, SF and WFR for the properties in Reference0

Property	A_{floor} [m^2]	Premises [%]	Residences [%]	SF [-]	WFR [%]
Reference001	4780	12.5	87.5	0.28	20.0
Reference002	13350	15.6	84.4	0.23	19.0
Reference003	12340	100.0	0.0	0.22	15.0
Reference004	24780	17.2	82.8	0.21	15.1
Reference005	7560	100.0	0.0	0.23	17.7
Reference006	8790	100.0	0.0	0.20	14.7

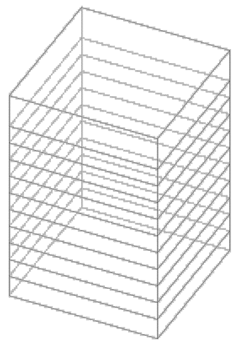
The existing DDP is studied and evaluated in terms of energy demand and daylight. The results are presented in the next chapter. The reference case will serve as comparison material for the upcoming cases.

5.5.2 Type buildings

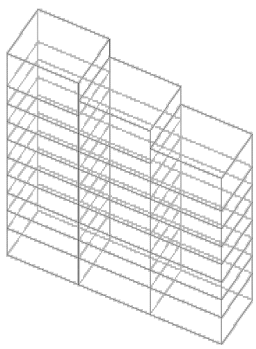
The existing DDP is redesigned using type buildings to study how different building shapes performs. Four typical building forms related to the *post modern city* are chosen and these are illustrated in figure 5.3.



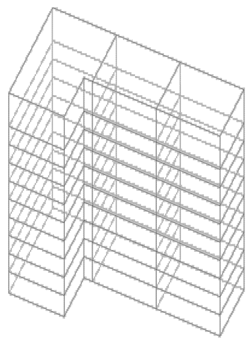
(a) Town houses with court yards (kvartershus)



(b) Block of flats (punkthus)



(c) Compact tower blocks (lamellhus)



(d) L-shaped compact blocks (L-hus)

Figure 5.3: The different type buildings, illustrations by A. Markgren

5.5.2.1 Town houses with court yards (kvartershus)

The plan map of the configuration with town houses with court yards (kvartershus) called Kvartershus0 is shown in figure 5.4 below.

Figure 5.4: Kvartershus0, illustration by A.Markgren

The floor area and share of residences and premises of each property, as well as the SF and the WFR are presented in table 5.2 below.

Table 5.2: Floor area, SF and WFR for the properties in Kvartershus0

Property	A_{floor} [m^2]	Premises [%]	Residences [%]	SF [-]	WFR [%]
Kvartershus001	10 080	25.0	75.0	0.24	16.7
Kvartershus002	22 680	11.1	88.9	0.21	14.3
Kvartershus003	5 040	100.0	0.0	0.26	19.0
Kvartershus004	22 730	61.2	38.8	0.21	14.2
Kvartershus005	11 390	100.0	0.0	0.23	16.4

5.5.2.2 Block of flats (punkthus)

The plan map of the configuration with block of flats (punkthus), which is called Punkthus0, is shown in figure 5.5 below.

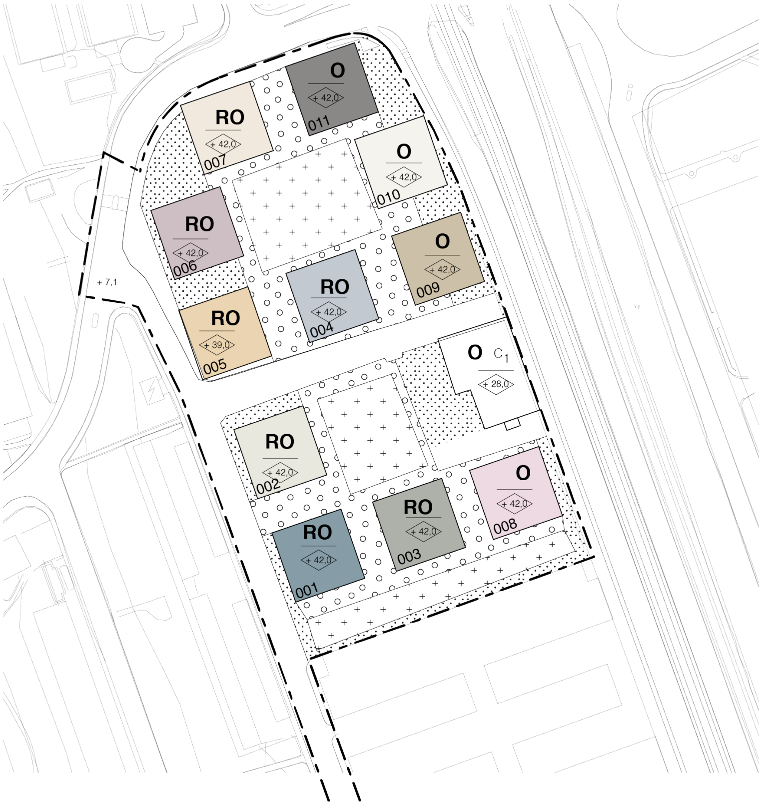


Figure 5.5: Punkthus0, illustration by A. Markgren

The floor area and share of residences and premises of each property, as well as the SF and the WFR are presented in table 5.3 below.

Table 5.3: Floor area, SF and WFR for the properties in Punkthus0

Property	A_{floor} [m^2]	Premises [%]	Residences [%]	SF [-]	WFR [%]
Punkthus001	6 875	18.2	81.8	0.22	15.7
Punkthus002	6 875	18.2	81.8	0.22	15.7
Punkthus003	6 875	18.2	81.8	0.22	15.7
Punkthus004	6 875	18.2	81.8	0.22	15.7
Punkthus005	6 250	10.0	90.0	0.22	15.7
Punkthus006	6 875	9.1	90.9	0.22	15.7
Punkthus007	6 875	18.2	81.8	0.22	15.7
Punkthus008	6 875	100.0	0.0	0.22	15.7
Punkthus009	6 875	100.0	0.0	0.22	15.7
Punkthus010	6 875	100.0	0.0	0.22	15.7
Punkthus011	6 875	100.0	0.0	0.22	15.7

5.5.2.3 Compact tower blocks (lamellhus)

The plan map of the configuration with compact tower blocks (lamellhus), which is called Lamellhus0, is shown in figure 5.6 below.

Figure 5.6: Lamellhus0, illustration by A. Markgren

The floor area and share of residences and premises of each property, as well as the SF and the WFR are presented in table 5.4 below.

Table 5.4: Properties of Lamellhus0

Property	A_{floor} [m^2]	Premises [%]	Residences [%]	SF [-]	WFR [%]
Lamellhus001	6 480	11.1	88.9	0.27	20.0
Lamellhus002	17 812	35.4	64.6	0.25	18.3
Lamellhus003	4 850	100.0	0.0	0.28	21.2
Lamellhus004	24 388	76.4	23.6	0.27	20.3
Lamellhus005	6 480	11.1	88.9	0.27	20.0
Lamellhus006	6 480	11.1	88.9	0.27	20.0

5.5.2.4 L-shaped compact blocks (L-hus)

The plan map of the configuration with L-shaped compact blocks, which is called L-hus0, is shown in figure 5.7 below.

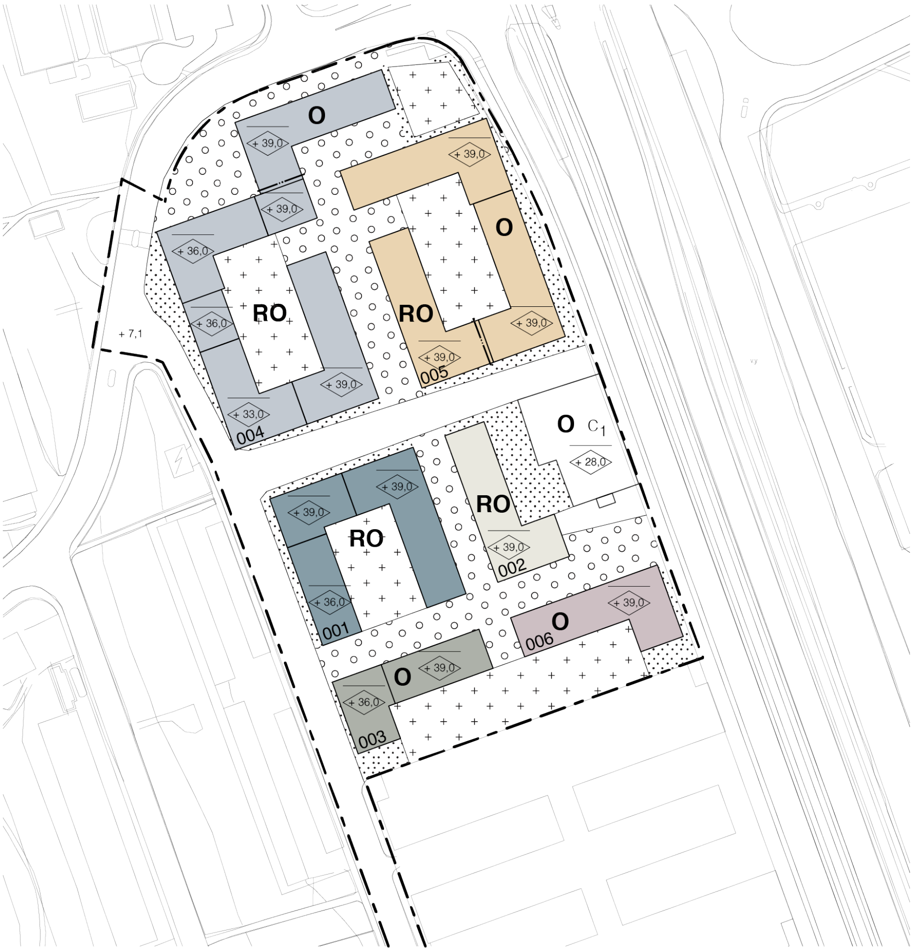


Figure 5.7: L-hus0, illustration by A. Markgren

The floor area and share of residences and premises of each property, as well as the SF and the WFR are presented in table 5.5 below.

Table 5.5: Floor area, SF and WFR for the properties in L-hus0

Property	A_{floor} [m^2]	Premises [%]	Residences [%]	SF [-]	WFR [%]
L-hus001	11 700	11.5	88.5	0.25	18.2
L-hus002	6 030	11.1	88.9	0.27	20.0
L-hus003	5 720	100.0	0.0	0.27	20.3
L-hus004	25 150	34.6	65.4	0.24	17.3
L-hus005	20 100	70.0	30.0	0.24	17.3
L-hus006	6 030	100.0	0.0	0.27	20.0

5.5.2.5 Type buildings - total floor area

The total floor area for each property and the change in floor area compared to Reference0 which the result will be compared to are presented in table 5.6.

Table 5.6: Comparison I - Floor area

Case	Floor area [m^2]	Premises [%]	Residences [%]	Δ Floor area [%]
Punkthus0	75 000	46.7	53.3	+4.8
Lamellhus0	66 490	48.0	52.0	−7.1
L-hus0	74 730	48.9	51.1	+4.4
Kvartershus0	71 920	49.2	50.8	+0.5

5.5.3 Additional cases

The impact of changing height, position of residences and premises and an increase in WWR are studied on the case with town houses with court yards. These cases are named Kvartershus1, Kvartershus2 and Kvartershus3 and the comparison is named Comparison II. Illustration of the DDP for Kvartershus1 is illustrated in figure 5.8 where the the change height is presented. Kvartershus2 looks the same as Kvartershus1 but with changes in position of residences and premises. Kvartershus3 have the same configuration as Kvartershus0 but with an increased WWR.

Figure 5.8: Kvartershus1, illustration by A. Markgren

The total floor area for Kvartershus1 and Kvartershus2 and the change in floor area compared to Kvartershus0 which the result will be compared to is presented in table 5.7.

Table 5.7: Comparison II - Floor area

Case	Floor area [m^2]	Premises [%]	Residences [%]	Δ Area [%]
Kvartershus1	60 570	49.2	50.8	−15.8
Kvartershus2	64 370	47.0	53.0	−10.5
Kvartershus3	71 900	49.2	50.8	0.0

Total area, share of premises and residences, SF and WFR for each property for Kvartershus1, Kvartershus2 and Kvartershus3 are presented in table 5.8. Kvartershus0 have been presented earlier.

Table 5.8: Comparison II - Property data

Property	Floor area [m^2]	Premises [%]	Residences [%]	SF [-]	WFR [%]
Kvartershus101	7 560	16.7	83.3	0.26	17.3
Kvartershus101	17 640	14.3	85.7	0.23	15.0
Kvartershus103	5 040	100.0	0.0	0.26	19.0
Kvartershus104	20 210	56.3	43.7	0.22	14.4
Kvartershus105	10 130	100.0	0.0	0.24	16.6
Kvartershus201	7 560	50.0	50.0	0.26	17.3
Kvartershus202	17 640	42.9	57.1	0.23	15.0
Kvartershus203	5 040	100.0	0.0	0.26	19.0
Kvartershus204	20 210	43.8	56.2	0.22	14.7
Kvartershus205	13 920	36.4	63.6	0.22	16.1
Kvartershus301	10 080	25.0	75.0	0.24	22.3
Kvartershus302	22 680	11.1	88.9	0.21	19.0
Kvartershus303	5 040	100.0	0.0	0.26	25.3
Kvartershus304	22 730	61.2	38.8	0.21	19.0
Kvartershus305	11 390	100.0	0.0	0.23	22.0

The impact on energy and daylight when implementing external corridors is investigated. This will apply to the residences for the lamellhus as it is more common on these kind of buildings. The case is named Lamellhus1 and the comparison is named Comparison III. The dimensions of some of the buildings is changed as a result of the external corridors.

The total floor area for Lamellhus1 and the change in floor area compared to Lamellhus0 are presented in table 5.9.

Table 5.9: Comparison III - Floor area

Case	Floor area [m^2]	Premises [%]	Residences [%]	Δ Area [%]
Lamellhus1	61630	49.1	50.9	+7.3

Data for each property is presented in table 5.10. Lamellhus0 have been presented earlier.

Table 5.10: Comparison III - Property data

Property	Floor area [m^2]	Premises [%]	Residences [%]	SF [-]	WFR [%]
Lamellhus101	5670	11.0	89.0	0.29	22.0
Lamellhus102	16190	38.0	62.0	0.27	20.0
Lamellhus103	4850	100.0	0.0	0.28	21.0
Lamellhus104	23580	79.0	21.0	0.27	21.0
Lamellhus105	5670	11.0	89.0	0.29	22.0
Lamellhus106	5670	11.0	89.0	0.29	22.0

The impact of changing WWR from 30% to 40% for the energy will be investigated on the reference case. This case is named Reference1 and the comparison named Comparison IV. All indata except for WWR is the same for Reference0 and Reference1. The WFR for Reference0 have been stated earlier in this chapter. The WFR for each property in Reference1 is presented together with the comparison of Reference0 in table 5.11.

Table 5.11: Comparison IV - WFR [%]

Property	WFR [%]	Δ WFR [%]
Reference101	27.0	+35.0
Reference102	26.0	+36.8
Reference103	20.0	+33.3
Reference104	20.0	+32.1
Reference105	24.0	+35.6
Reference106	20.0	+36.3

5.5.4 Summary of cases and comparisons

The different cases are summarized in table 5.12 below.

Table 5.12: Case study list

Case	Explanation
Reference0	The reference case
Reference1	The reference case with WWR 40%
Punkthus0	Compact tower blocks
Lamellhus0	Block of flats
Lamellhus1	Block of flats with external corridors
L-hus0	L-shaped compact blocks
Kvartershus0	Town houses with court yards
Kvartershus1	Town houses with court yards, changed height
Kvartershus2	Town houses with court yards, changed height and position of premises/residences
Kvartershus3	Town houses with court yards, WWR 40%

The comparisons are the following:

- Reference0: the reference case
- Comparison I: Reference0 is compared with Punkthus0, Lamellhus0, L-hus0 and Kvartershus0
- Comparison II: different options of town houses with court yards; Kvartershus0, Kvartershus1, Kvartershus2 and Kvartershus3
- Comparison III: lamellhus with and without external corridors; Lamellhus0 and Lamellhus1
- Comparison IIII: Reference0 and Reference1

6
RESULTS

This chapter contains the results from the case study together with conclusions. A more detailed summery of the output from the simulations can be found in appendix C.

6.1 Reference0

Results and conclusions regarding the original DDP, called Reference0, are presented below.

6.1.1 Reference0 - Results

Figure 6.1 presents EP_{pet} in correlation to the maximum allowed EP_{pet} due to BBR28.

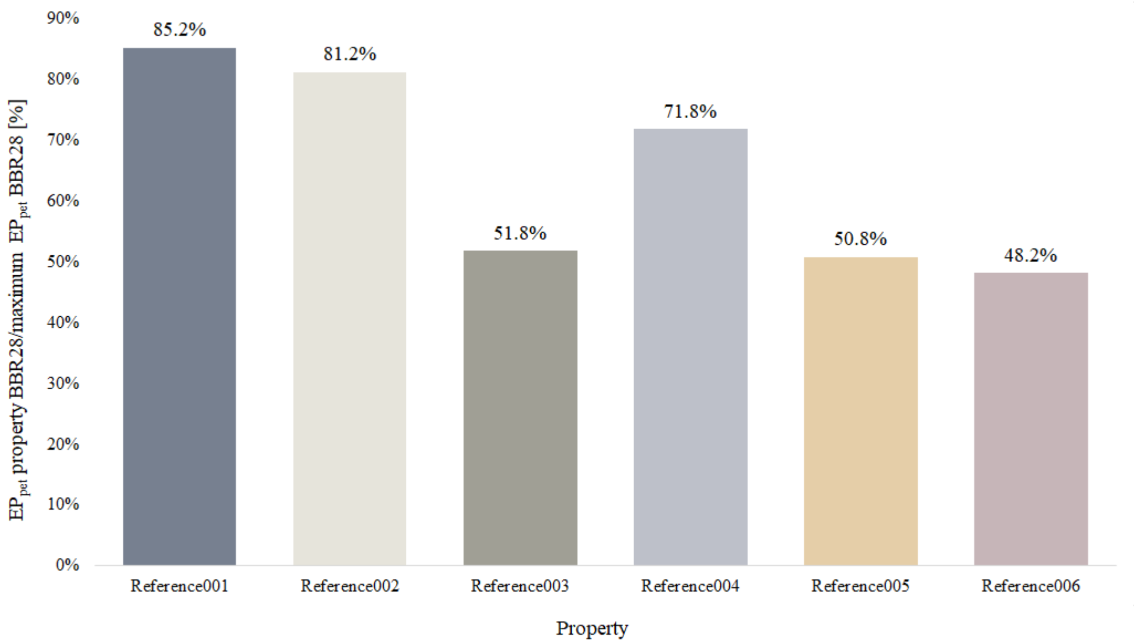


Figure 6.1: Reference0 - EP_{pet} per property BBR28 in relation to the maximum allowed EP_{pet} for BBR28 [%]

Energy use for the properties in Reference0 are illustrated in figure 6.2. To be able to compare the reference case with the other cases, the total heating and cooling for the whole site is also presented, see figure 6.3.

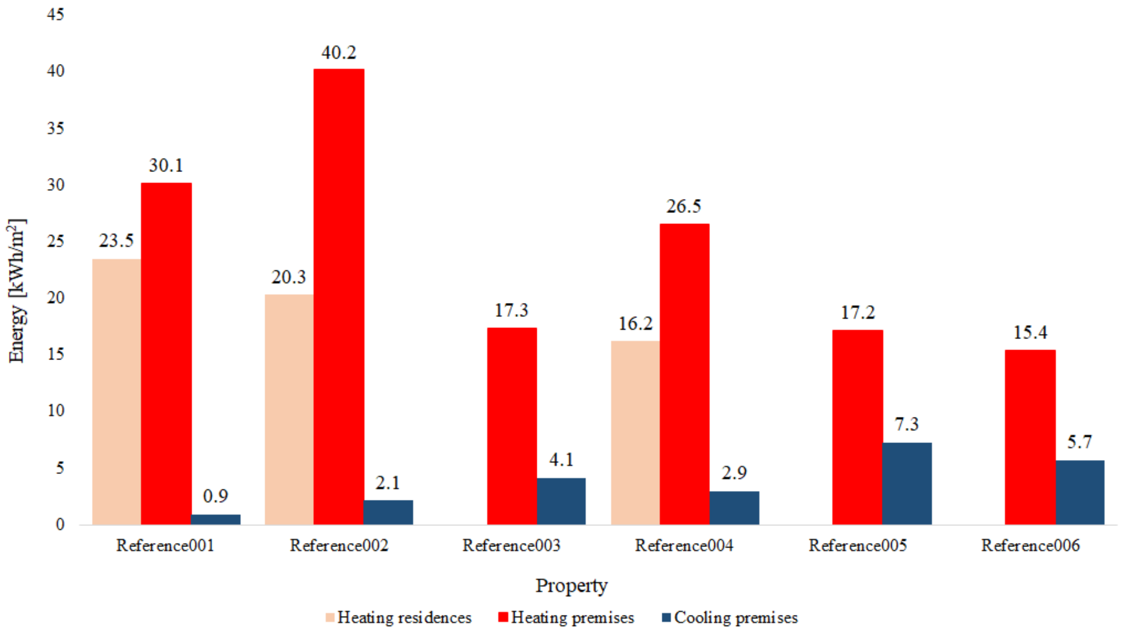


Figure 6.2: Reference 0 - Heating and cooling property [kWh/m^2]

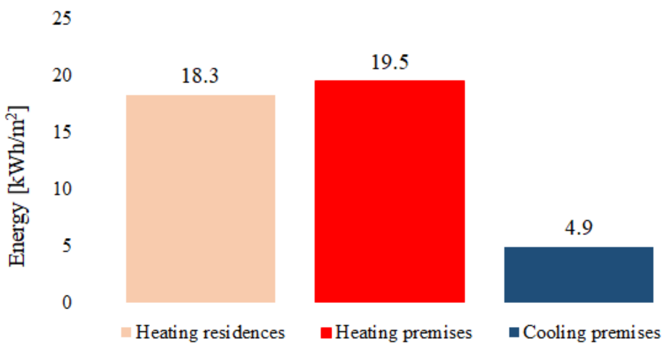


Figure 6.3: Reference 0 - Heating and cooling case [kWh/m^2]

Figure 6.4 presents the % of facade within the different intervals of VSC. To be able to compare the case with the other cases, result for the whole site is also presented, see figure 6.5.

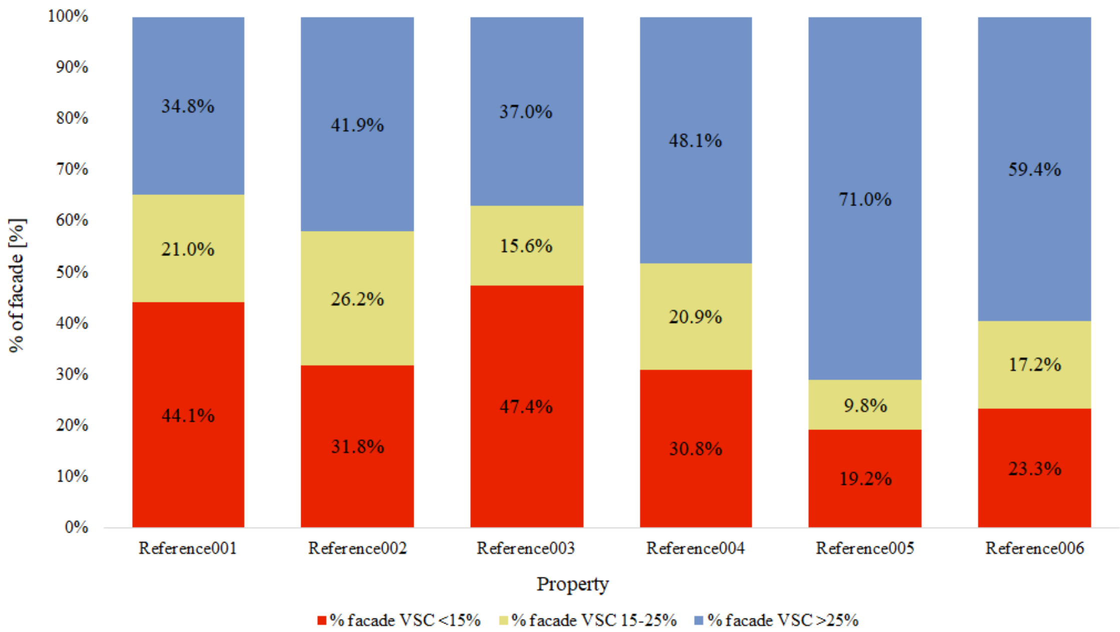


Figure 6.4: Reference0 - % of facade within the different intervals of VSC for each property [%]

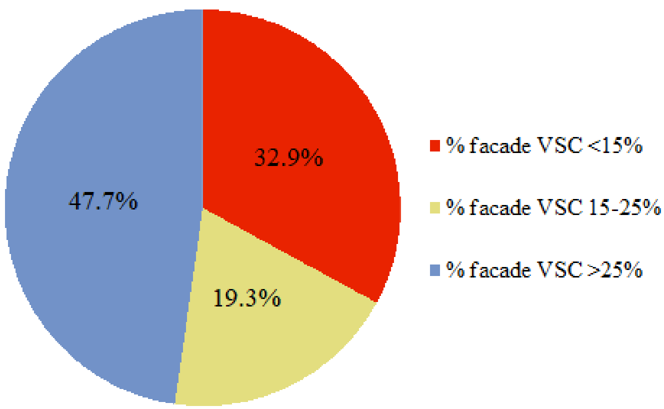
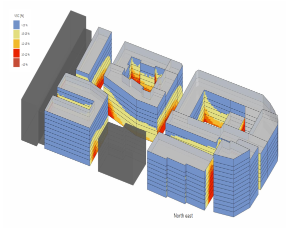
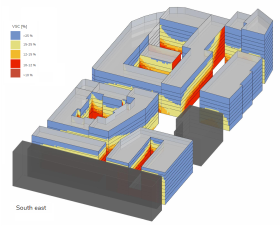


Figure 6.5: Reference0 - % of facade case within the different intervals of VSC for the whole site [%]

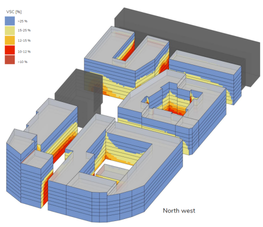
To identify the level of VSC on the different parts of the facade, figure 6.6 visualizes the VSC of reference0. The results can also be seen in appendix D.2.



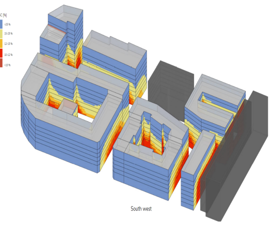
(a) VSC north east facade [%]



(b) VSC south east facade [%]



(c) VSC north west facade [%]



(d) VSC south west facade [%]

Figure 6.6: VSC for Reference0 seen from different orientations

6.1.2 Reference0 - Conclusions

Conclusions about energy and daylight performance of the reference case are presented in this chapter.

6.1.2.1 Reference0 - EP_{pet}

To start with, all properties fulfill the demands regarding EP_{pet} due to BBR28. Generally, the higher degree of premises, the lower EP_{pet} compared to the maximum allowed. The reason for this could be many, for instance:

- Premises have a higher allowed EP_{pet} than residences
- The internal heat loads for premises are assumed a bit to low resulting in lower cooling demand compared to the reality
- The energy for Domestic Hot water use (DHW) is 2 kWh/m^{2}A$_{temp}$ for premises compared to 25 kWh/m^{2}A$_{temp}$ for residences

6.1.2.2 Reference0 - Cooling premises

The property that uses the highest amount of cooling is Reference005 and the property using least cooling is Reference001. To explain why this is, the following are studied:

- Share of premises and residences and the position of these
- Position on the site in combination with the surrounding
- Height

- SF and WFR

Reference001 have the shape of a lamellhus, is positioned in the south of the site and have a height on 32.5 m. The property is surrounded by two properties with similar height. To the south there is a property with unknown height not belonging to the studied DDP, but with a height slightly higher than Reference001. Reference001 contains of 87.5% residences and 12.5% premises, the SF is 0.28 and the WFR 20.0%. Premises is located at the bottom floor.

Reference005 is divided into two parts with different heights which have a height on 40.5 and 48.0 m. The property is positioned on the north side of the site and surrounded by a street in both north/north east and east. In west/north west there is a property which have a height on 32.0 m for the parts closest to Reference005. A building with a height on 34.0 m is positioned in south/south east. Reference005 only contains premises and the property have a SF on 0.23 and a WFR on 17.7%.

Conclusion based on the above is that the position when it comes to north or south on the site have less importance when it comes to the cooling demands for premises in this case. The same conclusion can be drawn from looking at the SF and WFR. One could imagine that a higher WFR always would lead to higher cooling demand but in this case Reference005, which uses more cooling, have a lower WFR compared to Reference001. On the other hand, one must remember that WFR ofcourse have an impact, but in this case the difference is small between the properties and do not affect the results in high degree. The aspect that seems to influence the cooling the most is the position of premises and the height of the property. For Reference001, the position of premises is on the bottom floors, while Reference005 is a property with premises on all floors. If the studied property is higher than the surrounding, some of the floors won't be shadowed by other buildings which leads to higher solar heat load and cooling demand.

Study the VSC could also give a hint on where there might be risk for high solar heat load. A high VSC means that the facade is not shadowed by the surroundings and in figure 6.6a, 6.6b, 6.6c and 6.6d one can see that Reference005 have a high VSC for almost all facade compared to Reference001.

6.1.2.3 Reference0 - Heating premises

When it comes to heating for premises, Reference002 uses most heating and Reference003, Reference005 and Reference006 the least. At the same time, Reference002 is the property using least cooling for premises.

Looking at the same aspects as for cooling, Reference002 is located to the north on the site and have a town house with court yard shape divided into two parts with different heights; 29.0 m and 32.5 m. The SF is 0.23 and the WFR 19.0 and it contains 84.4% residences and 15.6% premises. The premises are located on the bottom floors. There is no high close by buildings in west/north west and in south east the closest property is quite far away. Surrounding the property in north/north west is a town house with court yard with a height similar to Reference002 and in north/north east there is a building with a height on 32.5 m.

Reference003 is 34.0 m high and have a SF on 0.22 and have a WFR on 15.0%. Reference006 SF is 0.20 and have a WFR on 14.7%. The height of Reference006 is 34.0 m. The conditions for Reference005 is already mentioned when looking at the cooling demand. All these three properties contains 100% premises but have quite different shape compared to each other and Reference002.

To the south/south east, Reference003 is facing a property with unknown height not belonging to the studied DDP but with a height slightly higher than Reference003. In north, a building 6 m lower than Reference003 is positioned. In east there is a road and in west/north west/south west there are two properties with similar height as Reference003.

Reference006 also faces a road in west/north west/south west and the property is surrounded by three buildings. The one in west/north west/south west have similar height, but the building part in north/north west is 14 m higher and the property in north/north east is 6 m lower.

Higher solar heat gains is favourable if considering heating. If arguing in similar way regarding VSC as for the cooling, Reference002 have quite large facade area on the bottom floors with low VSC which means low solar heat loads and thus increase the heating demand as the premises are located in the bottom. The VSC is low especially in the court yards. Reference003, Reference005 and Reference006, that contains only premises, is not shadowed in the same degree as Reference002. All these properties are facing a road which means that there is no close by buildings on that side leading to higher VSC.

However, one can not only look at the WFR and conclude a lower heating demand as higher WWR and WFR also means higher transmission losses. This because the value for thermal transmittance is much higher for windows compared to the exterior wall. Reference002, which uses most heating for premises, have the highest WFR. One can conclude that the reason to why Reference002 uses most heat could be due to the combination of high WFR and low solar heat loads.

Looking at the SF, all properties have a value between 0.20-0.23. Heating is related to transmission losses, which depends on the building envelope area which relates to the SF. So one can expect a relationship between the SF and transmission losses. However, important to have in mind is that the heating demand can't be explained only by looking at the SF.

6.1.2.4 Reference0 - Heating residences

By looking at heating for premises, it is only Reference001, Reference002 and Reference004 that contains residences. Of these three, Reference001 uses most heat and

Reference004 the least. To mention is that Reference001 uses the least amount of cooling of the six studied properties.

Reference001 have the shape of a lamellhus and the building height and surrounding condition are described earlier when looking at the cooling demand.

Reference004 have the shape of a town house with court yard. The property is divided into multiple parts with different heights. In the middle there is a lower part with a height on 20.5 m. The parts in north/north east/east/south east parts have a height on 32.0 m and in west/south west/south the height is 29.0 m. In north/north west/west/south west there is no high close by buildings. In north east/east/south there are properties with similar height as Reference004. In south east, the distance to the next building is quite long. The SF is 0.21 and the WFR 15.1%.

If having the same argumentation as for heating of premises, one can by looking at the VSC conclude that Reference001 have more facade with a lower VSC than Reference004, resulting in lower solar heat gains and higher heating demand. Comparing the SF and WFR, Reference001 have both a higher SF and WFR compared to Reference004, which means higher transmission losses. Even though a higher WFR is positive if considering the solar heat load, the combination of having high WFR at the same time as having larger part of the facade shadowed by surrounding buildings leads to higher heating demand in this case.

Important to mention about solar heat gains and the relation to heating demand is that one may never know if people living and working may experience glare or dissatisfaction with solar radiation and due to this use solar shading. This makes establish a solar shading schedule difficult. To rely on solar radiation when it comes to heat the building to desirable indoor temperature is therefore not suitable or durable. Solar radiation must be handle with caution and in combination with other aspects.

6.1.2.5 Reference0 - VSC

It is important to remember to not only look at the level of facade within different intervals of VSC, but also where the VSC is low. In this case study, premises could infer to both offices, shops and other activities. Daylight requirement differs depending on kind of activity so even if there is parts of the property with a low VSC it must not necessary be an issue. By combining visualization and diagrams, a better understanding of the daylight condition is possible. If studying the total case, 19.3% of the facade have a VSC between 15-25%, and 32.9% below 15%. So almost 1/3 of the properties may experience issues reaching the daylight demands, regardless if increase the window area. However, as been mentioned there might be premises without daylight demands at these positions which makes the low VSC not an issue.

Studying each of the properties separately, all properties except Reference005 and Reference006 have a VSC below 25% at more than 50% of the facade. Reference001 and Reference003 have the highest degree of facade with a VSC below 15%. Reference005 performs the best when it comes to VSC, Reference006 is also good.

Looking at the conditions for the properties that performs well, these buildings have first of all at least one facade not facing any close by buildings. The facades facing other buildings have varying degree of results depending on the distance to and the height of the next property.

Studying figure 6.6a, it is clear that Reference006 have one side of the facade where the VSC is low on almost all floors. In figure 6.6c, it can be seen that a big part of the facade for Reference006 have a VSC below 25%. Also, figure 6.6c shows that Reference005 have a high degree of low VSC at the facade closest to Reference004. Again, if this is an issue or not is depending on what kind of activity will take place and also on the condition of the other facades. For instance, if looking at the north facade in figure6.6c, the VSC is above 25% at the whole facade which means that daylight hitting that side of the building may be enough to ensure good daylight conditions depending on the room geometry.

There are two kvartershus on the site and both of these may experience issues with daylight at the corners, in the court yards and on the bottom floors. Reference001, which performs less good when it comes to VSC, is facing other buildings with similar height on all sides besides one smaller part. Looking at figure 6.6a and figure 6.6d, one can see that the two longer sides and especially the south, have large facade area with low VSC. Reference003 have an opening in the middle of the building which have very low access to daylight if looking at figure 6.6b and figure 6.6c.

What affects the VSC conditions are the distance to and height of surrounding buildings, geometry like corners and also important to mention is that even though the VSC may be high on the facade, the building depth is limited if wanting to achieve good daylight. Rooms with a facade with lower VSC may require more windows, which increase the solar heat load and transmission losses. Glare and view from the inside out and outside in must also be taken into consideration.

6.2 Comparison I

The results and conclusions for comparison 1 is presented in this section.

6.2.1 Comparison I - Results

Heating and cooling for each property are presented in figure 6.7, figure 6.8 and figure 6.9. The results compared to Reference0 can be seen in figure 6.10.

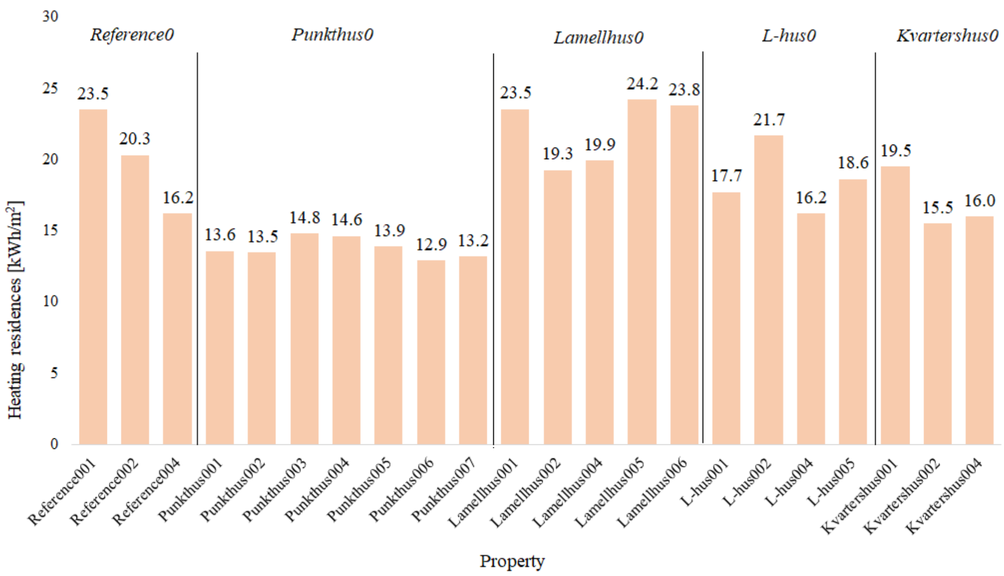


Figure 6.7: Comparison I - Heating residences [kWh/m^2]

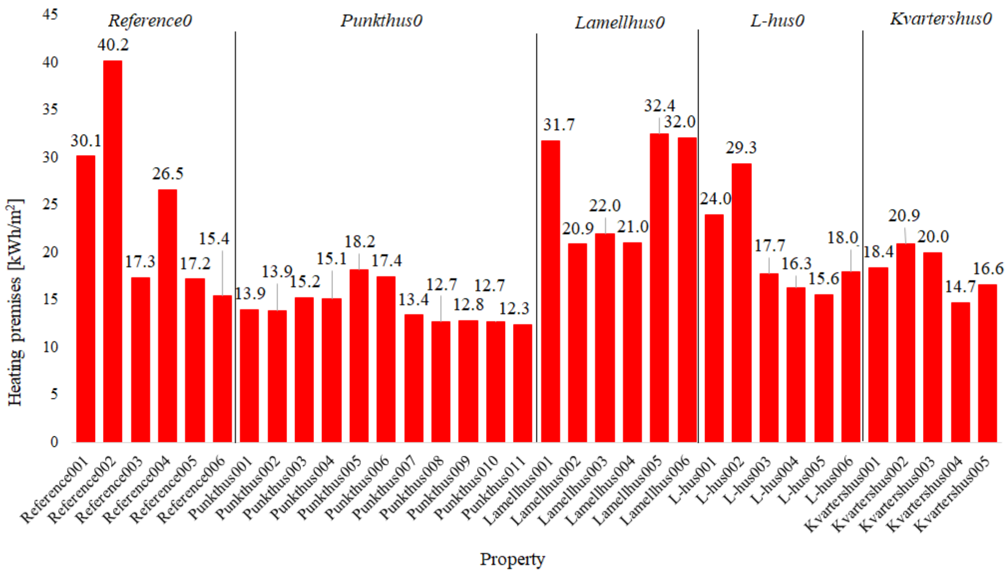


Figure 6.8: Comparison I - Heating premises [kWh/m^2]

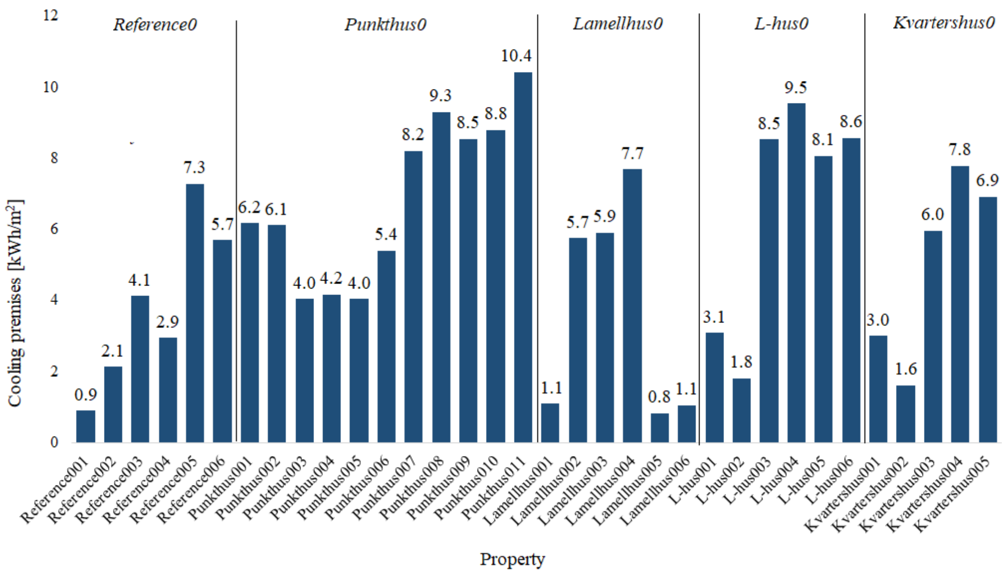


Figure 6.9: Comparison I - Cooling premises [kWh/m^2]

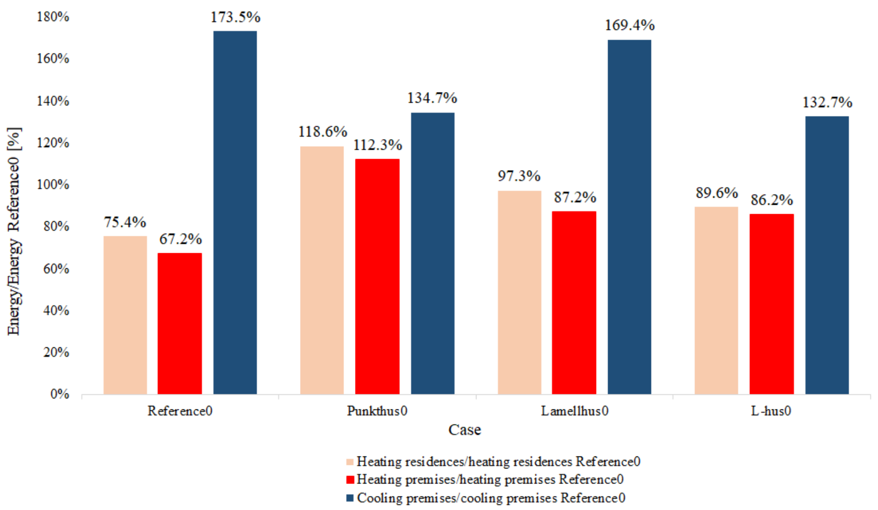


Figure 6.10: Comparison I - Heating and cooling compared to Reference0 [%]

In figure 6.11, the total transmission losses per property in relation to the SF is presented.

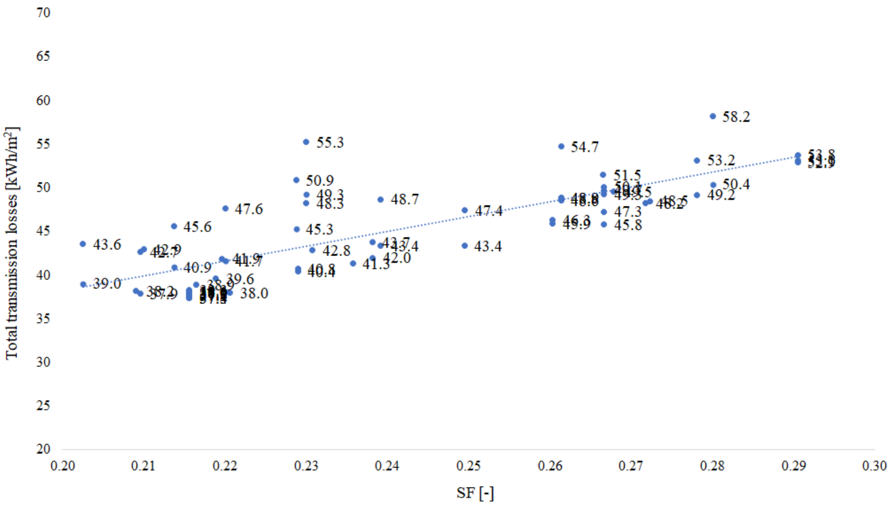


Figure 6.11: Comparison I - Transmission losses [kWh/m^2] vs. SF [-]

The VSC for each property is presented using diagrams, see figure 6.12. The summarized result for each of the cases is illustrated in figure 6.13. In figure 6.14 the difference between the cases compared to Reference0 is illustrated.

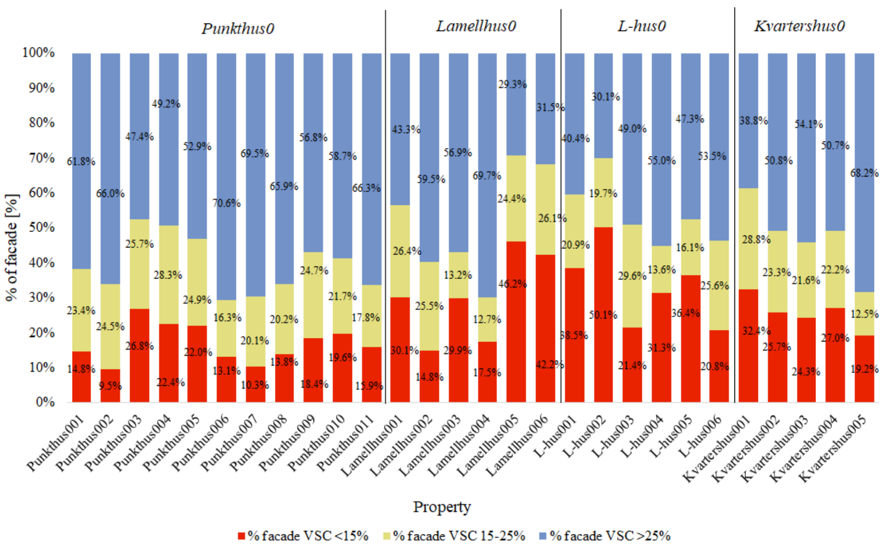


Figure 6.12: Comparison I - % of facade within different level of VSC per property [%]

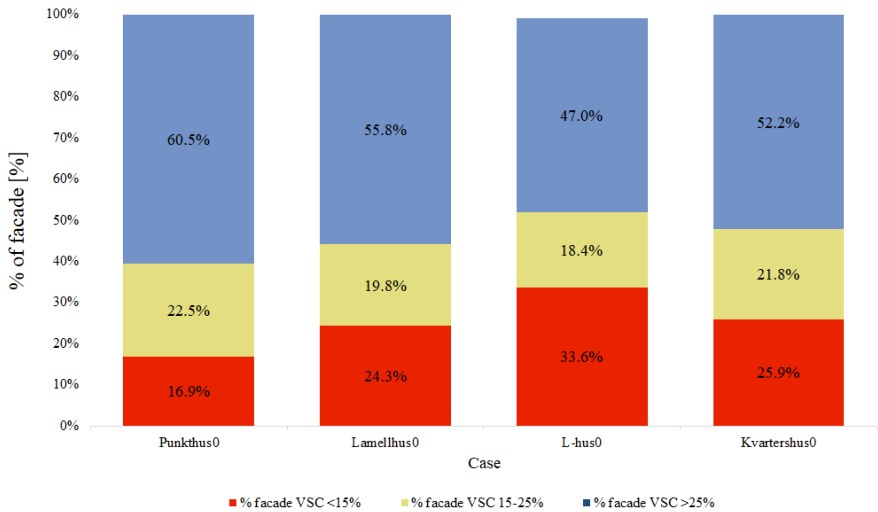


Figure 6.13: Comparison I - % of facade within different level of VSC per case [%]

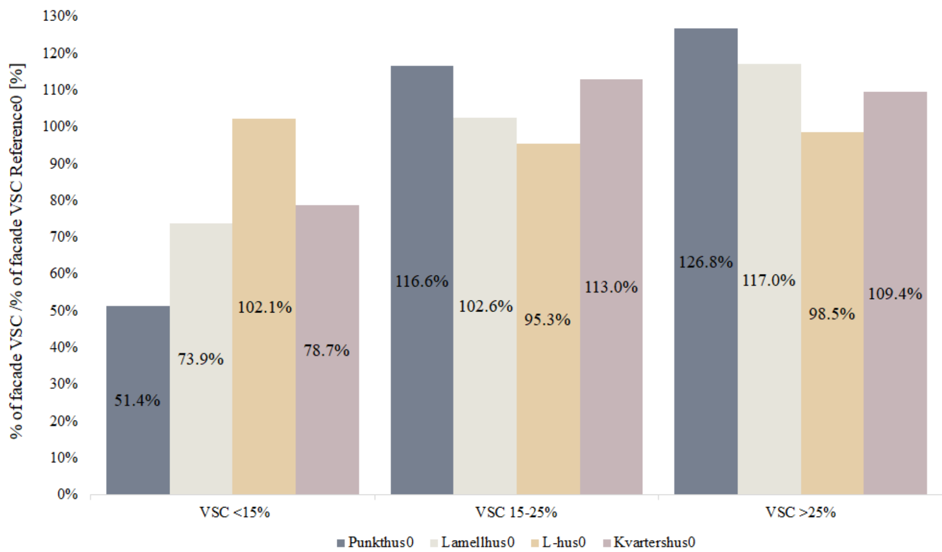
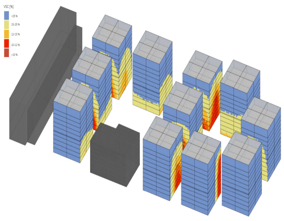
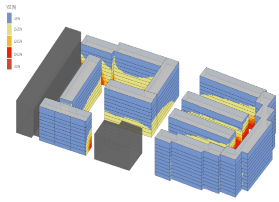


Figure 6.14: Comparison I - % of facade within different level of VSC per case compared to Reference0 [%]

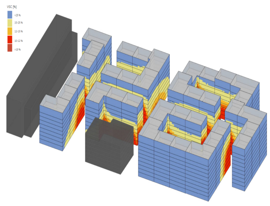
The VSC looking from north east are visualized in figure 6.15. The visualizations can also be seen in appendix D.3



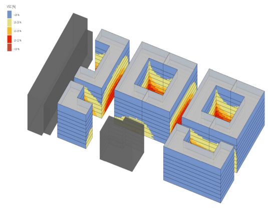
(a) VSC Punkthus0 [%]



(b) VSC Lamellhus0 [%]



(c) VSC L-hus0 [%]



(d) VSC Kvarterhus0 [%]

Figure 6.15: VSC of Comparison I on north east facade

6.2.2 Comparison I - Conclusions

This section summarize the conclusions based on the results for Comparison I.

6.2.2.1 Comparison I - Cooling premises

Studying each property separately, Punkthus007-Punkthus011, Lamellhus004 and L-hus003-L-hus006 are the properties using most cooling. Lamellhus001, lamellhus005, lamellhus006, L-huss02 and Kvartershus002 uses the least. If comparing the cases with Reference0, all have higher cooling demand. Punkthus0 and L-hus0 in top with an increased cooling demand on about 70%. Lamellhus0 and Kvartershus0 have an increased cooling demand of around 30%.

If looking at Punkthus011, which is one of the properties that uses most cooling, it is position in the north of the site, surrounded by buildings with the same height. The whole building consist of premises. The property have no close by buildings in north/north east/north/north west. The SF is 0.22 and the WFR is 15.7%.

L-hus004 is a quite big property that contains both offices and residences. The property covers approximately about 1/4 of the site and is located in the north west, divided into two heights; 36.0 m and 39.0 m. It has no surrounding buildings in north/north east/west/south west. In south there is a building with similar height, and in north west/west/south west there is also a property with similar height. The SF is 0.24 and the WFR is 17.3%.

Studying the lamellhus which use lower amount of cooling compared to the other properties, Lamellhus001 is positioned in south with a height on 36.0 m. Surrounding the property is to the north east a property with similar shape as Lamellhus001 and in north/north west/west/south west a larger property. In south/south east there are buildings not belonging to this site but with a slightly higher height than Lamellhus001. The property is facing a court yard in north west and a quite open area in north west. The SF of Lamellhus001 is 0.27 and the WFR is 20.0%. Lamellhus005 and Lamellhus006 are positioned in the north surrounded by a larger property (Lamellhus004). The property have one side each facing green areas and in the south there is a road. The height of the properties is 36.0 m and Reference004 that surrounds the properties have the same height in west and is a few meters higher in north west/north/north east/east. Both properties have the same SF and WFR, 0.27 respective 20.0%.

Looking at the VSC; Lamellhus001, Lamellhus005 and Lamellhus006 have a high degree of facade with a lover VSC also meaning that the solar radiation hitting the facade is low resulting in lower cooling demand. If looking at Punkthus0, one may expect that the properties in south may be the properties with higher cooling demand but in this case, these are shadowed by buildings outside the site. Punkthus001 have two facades facing no other buildings and have a high VSC on large parts of the facade. This is due to not being shadowed as the distance between the property and open areas are large. L-hus004 have a lot of facade not facing any nearby buildings and because of this, the solar heat loads are higher.

As been concluded earlier, the aspects of shadowing have big influence. Of course the WFR also matter but as the WFR is not varying in high degree it's a matter of the position of the properties in relation to each other and the height of these that in high degree affects difference in cooling demand.

6.2.2.2 Comparison I - Heating premises

Generally, the lower SF, the lower heating demand. Comparing the cases against Reference0, it is only Lamellhus0 that have a higher heating demand than Reference0. That Lamellhus0 would have high heating demand is expected if looking at figure 6.8 where almost all lamellhus uses more heat per m^2 compared to the properties in the other cases. Punkthus0, that has the highest increase in cooling demand compared to the Reference0, is however also the case with the highest decrease in heating. Why there is such a difference in heating could be explained by first of all studying figure 6.11. The diagram shows that there is a correlation between the SF and the total transmission losses. All properties in Punkthus0 have a SF on 0.22 which results in lower transmission losses than for the lamellhus which have a SF between 0.25 to 0.27. If looking at the WFR, punkthus generally have lower values than the rest of the studied properties which should lead to lower solar heat gains if considering the window area. However, it is also about the access to sun and by studying figure 6.12 and figure 6.14 it can be seen that punkthus in general have higher degree of VSC than than the other properties. This means more access to sun and higher solar heat loads which in turn decrease the heating demand. To add, as been mentioned earlier, it is important to not only rely on solar heat gains to heat the building as there might be aspects obstruct solar radiation coming into the property, like human behavior related to use of solar shading systems.

6.2.2.3 Comparison I - Heating residences

As for the premises, Lamellhus0 is the only case with higher heating demand than the reference case. One can draw the same conclusion as for the residences, that the lamellhus uses more heat due to higher transmission losses and less solar heat gains.

6.2.2.4 Comparison I - VSC

Figure 6.12 shows that in general, punkthus is the building type providing the best conditions for a high VSC if wanting to establish similar BTA as the reference case. Figure 6.14 shows that if looking at the site in total, the share of facade with a VSC below 15% decrease with almost half compared to Reference0 and the share of facade area that have a VSC between 15-25% and above 25% increases with 16% respective 27%. L-hus0 performs quite similar as Reference0 if only looking at the % of facade within different level of VSC. Lamellhus0 and Kvartershus0 performs slightly better in this case.

If looking at each property separately, Lamellhus005, Lamellhus006, L-hus001 and L-hus002 have a high degree of facade with a VSC below 15% which results in difficulties reaching the daylight demands in these parts of the building. However, as been pointed out before, it is about which kind of activities will take place as not all of these have daylight requirement. The conditions for Lamellhus005 and Lamellhus006 have been explained earlier when discussing the outcome of cooling. The properties are positioned in the north surrounded by Lamellhus004 which is a large property that decrease the daylight hitting the facade. L-hus001 is facing other buildings on all sides besides north west/west/south west and is surrounded by properties on all sides. In figure 6.15c the conditions for L-hus is illustrated and the compactness of the site explains the low VSC.

The visualization of VSC helps conclude where the conditions for daylight is less good and together with the summarized result for each of the case and each property, it enables identification of challenges and opportunities for improvement.

6.3 Comparison II

This section contains the result and conclusions for Comparison I.

6.3.1 ComparisonII - Results

The heating and cooling for each property is presented in figure 6.16.

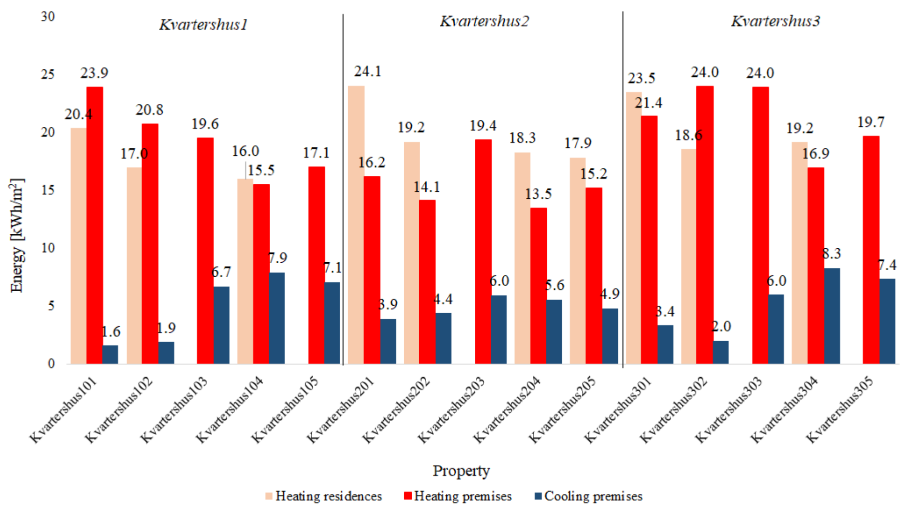


Figure 6.16: ComparisonII - Heating and cooling per property [kWh/m^2]

The change in energy use for all cases compared to Kvartershus0 can be seen in figure 6.17.

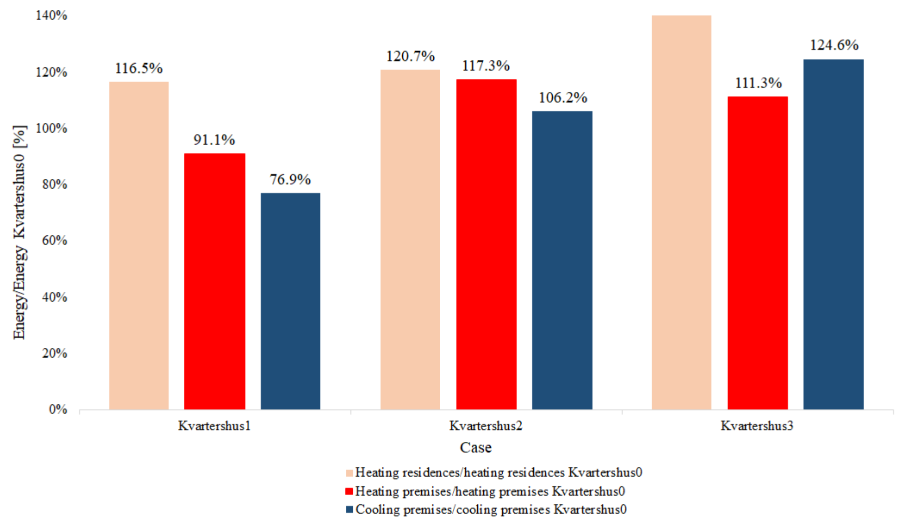


Figure 6.17: ComparisonII - Heating and cooling compared to Kvartershus0 [%]

The change in heating and cooling per property compared to Kvartershus0 is presented in figure 6.18.

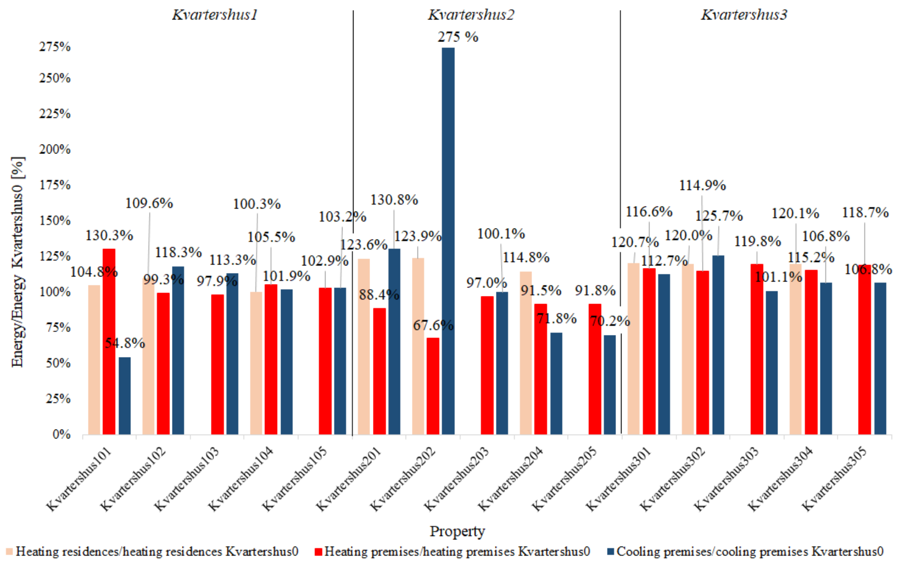


Figure 6.18: ComparisonII - Change in heating and cooling per property compared to Kvartershus0 [%]

Results for VSC is presented in figure 6.19. Kvartershus3 have the same shape as Kvartershus0 but with increased WWR and therefore, the results for VSC are the same and will not be presented. In figure 6.20, the difference in VSC for Kvartershus1 and Kvartershus2 compared to Kvartershus0 is illustrated.

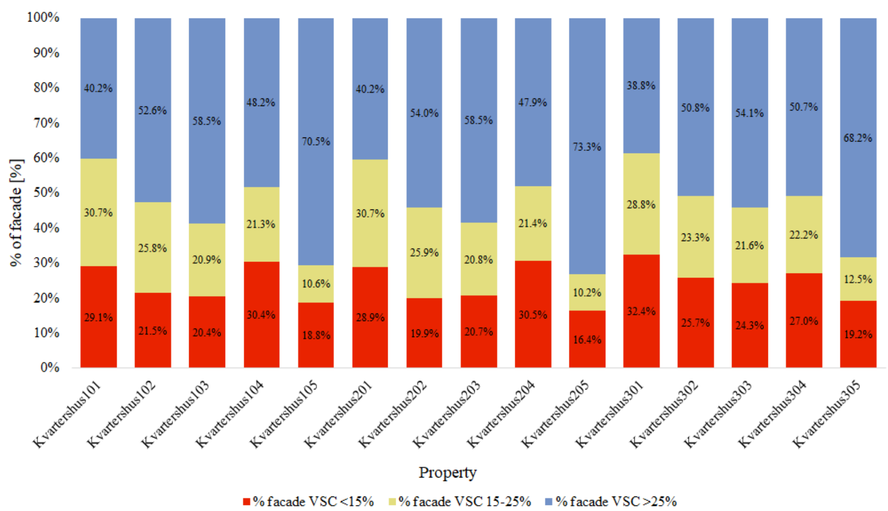


Figure 6.19: ComparisonII - % of facade within different level of VSC per property [%]

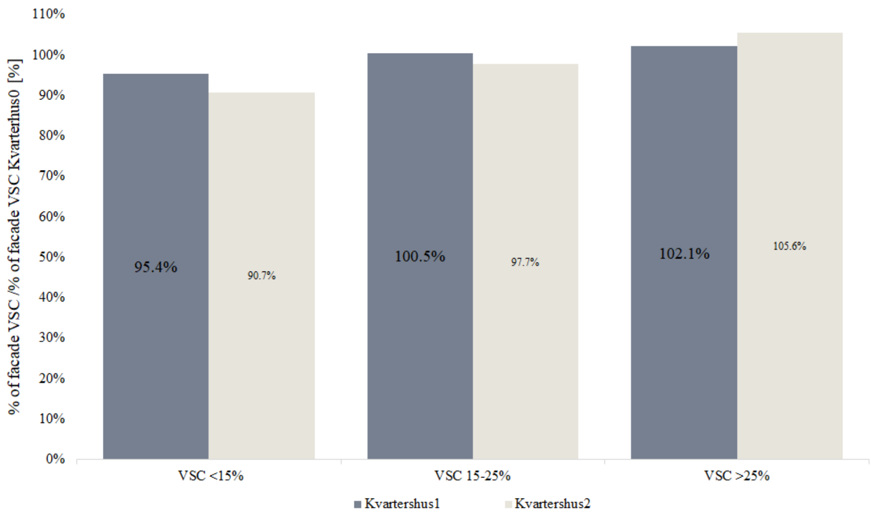


Figure 6.20: ComparisonII - % of facade within different level of VSC per case compared to Kvartershus0 [%]

6.3.2 Comparison II - Conclusion

This section summarize the conclusions based on the results for Comparison II.

6.3.2.1 Comparison II - Cooling premises

Studying and comparing the cases, Kvartershus003 have the highest increase in cooling which do not come as surprise as the solar heat gains increase with a higher amount of windows. The difference between Kvartershus0 and Kvartershus1 is an increase of height in north and a decrease in height north. This results in an increase in cooling by a few % which is related to less shadowing.

The properties in Kvarterhus0 and Kvarterhus3 looks the same except from an increase in WWR from 30% to 40%. If studying each property in the case with incresed WWR, the results for cooling are varying. Figure 6.18 shows that the cooling have increased in higher degree for Kvartershus301 and Kvartershus302 compared to the other if looking at the percentage. However, these two properties uses less cooling per m^2 premises. Studying the conditions of these buildings, Kvartershus301 and Kvartershus302 are positioned to the south on the site and it is the position and how the buildings are shadowed that explains the increase.

In figure 6.18 it is clear that in percentage, Kvartershus202 is the property with the highest increase in cooling with about 175%. What have changed is that the height of the property. The height before were 33.0 m but now the property have been divided into two parts with different height on 33.0 m in north and 27.0 m in south. The SF have increased from 0.21 to 0.23 and the WFR from 14.3% to 15.0%. Kvartershus202 have one facade not facing any high buildings which results in high VSC. This also means access to solar radiation. Having good access to solar radiation means that an increased WWR have a bigger affect on cooling than if the facade is shadowed. However, in total, changing position of premises and residences in this case decrease the cooling if consider the whole site.

Studying Kvartershus2, changing position of premises and residences with premises located mainly in the lower parts of the properties decrease the cooling demand. If looking at the whole site, the decrease is about 9%. How this come have been examined. In kvartershus0, the properties containing 100% premises are Kvartershus003 and Kvartershus005. Kvarterhus004 also contains high degree of premises, around 61%. The height and shape for this properties can be seen in figure 5.4. Kvartershus004 and Kvarterhus005 is located in the north, and Kvartershus003 in the south. Kvartershus003-Kvartershus005 are the properties using most cooling per m^2 if studying the whole site. In kvartershus2, Kvarterhus203 still consists of only premises but Kvartershus204 now only contains around 44% premises and Kvartershus205 36.4%. The premises that before used the most cooling due to the position on the site now contains higher degree of residences, which do not require cooling. All properties do now consists of premises in varying degree and these are positioned in the lower floors of the buildings, resulting in lower cooling demand.

Conclusion about cooling for kvartershus; changing height affects the cooling, negative in this case, depending on how the difference in height between the properties are positioned. Higher buildings in north leads to less overshadowing and higher solar heat gains with increase in cooling as consequence. A higher WWR can have a negative effect on cooling depending on where the building is positioned and the shape and height compared to the surrounding. Changing position of premises and concentrate these to the parts which have less solar heat gains, often the lower parts of the properties, have positive effect on the use of cooling.

6.3.2.2 Comparison II - Heating premises

Changing height in Kvartershus1 have some impact on the heating looking at the site in total. However, the change in total is about 4% for premises. Changing height change the SF with a bit higher values for all properties except for Kvartershus003. As been presented before, a higher SF leads to higher transmissions losses which can explain the slightly higher heating demand. The WFR have also increased, even if it's below 1% for all properties, which could result in higher solar heat gains. But it is also about shadowing and in this case, the increase in solar heat gains does not weight up for the higher transmission losses.

The heating demand for premises have decreased if comparing Kvartershus2 with Kvartershus0. The premises is now located mostly in the lower parts of the buildings and as been mentioned when examine the cooling, there is an other distribution of premises and residences in the properties and on the site. One explanation to the decrease in heating could be the mentioned distribution of premises, that these are now connected to residences in higher degree than before and thus receive heat by transmission losses through the internal slab. The premises are generally less affected by the solar radiation as the solar shading system reduces a lot of the solar heat load (a lower g-value for the windows and the shading system). So even if the premises have moved and is now shadowed in higher degree than before, the change in solar heat load is not the aspect that contribute the most to the change.

Comparing Kvartershus3 with Kvartershus0, the heating for premises increases with 17% if looking at the total site. Looking at each property, the increase is about 15-20% for each property and is explained by higher transmission losses. Even if higher WWR leads to higher solar heat gains, it does not weight up for the increased transmission losses. Also, the need of heating is higher during the colder part of the year where the solar radiation at the same time is lower.

6.3.2.3 Comparison II - Heating residences

Studying the whole site, all cases have higher heating demand for premises compared to Kvartershus0. If starting with Kvartershus1, the heating increase with around 6%. The reason for this is the same argument as for heating of premises; a higher SF and higher transmissions losses. The low increase in WFR does not compensate for the higher transmission losses even though the solar heat gains may have increased.

Heating of residences have increased with about 16% if looking at the whole site when changing position of residences and premises. To explain this, one may study where on the site the residences is mainly positioned. Before, there were mainly residences in Kvartershus001 which contains 75% residences and Kvartershus002 around 90% residences. Kvartershus004 have also some share of residences; around 40%. As been mentioned before, Kvartershus004 is located to the north on the site, Kvartershus001 and Kvartershus002 in south. In Kvartershus2, there are residences in four of the five properties compared to the previously three. Now, Kvartershus201 contains 50% premises, Kvartershus202 around 44%, Kvartershus204 43.8% and Kvarterhus205 36.4%. So in general, there is a more even distribution of residences and premises in the properties.

In Kvartershus0, all properties uses between around 15-21 kWh/m^2 with Kvartershus001 in top. Kvartershus2 and Kvartershus201 still uses the most heating but now the property have a lower degree of residences and also a decreased height. What may explain the increase in heating for Kvarterhus201 could be the lower height which results in higher degree of shadowing by the properties not belonging to the site located to the north. This increase the heating. Also, there have been, as already mentioned, an increase in the SF and WFR which increase the transmission losses. If the property isn't shadowed in the same degree as it is actually is, the solar heat gains due to more windows may had decreased the heating a bit but the combination of increased window area and increased shadowing leads to higher heating demand.

Kvartershus3 has, as already been stated, an increased cooling demand and do also have an increased heating demand for premises. It is the case where, if looking at the whole site, the heating demand have increased the most. The same argumentation as for heating of premises is valid; higher transmission losses that aren't compensated for by for instance increased solar heat load.

To conclude; changes in height affects the heating. Whether the change is positive or negative is depending on which building are changed and how it's changed in relation to the surrounding. Also, the WWR matters as it increase the transmission losses at the same time as the solar heat gains could increase depending on if the facade is shadowed or not. The position of premises and residences have earlier been concluded matters for the cooling demand, but do also have affect on the heating demand.

6.3.2.4 Comparison II - VSC

Changing height have an impact on the VSC, in this case a small impact, but still a positive improvement. This can be seen by studying figure 6.19 and figure 6.20. Studying the whole site, the share of facade with a VSC below % decrease with 5% for Kvarterhus1. The share of facade with VSC on 15-25% and above 25% remains quite similar. Looking at the property separately, Kvarterhus101 have higher the highest degree of VSC between 0-25%, and Kvarterhus103 the lowest. What distinguish these two are the shape and the properties relation to the surrounding buildings when it comes to height and distance. In figure 5.8 it can be seen that Kvarterhus103 have more free space around than Reference001 and is also higher than the surrounding properties which is positive through a daylight perspective, at least for the top floors.

The VSC is measured on the outside facade and the result of illuminance on the vertical surface compared to an unobstructed sky on the horizontal surface. The kind of activity going on inside does not affect the VSC. However, the resulting VSC may have an affect on where it's possible to position offices, residences and stores. It's a matter of which kind of activity have daylight demands and which do not. What do affect the VSC in Kvartershus2 is the fact that the height is also changed and not only the position of residences and premises. Compared to Kvartershus0, the facade with a VSC below % decreases with around 9%, and the facade with VSC above 25% increases with around 6%. The change for VSC below 15-25% is 3%. So in this case, the change in height had an positive outcome when it comes to the VSC.

As Kvartershus3 looks the same as Kvartershus0, the result for VSC will not be comment as it has been evaluated in Comparison I.

To add, as been mentioned before, it is important to study where the VSC is low as this may result in higher window area demands to be able to reach the daylight requirement which increase the solar heat load and transmission losses. Increased solar heat load could be both desirable and not depending on what kind of activity is going on.

6.4 Comparison III

The results and conclusion regarding Comparison III is presented in this section.

6.4.1 Comparison III - Results

Implementing external corridors increase the thermal bridges with 13.5% if comparing case Lamellhus1 with Lamellhus0. Looking at each property, the increase for residences is presented in figure 6.1.

Table 6.1: Comparison III - Thermal bridges

Property	Δ Thermal bridges residences [%]
Lamellhus101	+23.5
Lamellhus102	+28.5
Lamellhus104	+26.6
Lamellhus105	+23.1
Lamellhus106	+23.1

The heating and cooling per property for Lamellhus0 and Lamellhus1 is presented in figure 6.21.

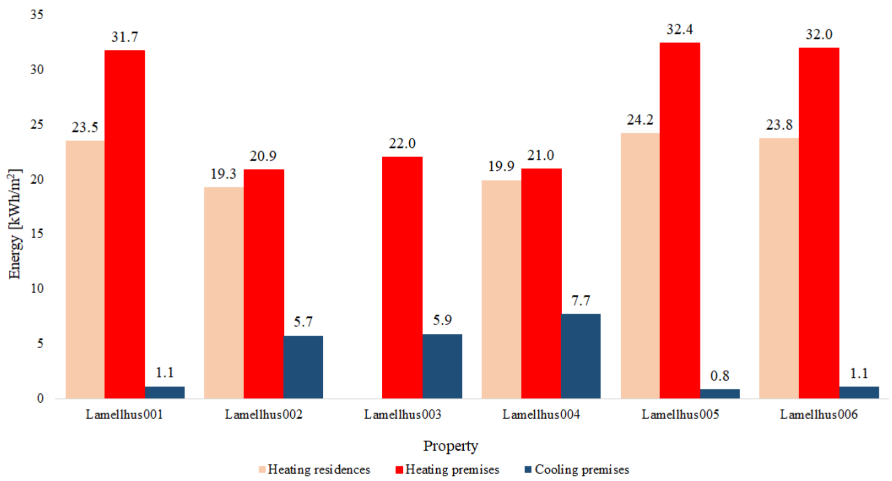


Figure 6.21: Comparison III - Heating and cooling per property Lamellhus0 and Lamellhus1 [kWh/m^2]

The change in heating and cooling per property for Lamellhus1 compared to Lamellhus0 is presented in figure 6.22.

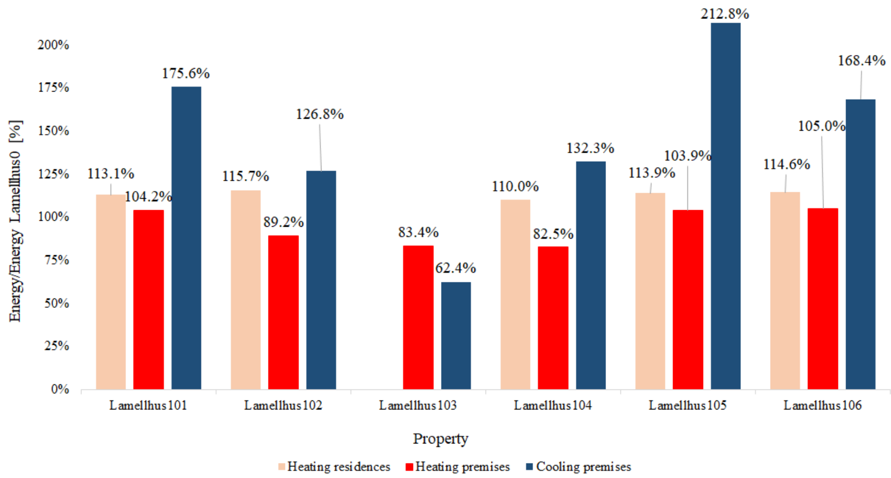


Figure 6.22: Comparison III - Heating and cooling per property Lamellhus1 compared to Lamellhus0 [%]

The change in heating and cooling between Lamellhus0 and Lamellhus1 is presented in figure 6.23.

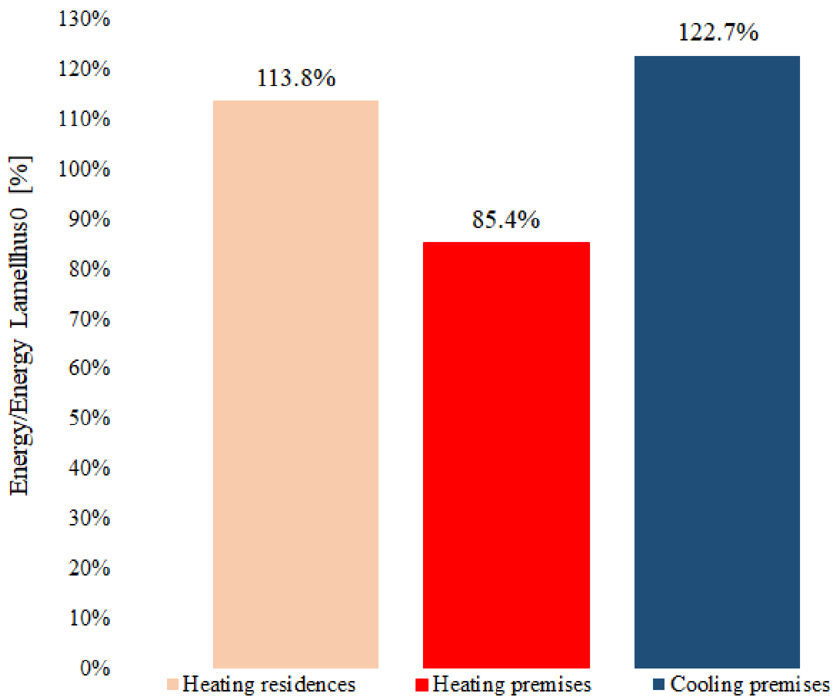


Figure 6.23: Comparison III - Heating and cooling Lamellhus1 compared to Lamellhus0 [%]

The change of % facade within the different levels of VSC for each property if comparing Lamellhus1 with Lamellhus0 is presented in figure 6.24. In figure 6.25, the difference in VSC if looking at the whole site is summarized.

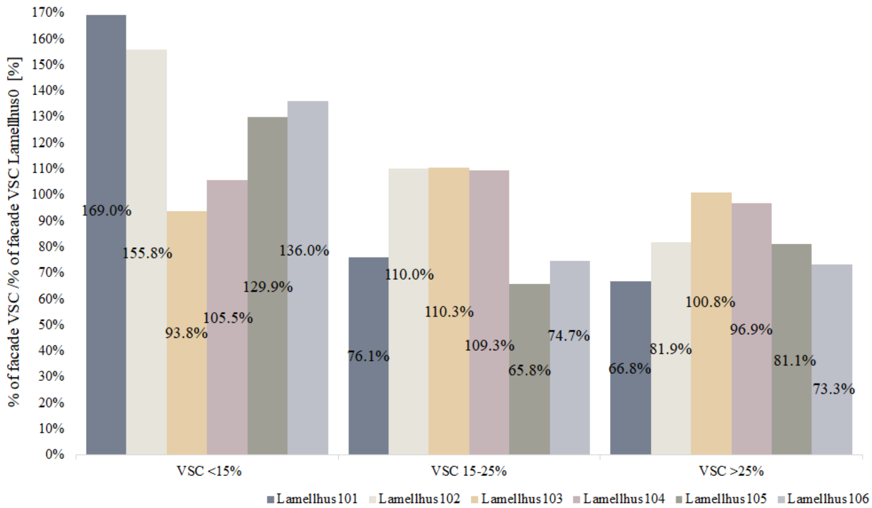


Figure 6.24: Comparison III - % of facade within different level of VSC per property [%]

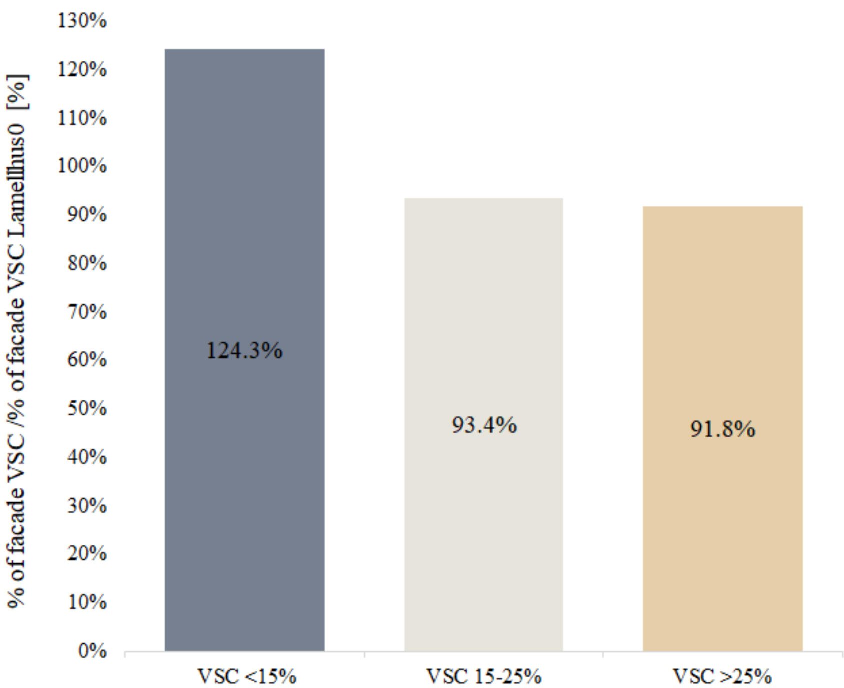


Figure 6.25: Comparison III - % facade within different level of VSC Lamellhus1 compared to Lamellhus1[%]

6.4.2 Comparison III - Conclusion

6.4.2.1 Comparison III - Cooling premises

In figure 6.23 it can be seen that if studying the whole area, the cooling demand have increased with around 23%. This can be explained by first study the properties separately. Figure 6.22 shows that Lamellhus101, Lamellhus105 and Lamellhus106 have the highest increase if looking at the percentage, but these property also have a low cooling demand in both case Lamellhus0 and Lamellhus1 which means that an increase in cooling in kWh/m^2 affects the outcome in increased percentage in higher degree than for the properties with a higher value for cooling. Even though these three properties are shadowed by the surrounding geometry, the small increase in cooling is probably due to the increase in WFR which increase the solar heat load and the cooling demand as a result of this. Lamellhus102 and Lamellhus104 have also an increase in cooling demand which probably could be explained by the same argument; a higher solar heat load.

The only property that is affected in a positive way when comparing the two cases regarding cooling is Lamellhus103, with a decrease on 37.6%. The decrease in this case is not due to implementing external corridors as the property contains 100% premises. The WFR have decreases with 0.2% but the decrease could perhaps be explained by looking at the position of the property. Lamellhus103 is located in the south east of the site, close to Lamellhus001 which contains mostly residences. It is also positioned besides Lamellhus102 which contains 62% residences. Implementing external corridors at the residences at these properties means that the properties are covered in high degree by these. These external corridors may shadowing Lamellhus103 and decrease the cooling demand due to lower solar heat loads.

Conclusions about cooling with regard to implementing external corridors at the residence parts in this case study is that it may have a positive affect on premises that are shadowed by these. To mention is that having external corridors may lead to changes in the geometry which also affects the cooling demand, in this case negative. It is important to take into account both the shadowing aspect and the changed geometry when it comes to cooling demand and external corridors.

6.4.2.2 Comparison III - Heating premises

Figure 6.23 shows that the heating for premises if studying the whole site have decreased with around 14%. Lamellhus101, Lamellhus105 and Lamellhus106 have an increase in heating with 3.9-5.0%. Why this is could be explained by both a higher SF that increase the transmission losses and a higher WFR which increase the heat losses through the windows. The three properties are surrounded by Lamellhus102 and Laemellhus104 which shadowed these properties and decrease the solar heat load. So even though the WFR is bigger for Lamellhus101, Lamellhus105 and Lamellhus106 than for Lamellhus001, Lamellhus005 and Lamellhus006, these windows are not exposed to enough solar radiation to compensate for the increase in transmission losses through the window glass. The increase in heating for these properties are also due to having high degree of residences which means that big parts of the property are covered with external corridors which shadows the windows at the premises. The solar heat load decreases and the heating demand increases due to this.

The rest of the properties have a decrease in heating for premises with 10.8-17.5% which can be a result of a higher WFR compared to Lamellhus0. These three properties are not shadowed by other properties in the same degree as Lamellhus001, Lamellhus005 and Lamellhus006 which means that the solar heat load increases and decrease the heat demand as result.

Conclusions regarding heating for premises is that the change in demand is connected to the geometrical changes of the property it self and the surrounding properties, but also the degree of residences as the external corridors are implemented at these parts of the property. The external corridors may shadow the windows at the premises and decrease the solar heat load and therefore increase the heating demand.

6.4.2.3 Comparison III - Heating residences

With external corridors implemented at the residences, the thermal bridges increases with 13.5% if comparing Lamellhus1 with Lamellhus0. This increase the heat losses, which combined with a higher degree of shadowed facade which lower the solar heat load leads to higher heating demand. The heating increases for all properties containing residences, which can be seen in figure 6.22. The increase is about 10.0-15.7%.

6.4.2.4 Comparison III - VSC

Implementing external corridors will affect the VSC which is presented in figure 6.24 and figure 6.25. For all property except Lamellhus103, the percentage facade with a VSC below 15% have increased and the percentage facade with a VSC above 25% have decreased. Why the result for Lamellhus103 differs from the rest is probably due to the fact that it is the only property that does not contain any residences and is therefore not affected in that way. Simultaneously, the close by property Lamellhus101, is changed in shape and may not obstruct the access to the sky in the same degree as before.

6.5 Comparison IV

Results and conclusions for Comparison IV are presented below.

6.5.1 Comparison IV - Results

This comparing includes the reference case and the reference case with an increased WWR from 30% to 40%. The impact of increasing WWR have also been investigated in comparison II which contains only kvartershus.

The result for heating and cooling for each property can be seen in figure 6.26 and the change for each property is presented in figure 6.27.

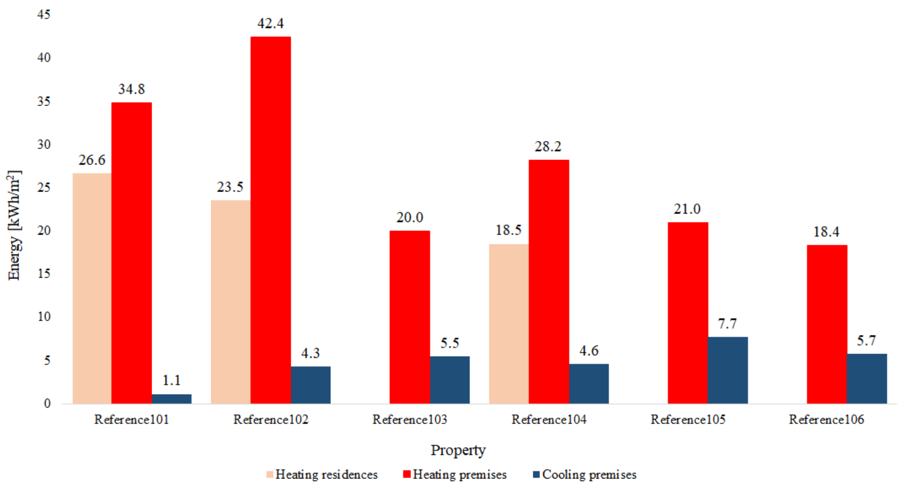


Figure 6.26: Comparison IV - Heating and cooling per property Reference1 [kWh/m^2]

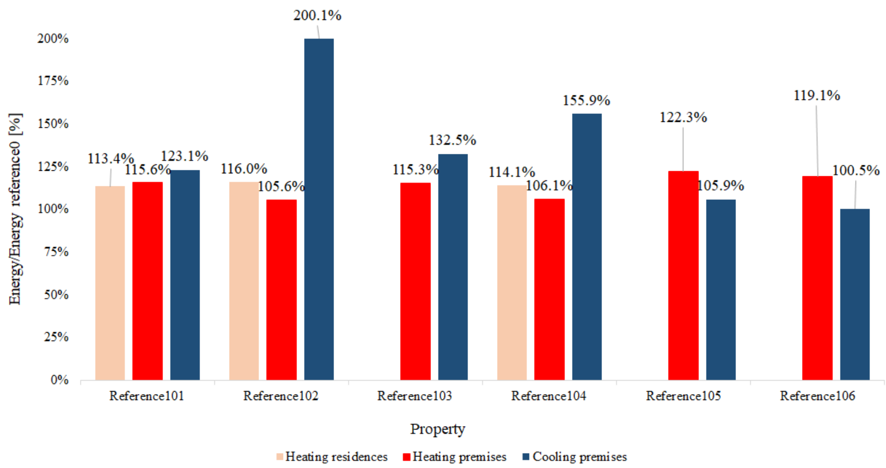


Figure 6.27: Comparison IV - Change in heating and cooling per property Reference0 compared to Reference1 [%]

The change in heating and cooling for the total case is presented in 6.28.

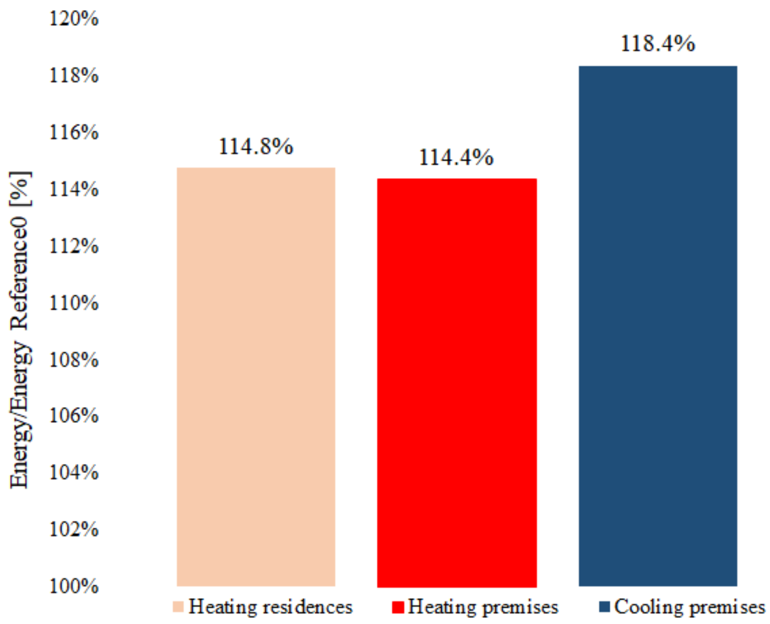


Figure 6.28: Comparison IV - Heating and cooling Reference0 compared to Reference1 [%]

As the VSC is measured on the facade and a change in WWR do not affect the VSC on the facade, the value for VSC is the same for Reference0 and Reference1 and will not be presented. The value of daylight inside the property is of course affected by the WWR but calculating the daylight inside the rooms is not included in this study as the room geometry is assumed to be unknown in this early stage.

6.5.2 Comparison IV - Conclusion

6.5.2.1 Comparison IV - Cooling premises

When studying figure 6.27 that presents the change in cooling looking at the whole site and figure 6.26 where the results for each property are presented, it is clear that an increased WWR have a negative impact on the cooling in this case. All properties except Reference105 and Reference106 have a large increase, between 23.1-100.1%. Reference102 have the highest increase with around the double compared to the original case. Why the properties are affected to different extent can be explained by the locations on the site and the shape of the buildings. Reference105 and Reference106 is both located in the north and also shadowed in higher degree by surrounding buildings. The impact of having a higher WFR do not affect these properties in the same degree as the others due to fact that the solar heat load do not increase that much.

Reference102 have the shape of a kvartershus and is located more to the south west on the site. The WFR have increased with 7.0% and due to being exposed to more sun due to the position on the site, the solar radiation affect this building in higher degree than some of the others. Reference104 have also a high increase in cooling, with a value on 55.9%. This can be explained by looking at the shape and position. Reference104 have big parts of the facade not facing any close by buildings. Due to this, the solar radiation hitting the facade and therefore the windows is high which increase the cooling demand due to increased solar heat load.

Conclusion regarding cooling is that an increased WWR have an impact on the cooling demand. How much is due to of course the increase in % but also the position of the site and the SF. Properties exposed to higher degree of solar radiation are affected more than properties shadowed by the surrounding. An increased SF results in a higher value for WFR when increase the WWR.

6.5.2.2 Comparison IV - Heating premises

It is not only the cooling demand that have increased, so have also the heating demand. The heating demand if studying the whole site have increased with around 15% and the heating for each property have increased with 5.6-22.3%. Reference105 and Reference106 have the highest increase and Reference102 and Reference104 the least. This is actually the opposite to the change in cooling where Reference102 and Reference104 had the highest increase and Reference105 and Reference106 the least.

The increase in WFR is between 32.1-36.8%, where Reference102 have the highest increase and Reference104 the least. So the highest increase in heating must not necessary be related to the highest increase in WFR, it is about where on the site the property is located and the surrounding conditions. Reference105 and Reference106 is located in the north and is, as been already mentioned when discussing the cooling demand, shadowed by surrounding buildings. These properties can not benefit from higher solar heat load and have instead mostly an increase in transmission losses through windows leading to higher heating demand. Reference102 and Reference104 on the other hand have higher solar heat load due to increased WFR and higher degree of facade not facing any other close by shadowing buildings compared to Reference105 and Reference106.

Conclusion regarding increased WWR and heating is that the results are based on both the SF and the location on the site combined with the condition of the surrounding. An increase in WWR will have a higher negative impact on the heating if the property is shadowed.

6.5.2.3 Comparison IV - Heating residences

It is only Reference101, Reference102 and Reference104 that contains residences. The increase in heating demand for these is similar, between 13.4-16.0%. For premises, the variation in increase between the three properties is 5.6-15.6%. Why the variation is lower for residences than for premises could be a matter of position of these activities. Premises are mainly positioned on the bottom floor and a consequence of this is that these are shadowed in higher degree than the floors located higher up in the property. The solar radiation and heat load is related to the access to sun and the heating demand is affected by this.

If arguing similar as for heating for premises, that it's related to transmission losses and solar heat load, one can conclude that the heating demand for residences is related to the resulting WFR due to WWR, the geometry of the building, the position on site and the surrounding.

6.6 Multi-parameter comparison

In order to be able to do an overall comparison of the SF, the results for the VSC and the transmission losses for all cases, a multi-parameter analysis have been carried out. This can be seen in appendix E. What can be seen is that the transmission losses have a quite strong relation to the SF as the transmission losses tend to increase with an increasing SF. The VSC has not as strong correlation to the SF as it is more related to its surrounding than the properties of the property itself, such as the SF.

However, there is a quite large spread of the values for some cases, such as the reference case and town houses with court yards (kvartershus). It could be favourable to have similar performing of the buildings in terms of energy performance as well as daylight, though depending on its use.

7

DISCUSSION

The last years master thesis within the development of BeDOT by Linda Wäppling concluded that to be able to really optimize a building, investigations of daylight condition and energy need to be implemented earlier, before stating the DDP. This matter is one of the main sources for inspiration of this master thesis that aims to investigate if the energy demand really could decrease if implementing BPS even earlier in the building process while guaranteeing no deterioration in daylight or indoor quality conditions. Focus on early stage design and BPS is an obvious choice due to the potential to influence and improve building performance further in form of energy use and daylight conditions.

When performing the literature study, it was no surprise finding that BPS:s are usually implemented in early design stage, but early stage means in this case after the DDP is already stated. As the DDP controls how the developer is allowed to build on the site, it seems that when talking about early stage design today, it is a matter of adapt and develop the best solution possible based on the allowed given conditions in the DDP.

To collect relevant theory possible to apply on the climate for the city of Gothenburg turned out to be not entirely without challenge. But conclusions from the theory are that the SF, WWR and the orientation of the building is of importance. One challenge in the case study was to make sure that the building shape is reasonable in terms of length and width to avoid buildings that in reality is unsuitable for people to live or work in. By collaboration with Amanda Markgren, a student within architecture and project management, assurance of that the building shapes are adapted to reasonable dimensions were guaranteed. Markgren also made sure that the buildings takes into account aspects like for example access to greenery and sun light.

One issue though with having Markgren producing the models were that important aspects that may be obvious for the authors of this master thesis may not be obvious for Markgren who has expertise within another discipline. One example of this is the importance of having the same total area and share of premises and residences for the site to facilitate the comparison between the different cases. The area and share of premises and residences differ in the final versions but due to the fact that the size of the site is large and allows expansions to a certain degree. Therefore, the difference if looking at the percentage is assumed not to affect the result to a large extent.

To add is that Markgren took the building orientation into consideration when position the properties on the site. This is based on the theory that rotating the property with ±15 % towards southeast or southwest from a south orientation can result in a decrease of heating and cooling with around 13-14% due to a parametric analysis by Bogdanović, Ignajatović et al. (2018). The influence of rotating the buildings was planned to include in the case study. However, an issue with rotation is that the properties may not longer fit on the site or next to each other. Rotating the properties were therefore excluded and other aspects like geometry were concluded to be more interesting to study.

To be able to perform the case study, BeDOT has been developed as it was before only possible to study one building at a time. The site to study contains multiple building and due to the fact that how the buildings affect each other are of great matter in this master thesis, develop BeDOT was a must. Developing BeDOT was a challenge and demanded a lot of time. The time effort of developing the tool further did cause some issues when it came to the time plan. This in combination with a very long simulation time resulted in fewer cases studied compared to what was initially planned. The simulation time need to be further develop if striving for efficiency in BPS.

To optimize the master thesis work, priority of which cases were most relevant to study were carried out. This resulted in the study of the actual DDP (the reference case) and the four different comparison options. To compare the reference case with the four different cases where the site contains only type buildings were of importance to be able to study the impact of SF. One of the purposes of the study was to investigate how the change in building height influence as well as changes in position of premises and residences, while maintaining the same building shape. These aspects might produce advises on how to think when planning a property based on energy and daylight. During the interview study, the impact of having external corridor were mentioned and due to the fact of these being implemented on properties today, the impact of having external corridor was included as one comparison. That the window shape, size and position influence both the daylight and energy is obvious and the additional studies provide further insights in this matter.

Regarding the case study, first of all; there are challenges with finding relationships between different aspects when studying a site with multiple buildings and not only one property. Depending on where the property is located and how the building shape is related to the surrounding, especially the view to the sky and different amount of daylight- and solar radiation reach the facade. If having just one building, the impact on energy and daylight when changing SF, WWR etc. would have been easier to investigate. But even though it is more difficult having multiple properties when interpreting the result, it is not a choice having only one building. As one of the purpose with the master thesis is to investigate if it is possible to affect and change the DDP process, study multiple buildings is a demand as many sites includes multiple buildings. How to study multiple buildings at the same time and which aspects to include need to be further investigated though.

To have access to correlations between different aspects would be helpful in the early design decision making. If knowing that finding relationships would be as difficult as it has turned out to be, maybe another approach on how to model the different design option cases had been made. One thought after concluding the case study is that there could have been a higher degree of similarity between the cases. For example, all properties could have similar share of premises and residences to make it easier to compare different building shapes. But at the same time, having equally share of activity is seldom the reality. Properties on a site will often have completely different conditions and shapes. It is a matter of balance the reality with the level of complexity possible to make an comparison.

But even if the outcome from the case study sometimes were difficult to interpret, some conclusion were possible to draw. First of all, there is a correlation between the SF and the transmission losses. The higher SF, the higher heat losses. What could also be seen is that the cooling demand increase with higher value for VSC. This is reasonable as access to the sky affects the access to solar radiation, which in turn increases the indoor temperature and cooling demand. Of course the amount, position and properties of the windows also affect the solar heat load. What is challenging is that a high VSC is desirable, while a high solar heat load most of the time is not. But the work towards reducing energy use has come a long way if having a strategy where different design options are compared with regard to cooling and at the same time make sure that the VSC is high enough.

Finding a correlation between the SF and the heating or cooling demand have proved to be more difficult. This due to what have already been discussed a bit, that the properties are affected by the surrounding. Regarding energy use of typical building shapes; punkthus has the lowest heating demand for both residences and premises compared to the reference case. However, punkthus also have the highest cooling demand which may cause issues when it comes to the indoor climate. In this master thesis, the indoor climate is not investigated because the level of details is to low in this early stage. But by implement BPS early and gain knowledge of aspects such as a high cooling demand, it communicates early in the project that interior measures need to be investigated further later in order to ensure a good indoor climate. This might lead to improvement in the design early which decrease the need of installations to solve issues with cooling in later stages. The result is savings in money, time and natural resources.

There are benefits with all type of typical building types, otherwise these kind of building shape wouldn't be common to implement. Choosing building shape only based on what is best from an energy or daylight point of view would result in a non aesthetic appealing city. It is therefore a matter of positioning these in a clever way and choose a shape that is suitable both with regard to energy and daylight and other important aspects like for instance architecture. The position and geometry of the properties on the site will determine the access to solar radiation which affect the energy use, so one may plan this so that buildings that benefit or disfavor from solar radiation get access to it and vice versa.

The VSC is completely depended on the surrounding. It is due to this difficult to find a correlation between for example SF and VSC. But generally, if looking just at the building shape, court yards and inner corners in the court yards have low VSC that might cause issues with achieving the amount of daylight required. In these positions, activities that do not have daylight demands could be situated which will solve the problem. One challenge though is that this early in the building process it may not be determined what kind of activity will actual be positioned at all positions.

An aspect that is important to mention when talking about the results is the input data used in the case study. As been mentioned before, residences and premises have different indata when it comes to internal heat gains for example and the values for internal heat gains do in high degree affect the end results. When comparing the percentage of BBR fulfilled, properties with a high proportion of premises are favoured which may indicate that the internal heat gains in the input data may have been too low. But as the main focus is comparison between cases and the difference in energy use, the most important thing is that the same value for internal heat gains have been used for all properties which is the case.

Something that has not been included in the study is which kind of energy carrier is chosen to provide heat, cooling and electricity. A matter that in high degree affects the environmental impact. But as previously been reasoned about, the main goal is compare geometry, WFR and position of activities which means that it is the difference between the different cases that is important. How to provide the property with energy is also often a matter of decision in later stage in the design process. This were also discussed by the municipality, that it is not legal to regulate this in the DDP.

Some further reflections about the outcome from the case study is that it contains a lot of data which have been studied with the hope of finding relationships. This proved to be harder than had been imagine when starting the master thesis. A lot of plots were produced that did not result in any valuable relationships, which seem reasonable after discussion why this could be. Of course one may study the total cooling and heating demand and draw conclusions but it is important to be aware of that just because one building type uses less energy than another does not automatically means that this is valid for all cases. It is site depended, as the size of the site will determine the sizes and distance between the properties.

The interviews helped in understanding the DDP process today and whether energy and daylight are somehow taken into consideration today, or for that matter, if it is of interest. The interview study aimed to evaluate the potential of influence the DDP process. The outcome is of course depended on the people that choose to participate. In this case, the range of occupational groups are quite wide which contributed to get a perception of energy and daylight in the DDP process. What is understood about the DDP process is that it's complicated and challenging to meet all requirements and requests due to so many different stakeholders involved. It is difficult, if even impossible, to assess which aspects is more important than the others even if what is compulsory due to laws needs to be of high priority. Regulations aims to create better buildings but to design buildings that people are satisfied with living and working is not only a matter of fulfill mandatory requirements, it requires well thought design suitable for the specific building. What is suitable for one user may not be desirable by another user is important to remember and how a property is used could change over time. This means a great challenge when it comes to the design.

The question regarding who's responsible for creating initial proposal of buildings that both live up to good daylight and is energy efficient at the same time is not easy to answer. It is the developer that in almost all cases is the one to initiate a DDP by applying for planning notification. The developer do hand in a overview of what the plan is for the site and for instance building volumes is specified in the application. It is on this information that the municipality develop the DDP. The municipality have control over the outcome for the area and could come up with a completely different proposal than was first applied for. Though, it was expressed by the municipality that it is more difficult to come up with a completely other solution than the suggested one when developers already have made up their mind. But it do happen and therefore the DDP is often a result of both the developers proposal and the municipalities opinion. Through that perspective, both are responsible.

What is mentioned as an issue by the developer Skanska is that the allowed building shape due to the DDP is not always possible to implement if having to fulfill a set requirements, especially the daylight demands. So it becomes an issue when the developer designs according to allowed conditions but gets a rejection when applying for building permit or starting clearance. The time effort and economical effect due to this must be negative for the project and the whole industry as it could demand large changes in the design and also new applications.

Understood is that the municipality haven't have any mandatory demands on performing BPS regarding daylight and energy during the developing of DDP today. But the issues with denials due to lack of daylight have been addressed especially during the recent years. When asking about daylight studies, the answer is that it do happens, but how detailed and at which occasions are not clear as none of the interviewed have that kind of assignment in the daily work.

What is certain though is that daylight is considered to be much more relevant than energy from the municipality point of view. Why energy is not equally up-to-date as daylight could be of many reasons than the already mentioned issue with denials. Energy calculation demands much more detailed information, details that often isn't available this early. It could also be due to lack of knowledge.

During the interview study it was noted from many of the interviewed at the municipality that including energy in the DDP is not suitable due to risks of locking details from an authority perspective when the DDP is meant only to by necessary limited. It seems to be a fear that having to much details will affect the architects creativity in a negative way. But energy studies may be possible to implement in a way that affects the DDP in a positive way. It does not have to be by mandatory demands, instead it can be included by for instance contribute with advises on how to plan and analyse the site. The DDP could be complemented with different kind of programs and to include the energy aspect in these might be one way to improve the energy performance. Discussing energy, it seem to be an aspects that is not ready to be accounted for today but might become more up-to-day in the future as energy and environmental impact are related. The climate change is and will continue to be important and a challenge to consider for the whole society.

The fact that The Urban Planning Department of Gothenburg this spring have been working with how to address and handle daylight in the DDP contributes to the importance of talking about BPS in the earliest stages of the building process. It also makes the topic of this master thesis relevant. Skanska addresses the issue with DDPs today quite well when expressing that daylight isn't tested until starting clearance and if daylight requirements haven't been studied in the planning process, projects with high and dense building mass could face issues with meeting the legal requirements. This tells that the municipality does understand that is not only the developers responsibility to make sure that the building shape fulfill the demands. If the guidelines to investigate daylight condition will be successful remains to be seen but it is exciting and it's a step against a more efficient DDP and building process.

Compare different options early to encourage low energy use, good daylight condition and provide DDPs possible to carry out without encounter obstacles when later apply for building permit is to strive for. To do this, all concerned disciplines needs to take their responsibility and develop more efficient and communicative ways to collaborate.

8

CONCLUSION

The purpose of the master thesis was partly to investigate if an implementation of BPS regarding energy and daylight could be advantageous in the earliest stage of building design. The results from the case study show that the geometry design influence the energy and daylight performance to a large extent. The SF of the building correlates to the transmission losses of the building which affects the energy demand. A low SF is advised. An increase of the WWR gave an significant increase of the heating demand. However, a lot of the investigated buildings in the case study have a low VSC value, indicating that it may be hard to reach the daylight requirements and an increase of WWR may be a necessity.

It needs to be ensured that the indoor environment is sufficient and that the solar heat load is not too high. There is a need of validation of this but it may be hard to do in the earliest stage of design as room design probably is unknown. It was found in the case study that there was a large variation of performance within the site. The different buildings in the reference case study had varying shapes which resulted in different performance in both energy and daylight. Homogeneous building design results in more even performance and it may be easier to control daylight performance as it is the surrounding rather than the studied building itself that make up for the daylight conditions. Varying shape may be a result of other qualities than studied in this thesis and it is about finding a balance between energy and daylight as well as other design aspects by evaluating different options in an iterative way.

Furthermore, the thesis was about to examine if studies of energy and daylight could be a positive supplement to current studies in the DDP process. Studies of daylight could be a positive supplement to current studies in the DDP process. The interviewees from the municipality expressed that DDP:s should not result in expectations on building volumes that is not possible to implement in later stages. To avoid measures such as having to choose different window design or an increase of WWR that may affect the energy and the economy in a bad way, geometry and daylight studies are suggested to be a positive supplement in the DDP process. If it can be managed in the right way, it will probably save resources in terms of time and energy while ensuring well performing building design.

8.1 Further studies

Suggestions for further work within the subject of early stage design are to study and develop more accurate relationships between interior and exterior measures to contribute to well working conditions right from the start.

Some of the simulations could take up to 8 hours as the radiance component took a lot of time. This is not a convenient way to work in early stage design. To be able to work in an iterative way, further development of working methods in the early stage design modelling of energy and daylight assessment are desirable to form guidelines for these.

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A

Interviews and inquires - Answers

A.1 The Urban Planning Department of Gothenburg

A.1.1 Inquire

Building Performance Simulation (BPS) i detaljplaneprocessen

Enkätundersökning Stadsbyggnadskontoret Göteborg

Hej.

Först och främst tack för att du tog dig tid att träffa oss.

Som komplement till mötet 20-02-18 skulle vi uppskatta om du även ville svara på några frågor. En del av dessa frågor tog vi upp redan när vi träffade dig, men vi hoppas att det är okej att upprepa en del av dina svar. Kanske väckte mötet någon ny tanke hos dig som kan vara oss till hjälp.

Tveka ej att höra av dig om du har några frågor eller synpunkter.

Vänliga hälsningar Julia Andersson, Sara Jonsson och Amanda Markgren

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Kort info

Vi är tre studenter som studerar vår sista termin på Chalmers Tekniska Högskola med inriktning byggnadsteknologi (Sara och Julia) och arkitektur/project management (Amanda). Under våren 2020 gör vi två parallella examensarbeten.

Våra examensarbeten syftar till att undersöka implementering av Building Performance Simulation (BPS) i detaljplaneprocessen. Building Performance Simulation (BPS) kan kort beskrivas som simuleringar av byggnadens prestanda rörande exempelvis energi och dagsljus.

Tidigare examensarbeten inom området BPS indikerar att genom att ta hänsyn till och undersöka förutsättningarna för dagsljus och energi i tidigt designskede kan energianvändningen minskas med 15-20%. Dock är slutsatsen att optimeringen begränsas av redan låsta parametrar i detaljplanen, såsom byggnadshöjd, "footprint" och orientering. Vi vill i vårt examensarbete undersöka om det är möjligt att minska energianvändning ytterligare om BPS är involverat redan i detaljplaneutvecklingen. Parallellt med detta undersöker vi möjligheterna att utveckla ett simuleringsverktyg anpassat till tidiga skeden som skall vara till hjälp i detaljplaneprocessen.

Intervjustudien genomförs genom en kvalitativ intervjustudie med verksamma inom området och vårt fokus är dagsljus- och energifrågor. Tanken med denna intervjustudien är dels att få en inblick i detaljplaneprocessen och dels att få input till utveckling av ett webbverktyg anpassat till detaljplaneskedet. Om du känner att frågan ej berör ditt kompetensområde så går det bra att hoppa över att svara.

Tack för ditt deltagande!

Om dig

Namn:

Företag/organisation:

Arbetstitel:

Arbetsbeskrivning:

Kontaktuppgifter:

Önskar vara anonym: Ja/Nej

Detaljplaneprocessen

Allmänt

1. Är det vanligt i er kommun att ni själva påbörjar en detaljplan utan att en byggherre ansökt om planbesked?
   Om ja:
   - Hur ser processen ut i det fallet (med fokus på energi- och dagsljusfrågor)?

2. Vilken/vilka är de största skillnaderna mellan när en byggherre ansöker om planbesked och när kommunen själva väljer att upprätta en detaljplan (avseende dagsljus och energi)?

3. Vilka handlingar skickar byggherren in när denne ansöker om planbesked (när det rör dagsljus och energi)?

4. Hur detaljerad är den information som byggherren ansöker om planbesked med (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?

5. Vilka faktorer skulle du säga har störst betydelse vid bedömningen av en byggnads tillåtna placering, höjd etc. (ljud, luftföroreningar osv.)?

6. Anser du att detaljplaneprocessen har förändrats de senaste åren / håller på att förändras? Om ja, hur?

Program

7. När är det av betydelse att ha ett program som komplement till detaljplanen?

8. Vilka fördelar finns med att ha ett program?

9. Vilka nackdelar finns med att ha ett program?

10. Vilken nivå av detaljstyrning kan tillämpas i ett program (t.ex. fasadmaterial, kulör etc. som kan tänkas påverka dagsljus och energi)?

Nyckeltal

11. Vilka nyckeltal/faktorer är främst av betydelse när detaljplanen utvecklas?

12. Finns det standardnyckeltal som används i utformningen av byggrätt (storlekar på utrymmen som styr utfallet på byggnadens djup etc.)?

Studier

13. Vilka studier genomförs i detaljplaneskedet (som kan påverka energi och dagsljus)?

14. Anser du att dessa är av betydelse? Varför/varför inte?

15. Anser du att det saknas någon studie? i så fall vilken och varför?

16. Vem är ansvarig för de olika studierna?

17. Enligt din vetskap; involveras energi på något sätt i detaljplaneskedet?
    Om ja:
    - Hur?

18. Anser du att energi är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?
    Om ja:
    - Varför?
    - Hur borde energi tas hänsyn till?

    Om nej:
    - Varför inte?

19. Enligt din vetskap; involveras dagsljus på något sätt i detaljplaneskedet?
    Om ja:
    - Hur?

20. Anser du att dagsljus är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?
    Om ja:
    - Varför?
    - Hur borde dagsljus tas hänsyn till?

    Om nej:
    - Varför inte?

Detaljnivå

21. Vilken detaljnivå rörande byggnadens design kan regleras i detaljplaneskedet?

22. Vilken detaljnivå rörande byggnadens design tycker du är önskvärd att regleras i detaljplaneskedet? Varför?

23. Vilka fördelar/nackdelar ser du med att detaljstyra design i detaljplanen (t.ex. maximal eller minimal andel fönsterarea)?

På nästa sida följer frågor inriktade specifikt på Building Performance Simulation (BPS).

Building performance simulation (BPS)

24. Har du kommit i kontakt med BPS i ditt arbete?
    Om ja:
    - På vilket sätt har du kommit i kontakt med BPS?
    - Vilka parametrar har du kommit i kontakt med (dagsljus etc.)?

25. Anser du att BPS är av betydelse i detaljplaneskedet?
    Om ja:
    - Varför?
    - Hur anser du att BPS ska implementeras i detaljplaneskedet?
    - Vilken detaljnivå är av relevans i detaljplaneskedet?

    Om nej:
    - Varför inte?

På nästa sida kommer några frågor som fokuserar på ett verktyg utvecklat för detaljplaneprocessen.

Verktyg för detaljplaneskedet

26. Om det fanns ett webbaserat verktyg för BPS (fokus på dagsljus och energi) speciellt anpassat till detaljplaneskedet, anser du att det vore av värde?
    Om ja:
    - Varför?
    - Vem skulle använda detta?
    - Vad anser du är de viktigaste egenskaperna ett sådant verktyg bör ha?
    - Vilka nyckeltal är viktig för dig som användare?
    - Hur lång tid tycker du att det är acceptabelt att en beräkning får ta?
    - Hur föredrar du att resultatet illustreras?
    - Hur skulle du föredra att byggnadsgeometrin hanteras (okej med ett antal färdiga byggnadsformer att välja mellan, rita själv etc.)?
    - Vilken detaljnivå på geometrin anser du är viktig för att göra verktyget användbart (exempelvis inkludera balkonger, loftgångar osv.)?

    Om nej:
    - Varför inte?

Nedan får du gärna lämna synpunkter på hur verktyget kan se ut samt innehålla. All feedback är uppskattat. Tänk fritt och brett (hur ser ditt drömverktyg i detaljplaneprocessen med fokus på energi och dagsljus ut?).

Till sist så kommer på nästa sida två avslutande frågor.

Avslutande frågor

27. Finns det något övrigt du vill tillägga?

28. Finns det ytterligare personer du tycker vi ska kontakta?

A.1.2 Answers

A.1.2.1 Participant I

Om dig

Namn: Simon Wallqvist

Företag/organisation: Stadsbyggnadskontoret Göteborg/ Planavdelningen

Arbetstitel: Planarkitekt/Projektledare

Arbetsbeskrivning: Projektledare för detaljplan Norr om Centralstationen, Assisterande stadsarkitekt

Kontaktuppgifter: simon.wallqvist@sbk.goteborg.se

Önskar vara anonym: Ja/Nej: Nej

Detaljplaneprocessen

Allmänt

1. Är det vanligt i er kommun att ni själva påbörjar en detaljplan utan att en byggherre ansökt om planbesked?
   Svar: Nej

   Om ja:
   - Hur ser processen ut i det fallet (med fokus på energi- och dagsljusfrågor)?
     Svar: Det sker sällan. I de fall då privat aktör inte sökt planbesked så är det oftast en kommunal aktör som söker planbesked i for av kommunal byggherre. I somliga fall ansöker fastighetskontoret om planbesked och plan för mark som senare säljs med tillhörande planerad byggrätt.

2. Vilken/vilka är de största skillnaderna mellan när en byggherre ansöker om planbesked och när kommunen själva väljer att upprätta en detaljplan (avseende dagsljus och energi)?
   Svar: Planbeskedsansökan hanterar inte frågan om dagsljus eller energi specifikt. Frågor som hanteras vid planbesked/ansökan om planbesked är mer generella om lämplighet att genomföra plan för ansökt område/fastigheter.

3. Vilka handlingar skickar byggherren in när denne ansöker om planbesked (när det rör dagsljus och energi)?
   Svar: Vet ej.

4. Hur detaljerad är den information som byggherren ansöker om planbesked med (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?
   Svar: Vet ej.

5. Vilka faktorer skulle du säga har störst betydelse vid bedömningen av en byggnads tillåtna placering, höjd etc. (ljud, luftföroreningar osv.)?
   Svar: Ett flertal faktorer samspelar för planering av bebyggelse, placering och volym.
   Läge i staden – vilken typ av område och omgivande bebyggelse finns. I ett villaområde kan det vara opassande med större bebyggelse, vid större kommunikationsknutpunkter är det mer lämpligt att planera för större och mer yteffektiv bebyggelse. I kvartersstaden kan det vara mer lämpligt att fortsätta med kvartersbebyggelse till exempel.
   Läge, stråk, noder, platser avgör mycket av lämplig typ av exploatering.
   Gatumiljö, Gårdsmiljö och parkmiljöer i närhet av bebyggelse spelar in på volym som är lämplig.
   Innehåll i planerad bebyggelse spelar stor roll. Är det bostäder, handel, kontor, skola, förskola, industri eller lager eller nåt annat som planeras är av avgörande

betydelse.

Luft, buller, risk, översvämningsrisk, dagvattenhantering, kulturmiljö är andra avgörande faktorer som spelar in på en byggnads möjliga utformning.

6. Anser du att detaljplaneprocessen har förändrats de senaste åren / håller på att förändras? Om ja, hur?
Svar: Den har och håller på att förändras. Min erfarenhet av planeringsprocessen är inte så lång (5 år). Men vi är i en förändringsprocess vad gäller vilka frågor och hur man utreder och avväger specifika frågor inom processen. En mer holistisk och sammanvägd stadsplanering efterfrågas samtidigt som det finns politiska och ekonomiska påtryckningar att effektivisera och minska handläggningstiderna för planläggning.
Förändringar som skett de senaste åren är till exempel att riktvärden för buller ändrats så att man tillåter bebyggelse i mer bullerutsatta miljöer. Frågan om riksintressens inverkan på planeringen utreds i dagsläget. Dagsljus är en aktuell fråga där riktlinjer och riktvärden säkerligen kommer att specificeras och revideras de närmaste åren.

Program

7. När är det av betydelse att ha ett program som komplement till detaljplanen?
Svar: Program (enligt Plan och bygglagen(PBL)) är av betydelse för att utreda större områdens möjliga utveckling. Program är ett betydelsefullt verktyg då avvägningar av mer strategisk natur för ett delområde bedöms behövas. Program kan hantera större frågor för ett större område än vad som är lämpligt och rimligt att utreda i en detaljplan.
OBS! Viktigt at inte banda ihop program för byggnad och program enligt PBL. Program för en byggnad beskriver vilket innehåll som byggnaden skall innehålla och tas fram av fastighetsutvecklare/fastighetsägare.
För program enligt PBL se:

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwi_s_3j1ZfoAhUPpIsKHUOuCC4QFjAAegQIBBAB&url=https%3A%2F%2Fgoteborg.se%2Fwps%2Fportal%3Furi%3Dgbglnk%253Agbg.page.bb7386fd-1152-47cb-9da4-d06bd7780a77%26projektid%3DBN0698%2F16&usg=AOvVaw2jwHKTn_wdPJrDh73rftZI

8. Vilka fördelar finns med att ha ett program(PBL)?
Svar: Kan svara på mer komplexa och övergripande frågeställningar än vad som kan hanteras inom en detaljplan.

9. Vilka nackdelar finns med att ha ett program(PBL)?
Svar: Det tar lång tid att fastställa och livslängden för de beslut som tas inom ett program har en tendens att inte vara aktuella för längre tid. I den komplexa natur som stadsutvecklingen sker är övergripande beslut en färskvara och

beroende av politik och många förutsättningar som snabbt an förändras.

10. Vilken nivå av detaljstyrning kan tillämpas i ett program (t.ex. fasadmaterial, kulör etc. som kan tänkas påverka dagsljus och energi)?
Svar: detaljnivån för program enligt PBL bör vara på en övergripande nivå. Om område för programmet är av specifik karaktär kan övergripande inriktning för fasadgestaltning, kulör, fönstersättning, volym, detaljer på bebyggelse hanteras. Detta bör ske på en övergripande detaljnivå och inte styra i detalj. En annan handling som är vanlig att ta fram men som inte har någon juridisk tyngd vid senare bygglovsgivning är så kallade kvalitetsprogram eller gestaltningsprogram. Dessa dokument brukar tas fram och hantera detaljer som rör gestaltningen eller kvalitetsaspekter av bebyggelse, mark och område för detaljplan. Då dessa dokument inte stöds eller hanteras under Plan och bygglagen så är det inte möjliga att följa upp vid en bygglovsgranskning.
Ett intressant exempel på när detta hände är bebyggelsen Studio 01 vid Stora torp. Gestaltningsprogrammet som togs fram dikterade att det bebyggelsen skulle uppföras i ljusa fasadmaterial liknande omgivande bebyggelse. Studio 01(som senare vann Kaspar Salin-priset) gestaltades i "svart" tegel, i rak motsatts till gestaltningsprogrammet. Så det finns en juridisk svårighet att hantera om man väljer att ta fram gestaltningsprogram.
http://www5.goteborg.se/prod/fastighetskontoret/etjanst/planobygg.nsf/vyFiler/Stora%20Torp%20-%20ca%20450%20nya%20bost%C3%A4der%20l%C3%A4ngs%20Delsj%C3%B6v%C3%A4gen-Plan%20-%20inf%C3%B6r%20antagande-Planbeskrivning/$File/Planbeskrivning.pdf?OpenElement

Nyckeltal

11. Vilka nyckeltal/faktorer är främst av betydelse när detaljplanen utvecklas?
Svar: Antal bostäder, Total BTA, uppdelning kvartersmark, gataumark, parkmark, övrig allmän plats.
Det finns en rad olika nyckeltal som används inom ett planprojekt i olika faser. Göteborgs stad arbetar i dagsläget med en ny riktljnije på stategisk nivå kring vilka indikatorer/nyckeltal och måltal som vi skall arbeta mot. En förlaga till det arbetet är Spacescapes mäta stad.
http://www.spacescape.se/project/indikatorer-for-stadskvalitet/

12. Finns det standardnyckeltal som används i utformningen av byggrätt (storlekar på utrymmen som styr utfallet på byggnadens djup etc.)?
Svar: vet ej

Studier

13. Vilka studier genomförs i detaljplaneskedet (som kan påverka energi och dagsljus)?
Svar: Det varierar på vilken typ av detaljplan och bedömningen av omfattningen av detaljplanen. Det finns generella krav på bedömningar och underlag som skall hanteras för alla detaljplaner. Det varierar med andra ord.

Se gärna de planer som pågår just nu och de utredningar som de tar fram på:
https://goteborg.se/wps/portal/start/byggande--lantmateri-och-planarbete/kommunens-planarbete/plan--och-byggprojekt/

Miljökonsekvenser av förslag i detaljplan redovisas inom detaljplanen och en rad avvägandes skall göras i förhållande till miljöaspekter. Man gör en så kallad lämplighetsprövning enligt 2 kap. Plan- och bygglagen samt en avvägning enligt 3 och 4 kap. Miljöbalken.

I detaljplanen bedöms och beskrivs hur detaljplanen medverkar eller påverka möjligheten till att uppfylla stadens miljömål.

14. Anser du att dessa är av betydelse? Varför/varför inte?
Svar: Jag anser att många av de utredningar som tas fram har stor betydelse för detaljplanernas utformning och förslag som presenteras och bedöms. En svårighet inom arbetet med att ta fram en detaljplan är att de flesta utredningar görs parallellt och bedömer ofta ett förslag, vilket innebär att utredningarnas resultat och förslag till förnedring kan stå i konflikt med varandra. Detta innebär att en iterativ process är svår att hantera. Inte minst rent upphandlingstekniskt.

15. Anser du att det saknas någon studie? i så fall vilken och varför?
Svar: Det är svårt att säga då det inte är

16. Vem är ansvarig för de olika studierna?
Svar: Vissa studier upphandlas av och hanteras av stadsbyggnadskontoret eller annan kommunal förvaltning (tex kretslopp och vatten som hanterar dagvattenutredningar), andra kräver vi(sbk) att exploatören tar fram.

17. Enligt din vetskap; involveras energi på något sätt i detaljplaneskedet?
Nej
Om ja:
    - Hur?
      Svar:

18. Anser du att energi är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?
Nej, eller kanske.
Om ja:
    - Varför?
      Svar:

    - Hur borde energi tas hänsyn till?
      Svar:

Om nej:
    - Varför inte?
      Svar: Detaljplaner reglerar markanvändning, var, vad och hur mycket av respektive användning som kan utvecklas inom ett område. Att reglera detaljer kring byggnadsutformning, materialval eller specifika energisystem är att från ett myndighetsperspektiv att låsa detaljer över

en lång tid med ett verktyg(detaljplanen) som är konstruerat för att vara enbart nödvändigt begränsande. Jag tror att detaljplanen är fel verktyg för att reglera energi i förhållande till byggnadsutformning.

19. Enligt din vetskap; involveras dagsljus på något sätt i detaljplaneskedet?
    Om ja:
    - Hur?
      Svar: Det är en superintressant fråga. Dagsljus kommer in i detaljplaneskedet mer och mer nu. Min uppfattning är att det är en fråga som tidigare inte varit så avgörande i planeringen. Men nu med dagens förtätningsideal och allmänna önskan efter större exploateringar i och av tätbyggda områden så blir den högaktuell.
      Vi strävar efter och det efterfrågas av oss generella detaljplaner som kan utvecklas över tid med bland annat olika innehåll. Inom detaljplaneskedet så är då dagsljusfrågan viktig men också enormt svår. Riktlinjerna är vaga kring vilka ytor som kräver god tillgång till dagsljus vilket är en fråga som kan bedömas fullt ut först vid en mer detaljerad utformning av byggnadsvolymer och invändiga lokaler och användning. För detaljplanen krävs att den inte är omöjlig att genomföra, vilket då kräver att man kan hantera utbyggnad i förhållande till användning och dagsljus.
      För djupa byggrätter skapar stora mörka kärnor utan god tillgång på dagsljus. I de fall får man bedöma hur lämpligt och troligt utnyttjande och användning av de ytor som skapas utan god tillgång på dagsljus kan bli. Hur många toaletter och skrivarrum kan en byggnad behöva? Är mötesrum vistelseytor som kräver dagsljus?

20. Anser du att dagsljus är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?
    Om ja: Ja
    - Varför?
      Svar: Övergripande kontroll av dagsljus och att utreda möjligheterna/problemen med planerade byggnadsvolymer ger möjligheter tidigt att reglera den bebyggda miljön så att god tillgång på dagsljus kan tillgodoses bättre.
    - Hur borde dagsljus tas hänsyn till?
      Svar: Genom utredning av dagsljusförhållanden givet planerade volymer och de problem som volymgestaltningen kan innebära med avseende på dagsljus.

    Om nej:
    - Varför inte?
      Svar:

Detaljnivå

21. Vilken detaljnivå rörande byggnadens design kan regleras i detaljplaneskedet?
    Svar: Övergripande nivå kan regleras. I särskilda fall, så som vid kulturmiljöintressanta områden kan mer specifik detaljnivå vara lämplig.

22. Vilken detaljnivå rörande byggnadens design tycker du är önskvärd att regleras i detaljplaneskedet? Varför?
    Svar:

23. Vilka fördelar/nackdelar ser du med att detaljstyra design i detaljplanen (t.ex. maximal eller minimal andel fönsterarea)?
    Svar:

På nästa sida följer frågor inriktade specifikt på Building Performance Simulation (BPS).

Building performance simulation (BPS)

24. Har du kommit i kontakt med BPS i ditt arbete?
    NEJ
    Om ja:
    - På vilket sätt har du kommit i kontakt med BPS?
      Svar:
    - Vilka parametrar har du kommit i kontakt med (dagsljus etc.)?
      Svar:

25. Anser du att BPS är av betydelse i detaljplaneskedet?
    Kanske, Jag är för dåligt insatt i vilka möjligheter som BPS ger som kan vara aktuella för detaljplaneskedet.
    Om ja:
    - Varför?
      Svar:
    - Hur anser du att BPS ska implementeras i detaljplaneskedet?
      Svar:
    - Vilken detaljnivå är av relevans i detaljplaneskedet?
      Svar:

    Om nej:
    - Varför inte?
      Svar: Kan inte svara då jag inte vet vilka möjligheter som finns.
      Men det är även här ett dilemma mellan att i en detaljplan studera och reglar något detaljerat samtidigt som ett mål är att hålla detaljplanerna generella och hållbara över tid.

På nästa sida kommer några frågor som fokuserar på ett verktyg utvecklat för detaljplaneprocessen.

Verktyg för detaljplaneskedet

26. Om det fanns ett webbaserat verktyg för BPS (fokus på dagsljus och energi) speciellt anpassat till detaljplaneskedet, anser du att det vore av värde?
    JA
    Om ja:
    - Varför?
      Svar: Ett enkelt verktyg som kan visa detaljplanens föreslagna volymers relation till dagsljus och energi skulle underlätta i bedömning och avvägning för bästa markanvändning.
    - Vem skulle använda detta?
      Svar: Planhandläggare/projektledare och exploatör.
    - Vad anser du är de viktigaste egenskaperna ett sådant verktyg bör ha?
      Svar: Enkelt gränssnitt, lättarbetat, Enkelt att visualisera och hantera resultat/bilder.
    - Vilka nyckeltal är viktig för dig som användare?
      Svar: Vet ej.
    - Hur lång tid tycker du att det är acceptabelt att en beräkning får ta?
      Svar:5 min
    - Hur föredrar du att resultatet illustreras?
      Svar: Bild och tabell
    - Hur skulle du föredra att byggnadsgeometrin hanteras (okej med ett antal färdiga byggnadsformer att välja mellan, rita själv etc.)?
      Svar: rita själv, eller importera i enkelt format,
    - Vilken detaljnivå på geometrin anser du är viktig för att göra verktyget användbart (exempelvis inkludera balkonger, loftgångar osv.)?
      Svar: vet ej.

    Om nej:
    - Varför inte?
      Svar:

Nedan får du gärna lämna synpunkter på hur verktyget kan se ut samt innehålla. All feedback är uppskattat. Tänk fritt och brett (hur ser ditt drömverktyg i detaljplaneprocessen med fokus på energi och dagsljus ut?).
Svar:

Till sist så kommer på nästa sida två avslutande frågor.

Avslutande frågor

27. Finns det något övrigt du vill tillägga?
    Svar: Lycka till!

28. Finns det ytterligare personer du tycker vi ska kontakta?
    Svar: Jon Tibell på Unit arkitekter, har stor erfarenhet från dagsljusstudier från arkitektsidan.

A.1.2.2 Participant II

Om dig

Namn: Stina Dahlström

Företag/organisation: Göteborgs Stad

Arbetstitel: Bygglovhandläggare

Arbetsbeskrivning: Handlägger bygglovsansökningar

Kontaktuppgifter: stina.dahlstrom@sbk.goteborg.se

Önskar vara anonym: Ja/Nej

Detaljplaneprocessen

Allmänt

1. Är det vanligt i er kommun att ni själva påbörjar en detaljplan utan att en byggherre ansökt om planbesked?
   Om ja:
   - Hur ser processen ut i det fallet (med fokus på energi- och dagsljusfrågor)?
     Svar: Nej, men planhandläggarna har bättre koll

2. Vilken/vilka är de största skillnaderna mellan när en byggherre ansöker om planbesked och när kommunen själva väljer att upprätta en detaljplan (avseende dagsljus och energi)?
   Svar: vet ej

3. Vilka handlingar skickar byggherren in när denne ansöker om planbesked (när det rör dagsljus och energi)?
   Svar: vet ej

4. Hur detaljerad är den information som byggherren ansöker om planbesked med (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?
   Svar: vet ej

5. Vilka faktorer skulle du säga har störst betydelse vid bedömningen av en byggnads tillåtna placering, höjd etc. (ljud, luftföroreningar osv.)?
   Svar: vet ej

6. Anser du att detaljplaneprocessen har förändrats de senaste åren / håller på att förändras? Om ja, hur?
   Svar: vet ej

Program

7. När är det av betydelse att ha ett program som komplement till detaljplanen?
   Svar: vet ej

8. Vilka fördelar finns med att ha ett program?
   Svar: vet ej

9. Vilka nackdelar finns med att ha ett program?
   Svar: vet ej

10. Vilken nivå av detaljstyrning kan tillämpas i ett program (t.ex. fasadmaterial, kulör etc. som kan tänkas påverka dagsljus och energi)?
    Svar: vet ej

Nyckeltal

11. Vilka nyckeltal/faktorer är främst av betydelse när detaljplanen utvecklas?
    Svar: vet ej

12. Finns det standardnyckeltal som används i utformningen av byggrätt (storlekar på utrymmen som styr utfallet på byggnadens djup etc.)?
    Svar: vet ej

Studier

13. Vilka studier genomförs i detaljplaneskedet (som kan påverka energi och dagsljus)?
    Svar: vet ej

14. Anser du att dessa är av betydelse? Varför/varför inte?
    Svar: vet ej

15. Anser du att det saknas någon studie? i så fall vilken och varför?
    Svar: vet ej

16. Vem är ansvarig för de olika studierna?
    Svar: vet ej

17. Enligt din vetskap; involveras energi på något sätt i detaljplaneskedet?
    Om ja:
    - Hur?
      Svar: vet ej

18. Anser du att energi är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?
    Om ja:
    - Varför?
      Svar: ja, eftersom placeringar, höjder etc har stor påverkan på förutsättningar i senare skeden.
    - Hur borde energi tas hänsyn till?
      Svar: vet ej

    Om nej:
    - Varför inte?
      Svar:

19. Enligt din vetskap; involveras dagsljus på något sätt i detaljplaneskedet?
    Om ja:

- Hur?
  Svar:

20. Anser du att dagsljus är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?
    Om ja:
    - Varför?
      Svar: Därför att placeringar, höjder etc har stor påverkan i senare skeden.
    - Hur borde dagsljus tas hänsyn till?
      Svar: t ex vsc-simuleringar

    Om nej:
    - Varför inte?
      Svar:

Detaljnivå

21. Vilken detaljnivå rörande byggnadens design kan regleras i detaljplaneskedet?
    Svar: Väldigt låg detaljnivå, t ex nockhöjd

22. Vilken detaljnivå rörande byggnadens design tycker du är önskvärd att regleras i detaljplaneskedet? Varför?
    Svar: Väldigt låg eftersom detaljplanen ska vara användbar i många år och vara flexibel när behov ändras. Hög detaljnivå är ofta svår att hävda rättsligt, jfr PBL.

23. Vilka fördelar/nackdelar ser du med att detaljstyra design i detaljplanen (t.ex. maximal eller minimal andel fönsterarea)?
    Svar: Svårt att ge generellt svar men det kan vara begränsande och göra planen oflexibel. Kan bli tvunget att ändra planen ganska fort vilket är resurskrävande.

På nästa sida följer frågor inriktade specifikt på Building Performance Simulation (BPS).

Building performance simulation (BPS)

24. Har du kommit i kontakt med BPS i ditt arbete?
    Om ja:
    - På vilket sätt har du kommit i kontakt med BPS?
      Svar:
    - Vilka parametrar har du kommit i kontakt med (dagsljus etc.)?
      Svar:

25. Anser du att BPS är av betydelse i detaljplaneskedet?
    Om ja:
    - Varför?
      Svar:
    - Hur anser du att BPS ska implementeras i detaljplaneskedet?
      Svar:
    - Vilken detaljnivå är av relevans i detaljplaneskedet?
      Svar:

    Om nej:
    - Varför inte?
      Svar:

På nästa sida kommer några frågor som fokuserar på ett verktyg utvecklat för detaljplaneprocessen.

Verktyg för detaljplaneskedet

26. Om det fanns ett webbaserat verktyg för BPS (fokus på dagsljus och energi) speciellt anpassat till detaljplaneskedet, anser du att det vore av värde?
    Om ja:
    - Varför?
      Svar: Troligen, eftersom det är tidskrävande och kräver kunskap att utföra dagsljusstudier med den "vanliga" programvaran.
    - Vem skulle använda detta?
      Svar: planhandläggare, plantekniker, kanske beställare som vill ha översikt innan konsulter upphandlas
    - Vad anser du är de viktigaste egenskaperna ett sådant verktyg bör ha?
      Svar: god läsbarhet i visualiseringar
    - Vilka nyckeltal är viktig för dig som användare?
      Svar: lätt att använda även utan rit-vana
    - Hur lång tid tycker du att det är acceptabelt att en beräkning får ta?
      Svar: Beror på komplexitet, ca 2 timmar
    - Hur föredrar du att resultatet illustreras?
      Svar: Färgmarkeringar i modeller och tabell
    - Hur skulle du föredra att byggnadsgeometrin hanteras (okej med ett antal färdiga byggnadsformer att välja mellan, rita själv etc.)?
      Svar: Rita själv, men fortfarande användbart med färdiga
    - Vilken detaljnivå på geometrin anser du är viktig för att göra verktyget användbart (exempelvis inkludera balkonger, loftgångar osv.)?
      Svar: inkl balkonger etc

    Om nej:
    - Varför inte?
      Svar:

Nedan får du gärna lämna synpunkter på hur verktyget kan se ut samt innehålla. All feedback är uppskattat. Tänk fritt och brett (hur ser ditt drömverktyg i detaljplaneprocessen med fokus på energi och dagsljus ut?).
Svar: Vet ej, är inte så insatt i detaljplanearbetet då jag jobbar med bygglov och mest tolkar planbestämmelser som redan finns. Men min upplevelse är att många handläggare inte är vana användare av ritprogram etc och snarast skulle använda ett lättillgängligt verktyg. Vår geodataavdelning (och säkert en del plantekniker) har kompetens att göra simuleringar i t ex Rhino men inte tillräcklig personalkapacitet för att hinna.

Till sist så kommer på nästa sida två avslutande frågor.

Avslutande frågor

27. Finns det något övrigt du vill tillägga?
    Svar:

28. Finns det ytterligare personer du tycker vi ska kontakta?
    Svar: Hamlet Mirjamsdotter på Länsstyrelsen Västernorrland har visat intresse för dagsljusstudier i detaljplaneskedet.

A.1.2.3 Participant III

Om dig

Namn: Hugo Lindblad

Företag/organisation: SBK Göteborg

Arbetstitel: Planhandläggare

Arbetsbeskrivning:

Kontaktuppgifter:
Hugo.lindblad@sbk.goteborg.se

Önskar vara anonym: Nej

Detaljplaneprocessen

Allmänt

1. Är det vanligt i er kommun att ni själva påbörjar en detaljplan utan att en byggherre ansökt om planbesked?
   Om ja:
   - Hur ser processen ut i det fallet (med fokus på energi- och dagsljusfrågor)?
     Svar: JA det händer. Dagsljus är en aspekt, det är dock på senare år man har börjat uppmärksamma att det är svårt att hantera dagljus. Det finns ett tydligt samband mellan en ökad explaotering och svårigheter att hantera dagsljus. Energi kollar man väldigt sällan på.

2. Vilken/vilka är de största skillnaderna mellan när en byggherre ansöker om planbesked och när kommunen själva väljer att upprätta en detaljplan (avseende dagsljus och energi)?
   Svar: Ingen skillnad. Ofta vill byggherrarna exploatera något mer än kommunen. En högre exploatering leder ofta till att man måste studera dagsljus mer.

3. Vilka handlingar skickar byggherren in när denne ansöker om planbesked (när det rör dagsljus och energi)?
   Svar: Ibland dagsljus om kontoret ber om det, aldrig energi.

4. Hur detaljerad är den information som byggherren ansöker om planbesked med (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?
   Svar: Användning och höjd är preciserade. Dock så är detaljplaneprocessen en prövning. Ett positivt planbesked innebär inte att det detaljplanen kommer medge samma förslag. I detaljplanen prövas förslaget mot lagar, diskuteras med allmänhet, diskuteras med andra förvaltningen och studeras utifrån ett stadsbyggnadsperspektiv. Energi är aldrig preciserat.

5. Vilka faktorer skulle du säga har störst betydelse vid bedömningen av en byggnads tillåtna placering, höjd etc. (ljud, luftföroreningar osv.)?
   Svar: Det är en samlad bedömning. Går inte att säga något som har störst betydelse. Förslaget måste klara acceptabla ljudnivåer inte överskrida luftkvalitetsnormerna, inte medför betydande påverkan på riksintressen etc.

6. Anser du att detaljplaneprocessen har förändrats de senaste åren / håller på att förändras? Om ja, hur?
   Svar: Mer aspekter att ta hänsyn till.

Program

7. När är det av betydelse att ha ett program som komplement till detaljplanen?
   Svar: När man behöver se frågor i ett större sammanhang.

8. Vilka fördelar finns med att ha ett program?
   Svar: Man kan ta ett helhetsgrepp på ett bättre sätt.

9. Vilka nackdelar finns med att ha ett program?
   Svar: Behövs det inte så är det bara tids- och resurskrävande.

10. Vilken nivå av detaljstyrning kan tillämpas i ett program (t.ex. fasadmaterial, kulör etc. som kan tänkas påverka dagsljus och energi)?
    Svar:

Nyckeltal

11. Vilka nyckeltal/faktorer är främst av betydelse när detaljplanen utvecklas?
    Svar:

12. Finns det standardnyckeltal som används i utformningen av byggrätt (storlekar på utrymmen som styr utfallet på byggnadens djup etc.)?
    Svar:

Studier

13. Vilka studier genomförs i detaljplaneskedet (som kan påverka energi och dagsljus)?
    Svar: Exploatering, utformning av förslaget

14. Anser du att dessa är av betydelse? Varför/varför inte?
    Svar: Alla studier som gör är för att få fram ett bra förslag.

15. Anser du att det saknas någon studie? i så fall vilken och varför?
    Svar:

16. Vem är ansvarig för de olika studierna?
    Svar: Kommunen eller exploatörerna.

17. Enligt din vetskap; involveras energi på något sätt i detaljplaneskedet?
    Om ja:
    - Hur?
      Svar: Nej.

18. Anser du att energi är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?
    Om ja:

- Varför?

- Hur borde energi tas hänsyn till?
  Svar:

Om nej:
- Varför inte?
  Svar: Svar: Det är en aspekt som är svår att ta in i ett tidigt skede, tror den är bättre lämpad i ett skedet där man hanterar frågor mer detaljerat.

19. Enligt din vetskap; involveras dagsljus på något sätt i detaljplaneskedet?
    Om ja:
    - Hur?
      Svar: I detaljplaneskedet görs en bedömning att det finns möjligheter att i ett senare skede kunna utforma lägenheter så att de får en god dagsljustillgång.

20. Anser du att dagsljus är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?
    Om ja:
    - Varför?
      Svar: tar man inte hänsyn till det finns stor risk att man inte kan uppföra byggnader som klarar dagsljusnivåerna. Studier har visat att det är viktgt med dagsljus bland annat för att människors psykiska hälsa, sömn, inlärningsförmåga m.m.
    - Hur borde dagsljus tas hänsyn till?
      Svar:

    Om nej:
    - Varför inte?
      Svar:

Detaljnivå

21. Vilken detaljnivå rörande byggnadens design kan regleras i detaljplaneskedet?
    Svar: Beror på placering.

22. Vilken detaljnivå rörande byggnadens design tycker du är önskvärd att regleras i detaljplaneskedet? Varför?
    Svar: Höjd, skala, utbredning. Inte detaljstyra för mycket.

23. Vilka fördelar/nackdelar ser du med att detaljstyra design i detaljplanen (t.ex. maximal eller minimal andel fönsterarea)?
    Svar: Bedömer det inte som lämpligt. Blir en för detalerad detaljplan. Detaljplanen ska visa att det finns ett sätt att uppföra en byggnad om det finns andra sätt som bedöms som acceptabla ska även det vara möjliga.

På nästa sida följer frågor inriktade specifikt på Building Performance Simulation (BPS).

Building performance simulation (BPS)

24. Har du kommit i kontakt med BPS i ditt arbete?
    Om ja: Nej
    - På vilket sätt har du kommit i kontakt med BPS?
      Svar:
    - Vilka parametrar har du kommit i kontakt med (dagsljus etc.)?
      Svar:

25. Anser du att BPS är av betydelse i detaljplaneskedet?
    Om ja:
    - Varför?
      Svar:
    - Hur anser du att BPS ska implementeras i detaljplaneskedet?
      Svar:
    - Vilken detaljnivå är av relevans i detaljplaneskedet?
      Svar:

    Om nej:
    - Varför inte?
      Svar:

På nästa sida kommer några frågor som fokuserar på ett verktyg utvecklat för detaljplaneprocessen.

Verktyg för detaljplaneskedet

26. Om det fanns ett webbaserat verktyg för BPS (fokus på dagsljus och energi) speciellt anpassat till detaljplaneskedet, anser du att det vore av värde?
    Om ja:
    - Varför?
      Svar: För dagsljus.
    - Vem skulle använda detta?
      Svar: Planhandläggare, exploatörer.
    - Vad anser du är de viktigaste egenskaperna ett sådant verktyg bör ha?
      Svar:
    - Vilka nyckeltal är viktig för dig som användare?
      Svar: VSC samt mängden mörk BTA.
    - Hur lång tid tycker du att det är acceptabelt att en beräkning får ta?
      Svar: Så kort tid som möjligt
    - Hur föredrar du att resultatet illustreras?
      Svar: I bild.
    - Hur skulle du föredra att byggnadsgeometrin hanteras (okej med ett antal färdiga byggnadsformer att välja mellan, rita själv etc.)?
      Svar:
    - Vilken detaljnivå på geometrin anser du är viktig för att göra verktyget användbart (exempelvis inkludera balkonger, loftgångar osv.)?
      Svar: Balkonger loftgångar bedömer jag inte behövs.

    Om nej:
    - Varför inte?
      Svar:

Nedan får du gärna lämna synpunkter på hur verktyget kan se ut samt innehålla. All feedback är uppskattat. Tänk fritt och brett (hur ser ditt drömverktyg i detaljplaneprocessen med fokus på energi och dagsljus ut?).
Svar:

Till sist så kommer på nästa sida två avslutande frågor.

Avslutande frågor

27. Finns det något övrigt du vill tillägga?
    Svar: Nej

28. Finns det ytterligare personer du tycker vi ska kontakta?
    Svar: Ingen jag kommer på.

//Hugo Lindblad

A.1.2.4 Participant IV

Om dig

Namn: Carl-Johan Karlsson

Företag/organisation: Stadsbyggnadskontoret Göteborgs Stad

Arbetstitel: Planarkitekt

Arbetsbeskrivning: Tar fram detaljplaner

Kontaktuppgifter: carl-johan.philip.karlsson@sbk.goteborg.se

Önskar vara anonym: Nej

Detaljplaneprocessen

Allmänt

1. **Är det vanligt i er kommun att ni själva påbörjar en detaljplan utan att en byggherre ansökt om planbesked?**
   Om ja:
   - **Hur ser processen ut i det fallet (med fokus på energi- och dagsljusfrågor)?**

   Svar: Nej, i dagsläget är mycket på initiativ av byggherre/exploatör

2. **Vilken/vilka är de största skillnaderna mellan när en byggherre ansöker om planbesked och när kommunen själva väljer att upprätta en detaljplan (avseende dagsljus och energi)?**
   Svar: En byggherre har oftast en idé om byggnadsutformning och har redan i tidigt skede tänkt på lägenhetsindelning och utformning. Det gör att det blir svårare att göra förändringar i förslaget. Oftast ligger det ett ekonomiskt intresse i botten och ändras förslaget så ändras lönsamheten vilket påverkar genomförbarheten i projektet.
   Håller kommunen själv i utformningen är det större chans att man tittar på förutsättningarna innan man tittar på gestaltningen vilket medför att det är enklare att göra ett förslag som uppfyller de krav som finns.

3. **Vilka handlingar skickar byggherren in när denne ansöker om planbesked (när det rör dagsljus och energi)?**
   Svar: I dagsläget nästan inga. Vi har krav på dagsljus först när det kommer till bygglov och det tillhörande startbeskedet. Vi börjar bli bättre på att efterfråga dagsljusstudier när det kommer till planarbete och planbesked men det är inte i alla fall detta utreds så tidigt. Energi kommer också sent.

4. **Hur detaljerad är den information som byggherren ansöker om planbesked med (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?**
   Svar: Det som brukar redovisas är volymer, situationsplan, sektioner och en beskrivning av den tänkta byggnaden. Det är få fall där man lämnar in beräkningar på dagsljus om vi inte efterfrågar det, samma gäller energi. Däremot brukar exploatörerna vara duktiga på att redovisa klimatsmarta lösningar som solpaneler eller gröna tak i sina tidiga skisser.

5. **Vilka faktorer skulle du säga har störst betydelse vid bedömningen av en byggnads tillåtna placering, höjd etc. (ljud, luftföroreningar osv.)?**
   Svar: Närhet till omkringliggande bebyggelse och påverkan från omgivningen (buller m.m.)

6. **Anser du att detaljplaneprocessen har förändrats de senaste åren / håller på att förändras? Om ja, hur?**

Svar: Ja, det märks att det är fler och fler förutsättningar som måste tas hänsyn till i tidigt skede för att inte få det som en överraskning sen i ett senare skede. Dagsljus är en av de faktorer som det snackas mycket om nu, men även luftmiljö i den täta staden. Autonoma transporter är någonting som vi kommer höra mycket om inom några år.

Program

7. **När är det av betydelse att ha ett program som komplement till detaljplanen?**
   Svar: Ett program tas fram för att underlätta kommande detaljplanearbeten. Det kan röra sig om att det finns komplexa frågor som måste lösas, stora motstående intressen eller många sakägare.

8. **Vilka fördelar finns med att ha ett program?**
   Svar: Ett program ger en vägledning och skapar samsyn kring frågor som annars kunde ältats länge under detaljplanearbetet.

9. **Vilka nackdelar finns med att ha ett program?**
   Svar: Det är resurskrävande och det finns oftast svårigheter med den ekonomiska värderingen av ett program. Alltså, är det värt det?

10. **Vilken nivå av detaljstyrning kan tillämpas i ett program (t.ex. fasadmaterial, kulör etc. som kan tänkas påverka dagsljus och energi)?**
    Svar: Det beror mycket på i vilket område som programmet tas fram. Detaljeringsgraden är högre t.ex. inom vallgraven än vad den är på norra Hisingen.

Nyckeltal

11. **Vilka nyckeltal/faktorer är främst av betydelse när detaljplanen utvecklas?**
    Svar: antalet bostäder/småhus, p-tal, kostnader

12. **Finns det standardnyckeltal som används i utformningen av byggrätt (storlekar på utrymmen som styr utfallet på byggnadens djup etc.)?**
    Svar: Det finns, men de används sparsamt.

Studier

13. **Vilka studier genomförs i detaljplaneskedet (som kan påverka energi och dagsljus)?**
    Svar:
    Buller, solstudie och dagsljusutredning, luftmiljöutredning.

14. **Anser du att dessa är av betydelse? Varför/varför inte?**
    Svar: Ja absolut! De ger ju förutsättningar att bedöma markens lämplighet för den specifika typen av användning.

15. **Anser du att det saknas någon studie? i så fall vilken och varför?**
Svar: Vi har möjlighet att begära in de utredningar som vi anser krävs för att bedöma lämpligheten för den användning som är föreslagen i förslaget.

16. **Vem är ansvarig för de olika studierna?**
Svar: Det kan vara både exploatör och kommun som står för utredningarna.

17. **Enligt din vetskap; involveras energi på något sätt i detaljplaneskedet?**
Om ja:
    - **Hur?**
    Svar: Ja, det skulle vara hur man avser att värma upp hus. I övrigt nej, inte enligt min vetskap.

18. **Anser du att energi är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?**
Om ja:
    - **Varför?**
    Svar: Ja och nej. För att bygga ett hållbart samhälle som tar hand om de resurser som vi har måste vi i ett tidigt skede tänka på hur vi kan skapa energieffektiva byggnader. Jag har svårt att se hur detta skulle implementeras i detaljplaneskedet mer än att vi möjliggör och tar höjd för olika typer av lösningar, t.ex. lågenergihus som har tjockare väggar eller trähus som generellt har ett tjockare bjälklag.
    - **Hur borde energi tas hänsyn till?**
    Svar: Hushållning med resurser och att bygga effektiva byggnader kommer att bli en förutsättning för vidare stadsutveckling. Att tidigt utreda om projekten blir hållbara är en god idé.

Om nej:
    - **Varför inte?**
    Svar: Å andra sidan kan inte en detaljplan lösa allt. Det märks mer och mer att många har en övertro till det detaljplanen kan reglera. Vi kan reglera användningen av mark och vatten ändamålsenligt. Vi kan inte reglera någonting som vi inte har stöd för i lagen, vilket innebär att det måste till ändringar i PBL om vi ska kunna ställa krav redan i detaljplanen på energi. Jag vet inte om det är effektivt att lösa alla frågor så tidigt, dessutom kan en detaljplan vara aktuell i flera hundra år, vilket innebär att en lösning vad gäller energi kan vara aktuell år 1 men inte lika aktuell år 50, men man måste ändå förhålla sig till den eftersom att detaljplanen är juridiskt bindande.

19. **Enligt din vetskap; involveras dagsljus på något sätt i detaljplaneskedet?**
Om ja:
    - **Hur?**
    Svar: Ja, vi gör solstudier och dagsljusutredningar i planskedet.

20. **Anser du att dagsljus är en viktig parameter att ta hänsyn till redan i detaljplaneskedet?**
Om ja:

- **Varför?**
  Svar: Ja, här har vi möjlighet att justera förslaget så att t.ex. en bostad får tillräckligt med dagsljus för att uppnå de krav som ställs.
- **Hur borde dagsljus tas hänsyn till?**
  Svar: Vi har börjat att tänka mer och mer på dagsljus och solljus, från att det var ett sätt att förhindra enkelsidiga lägenheter i norrläge till dagens forskning som visar att vi mår bättre om vi har tillgång till dagsljus. Frågan har börjat få betydelse och kommer att bli en starkare faktor när vi bedömer lämpligheten i framtiden.
  Om nej:
- **Varför inte?**
  Svar:

Detaljnivå

21. **Vilken detaljnivå rörande byggnadens design kan regleras i detaljplaneskedet?**
    Svar: Så mycket som krävs. Det är så stor skillnad från detaljplan till detaljplan. Om man bygger i närhet av kulturhistoriskt värdefull bebyggelse eller om man rullar ut en villamatta i Angered.
    Detaljeringsgraden anpassas efter detaljplanens komplexitet och förutsättningar.

22. **Vilken detaljnivå rörande byggnadens design tycker du är önskvärd att regleras i detaljplaneskedet? Varför?**
    Svar: Det kan hända mycket mellan detaljplan och bygglov, ibland kan det gå flera år innan man kommer igång med byggnation, då är det viktigt att vi beslutar om hållbara regleringar i detaljplanen och inte anpassar oss efter gällande designnormer som gäller just idag. Jag skulle därför önska en flexibel reglering före en detaljerad reglering.

23. **Vilka fördelar/nackdelar ser du med att detaljstyra design i detaljplanen (t.ex. maximal eller minimal andel fönsterarea)?**
    Svar: Det är en balansgång. Det är dumt att måla in detaljplanen i ett hörn med bara en lösning på ett problem om den lösningen är dyr och dålig. Därför bör detaljplanen vara flexibel och hålla den detaljeringsgrad som krävs för att den tänkta användningen ska vara lämplig.

På nästa sida följer frågor inriktade specifikt på Building Performance Simulation (BPS).

Building performance simulation (BPS)

24. **Har du kommit i kontakt med BPS i ditt arbete?**
    Om ja:
    - På vilket sätt har du kommit i kontakt med BPS?
      Svar: Nej
    - Vilka parametrar har du kommit i kontakt med (dagsljus etc.)?
      Svar: VSC, dagsljusfaktor

25. **Anser du att BPS är av betydelse i detaljplaneskedet?**
    Om ja:
    - **Varför?**
      Svar: En tidig indikation ur ett hållbarhetsperspektiv är alltid bra. Att ha en iterativ process med exploatör där vi även tar hänsyn till hållbarhetsperspektivet kan inte vara dåligt.
    - **Hur anser du att BPS ska implementeras i detaljplaneskedet?**
      Svar: Använd det som metod att utvärdera hållbarhet och energieffektivitet.
    - **Vilken detaljnivå är av relevans i detaljplaneskedet?**
      Svar: Hur väl byggnaden stämmer överens med kommunens mål om energihantering och hållbarhet samt ett förslag på hur man kan förbättra designen för att bli än mer effektiv. Hållbart över tid.

    Om nej:
    - **Varför inte?**
      Svar:

På nästa sida kommer några frågor som fokuserar på ett verktyg utvecklat för detaljplaneprocessen.

Verktyg för detaljplaneskedet

26. O**m det fanns ett webbaserat verktyg för BPS (fokus på dagsljus och energi) speciellt anpassat till detaljplaneskedet, anser du att det vore av värde?**
    Om ja:
    - **Varför?**
      Svar: tidigt identifiera energiåtgång och hur man kan effektivisera, samt tillgång till dagsljus för att bedöma en byggnads lämplighet är positivt.
    - **Vem skulle använda detta?**
      Svar: Handläggare.
    - **Vad anser du är de viktigaste egenskaperna ett sådant verktyg bör ha?**
      Svar: Lättanvänt. In med en färdig modell och sen få en utvärdering.
    - **Vilka nyckeltal är viktig för dig som användare?**
      Svar: VSC, dagsljus, enegieffektivitet och hushållning med resurser.
    - **Hur lång tid tycker du att det är acceptabelt att en beräkning får ta?**
      Svar: en timme max.
    - **Hur föredrar du att resultatet illustreras?**
      Svar: tabeller och illustrationer.
    - **Hur skulle du föredra att byggnadsgeometrin hanteras (okej med ett antal färdiga byggnadsformer att välja mellan, rita själv etc.)?**
      Svar: färdiga former med möjlighet till frihandsritning.
    - **Vilken detaljnivå på geometrin anser du är viktig för att göra verktyget användbart (exempelvis inkludera balkonger, loftgångar osv.)**?
      Svar: Balkonger ska kunna inkluderas vid behov.

    Om nej:
    - **Varför inte?**
      Svar:

Nedan får du gärna lämna synpunkter på hur verktyget kan se ut samt innehålla. All feedback är uppskattat. Tänk fritt och brett (hur ser ditt drömverktyg i detaljplaneprocessen med fokus på energi och dagsljus ut?).
Svar: -

Till sist så kommer på nästa sida två avslutande frågor.

Avslutande frågor

27. **Finns det något övrigt du vill tillägga?**
    Svar: Lycka till!

28. **Finns det ytterligare personer du tycker vi ska kontakta?**
    Svar: -

A.2 Skanska AB

A.2.1 Inquire

Building Performance Simulation (BPS) i detaljplaneprocessen

Enkätundersökning affärsutveckling Skanska Göteborg

Hej.

Vi är tre studenter som studerar vår sista termin på Chalmers Tekniska Högskola med inriktning byggnadsteknologi (Sara och Julia) och arkitektur/project management (Amanda). Under våren 2020 gör vi två parallella examensarbeten. Våra examensarbeten syftar till att undersöka implementering av Building Performance Simulation (BPS) i detaljplaneprocessen. Building Performance Simulation (BPS) kan kort beskrivas som simuleringar av byggnadens prestanda rörande exempelvis energi och dagsljus.

Tidigare examensarbeten inom området BPS indikerar att genom att ta hänsyn till och undersöka förutsättningarna för dagsljus och energi i tidigt designskede kan energianvändningen minskas med 15-20%. Dock är slutsatsen att optimeringen begränsas av redan låsta parametrar i detaljplanen, såsom byggnadshöjd, "footprint" och orientering. Vi vill i vårt examensarbete undersöka om det är möjligt att minska energianvändning ytterligare om BPS är involverat redan i detaljplaneutvecklingen. Parallellt med detta undersöker vi möjligheterna att utveckla ett simuleringsverktyg anpassat till tidiga skeden som skall vara till hjälp i detaljplaneprocessen.

Intervjustudien genomförs genom en kvalitativ intervjustudie med verksamma inom området och vårt fokus är dagsljus- och energifrågor. Tanken med denna intervjustudien är dels att få en inblick i detaljplaneprocessen och dels att få input till utveckling av ett webbverktyg anpassat till detaljplaneskedet. Om du känner att frågan ej berör ditt kompetensområde så går det bra att hoppa över att svara.

Tack för ditt deltagande! Tveka ej att höra av dig om du har några frågor eller synpunkter. Vänliga hälsningar Julia Andersson, Sara Jonsson och Amanda Markgren

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Om dig

Namn:

Företag/organisation:

Arbetstitel:

Arbetsbeskrivning:

Kontaktuppgifter:

Önskar vara anonym: Ja/Nej

Planbesked och bygglov

1. Vilken/vilka är de största skillnaderna mellan när ni som byggherre ansöker om planbesked och när kommunen själva väljer att upprätta en detaljplan (avseende dagsljus och energi)?
   Svar:

2. Vilka handlingar skickas in när ni ansöker om planbesked (när det rör dagsljus och energi)?
   Svar:

3. Hur detaljerad är den information som ni skickar in vid ansökan om planbesked (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?
   Svar:

4. Anser du att processen vid ansökan om planbesked har förändrats de senaste åren / håller på att förändras (fokus på energi och dagsljus)? Om ja, hur?
   Svar:

5. Vilka handlingar skickas in när ni ansöker om bygglov (när det rör dagsljus och energi)?
   Svar:

6. Hur detaljerad är den information som ni skickar in vid ansökan om bygglov (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?
   Svar:

7. Anser du att processen vid ansökan om bygglov har förändrats de senaste åren / håller på att förändras (fokus på energi och dagsljus)? Om ja, hur?
   Svar:

8. Vilket/vilka är de vanligaste orsakerna till avslag vid bygglovsansökan?
   Svar:

9. Finns det något du önskar att kommunen gjorde som ej görs idag när det rör energi/dagsljus och detaljplanen/bygglov?

Program i detaljplaneprocessen

10. Tycker du att det är hjälpsamt med program som komplement till detaljplanen?
    Om ja:
    - Vid vilka tillfällen är detta hjälpsamt/ej hjälpsamt?
      Svar:
    - Vilka fördelar finns med att ha ett program som komplement till detaljplanen??
      Svar:
    - Vilka nackdelar finns med att ha ett program som komplement till detaljplanen??
      Svar:

11. Vilken nivå av detaljstyrning tycker du är önskvärt att tillämpa i ett program (som kan tänkas påverka dagsljus och energi)?
    Svar:

Studier i plan- och bygglovsprocessen

12. Vilka studier genomförs i samband med framtagande av ansökan om planbesked(som kan påverka energi och dagsljus)?
    Svar:

13. Anser du att dessa är av betydelse? Varför/varför inte?
    Svar:

14. Anser du att det saknas någon studie? i så fall vilken och varför?
    Svar:

15. Vilka studier genomförs i samband med framtagande av bygglovshandlingar (som kan påverka energi och dagsljus)?
    Svar:

16. Anser du att dessa är av betydelse? Varför/varför inte?
    Svar:

17. Anser du att det saknas någon studie? i så fall vilken och varför?
    Svar:

18. Anser du att studier av dagsljus kan vara ett hjälpmedel för kommunen i detaljplaneprocessen?
    Svar:
    Om ja:
    - Varför?
      Svar:
    Om nej:

- Varför inte?
  Svar:

19. Anser du att studier av energi kan vara ett hjälpmedel för kommunen i detaljplaneprocessen?
    Svar:
    Om ja:
    - Varför?
      Svar:

    Om nej:
    - Varför inte?
      Svar:

Design i tidiga skeden

20. Finns standardmått som hjälper till att bestämma en byggnads geometri (rumsdjup för bostäder, kontor etc.)?
    Svar:

21. Hur påverkar den ekonomiska aspekten utformningen av en byggnad?
    Svar:

22. Av vem, när och hur bestäms byggnadsform, höjd och väderstreck?
    Svar:

23. Brukar man ta hänsyn till energi och dagsljus när man bestämmer byggnadsform, höjd och väderstreck?
    Svar:

24. Vilka faktorer skulle du säga har störst betydelse för en byggnads form? finns det faktorer som är i konflikt med varandra och hur hanterar man detta?
    Svar:

25. Om en byggnad skall optimeras utifrån dagsljus och energi, vilka andra faktorer anser du är viktigast att samtidigt ta hänsyn till (kvaliteér som ljus, buller, tillgång till grönytor etc.)?
    Svar:

Avslutande frågor

26. Finns det något övrigt du vill tillägga?
    Svar:

27. Finns det ytterligare personer du tycker att vi ska kontakta?
    Svar:

A.2.2 Answers

Om dig

Namn: Johan Franzén och Karolina Olsson

Företag/organisation: Skanska Sverige AB

Arbetstitel: Projektutvecklare (Johan) och affärsutvecklare (Karolina)

Arbetsbeskrivning: Bostadsutvecklare och byggherreansvarig från framtagande utav detaljplan och tidig projektering till produktion och eftermarknad. Med och utvecklar detaljplaner och områden med fokus på bostäder.

Kontaktuppgifter: johan.franzen@skanska.se

Önskar vara anonym: Ja/Nej: Nej

Planbesked och bygglov

1. Vilken/vilka är de största skillnaderna mellan när ni som byggherre ansöker om planbesked och när kommunen själva väljer att upprätta en detaljplan (avseende dagsljus och energi)?
   Svar: Allmänt kan jag kommentera att när vi själva är med och utformar detaljplaner (i jämförelse med att vi köper detaljplanelagd mark) har vi större möjlighet att se till helheten och utforma produkten optimalt utifrån bland annat ovan nämnda parametrar, även om jag får medge att fokus oftast snarare är utifrån en målgruppsanalys och ekonomiska parametrar.

2. Vilka handlingar skickas in när ni ansöker om planbesked (när det rör dagsljus och energi)?
   Svar: Jag har inte varit med och ansökt om planbesked, då jag hittills främst jobbat i ett senare skede, dock har jag svårt att tro att vi behövt skicka in specifika handlingar rörande dagsljus och energi. Vi på Skanska Nya Hem Svanenmärker dock alltid våra bostäder, vilket bland annat innebär att vi ska leverera 15% lägre energiförbrukning än BBR-kraven, samt att vi behöver uppfylla dagsljuskraven, så möjligt att vi motiverar ett planbesked med detta för att få större tyngd i ansökan.

3. Hur detaljerad är den information som ni skickar in vid ansökan om planbesked (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?
   Svar: Se svar på fråga 2

4. Anser du att processen vid ansökan om planbesked har förändrats de senaste åren / håller på att förändras (fokus på energi och dagsljus)? Om ja, hur?
   Svar: Kanske inte just i samband med planbesked, men det är större fokus generellt på dagsljus och energi, men framförallt i bygglovsprocessen.

5. Vilka handlingar skickas in när ni ansöker om bygglov (när det rör dagsljus och energi)?
   Svar: Inte alltid något utav ovan efterfrågas i samband med bygglov, utan först i samband med tekniskt samråd och fråga om startbesked. Generellt brukar dock skicka in dagsljusberäkningar och ibland energiberäkningar. Framförallt det sistnämnda efterfrågas dock oftast först i samband med tekniskt samråd.

6. Hur detaljerad är den information som ni skickar in vid ansökan om bygglov (preliminära energi- och dagsljusberäkningar, byggnadshöjd, tilltänkt användning av byggnader etc.)?
   Svar: Själva bygglovsansökan består till främsta delen utav arkitektritningar, inkl material och kulörbeskrivningar, samt yt- och lägenhetssammanställningar, så själva utformningen utav byggnaderna är detaljerad. Främst fokus på höjd, våningsantal mm (lite beroende på vad som står i detaljplanen). Vi brukar även skicka in tillgänglighetsutlåtande, samt utlåtande från akustik och brand, samt

numera i Göteborg även mobilitetsutredningar och mobilitetsavtal med Göteborgs stad. Min känsla är att det är större fokus på ovan frågor än energi- och dagsljusfrågor, även om dessa börjar uppmärksammas mer och mer. Här upplever jag dock att vi som byggherrar har hårdare fokus på frågorna via våra interna Svanenkrav, än vad staden har.

7. Anser du att processen vid ansökan om bygglov har förändrats de senaste åren / håller på att förändras (fokus på energi och dagsljus)? Om ja, hur?
   Svar: Ja känslan är att dessa frågor får allt större fokus, även om de som sagt än så länge har mindre betydelse än många andra parametrar. Man märker också att Länsstyrelsen och andra myndigheter än så länge fokuserar betydligt mer på luft, buller och trafikfrågor.

8. Vilket/vilka är de vanligaste orsakerna till avslag vid bygglovsansökan?
   Svar: Det kan vara avsteg från detaljplanen som inte beviljas. Sällan utifrån dagsljus och energi utan snarare tolkningar utifrån byggnaden storlek, antingen fotavtryck, höjd eller volym.

9. Finns det något du önskar att kommunen gjorde som ej görs idag när det rör energi/dagsljus och detaljplanen/bygglov?
   Min känsla är att kommunen fokuserar väldigt lite på dessa frågor i samband med framtagandet utav detaljplaner. Den största fokusen ligger i samband med bygglov/startbesked, vilket gör att vi som byggherrar tar en stor risk. Om man kunde medvetandegöra dessa frågor tidigare och utifrån dessa göra medvetna val i detaljplaneprocessen hade det varit bättre för oss som byggherrar. Kortfattat kan man säga att bygglovshandläggarna kan acceptera avsteg om dessa framgår utav detaljplanen, därmed hade det varit betydligt bättre för oss byggherrar om detaljplanerna var tydligare kring dessa frågorna.

Program i detaljplaneprocessen

10. Tycker du att det är hjälpsamt med program som komplement till detaljplanen? Om ja:
    - Vid vilka tillfällen är detta hjälpsamt/ej hjälpsamt?
      Svar: Ja det är hjälpsamt. Dels för att under framtagandet utav detaljplanen veta vad som fungerar och inte fungerar, men också som ett verktyg att luta sig mot senare i processen.
    - Vilka fördelar finns med att ha ett program som komplement till detaljplanen??
      Svar: Man medvetandegör vad som fungerar och inte fungerar redan i ett tidigt skede och kan ta fram realistiska planer som går att genomföra så att vi som byggherre slipper sitta med Svarte-Petter vid en bygglovsansökan.
    - Vilka nackdelar finns med att ha ett program som komplement till detaljplanen??
      Svar: Generellt önskar vi så flexibla detaljplaner som möjligt, så det får helst inte vara alltför styrt i en detaljplan. Främst för att det är en

förändерlig marknad och en lång detaljplaneprocess kan innebära att det man projekterat för inte längre är aktuellt eller genomförbart. Då är det en fördel med flexibla planer som tillåter ett annat utförande.

11. Vilken nivå av detaljstyrning tycker du är önskvärt att tillämpa i ett program (som kan tänkas påverka dagsljus och energi)?
Svar: Rätt nivå är att med enkla studier kunna säkerställa att aktuella krav kan uppfyllas, alternativt ge vägledning till hur de skulle kunna uppfyllas. Dock ska vi vara medveten om att det framförallt på energisidan kommer allt skarpare krav, så det kan vara farligt med en alltför snäv byggrätt.

Studier i plan- och bygglovsprocessen

12. Vilka studier genomförs i samband med framtagande av ansökan om planbesked(som kan påverka energi och dagsljus)?
Svar: Min känsla är att solljusstudier är vanligare än dagsljusstudier från kommunens sida. För att se hur den nya bebyggelsen påverkar den befintliga. Det är inte lika stor fokus på dagsljus för den kommande bebyggelsen. Däremot utför vi själva som regel dagsljusstudier innan vi köper någon mark för att kunna säkerställa att det vi önskar eller räknar med ska byggas i samband med en markaffär även är genomförbart i praktiken.
När det gäller energiberäkningar mm, så efterfrågas dessa som regel inte från stadens sida. I vår interna projekteringsprocess ligger de däremot med och vi utför energiberäkningar såväli förslagshandlingsskedet, som systemhandlingsskedet (bygglov) och i bygghandlingsskedet. Det är oftast först de sistnämnda handlingarna som kommunen efterfrågar.

13. Anser du att dessa är av betydelse? Varför/varför inte?
Svar: Ja. För att kunna säkerställa att den produkt som är tänkt till en plats även fungerar att genomföra.

14. Anser du att det saknas någon studie? i så fall vilken och varför?
Svar: Egentligen inte, men i och med att dagsljusfrågorna får allt större fokus så finns det en önskan att man tar fram realistiska planer, så med tanke på det är det viktigt med dagsljusstudier redan i ett tidigt skede.

15. Vilka studier genomförs i samband med framtagande av bygglovshandlingar (som kan påverka energi och dagsljus)?
Svar: Dagsljusstudier/simuleringar och energiberäkningar.

16. Anser du att dessa är av betydelse? Varför/varför inte?
Svar: Ja, åtminstone för oss som byggherrar, så att vi vet att de byggnader vi projekterat går att genomföra och att vi håller vad vi lovar gentemot våra köpare.

17. Anser du att det saknas någon studie? i så fall vilken och varför?
Svar: Nej

18. Anser du att studier av dagsljus kan vara ett hjälpmedel för kommunen i detaljplaneprocessen?
    Svar: Ja
    Om ja:
    - Varför?
      Svar: För att medvetandegöra för kommunen om planen är genomförbar.

    Om nej:
    - Varför inte?
      Svar:

19. Anser du att studier av energi kan vara ett hjälpmedel för kommunen i detaljplaneprocessen?
    Svar: Nja.
    Om ja:
    - Varför?
      Svar:

    Om nej:
    - Varför inte?
      Svar: Än så länge är min känsla att energin inte är den trånga sektorn. Det går oftast att lösa. Med det sagt så kommer kraven bli hårdare och hårdare, så behovet kommer att finnas inom en snar framtid.

Design i tidiga skeden

20. Finns standardmått som hjälper till att bestämma en byggnads geometri (rumsdjup för bostäder, kontor etc.)?
    Svar: Vi på Skanska har interna hjälpmedel i form utav något som vi kallar för Skanskas bostadsplattformar. Dessa innehåller handböcker för alltifrån arkitekter, till installationer och även ett särskilt hjälpdokument kring dagsljusnyckeltal.

    I så stor utsträckning som möjligt försöker vi prefabricera våra bostäder. Det är inte så hårt styrt att vi är bundna till strikta byggnadsdjup och bredder, däremot finns det riktlinjer om våningshöjd beroende på byggmetod och planlösningar och bärande väggar är direkt kopplade till de spännvidder på elementen som aktuell byggmetod klarar av .

21. Hur påverkar den ekonomiska aspekten utformningen av en byggnad?
    Svar: Det är ekonomiskt mer fördelaktigt att bygga med så få hörn som möjligt, samt att om möjligt hellre bygga fler våningar och därmed minska utbredningen av husen. Utgångspunkten i detaljplanen ska vara en relativ enkel och rationell produkt. Det är lättare att i senare skede addera mervärden om projektekonomin så tillåter.

    Vidare gäller att inom ett projekt med flera huskroppar bör samma hustyp upprepas i möjligaste mån. Det är avsevärt mer gynnsamt att återupprepa en hustyp genom att rotera eller parallellförskjuta den, jämfört med att spegla en hustyp. En genomtänkt byggnadsutformning är en förutsättning för att åstadkomma en effektiv produktionsprocess, robusta byggnader och låga garantikostnader. Byggnader ska därför helst utformas på sådant sätt att komplicerade geometrier som är svåra att producera med säkerställd kvalitet och ekonomi undviks. Maximering av bostadsarean måste balanseras mot eventuell merkostnad på grund av mer komplicerad byggnadsgeometri.

Rent ekonomiskt är ett loftgångshus oftast en kostnadseffektiv produkt, då man får ut större andel BOA i förhållande till BTA som byggs, i jämförelse med ett hus med invändigt trapphus. Om man inte har en köpstark målgrupp kan ett loftgångshus därför vara att föredra. Man bygger billigare BOA som därmed inte behöver säljas lika dyrt.

22. Av vem, när och hur bestäms byggnadsform, höjd och väderstreck?
Svar: I detaljplanen sätts grunderna och det markeras var i ett område det är tillåtet att uppföra en byggnad, samt hur den får utformas. Lite beroende på detaljplanens flexibilitet är det slutligen vi byggherrar som med hjälp utav bland annat arkitekter och inom detaljplanens förutsättningar utformar den slutliga produkten.

23. Brukar man ta hänsyn till energi och dagsljus när man bestämmer byggnadsform, höjd och väderstreck?
Svar: Ja vi som byggherrar gör så gott som alltid dessa studier. Däremot är jag inte lika säker på att man från stadens sida alltid tagit hänsyn till dessa parametrar, särskilt inte vad gäller detaljplaner som baseras på slutna kvarter.

24. Vilka faktorer skulle du säga har störst betydelse för en byggnads form? finns det faktorer som är i konflikt med varandra och hur hanterar man detta?
Svar: Ur vår aspekt som byggherre handlar det i första hand om en marknadsanalys. Vilken målgrupp ser vi och vilken produkt efterfrågar denna målgrupp? Sedan finns det massvis med yttre faktorer som man behöver ta hänsyn till. Dagsljus och energi är två, liksom brand och buller. Sedan ska man inte heller underskatta närområdets synpunkter. Grannar som överklagar innebär utdragna processen, vilket i förlängningen försvårar arbetet. Därför försöker vi i allt större utsträckning, genom dialogarbete, även ta hänsyn till vad de kringboende tycker och tänker. I slutändan brukar det allt som oftast bli en kompromiss utav alla ovan faktorer.

Vad grannarna anser är definitivt en faktor som vi behöver ta hänsyn till, liksom Länsstyrelsen. Sedan finns det många andra faktorer som motverkar varandra. Dagsljus ställer exempelvis krav på fönsterytor, medan mängden fönster påverkar energin och ekonomin. På samma sätt kan slutna kvarter vara gynnsamt ur bullerperspektivet, men förödande när det kommer till dagsljus.

25. Om en byggnad skall optimeras utifrån dagsljus och energi, vilka andra faktorer anser du är viktigast att samtidigt ta hänsyn till (kvaliteér som ljus, buller, tillgång till grönytor etc.)?
Svar: Ljus, buller, grönytefaktorer är några, liksom hållbarhet, trygghet och tillgänglighet. Jag skulle också vilja påstå att det i förlängningen blir en

omöjlighet att förtäta staden om samtliga krav måste tillgodoses. Alla krav innebär också en allt dyrare produkt, vilket stänger ute en allt större andel människor från att ha råd att köpa en bostad, så människors betalningsförmåga är ytterligare en parameter att ta hänsyn till.

Avslutande frågor

26. Finns det något övrigt du vill tillägga?
    Svar: Är det rimligt och rätt väg att gå att alla krav alltid måste uppfyllas? Hur rimmar detta med en önskan om att förtäta stadskärnorna? Är det exempelvis så att dagsljus ska vara dimensionerande, eller bör en framkomlig väg snarare vara att hitta lättnader i regelverket? Vad anser de som arbetar skift och sover på dagarna, efterfrågar de dagsljus?
    Hur är det med oss som jobbar dagtid och under den största delen utav den ”ljusa” tiden befinner oss på arbetet och inte i bostaden, är vi i behov utav mer dagsljus i våra bostäder, eller finns det andra vägar att gå? Mår vi exempelvis bättre av att gå ut i friska luften och få dagsljuset den vägen?
    Det är inga enkla frågor och människors hälsa är viktigare än allt annat, men i förlängningen handlar det mycket om att kunna förstå problematiken och göra medvetna val utifrån detta. Ju mer som går att simulera i tidigt skede, desto bättre. Ur ett ekonomiskt perspektiv är förhållandet mellan tid och åtgärd intressant. Kostnaden för åtgärd växer exponentiellt med tiden.

27. Finns det ytterligare personer du tycker att vi ska kontakta?
    Svar:

B
Input data

B.1 Input data BeDOT

Parameters		Residences	Premises
U_{wall}	[W/m²K]	0.14	0.14
U_{roof}	[W/m²K]	0.13	0.13
U_{window}	[W/m²K]	0.9	0.9
$\Psi_{windows}$	[W/m·K]	0.14	0.14
$\Psi_{slab\text{-}wall}$	[W/m·K]	0.008	0.008
$\Psi_{ground\ slab\text{-}wall}$	[W/m·K]	0.221	0.221
$\Psi_{roof\text{-}wall}$	[W/m·K]	0.265	0.265
$\Psi_{external\ corridors}$	[W/m·K]	0.2	-
Heat capacity, C_m	[J/K]	Medium, 165 000 × A_{floor}	Medium, 165 000 × A_{floor}
g_{window}	[-]	0.55	0.5
$g_{solar\ shading}$	[-]	0.7	0.4
Shading control setpoint	[W/m²]	100	100
Hygienic flow	[l/sm²]	0.35	0.6
Schedule	*Hour 07-18*	*100%*	*100%*
	Hour 19-06	*100%*	*60%*
Leakage flow	[l/sm²]	0.021	0.021
Set temperature heating	[°C]	21	21
Set temperature cooling	[°C]	80	25
Light	[W/m²]	0	0
Equipment	[W/m²]	3	5
Schedule	*Hour 07-18*	*0%*	*100%*
	Hour 19-06	*100%*	*0%*
Occupancy	[W/m²]	2.29	5.4
Schedule	*Hour 07-18*	*0%*	*100%*
	Hour 19-06	*100%*	*0%*
η_{AHU}	[-]	0.8	0.8
Coil temperature	[°C]	10	10
SFP	[kPa]	1.6	1.6
T1 [°C]	[°C]	20	20
T2 [°C]	[°C]	18	18
T3 [°C]	[°C]	12	12
T4 [°C]	[°C]	18	18

B.2 Input data EPpet

Parameters		Residences	Premises
F_{geo}	[-]	0.9	0.9
q_{mean}	[l/sm^2]	0.35	0.6
$PE_{District\ heating}$	[-]	1	1
$PE_{Electricity}$	[-]	1.6	1.6
DHW	kWh/m^2	25	2
Weathering losses	kWh/m^2	4	0
VVC losses	kWh/m^2	4	3
Distribution losses	kWh/m^2	5% of heating demand	5% of heating demand
Facility energy outdoor lightning	kWh/m^2	1	1
Facility energy elevators	kWh/m^2	0.7	0.7
Facility energy entrances	kWh/st	4000	4000

Number of entrances							
Reference001	4	Reference101	4	Lamellhus001	4	Lamellhus101	4
Reference002	8	Reference102	8	Lamellhus002	8	Lamellhus102	8
Reference003	8	Reference103	8	Lamellhus003	8	Lamellhus103	8
Reference004	8	Reference104	8	Lamellhus004	8	Lamellhus104	8
Reference005	4	Reference105	4	Lamellhus005	4	Lamellhus105	4
Reference006	4	Reference106	4	Lamellhus006	4	Lamellhus106	4
Kvartershus001	4	Kvartershus101	4	Kvartershus201	4	Kvartershus301	4
Kvartershus002	8	Kvartershus102	8	Kvartershus202	8	Kvartershus302	8
Kvartershus003	8	Kvartershus103	8	Kvartershus203	8	Kvartershus303	8
Kvartershus004	8	Kvartershus104	8	Kvartershus204	8	Kvartershus304	8
Kvartershus005	4	Kvartershus105	4	Kvartershus205	4	Kvartershus305	4
L-hus001	4	Punkthus001	4	Punkthus007	4		
L-hus002	8	Punkthus002	4	Punkthus008	4		
L-hus003	8	Punkthus003	4	Punkthus009	4		
L-hus004	8	Punkthus004	4	Punkthus010	4		
L-hus005	4	Punkthus005	4	Punkthus011	4		
L-hus006	4	Punkthus006	4				

C

Results case study

C.1 Volume, thermal envelope area and facade area

Property	Volume [m^3]	Thermal envelope area [m^2]	Facade area residences [m^2]	Facade area premises [m^2]
Reference001	15772	4387	2778	379
Reference002	51106	11867	6348	1209
Reference003	43802	9624		6564
Reference004	93835	20049	9855	2054
Reference005	25138	5750		4420
Reference006	30919	6261		4001
Punkthus001	22500	4850	2945	655
Punkthus002	22500	4850	2945	655
Punkthus003	22500	4850	2945	655
Punkthus004	22500	4850	2945	655
Punkthus005	20625	4550	2970	330
Punkthus006	22500	4850	3273	327
Punkthus007	22500	4850	2945	655
Punkthus008	22500	4850		3600
Punkthus009	22500	4850		3600
Punkthus010	22500	4850		3600
Punkthus011	22500	4850		3600
Lamellhus001	21600	5760	3840	480
Lamellhus002	59372	14817	7017	3839
Lamellhus003	16165	4496		3416
Lamellhus004	80695	21511	3890	12581
Lamellhus005	21600	5760	3840	480
Lamellhus006	21600	5760	3840	480
L-hus001	39120	9760	6269	811
L-hus002	20100	5360	3573	447
L-hus003	19170	5210		3870
L-hus004	83490	19886	9495	5031
L-hus005	66330	15636	3485	8131
L-hus006	20100	5360		4020
Kvartershus001	34020	8136	4212	1404
Kvartershus002	75600	15840	9600	1200
Kvartershus003	17010	4446		3186
Kvartershus004	75768	15841	4191	6610
Kvartershus005	37968	8761		6241
Kvartershus101	26460	6888	3640	728
Kvartershus102	60480	13848	7550	1258
Kvartershus103	17010	4446		3186
Kvartershus104	68191	14762	4244	5478
Kvartershus105	34171	8138		5618
Kvartershus201	26460	6888	2184	2184
Kvartershus202	60480	13848	5033	3775
Kvartershus203	17010	4446		3186
Kvartershus204	68208	14929	5562	4326
Kvartershus205	45561	10007	4764	2722
Kvartershus301	34020	8136	4212	1404
Kvartershus302	75600	15840	9600	1200
Kvartershus303	17010	4446		3186
Kvartershus304	75768	15841	4191	6610
Kvartershus305	37968	8761		6241
Lamellhus101	18900	5490	3765	465
Lamellhus102	53972	14457	6815	4177
Lamellhus103	16165	4496		3416
Lamellhus104	77995	21241	4196	15785
Lamellhus105	18900	5490	3604	445
Lamellhus106	18900	5490	3604	445
Reference101	15772	4387	2778	379
Reference102	51106	11867	6348	1209
Reference103	43802	9624		6564
Reference104	93835	20049	9885	2025
Reference105	25138	5750		4420
Reference106	30919	6261		4001

Figure C.1: Volume [m^3], thermal envelope area and facade area [m^2]

C.2 Transmission losses

	Premises			
	Transmission losses [kWh]			
Property	Exterior walls	Roof	Thermal bridges	Windows
Reference001	5288	0	10166	14571
Reference002	25573	0	32148	70728
Reference003	86587	31292	141067	238439
Reference004	39448	0	56297	108683
Reference005	61830	11245	91693	170367
Reference006	60073	19224	85738	165272
Punkthus001	8292	0	13755	22787
Punkthus002	8295	0	13760	22793
Punkthus003	8113	0	13454	22291
Punkthus004	8131	0	13484	22339
Punkthus005	4322	0	8166	11885
Punkthus006	4360	0	8237	11989
Punkthus007	8364	0	13877	22984
Punkthus008	46594	10076	67975	128119
Punkthus009	46481	10042	67816	127806
Punkthus010	46543	10031	67910	127978
Punkthus011	46886	10064	68421	128929
Lamellhus001	6443	0	12173	17755
Lamellhus002	53958	9326	85620	148675
Lamellhus003	46281	9247	68741	127611
Lamellhus004	175170	30785	260540	482925
Lamellhus005	6359	0	12014	17522
Lamellhus006	6428	0	12144	17713
L-hus001	10099	0	22439	27840
L-hus002	5397	0	11510	14880
L-hus003	48579	10606	75270	133969
L-hus004	65656	10713	112562	180917
L-hus005	101819	21338	162995	280469
L-hus006	50353	10625	77838	138821

Figure C.2: Transmission losses premises [kWh] (Reference0 - L-hus0)

	Premises			
	Transmission losses [kWh]			
Property	Exterior walls	Roof	Thermal bridges	Windows
Reference001	5288	0	10166	14571
Reference002	25573	0	32148	70728
Reference003	86587	31292	141067	238439
Reference004	39448	0	56297	108683
Reference005	61830	11245	91693	170367
Reference006	60073	19224	85738	165272
Punkthus001	8292	0	13755	22787
Punkthus002	8295	0	13760	22793
Punkthus003	8113	0	13454	22291
Punkthus004	8131	0	13484	22339
Punkthus005	4322	0	8166	11885
Punkthus006	4360	0	8237	11989
Punkthus007	8364	0	13877	22984
Punkthus008	46594	10076	67975	128119
Punkthus009	46481	10042	67816	127806
Punkthus010	46543	10031	67910	127978
Punkthus011	46886	10064	68421	128929
Lamellhus001	6443	0	12173	17755
Lamellhus002	53958	9326	85620	148675
Lamellhus003	46281	9247	68741	127611
Lamellhus004	175170	30785	260540	482925
Lamellhus005	6359	0	12014	17522
Lamellhus006	6428	0	12144	17713
L-hus001	10099	0	22439	27840
L-hus002	5397	0	11510	14880
L-hus003	48579	10606	75270	133969
L-hus004	65656	10713	112562	180917
L-hus005	101819	21338	162995	280469
L-hus006	50353	10625	77838	138821

Figure C.3: Transmission losses premises [kWh] (Kvartershus0 - Reference1)

	Residences			
	Transmission losses [kWh]			
Property	Exterior walls	Roof	Thermal bridges	Windows
Reference001	37286	10354	53444	103010
Reference002	89574	36190	131633	247500
Reference004	133518	68351	194301	368468
Punkthus001	38372	10132	54346	105814
Punkthus002	38422	10137	54417	105954
Punkthus003	37839	10143	53595	104339
Punkthus004	37895	10147	53675	104496
Punkthus005	37873	9933	53637	104431
Punkthus006	42558	10139	60240	117343
Punkthus007	38882	10162	55065	107225
Lamellhus001	51688	12611	73270	142801
Lamellhus002	96137	25166	137888	265492
Lamellhus004	51463	12533	73199	142159
Lamellhus005	50754	12386	71946	140209
Lamellhus006	51253	12429	72651	141594
L-hus001	78211	21294	116336	216066
L-hus002	43231	10608	63762	119460
L-hus004	118773	32115	177541	328019
L-hus005	44035	10694	65224	121604
Kvartershus001	58281	21787	82761	160900
Kvartershus002	132855	44004	190796	366381
Kvartershus004	58860	21901	84142	162354
Kvartershus101	49625	21769	70572	137057
Kvartershus102	104671	43826	150387	288873
Kvartershus104	58761	21887	84003	162080
Kvartershus201	32485	21730	46433	89845
Kvartershus202	74784	43832	108175	206598
Kvartershus204	82635	43809	119010	228207
Kvartershus205	68767	22224	97635	189806
Kvartershus301	49059	20197	81992	210553
Kvartershus302	112306	40910	193548	481562
Kvartershus304	49661	20442	84514	212977
Lamellhus101	44899	10154	85415	124247
Lamellhus102	83396	20127	170101	230717
Lamellhus104	43645	10021	84312	120747
Lamellhus105	44157	9859	84047	122180
Lamellhus106	43957	9920	83630	121627
Reference101	32238	10765	54884	138498
Reference102	76507	35748	132223	328673
Reference104	113945	67149	192452	488918

Figure C.4: Transmission losses residences [kWh/m^2]

C.3 Air leakage, ventilation losses and thermal bridges

	Premises		
Property	Air leakages [kWh]	Ventilation losses [kWh]	Thermal bridges [%]
Reference001	1399	6269	32,92%
Reference002	9592	22185	24,32%
Reference003	29958	188501	27,42%
Reference004	11501	53178	26,52%
Reference005	18369	119627	26,77%
Reference006	20227	144808	25,00%
Punkthus001	2152	20074	29,84%
Punkthus002	2153	20092	29,84%
Punkthus003	2110	18138	29,81%
Punkthus004	2114	18323	29,82%
Punkthus005	1131	8784	32,57%
Punkthus006	1139	9145	32,66%
Punkthus007	2168	20751	29,85%
Punkthus008	14080	117109	26,17%
Punkthus009	14050	116039	26,17%
Punkthus010	14062	116740	26,18%
Punkthus011	14146	120311	26,19%
Lamellhus001	1707	7352	32,67%
Lamellhus002	15995	90487	28,04%
Lamellhus003	14007	69088	26,65%
Lamellhus004	52065	274951	26,83%
Lamellhus005	1686	6657	32,66%
Lamellhus006	1703	7238	32,66%
L-hus001	2660	16126	36,14%
L-hus002	1429	6523	35,29%
L-hus003	14837	88897	27,28%
L-hus004	19254	139996	29,60%
L-hus005	30769	222637	27,99%
L-hus006	15294	91932	27,30%

Figure C.5: Air leakage [kWh], ventilation losses [kWh] and thermal bridges [%] (Reference0 - L-hus0)

	Premises		
Property	Air leakages [kWh]	Ventilation losses [kWh]	Thermal bridges [%]
Kvartershus001	4787	35295	29,62%
Kvartershus002	4392	31646	33,57%
Kvartershus003	13534	73107	26,16%
Kvartershus004	28451	235471	26,87%
Kvartershus005	26921	179566	26,08%
Kvartershus101	2524	15291	32,10%
Kvartershus102	4405	32250	33,28%
Kvartershus103	13593	75148	26,16%
Kvartershus104	24443	190519	26,87%
Kvartershus105	24660	159431	25,96%
Kvartershus201	7087	56883	28,25%
Kvartershus202	12421	121657	28,77%
Kvartershus203	13598	75337	26,16%
Kvartershus204	14464	147110	28,53%
Kvartershus205	9358	78109	28,33%
Kvartershus301	4760	34096	27,65%
Kvartershus302	4381	31166	31,16%
Kvartershus303	13332	69045	23,54%
Kvartershus304	27967	222146	24,49%
Kvartershus305	26440	168908	23,59%
Lamellhus101	1502	6089	35,36%
Lamellhus102	14777	90768	28,90%
Lamellhus103	12907	73555	26,61%
Lamellhus104	47961	290748	27,38%
Lamellhus105	1492	5767	35,24%
Lamellhus106	1489	5686	35,24%
Reference101	1398	6225	30,55%
Reference102	9655	23385	16,50%
Reference103	29800	179139	25,86%
Reference104	11544	54710	19,00%
Reference105	17949	111980	24,02%
Reference106	19718	132575	22,66%

Figure C.6: Air leakage [kWh], ventilation losses [kWh] and thermal bridges [%] (Kvartershus0 - Reference1)

C.4 Heat losses to ground

Property	Ground flux [kWh/m^2,property]
Reference001	1,44
Reference002	1,80
Reference003	1,38
Reference004	1,83
Reference005	0,98
Reference006	1,44
Punkthus001	1,02
Punkthus002	1,02
Punkthus003	1,02
Punkthus004	1,02
Punkthus005	1,12
Punkthus006	1,02
Punkthus007	1,02
Punkthus008	1,02
Punkthus009	1,02
Punkthus010	1,02
Punkthus011	1,02
Lamellhus001	1,24
Lamellhus002	1,24
Lamellhus003	1,24
Lamellhus004	1,15
Lamellhus005	1,24
Lamellhus006	1,24
L-hus001	1,28
L-hus002	1,24
L-hus003	1,31
L-hus004	1,19
L-hus005	1,12
L-hus006	1,24
Kvartershus001	1,40
Kvartershus002	1,24
Kvartershus003	1,40
Kvartershus004	1,24
Kvartershus005	1,24
Kvartershus101	1,86
Kvartershus102	1,60
Kvartershus103	1,40
Kvartershus104	1,39
Kvartershus105	1,39
Kvartershus201	1,86
Kvartershus202	1,60
Kvartershus203	1,40
Kvartershus204	1,39
Kvartershus205	1,01
Kvartershus301	1,40
Kvartershus302	1,24
Kvartershus303	1,40
Kvartershus304	1,24
Kvartershus305	1,24
Lamellhus101	1,24
Lamellhus102	1,19
Lamellhus103	1,24
Lamellhus104	0,30
Lamellhus105	1,42
Lamellhus106	1,42
Reference101	1,44
Reference102	1,80
Reference103	1,38
Reference104	1,83
Reference105	0,98
Reference106	1,44

Figure C.7: Heat losses to ground [kWh]

C.5 Energy

	Energy premises [kWh/m^2,premises]							
Property	**Zone heating**	**Hyg. Heating**	**Added heat**	**Added recovered heat**	**Hyg. Cooling**	**Free cooling**	**Added cooling**	**Fan energy**
Reference001	20,6	20,6	0,0	0,0	0,8	56,7	6,7	6,7
Reference002	30,7	30,7	0,0	0,0	0,8	56,7	6,7	6,7
Reference003	7,8	7,8	0,0	0,0	0,8	56,7	6,7	6,7
Reference004	17,0	17,0	0,0	0,0	0,8	56,7	6,7	6,7
Reference005	7,7	7,7	0,0	0,0	0,8	56,7	6,7	6,7
Reference006	5,9	5,9	0,0	0,0	0,8	56,7	6,7	6,7
Punkthus001	5,6	5,6	0,1	1,3	1,8	51,0	6,7	6,7
Punkthus002	5,5	5,5	0,1	1,3	1,8	51,0	6,7	6,7
Punkthus003	6,9	6,9	0,0	0,5	1,8	51,0	6,7	6,7
Punkthus004	6,8	6,8	0,0	0,6	1,8	51,0	6,7	6,7
Punkthus005	9,9	9,9	0,0	0,2	1,8	51,0	6,7	6,7
Punkthus006	9,1	9,1	0,0	0,5	1,8	51,0	6,7	6,7
Punkthus007	5,0	5,0	0,1	2,1	1,8	51,0	6,7	6,7
Punkthus008	4,3	4,3	0,1	2,8	1,8	51,0	6,7	6,7
Punkthus009	4,4	4,4	0,1	2,4	1,8	51,0	6,7	6,7
Punkthus010	4,3	4,3	0,1	2,5	1,8	51,0	6,7	6,7
Punkthus011	3,9	3,9	0,2	3,3	1,8	51,0	6,7	6,7
Lamellhus001	22,2	22,2	0,0	0,0	0,8	56,7	6,7	6,7
Lamellhus002	11,2	11,2	0,1	2,2	0,8	56,7	6,7	6,7
Lamellhus003	12,4	12,4	0,1	2,2	0,8	56,7	6,7	6,7
Lamellhus004	11,3	11,3	0,2	3,2	0,8	56,7	6,7	6,7
Lamellhus005	22,9	22,9	0,0	0,0	0,8	56,7	6,7	6,7
Lamellhus006	22,5	22,5	0,0	0,0	0,8	56,7	6,7	6,7
L-hus001	15,7	15,7	0,0	0,1	1,8	51,0	6,7	6,7
L-hus002	21,0	21,0	0,0	0,0	1,8	51,0	6,7	6,7
L-hus003	9,4	9,4	0,1	1,9	1,8	51,0	6,7	6,7
L-hus004	7,9	7,9	0,2	2,7	1,8	51,0	6,7	6,7
L-hus005	7,2	7,2	0,1	2,1	1,8	51,0	6,7	6,7
L-hus006	9,6	9,6	0,1	1,9	1,8	51,0	6,7	6,7

Figure C.8: Energy premises [kWh/m^2] (Reference0 - L-hus0)

	Energy premises [kWh/m^2,premises]							
Property	Zone heating	Hyg. Heating	Added heat	Added recovered heat	Hyg. Cooling	Free cooling	Added cooling	Fan energy
Kvartershus001	8,8	8,8	0,0	1,0	0,8	56,7	6,7	6,7
Kvartershus002	11,4	11,4	0,0	0,2	0,8	56,7	6,7	6,7
Kvartershus003	10,4	10,4	0,1	2,3	0,8	56,7	6,7	6,7
Kvartershus004	4,9	4,9	0,3	4,2	0,8	56,7	6,7	6,7
Kvartershus005	6,9	6,9	0,2	3,2	0,8	56,7	6,7	6,7
Kvartershus101	14,4	14,4	0,0	0,2	0,8	56,7	6,7	6,7
Kvartershus102	11,3	11,3	0,0	0,3	0,8	56,7	6,7	6,7
Kvartershus103	9,9	9,9	0,1	2,8	0,8	56,7	6,7	6,7
Kvartershus104	5,7	5,7	0,3	4,3	0,8	56,7	6,7	6,7
Kvartershus105	7,4	7,4	0,2	3,3	0,8	56,7	6,7	6,7
Kvartershus201	6,7	6,7	0,0	0,0	0,8	56,7	6,7	6,7
Kvartershus202	4,6	4,6	0,0	0,0	0,8	56,7	6,7	6,7
Kvartershus203	9,9	9,9	0,0	0,0	0,8	56,7	6,7	6,7
Kvartershus204	4,0	4,0	0,0	0,0	0,8	56,7	6,7	6,7
Kvartershus205	5,7	5,7	0,0	0,0	0,8	56,7	6,7	6,7
Kvartershus301	11,9	11,9	0,0	1,0	0,8	56,7	6,7	6,7
Kvartershus302	14,5	14,5	0,0	0,3	0,8	56,7	6,7	6,7
Kvartershus303	14,3	14,3	0,1	2,3	0,8	56,7	6,7	6,7
Kvartershus304	7,1	7,1	0,3	4,5	0,8	56,7	6,7	6,7
Kvartershus305	10,0	10,0	0,2	3,4	0,8	56,7	6,7	6,7
Lamellhus101	24,8	24,8	0,0	0,0	1,8	51,0	6,7	6,7
Lamellhus102	10,2	10,2	0,1	1,5	1,8	51,0	6,7	6,7
Lamellhus103	10,0	10,0	0,1	1,7	1,8	51,0	6,7	6,7
Lamellhus104	8,9	8,9	0,1	2,5	1,8	51,0	6,7	6,7
Lamellhus105	25,4	25,4	0,0	0,0	1,8	51,0	6,7	6,7
Lamellhus106	25,3	25,3	0,0	0,0	1,8	51,0	6,7	6,7
Reference101	25,3	25,3	0,0	0,0	0,8	56,7	6,7	6,7
Reference102	32,9	32,9	0,0	1,1	0,8	56,7	6,7	6,7
Reference103	10,4	10,4	0,1	2,0	0,8	56,7	6,7	6,7
Reference104	18,7	18,7	0,0	0,0	0,8	56,7	6,7	6,7
Reference105	11,5	11,5	0,0	0,0	0,8	56,7	6,7	6,7
Reference106	8,8	8,8	0,0	0,0	0,8	56,7	6,7	6,7

Figure C.9: Energy premises [kWh/m^2] (Kvartershus0 - Reference1)

Property	Energy residences [kWh/m^2,residences]		
	Zone heating	Hyg. Heating	Fan energy
Reference001	16,3	7,2	4,9
Reference002	13,1	7,2	4,9
Reference004	9,0	7,2	4,9
Punkthus001	7,3	6,3	4,9
Punkthus002	7,2	6,3	4,9
Punkthus003	8,5	6,3	4,9
Punkthus004	8,3	6,3	4,9
Punkthus005	7,6	6,3	4,9
Punkthus006	6,7	6,3	4,9
Punkthus007	6,9	6,3	4,9
Lamellhus001	16,4	7,2	4,9
Lamellhus002	12,1	7,2	4,9
Lamellhus004	12,8	7,2	4,9
Lamellhus005	17,0	7,2	4,9
Lamellhus006	16,6	7,2	4,9
L-hus001	11,4	6,3	4,9
L-hus002	15,4	6,3	4,9
L-hus004	9,9	6,3	4,9
L-hus005	12,4	6,3	4,9
Kvartershus001	12,3	7,2	4,9
Kvartershus002	8,3	7,2	4,9
Kvartershus004	8,8	7,2	4,9
Kvartershus101	13,3	7,2	4,9
Kvartershus102	9,8	7,2	4,9
Kvartershus104	8,9	7,2	4,9
Kvartershus201	16,9	7,2	4,9
Kvartershus202	12,1	7,2	4,9
Kvartershus204	11,2	7,2	4,9
Kvartershus205	10,7	7,2	4,9
Kvartershus301	16,4	7,2	4,9
Kvartershus302	11,4	7,2	4,9
Kvartershus304	12,0	7,2	4,9
Lamellhus101	20,3	6,3	4,9
Lamellhus102	16,0	6,3	4,9

Figure C.10: Energy residences [kWh/m^2]

	Total energy				
	Residences [kWh/m^2,residences]		Premises [kWh/m^2,premises]		
Property	Heating	Fan Energy	Heating	Cooling	Fan Energy
Reference001	23,5	4,9	30,1	0,9	6,7
Reference002	20,3	4,9	40,2	2,1	6,7
Reference003			17,3	4,1	6,7
Reference004	16,2	4,9	26,5	2,9	6,7
Reference005			17,2	7,3	6,7
Reference006			15,4	5,7	6,7
Punkthus001	13,6	4,9	13,9	6,2	7,4
Punkthus002	13,5	4,9	13,9	6,1	7,4
Punkthus003	14,8	4,9	15,2	4,0	7,0
Punkthus004	14,6	4,9	15,1	4,2	7,1
Punkthus005	13,9	4,9	18,2	4,0	7,0
Punkthus006	12,9	4,9	17,4	5,4	7,2
Punkthus007	13,2	4,9	13,4	8,2	7,8
Punkthus008			12,7	9,3	8,0
Punkthus009			12,8	8,5	7,9
Punkthus010			12,7	8,8	7,9
Punkthus011			12,3	10,4	8,2
Lamellhus001	23,5	4,9	31,7	1,1	6,7
Lamellhus002	19,3	4,9	20,9	5,7	7,7
Lamellhus003			22,0	5,9	7,7
Lamellhus004	19,9	4,9	21,0	7,7	8,0
Lamellhus005	24,2	4,9	32,4	0,8	6,7
Lamellhus006	23,8	4,9	32,0	1,1	6,7
L-hus001	17,7	4,9	24,0	3,1	6,8
L-hus002	21,7	4,9	29,3	1,8	6,7
L-hus003			17,7	8,5	7,8
L-hus004	16,2	4,9	16,3	9,5	8,0
L-hus005	18,6	4,9	15,6	8,1	7,8
L-hus006			18,0	8,6	7,8
Kvartershus001	19,5	4,9	18,4	3,0	7,1
Kvartershus002	15,5	4,9	20,9	1,6	6,8
Kvartershus003			20,0	6,0	7,7
Kvartershus004	16,0	4,9	14,7	7,8	8,2
Kvartershus005			16,6	6,9	7,9
Kvartershus101	20,4	4,9	23,9	1,6	6,8
Kvartershus102	17,0	4,9	20,8	1,9	6,9
Kvartershus103			19,6	6,7	7,9
Kvartershus104	16,0	4,9	15,5	7,9	8,2
Kvartershus105			17,1	7,1	8,0
Kvartershus201	24,1	4,9	16,2	3,9	6,8
Kvartershus202	19,2	4,9	14,1	4,4	6,9
Kvartershus203			19,4	6,0	7,9
Kvartershus204	18,3	4,9	13,5	5,6	8,2
Kvartershus205	17,9	4,9	15,2	4,9	8,0
Kvartershus301	23,5	4,9	21,4	3,4	7,2
Kvartershus302	18,6	4,9	24,0	2,0	6,9
Kvartershus303			24,0	6,0	7,7
Kvartershus304	19,2	4,9	16,9	8,3	8,3
Kvartershus305			19,7	7,4	8,0
Lamellhus101	26,6	4,9	33,1	1,9	6,7
Lamellhus102	22,3	4,9	18,6	7,3	7,6
Lamellhus103			18,4	3,7	7,7
Lamellhus104	21,9	4,9	17,3	10,2	8,1
Lamellhus105	27,6	4,9	33,7	1,8	6,7
Lamellhus106	27,2	4,9	33,6	1,8	6,7
Reference101	26,6	4,9	34,8	1,1	6,7
Reference102	23,5	4,9	42,4	4,3	7,3
Reference103			20,0	5,5	7,6
Reference104	18,5	4,9	28,2	4,6	6,7
Reference105			21,0	7,7	6,7
Reference106			18,4	5,7	6,7

Figure C.11: Total energy property [kWh/m^2]

	Total energy		
	Residences [kWh/m^2,residences]	Premises [kWh/m^2,premises]	
Case	Heating	Heating	Cooling
Reference0	18,3	19,5	4,9
Punkthus0	13,8	13,1	8,5
Lamellhus0	21,7	21,9	6,6
L-hus0	17,8	17,0	8,3
Kvartershus0	16,4	16,8	6,5
Kvartershus1	17,4	17,5	6,7
Kvartershus2	19,1	15,3	5,0
Kvartershus3	19,8	19,7	6,9
Lamellhus1	24,7	18,7	8,1
Reference1	21,0	22,3	5,8

Figure C.12: Total energy case [kWh/m^2]

C.6 EP_{pet}

	EPpet BBR28			
Property	Residences [kWh/Atemp,residences]	Premises [kWh/Atemp,premises]	Property [kWh/Atemp,property]	EPpet property/EPpet BBR28 [%]
Reference001	75,8	59,5	73,8	85,2%
Reference002	70,5	71,3	70,6	81,2%
Reference003		50,5	50,5	51,8%
Reference004	64,2	55,2	62,6	71,8%
Reference005		49,5	49,5	50,8%
Reference006		47,0	47,0	48,2%
Punkthus001	62,4	44,6	59,2	67,8%
Punkthus002	62,3	44,5	59,0	67,6%
Punkthus003	63,8	44,7	60,4	69,2%
Punkthus004	63,6	44,6	60,2	68,9%
Punkthus005	63,6	47,8	62,0	71,9%
Punkthus006	62,2	47,8	60,9	70,7%
Punkthus007	61,9	45,3	58,9	67,5%
Punkthus008		50,4	50,4	51,7%
Punkthus009		50,1	50,1	51,3%
Punkthus010		50,2	50,2	51,4%
Punkthus011		50,7	50,7	52,0%
Lamellhus001	74,7	61,3	73,2	84,7%
Lamellhus002	67,4	52,6	62,1	69,5%
Lamellhus003		65,3	65,3	67,0%
Lamellhus004	65,7	55,5	57,9	61,3%
Lamellhus005	75,5	62,0	74,0	85,6%
Lamellhus006	75,0	61,6	73,5	85,1%
L-hus001	66,3	53,8	64,9	75,1%
L-hus002	76,6	59,6	74,7	86,4%
L-hus003		61,3	61,3	62,8%
L-hus004	63,3	50,1	58,7	65,8%
L-hus005	64,2	49,4	53,8	57,4%
L-hus006		49,9	49,9	51,2%
Kvartershus001	68,0	47,4	62,8	71,3%
Kvartershus002	63,8	48,9	62,1	71,9%
Kvartershus003		62,6	62,6	64,2%
Kvartershus004	61,9	47,5	53,1	57,3%
Kvartershus005		51,2	51,2	52,5%
Kvartershus101	70,2	52,8	67,3	77,3%
Kvartershus102	65,9	49,1	63,5	73,2%
Kvartershus103		62,5	62,5	64,1%
Kvartershus104	62,3	48,5	54,5	59,2%
Kvartershus105		52,1	52,1	53,5%
Kvartershus201	72,4	45,6	59,0	64,7%
Kvartershus202	66,9	42,6	56,5	62,5%
Kvartershus203		60,8	60,8	62,3%
Kvartershus204	65,6	43,8	56,1	62,0%
Kvartershus205	65,1	44,9	57,7	64,5%
Kvartershus301	72,7	51,2	67,3	76,4%
Kvartershus302	67,4	52,8	65,8	76,2%
Kvartershus303		67,2	67,2	69,0%
Kvartershus304	65,6	50,4	56,3	60,8%
Kvartershus305		55,1	55,1	56,5%
Lamellhus101	78,8	63,6	77,1	89,2%
Lamellhus102	71,0	52,0	63,8	71,1%
Lamellhus103		63,5	63,5	65,2%
Lamellhus104	67,9	54,0	57,0	60,1%
Lamellhus105	79,9	64,2	78,2	90,5%
Lamellhus106	79,5	64,1	77,8	90,1%
Reference101	79,5	65,2	77,7	89,7%
Reference102	74,3	76,1	74,6	85,7%
Reference103		56,3	56,3	57,7%
Reference104	66,8	57,0	65,1	74,7%
Reference105		54,0	54,0	55,4%
Reference106		50,4	50,4	51,7%

Figure C.13: EP_{pet} property [kWh/m^2A_{temp}]

Case	EPpet BBR28 Property [kWh/Atemp,property]	Residences [kWh/Atemp,residences]	Premises [kWh/Atemp,premises]	Eppet case/EPpet BBR28 [%]
Reference0	59,4	67,5	51,3	65,2%
Punkthus0	56,5	62,8	49,3	62,2%
Lamellhus0	64,2	70,9	56,8	70,5%
L-hus0	59,1	66,1	51,8	64,9%
Kvartershus0	57,7	64,2	50,9	63,3%
Kvartershus1	59	65,8	52,3	64,7%
Kvartershus2	57,3	66,6	46,7	63,0%
Kvartershus3	61,4	68,1	54,5	67,4%
Lamellhus1	65	74,7	55,7	71,1%
Reference1	63,2	70,6	55,7	69,3%

Figure C.14: EP_{pet} case [kWh/m^2A_{temp}]

D

VSC results

D.1 VSC summery

Property	VSC [%]								
	Property			Residences			Premises		
	% facade <15	% facade 15-25	% facade >25	% facade <15	% facade 15-25	% facade >25	% facade <15	% facade 15-25	% facade >25
Reference001	44,1%	21,0%	34,8%	38,2%	22,9%	38,9%	78,7%	9,9%	11,4%
Reference002	31,8%	26,2%	41,9%	20,9%	29,8%	49,1%	71,4%	12,9%	15,8%
Reference003	47,4%	15,6%	37,0%				47,4%	15,6%	37,0%
Reference004	30,8%	20,9%	48,1%	21,1%	24,3%	54,5%	65,4%	9,0%	25,4%
Reference005	19,2%	9,8%	71,0%				19,2%	9,8%	71,0%
Reference006	23,3%	17,2%	59,4%				23,3%	17,2%	59,4%
Punkthus001	14,8%	23,4%	61,8%	10,0%	22,3%	67,7%	37,6%	28,8%	33,6%
Punkthus002	9,5%	24,5%	66,0%	6,8%	18,8%	74,4%	22,2%	51,8%	25,6%
Punkthus003	26,8%	25,7%	47,4%	20,0%	22,6%	57,3%	59,5%	40,5%	0,0%
Punkthus004	22,4%	28,3%	49,2%	17,0%	23,4%	59,5%	48,2%	51,8%	0,0%
Punkthus005	22,0%	24,9%	52,9%	19,7%	25,0%	55,1%	44,2%	23,9%	31,9%
Punkthus006	13,1%	16,3%	70,6%	11,0%	16,6%	72,5%	35,4%	13,1%	51,0%
Punkthus007	10,3%	20,1%	69,5%	5,4%	20,9%	73,7%	34,0%	16,4%	49,4%
Punkthus008	13,8%	20,2%	65,9%				13,8%	20,2%	65,9%
Punkthus009	18,4%	24,7%	56,8%				18,4%	24,7%	56,8%
Punkthus010	19,6%	21,7%	58,7%				19,6%	21,7%	58,7%
Punkthus011	15,9%	17,8%	66,3%				15,9%	17,8%	66,3%
Lamellhus001	30,1%	26,4%	43,3%	26,1%	25,5%	48,1%	65,3%	34,7%	0,0%
Lamellhus002	14,8%	25,5%	59,5%	9,9%	23,1%	66,8%	22,7%	29,4%	47,7%
Lamellhus003	29,9%	13,2%	56,9%				29,9%	13,2%	56,9%
Lamellhus004	17,5%	12,7%	69,7%	10,5%	15,0%	74,5%	19,4%	12,1%	68,5%
Lamellhus005	46,2%	24,4%	29,3%	41,9%	25,4%	32,7%	84,0%	16,0%	0,0%
Lamellhus006	42,2%	26,1%	31,5%	36,8%	27,9%	35,1%	89,8%	10,0%	0,0%
L-hus001	38,5%	20,9%	40,4%	33,8%	22,9%	43,1%	76,5%	4,7%	18,7%
L-hus002	50,1%	19,7%	30,1%	45,4%	20,9%	33,6%	89,7%	10,3%	0,0%
L-hus003	21,4%	29,6%	49,0%				21,4%	29,6%	49,0%
L-hus004	31,3%	13,6%	55,0%	31,5%	17,7%	50,7%	30,8%	6,3%	62,9%
L-hus005	36,4%	16,1%	47,3%	46,8%	22,5%	30,5%	31,7%	13,3%	54,9%
L-hus006	20,8%	25,6%	53,5%				20,8%	25,6%	53,5%

Figure D.1: VSC summery property [%]

	VSC [%]								
	Property			Residences			Premises		
Property	% facade <15	% facade 15-25	% facade >25	% facade <15	% facade 15-25	% facade >25	% facade <15	% facade 15-25	% facade >25
Kvartershus001	32,4%	28,8%	38,8%	26,1%	31,6%	42,2%	75,3%	9,6%	15,1%
Kvartershus002	25,7%	23,3%	50,8%	20,2%	24,7%	55,0%	67,4%	13,2%	19,0%
Kvartershus003	24,3%	21,6%	54,1%				24,3%	21,6%	54,1%
Kvartershus004	27,0%	22,2%	50,7%	25,6%	28,7%	45,5%	28,0%	17,2%	54,7%
Kvartershus005	19,2%	12,5%	68,2%				19,2%	12,5%	68,2%
Kvartershus101	29,1%	30,7%	40,2%	21,5%	34,1%	44,4%	73,2%	10,8%	15,7%
Kvartershus102	21,5%	25,8%	52,6%	14,7%	27,5%	57,7%	67,0%	14,4%	18,3%
Kvartershus103	20,4%	20,9%	58,5%				20,4%	20,9%	58,5%
Kvartershus104	30,4%	21,3%	48,2%	22,1%	23,2%	54,6%	43,3%	18,3%	38,2%
Kvartershus105	18,8%	10,6%	70,5%				18,8%	10,6%	70,5%
Kvartershus201	28,9%	30,7%	40,2%	8,5%	31,8%	59,7%	53,7%	29,5%	16,5%
Kvartershus202	19,9%	25,9%	54,0%	2,7%	22,4%	74,8%	47,1%	31,4%	21,3%
Kvartershus203	20,7%	20,8%	58,5%				20,7%	20,8%	58,5%
Kvartershus204	30,5%	21,4%	47,9%	11,4%	27,8%	60,8%	58,2%	12,2%	29,3%
Kvartershus205	16,4%	10,2%	73,3%	4,2%	13,4%	82,4%	39,9%	4,3%	55,8%
Kvartershus301	32,4%	28,8%	38,8%	26,1%	31,6%	42,2%	75,3%	9,6%	15,1%
Kvartershus302	25,7%	23,3%	50,8%	20,2%	24,7%	55,0%	67,4%	13,2%	19,0%
Kvartershus303	24,3%	21,6%	54,1%				24,3%	21,6%	54,1%
Kvartershus304	27,0%	22,2%	50,7%	25,6%	28,7%	45,5%	28,0%	17,2%	54,7%
Kvartershus305	19,2%	12,5%	68,2%				19,2%	12,5%	68,2%
Lamellhus101	50,9%	20,1%	28,9%	45,3%	22,4%	32,2%	100,0%	0,0%	0,0%
Lamellhus102	23,1%	28,1%	48,8%	22,4%	27,2%	50,3%	24,0%	29,4%	46,5%
Lamellhus103	28,0%	14,6%	57,4%				28,0%	14,6%	57,4%
Lamellhus104	18,5%	13,9%	67,6%	20,1%	17,1%	62,7%	18,1%	13,1%	68,7%
Lamellhus105	60,0%	16,1%	23,8%	56,5%	16,8%	26,5%	90,6%	9,4%	0,0%
Lamellhus106	57,4%	19,5%	23,1%	53,4%	20,9%	25,7%	92,7%	7,3%	0,0%
Reference101	44,1%	21,0%	34,8%	38,2%	22,9%	38,9%	78,7%	9,9%	11,4%
Reference102	31,8%	26,2%	41,9%	20,9%	29,8%	49,1%	71,4%	12,9%	15,8%
Reference103	47,4%	15,6%	37,0%				47,4%	15,6%	37,0%
Reference104	30,8%	20,9%	48,1%	21,1%	24,3%	54,5%	65,4%	9,0%	25,4%
Reference105	19,2%	9,8%	71,0%				19,2%	9,8%	71,0%
Reference106	23,3%	17,2%	59,4%				23,3%	17,2%	59,4%

Figure D.2: VSC summery case [%]

D.2 Reference0

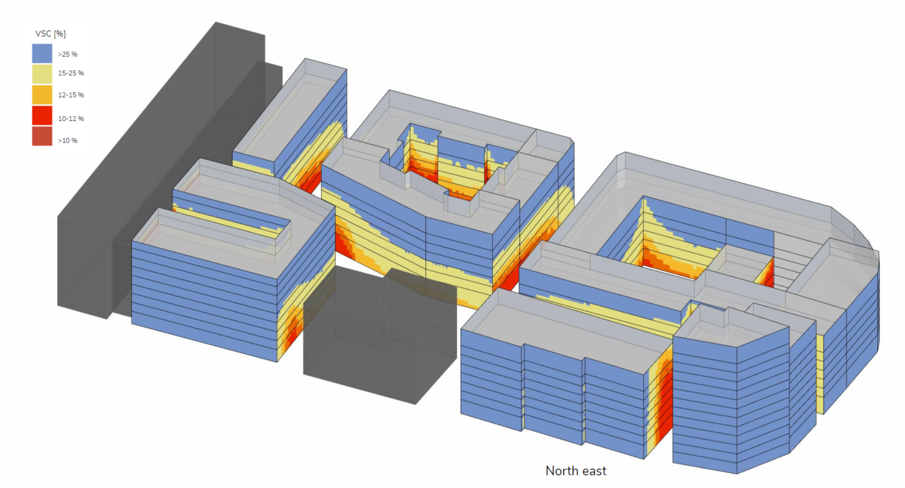

Figure D.3: VSC north east facade [%]

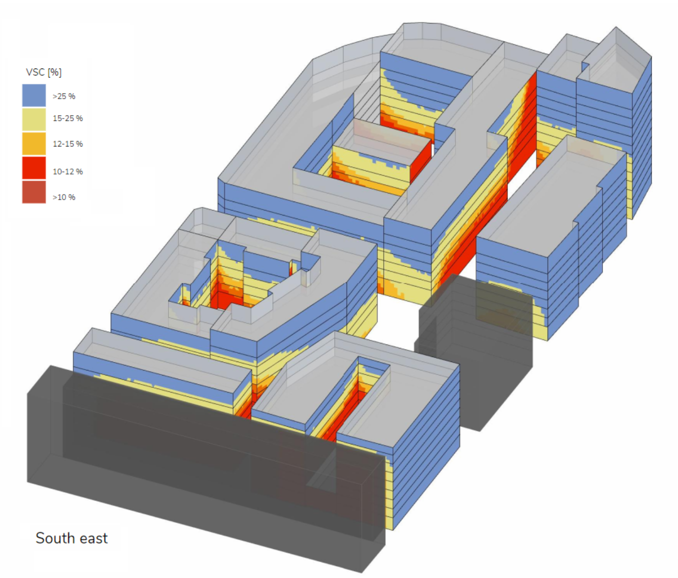

Figure D.4: VSC south east facade [%]

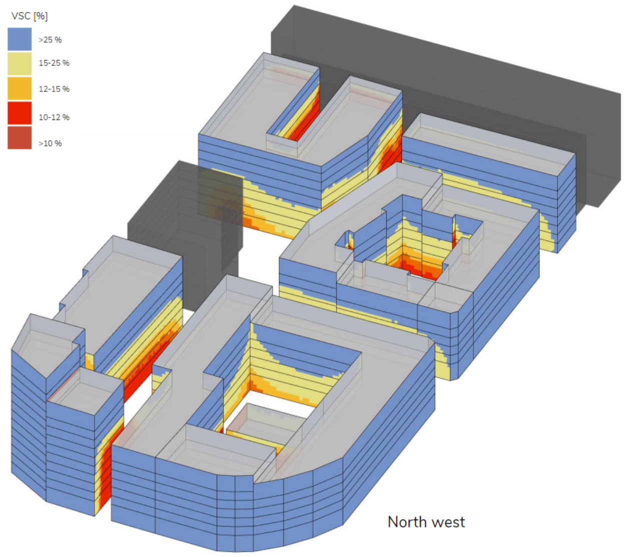

Figure D.5: VSC north west facade [%]

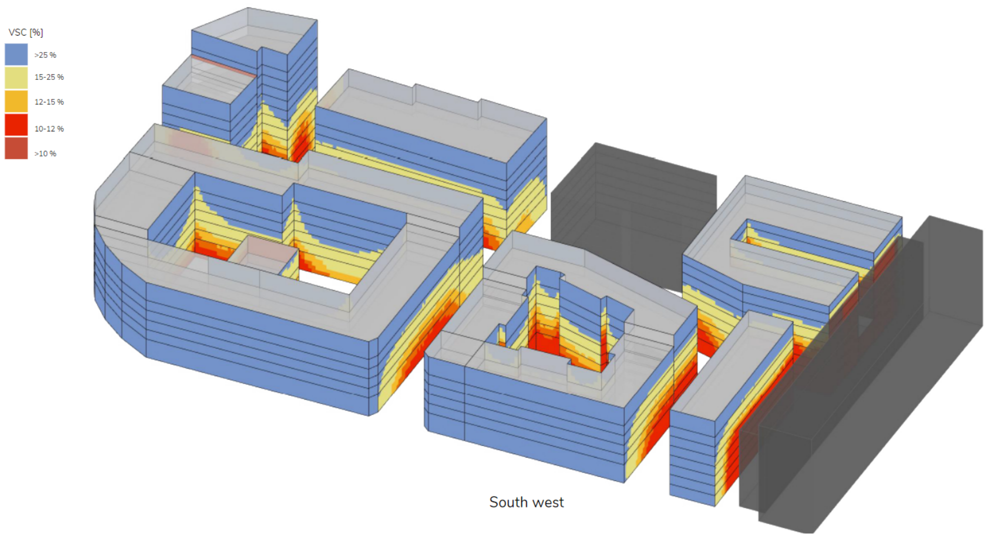

Figure D.6: VSC south west facade [%]

D.3 Comparison I

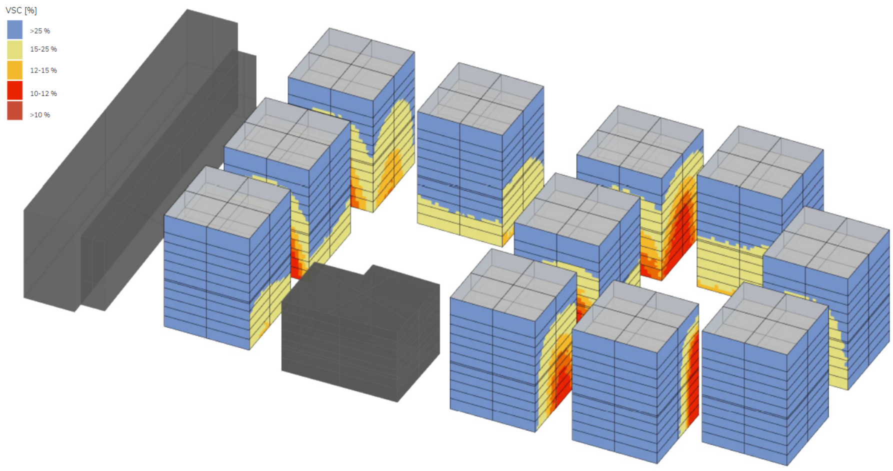

Figure D.7: VSC Punkthus0 [%]

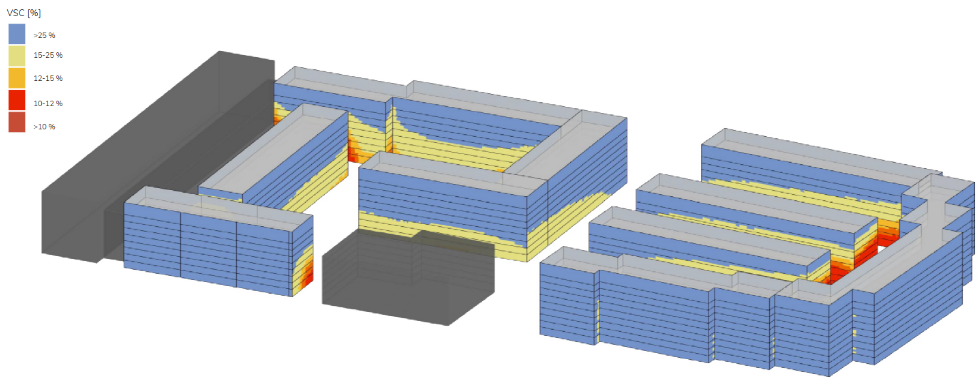

Figure D.8: VSC Lamellhus0 [%]

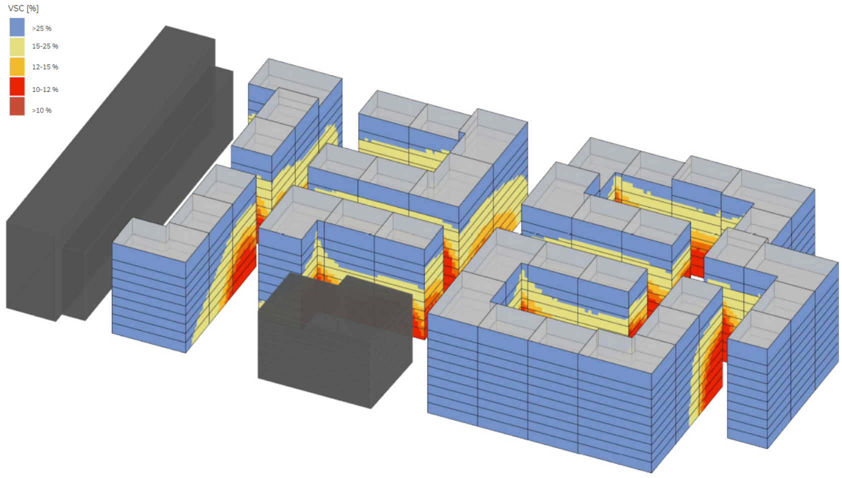

Figure D.9: VSC L-hus0 [%]

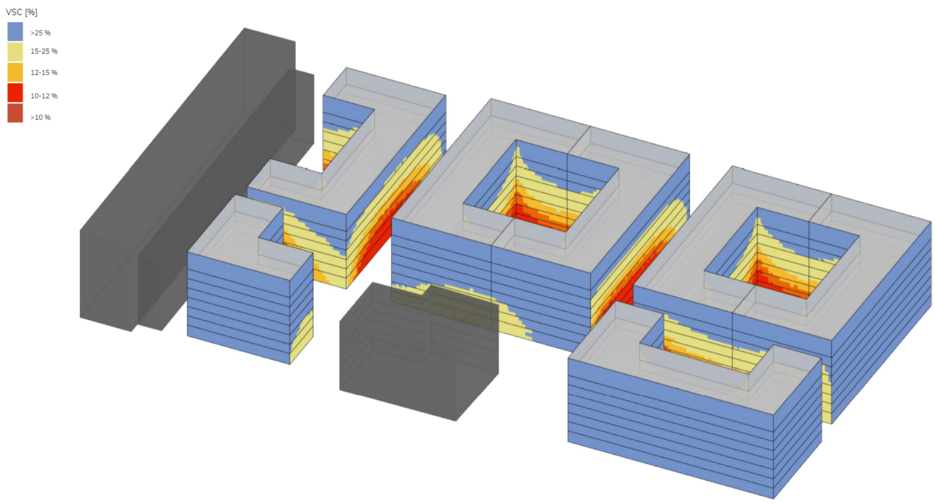

Figure D.10: VSC Kvarterhus0 [%]

E

Multi-parameter comparison