# Solar planning tools

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# Solar planning tools

- Subtask C:
  - Solar planning tools important due to increasing need of supporting decisions in the early planning phases.
  - focus on assessing
    - active solar potential,
    - passive solar potential (daylighting, solar access)

- Include tools from all platforms (GIS, CAD, or BIM)

# Activities / Deliverables STC

- DC1: Identification of existing tools and workflows for solar neighborhood planning
  - Rapporten finns på task63.iea-shc.org/publications


- DC2: Opportunities for improved workflows and development needs of solar planning tools

# Highlights of report DC1

I. National Common Indicators

II. Workflow Stories

III. Benchmark Study

# I) NATIONAL COMMON INDICATORS

## Legislative Common Indicators

The Tables 3-5 show the legislated NCIs for Direct Solar Access, daylight, and Active Solar Energy.

**Table 3. National Common Indicators for Direct Solar Access (legislated)**

| Country | Metric | Threshold | Date | Time | Place | Type of building |
|---|---|---|---|---|---|---|
| Australia (ACT: Molonglo Valley) | Solar Envelope | | 21 June, 21 December | | | Residential |
| Australia (New South Wales) | Direct solar access hours | not specified | | | | Residential |
| Canada (Toronto) | Urban Heat Island / Solar Reflectance Index (SRI) | ≥ 29 | | | at least 50 % of site's non-roof hardscape (Tier 1) | |
| China | Direct solar access hours | ≥ 2, 3 hours | 20-Jan | | | |
| China | Direct solar access hours | ≥ 1 hours | 21-Dec | | | |
| Czech republic | Direct solar access hours | > 1.5 % | 01-Mar | | | |
| Denmark | Window to Floor Ratio | > 10 % | | | | |
| Estonia | Direct solar access hours | ≥ 50 % probable sun hours | 22-Apr to 22-Aug | | | |
| France | Direct solar access hours | ≥ 2 hours | 21-Dec | | façade of every living space | |
| France | Window to Floor Ratio | >1/6 | | | | |
| France | Window to Wall Ratio | at least one room with >30% glazed surface | | | | |
| Germany | Direct solar access hours | ≥ 1 hour | 17-Jan | | at least one window | Residential |
| Germany | Direct solar access hours | ≥ 4 hours | 21-Mar, 21-Sep | | at least one window | Residential |
| Italy | Window to Floor Ratio | ≥ 1/ 8 | | | | |
| Netherlands | Window to Floor Ratio | ≥ 1/ 10 | | | | Residential |
| Norway | View outside | | | | Every room for continuous occupancy must have at least 1 window with sufficient view to the outside | |
| Norway | Obstruction angle | ≤ 45° | | | Blockage of the view to the outside | |
| Poland | Direct solar access hours | ≥ 3 hours | 21-Mar, 21-Sep | 7:00 - 17:00 | permanently occupied rooms | |
| Poland | Direct solar access hours | ≥ 1.5 hours | 21-Mar, 21-Sep | 7:00 - 17:00 | at least one room in apartment buildings | |
| Slovenia | Direct solar access hours | ≥ 2 hours | 21-Dec | | | |
| Slovenia | Direct solar access hours | ≥ 4 hours | 21-Mar, 21-Sep | | | |
| Slovenia | Direct solar access hours | ≥ 6 hours | 21-Jun | | | |
| Slovakia | Direct solar access hours | ≥ 1.5 hours | 1-Mar to 13 Oct | | windows of 1/3 of apartment living area, calculated on point centered on the glazing | Residential |
| UK | Direct solar access hours | 25 % Annual Probable Sunlight Hours | whole year | | room window. | |
| European Union | Direct solar access hours | ≥ 1.5 hours (good), ≥ 3hrs (very good), ≥ 4 hours (optimal) | between 1-Feb and 21-Mar | | At least one habitable room in the dwelling should have exposure to sunlight | |

**Table 5: National Common Indicators for Active Solar Energy (legislated)**

| Country | Metric | Threshold |
|---|---|---|
| Norway | Aesthetical design of surroundings | |
| Norway | Good architectural design | |
| Norway | Good visual qualities, both for itself and with respect to its function and its surrounding environment and placement in accordance with the municipality's standards | PV or solar thermal collectors contrasting strongly with the roof/building materials |
| Switzerland (Vaud) | Domestic Hot Water solar coverage | ≥ 30% |
| Switzerland (Vaud) | Electricity solar coverage | ≥ 20% |
| Switzerland (Geneva) | Domestic Hot Water solar coverage | up to 50% |
| Switzerland (Geneva) | Electricity solar coverage | up to 30 W/m2 area built |

# II) WORKFLOW STORIES

# G2 Solaire (INTERREG)

### University of Applied Sciences and Arts Western Switzerland (HES-SO)

## About the project

Through the development of a solar cadastre on the scale of Greater Geneva (about 2'000 km2), the objective of the G2-Solaire project is to provide the means to intensify the use of solar energy, to generate economic activities around the solar sector and ultimately contribute to achieving the energy transition objectives in a context of urban densification.
The project is structured around two main components: A first technical component, associating French and Swiss research laboratories, aims to develop a map of solar potential at the cutting edge of innovation; the second institutional and political component aims to make the cadastre known and to facilitate its appropriation by all the actors concerned (elected officials, public administrations, energy suppliers, investors, professionals in the sector, civil society, individuals).
More information on G2 Solaire

Besides, it is worth mentioning that the modelling tools used in G2 Solaire was also used in other applications, in particular in the project of Solar planning of the municipality of Carouge (State of Geneva). Carouge is famous for its historical part involving thus high heritage issues. Therefore, the scope of the project was to map and classify the districts Carouge according to high (new developments), middle (existing districts) and low opportunities (historical part) for solar installation with the support of the solar cadaster. Solar potential was also simulated on facades of new building developments. This pilot project (2016 – 2018) was supported by the Swiss Federal Office of Culture (related to heritage issues). More information on this website.

## Key Performance Indicators in the project

Solar potential on roof is considered under the two conditions:

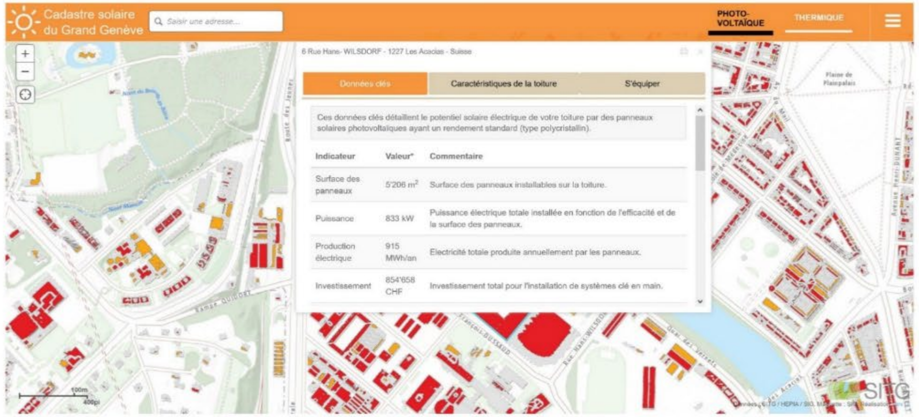
-Useful areas defined by minimum yearly solar radiation of 1000 kWh/m2/year;
-Minimum area of 5 m2.

Besides, the solar cadastre of the Greater Geneva does not rely on particular KPI in the sense of goals and thresholds associated to indicators. It displays a set of energetic, economic and environmental indicators (as illustrated below / Output) allowing then the user to conclude on the opportunity to install solar panel on his/her roof.

## Tools in the project

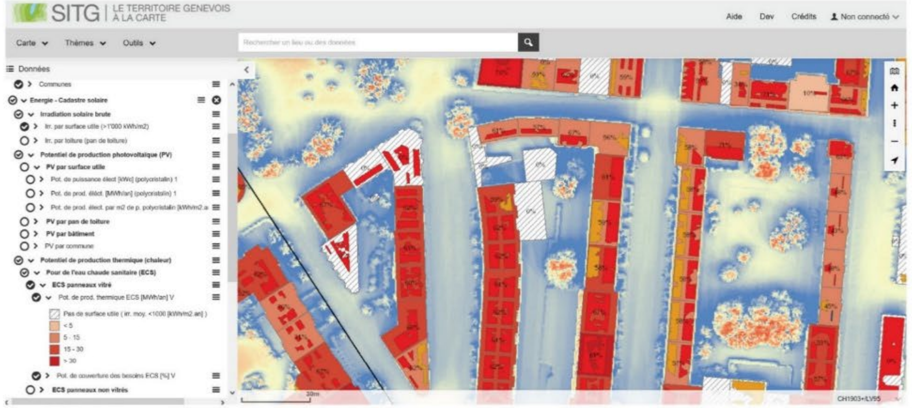
### *Output*

The main output of G2 Solaire is the Web interface of the solar cadastre of the Greater Geneva that displays the main solar maps and indicators to users for both application: PV and thermal.




*Web interface of the solar cadastre of the Greater Geneva (PV use in the example) https://sitg-lab.ch/solaire/*

This interface supports a given owner in identifying if the roof is suitable for solar installation and give useful indicators for pre-design of the installation. At the level of ND, municipality or wider, aggregated data (using GIS) support in devising solar planning strategies.
A second version of the interface is currently under development. It will propose a more dynamic use allowing the user to modify the installation area (through a cursor) and to identify the optimum size (according to minimum return period of the investment).
For professional use, the Geoportail of the State of Geneva displays more specific indicators together with other energy layers.




*Geoportail displaying energy layers, among them solar (thermal use in the example) (link)*

Denmark

# Fælledby

**Henning Larsen**

## About the project

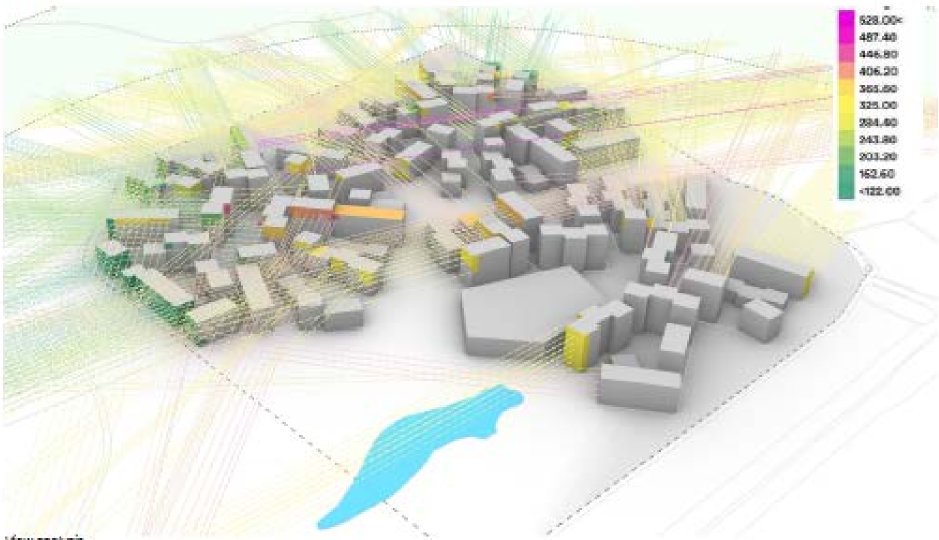
Just beyond the Copenhagen city center, Fælledby transforms the former junkyard site into a model for sustainable living, balancing human priorities with a strong commitment to the natural surroundings. Fælledby explores a living model with nature at its core, simultaneously crafting a new neighborhood to accommodate the demands of the growing city and increasing local biodiversity. The neighborhood merges traditional Danish urban and rural typologies to create a hybrid that balances the city and its natural surroundings. Fælledby will develop in phases, growing outward from three distinct "cores" that together frame the neighborhood at large. This diffuse approach will maximize access to nature for residents and will allow the landscape to be organically integrated in the site.

## Key Performance Indicators in the project

The goal in this project was to optimize the Key Performances solar access, view and daylight access to optimize the form and density in the neighbourhood.

## Tools in the project

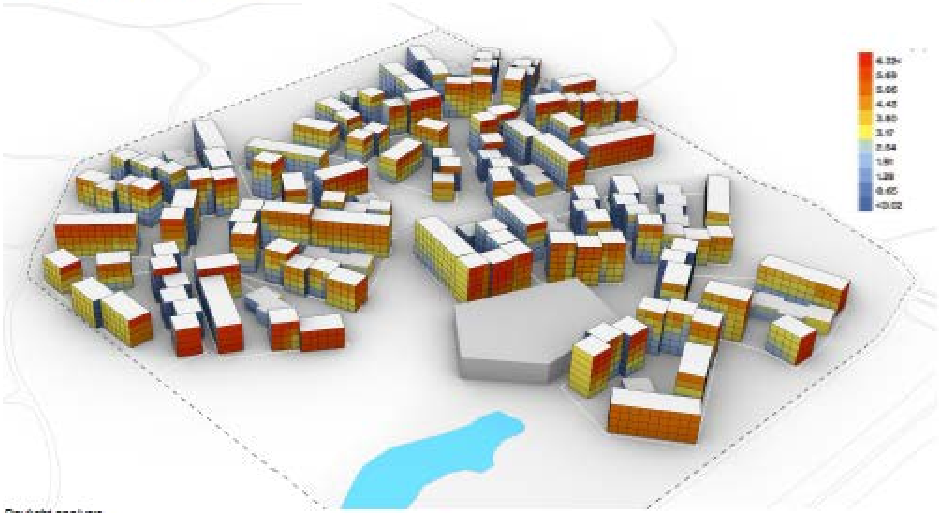
### Output



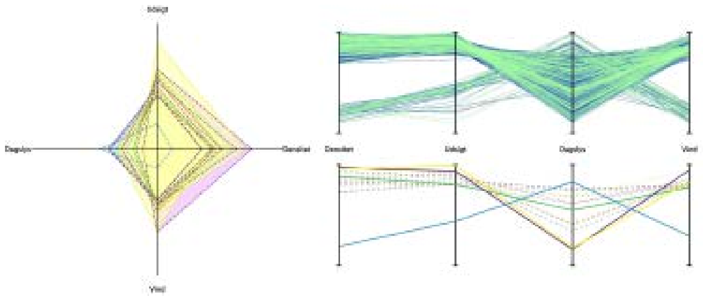

*View analysis*

The daylight access was in this project studied as the amount of solar hours on facades at equinox (~March 20 & September 23). In other projects, the architects have used the Vertical Daylight Factor.

The view analyis in this project was conceived as the distance to nature (m).



*Daylight analysis*



*Multi-criteria analysis regarding view, daylight, wind and density*

### Used tools

All analyses were performed with Rhino/Grasshopper, to enable a close connection with the architects' workflow. Within Grasshopper, both third-party tools and in-house tools were used, while the Grasshopper plugin "Octopus" was used for the evolutionary multi-objective optimization. The view, wind and sunlight studies are C# scripts developed in house, which increases the simulation speed with approximaely 10x compared to most third party python plugins.

*Authors of this workflow story: Jouri Kanters*

Norway

# Gullhaug Torg 5

**Erichsen & Horgen AS**

## About the project

The project is an office building located in Nydalen (Oslo). The completion of the building is planned spring 2022. The building is structured around an inner atrium. The interior plan for the office spaces are laid out as a flexible and scalable system, oriented towards the outer glass facade. The building has been planned with integrated PV (BIPV) system and a glass facade that has strategically integrated sun shading (ConverLight) as a part og the window glass. The solar shading helps enhance the architecture concept of a visually transparent building. Worth mentioning is also the environmental strategies to reduce the need of glass material in the building by using a heat mirror foil on the centre glass pane. Sufficient insulation value is achieved without using extra panes of glass.

Erichsen & Horgen was contracted to work on the development of the façade design and to work on energy, daylight, solar shading, and the evaluation of potential PV production on the building surfaces.

*Project rendering (Avanton/Arcasa Architects)*

*Situation perspective (Erichsen & Horgen )*

## Key Performance Indicators in the project

The building is planned to achieve energy standard BREEAM NOR Excellent and has received governmental support from Enova for the work on the innovative facade design.

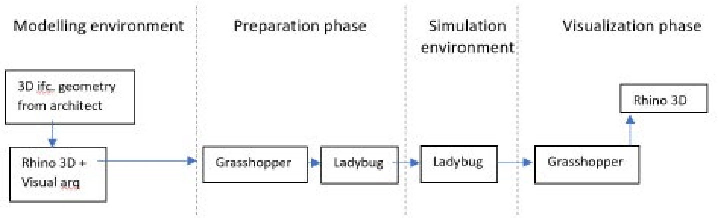
The following calculations and tools were used:
1. Evaluate the need of sunshading/glass quality (Grasshopper for Rhino), 2. PV production (Grasshopper for Rhino), 3. Early phase daylight – Sky View component (Grasshopper for Rhino), 4. Detailed daylight calculations (IDA Ice).

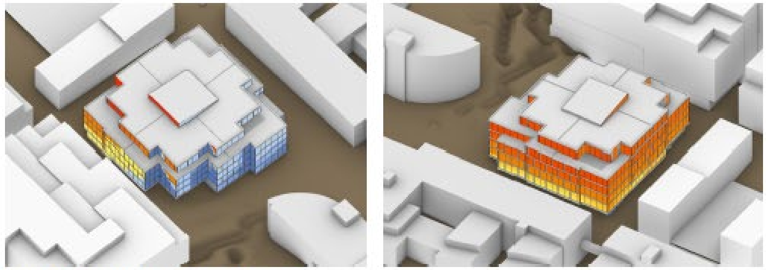
Parameters for evaluating the calculations:
1. Solar shading should be evaluated when peak solar radiation is higher than 900W/m².
2. Solar potential considered useful on areas defined by minimum average yearly solar radiation of 120kWh/m².
3. Sky view component of 15% is considered lower value for when areas can be reasonably utilized as working spaces.
4. Average daylight factor of minimum 2.0%

## Tools in the project

### Output

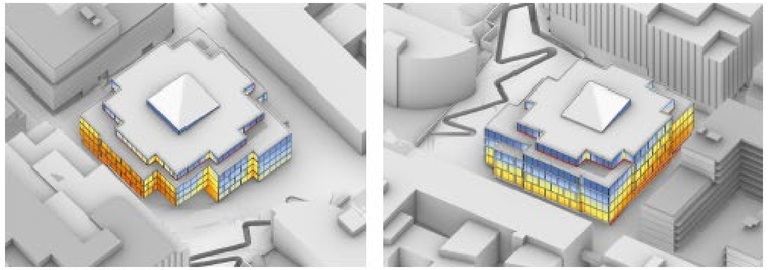
The studies shown is early phase analysis that effectively contribute as visual representations in the decision making process.



*Analysis 1: Evaluation of the need for sunshading/glass quality*

*Analysis 2: PV production potential*



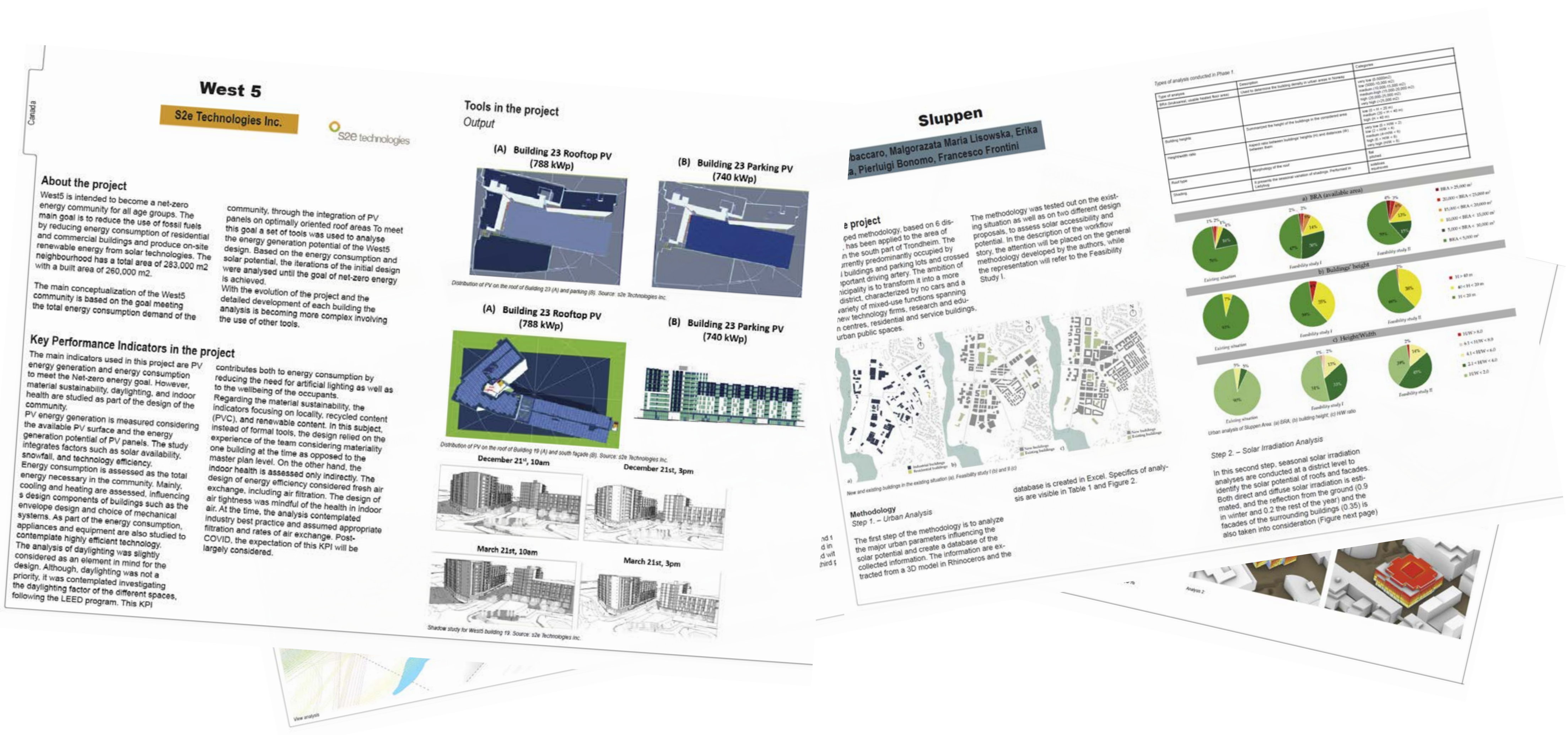
*Analysis 3: Sky View Component*

| Performance indicators | Weather data | Tool / engine used | Interface | Sky |
|---|---|---|---|---|
| Peak solar radiation | Fornebu STAT. data + Blindern EPW data | Ladybug | Ladybug | Clear sky |
| Radiation analysis | Blindern EPW data | Ladybug | Ladybug | Cumulative sky |
| Vertical Sky Component | n/a | Ladybug | Ladybug | n/a |

### Challenges / Lessons learnt

Grasshopper for Rhino is a powerful tool for generating visual images that can be used in a decision-making process. The process of building optimal calculation models based on ifc files from the architect are often time consuming.
The calculation results must be considered rough and are less useful for detailed calculations. Software with more detailed parameters such as mounting angles, product specific performance and wiring/grouping may be more reasonable in more detailed planning.

*Authors of this workflow story: Joar Tjetland*



Canada

## West 5

S2e Technologies Inc.

s2e technologies

### About the project

West5 is intended to become a net-zero energy community for all age groups. The main goal is to reduce the use of fossil fuels by reducing energy consumption of residential and commercial buildings and produce on-site renewable energy from solar technologies. The neighbourhood has a total area of 283,000 m2 with a built area of 260,000 m2.

The main conceptualization of the West5 community is based on the goal meeting the total energy consumption demand of the community, through the integration of PV panels on optimally oriented roof areas To meet this goal a set of tools was used to analyse the energy generation potential of the West5 design. Based on the energy consumption and solar potential, the iterations of the initial design were analysed until the goal of net-zero energy is achieved.

With the evolution of the project and the detailed development of each building the analysis is becoming more complex involving the use of other tools.

### Key Performance Indicators in the project

The main indicators used in this project are PV energy generation and energy consumption to meet the Net-zero energy goal. However, material sustainability, daylighting, and indoor health are studied as part of the design of the community.

PV energy generation is measured considering the available PV surface and the energy generation potential of PV panels. The study integrates factors such as solar availability, snowfall, and technology efficiency.

Energy consumption is assessed as the total energy necessary in the community. Mainly, cooling and heating are assessed, influencing s design components of buildings such as the envelope design and choice of mechanical systems. As part of the energy consumption, appliances and equipment are also studied to contemplate highly efficient technology.

The analysis of daylighting was slightly considered as an element in mind for the design. Although, daylighting was not a priority, it was contemplated investigating the daylighting factor of the different spaces, following the LEED program. This KPI contributes both to energy consumption by reducing the need for artificial lighting as well as to the wellbeing of the occupants.

Regarding the material sustainability, the indicators focusing on locality, recycled content (PVC), and renewable content. In this subject, instead of formal tools, the design relied on the experience of the team considering materiality one building at the time as opposed to the master plan level. On the other hand, the indoor health is assessed only indirectly. The design of energy efficiency considered fresh air exchange, including air filtration. The design of air tightness was mindful of the health in indoor air. At the time, the analysis contemplated industry best practice and assumed appropriate filtration and rates of air exchange. Post-COVID, the expectation of this KPI will be largely considered.

### Tools in the project

*Output*

(A) Building 23 Rooftop PV (788 kWp)

(B) Building 23 Parking PV (740 kWp)

Distribution of PV on the roof of Building 23 (A) and parking (B). Source: s2e Technologies Inc.

(A) Building 23 Rooftop PV (788 kWp)

(B) Building 23 Parking PV (740 kWp)

Distribution of PV on the roof of Building 19 (A) and south façade (B). Source: s2e Technologies Inc.

December 21st, 10am

December 21st, 3pm

March 21st, 10am

March 21st, 3pm

Shadow study for West5 building 19. Source: s2e Technologies Inc.

View analysis

## Sluppen

...baccaro, Malgorazata Maria Lisowska, Erika ...a, Pierluigi Bonomo, Francesco Frontini

### ...e project

...ped methodology, based on 6 dis... has been applied to the area of ...in the south part of Trondheim. The ...urrently predominantly occupied by ...l buildings and parking lots and crossed ...portant driving artery. The ambition of ...nicipality is to transform it into a more ...district, characterized by no cars and a ...variety of mixed-use functions spanning ...new technology firms, research and edu...n centres, residential and service buildings, urban public spaces.

The methodology was tested out on the existing situation as well as on two different design proposals, to assess solar accessibility and potential. In the description of the workflow story, the attention will be placed on the general methodology developed by the authors, while the representation will refer to the Feasibility Study I.

New and existing buildings in the existing situation (a), Feasibility study I (b) and II (c)

### Methodology

*Step 1. – Urban Analysis*

The first step of the methodology is to analyze the major urban parameters influencing the solar potential and create a database of the collected information. The information are extracted from a 3D model in Rhinoceros and the database is created in Excel. Specifics of analysis are visible in Table 1 and Figure 2.

Types of analysis conducted in Phase 1

a) BRA (available area)

b) Buildings' height

c) Height/Width

Urban analysis of Sluppen Area: (a) BRA, (b) building height, (c) HW ratio

*Step 2. – Solar Irradiation Analysis*

In this second step, seasonal solar irradiation analyses are conducted at a district level to identify the solar potential of roofs and facades. Both direct and diffuse solar irradiation is estimated, and the reflection from the ground (0.9 in winter and 0.2 the rest of the year) and the facades of the surrounding buildings (0.35) is also taken into consideration (Figure next page)

Analysis 2

# III) BENCHMARK STUDY

# Benchmark: Tools

- CitySim (Energy in cities)
- Diva (Daylighting)
- EnviMet (Urban microclimate)
- Indalux (Daylighting)
- LadyBug-LB (Daylighting)
- Honeybee-HB (Daylighting)
- De Luminae (Daylighting)
- Solar Cadastre of Geneva (Solar Map)
- htrdr (MESO-star) (Physic model)
- SpaceMaker (BIM)

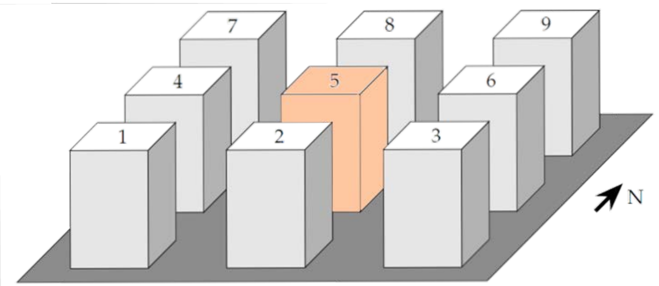



**Figure 1.** Sketch of the Homogeneous Neighborhood

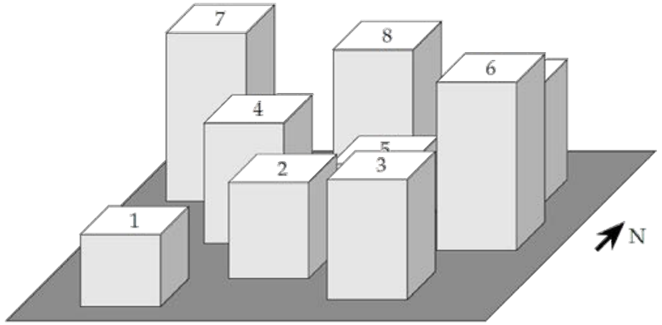
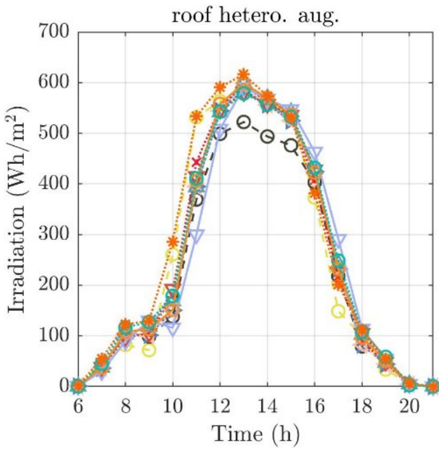



**Figure 2.** Sketch of the Heterogeneous Neighborhood

Location: Geneva
Weather: 2 representative days (august and february)

ENVI_MET
DIVA
htrdr
De Luminæ
Honeybee
SPACEMAKER



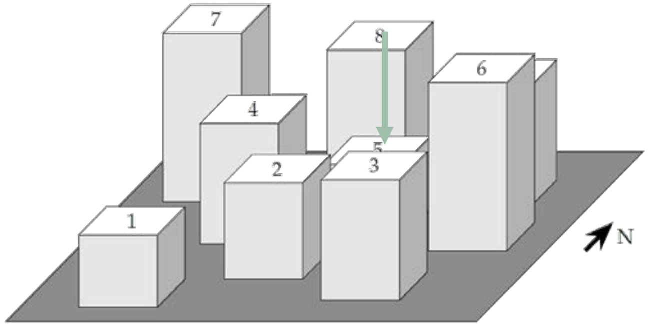
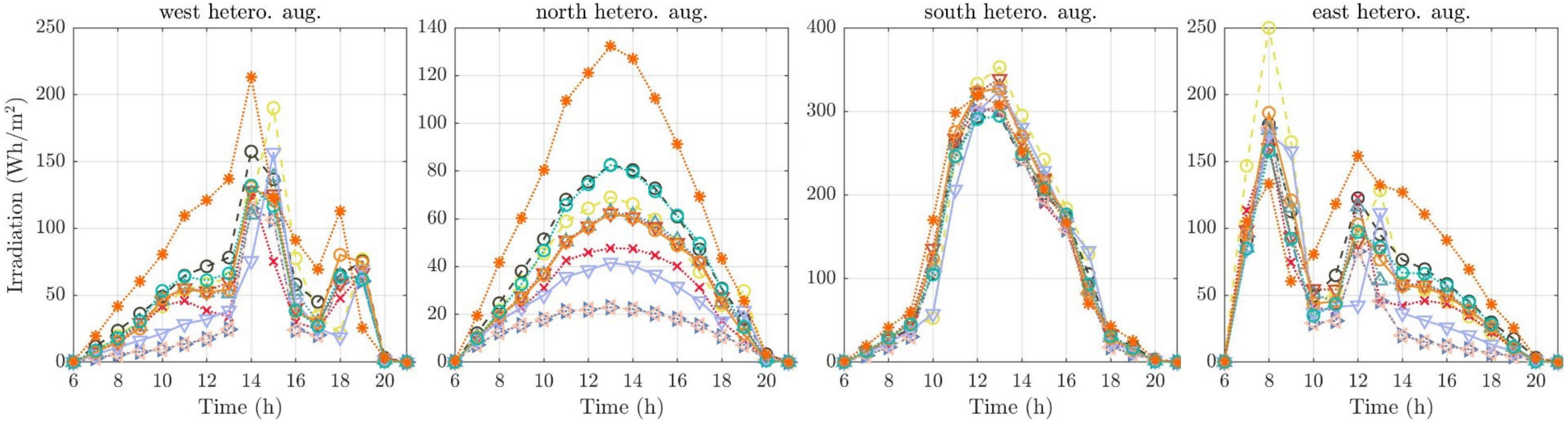




Figure 2. Sketch of the Heterogeneous Neighborhood




- As many different results as tools.
- Small variations when direct sunligth
- Variations by up to 150 Wh/m² in the present case (40% in relative error).
- No single tool constantly over- or under-estimates hourly spatially-aggregated results

# Highlights of DC2 (so far)

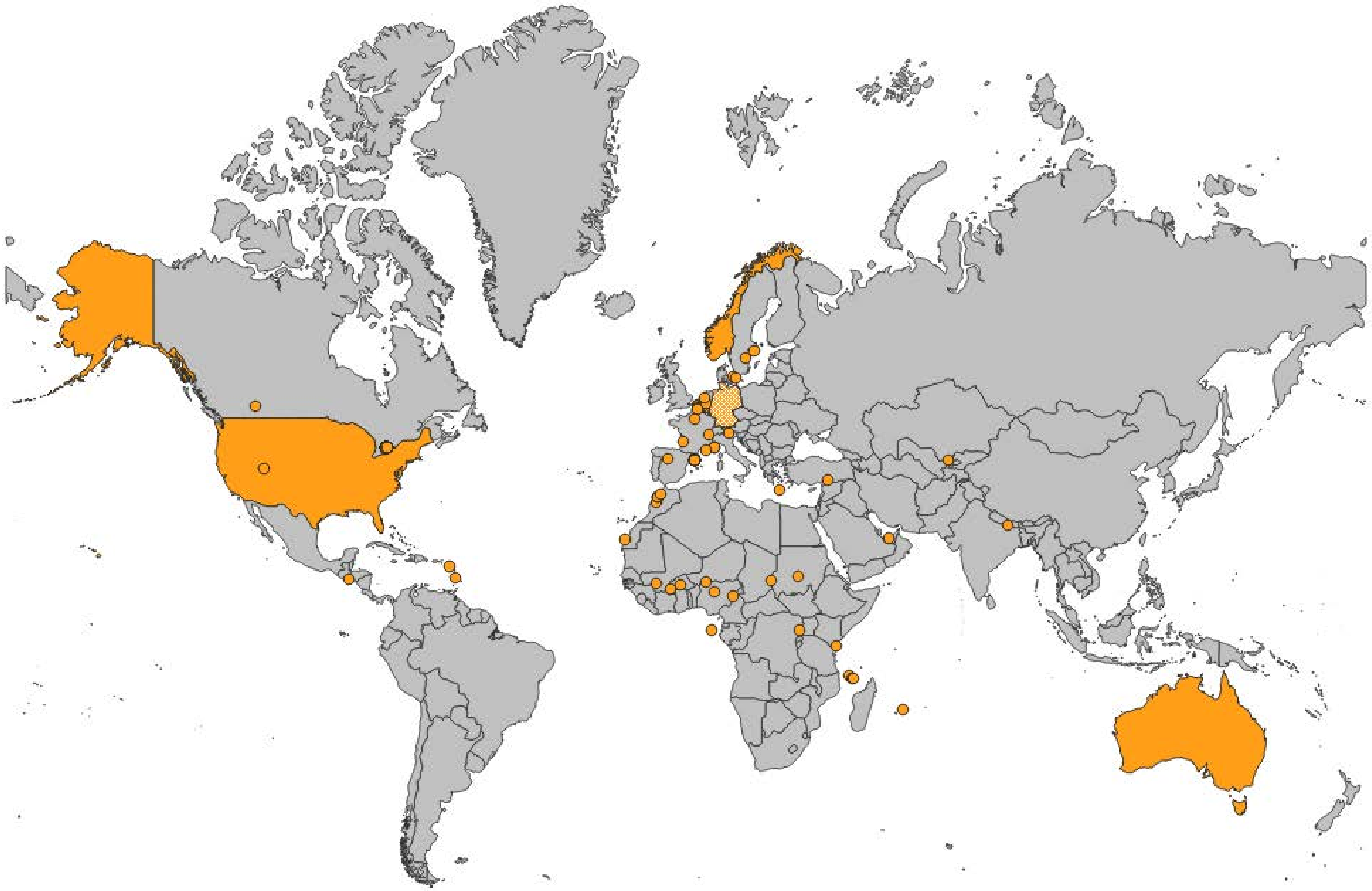
- Generalisation of use of tools
- Mapping the solar potential
- Added value of the use of tools

# GENERALISATION OF THE USE OF TOOLS

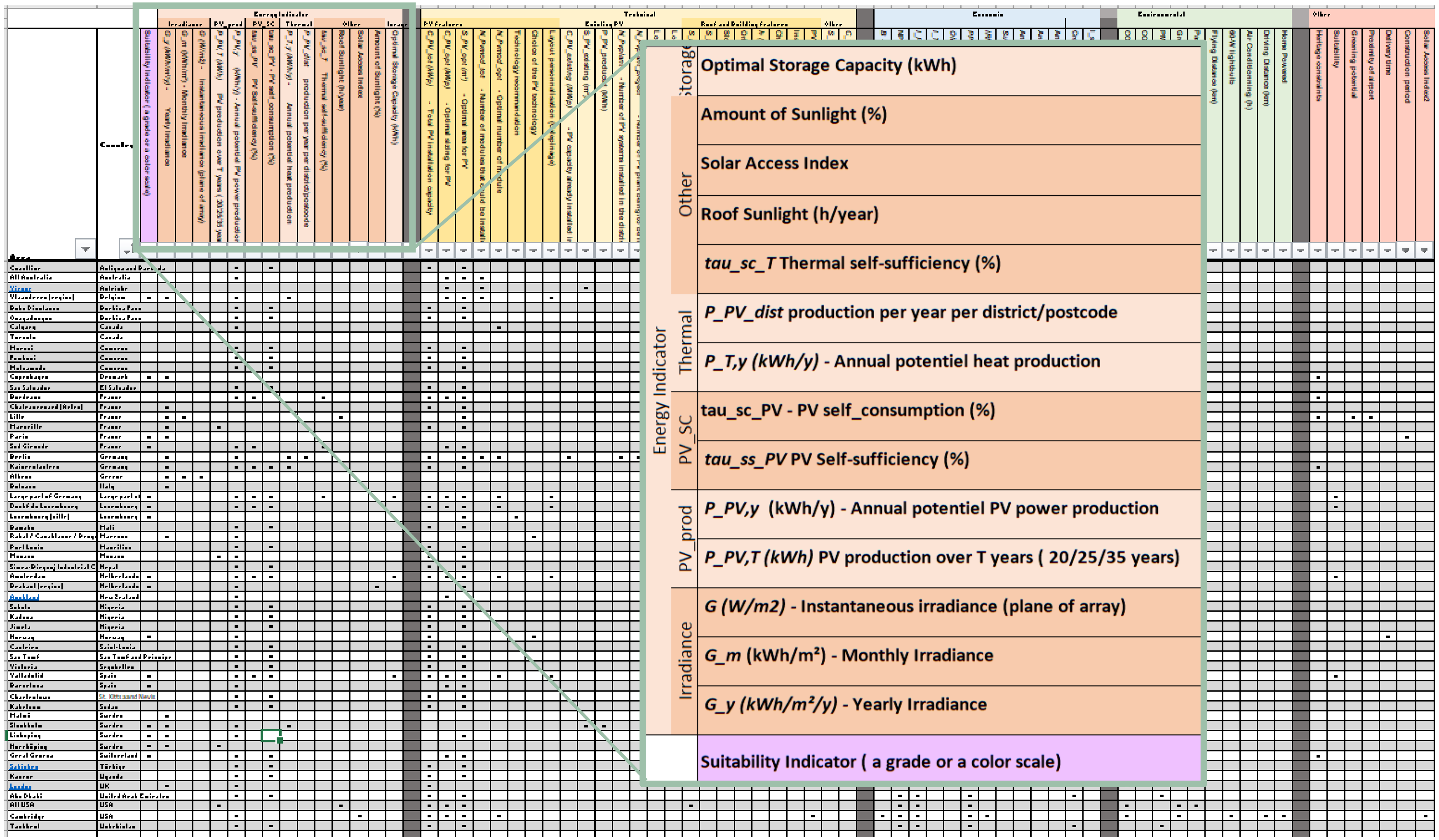
| | Urban Planning Process | | Building Design Process | | |
|---|---|---|---|---|---|
| | **Strategical planning** | **Urban Design** | **Concept Design** | **Schematic Design** | **Detailed Design** |
| *Available data* | -Geometrical data<br>-Local climate data<br>-Legislative restrictions<br>-Other relevant (energy-related) data | -Geometrical data<br>-Local climate data<br>-Legislative restrictions<br>-Other relevant (energy-related) data | -3D Volume studies<br>-Requirements of project | -Interior layout<br>-Exterior layout | -Detailed design (interior & exterior), with full 3D model |
| *KPIs* | -Geometrical KPIs (density, etc)<br>-Energy KPIs (zero carbon, plus energy). Active production requirement (CH)<br>-Liveability KPIs | -Geometrical KPIs (density, etc)<br>-Energy use KPIs (zero carbon, plus energy)<br>-Solar Energy production (DSH, skyview, daylight, peak solar radiation, VSC) | -National regulations regarding passive solar utilization, energy, thermal comfort<br>-Building certification assessment (WELL, Breeam etc)<br>-Legislative restrictions (height limitatations, ) | -National regulations regarding passive solar utilization, energy (avg U-value), thermal comfort<br>-Local energy production (RE)<br>-Building certification assessment (WELL, Breeam etc)<br>-Legislative restrictions (height limitatations, ) | -National regulations regarding passive solar utilization, energy (avg U-value), thermal comfort<br>-Local energy production (RE)<br>-Building certification assessment (WELL, Breeam etc)<br>-Legislative restrictions (height limitatations, ) |
| *Actors* | Local governments (politicians, urban planners), real estate developers, energy consultants, utilities, academy | Local governments (politicians, urban planners), real estate developers, architects, engineers | Urban planners, Architects, Engineers, Real estate developers (clients) | Urban planners, Architects, Simulation specialists, Engineers, Real estate developers (clients) | -Urban planners, Architects, Simulation specialists, Engineers (HVAC), Real estate developers (clients), Electricians |
| *Tools / analyses* | -Rules of thumb<br>-Analogue tools (sketches, models, presentations)<br>-Energy use simulation (low accuracy)<br><GIS, CAD (Sketchup), BPS tools (E+) > | -Possible solar energy production / irradiation<br>-Daylight símulations<br>-Energy modelling and load matching (production vs consumption)<br>-3D modelling<br>-Microclimate<br><Rhino / Grasshopper, ArcGIS, Spacemaker, Helioscope, PVSyst, LB/HB, E+-, hand calculations –python, excel, MatLab> | -Energy use analysis<br>-Solar energy production<br>-Passive solar utlisation<br>-3D modelling<br><Simien, Rhino/GH, IDA ICE, Sketchup, Own developed tools, Dragonfly> | -Energy use analysis<br>-Solar energy production<br>-Passive solar utlisation / daylight (climate-based KPIs)<br>-3D modelling<br><Simien, Rhino/GH, IDA ICE, PVSyst, Sketchup, Own developed tools, ENVIMet> | -Energy use analysis (load matching)<br>-Solar energy production<br>-Passive solar utlisation / daylight (climate-based KPIs)<br>-3D modelling<br><Simien, Rhino/GH, IDA ICE, PVSyst, Sketchup, Own developed tools, ENVIMet, ClimateStudio> |

# MAPPING THE SOLAR POTENTIAL

# Solar Cadastres in the world (non-exhaustive review)

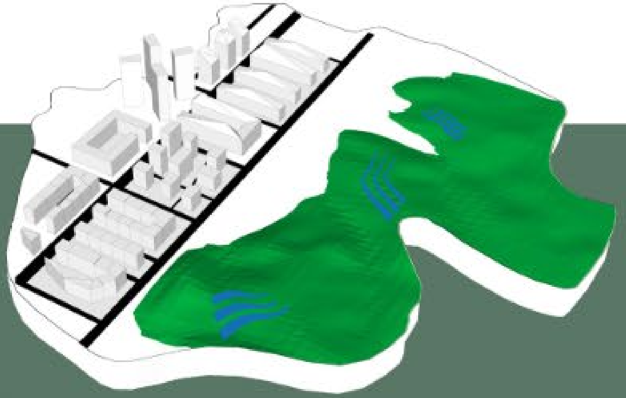


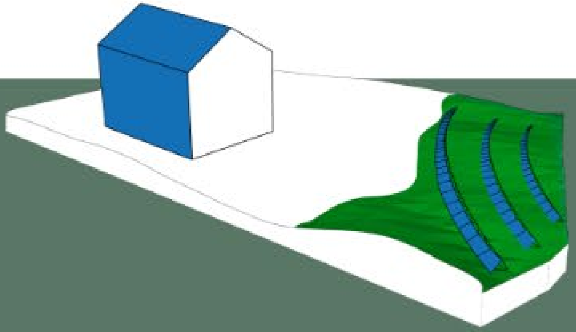
# Used indicators



# ADDED VALUE OF INCREASED USE OF TOOLS

# Enhanced Daylight Process – research ”injection”



***Structure plan***
*Skala: 1:1000 – 1:5000*

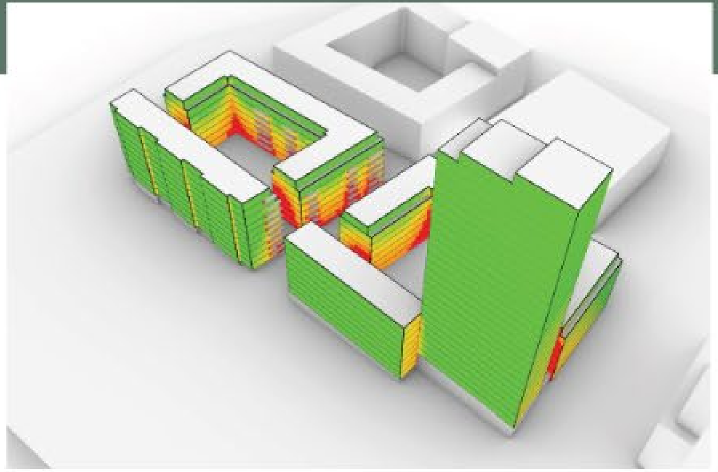
- Early Vertical Sky Component studies of daylight

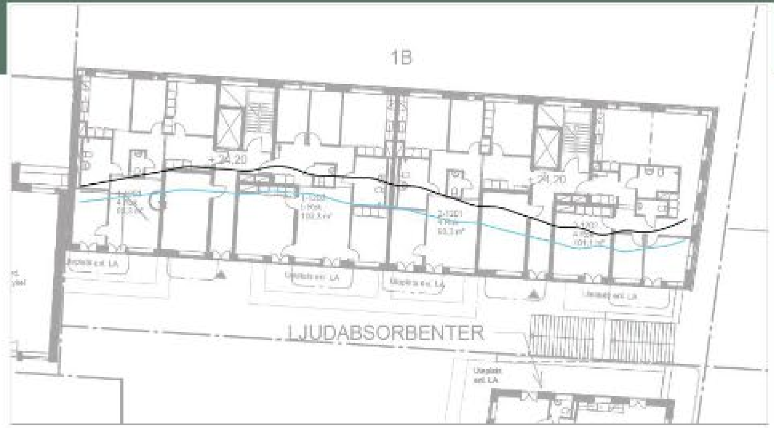
***Detailed plan***
*Skala: 1:500 – 1:2000*

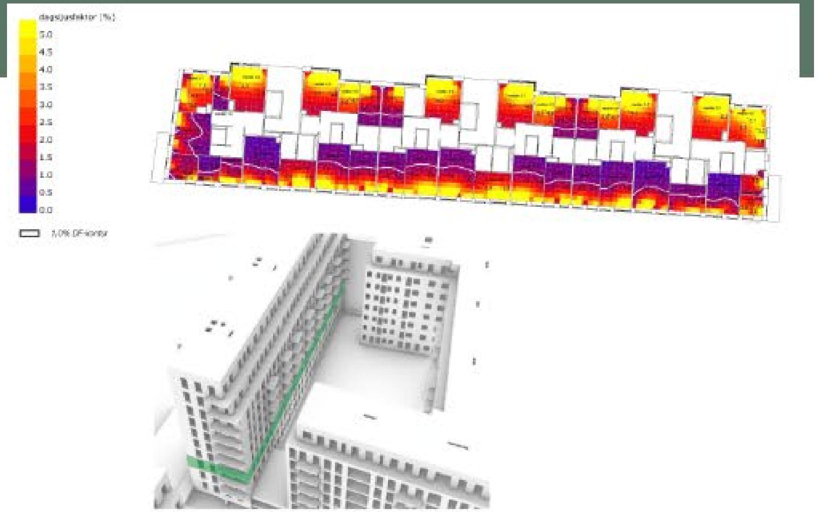
- Enhanced Vertical Sky Component study

***Building permit***
*Skala: 1:10 – 1:500*

- Daylight Factor Compliance



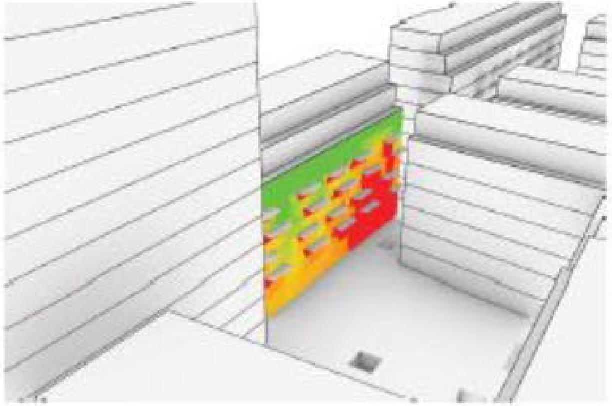


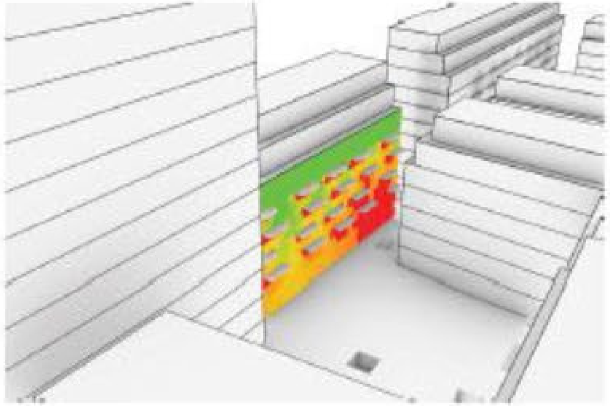
## Enhanced Daylight Process – research ”injection”

### Obstruction angle

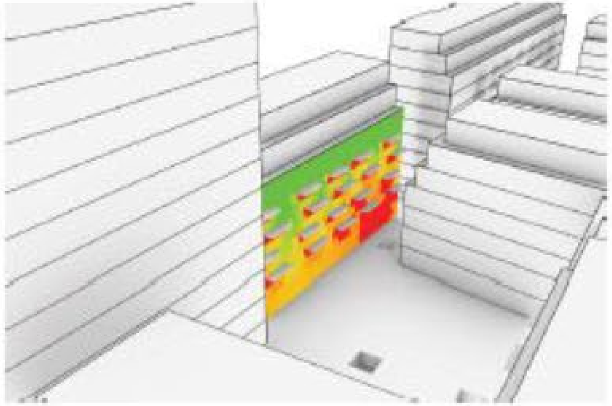
Fokusområde 2



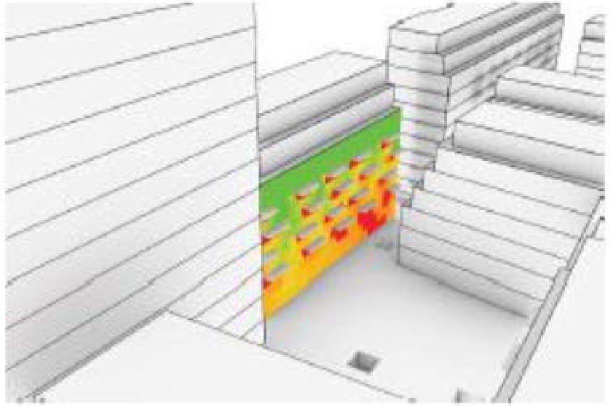
*Dagsljustillgång på fasad (VSC)*
*-0 kvm BTA*



*Dagsljustillgång på fasad (VSC)*
*-50 kvm BTA*



*Dagsljustillgång på fasad (VSC)*
*-105 kvm BTA*



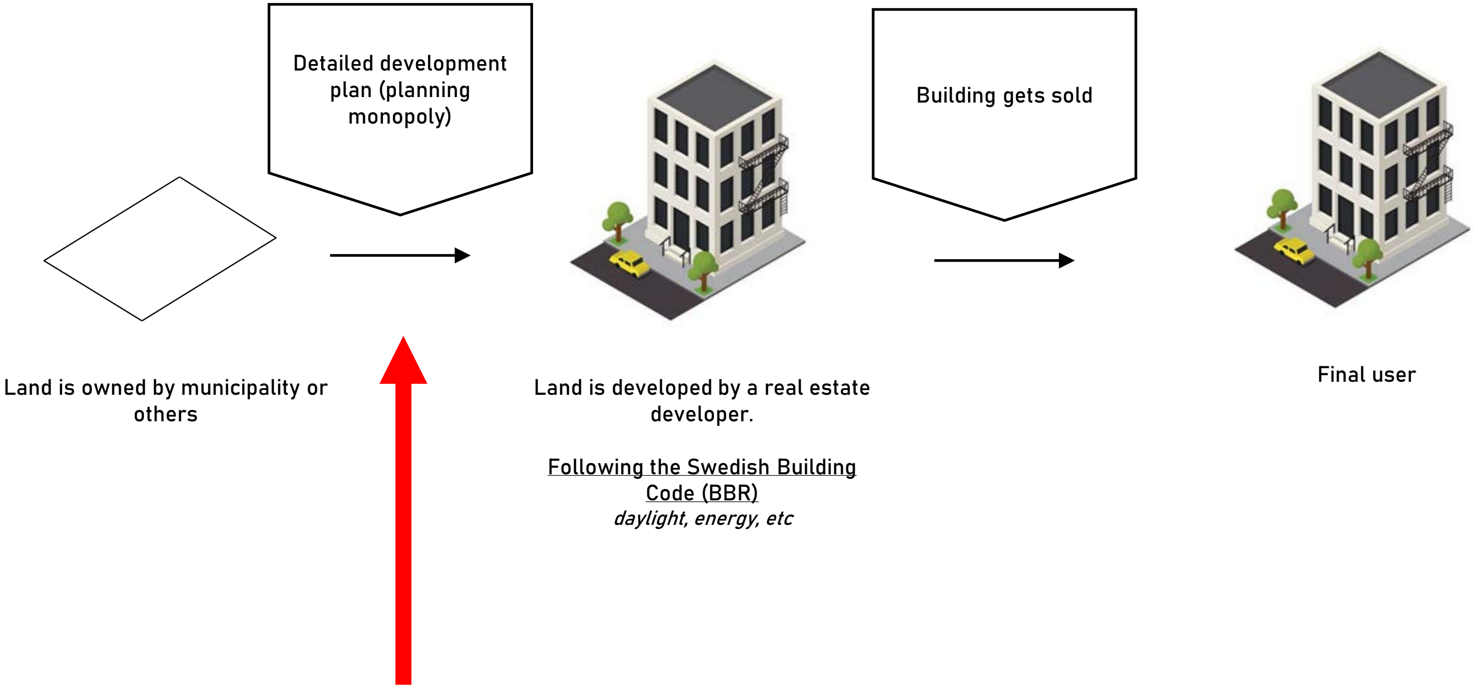
*Dagsljustillgång på fasad (VSC)*
*-180 kvm BTA*

# Questions?

# EXAMPLE SWEDISH CASE STUDY

## Malmö Hyllie & Lund Brunnshög

# Planning process (Sweden)



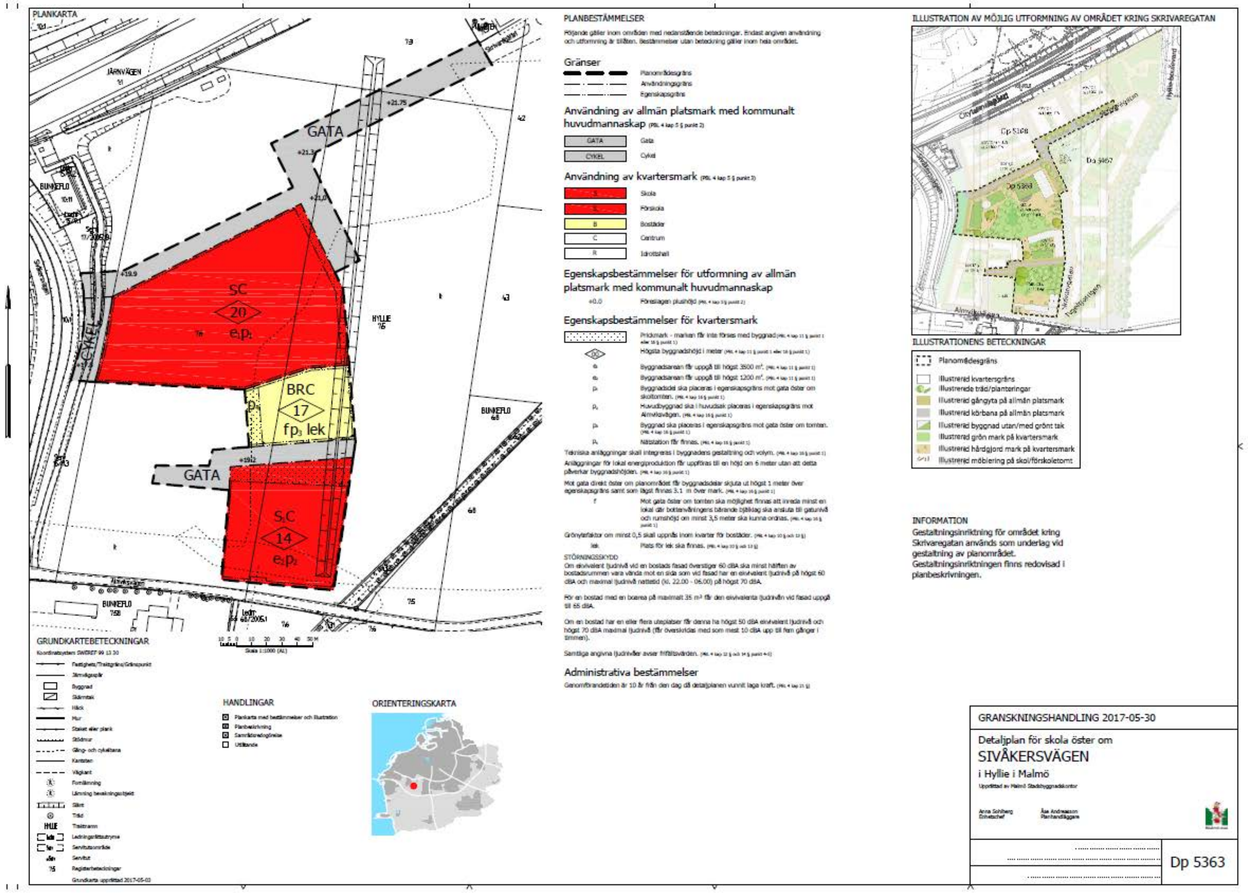

Lokalt projekt inom Task 63

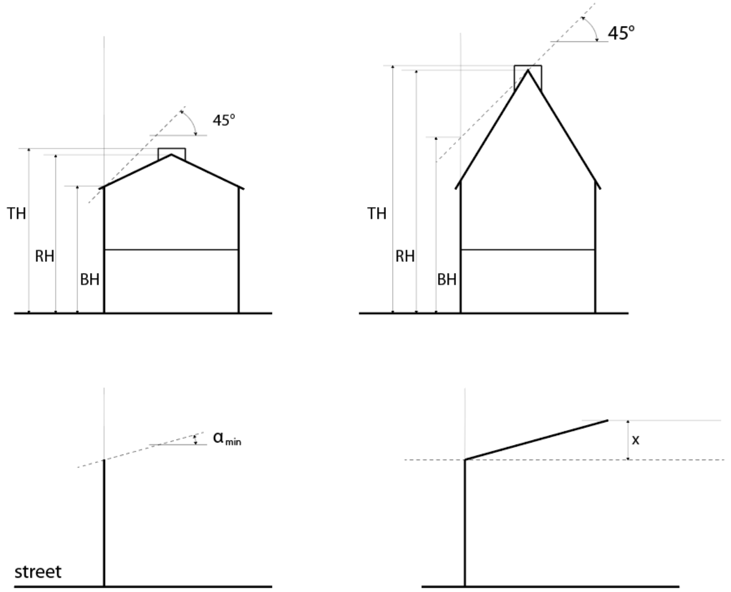
# Planning for solar energy in Sweden

- Survey amongst urban planners
  - Definition of solar access is missing
  - Only provision of daylight indoors is regulated (in Swedish building regulations)
  - Therefore, priority:
    - I: daylight indoors,
    - II: day- and sunlight outdoors,
    - III: active solar energy production.
  - No established routines for solar access for outdoor spaces or active solar energy production.

*Planning for solar access in Sweden: routines, metrics, and tools (2020). Kanters, J., Gentile, N.,Bernardo, R*

# Detailed development plan




TH: Total Building Height
RH: Ridge Height
BH: Building Height
x: Additional Height that occurs due to roof inclination
$\alpha_{min}$: Minimum roof inclination

# Brunnshög (Lund) & Hyllie (Malmö)

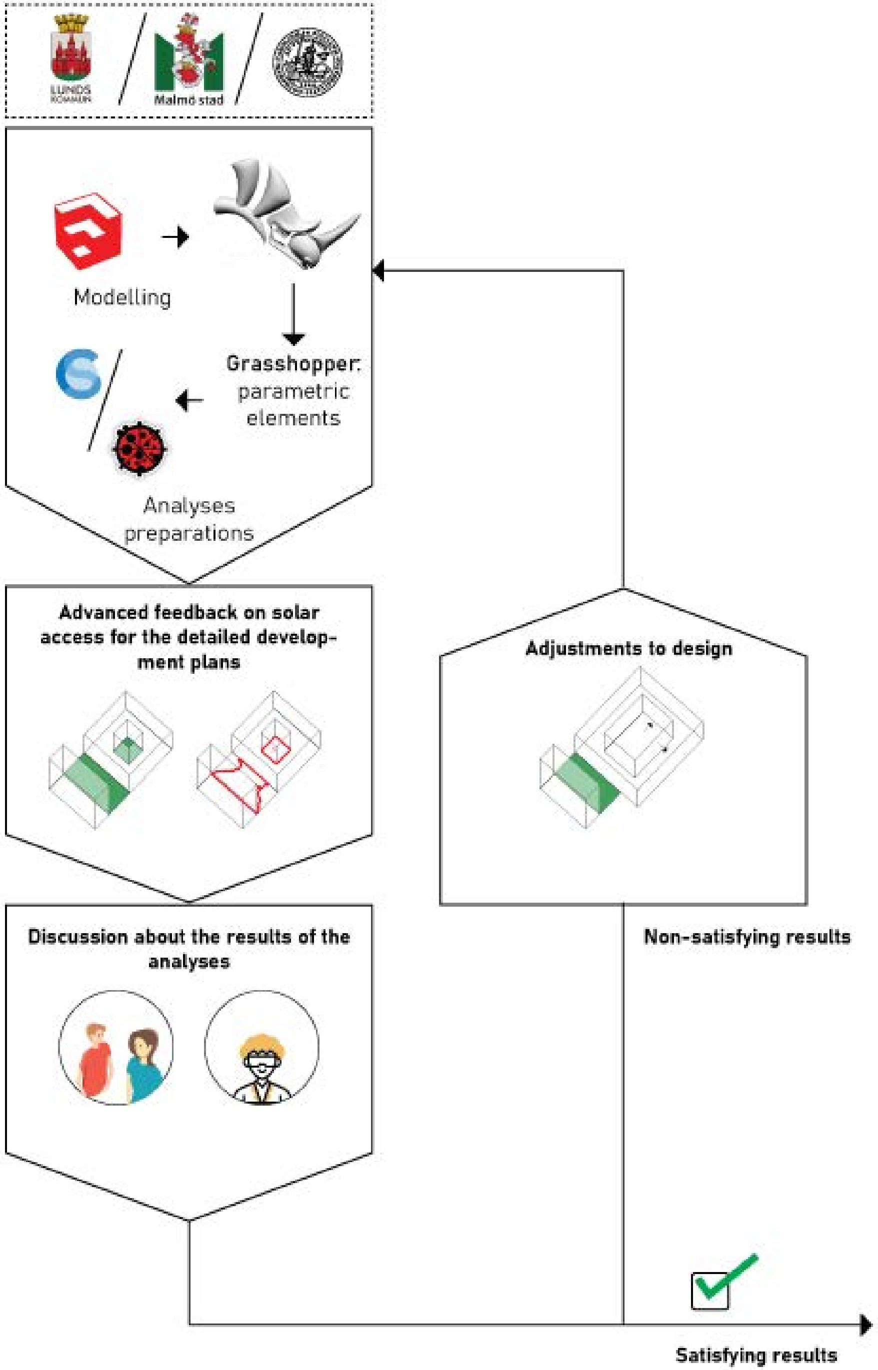
# Procedure

I. Ensuring buildings have enough daylight provided

II. Solar access on outdoor spaces

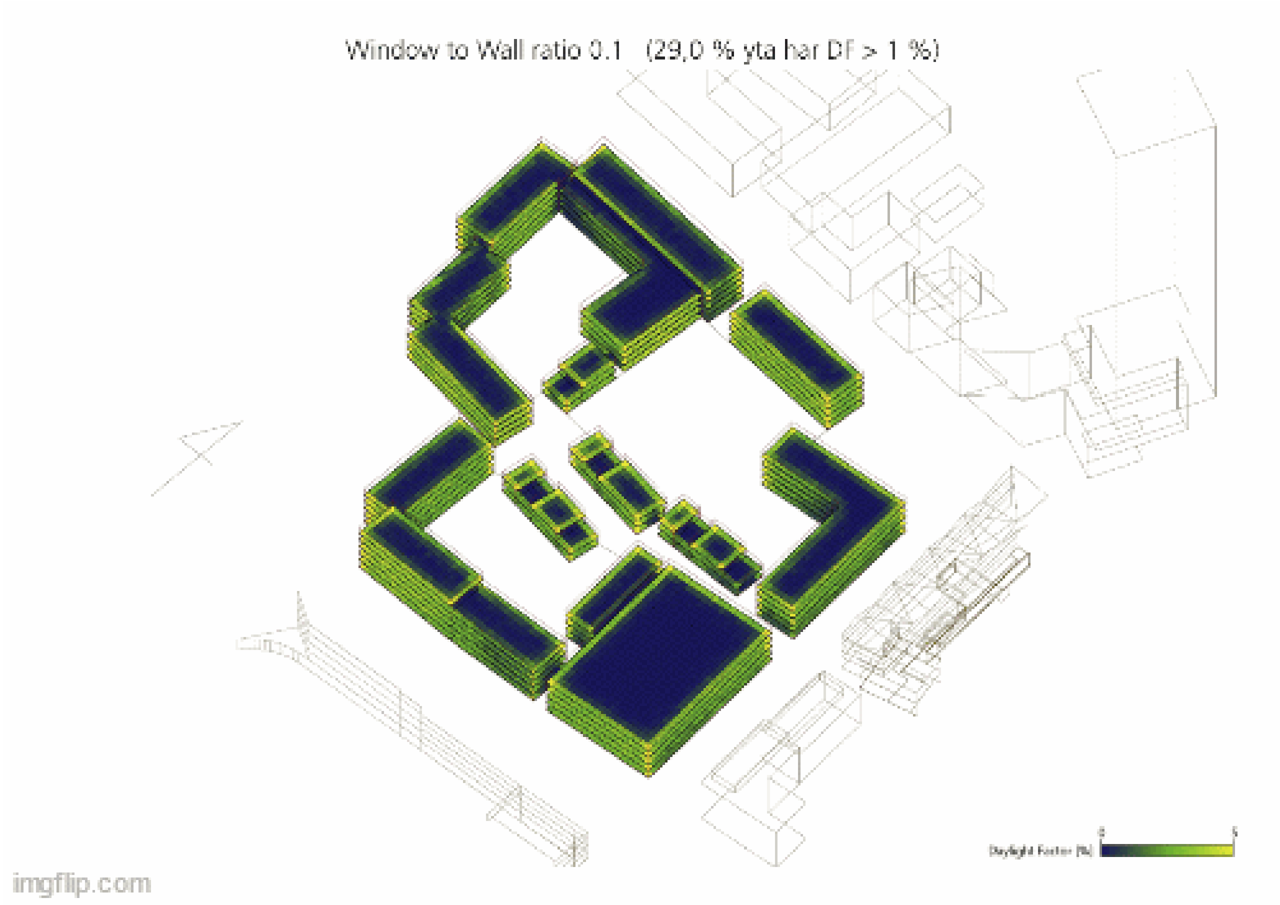
III. Active solar energy production

# Workflow



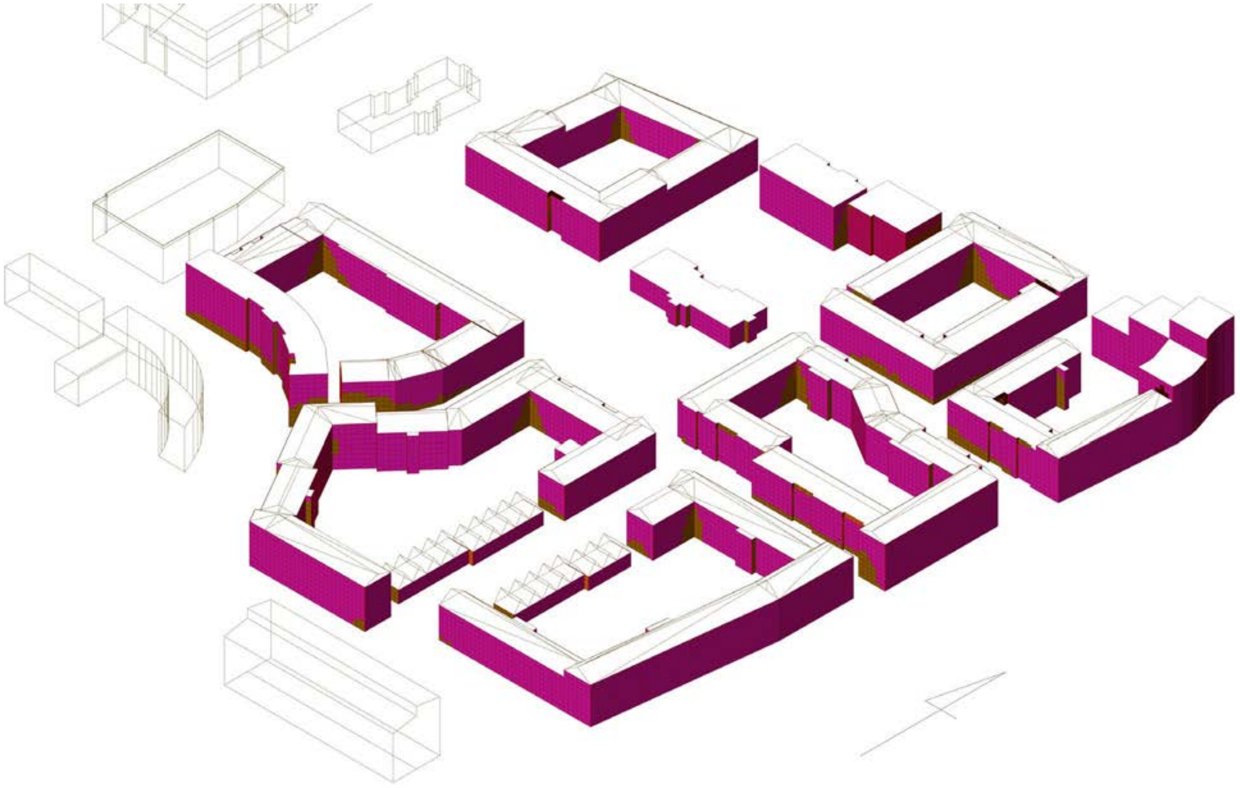
LUNDS KOMMUN
Malmö stad
Modelling
Grasshopper: parametric elements
Analyses preparations
Advanced feedback on solar access for the detailed development plans
Discussion about the results of the analyses
Adjustments to design
Non-satisfying results
Satisfying results

# Daylight provision




With different WWR

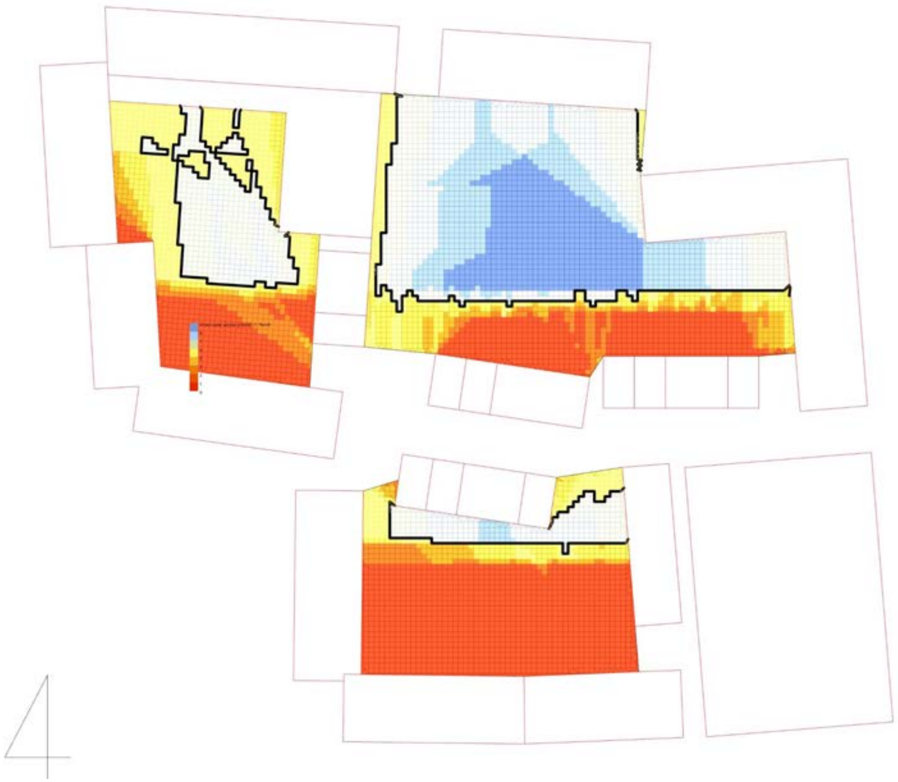
# Daylight provision



Vertical sky component

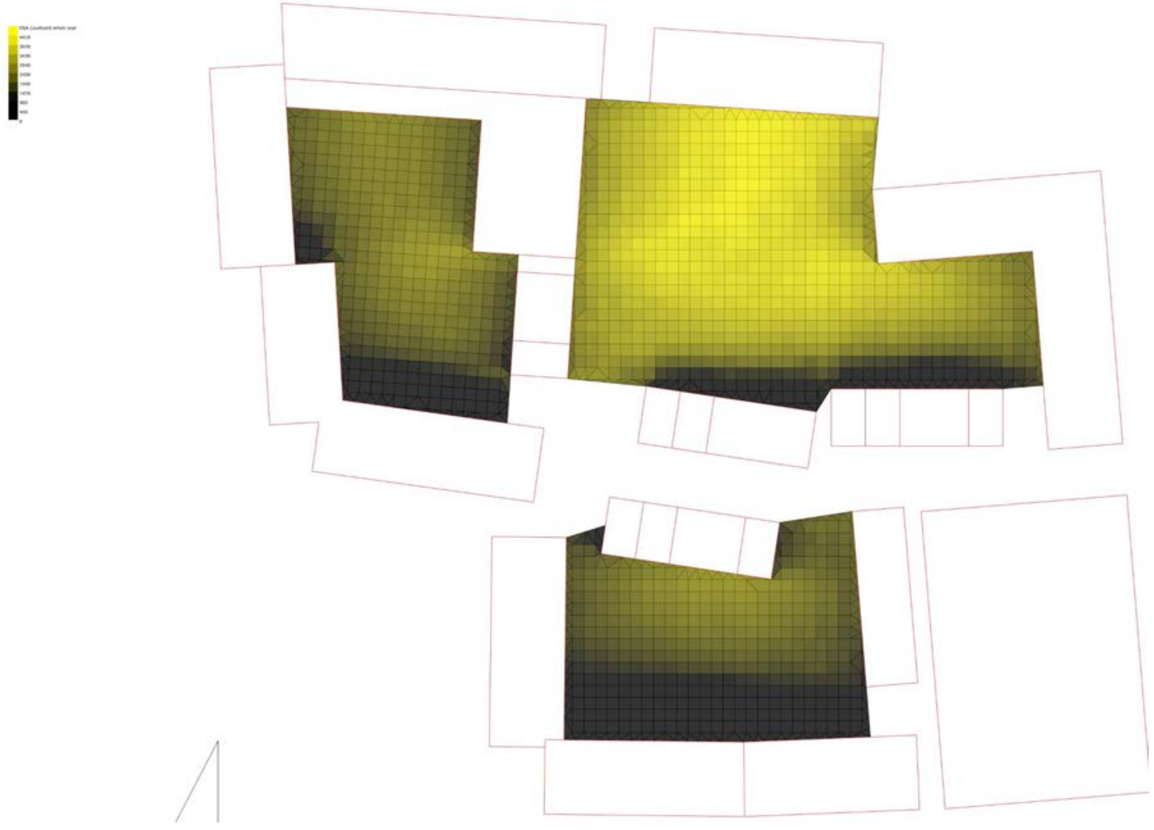
# Direct solar access


March 21st (noon)

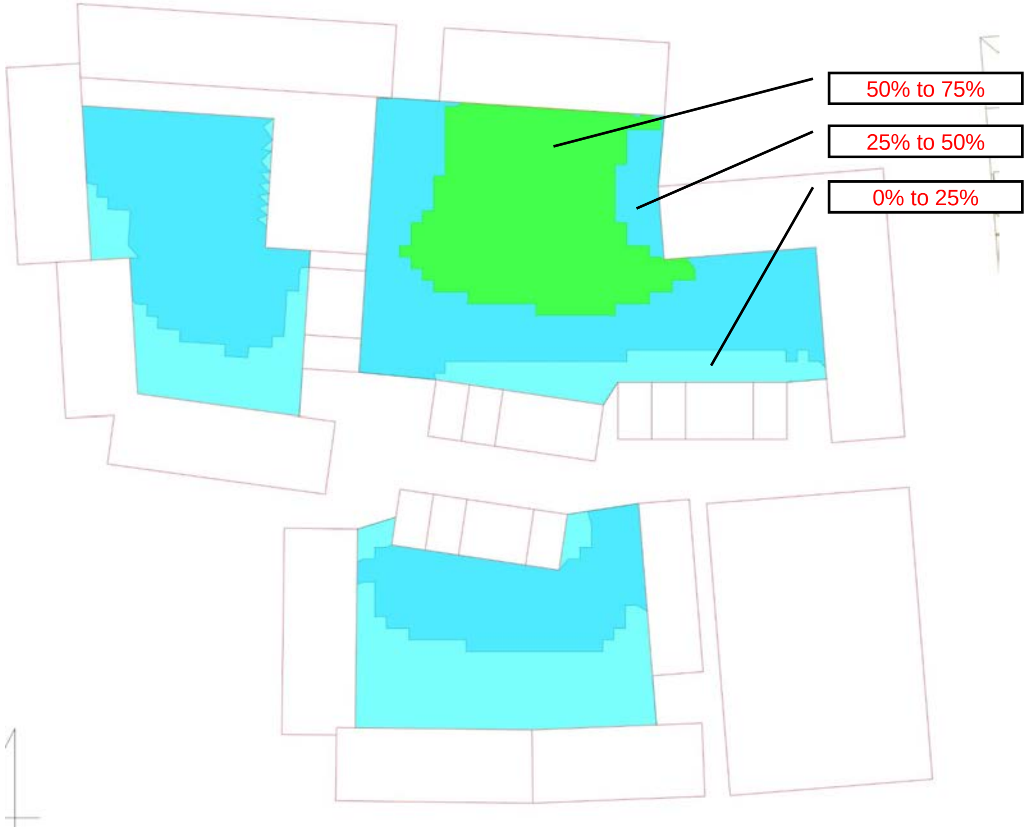


March 21st

# Direct solar access



Annual Direct Solar access

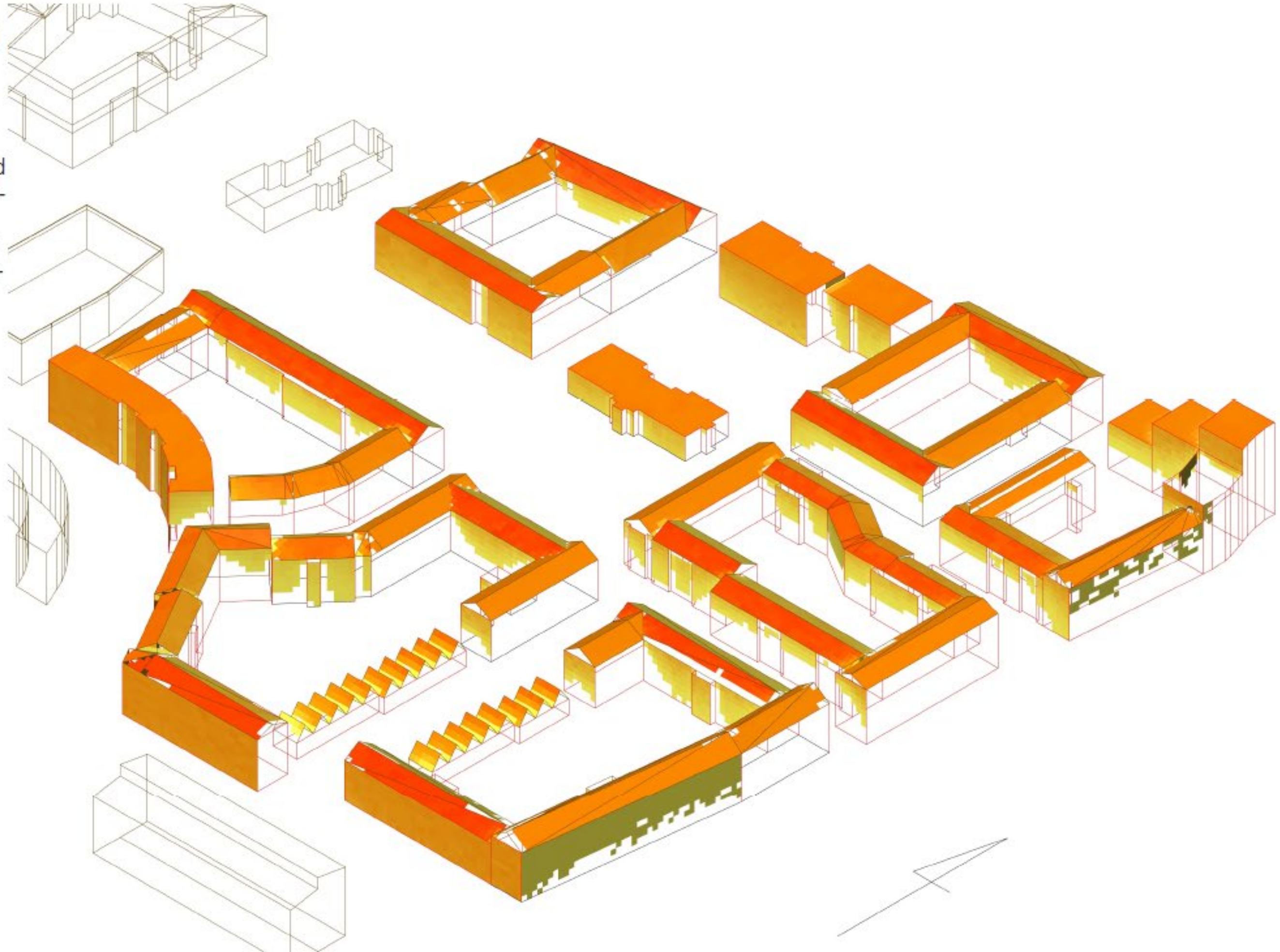



Annual Direct Solar access as percentage of possible Direct Solar Hours

# Active solar energy production

Bilden till höger visar de ytorna som kan vara lämpliga för installationen av solceller (använd tröskelvärde är 600 kWh/$m^2$). Simuleringen är gjord i Rhin, Grasshopper och Radiance med Köpenhamns väderdata.

Om 100 % alla lämpliga ytor skulle täckas med solceller, kan man beräkna den teoretiska solel-produktion (antagen verkningsgrad 15 %).
Med en elkonsumption på 50 kWh/$m^2$/år (som täcker en hushållsel och en del av uppvärmningen) kan man beräkna den täckningen av solcellerna mot elkonsumptionen.
I det här fallet är soleltäckningen **75%**



# FRÅGOR?

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