Illustrative Prospective of Solar Energy in Urban Planning: Collection of International Case Studies

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IEA SHC Task 51 Solar Energy in Urban Planning

Subtask C – Case Studies and Action Research

Task 51/Report C1 - Illustrative Prospective of Solar Energy in Urban Planning: Collection of International Case Studies

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Within the framework of Solar Heating and Cooling Programme - International Energy Agency Task 51 *"Solar Energy in Urban Planning" in the Subtask C – Case Studies and Action Research*, the *Illustrative Prospective of Solar Energy in Urban Planning: Collection of International Case Studies* across Subtask topics have been set as an objective. The goal is to stimulate successful practice and facilitate the replicability of good practices, by documenting ongoing experiences, exposing potential pitfalls and creating arenas for mutual interaction between researchers and city representatives.

A collection of case studies is presented, addressing how the planning process has been developed, how the stakeholders have been involved, which instruments have been applied, which energy technology and environmental impact have been addressed and what the role is of the researchers during the entire process.

The countries taking part in the IEA SHC Task 51 are represented by 34 case studies included in this report which are divided into:

1. New urban areas
2. Existing urban areas
3. Landscapes

SUMMARY

We would like to thank all authors and organizations who contributed to developing case studies for this report – their contribution is stated at the end of each case study text. While all authors gave inputs and comments on the method used to obtain the information for this report, we would particularly like to thank Johan Dahlberg and Marja Lundgren of White Arkitekter AB, Sweden (Subtask leaders in Task 51); Professor Maria Cristina Munari Probst, Professor Christian Roecker and PhD Candidate Pietro Florio of École Polytechnique Fédérale de Lausanne (EPFL), Switzerland and Dr. Alessandra Scognamiglio of Photovoltaic Technologies Unit (UTTP-FOTO ENEA, Italy for their contribution to developing the method.

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The information and images included in this report are under the responsibility of authors of the individual case studies. Editors have asked authors to obtain permission to use images and to the best of the knowledge of the editors, this has been done for all case studies.

A special thank to NTNU research assistant Nava Shahin (NTNU Scientific assistant, Department of Civil and Environmental Engineering, Faculty of Engineering) which gave a valuable contribution in collecting and sistematizing all the information for the case studies as well as for her support in the conception of the templates.

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1 INTRODUCTION

1.1 Objectives

A large portion of the potential for energy efficiency in existing buildings and potential to utilize solar energy still remains unused. Globally, goals and specific targets are set up to reduce our environmental impact on climate and secure future supply of energy. An increased use of solar energy is one important part of the development ahead to achieve targets and goals. The urban fabric needs to utilize passive solar gains and daylight to reduce the energy use in buildings and for lighting outdoor environments, as well as to improve the inhabitants' comfort indoors and in urban outdoor areas. Also, active solar energy systems integrated in the urban context will enable a supply of renewable energy primarily as heat and electricity, but also of solar cooling, helping cities reach sustainable solutions. IEA SHC Task 51 Solar Energy in Urban Planning scope includes solar energy issues related to:

1. New urban area development
2. Existing urban area development
3. Landscapes – Photovoltaic (PV) and Solar Thermal (ST)

In all three environments listed above, both solar thermal and photovoltaics are taken into account. In addition, passive solar were considered in the urban environment (1 and 2). Passive solar includes passive solar heating, daylight access and outdoor thermal comfort. The main work is focused on active solar strategies due to a great need of development in this area, related to urban planning.

The objective of this report is to facilitate replicability of successful practice and mitigate common pitfalls in solar energy in urban planning. This is done through the presentation of case studies and stories. Subtask C, led by Norwegian University of Science and Technology (NTNU), illustrates applied practices of the development of solar energy in urban planning based on the subtask topics of Task 51 Solar Energy in Urban Planning which are outlined below:

- Subtask A: Legal framework, barriers and opportunities for solar energy implementation
- Subtask B: Development of processes, methods and tools
- Subtask D: Education and dissemination

In this report, references are made to specific reports from Subtask A, B and D. Subtask C develops urban planning case studies as case stories by analyzing the inter-relationship between the variables of the urban surrounding, solar integration technologies, environment, social, aesthetics, methods, planning processes, approaches and tools. The analysis contributes to lessons learned and recommendations in order to develop urban planning guidelines for different target groups. Specifically, a database of best practices on individual cases in each participating country in relation to the aforementioned subtask topics of Solar Energy in Urban Planning has been combined into this report. The report facilitates and documents the development and testing of approaches, methods, tools and process models in at least one city in each participating country, in cooperation with local decision makers, industries and research institutes.

34 cases from Austria, Canada, China, Denmark, France, Germany, Italy, Norway, Sweden and Switzerland have been gathered, which is indicative of the state of the art of leading developments in the planning of solar energy in new and existing urban areas as well as landscape.

The coordination of *D.C1 - Best Practice Case Studies and Case Stories* is summarized through the following activities:

- C.1.1. Identify relevant case studies, and align them in one template to be filled out for all case studies (link to Subtasks A, B).
- C.1.2. Collect case study templates from partners, literature and networks, and gather them in one database (link to Subtasks A, B, D).
- C.1.3. Publish the database on the website, and facilitate information access for various user groups, amongst others education (link to Subtask D).

The following sub-sections details further the methods used in order to develop the case studies/stories.

Subtask C provides recent examples from real applications across the world. The cases should inspire others responsible and influential on urban planning to consider solar energy as well as be made aware of issues that must be addressed, such as solar rights or heritage concerns.

The case studies test approaches, methods, process models and tools which are described and explained in Subtask B. They provide illustrative examples of legal framework, barriers and opportunities that are further detailed in the work of Subtask A. Finally, the case studies give two educational scenarios (i.e. Øvre Rotvoll case study in Norway) of how solar energy in urban planning is used, which builds on a report from Subtask D.

The objectives of providing a collection of best practices through case stories and case studies was achieved but are limited to illustrating cases on an individual context without comparison of similar situations in another context. One reason for this limitation is that urban planning projects are complex by nature and involve a wide range of different stakeholders. They often appear context specific which makes replicability and comparison difficult. However, comparison of cases is addressed in the deliverable *D.C2 - Cross Cutting Analysis: Comparison of National and International Best Practice Case Studies and Case Stories*.

The present report is focused on the individual cases contain lessons learned, however, does not contain a summary of key lessons learned from all the cases. This limitation is to be addressed in a follow up in the deliverable *D.C3- Supportive Practice Guidelines for Solar Energy in Urban Planning: Lessons Learned from Case Studies and Case Stories*.

2 METHODOLOGY

2.1 Phases, materials and templates

The methodology used for developing the case study templates which were core in obtaining the information for the case studies was done collaboratively with Subtask leaders, experts and organizations which are involved in Task 51. The templates were developed in collaborative work with experts/researchers from NTNU, White Arkitekter AB, EPFL and ENEA as well as inputs from the other partners of Task 51.

Guidance documents from Subtask C were provided for D.C1 which focused on general and technical summary of individual cases as well as a short description regarding energy regulation in each country linked to Subtask A.

Templates were elaborated through dialogue between Subtask leaders and experts in Task 51 in order to take into consideration the uniqueness of each case study which was submitted.

1. Phases

The phases for developing the methodology were composed of:

- Definition of Case Studies included in Task 51
- Overview and characterization of main features
- Set up of standard templates
- Creation of a template for the case study

2. Materials

All participants from Task 51 were requested to answer four questions about the case(s) they would include in this report. The four questions are:

- What is the vision of the case? (aims and goals)
- What is the organization of the case? (e.g. time scales, funding and milestones)
- Who is involved in the case? (e.g. municipalities, architects, researchers, etc.)
- What is the role of the researcher? (e.g. Influencing stakeholder or evaluating case)

Templates were developed by partners in Task 51, based on the available information in order to underline relevant features and provide consistent information of the different case studies. All participants of Task 51 were asked to input information on their case study using the template as well as by following guidelines.

3. Case study templates

Once the information for each case study was collected, it was decided to use an unique template to present the data. For that purpose, a standard template was developed and built up taking into account the possible differences of case studies and their similarities. Templates were made flexible and adaptable based on the needs of partners, but with a common structure for consistent outcomes across case studies. These models were improved by exchange of views with experts of the Task 51.

2.2 Definition of environments

The case studies were divided according to the following definitions of environments. Specifically, the type of environment was classified into three categories:

1. Existing urban areas

The first kind of environment is the existing areas, which consists of existing urban infrastructure defined by two main scenarios and shown in the orange diagrams a) and b). Diagram a) represents the fill-ins and densification case and characterizes new buildings connected to surrounding fabrics at a high level. Diagram b) on the existing urban fabric represents the case of alterations, refurbishment or new buildings within existing regulation. These diagrams indicate how urban planning decisions require a scale larger than a building alone to obtain an overview of the impact assessment buildings have in an urban area.

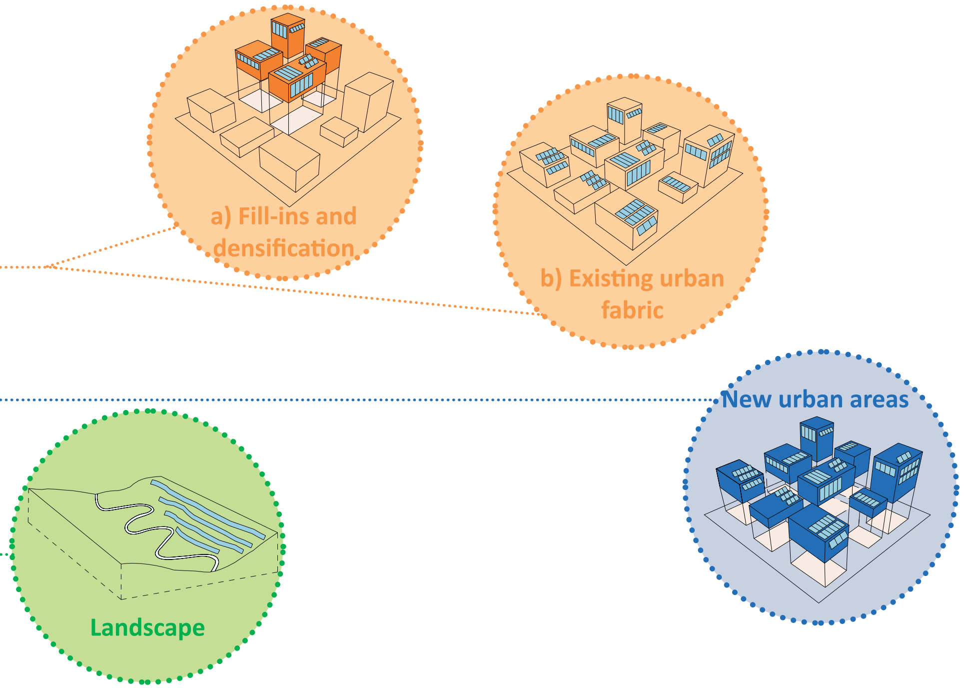
2. New urban areas

The second type of environment represents the new urban areas, developed when new buildings are demanded for new infrastructures and detailed development plans. In this scenario, urban planners are involved from the beginning and it usually requires in-depth urban design.

3. Landscape

The third typology of environment analyzed is landscape, which involves solar arrays – a large system in landscape areas. The aim is to explore the potential impacts, both positive and negative, of solar energy in landscapes.

The extent and scale of case studies compiled in this document varies from studies concerning single buildings to smaller communities and large urban districts. The majority of the case studies are located in urban areas with the exception of the 'Landscape' category. Landscape case studies are an important element in the context of urban development, since the majority of urban areas rely on energy supply that is provided outside of the immediate urban spatial boundaries.



2.3 Sections of the case study templates

The templates are divided in different sections. Each section is represented by the icons of the following figure and explained in the table shown in Figure 1 below:

Sections

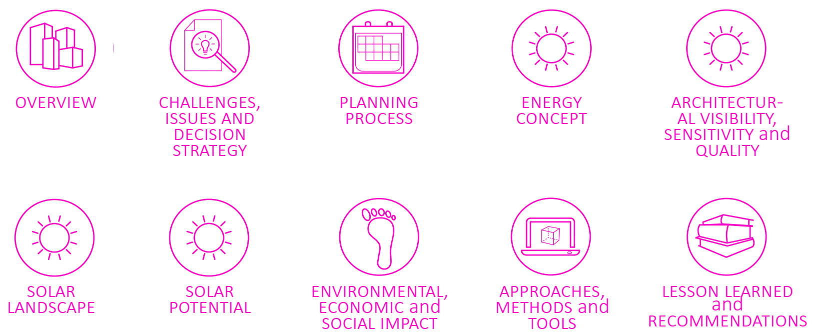


Figure 1 - The sections of the case study templates.

In Figure 2, the framework of the template is presented: the fully coloured pages identified the common sections available for all case studies, while the pages in dashed lines are free and they are filled out according to the in-depth analysis specific for each case study.

The templates have been developed in order to have links with the different Subtasks and other reports of Task 51. Specifically, the sections are illustrated in Figure 1 and indicate (starting from left to right) “1- Overview” represents the link with Subtask A *Legal framework, barriers and opportunities*, “3- The planning process” and “4- Approaches, Methods and Tools” linked with Subtask B *Processes, methods and tools* and Subtask D *Education and dissemination*.

Furthermore, other sections allowed to connect the work that was done in IEA SHC Task 41 “Solar Energy and Architecture” with Task 51. In the templates related to Existing and New Urban Areas the section called “5- Architectural Visibility, Sensitivity and Quality” was a preliminary idea of integrating the LESO QSV tool at large scale [1] [2], while in the template for Landscape case studies some have been developed according to the experience of ENEA in this research field [3].

References: *[1] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

[2] 700 Legge federale sulla pianificazione del territorio, LPT del 22 giugno 1979 (Stato 1° gennaio 2016)

[3] Scognamiglio, A. (2016). ‘Photovoltaic landscapes’: Design and assessment. A critical review for a new transdisciplinary design vision, Renewable and Sustainable Energy Reviews, pp 629-661

2.3 Sections of the case study templates

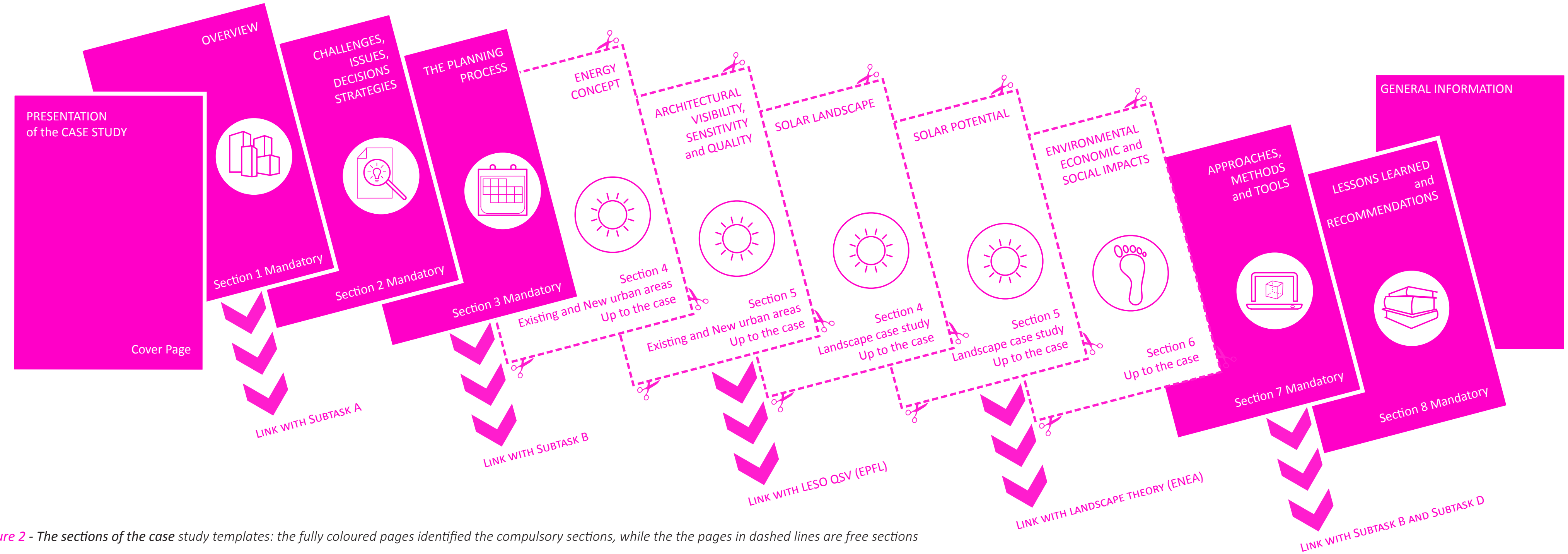


Figure 2 - The sections of the case study templates: the fully coloured pages identified the compulsory sections, while the the pages in dashed lines are free sections

CASE STUDY TEMPLATES

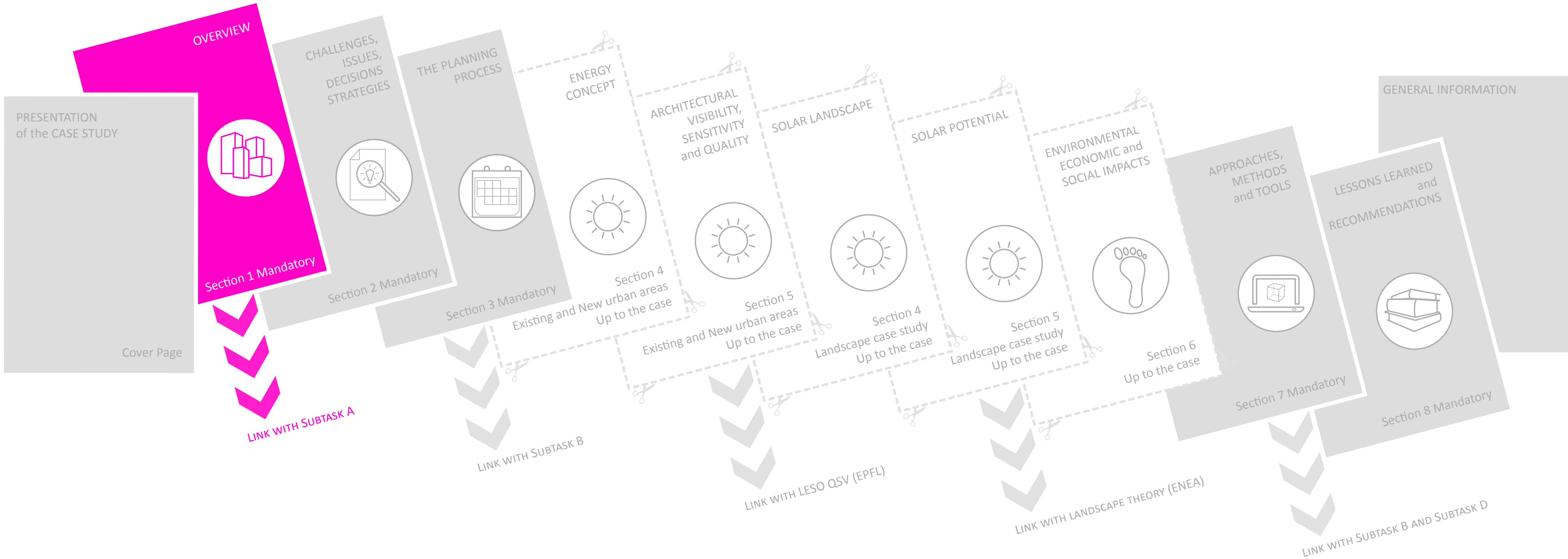
Overview

Authors of each country filled in the framework template to document case studies.

"Overview" is the first section of each template, common for case studies based in the three environments and available in all case studies.

This section contains a set of pictures to illustrate the contextual background and mapping of the case study. Geography, climate and analysis of the case study context is emphasized. The overview section underlines specific references on how the case studies were followed and satisfied requirements. Solar energy strategies, local and national regulations and future planning developments were stressed in the case studies. There is further information on these areas available in a separate report *D.A1/D.B1. - Current status of Solar Energy in Urban Planning* (which is part of a joint report by Subtask A and B).

2.3 Sections of the case study templates



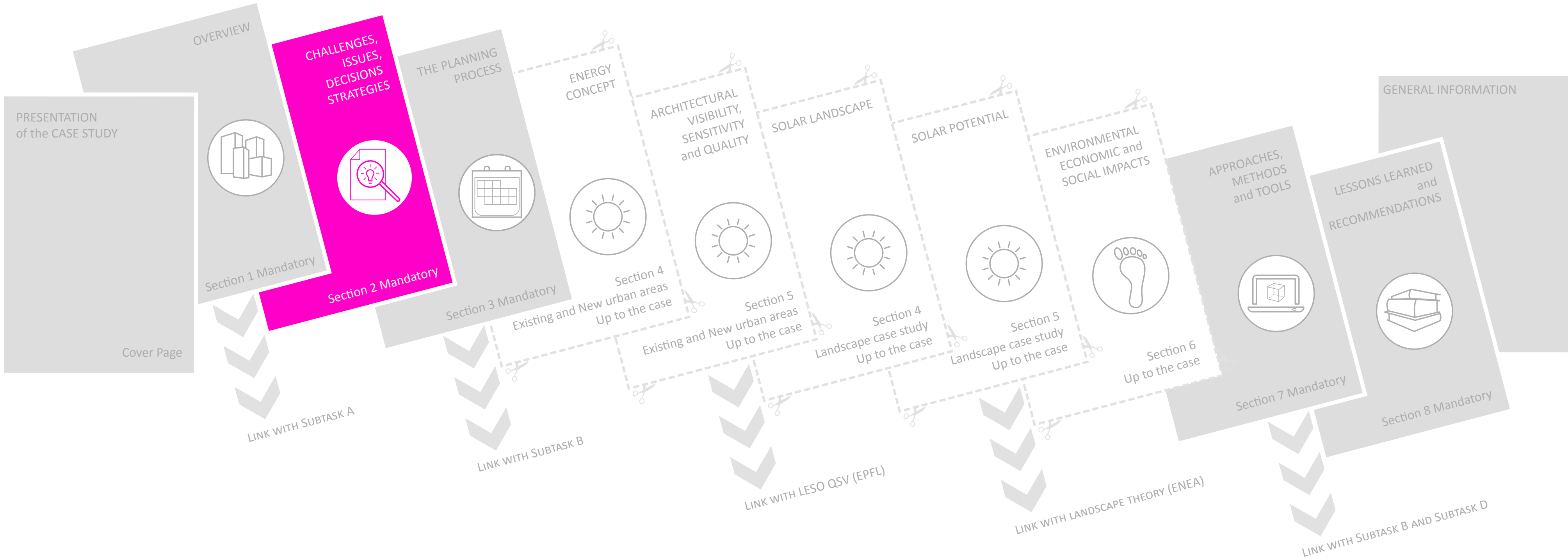
CASE STUDY TEMPLATES

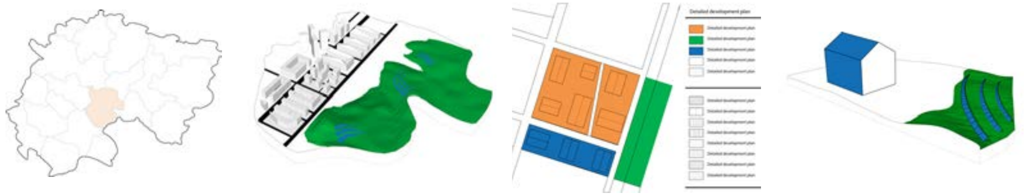
Challenges, issues and decision strategies

The second section on “Challenges, issues and decision strategies” is available for all case studies.

It contains highlights, important topics related to the case study and focuses on issues and challenges. In particular, this section underlines relevant features of energy characterization, as the presence of integrated panels or of overshadowing. This section is also relevant to a separate *D.A2. - Barriers, challenges and needs of Urban Planning for Solar Energy implementation* (which is part of subtask A).

2.3 Sections of the case study templates





Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans.
Scale: 1:2000-1:100 000.e system

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area.
Scale 1:1000- 1:5000.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents.
Scale. 1:500-1:2000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered.
Scale. 1:10-1:500.

Figure 3 - Definition of planning process (Illustration by White Arkitekter)

The planning process

The third section is "The Planning Process" included in all case studies.

This section is common for all environments. It describes how the case study related to different spatial scales and stages of urban and landscape planning; Comprehensive/Strategic planning, Urban and Landscape Design, Detailed Development Plans and the Architectural Design stage. The section also gives a brief history of involved stakeholder, which influential decisions that were taken during the planning process and how and when researchers have been involved in the case study. As the context and process of each case is very specific the content of this section varies greatly between cases. A further description of the planning process is detailed in the *D.B4 - Strategies for enhancing solar energy implementation within urban and landscape planning - approaches, methods and tools* (which is part of subtask B).

In Figure 3 the definition of the different scales of the planning process are visualized.

2.3 Sections of the case study templates

CASE STUDY TEMPLATES

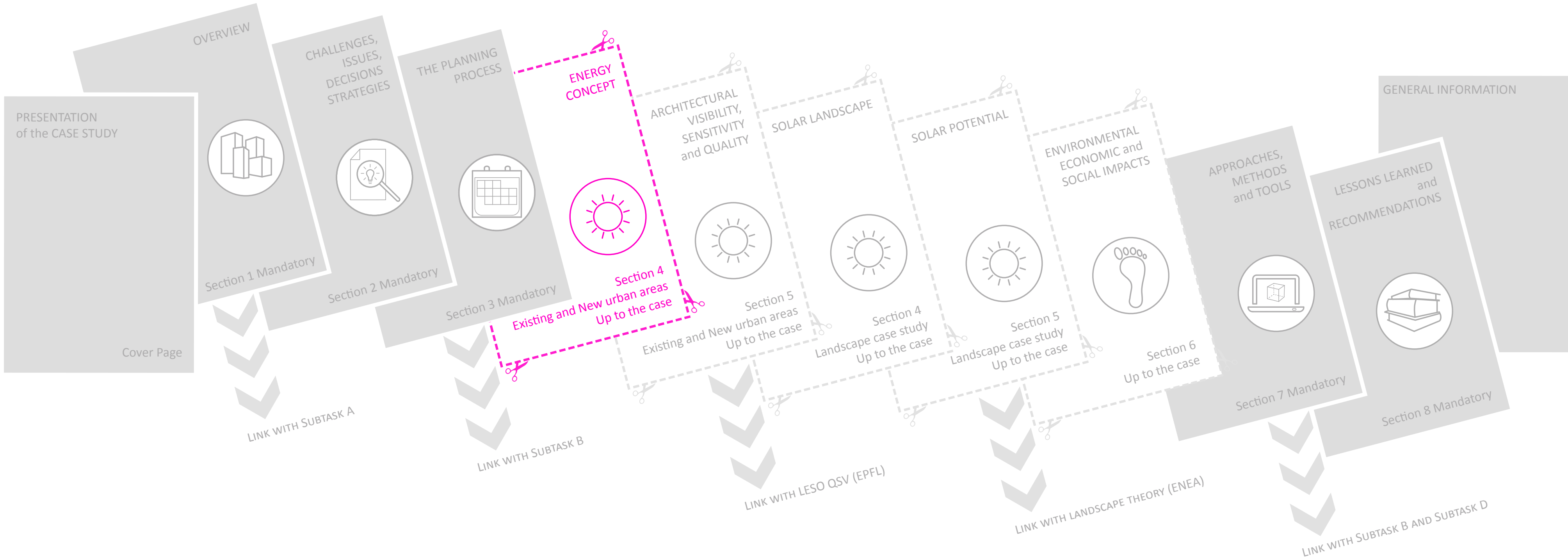
Energy concept

This section is on the energy technology (Photovoltaic, Solar thermal and solar gains specifically) used in the case study.

A description of the energy concept and specific solar technologies (active, passive or both) adopted in each case study are presented. Furthermore, energy needs and the definition of systems installed to cover the energy demand are included in this section.

This section was developed for case studies where the energy system has been considered relevant for the scope of Task 51.

2.3 Sections of the case study templates



CASE STUDY TEMPLATES

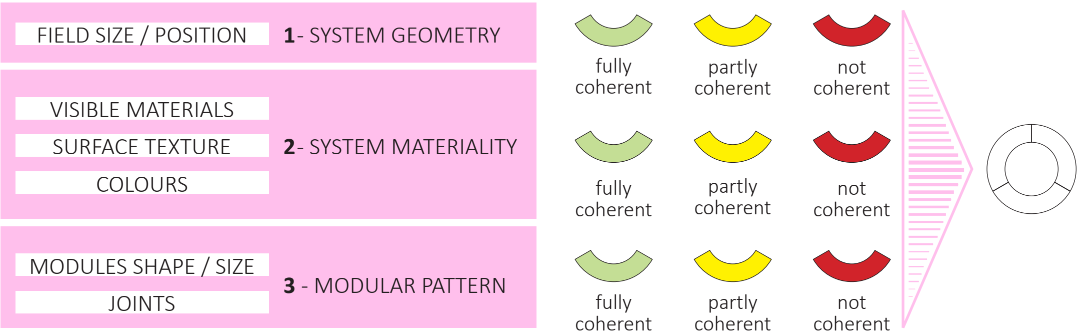


Figure 4 - Definition of level of criticity of the installed active system

Architectural Visibility, Sensitivity and Quality

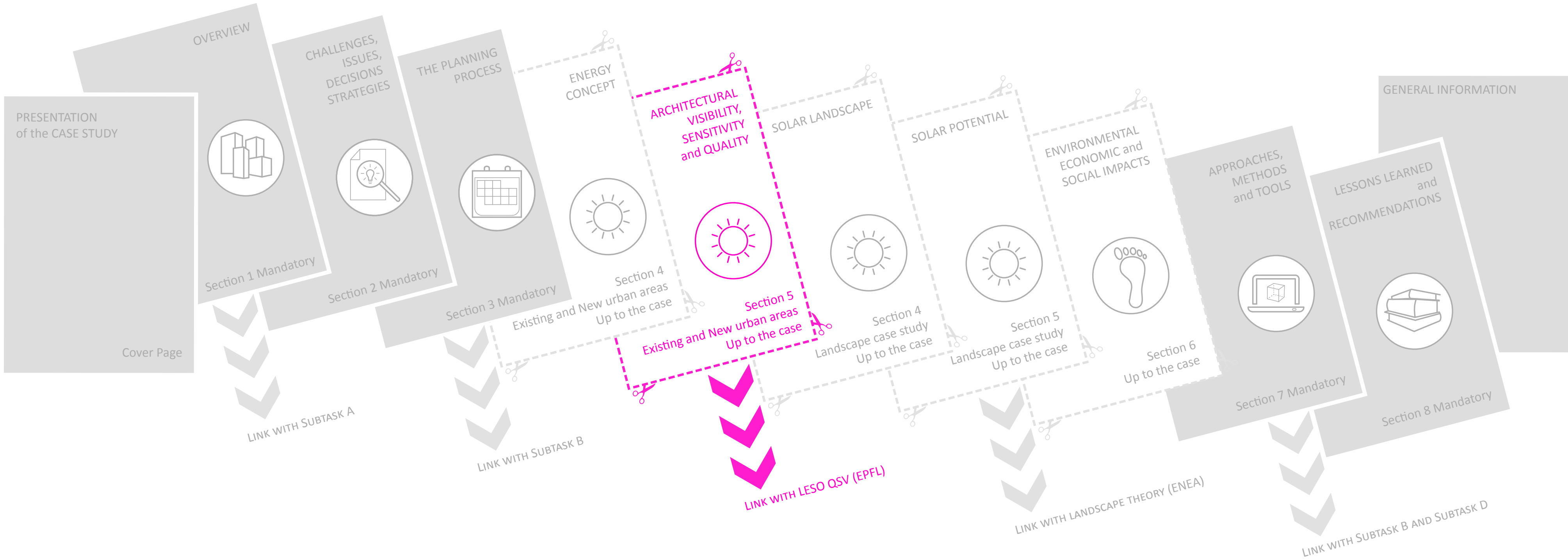
This section is linked with the work framed in the IEA SHC Task 41 "Solar Energy and Architecture" by EPFL-LESO and now integrated in the LESO-QSV tool at urban scale [1][2].

This section is composed by four parts:

1. *Architectural integration quality: evaluation of integration quality of the solar systems installed*. To be perceived as integrated, the system has to be designed as an integral part of the building architecture, i.e. all the formal characteristics of the solar system (field size/position; visible materials; surface textures; colours; module shape/size; joints) should be coherent with the global building design logic. Based on these findings the qualitative assessment is articulated into 3 simplified steps, grouping the mentioned integration criteria. The coherency of System geometry, System materiality, and System modular pattern, is evaluated using a three level scale (fully- partly- not coherent). The global system quality will then be expressed by a circle made of 3 separated coloured sectors (green, yellow or red according to the level of coherency) (Figure 4).

References: *[1] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.
[2] 700 Legge federale sulla pianificazione del territorio, LPT del 22 giugno 1979 (Stato 1° gennaio 2016)

2.3 Sections of the case study templates



CASE STUDY TEMPLATES

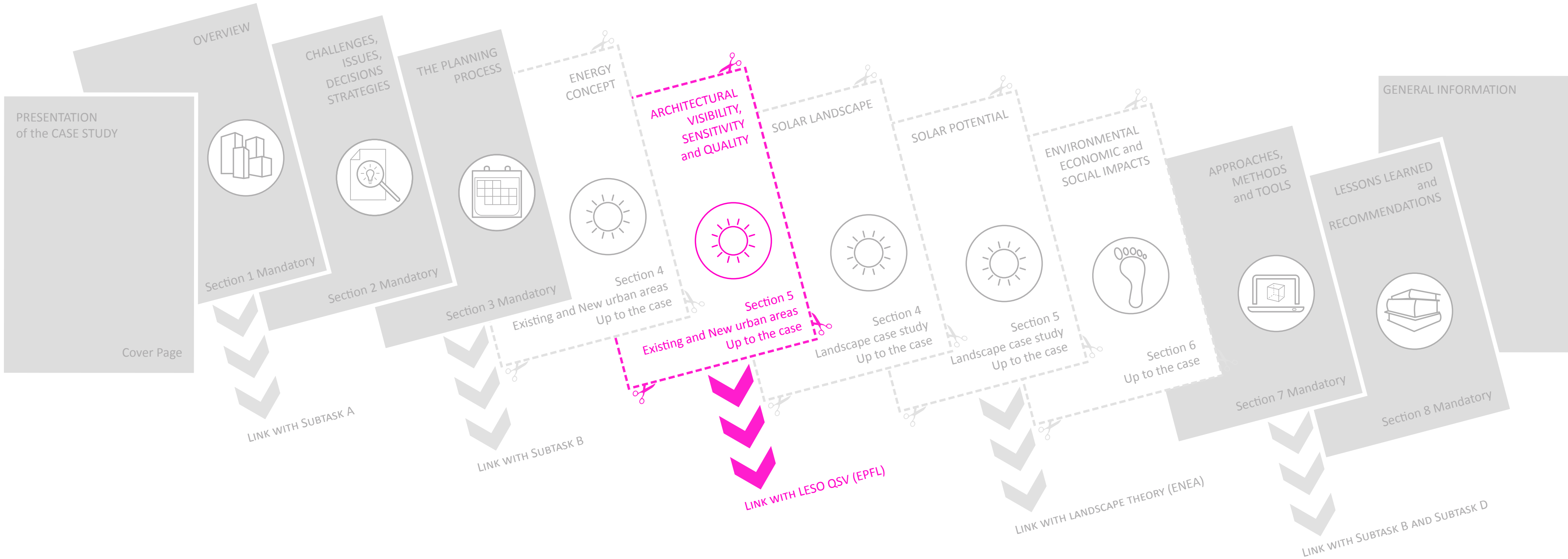
Figure 5 - Criticity of city surfaces in relation to architectural integration quality (on the left); Different levels of urban context sensitivity (on the right) [2]

References: [1] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.
[2] 700 Legge federale sulla pianificazione del territorio, LPT del 22 giugno 1979 (Stato 1° gennaio 2016)

Architectural Visibility, Sensitivity and Quality

2. *Criticity.* The quality requirements for architectural integration should be adapted to the local situation, specifically to the sensitivity of the urban area and the visibility of the building surface. The concept of architectural «criticity» embodies this notion by combining the sensitivity of an urban context with the visibility of the city surfaces (Figure 5).
3. *Context sensitivity.* It is the socio-cultural value of the urban zone that the described building(s) is or will be located into. It is linked with the historical development and the morphology of the buildings, the cultural and vernacular heritage, the traditional space use made by the citizens, the presence of symbols, icons, landmarks, monuments or institutions in which inhabitants reflect their habits, the common affection and diffuse wellbeing for that place. It is specifically related to the particular history and identity of a given context: for instance an historical center can be considered to be high sensitive, a post-war residential development as medium sensitive and a low quality industrial district as low sensitive; a new urban development should be evaluated according to the overall urban vocation that will assume after the realization (e.g: new high-standards of living neighborhood on previously industrial exploited land). Some indicators of sensitivity can be found in traditional urban planning tools, such as the land use plan.

2.3 Sections of the case study templates



CASE STUDY TEMPLATES

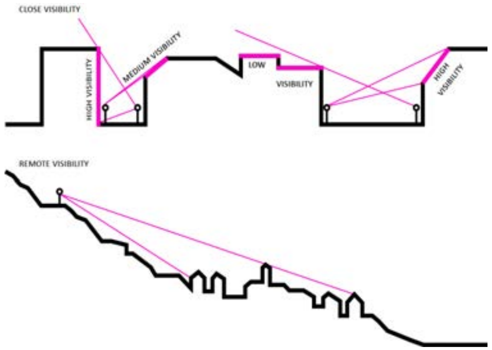


Figure 6 - Different levels of visibility of city surfaces from public domain [2]

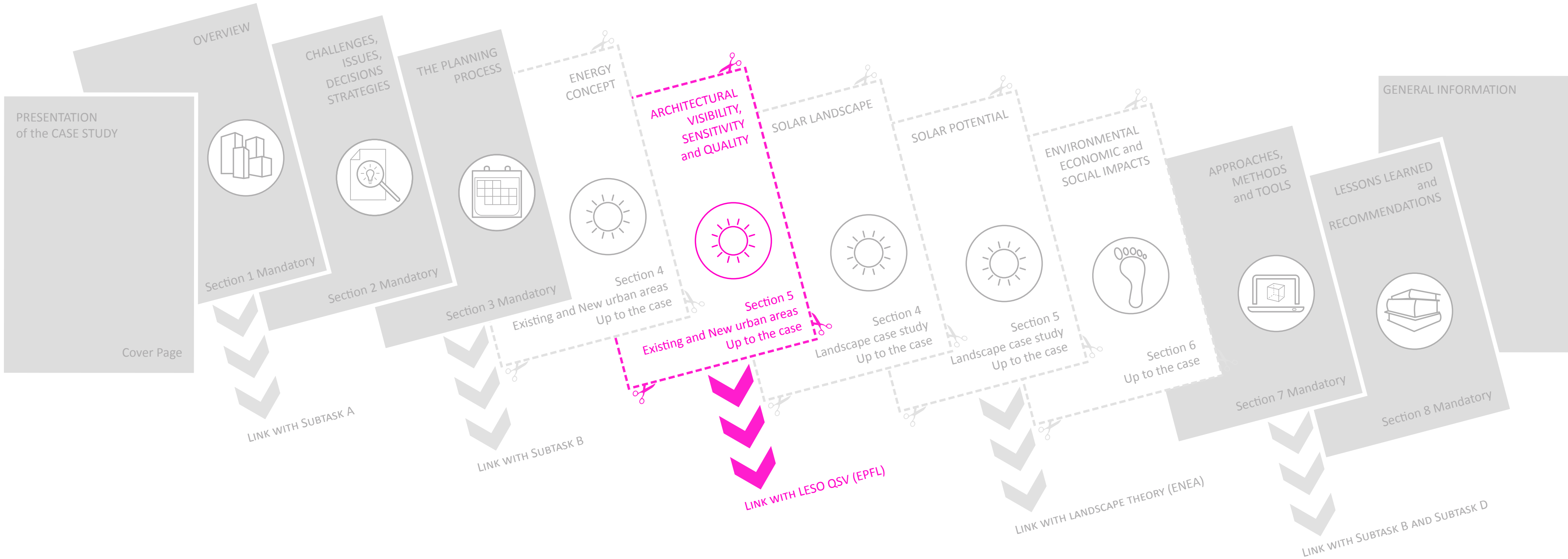
Architectural Visibility, Sensitivity and Quality

4. *System visibility.* Visibility assesses the perception of a solar system from the public space. It can be defined as close visibility from an urban canyon perspective, or remote visibility from a far observation or sightseeing point. The incidence of solar collectors on the visual field of all possible observers in the public space has to be considered. When the case study involves an intervention modifying the external appearance of the building envelope (i.e. construction of new surrounding buildings, change of façade configuration), the visibility level of the affected envelope parts before the modification should be specified (Figure 6).

References: *[1] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

[2] 700 Legge federale sulla pianificazione del territorio, LPT del 22 giugno 1979 (Stato 1° gennaio 2016)

2.3 Sections of the case study templates



CASE STUDY TEMPLATES

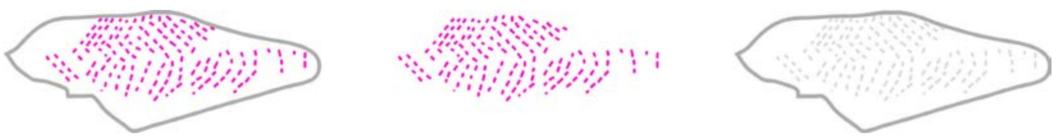


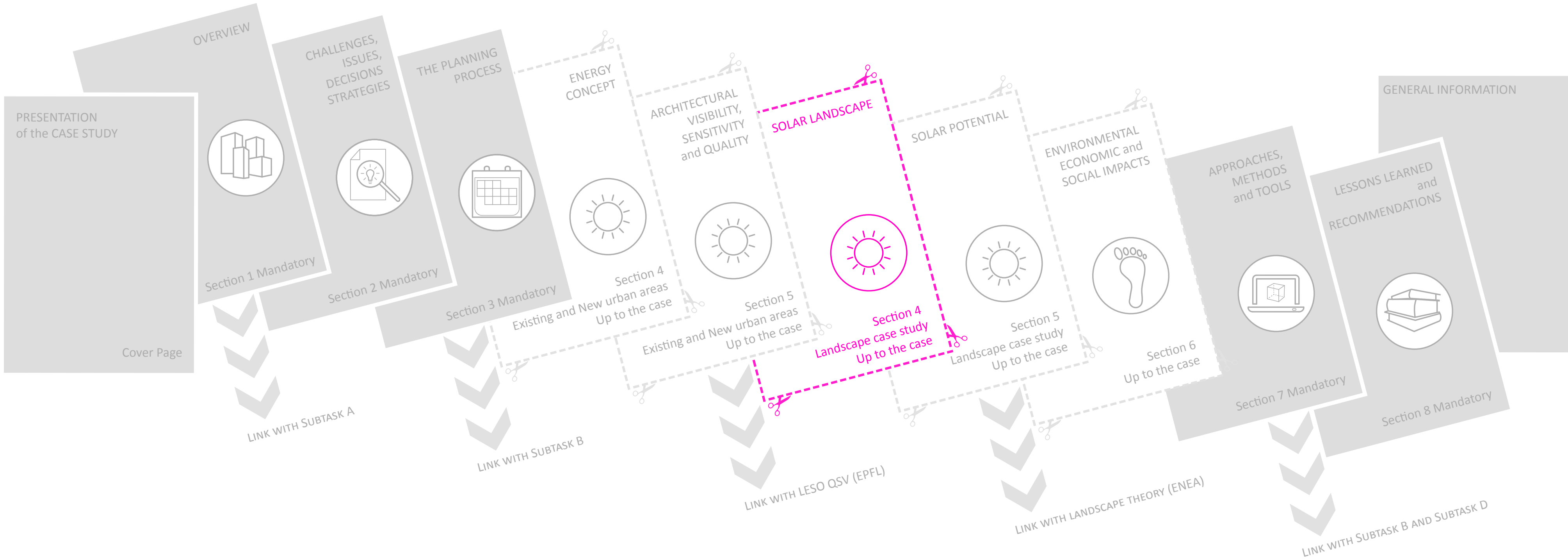
Figure 7 - The spatial system as a whole (Pattern) (on the left), the photovoltaic space (in the middle) and the "pore" space (on the right) [3]

References: [3] Scognamiglio, A. (2016). 'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision, Renewable and Sustainable Energy Reviews, pp 629-661

Solar landscape

In this section, related to the landscape environment, there is a definition of the solar system used. It includes the formal functional features (as the kind of pattern or the presence of edges) and specifications about energy production in the total area. This section has been taken from the work developed by ENEA on solar landscape plants [3]. The ST/PV landscape mosaic pattern proposes an understanding of a ST/PV landscape in terms of mosaic pattern (patch, corridor, matrix model) based on landscape ecology approach and methods. Three scales of reading (linked to different planning and design scales) have been envisioned together with related design parameters and choices. Figure 7 proposes concise "reading" of a large ST/PV system in the landscape, according to the "Solar thermal/photovoltaic landscape" approach. The landscape is seen as a pattern, and the ST/PV landscape is a pattern within a pattern. It is a spatial system made out of a space (the 'pore' space), and its partition (the ST/PV modules), to which energy features and performances and landscape ecological performances are associated. The scheme addresses design parameters and needs for ST/PV landscapes at the scale of planning, landscape and architecture design, and describes the main design parameters to be controlled.

2.3 Sections of the case study templates



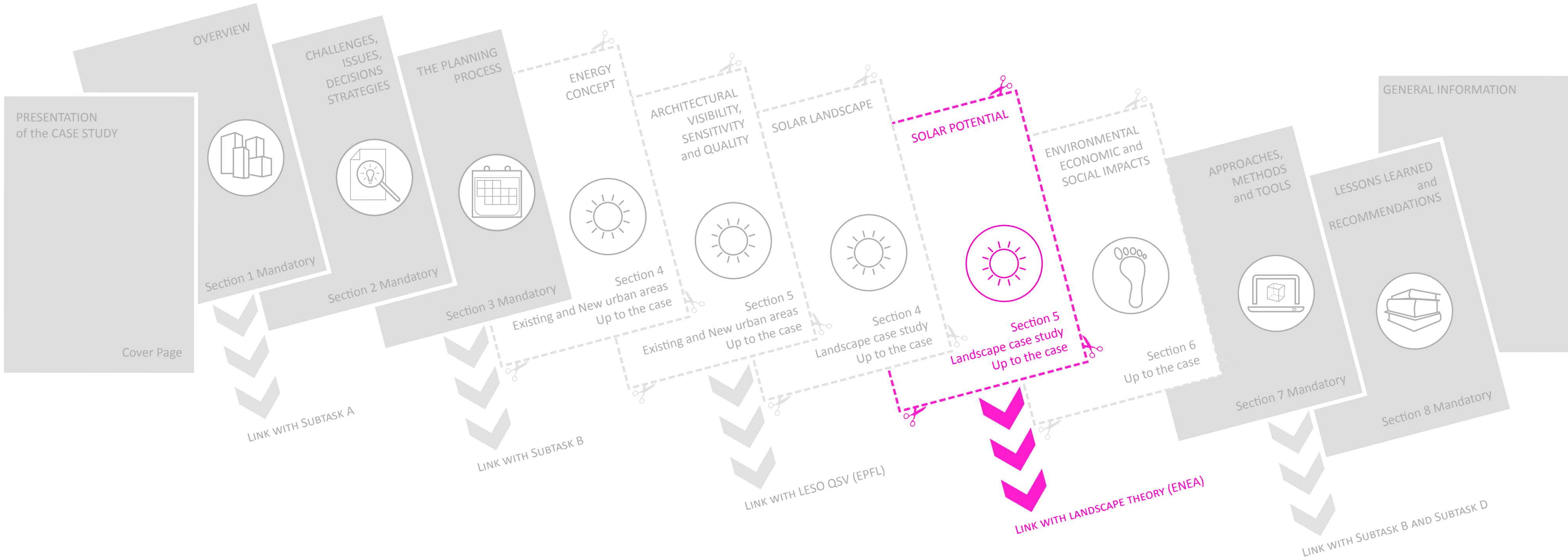
Solar potential

In this section, related to the landscape environment, there is a definition of site potential (sensitivity). Landscape factors associated to site potential for Solar thermal / Photovoltaics.

The features of a certain landscape that strongly influence the site selection in order to optimize the solar potential as well as the ST/PV installation are described in this section. Furthermore, landscape factors that influence the suitability of a site for the installation of ST/PV have been identified and somehow, qualitatively, assessed [3].

References: [3] Scognamiglio, A. (2016). 'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision, Renewable and Sustainable Energy Reviews, pp 629-661

2.3 Sections of the case study templates



CASE STUDY TEMPLATES

Environmental, economic and social impacts

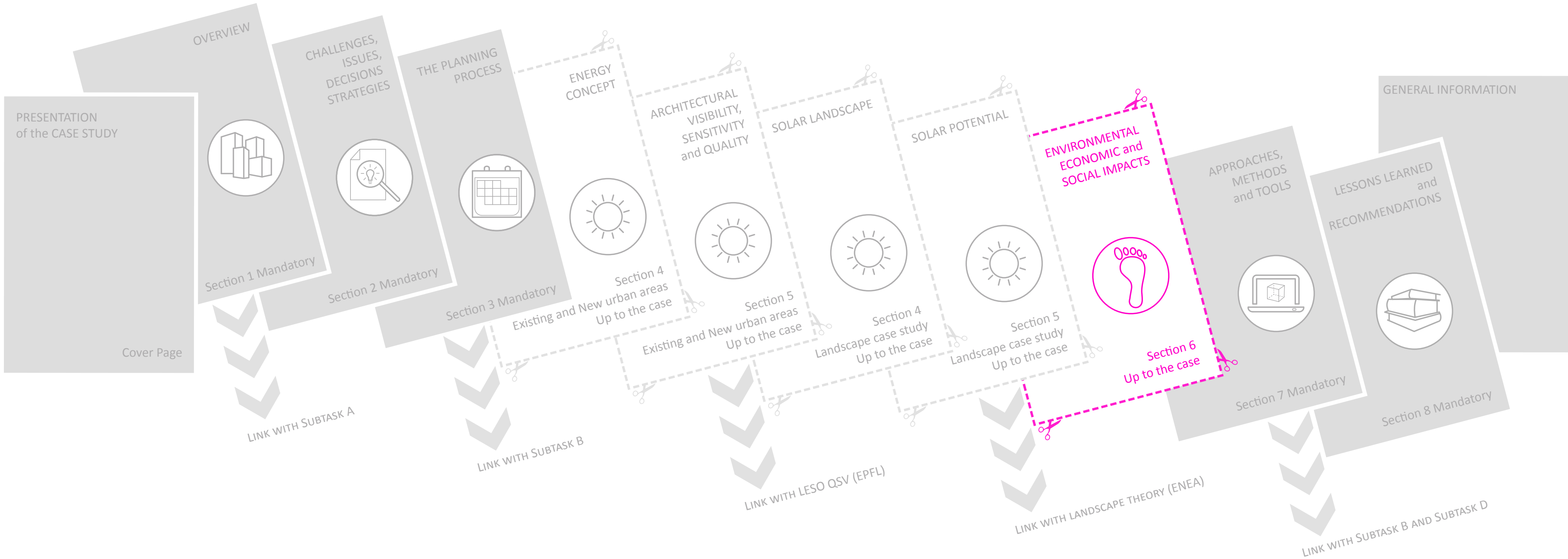
This section is developed in a similar way for the three typology environments.

In this part environmental, social and economic impacts of the case study and feasibility studies or analyses are described.

In particular, the integration between the energy/solar systems and the surrounding environment is described. The community and users were intended as part of the planning process. Evaluation on green gas emissions of the case studies is also described.

This section is available for all cases.

2.3 Sections of the case study templates



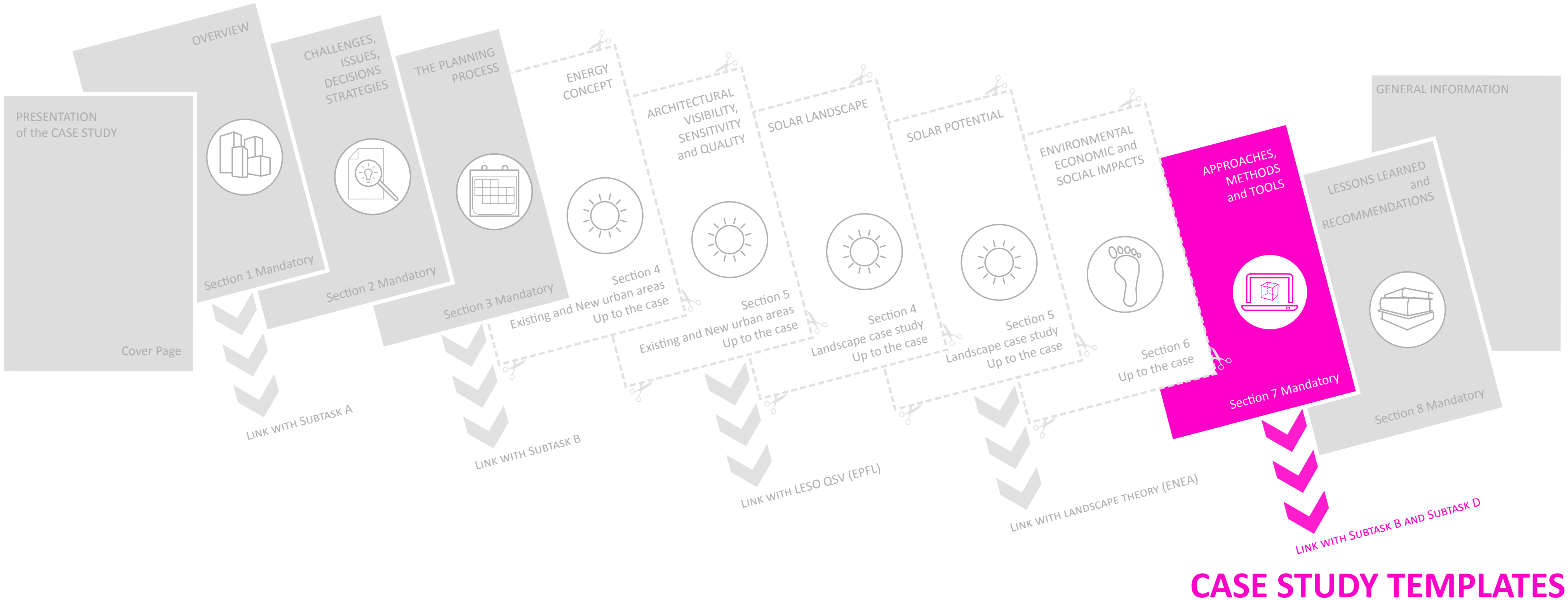
CASE STUDY TEMPLATES

Approaches, methods and tools

The seventh section is “Approaches, methods and tools”. This section contains information on tested Approaches (means of incorporating solar methods and tools into regular planning processes. E.g. Policies, Community engagement etc.), Methods (planned procedures to assess and evaluate solar in relation to other aspects in urban planning) and Tools (a rule of thumb, a calculation or a modelling software that give geometrical or numerical results. E.g. Solar maps, Solar potential software, GIS software etc.). The section focuses mainly on the use of the approaches, methods and tools in the case studies.

A separate report *Strategies for enhancing solar energy implementation within urban and landscape planning - approaches, methods and tools* (Link to Subtask B) has further details on the types of approaches, methods or tools available and explanations on how they can be used or taught (link to Subtask D).

2.3 Sections of the case study templates

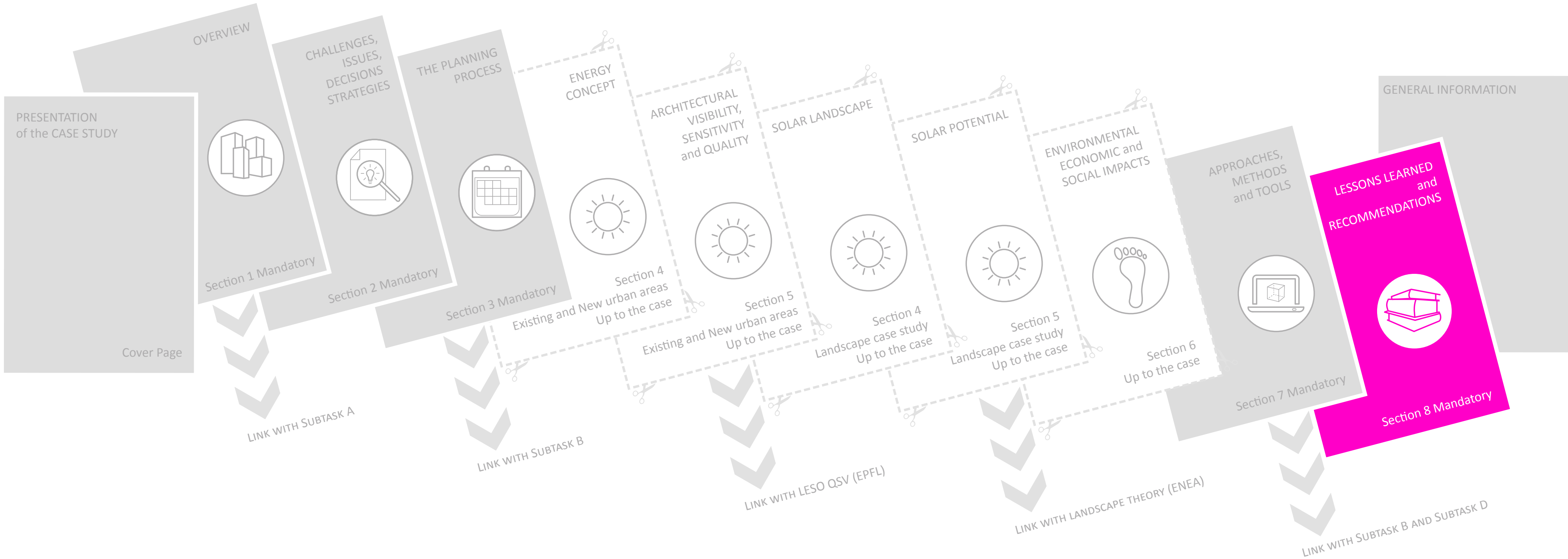


Lessons learned and recommendations

The final section is available for all case studies and is included in every typology environment. It includes the results of the previous analysis in addition to solutions, recommendations and suggestions from each case study.

Further work containing a lesson learned perspective from all Subtasks of Task 51 will be presented in the *Task 51/Report C3 - Lesson Learnt from Case Studies of Solar Energy in Urban Planning* based on, and referring to, developed processes, methods, tools, strategies and case studies/stories – presented also in the “umbrella document” with links to other Task 51 results and deliverables.

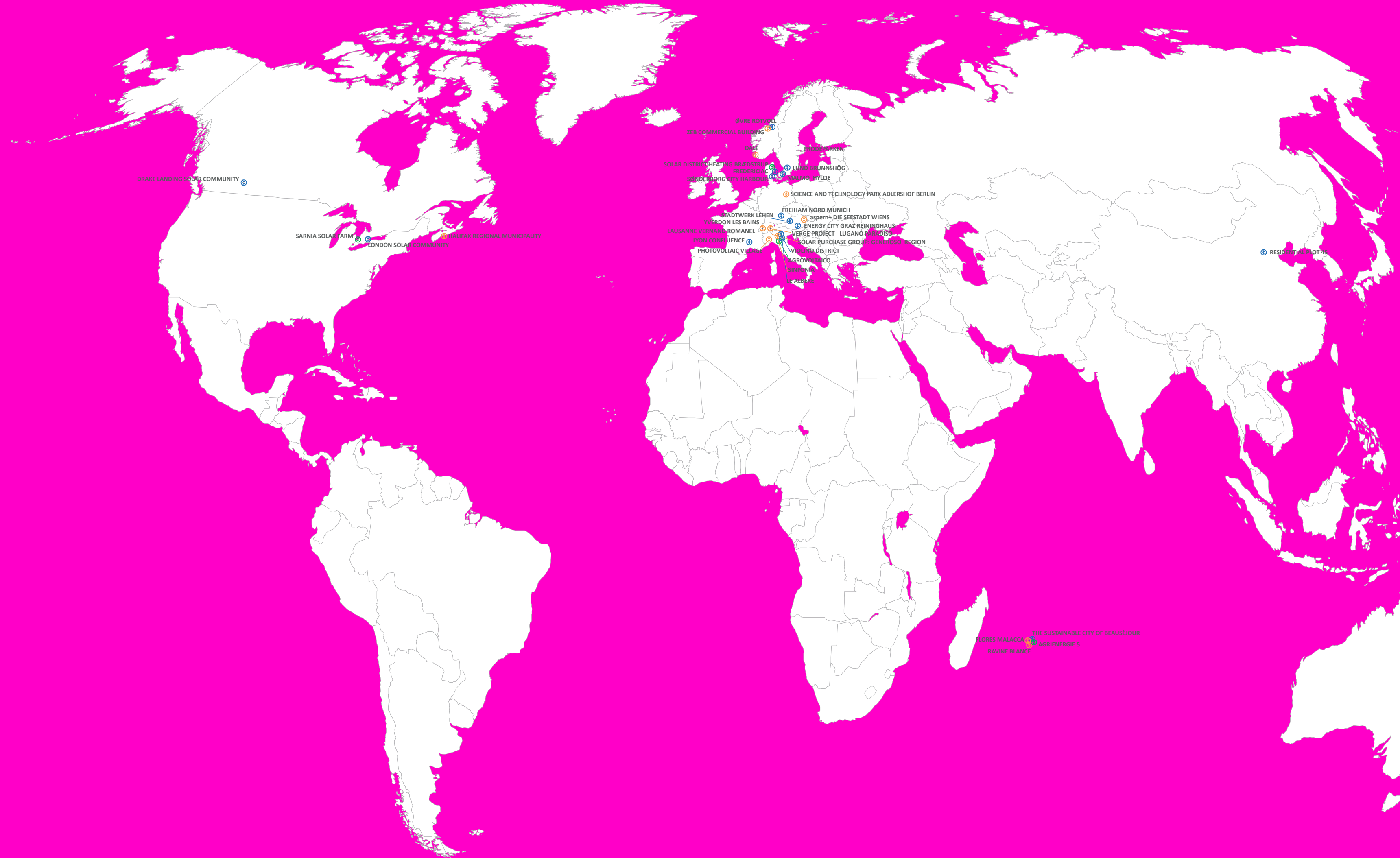
2.3 Sections of the case study templates



CASE STUDY TEMPLATES

CASE STUDIES COLLECTION

3



COLLECTION OF CASE STUDIES

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

3.1 AUSTRIAN CASE STUDIES

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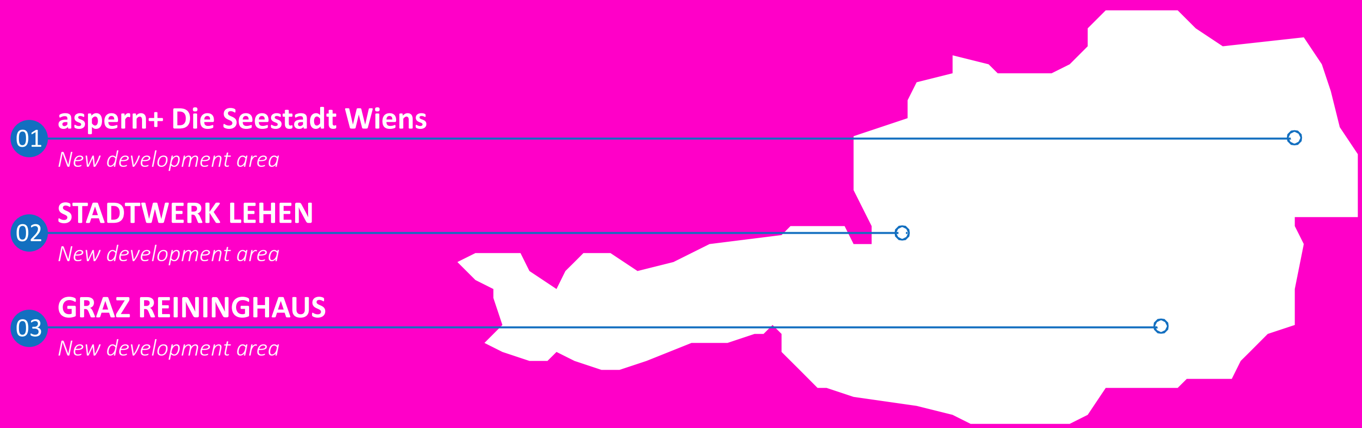


AUSTRIA

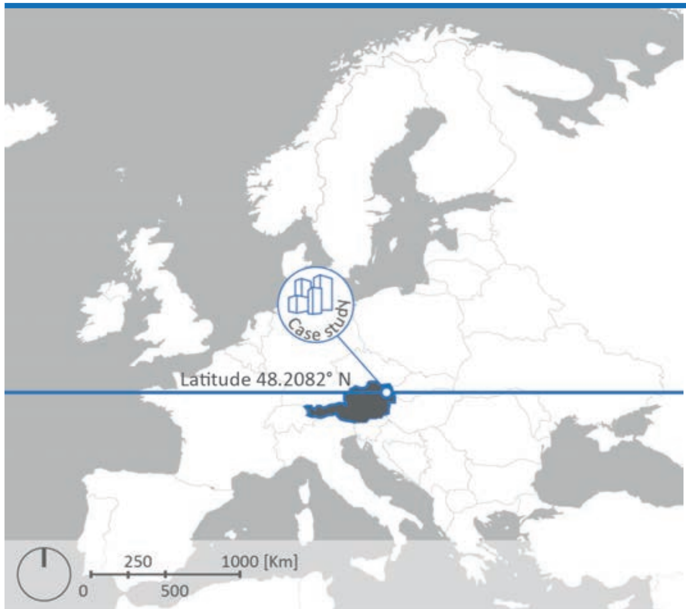
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

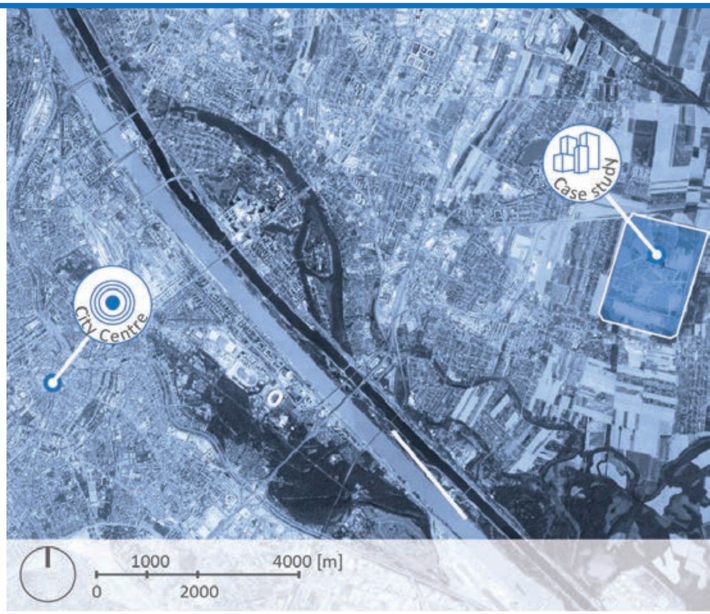

Photo: aspern - die Seestadt Wiens. © Daiva Jakutyte-Walangitang

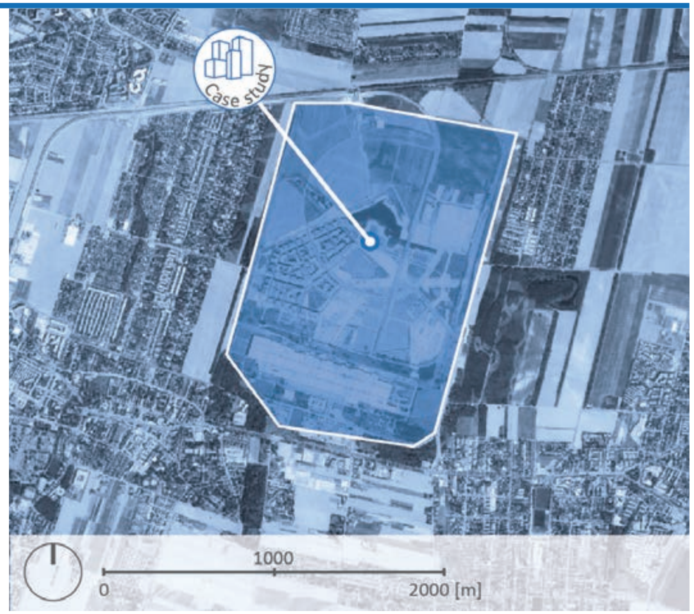
aspern+ Die Seestadt Wiens

AUSTRIA

Overview







GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Austria
Location: Vienna (Lat. 48°13′30″N; Lon. 16°30′26″E)
Climate: Dfb (D: snow/ f: fully humid/b: warm summer) [1]

AREA OF INTEREST

Targets and goals and Planning process

NATIONAL AND LOCAL CONTEXT

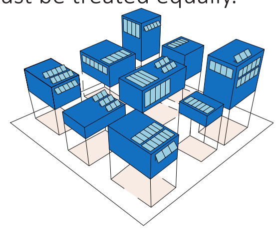
aspern- die Seestadt Wien's development is situated in the former airfield Aspern, approximately 13 kilometers east of the city centre of Vienna. The core aim of aspern – die Seestadt Wien's development is to establish a diverse, resource friendly urban district while strengthening adjacent urban quarters.
In the context of the overall city, aspern Seestadt development is a role model for development in terms of high quality living environment and resource efficiency. By 2028, 240 ha of land is planned to house 20 000 people and approximately 20 000 workplaces. aspern- die Seestadt Wien's Masterplan contains a mix of residential, office, scientific, commercial, research and educational uses. The development will demonstrate the implementation of an ecological district, in alignement with the goals of Smart City Framework Startegy of Vienna (approved in 2014).

ABOUT THE CASE STUDY

In compliance with the requirements of Environmental Impact Assessment (2010) for aspern- die Seestadt Wien's, energy supply generated from renewable energy sources (e.g. solar) has to be given priority, where economically feasible. A specification of a particular renewable technology in an early planning stage is against Austrian planning regulation as the potential application of different available technologies must be treated equally.

Definition of environment:
New Urban Areas

Gross site area:2 400 000 m^2
Built site area: 1 000 000 m^2
Building area: 2 000 000 m^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Issues, challenges and decision strategies

Figure 1 - Aspern development and surroundings. (Source: www.aspern-seestadt.at)

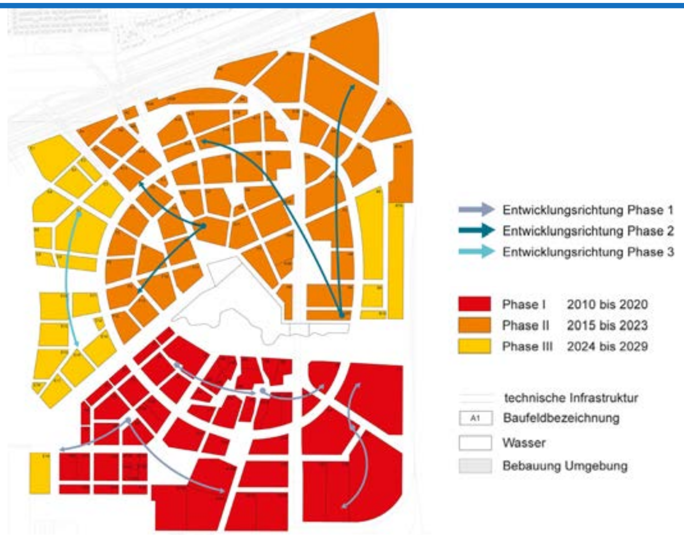


Figure 2 - Aspern development stages. (Source: www.aspern-seestadt.at)

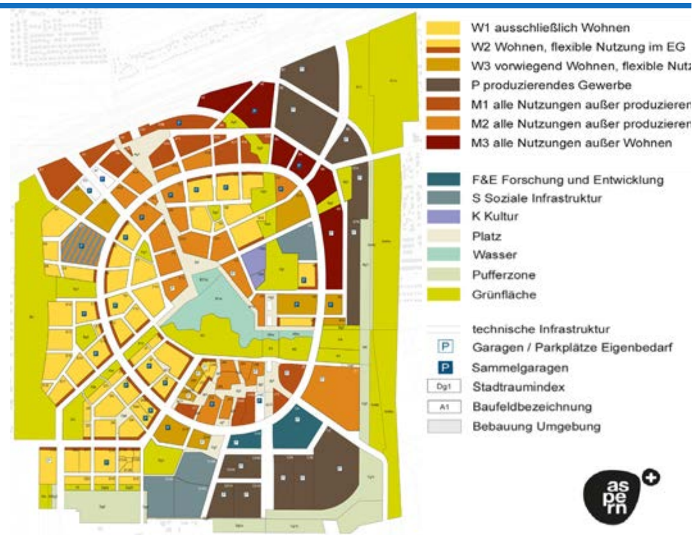


Figure 3 - Aspern mix of uses and landscape. (Source: www.aspern-seestadt.at)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the ongoing develop of aspern Seestadt are:

- 2007 Approval of the Masterplan by the Municipal Council
- 2009 Publication of the public space manual by Gehl Architects
- 2009 Start of U2 subway construction
- 2010 1st Environmental Impact Assessment and Zoning Plan
- 2012 1st developer competition housing/educational clusters
- 2012 Opening of "aspern IQ" - first building in Aspern
- 2013 Opening of U2 Subway Line
- 2014 Opening of the first housing object in Aspern
- 2015 Commissioning of the educational campus
- 2014/15 Completion of the first residential area
- 2015 2nd Environmental Impact Assessment and Zoning Plan
- 2016: Hoerbiger with 600 employees

ISSUES AND CHALLENGES

One of the main challenges in aspern Seestadt development is the timely integration between energy planning and urban planning concepts and implementation in the context of existing regulatory and legal framework conditions [2].

The success of aspern Seestadt development is depending on a close collaboration between diverse stakeholders. Stakeholders include various departments of the City Municipality, wien 3420 - aspern development agency, private developers, civil engineers, infrastructure providers, architects, research organisations, residents, etc. Communication, coordination and alignment of partially conflicting interests in the planning setting are challenging.

The challenges of availability of data and information substantiating the decision making processes are also being addressed by multiple actors .

DECISION STRATEGIES

New steps have been undertaken in the creation of aspern Seestadt District, which is beyond the standardized decision making processes typical in the development of urban land in Vienna [2]. Above all, the integration of interdisciplinary partners in different projects concerning aspern Seestadt enabled the process of innovation and provided a platform for a variety of testing possibilities. Numerous research projects have influenced the decision making processes in aspern Seestadt, including projects supported by Austrian and European funding. Some of the projects are listed below:

- Nachaspern, Energie der Zukunft (Energy of the Future)[3]
- SUN power City [4]
- TRANSFORM+ [5]
- aspern Seestadt-Smart urban lab in EU FP7 TRANSFORM [6]

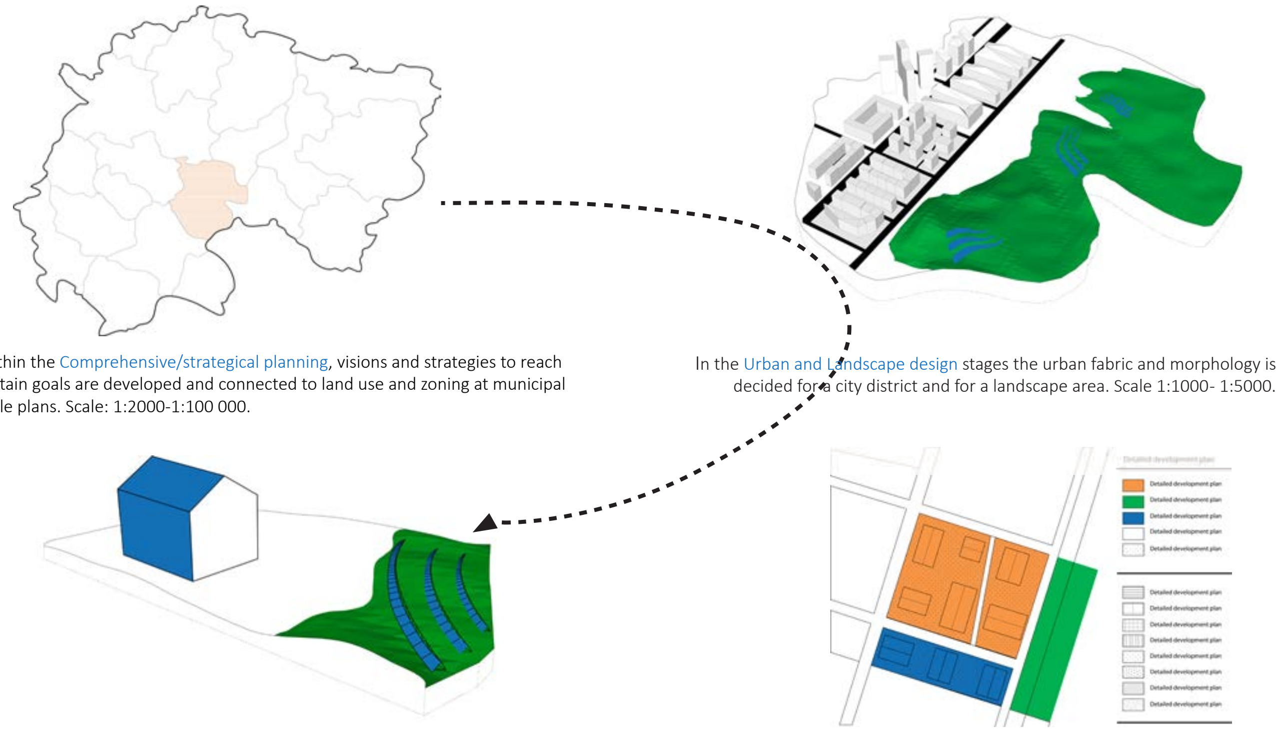
References: [2] Landesrecht Wien: Gesamte Rechtsvorschrift für Bauordnung für Wien, Version 07.06.2016; [3] C. Nutz, P. Hinterkörner, Nachhaltiger Stadtteil "Aspern", Berichte aus Energie- und Umweltforschung
[4] F. Tragner et al, SUN power City, Blue Globe Report – Klima- und Energiefonds; [5] http://www.transform-plus.at/ ; [6] http://urbantransform.eu/

THE PLANNING PROCESS

"Sustainability in urban planning is about long term respect for changing ways of living, respect for basic human needs and for the integration into the context. Creation of a new community must reflect and cater for changes over short and long periods of time, it needs to be precise as to the goals and aspirations on the one hand, to retain flexibility and stay open-minded on the other"

Johannes Tovatt, Tovatt Architects & Planners, Winners of the Competition for the aspern Seestadt Masterplan [7].

aspern Seestadt development follows the overall goals of the city of Vienna in compliance with urban development plans STEP 2005 [8] and STEP 2025 [9] as well as Smart City Vienna Framework Strategy [10]. In this context, the logic of aspern Seestadt development is based on the main principles of integrated, sustainable urban development including the dimensions: compact city, energy and resource efficiency, spatial and functional quality and diversity, high level of connectivity, provision of qualitative public spaces, as well as co-creation with the local people. Integration of renewable energy, including solar, is taken into account as part of a resource and energy concept.



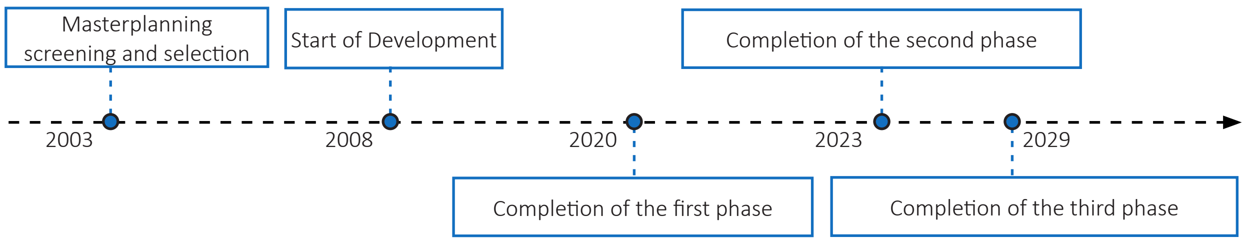
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [7] Vision + Wirklichkeit. Die Instrumente des Städtebaus (2011); Ein aspern Sesstadt Citylab Report-2 , p.139; [8] www.wien.gv.at; [9] www.wien.gv.at; [10] smartcity.wien.gv.at

aspern Seestadt development is a long term undertaking, which will be implemented in three phases: 1) 2009 – 2020; 2) 2017 – 2023; 3) 2024 – 2029.

Two main forces drive the development of aspern Seestadt.

Firstly, Vienna is a growing city with a high demand for quality housing.

Secondly, creation of new workplaces and accommodation of changing life styles require affordable places in the city, which are becoming ever more limited within existing built fabric. In this context, aspern Seestadt development is planned to accommodate 20.000 residents and approximately the same number of jobs by the time of completion in the year 2029.

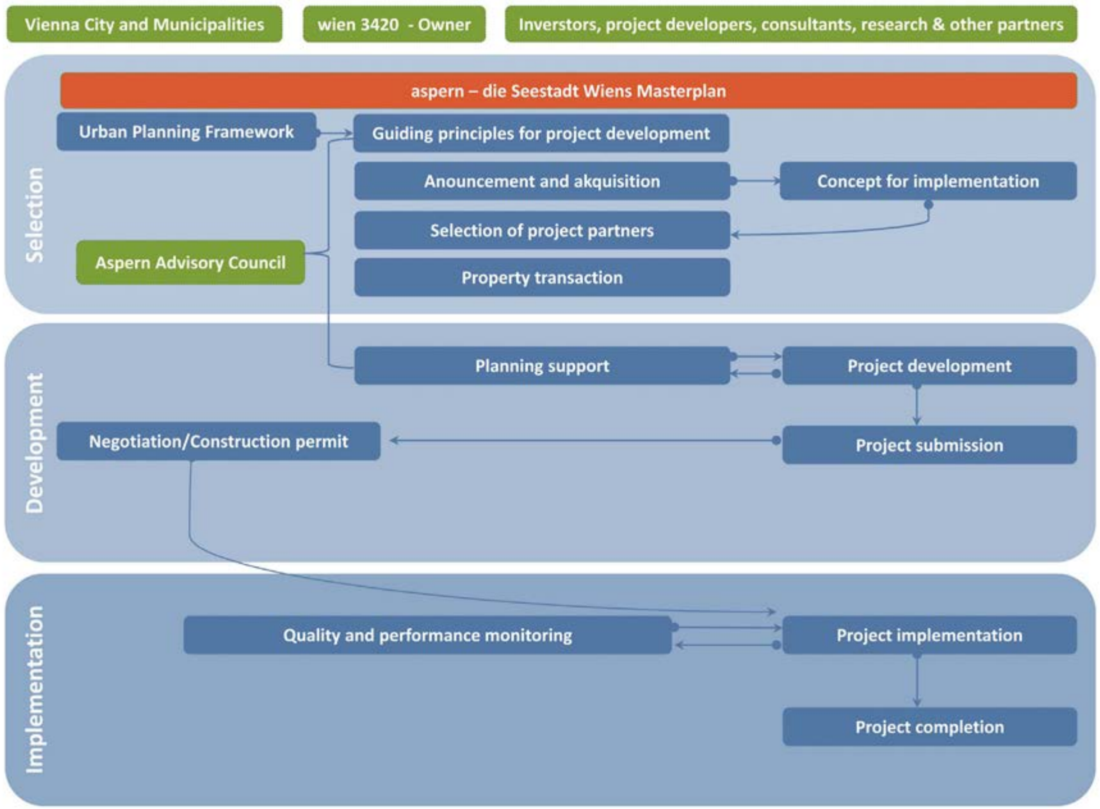


Figure 5 - The Process of Aspern Development. (Source: [7] Translation from German in English by Daiva Jakutyte-Walangitang, AIT)

References: [7] Vision + Wirklichkeit. Die Instrumente des Städtebaus (2011); Ein aspern Sesstadt Citylab Report-2 , p.139; [8] www.wien.gv.at; [9] www.wien.gv.at; [10] smartcity.wien.gv.at

Figure 6 - Sustainbability in urban development. (Source: Wien 3420 Aspern Development AG)

Figure 7 - Aspern IQ - first building in aspern Seestadt . (Photo: ©Daiva Jakutyte-Walangitang)

SUMMARY

The development of energy concept for aspern Seestadt evolved through numerous phases. A range of studies and analyses have been performed in different research activities and other related projects. This process delivered different scenarios for optional energy concepts. One example of important steps undertaken is the specification of sustainability criteria for different building blocks within the development. This included quantitative and qualitative criteria focusing on the energy efficiency and energy generation (including energy from renewables). Stakeholders involved in this process were different Municipal Departments of Vienna city, wien 3420 - aspern development agency, Wien Energie - energy service company, Wiener Netze - energy infrastructure utility, Wiener Linien – public transport provider, Aspern Smart City Research, etc.

TECHNOLOGY STRATEGY

A range of technologies and approaches have been applied and planned for the future application, which match the complexity and the size of the development. Complexity is reflected in the way each building block is being treated in consideration of its specifics. Such specifics consider the great variety of property owners who will inhabit the area in terms of needs and requirements related to different uses as a single technology or application cannot be prescribed for the entire district.

Maximum possible and feasible PV and Solar Thermal installations are being encouraged and subsidized in the entire area. A good example of a specific PV application in aspern Seestadt is the Aspern IQ building [11]

ENERGY SYSTEM

Spatial design that ensures a high quality urban environment and high level of connectivity, following of the principles of a compact city, has a priority in aspern Seestadt. The energy related aspects in physical shaping of the district are taken into account. A range of energy demand and energy generation simulations have been performed on the scale of the entire aspern Seestadt. In addition, overshadowing simulations have been conducted. The overall energy demand of the district is highly dependent on multiple factors, such as the quality of constructed buildings. It is difficult and of little use to fix the energy demand of the expected number of buildings to a single number. Therefore, areas available for the installation of PV and solar thermal versus the use of green roofs and other technical installations, etc.are being decided in ongoing phases of planning and implementation.

References: [7] Vision + Wirklichkeit. Die Instrumente des Städtebaus (2011); [11] http://www.asperniq.at/

Environmental, economic and social impacts

Figure 8 - Aspern under construction (Photo: ©Daiva Jakutyte-Walangitang)


Figure 9 - Aspern development around the lake (Photo:©Daiva Jakutyte-Walangitang)


Figure 10 - Public space in Aspern (Photo: ©Daiva Jakutyte-Walangitang)

ENVIRONMENTAL IMPACT

Three Environmental Impact Assessments (EIA) have been conducted for aspern Seestadt: the first – strategic EIA - was conducted in the year 2003, the second in year 2010 and the third in year 2015. The overall development is being implemented in accordance with the guiding principles outlined in the final EIA. The EIA for aspern Seestadt covers the following dimensions:

- Human, animal and plant habitat;
- Soil, water, air and climate;
- Landscape;
- Property and cultural assets

A set of conditions and measures have been outlined in the EIA for the entire development of aspern Seestadt. Maximum possible and feasible energy efficiency and preservation of ressources in aspern Seestadt form an important segment in the EIA.

ECONOMIC IMPACT

The main aims of aspern Seestadt development are to provide Vienna's citizens with high quality, environmentally friendly and affordable urban housing and additional jobs. Fulfilling these objectives would present the greatest economic impact that a project can deliver. Sustainability (including economic sustainability) in aspern Seestadt is being implemented from a holistic point of view. In addition to the provision of social and affordable housing, a variety of urban lab activities are being continuously tested in aspern Seestadt. In this context, local people are involved in collective urban gardening, local resource preservation, co-development of innovative mobility concepts, organisation of food coops and local markets. All of these activities ensure the strengthening of the local micro-economy taking the overall idea of sustainability beyond technological development.

SOCIAL IMPACT

'Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody.' Jane Jacobs

A range of co-creation and participation programs were organized in aspern Seestadt. At the start of aspern Seestadt development, a variety of participatory activities were organized on topics of public space, landscape, resource preservation and the meaning of sustainable human habitat. Ceative methods were applied to activate the synergetic capacities, lying in the integration of future residents, experts, artists, public actors, politicians and stakeholders. The first residents have already inhabited the completed sections of aspern Seestadt South. A local community network was established to generate a vibrant exchange and collaboration between local residents and authorities [12].

References: [12] http://meine.seestadt.info/seestadtinitiativen/

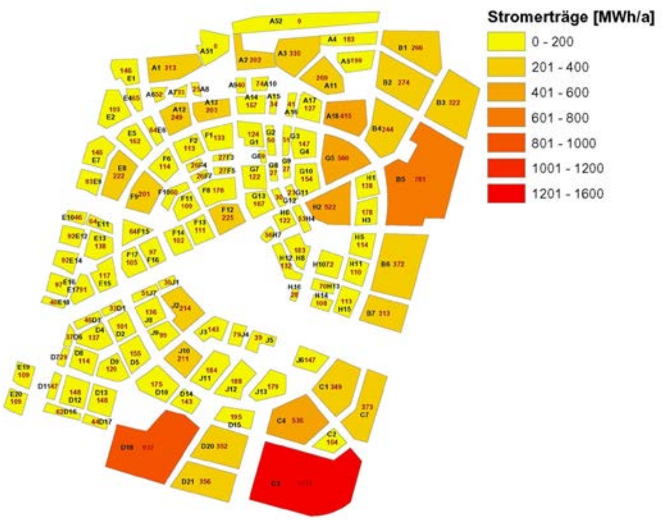


Figure 11 - Study of potentials for roof Solar PV.
(Source: Austrian Institute of Technology - AIT)

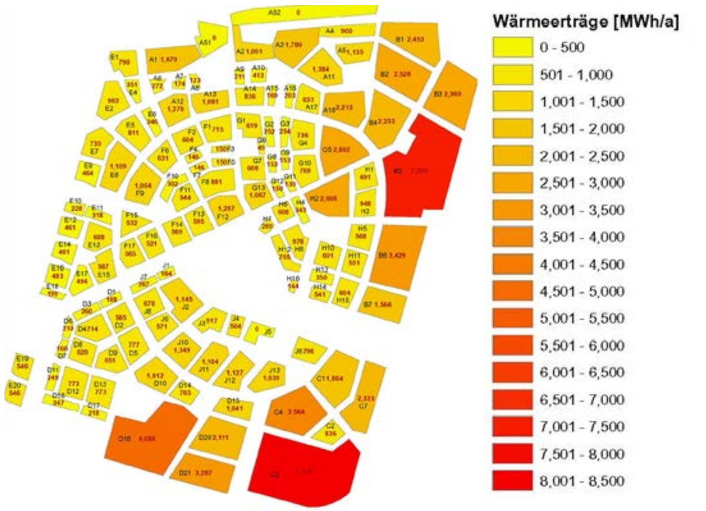


Figure 12 - Study of potentials for roof Solar Thermal installations.
(Source: Austrian Institute of Technology - AIT)

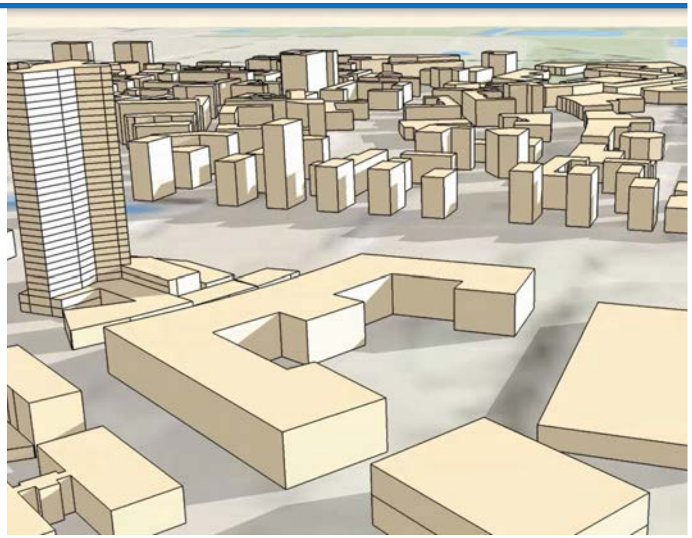


Figure 13 - Overshadowing simulation for aspern Seestadt Masterplan.
(Source: ©Austrian Institute of Technology - AIT)

INTEGRATION BETWEEN URBAN AND ENERGY PLANNING

A variety of approaches and methods were applied in urban and energy planning on the scale of entire aspern Seestadt district:

- Environmental Impact Assessment
- Zoning
- Development of an Environmental Concept
- Development of Energy Concept and environmental criteria catalogue
- Integration of energy efficiency goals in the overall environmental concept
- Modelling of heat supply (connecting to district heating)
- Modelling of district cooling supply in selected areas
- Simulation of the PV potential
- Simulation of ST potential

References: [5] http://www.transform-plus.at/ ; [6] http://urbantransform.eu/

During the projects Transform+ [5] and TRANSFORM [6] an ‘aspern Seestadt energy group’ was set up, consisting of experts in energy and urban planning, city authorities, the aspern Seestadt development agency and energy utility/supplier. This group of experts has elaborated on the most recent Smart City scenario for aspern Seestadt North. This scenario follows the Swiss Vision of 2 000 Watt-society (corresponding with the goal of 17 500 kWh primary overall energy consumption per capita). One of the key integral goals of this concept is to cover the greatest possible amount of energy demand in a district through energy generation from local renewable energy sources. However, in order to achieve this, the primary focus is shifted to energy efficiency measures, such as ensuring low/passive energy building standards and connecting large sections of the district to district heating network, etc.

IN RELATION TO THE SCALE

Exploitation of the local renewable sources, including geothermal, solar thermal and photovoltaics is a central topic in aspern Seestadt. On the scale of the entire district a set of simulation were performed considering the values of solar irradiation as well as overshadowing effect during the year. aspern Seestadt is being developed and implemented in three stages. On the scale of each stage of development and implementation, additional analyses were conducted. The goal of these studies was finding most convincing energy concepts for each development stage. Each project phase stretches over many years. During this time the available technologies and methods of application advances and the relevant concepts have to be adapted accordingly. In such circumstances, the planning processes as well as methods have to remain flexible and adjustable to the changing needs.

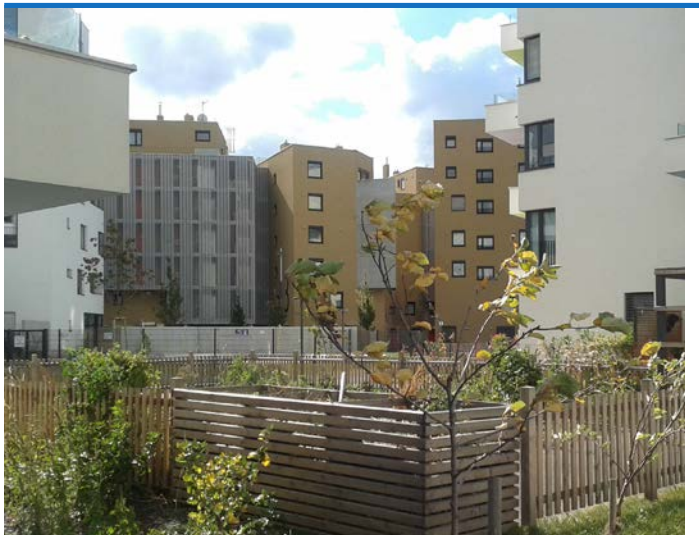


Figure 14 - "Urban gardening" is an essential part of aspern+ development (Photo: ©Daiva Jakutyte-Walangitang)

Figure 15 - One of the main streets in aspern+ development (Photo: ©Daiva Jakutyte-Walangitang)

LESSONS LEARNED

aspern Seestadt is an ongoing development, which will be completed by the year 2029. The lessons learned will continue to evolve together with the projects. The essential lessons learned at present is the importance of the involvement of all the relevant stakeholders representing urban as well as energy planning. This integration is most useful, if started at an early stage of the development. In order to be able to embed innovative concepts from research into reality, open-mindedness is important on both sides: research and urban planning and implementation.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

Stakeholders such as utility companies, energy suppliers, developers, civil engineers, relevant municipal departments, experts, etc who drive decisions on urban planning, must be involved early in the process. Applying an Urban Lab setting and a methodology that include citizens as co-developers and not only 'consumers' to generate and test new solutions provides added value and long term co-ownership. This approach reaches beyond the provision of data and tools. It enables truly innovative and interdisciplinary methods for integration of new approaches and technologies.

TARGET GROUPS

- Urban planners
- Academia/Research
- Engineers/Architects
- Technology providers

PUBLIC AND EDUCATION ACTIVITIES

Several culture and social events, such as the exhibition 'Wien in Arbeit' have been organized in aspern Urban Lakeside.

(Photo: © Daiva Jakutyte-Walangitang)

DEVELOPMENT AGENCY

Wien 3420 aspern development AG

OWNERS

Wien 3420 aspern development AG, die GELUP GmbH, VIENNA INSURANCE GROUP, Bausparkasse der österreichischen Sparkassen Aktiengesellschaft, Die Bundesimmobiliengesellschaft BIG.

STAKEHOLDERS

Numerous stakeholders. Vienna City and various Municipal Departments, Wien Stadtwerke- Vienna Utility Companies, ASCR- Aspern Smart City Research and other research organisations, companies, consultants, etc. have been involved in the research, development and implementation activities in aspern+ Vienna's Urban Lakeside.

CASE STUDY AUTHORS

Daiva Jakutyte – Walangitang, Austrian Institute of Technology (AIT)

ACKNOWLEDGEMENTS

The authors wish to thank all the partners in Transform+ and TRANSFORM project and the aspern Energy Group.

RESEARCH ORGANIZATIONS

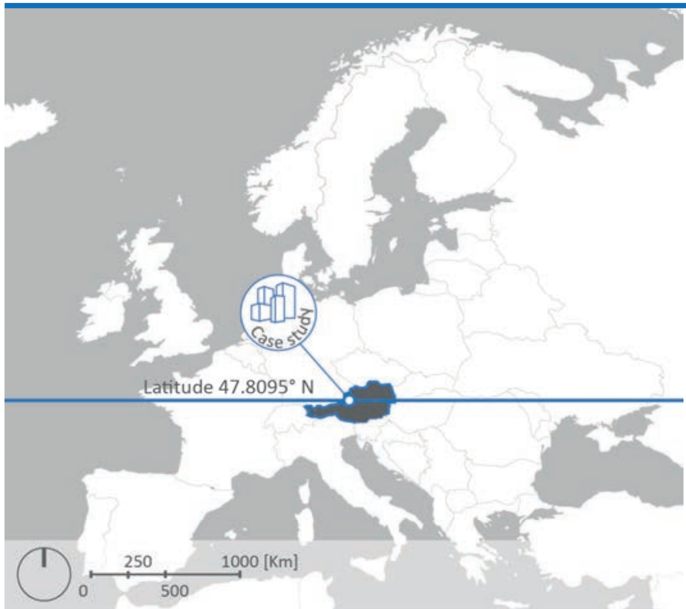
FUNDING ORGANIZATIONS

Photo: © Fotohof Phelps

STADTWERK LEHEN

AUSTRIA

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Austria
Location: Salzburg (Lat. 47°80′95″N; Lon. 13°03′11″E)
Climate: Cfb (C: warm temperature, f:fully humid, b:warm summer) [1]

AREA OF INTEREST

Legislation and technology

NATIONAL AND LOCAL CONTEXT

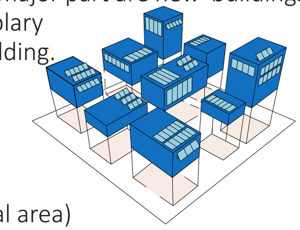
During planning and construction of the project starting in 2006, several national and local regulations have been effective. Following these regulations and also to fulfil own requirements, the energy system should mainly use renewable energy. To achieve this objective, there were two main pillars:

- High efficient buildings (building envelope, high efficiency of electricity consumers)
- Extended use of thermal solar power and photovoltaic

Moreover, a preferable high approach of different aspects in energy efficiency and sustainability (such as ecology, social aspects, mobility and the planning of free spaces) has been implicate in all considerations.[2]

ABOUT THE CASE STUDY

Stadtwerk Lehen is a masterplan to increase living quality in Lehen, a district of Salzburg with about 15 000 inhabitants. The district was changed essentially. On the former area of the local energy supply company about 300 apartments, a kindergarten, a student hostel and other accomplishing usage have been established. A science and technology park has been erected in the southern part of the site. The major part are new buildings, the project includes also an exemplary renovation of a high rise office building.



Definition of environment:
New Urban Areas
Site area: 43 000 m^2
Built site area: 27 000 m^2
Areas density: 0.45 (Built area/total area)

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Blachfellner, W.; Padutsch, J. (2010). Vorwörter, StadtUMBAU Lehen, p. 4

Issues, challenges and decision strategies

Figure 1 - Heat storage (200.000 l) during construction. (Photo: ©SIR Strassl)

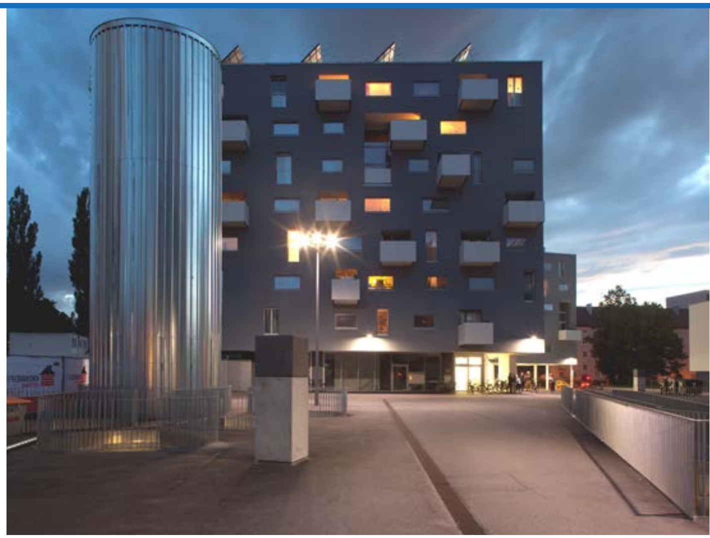


Figure 2 - Heat storage as a landmark of the central boulevard. (Photo: ©Fotohof Phelps)

Figure 3 - Residential building with 2.000 m² of solar thermal collectors and 50 kWp PV on the roofs. (Photo: ©Fotohof Phelps)

HIGHLIGHTS OF THE CASE STUDY

Outstanding features of Stadtwerk Lehen are [3]:

- Accompanied by a socio-cultural process with integration of local population and economy.
- Implementation of an "urban pedestal area" as central component of a vital, multi-use city district.
- A transparent process to realize a socially differentiated, integrated neighborhood was moderated.
- Neighborhood management as a social spatial tool for successfully implementing integrated urban development
- Big solar thermal system with 2.000 m² collector combined with improved buffer technology (200 000 l) [4].
- Integration of a renovation area into energy concept for solar summer surplus.

ISSUES AND CHALLENGES

The innovation process in the project Stadtwerk Lehen was mainly focused on two strategic aspects:

- The socio-cultural aspects found consideration in a wide range of information and public relation activities in order to communicate the ambitious purposes to the present population of the city district. Continuative new inhabitants of Stadtwerke Lehen should be well integrated into the existing environment.
- The project shows how solar buildings with high solar fraction can be realized without large seasonal storage due to an innovative overall concept.

DECISION STRATEGIES

The challenge in this project was to increase the energy efficiency of the buildings and to integrate as much solar energy in an area with existing district heating system. The partners in the project (city of Salzburg, housing associations, energy supply company and SIR as scientific partner) decided a quality agreement at the beginning to fix the targets and milestones. This was the base for the whole process. External simulation and monitoring was performed by Steinbeis Institute, which was funded by the EU program Concerto "Green Solar Cities".

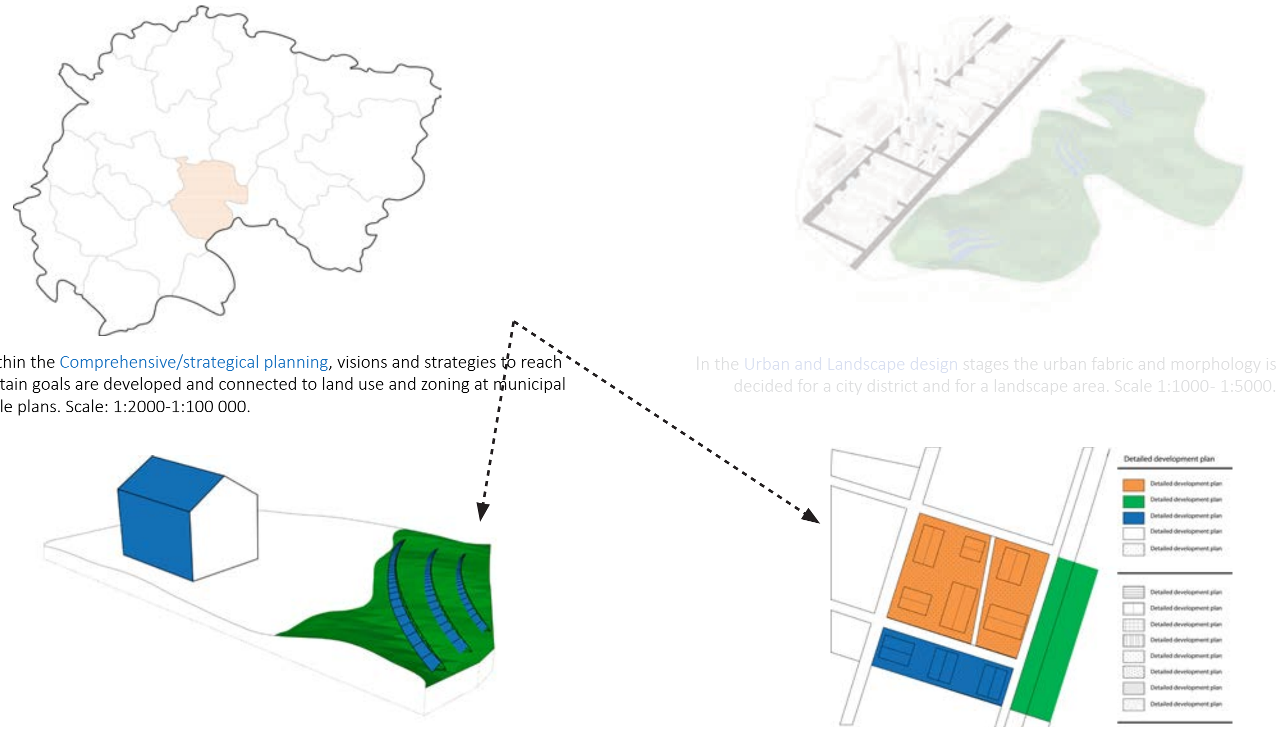
References: [3] Klock, E.-M.; Gutman, R.; Untner, S. (2013). Modernes Wohnen auf dem Stadtwerke Areal, Folder Stadtwerk Lehen, pp 10-11.
[4] Strassl, I. (2013). Green Solar Cities. Project implementation in Salzburg finalised, Deliverable 5.3, Report on local Building Process Preparation in Salzburg.

The planning process

The key project "Stadtumbau Lehen" ("urban consolidation Lehen") coordinates several projects at the urban district of Lehen. Numerous activities in the district have the goal to renew the district and to create a sustainable and attractive living environment. Especially sustainable and energy-related aspects are pursued intensively. Starting in 2004 a workshop-based process resulted in a masterplan including two urban development projects (on former industrial area and former football stadium) and three major renovation projects. The first phase of realization started in 2009, the last buildings of Stadtwerk Lehen were finished in 2013 [5].

Led by the municipality of Salzburg, the energy supplier Salzburg AG and the scientific institutions SIR and Steinbeis, the masterplan for the whole district was generated. Those organizations were also responsible for the overall concept of the project Stadtwerk Lehen. Divided into several project phases and areas, four different developers (three of them as public utility housing enterprises) together with ten teams of architects were put in charge of finally erecting the buildings [6].

Due to its mobility concept with high attractive public means of transportation for residents, staff and visitors of Stadtwerk Lehen it is a perfect opportunity to rethink the mobility habits and switch to public transport. The high favorable location in terms of transportation was displayed very early to direct as many ways as possible to public transport, bicycle and pedestrian traffic. A specially developed "Welcome Package" of the local transportation company included extensive information on schedules and fares, and even a free weekly card to test the environmentally friendly public transportation network [7].



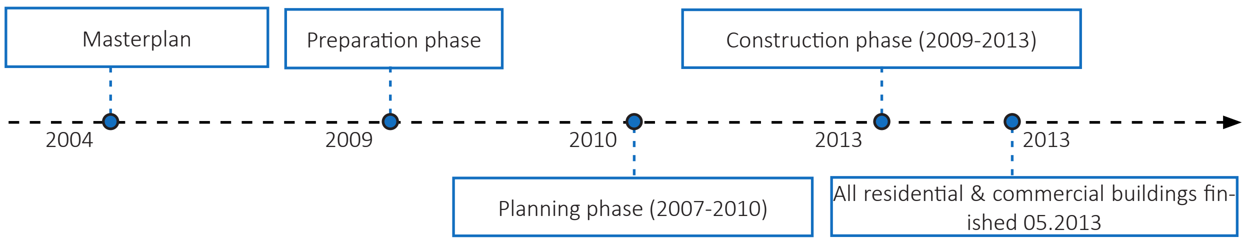
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [5] Strasser, H.; Dorfinger, M.; Mahler, B. (2012). Stadtwerk: Lehen – Solar energy in urban community in City of Salzburg, Austria, Energy Procedia 30, pp 866-874. [6] Klock, E.-M.; Straßl, I. (2013). Qualitätssicherung: Steuerungs gruppe – Qualitätsvereinbarung Thermografie, Folder Stadtwerk Lehen, pp 24-25. [7] Weiß, A. (2013). Mobilitätsmanagement, Folder Stadtwerk Lehen, p 26.

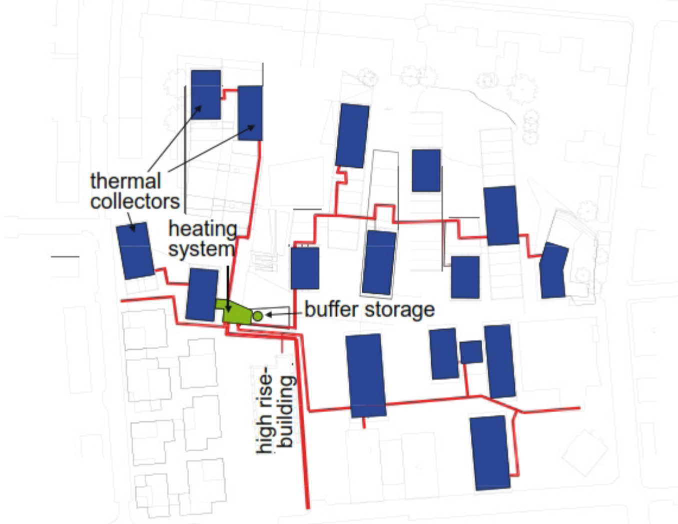


Figure 5 - Overview of the thermal supply network (mirco net) in combination with solar thermal collectors. (Source: [9])

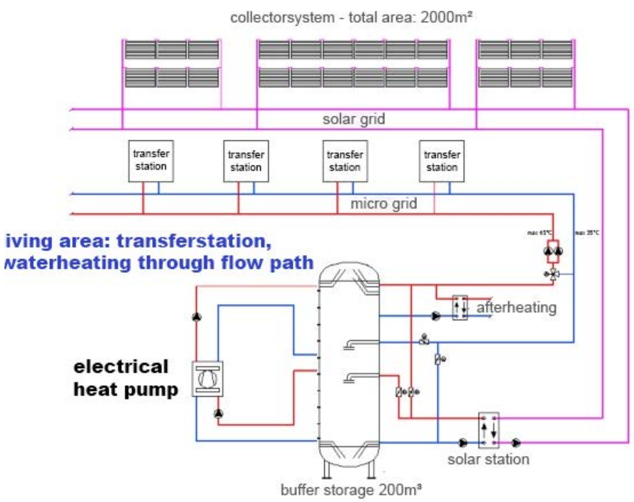


Figure 6 - Scheme of the solar-thermal heating system. (Source: [9])

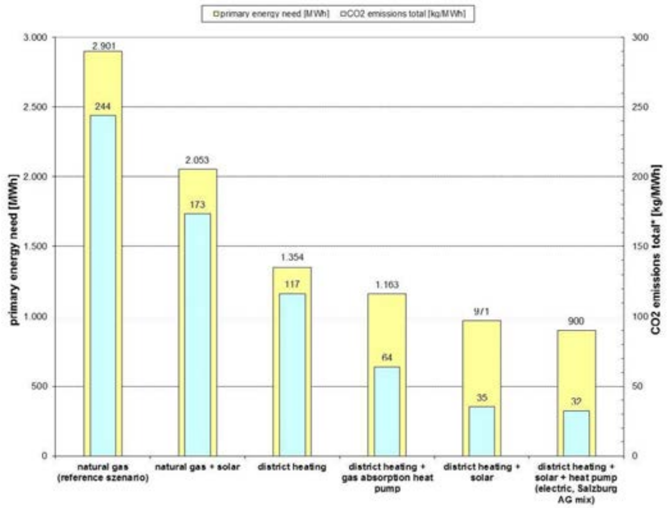


Figure 7 - Diagram with primary energy need and CO2-emissions of several planning variants. (Source: [5])

SUMMARY

The main objective of the energy concept was the development of an integrated and optimized system with low emissions and high cost efficiency. The existing district heating system – loaded mainly with industrial waste heat – was declared as the base system. To achieve low emissions a combination of a high efficient building envelope (close to passive house standard) and a big solar thermal system was planned. To avoid installation of very cost-intensive long-term storages it was decided to combine a medium-sized buffer storage with a heat pump to increase solar ratio. Due to the consequent implementation of a micro net with low system temperatures it was possible to increase solar gains. Additionally, a PV-system provides energy for the heat pump [8] .

INTEGRATED THERMAL SYSTEM

The challenging goals concerning the thermal energy system were to achieve a solar ratio of at least 30 % and a solar output of the collectors of more than 400 kWh/m². Such a combination of high solar ratio and high specific collector output is very hard to fulfil without a very expensive seasonal storage due to oversizing in summer. To reach this goal with 2.000 m² of flat plate collectors and a buffer storage with a volume of 200.000 l, it was necessary to increase the share of domestic hot water on total thermal energy demand. By reducing heating demand of residential and office buildings to less than 20 kWh/m².y the share of domestic hot water got dominating. Additionally, the solar summer surplus is used for the new heating and hot water of a renovated residential area beside [8].

THERMAL COLLECTORS & SOLAR HEAT PUMP

To provide solar thermal energy with useable temperatures, a solar heat pump was included into the central heating system. The heat pump's evaporator reduces temperatures in low layers of the stratified storage and raises higher levels to supply temperature of 65 °C (return temperature 35 °C). Due to reduced temperatures at the bottom of the storage, energy of solar thermal collectors can be used also at very low temperatures. Thus it was possible to increase the solar output of the collectors to planning values of 423 kWh/m² [9]. Measurements since 2013 are showing even better results for the solar thermal system: The specific solar output grew to annually 499 kWh/m². The results concerning heating demand of the buildings show an increase of about 24 % compared to estimated values. The reasons for this increase could be caused by higher room-temperatures. [9, 10].

References: [8] Dorfinger, N. (2013). Energieversorung und thermische Großsolaranlage, Folder Stadtwerk Lehen, pp 18-18. [9] Mahler, B. (2010). Solarenergie für städtische Lösungen, StadtUMBAU Lehen, p 5.
[10] Strasser, H. (2015). Implementation of Energy Strategies in Communities-From Pilot Project in Salzburg, Austria, to Urban Strategy, ASHRAE Transactions 121, pp 176-184.

Figure 8 - Central role of free space concept in the whole district of Lehen and especially in Stadtwerk Lehen. 287 apartments and a kindergarten. (Photo: ©SIR Strassl)

Figure 9 - Funded by means of European Union and national ministries an outstanding energy concept was established. (Photo: ©Fotohof Phelps)

Figure 10 - Cooperative neighbourhood management as a hub for district marketing and public information. (Photo: ©Verein Stadtwerk)

ENVIRONMENTAL IMPACT

One of the main goals of the project was the integration of a superior energy concept based on solar thermal collectors and renewable district heating system for high efficient buildings. The overall primary energy demand for heating and domestic hot water was reduced to 900 MWh/a and CO_2- emissions were decreased to 64 g/kWh. This meant a reduction of 68 % (primary energy demand) respectively 76 % (CO_2- emissions) compared to oil-heated systems [8]. The formation of a free space concept came to a central role in project development for Stadtwerk Lehen from the early phases. In the masterplan-studies of architect Max Rieder in 2004, which lay path for the urban and architectural design competitions, the new city district was connected via prominent space corridors to the surrounding urban areas and abolished the insularity of the former gasworks area.[11].

ECONOMIC IMPACT

Stadtwerk Lehen is one part of the project “Green Solar Cities” funded by means of the European Union in the Concerto program with focus on optimization and long-term improvement of energy systems. “Green Solar Cities” is a partner-project of the districts Lehen in Salzburg and Valby in Copenhagen. Projects and accompanying research activities in Salzburg were funded with 2.3 million €. The total investment into the erection of 14 buildings with a built building volume of 180.000 m³ was 48 million € [12].

Additionally, outstanding innovation-topics of the project such as the solar thermal system, neighborhood management concept and exemplary renovation of a high rise office building were bundled to a key project funded by Austrian Ministry for Transport, Innovation and Technology in the program “building of tomorrow” (Haus der Zukunft Plus) [13]

SOCIAL IMPACT

A special feature of Stadtwerk Lehen is the social organizational support through a cooperative neighbourhood management, which serves as a hub for district marketing and public information, and for developing participation, networks and cooperation. The central task of management is to develop the residential and urban qualities in the area and in the adjacent district through social and organizational measures and crosslinking activity. The needs and resources of long-established and “new” residents will be equally considered and developed through offers for participation. Four measures are emphasized:

- “infopoint” as a hub
- interactive (online) public information
- development of “urban pedestal area”
- moderated occupancy process [14]

References: [11] Proksch, T. (2013). Freiraumentwicklung Stadtwerk Lehen, Folder Stadtwerk Lehen, pp 22-23.; [12] Straßl, I. (2013). Concerto – Ziele Energetisches Konzept, Folder Stadtwerk Lehen, pp 16-17.
[13] Dankl, C. (2010). Haus der Zukunft Plus – auf dem Weg zum Gebäude der Zukunft, StadtUMBAU Lehen, p 4.; [14] Gutman, R.; Untner, S. (2013). Kooperatives Quartiersmanagement, Folder Stadtwerk Lehen, pp 12-13.

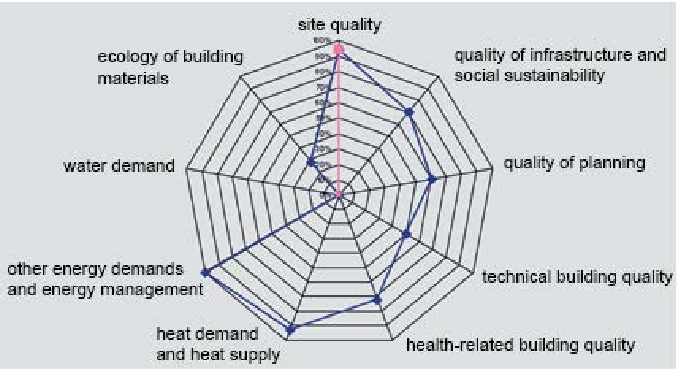


Figure 11 - Checklist for pioneering housing construction. (Source: [6])

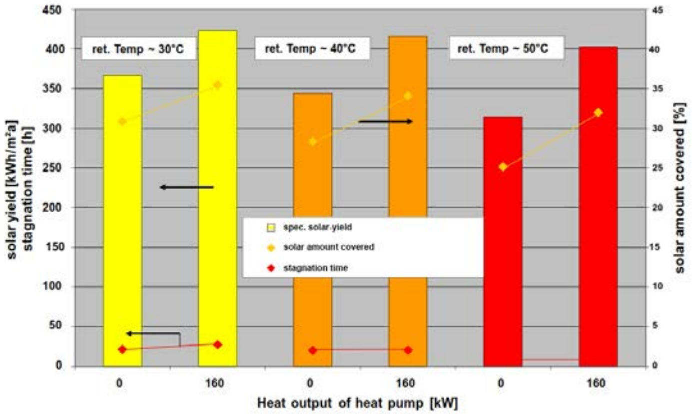


Figure 12 - Influence of return temperature as a result of detailed simulation. (Source: [5])

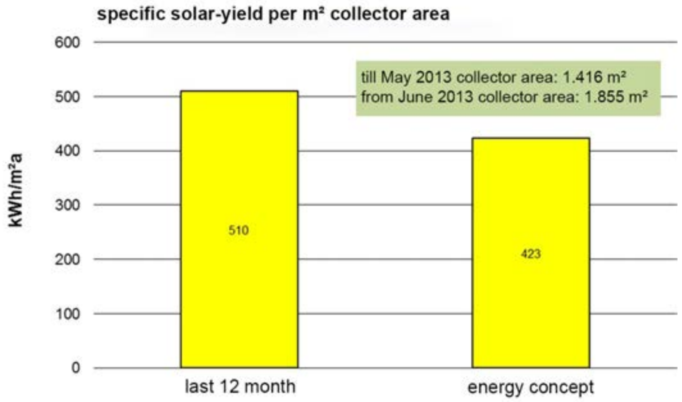


Figure 13- Monitoring results of specific solar gains. (Source: [15])

QUALITY ASSURANCE

A "high quality agreement" was signed as tool of quality assurance by all involved parties in order to guarantee a coordinated cooperation. The quality assurance includes with ambitious quality goals concerning energy efficiency, renewable energy, ecology, mobility and social factors. Thermal standards for the buildings and requirements derived from energy concept as described above were integrated [6]. A steering group of leaders of key actors was installed to monitor the fulfilment of quality agreement. The steering group has monthly meetings and is chaired by the city of Salzburg. In addition to the steering group two working groups were established for the main issues of the project, the energy concept and the renovation. Within this group it was possible to solve major problems during the process in a simple manner. This included all administrative procedures such as individual development plans, building site observations or coordination of building permits. During the implementation phase of the projects, there are a variety of procedures to coordinate and accordingly, the steering group performed its task until almost 300 apartments were ready for occupation. Due to its overwhelming success, meanwhile this kind of participation process is established as a standard in Salzburg [6].

A "checklist for pioneering housing construction" ("Checkliste für zukunftsweisenden Wohnbau) created by the municipality of Salzburg was used to review Stadtwerk Lehen in terms of sustainability (figure 13). The checklist intends to make sustainability in housing applicable by displaying the different dimensions (social, technical, economical) simply and clearly [6].

IN RELATION TO THE SCALE

Based on the heat-supply concept (Figure 11) detailed simulation were done in order to optimize the whole system. Several scenarios varying planning parameters such as assumptions of heating demand because of different time-tables of planning, sizes and types of collector field, storage tank and heat-pump, return temperature of micro-net were calculated.

As an example figure 9 shows the influence of the return temperature of the micro-net on the collector yield. It is evident, that return temperature has generally a high influence on efficiency of the system, due to lower efficiency of solar system and lower capacity of storage tank. By using a heat pump the influence of return temperature on solar yield can be reduced.

References: [15] Guigas, M.; Rieger, U. (2016). Abschlussbericht für das Monitoring der Anlage Stadt:Werk:Lehen, EGS-plan, Stand 11.01.2016

INTELLIGENT E-MONITORING CONCEPT

A monitoring for the whole system (solar, district heating, micro-net; including 300 measuring points) was installed as well as a monitoring system with different types of feedback for selected apartments. The monitored measures of energy balance data will help evaluate how well the project goals, such as specific heat demand and solar fraction, have been met. Monitoring results show that in 2014 specific solar gains of more than 500 kWh/m² were reached, which are about 18% higher than expected values of 450 kWh/m² (figure 10). The total solar fraction is about 28 %, even though the residential units achieve a solar fraction of 42 %. In summer months, the solar fraction is almost 100%. However, monitoring also showed that heat demand of apartments is 29 % higher than expected. [5, 10].

78 units of all new dwellings have been equipped with smart meters and integrated in the project as test dwellings. Tenants have been informed about the project and its targets from the beginning and intensively counselled during the whole period of the research project by a 24-h-serviceline, personal energy advise and feedback discussions. By different test groups potential barriers resp. incentives for the use of monitoring tools should have been evaluated. [16, 17]

RESULTS AND DISCUSSION

The creation of a quality agreement at the beginning of a large project has proved successful. Certain objectives and issues are formulated clearly and with an increased liability. Technical target values and clearly defined objectives can be implemented more easily than “soft” targets (social) [6].

The steering group has been very successful. Because of the regular meetings, all parties had the same information level and in the joint discussion it was possible to well-prepare necessary decisions [6].

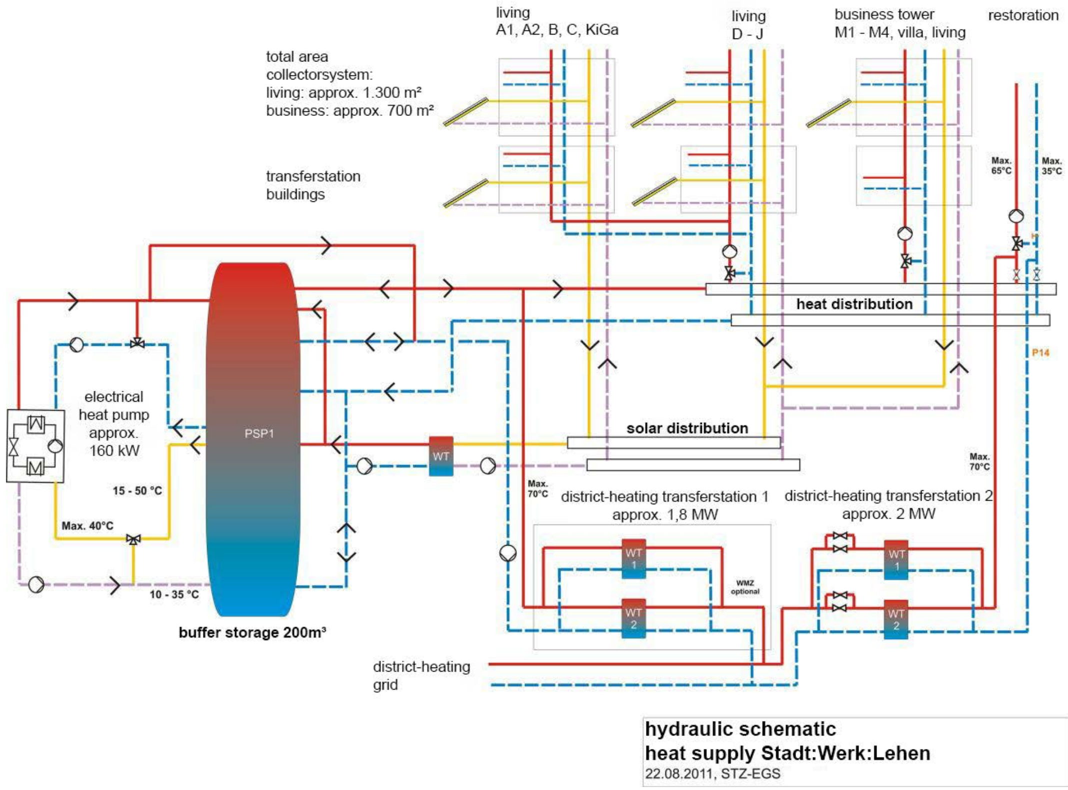


Figure 14 - Hydraulic scheme thermal heating system. (Source: [5])

References: [16] Meisl, H. (2010). Intelligentes e-Monitoring, StadtUMBAU Lehen, p 8.
[17] Lüftenegger, E.-K. (SIR) (2013). Subprojekt 3: Demonstrationsprojekt – Intelligentes E-Monitoring, project report.

LESSONS LEARNED AND RECOMMENDATIONS

Figure 15 - New dwellings in the district Stadtwerk Lehen. (Photo: ©Fotohof Phelps)

Figure 16 - Common activities like "Herbstfest 2012" are essential elements of a cooperative neighbourhood management process. (Photo: ©SIR Strassl)

Figure 17 - Visualization at buffer storage for flexible display of solar gains. (Photo: ©SIR Strassl)

LESSONS LEARNED

- Process management and quality assurance are important elements of integrated urban development projects.
- Cooperation between participants and communication to all stakeholders of the development process is vital.
- Comprehensive processes help to create win-win situations concerning communication and motivation of involved parties
- Energy efficient buildings are really sustainable for the environment and for the people living there.
- The EU-project Concerto was the "engine" for the city renewal process and led Salzburg into the status of EU-Smart City.

PUBLIC AND EDUCATION ACTIVITIES

Book: Strassl, I. (2015). Green Solar Cities: Salzburg. In: Pedersen, P.V.: Green Solar Cities, pp 110-138

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

To guarantee a successful implementation of ambitions goals concerning local energy politics it is necessary to force four main aspects [18]:

- Formulate realistic goals
- Support of the objectives of all parties
- Agreement on interdisciplinary approach
- Follow a continuous process

TARGET GROUPS

- Urban decision makers
- Municipalities and local authorities
- Urban planners, architects
- Researchers

References: [18] Strasser, H.; Pol, O. (2014). IEA Energie in Gebäuden und Kommunen Annex 51: Energieeffiziente Siedlungen, Berichte aus Energie- und Umweltforschung 48/2014.


(Photo: © SIR Strassl)

ARCHITECTS

Architekturbüro transparadiso (and others)

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DEVELOPERS

GSWB, Heimat Österreich, Prisma

STAKEHOLDERS

Stadt Salzburg

ACKNOWLEDGEMENTS

The authors wish to thank all the partners in Transform+ and TRANSFORM project and the aspern Energy Group.

RESEARCH ORGANIZATIONS

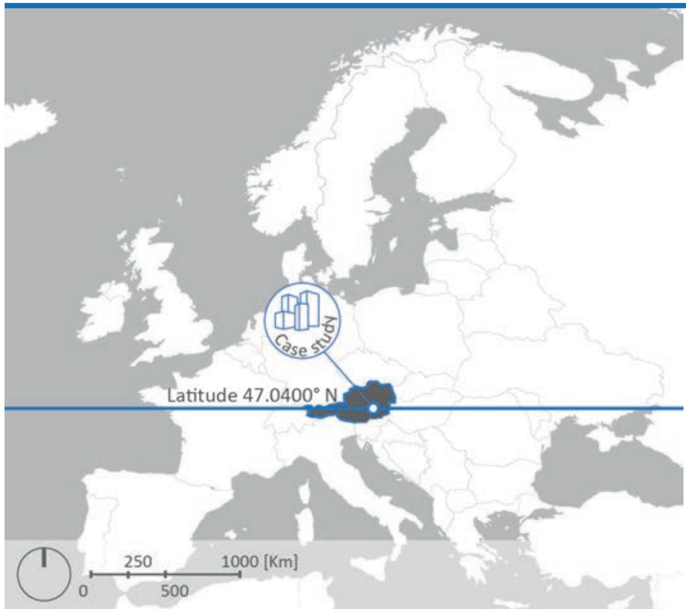
SIR

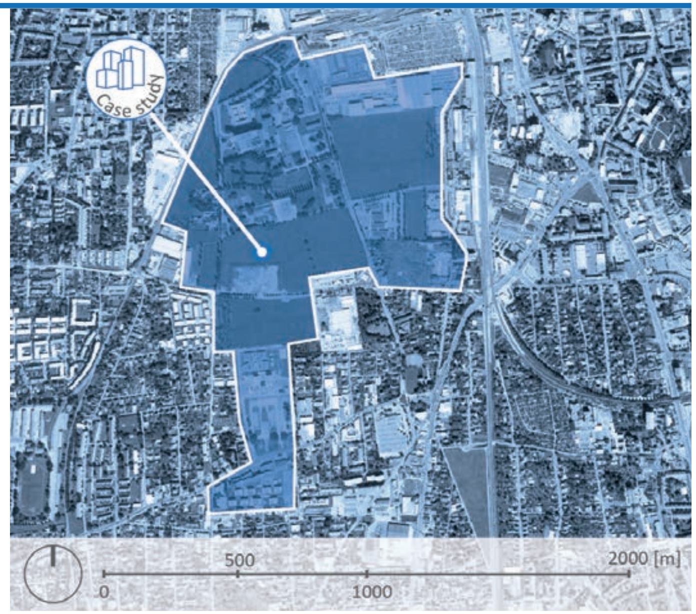
fhs Fachhochschule Salzburg University of Applied Sciences

GRAZ REININGHAUS

AUSTRIA

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Austria
Location: Graz (Lat. 47,0400°N; Lon. 15.4500°E)
Climate: Dfb (D: snow/ f: fully humid/b: warm summer) [1]

AREA OF INTEREST

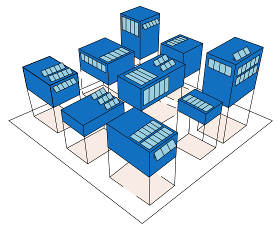
Targets and goals and Planning process

NATIONAL AND LOCAL CONTEXT

The Case Study Project "Graz Reininghaus" is located in the City of Graz, which is the capital of the Federal Province of Styria. Styria is located in the southeastern part of Austria and borders to the Republic of Slovenia. The City of Graz is currently one of the fastest growing capital cities in Austria. The demand for living space has grown rapidly in recent years and, according to future previsions, it will continue to grow in the coming decades. In this context, the upcoming major construction volumes require sophisticated growth, which has to meet the requirements of sustainability. Based on this initial position the research project "ECR Energy City Graz Reininghaus" has been developed.

ABOUT THE CASE STUDY

According to the urban standards the Reininghaus is classified as under¬developed area situated about 1 800 m from the city center of Graz. The district offers about 110 ha space and a possible full capacity for about 12 000 future inhabitants on a maximum gross floor area up to 560 000 m². Architects and other stakeholders (such as administration, politics, economy and research) variably focus on different quarters of Reininghaus should become the new city center for the western part of Graz with area density of 2.5 inhabitant/m^2



Definition of environment:
New Urban Areas

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

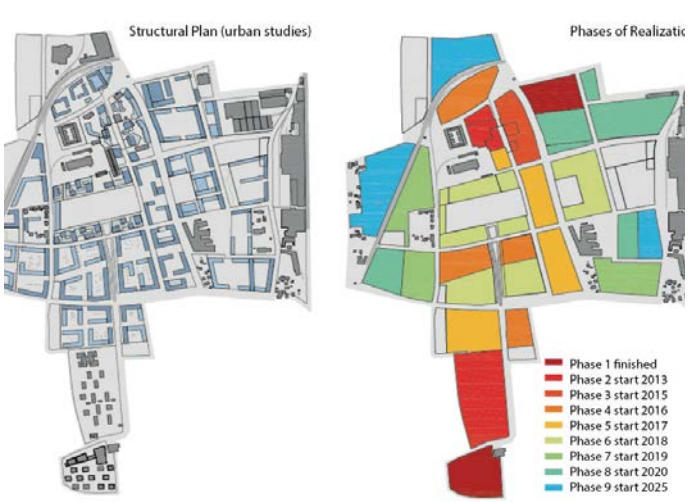


Figure 1 -Left side: shows the structural planning concept (modular building structures), including the finished competition projects in quarter 1, 4a and 5 / Right side: shows the phases of realization (Source: TU Graz. Institute of Urbanism)

Figure 2 - This plan shows the diversity and programming of uses at the ground floor level, which was one main challenge and basis for simulations and the choice for an urban energy system (Source: TU Graz. Institute of Urbanism)

HIGHLIGHTS OF THE CASE STUDY

The main-highlight was the interdisciplinary collaboration within the research project ECR Energy City Graz Reininghaus, which was focused on developing urban strategies for the new development, building construction, operation and the restructuring of the city district Reininghaus [2]. In order to face this huge and complex task, a transdisciplinary team, including five institutes of the Graz University of Technology, the City of Graz and the Federal Province of Styria worked jointly together. Further highlights have been the realization of demo-projects: “Peter Rosegger Straße” (the southern center of Reininghaus) and “Hummelkaserne Süd” (a former military area). The heart of the district will be “Alt-Reininghaus” (Quarter 1 and 4a), planned and now realized by the architect Thomas Pucher [3].

ISSUES AND CHALLENGES

The overall aim of the research project ECR Energy City Graz-Reininghaus was to support the developing activities of the municipality of the City of Graz to establish a new, smart and sustainable city district (Figure 1). One of the most relevant challenges was the collaboration within the interdisciplinary project team itself and the interaction with a complex network of investors, planners, energy suppliers, interest representatives and locally-based companies. This collaboration initiated a lot of innovative ideas and concepts and was able to manage the realization of first milestones.

DECISION STRATEGIES

The pursued research approach included the strategy to examine the local energy potentials as the first step of the development of the future energy supply system, which has to be investigated referring to the following principles:

- Highest possible degree of sustainability
- Highest useful degree of energy autarky under given economic conditions
- Modular building structures of the city- quarters for the future and their uses as a concept in the future
- High diversity of programmed types of use (Figure 2)
- Supply security has to be guaranteed at any time
- Economic, political and legal framework conditions have to be taken into account.

References: [2] Rainer, E.; Schnitzer, H.; Mach, T.; et. al., (2015). Rahmenplan Energie, Energy City Graz-Reininghaus, report; [3] www.thomaspucher.com

The planning process

The planning process is developed based on the activities of numerous groups of stakeholders (administration, politics, economy and research) in a multi-year process. In the following, the complexity of the actual process has been reduced to single striking milestones.

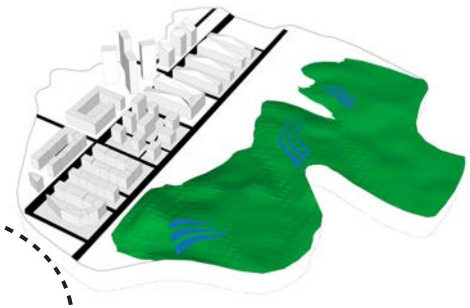
(1) the discovery of Reininghaus as the largest land resource in the City of Graz, (2) Starting the discussion with the relevant stakeholders, (3) Generating a framework-plan (Masterplan), (4) Making a new land use plan and contracts between the investors and the city, (5-6) Starting the scientific research with urban and structural studies, finding potentials and create urban energy systems, (7) Starting competitions for architecture and public spaces, (8) Getting competition results, (9) Choosing an urban energy supply system, (10) Generating a "Bebauungsplan" (similar to the UK legally binding land-use plan), (11-12) Starting realization of buildings, (12) Finishing first demo-projects, (13-14) Going on together "step by step" to a new city district Reininghaus until the year 2035 .

The focus is to develop a city district with compact urban building structures, integrated sustainable energy systems and optimal green infrastructures. Improvement of walkability, bike accessibility and public transport systems with the aim to reduce the vehicular private transport.

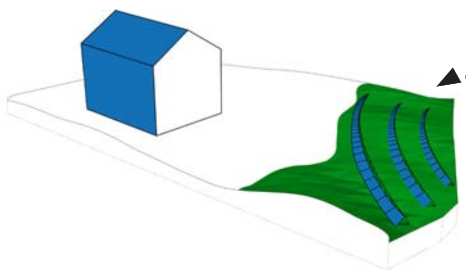
The stakeholders involved in the planning process were: the city of Graz, Federal Province of Styria, energy agencies, investors, industrial companies, planners, energy suppliers, interest representatives, other experts.

The research involved were: Graz University of Technology, University of Graz, AEE INTEC.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.



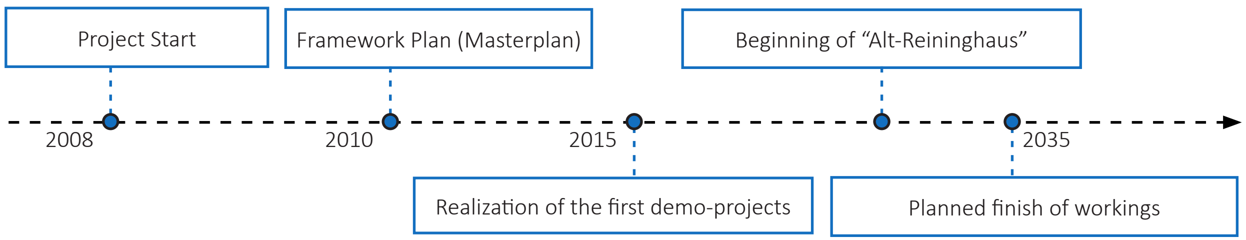
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



References: https://www.tugraz.at/

All implemented steps and approaches are based on the motivation to influence the urban planning processes towards a strengthened sustainability. Urban areas play a central role in achieving the objectives of the EU strategy for sustainable development [3].

The design of the research project ECR is based on the idea that the linking of different disciplines and those experts, edits added value. The networking between agencies, policy makers, business representatives and experts of technical sciences better solutions can be found. The approach assumes that sustainable solutions can be developed and implemented at the best through the open dialogue between these stakeholders.

The processing of an entire urban development area, as in the present case of Reininghaus, requires a bundle of multiple and diverse development activities. Some of these development activities affect the entire development area of Reininghaus, others only one or more sub-districts. To ensure a coherent treatment of the issues, unique names and system boundaries are required to be defined in a complex and interdisciplinary working process. During the development process, a division into five different areas was defined for the scientific work (Figure 4).

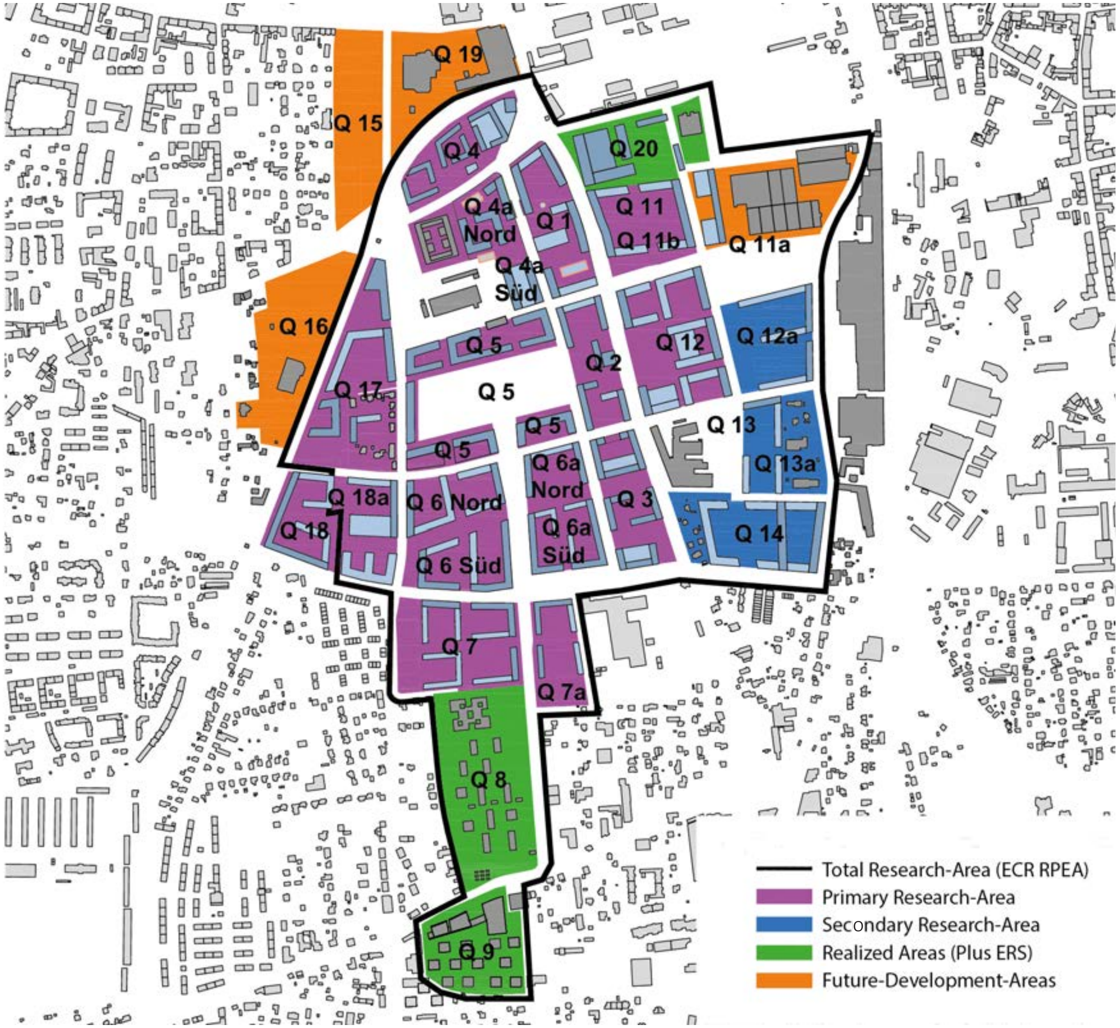


Figure 4 - Overview of the Research Areas and the Quarters [Q] (Source: TU Graz. Institute of Urbanism)

References: [3] COUNCIL OF THE EUROPEAN UNION. (2006). Review of the EU Sustainable Development Strategy (EU SDS)– Renewed Strategy

Figure 5 - System for a Local Heat Network at the primary research area (Source: TU Graz. Institute of Thermal Engineering: S. Grünewald)

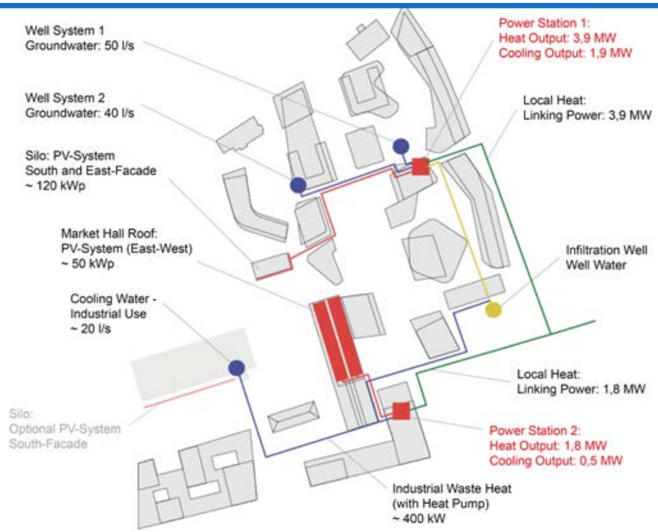


Figure 6 - Energy Concept of the Quarter 1, 4a and 5 (Source: m-consult: J. Maxones)

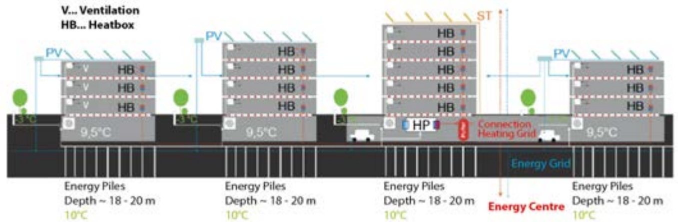


Figure 7 - System "Plus Energy Combination" in the sothern part of Reininghaus (Source: AEE INTEC, Nussmüller Architekten)

UTILIZATION OF INDUSTRIAL WASTE HEAT

In close proximity to the area of Reininghaus a steel processing industrial plant is causing large amounts of unused waste heat. In addition to the implemented excess waste heat supply in the district heating system, with a temperature level of > 90 °C, a great potential of waste heat, to about 34 °C, remains unused. A cluster of industrial heat pumps (seasonal performance factor = 4.9) increases the temperature to 68 °C. The distribution to all Quarters (except Quarter 8 and 9 will be implemented by a district heating system, consisting of a primary grid (Figure 5 – black lines) to supply the urban Quarters, a secondary grid (red lines) to supply the buildings and tertiary grids (green lines) to implement the distribution inside buildings. Buildings will be supplied by 8.7 GWh/a thermal energy for domestic hot water and 36.9 GWh/a for covering the heating demand.

GROUNDWATER WELL SYSTEM WITH HEAT PUMP

Quarter 1 and Quarter 4a are situated (Figure 6) on the north-east of the city district Graz Reininghaus. Under the assumptions of sustainable development apartments, office and commercial buildings as well as leisure facilities are currently being developed. The energy concept includes the use of the two existing wells using heat pumps. Usable roof and facade surfaces are covered with photovoltaic elements, which are used to power the heat pumps and the general equipment used. In the basement area of the underground parking, a new energy center has been built. From there, the individual objects are powered by energy transitions in the garage with heating water or cooling water. The peak loads are covered by the public networks. Since all energy flows are routed via centrally positioned energy centers, the question of the optimal management of this complex system is ongoing research projects.

SOLAR ENERGY AND ENERGY NETWORK

Quarter 9 is the most southern and developed district of Graz Reininghaus. The building structure contains an office and shopping complex and 12 residential buildings, which are constructed as Passive Houses with ventilation system and heat recovery (Figure 7). The heating demand of individual buildings ranges between 6.5 and 8.9 kWh/m² a. The average final energy demand is 36 kWh/m² a. The energy for heating and domestic hot water is provided by geothermal ground piles using three heat pumps situated in three energy centers with a total capacity of 215 kW; 90 m² of ST collectors and 603 m² PV modules. The key measure to achieve the energy standard for the apartment houses is the approach, to regard the site as a system. Therefore the energy centers are connected to each other by a pipe and an information system, to enable an efficient operation behavior [4].

References: [4] Staller, H. (2016). +ERS – Plus Energy Network Reininghaus Süd: A pilot project towards an energy self-sufficient urban district, Energy and Buildings, pp 138-147.

Environmental, economic and social impacts

Figure 8 - Urban Gardening at the southern part of Reininghaus (Quarter 9) – "Peter Rosegger Straße" (Source: TU Graz. Institute of Urbansim: Martin Grabner)

Figure 9 - Social housing (Quarter 8) at the southern part of Reininghaus. (Source Nussmüller Architekten ZT GmbH)

Figure 10 - Workshop with stakeholders, planners and experts (Source: TU Graz. Institute of Urbanism)

ENVIRONMENTAL IMPACT

The whole urban project "Graz Reininghaus" became an emblematic example for great ideas, projects, start up´s and much more. The district is more and more becoming a hot spot for the development of architectural, social and energy technology innovation.

ECONOMIC IMPACT

The urban project was financed by private investors (buildings) and the City of Graz (urban infrastructure – streets – energy grid).

SOCIAL IMPACT

With the initialization of some private cultural associations (for example "Reiningherz", some urban gardening initiatives, etc.) platforms have been founded and a public and private participation process started, where neighborhood, citizens, investors, planners, politics and municipality can come and have dialogue together.

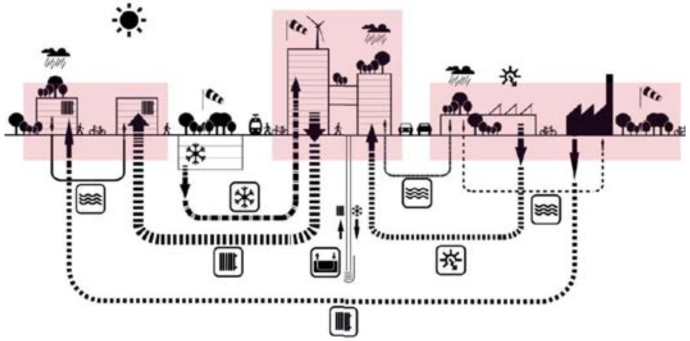


Figure 11 - "Synergy by Crosslinking" as an approach for the development of Urban Energy Systems (Source: TU Graz. Institute of Process and Particle Engineering)

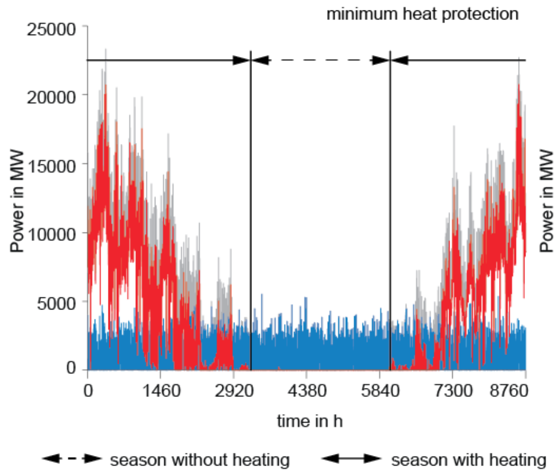


Figure 12 - Thermal Power for Heating (red line) and for domestic hot water (blue line) for the Primary-Research Area for the period of one year (8760 hours) in the scenario of a "minimal heat protection" (Source: TU Graz. Institute of Thermal Engineering)

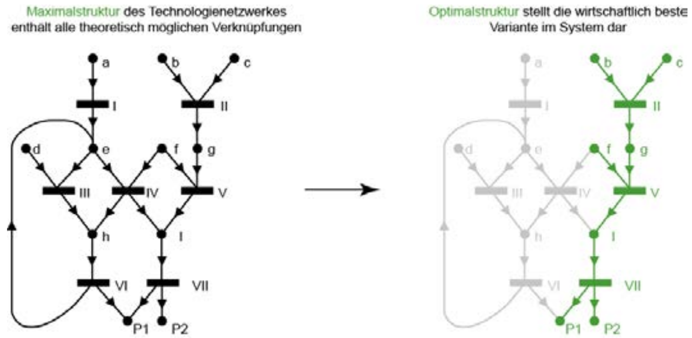


Figure 13 - Process-Network-Synthesis Method - PNS. Maximal structure versus optimal structure of a technical urban network (Source: TU Graz. Institute of Process and Particle Engineering)

INVESTIGATION OF THE ENERGY SUPPLY SYSTEM

According to the aims of the City of Graz , the city district Graz Reininghaus should be developed into a mixed use district [5].

The mixed use approach allows linking local energy potentials with local consumers, such as the use of industrial waste heat for space heating and domestic hot-water. Through this approach Synergy by Crosslinking [6] the synergies can be expanded from the system limit of a building to the system limit of a neighborhood (Figure 20). Based on this approach, the research project ECR developed and evaluated different scenarios for the future energy supply of the district Graz Reininghaus. During this development methods and tools have been tested, according to the interdisciplinary approach of the research project, in a stepwise working process. In the first step, an analysis of the local available renewable energy sources has been carried out.

Available solar radiation, wind, geothermal sources, heat content of the waste water, organic waste, waste heat from air conditioning systems, waste heat from industrial production, were qualitatively and quantitatively collected and recorded in a report [6]. In a second step, the expected thermal and electric energy demand was modelled in dynamic energy simulation tools TRNSYS and MATLAB. The expected electrical services were defined by electrical load profiles, which were integrated in the simulations as thermal loads. Afterwards for the whole building structure thermal building and system simulation were performed. Figure 11 shows the demand for heating and domestic hot water for the Primary-Research Area. Then the demand for electrical energy, which has to be applied to provide space heating, domestic hot water and cooling, was estimated.

Thereafter, the overall demand for electrical power and the energy production by PV have been derived. Finally, the degrees of energy autonomy and energy self-sufficiency for the city district were calculated in different scenarios. Based on the evaluated energy demand, in a third step, a design based approach was implemented.

The application of the Process-Network-Synthesis (PNS) enabled to find the most cost efficient and the most sustainable energy supply system. PNS is based on genetic optimization algorithms, which are able to find the optimum structure of energy supply systems (Figure 22). In addition studies have been conducted to assess the sustainability of different planning alternatives, based on the Assessment Method DGNB-NSQ12.

References: [5] www.stadtentwicklung.graz.at; [6] Rainer, E., Schnitzer, H., Mach, T., Wieland, T., Reiter, M., et al (2015), RAHMENPLAN ENERGIE Energy City Graz-Reininghaus, report, Haus der Zukunft plus

Figure 14 - Workshop with stakeholders, planners and experts (Source: TU Graz. Institute of Urbanism)

Figure 15 - Presentation of the research project ECR with all involved participants (Source: City of Graz: Fischer)

Figure 16 - The Green Tower in "Alt-Reininghaus" (Source: Erber Unternehmensgruppe)

LESSONS LEARNED

The whole development process of the city district Graz Reininghaus has benefitted directly from the scientific research carried out simultaneously. The scientific results were communicated directly to the stakeholders of the development process. It would be valuable to implement the results from the research project ECR Energy City Graz Reininghaus in further urban development projects. Many results of the studies could be used for similar urban development projects. Everyone was proud, that such an interdisciplinary collaboration worked in an efficient way.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

The research project ECR Energy City Graz Reininghaus offered the possibility of an initiation and a widespread scientific cooperation in the development process of a new city district. Available energy potentials of the city district were investigated and sustainable energy supply systems could have been defined. In the development phases, a couple of demonstration buildings have been realised as well as further pilot buildings on the site have already been started.

Based on the experience of similar European city development projects the initiated ECR-Platform and all involved institutes from the Graz University of Technology and the University of Graz recommend the alignment of an International Building Exhibition called "IBA Graz-Reininghaus".

Experiences from Malmö and Hamburg show, that an International Building Exhibition (IBA) could continue and generate further potentials based on the prepared know-how from such a research project like Energy City Reininghaus.

Figure 17 - ECR network (source: TU Graz. Institute of Urbanism)

Figure 18 - Social life at the Central Park in the Quarter 5. (Source: PENTAPLAN ZT-GmbH)

TARGET GROUPS

- Urban Planners
- Municipality
- Architects
- Engineers
- Researchers
- Industries

PUBLIC AND EDUCATION ACTIVITIES

Several workshops and public seminars have been organized as well as student works (design studios and master degrees) have been part of the ECR project.


(Photo: ©www.erber.at)

DEVELOPER

City of Graz, and Graz Reininghaus

CONSULTANTS

AEE- Institute for Sustainable Technologies, Nussmüller Architekten ZT GmbH, Rosenfelder & Höfler Consulting Engineers, Atelier Thomas Pucher ZT GmbHm-consult.

CASE STUDY AUTHORS

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OWNERS

Aktiv Klimahaus Süd GmbH, WEGRAZ Gesellschaft für Stadterneuerung und Assanierung m.b.H., Erber Holding GmbH, ENW- Gemeinnützige Wohnungsgesellschaft m.b.HÖWGES Gemeinnützige Wohnbaugesellschaft.

STAKEHOLDERS

Chamber of Architects and Engineering Consultants for Styria and Carinthia.

ACKNOWLEDGEMENTS

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RESEARCH ORGANIZATIONS

3.2 CANADIAN CASE STUDIES

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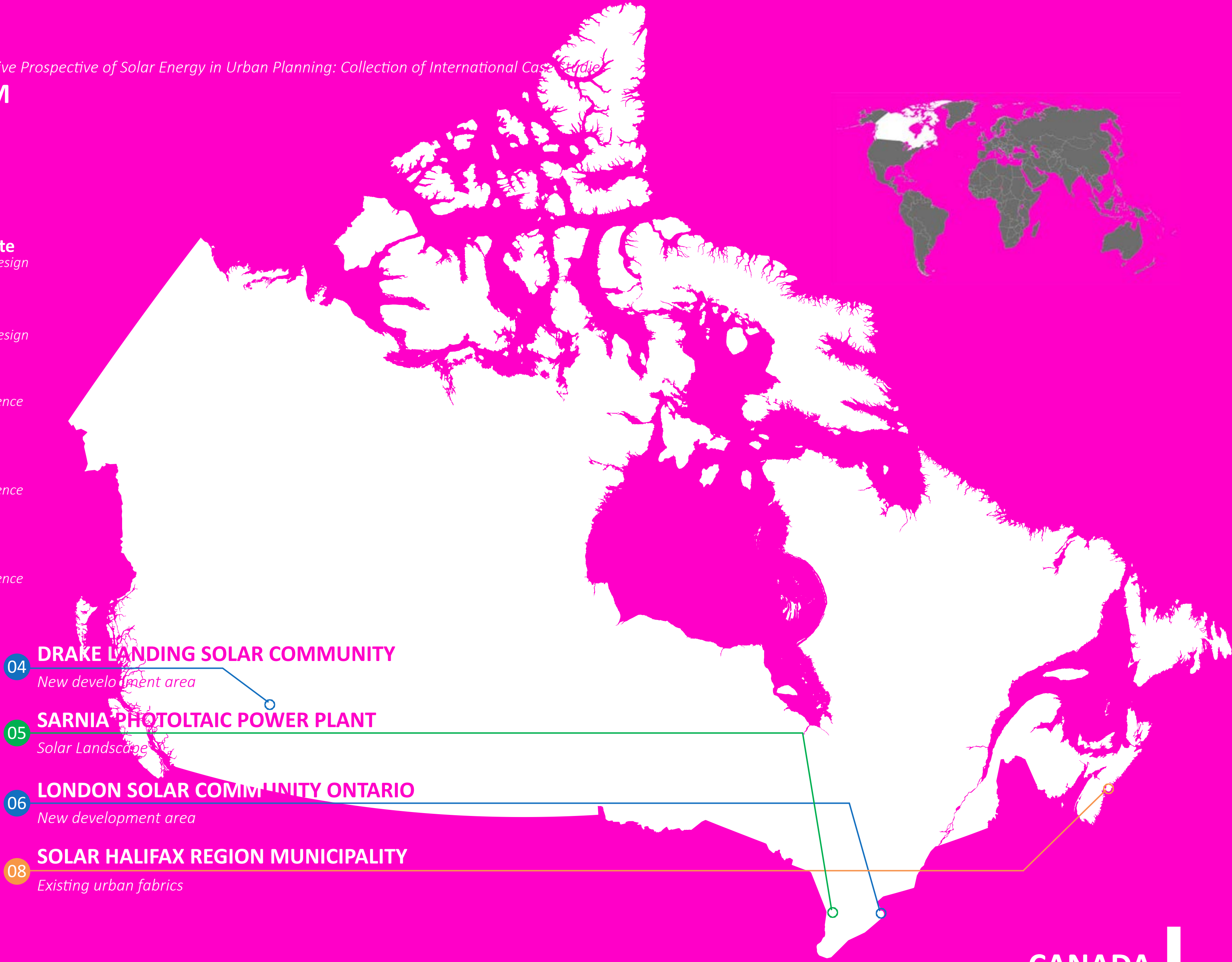


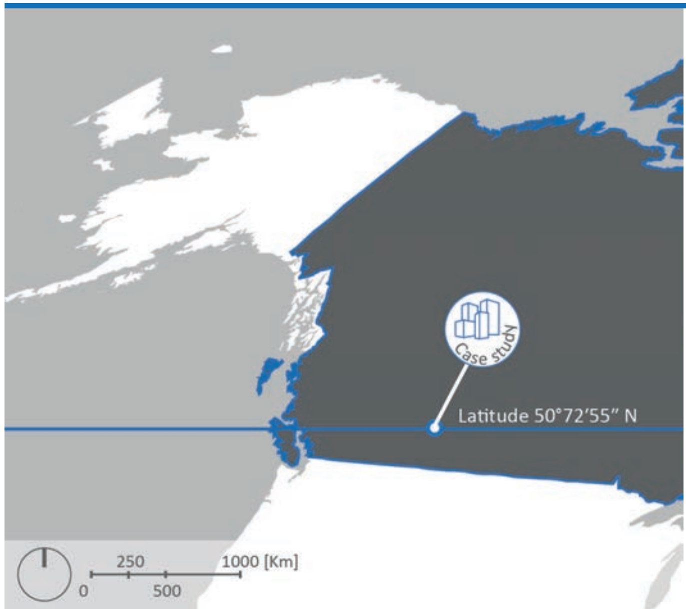
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

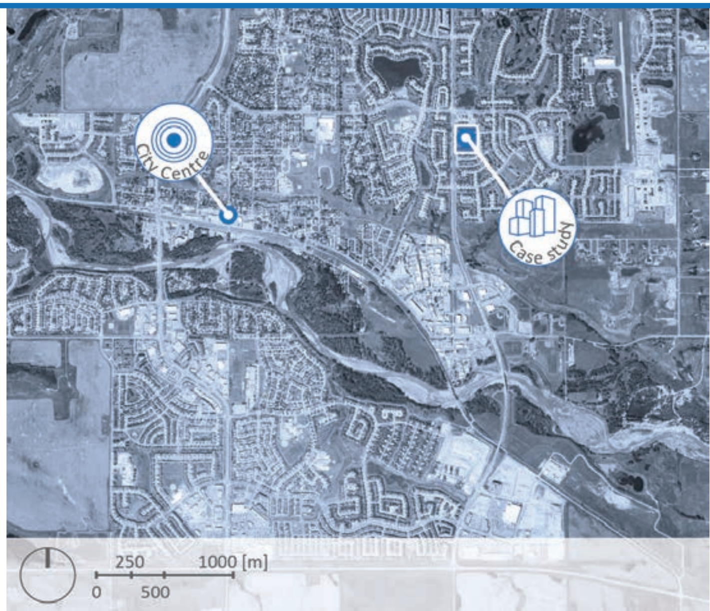

Source: (© CanmetENERGY, Natural Resources Canada)

DRAKE LANDING SOLAR COMMUNITY

CANADA

OVERVIEW





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Canada
Location: Okotoks, Alberta (Lat. 50°72′55″N; Lon. 113°97′49″W)
Climate: Cold temperature, without dry season, cold summer (Dfc) [1]

AREA OF INTEREST

Legislation and technology

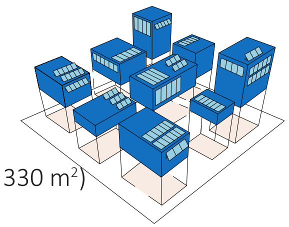
NATIONAL AND LOCAL CONTEXT

This case study represents a Canadian demonstration project, therefore there is no local legislation covering the deployed technology. The site was selected because of the ample sunshine hours it receives, approximately 2 400hrs/a[2] coupled with its more northerly location.

ABOUT THE CASE STUDY

This project was established in a new subdivision in the Town of Okotoks, include 52 homes on four streets. The project aimed to uncover the potential of use thermal energy storage on a domestic scale and used a Federal government incentive program (ecoENERGY fund [3]) to facilitate and cover research and development.

Definition of environment:
New Urban Areas



Site area: 29 500 m^2
Building area: 11 600 m^2
Number of buildings: 52 homes (11 330 m^2)

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] www.climate.weather.gc.ca; [3] www.nrcan.gc.ca/energy/

Figure 1 - Energy Centre (Source: © CanmetENERGY, Natural Resources Canada)

Figure 2 - DHW PV panels visible on front sides (Source: © CanmetENERGY, Natural Resources Canada)

HIGHLIGHTS OF THE CASE STUDY

The highliths of the case are:

- First large-scale seasonal energy storage solar heating project in North America;
- Uses Borehole Thermal Energy Storage (BTES) ;
- Reduction of 5 tonnes of GHG emissions per home/year;
- Includes a parallel Domestic Hot Water (DHW) system;

ISSUES AND CHALLENGES

- Optimization of the control strategy to deliver heat when needed and collect heat when available;
- Unpredictability of weather;
- Decreasing collector efficiency at higher temperatures, and thermal loss from within the BTES field;
- Operating the District Loop (DL) at the lowest possible temperature without compromising occupant comfort;
- Operating the BTES using the minimum amount of heat, and monitored only based on entering/leaving water temperatures.

DECISION STRATEGIES

Canada's ecoENERGY fund is designed specifically to encourage research, development and demonstrations. Five different fund allocation programs under this umbrella [3].

After establishing a maximum population limit in 1998, Okotoks re-examined their strategy and implemented a sustainability plan to manage growth in the early 2000s. The Drake Landing BTES project fell within the new parameters and goals of reduced environmental impact and increased sustainability, and so was supported by the Town of Okotoks as a feasibility study. All decisions after locating the test site in Okotoks were made based on increasing the efficiency not only of the system, but of the houses themselves, and so were part of the over-arching vision of the Town [4].

References: [3] www.nrcan.gc.ca/energy/
[4] www.okotoks.ca/sites/

THE PLANNING PROCESS

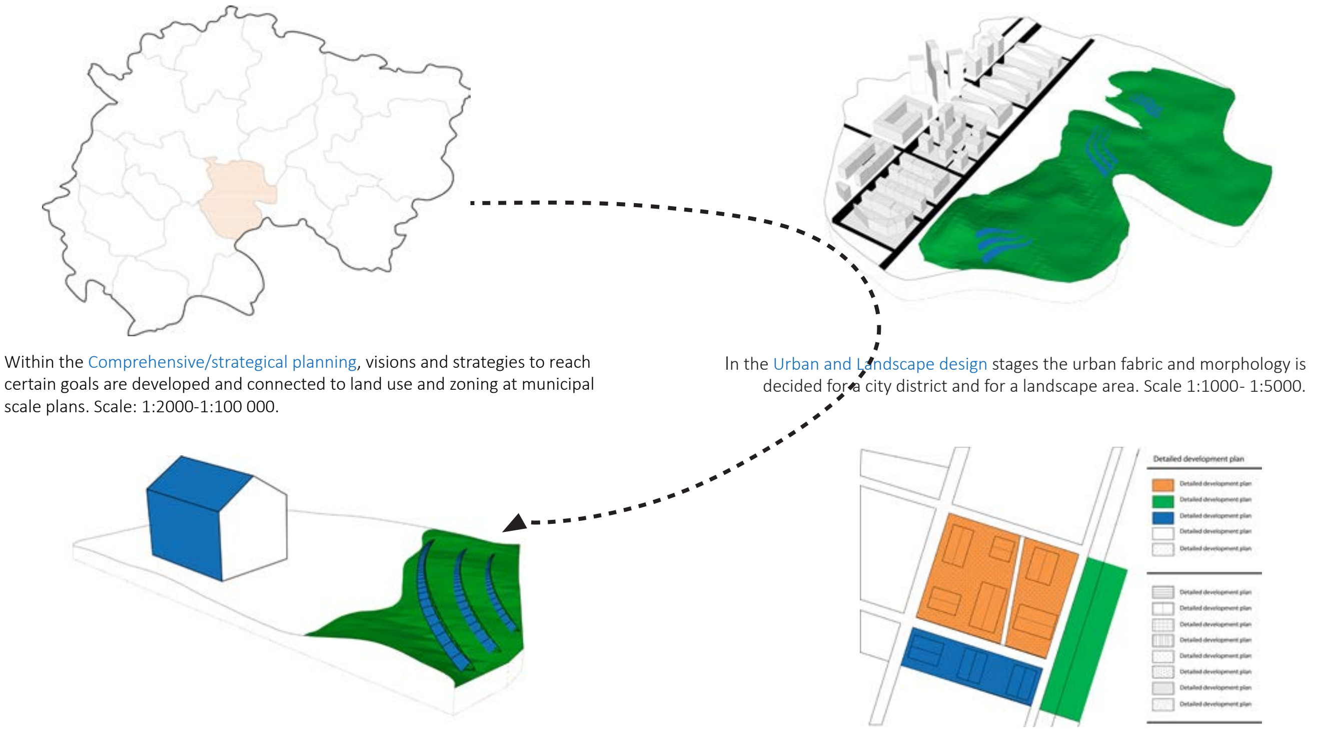
Prior to any planning or architectural design work, the project began with a technological feasibility study initiated and led by Natural Resources Canada's (NRCan) main research and development arm, CANMET Energy Technology Centre, in 2003-04.

Financial support was provided by:
- Program of Energy Research and Development (PERD)
- Renewable Energy Deployment Initiative (REDI)
- Sustainable Development Technology Canada (SDTC) through SDTech Fund and the NextGen Biofuels Fund
- Environment Canada
- Technology Early Action Measures (TEAM)
- Federation of Canadian Municipalities (Green Municipal Fund)
- Climate Change Central (a public-private partnership)
- United Communities
- Government of Alberta Innovation Program
- Alberta Environment

After a plan of action was devised in terms of the technological requirements and solar potential, the project proceeded on:
1. R+D of the borehole and heat delivery systems;
2. Design and construction of the homes, a process falling to the developer (United Communities) and the home builder (Sterling Homes).

Several researchers and institutions were involved in the project:
- Natural Resources Canada
- SAIC Canada
- Enermodal (provided the solar technology for the project)
- ATCO gas
- The Drake Landing Steering Committee from Chalmers University (Sweden)
- The Bavarian Centre of Applied Energy Research (Germany)
- The University of Calgary
- Queen's University
- Environment Canada

The specific design of the borehole system was done by IFF Tech International, and energy modelling was done by Thermal Energy Systems Specialists.



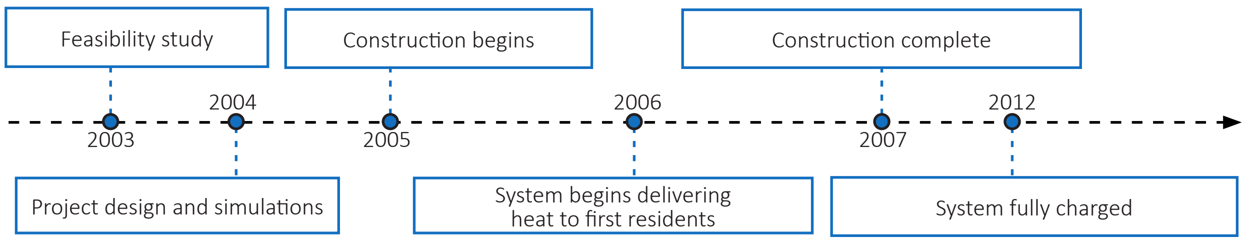
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



Energy concept

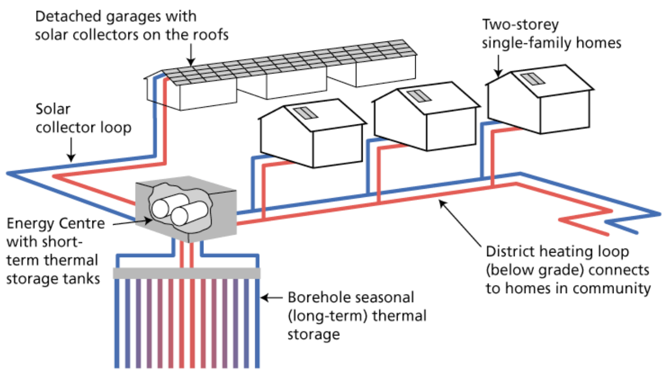


Figure 4 - Schematic of the BTES system. (Source: © www.dlsc.ca)

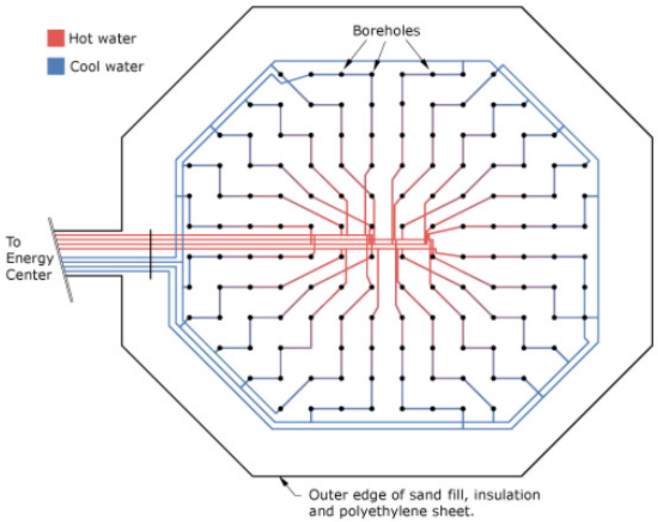


Figure 5 - Aerial schematic of the borehole field. (Source: © www.dlsc.ca)

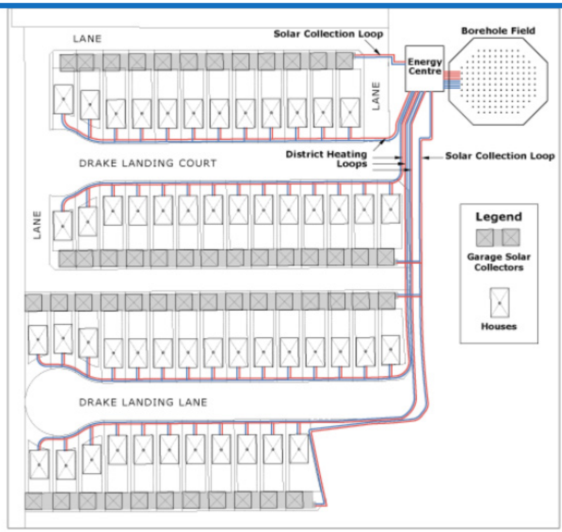


Figure 6 - Site plan of collectors and borehole field. (Source: © www.dlsc.ca)

SUMMARY

During hot summer months, solar-heated glycol water is pumped into the center of the BTES field. Heat from the water transfers to the surrounding earth, and as the water moves through the system, it cools and works its way to the outer edge of the field. When homes require heat (in winter), cooler water is pumped to the edges of the field, and the water picks up heat as it flows through the center. This heated water is stored temporarily in tanks (STTS) in the Energy Centre (EC) and subsequently makes its way to each home using the district heating loop. End of summer temperatures in the field are approximately 80° C.

TECHNOLOGY

This system is both active and passive and is made of five different components: 1) 798 flat plate Solar Thermal (ST) panels; 2) the EC; 3) the BTES; 4) the district heating supply system, and; 5) the 52 homes.

- Type of system: BTES consists of 144 boreholes in a 35 m diameter field at a depth of approximately 35 m below ground. There are 24 sets of 6 boreholes each, and each hole is 150 mm diameter, spaced 2.25 m on center.
- Area ST: 2300 m^2 of ST
- Area Borehole field: 908 m^2
- Orientation/inclination of ST: south-facing, 45° roof pitch.
- 124 918.6 L of water (125 m^3) [5]

SOLAR ENERGY AND ENERGY SYSTEM

To maximize the ST panel area, the garage roofs form one continuous structure. The homes have a 30% lower heating load than other similar. In cases of prolonged extreme cold resulting in the depletion of stored heat, a gas-fired generator in the EC provides supplemental power. After being fully-charged, the system operates at 97% solar fraction (target was 90%).

- Energy production: 55.2 kWh/m^2
- Power of the system: 1.5MW/day, during the summer
- 22kW PV system on EC roof provides emergency power for critical loads and powers collector and storage pumps [6].

References: [5] McDowell, T.& Thornton, J. (2008). Simulation and model calibration of a large-scale seasonal storage system. Proceedings of the 3rd National Conference of the International Buildings Performance Simulation Association, USA, Berkeley

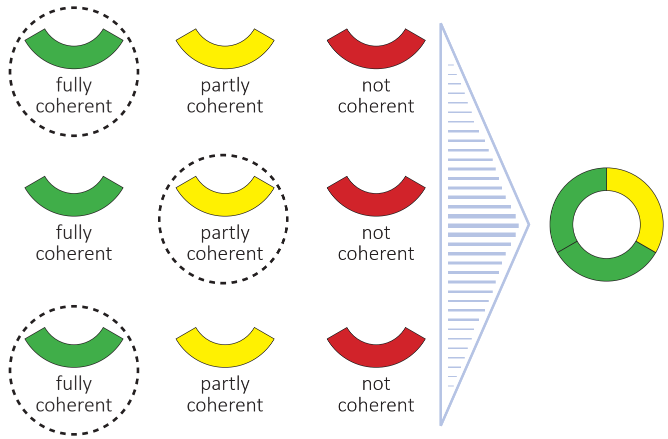
[6] Sibbit, B., McClenahan, D., Djebbar, R., Paget, K. (2015) Groundbreaking Solar, High Performance Buildings Magazine p 1-12

Figure 7 -System geometry. (Source: © www.dlsc.ca) [8]

Figure 8 - Modular pattern. View of ST collectors on garage roofs (foreground) and DHW panels on homes. (Source: © CanmetENERGY, Natural Resources Canada) [8]

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



COMMENTS

The system covering the garages fabric could be considered integrated because it completely matches the roof surface. The extended form of the roof is built and designed specifically to accommodate and maximize the surface area of the ST panels. However, the materiality of the panels is not entirely consistent with the architecture of surrounding neighborhood structures or even the houses.
Because the BTES is underground, it is not considered as having any impact or visual integration issues.

References: *[7] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.
[8] www.dlsc.ca/photos/

Figure 9 - View from outside the neighbourhood (Photo: © N. Robertson, 2016

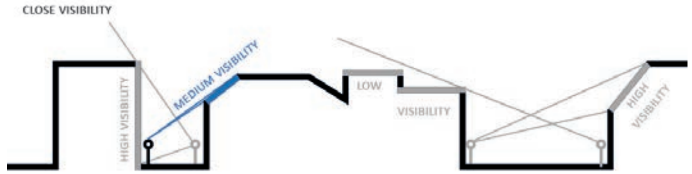


Figure 10 - Different levels of visibility of city surfaces from public domain. [7]

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	○	●
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT

The context maintains a medium-to-low sensitivity requirement because it is a new development. On one hand, there is little integrity to preserve, but conversely, the visual integration of the ST panels are not entirely compatible with the architectural form of the garages and houses. As isolated structures, the garages are consistent with each other, but within the context of the houses, they are somewhat at odds, and increasingly so when considering the wider neighborhood operating outside the case study.

SYSTEM VISIBILITY

Visibility is quite low, the system is primarily only visible by either participating neighbors' windows, or from the back alley. There is some visibility by the wider public offered by the proximity of a main thoroughfare/highway, making the system visible to passing traffic, though only briefly. The system does not affect the quality of the view offered from the highway, however.

References: [7] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Environmental, economic and social impacts

Figure 11- Borehole field under construction (Source: © CanmetENERGY, Natural Resources Canada)

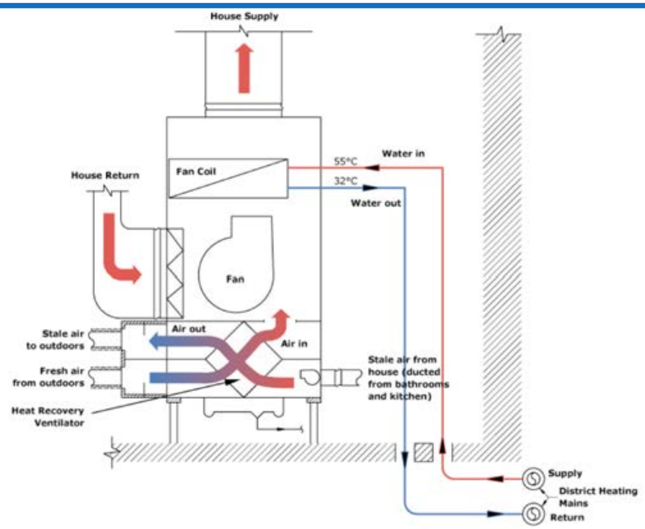


Figure 12 -Air Handler schematic (Source: © www.dlsc.ca) [9]

Figure 13 - Borehole field (foreground) and Energy Centre after construction (Photo: © N.Robertson, 2016)

ENVIRONMENTAL IMPACT

The carbon footprint of the system has been assessed at 38.1kg CO_2e/m^2 a

ECONOMIC IMPACT

Final cost of the project amounted to approximately $15 million, of which $7 million was allocated directly to system costs, and is broken down as follows:

- $3 million for one-time R+D
- $2 million from federal agencies
- $3 million from the Federation of Canadian Municipalities and the Green Municipal Fund
- $625,000 from the Alberta Government.

Natural Resources Canada estimates it would take only $4 million to repeat the project elsewhere.
This works out to $1 237/m² ($115/ft²) and $2 013/m² ($187/ft²) for the homes and EC, respectively [6].
Homes sell for an average of $380 000, a typical price.
Residents pay an average of $60/month in heating bills

SOCIAL IMPACT

The houses and their systems have had very little social impact on the region.

References: [6] Sibbit, B., McClenahan, D., Djebbar, R., Paget, K. (2015) Groundbreaking Solar, High Performance Buildings Magazine p 1-12
[9] www.dlsc.ca/air_handler

Figure 14 - Schematic of the BTES system. (Source: © www.dlsc.ca)

Figure 15 - Aerial schematic of the borehole field. (Source: © www.dlsc.ca)

STAKEHOLDERS

The team for this project was quite large.
Natural Resources Canada, through their CanmetENERGY program [10] lead the project and oversaw the rest of the stakeholders:

- Project Coordinator: Leidos Canada
- General Contractor (residential): Sterling Homes
- General Contractor (EC):Hurst Construction
- Mechanical Engineer: Enermodal Engineering
- Energy Modeler: Thermal Energy Systems Specialists
- Land Developer: United Communities
- Borehole Storage Design: IF Tech International

SOLAR SIMULATION TOOLS

A TRNSYS (Transient System simulation program) model was built to simulate each part of the collection, storage, and energy distribution systems. Building heating loads were calculated by a simulation analysis of typical construction practices used in the neighborhood and input into TRNSYS. The model could then predict temperatures and energy flow in each component of the system. House heating loads were predicted using detailed ESP-r simulations, driven by Canadian Weather for Energy Calculation (CWEC) data [11].
Several sample collectors supplied to the case study were tested at the National Solar Test Facility (NSTF) [12].

IN RELATION TO THE SCALE

Project-specific constraints such as funds, land area, available area for solar collection, as well as other parameters such as solar collector distribution, STTS tank size, borehole depth and quantity, were used to calculate the most efficient combination to maximize economic performance at different scale from building to the district level.

References: [10] www.nrcan.gc.ca/energy/; [11] datahub.io/dataset/
[12] Sibbitt, B., McClenahan, D., Djebbar, R., Thornton, J., Wong, B., Carriere, J., Kokko, J. (2011), The Performance of a High Solar Fraction Seasonal Storage District Heating System – Five Years of Operation, Energy Procedia, p 1-10

ISSUES ASSOCIATED WITH SIMULATIONS

Overall the TRNSYS simulations have been quite accurate, though 100% accuracy is impossible due to a variety of technical issues and interruptions occurring throughout the year such as snow covering the PV panels, emergency power system testing, retrofits, etc. The TRNSYS model under-predicted the useful energy gain by the collectors.

One significant potential error revealed during modeling was the ability of an assumed outdoor reset schedule to adequately maintain indoor comfort conditions based on an assumed outdoor reset curve for the District Loop [13].

RESULT AND DISCUSSION

As predicted, the Drake Landing system is too small to be economically competitive with the extremely low local cost of natural gas. The optimal size for this type of system is between 200-300 homes, or possibly more if passive design features were incorporated into the architecture.

The 90% solar fraction after five years was predicted based on historical weather data going back 50 years because of the time required to 'charge' the ground/borehole field. A notable solar fraction of almost 98% was achieved in year six [12].

The efficiency of the entire system is supported heavily by other measures, such as R-2000 building standards as well as water conservation measures.

There was a measured heat loss 20% higher than predicted in the District Loop piping system.

The STTS storage tank losses were two times greater than anticipated because original losses were based on manufacturer's specifications regarding insulation etc., these appear to be increasing over time [5].

YEAR	1 (2007-08)	2 (2008-09)	3 (2009-10)	4 (20010-11)	5 (20011-12)	6 (20012-13)	7 (20013-14)
HEATING DEGREE DAYS	9 085	9 309	8 913	10 059	8 240	9 027	9 738
a) INCIDENT SOLAR	512	534	488	479	498	488	488
b) COLLECTOR EFFICIENCY	33.5	31.6	33.6	32.5	34.1	34.0	34.0
c) TOTAL HEAT DELIVERED	2 877	2 809	2 412	2 710	2 008	2 363	2 875
d) SOLAR FRACTION	55.0	60.4	79.6	85.9	96.7	97.6	91.7
e) PURCHASED ELECTRICITY	187	187	177	155	91	68	82
f) PV GENERATED ELECTRICITY	10	13	12	28	73	66	63
d) PURCHASED GAS	1,491	1,132	515	413	62	40	220

a) Based on gross collector area and radiation on the 45° collector slope
b) Collected energy divided by incident energy
c) Heat delivered to the district heating loop
d) Fraction of heat load provided by solar heat
e) Purchased electricity used to operate the solar collection, storage and central heating system
f) Generated electricity from the 22 kW solar array on the Energy Centre roof
g) Purchased gas used to supplement the solar heat delivered by the central heating system.

(Source: [6]

References: [5] McDowell, T.P.& Thornton, J.W. (2008). Simulation and model calibration of a large-scale seasonal storage system. Proceedings of the 3rd National Conference of the International Buildings Performance Simulation Association, USA, Berkeley; [6] Sibbit, B., McClenahan, D., Djebbar, R., Paget, K. (2015) Groundbreaking Solar, High Performance Buildings Magazine p 1-12; [12] Sibbitt, B., McClenahan, D., Djebbar, R., Thornton, J., Wong, B., Carriere, J., Kokko, J. (2011), The Performance of a High Solar Fraction Seasonal Storage District Heating System – Five Years of Operation, Energy Procedia, p 1-10; [13] Wong, W.P. & McCLung, J.L. (N.D.) First large-scale solar seasonal borehole thermal energy storage in Canada, SAIC;

LESSONS LEARNED AND RECOMMENDATIONS

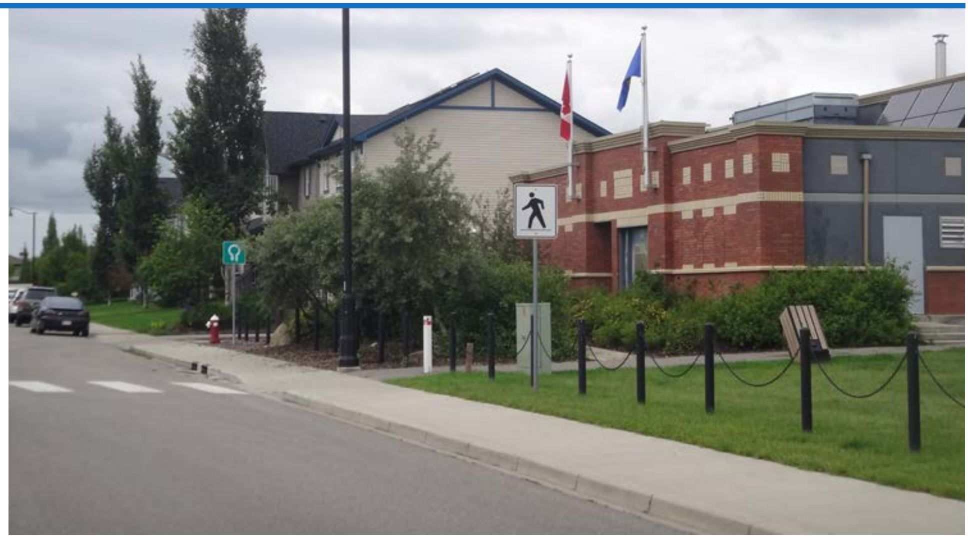


Figure 16 - Typical suburban house design. (Source: © www.dlsc.ca)

LESSONS LEARNED

- The Drake Landing builder and land developer were included in the project planning process from the beginning and this helped build confidence in the project.
- The success of this project invites future possibilities of implementing larger systems.
- Shut-off valves in the utility easement near the street should be considered in subsequent projects to simplify the installation of the District Loop piping line [6].
- Almost ten years of operation has proven that this type of system is technically feasible in a cold Canadian location with 5200 heating degree days and a design temperature of -31° C [14].

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

Heating requirements were met with this system, however, the heating load could have been further reduced using passive design strategies for the houses, and so potentially, the same size system, in terms of area of ST collectors, could possibly have been implemented for more homes, making the technology more affordable for future sites. Furthermore, because the homes were of a standard design and not solar optimized in terms of design or orientation, almost all homes have since added air conditioners to deal with excessive summer temperatures. This high temperature is further exacerbated by very wide, paved back lanes, (Figure 18).

TARGET GROUPS

- Researchers in solar field
- Municipalities
- Urban planners
- Architects
- Micro-utility companies
- Developers

PUBLIC AND EDUCATIONAL ACTIVITIES

Annual Reports are/have been produced beginning in 2007; www.dlsc.ca is maintained and provides pdfs and links to research papers on the project.

References: [6] Sibbit, B., McClenahan, D., Djebbar, R., Paget, K. (2015) Groundbreaking Solar, High Performance Buildings Magazine p 1-12;
[14] Flynn, C., Siren, K. (2015), Influence of location and design on the performance of a solar district heating system equipped with borehole seasonal storage, Renewable Energy, p377-388

DEVELOPER

Sterling Homes
United Communities

OWNERS

Private Clients

ACKNOWLEDGEMENTS

The wish to thank Doug McClenahan and Natural Resources Canada (NRCan), Ottawa.

References: [15] DLSC_e.pdf, available at http://www.dlsc.ca

CONSULTANTS

A full list is available in the DLSC brochure [15].

STAKEHOLDERS

Project Coordinator: Leidos Canada (formerly SAIC)
General Contractor (residential): Sterling Homes
General Contractor (EC):Hurst Construction
Mechanical Engineer: Enermodal Engineering
Energy Modeler: Thermal Energy Systems Specialists
Land Developer: United Communities
Borehole Storage Design: IF Tech International
General Contractor (EC):Hurst Construction

CASE STUDY AUTHORS

Caroline Hachem-Vermette and Natalie Robertson (University of Calgary)

Mechanical Engineer: Enermodal Engineering
Energy Modeler: Thermal Energy Systems Specialists
Land Developer: United Communities
Borehole Storage Design: IF Tech International

RESEARCH ORGANIZATIONS

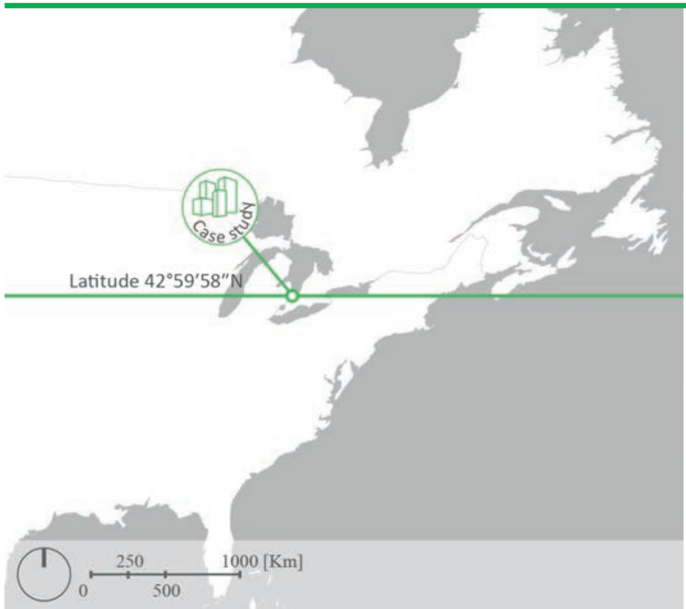
UNIVERSITY OF CALGARY
FACULTY OF ENVIRONMENTAL DESIGN

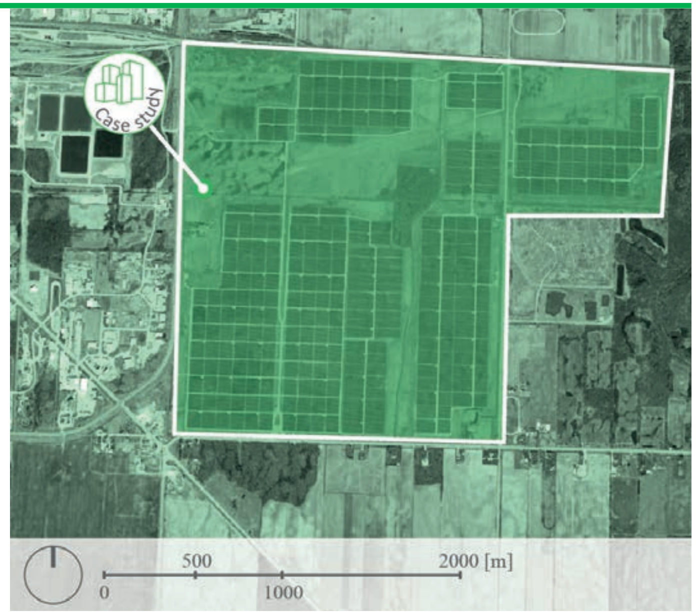

Photo: © Daniel Bellyk

SARNIA PHOTOVOLTAIC POWER PLANT

CANADA

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Canada

Location: City of Sarnia (Ontario)
(Lat. 42°59′58″N; Lon. 82°18′32″W)

Climate: Humid continental climate – Dfb [1]

AREA OF INTEREST

Targets and goals

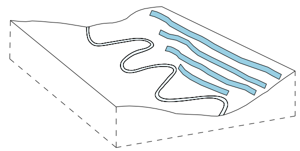
NATIONAL AND LOCAL CONTEXT

This project was developed under the RESOP (Renewable Energy Standard Offer Program), that was launched in 2006 by the Ontario Power Authority (OPA) in order to stimulate smaller distribution connected renewable energy projects, that are ≤ 10MW. The program payments for the solar generation was $420/MWh, but was not eligible for the inflation increases or on-peak performance as biomass and waterpower projects were [2]. The program was so attractive that the developers were breaking the larger scale projects in order to qualify. Sarnia Photovoltaic Power Plant was also done in phases, originally by the First Solar Inc., but bought and upgraded by Enbridge Inc. to its final size of 80MW in 2010 [3].

ABOUT THE CASE STUDY

The Sarnia Photovoltaic Power Plant is located in Sarnia, in the Ontario province. The plant is situated on 385 hectares of land and generates enough power to serve 12,800 homes. Upon completion of the installation in 2010, tit was the largest solar installation in the world [3].

Definition of environment:
Landscape PV



Site area: 3 845 m^2
Building area: 966 000 m^2 covered by PV panels

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263;
[2] MacDougal, Jim, (2008), Ontario's Renewable Energy Standard Offer Program: Lessons from a Large Scale Distribution Connected Electricity Procurement Program, 3rd International Conference on Integration of Renewable and Distributed Energy Resources, Nice, France, December 2008;
[3] Enbridge completes Sarnia solar farm, CBS news, October 4th, 2010.

Issues, challenges and decision strategies

Figure 1 - Aerial view of the Sarnia Solar Project. (Source: © Enbridge Inc.)

Figure 2 - Reflection of the sky off of the solar modules. (Source: © Enbridge Inc.)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- To create the largest solar power plant on the planet;
- To show that solar energy generation is economically feasible in Ontario with the FIT program.
- Over 39 000 tonnes CO_2 saved per year (if this amount of energy was produced by coal powered plant);
- Largest solar PV system in the world when completed in 2010 and continues to be Canada's largest.

ISSUES AND CHALLENGES

The scale of the project brought logistical challenges, such as the scheduling, coordination of people, equipment and material [4]. The project had a peak workforce of over 250 people. To achieve maximum construction velocity, the construction effort was split into two separate teams working on different parts of the plant. These teams effectively 'competed' with each other on installation rate in order to expedite construction. Another facet of the project (required by the local conservation authority) was to improve drainage on the site by increasing the capacity of an existing drainage culvert underlying the main railroad line, which runs along the northern border of the site. With constant train traffic, this drainage improvement required close communication with the railway and coordinatione with railway flagpersons, supervisors, and schedulers [5].

DECISION STRATEGIES

The highlights of the case study are:

- Availability of interconnection capacity for the project;
- Acceptance and cooperation of project neighbours, local First Nations, the municipality and the connecting utility;
- Availability of suitable land area for the project;
- Outreach to project neighbours concerning potential project impacts and mitigation measures (eg., tree screens, plantings of native plant species, control of invasive plant species).

References: [4] A. Obin, personal communication with K. Saunders, March 11, 2016.
[5] P. Carrie, personal communication with M. Horvat, July 15, 2016.

The planning process

The Sarnia Solar Project was developed under the Government of Ontario's Green Energy Act, through the RESOP (Renewable Energy Standard Offer Program), whose original intent was to stimulate development of small-scale grid-connected renewable energy projects. The RESOP created such initial success that, in 2009, evolved into the Ontario's Feed-In-Tariff (FIT) programs: microFIT for installations ≤ 10MW and FIT for those > 10MW. Applications were approved by the Ontario Power Authority, now known as the Ontario Independent Electricity System Operator (IESO), which balances the supply and demand of electricity in Ontario. The IESO then purchases the generated power at a higher rate than the local cost of electricity.

The goal of the Sarnia Photovoltaic Power Plant project was to create the largest solar power plant on the planet, and to show that solar energy generation is economically feasible in Ontario with the FIT program.

The project has two main stakeholders. The developer is First Solar, Inc., one of the largest solar module manufacturers in the world at the time. First Solar, Inc. is also under a long term contract to operate the facility. The owner and financer of the project is Enbridge, Inc., a Canadian energy supply company. Phase 1, consisting of 20 MW of PV modules, was completed in 2009 for $100-million CAD. The second phase, an additional 60 MW, was completed in 2010 and cost approximately $300-million CAD [3].

Upon completion of the second phase in 2010, the 80 MW solar installation was deemed the largest solar photovoltaic plant in the world.

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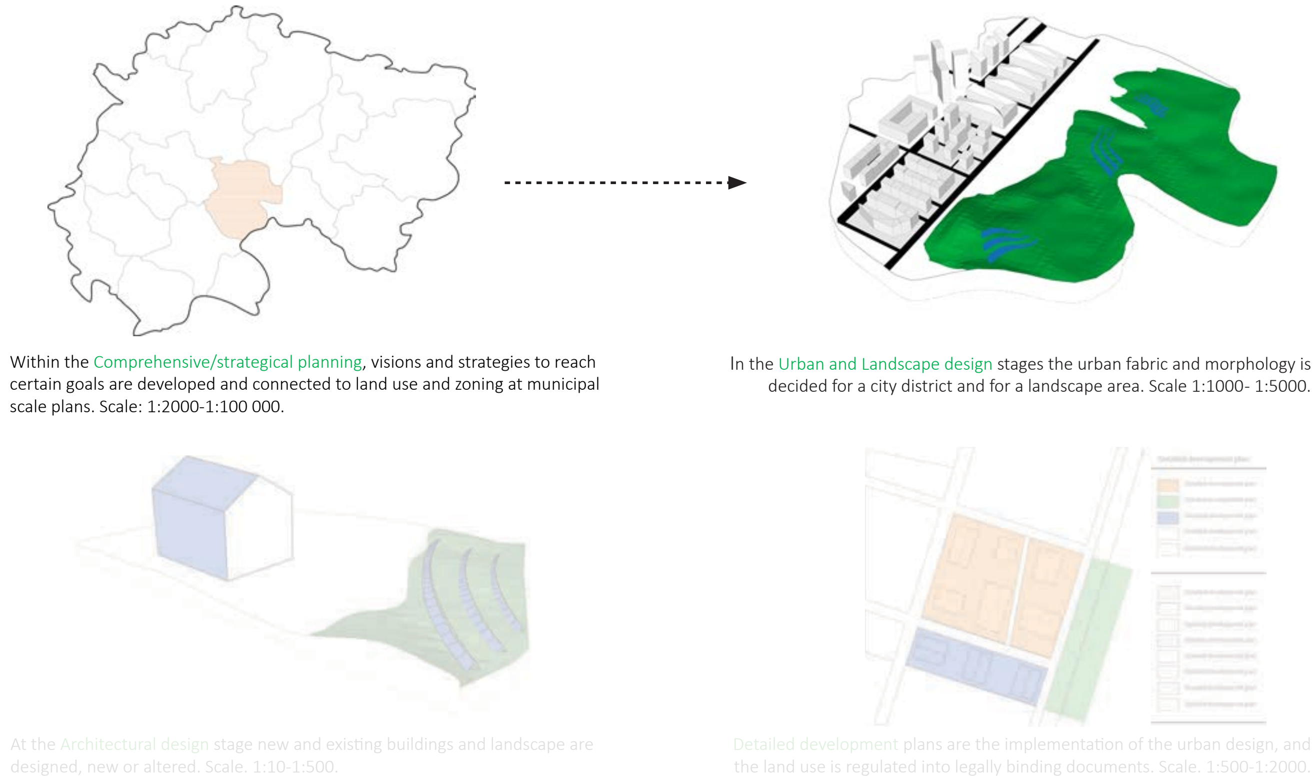
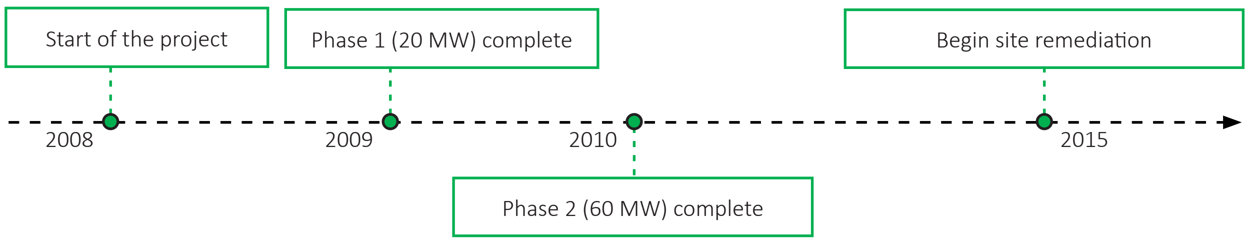


Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [3] Enbridge completes Sarnia solar farm, CBS news, October 4th, 2010.

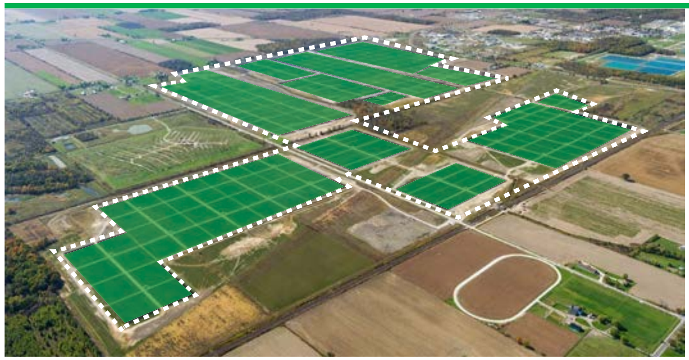


Figure 4 - The spatial system as a whole (Pattern) [6]) (Photo: © Daniel J Bellyk)

Figure 5 - The photovoltaic space [6] (Source: © Enbridge Inc.)

Figure 6 - The “pore” space [6] (Source: © Getty Images)

FORMAL FUNCIONAL FEATURES

PATCH - PATTERN - EDGES/BORDERS

Patch type

Small	○	Large	●
Straight borders	●	Convoluted borders	○

Grain type

Small patches	○	Large patch	●

Pattern

Porous	○	Dense	●

Pattern type

Stripes	Parallel	●	Not parallel	○
Island	Uniform patches	●	Varied patches	○
Random		○		

Edge/Borders

Continuous	●	Discontinuous	○

SOLAR SYSTEM

TECHNOLOGY AND PRODUCTION OF TOTAL AREA OF MODULES

1. Energy features

Nominal power:	80 MWp
Number of modules:	1.3 million
Technology:	CdTe (cadmium telluride) Thin-Film
Density of power:	0.83 MWp/m^2
Land use intensity:	1 242 MWh/m^2/a
Normalized yearly energy generation:	1,500 MWh/MWp/a

2. Engineering features

Fixed-tilt ground-mounted system with steel posts and steel tilt *brackets.*

3. Spatial features

Modules:	Height: 0.6m; Width: 1.2m; Area: 966 000 m^2; Color: Blue Azimuth angle: 0°; Tilt angle: 25°; Height from the ground: 1 m
Borders:	Thickness: 0 m; Height : 0 m;

SOLAR SYSTEM SPACE

PATCH AREA

Connectivity

There is a tree-lined fence surrounding the solar power plant. However, animals and people can access the site from the same points provided for vehicular access. The surrounding landscape is farmland to the north, south and west and the town of Sarnia to the east. From above, the solar module layout fits within the grid of the surrounding farmland

Functions

The photovoltaic installation is ground-mounted. The land under the solar modules, which was once used for agriculture, does not have any alternate use.

Other features

First Solar’s cost-effective structure was mounted using driven galvanized steel posts (no concrete foundations except for inverter bases), with the solar modules mounted at a 25° tilt from horizontal. The structure was designed to conform to site-specific wind- and snow-load requirements.

References: [6] Scognamiglio, A. (2016). ‘Photovoltaic landscapes’: Design and assessment. A critical review for a new transdisciplinary design vision, Renewable and Sustainable Energy Reviews, pp 629-661

Site potential

Figure 7 - Solar Panels. (Source: © Enbridge Inc.)

Figure 8 - Solar Panels. (Source: © Postmedia Network)

LANDSCAPE FACTOR

SENSITIVITY	LOW	HIGH
Landform	●	○
Landscape pattern and complexity (patches and grain)	●	○
Land use	○	●
Land cover	○	●
Settlement and man-made influence	●	○
Historic landscape character	●	○
Distinctive landscape features	●	○
Inter-visibility with adjacent landscapes	●	○
Sense of remoteness/tranquility	●	○
Sense of openness/enclosure	○	●

LANDSCAPE PRESERVATION (SOFT BARRIERS)

- Agricultural landscape.
- Valuable land use.
- The landscape consists of mainly farmland surrounding the site to the north, south and west, with the town of Sarnia, to the east.
- Not listed under preservation.
- A remediation program was initiated in 2015 to return the site to a bio-diverse and hospitable landscape for local flora and fauna.

MULTI-FUNCTIONALITY

The solar farm does not perform any additional function aside from energy generation.

Environmental, visual, economic and social impact

Figure 9 - Aerial view of the Sarnia Solar Project (Photo: © Daniel J Bellyk)

IMPACT CATEGORY	IMPACT - BURDEN	ALLEVIATION, MITIGATION STRATEGIES, DESIGN APPROACHES
Land use	The nature of the ground-mounted installation renders the land useless for any purpose aside from energy generation.	Visibility from the street is mitigated using a tree-lined fence that blocks the view into the solar farm.
Visual impact	The system is located close to a town and within a sprawling and flat agricultural landscape.	Enbridge Inc. has initiated a remediation project with a local native plant rescue and restoration organization to naturalize and restore habitat on 80 ha (21%) of the site. Since this initiative, biodiversity on the site has improved and this program will continue into 2020 [7].
Environmental impact	Although the 385 ha piece of land was previously farmland, it was re-zoned as industrial land prior to this project for the future industrial development under the then-current Sarnia municipal plan [7]. Therefore, the re-zoning was not necessary.	
Public awareness and participation	Neighbors were concerned about drainage, lighting in the plant at night, and vegetation management.	Neighbors' concerns were addressed with a strong biodiversity remediation project and light pollution reduction lighting strategies. Furthermore, during the construction, grading of some parts of the site was done to better facilitate draining, and various sub-surface drainage tiles were installed for the same purpose. Overall, the public has been very supportive [8].

References: [7] P. Carrie, personal communication with M. Horvat, July 15, 2016.
[8] Morden, P. (2015). Habitat restoration project planned for Enbridge solar farm. Sarnia Observer. Retrieved from http://www.theobserver.ca/2015/06/12/habitat-restoration-project-planned-for-enbridge-solar-farm

Figure 10 - Integration of the solar modules and the landscape (Source: © Postmedia Network)

TOOLS AND METHODS

The Sarnia Solar Project used numerous tools in the development, design and construction of the plant. These include PVSYST software for evaluating the plant's energy performance, CAD software for the layout and design, and propriety First Solar software for plant costing and financial evaluation.

Specialized proprietary software was also used for the electrical design and interconnection design.

Hydrological software was used to evaluate drainage requirements and design the site drainage infrastructure.

To assist construction contractors, a 'sandbox' array area was set up to allow contractors to work with the structure and module mounting techniques to accelerate learning and help to provide better construction cost estimates.

Also, a small 'dummy' array was constructed near First Solar's office in Sarnia, so that project neighbours could evaluate the visual look of the arrays and potential reflections from the arrays.

Prior to installation of the First Solar modules, part of the site had been constructed using OptiSolar modules with a concrete ballast type of foundation. When First Solar acquired the site from OptiSolar, the Optisolar modules and foundations were removed and that portion of the site was re-graded. This increased the overall amount of grading on the site. For the installation of First Solar modules, grading of some parts of the site was required to provide a level area for the solar arrays and to ensure proper drainage. Various sub-surface drainage tiles were also installed to facilitate drainage.

FOLLOW-UP AND MONITORING

The plant's performance is monitored on a 24/7 basis by First Solar and Enbridge. First Solar is performing Operations and Maintenance on the project under contract with Enbridge. Plant performance is consistent with the original predicted outputs and Enbridge is pleased with the environmental and financial results [9].

References: [9] P. Carrie, personal communication with M. Horvat, September 21, 2016

Figure 11 - Installing solar panels. (Source: © Postmedia Network)

Figure 12- Official opening of Sarnia Solar Farm. (Source: © Postmedia Network)

LESSONS LEARNED

- Large-scale solar photovoltaic installations are feasible in Ontario when connected to the grids Feed-In-Tariff program.
- Large-scale solar PV power plants can help to offset peak cooling electricity demands in summer with peak electricity generation occurring simultaneously.
- The most important lesson learned from the construction site was on grading and drainage. Today, most solar farms do minimal grading and try to maintain the natural drainage previously available to them. Sarnia removed a lot of “dirt” to provide a level surface for solar arrays and ensure proper drainage. Given the landscape in Lambton County, tiling the site for drainage during the construction is recommended, as it is a challenge to do after the fact [10,11].

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- Further study for Ontario is required to determine how PV can be better integrated into the landscape to preserve and promote multi-functional opportunities for land use.
- Legislation in Ontario needs to investigate improved options to better control the siting of large-scale PV projects in the future for development of more appropriate sites such as brownfields.
- Future installations should consider the potential for multi-functional land use.

TARGET GROUPS

- Investors
- Private companies in the energy sector
- Agricultural producers
- Local communities

References: [10] A. Obin, Enbridge Inc., personal communication with Kelsey Saunders, March 11, 2016.
[11] P. Carrie, personal communication with M. Horvat, July 15, 2016.


(Photo: © Daniel Bellyk)

ARCHITECT, DESIGNER AND DEVELOPER

Enbridge Inc.
First Solar, Inc.

CONSULTANTS

First Solar, Inc.

CASE STUDY AUTHORS

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OWNERS

Enbridge Inc.

STAKEHOLDERS

Enbridge Inc., First Solar, Inc.,

Ontario Power Authority (OPA) since 2014 known as Independent Electricity System Operator (IESO).

RESEARCH ORGANIZATIONS

Ryerson University
Faculty of Engineering & Architectural Science

ACKNOWLEDGEMENTS

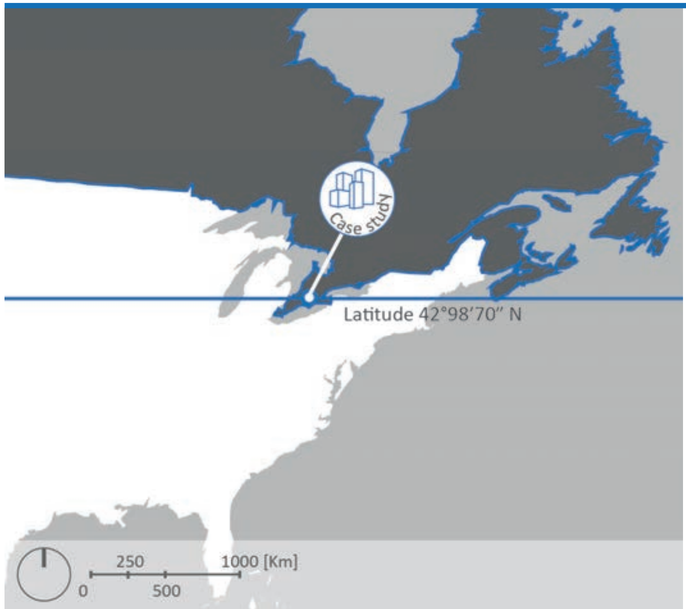
The authors wish to thank Peter Carrie, First Solar Development Canada Inc. (Kitchener, Ontario), Aja Obin, Enbridge Inc. (Calgary, Alberta)

Source: (© west5)

LONDON SOLAR COMMUNITY ONTARIO

CANADA

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Canada
Location: London, Ontario (Lat. 42°98'70"N; Lon. 81°24'32"W)
Climate: Cold temperature, without dry season, cold summer (Dfc) [1]

AREA OF INTEREST

Targets and goals

NATIONAL AND LOCAL CONTEXT

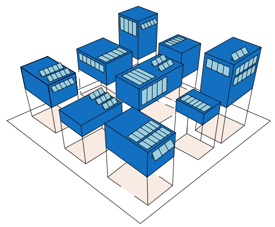
Despite having no local, provincial or national policies, the developer's (Sifton) vision is to create mixed-used community that would provide a live/work/play environment focused on sustainable principles such as renewable energy production, water conservation, energy efficiency, and walkability. This initiative compliments the City of London's Community Energy Plan [2], and the recent GEA [3] (Green Energy Act) created by the Ontario government. Sifton is an active member of LEEP (Local Energy Efficiency Partnerships), and because of this project, the local municipal government has been spurred into developing legislation and infrastructure to accommodate micro-grids.

ABOUT THE CASE STUDY

This greenfield development is aiming to achieve a net- zero energy status. It will take 5 years to build out the area with office, retail and residential (2000 units in apartments, condos, retirement, townhouses). Main office building construction began in 2014, 87 townhouse units will be.

Definition of environment:
New Urban Areas

Site area: 283 00 m^2
Area density: 2000 residential units (average of 28.5 u/a)



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] www.london.ca/; [3] www.energy.gov.on.ca/

Issues, challenges and decision strategies

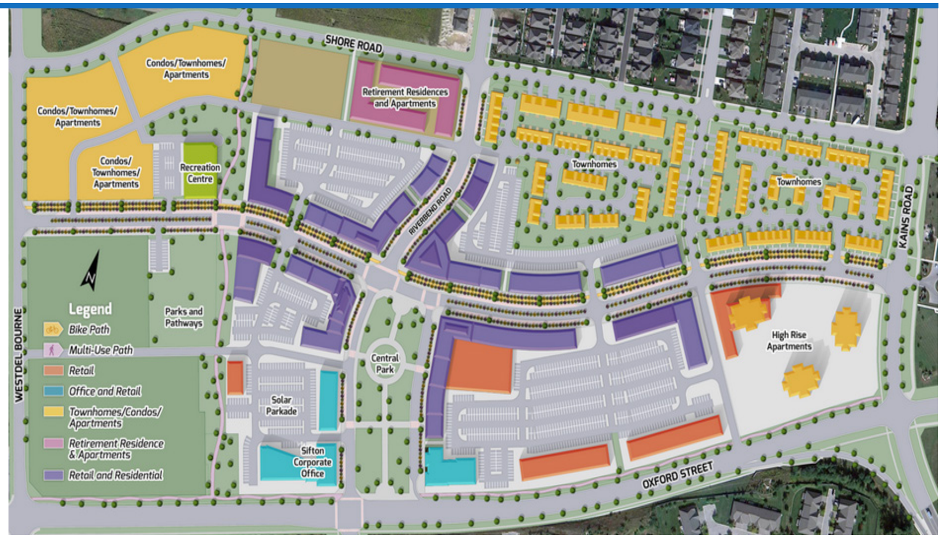


Figure 1 - Community Map. (Source: © west5)

HIGHLIGHTS OF THE CASE STUDY

The highliths of the case are:

- First intervention of its kind in the region
- Site includes residential, commercial and retail
- 2 000 multi-family residential units (roof top PV)
- 41 806.4 m^2 of commercial space (rooftop and BIPV)
- Solar parkade for supplemental power

ISSUES AND CHALLENGES

- Some existing road layout to work around;
- Architectural design is not optimized for solar integrating solar technologies;
- Solar potential is limited because of the configuration of the buildings on the site in terms of street orientation and building placement
- Site planning occurred without much consideration to solar optimization in terms of structure layout
- The plan had always been for mostly add-on PV panels, as opposed to BIPV (Building Integrated Photo Voltaic) strategies.

DECISION STRATEGIES

As a commercial venture, the primary motivation is to create a unique product in the local market, with a long-term objective of reducing negative environmental impact.

Market research was undertaken to gauge local interest in energy efficiency, and it was found that renters were relatively unconcerned with efficiency compared to owners.

THE PLANNING PROCESS

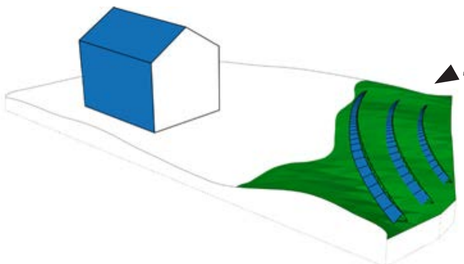
Private developer, Sifton Developments, wanted to create a sustainable suburb combining commercial, retail and residential components. Solar optimization was not considered at the early design phase of the site, and optimization was further constrained by two existing roadways. And so, building orientation were not considered, and PV electric power was seen as technological endeavor, separate from the design process.

Sifton's initial building designs and community layout were assessed for solar optimization by Hachem [4] as part of a research study, using simulation tools. The assessment revealed several areas where solar potential could increase and more passive strategies implemented to diminish loads; taking into account technology, shadow casting, architectural designs, building and street orientation. Some changes were made, but in general the plans remained unchanged. The construction began in 2014 with the main office building.

Sifton developed partnerships with Samsung and LG to provide cutting-edge technology within the site and another private company, S2E is actively involved in the PV network and surface optimization. Thus far, PV electrical production falls below anticipated demand, and so off-building harvesting is occurring. Municipal legislation lags behind the proposed micro-grid, so Sifton opted to install necessary infrastructure regardless, in anticipation of eventual approval/agreement.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

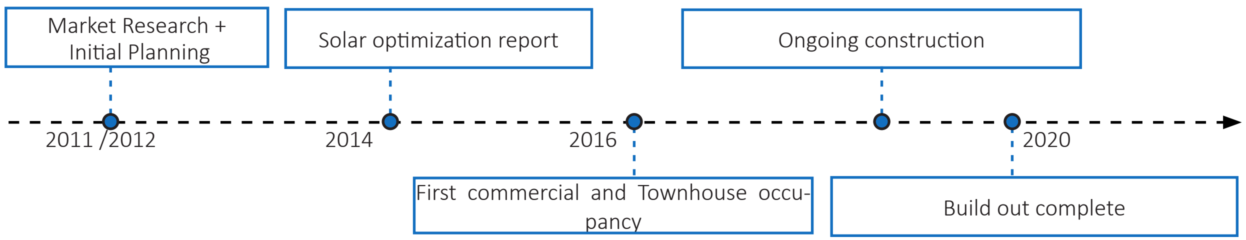
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 2 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [4] Hachem, C. 2014, Design of Solar Optimized Community, Final Report.

Figure 3 - Main commercial street, detail. (Source: © west5) [5]

SUMMARY

The overall goal is to create a solar-powered micro-grid for a net zero sub-division by adding PV panels to 95% of local roof tops, with some BIPV panels on the main commercial building, integrated onto the south façade.

TECHNOLOGY

There have been some efficiency measures planned to be implemented. This is in addition to PV technologies for active solar collection. The system is still to be installed, but a number of simulation software are employed in the planning and analysis, including:

- HOT2000
- RETScreen International
- HOT2XP
- HOT2EC

The project is still under construction and total area of PV installed is unknown [6].

SOLAR ENERGY AND ENERGY SYSTEM

Individual rooftop PV panels (added system) will be mounted on the first 2-storey commercial building. Low-consumption technologies have been integrated, such as motion sensor lighting and dynamic glazing.

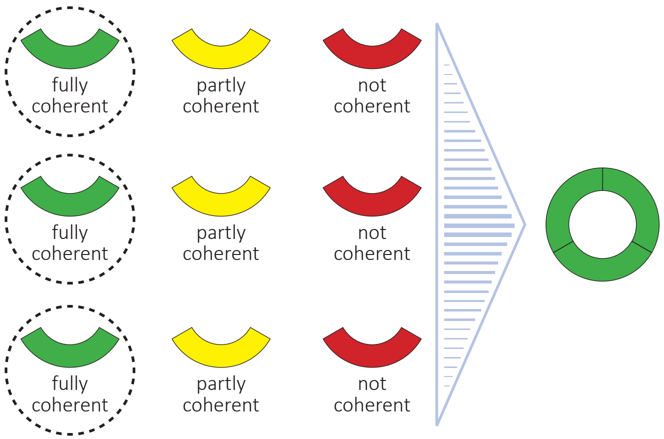
References: [5] www.west5.ca/townhomes
[6] Conversation with Sifton Properties

Figure 4 -System geometry, main commercial building. (Source: © west5) [8]

Figure 5 - View of the main commercial building. (Source: © west5) [8]

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



COMMENTS

Figure 5 shows the design adopted for the first building to be constructed on-site. The solar panels on the south façade are fully integrated into the building architecture and complement the overall aesthetic of the building, streetscape and façade. Geometrically, they are in proportion to the other façade elements in terms of materiality and color. Their rectangularity complements the other, non-PV parts of the building.

References: *[7] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.
[8] www.west5.ca

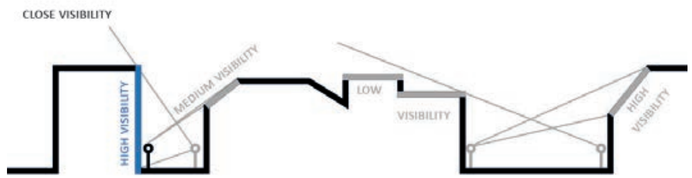


Figure 6 - Different levels of visibility of city surfaces from public domain for main commercial building.

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○

SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	○	●

Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT

Because the area is a new development, there is no relevant historical sensitivity required. However, the overall aesthetic for the area once it is built out, offers a new context for the integration of the panels, and in this way, the current design is quite sympathetic to the community's trajectory.

SYSTEM VISIBILITY

PV panels are integrated into the building's aesthetic so that they are visible (and likely 'celebrated') as well as part of the façade. The topography in the area is fairly flat, and remote visibility is not an issue.

References: [7] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.
[8] www.west5.ca

ENVIRONMENTAL IMPACT

Most of the environmental impact of this case study has not been evaluated yet.

ECONOMIC IMPACT

A financial analysis has been conducted on the return on investment and the potential of a FIT (Feed-in-Tariff) contract with London Hydro. Currently, the price sits at 22 cents/kW for 20 years, allowing for a slight deduction to secure a priority position.

For the townhouses, an additional $376.75/m^2$ ($35/ft²) has been incorporated into the cost of construction to cover the new energy features (insulation, water recycling + PV), (bringing the total cost to $1722.28/m² ($160/ft²) [9].

Other than the above figures, the development follows similar parameters of cost and financing for any new greenfield development in that region.

SOCIAL IMPACT

One of the goals of the project is to create a sustainable community. For the developer, a focus group was conducted to gauge public opinion and uncover the level of interest of living in efficient homes powered by renewable energy. Results of the group indicated that for renters, home efficiency performance was not an important deciding factor, whereas, not surprisingly, the opposite was true for potential buyers. This finding was relevant for marketing the properties, as some are designed specifically as rental units – though these will still be as efficient as possible.

References: [8] mi-group.ca/
[9] Conversation with Sifton Properties

Figure 7 - Electric charge station parking covered by PV panels. (Source: © west5)

OPTIMIZED UTILIZATION OF PV

A number of simulation programs were used in the analysis of the performance of various layouts of the neighborhoods. Those simulation tools include [9]:

- EnergyPlus
- HOT2000
- RETScreen International
- HOT2XP
- HOT2EC

RESULTS AND DISCUSSION

Conclusions in this case are difficult because the project is ongoing.

PRE-CONSTRUCTION ANALYSIS

The in-depth initial analysis provided by Hachem [4] examined a variety of factors contributing to solar generation potential through aspects such as:

- Roof tilt angle
- Roof orientation
- Roof surface area
- Roof shape/design/orientation
- Adjacent building height
- South façade to west or east façade ratio
- Building envelope/glazing
- Shading
- Internal efficiency measures (appliances, etc.)
- BIPV
- Building configuration

IN RELATION TO THE SCALE

The initial analysis, helped stakeholders understand the effect of specific layouts on the solar access on the site, and therefore on the potential of passive and active design within the community. Some concepts have been taken into account, especially those related to increasing the energy efficiency and installing PV systems on some roofs. The analysis is not expected to influence reshaping the neighbourhood to give priority to resolving solar access issues, and increasing the benefits of passive solar design, nor introducing BIPV (Building Integrated Photo Voltaic) systems instead of BAPV (Building Added Photo Voltaic).

References: [4] Hachem, C. 2014, Design of Solar Optimized Community, Final Report.
[9] Conversation with Sifton Properties

LESSONS LEARNED

An integrated design process from the early design stages was not implemented. This created a number of issues in terms of optimizing the site design to include various sustainable and energy efficiency measures, such as optimal solar access.
Regarding the adopted designs for the buildings currently under construction, the actual cumulative solar potential of the PV panels is not fully integrated into the design of these buildings. As a result, roof-mounted panels are added until they fulfill the required anticipated load. This strategy will only work if the load can be met with the available roof area, something that was not possible for the first commercial building, and so an adjacent solar parkade was incorporated into the building's system. It is possible that additional solar PV structures may be required to off-set the needs of future buildings, but this remains to be seen.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

Extensive resources were invested into the original designs of this community in order to transform it into a 'smart' community. The real potential of the site in terms of solar was revealed after the initial masterplan was conceived. For future developments, a site analysis specifically from a solar perspective should be included at the earliest possible phase of design in order to mitigate time and effort losses associated with re-doing design work. Maximizing the passive design of the buildings would have lessened the electrical load and resulted in the integration of less PV technology, possibly reducing the overall cost of these buildings and the necessity to integrate off-site solar power.

TARGET GROUPS

- Researchers in solar field
- Municipalities
- Urban planners
- Architects
- Micro-utility companies


(Source: © S2e technologies)

DEVELOPER

Sifton Properties

CONSULTANTS

S2E Technologies Inc.
London Hydro
Samsung, LG

CASE STUDY AUTHORS

Caroline Hachem-Vermette and Natalie Robertson (University of Calgary)

OWNERS

Sifton Properties

STAKEHOLDERS

Sifton Properties

ACKNOWLEDGEMENTS

The wish to thank the Sifton Properties

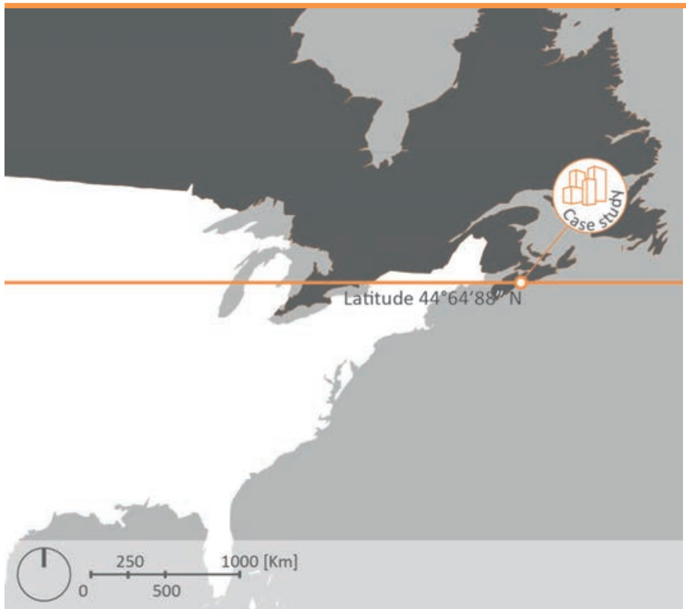
RESEARCH ORGANIZATIONS

UNIVERSITY OF CALGARY
FACULTY OF ENVIRONMENTAL DESIGN

SOLAR IN HALIFAX REGIONAL MUNICIPALITY

CANADA

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Canada
Location: Halifax Regional Municipality
(Lat. 44°64′78″ N; Lon. 63°57′14″ W)
Climate: Humid continental climate with severe winters, no dry season, warm summers and strong seasonality (Dfb) [1].

AREA OF INTEREST

- Targets and goals
- Legislation and technology
- Planning process

NATIONAL AND LOCAL CONTEXT

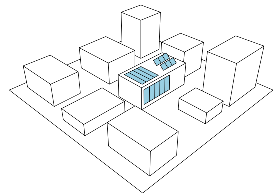
Halifax Regional Municipality (HRM) is Canada's fourth largest municipality by geographic size, and it is ranked as the 14th largest by population. In 2013 HRM developed a growth scenario strategy to minimize its service costs and environmental footprint. While municipalities in Atlantic Canada see themselves as national leaders in areas of sustainability, climate change initiatives, energy security, and greening their communities, complex regulatory and legislative relationships between municipalities and provincial governments limit the municipal regulatory capacity. There is no existing municipal legislation in Atlantic Canada's coastal cities that requires consideration of planning for passive or active solar energy generation as a function of urban planning. A number of leading national initiatives in urban solar energy use such as HRM Solar City program have been deployed in HRM at district level [2].

ABOUT THE CASE STUDY

The case study provides information on three projects in the Halifax Regional Municipality: Solar Energy in Municipally-Owned Buildings, Solar Energy in Residential Houses (HRM Solar City Program) and Solar Energy at Dalhousie University Campus (Dalhousie University Renewable Energy Planning and Project Implementation).

Definition of environment:
Existing urban fabric

Site area: 262,5 m^2 (of HRM)
Urban population: 297 943
Area density: 1 077 residents/km^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Quantifying the Costs and Benefits to HRM, Residents and the Environment of Alternate Growth Scenarios. Final Report. Halifax Regional Municipality, Nova Scotia April 2013

Issues, challenges and decision strategies

Figure 1 - A view of the Halifax Canada Games Centre with photovoltaic panels installed on the roof of the building. (Source: © Canada Games Centre)

HIGHLIGHTS OF THE CASE STUDY

Solar Energy in Municipally-Owned Buildings
Halifax Regional Municipality (HRM) is committed to energy efficient and clean energy solutions at municipally owned buildings. In its solar energy deployment program, the municipality focused on applying solar water heating (SWH) technology.

Solar Energy in Residential Houses (HRM Solar City Program)
The Solar City program offers homeowners in Halifax innovative solar energy options, which can be financed through municipal rate adjustments for up to ten years [3].

Solar Energy at Dalhousie University Campus
Dalhousie University was involved in promoting sustainability in its operations for over 30 years. Dalhousie's Office of Sustainability focuses on supporting solutions that create positive social, ecological and economic change in university operations.

ISSUES AND CHALLENGES

Solar Energy in Municipally-Owned Buildings
The major categories buildings that benefit from solar water heating solutions are sport facilities (i.e. Centennial Pool and Halifax Canada Games Centre) and fire stations (i.e. Central, Sackville and Mainland North).

Solar Energy in Residential Houses
The new Solar City program aims to complete 450 installations of solar technologies annually; increase the opportunities for residents and businesses to reduce cost and environmental footprint, and continue to administer the program on a cost neutral.

Solar Energy at Dalhousie University Campus
Dalhousie University is actively involved in sustainability issues and has received a number of sustainability awards for academic programs, university operations, and research.

DECISION STRATEGIES

Solar Energy in Municipally-Owned Buildings
HRM rated municipally owned buildings for suitability and efficiency of SWH applications to demonstrate net benefits, including cost savings and GHG emissions reductions that could be deployed on a larger scale throughout the entire municipality.

Solar Energy in Residential Houses
In 2015, after a successful two year pilot, Halifax Regional Council approved the Solar City Program for another three years.

Solar Energy at Dalhousie University Campus
Dalhousie developed its new Campus Master Plan, including solar suitability assessment of the campus. A campus utility master plan released in 2012 includes energy and water audits of buildings on campus, and a renewable energy plan. In 2014, the university released a renewable energy plan for the AC.

References: [3] https://www.halifax.ca/solarcity/
[4] Solar Suitability Assessment of Dalhousie University, Halifax, NS. Green Power Labs, 2009

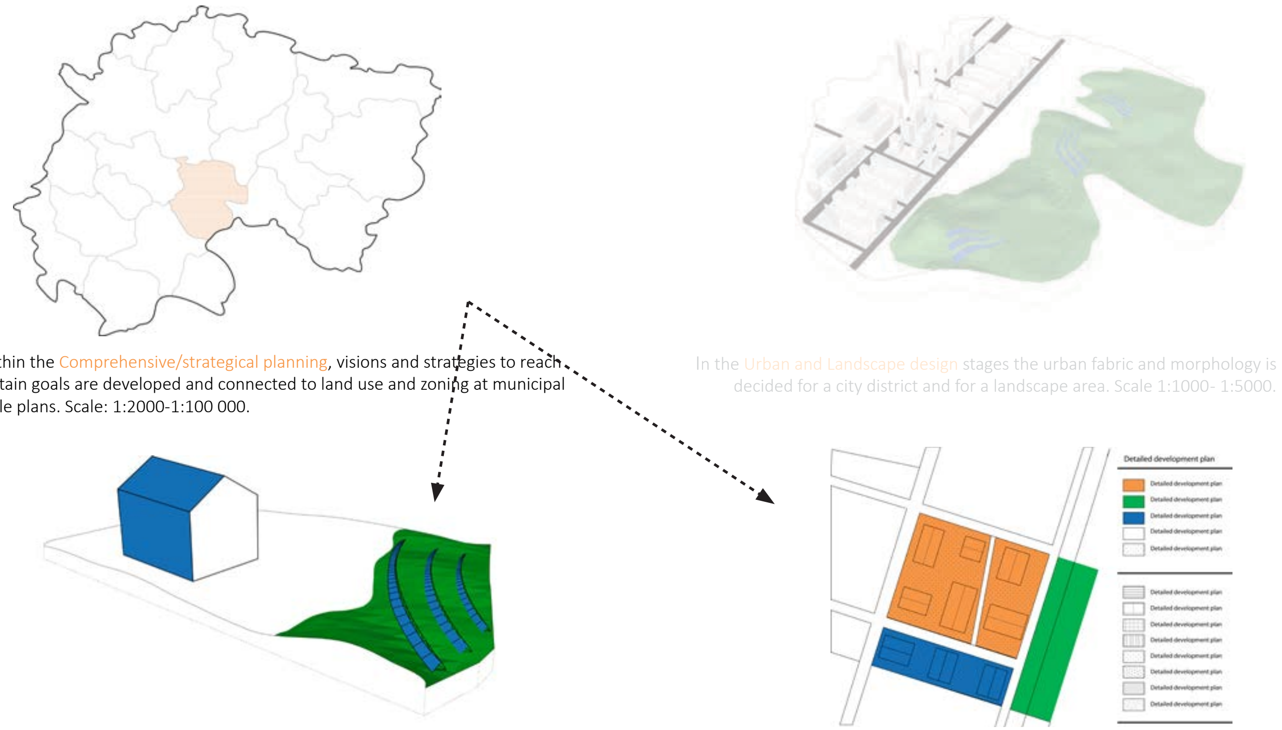
The planning process

In 2010 Dalhousie University located in the Halifax urban core developed a new Master Plan based on leading principles of sustainability and green building.

The Master Plan document, developed by IBI Group and WHW Architects, mapped out a vision for Dalhousie's physical space over the next 10 years. The Master Plan document represented two years of consultation and several phases of work in the development of a comprehensive framework for Dalhousie University's future. As an integral part of the Master Plan, Green Power Labs conducted a solar suitability assessment of the three university campuses.

The objectives of this solar suitability assessment were to determine the suitability of the university facilities and open areas to solar energy generation, and to develop recommendations for using solar energy technologies in the University's energy mix. The solar suitability assessment included high resolution solar resource mapping of the campus areas based on satellite-derived solar resource data, LiDAR-based digital elevation model of the campuses, and fisheye imagery processing technology for consideration of obstructions to sunlight on the campus buildings roofs and walls as well as on the open spaces. Energy generation potential for solar water heating, air heating and photovoltaic power generation technologies was defined for every campus building.

The results of this assessment formed a roadmap for solar energy generation deployment on the university campuses and were integrated in the Campus Energy Master Plan presenting a comprehensive analysis of the current and future use and production of energy on the Halifax campuses. To date, the university has installed two solar thermal systems, one solar air system, a combined solar PV/thermal system, and two solar PV systems. More solar PV is in the planning stages. At the Agricultural campus a Renewable Energy Master Plan was completed. It outlined over 10 projects including solar [5].



Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

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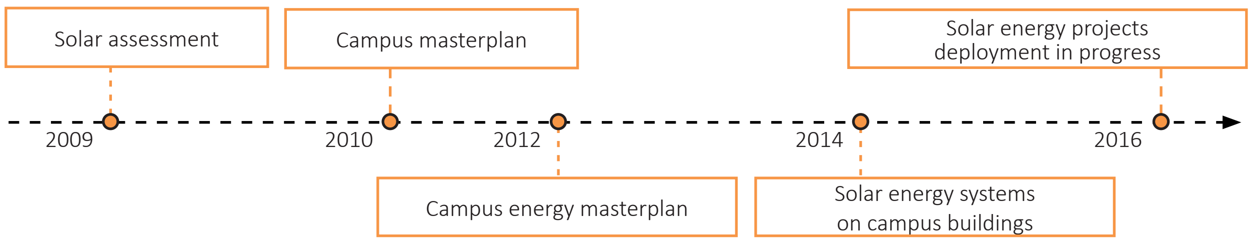
Figure 2 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [5] Dalhousie University Campus Mater Plan, 2010, AC Renewable Master Plan

Figure 3 - Solar Water heating at Dalhousie Life Science Center.
(Source: © Halifax Regional Municipality)

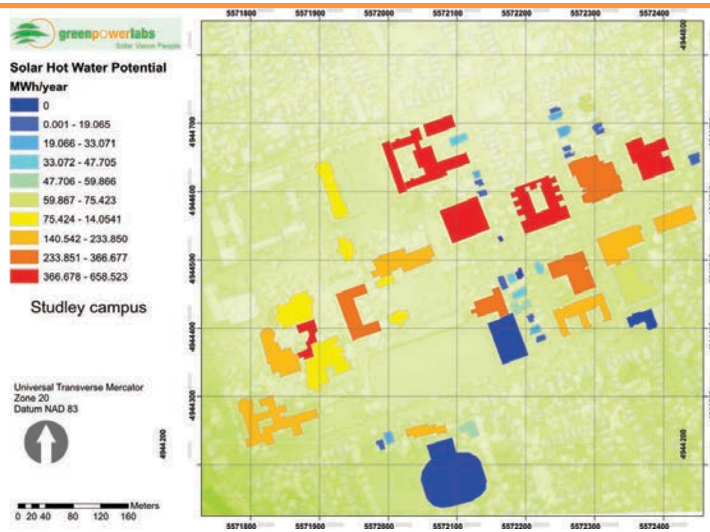


Figure 4 - Study Campus Solar Water Heating Potential, Dalhousie University (HRM).
(Source: © Green Power Labs Inc.)

SOLAR WATER HEATING IN MUNICIPALITY-OWNED BUILDINGS: SWIMMING POOLS AND FIRE STATIONS

As one of Eastern Canada's two 50 m pools, Centennial Pool is home to many of the area's elite swim and dive athletes. The pool contains 2,500 cubic meters of water and remains at a steady temperature of 77 to 82 °F (25 to 27 °C). Built for the 1967 Canada Games, the facility had not had any significant upgrades since it's construction. As a major community energy retrofit, SWH technology was selected. As a part of this project, HRM created a new District Energy System between the Centennial Pool and the neighboring HRM Police Department. New natural gas boilers and 62 solar panels have been installed at the Halifax Police Department (HPD). The buildings have a shared heating system connected by a newly constructed underground trench.Forty eight solar panels have been installed on Centennial Pool to provide domestic hot water to the building.

SOLAR CITY PROGRAM (PHASE 1): SOLAR WATER HEATING RESIDENTIAL HOUSES

Halifax's Solar City Pilot Project was launched in 2012 to promote the utilization of solar energy and reduce Halifax's carbon footprint. The Program [6] enabled homeowners of up to 1 000 residences to install solar water heating equipment as a part of their domestic hot water (DHW) systems. Of the 381 installations completed by August 2015, 47% (178) had electrically-heater domestic hot water systems, 30% (116) had oil-fired systems, and 21% (79) converted from oil-heating to electrical-heating during the installation. The DHW heating of the remaining 2% (6 homes) were by propane or natural gas. The Program included the installation of monitoring systems at 227 homes, which provide data on solar energy use and, in some locations, DHW use. The Program also provided the possibility to replace aging electrical hot water storage tanks or to convert from oil to electrical heating of hot water.

SOLAR ENERGY AT DALHOUSIE UNIVERSITY CAMPUS: SOLAR ASSESSMENT AND DEPLOYMENT PLANNING

A solar study of the three downtown campuses of Dalhousie University was conducted as an integral part of the Campus Master Plan. The study determined solar energy generation potential of the campus facilities, possible role of solar energy technologies in the facilities energy mix and the deploying of solar energy at the campuses. It formed the foundation of the University's solar energy deployment planning [4]. A first implementations of this plan was the solar thermal system used to preheat DHW for the Dalhousie Life Science Center. The system manufactured by Thermo Dynamics Ltd., a major Canadian manufacturer of solar water heating equipment, featured 40 solar collectors for a total of 120 m^2 of gross collector area, 4 500 liters of insulated DHW storage, PV-powered Solar Pumps to circulate the heat transfer fluid and an internet-based monitoring system.

References: [4] Solar Suitability Assessment of Dalhousie University, Halifax, NS. Green Power Labs, 2009
[6] https://www.halifax.ca/solarcity/pilotprojects

Figure 5 - Solar PV on the roof of the room of the Goldberg Computer Science Building.. (Photo: © Dalhousie University)

Figure 6 - Facilities Management's Max Zhao (left) leads a tour of Dal's new Solar PV/solar wall installation on the room of the Goldberg Computer Science Building. (Photo: © Bruce Bottomley)

ENVIRONMENTAL IMPACT

Following the initial HRM solar thermal installations on city property, the community through a unique city program installed 381 installations of solar thermal systems within two years. The residents who installed the system are expected to save over $5.5 million over the expected 25+ year lifespan of the system and reduce greenhouse gases by 16.1 million kg of CO_2.

Fuel type	Proportion of homes [%]	GHG without solar [kgCO2e]	GHG with solar [kgCO2e]	GHG saving [kgCO2e]
Electricity	67.7	977 285	468 120	509 166
Oil	30.7	233 637	111 912	121 725
Propane	1.3	9 627	4 611	5 016
Natural gas	0.3	1 007	482	525
Total	100.0	1 221 556	585 125	636 431

ECONOMIC IMPACT

The Solar City Pilot was managed to be cost-neutral to HRM and to non-participating tax-payers, and to have economic value to its participants.

A screening process, including site assessment and measurement, was followed for each residence to determine the suitability of the proposed location of the equipment, the installation cost, the expected energy cost savings, and the projected return on investment. The information was provided in report form to homeowners for their consideration and approval. HRM offered financing arrangements for projects which met a threshold value of 2% estimated return on investment. Related economic benefits include the use of locally-manufactured solar collectors, monitoring equipment and related components, and all installation by local contractors.

SOCIAL IMPACT

Citizens of HRM are actively engaged in the city's Community Energy Planning; the subsequent Solar City Program have engaged citizens across all districts of the city, and diverse socio-economic groups.

In the course of the Pilot project, HRM hosted eleven 'open house' information sessions throughout the community, which described the SWH technology, how it works, how the economic and environmental benefits and costs are assessed, and the process for implementing a system at a home through the program. The Solar City Program attracted extraordinary amount of media attention and public interest due to its vision, sign-up system and simplicity.

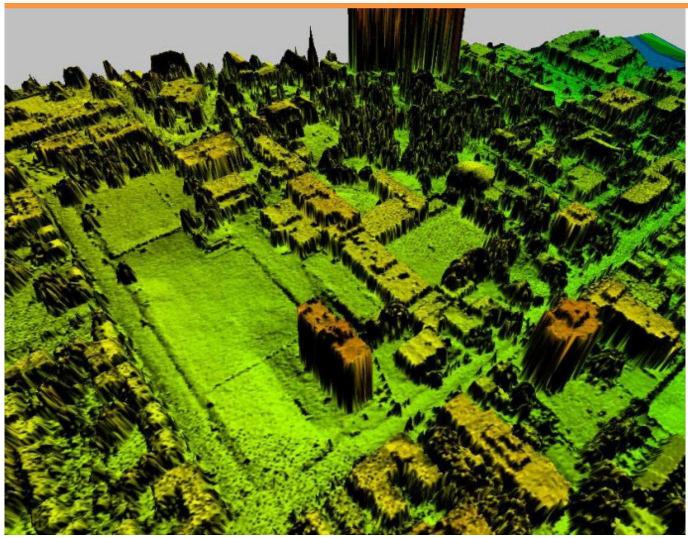


Figure 7 - LIDAR-based Urban Digital Elevation Modeling (Source: © Green Power Labs Inc.)

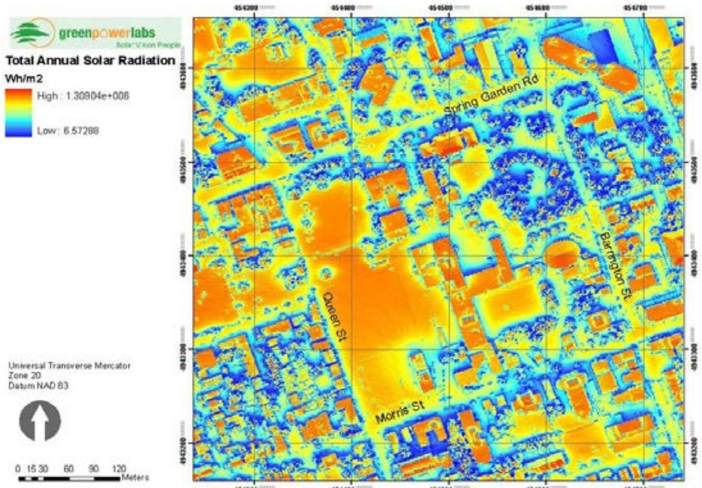


Figure 8 - High Resolution Urban Solar Resource Mapping (Source: © Green Power Labs Inc.)

STRATEGY

The complexity of urban design requires advanced methods and tools to support zoning by laws within a legal framework through efficient decision support, providing tangible information on available solar resource, and addressing the existing and future urban design architectural and approval process in an efficient and harmonized manner. These methods and tools involve high resolution solar resource mapping of the urban environment featuring the distribution of solar irradiation on buildings roofs and walls and providing tangible data on available solar resource at any surface like rooftop solar panel or third-floor southwest facing windows during the entire year. Such urban solar maps also provide a solid foundation for addressing urban solar rights issues as they allow to develop “solar envelopes” as a zoning device to achieve solar access by regulating development within limits derived from the sun’s relative motion.

METHODS AND TOOLS FOR URBAN SOLAR MAPPING

To ensure required level of accuracy in determining solar resource on buildings roofs and walls in urban environment, a combination of three major tools was used: satellite imagery processing for solar resource data, LiDAR based digital elevation modeling and fisheye imagery processing. Satellite imagery processing allows to determine solar irradiation in North America and Europe at spatial resolution of 1 sq.km and temporal resolution of 15 min. Satellite-derived solar irradiation data calibrated by ground-based measurements presented the best solar microclimatology data. To adjust this data to building site and building surface, urban 3D models based on LiDAR data were used; this models provided 0.5 m spatial resolution. Fisheye processing tool applied to this ultra-high resolution 3D model described the variability of solar resource on individual building faces with consideration of all obstructions to solar irradiation by existing natural and built environment.

METHODS AND TOOLS FOR SOLAR SUITABILITY ASSESSMENT

For residential applications in HRM Solar City Program in the areas not covered by LiDAR survey, a combination of tools was used for solar suitability assessment including Pictometry’s high resolution aerial oblique imagery tools and Green Power Labs’ SolarRating Online tool. The oblique imagery tool allowed for online measurements at the assessed property, including locating and measuring obstructions to solar irradiation. The SolarRating Online tool allowed to use these measurements for determining the available unobstructed solar resource on the target roof or wall of the property, and then to calculate the impact of existing obstructions on solar resource availability and the output of solar energy systems considered. The Solar City Program used this toolset to assess solar suitability of the candidate houses and related business cases for SWH system deployment and select the applications with best economic performance most beneficial to the property owners.

SOLAR SHADING

The "Solar in Halifax Regional Municipality" case study presented a holistic view on the deployment of solar energy generation in the municipality in three major areas: urban solar planning, deployment of solar energy systems on municipal properties and on residential houses. Halifax Solar Map [7] presented the first municipal tool for public engagement and municipal solar planning in Canada. Solar energy generation potential was determined for a part of Halifax urban core (Dalhousie University campuses) using LiDAR data and urban obstruction analysis techniques; the resulting data was used in planning and deploying solar energy systems on the university facilities.

The study analyzed current deployment of solar energy at municipally owned facilities; two major types of facilities were provided with solar solutions – sport facilities (Centennial Pool and Halifax Canada Games Centre) and fire stations (Central, Sackville and Mainland North Fire Stations) were reviewed in detail in the study. Solar water heating technology was used in all municipal applications; the sport facilities utilized flat plate solar collectors while the fire stations tested the use of flat plate, evacuated tube and concentrated solar beam collector technologies.

HRM Solar City Program was evaluated; the Program featured massive public engagement and advanced methods and tools for evaluating and selecting best performing cases featuring positive cash flow for candidate participants. The Program enabled homeowners of up to 1 000 residences to have solar water heating equipment installed with financing managed via municipal rate adjustments for up to ten years. Solar monitoring map was developed for ongoing public review [8].

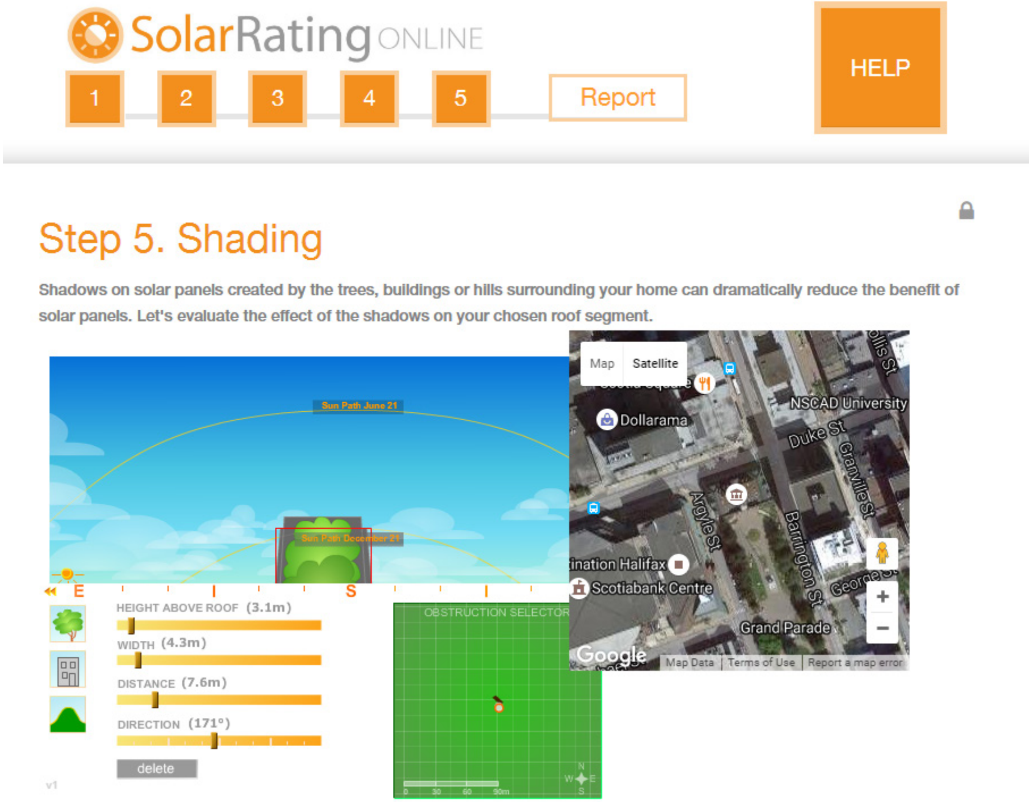


Figure 9 - SolarRating Online Solar Assessment Tool was used by the HRM Solar City Program for pre-screening and evaluating program applications. (Source: © Green Power Labs Inc.)

References: [7] Halifax solar maps
[8] HRM Solar Monitoring Map

Figure 10 - HRM Solar City Program: Call for Action. (Photo: © H. Douris)

LESSONS LEARNED

The Solar City Program has engaged Halifax in an activity which is consistent with the interests of its residents in a manner which is understood to be: innovative on the part of HRM, enabling residents to act on their environmental and financial objectives, and without penalty to non-participating tax-payers. The Program has increased awareness of a major social issue (environmental stewardship) in terms of Halifax's ability to act as a community. The Program contributed to the community's understanding of practical, economic and environmental considerations related to implementing renewable energy technologies. The Program has prepared the way for future technology applications of renewable energy, demonstrated the process and provided insight into what changes may be advised.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

Direct the next phase of the Solar City program at increasing the opportunities for residents and businesses to save money and reduce their environmental footprint, consistent with HRM's Community Energy Plan, Economic Strategy and Regional Plan. Include specific goals:- 450 installations from a variety of solar technologies, inclusion of solar photovoltaic (PV) power, solar air heating and solar water heating technologies;- continue the Solar City program on a cost-neutral basis for the municipality;- monitor factors influencing potential participation such as evaluation of future participation, pre-screening of potential sites, detailed evaluation of the return on investment of solar technology applications, and evaluation of installation cost options and financing options available to home-owners.

TARGET GROUPS

- Halifax Regional Municipality Citizens
- Federal and Provincial Stakeholders in Climate Initiatives
- Local Business (Deployment and Economic Opportunities)
- Local Universities and Nova Scotia Community College (knowledge and skills development)
- Buildings Owners and Managers Association
- Nova Scotia Homebuilders Association
- Solar Nova Scotia
- Canadian Solar Industries Association
- Nova Scotia Department of Energy
- Efficiency Nova Scotia

PUBLIC AND EDUCATION ACTIVITIES

Online Project Reports, Town Hall Meetings, Council Meetings, Local Print and Visual Media

(Source: © Renewable Energy Storage Laboratory (RESL) Dalhousie University)

ARCHITECT, DESIGNER AND DEVELOPER

Thermo Dynamics Ltd

CONSULTANTS

WHW Architects

CASE STUDY AUTHORS

Dr. A. Pavlovski. P. Eng. and M. Moore (Green Power Labs Inc.)

OWNERS

Halifax Regional Municipality
Dalhousie University

STAKEHOLDERS

Halifax Regional Municipality

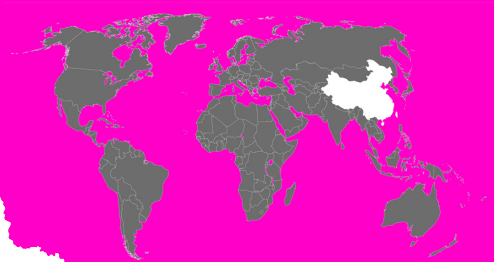
RESEARCH ORGANIZATIONS

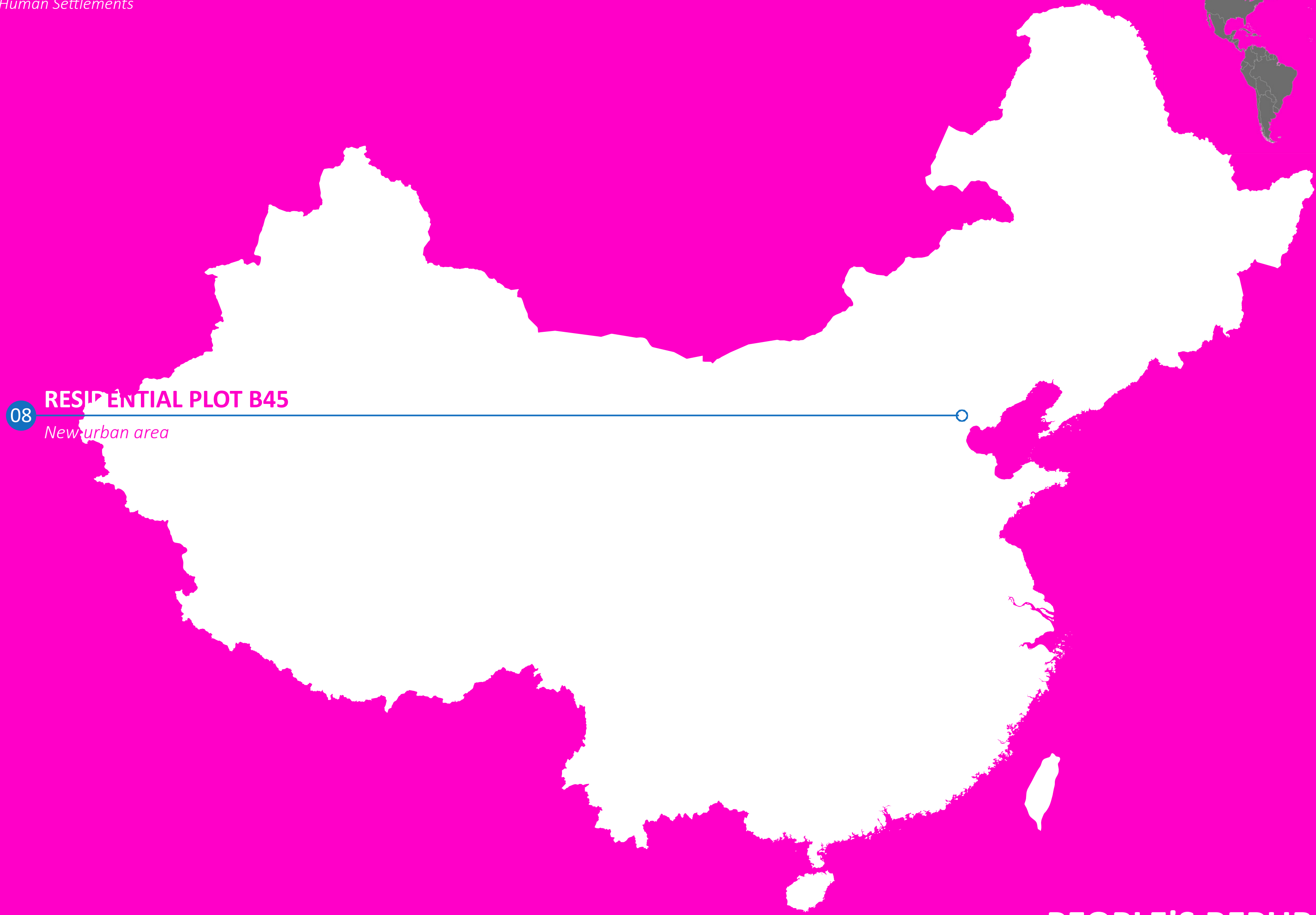
greenpowerlabs

3.3 CHINESE CASE STUDY

CHINESE TEAM

Jianqing **He**
China National Engineering Research Centre for Human Settlements





PEOPLE'S REPUBLIC OF CHINA

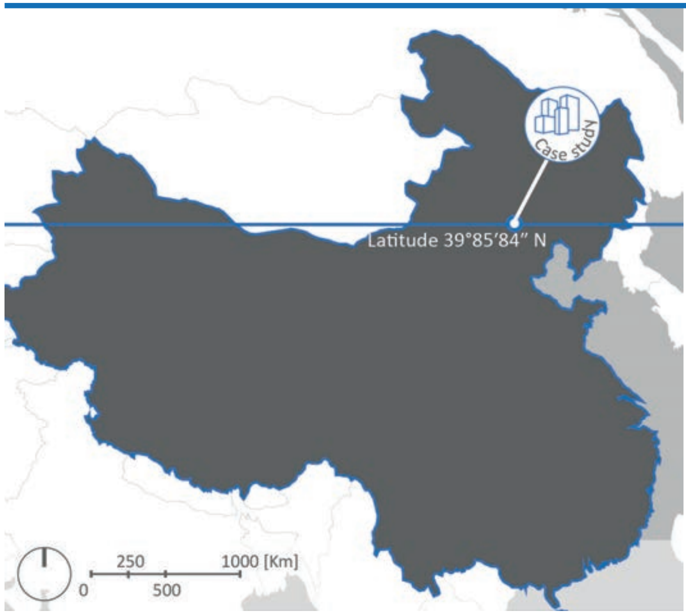
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

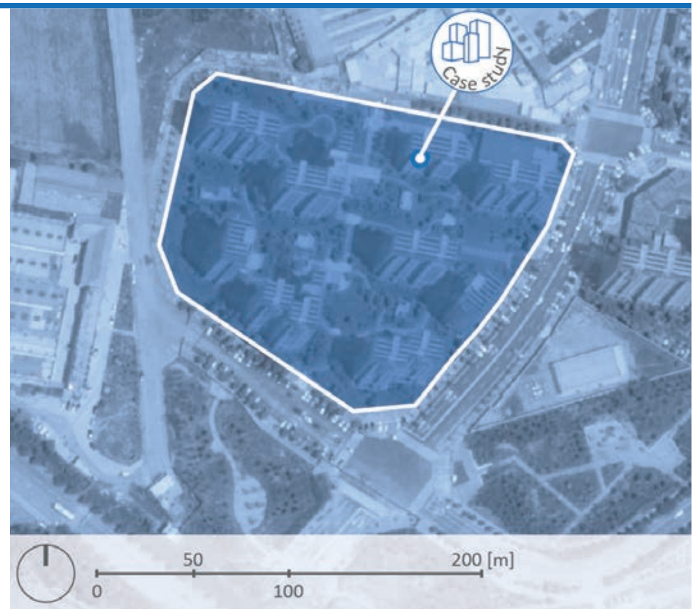

Source: (© zhulong.com)

RESIDENTIAL PLOT B45

CHINA

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: China
Location: Fengtai District, Beijing
(Lat. 39°85'84"N; Lon. 116°28'71"E)

Climate: Cold temperature, dry winter, hot summer (Dwa) [1]

AREA OF INTEREST

- Targets and goals
- Planning process

NATIONAL AND LOCAL CONTEXT

The local authority of Fengtai District, supports ecological development in the Changxindian new town planning with population of 30 000 and area of 500 ha by the Yongding River.

The Eco-city Criteria focuses on technical specifications for community and landscape planning, building design and property management with much concern on Renewable Energy, Microclimate, Carbon Fixation and Ecological built environment as a whole in sustainable development.

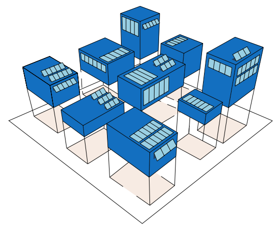
Green Building regulations and eco-city criteria are being implemented in Plot B45 included 21% of the total energy consumption which is being covered by renewable energy [2][3].

ABOUT THE CASE STUDY

Plot B45 is a remarkable project which benefits from eco-city and green building development. Integrated solution of SWH system for tower buildings and may contribute to the scale-up of solar energy use in urban planning and design.

Definition of environment:
New Urban Areas

Site area: 25 000 m^2
Building area: 71 000 m^2
Urban density: 18.33



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Beijing Planning Commission et al. (2012). Design Standard of Green Buildings, DB11/938-2012
[3] Beijing Vanion Investment Group Co., Ltd. (2016). Changxindian Eco-city

Issues, challenges and decision strategies

Figure 1 - Schematic layout of roofing system for solar collector arrangement (Source: © Beijing Institute of Residential Building Design & Research Co., Ltd, 2011.)

Figure 2 - Distribution of solar collectors in Plot B45. (Source: © Xiaoxuan Zhang)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case are [4]:

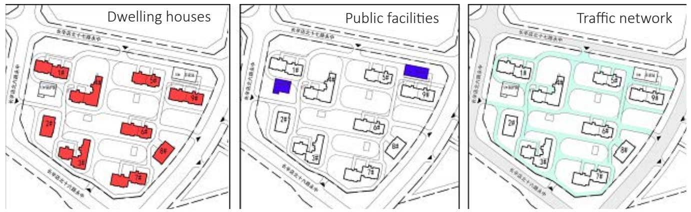
- Eco-city indicators are controlled strictly by multi-stakeholders through planning process;
- 9 tower buildings ranging from 11-storey to 15-storey with diverse orientations formed 30m wide ventilation corridor for summer while keep microclimate in winter;
- SWH system with roof-top solar collectors integrated into site planning, landscaping and building design at early stage by condition setting and scenario analyzing;
- Green roofing layout took solar collectors as shading in summer and transparent parapets as protection in winter for growing plants.

ISSUES AND CHALLENGES

- Tower building has disadvantages in solar collecting area. Operation and maintenance friendly layout for SWH system installation and retrofit condition is the key issue in all buildings. Making maintenance safer and convenient is another key issue [5].
- Considering green roof and solar collector as an integrated design object to avoid segregated layout.
- Central collecting and individual storing SWH system has higher percentage of solar fraction when taking each single tower building as a whole. Nine central heating systems with individual storages were finally selected.
- Beyond the planning process, the responsibilities regarding design, installation and management of SWH systems may be unclear and cause difficulty to operation management later on as learnt from previous projects.

DECISION STRATEGIES

- Integration of urban design and passive design.
- Design for a visible and remarkable characteristic from architectural and urban landscaping perspective.
- Using standard solar modules and set them free from flat building roof by using steel framework structure.
- Potentialities to monitor SWH system and coherent Eco-city indicators in a life cycle consideration.



References: [4] Beijing Vanion Real Estate Development Company. (2016). Application Portfolio for 2-star Green Building Label, bj.gbonline.org, 2016-2-1.
[5] MoHURD. (2005).Technical Code for SWH System of Civil Buildings, GB 50364-2005

THE PLANNING PROCESS

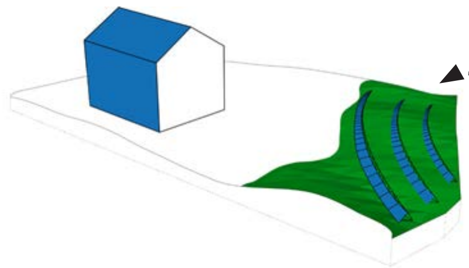
Residential Plot B45 is one block of the eco-community in Changxindian Eco-city. In 2009 Beijing Vanion Investment Group Co., Ltd. coordinated with Beijing Institute of Urban Planning and Beijing Institute of Urban Infrastructure, finished the Master Planning of Changxindian Eco-city. It marked that the New Town has been selected as a National Pilot Project for ecological development by benchmarking eco-city criteria to regulate zoning, urban design, site planning and building design indicators. This challenging work earned ISOCARP's Award for Excellence in 2009 [6].

It took approximately 2 years to obtain zoning and land use approval. Residential Plot B45 was permitted to be developed by Beijing Vanion Real Estate Development Company, a subsidiary company owned by Beijing Vanion Investment Group Co., Ltd. and contracted Beijing Institute of Residential Building Design as designer and Gao Zhe as chief architect .

The design cycle is quite limited. Urban planners and architects had to work with engineers, consultants, solar product/ construction/ supervision companies simultaneously. As a result of this cooperation, the layout of SWH system in tower buildings did not compromise on aesthetics in proportion, texture and perspective. Plot B45 was completed in 2014 and certified twice as 3-star Design and 2-star Operation Label of Green Building Program [7].

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

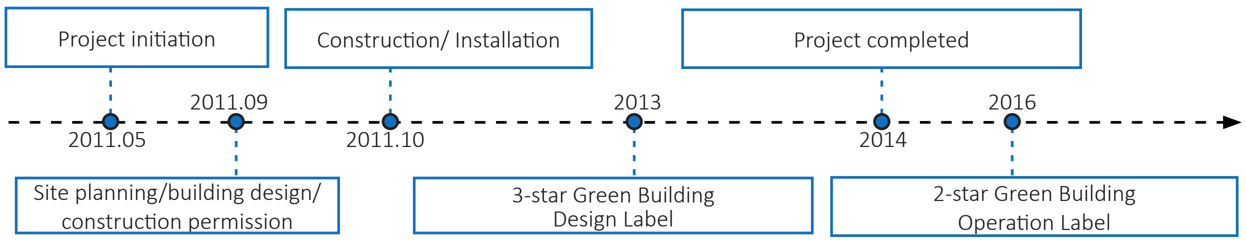
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [6] Editor. (2009). ISOCARP's Award for Excellence 2009'. Landscape, Vol.83, No.6, 10-10

[7] Beijing Municipality. (2014). Beijing Green Building Action Implementation Plan, www.beijing.gov.cn, 2013-6-24

Figure 4 - Top view of the intervention.
(Source: © Beijing Institute of Residential Building Design & Research Co., Ltd, 2011.)

SWH for all households. Layout of 1020 modules with collecting area 4.8 m^2 for each and 0.53 m^2 for each household is as below:

Building No.	Orientation	Storey	Roof inclination	Solar collector orientation	Number of solar collectors	Solar collector inclination
B45- 1	SW 11°	14	0°	SW	98	30°
B45- 2	ES 11°	15	0°	SW	61	30°
B45- 3	SW/ES 11°	13-15	0°	SW/ES	72/19	30°
B45- 4	SW/ES 11°	15	0°	SW/ES	72/19	30°
B45- 5	SW 11°	11	0°	SW	75	30°
B45- 6	SW 11°	15	0°	SW	88	30°
B45- 7	SW 11°	13-15	0°	SW	90	30°
B45- 8	ES 51°	15	0°	SW	61	30°
B45- 9	SW 11°	14	0°	SW	98	30°

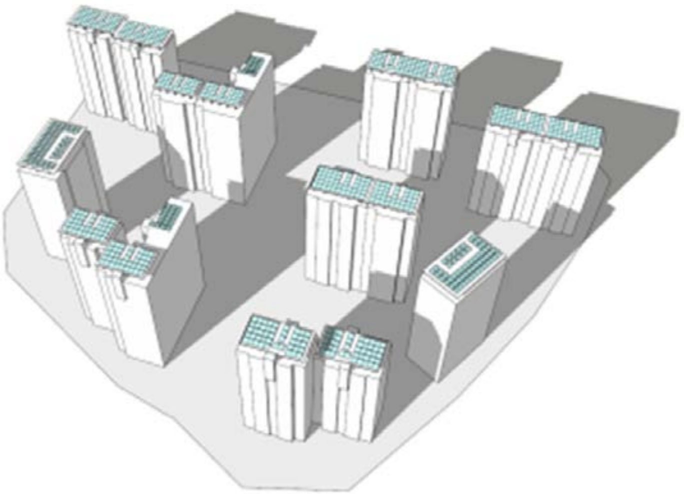


Figure 5 - 3D model of the intervention: view of the PV installed o the roof and the shadows created by the buildings (Source: © Xiaoxuan Zhang)

SUMMARY

- Plot design has decided on two renewable energy utilization methods: solar hot water for domestic use and geothermal heat pumps. Renewable energy should account for 21% of the total energy demand, 50% of domestic hot water should come from solar energy. Solar energy should account for 9% of the total energy demand [4].
- Building energy consumption regulated by eco-city criteria, enterprise level, should be 21% less than the current national level, that is, the energy conserving rate should reach 72%.
- Roof collection is selected. Central collecting and individual storing forms the SWH and DHW system.

TECHNOLOGY

The important feautures of the solar system are:

Equipment	Specification
Collectors	Total glass vacuum tube. Type: LPC 58-1830
Indoor water tank	120L with 2 kW subsidiary electricity heating
Buffer tank	0.5 T with 5 kW subsidiary electricity heating
Circulating water pump	PH-254E PH-403E
Control cabinet	18 kW

Roof-top solar thermal collectors can work simultaneously for 4 hours, conforming to the standard of minimum 2 hours per day set by National Design Code [5]. The collectors have the same orientation as the buildings with 11° south by west (even the east by south oriented B45-2 and B45-8), which can collect as much radiation as possible [6]. The inclination angle of the collectors is 30°.

SOLAR ENERGY AND ENERGY SYSTEM

Solar radiation by 39°48’ inclination	17.2 MJ/(m^2·d)
Designed solar fraction	65 %
Designed efficiency of SWH system	72 %
Initial water temperature	13°c
DHW final temperature	55°c
Energy consumption of storage re-heating	5000 kWh/a (anti-frozen by electricity)
Energy consumption of water-loop heat pumps	72000 kWh/a
Household energy consumption of DHW subsidiary heating	200 kWh/ household·a
Conventional energy alternative	210 tce/a
Cost-effectiveness ratio	0.31
DHW price	CNY 1.70/t
Static payback period of investment	3.5 a

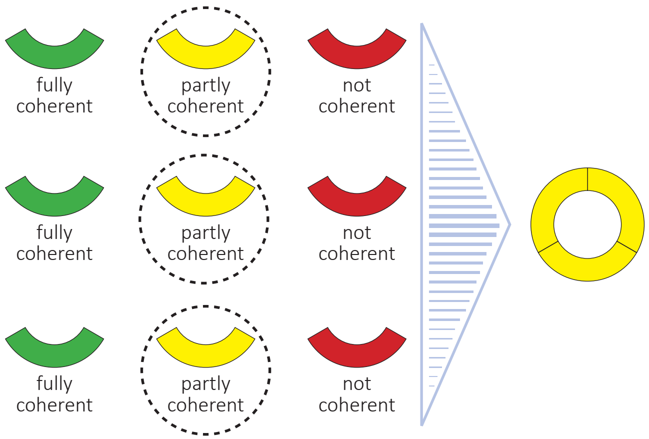
References: [4] Beijing Vanion Real Estate Development Company. (2016). Application Portfolio for 2-star Green Building Label, bj.gbonline.org, 2016-2-1.; [5] MoHURD. (2005). Technical Code for SWH System of Civil Buildings, GB 50364-2005; [6] Zuo, T. (2015). SWH Case Study on Park Yuanbofu of Vanion Eco-city, Construction Science and Technology, No.8, pp 66-69.

Figure 6 -System geometry. (Source: © www.dlsc.ca) [8]

Figure 7 - Modular pattern. (Source: © www.zhulong.com) [8]

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	**1** - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	**2** - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	**3** - MODULAR PATTERN



COMMENTS

The collectors have the same orientation as the buildings. Roof-top solution with enlarged steel platform for solar modules creates new possibilities.

References: *[8] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 8 - Integration layout of solar modules and green roof (Source: © www.zhulong.com)

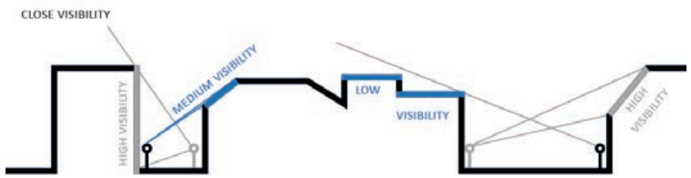


Figure 9 - Different levels of visibility of city surfaces from public domain. [8]

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	●
REMOTE VISIBILITY	○	○	●
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

Plot B45 is located in a completely new urban area. It is the first residential block being developed in Changxindian Eco-city area and it is a landmark in the new town area.

SYSTEM VISIBILITY

Nine roof-top solar collectors' platforms shaped the skyline of Plot B45. This scene can be closely or remotely found from the underground station, Park Expo, river front and new town center, without clearly distinguishing the solar collectors though, being on the top of the towers.
Plot B45's recognizable façade with color and texture is another scenic view which has become a landmark.

There is no doubt that Plot B45's practice would be referential to solar energy use in tower buildings and residential block planning.

References: [8] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 10 - View of green roof. (Source: © www.zhulong.com)

Figure 11 - A view when the intervention has been completed (Source: © Xiaoxuan Zhang)

ENVIRONMENTAL IMPACT

After the project completed and until the end of 2015, Plot B45 saved 6,034 tons of coal equivalents, reduce 2,876 tons of CO_2, 87 tons of SO_2, 43 tons of NOx and 784 tons of dusts [4]. SWH system contributed to conventional energy alternative as 210 tons of coal equivalents annually [9].

Eco-city criteria implemented in Plot B45, including renewable energy use, building energy efficiency and emission reduction indicators, are higher than National level and Local level [10]. It is regulated that in Article 4.2.11, Green Building Evaluation Standard , 10% of the total energy consumption should be provided by renewable energy [11]. Plot B45 increased it to 21% by using SWH system to cover 9% and geothermal to cover 12% [9].

ECONOMIC IMPACT

- Integral design, operation and management can ensure a higher return with lower investment. It is expected that a running cost of CNY 554 200 can be saved yearly [4].
- Refunding to 3-star Design and 2-star Operation Labels of Chinese Green Building Program is approximately as much as CNY 45/m^2 subsided by Beijing municipality.
- The total incremental costs of Green Building measures and means are CNY 3 316 100 (CNY 35.28/m^2), of which SWH system took CNY 3 000 000 (equivalent to 90.46% of total). It is about 0.37% of the total construction cost (excluding land value). The payback period is estimated to be about 5.98 years statically and 9.59 years dynamically [9].

SOCIAL IMPACT

- The Plot B45 takes international practice on ecological development as referential prototype of eco-community planning.
- Experience gain from this case and Changxindian Eco-city had helped local authority to enroll eco-city criteria into urban planning permission and approval. Implementation monitoring of these criteria with life cycle concern is gradually developed for inclusive urban governance.
- Dwellers and homeowners of Plot B45, later with those of Plot 57 and Plot 54 nearby highly appreciated the coefficient of performance and running cost.
- The unique and amazing architecture image is highlighted by urban planners, architects and professionals.

References: [4] Beijing Vanion Real Estate Development Company. (2016). Application Portfolio for 2-star level Green Building Labeling, bj.gbonline.org, 2016-2-1.6
[9] Beijing Zhongchengshenke Ecological Science Co., Ltd. (2012). Application Portfolio for 2-star level Green Building Labeling, bj.gbonline.org, 2016-2-1
[10] MoHURD. (2006). Standard for Green Building Evaluation, GB/T50378-2006 (updated to GB/T50378-2014).
[11] Beijing Housing and Urban-Rural Development Commission et al. (92015). Evaluation standard for Green Buildings, DB11/T 825-2015

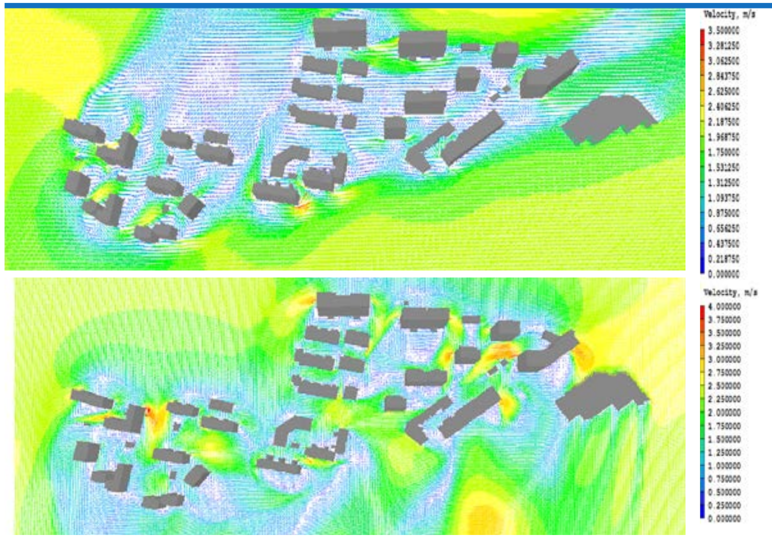


Figure 12 - Summer (upper, 2.1m/s SW) and winter (lower, 2.6m/s N) season wind environment simulation in an enlarged area at 1.5 m ground level above by Phoenics 2009. (Source: © Beijing Zhongchengshenke Ecological Science Co., Ltd.)

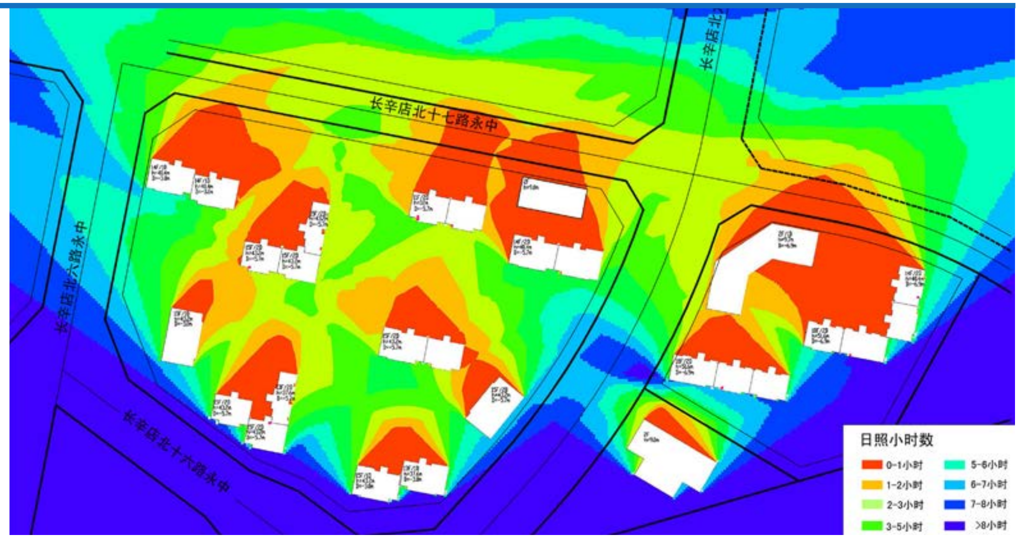


Figure 13 - Light environment analysis by SUNSHINE-V 3.0 based on AutoCAD R14/ 2000-2008. (Source: © Beijing Institute of Residential Building Design & Research Co., Ltd).

TOOLS FOR THE PLANNING LAYOUT OPTIMIZATION

- Microclimate control was made by wind environment simulation with Phoenics2009, air pollution simulation with SCREEN3, noise simulation with Cadna/A, light environment simulation with SUNSHINE-V 3.0 [9].
- Feasibility layout and 3D modeling of site planning were simulated and optimized with SketchUp [12].
- Building energy efficiency calculation tools are: PKPM- PBECA V1.0, Regulated Indicator Calculation Sheet (Excel format) [9] required by National [10] or Beijing Local [2] Design Code .
- There is no SWH system calculation tool used in this project but regulated indicators (see: Solar System Details) were calculated and revised .

IN RELATION TO THE SCALE

- At the first stage of site planning residential illumination was simulated by SUNSHINE-V 3.0 with measuring and reporting means. To control illuminate hours under Major Cold Day distances between 9 tower buildings were optimized and relevantly enlarged [9].
- SUNSHINE-V 3.0 can provide analytical, dynamic search and genetic algorithm method in computer graphics for simulation and analysis. It is the official tool for urban design and site planning in Beijing.
- Plot B45's roof-top solar collector layout provide rich and flexible arrangement to gain simultaneous solar radiation.

PLANNING TOOLS OUTWEIGH BUILDING ENERGY EFFICIENT DESIGN

- Besides computer graphics there are more options and accessibilities of tools for engineers and consultants in Building Energy Efficient (BEE) design, but lesser opportunity of tools for urban planners in site planning.
- Passive design tools need to be developed in a scale-up approach.

References: [2] Beijing Planning Commission et al. (2012). Design Standard of Green Buildings, DB11/938-2012
[9] Beijing Zhongchengshenke Ecological Science Co., Ltd. (2012). Application Portfolio for 2-star level Green Building Labeling, bj.gbonline.org, 2016-2-1
[10] MoHURD. (2006). Standard for Green Building Evaluation, GB/T50378-2006 (updated to GB/T50378-2014).
[12] Beijing Institute of Residential Building Design & Research Co., Ltd. (2011). Application Portfolio for 2-star level Green Building Labeling, bj.gbonline.org, 2016-2-1

CONSULTING BY TOOLS TO SCALE UP SOLAR ENERGY USE

Previous solar energy use is mainly emphasized on BEE with passive design. The urban planner and architects team work with aptimazation tools and concultants simultaneously during the planning and designing process.

Normally urban planners and architects are responsible for 3D modeling to optimize skyline, building orientation, and landscape. On implementation of eco-city and green building criteria they accepted wind and light environment simulation, air pollution simulation and other tools to enable final results and effects being foreseen and visualized in large dimension planning works.

RESULT AND DISCUSSION

The urban planning and building design of Plot B45 was consulted with microclimate control, illumination, building energy efficient.

Integration of SWH system into tower buildings was done by architects and solar manufacturers.

A tool to link architect and manufacturer work together is needed in order to share information of solar collector's layout and system specifications.

Building B45-2# and B45-8# changed solar collector orientation from ES to SW while L-shaped B45-3# and B45-4# kept SW orientation as a result of optimization under scenarios and conditions [4].

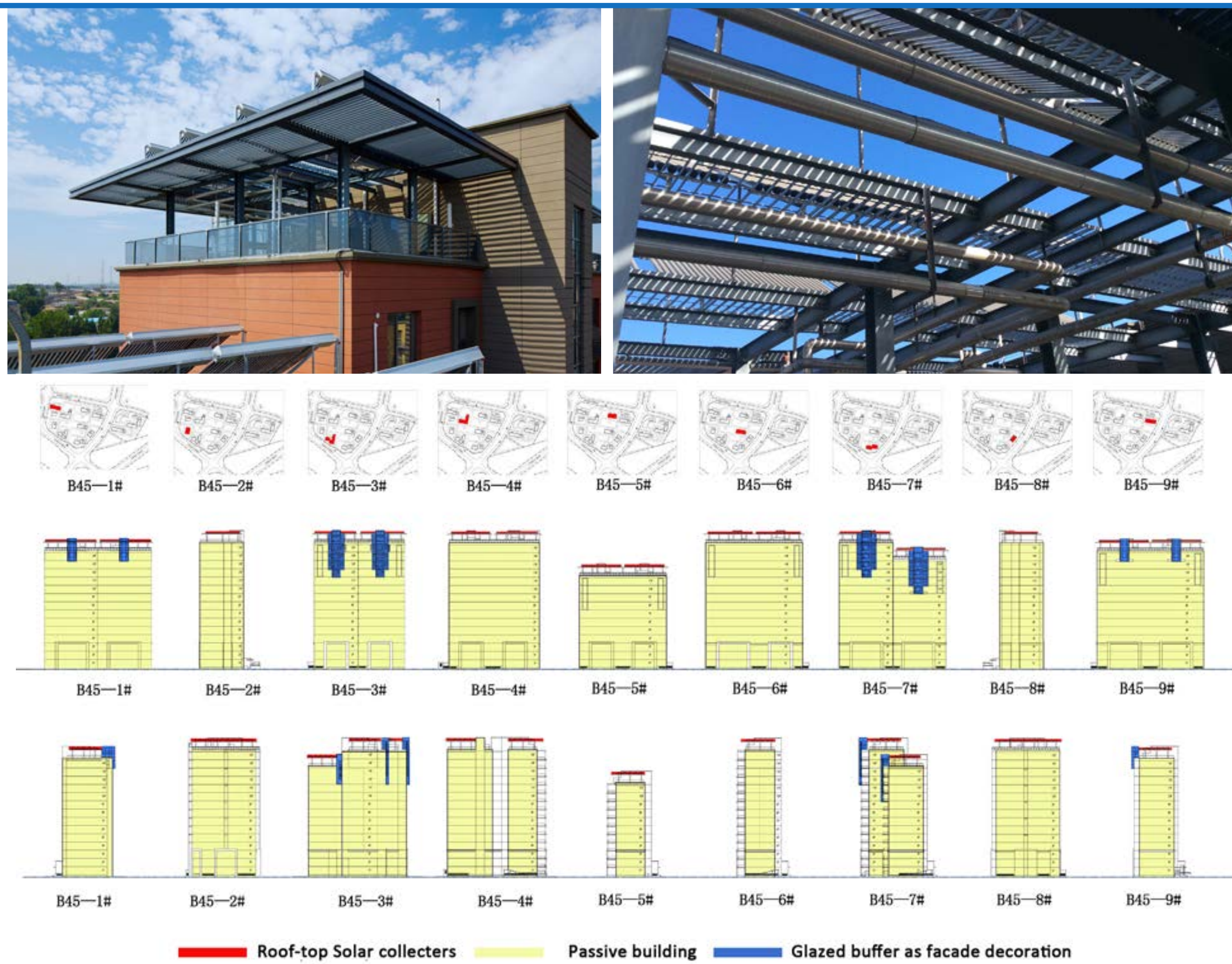


Figure 14 - Total glass vacuum tubes on their supporting framework (Photo: © Jianqing He) and analysis of solar collector and glazed facades (Source: © Xiaoxuan Zhang)

References: [4] Beijing Vanion Real Estate Development Company. (2016). Application Portfolio for 2-star level Green Building Labeling, bj.gbonline.org, 2016-2-1.6

Figure 15 - View of green roof. (Source: © www.zhulong.com)

LESSONS LEARNED

- Tower building is a widely referred to prototype in large cities of China which have little space for solar collectors on the roof.
- Alternatively Plot B45 selects steel supporting framework so as to enlarge total collecting area and to free module arrays from ventilation outlets, rainwater inlets, etc. on roof surface.
- Combine central solar collecting system with green roofing system together is desirable and adoptable for a tower building's SWH solutions.
- Using vacuum tube module and not flat panel is better to avoid strong wind impact in winter and spring period, and can provide shading in summer for green roof planting.
- Solar roof plus green roof reduces heat island effect by cooling the outdoor air about 3- 5 °C.
- For green roof's soil moisture control and the ventilation pipes are buried to enable plants to grow [13].

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- For solar energy in urban planning, it is necessary to launch higher eco-city criteria in master planning, zoning, and urban design.
- Participation of multi-stakeholders at early stage is important for new urban area development because final users are unknown.
- Integral layout oriented urban planning and architecture innovation for solar energy use at earlier phase of new construction project (e.g. programming, energy strategy, building engineering design, etc.) play an important role during the whole procedure.
- R&D of user friendly tools and measurements are still behind the need of solar energy use in urban planning and building design.
- Life-span launching of eco-city related criteria, e.g. green building, healthy community is still challengingreal estate.
- Corresponding beyond Green Building's terms are expected to explore further potentialities and scale-up policies of incentive solar energy programs.

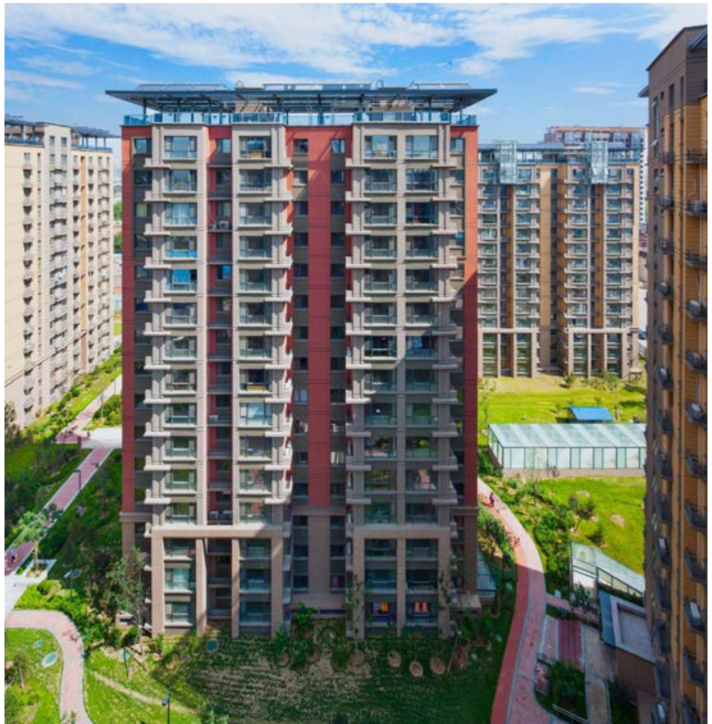
TARGET GROUPS

- Decision makers
- Developers
- Owners/ clients
- Planning management
- Planners
- Designers and engineers
- Solar product manufacturers
- SWH system Installers
- Consultants
- Property management
- Energy management
- Investors
- Donors

PUBLIC AND EDUCATIONAL ACTIVITIES

On-site workshop, career and continuant training for registered architects, MEP engineers and certified urban planners organized by Non-profit Organisations .

References: [13] Beijing Housing and Urban-Rural Development Science and Technology Promotion Center. (2016). Application portfolio of Residential Plot B45, bj.gbonline.org, 2016-2-1



(Source: © zhulong.com))

DEVELOPER

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Individual homeowners
Beijing Vanion Real Estate Development Company

STAKEHOLDERS

China Railway Electrification Bureau (Group) Co., Ltd
Beijing Jianyuanjinsha Project Management Co., Ltd.
Shandong Linuo Paradigma Co., Ltd
Beijing Xingbang Property Management Co., Ltd.

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CHINA NATIONAL ENGINEERING RESEARCH CENTER FOR HUMAN SETTLEMENTS

ACKNOWLEDGEMENTS

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3.4 DANISH CASE STUDIES

DANISH TEAM

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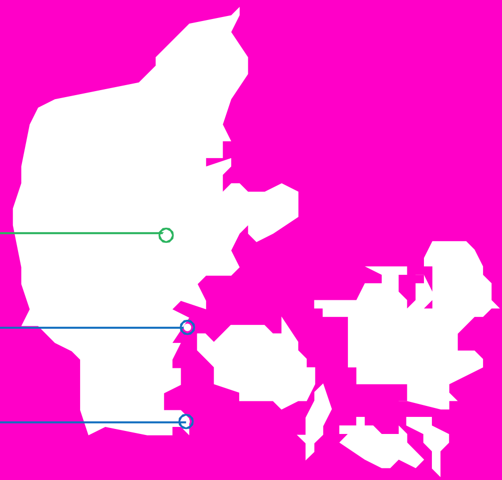
Solar City Denmark
Arkitekternes Hus

Simon **Stendorf Sørensen**
PlanEnergi

09 **SOLAR DISTRICT HEATING BRÆDSTRUP**
Landscape Solar Thermal plant

10 **FREDERICIAC**
New development area

11 **GEHRY CITY HARBOR IN SØNDERBORG**
New development area



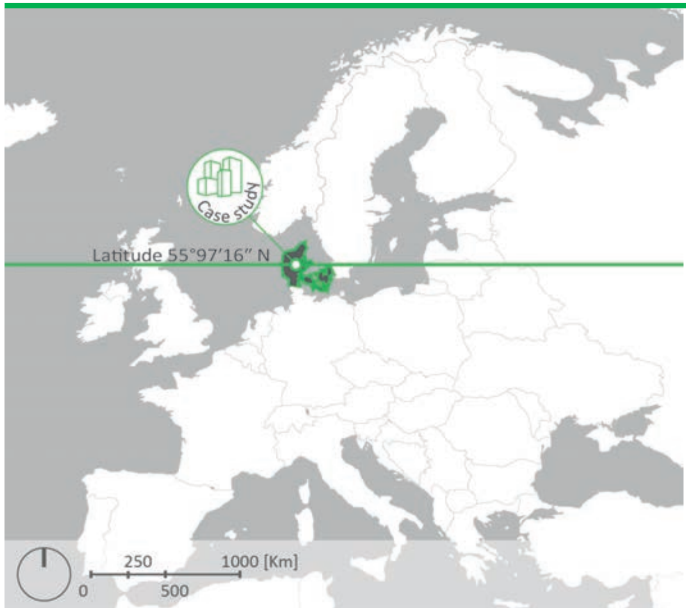
DENMARK

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

SOLAR DISTRICT HEATING BRÆDSTRUP

DENMARK

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Denmark

Location: Brædstrup, Central Jutland Region
(Lat. 55°97′16″N; Lon. 9°61′10″E)

Climate: Humid continental climate- (Dfb) [1]

AREA OF INTEREST

Targets and goals

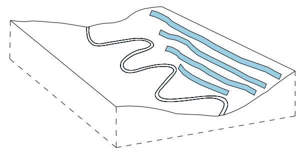
NATIONAL AND LOCAL CONTEXT

District heating is the most common heating source in Denmark and heat production from large-scale solar thermal (ST) plants has been an integrated part of the Danish district heating system since early 1990s [2]. In the last 10 years, the district heating companies' installation of large-scale ground mounted solar collector plants have increased strongly reaching a total installed capacity of 550 MW in 2015 equivalent to twenty times the installed capacity in 2005 [3]. This trend is caused by several conditions including national regulation aimed to transform the energy sector towards renewable energy sources by e.g. taxes on fossil fuels. Alongside other conditions such as technological maturity, this has triggered that large-scale ST plants have become an accessible and cost-competitive source for heat production to many district heating companies.

ABOUT THE CASE STUDY

The case is a land area with 18 600 m^2 ground mounted solar collectors and a seasonal heat storage located in relation to the Danish town Brædstrup of approx 3 500 inhabitants. The plant has been developed in two stages and is a typical example of landscape solar thermal plants in Denmark, with a heat production covering around 20 % of the annual heat demand in the local district heating system

Definition of environment:
Landscape ST



Site area: 70 000 m^2

System area (solar collector area):
18 600 m^2

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263;
[2] Danish Energy Agency (2016): Energy Statistics 1972-2014; [3] PlanEnergi (2016): List of Danish Solar District Heating Plants – January 2016.

Issues, challenges and decision strategies

Figure 1 - Aerial view of the solar plant in landscape next to the town of Brædstrup. (Photo: © Brædstrup Fjernvarme)

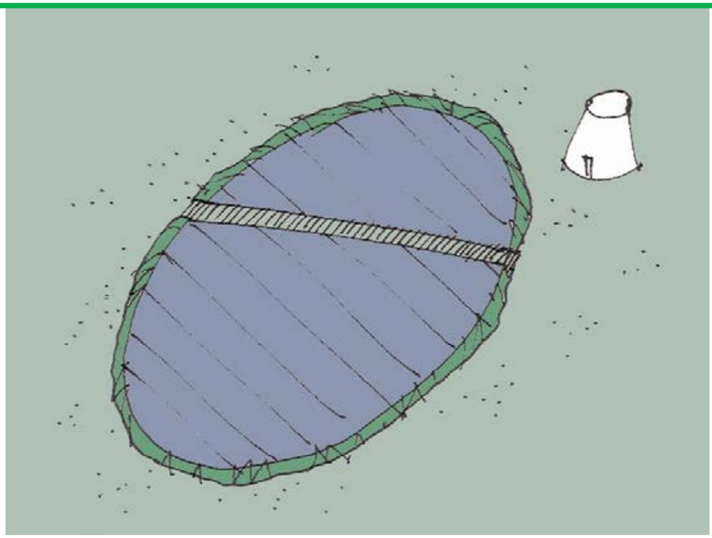


Figure 2 - Drawing example created by the local municipality of an alternative formation of the ground mounted solar collectors, with dedicated passage across the area to promote access and attractiveness of the area. (Source: © Municipality of Horsens)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- Local long-term strategic energy planning towards the goal of a district heating system based on renewable energy.
- Business case for substituting fossil fuel based district heating production with solar thermal heat production.
- Demonstation project for borehole seasonal heat storage in a Danish context.
- Utilizing the existing terrain to break up the conventional monotonous flat solar plant area by different levels of elevation.

ISSUES AND CHALLENGES

- Challenging the conventional design approach of mainly technical optimization of energy performance.
- Preserving/enhancing landscape values in the area with the technical installations.

DECISION STRATEGIES

Following successful installation of the first stage of the project, the local municipality to a greater extent addressed the challenge of maintaining the area as accessible and attractive to the local citizens prior to stage two. The area is located on the fringe of the town Brædstrup (3 500 inhabitants), and with the area's new main purpose of energy production, the layout would naturally be based on technical optimization before e.g. recreational value. Discussions for increasing access and attractiveness were held during the planning process towards the go-ahead point for stage 2 of the project. One result was that certain areas in stage 2 have been reserved for sports- and cultural activities (primarily football fields). However, combining technical optimization with attractive and accessible area remains a challenge, which is still at the attention of the project cooperation behind the project.

THE PLANNING PROCESS

The plant was constructed in two stages with the possibility of a third stage in the future. Stage one was a full-scale demonstration project of combining solar thermal and natural gas fired CHP. Stage two was a demonstration project of a borehole seasonal heat storage. An important overall setup in the project has been the strategic energy planning approach from the municipality and the local district heating company's vision producing heat in an environmentally preserving way.

In the first stage a solar collector area of 8 000 m^2 were installed in 2007 and in stage two a collector area of 10 600 m^2 and a seasonal borehole heat storage to store heat from summer to winter were added in 2012. When the second stage was finished, it was the largest solar thermal plant in Europe.

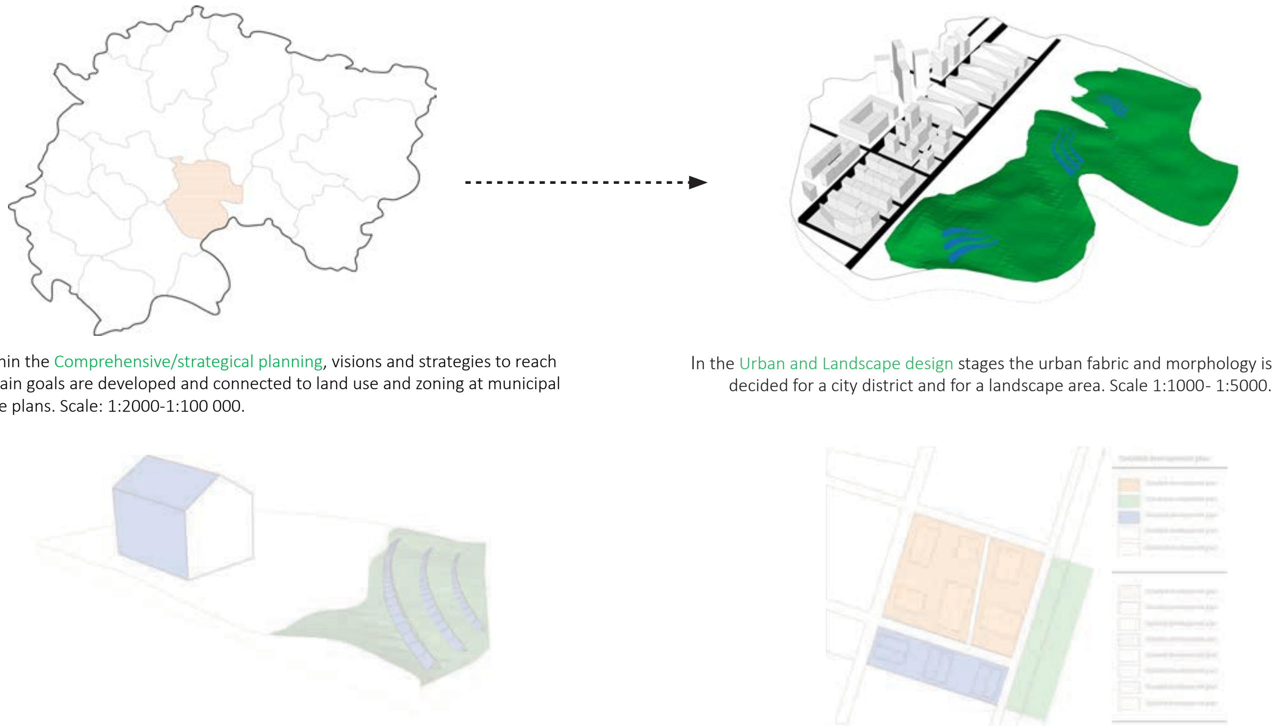
The aim is to realize stage three expanding the solar collector area to a total of 50 000-60 000 m^2 and expand the seasonal heat storage to gradually achieve the goal of a local heat production based on 100 % renewable energy in 2035.

Achieving funding: stage one from Energinet.dk, stage two from Energinet.dk (ForskEL), Region Midtjylland and EUDP.

Municipality of Horsens has been responsible for the overall planning of the area, while Brædstrup Fjernvarme (district heating company) has been initiator of the project.

PlanEnergi has been involved as consultant in the project.

Financing: Energinet.dk (energy organisation owned by Danish state), EUDP and Region Midtjylland (local region). The municipality has guaranteed loans for remaining funding.



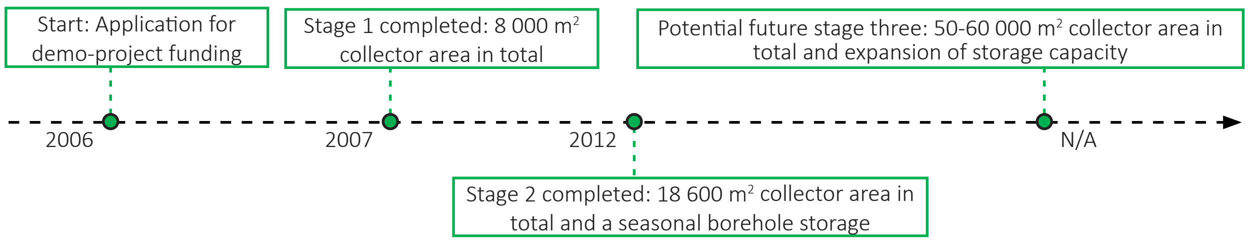
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [3] Enbridge completes Sarnia solar farm, CBS news, October 4th, 2010.

Solar landscape

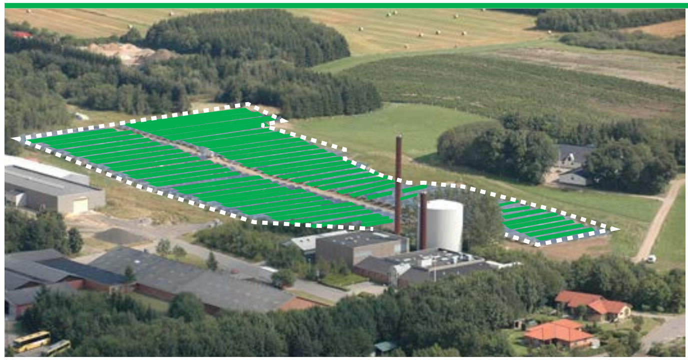


Figure 4 - The spatial system as a whole (Pattern) (Source: [6])

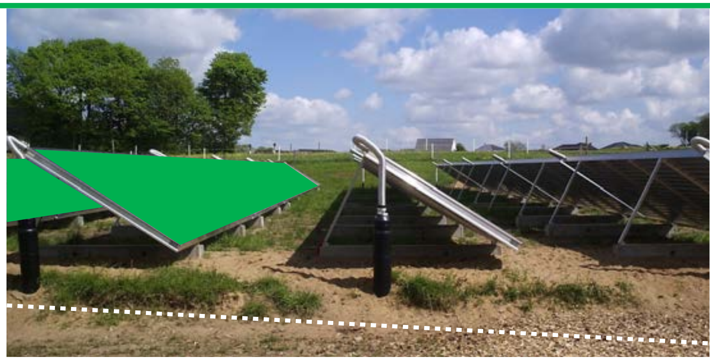


Figure 5 - The solar collector space (Source: [6])

Figure 6 - The "pore" space (Source: [6])

FORMAL FUNCIONAL FEATURES

PATCH - PATTERN - EDGES/BORDERS

Patch type

Small	○	Large	●
Straight borders	●	Convoluted borders	○

Grain type

Small patches	○	Large patch	●

Pattern

Porous	○	Dense	●

Pattern type

Stripes	Parallel	●	Not parallel	○
Island	Uniform patches	○	Varied patches	○
Random		○		

Edge/Borders

Continuous	○	Discontinuous	●

SOLAR SYSTEM

TECHNOLOGY AND PRODUCTION OF TOTAL AREA OF MODULES

1. Energy features

Nominal power:	14 MW thermal (calculated effect)
Number of modules:	1 487
Technology:	ST Arcon-Sunmark HT-Heatstore
Density of power:	0.75 kW(thermal)/m^2
Land use intensity:	0.12 MWh/m^2/a
Normalized yearly energy generation:	8 700 MWh/a

2. Engineering features

Each panel is supported by steel brace founded in 2 m long sleeper of concrete in stage 1; in concrete point foundations in stage 2.

3. Spatial features

Modules:	Height: 2.27 m; Width: 5.96 m; Area: 13.57 m^2; Color: Blue Azimuth angle: 0°; Tilt angle: 35°; Height from the ground: 2 m
Borders:	Thickness: 0 m; Height : 0 m;

SOLAR SYSTEM SPACE

PATCH AREA

Connectivity

A protected sensitive natural area is located within the solar field area and another sensitive natural area is located nearby. In the planning phase this was assessed and it was emphasized that the accessible space between and under the solar panels ensures the areas function as ecological connection line between the two protected areas.

Functions

Sheeps are grazing on the area underneath the solar collectors. The area was previously used for agriculture.

Other features

The panels are free-standing on grassland. The panels have glass as cover of the fronts and aluminum as cover of the backs.

References: [6] Scognamiglio, A. (2016). 'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision, Renewable and Sustainable Energy Reviews, pp 629-661

Site potential

Figure 7 - Aerial view of the total area: Stage 1 and 2 ("Yesterday" and "today") and the potential stage 3 ("Tomorrow?") showing the vision for a future expansion of the solar thermal plant. (Source: © Municipality of Horsens)

LANDSCAPE FACTOR

SENSITIVITY	LOW	HIGH
Landform	●	○
Landscape pattern and complexity (patches and grain)	●	○
Land use	○	●
Land cover	●	○
Settlement and man-made influence	○	●
Historic landscape character	●	○
Distinctive landscape features	○	●
Inter-visibility with adjacent landscapes	○	●
Sense of remoteness/tranquility	●	○
Sense of openness/enclosure	○	●

LANDSCAPE PRESERVATION (SOFT BARRIERS)

- The area has previously been reserved for agricultural use and agricultural use is still the main characteristic of the fields surrounding the area (away from the town). Thus, the plant has been incorporated into the existing field structure.
- The project area as a whole is not valuable, but contains groundwater interests thus limiting the use of the area.
- The area contains a smaller sensitive natural area, which is protected from alterations by a regulation in the Danish Planning Act, and a protected stone- and earth dike and two plowed over burial mounds.

MULTI-FUNCTIONALITY

Part of the area has been reserved for leisure and recreation, especially for football fields.

Figure 8 - Illustration from the local plan of the visual impact of the first stage in the project. (Source: © Municipality of Horsens)

Figure 9 - View of the actual visual impact of the first stage in the project including integration of a wooden pavilion built to invite local citizens to visit the area. (Source: © Brædstrup Fjernvarme)

IMPACT CATEGORY	IMPACT - BURDEN	ALLEVIATION, MITIGATION STRATEGIES, DESIGN APPROACHES
Land use	The project area is 70 000 m^2 reserved to the content and functions within the project plans. If stage three of the project is realized this area will rise to around 150 000 m^2.	In the project solar thermal heat production has been assessed as the most effective energy producing technology in terms of land use. It is evaluated as the most suitable technology to reach the goal of 100 % renewable energy in the district heating production.
Visual impact	The visual impacts have been assessed from visualizations of the project, showing the solar collector field expression in and the surrounding landscape.	To alleviate the visual impacts it is stated in the local plan for stage two, that solar field expansions require establishment of fence planting as a visual shielding effect.
Environmental impact	The plant is expected to give an annual reduction in CO_2 emissions by 3 700 tons. In accordance with Danish and European regulation, the local municipality made an EIA-screening to investigate potential environmental impacts from the project.	The screening showed that an environmental impact assessment (EIA) statement was not necessary. A specific permission was obtained for the borehole storage ensuring that the groundwater interests were not affected.
Public awareness and participation	In accordance with regulation in the Danish Planning Act, both stage one and two in the project have involved a public hearing period of 8 weeks as part of the implementation of new local plans.	During the hearing periods citizens were encouraged to let the municipality know of their opinions which e.g. in stage one resulted in 3 responses that was then incorporated in the project plans.

SOLAR DISTRICT HEATING IN A FLEXIBLE ENERGY SYSTEMS

A key element for implementation of the large-scale solar thermal plant in the district heating system in Brædstrup has been to assess and balance all the interrelated parts of the full system together. This is essential to integrate the large amounts of fluctuating heat production in the system, and thus substitute heat production from the natural gas fired boiler with heat produced from solar energy. A heat pump and an electric boiler ensures that the system is also able to integrate fluctuating electricity production from e.g. solar or wind.

THE PARTS IN BRÆDSTRUO SOLAR DISTRICT HEATING SYSTEM

Besides the 8 000 m^2 solar collectors established in stage one of the project, the energy plant also had two gas engines, two gas boilers and an accumulation tank at disposal. The second stage added an additional ground mounted solar collector area of app. 10 600 m^2, a pilot borehole storage, a buffer tank and a heat pump. Especially the seasonal heat storage is a crucial part for large-scale solar thermal systems, as it offers the possibility of storing the large heat production from the solar thermal plant in the warm summer period to be used in the colder winter. The parts in Brædstrup district heating system is shown on the illustration to the right.

THE PARTS IN BRÆDSTRUO SOLART DISTRICT HEATING SYSTEM

As the second stage of the project should only be the next step towards a full-scale plant covering 50 % of the yearly consumption with solar energy, the design of the second stage started with design of the full-scale plant. In the area pointed out for new solar collectors, up to 42.000 m^2 of solar collectors could be placed, bringing the total collector area up to 60.600 m^2. Therefore, this parameter was fixed in the design calculations for the full-scale plant, which was then used in preparations of the new local plan. This means that a potential stage three of the project already has the preliminary permission in place.

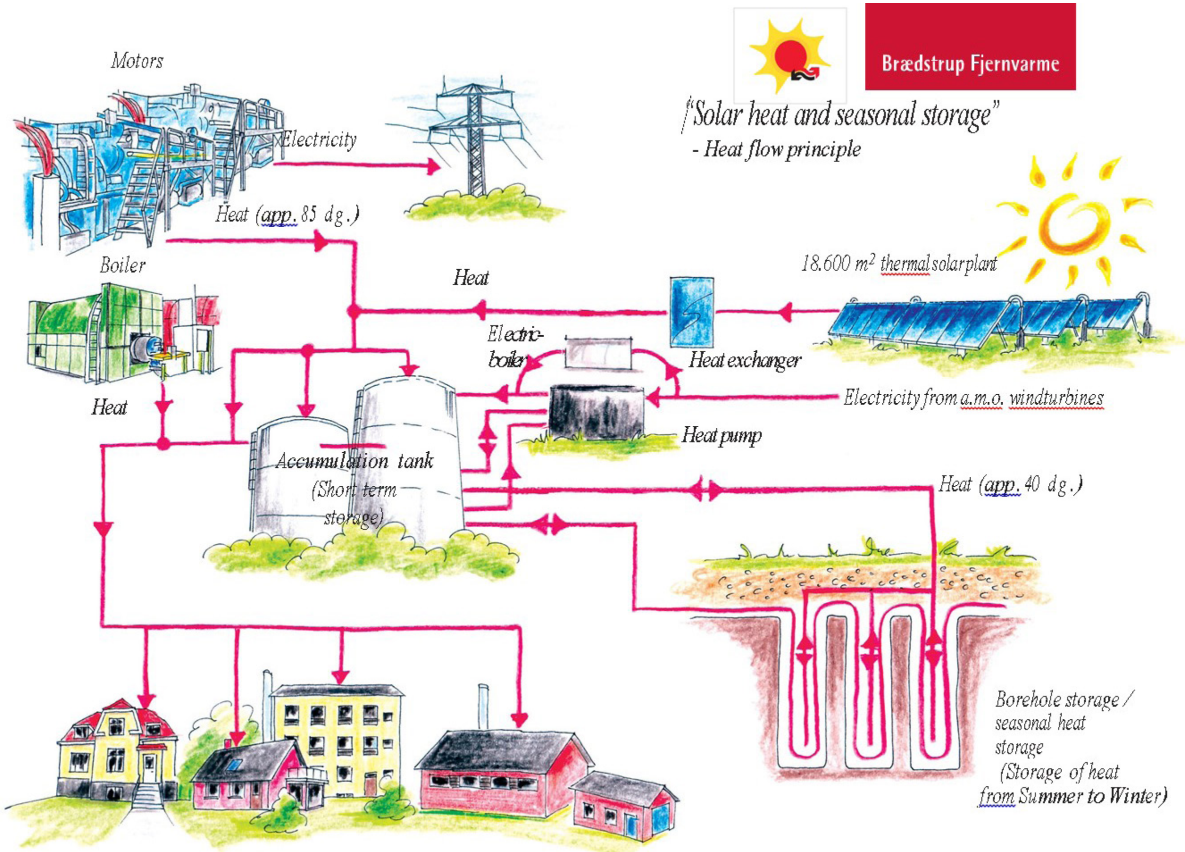


Figure 10 - Drawing of the heat flow in the local district heating system in Brædstrup following the implementation of stage 2 in the case project. The solar thermal collectors delivers heat to the accumulation tank from where it is distributed to the district heating customers or the borehole storage. (Source: © Brædstrup Fjernvarme)

Figure 11 - View of solar collectors in the first stage of the project. (Photo: © Brædstrup Fjernvarme)

Figure 12 - Drawing example from the local municipality as inspiration to alternative layouts of the solar collector area promoting access and attractiveness of the area. (Source: Municipality of Horsens) (Source: © Postmedia Network)

LESSONS LEARNED

- Large-scale solar thermal plants can substitute the use of fossil fuels in district heating systems.
- Seasonal borehole heat storages can store heat from summer to winter, utilizing the heat when it is needed and reasonable priced electricity is present in the system to run a heat pump.
- A strategic and "full-system" approach to energy planning contributes to open up the potential solutions, which can be used to implement the most suitable and cost-effective solution.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- Large-scale solar thermal plants are by default best suitable in small and medium scale towns with an existing district heating network, but the local conditions and context is fundamental.
- Alternative design layouts for large-scale solar thermal plants need to be developed and tested to create areas that are attractive and multifunctional. This is in particular relevant in locations with limited land areas available e.g. in urban areas.
  - A potential test approach would be to involve knowledge and ideas from design professionals in the planning process of a plant on equal terms as technical knowledge.

TARGET GROUPS

- Decision makers engaged in heat planning.
- District heating companies and regulating authorities.

(Photo: © Municipality of Horsens)

ARCHITECT, DESIGNER AND DEVELOPER

Brædstrup Fjernvarme

CONSULTANTS

PlanEnergi

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Municipality of Horsens

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Brædstrup Fjernvarme

PlanEnergi

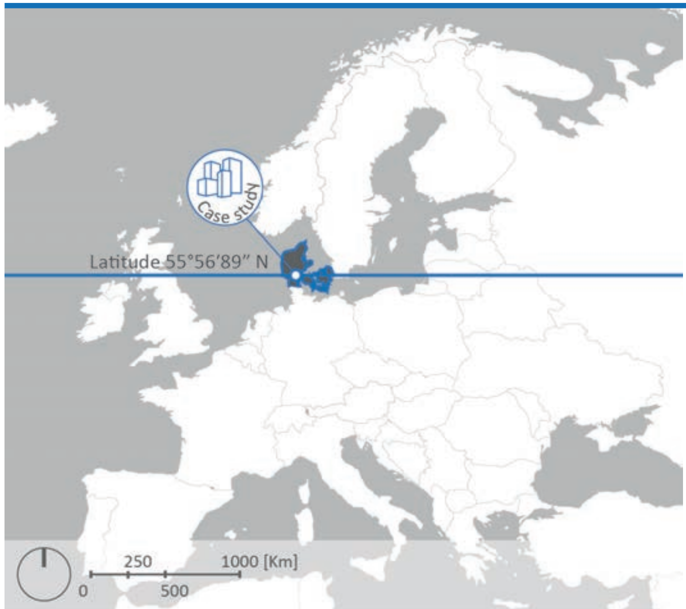
ACKNOWLEDGEMENTS

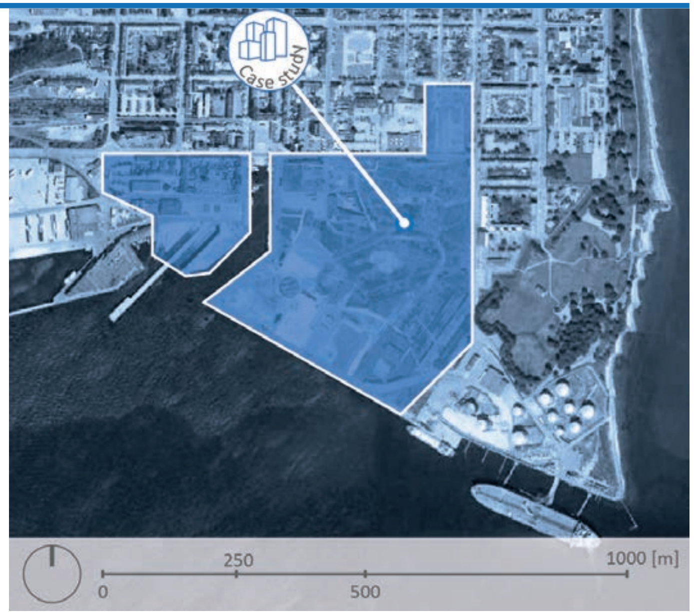
The authors wish to thank the Municipality of Horsens.

FREDERICIAC

DENMARK

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Denmark
Location: Fredericia (Lat. 55°56'89"N; Lon. 9°74'95"°E)
Climate: Warm temperate, fully humid, warm summer (Cfb) [1]

AREA OF INTEREST

Planning process

NATIONAL AND LOCAL CONTEXT

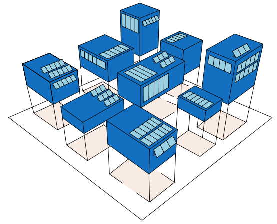
In urban areas in Denmark, the heating supply is typically based on district heating from Combined Heat & Power plants. As the energy price for district heating consists of a fixed and a variable part, district heating in many cases will not be cost-effective in new low energy buildings. In Denmark it has been decided, that low energy buildings are not obliged to be supplied with district heating, meaning that other energy supply systems (heat pumps, solar based heating systems, etc.) may be relevant. In Denmark there are no regulations deciding that energy supply for new urban areas must be provided with solar energy. In most cases such demands are set up by the local land owners. This is also the case with respect to different voluntary initiatives (LEED Neighborhood, BREEAM Communities, DGNB, etc.).

ABOUT THE CASE STUDY

FredericiaC is a new urban area in the heart of Fredericia including apartments, offices, shops, cafés, etc. It has been the intension of the developer to plan a CO_2-neutral urban area through optimization of the possibilities of solar utilization, daylight access and solar incidence in urban spaces, while also ensuring a living city. There have been no local regulations supporting this as the development is controlled by the land owner.

Definition of environment:
New Urban Areas

Site area: 204 000 m^2
Building area: 265 580 m^2
Area density: 1.3



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Figure 1 -Existing and planned district heating pipes next to FredericiaC. (Source: © FredericiaC)

Figure 2 - Proposed heating supply, Blue: Heat pumps, Red: District heating, Yellow: Heat pumps or District heating (Source: © FredericiaC)

HIGHLIGHTS OF THE CASE STUDY

To optimize the urban development with respect to the following topics, while also creating a new modern and viable urban area.

- CO_2-neutral urban development
- Building Integrated Photovoltaics
- Daylight optimization
- Solar gain and shading in urban areas

ISSUES AND CHALLENGES

The main challenges have been to plan an area providing a cost effective heating supply solution taking existing district heating supply and PV-driven heat pump solutions into consideration. And at the same time optimizing the possibilities of solar utilization, maximizing the daylight access and ensuring solar incidence in urban spaces, while also ensuring a living city and at the same time respecting the local legislations with respect to building heights as well as the wishes of the developer to increase the amount of m² to be developed for sale in the area.

In order to ensure the implementation of the various sustainable measures a set of general design guides for implementation of solar and daylight in urban planning when detailing the urban development has been set up.

DECISION STRATEGIES

A topic of key importance for the landowner has been to identify the most cost-effective heating supply for the area.

The areas next to FredericiaC are supplied with district heating today. The new buildings in FredericiaC will have a very low energy demand for space heating which means that it may not be financially attractive to cover the heating demand with district heating. Therefore alternative heating supply sources such as different heat pump solutions and solar thermal solutions have been considered and proposed.

The planning process

The main aim has been to develop a CO_2-neutral new urban development using BIPV and ensuring good quality daylight access and attractive solar gain to urban spaces.

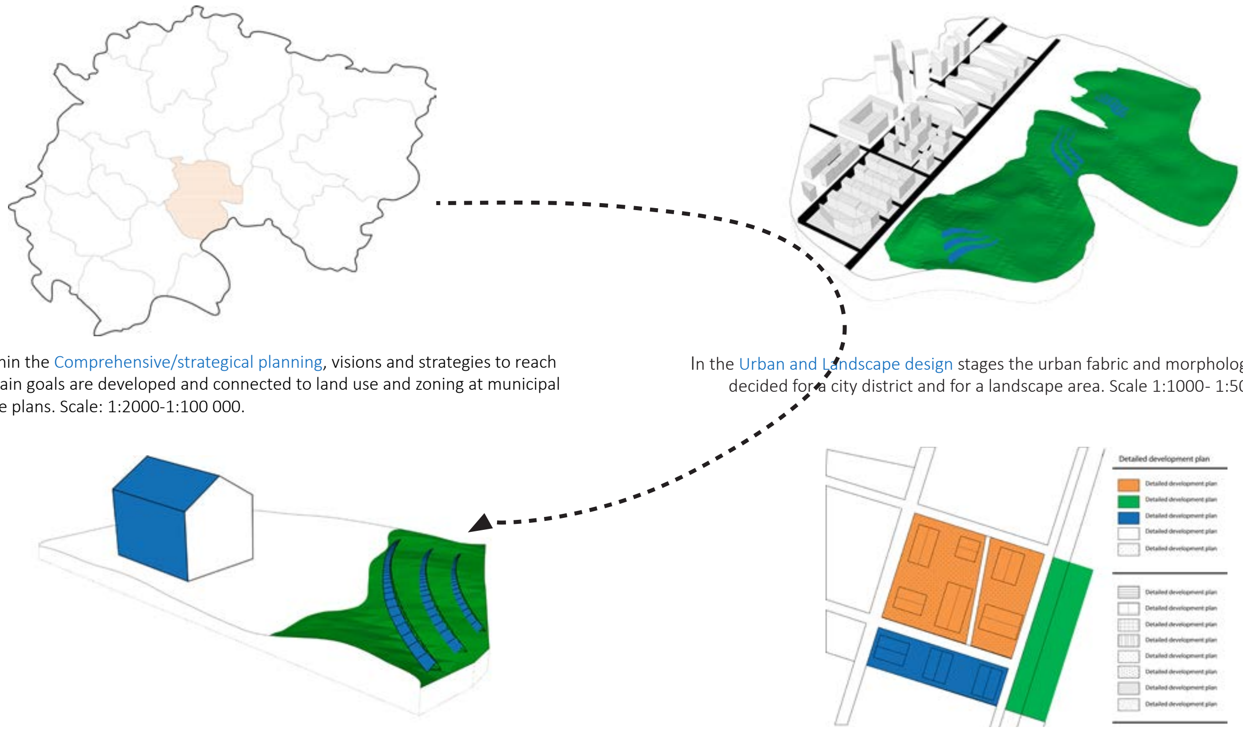
The project has focused on creating a development plan to be followed when detailing the individual projects in the area. In total 23 250 m² of PV-panels are proposed to be implemented.

Local legislation includes maximum building heights which had to be taken into consideration when optimizing daylight conditions. This was considered in early stage of developing the urban plan.

The key stakeholders were FredericiaC (initiator), the urban planning department and the consultants of FredericiaC. The role of private sector partners was to identify aims and objectives and to develop a sustainable plan for the area.

Activities are based on computer simulations and analyses of possibilities for utilizing solar energy, daylight and solar access to urban areas. The studies were carried out in parallel with the architectural development of the area in a close dialogue with the architects involved.

All activities are financed by FredericiaC P/S which is owned by the private partner Realdania By & Byg (75%) and the Municipality of Fredericia (25 %).



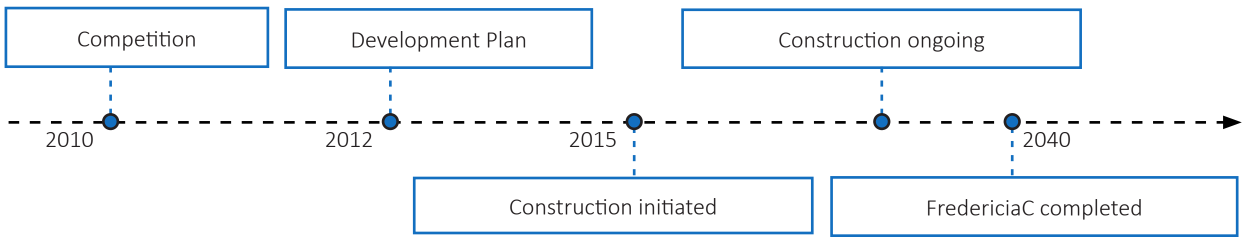
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



Energy concept

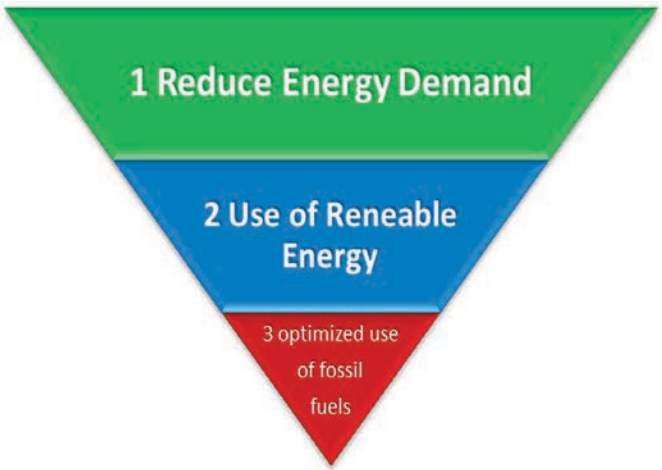


Figure 4 - Principle of Trias Energetica. (Source: © DEM & Esbensen A/S)

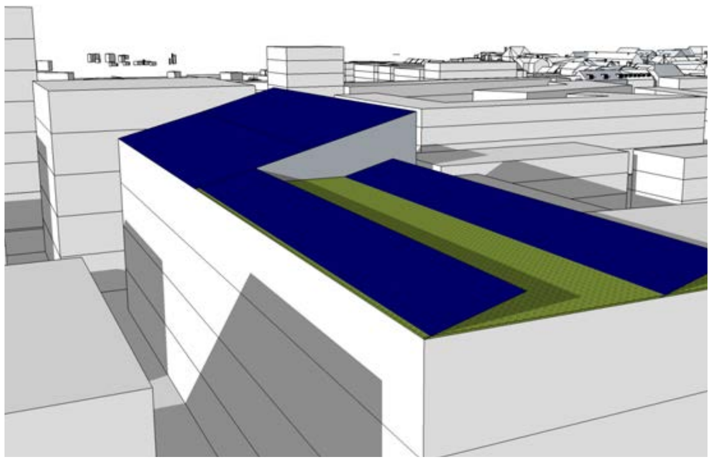


Figure 5 - Principle of PV implementation. (Source: © DEM & Esbensen A/S)

Figure 6 - Illustration of roof mounted PV + green roof. (Source: www.google.com)

SUMMARY

The energy concept for the new development is based on the principle of Trias Energetica, which in short is described as:

1. Minimized energy demand (optimized thermal envelope, elimination of cold bridges, ensure high air tightness)
2. Utilization of renewable energy sources (daylight, active & passive building integrated solar energy systems)
3. Optimised use of fossil fuels and energy efficient installations

The solar energy concept is based on production of electricity from PV-panels used for lighting and for running heat pumps for space heating and on high utilization of daylight to reduce energy demand for lighting.

TECHNOLOGY

Passive solar is used through solar gains through windows.

Active solar consists of utilizing a potential of 23 250 m² of roof mounted or roof integrated PV-panels ensuring the development of a CO_2-neutral new urban area with respect to building operation. The PV-panels are to the extent possible intended to be oriented towards South with a tilt angle of 38°.

Furthermore, daylight is used to ensure good visual indoor climate conditions and to reduce the energy demand for artificial lighting.

SOLAR ENERGY AND ENERGY SYSTEM

The solar design solutions include active solar through roof mounted or roof integrated PV panels for two purposes:

- Electricity for driving heat pumps for space heating and domestic hot water
- Electricity for lighting and power driven systems

Other heating demands are covered by passive solar gains through windows and by district heating.

The energy performance of the PV system is described below:

- Energy production: 125 kWh_{elec}/m^2 panel area corresponding to a total annual energy production of approx. 2 900 MWh_{elec}
- Power of the system: 3 100 kWp
- Expected energy demand for building operation when FredericiaC is fully developed: 16.0 kWh_{heat}/m^2 a
  7.3 kWh_{elec}/m^2 a

ENVIRONMENTAL, ECONOMIC AND SOCIAL IMPACTS

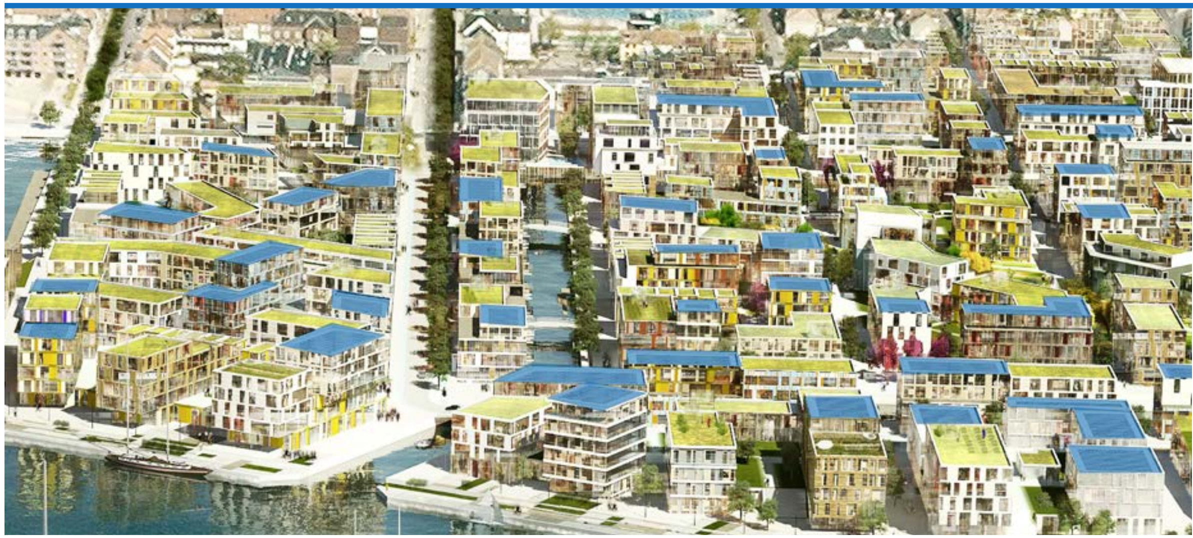


Figure 7 - PV-panels implemented on roofs. (Source: © KCAP)

Figure 8 - Green park used for gardening, sports and recreation. (Source: © KCAP)

ENVIRONMENTAL IMPACT

The CO_2-neutral urban area aims to develop a cooperation based on an integrated planning process involving landowners, architects, consultants and identifying a set of design guides to be followed in planning. It has included focus on environmental issues. The environmental impact is significant as the design guides developed will ensure the development of a new urban area which on an annual basis will be CO_2-neutral with respect to building operation. It is achieved through the implementation of 23 250 m² of PV. Should the CO_2-neutrality ambition include electricity use for appliances and lighting in residential buildings, the PV area needed would be 72 000 m². CO_2-emission calculations were carried out using two different methods; (i) CO_2-emission factors identified by the Danish Ministry of Energy [3], (ii) “KL CO_2 calculator” developed by the Danish Municipalities.

References: [3] www.energinet.dk

ECONOMIC IMPACT

For FredericiaC as a company it is a prerequisite that the project is financially sustainable. This requires that the project continuously has a positive liquidity and that a reasonable return of the invested capital is generated all through the development and construction process. Financial sustainability also means that the economic situation of other project partners is not stressed unnecessarily. This relates in particular to the co-owner, the Municipality of Fredericia, who has many other concerns associated with the citizens of Fredericia and the new tenants and users of the area. Therefore, financially sustainable solutions are always in focus when developing the area, also when it comes to the continuous operational expenses once the new area has been developed. For these purposes various business model analyses have been carried out when identifying the final development plan for FredericiaC.

SOCIAL IMPACT

The physical plan itself supports the social sustainability through various aspects. The open blocks with common outdoor areas, meeting points at the canals and open spaces and the “green band” with playgrounds, urban gardens and sports facilities and the retail area. Through its variation and flexibility the urban plan invites to a diversity of business activities in the area, which will function side by side with housing, innovative businesses focusing on development and export, creative businesses for culture and design, service and offices. The jobs which are created from these activities can attract residents who will settle in the area having different educational backgrounds leading to a high degree of social diversity. The social sustainability is supported by concepts of co-ownership that is offered to residents and companies regarding social as well as professional initiatives.

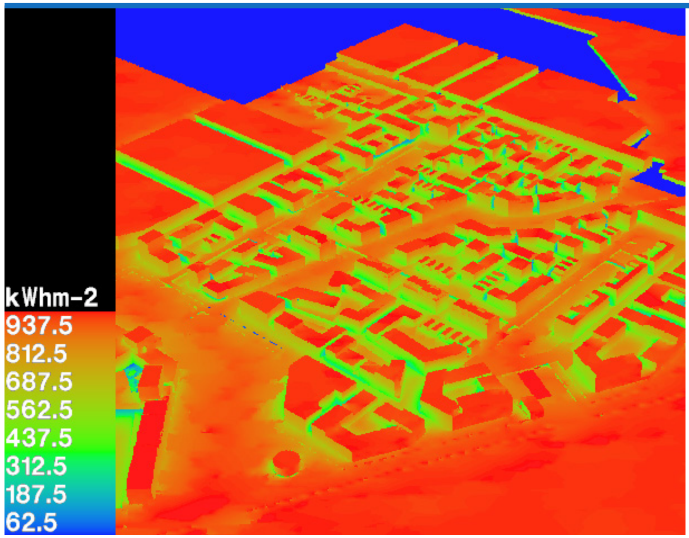


Figure 9 - Solar irradiance on roofs and facades, early stage. [4] (Source: © DEM & Esbensen A/S)

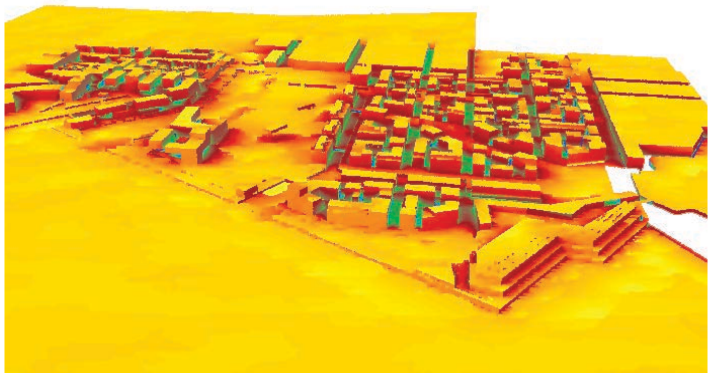


Figure 10 - Solar irradiance on roofs and facades, during planning phase. [4] (Source: © DEM & Esbensen A/S)

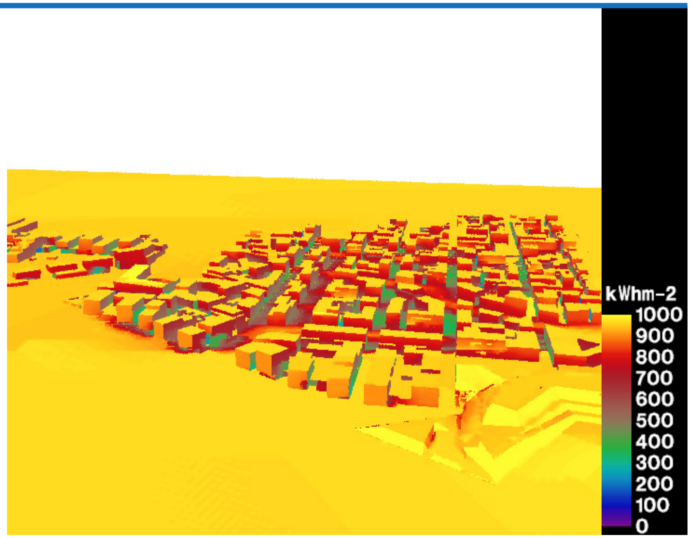


Figure 11 - Solar irradiance on roofs and facades, final development plan. [4] (Source: © DEM & Esbensen A/S)

OPTIMIZED UTILIZATION OF PV

In order to ensure a high implementation of PV systems for production of electricity and to prevent future buildings from shading PV-systems implemented in buildings, the solar irradiance on roofs and facades was calculated from the early design stage. The simulation was used as a design and verification tool in order to maximize building heights and minimize building distances to guarantee high solar gains on roofs and facades.

Several set of simulations were conducted during the development plan phases, given it was continuously changed. This included various aspects other than energy, such as issues of traffic, urban density, urban spaces, etc.
The solar energy potential for three different development plans is shown in Figure 9, 10 and 11 [4].

For all three development plans it is seen that in general there are good conditions for implementation of roof integrated PV-panels and only few buildings have a shading effect on the roofs of buildings north of them.

For the final lay-out of the development plan it was calculated that more than 95 % of the roof area could be used for PV corresponding to an effective area of 65 000 m² of PV-panels. Thus, the total potential electricity production from PV-panels would be approx. 8 750 MWh_{elec}/a.

Simulations of solar gains were carried out using the Rhino software package. Electricity production from PV-panels were calculated using PV-SYST.

IN RELATION TO THE SCALE

The studies of solar irradiance for optimization of implementation of PV were mainly used when deciding building heights in the development plan. The focus was put on ensuring, to the extent practically possible, no buildings should cause problematic shading to neighboring buildings.

References: [4] Jørgensen, O B (OBJ) & Nors, FE (FEN), 2012. FredericiaC – Energy Development Plan, Dansk Energi Management & Esbensen A/S

DAYLIGHT

Daylight analyses were carried out for various proposals for the development plan in order to ensure attractive daylight access in all relevant situations in the new urban plan.

The studies were based on a method [5] using the Window to Wall Ratio factor (WWR), to identify whether it will be possible to achieve good daylight conditions for the actual plan. The model defines the necessary percentage of glazed area of the façades needed to obtain good daylight conditions.

The key findings were used to ensure that the daylight conditions for the various building types (offices, apartments, houses, retail etc.) would all meet the daylight requirements for the respective building types.

RESULTS AND DISCUSSION

For the key building types the conclusions were:

Apartments: The majority of apartments located on the ground floor have good daylight conditions. As the access of daylight increases with the floor level, it was recommended to have ground floor apartments in two levels in areas with minor access to daylight (blue and pink areas).

Offices: It is possible to achieve sufficient daylight access for most of the facades on the ground level and ensure good conditions for sufficient daylight in the offices at this level.

Hotels, retail and culture: All these functions have good daylight conditions.

Based on the results from the analyses it was possible to set up guidelines for maximum building heights, minimum building distances, recommended façade reflectances and façade window areas in order to ensure good daylight conditions in the new urban development.

Figure 13 - Daylight levels on facades in the final development plan. (Source: © DEM & Esbensen A/S)

References: [5] Iversen, A (AI), 2012. Development of a simple framework to evaluate daylight conditions in urban buildings in the early stages of design. PhD Thesis. Civil Engineering Report R-256. ISBN: 9788778772288. Department of Civil Engineering. Technical University of Denmark

SHADING AND SOLAR GAIN IN PUBLIC SPACES

In order to ensure a pleasant outdoor climate in the urban spaces of FredericiaC, the various proposals for the urban plan have been analyzed for direct sunlight/shadows in central public spaces. The shadow analysis is made for the hours from 09:00, 12:00 and 15:00 for the critical time of the year at equinox (March and September 21st).

The shadow rendering (Figure 14) shows the shadows in the plan for the entire area of FredericiaC.

RESULTS AND DISCUSSION

Shadows in central public spaces and courtyards are influenced by the surrounding buildings. In general, public spaces with no buildings south of them have great sunlight conditions.

Shadows in central public spaces are indicated on figure to the right. From the figure it is seen that most of the public spaces have good direct sunlight conditions. A number of spaces have good daylight conditions in the northern parts of the public spaces. This is of course improved in the summer [4].

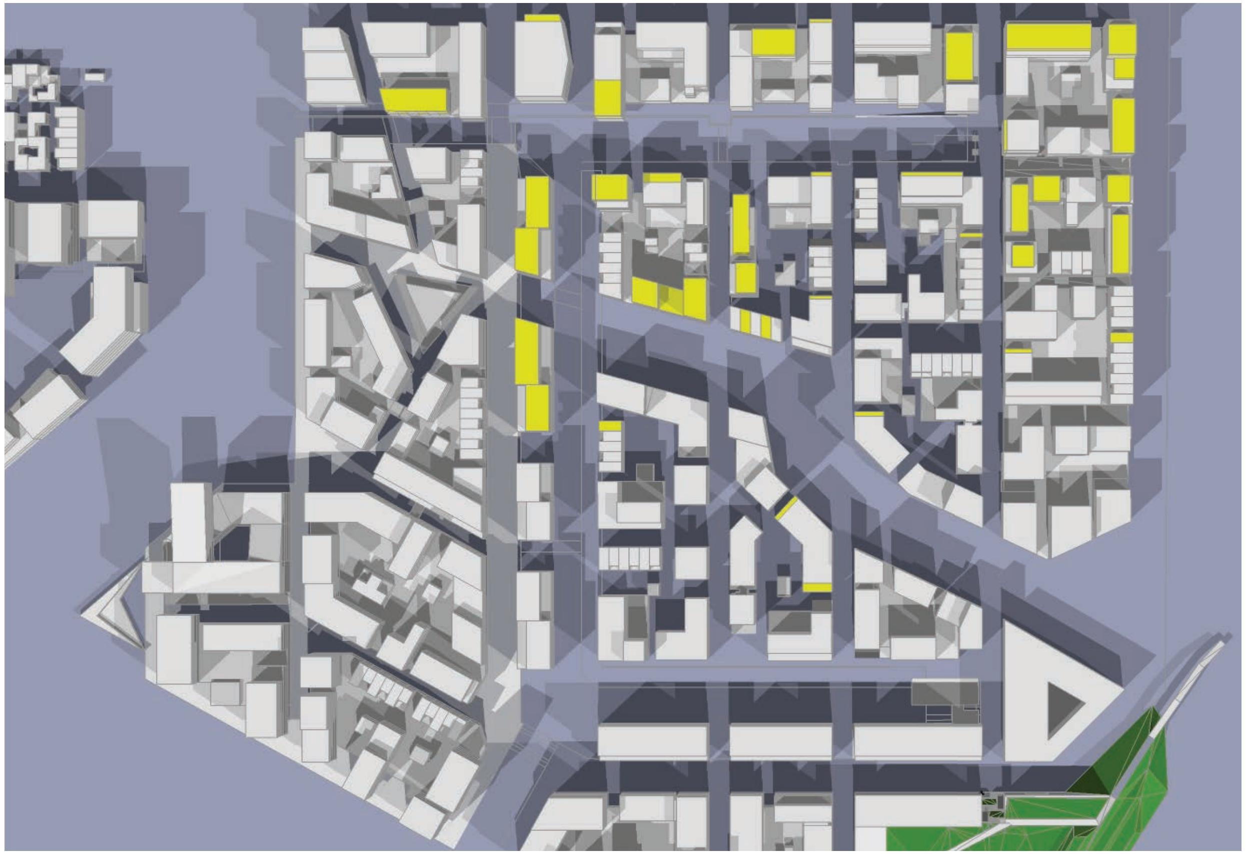


Figure 14 - Merged shadows on March/September at 09:00, 12:00 and 15:00 in the final development plan. (Source: © DEM & Esbensen A/S)

References: [4] Jørgensen, O B (OBJ) & Nors, FE (FEN), 2012. FredericiaC – Energy Development Plan, Dansk Energi Management & Esbensen A/S

Lessons learned and recommendations

LESSONS LEARNED

If solar energy is to become a fully integrated element when developing a new urban area, it is crucial that the developer/land owner as well as the complete design team understands that solar and daylight optimization is to be considered at the very beginning of the planning phase.

Many other topics, which may be in conflict with implementation of solar, are also of high importance for the decision makers/land owners (e.g. area density, minimizing construction costs, etc.).

Existing energy supply systems in the area (e.g. district heating) might be a serious barrier for implementation of active solar systems.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

In order to ensure implementation of active solar system in new urban areas, land owners and/or local municipalities shall set up specific targets regarding the amount of energy to be provided for the actual development via solar solutions.

When initiating a new development the client shall ensure that the design team has the necessary knowledge and skills to include solar measures in the design work.
Teaching about solar energy solutions at schools of architecture and engineering shall be increased.

The solar industry shall continue to develop cost-effective solutions in order to be able to compete with more conventional energy supply systems.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects
- Developers.

DEVELOPER

KCAP Architects Planners
Vandkunsten
FredericiaC P/S

CONSULTANTS

Dansk Energi Management & Esbensen A/S

CASE STUDY AUTHORS

Olaf Bruun Jørgensen, Dansk Energi Management & Esbensen A/S

OWNERS

FredericiaC P/S

STAKEHOLDERS

FredericiaC P/S
The planning department of the Municipality of Fredericia
Private developers

ACKNOWLEDGEMENTS

The authors wish to thank FredericiaC P/S

RESEARCH ORGANIZATIONS

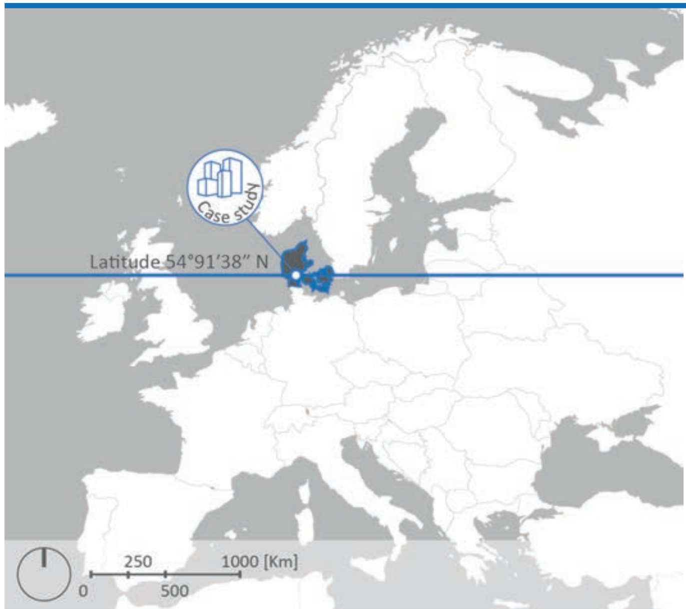
Dansk Energi Management & Esbensen
En del af Danish Management Group

Source: (© Gehry Partners, LLP)

GEHRY CITY HARBOR IN SONDERBORG

DENMARK

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Denmark
Location: Sønderborg (Lat. 54°91’38”N; Lon. 9°79’22”°E)
Climate: Warm temperate, fully humid, warm summer (Cfb) [1]

AREA OF INTEREST

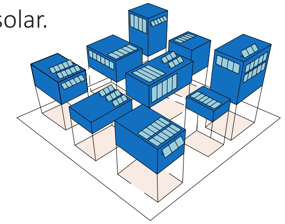
Planning process

NATIONAL AND LOCAL CONTEXT

In urban areas in Denmark, the heating supply is typically based on district heating from Combined Heat & Power plants. As the energy price for district heating consists of a fixed and a variable part, district heating in many cases will not be cost-effective for new builds. In Denmark it has been decided, that low energy buildings are not obliged to be supplied with district heating, meaning that other energy supply systems (heat pumps, solar based heating systems, etc.) may be relevant. In Denmark there are no regulations deciding that energy supply for new urban areas must be provided with solar energy. In most cases such demands are set up by the local land owners. This is also the case with respect to different voluntary initiatives (LEED Neighborhood, BREEAM Communities, DGNB, etc.).

ABOUT THE CASE STUDY

The “Gehry City Harbor in Sonderborg” is a new urban development on the harbor front of Sonderborg. The project will include new buildings for housing, hotel, culture, retail, café’s and offices. There were not specific local regulations for implementation of solar. Through the Project Zero activities, the Municipality of Sonderborg strongly supports initiatives focusing on sustainability including various solar measures. The landowner also has a strong focus on implementation of solar.



Definition of environment:
New Urban Areas

Site area: 50 000 m^2
Building area: 52 400 m^2
Area density: 1.05

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

ISSUES, CHALLENGES AND DECISION STRATEGIES

Figure 1 -Sønderborg Harbor Masterplan by Gehry Partners, LLP (Source: © Sønderborg Harbor Company)

Figure 2 - Roof areas suitable for implementation of PV. Green marks roof areas with no shading. Yellow marks roof areas with shading 2 – 3 hours pr. day. In total 70 % of the roof area is suitable for implementation of PV. (Source: © Dansk Energi Management & Esbensen A/S)

HIGHLIGHTS OF THE CASE STUDY

The objective of the project is to obtain CO_2 neutrality by 2029 within the borders of *The City Harbor in Sonderborg*. By 2020 the CO_2 emissions should be reduced by 75 % compared with the standard level in DK in 2008. The aim is to reduce the energy demand by constructing buildings at a very high energy standard and to produce renewable energy from local resources.

The ambition is to create a sustainable urban development with state-of-the art standards for consumption of energy and resources and to utilize sustainable materials and recycling. At the same time, the new urban development must be at a world class level in terms of sustainable transport solutions and social and economic sustainability.

ISSUES AND CHALLENGES

The urban area surrounding the City Harbor area is supplied with conventional district heating. By time the district heating is expected to be converted into a renewable energy supply system. However, as the current price structure for district heating may not be very attractive for consumers living in low energy buildings, other energy supply solutions need to be considered. Such systems typically need to be situated inside the area which may challenge the planning process as this will reduce the “sellable” m²’s in the area. Another complexity is that the various building types in the area have very different energy demands meaning that some buildings need a lot of heat for hot water (hotel, waterpark & wellness), while others have very modest hot water demands (e.g. offices). Thus, district heating may be very attractive in some areas and less attractive in other areas.

DECISION STRATEGIES

Frank Gehry’s master plan of The City Harbor in Sonderborg has focused on creating a vibrant and unique urban environment with minimized energy demands and optimized indoor and outdoor climate conditions. Therefore, all buildings are carefully placed in the master plan with the intention to ensure optimum solar and daylight conditions for both buildings and urban areas. Thus, office buildings and one high rise hotel are located towards the water front in order to offer the best possible view and use of daylight, while buildings with small passive solar requirements are located behind the high rise hotel. Another key design issue was to optimize the possibilities for local utilization of active solar energy from PV or solar thermal collectors on the roofs in the area.

THE PLANNING PROCESS

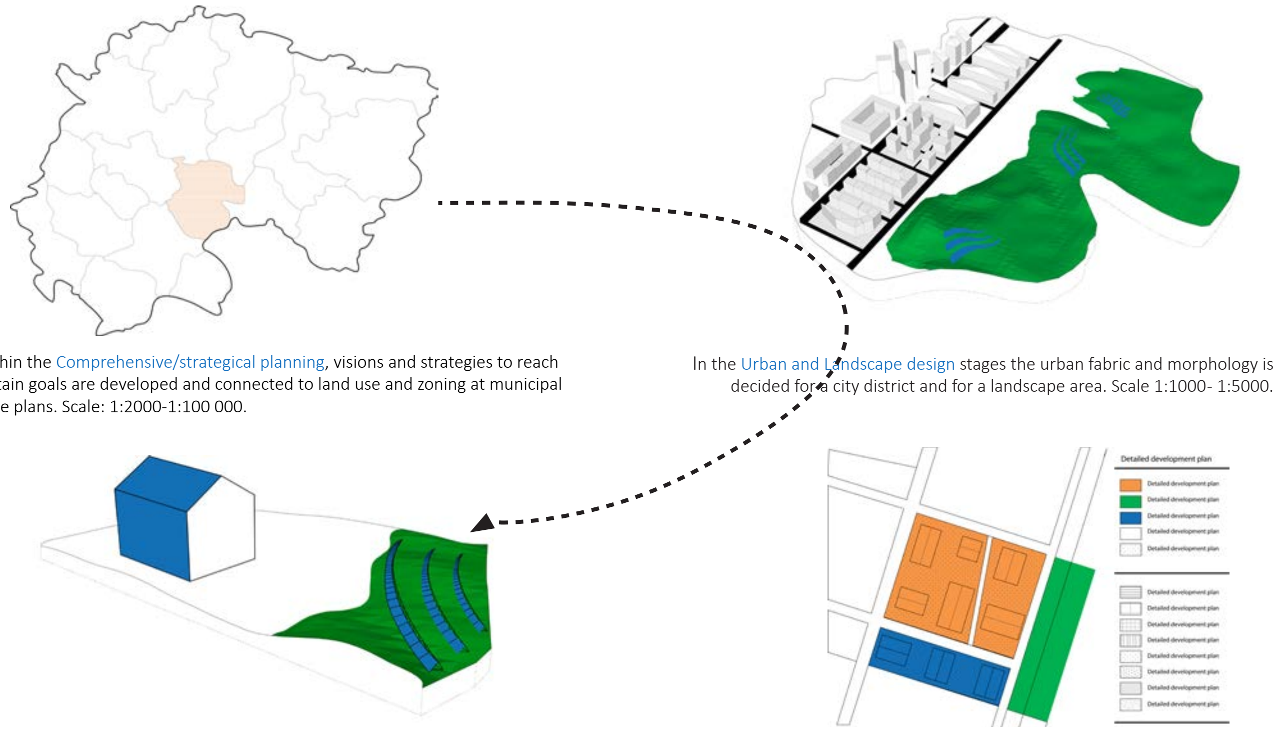
The main aim was to develop a CO_2-neutral new urban development using BIPV and ensuring good quality daylight access and attractive solar gain to urban spaces.

The project has focused on creating a development plan to be followed when detailing the individual projects in the area. In total 8 150 m² of PV-panels are proposed to be implemented.

The key stakeholders were City Harbor Sonderborg A/S (initiator), the urban planning department of the Municipality of Sonderborg. The role of private sector partners was to identify aims to develop a sustainable plan for the area.

Activities are based on computer simulations and analyses of possibilities for utilizing solar energy, daylight and solar accessibility to urban areas. The studies were carried out in parallel with the architectural development of the area in close dialogue with the involved architects.

All activities are financed by City Harbor Sonderborg A/S which is owned by the private fund Bitten og Mads Clausens Fond, by Bjarne Rasmussen Holding and by the Municipality of Sonderborg.



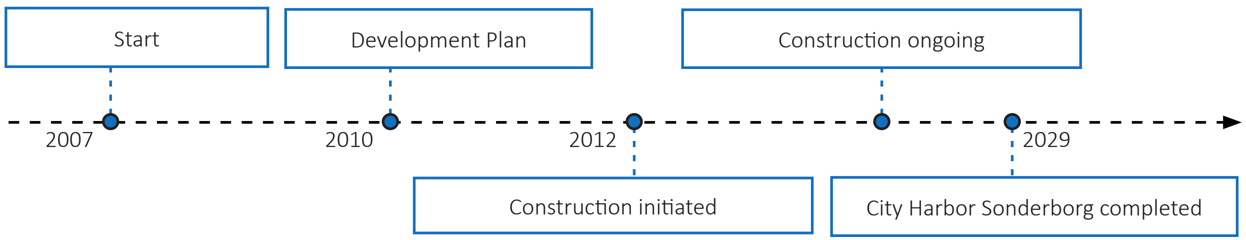
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



Energy concept

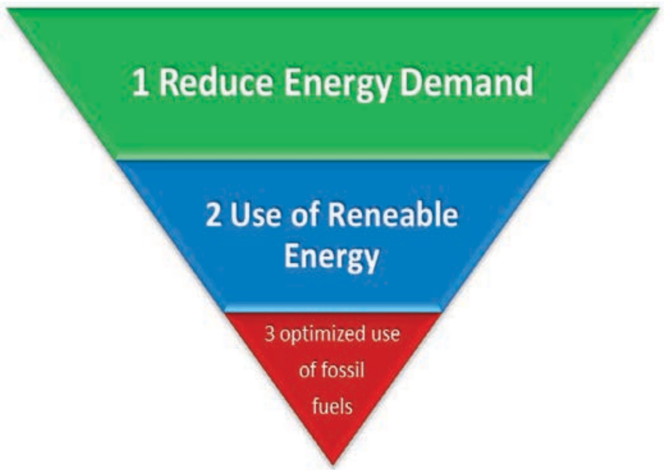


Figure 4 - Principle of Trias Energetica. (Source: © DEM & Esbensen A/S)

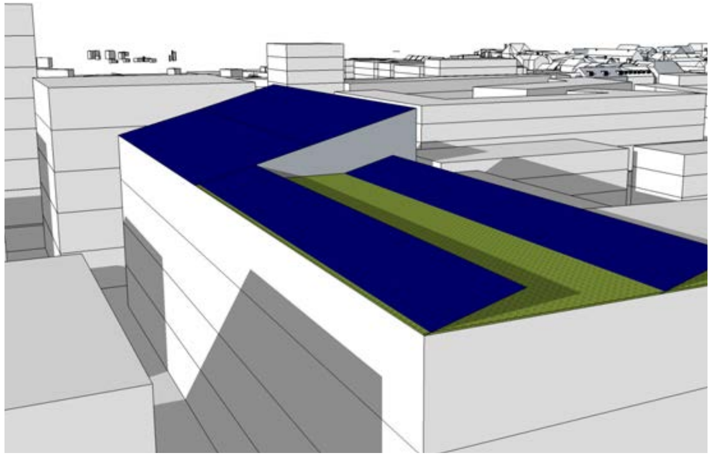


Figure 5 - Principle of PV implementation. (Source: © DEM & Esbensen A/S)

Figure 6 - Illustration of roof mounted PV + green roof. (Source: www.google.com)

SUMMARY

The energy concept for the new development is based on the principle of Trias Energetica, which in short is described as:

1. Minimized energy demand (optimized thermal envelope, elimination of cold bridges, ensure high air tightness)
2. Utilization of renewable energy sources (daylight, active & passive building integrated solar energy systems)
3. Optimised use of fossil fuels and energy efficient installations

The solar energy concept is based on production of electricity from PV-panels used for lighting and for running heat pumps for space heating and on high utilization of daylight to reduce energy demand for lighting

TECHNOLOGY

Passive solar is used through solar gains through windows.

Active solar consists of utilizing a potential of 8 150 m² of roof mounted or roof integrated PV-panels ensuring the development of a CO_2-neutral new urban area with respect to building operation. The PV-panels are to the extent possible intended to be oriented towards South with a tilt angle of 38°.

Furthermore, daylight is used to ensure good visual indoor climate conditions and to reduce the energy demand for artificial lighting.

SOLAR ENERGY AND ENERGY SYSTEM

The solar design solutions include active solar through roof mounted or roof integrated PV panels for two purposes:

- Electricity for lighting and power driven systems

Other heating demands are covered by passive solar gains through windows and by district heating.

The energy performance of the PV system is described below:

- Energy production: 135 kWh_{elec}/m^2 panel area corresponding to a total annual energy production of approx. 1 100 MWh_{elec}
- Power of the system: 1 175 kWp
- Expected energy demand for building operation for fully developed City Harbor Sonderborg: 11.0 kWh_{heat}/m^2 a
  1.3 kWh_{elec}/m^2 a

ENVIRONMENTAL, ECONOMIC AND SOCIAL IMPACTS

Figure 7 - Apartment building at City Harbor Sonderborg. (Source: © www.arkark.dk)

Figure 8 - Visualisation from hotel project at City Harbor Sonderborg (Source: © Henning Larsen Architects)

Figure 9 - Office building at City Harbor Sonderborg (Source: www.google.com)

ENVIRONMENTAL IMPACT

It is the ambition of City Harbor Sonderborg to develop a new urban development with a minimized impact on the environment. This is achieved through a number of measures which will reduce the CO_2-emission in the area. From energy conscious building design and by implementing energy efficient lighting and waste handling the CO_2-emission is reduced by 1 600 tons of CO_2 corresponding to 35 % compared to the standard situation. The remaining CO_2-emissions are displaced through sustainable energy production from building integrated PV and CO_2-neutral district heating.
CO_2-emission calculations have been carried out using a method based on CO_2-emission factors identified by the Danish Ministry of Energy [2].

References: [2] www.energinet.dk

ECONOMIC IMPACT

This case study has not included detailed studies of the economic impact of the project. As a part of the case study, the additional costs from construction of low energy building with various VE-elements (PV, Solar Thermal, Wind Power, Water Power) have been estimated. In was concluded that the additional costs for constructing low energy buildings will be approx. 5 – 10 % compared to standard new buildings. This does not include expenses for PV, Solar Thermal etc.

A successful business model has been developed by Sønderborg Havneselskab A/S which has attracted several developers and several projects are currently being designed or constructed in the area including an apartment building, offices and a high quality hotel.

SOCIAL IMPACT

The layout of the development plan and the mix of functions in the area, in itself support the social sustainability of City Harbor Sonderborg as the development includes housing, offices, a hotel, wellness and spa functions, a multi house, retail and cafès which all together will create a vibrant and living new area in Sonderborg. Another element which will support the social impact is the existence of the harbor front just next to the area which will automatically generate social activity in the area.

OPTIMIZED SOLAR GAINS IN COMMON URBAN AREAS

In order to ensure a pleasant outdoor climate in the urban spaces of City Harbor Sonderborg, various proposals for the urban plan have been analyzed [3] for direct sunlight / shadows in central public spaces. The shadow analysis is made for the hours from 09:00, 12:00 and 15:00 for the critical time of the year at equinox (March and September 21st).

The calculations document that a dynamic varied solar incidence is achieved on the key urban spaces in the final development plan.

Figure 10 - Shadows at 9.00 (a), 12:00 (b) and 15:00 (c) on the 21st of September in the first version of the masterplan (Source: © Dansk Energi Management & Esbensen A/S).

IN RELATION TO SCALE

Direct solar gains to key urbans spaces were analyzed for various versions of the masterplans in order to ensure attractive outdoor climate conditions in these areas. These studies were carried out in parallel with studies of solar gains on facades and roofs and studies of daylight access on facades.

The studies helped to ensure an environmentally sustainable urban masterplan.

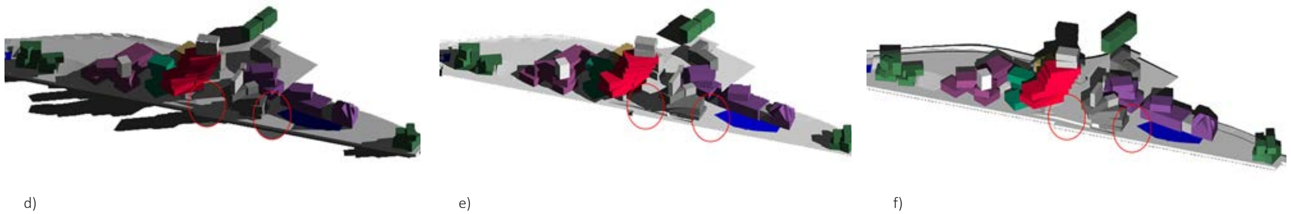


Figure 11 - Shadows at 9.00 (d), 12:00 (e) and 15:00 (f) on the 21st of September after adjusting the masterplan (Source: © Dansk Energi Management & Esbensen A/S).

Figure 12 - (on the left) The first version of the masterplan; (on the right) the masterplan after the adjustments for improving the solar accessibility. (Source: © Dansk Energi Management & Esbensen A/S).

References: [3] Esbensen Rådgivende Ingeniører A/S (2010). Sønderborg Havn – en bæredygtig bydel.

DAYLIGHT

Daylight analyses were carried out for various proposals for the development plan in order to ensure attractive daylight access in all relevant situations in the new urban plan.

The studies were based on a method [4] using the Window to Wall Ratio factor (WWR), to identify whether it will be possible to achieve good daylight conditions for the actual plan. The model defines the necessary window to wall percentage of the facades needed to obtain good daylight conditions.

The key findings were used to ensure that the daylight conditions for the various building types (hotel, offices, apartments, houses, retail, cafés etc.) would all meet the daylight requirements for the respective building types.

RESULTS AND DISCUSSION

Based on the daylight studies, the following design guidelines were defined:

- For facades marked with orange and red in figure 9, special attention shall be addressed to the height of opposite buildings, street width, color of opposite façade and size and type of window in order to obtain a good daylight access.
- It is recommended to implement atriums/skylights in buildings with facades marked with red and orange.
- On lower floors it may be necessary that all rooms have two-sided daylight access to obtain a satisfying level of daylight.

After the daylight studies were carried out the masterplan was changed. These changes did not decrease the daylight gains and no new calculations were carried out.

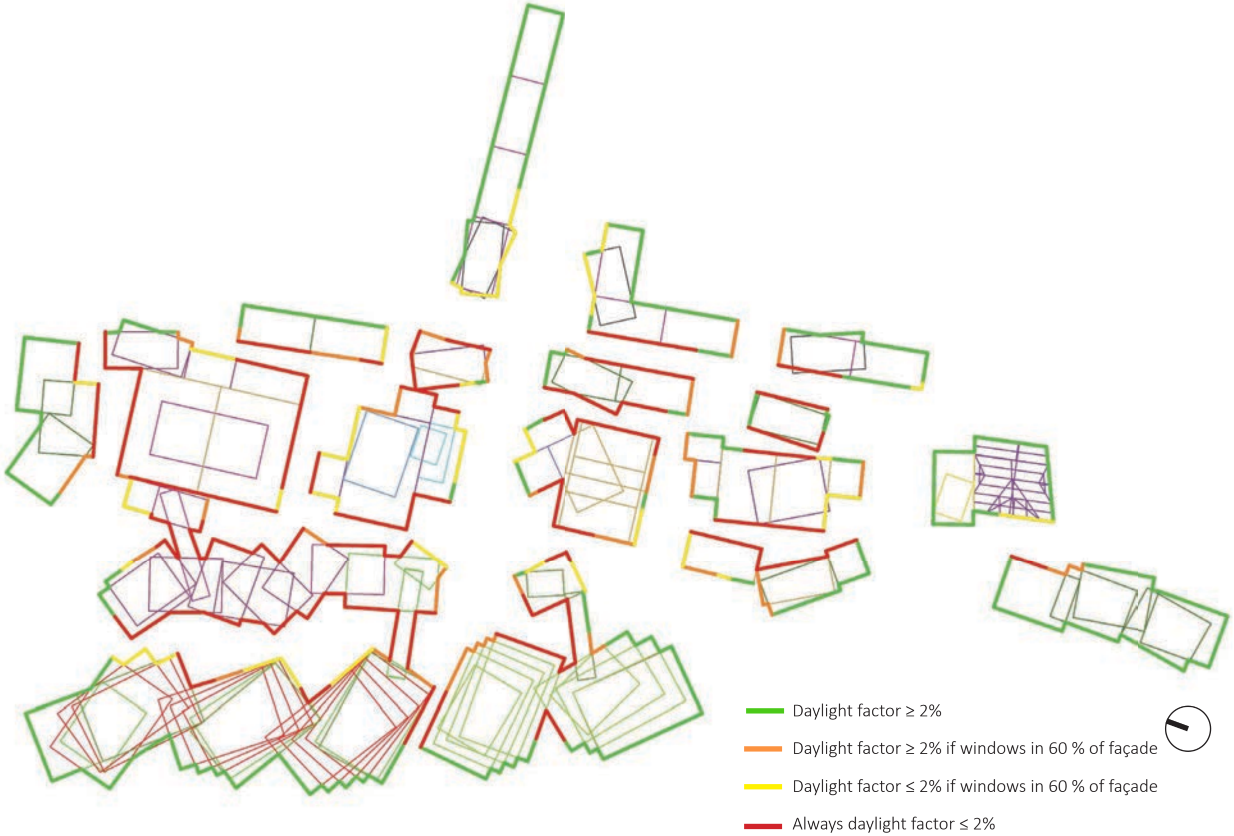


Figure 13 - Daylight levels on facades in the development plan. (Source: © Dansk Energi Management & Esbensen A/S)

References: [4] Iversen, A (Al), 2012. Development of a simple framework to evaluate daylight conditions in urban buildings in the early stages of design. PhD Thesis. Civil Engineering Report R-256. ISBN: 9788778772288. Department of Civil Engineering. Technical University of Denmark

OPTIMIZED UTILIZATION OF PV

A high implementation of PV for production of electricity was ensured by analyzing the solar irradiance on roofs and facades for various schemes of the masterplan. The simulation was used as a design tool when identifying the optimal orientation and shape of buildings regarding building heights and building distances to ensure high solar gains.

As an example the suitability for implementation of PV was analyzed for one proposal. From the results it is seen that the proposed design did not offer optimum conditions. As a consequence the masterplan was changed into a design which offers much better conditions for installing solar systems.

RESULTS AND DISCUSSION

For the final masterplan it was calculated that ~70 % of the roof area could be used for PV corresponding to 8 150 m² of PV-panels. Thus, the total electricity production from PV-panels would be ~ 1.100 MWh_{elec}/a corresponding to ~ 40 % of the total use of electricity in the area.

Simulations of solar gains were carried out using the Rhino software package. Electricity production from PV-panels was calculated using PV-SYST.

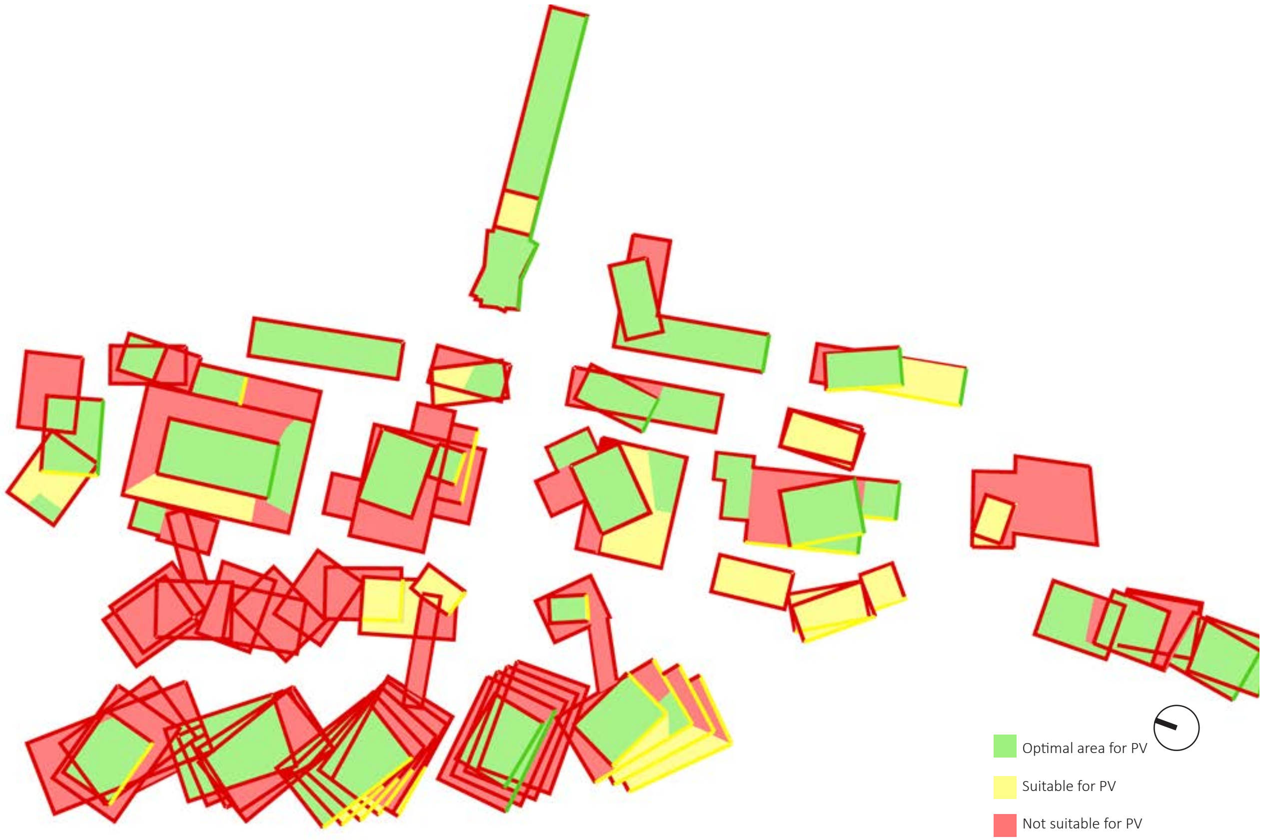


Figure 14 - Solar incidence on originally proposed scheme (Source: © Dansk Energi Management & Esbensen A/S)

References: [3] Esbensen Rådgivende Ingeniører A/S (2010). Sønderborg Havn – en bæredygtig bydel.

Figure 15 - Visualization of the new hotel at the harbor (Source: © Henning Larsen Architects)

LESSONS LEARNED

If solar energy is to become a fully integrated element when developing a new urban area, it is crucial that the developer/land owner as well as the complete design team understands that solar and daylight optimization is to be considered at the very beginning of the planning phase.

From this study it has been experienced that it may be a challenge in a market which is under financial pressure like the construction market to attract sufficient investors or developers if the sustainability goals are set too high. Through a focused effort it has however been possible to attract such developers and several buildings have been or are being constructed at City Harbor Sonderborg.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

In order to ensure implementation of active solar systems in new urban areas, land owners and/or local municipalities shall set up specific targets regarding the amount of energy to be provided for the actual development via solar solutions.

When initiating a new development, the client shall ensure that the design team has the necessary knowledge and skills to include solar measures in the design work.

Teaching about solar energy solutions at schools of architecture and engineering shall be increased.

The solar industry shall continue to develop cost-effective solutions in order to be able to compete with more conventional energy supply systems.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects
- Developers

References: [3] Esbensen Rådgivende Ingeniører A/S (2010). Sønderborg Havn – en bæredygtig bydel.


(Source: © Gehry Partners, LLP)

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ACKNOWLEDGEMENTS

Sønderborg Havneselskab A/S & Danish Ministry of Energy

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3.5 FRENCH CASE STUDIES

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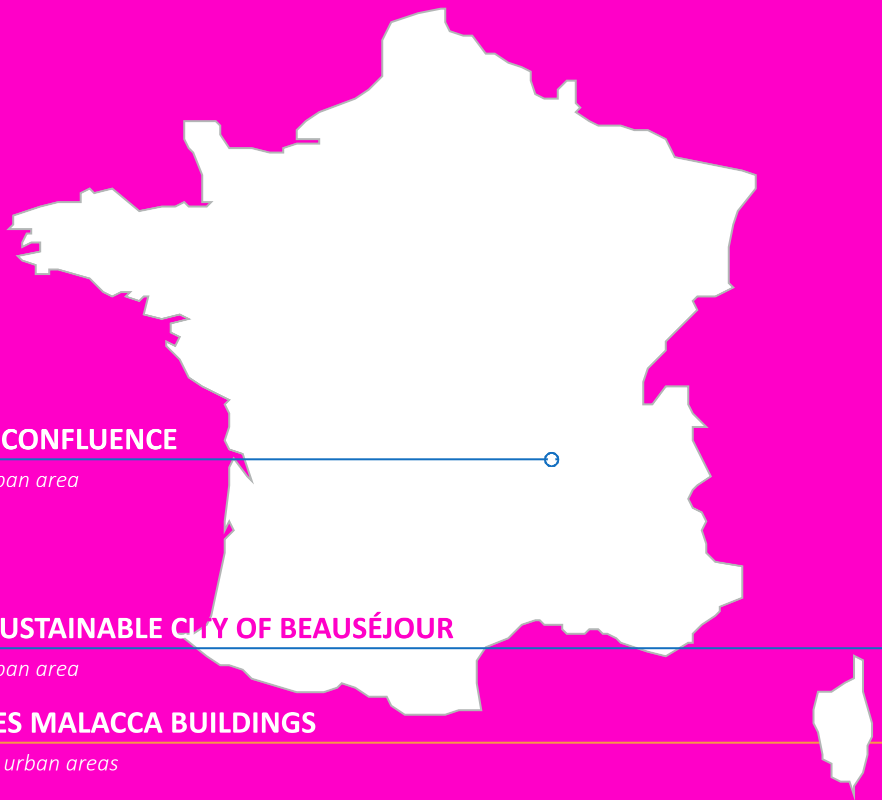


12 **LYON CONFLUENCE**
New urban area

13 **THE SUSTAINABLE CITY OF BEAUSÉJOUR**
New urban area

14 **FLORES MALACCA BUILDINGS**
Existing urban areas

15 **THE ECO NEIGHBORHOOD OF RAVINE BLANCHE**
New urban area

16 **AGRIENERGIE 5**
Landscape PV

17 **LES CEDRES**
Landscape PV

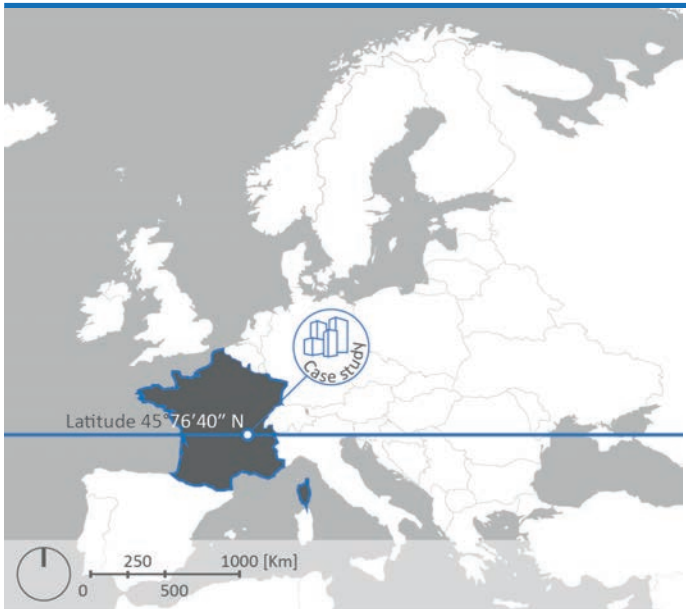
FRANCE AND RÉUNION ISLAND

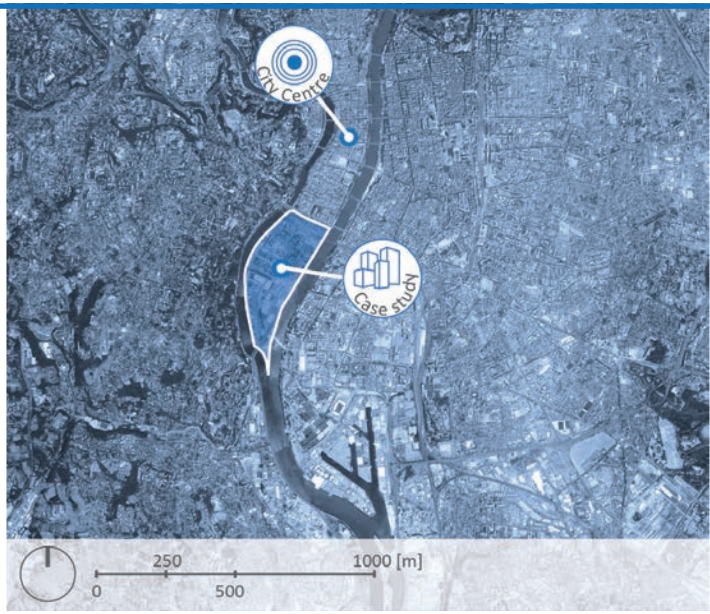
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

LYON CONFLUENCE

FRANCE

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: France
Location: Brescia (Lat. 45°76′40″N; Lon. 4°83′57″E)
Climate: Maritime temperate climate (Cfb) [1]

AREA OF INTEREST

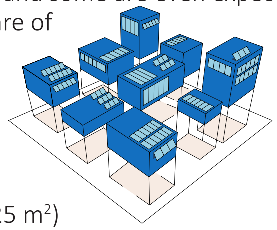
- Targets and goals
- Planning process

NATIONAL AND LOCAL CONTEXT

The Lyon-Confluence district is an actual urban planning operation within the Metropolis of Lyon. It is part of a global sustainable development process, mixing economic development, social equity and preservation of natural resources. On a global surface of 41.5 hectares, the urban redevelopment is concerning a 30 year plan including more than 1 200 000 m^2 of new buildings (housing, commercial, services and cultural infrastructures), plus the deep renovation of 60000 m^2 of existing buildings interconnected to local smartgrid. The Metropolis of Lyon aims to showcase best practice in terms of design and construction of energy efficient buildings. The strong commitment of Grand Lyon in favour of sustainable development dates back more than 15 years, with the first taking place in 1992, in the wake of the Rio Earth Summit: this was the beginning of Grand Lyon's Urban Ecology Charter.

ABOUT THE CASE STUDY

Lyon Confluence is a 2 phases project. From 2005 to 2012, the RENAISSANCE project funded by a European Commission under the CONCERTO initiative involved the first phase of the construction of 80 000 m² of energy efficient eco-buildings equipped with renewable energy systems. The first blocks built in La Confluence consume 30-60 kWh/m^2 a. The second generation of buildings consume 15-30 kWh/m^2 a; and some are even expected to reach 0-15 kWh/m^2/a. 55% share of phase 2 electricity needs should be supplied by solar energy.



Definition of environment:
New Urban Areas
Site area: 1.5 x 10^6 m^2
Building area: 1 200 000 m2 (By 2025 m^2)

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Figure 1 - Buildings of phase 1. (Photo: © C.Ménézo)

Figure 2 - Commercial Buildings of phase 1. (Photo: © C. Ménézo)

HIGHLIGHTS OF THE CASE STUDY

Long-term (2000-2030) ambitious project of a district renewal at the city centre of Lyon. The city centre of Lyon will be doubled aiming exemplary high quality in terms of urban planning, architecture, landscaping and environmental impact, using 150 hectares of industrial area. There will be wide range of housing; the three central blocks of new buildings will contain 44 % luxury homes, 33 % standard and mid-price rental and 23 % social housing. New offices will be built, increasing the number of jobs. Local parks, new squares and sport facilities will be created. Cultural activities are planned and a museum (Musée des Confluences- 25 000 m^2) with emblematic shape is devoted to sciences and society.

ISSUES AND CHALLENGES

The Lyon Confluence project is one of the most ambitious city-centre urban regeneration projects in Europe. Innovative methods concerning technical (bioclimatic approach, power generation, integrated monitoring systems) and social issues (tendering procedures, relationships with private developers, promotion and training activities, social monitoring) are developed.

In the first phase of the project energy issues focused on the building scale and their individual performance. In the second phase, attention has been paid to environmental issues right from the master plan design.

DECISION STRATEGIES

The Grand Lyon authority has planned this district renewal since the beginning of the 2000s. In 2003, some architects and real-estate developers were called to plan the first phase. The main criteria for the tender was high quality of architectural design. The CONCERTO Project named RENAISSANCE allowed to consider huge energy targets in terms of both building energy efficiency and share of renewable energy. This has led the Grand Lyon to set up the first Agenda 21. These plans have continually been strengthened . A local platform on eco-renovation was realized and a masterplan on Energies defined. For the 1st stage, CONCERTO programme focused on energy issues, taken into account in an early stage of design. The other ecologic principles wa considered with the start of the partnership with WWF (2nd phase of the project). It is related to waste (reduction of the ratio of non-recycled, non-recovered and non-composted waste to 30 %), health and water, green areas (35 hectares of green space) and transportation.

THE PLANNING PROCESS

1999. A mixed Enterprise, the semi-public company (SEM) Lyon Confluence was established. Phase 1 was created and construction work begins.

2003. SEM Lyon Confluence, which has signed a public development agreement, is officially appointed planning authority for the Lyon Confluence project on behalf of Greater Lyon.

2005. A year after selecting the first contracting authorities for the construction of the first buildings, work on the inner harbor begins with great precaution. In 2007, the first buildings at the Docks – the headquarters of Lyon daily Le Progrès and the Customs House – are opened. In 2008, SEM becomes SP.

2009. Architects and town planners Herzog & de Meuron and MDP Michel Desvigne, a landscape architect, are chosen to design the Phase 2 urban project. They meet Gérard Penot and his team, l'Atelier Ruelle, who are working on the Saône development and on the Perrache hub.

2010. The inn harbor is delivered. Saône Park and the first housing units around the harbor basin come to life. Lyon Confluence becomes the first sustainable neighborhood in France to receive the WWF label. The first group of studies on Phase 2 is completed.

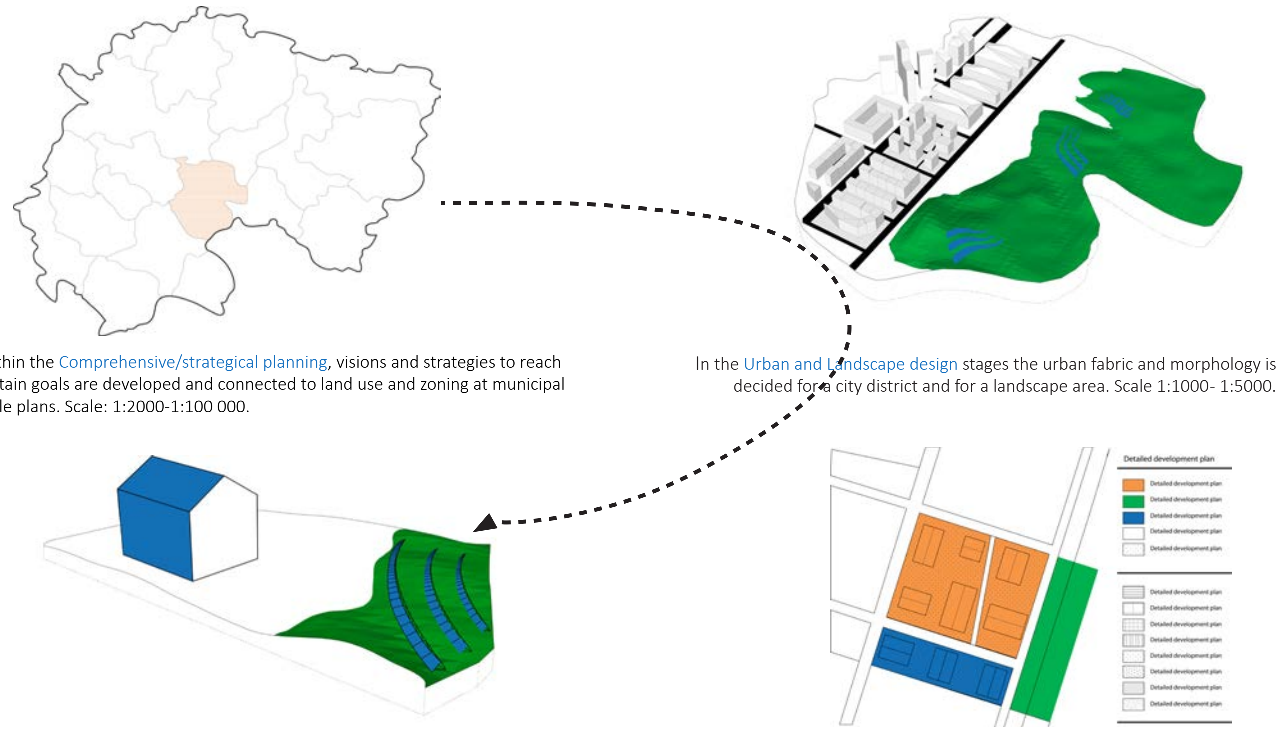
2012. The Confluence shopping center opens. Work on blocks E and F, including the children's area, comes to completion. The first land sales for Phase 2 begin. The SPLA becomes SPL (Local Public Company).

2013. The prison demolition and redevelopment worksite is started. The Youth and Culture Center (MJC) and Harbor Master's Office are opened, as is the head office of Banque de France. Construction work on the François Mitterrand esplanade begins.

2014. The Raymond Barre Bridge is opened, and the tramway now links La Confluence to Gerland. The application for the building permit for Block A3 is filed, and the permit for the first shared parking area is obtained.

2015. The Lyon-Munich-Vienna consortium wins H2020. The Vurpas team is chosen to redevelop Halle Girard [2].

References: [2] lyon-confluence.fr



Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)

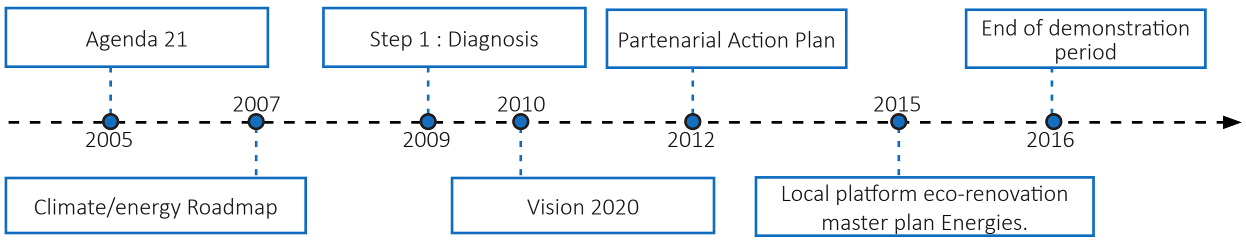


Figure 4 - View of the new buildings in Lyon Confluence intervention (Source: © © C. Ménézo)

SUMMARY

Lyon Confluence demonstrates that strong local political commitment to sustainable development, social involvement, and public private partnership can lead to energy high performance and replicable urban regeneration projects in two large cities of contrasting character. The programs including a comprehensive part of research and technical development as well as active and widespread dissemination activities. The eco-building solutions are based on thermal simulations led at design level. A large share of renewable energy sources are integrated (mainly wood fuel and photovoltaics). Commercial and fiscal solutions such as ESCo as well as socio-economic activities are developed. A huge monitoring campaign is displayed. Training sessions have been suggested to inhabitants with the intention to reach the optimum comfort that leads to efficient buildings.

References: [3] grandlyon.com

TECHNOLOGY

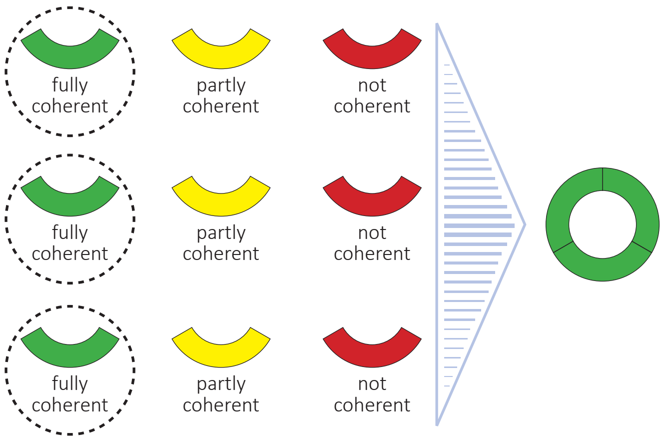
For dwelling buildings, a maximum heating energy consumption of 60 kWh/m² a, and 25 kWh/m² a for domestic hot water (DHW) were targeted for the 1st phase (Renaissance Concerto). 80% of heat and domestic hot water demand is provided by renewable energy (solar thermal and wood burner). For Electricity demand for shared spaces (entrance, stairs etc.) less than 10kWh/m² a is targeted with a share of 50% provided by renewable energy (solar PV). The cooling of dwelling buildings is passive and based on combining night free cooling (natural crossing ventilation) and thermal mass. For office buildings, a maximum heating energy consumption of 40 kWh/m² a and 10 kWh/m² a for cooling were targeted, a maximum of 5 kWh/m² a for DHW. For other electrical use less than 35 kWh/m² a of energy consumption is targeted.
The new generation of buildings (2nd phase) is designed to reach 5 to 30 kWh/m²/yr for heating needs. Some should even be Net-zero energy. To produce heat to the entire neighborhood of La Confluence, a district wood heating system will be built. Politics is also addressing the improvement of existing buildings (built before 1990). Grand Lyon Metropolis has initiated a broad program of General Interest eco-renovation involving the use of roofs. Resources are analyzed to increase the proportion of green roofs (which temper buildings) and photovoltaic surfaces. The roofs of the Perrache railway station and the ice rink, for example, could alone generate about 1 MWp. This area is a real technological showcase that attracts multiple implementation of high tech buildings such as Hikari (partnership with NEDO) and appears to be pilot site of an experiment Smart Grids (Lyon Smart Community) [3].

Figure 5 - System geometry on the Ikari building: Positiv Energy Building. (Photo: © C. Ménézo)

Figure 6 - System modular pattern [4] (Photo: "Hikari" (avril 2016) Aurélie Pétrel SPL Lyon Confluence, Kengo Kuma)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1- SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2- SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



References: *[4] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

COMMENTS

More recently the Ikari building has a BIPV solution through a semi-transparent facade. PV cells carrying a kind of façade pixelisation. They are integrated in a glazed panel, acting as a filter between the balconies and the outdoor environment. PV cells are concentrated at the fencing level, and are compliant with the overall glazed-metallic façade.

Figure 7 - Solar PV Roof at Lyon Confluence (Photo: © Panorama by Lionel TISSOT-BEZ)

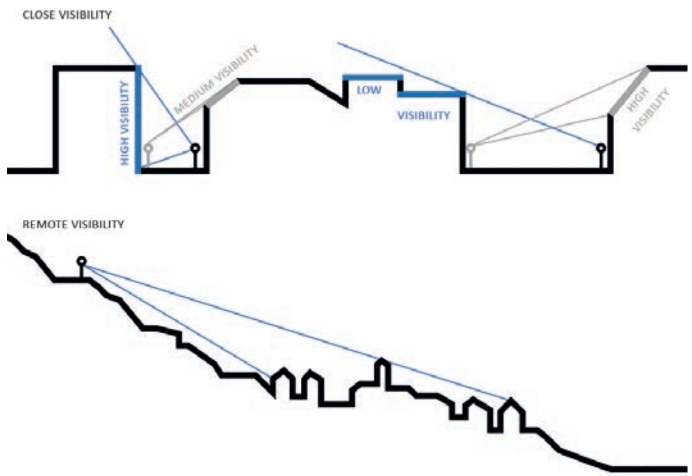


Figure 8 - Different levels of visibility of city surfaces from public domain in Lyon Confluence.

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	●	○
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

In consideration of the fact that the buildings don't have any historical value, neither there is the presence of monuments or meaningful elements, the zone can be considered at medium sensitivity.

SYSTEM VISIBILITY

On the first phase of the project, there was no visual integration effort because most of solar installations are PV roofing. Lyon Confluence is a laboratory of contemporary architecture. The architects rather relied on the use of different materials such as façade cladding, stainless steel, polymers materials, glass, etc.

The thermal and photovoltaic solar components have been in this first phase arranged on the roof. The perception of a solar system from the public space from this first phase was therefore almost non-existent. However, the installation of solar systems on the façades, allowed to have a high visibility from the pedestrian level.

The remote visibility results possible but low from the hills around the site area of Lyon Confluence on the opposite side of the Saône river.

References: [4] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 9 - Grand Lyon "Plan Climat Energie Territorial" [5]

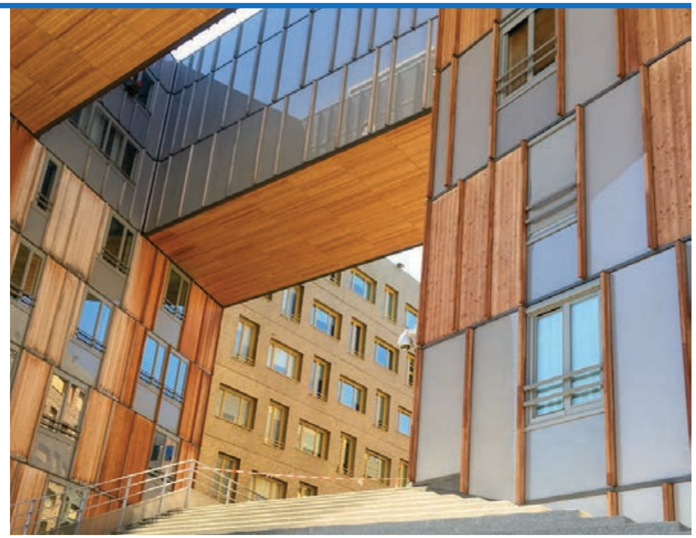


Figure 10 - The Monolithe - ECDM architects: a mixed block. (Photo: © C. Ménézo)

ENVIRONMENTAL IMPACT

Lyon-Confluence aims to showcase best practice in terms of design and construction of energy efficient buildings. The objective is to design and construct architecturally pleasant and energy efficient buildings powered by renewable energy sources. A district wood heating system will be realized based on the estimated heat demand of existing buildings and construction, as well as the objectives of the Sustainability Action Plan signed with WWF. This heating network contributes to the objective of maintaining in 2020 the emissions of carbon dioxide from the neighborhood to their 2000 level.

ECONOMIC IMPACT

The economic challenge is to create and attract jobs on the area targeting 25000 jobs in the district. Lyon Confluence is a coveted central territory. Extension of the city center, it is also popular for the quality of life it offers, both in the environmental setting and diversity of green spaces and the quality of the frame.
A neighborhood made of a sustainable development in a district that offers residents the opportunity to benefit from local services. On the one hand to limit travel and on the other to create a mixed functional community: residents, workers, walkers etc. Hosting companies create businesses, but also attract and bring people from other areas and create a sustainable dynamic.
Currently 10 000 inhabitants on site and 16 000 are targeted at the end. Currently 14 000 jobs are on site and 25 000 are targeted at the end.

SOCIAL IMPACT

Social diversity in the Lyon-Confluence is a proactive choice stated at the design of the project.

For the ZAC (Zone d'aménagement concerté / urban development zone)1 regarding housing: 62% are sold of free accession, 10% social home, 4% and 23% PLS (Prêt locatif social - social rental loan).

ZAC 2 is in turn 2 000 dwellings, 25% to 30% of social housing. Short description of the social impacts of the case study and the feasibility studies or analyses did.

25 % average of social housing built in La Confluence.

33 % of owners of less than 35 years on the Saône ZAC 1 side.

References: [5] Plan Climate Energie Territorial, Point d'étape 2015

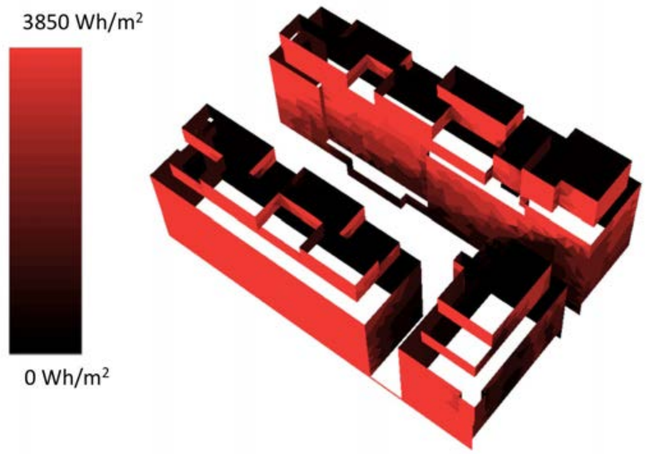


Figure 11 - Calculation of the cumulated solar energy received by a first phase block of Lyon confluence over the 31st March day using SOLENE. (Author: © M. Musy)

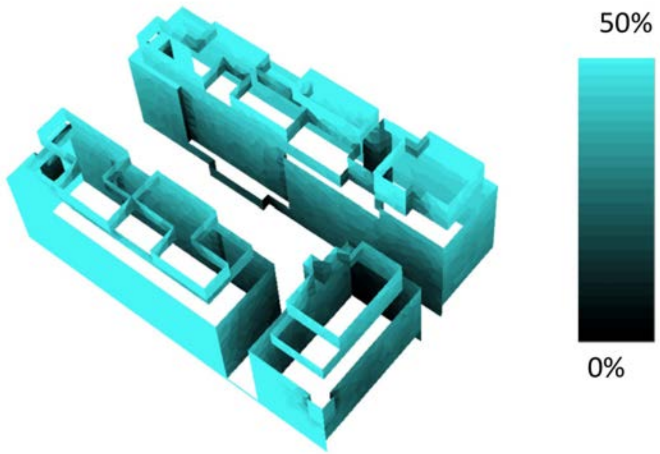


Figure 12 - Calculation of the facades' sky view factor of a first phase block of Lyon Confluence using SOLENE, (Author: © M. Musy)

EFFECT OF BUILDING ORIENTATION ON FACADES SOLAR GAINS

	21 MARCH	21 JUNE	21 DECEMBER
A South	98 %	136 % >	78 % <
B North	95 %	151 % >>	66 % <<
B South	98 %	145 % >>	73 % <<

Energy received daily by the building, without taking into account masks / Energy that would have received a theoretical North-South building with the same facades surface

EFFECT OF MASKS

	21 MARCH	21 JUNE	21 DECEMBER
A South	98 71 %	136 107 % >	78 47 % <
B North	95 50 %	151 83 % >>	66 25 % <<
B South	98 58 %	145 83 % >>	73 44% <<

Figure 13 - Study of urban form (orientation and masks) effects on solar potential of three urban blocks within first phase of Lyon Confluence. (Author: © M. Musy)

FIRST PHASE: AN ANALYSIS OF URBAN FORM IMPACTS

The first phase has been studied to show the necessity to have an energy efficiency approach at the master plan stage, so that the second phase's master plan has been studied for its impact on natural lighting and solar access. It has been imposed that each flat must have at least 2 hours of sunlight whatever the season. The real difficulty was that a highway runs along the eastern border of the district. The urban form was thus first compelled to produce a noise shield. The major impact of sunlight studies was to avoid the construction of two high towers in the south of the district that would have shaded most of it.

Using SOLENE software, solar simulation and sky view factors have been calculated over the blocks facades (Figures 12, 13).

Simulations have been carried out and communicated progressively so that to show the relative impacts of the different characteristics of the urban form: orientation, buildings' arrangement and facades' shape (tables in Figure 14).

These simulations addressed three important issues of the project, at the building scale: free solar gains, summer overheating risks and natural lighting. Simulations have also been carried out at the public spaces scale to assess their access to daylight and solar beams. They lead to show that with such densities, a particular attention should be paid to buildings proximity (relatively to their height) that can imply particularly poor ambiences in terms of natural light and solar access.

SIMULATION TOOLS AND SCALE

SOLENE [6] is well adapted to perform a study at the district scale. Indeed, details as cantilevered floors can be modeled as well as effects of buildings on each other. The issues related to public spaces has also been addressed. At the master plan stage, usually a process simulation step by step was chosen in order to explain causes and effects.

A bioclimatic method is adopted to study the phenomenon (sun, wind, light, acoustics) separately in order to give the urban planner key parameters to the design of the master plan. More complex simulations using SOLENE-microclimat [7] can be carried out when most of the parameters of the urban project are decided (forms and materials).

References: [6] Miguet F., Groleau, D., 2002, « A daylight simulation tool for urban and architectural spaces : Application to transmitted direct and diffuse light through glazing ». Building and Environment 37, no 8-9: 833-43.
[7] Musy M., Malys L., Morille B., Inard C., 2015, « The use of SOLENE-microclimat model to assess adaptation strategies at the district scale ». Urban Climate 14, Part 2: 213 23.

SECOND PHASE: AN INTEGRATED APPROACH OF URBAN FORM'S IMPACT ON AMBIENCES

In the second phase, the proposals of urban planners have been studied in detail using SOLENE, both for solar simulations and natural lighting. On the basis of these simulations, different choices have been done, for example, the project of implanting two towers at the south of the Confluence has been given up due to their strong mask effect all over the district. In this phase, the potentials of SOLENE have been exploited to perform more complex simulations so that to calculate equivalent albedo of the district, which is a main factor of Urban Heat Island Effect. It implies both urban form and materials.

RESULT AND DISCUSSION

During this project, as well as during previous ones, we have verified that simulations have led to many discussions between stakeholders, which are more important than the detailed results themselves. Indeed, simulations results bring the focus on points that must be discussed. They are a support and starting point of the discussion that is essential to decision. Indeed, the final decision will have to take into account many aspects of the projects that cannot be handled by simulation tools. However, at master plan phase, the treated aspects must remain sensitive so that the stakeholders can reason together on urban form and its impacts.

In another project, we have shown that giving the results of master plan analysis to the architects who will be in charge of blocks, design is a good base to an environmental sensitive design.

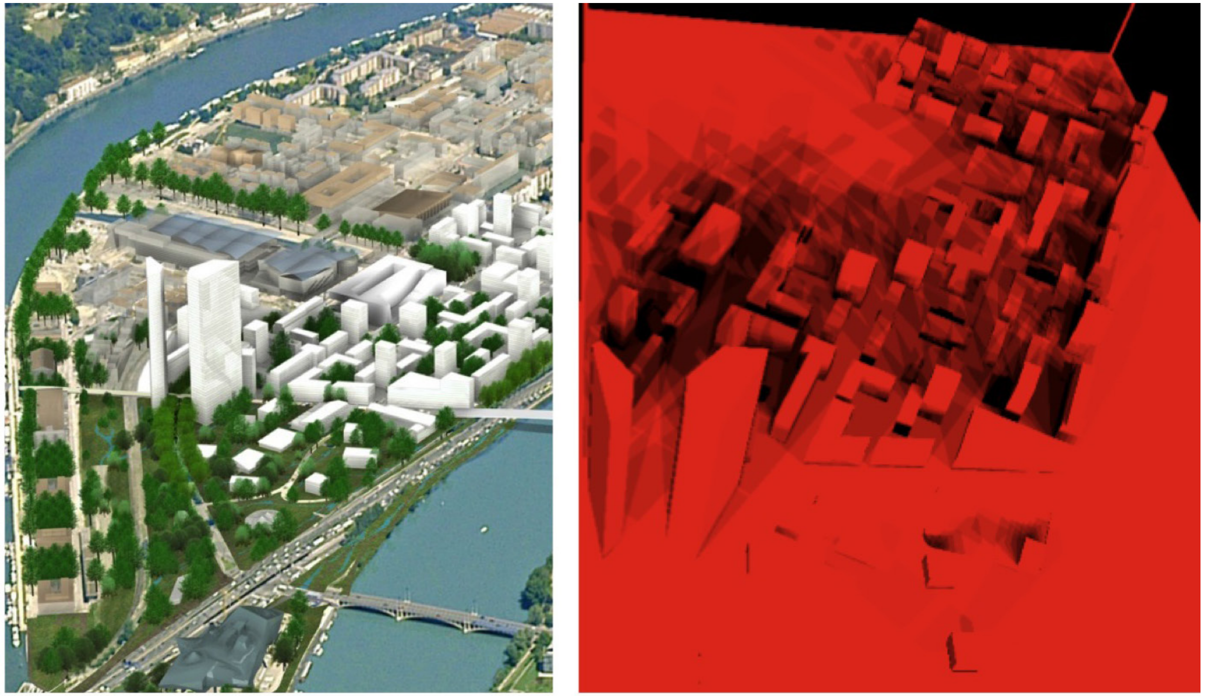


Figure 14 - Lyon Confluence second phase. South towers and their masking impact. Left : the project (Herzog & Demeuron). Rigth: simulation with SOLENE (Author: © M. Musy)

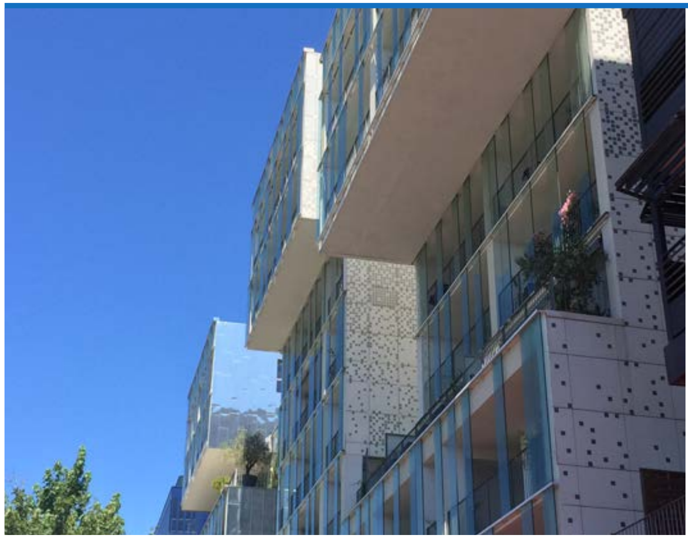


Figure 15 - Mix between Polymer materials and stainless steel. (Photo: © C.Ménézo)

Figure 16 - Stainless steel building envelope. (Photo: © C.Ménézo)

LESSONS LEARNED

Lyon Confluence is a large scale and long term demonstration led thanks to a strong political will. The project allowed to:

- Enforcement and improvement of Grand Lyon local energy performance standards for new residential and office buildings
- Preparation of a local action plan focused on low-energy renovation of privately owned housing co-ownerships in Ste Blandine neighborhood district
- Development and enforcement at regional level (Rhône-Alpes) of a massive low energy new social housing support policy, including economic monitoring, based on Renaissance outputs
- Example-based highly positive influence on the on-going political decisions process at national level.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

Social/cultural: To develop a raising awareness and education campaign toward general public. To open architecture courses to technical issues given by engineers. To develop a co-operative culture between architects and engineers in design teams.

Law: To adopt a range of consistent measures for simplification and clarification of solar energy legal and administrative framework, especially solar BIPV.

Economics: To accelerate the massive implementation of low-energy design and techniques so as to reduce the additional materials and labor costs associated with their innovative character. [9]

TARGET GROUPS

- Municipalities
- Urban planners
- Architects
- Developers
- Project managers
- Final receivers such as: members of cooperatives, public housing applicants and sales operator.

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ECDM

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CONSULTANTS

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STAKEHOLDERS

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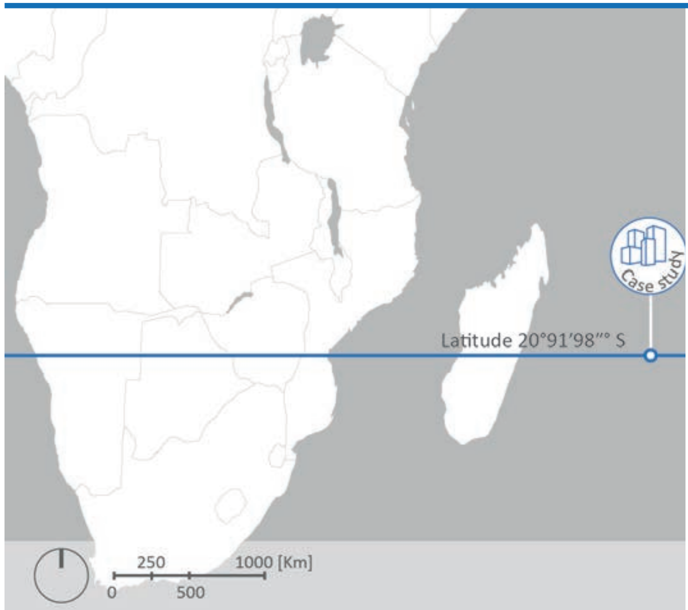
RESEARCH ORGANIZATIONS

THE SUSTAINABLE CITY OF BEAUSÉJOUR

FRANCE

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: France
Location: Sainte-Marie, Reunion Island
(Lat. 20°91'98"S; Lon. 55°53'07"E)
Climate: Warm temperate climate with dry summer (Csa) [1]

AREA OF INTEREST

Planning process

NATIONAL AND LOCAL CONTEXT

Reunion Island is an exceptional territory vulnerable to the effects of climate change, and therefore particularly involved in tackling this phenomenon and developing renewable energy. The characteristics of its humid tropical climate (high temperature, high humidity, lots of sunshine, regular force of the trade wind, southerly swells) are constraints to address with strategic town planning policies (bioclimatic housing, passive energy buildings) [2] and energy management policies.

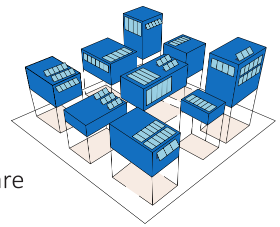
In accordance with French legislation requirements, the Regional Plan for Climate, Air & Energy of Reunion Island has set five major quantitative targets that comprises to achieve self-sufficiency in 2030 and to provide 50-60 % of homes with solar-powered hot water systems by 2020 and 70-80 % by 2030.

ABOUT THE CASE STUDY

Beausejour is an on-going city development project located on a mid-slope area over the city of Sainte-Marie in the North of the island. It fills the gap between two existing residential developments. Beausejour has launched, thanks to an innovative planning process, the ecological transition program of the island and it could become a model for sustainable urban planning in the tropics.

Definition of environment:
New Urban Areas

Site area: 780 000 m^2
Building area: 261 000 m^2
Area density: 50 housing units/hectare



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] De Schiller, S. & Evans, J.M., 1998. Sustainable urban development: design guidelines for warm humid cities. Urban Design International, 3(4), pp.165–184.

Issues, challenges and decision strategies

Figure 1 - 3D visualisation of the expected finished project. (Source: © CBo Territoria)

Figure 2 - The project proposes buildings up to 6 levels for maximising development density and conserving land that is increasingly precious to the island. (Source: © Julien Lebreton)

Figure 3 - The management of the run-off water flow with aerial canals and pools has been a structural principle in the design of the master plan. (Source: © H. Douris).

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- Well-reasoned density
- Social diversity
- Economic activities
- Soft mobility
- Natural water management
- Strong presence of native vegetation
- Passive bioclimatic measures
- Solar-powered hot water for all housing units

ISSUES AND CHALLENGES

With a population expected to reach the million in 2030 and limited available land for construction, the reduction of the ecological footprint of human settlements is vital for Reunion Island. High density development represents a solution capable of meeting the demographic needs and requirements for preservation of land. It also remains an unexplored field with only a few sustainable cities' projects in tropical areas listed so far.

In this context, the challenge of the urban development project of Beausejour consists in the creation of a new livable and economically viable town out of 80 hectares of sugar cane fields that brings together density of construction, all necessary urban functions (housing, work, local services, shopping, entertainment, etc.), social diversity and transport services.

DECISION STRATEGIES

Sustainable issues must also be considered in the holistic vision of the urban development project with bioclimatic measures integrated from the structure of the master plan to the design of all the buildings in order to ensure comfort, energy efficiency and quality at the city scale.

Climate change and the expectation of more severe tropical storms in the future is another challenge regarding run-off water flow management in dense urban areas with a significant slope.

The planning process

The Beausejour development project is built by a unique local contractor, CBo Territoria, whose business model allows an original planning and management of this new city.

This new planning project started in 2008 with the commission of an Environmental Approach to Urban Planning to orient the plan towards the sustainable town.

At its completion in 2020, Beausejour will hosts 2 300 housing units, 150 770 m² of shops and 75 100 m² of offices.

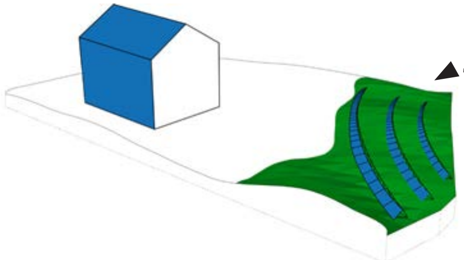
This program was defined to respond to the regional stakes of building urban housing density compatible with a rational land use.

Whereas the first objectives defined according to the local area requirements did not deal with environmental features, a key turn in the project was taken when the principle of “Green Urbanism ” [3] was integrated during the pre-operational studies to ensure the economic viability of the project.

This was also ensured by an original business model, which combines the roles of developer contractor, real-estate developer and assets and properties management; and the iterative and transversal process of managing the project in synergy with public and private stakeholders makes the consideration of the environmental issues optimal at both urban and construction scales.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

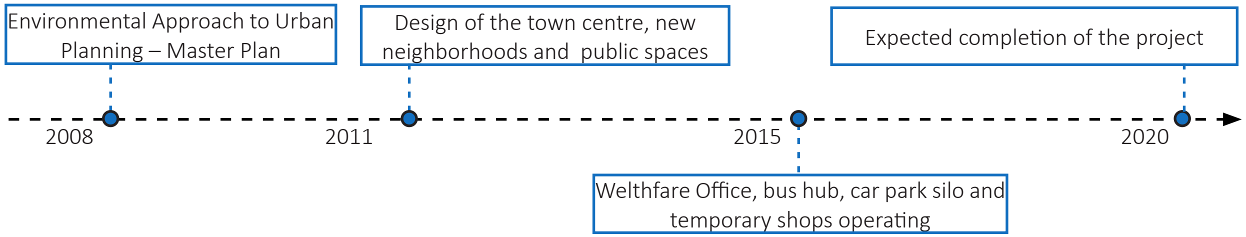
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [3] Newman, P., 2010. Green urbanism and its application to Singapore. Environment and urbanization Asia, 1(2), pp.149–170

ENERGY CONCEPT

Figure 5 - The integrated passive bioclimatic measures ensure comfort for the buildings' occupants even in a high density development. (Source: © AP Architectures/2APMR)

Figure 6 - Buildings integrate traditional creole porches and large roof overhangs to protect the buildings from adverse solar heat gains. (Source: © H. Douris)

Figure 7 - The Portes de Beausejour apartment buildings are cooled by evapotranspiration and cross ventilation. Venturi-effect wind generators ensure the ventilation of bathrooms and kitchens. (Source: © JLU- Julien Lebreton).

SUMMARY

The energy concept of Beausejour was inspired by the "Negawatt" [4] energy saving approach. Simplicity and economy were thus defined as prime environmental principles. Every building is designed according to passive bioclimatic measures ensuring thermal and humidity comfort without using air conditioning. The different building typologies all favor solar and rain protection, natural ventilation, the use of wood, large outdoor vegetated spaces and strong soil permeability. Building envelopes are highly porous to promote both natural ventilation and daylighting. Openings are protected from direct sunlight with various types of solar shadings to limit any heating or glare issues.
The concrete cores of the buildings are protected by vegetated buffer zones which reduce the air temperature and create a favorable microclimate.

TECHNOLOGY

- Over-roofs with integrated PV (business buildings) and solar thermal panels (residential buildings)
- Architecturally integrated solar shading features of various types (overhangs, balconies, blades, fins, overhangs, sliding panels with semitransparent fabric…)
- Porous facades and narrow blocks and parcels adapted for cross natural ventilation
- Buffer spaces regulating external thermal atmospheres to protect homes
- Marked presence of greenery (green roofs, parks, in the public and private spaces) contributing to cooling by evapotranspiration and to the management of rainfall
- Energy efficient artificial lighting features (energy saving lamps, fluorescent tubes, LEDs, timers controlled by illumination levels).

SOLAR ENERGY AND ENERGY SYSTEM

The domestic hot water of all housing units is produced thanks to solar thermal collectors.

The annual electric energy consumption of apartments (Porte de Beausejour building) is under 28 kWh/m^2 a (simulated for all uses, conventional equipment and users' behavior).

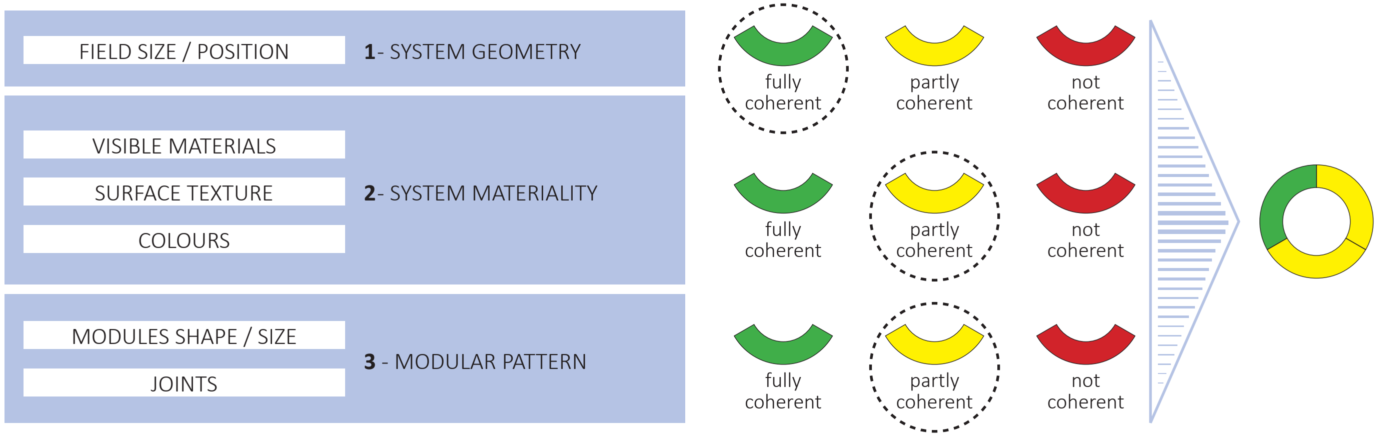
The operational daylight autonomy level for living rooms is greater than 80%.

The integration of PV panels on the roofs of several business and service buildings is also effective in Beausejour.

References: [4] Steinberger, J.K., van Niel, J. & Bourg, D., 2009. Profiting from negawatts: Reducing absolute consumption and emissions through a performance-based energy economy. Energy Policy, 37(1), pp.361–370.

Figure 8 - System geometry (Photo: © JLU-Julien-Lebreton) [2].

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED



References: *[2] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

COMMENTS

The presented PV field (Figure 8) is installed on the new secondary school buildings of Beausejour. Its size and position are fully coherent since following the roof pans slopes. The material and color of the panels have not been particularly selected to merge with the roof color which make them poorly integrated. Also, the joints of the modules are quiet thick and visibly attracting because of their light contrasting color.

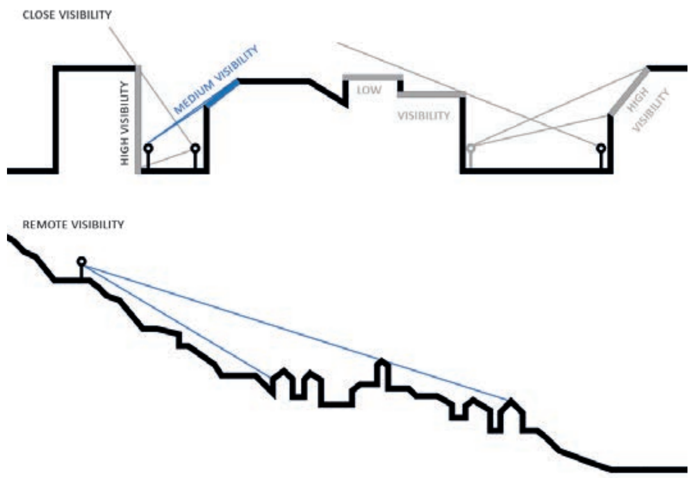


Figure 9 - Different levels of visibility of city surfaces from public domain in Lyon Confluence.

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	●	○
REMOTE VISIBILITY	○	●	○
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

As a new district built on mid-slope sugar cane fields, the context sensitivity comes from the integration of the new development in the natural landscape. Beausejour was designed by and for the place, by considering the ecological potentials of the site, mixing the topography, the routes of run-off water flow, the passage of ecological corridors and the routes followed by winds. These natural lines structure the development of the city and are combined with progressive building block heights to respect the landscape scale for an acceptable visual impact. Wooden porches and kiosks as cultural and architectural features of traditional creole houses are preserved and integrated in the design of the new buildings. They easily provide protection from the sun in complement of the various other architectural features that act as solar shadings (blades, fins, overhangs, sliding panels, etc.).

SYSTEM VISIBILITY

The most sensitive aspect from a visibility point of view comes from higher altitude locations on the slope of Sainte-Marie.

PV and solar thermal panels have little visual impact since they are integrated to the large over-roofs of the buildings. People have few chances to have panels in their visual field from the streets and pedestrian ways. However, since Beausejour is built on the slopes of Sainte-Marie, remote visibility is more sensitive with various view angles onto the roofs of the district from upper locations.

References: [4] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 10 - One of the several green corridors on site. This "gardened forest" made of native trees and plants is expected to become a large cooling canopy over the whole city (Photo: © Atelier LD)

Figure 11 - The run-off water flow, the green corridors and the topography disrupt the regularity of the tight urban grid and form a special link with the landscape. (Source: © Atelier LD)

Figure 12 - The Welfare Office, a structuring building of the district. (Source: © Atelier LD)

ENVIRONMENTAL IMPACT

Despite its implementation on former sugarcane fields, Beausejour has a limited and positive impact on its environment. This is achieved by combining a unique density for the island of 50 housing units/hectare (10 times higher than the average in the region) that preserve the land with an environmental approach to urban planning that focused on the continuity between soft mobility, green corridors and natural water flows from the early design stages. Beausejour is designed as a city within nature, where native trees and plants are merged with architecture. Dense vegetation covers nearly one-third of the whole development with a large urban park, a botanical garden and home gardens. It participates to an ecological restoration dynamic where new biotopes are created and insects, birds and small animals that had been displaced long ago by the sugarcane plantations are welcomed back on site.

ECONOMIC IMPACT

In order to reduce the overall economic impact of the development operation, an original financing package combined a real estate product to a financial product.

SOCIAL IMPACT

Beausejour mixes both social and urban planning briefs from the basis of its plan, at all scales. The wide variety of housing types (apartment blocks, intermediate housing or detached/individual homes) ensures the diversification of the sections of the population, including different generations. To meet the needs of a socially fragile population, 40% of units are subsidised public housing with high architectural quality. The developer contractor has initiated an original approach for advocacy planning in which the residents were incorporated in the planning process in a participatory way. This makes residents enthusiastic and makes them adhere to the eco-citizen project which is crucial in the urbanisation of an ecological sensible site. Amenities (schools, sports complexes, health and community centre, post office, car park silo, etc.) and services (Welfare Office, police station, urban park etc.) are also part of the project and provide all facilities on the scale of the catchment area while bringing economic activity.

ENVIRONMENTAL APPROACH TO URBAN PLANNING

The Environmental Approach to Urban Planning or Green Urbanism integrated from the pre-operational stages of the project is a decisive step towards the sustainability of Beausejour.

RESULTS AND DISCUSSION

Although some environmental features could have been implemented at the scale of a city, such as the creation of biomass; important decisions for the structure of the city plan were balanced based on the judgment of multidisciplinary team (landscape architects, planners and engineers) and on three criteria: law and regulation, financial feasibility and technical feasibility.

This led to a comprehensive design based on the ecological potentials of the site, in which all the elements are working in synergy to ensure the frugality and the sustainability of the whole city.

In this approach, the soft mobility framework is linked to the green framework. This not only creates a friendly environment for people but also contributes to cool the site and to mitigate the Urban Heat Island effect. The green framework participates to the ecological restoration of the site and is also working in synergy with the blue framework which takes advantage of the topography to manage the rain water run-off while minimising the water needs of the green public spaces.

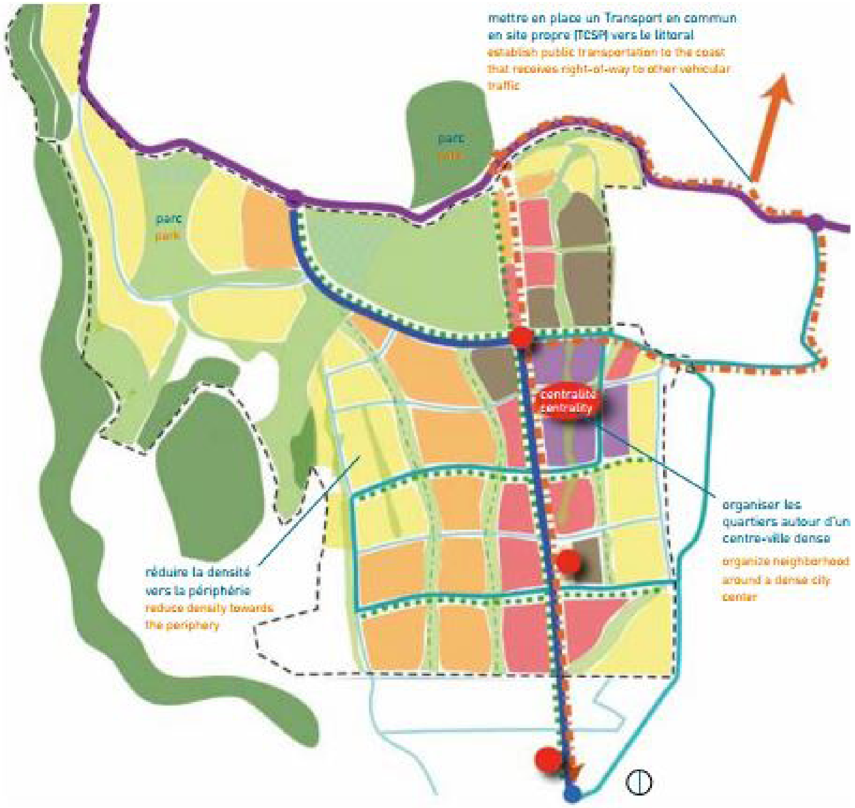


Figure 13 - Following Green Urbanism principles, the master plan of Beausejour mixes soft mobility, green and blue frameworks. (Source: © Teknê architectes)

Lessons learned and recommendations

Figure 14 - Temporary shops were built early 2013 to provide services to the first inhabitants of the district. (Photo: © Tekhnê Architectes)

Figure 15 - The marked presence of greenery in the public space contribute to cooling by shading, by evapotranspiration and to the management of rainfall. (Photo: © Atelier LD)

Figure 16 - The mix of both social and urban planning programmes form the basis of the plan allows Beausejour to provide all facilities on the scale of the catchment area (here the new marketplace) (Photo: © JLU - Julien Lebreton)

LESSONS LEARNED

- The time-scale and temporality of the project makes it flexible for operational adjustment and improvement
- Greenery plays a major role: to guaranty privacy of the housing working as screens, to improve comfort by evapotranspiration cooling and shading, to contribute to rainfall management, to support biodiversity and to enhance the quality of the public space which is essential for the sociability and the community interactions.
- High density, bioclimatic design, social diversity and sustainability are compatible with land preservation and reduction of the urban sprawl in tropical climate.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- Combining the direct and indirect benefits of all the elements, mixing urban objectives with environmental issues is what contributes to the sustainability of a city.
- Synergy between elected officials, administration and developer is the key that enables flexibility and creativity.
- Advocacy planning allows inhabitants to feel involved, to adhere and to contribute to the project.
- Translation of urban objectives into an environmental and bioclimatic-sensitive design leads to sustainability.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects
- Project Developers
- Actors of projects located in tropical climates.

DEVELOPER

Tekhnê Architectes
CBo Territoria

CONSULTANTS

Atelier LD; UPAU
Antoine Perrau Architectures; 2APMR; LEU Réunion
Agatha Argod; EGIS; CER

CASE STUDY AUTHORS

François Garde and Aymeric Delmas, PIMENT, University of Réunion Island.

OWNERS

CBo Territoria/Municipality of Sainte-Marie

STAKEHOLDERS

Project management team/External consultants/Enterprises.

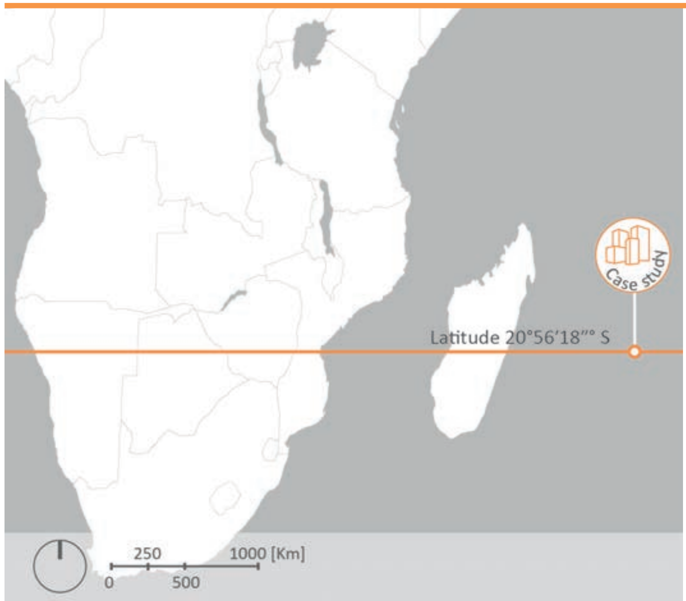
ACKNOWLEDGEMENTS

RESEARCH ORGANIZATIONS

FLORES MALACCA BUILDINGS

FRANCE

OVERVIEW



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: France
Location: Le Port (Lat. 20°56’18” S; Lon. 55°17’45” E)
Climate: Warm temperate climate with dry summer (Csa) [1]

AREA OF INTEREST

Targets and goals

NATIONAL AND LOCAL CONTEXT

Reunion Island is an exceptional territory vulnerable to the effects of climate change, and therefore particularly involved in tackling this phenomenon and developing renewable energy. The characteristics of its humid tropical climate (high temperature, high humidity, lots of sunshine, regular force of the trade wind, southerly swells) are constraints to address with strategic town planning policies (bioclimatic housing, passive energy buildings) and energy management policies.

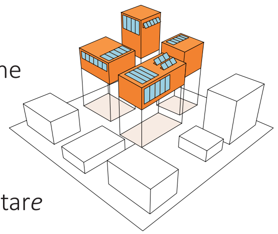
In accordance with French legislation requirements, the Regional Plan for Climate, Air & Energy of Reunion Island [2] has set five major quantitative targets that comprises to achieve self-sufficiency in 2030 and to provide 50-60 % of homes with solar-powered hot water systems by 2020 and 70-80 % by 2030.

ABOUT THE CASE STUDY

The two triangular islets Flores and Malacca belong to a large urban development project initiated by the city of Le Port for the requalification and the densification of its city centre. The five buildings of the operation are designed according to passive bioclimatic principles to provide 138 comfortable and energy efficient subsidised homes (including 53 student apartments).

Definition of environment:
Fill-ins and densification district in the existing urban area

Site area: 2,706 m^2
Building area: 9076 m^2
Area density: 509 housing units/hectare



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] http://www.cg974.fr/

Issues, challenges and decision strategies

Figure 1 - The urban development project of "Le Mail de l'Ocean" aims to strengthen the link between the city, the port and the sea by the creation of a new avenue. (Source: © AP Architectures/2APMR).

Figure 2 - Original sketch of the Flores and Malacca islets. (Source: © AP Architectures/2APMR)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- Well-reasoned density
- Vegetated and porous spaces
- Preserved inhabitants' privacy
- High porosity
- Common spaces favoring social meeting and mixing
- Harmonious vertical and horizontal visual integration.

ISSUES AND CHALLENGES

The site of a project and its concomitant microclimate is of particular importance in the tropics. Favourable conditions on site will impact the performance of buildings constructed there.
The city of Le Port owns the record of highest solar irradiation and temperatures of the island. Thus, the design of the buildings of the Flores Malacca project had to respond to three main objectives:

- Improving the living environment of residents with comfortable housing
- Reducing the environmental impact of urban development with low energy consumption and CO_2 emissions
- Supporting the ambitious national and regional environmental policy with a high integration of renewables.

DECISION STRATEGIES

From its historical background, the city Le Port has kept a strong identity which needs to be highlighted through new urban developments that will contribute to:

- Strengthen the link between the city, the port and the sea
- Get back the original charming and liveability of the city centre
- Anticipate the population growth (10 000 inhabitants expected in 2025) with a diversified offer of housing
- Respect the principles of sustainable development through a "green" master plan.

The planning process

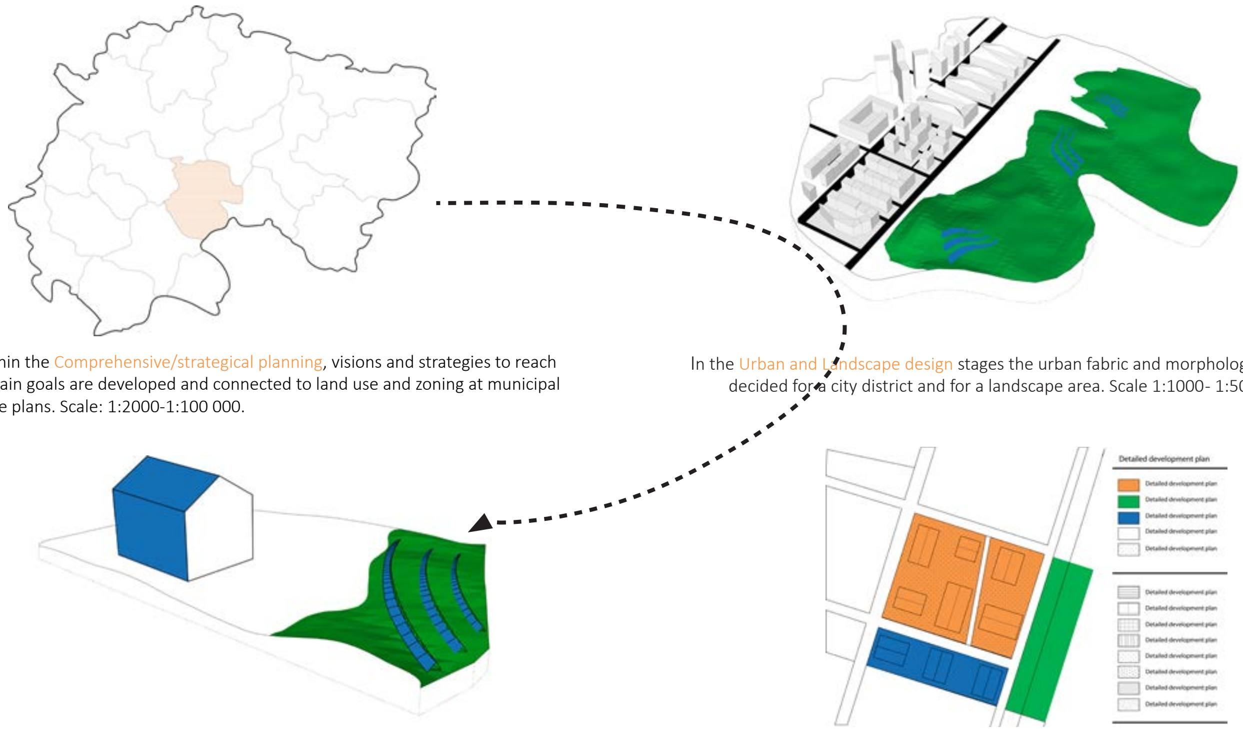
The Flores Malacca social housing project is part of a wider urban development, “Le Mail de l’Ocean” (36.5 ha), conducted by a unique local contractor, SIDR (Reunion Island Real Estate Company) who was commissioned by the Municipality of Le Port.

A preoperational participatory approach, in which residents, private and public stakeholders had been consulted since 2005, defined some elements taken into account in the urban development project “Le Mail de l’Ocean”.

The aim of the urban development was to combine density, social diversity, energy savings and adaptation to climatic constraints.

The municipality of Le Port asked the developer to integrate an Environmental Approach to Urban Planning at all the stages of the urban development project. This resulted in a comprehensive master plan that ensures the efficiency of the bioclimatic design of the Flores Malacca buildings.

The French Environment and Energy Management Agency played a crucial role with technical and financial support regarding the environmental issues of the project.



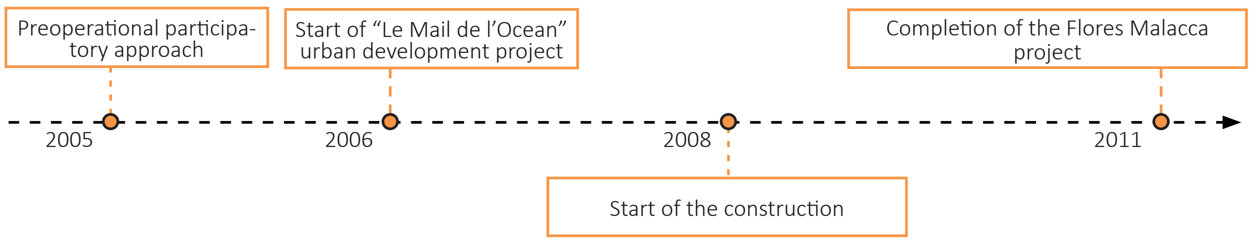
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



ENERGY CONCEPT

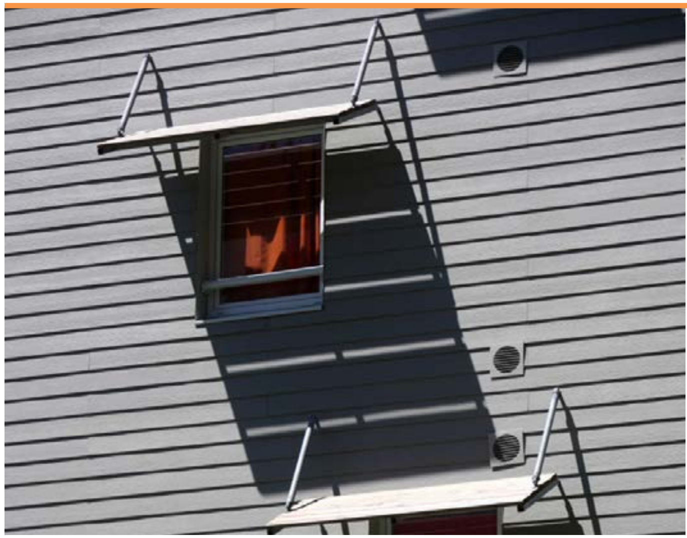


Figure 4 - Various solar shading devices, optimised according to the orientation of the facades, protect the numerous openings. (Source: © H. Douris).

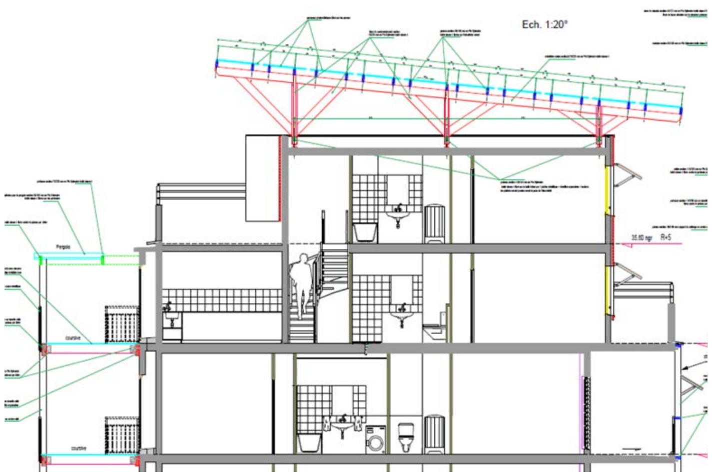


Figure 5 - PV panels are integrated on over-roofs. This architectural feature enhances the efficiency of the panels by avoiding potential overheating and limits solar radiation on the roofs (Source: © LEU Reunion)

SUMMARY

The design of five buildings of Flores Malacca is based on passive measures. Solar shading is achieved by various architecturally integrated features designed according to the orientation of the facades, the views and the openings to protect: louvered porches, shading external passageways; horizontal blinds, vertical fins, trellised screens, over-roofs with wide overhangs.

Cooling is performed by natural ventilation combined with the evapotranspiration induced by the omnipresent native vegetation: all housing units are cross naturally ventilated and equipped with louvered windows; offices and shops are equipped with fans and the breakdown of the buildings facilitates the air flow at the scale of the building block.

TECHNOLOGY

- No air conditioning. Limited use of mechanical systems for the ventilation of the bathrooms and toilets which are preferably located on the facades and naturally ventilated throughout louvered windows
- The buildings are oriented facing the dominant wind for natural cross ventilation
- PV panels and solar thermal collectors are integrated to the over-roofs which are used for shading the roofs of the buildings and for limiting the adverse thermal gains through material conduction. This feature also allows cooling the panels and avoiding potential overheating which affects their efficiency
- East and West facades are thermally protected with wooden cladding. A reflective cladding is also installed and reflects up to 90% of the solar radiation.

ENERGY SYSTEM AND SOLAR ENERGY DESIGN

- Domestic hot water for all the buildings is produced thanks to 219 m² of solar thermal collectors. Individual water tanks are installed in each apartment
- 420 m² of PV panels (88kW power) are installed on the over-roofs of the buildings. Unique feature for a social housing building on the island, the PV panels which are connected to the grid, generate 10 000 kWh per month
- An electric backup power supply is installed and run in case of low solar availability in winter
- Annual energy consumption: between 28 and 40 kWh/m^2 a.

Architectural Quality - system Visibility - context Sensibility

Figure 6 - System geometry [3]. Overview of the combined PV and solar thermal panels roof plant. (Surce: © AP Architectures/2APMR)

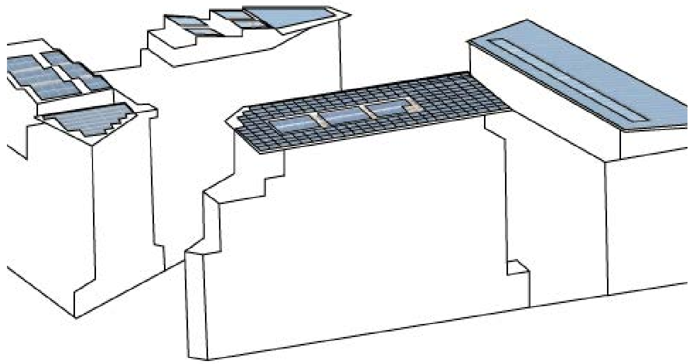
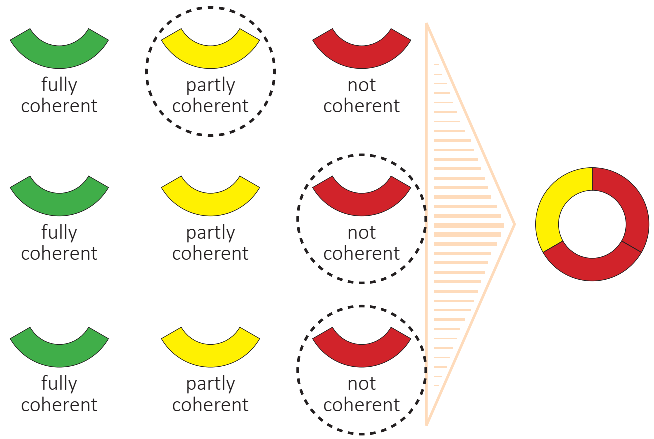


Figure 7 - System materiality [3]

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



COMMENTS

The field size and position is only partly coherent because of the various orientations of the panels and the arrays layout leaving some uncovered space on the roof and many polygonal artifacts.

However a particular work has been done in order to integrate both solar thermal and PV panels on the same over-roof pans. Their different sizes and materials and in between space make them however not coherently integrated with the roof.

References: *[3] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT. (click here to download)

Figure 8 - Flores Malacca and the newly created axis towards the sea. (Source: © H. Douris)

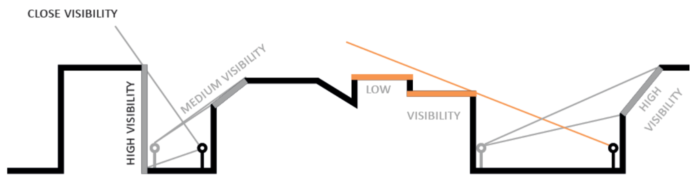


Figure 9 - Different levels of visibility of city surfaces from public domain.

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○

SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	●
REMOTE VISIBILITY	○	●	○

Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

The context sensitivity is moderate in the area of construction of the Flores and Malacca buildings which mainly comprises low-rise residential buildings with no particular historical heritage.

Several architectural choices make the project harmoniously integrated in its surrounding environment. Progressive and limited building heights (with maximum 5 storeys) with recessed penthouses respect the scale of the district.

The vertical layout of the buildings is also integrated in the topography of the site and avoids unnecessary earthworks.
Visual comfort is also taken into account in the sizing of the windows with a window to wall ratio higher in the lower storeys than in the higher ones. Plants also contribute to ensure housing privacy by creating real vegetal screens.

SYSTEM VISIBILITY

From an urban canyon perspective, the installed solar systems are hardly visible from the public space since installed on very high over-roofs. Their remote visibility is more sensitive but remain moderate since view spots from higher altitudes locations on the slopes over the city of Le Port are quite distant.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT. (click here to download)

Figure 10 - The presence of wooden elements is marked on the project: from the structure of the over-roofs and passageways to solar shading blades. (Photo: © H. Douris)

Figure 11 - The numerous common and open spaces favor interactions and social integration between the diverse inhabitant populations. (Source: © H. Douris)

ENVIRONMENTAL IMPACT

To reduce the green gas emissions related to construction materials, wood is widely used and integrated in the project : structure, over-roofs, pergolas, passageways, decks, solar shadings, façade cladding. Water is preserved by the project with rain water and grey water management systems connected to the vegetated spaces. Several strategies were defined to reduce the environmental impact of the construction of the buildings:

- Sorting building waste
- Shared management of the several construction sites of the development area
- Communication to the public
- Storage areas
- Specific construction site circulation.

ECONOMIC IMPACT

The French Development Agency chose the urban development project as “pilot operation” for testing original financial mechanisms. Loans were accorded to the municipality and the developer contractor in order to propose a consistent and global answer to the urban development objectives. 2.4 million euros were used to balance the cost of the construction of bioclimatic buildings and the cost of the solar water heating systems.

SOCIAL IMPACT

Several architectural features favor social integration. The absence of separate building entries avoids the sense of social hierarchy. Discontinuous paths, open passageways and stairs, shaded terrace gardens are common places that favor social meeting and mixing. They favor the interactions between the inhabitants, which enhances their sense of ownership and community.

SOLAR SHADING

The design and optimisation of the solar shading devices were performed thanks to dynamic solar simulation using SketchUp. The design of the various solar shading devices is adapted according to the orientation of the façade and the room operation.

RESULTS AND DISCUSSION

The study and the optimisation of each specific solar shading device allow ensuring facades with a high porosity (25%) that favors the cross-natural ventilation of the buildings while avoiding any overheating or glare issues.

Parallel to this reflection on solar protection, dynamic thermal simulations were also performed in order to ensure that every housing unit provides comfortable conditions to its occupants. It should be noted that the concept of comfort temperature is different from the temperature measured with a thermometer and is not absolute but depends on several parameters: humidity, air velocity, air temperature, the radiation temperature of the walls, metabolism and clothing.

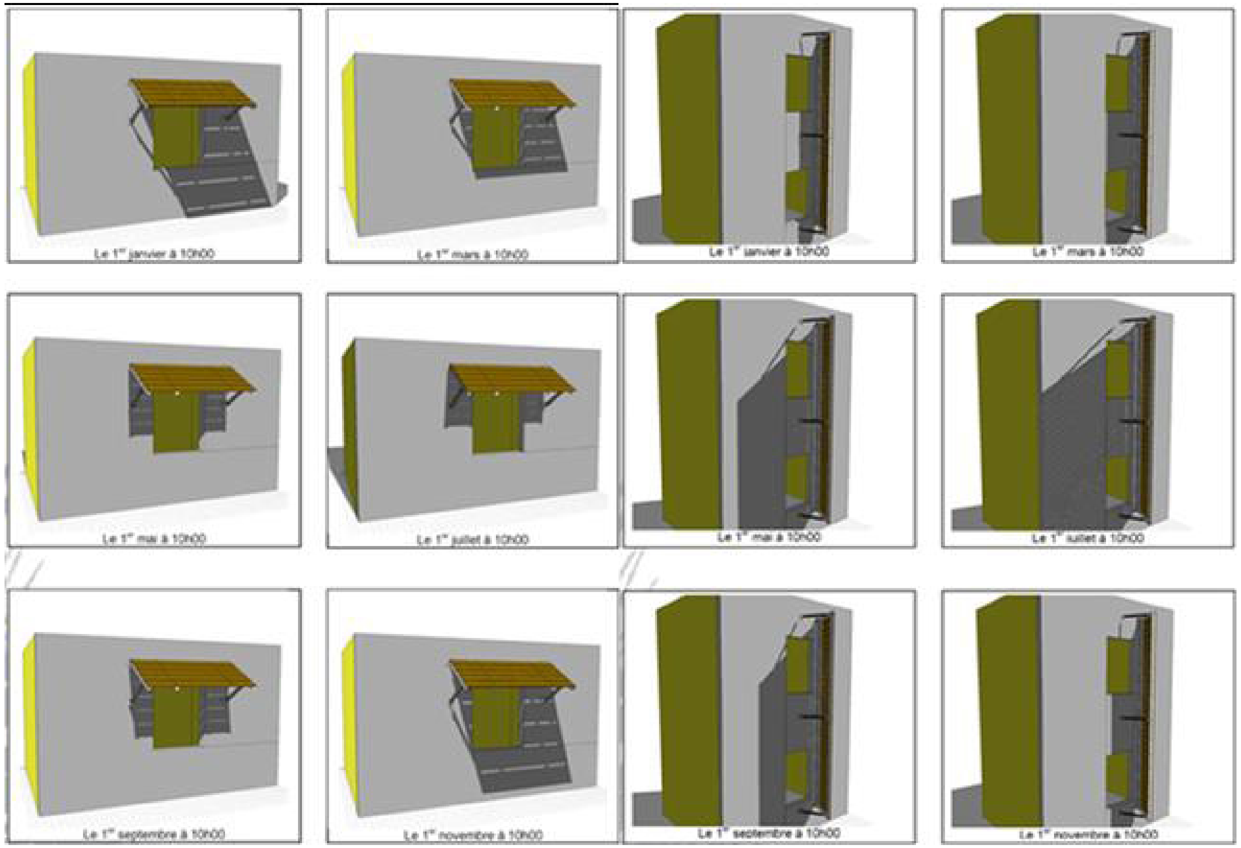


Figure 12 - Study of the solar shading devices on the North-East and South-East facades. (Source: © LEU Reunion)

LESSONS LEARNED AND RECOMMENDATIONS

Figure 13 - The vegetated buildings' surroundings that contribute to cooling the atmosphere by evapotranspiration are watered with the rain and grey water collected on site. (Photo: © H. Douris)

Figure 14 - The open and shaded passageways, stairs and common spaces favor the interactions between the inhabitants which enhances their sense of ownership and community. (Photo: © H. Douris)

Figure 15 - Solar protection is the key in the tropical climate of Reunion Island. Optimised solar shading devices, over-roofs and external passageways are architecturally integrated in the Flores Malacca project. (Photo: © H. Douris)

LESSONS LEARNED

- Social mixing must be parsimonious and requires prior teaching and awareness of the diverse populations intended to cohabit together. The vertical management of the mix adopted in the project (rather than in parts of the buildings) generated some tensions, in particular between students and families
- The common areas designed as real social spaces are victims of their success. This is reflected by the presence of outsiders who are not necessarily desired .
- The design of some façade claddings needs to be improved to prevent possible intrusion by climbing.
- Concrete solar shading overhangs are efficient but store and release heat.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- 70% of the heat input comes through the roof, and so this element of the design should be treated with the utmost consideration and care. Over-roofs are a very efficient feature mutualising energy generation and solar protection
- The breakdown of the operation into two islets and five narrow buildings makes the natural efficient throughout both islets
- A high level of porosity of the facades combined with optimised solar shading devices and vegetated surroundings ensure good visual and thermal comfort even in harsh tropical conditions.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects
- Project developers
- Actors of projects located in tropical climates.

PUBLIC AND EDUCATION ACTIVITIES

Open Symposium on *"Solar energy in Urban Planning"*- Friday 20. March 2015, Trondheim.

ARCHITECT, DESIGNER AND DEVELOPER

AP Architectures
2APMR
SIDR

OWNERS

SIDR
Municipality of Le Port

CONSULTANTS

LEU Reunion
GECP
SOCETEM
TOP BIS

STAKEHOLDERS

ADEME
AFD

RESEARCH ORGANIZATIONS

CASE STUDY AUTHORS

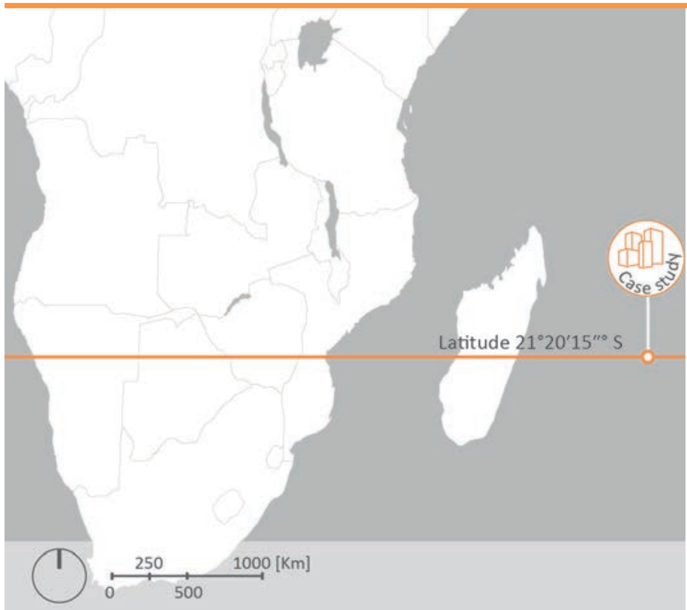
François Garde and Aymeric Delmas, PIMENT, University of Réunion Island (France).

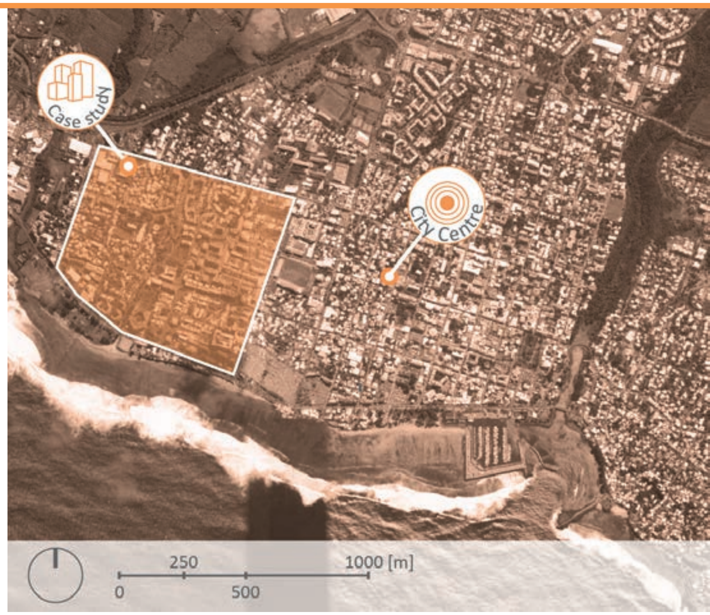
Photo: © H. Douris / City of Saint-Pierre

THE ECO NEIGHBORHOOD OF RAVINE BLANCHE

FRANCE

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: France
Location: Saint-Pierre, Reunion Island
(Lat. 21°20′15″ S; Lon. 55°27′48″ E)
Climate: : Equatorial Winter Dry (Aw) [1]

AREA OF INTEREST

Planning process

NATIONAL AND LOCAL CONTEXT

Reunion Island is an exceptional territory vulnerable to the effects of climate change, and therefore particularly involved in tackling this phenomenon and developing renewable energy. The characteristics of its humid tropical climate (high temperature, high humidity, lots of sunshine, regular force of the trade wind, southerly swells) are constraints to address with strategic town planning policies (bioclimatic housing, passive energy buildings) and energy management policies.

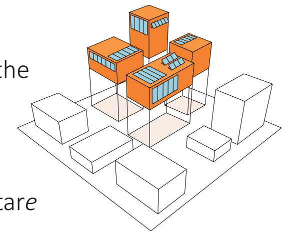
In accordance with French legislation requirements [2], the Regional Plan for Climate, Air & Energy of Reunion Island [3] has set five major quantitative targets that comprises to achieve self-sufficiency in 2030 and to provide 50-60 % of homes with solar-powered hot water systems by 2020 and 70-80 % by 2030.

ABOUT THE CASE STUDY

The neighborhood of ‘Ravine Blanche’ is located in Saint-Pierre, Reunion Island. It is an old neighborhood that emerged in the 1960’s- 1970’s. The existing neighborhood is under an urban renewal program, which covers an area of 148 acres with an estimated population of 6000 inhabitants. The project has been awarded the French sustainable neighborhood certification in the tropics in 2013.

Definition of environment:
Fill-ins and densification district in the existing urban area

Site area: 600 000 m^2
Building area: 275 000m^2
Area density: 50 housing units/hectare



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Loi no 2010-788 du 12 juillet 2010 portant engagement national pour l’environnement dite loi ENE;
[3] Schéma Régional du Climat, de l’Air et de l’Energie (SRCAE) de La Réunion ,18th December 2013 [online]

Issues, challenges and decision strategies

Figure 1 - The new urban development project aims to reconnect the district to the city center (Source: © City of Saint-Pierre)

Figure 2 - The green and blue infrastructure as a network of corridors for biodiversity. (Source: © Hélios Paysage / City of Saint-Pierre)

Figure 3 - Urban street pattern enhances street blocks' wind porosity and opens the neighborhood to the sea. Buildings and trees are aligned along the streets. (Source: © City of Saint-Pierre)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- Well-reasoned density and social diversity
- Increase in inhabitants' privacy
- Public spaces such as a new urban park enhancing social meeting and mixing
- Development of facilities and public services
- Strong potential due to its proximity to the sea
- Soft mobility with bicycle path and bus reserved-lane
- Rainwater management and protection of the marine environment
- Strong presence of native vegetation
- Passive bioclimatic strategies for the retrofitting of existing buildings and the construction of new buildings
- Solar thermal panels for domestic hot water supply of all units and PV panels on two buildings.

ISSUES AND CHALLENGES

'Ravine Blanche' is an old neighborhood composed of mass housing blocks often in the form of tower blocks that were built in the years 1970-1980, with the purpose of housing people at low-level income in a short period of time. Most traditional buildings of this period were not originally designed according to bioclimatic principles and do not incorporate energy efficient systems. In addition, the district was isolated, neglected and totally disconnected to the city center despite their relative proximity. The existing neighborhood was composed of 80% of social housing with a low rate of shops and public services. In addition to poor physical conditions of the housing, the concentration of disadvantaged social housing tenants was also a key concern, with 89% of unemployed people under the age of 20, 25% of sole parents and 30% of people with very low annual incomes.

DECISION STRATEGIES

Key principles of the project were to increase the housing supply, to encourage greater social diversity by creating more varied living conditions and to reconnect the district to the city center. The renewal program encompassed the retrofitting of 842 social housing units, the construction of 558 new housing units and the 'densification' of 1 340 units. It also focused on creating a mixed district by renewing and developing facilities with the creation of 6 000 m^2 of shops, offices and public services, the renovation of three schools and the construction of a new sustainable school. Major improvements were done in terms of urban infrastructure, especially soft mobility with the creation of bicycles paths and a bus reserved-lane. An urban park of around 5 acres with a series of landscaped ditches and basins for the management of rainwater was created and helps to reduce the urban heat island effect.

The planning process

Ravine Blanche is an old neighborhood that is under a renewal project.

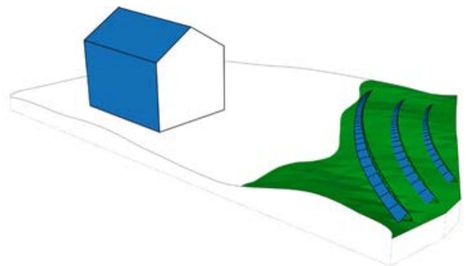
The urban renewal project really started in 2007 with the signature of the agreement between the different stakeholders and the political decision-makers. The first technical and operational studies were done afterwards so as to set up the main urban strategies. Total completion is scheduled for 2019.

The urban project developed aims at reconnecting the neighborhood to the city center and the sea, promoting social mix and urban diversity, improving public facilities and green areas, clarifying property rights, implementing soft mobility, enhancing water management and biodiversity.

A multi-stakeholders governance has been implemented in this project. On one hand, an agreement has been set up between the main influential stakeholders involved in the planning process. On the other hand, a Steering Committee, representative of all interested stakeholders and decision makers, has been established so as to work on clear and commonly held objectives. Consultants and advisers on urban project management, evaluation and communication strategy as well as social, economical and environmental studies also contributed to the achievement of this project.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

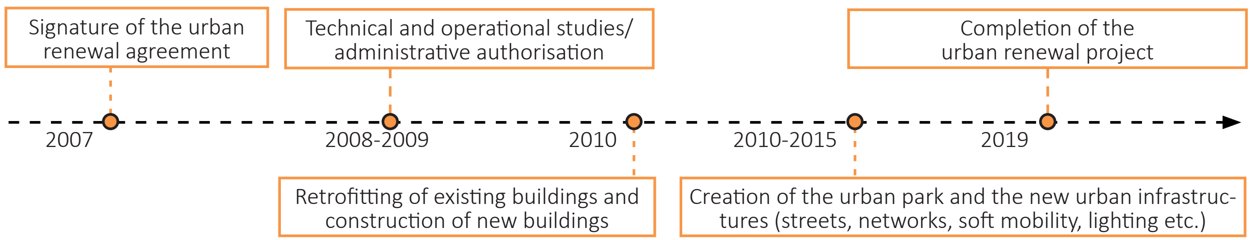
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



Energy concept

Figure 5 - Different passive design strategies have been implemented in order to reduce energy consumption while maintaining satisfactory thermal comfort conditions inside the buildings. (Source: © T. Giraud / City of Saint-Pierre)

SUMMARY

Energy concept applied in the project was based on the passive design of the buildings, the use of solar energy for the production of domestic hot water, the installation of energy efficient equipment inside the apartment units as well as the optimization of streets' lighting requirements. The new constructions and the retrofitted buildings were built according to the passive bioclimatic principles ensuring thermal and humidity comfort while reducing air conditioning. The main passive features set up include solar and rain protection, insulation of solar exposed facades and roofs, natural cross ventilation, the use of wood and low-emissivity materials, large green spaces and gardens.

Building porosity is favored thanks to large openings that are protected from solar radiation by using various types of solar shading devices.

PASSIVE DESIGN STRATEGIES

- Highly porous buildings with large louvered windows to enhance natural ventilation;
- Main facades are North-South orientated to benefit from thermal breezes;
- Various types of solar shading devices such as simple roof overhang, protected exterior verandas and louvered shutters;
- Energy efficient equipment: Led lamps, ceiling fans, etc.
- Solar thermal and PV panels on the rooftop of the buildings for domestic hot water and electricity production;
- Buffer spaces regulating external thermal atmospheres and enhancing indoor thermal conditions;
- Solar exposed facades (East and West) as well as the roof, are thermally protected with insulation and highly reflective metal or wooden cladding.

ENERGY SYSTEM

The energy systems installed include solar thermal panels and PV panels. All social housing buildings have been equipped with flat plate collectors with an estimated annual energy production superior to 650 kWh/m^2 a.

The ecodistrict is also composed of two PV systems connected to the grid, one installed on a school, the other one installed on a childcare facility. The school is equipped with both a BiPV element on the sun protection devices and a rooftop PV system.

The technical information of the PV systems installed on the school are given below:

SCENARIO	BIPV	ROOF PV SYSTEM
Area [m^2]	35.4	116.5
Power of the system [kWp]	4.4	18.6
Average energy production [kWh/m^2 a]	192	188
Orientation and inclination	20° north	

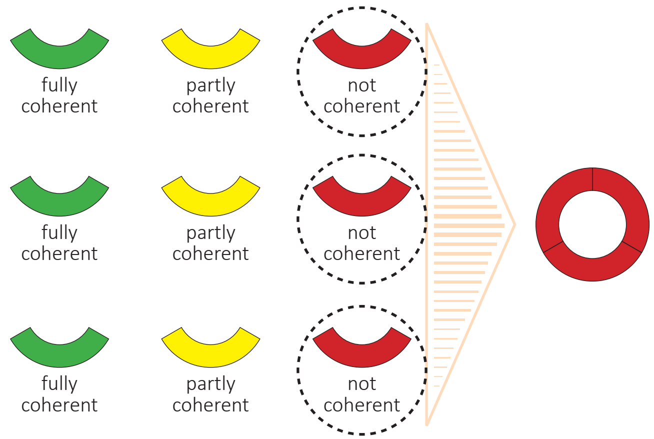
ARCHITECTURAL QUALITY - SYSTEM VISIBILITY - CONTEXT SENSIBILITY

Figure 6 - System geometry [3] (Source: © City of Saint-Pierre)

Figure 7 - System modular pattern [3]. (Source: © City of Saint-Pierre)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



COMMENTS

The field size and position is not coherent because of the various orientations of the panels, the gaps between the modules and the asymmetric layout of the overall system. A particular work has been done in order to integrate both solar thermal on the same over-roof pans. Their different sizes and materials though make them not coherently integrated with the roof.

References: *[3] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT. (click here to download)

Figure 8 - Various solar shading devices, optimized according to the orientation of the facades, protect the numerous openings. (Source: © City of Saint-Pierre).

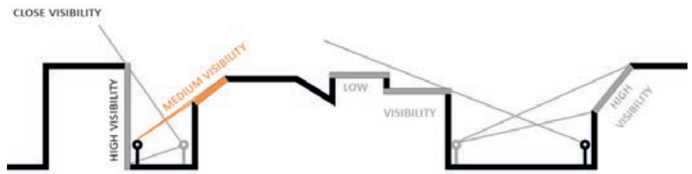


Figure 9 - Different levels of visibility of city surfaces from public domain.

CRITICITY

	HIGH	MEDIUM	LOW
CONTEXT SENSITIVITY			
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	●	○
REMOTE VISIBILITY	○	●	○
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

The visual transition between public, semi public and private spaces was a major concern. Clear physical and symbolic property signs were used, including plantings and landscaping. Particular attention was paid to the urban design of the district elements. For instance, the street furniture included different types of materials for roads and sidewalks, colored sidewalks bollards and creative bus stops.

Given this attention to the citizens' appropriation of urban space, the planned sensitivity for this zone is medium: no particular cultural heritage is located here.

SYSTEM VISIBILITY

From an urban canyon perspective, the installed solar systems are seldom visible from the public space since installed on very high over-roofs.

A progressive gradation in new buildings' height was promoted to create a better harmony between high collective housings and individual houses.. Finally, the urban pattern of the district was oriented according to the historical grid plan of the city center, enhancing visual and wind porosity of urban blocks. Urban blocks and streets pattern were designed to create large open spaces with an unobstructed view of the sea.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT. (click here to download)

Environmental, economic and social impacts

Figure 10 - The urban park, an ecological corridor with rainwater management and a strong presence of native vegetation. (Source: © City of Saint Pierre)

Figure 11- Soft mobility and urban design with the new bus reserved lane and its bus stop (Photo: © City of Saint Pierre)

Figure 12 - The inhabitants have played a pivotal role in the project with the implementation of a consultative approach and different workshops and surveys as well. (Photo: © City of Saint-Pierre)

ENVIRONMENTAL IMPACT

Major efforts were made to reduce the energy consumption and the associated GHG emission inside the neighborhood and to leverage the landscape to manage water. Key strategies implemented are soft mobility, reduction of the car park number, installation of solar thermal and PV panels, efficient management of streets lighting, strong soil permeability, green corridors and natural water flows. Special attention was paid to respect the existing landscape and integrate the new buildings and the green urban infrastructures within it, especially concerning the natural canal that crosses the neighborhood and flows in the sea. The urban park is hence composed of four bioretention ponds and different bioswales for a water capacity of 1 000 m^3. Moreover, vegetated areas such as the urban park act as buffer zones and help to lower air temperatures, which is crucial in districts facing the Urban Heat Island effect.

ECONOMIC IMPACT

The project costs is about 154 M€ over 6 years. It was financed thanks to 8 different financing bodies: 50.4% from the social landlords, 19.8% from the French government, 14.8% from the municipality of Saint-Pierre, 7.8% from the French National Agency for Urban Renovation (ANRU), 2.4% from the European funds 'FEDER', 0.3% of loans with the French financial organization 'Deposits and Consignments Fund' and the last 5% from other local public bodies.

SOCIAL IMPACT

Since the beginning of the renewal project, a consultant in communication called 'Technicite' was chosen so as to collaborate with the local population and incorporate them during the planning process in a participatory way. Different workshops were organized and surveys were distributed to enhance the social acceptance of the project and allow the inhabitants to be key actors and get involved in the future of their neighborhood. Standard information tools including informative brochures, newspapers, leaflets were developed. Consultation with the residents played a key role, especially for the planning of the new urban park and the choice of its facilities. In addition, social diversity was ensured thanks to a wide variety of housing types from social housing to detached/individual homes. The program also aimed to create a mixed district bringing economic activity, with the creation of shops, offices and public services.

URBAN DESIGN APPROACH

The analysis of the urban structure and the urban design proposals were conducted by the 'Co-Architects' consultancy. The urban restructuring of the district was set up through the creation of an orthogonal grid, which is connected to the historical grid plan of the city center, and creates a new system of street pattern and urban blocks. Main building façade were orientated on a longitudinal axis and parallel to the sea. Visual and wind porosity are emphasized by the appropriate orientation of the buildings. Climate conditions and site integration have been taken into account in the construction principles of the buildings. The strategy also focused on how to adapt to the slope of the ground to provide unobstructed lines of sight. The urban park has a key position and structures the overall urban pattern, allowing the green spaces to enter into the urban blocks. An intermediate level between the height of social tower blocks and individual houses was applied so as to enhance visual harmony.

RESULTS AND DISCUSSION

In 2006, before the beginning of the project, a preliminary diagnosis and questionnaire surveys realized by the local inhabitants highlighted that the neighborhood is perceived to be unsafe and slightly clean.

In 2014, a participatory evaluation was organized by 'Pluricité' and 'Robin des villes' so as to assess the satisfaction of the population and compare the results obtained with the first study. It has been observed an improvement in the sense of well-being, security and safety. People feel that they benefit from more decent housing and living conditions and noticed a significant difference in the cleanliness and upkeep of urban sites.

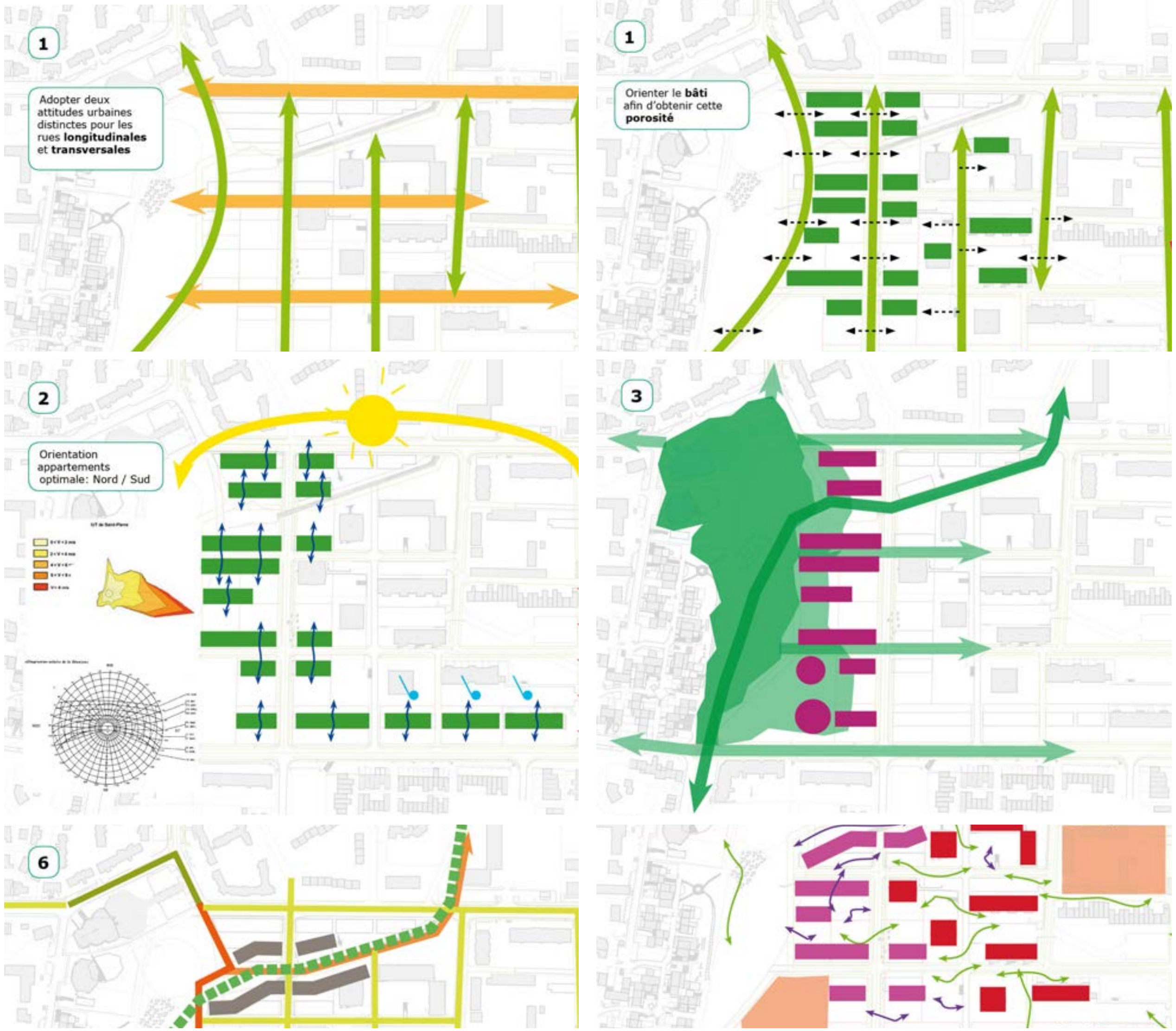


Figure 13 - Analysis of the urban structure and urban design proposals. (Source: © Co-architectes / City of Saint-Pierre)

LESSONS LEARNED AND RECOMMENDATIONS

Figure 14 - Light effects and decorative illumination by night of the urban park and the church in Ravine Blanche to raise and enhance the social attractiveness of the place. (Photo: © Jérôme Balleydier).

Figure 15 - Particular attention was paid to the visual transition between public, semi public and private spaces, where vegetation and urban elements play a pivotal role. (Photo: © City of Saint-Pierre)

Figure 16 - A social housing building, i.e. small, self-contained residential units with limited access via enclosures, which are intended to enhance security, social control and appropriation. (Photo: © City of Saint-Pierre)

LESSONS LEARNED

- Open space in urban environments provides many advantages such as the provision of green space, natural rainwater management, shading, an improved level of urban comfort conditions and privacy as well as the reduction of urban heat island effect. The urban park also acts as a community center for recreation and social exchange.
- Public consultation and information campaign have played a pivotal role the in renewal project and especially in the social acceptability of urban change, allowing local inhabitants to feel involved, to adhere and to contribute to the project.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- To promote partnership governance between influential stakeholders and decision makers involved in the planning process allow to mobilize considerable financial, human and technical resources as well as to complete such an enormous task in a relative short period of time.
- To conduct rigorous preliminary observations and diagnosis before the beginning of a renewal project ensures to have a better knowledge of the historical, social, economical, urban and environmental aspects of the territory, and hence define the suitable urban orientation strategy. Initial data can serve as benchmark values for future surveys and diagnosis so as to evaluate the performance of the policies set up and the inhabitants' satisfaction.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects
- Project developers
- Actors of projects located in tropical climates.

(Photo: © T. Giraud)

ARCHITECT, DESIGNER AND DEVELOPER

Co-architectes
LEU Reunion
A. Cheyssial

OWNERS

The Municipality of Saint-Pierre

CONSULTANTS

LEU Reunion; CCIR; 21° SudTechnécité; SQA; SEDRE; HELIOS
FEDT; CER; Pluricité; Robins des Villes

STAKEHOLDERS

The social landlords (SEMADER, SIDR and SHLMR), The French financial organization 'Caisse des Dépôts et consignations', the French housing association 'Foncière Logement', the French local authorities cooperation 'CIVIS', the French State, DEAL, Conseil Général, CCIR, ARER and CAF.

CASE STUDY AUTHORS

Virginie Grosdemouge[1,2] and François Garde[1]
1 PIMENT Laboratory, University of Réunion Island, France
2 City of Saint-Pierre

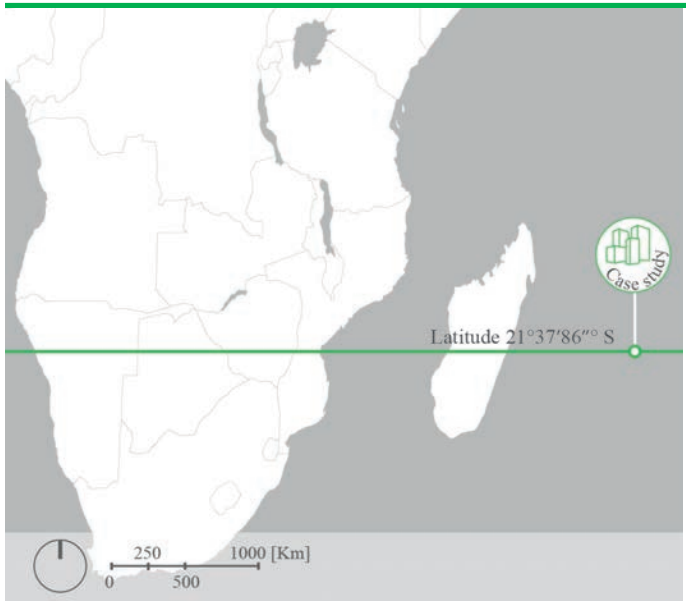
RESEARCH ORGANIZATIONS


Source: (© akuoenergy)

AGRINERGIE 5

FRANCE

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: France

Location: Saint Joseph, La Reunion
(Lat. 21°37′86″S Lon. 55°61′92″E)

Climate: Maritime temperate climates or Oceanic climates (Cfb) [1]

AREA OF INTEREST

Targets and goals

NATIONAL AND LOCAL CONTEXT

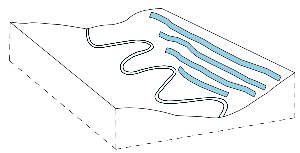
In France and overseas territories, it is prohibited to build on agricultural zones anything else than structures or buildings necessary for agriculture. Moreover, on islands, the land pressure is so high that solar ground mounted fields are not permitted anymore by prefectures.

ABOUT THE CASE STUDY

Agrinergie 5 project can be found in Saint-Joseph on the Reunion Island. This installation has to be considered of exemplary value as it has successfully demonstrated that solar panels can be integrated in an agricultural area without reducing the cultivated areas.

Definition of environment:
Landscape PV

Site area: 13 000 m²
System area: 7 500 m²



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263;

ISSUES, CHALLENGES AND DECISION STRATEGIES

Figure 1 - Aerial view of the Agrinergie 5 from the South. (Source: © akuoenergy)

Figure 2 - View of the PV system integrated in the roof of the greenhouses from the North. (Source: © akuoenergy)

Figure 3 - Inner view of the farmer working in the greenhouse covered by PV system. (Source: © akuoenergy)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- Developing partnerships between agriculture, environment and energy actors
- Reducing the ecological footprint and the CO_2 emissions
- Combining food and PV energy production

ISSUES AND CHALLENGES

- High CO_2 emission factor per kWh of electricity produced (0.8 kg of CO_2)
- Prohibition of building anything else than structures or buildings necessary for agriculture
- Prohibition of installing ground mounted PV systems

DECISION STRATEGIES

After the installation of PV panels in the Agrienergie5 project the government decided to abolish the prohibition of installing solar system in the landscape environment in La Réunion Island.

The planning process

Agrinergie 5, as the other Agrinergie project, it aims at combining agriculture and electricity production thanks to solar panels installed on rooftops of greenhouses.

Project Agrinergie 5 is financed by AFD and Natixis. This project was developed in 2009 and operation was in 2011.

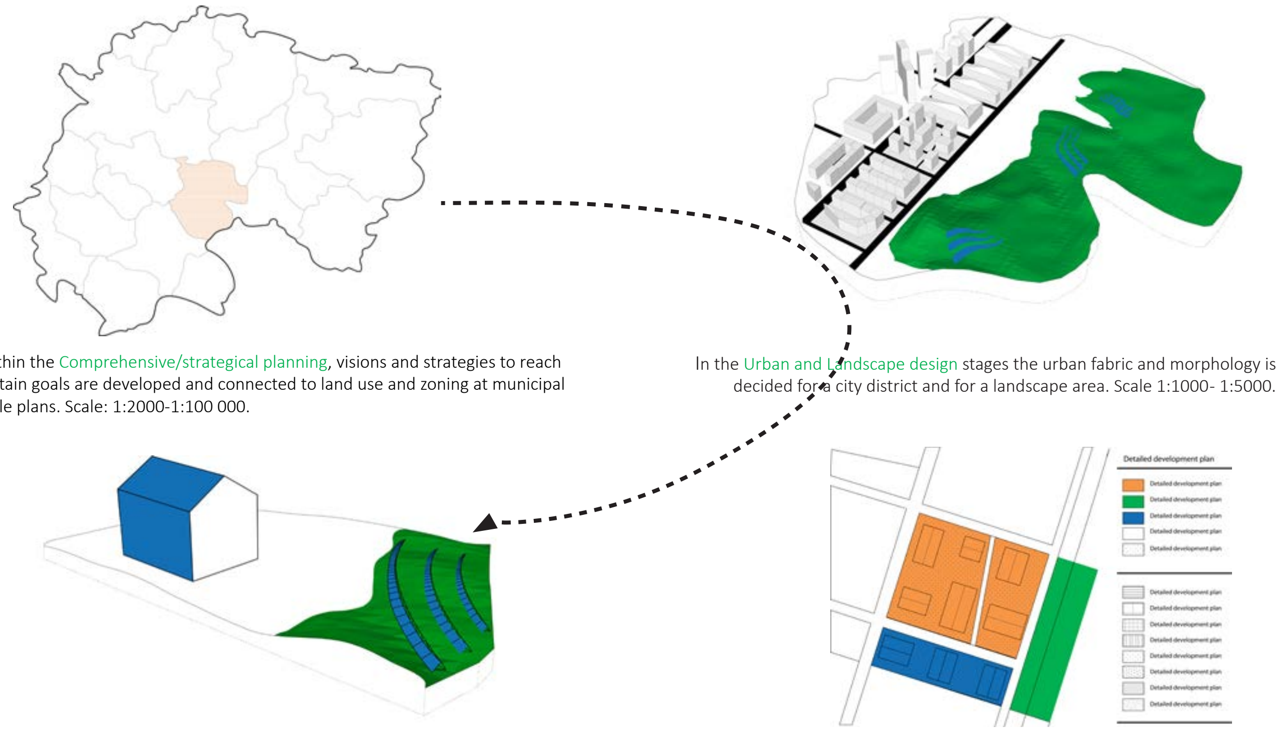
The Agrinergie process aims at developing partnerships between agriculture, environment and energy actors. This installation has to be considered of exemplary value as it has successfully demonstrated that solar panels can be integrated in an agricultural area without reducing the cultivated areas. The agricultural part of the project can also be considered of exemplary value.

The successful installation of PV in the Agrienergie5 project allowed to change the prohibition of installing solar system in the landscape environment in La Réunion Island.

Jean Bernard Gonthier, Vice-President of Réunion Chamber of Agriculture, operates on Agrinergie's greenhouses in Saint Joseph and he is converting his farm into a certified organic farm. He produces the compost he uses himself and takes part in the CIRAD's agro-ecological project of managing the vegetable fly on the Reunion island.

Jean-Bernard Gonthier who operates on the greenhouses growing organic certified vegetables but also passion fruit, which have been disappearing from the Reunion Island over the last years. His products are to be sold to the local market and to be served in local scholar canteens.

Financial support provided by AFD, Natixis.



Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

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Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)

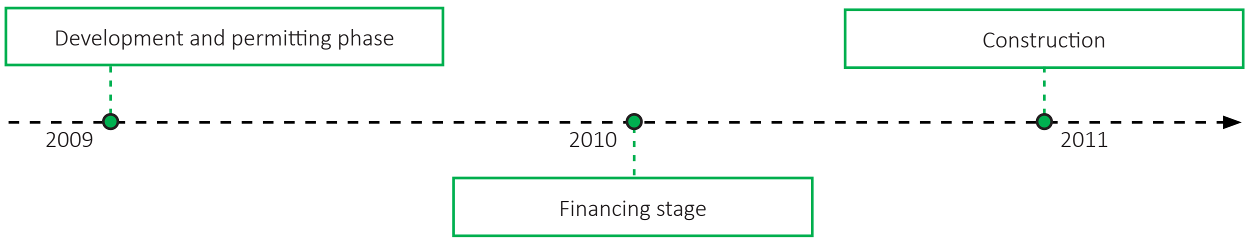


Figure 5 - The spatial system as a whole (Pattern) (Source: [2])

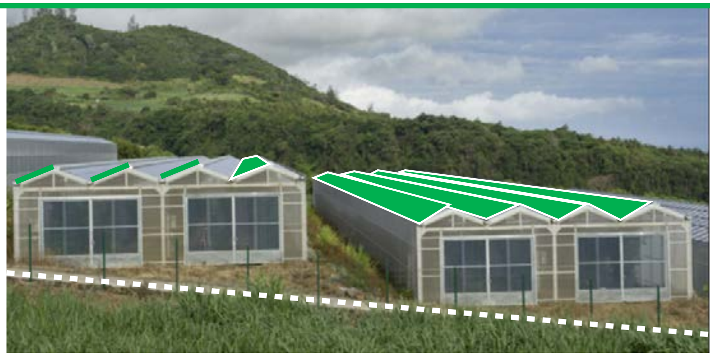


Figure 6 - The photovoltaic space (Source: [2])

Figure 7 - The "pore" space (Source: [2])

FORMAL FUNCIONAL FEATURES

PATCH - PATTERN - EDGES/BORDERS

Patch type

Small	○	Large	●
Straight borders	●	Convoluted borders	○

Grain type

Small patches	○	Large patch	●

Pattern

Porous	○	Dense	●

Pattern type

Stripes	Parallel	●	Not parallel	○
Island	Uniform patches	○	Varied patches	○
Random		○		

Edge/Borders

Continuous	○	Discontinuous	●

SOLAR SYSTEM

TECHNOLOGY AND PRODUCTION OF TOTAL AREA OF MODULES

1. Energy features

Nominal power:	1.4 MWp
Number of modules:	7 500 m^2
Technology:	PV panels Sunpower SP320 Wc
Density of power:	1 MWp/ha
Land use intensity:	-
Normalized yearly energy generation:	2 000 MWh/MWp/a

2. Engineering features

Orientation, inclination and patterns is defined as regular, linear and parallel associated. Cover: grazing for greenhouse function.

3. Spatial features

Modules:	Height: 0.9 m; Width: 1.2 m; Area: 7 500 m^2; Color: Blue; Azimuth angle: varies; Tilt angle: varies; Height from the ground: 3.5 m
Borders:	Thickness: 0 m; Height : 0 m;

SOLAR SYSTEM SPACE

PATCH AREA

Connectivity

Looking from the top view there is a kind of discontinuity between the ground where the solar field is placed and the surrounding landscape.

Functions

The solar field performs other added function such as organic agriculture under greenhouses and recuperation of water.
The ground underneath of the modules is agricultural and natural, while the feature of the supporting systems was studied for having a greenhouse function.

Other features

The occupation ratio (%) of the system results equal to 40%, while the height from the ground has been set as follows: minimum height equal to 3.5 m and maximum height is 4.1 m.

References: [2] Scognamiglio, A. (2016). 'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision, Renewable and Sustainable Energy Reviews, pp 629-661

Figure 8 - View of the solar panels on the roof of the greenhouse space (Source: © akuoenergy)

LANDSCAPE FACTOR

SENSITIVITY	LOW	HIGH
Landform	○	●
Landscape pattern and complexity (patches and grain)	●	○
Land use	○	●
Land cover	○	●
Settlement and man-made influence	●	○
Historic landscape character	●	○
Distinctive landscape features	○	●
Inter-visibility with adjacent landscapes	●	○
Sense of remoteness/tranquility	○	●
Sense of openness/enclosure	○	●

LANDSCAPE PRESERVATION (SOFT BARRIERS)

Half of the island is now part of the UNESCO World Heritage Sites, so solar fields are not possible to be installed in this protected area. However, it is under the protection and vigilance of sugar cane industry. In fact, the agricultural and natural function is to produce sugar cane fields and ravines. Therefore, the landscape has the following features: it is a valuable landscape with historical value.

The landform of the site results in really high reliefs, without any presence of strong topography or distinctive landform features around the site area. However, the landform around Agrinergie 5 is characterized by a cliff of a valley along the East side.

MULTI-FUNCTIONALITY

The solar field performs other added functions such as organic agriculture under greenhouses and recuperation of water. The agricultural part of the project can also be considered of exemplary value. Indeed, Jean-Bernard Gonthier who operates on the greenhouses grows organic certified vegetables but also passion fruit, which have been disappearing from the Reunion Island over the last years. His products are to be sold to the local market and to be served in local scholar canteens.

The farm supplies more than 1 000 people with clean energy and supports the Saint-Joseph grid. For the past 3 years, this innovative project has successfully produced electricity. The solar field is not really connected. The people and animals cannot access or walk through the solar modules: there are fences surrounding field.

ENVIRONMENTAL, VISUAL, ECONOMIC AND SOCIAL IMPACT

Figure 9 - Aerial view of the Agrinergie 5 from the South (Source: © akuoenergy)

Figure 10 - Aerial view of the Agrinergie 5 from the North (Source: © akuoenergy)

Figure 11 - Inner views of the greenhouses covered by PV . (Source: © akuoenergy)

IMPACT CATEGORY	IMPACT - BURDEN	ALLEVIATION, MITIGATION STRATEGIES, DESIGN APPROACHES
Land use	During routine operation: excessive run-off/direct run-off into water curses and other sensitive areas. There is no presence of water catchment areas.	Good quality water is collected in a pond. Hydrographic timing which is the alternation of wet and dry season. Groundwater recharge and water purity .
Visual impact	The visual impact implies a little inter-visibility with adjacent sensitive landscapes or viewpoints and a sense of physically or perceptually remote, peaceful or tranquility.	Habitat fragmentation includes the breaking of a large habitat into smaller pieces [3].It was already a parcel precut. The local habitat quality has good soil.
Environmental impact	The environmental impact includes the protection from humidity and climatic hazards such as cyclones and hurricanes.	The protection from insects gave a substantial reduction of the use of phytosanitary products; and from a local virus that affects passion fruit grown outdoor on the island.
Public awareness and participation	The farmer uses one of the greenhouses to carry out experiments with new cultures and new vegetable varieties; and the landscape allows the farmer to grow off-season vegetables and fruits to provide the local market and school canteens.	This project has been successfully producing both organic vegetable and environmental-friendly electricity for the last 3 years.

References: [3] Forman, R. T. T. (1995), Land Mosaics, Cambridge University Press, Cambridge

Figure 12 - Detailed view of the PV system integrated in the roof of one greenhouse block. (Source: © akuoenergy)

Figure 13 - View of the greenhouses (Source: © akuoenergy)

LESSONS LEARNED

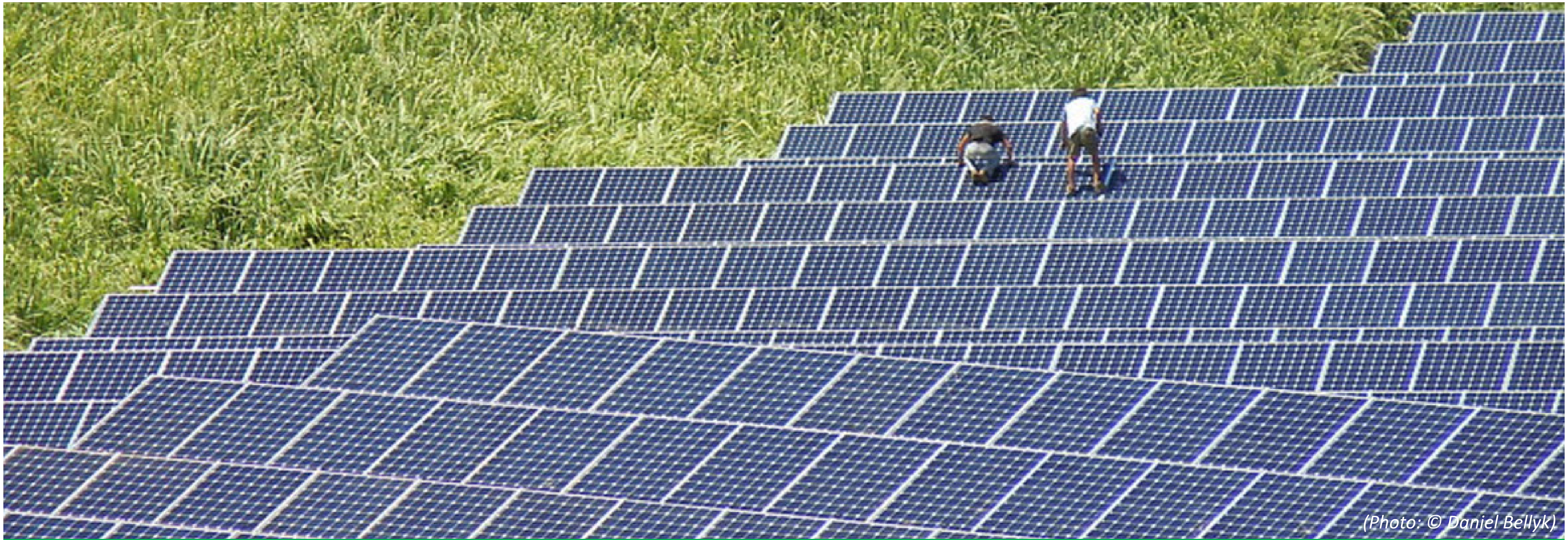
- Combining PV systems and agriculture have a double added value in both: producing energy and grow vegetables.
- The case represents a solution PV that developers found for overcoming a barrier set by local governments to the implementation of ground mounted PV.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- Alternative design solutions for PV need to be tested in all design phases given their installation in landscape could allow for a dual use of land. However, those installations are still few, and data on the performance of such systems are rare.
- In order to maintain or improve ecosystem services for the communities, and also to improve the social acceptance of PV, a planning process at regional level should be encouraged. Through multi-criteria decision supporting systems, the right siting should be chosen, and guidelines based on landscape quality objectives should be developed

TARGET GROUPS

- Urban decision makers
- Investors
- Agricultural producers



(Photo: © Daniel Bellyk)

ARCHITECT, DESIGNER AND DEVELOPER

Akuo Energy
Austral energy

OWNERS

Energy company (N/A)

CONSULTANTS

Engineering company (N/A)

STAKEHOLDERS

Jean Bernard Gonthier, farmer

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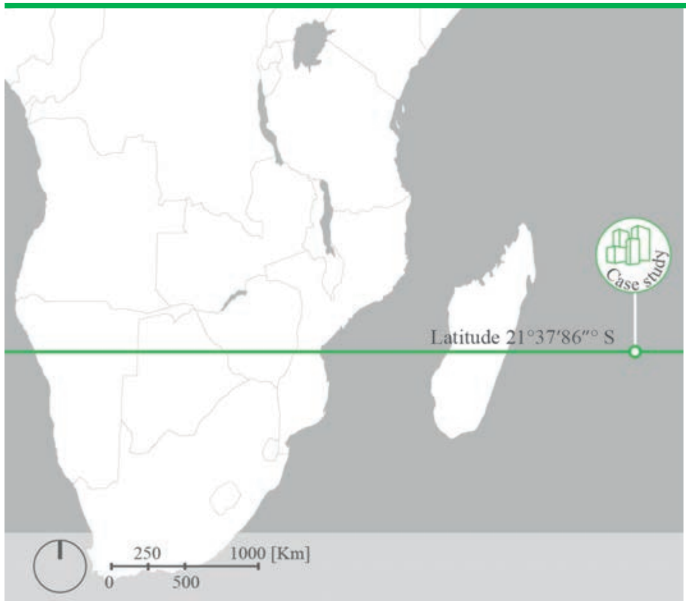
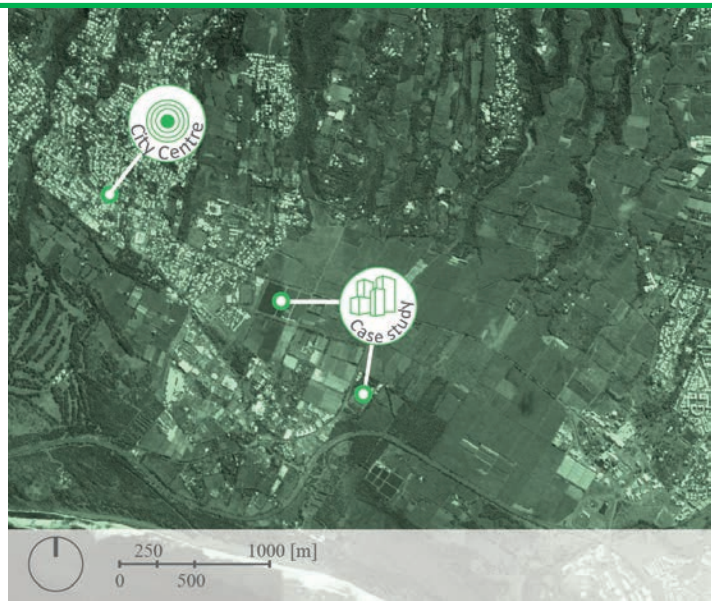
RESEARCH ORGANIZATIONS

LES CEDRES

FRANCE





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: France

Location: Etang-Salé les Bains, La Reunion
(Lat. 21°16'25"S Lon. 55°22'42"E)

Climate: Tropical climate (Af) [1]

AREA OF INTEREST

Targets and goals

NATIONAL AND LOCAL CONTEXT

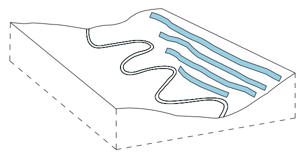
On French islands at tropic latitudes, the land pressure is so high that solar ground mounted fields cannot compete anymore with food crops lands, so Ground Mounted Photovoltaics (GMPV) farms are not permitted anymore by authorities.
Furthermore, the zone face hurricanes every year and the infrastructure projects have to be resistant.

Last but not least, the local grid already reach 30 % of intermittent energy penetration and it does not accept more solar power into the grid without smoothing the electrical signal.

ABOUT THE CASE STUDY

Les Cèdres has been designed in order to meet all these challenges. It is a combination of innovations as it has successfully demonstrated that solar panels can be integrated without reducing the agriculture surfaces, on hurricane proof structures, and can be coupled to a storage device for a smart integration of the electricity produced in the grid.

Definition of environment:
Landscape PV



Site area: 9 000 m^2 on 2 sites
PV *System area*: 65 000 m^2

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263;

Figure 1 - Inside view of battery system integrated in containers (Source: © akuoenergy.com)

Figure 2 - Inner integration of the Agrinergie farm with the shadow structures covered by PV system. (Source: © akuoenergy.com)

HIGHLIGHTS OF THE CASE STUDY

Les Cèdres, has an installed capacity of 9 MW coupled to 9MWh Lithium-ion battery. The project goes further by developing Aquanergie® and Agrinergie®. These two concepts created by Akuo Energy group allow to combine agricultural and aquaculture activities and energy production on the same plot in order to achieve optimal use of space.

Also, beyond coupling two types of activity on a unique site, it integrates in addition a storage device to the solar production for smoothing the solar production signal connected to the grid.

ISSUES AND CHALLENGES

- The two sites are situated in flooding area with no possibility to build, one of the challenge was developing solar activity without perturbing the natural drain while protecting electrical equipment.
- A second issue was defining a perfect cohabitation with partners (fish farmer and farmer) during construction and during operation with the fish farmer activity.
- To develop a Smart System for regulating solar signal with storage device.

DECISION STRATEGIES

After the construction of this project, the government was proud of its esthetic and about the exemplary of the combined activities. Now it decided to inaugurate it with authorities and it wants to make it as a virtuous example for future installations in the country. The grid operator asked for more storage given that they are satisfied of the grid services proposed.

THE PLANNING PROCESS

During development phase and urbanism work for developing the most virtuous project, a lot of variations have been deeply studied and instructed by the authorities. Finally, the best was selected according social and local integration. It was selected by finding a compromise with solar efficiency, costs, esthetical features and social integration.

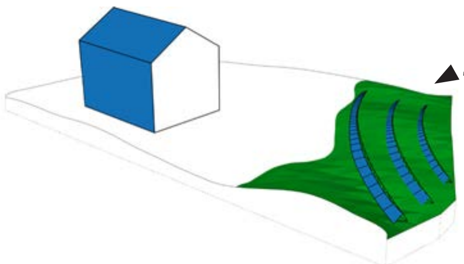
Les Cèdres was financed by three French banks, such as Cepac, Natixis-Energeco and with the participation of Agence Française du Développement (AFD). The development phase began in 2009 and it was in operation in 2015.

Two main partners take part of les Cèdres:

- Aquanergie®: Max Dyckeroff, the fish farmer and owner of the land, has diversified his initial production (tilapia fishes) with a certified production of sturgeons for a local caviar production thus producing an added value.
- Agrinergie®: The aim of the second local partner, Agriterra, is to combine local producers, to supply the local market and to re-evaluate of certain traditional crops. The agricultural project finally turned to be a permaculture introduction in the island.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)

- 2009 – Start development for fish farm
- 2011 – Award for a Power Purshse Agreement (PPA)
- 2012 – Urbanism work with administration
- Validation of Building permit
- 2015 – Commissionning

Solar Landscape

Figure 4 - The spatial system as a whole (Pattern) (Source: © akuoenergy.com) [2]

Figure 5 - The photovoltaic space (Source: © akuoenergy.com) [2]

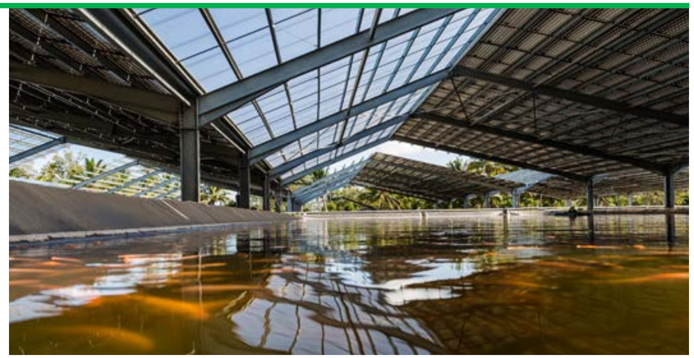


Figure 6 - The "pore" space (Source: © akuoenergy.com) [2]

FORMAL FUNCIONAL FEATURES

PATCH - PATTERN - EDGES/BORDERS

Patch type				
Small		○	Large	●
Straight borders		●	Convoluted borders	○
Grain type				
Small patches		○	Large patch	●
Pattern				
Porous		○	Dense	●
Pattern type				
Stripes	Parallel	●	Not parallel	○
Island	Uniform patches	○	Varied patches	○
Random		○		
Edge/Borders				
Continuous		○	Discontinuous	●

SOLAR SYSTEM

TECHNOLOGY AND PRODUCTION OF TOTAL AREA OF MODULES

1. Energy features

Production of a low-carbon electricity to prevent the emission of 11 400 tons of CO_2 per year, equivalent to 13 500 MWh of green electricity, while the nominal power is equal to 9 MWp.
Les Cèdres is composed by 7.5 ha of opened greenhouses (shadow protection) and 12 ponds of 400 m² each covered by huge PV structure. The power density is equal to 1 MWp/ha.
Modules technology: PV panels Sunpower SP327 Wc.

2. Engineering features

The occupation ratio (%) of the system results equal to 60%, while the height from the ground has been set as follows: minimum height equal to 3 m and maximum height is 7 m.

3. Spatial features

Modules:	Color: Blue; Azimuth angle: 10 and 25 ° N-E; Tilt angle: 12 °;
Borders:	Thickness: 5 m

SOLAR SYSTEM SPACE

PATCH AREA

Connectivity

The solar plant landscaping considers the overall coherence of the landscape across the territory. Looking from the top view, a particular attention has been done for keeping the natural lines of the environment to imitate the existing pattern.

Functions

The solar field allowed to add an new function such as organic agriculture under greenhouses as well as the water waste treat system.

The ground underneath of the modules is agricultural and natural, while the feature of the supporting systems was studied for having a greenhouse function.

Other engineering features

Orientation, inclination and patterns is defined as regular, linear and parallel associated. Cover: grazing for greenhouse function.

References: [2] Scognamiglio, A. (2016). 'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision, Renewable and Sustainable Energy Reviews, pp 629-661

SITE POTENTIAL

Figure 7 - Aerial view of the Agrinergie 5 from the North-East (Source: © akuoenergy.com)

LANDSCAPE FACTOR

SENSITIVITY	LOW	HIGH
Landform	○	●
Landscape pattern and complexity (patches and grain)	●	○
Land use	○	●
Land cover	○	●
Settlement and man-made influence	●	○
Historic landscape character	●	○
Distinctive landscape features	○	●
Inter-visibility with adjacent landscapes	●	○
Sense of remoteness/tranquility	○	●
Sense of openness/enclosure	○	●

LANDSCAPE PRESERVATION (SOFT BARRIERS)

Agrinergie® project includes installation of photovoltaic structures for enhanced development ground of biological farming, on 5.7 hectares. The challenge of this project was to apply the principles of permaculture in order to restore a natural character to this industrial site by erasing the harmful effects of past conventional farming practices. Thus, in partnership with the Ferme du Bec Hellouin and local structures (Research Center, Technical Institute, Consular Chamber), the team of Agriterra - subsidiary of Akuo Energy deploying the Agrinergie® in Reunion - working to demonstrate an organic and sustainable agricultural production is feasible in middle constrained by a warm climate subject to climatic hazards such as cyclones and highly degraded soil and polluted plastic residues from previous crops.

MULTI-FUNCTIONALITY

The permaculture practices, such as agroforestry, grazing, cultivation mounding, organic gardening, intercropping, inspired by the observation of nature, provide answers to the major issues that local agricultural production in La Réunion Island have to face such as to limit import dependence, and protect biodiversity. These practices offer yields estimated at 10 times higher than those of conventional agriculture. It also contributes to regenerate soils and biodiversity through the creation of a natural ecosystem. The site provides agricultural production favoring products highly consumed in La Réunion Island, as well as developing local markets and short circuits to maximize local economic benefits.

Figure 8 - Aerial view of the initial site of aquaculture (Source: © akuoenergy)

Figure 9 - Inner views of the s hadow structure covered by PV with organic grazing. (Source: © akuoenergy)

AQUACULTURE SITE: AN IMPORTANT PARTNER

Aquanergie® project includes the installation of 12 photovoltaic shade structures over 12 fish farming basins (the equivalent of an Olympic swimming pool), on a 1.2 hectares field. The total installed capacity is 1.45 MWp.

It is the first performed symbiosis between aquaculture and energy production. The project was developed since its conception in partnership with Max Dyckerhoff, operator of livestock. This farmer is part of the pioneers in developing aquaculture on the island, and caters for over 25 years of local market.

MANY BENEFITS

Beyond the energy aspects, this installation has major advantages for optimizing fish farming such as:

1. Shade structures protect livestock from predators lurking around the pools.
2. It helps to regulate the water temperature by reducing the fish mortality and by increasing the oxygenation of the water to preserve their appetite and growth.
3. The regulation of water's temperature has the advantage of avoiding the phenomenon of algal bloom, contaminating toxic brown algae basins. It also limits the evaporation of water, and allows better management of the resource.

IMPACT ON LOCAL EMPLOYMENT

The shadows also contribute to cool the workspace by reducing drudgery for employees during the work on ponds and feeding the fish. In fact this allowed to shift the morning fishing, usually at 4:30, at a time of classical hiring.

Moreover, Akuo Energy Solutions, a subsidiary of Akuo Energy that have built the project, has employed many local workers. Over 80% of companies that participated in the construction via foundations, erection of structures, as well as civil and electrical works are local companies and employees.

Lessons learned and recommendations

Figure 10 - Max Dyckeroff, the fish farmer, partner of the project. (Source: © Adrien Diss)

Figure 11 - Freddy Cheda (Agriterra) and Charles Hervé-Gruyer (Ferme du Bec Hellouin), pioneer of permaculture in France, talking about adapting permaculture in la Réunion (Source: © Adrien Diss)

LESSONS LEARNED

- Combining PV systems to local agriculture and aquaculture have a double added value: producing green energy and feed the local community.
- Before being Industrial companies, the Electricity producers at a landscape scale should think and act as urban planners above all, to avoid the negative impacts that big scale solar farms can have on the environment.
- The place of the Solar Energy should be centered on human purpose, and for being a good pretext for creating in rural areas good places to live.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- Listen and interact with local people as well as work with local entrepreneurs could help to develop technical and social valuable projects. They will express their needs by pointing out their daily problems. Indeed, it would be easier to find technical solutions with solar energy integrated in the environment and able to solve practical social and economic issues.
- In order to maintain or improve ecosystem services for the communities, as well as to improve the social acceptance of PV, a planning process at regional level should be encouraged. Through multi-criteria decision supporting systems, the right siting should be chosen, and guidelines based on landscape and social quality objectives should be developed.

TARGET GROUPS

- Urban decision makers and authorities
- Investors
- Agricultural producers
- Solar Energy developers
- Independent Power Producers (IPP)
- Industrial owner.

ARCHITECT, DESIGNER AND DEVELOPER

Akuo Energy Solutions – Austral energy

CONSULTANTS

Ferme du bec Hellouin

CASE STUDY AUTHORS

Anne Monnier, Akuo Energy (France)
Alessandra Scognamiglio, ENEA (Italy)

OWNERS

Akuo Energy

STAKEHOLDERS

Max Dyckeroff, Fish farmer, Agriterra

RESEARCH ORGANIZATIONS

Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

3.6 GERMAN CASE STUDIES

GERMAN TEAM

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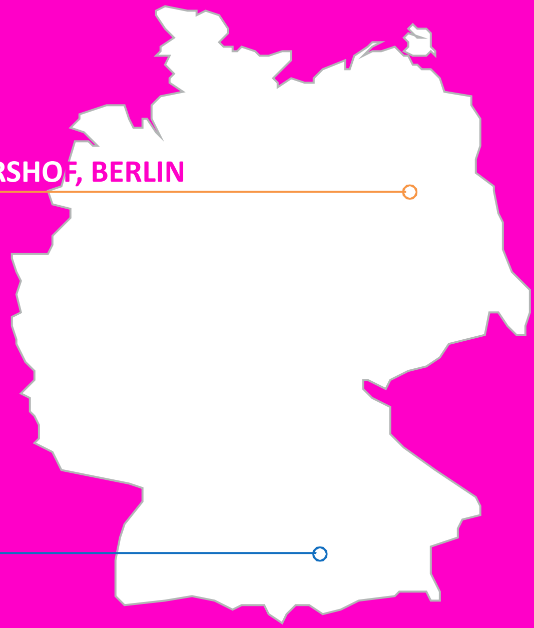


18 **SCIENCE AND TECHNOLOGY PARK ADLERSHOF, BERLIN**
Existing urban area

19 **FREIHAM NORD MUNICH**
New urban area

GERMANY

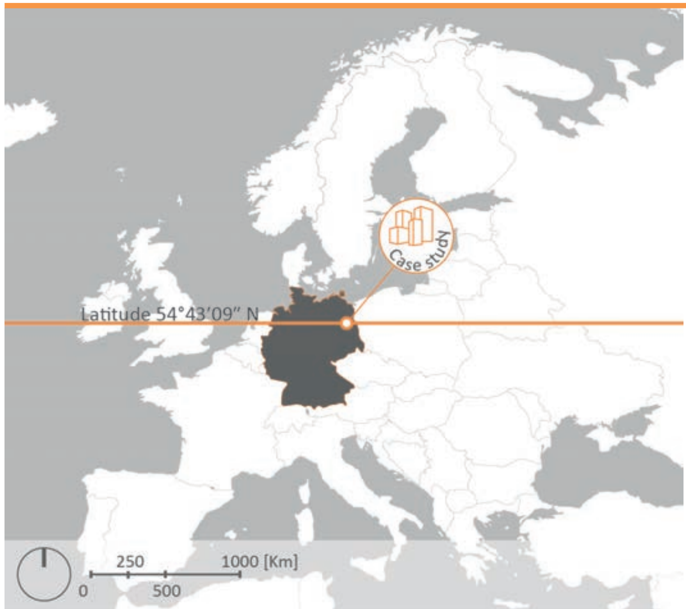
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

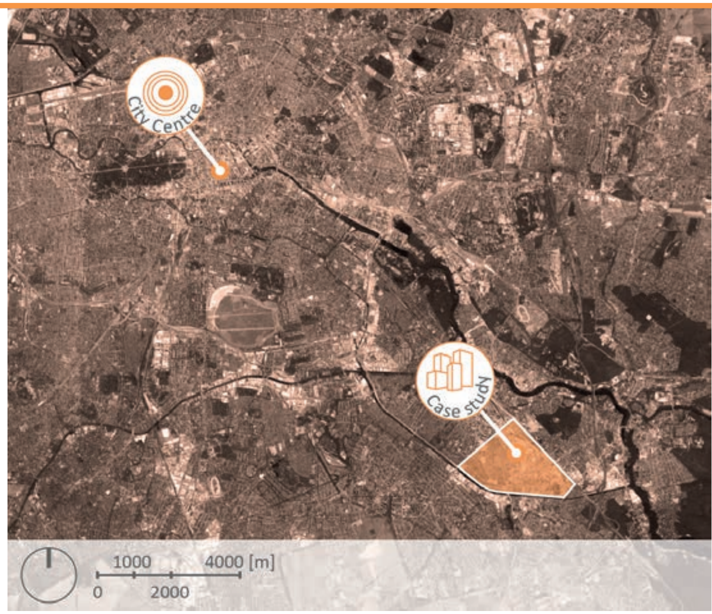
Photo: © Senatsverwaltung für Stadtentwicklung und Umwelt, Berlin

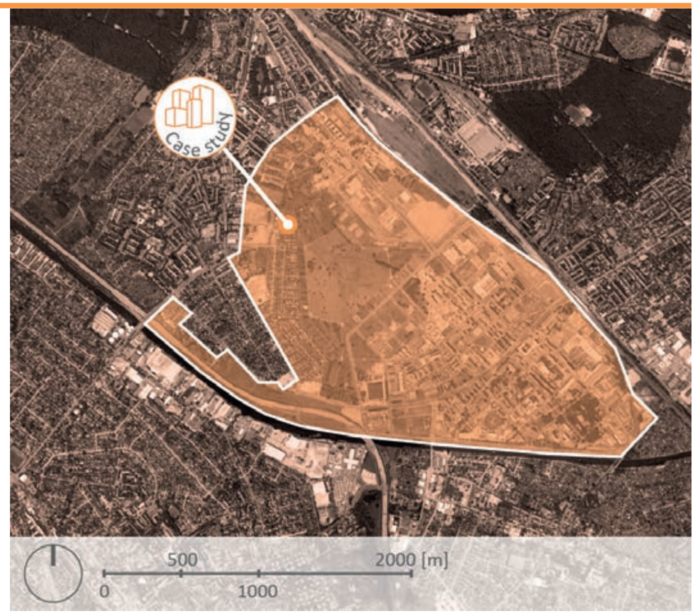
SCIENCE AND TECHNOLOGY PARK ADLERSHOF, BERLIN

GERMANY

Overview







GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Germany
Location: Berlin (Lat. 52°43′09″S; Lon. 13°53′42″E)
Climate: Warm temperate, fully humid, warm summer (Cfb) [1]

AREA OF INTEREST

Targets and goals

NATIONAL AND LOCAL CONTEXT

The City of Berlin has the goal to be climate neutral by 2050. The measures of the introduction of an “energy transition law” and the development of a Berlin Energy and Climate Protection Programme facilitate in reaching that goal [2]. There are solar and environmental atlases available for Berlin which can support decision making in urban projects .

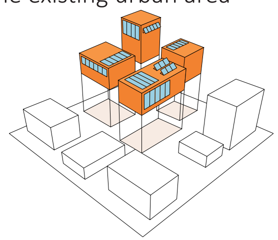
After the German reunification in 1990, the City of Berlin was defined into five urban development areas- one of which is Adlershof. The City of Berlin developed Adlershof as Science and Technology Park. As a result, companies dealing with renewable energies are located in Adlershof. The buildings are intended to be representative of an energy efficient urban area.

ABOUT THE CASE STUDY

The development area located in the district of Adlershof is part of the municipality Treptow-Köpenick. Adlershof is a mixed functional urban area made up of offices, a university campus, research institutes, industry, residential and commercial buildings.

Definition of environment:
Fill-ins and densification district in the existing urban area

Site area: 4 200 000 m^2
Building area: 1 485 000 m^2
Planned: up to 3 400 000 m^2 [3]



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Article available at: http://www.stadtentwicklung.berlin.de/umwelt/klimaschutz/bek_berlin/ access: June.2016
[3] Senatsverwaltung für Stadtentwicklung und Umwelt. (2013). Berlin Adlershof – Stadt für Wissenschaft, Wirtschaft und Medien.

Figure 1 - *Welcome sign near the train station.*
(Photo: © Margarethe Korolkow)

Figure 2 - *Abandoned factory.*
(Photo: © Margarethe Korolkow)

Figure 3 - *Listed "buildings": The Egg and the wind tunnel.*
(Photo: © Margarethe Korolkow)

HIGHLIGHTS OF THE CASE STUDY

The targets and goals to reduce energy demand to 30% by 2020 are the main areas of interest in this case study description which is considered together with the planning processes. The development of Adlershof must consider the diverse complex functionality and long history in this large urban area. Adlershof is a steadily growing urban area with a multitude of problems. In the last two decades, a lot of buildings in the area were refurbished and new buildings were constructed. Future development is planned to incorporate energy efficiency and renewable energies which are core targets developers have to consider in order to realize the requirement of a competitive and trend setting Science and Technology Park.

ISSUES AND CHALLENGES

The stakeholders committed themselves to do it in an innovative way, trying to solve goal conflicts and being an example for other urban areas.

The City of Berlin charged WISTA MANAGEMENT GmbH with the responsibility for marketing the Science and Technological Park start-ups dealing with renewable energies can rent office or laboratory space at relatively low costs. The companies are located close to other companies dealing with similar topics. Networking is important not only for business, but also for realizing innovative energy concepts including smart grids or district heating and cooling systems.

The existing building stock in Adlershof is functionally diverse. Some buildings were built at the beginning of the 20th century as part of the first German airport Johannisthal-Adlershof. There are listed buildings from the 1930s. Over the last century, there has been a constant growth in the area. In 2011 the building area was about 1 485 000 m². There are still parcels of land available for further growth and, according to the Master Plan, there could be a building area of 3 400 000 m² in 2030. The densification of the area and the development of available spaces while respecting the local history is a big challenge. The combination of residential, university and public buildings, television and film production, commercial parks and industry and landscape is also a quite unique. It is really a mixed urban area where all every day needs can be located at short distances.

THE PLANNING PROCESS

In the early 1990s, a lack of dwelling area and industrial real estate in Berlin was prognosed. Adlershof was identified as one possible location for new buildings.

In 1991, the Humboldt University decided to move its natural sciences institutes to Adlershof and other research institutes followed suit discovering the potentialities of this urban area.

In 1992, it was decided that Adlershof should be developed as “City for Science and Economy”. Therefore the City of Berlin incorporated an urbanistic development agency and Public Trustee of the state of Berlin. Together with WISTA MANAGEMENT GmbH, the Senate Department for Urban Development and the Environment strategically developed (and is still developing) the urban area using the special legal situation of an Urban Development Measure.

Since 1994 Adlershof has been defined as an urban development area. In the late 1990s six institutes of the Humboldt University moved to Adlershof.

In 2003 the original master plan from the 1990s was adapted to the functional diverse needs of the area: residential buildings were converted to mixed areas and an area for single family houses was defined.

From 2004 to 2010, 370 single family houses were constructed. During the European Solar Building Exhibition in 2005, several individual low energy or passive houses were built. These models led to a more ecological building construction.

In 2007 the construction of the train station began and the decision to extend a tram line was made.

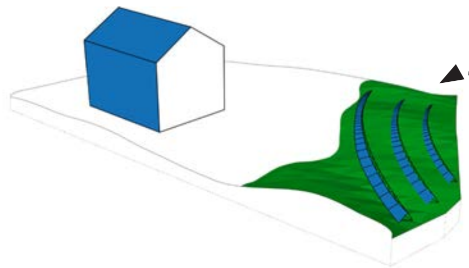
From 2009 to 2012 the construction of a new residential area with 1300 housing units started.

In 2013 an overall energy concept was developed to reduce 30% primary energy by 2020. Currently there are various research projects dealing with reaching this goal.

The final stage of development in terms of building area is expected to be reached in 2030 [3][4].

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

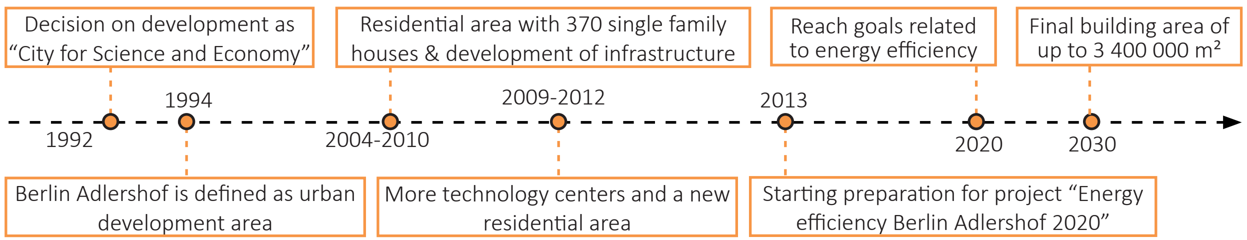
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [3] Senatsverwaltung für Stadtentwicklung und Umwelt. (2013). Berlin Adlershof – Stadt für Wissenschaft, Wirtschaft und Medien.
[4] Senatsverwaltung für Stadtentwicklung. (2007). Städtebaulicher Entwicklungsbereich Johannisthal/Adlershof – Bilanz der Entwicklung.

Energy concept

Figure 5 - Heating power plant with storage tanks and PV system. (Photo: © Margarethe Korolkow)

Figure 6 - Courtyard with green area and ventilation tower. (Photo: © Margarethe Korolkow)

Figure 7 - Impressions of PV systems. (Photo: © Margarethe Korolkow)

SUMMARY

The main source of energy in buildings is district heating. The primary energy factor of 0.24 is low as the district heating is based on biomass which includes combined heat and power generation [5]. Cooling is mainly realized based on building scale. Some buildings use absorption refrigeration converting the heat from the district heating network. Electricity is supplied by the public grid. Most existing PV systems feed into the grid. So far, there is an installed PV power of more than 2 MW_{peak}.

In the residential area with 370 single family houses there are individual heat-producing appliances.

A potential analysis for small wind turbines was made by the Technical University of Berlin. The next years will show, if some wind projects will be realized.

References: [5] www.btb-berlin.de/ (access: May 2016)
[6] www.eneff-stadt.info/de/ (access: May 2016)

SOLAR THERMAL SYSTEMS

To date, the solar thermal systems are not widely used in Adlershof. One reason is the district heating. A "democratic grid" is planned to encourage more solar thermal systems where solar thermal energy can be fed into the district heating grid. A research project is associated with the democratic grid in the partners are developing regulations and defining base conditions for it. The research will deal with a heterogenic residential area.[6]

PHOTOVOLTAIC SYSTEMS

The first PV system in Adlershof was installed in 1998. It is a façade integrated semi-transparent system with polycrystalline cells. Today there are a lot of different systems with different design approaches. There are building integrated systems, systems with double functions and buildings address different architectural qualities.

In Adlershof green roofs are obligatory in order to retain water during heavy rain events and to minimize the heat island effect. PV systems are accepted as alternative measure.

The pictures above give a small impression of the different PV systems in the development area Adlershof.

Architectural Quality - system Visibility - context Sensibility

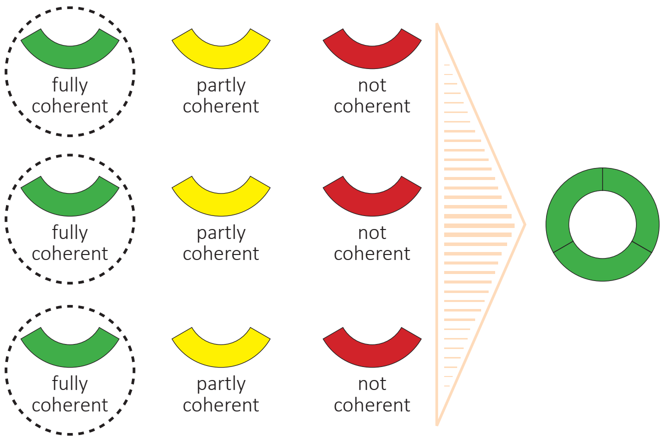
Figure 8 - System geometry - Solon Headquarters. (Photo: © Margarethe Korolkow)

Figure 9 - System materiality - Solon Headquarters. (Photo: © Margarethe Korolkow)

Figure 10 - Modular pattern - Solon Headquarters. (Photo: © Margarethe Korolkow)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



References: *[7] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT. (click here to download) [8] WISTA MANAGEMENT GmbH. (approx. 2013). Photovoltaik und Erneuerbare Energien in Berlin Adlershof.

COMMENTS

This building was built as headquarters of the former company Solon. As a PV manufacturer and a planner for PV systems it was a must have to integrate PV panels into the building and to show how solar energy applications can be used. Besides the power generation with PV, energy efficiency and internal flexibility were focused. The pictures above show the office building. Next to it there is the PV factory. The two building parts are connected through 3 bridges. The produced energy is used to cover parts of the energy demand of the administration and the production. The installed power is 210 kWpeak [8].
The building skin is basically made of glass, steel and wood. On the roof green parts contrast with the dark PV modules and the rusted COR-TEN steel staircase towers. The shown PV system has a double function as shading device and its form follows the shape of the building. The semi-transparent PV modules with two-paned glazing harmonize with the glass dominated façade with wooden elements.

Figure 11 - Solon Headquarters (Photo: © Margarethe Korolkow)

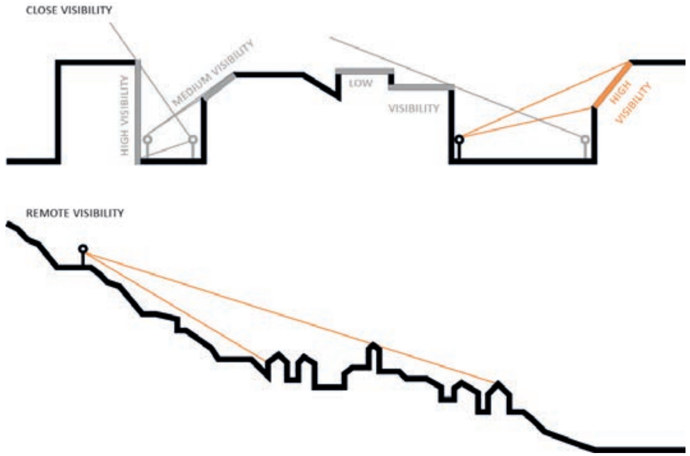


Figure 12 - Different levels of visibility of city surfaces from public domain. [5]

CRITICITY

	HIGH	MEDIUM	LOW
CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	●	○
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

Adlershof is a mixed urban area with buildings from the beginning of the 20th century up to new buildings with different utilizations. This mix of buildings leads to a very heterogeneous appearance.

The former Solon Headquarters are located in the south eastern part of Adlershof. The building is located at one of the entrances to the urban area. It forms the transition from city gardens to the Science and Technology Park Adlershof.

SYSTEM VISIBILITY

In the Science and Technology Park Adlershof, there are mainly flat roofs with low visibility.

The solar system which is integrated in the roof overhang has a high visibility. The underside is visible from the street level and the upper surface when the observer approaches from the southern side. Then the solar system, the roof gardens and the staircases are visible.

Since Adlershof is mainly flat, remote visibility is not an issue. The only possibility is from higher levels or roofs of the same or other buildings.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

ARCHITECTURAL QUALITY - SYSTEM VISIBILITY - CONTEXT SENSIBILITY

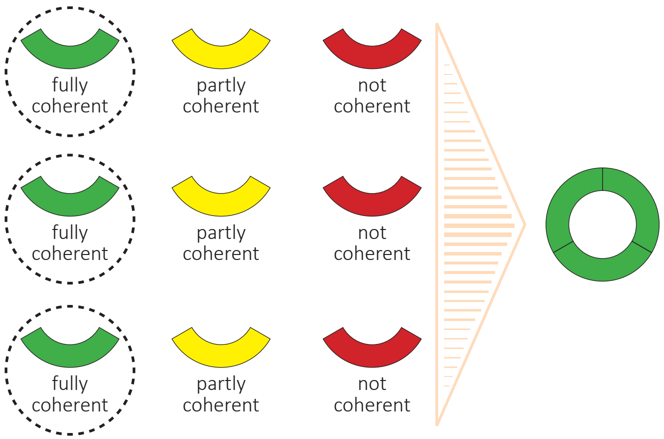
Figure 13 - System geometry - Ferdinand Braun Institute . (Photo: © Margarethe Korolkow)

Figure 14 - System materiality – Ferdinand Braun Institute. (Photo: © Margarethe Korolkow)

Figure 15 - Modular pattern – Ferdinand Braun Institute (Photo: © Margarethe Korolkow)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



References: [8] WISTA MANAGEMENT GmbH. (approx. 2013). Photovoltaik und Erneuerbare Energien in Berlin Adlershof.
[9] www.fbh-berlin.com

COMMENTS

The Ferdinand Braun Institute deals with application-oriented research in close cooperation with the industry. Main research areas are mircowaves, optoelectronics and modules and systems based on compound semiconductors.
The PV wall covers one side of a laboratory building and creates a special impression with its slight curve. The dark thin film modules based on copper indium selenide (CIS) contrast with the white bricks of the building. The patterns also contrast because the modules are one directly above the other and the bricks are arranged as a header bond where the offset of each successive course is half a header. [9]

The installed power of the PV system is 41.3 kWpeak[8].

A building added PV system is located on the roof.

Architectural Quality - system Visibility - context Sensibility

Figure 16 - Ferdinand Braun Institute (Photo: © Margarethe Korolkow)

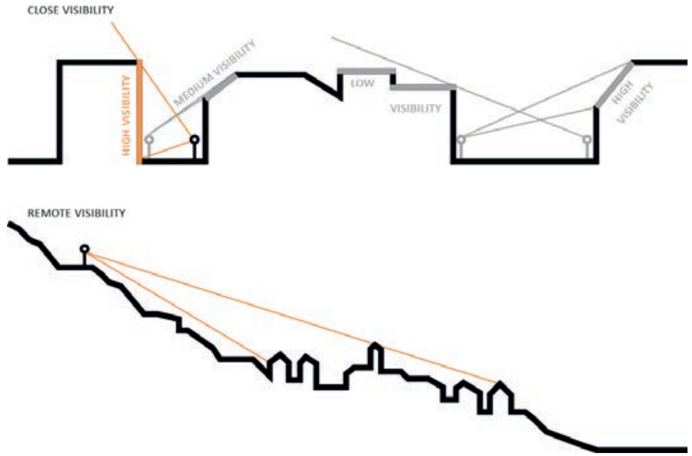


Figure 17 - Different levels of visibility of city surfaces from public domain. [5]

CRITICITY

	HIGH	MEDIUM	LOW
CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	○	●
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

Adlershof is a mixed urban area with buildings from the beginning of the 20th century up to new buildings with different utilizations. This mix of buildings leads to a very heterogeneous appearance.

The Ferdinand Braun Institute is located in front of the circular building called BESSY II which contains a synchrotron radiation source. The high tech appearance of both buildings suits the image of a Science and Technology Park.

SYSTEM VISIBILITY

In the Science and Technology Park Adlershof, there are mainly flat roofs with low visibility. But the solar system of the Ferdinand Braun Institute is highly visible. It covers the whole south west façade of a laboratory building. The solar system on the roof is not visible.

Since Adlershof is mainly flat, remote visibility is not an issue. The only possibility is from higher levels or roofs of other buildings.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

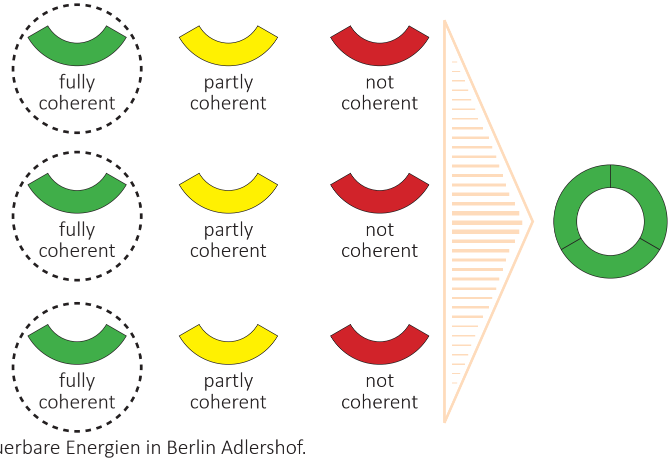
Figure 18 - System geometry - Centre of Biotechnology and the Environment.
(Photo: © Margarethe Korolkow)

Figure 19 - System materiality – Centre of Biotechnology and the Environment
(Photo: © Margarethe Korolkow)

Figure 20 - Modular pattern – Centre of Biotechnology and the Environment
(Photo: © Gustav Hillmann)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



References: [8] Wista Management GmbH. (approx. 2013). Photovoltaik und Erneuerbare Energien in Berlin Adlershof.

COMMENTS

The PV system of the Centre of Biotechnology and the Environment is the oldest one in this urban area. It was installed 1998 and consists of semi-transparent modules that are located in vertical stripes in front of the west façade. The main visible materials of the building are glass, concrete, metal and the grey polycrystalline PV cells.

The PV system has a double functio¬¬n since it is for shading and energy generation. The installed power is 14 kWpeak[8].

A less visible PV system is located on the roof as an added system.

Figure 21 - Centre of Biotechnology and the Environment (Photo: © Margarethe Korolkow)

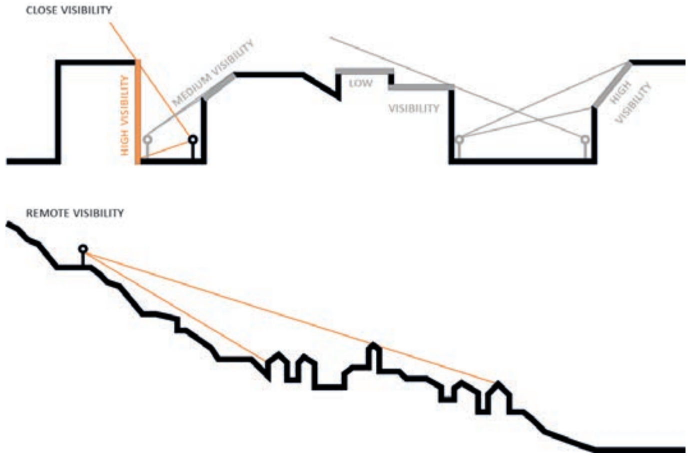


Figure 22 - Different levels of visibility of city surfaces from public domain. [5]

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	○	●
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

Adlershof is a mixed urban area with buildings from the beginning of the 20th century up to new buildings with different utilizations. This mix of buildings leads to a very heterogeneous appearance.

The Centre of Biotechnology and the Environment is located in an area with mainly office buildings that were built after 1990.

SYSTEM VISIBILITY

In the Science and Technology Park Adlershof, there are mainly flat roofs with low visibility. The system has a high visibility. It is located on the south west façade. The system on the roof is not visible from the street level.

Since Adlershof is mainly flat, remote visibility is not an issue. The only possibility is from higher levels or roofs of other buildings.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

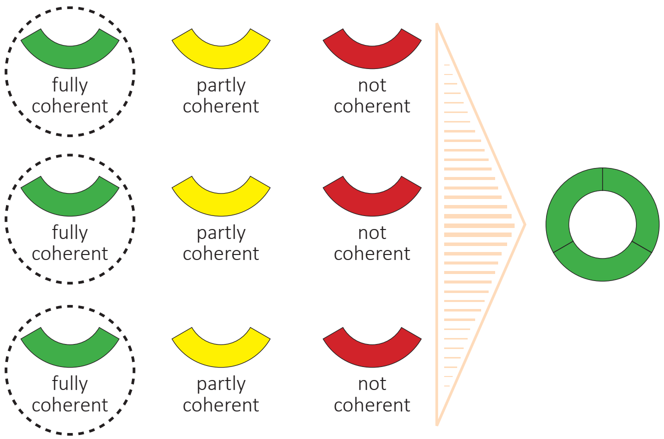
Figure 23 - System geometry - ZPV (Photo: © Margarethe Korolkow)

Figure 24 - System materiality – ZPV (Photo: © Margarethe Korolkow)

Figure 25 - Modular pattern – ZPV (Photo: © Margarethe Korolkow)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	**1** - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	**2** - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	**3** - MODULAR PATTERN



References: [10] www.adlershof.de (access: May 2016)

COMMENTS

The ZPV (Centre for PV and Renewable Energies) is one of the technological centers that are administrated by WISTA MANAGEMENT GmbH. It is certified by DGNB (German Sustainable Building Council) and reached the DGNB Gold Certificate.

The façade of the main entrance is fully glazed. In order to prevent overheating a shading system made of semi-transparent PV modules that are mounted on a steel structure is located in front of the façade.

The pattern of the mullion-transom façade is repeated by the PV system.

A charging point for electric cars or pedelec s allows e-mobility [10].

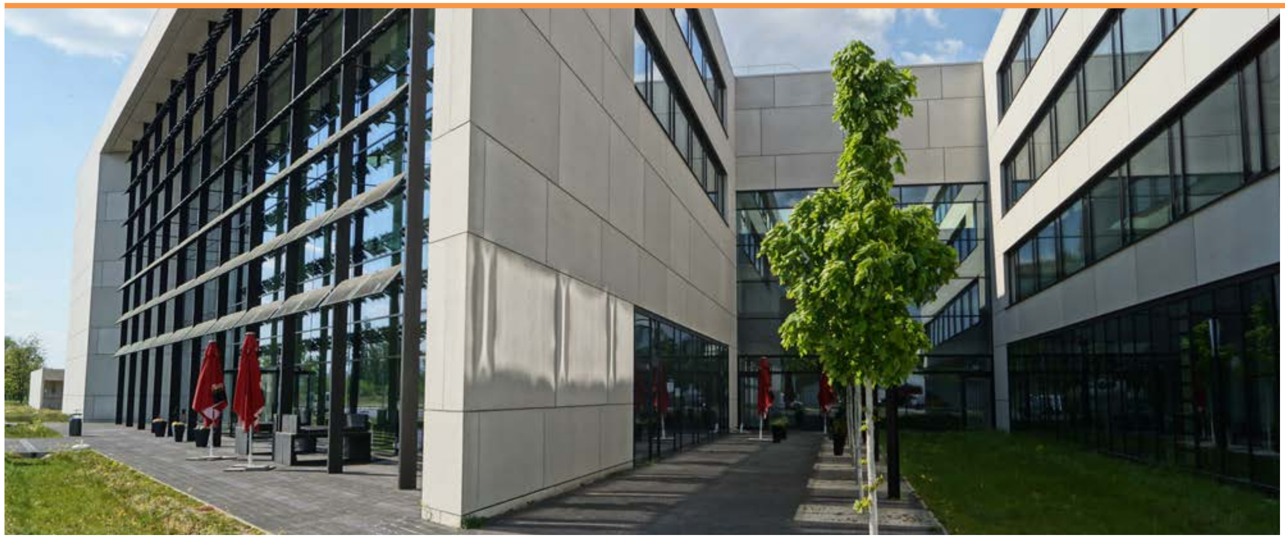


Figure 26 - ZPV (Photo: © Margarethe Korolkow)

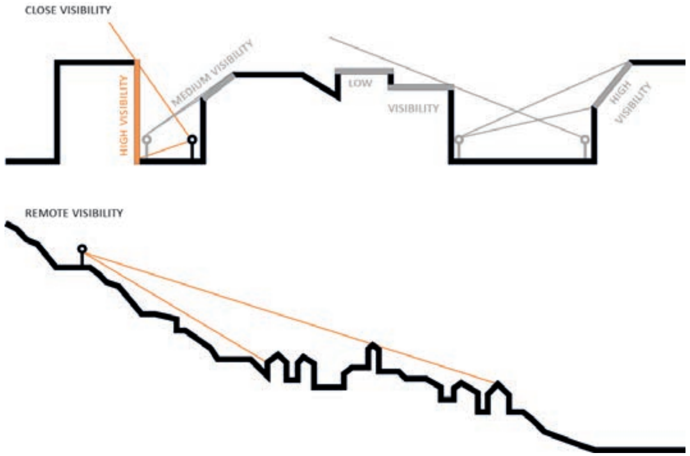


Figure 27 - Different levels of visibility of city surfaces from public domain. [5]

CRITICITY

	HIGH	MEDIUM	LOW
CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	○	●
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

Adlershof is a mixed urban area with buildings from the beginning of the 20th century up to new buildings with different utilizations. This mix of buildings leads to a very heterogeneous appearance.

The ZPV is located in between new buildings. North of the building, there are still empty spaces and an area where during the next years new buildings will be constructed.

SYSTEM VISIBILITY

In the Science and Technology Park Adlershof, there are mainly flat roofs with low visibility. The solar system covers the façade of the entrance hall. It has a double function as shading system and is highly visible.

Since Adlershof is mainly flat, remote visibility is not an issue. The only possibility is from higher levels or roofs of other buildings.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Architectural Quality - System Visibility - Context Sensibility

Figure 27 - System geometry – Soltecture Headquarters (Photo: © Margarethe Korolkow)

Figure 28 - System materiality – Soltecture Headquarters (Photo: © Margarethe Korolkow)

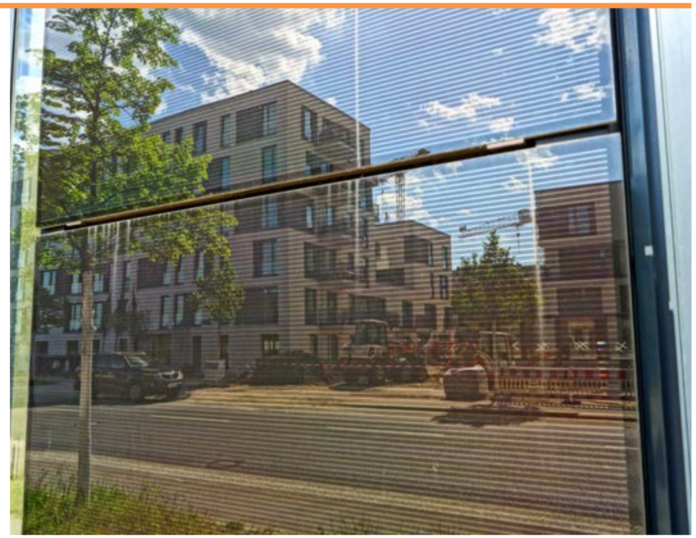
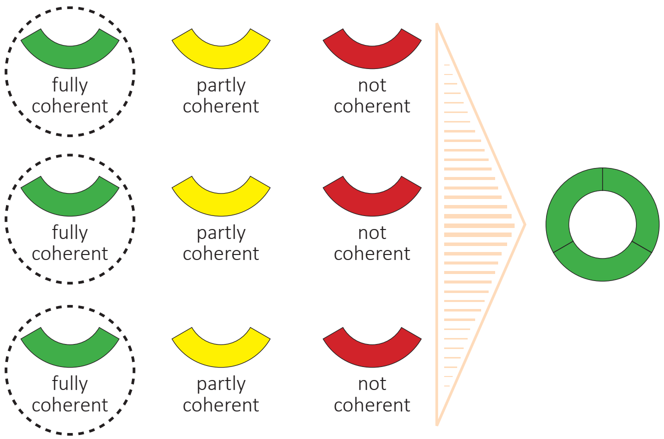


Figure 29 - Modular pattern – Soltecture Headquarters (Photo: © Margarethe Korolkow)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	**1** - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	**2** - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	**3** - MODULAR PATTERN



References: [10] www.adlershof.de (access: May 2016)

COMMENTS

The pictures show the former headquarter of the PV producer Soltecture. Formerly the producer was called Sulfurcell, based on the thin film technology they use for their PV modules. In the development of the company the importance of building integrated PV systems was recognized and therefore the company's name was changed. Of course, the headquarter building includes BIPV. The main visible materials are glass, copper colored metal panels and black PV panels or dummies. The façade was designed to include the thin film modules. The reflections in the PV panels are influencing the perception on the building depending on the weather and the viewing direction.

Another PV system is located on the roof. The installed power of the systems is 204 kW_{peak} [8].

Figure 30 - Soltecture Headquarters (Photo: © Margarethe Korolkow)

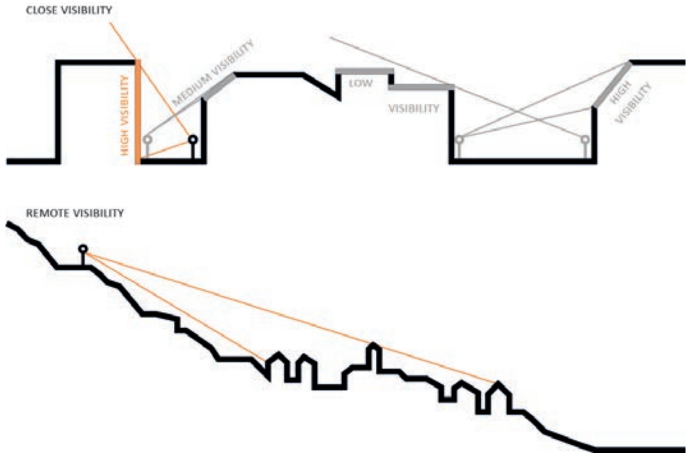


Figure 31 - Different levels of visibility of city surfaces from public domain. [5]

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	○	●
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

Adlershof is a mixed urban area with buildings from the beginning of the 20th century up to new buildings with different utilizations. This mix of buildings leads to a very heterogeneous appearance.

The building is located next to very different uses: east and north of it there is commercial area, south there are former barrack buildings that are used now for offices of mainly public services, and west of the building there is a residential area under construction. These new buildings shade parts of the BIPV from autumn to spring.

SYSTEM VISIBILITY

In the Science and Technology Park Adlershof, there are mainly flat roofs with low visibility. The solar system is façade integrated and highly visible (in case the observer knows that the black modules are PV panels). The PV system on the roof is not visible from the street level.

Since Adlershof is mainly flat, remote visibility is not an issue. The only possibility is from higher levels or roofs of other buildings.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT. (click here to download)

Figure 32 - Landscape park. (Photo: © Margarethe Korolkow)

Figure 33 - Construction site for residential buildings. (Photo: © Margarethe Korolkow)

Figure 34 - Residential area with mainly single family houses. (Photo: © Margarethe Korolkow)

ENVIRONMENTAL IMPACT

As one of the largest Science and Technology Parks in Germany, Adlershof set itself the medium term goal of reducing its primary energy consumption by 30% until 2020. This is quite ambitious taking into account that the prediction of growth from 2011 to 2020 is almost 50% of the building area.

Besides energy efficiency aspects of buildings, the infrastructure and transportation is important for the environmental impact. As a mixed urban area , Adlershof is a "city of short distances". However, numerous commuters come into the area every day but there is good connection to the urban train, tram and bus service which encourages the utilization of public transportation. The nearby highway and airport, Berlin Schönefeld, connect the Science and Technology Park nationally and internationally [3][4].

ECONOMIC IMPACT

There are about 1 000 companies and 16 scientific organizations with almost 16 000 employees and more than 6 500 students coming to Adlershof [11]. One residential area with 370 single family houses was constructed from 2004 to 2011. Another area with 1 300 housing units is planned and partially under construction.

The energy efficiency and sustainability goals help to generate locational advantages for the Science and Technology Park which again help to develop the urban area [3][4].

SOCIAL IMPACT

The users (residents, employees, companies, students) are involved through participation processes and public exhibitions, guided tours and symposia. A website offers information about the history, current activities and future plans for Adlershof.

The local energy manager is a central contact person for energy related topics. He informs and supports local stakeholders.

References: [3] Senatsverwaltung für Stadtentwicklung und Umwelt. (2013). Berlin Adlershof – Stadt für Wissenschaft, Wirtschaft und Medien.
[4] Senatsverwaltung für Stadtentwicklung. (2007). Städtebaulicher Entwicklungsbereich Johannisthal/Adlershof – Bilanz der Entwicklung.
[11] www.adlershof.de/ (access: May 2016)

ORGANIZATION AND COOPERATION

The City of Berlin put WISTA MANAGEMENT GmbH and Adlershof Projekt GmbH in charge of developing Adlershof as Science and Technology Park. WISTA MANAGEMENT GmbH manages the public relations for the entire development district. It realizes the marketing and sales (together with Adlershof Projekt GmbH), establishes and manages the local technology centres. One employee is the local energy manager.

Adlershof Projekt GmbH is an urban development agency and trustee of the Federal State of Berlin. It is responsible for development, urban planning, building plan and infrastructure project management, trust fund administration, sale of plots, and marketing.

The Senate Department for Urban Development and the Environment is also involved in the development of the district.

Adlershof Facility Management GmbH is another subsidiary company of WISTA MANAGEMENT GmbH. The main function of Adlershof Facility Management is the technical management and maintenance of buildings and their technological equipment.

Quite some established companies and factories are working in the field of renewable energies and energy efficiency. Up to now there is an installed PV power of more than 2 MW_{peak}.

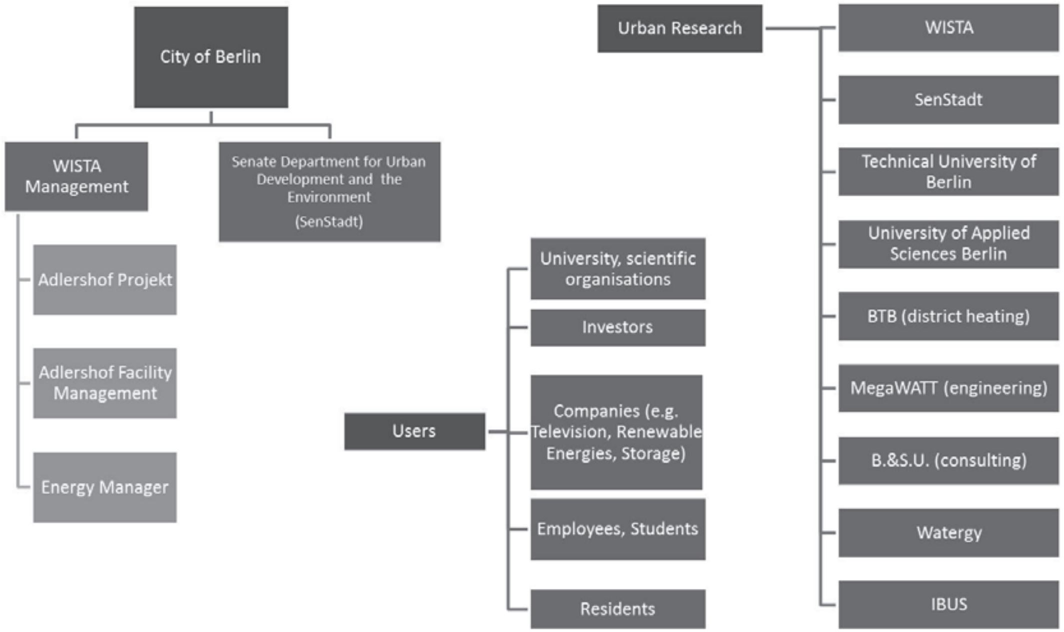


Figure 35 - Overview (no claim to completeness) of involved stakeholders in Adlershof (Source: © IBUS GmbH)

RESULTS AND DISCUSSION

The structure of the organization allows the energy efficiency development of the urban area. Local stakeholders ease the communication and enhance the mediation and procurement of possible cooperation [3][4].

References: [3] Senatsverwaltung für Stadtentwicklung und Umwelt. (2013). Berlin Adlershof – Stadt für Wissenschaft, Wirtschaft und Medien.
[4] Senatsverwaltung für Stadtentwicklung. (2007). Städtebaulicher Entwicklungsbereich Johannisthal/Adlershof – Bilanz der Entwicklung.

Figure 36 - Forum Adlershof – Convention Center. (Photo: © Margarethe Korolkow)

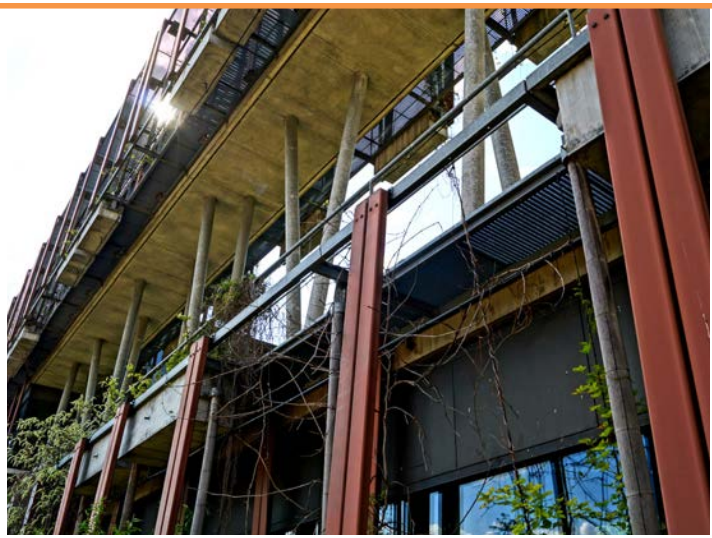


Figure 37 - Vegetation as shading system. (Photo: © Margarethe Korolkow)

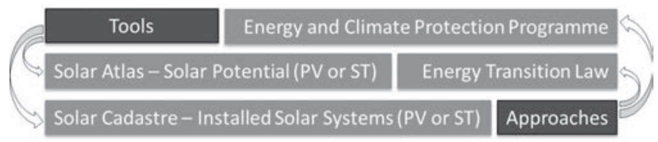


Figure 38 - Tools and Approaches in Berlin. (Author: © Margarethe Korolkow)

URBAN DEVELOPMENT MEASURE

An Urban Development Measure allows a fast and target-oriented development of an urban area. Both, community and owners have to support the development. The community buys, prepares and sells buildings plots. The selling process does not only consider monetary benefits but also the building and utilization concept. On sold plots the new owners are bound to build [4].

If owners want to develop their plots during a reasonable timeframe, they can do so. Owners, that do not want to or cannot develop their land, can request that the community buys their property. If they want to sell it to others, they need the permission of the community [4].

RESEARCH PROJECT

There were/are several research projects dealing with the energy efficiency of the Adlershof. One project led to an integrated energy concept that shows ways of reaching a reduction of the primary energy use of the whole area by 30% until 2020 [12]. One ongoing research project is dealing with energy planning guidelines where a multi-media energy planning map for the area is realized. The goal is to provide a future-compliant and flexible infrastructure and its optimization through foresighted and sustainable planning. Therefore, a preplanning of the grids and the corresponding infrastructure as well as the development of an energy utilization plan for existing areas, fill-ins and undeveloped areas based on four different utilization scenarios [12][13]. Other research projects are dealing with the topics “Smart Grids” or “Networking of Energy Flows” [12].

IN RELATION TO THE SCALE

The size of this urban area allowed to establish an own development company that concentrates the knowledge about the site, the different stakeholders and the future development.
The involvement of Senate Department for Urban Development and the Environment ensures that city goals concerning energy efficiency, environmental protection and sustainability are taken into account.

Since 2014, the “Energy Manager” is the central contact person for energy concerning issues. He informs and acts as a mediator and offers energy-related advisory service. Information about research projects, private initiatives and available supportive planning tools can be distributed and cooperation partners can be connected. [14]

References: [4] Senatsverwaltung für Stadtentwicklung. (2007). Städtebaulicher Entwicklungsbereich Johannisthal/Adlershof – Bilanz der Entwicklung; [12] www.eneff-stadt.info/en/ (Access: May 2016);
[13] www.htw-berlin.de/ (Access: June 2016); [14] www.adlershof.de/wista-management-gmbh/ (access: May 2016).

Lessons learned and recommendations

Figure 39 - Impressions of the Science and Technology Park Adlershof. (Photo: © Margarethe Korolkow)

Figure 40 - Impressions of the Science and Technology Park Adlershof. (Photo: © Margarethe Korolkow)

Figure 41 - Impressions of the Science and Technology Park Adlershof. (Photo: © Margarethe Korolkow)

LESSONS LEARNED

The establishment of a local development company is working for the development of Adlershof. The buildings and panels are in great demand and Adlershof is steadily growing. It seems, companies not only want a good location for their offices in terms of infrastructure, but that also the energy efficiency goals which increases the attractiveness to the area. Having a cluster of like-minded companies enables cooperation and the nearby-campus of the Humboldt University helps to get in contact with young researchers .

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

The approach to encourage building owners to voluntarily set energy efficiency goals is recommendable. The establishment of an energy manager as one important stakeholder to support decision makers could be replicated in other urban areas.
During concept phases, the collaboration with local universities and residents can give valuable input for development options of an urban area.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects
- Operators of Technology Parks

DEVELOPER

WISTA MANAGEMENT GmbH
Adlershof Projekt GmbH

CONSULTANTS

Senate Department for Urban Development and the Environment (SenStadt), WISTA MANAGEMENT GmbH, Adlershof Projekt GmbH, BTB (district heating provider) and more.

CASE STUDY AUTHORS

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OWNERS

City of Berlin
WISTA MANAGEMENT GmbH
Private and Public Owners

RESEARCH ORGANIZATIONS

IBUS

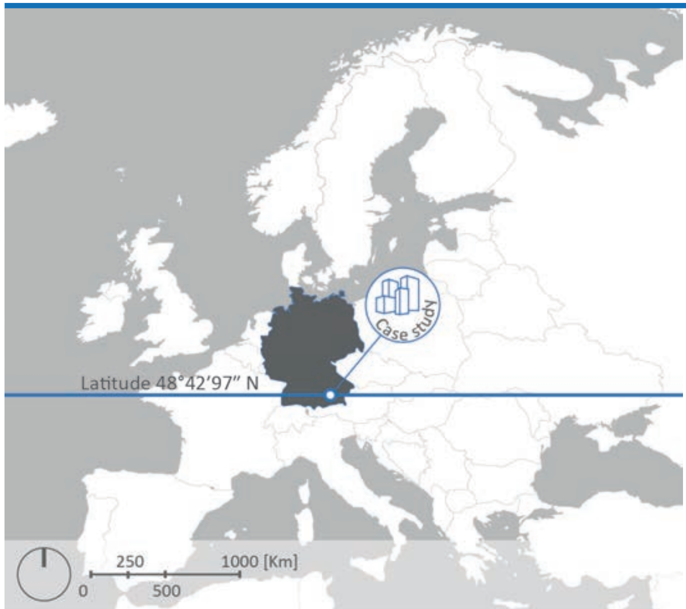
ACKNOWLEDGEMENTS

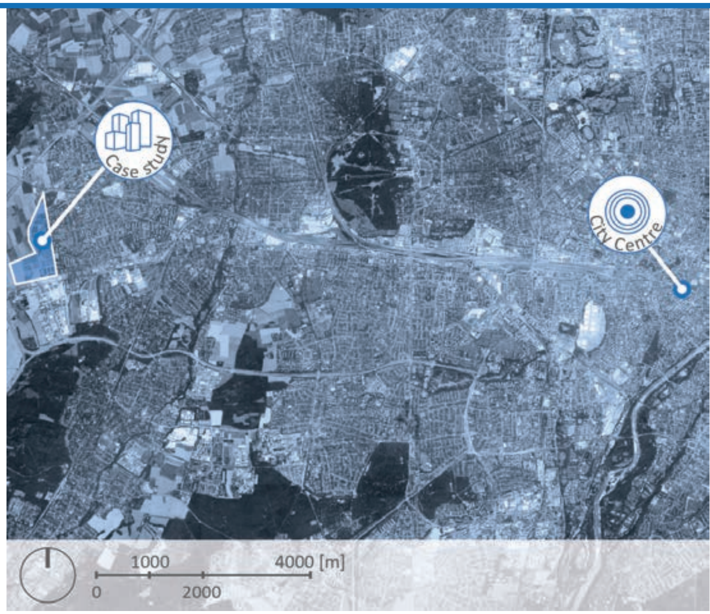
Thanks to WISTA MANAGEMENT, SenStadt, Technical University and HTW Berlin for the information provided and the collaboration.

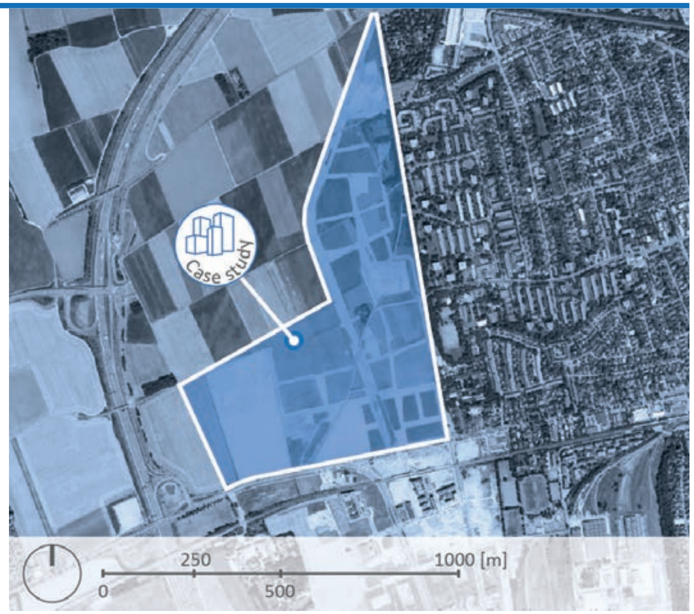
FREIHAM NORD MUNICH

GERMANY

Overview







GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Germany
Location: Munich (Lat. 48°42′97″S; Lon. 11°58′20″E)
Climate: Warm temperate (Cfc) [1]

AREA OF INTEREST

Planning process

NATIONAL AND LOCAL CONTEXT

The German federal Ministry of Environment has set the ambitious goal of climate neutrality by 2050 [2].

To reach this objective, the City of Munich is following a road map, leading to a 10% reduction of its CO_2 emissions every 5 years.

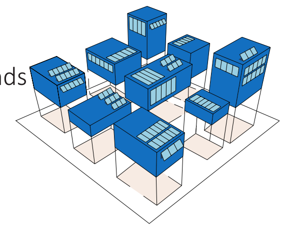
In parallel, Munich is facing a high demographic pressure: its residential park is required to increase by 30% between 2005 and 2025. Having already a densely built city center, Munich is extending to its periphery, with the construction of nearly climate neutral new districts.

ABOUT THE CASE STUDY

Freiham Nord is a new city district developed on a former 85 hectares agricultural field close to the West City Ring of Munich. At term, it should be the residential place for nearly 10 000 inhabitants, offering also a city center with services, education and sport installations. Its site plan has been disclosed in 2011, following the urban planning competition “Freiham Nord”.

Definition of environment:
New Urban Areas on agricultural lands

Site area: 850 000 m^2
Building area: 640 000 m^2
Area density: 0.75 area/m^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Klimaneutraler Gebäudebestand in Deutschland bis 2050 ist möglich

Issues, challenges and decision strategies

Figure 1 - Materplan of the entire intervention of Freiham North, Munich . (Photo: © West8)

Figure 2 - Planning field of Freiham Nord, close to existing district Neuaubing. (Source: © City of Munich)

Figure 3 - Map of goal conflicts in Freiham - Neuaubing. (Source: © Final report "Energiegerechte Stadtentwicklung in München", 2013, p.102).

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- Planning of a new nearly climate neutral energy district, integrating the development of an energy concept in the early design phases.
- Organization of an urban planning competition, evaluated by a multi-disciplinary team gathering city planners, architects but also energy experts.
- Comparison of urban form variants in a site plan parcel
- Goal conflict management between renewable technologies (mainly geothermal district heating and solar thermal energy).

ISSUES AND CHALLENGES

30% of Freiham Nord parcels will remain public-owned (social buildings and campus) while the rest will be sold to private developers. In this private-owned parcels, beside the application of a catalog of ecological criteria, the City of Munich has a relatively limited influence, in particular concerning the building form, the choice of the renewable technologies (which can't be legally imposed by the cities) or the roofs' use (e.g. private developers might prefer a large roof terrace for good living standard, to a photovoltaic installation).

Another issue related to the roofs' use comes from the high ground water level of this zone. In order to keep the rainwater management working, all buildings' roofs must be flat and green to store water and intensify the evapotranspiration. This aspect impacts the design and the installation of the solar systems on the buildings' roofs.

DECISION STRATEGIES

Some barriers exist also among renewable energy technologies: the local energy supply company invested massively in a geothermal installation on the south of the district to provide low carbon heat energy to Freiham Nord through a district heating network. In order to remain profitable in a context of energy-efficient district with low heat demand buildings, new building owners have been forced to connect to the district heating network, and concurrent heat production technologies as solar thermal panels or heat pumps have been contractually prohibited.

Finally, due to the large scale of this urban project, the planning and construction of the different parcels will be phased over almost two decades. As a consequence, designing the parcels with consideration of their mutual influences (in particular the solar access) represent challenging issues to be faced.

The planning process

After several workshops with local stakeholders to define the boundary conditions of the new urban development Freiham Nord, the City of Munich organized an urban and landscape planning competition in 2011.

Among 14 candidates, the project of West8 (from Netherland) has been selected by a multidisciplinary team, gathering city planners, architects but also energy experts. The evaluation committee has qualitatively evaluated the site plan of the city planning variants, according to a series of criteria, including building compactness, general solar orientation, district heating network supply etc.

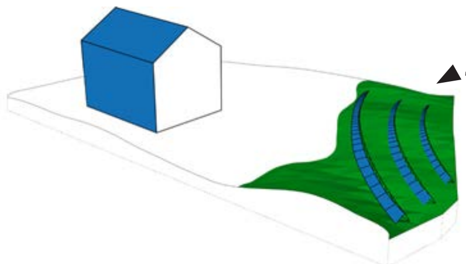
The site plan fixes the building line, height and occupancy ratio of each parcel. In each of them, the architectural and energy design decisions are postponed to the developers, provided that they respect the binding criterias. The parcels will be planned and built successively over the next decades.

The City of Munich, who owns the land, is the initiator of this urban area development project. The municipal energy supply company Stadtwerke München, has been also involved in the project conceptualization phase (2007) to plan the energy infrastructures and set the catalog of local ecological criteria together with the City Municipality.

The research team of the Hochschule für Technik Stuttgart was involved in the competition evaluation comittee and participated to a solar potential study to optimize the building form of the parcel "Cluster13".

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

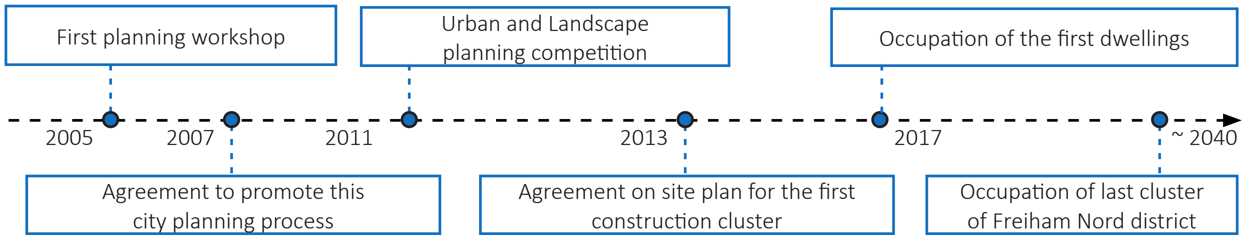
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



ENERGY CONCEPT

Figure 5 - Chimney of the heating plant of Freiham, including PV modules. (Photo: © Stadtwerke München)

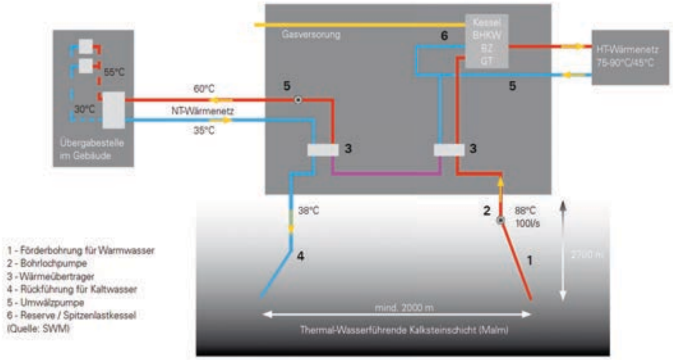


Figure 6 - Scheme of geothermal plant with hot and low-temperature network. (Source: © Final report "Energiegerechte Stadtentwicklung in München"[3], p.48)

SUMMARY

The Freiham Nord energy concept has been developed in the earliest phase of the project, together by the City of Munich and the municipal energy supply company Stadtwerke München. It resulted in the development of a catalog of binding ecological criteria, including a minimum building energy standard (Effizienzhaus 70), efficient energy systems, low energy construction material etc [4]. Furthermore, Stadtwerke München decided to invest in a new district heating system based on geothermal energy, to provide low carbon heat energy to the buildings.

The chimney of the district heating plant (Figure 4), built on the south of the new district and equipped with photovoltaic solar panels, has been architecturally designed to become a landmark of the district energy excellence.

A ENERGY CONCEPT BASED ON GEOTHERMIC HEAT

The district heating plant of Freiham is based on a geothermal installation and a Combined Heat and Power system that produces extremely low carbon heat energy. The heat is delivered to the buildings through a low-temperature district heating network (60°C/35°C), minimizing the network heat losses (Figure 6).

Solar thermal panels are contractually banned in the parcels connected to the district heating network, whereas solar photovoltaic panels are encouraged without being mandatory.

SOLAR ENERGY SYSTEM INSTALLATION

In public-owned parcels, the City of Munich, through its public housing company GWG München, has decided concrete energy efficiency measures even more ambitious than the ecological criteria catalog, like 100% green electricity, photovoltaic modules on the roof and solar-optimized building forms.

In privately owned areas, the choice of renewable technologies or the area of photovoltaic panels is left to the decision of investors, providing that the building meet the primary energy criteria.

References: [3] Sitzungsvorlagen Nr. 08-14 / V 08797 of Referat für Stadtplanung und Bauordnung – Landeshauptstadt München (english: Official meeting document nr. 08-14 / V 08797 of the Department Urbanism and building regulation of the City of Munich; [4] Landeshauptstadt München, Referat für Stadtplanung und Bauordnung (2013). Energiegerechte Stadtentwicklung in München. Landeshauptstadt München, Referat für Stadtplanung und Bauordnung. In cooperation with HFT Stuttgart and Stadtwerke München GmbH.

Figure 7 - Architectural view of the subproject field A from the winner project of the urban and landscape planning competition (source: ©West8).

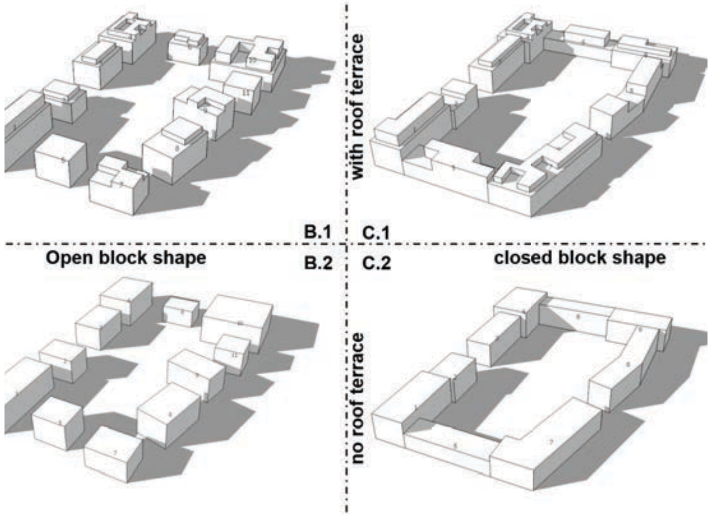


Figure 8 - Four studied variants for the Cluster13 of Freiham Nord. (Source: © HFT Stuttgart)

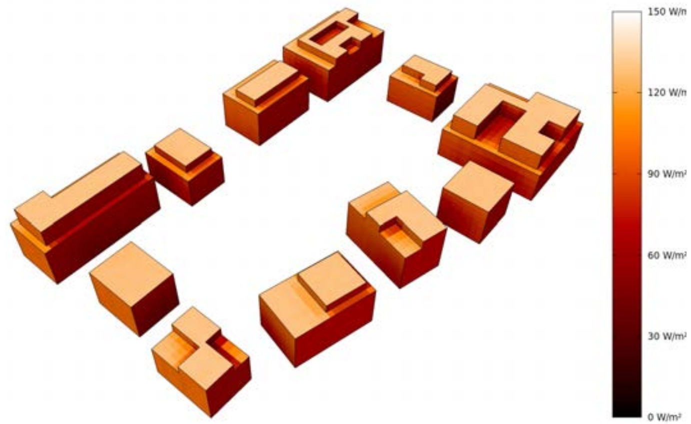


Figure 9- Yearly average irradiance on façade and roof for variant B.1 of Cluster13 (source © HFT Stuttgart)

TWO ANALYSES OF PROJECT'S SOLAR DESIGN

The City of Munich asked HFT Stuttgart to evaluate the solar design of different urban/building forms in two different phases of the planning process, related to two different scales:

Phase 1: During the urban and landscape planning competition (Dec. 2011) for the whole Freiham Nord site plan (85 ha). Because of the non-exploitable input formats (Figure 7) and the narrow time frame, the solar design of the 14 planning variants have been evaluated qualitatively, by visually determining the main orientations of the façades, the impact of the building height on solar accessibility, and the coherency between building usage and passive solar gains. A subjective score between 1 and 10 has been given to each criteria. These scores seemed not having impressed the jury of the competition, since the winner project was placed at the bottom of our ranking.

Phase 2: During a solar and energy optimization study (2013) for the parcel called "Cluster13" (1.7 ha), in the framework of the research project NSP München:
West8, proposed HFT Stuttgart different variants for the studied parcel, corresponding to combinations of open and closed shapes, and with or without roof terraces, while Floor Area Ratio and building lines remained fixed (Figure 8). The input documents (.dxf files with semantic information) and time frame allowed to realize a quantitative study for each variant, based on their 3D district models (Figure 9). The yearly average irradiance on each façade and roof , the resulting photovoltaic electricity production for different solar installations' variants, and the building heating demands were calculated and analyzed by using the urban simulation platform SimStadt [5].

RESULTS

The variant C.2 with closed block shape and without roof terrace allows the highest PV electrical production, followed by the variant B.2. Between 46% and 96% of the site electricity demand could be covered based on an installation of optimally-tilted PV modules (35°) mounted on a flat roof.

The electricity coverage rate always exceeds 100% with a maximum of 209% for the variant C.2 when PV panels are directly mounted on a quasi-flat roof (only 5° slope for water drain). These results are specific to the "Cluster13" and its characteristics (Floor Area Ratio of 1.4, and number of floors including between 2 and 5). This methodology would be however easily replicable/transposable to other Clusters and urban planning projects.

References: [5] Eicker, U., Monien, D., Duminil, E., Nouvel, R. (2015). Energy performance assessment in urban planning competitions, Applied Energy 155, pp 323-333.

Lessons learned and recommendations

Figure 10 - Model of the prized project (source: © HFT Stuttgart).

Figure 11 - Meeting of the multi-disciplinary team of project NSP München. (Source: © HFT Stuttgart)

LESSONS LEARNED

- Solar design is presently a minor criterion among many other criteria for decision makers in an urban planning competition.
- Architect and urban planning offices participating to urban planning competitions rarely integrate explicitly solar design aspects in their project, They do not provide data or a digital plan allowing experts to evaluate quantitatively the solar planning.
- Expert solar design ranking of projects was not considered by decision makers in (Phase 1) of the competition. They would have preferred to know which projects do not answer the minimum solar requirements.
- Setting a common energy concept in the early urban planning phases allow to achieve nearly climate neutral districts.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- The use of an objective and comprehensive evaluation method is essential, in order to check the outputs of solar design studies considered by the decision makers and addressed as a criteria in an urban planning competition.
- Input formats of candidate project layouts during an urban planning competitions should be precisely specified (for instance a .dxf file including given layers and semantic information), in order to be exploitable and to automatize as far as possible their evaluation process.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects

DEVELOPER

West8
Urban Design & Landscape Architecture

CONSULTANTS

Landeshauptstadt München (City of Munich)
Stadtwerke München, West8

CASE STUDY AUTHORS

Romain Nouvel, HFT Stuttgart.

OWNERS

Landeshauptstadt München (City of Munich).

STAKEHOLDERS

Project management team/External consultants/Enterprises.

RESEARCH ORGANIZATIONS

Hochschule für Technik Stuttgart

ACKNOWLEDGEMENTS

The authors wish to thanks the City of Munich for the information provided and the long-term collaboration.

3.7 ITALIAN CASE STUDIES

ITALIAN TEAM

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ENEA

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University of Applied Sciences and Arts of Southern Switzerland (SUPSI),
Dept. of Environment Constructions and Design (DACD)
Institute of Applied Sustainability to the Built Environment (ISAAC)
Swiss BiPV Competence Centre

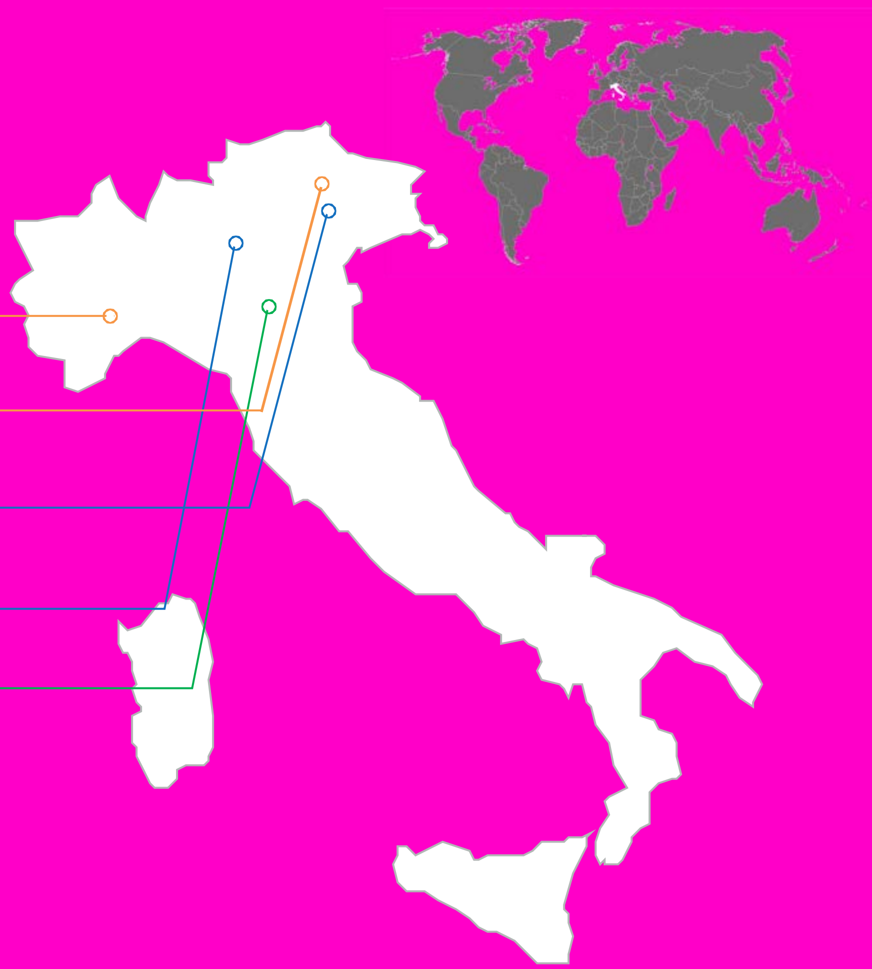
20 **PHOTOVOLTAIC VILLAGE IN ALESSANDRIA**
Existing urban area

21 **SINFONIA**
Existing urban area

22 **LE ALBERE**
New urban area

23 **VIOLINO DISTRICT IN BRESCIA**
New urban area

24 **AGROVOLTAICO**
Landscape PV



ITALY

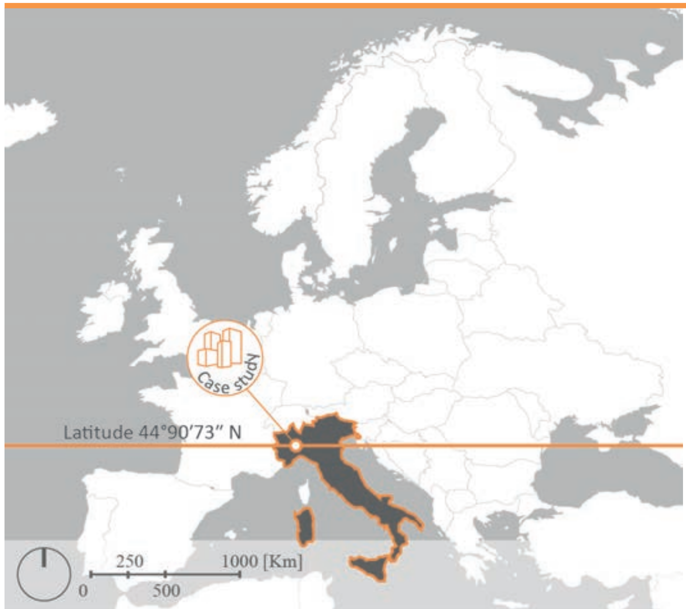
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

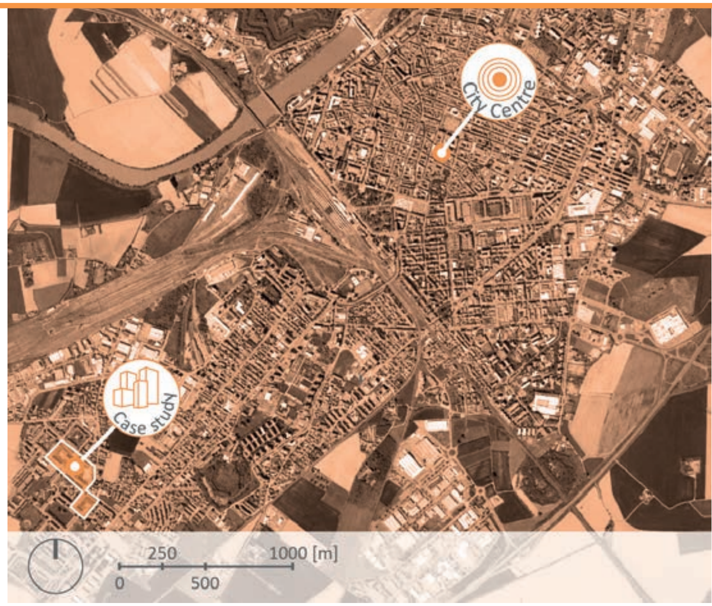

Photo: © PierFranco Robotti

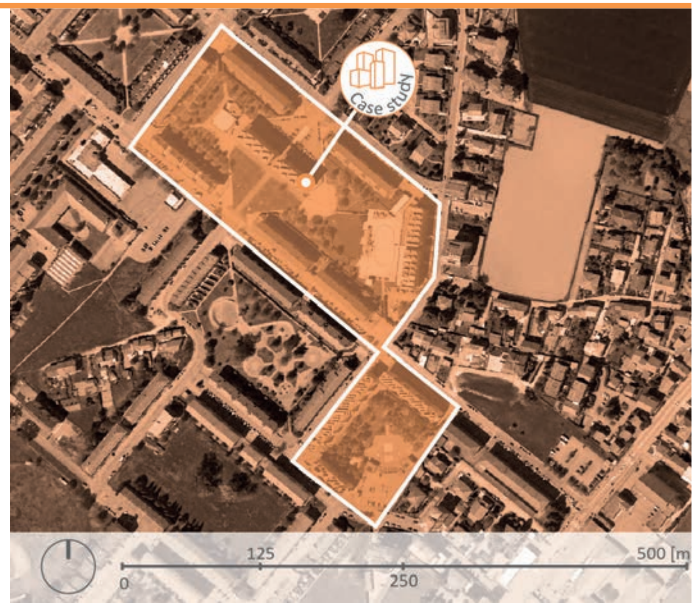
PHOTOVOLTAIC VILLAGE IN ALESSANDRIA

ITALY

Overview







GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Italy
Location: Alessandria (Lat. 44°90′73″ N; Lon. 8°61′17″ E)
Climate: Warm Temperature Climate (Cfb) [1]

AREA OF INTEREST

Legislation and technology

NATIONAL AND LOCAL CONTEXT

The framework of Italian legislation on urban and energy planning is characterized by a hierarchical approach stretching from the national level downward to the regional, provincial and municipal level.

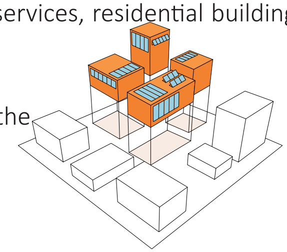
With regard to the Photovoltaic Village, the main driver that leads to include solar energy in the plan is represented by the introduction of the Environmental, Building and Urban Requalification Programme at the Regional level [2], which identifies the energy saving as a qualifying objective of urban and building projects.

According to such legislative framework, the municipality of Alessandria proposed a new local urban plan in order to realize a public residential urban intervention, designed in order to improve sustainability and energy savings.

ABOUT THE CASE STUDY

The Photovoltaic Village is a residential neighborhood (Cristo Area) in Alessandria. It is the result of a complex urban process aimed at the requalification of an existing suburban area in accordance with a sustainable approach. The intervention regarded the application of photovoltaic systems on existing buildings and the realization of an urban area with parking lot, green zones, sporting fittings and services, residential buildings (n° 192 flats).

Definition of environment:
Fill-ins and densification district in the existing urban area



Site area: 72 000 m^2
Building area: 47 000 m^2

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Regional Law 9th April 1996, n. 18. Integrated Intervention Programme of the Environmental, Building and Urban Requaification enacting the article 16 of law 17 february 1992, n. 179. (B.U. Piemonte Region 17 april 1996, n.16).

Figure 1 - Aerial view of the eastern area of the Photovoltaic Village.(Source: © Municipality of Alessandria)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- First Italian case Public Residential Building Intervention [3] where solar energy is considered and applied at the urban scale.
- Use of Photovoltaics to supply the 100% of electricity consumptions related to common areas and the 70% of electricity consumptions of each flat (192).

ISSUES AND CHALLENGES

The main challenges of this case are:

- Definition of integrated innovative process between Public and Private Agents for the definition of new urban plan characterized by energy goals. Moreover, the existing urban plan envisioned for that area needed to be substituted with the new one involving the introduction of new legislative procedures.
- The promotion of energy efficiency and the use of renewable energy sources, in line with the aims of the environmental energy plan [2].

DECISION STRATEGIES

Decision strategies founded on the following principles:

- Communication: many actors with their own capacities and prerogatives contributed to the success of this experience though active participation, dialogues and collaborative behaviors.
- Strategic Behavior: Municipal authorities were involved in all the phases of the project in order to develop a precise and feasible programme.
- Pilot Study: the programme is integrated within a complex operation involving town-planning, building and environmental requalification, in a suburban area of the city.

References: [2] Regional Law 9th April 1996, n. 18. Integrated Intervention Programme of the Environmental, Building and Urban Requaification enacting the article 16 of law 17 february 1992, n. 179. (B.U. Piemonte Region 17 april 1996, n.16).
[3] Comune di Alessandria. Alessandria's Photovoltaic Village. Edited by Comune di Alessandria in collaboration with Consulta per l'Edilizia Residenziale e le Infrastrutture della Provincia di Alessandria, pp 1-48.

The planning process

The application of photovoltaic technology in this case study has taken place in the complex Public Residential Building intervention within the context of the Integrated Intervention Programme (P.I.I.) [3].

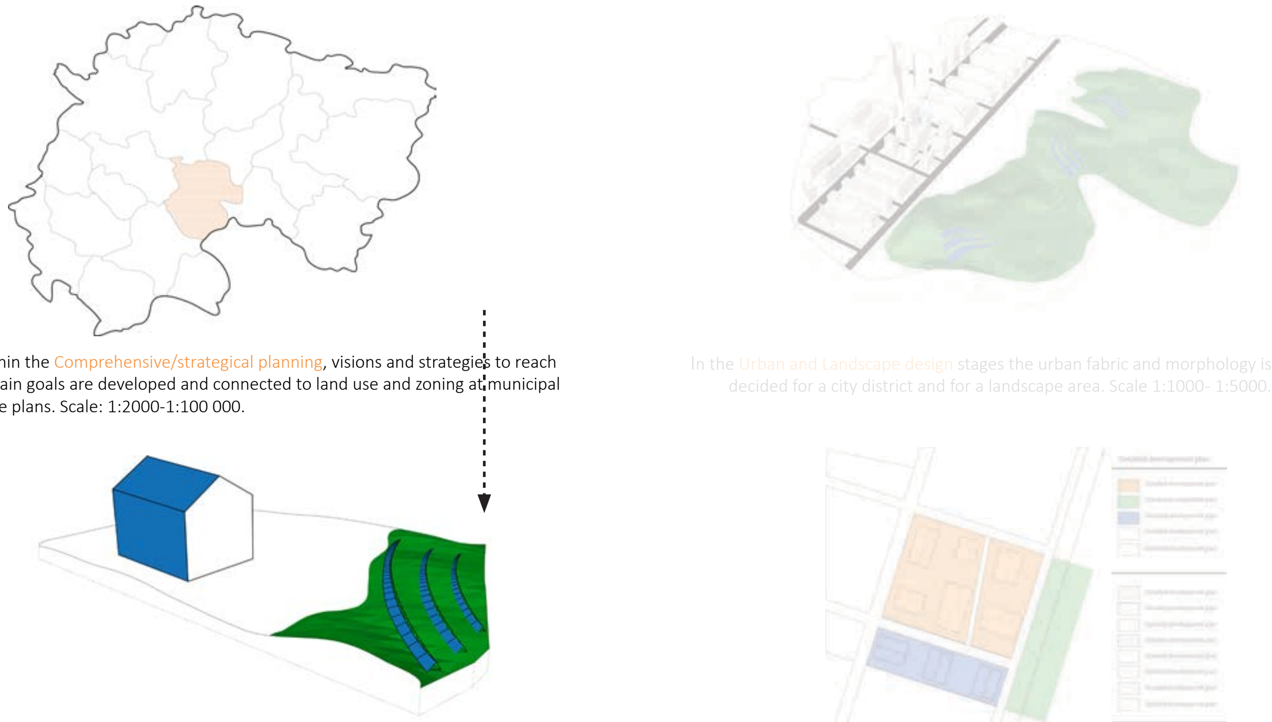
In 1996 the project starts with the definition of the Environmental, Building and Urban Requalification Programme followed in 1997 by the creation of The Building Council. The project was approved in 2000 and construction works started. The project has been completed in 2005.

The project was aimed at the requalification of a residential urban area with an adequate solar exposition and with buildings and urban furniture equipped with photovoltaic systems in order to improve sustainability and energy savings.

One of the main drivers was the introduction of the Environmental, Building and Urban Requalification Programme at the Regional level [2], which identifies the energy saving as a qualifying objective of urban and building projects.

Municipal Town Council, Consortia of private and cooperative builders in the Province of Alessandria, architects, researchers and private stakeholders have been involved in the process of the project.

Researchers of the Politecnico of Torino have been involved in the design of the solar system and in the monitoring phases.



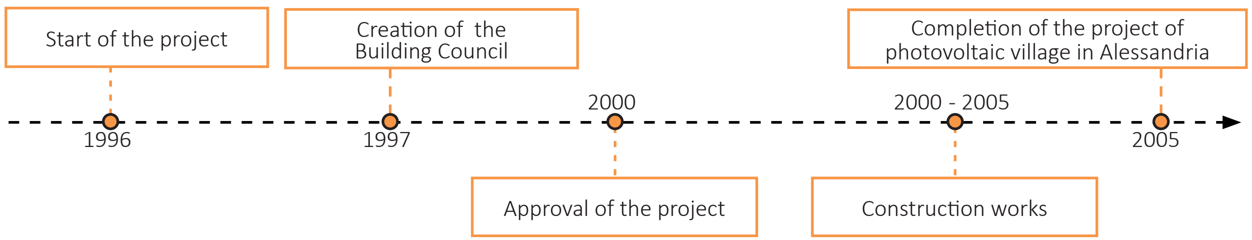
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 2 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [2] Regional Law 9th April 1996, n. 18. Integrated Intervention Programme of the Environmental, Building and Urban Requaification enacting the article 16 of law 17 february 1992, n. 179. (B.U. Piemonte Region 17 april 1996, n.16).
[3] Comune di Alessandria. Alessandria's Photovoltaic Village. Edited by Comune di Alessandria in collaboration with Consulta per l'Edilizia Residenziale e le Infrastrutture della Provincia di Alessandria, pp 1-48.

Figure 3 - The iron pylon with the photovoltaic unit. (Source: © Municipality of Alessandria).

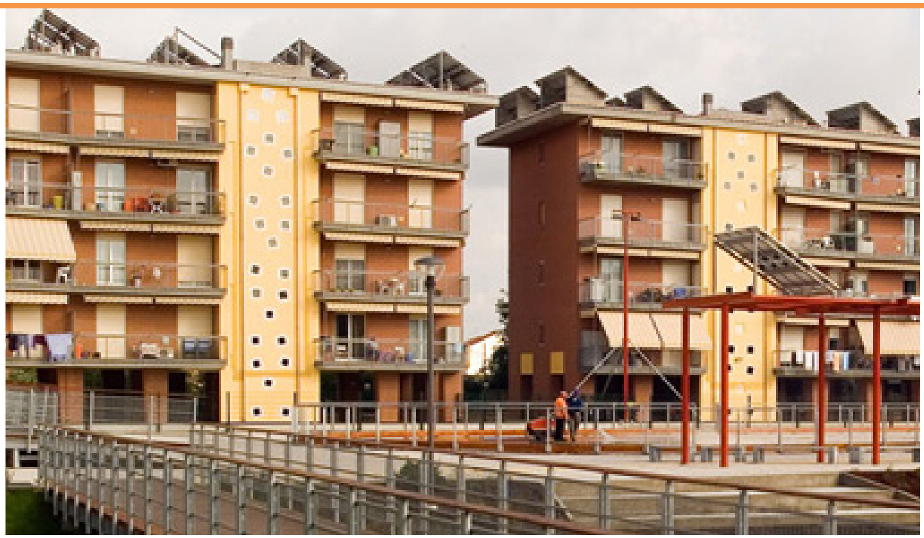


Figure 4 - PV panels installed on over-roofs on the row housesof the district. (Source: © A4 - Architettura integrata)

SUMMARY

In accordance with a sustainable approach, several solutions have been adopted. Eco-sustainability and health & well-being of final users have been achieved with:

- Products of low negative impact on the environment, that improve exposure conditions for inhabited environments;
- Buildings designed to achieve energy savings, recourse to renewable energy and consequent reductions in the emission levels.

With regard to the energy concept, the goal is to supply the 100% of electricity consumptions related to common areas and the 70% of electricity consumptions of each of the 192 flats by means of PV installations [3].

TECHNOLOGY

BAPV, BIPV and "urban integrated" PV systems have been installed in the Photovoltaic Village. Type of system:

- The PW750 module uses Photowatt' s multicrystalline technology. The PW750 is made with 4 X 9 high efficiency (up to 15%) polycrystalline 5 inch cells (125mm X 125 mm), with a silicon nitride anti-reflective coating;
- Area of PV systems: 1 600 m^2;
- Orientation and inclination: south (façade); south, 30° (roof)

ENERGY SYSTEM AND SOLAR ENERGY DESIGN

The PV systems should supply 100% of electricity consumptions related to common areas and 70% of electricity consumptions of 192 flats. Whereas PV systems cannot always provide the electricity in order to fulfill the energy demand, the connection with the electricity grid has been realized.

- Energy production: 674-830 kWh/kWp a;
- Power of the system: 163 kWp;
- Energy demand/consumption: 10 682 KWh.

References: [3] Comune di Alessandria. Alessandria's Photovoltaic Village. Edited by Comune di Alessandria in collaboration with Consulta per l'Edilizia Residenziale e le Infrastrutture della Provincia di Alessandria, pp 1-48.

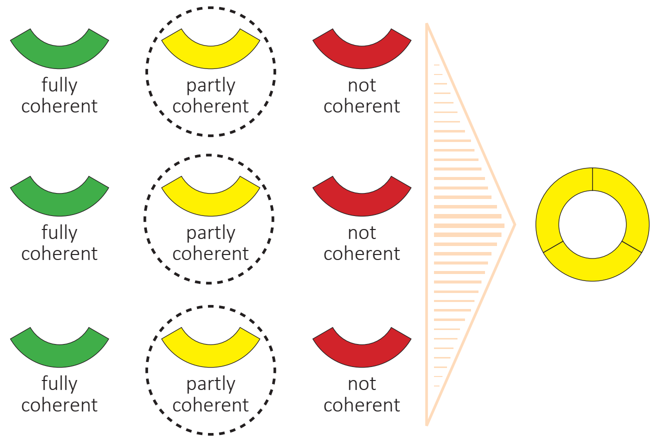
Architectural Quality - system Visibility - context Sensibility

Figure 5 - System geometry [4] erial view on BAPV systems on roof (Source: © Municipality of Alessandria)

Figure 6 - System modular pattern [3] The PV panels installed on façade of the row houses of the district (Source: © PierFranco Robotti).

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



COMMENTS

The system applied on the roof is overlaid and not integrated. The system applied on the façade, hereby analyzed, covers a rectangular portion of the façade; nevertheless, the architectural composition logic is not clear. The blue solar cells contrast with the color of the underlying façade and the modules are not designed as an integral part.

References: *[4] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 7 - High visibility of the PV panels installed on façade of the row houses of the district (Source: © Google).

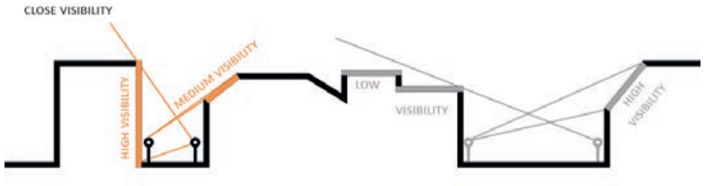


Figure 9 - Different levels of visibility of city surfaces from public domain.

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	**HIGH**	**MEDIUM**	**LOW**
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	●	○
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

In general, the programme sets itself the objective of creating an inter-connective "continuum" through the integration with the surrounding industrial context. The aim is to facilitate the recovery of a precise urban identity, with an harmonic integration of residency, with equipped public green areas, services and traffic routes.

In consideration of the fact that the buildings does not have any historical value, there is no presence of monuments nor meaningful elements, the zone can be considered at medium sensitivity.

SYSTEM VISIBILITY

By considering an hypothetic observer at ground level in the public space, the close visibility has to be considered medium for the solar collectors installed on the roofs of the residential blocks, while for the parts where PV panels are installed on the façade, the close visibility is very high.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT. (click here to download)

Figure 10 - Pedestrian public area covered by PV. (Source: © Municipality of Alessandria)

ENVIRONMENTAL IMPACT

The approach adopted during the design was aimed at respecting the environment, in accordance with eco-sustainability and biocompatibility principles. For instance, the social center has been realized in thermo-insulating bricks, with external coating in wooden panels, roofing with a laminar wood structure and wooden boards.
Moreover, during the design process the study of green areas and urban furniture has been carried out in order to create some bioclimatic areas for building users [3].

ECONOMIC IMPACT

The project was financed by different financial sources, both public and private. The initiative, has received a public residential financing by the region, due to its environmental sustainability implications (taking first place in the competition for the assignment of the, "Award for Sustainable Cities 2000", announced by the Ministry of the Environment). It was also financed by the region itself, with a contribution of 210 000 euro to the City of Alessandria, corresponding to 65% of the finance investment for application of the photovoltaic technology, entirely paid to the operators. An innovative business model was implemented to realize the project and involved both public and private partners [3].

SOCIAL IMPACT

The project envisioned a significant provision of public green areas for strolling and relaxing, for physical activities and for providing opportunities for people to meet and socialize (i.e. iron pylon with the photovoltaic unit, which shades benches and seats and a social center) [3].

References: [3] Comune di Alessandria. Alessandria's Photovoltaic Village. Edited by Comune di Alessandria in collaboration with Consulta per l'Edilizia Residenziale e le Infrastrutture della Provincia di Alessandria, pp 1-48.

Figure 11 - Wiew of the residential complex of Piazza Pertini (Source: © Municipality of Alessandria)

ANALYSIS

Monitoring is carried out to evaluate the functioning of the PV installation and measure the amount of electricity generated by the system, in operational conditions, correlating the absorbed energy values with the levels of solar radiation and other climatic variables. The monitoring system includes:

- Solar irradiation measurement center.
- Precision PT100 with 1/3 DIN external temperature sensor, calibrated for approx. 0.1°C difference in temperature.
- Relative humidity sensor.
- DT 500 Data Logger with 10 PT100 channels (4 cables).

The system permits data acquisition with variable frequency, with average values taken every 15 minutes. Data downloading, carried out every two weeks, makes it possible to periodically check the data precision and acquisition system [3].

The activity is structured in the following phases:

- Significant data collection;
- Simplification of data in typical progress and function curves (daily, weekly, monthly);
- Verification of functional conditions and any critical factors in the remaining photovoltaic village systems.

The continuous variables measurement campaign was developed over a period of twelve months (September 2004 - August 2005), in order to make it possible to construct an annual function profile [3].

RESULTS

The realisation of “Alessandria’s Photovoltaic village” was developed within the context of a complex initiative, undertaken by the Alessandria Municipal Council relative to the subjects of sustainability in Public and Private Residential Construction and integration of those actions that helped realize such a highly specific project. The national and international success of the Photovoltaic Village lies- and it could hardly be otherwise- not in the volumes realized but in the method, in the process experimentation. Its small scale can therefore always be extended and re-elaborated [3].

References: [3] Comune di Alessandria. Alessandria’s Photovoltaic Village. Edited by Comune di Alessandria in collaboration with Consulta per l’Edilizia Residenziale e le Infrastrutture della Provincia di Alessandria, pp 1-48.

APPROACH

Research and monitoring activities for assessing the efficiency of the PV systems have been conducted by the researchers of the Politecnico di Torino.

Some PV systems have been monitored and their data have been collected during a period of 12 months, with a frequency of two weeks. At the same time, also the data of the electricity grid have been collected. In such a way, the electricity produced by PV generators have been compared with the electricity absorbed from buildings. From this analysis it arises that the electricity demand is fulfilled for seven months by the PV systems, but the supply of the electricity grid is needed.

RESULTS AND DISCUSSION

The economic verification of the solution is carried out taking into account the net costs of the photovoltaic systems, in the absence of regional, national and/or community incentives.

The cost of electricity absorbed by ENEL (Ente nazionale per l'energia elettrica) is assumed to be equal to, 0.16 €/kWh, corresponding to an average residential consumption category. As regards to the the sampled buildings, the energy produced per kWp of photovoltaic system varies from 674 to 830 kWh/year, with an avoided cost in regards to electricity equal to 108-133 €/kWp a year and with consequent depreciation of the capital invested varying between, 38 and 46 years.

Figure 12 - Aerial view of the whole district. (Source: © Municipality of Alessandria)

Figure 13 - Internal view of the park in the courtyard of the district. (Photo: © PierFranco Robotti)

LESSONS LEARNED

The national and international success of the Photovoltaic Village lies not in the volumes realized but in the method, in the process experimentation. The true result of all the work has been expressed by the methodological definition of a process, including- initially, during and subsequently- actions and checks that have affected all the procedures, starting with the definition of the role of actors and their coordination. To achieve all this it was necessary "to reason" ex ante about the necessary instruments, and ex post about the verifications concerning the objectives.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

New considerations over architectural integration of photovoltaics should be considered for similar future urban plans. In this case study the photovoltaic technological innovation has been applied in an original manner on building work aimed at the medium low category of the population, through appropriate instruments such as executive urban planning and the integrated programme, which have imposed, in regard to their differing provisions and regulations, a specific time schedule relative to urban constraints and realization phases, leading to the complete performance of the intervention well in advance of the estimated time.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners

PUBLIC AND EDUCATION ACTIVITIES

Workshop "Renewable energies in new urban installations"- Energy savings agency of Rome;

Workshop for the working group connected to "HIP.HIP Project" at Nizza (France).

(Photo: © Municipality of Alessandria)

ARCHITECT, DESIGNER AND DEVELOPER

A4- Architettura Integrata

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RESEARCH ORGANIZATIONS

Università degli Studi di Padova

ACKNOWLEDGEMENTS

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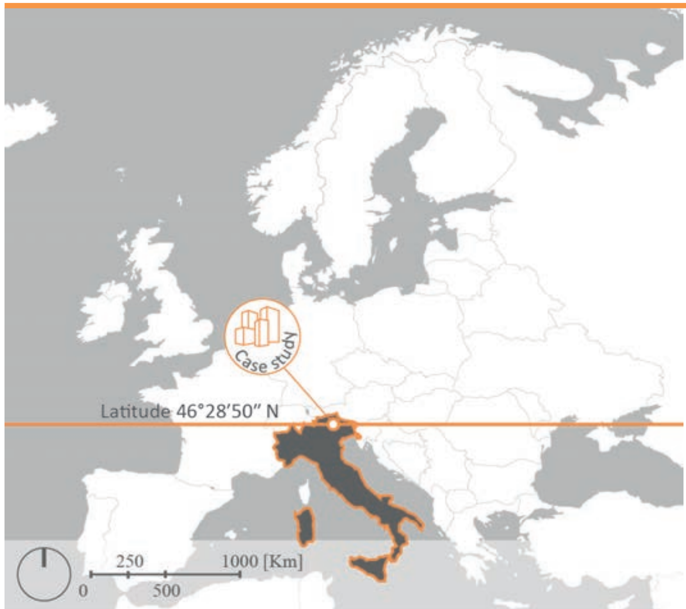
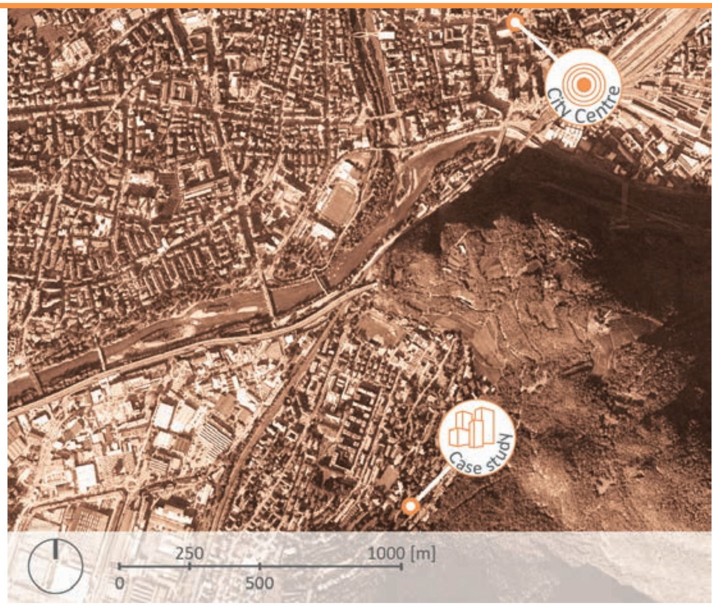
SINFONIA

ITALY

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Italy
Location: Bolzano (Lat. 46°28′50″ N; Lon. 11°20′48″ E)
Climate: Warm temperature, fully humid, warm summer (Cfb) [1]

AREA OF INTEREST

- Target and goals
- Planning process

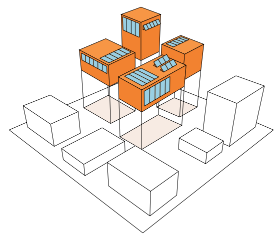
NATIONAL AND LOCAL CONTEXT

The European project SINFONIA [2], which stands for "Smart INitiative of cities Fully cOmmitted to iNvest In Advanced large-scaled energy solutions", is a five-year initiative to deploy large-scale, integrated and scalable energy solutions in mid-sized European cities. Technical and technological innovative solutions are being implemented in two demo-cities, Bolzano (IT) and Innsbruck (AT), with the aim to transform them into smart cities and to propose solutions easily replicable and adoptable by other European cities.

Bolzano is the capital of the province of South Tyrol, in northern Italy. The work undertaken in the framework of SINFONIA comply with the commitment of the Municipality to reduce energy consumption and increase the share of renewables [3], and with its investment plan for large scale urban refurbishment.

ABOUT THE CASE STUDY

Within the framework of SINFONIA, building refurbishment interventions to achieve high energy performance and to improve interior comfort have been undertaken for six residential complexes in the district of Bolzano South, for a total of 422 dwellings. Among those, the apartment complex located in Passeggiata dei Castagni, which consists of two blocks, each made of 36 flats.



Definition of environment:
Existing urban fabric

Site area: 1 750 m^2
Building area: 7 877 m^2

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Sinfonia. Low Carbon Cities for Better Living. Available at: www.sinfonia-smartcities.eu
[3] Municipality of Bolzano, Eurac Research. (2014). Piano d´Azione per l´Energia Sostenibile di Bolzano (Sustainable Energy Action Plan).

Issues, Challenges and Decision Strategies

Figure 1 - Map of the city of Bolzano with key figures and indication of the different interventions carried out in the context of SINFONIA project. The complex of Passeggiata dei Castagni is highlighted in red. (Source: © SINFONIA)

Figure 2 - Current status: view from the North side of one of the buildings in Passeggiata dei Castagni. (Photo: © Eurac Research)

HIGHLIGHTS OF THE CASE STUDY

The actions undertaken in Bolzano within the SINFONIA project focus on three main areas:

- Building refurbishment: 37 000 m² of social housing buildings retrofitted in order to improve energy performance and interior comfort;
- District heating and cooling: optimization and extension of the heating and cooling grid to reduce CO_2 equivalent and nitrogen oxides emissions;
- Electricity grid: implementation of an Urban Service-Oriented Sensible Grid (USOS-grid) system for improved energy distribution control.

The measures applied in the project of Passeggiata dei Castagni include: building envelope retrofit with multifunctional façades, and integration of renewable energy sources for electricity, heating, and domestic hot water.

ISSUES AND CHALLENGES

With regard to the implementation of solar energy in the project of Passeggiata dei Castagni, the main issue is the location of the complex in a shelter of a mountain to the Southeast side, which limits the possibilities of solar systems´ integration. Furthermore, due to the presence of four stairwell towers above the roof level of each building and the shading created by these elements, the position of PV panels has to be investigated very carefully.

In general, the retrofit interventions of Passeggiata dei Castagni face the following main constrains:

- The intervention should have the minimal possible impact on the tenants who occupy the flats during the renovation;
- The Southeast sides of the buildings are almost inaccessible because of the mountain slope and the small space between the building and the retaining wall.

DECISION STRATEGIES

During the design phase of Passeggiata dei Castagni, an Integrated Design Process (IDP) was applied by involving the different stakeholders of the project.

With regard to the energy concept, the following targets has been set as constraints, which the final performance of the buildings after the renovation interventions has to comply with:

- Final energy balance ≤ 22.52 kWh/(m² a);
- DHW from renewable energy ≥ 9 kWh/(m² a);
- PV plant installation ≥ 53 kWp for the whole complex.

Futhermore, optimizing the design of the solar system and improving daylight level of the apartment was also examined.

The planning process

Within SINFONIA project, the refurbishment of the residential complexes in Bolzano is following a process constituted by three steps:

1. Design phase guided by an interdisciplinary team;
2. Construction phase with lived-in apartments;
3. Monitoring phase lasting for 1 year.

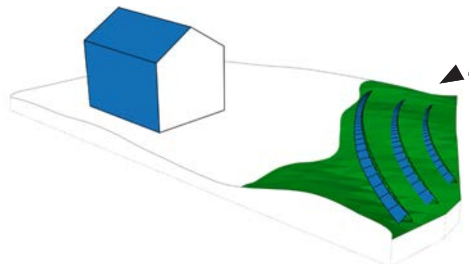
During the design phase of Passeggiata dei Castagni refurbishment project, the Integrated Design Process (IDP) was applied. The IDP is a multidisciplinary collaborative process that analyses and integrates different aspects and knowledge during all phases of a building development.

The project team of Passeggiata dei Castagni integrated the performance target set by the SINFONIA technical requirements with other requirements defined by the customer, such as some extraordinary maintenance, correction and adjustments to certain faults of the building. A deep analysis of the existing buildings has been carried out and several possible energy concepts have been developed.

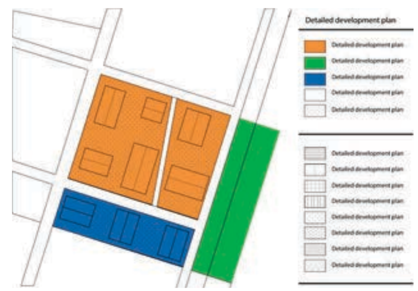
The stakeholders involved in the Integrated Design Process are the Municipality of Bolzano, the designers of the project, researchers and Agenzia Casaclima (i.e. certification body for the energy efficiency of the construction sector).

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

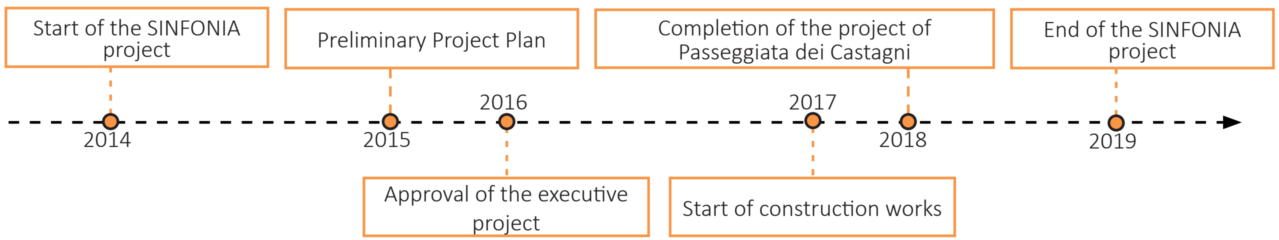


At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.



Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: © White Arkitekter)



The research process

SINFONIA is a Smart Cities project that aims to demonstrate the deployment of large-scale, integrated and scalable energy solutions in mid-sized European cities in view of fostering the uptake of smart energy efficient solutions Europe-wide and improving citizens' quality of life [2].

The SINFONIA project aims to:

- Achieve 40 to 50% primary energy savings and increase the share of renewables by 20% in pioneer districts in Innsbruck and Bolzano;
- Demonstrate the feasibility of large scale energy measures, combining building retrofitting, electricity grid optimisation, and district heating and cooling systems;
- Define district typologies and refurbishment models to ensure their scalability and transferability to other cities;
- Engage and support other cities in deploying their own smart energy solutions in view of triggering the deployment of smart energy solutions EU-wide.

Scalability and transferability of SINFONIA solutions will further be ensured by the active involvement of five 'early adopter' cities in the project, namely La Rochelle (FR), Rosenheim (DE), Pafos (CY), Seville (ES) and Borås (SE). Furthermore, the experiences of the DEMO cities and the 'early adopter cities' will be shared to other European cities and communities interested in implementing their own district-scale refurbishment strategies (i.e. 'replication cities').

Launched in June 2014, SINFONIA is set to run until May 2019.

Figure 4 - SINFONIA Pilot Cities and key figures of the project. (Source: © SINFONIA)

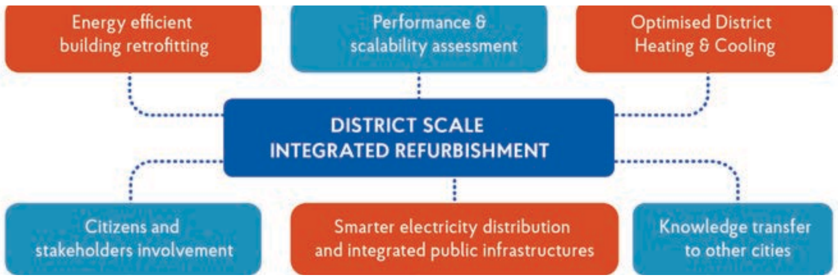


Figure 5 - Main actions of SINFONIA project. (Source: © SINFONIA)

References: [2] Sinfonia. Low Carbon Cities for Better Living. Available at: www.sinfonia-smartcities.eu

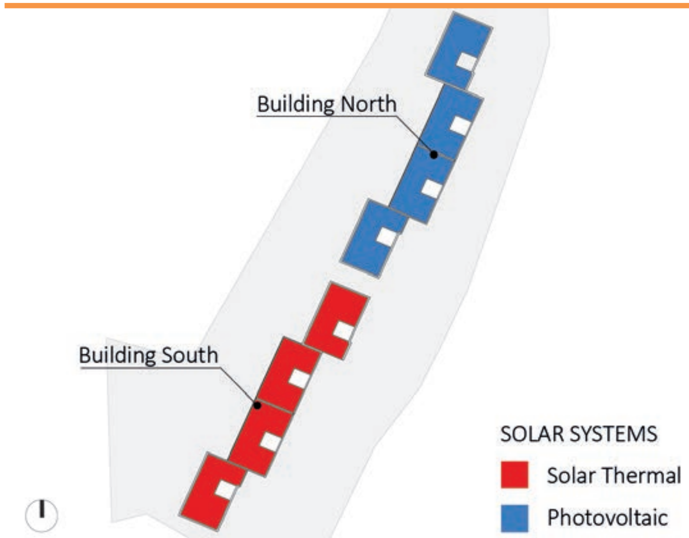


*Figure 6 - Disposition of the buildings in the lot of **Passeggiata dei Castagni** and identification of the solar system installed on each one. **(Source: © Eurac Research)***

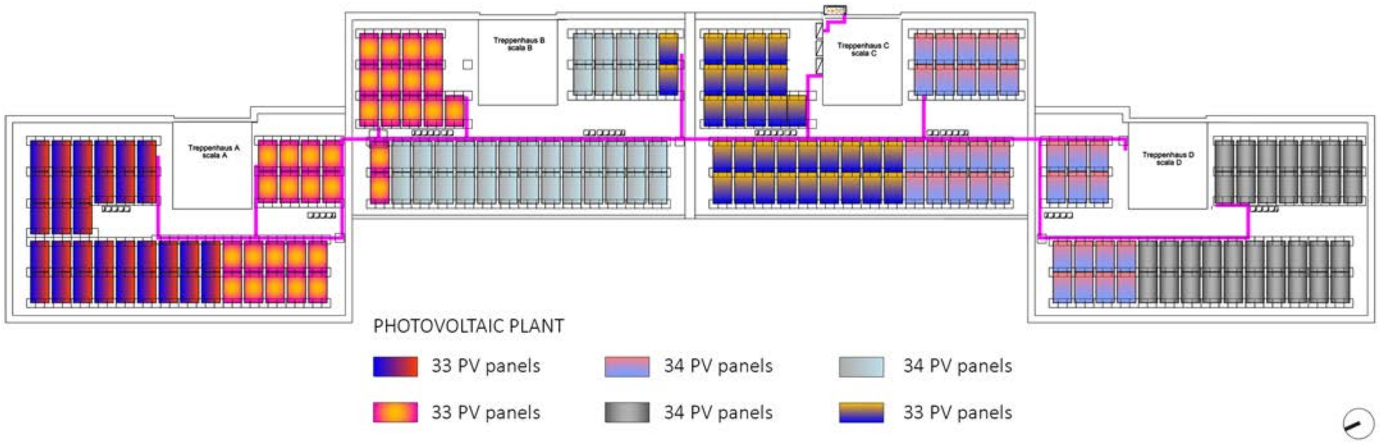


*Figure 7 - Technical plan of the photovoltaic system to be installed on the roof of Building North. **(Source: © EQ Ingegneria)***

SUMMARY

The apartment complex was built during the 90's without any energy saving criteria unless thin insulation layer inside external walls. Therefore, the building renovation strategy is based on a comprehensive approach and on the implementation of different interventions:

- Envelope retrofit to increase the indoor comfort, reduce the energy consumption and rehabilitate both the aesthetic and the functionality of the building;
- Geothermal heat pump;
- Installation of photovoltaic and solar thermal systems.

The solar systems, both PV and ST, are installed on the roofs of the buildings as added elements, hence in a not integrated way.

PV SYSTEMS

A photovoltaic plant has been designed on the roof of Building North. The panels are oriented following the direction of the building and installed horizontally for avoiding their mutual shadowing.

The PV system has the following characteristics:

- Type of system: polycrystalline silicon PV modules (15.51 % efficiency)
- Tilt angle: 0°
- Total area: 337 m^2 (201 panels)
- Energy production: 5.61 kWh/(m^2 a)
- Power of the system: 52.26 kWp

ST SYSTEMS

On the South Building, a solar thermal system covering will be installed by covering the majority of the roof´s surface. The plant is intended exclusively for the production of DHW, in compliance with the national legislation that requires 35 % of the energy needs for DHW to be covered by RES [3].

The ST system has the following characteristics:

- Type of system: flat solar thermal collectors;
- Tilt angle: 10°
- Total area: 476.9 m^2
- Energy production: 11.19 kWh/(m^2 a)

References: [3] Italian Republic. (2011). Legislative Decree no. 28 of 3/3/2011 "Attuazione della direttiva 2009/28/CE sulla promozione dell'uso dell'energia da fonti rinnovabili".

Figure 8 - North Building: render of the project. (Image: © Studio Mellano & ARCH+MORE)

Figure 9 - North Building: current status. (Photo: © Eurac Research)

ENVIRONMENTAL IMPACT

Beyond technological solutions, SINFONIA addresses districts as living spaces, and therefore integrates air quality and smart mobility measures to improve the citizens' quality of life.

The installation of 150 smart points is planned in Bolzano. They will serve for recharging electric vehicles, weather and air quality monitoring, info and services for the citizens, and lighting of public spaces.

ECONOMIC IMPACT

The total cost of the planned SINFONIA interventions in Bolzano is 15 million Euros, of which 8.7 are covered by the European Union.

In the feasibility study for the refurbishment project of Passeggiata dei Castagni, the total cost for the interventions was estimated in 3.2 million Euro. However, the cost has increased to 4.8 million Euro in the final project, mostly due to the large use of the renewable energy sources.

The costs of the solar systems are the following:

- Photovoltaic: 95 000 €;
- Solar Thermal: 253 700 €.

SOCIAL IMPACT

Occupants have an impact on the energy performance of their own buildings, due to their presence and their behaviour. Specifically, they have a strong influence on both the energy consumption (i.e., energy needs for space heating and cooling) and the indoor environment conditions (i.e., natural ventilation rates, air temperature control, etc.). For this reasons, the tenants of the apartments being refurbished have been involved in the SINFONIA project through informative meetings and questionnaire-based surveys.

After the renovation, the tenants will be involved in the analysis of their behaviours through information points installed in the apartments showing the electricity consumption of their appliances.

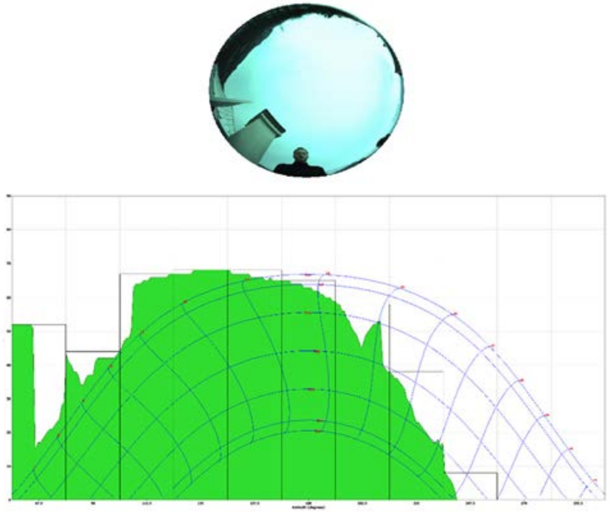


Figure 10 - Determination of the horizon line from the data acquired with the solmeter Suneye. (Source: © Eurac Research)

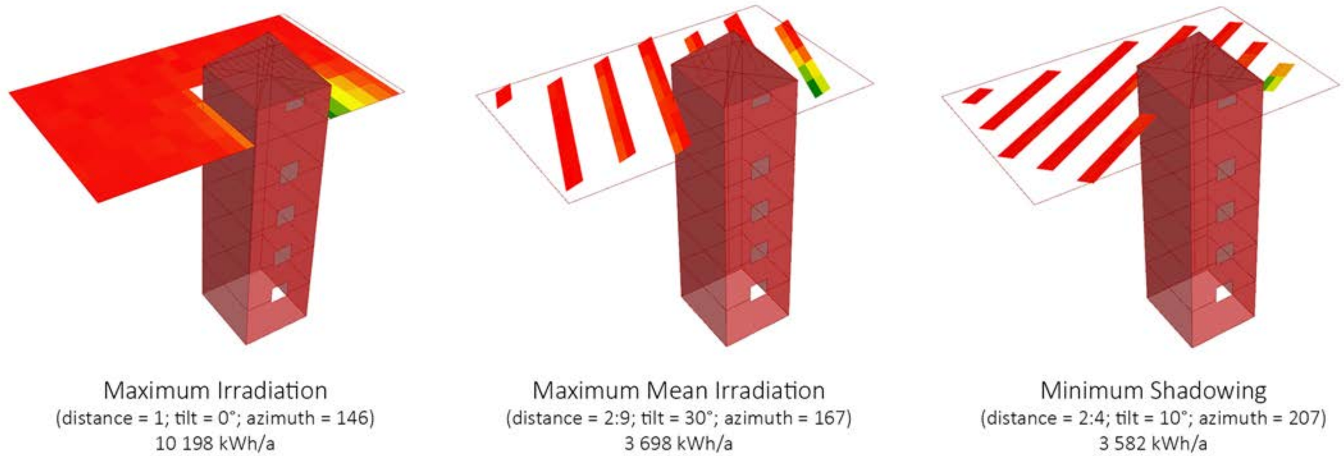


Figure 11 - Results from the solar potential analysis on a portion of the roof: parameters maximizing each configuration and potential energy production for each case. (Source: © Eurac Research)

INTEGRATED DESIGN PROCESS

For the building envelope retrofit, the design team evaluated three different hypothesis and chose a mixed solution with traditional insulation in the lodges and use of prefabricated multifunctional façades (MFF) covering other surfaces. This solution allows intervening in the traditional way in the lodges without the use of scaffolding and with prefabricated facades, which do not require scaffolding, for the rest of the structure. In this way, the construction phase is simplified and speeded up. Furthermore, in order to define the best solutions for the MFF, a prototype was constructed and tested in laboratory.

For the choice of the heating plants, different scenarios and technologies were evaluated according to criteria such as energy performance, maintenance, and regulatory restrictions.

SOLAR POTENTIAL ANALYSIS

The IDP has also focused on the definition of the solar systems to be installed on the buildings. In order to distinguish the optimal solution and to assess the potential energy production, the total annual irradiation has been estimated for different configurations of the modules by running simulations in Radiance and Diva-for-Rhino. In the simulation scene, a map generated on the base of the data measured with the solmetric Suneye has been used for the distant shadings, such as those caused by the mountain at South Building. The close shading elements (e.g. the stairwell towers) have been modelled and analysed directly in Rhinoceros environment. The parameters set for the analysis are the followings:

- Distance between two consecutive rows of panels (varying from 1 to 3 times the dimension of the panel itself);
- Tilt (varying from 0° to 90°);
- Azimuth (varying from 0 to 360).

Since the majority of the horizon at South Building is covered by the mountain, also the possibility to orient the panels toward the North Building has been studied.

A genetic algorithm has been applied in order to obtain the most relevant results, focusing on:

- Maximization of the total annual irradiation;
- Maximization of the average irradiation;
- Minimization of the overshadowing on the panels.

Furthermore, solar potential of façades has been evaluated by estimating the potential energy production of photovoltaic systems on the Southwest and Northwest façades.

The results of this analysis have been used as guidance for the choices adopted in the approved executive project.

DAYLIGHT ANALYSIS

The design team focused attention on the visual comfort inside the living spaces. The installation of the new multifunctional façades causes the reduction of daylight level inside the apartments. Therefore, daylight simulations have been performed with Radiance´s plug-in for Rhinoceros to evaluate the mean daylight factor (MDF). Details like windowsills' material and loggias' finishing colors were investigated in the simulation process in order to improve the reflected rate of sunlight. The different configurations have been tested and indications regarding the visible light transmission of the window (Tvis) and the solar reflectance of the finishing materials (Refl) have been given to the designers in order to guarantee the minimum mean daylight factor (MDF≥ 2 %) in compliance with the Italian legislation [4].

Furthermore, the use of metallic parapets with steel bars instead of the existing concrete elements has been designed to improve the apartments internal daylight.

RESULTS AND DISCUSSION

As a result of the conducted IDP, the final project of Passeggiata dei Castagni has become the most innovative project among all the SINFONIA sites in Bolzano South district. The energy retrofit of the buildings integrates the application of innovative multi-functional prefabricated façades, heat pumps with geothermal energy, and photovoltaic and solar thermal systems. Although the design phase took longer time – due to the several simulations and analysis, and the test conducted in laboratory - several risks and uncertainties that could appear during the construction phase were reduced. This allows also the decrease of the refurbishment time.

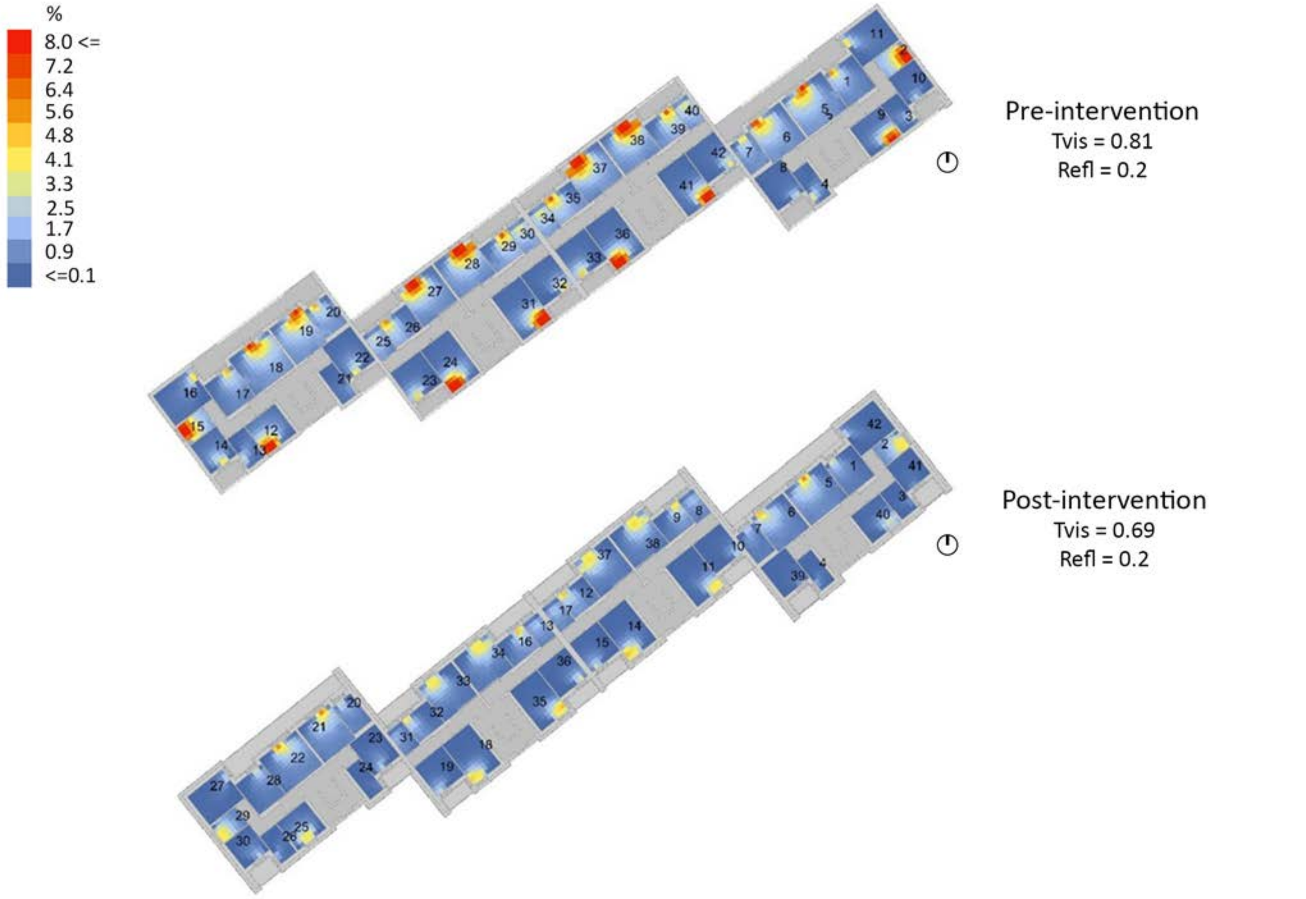


Figure 12 - Daylight analysis for the first floor of the Building South. Tvis: visible light transmission of the windows - Refl: reflectance value of the finishing materials of the loggia´s floor and windowsills. (Source: © Eurac Research)

References: [4] Italian Republic. (1975). Ministerial Decree of 5/5/1975 "Modificazioni alle istruzioni ministeriali 20 giugno 1896 relativamente all´altezza minima ed ai requisiti igienico-sanitari principali dei locali d´abitazione".

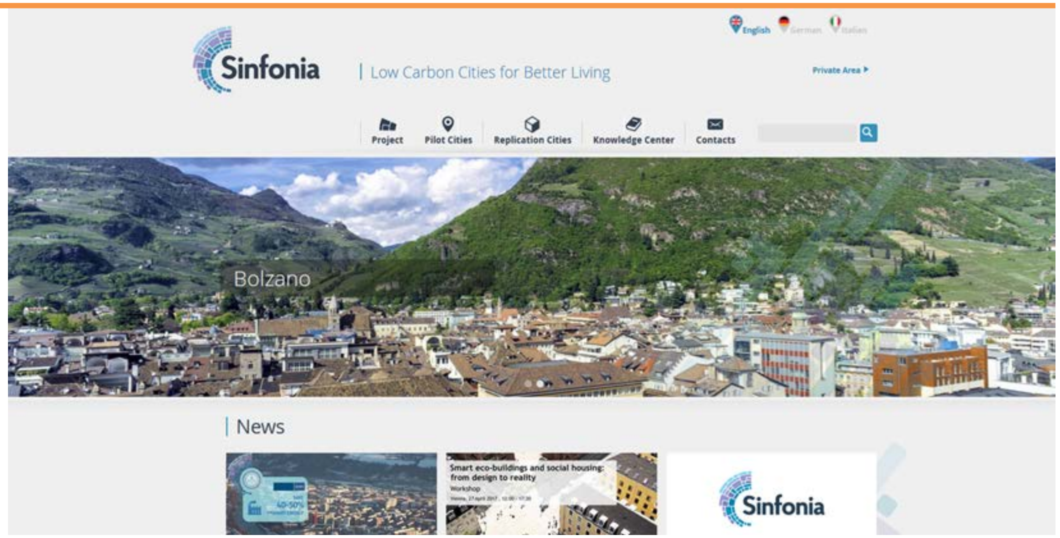


Figure 13 - Sinfonia web-site. (Source: © sinfonia-smartcities.eu)

LESSONS LEARNED

The SINFONIA project is still ongoing and will be completed in 2019. Therefore, the lessons learned will continue to evolve together with the different phases of the project.

The essential lesson learned from the design and planning phase regards the positive influence of IDP on the energy efficient related design of the buildings. The level of collaboration between energy consultants, designers, owners, researchers, and technicians is fundamental for a successful development of the project.

Furthermore, the case study demonstrates the key role played by daylight and solar potential analysis during the design phases of retrofit projects. The former can assist the choice of windows and buildings´ finishing materials in order to enhance the level of internal comfort. The latter can support the integration of solar active systems on the edifices by avoiding overshadowing and enhancing the energy production.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

A comprehensive approach considering the combination of all the different technical and technological aspects of the project is fundamental for the success of urban districts´ energy refurbishment initiatives. All the stakeholders should be involved from the early design phases.

The common design process for energy retrofit does usually not incorporate the buildings' occupants behaviour and their effect on the buildings related energy performance. However, whenever an energy refurbishment of existing buildings is undertaken, the occupants' influences should be examined.

PUBLIC AND EDUCATION ACTIVITIES

The solutions developed in the framework of the SINFONIA project are being presented at different conferences and fairs. Furthermore, the website www.sinfonia-smartcities.eu is maintained up to date. The website contains information on the pilot and replication cities, and links to deliverables and research papers on the project.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects
- Researchers
- Technology providers

ARCHITECTS, DESIGNERS AND DEVELOPERS

Studio Mellano Associati, Arch+More, Arch. Alberto Sasso, Studio Benedikter, EQ Ingegneria, Studio Tecnico Vettori, Ing. Giuseppe Glionna

STAKEHOLDERS

Municipality of Bolzano, IPES, alperia, SEAB, Agenzia per l'Energia Alto Adige - Casaclima

CASE STUDY AUTHORS

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OWNER

Municipality of Bolzano

SCIENTIFIC AND TECHNICAL PARTNERS

Eurac Research, ACC, TISS

RESEARCH ORGANIZATIONS

eurac research

RESEARCH FRAMEWORK

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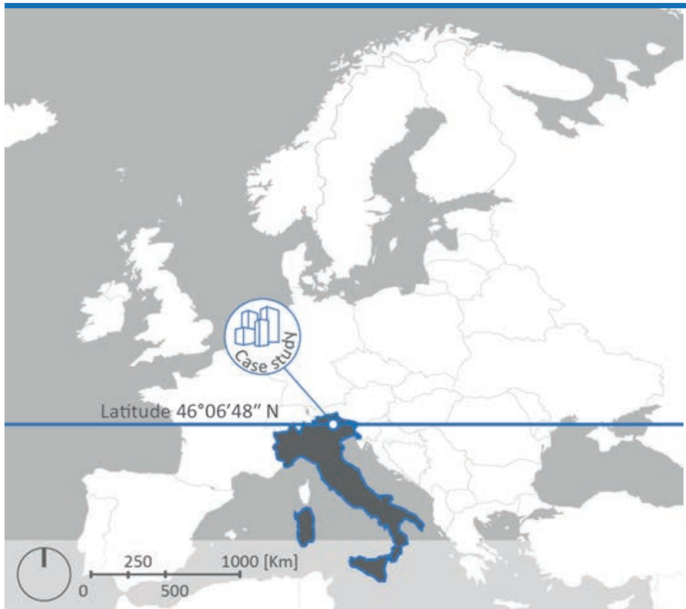
ACKNOWLEDGEMENTS

The author wish to thank Municipality of Bolzano, Studio Mellano Associati, Arch+More, Arch. Alberto Sasso, Studio Benedikter, EQ Ingegneria, Studio Tecnico Vettori, Ing. Giuseppe Glionna for the information on the project and for the images.

LE ALBERE

ITALY

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Italy
Location: Trento (Lat. 46°07′48″N; Lon. 11°12′17″E)
Climate: Warm temperature, fully humid, warm summer (Cfb) [1]

AREA OF INTEREST

- Target and goals
- Legislation and technology

NATIONAL AND LOCAL CONTEXT

The Italian national legislation on energy planning sets the targets for renewable energy production by 2020 without defining any specific target with regard to the implementation of solar energy [2]. Similarly, the urban planning instruments at national, regional and municipal level support the use of renewable energy systems without forcing the use of solar energy. Therefore, the definition of the energy strategies for new urban development districts and the integration of solar systems in their design is mainly left to the single municipalities, urban planners and stakeholders involved in each project.

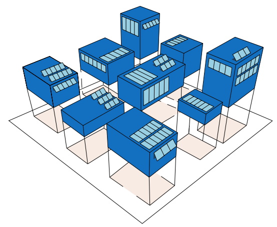
The district of Le Albere is located on a former industrial site in Trento, in the North of Italy. The urban renewal project for the area has been designed by Renzo Piano and has seen the direct involvement of the Municipality through its planning instruments [3].

ABOUT THE CASE STUDY

Le Albere is a new development district enclosed between the river Adige, at West, and the railway line, at East. The urban renewal project aimed to reconnect the area both to the city center and to the surrounding natural context, defined by the river Adige and Monte Bondone. It includes a mixed use district, a public park, the science museum MuSe and the library of the University of Trento.

Definition of environment:
New Urban Areas

Site area: 116 000 m^2
Building area: 97 600 m^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Italian Republic. (2011). Legislative Decree no. 28 of 3/3/2011 Attuazione della direttiva 2009/28/CE sulla promozione dell'uso dell'energia da fonti rinnovabili
[3] Comune di Trento. (2003). Piano strategico della cittá di Trento 2001-2010.

Issues, challenges and decision strategies

Figure 1 - *Aerial view of the district. (Source: © Google Earth)*

Figure 2 - *Masterplan of the entire project. (Source: © RPBW)*

Figure 3 - *Mixed-use buildings. (Photo: © Silvia Croce)*

HIGHLIGHTS OF THE CASE STUDY

The renewal of the former industrial area and the project of Le Albere district had two main goals:

- Town planning: reconnecting the site with the city center, giving back its urban role;
- Sustainability: reaching high quality of life, low energy consumption and eco-sustainability.

Photovoltaic modules have been integrated in all the buildings of the district, in the MuSe and in the University Library, representing one of the most important and unifying features of the entire project.

ISSUES AND CHALLENGES

One of the main issue of the case study was the formal integration of the PV systems in the architectural design of the district. The architect Renzo Piano decided to use the PV modules as key elements in the aesthetic composition of the district instead of hiding or camouflaging them. For this reason, the main challenge in the design of the BiPv system was the customization of the PVmodules in order to satisfy the architect´s requirements in terms of appearance, colour and dimensions, keeping at the same time the costs in an acceptable range.

DECISION STRATEGIES

“A development of great quality for the urban and architectural planning of the area, in order to pass on the sign of the best contemporary urban and architectural and culture to future generations.”
- Municipality of Trento [4]

Energy efficiency and eco sustainability are key priority areas in guiding the entire project, taking into account both the integration of renewable energy sources and the minimization of the environmental impact.

References: [4] Municipality of Trento. (2010). Variante parametri edificatori area C5 ex Michelin.

THE PLANNING PROCESS

The area of Le Albere was a former industrial site, occupied since 1927 by the Michelin factory. In 1998 the factory ceased its activity and a group of local public and private entrepreneurs, Iniziative Urbane, purchased the area.

The following year, the Province of Trento comprised the renewal of Le Albere into its Program for Urban Regeneration and Sustainable Development of the Territory (PRUSST), which was approved by the Ministry for Public Works in 2000. The project was also one of the main actions of urban regeneration included in the Trento Strategic Masterplan 2001-2010 [3]. The plan zoned the area as C5A, subject to urban renewal, it included several measures to improve the accessibility of the area and to reduce carbon emission, such as pedestrian paths, new connections with the city and a public park. In 2002, after a first announcement of a public design competition, Iniziative Urbane designated directly the architect Renzo Piano and his study RPBW as designer of the project. In March 2004, the Municipality of Trento approved the masterplan proposed for the area by Renzo Piano. The final zoning plan of Quartiere Le Albere was approved by the Municipality in 2005. In accordance to the plan, after the ratification of the convention between the Municipality and Iniziative Urbane, 70000 m^2 of the total area (116 000 m^2) have be allocated to a public destination [5].

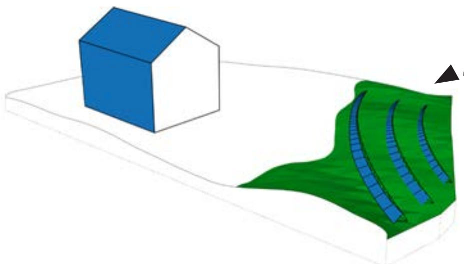
The project obtained the Construction Permit from the Municipality in 2006. Successively, in March 2009, a modification to the Permit was approved for an update of the project to introduce the PV system.

The construction site of both the mixed-use district and the MuSe opened in 2008 and finished in 2013. The entrepreneurship Iniziative Urbane has entrusted the management of the real estate initiative to the Clesio fund, a real estate fund reserved to institutional investors, managed by the Castello Srg S.p.A.

The library of the University of Trento which is located in the South sector of the area was inaugurated in November 2016.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

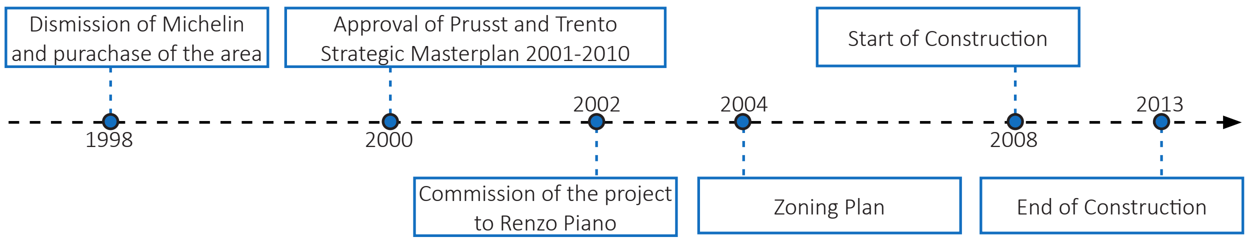
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [3] Comune di Trento. (2003). Piano strategico della cittá di Trento 2001-2010.
[5] Cribari, V. (2011). Albere a Trento il nuovo quartiere di Renzo Piano. EWT Eco Web Town – on-line Magazine of Sustainable Design. Retrieved from: http://www.ecowebtown.it/n_4/pdf/11_cribari_it.pdf

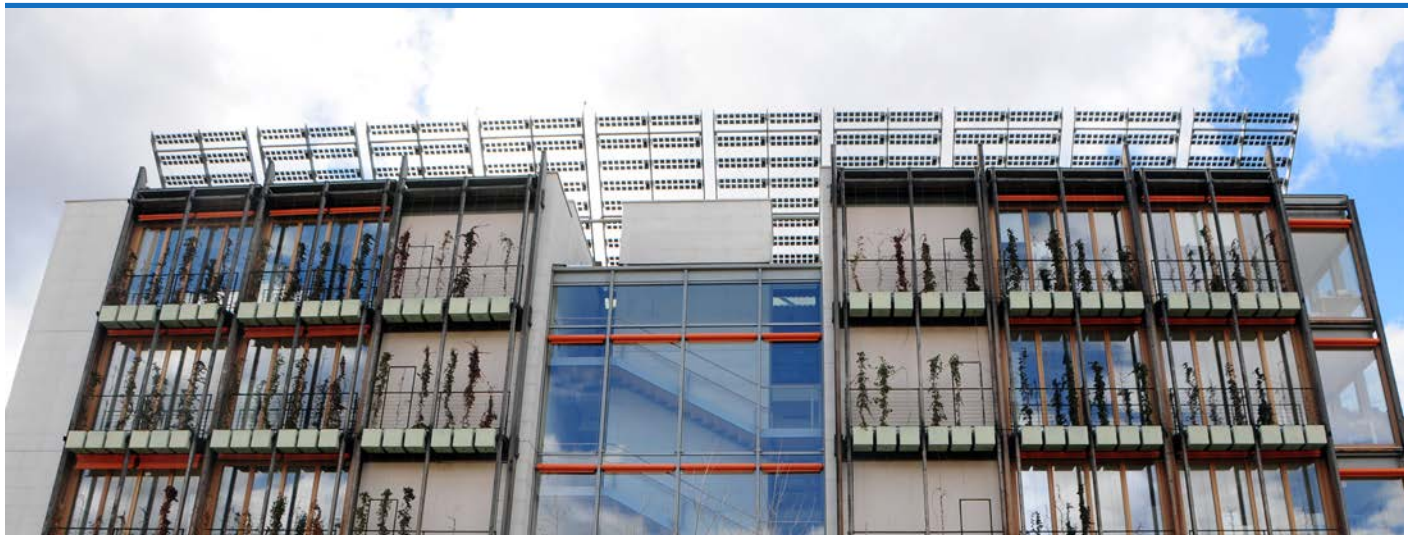


Figure 4 - PV systems on the roof of the commercial buildings facing the railway at the west side of Le Albere. (Photo: © Silvia Croce)

Figure 5 - The two tipologies of BiPV systems: Tedlar-glass modules on the zinc roof and glass-glass modules (Photo: © Silvia Croce).

Summary

The energy provision of the buildings in Le Albere district is guaranteed by systems exploiting different renewable energy sources. The energy production of the BiPV plants supplies the electrical demand of offices, common spaces, pump rooms, and the lighting in the basemen area. A central combined cooling, heating and power (CCHP) plant covers the energy demand for both heating and cooling in the whole district. The plant, located beyond the confines of the complex on the right shore of the River Adige, generates an electric power of 1 800 kW, a thermal power of 14 800 kW and a cooling power of 9 600 kW. In addition to this, there is a geothermal pilot plant serving the MuSe complex.

Technology

Polycristalline photovoltaic modules with silver colour have been integrated on the roof of MuSe and of the University library, and on both the roof and the façade of the buildings in the district.

BiPV system data:

- Nominal power: 279 kWp;
- Area: 3 258 m^2;
- Orientation (depending on the surface): South, West, East;
- Inclination (depending on the surface): 5°, 7.5°, 15° (Tedlar-glass modules on tilted roofs), - 12° (glass-glass modules).

Technological Integration

The BiPV systems consist of different typologies of custom made modules, specially designed for this project:

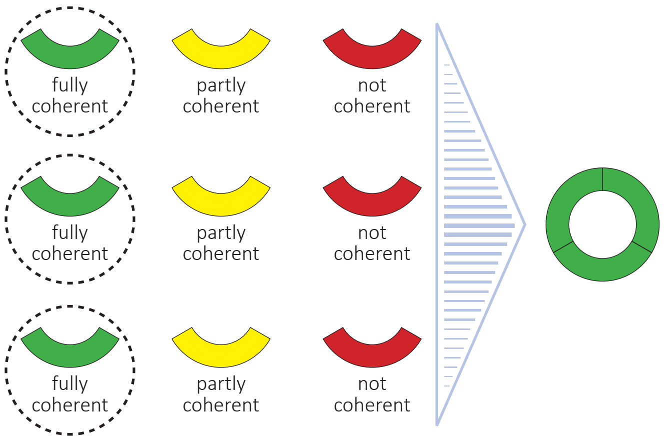
- 4160 Tedlar-glass modules 1600x400 mm with high efficiency solar cells are installed on the roofs. The modules are mounted on 520 aluminum frames, each containing 8 photovoltaic panels;
- 828 glass-glass modules 1600 x 400 mm are anchored to the roofs metal sheets with special clamps;
- 157 glass-glass modules are secured on the façades with specific aluminum clamps and serve as sun-breaker.

Figure 6 - System geometry: view of the PV systems integrated in the roofs from the terrace of the MuSe (Photo: © Silvia Croce).

Figure 7 - System materiality: glass-glass PV modules installed on the façades (Photo: © Silvia Croce)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

Criteria	Category
FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



References: *[6] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

COMMENTS

The roofing system, built with wood and steel structures, represents one of the most important and unifying features of the project Le Albere. Despite the diversity of the buildings functions, heights and inclinations, these elements work together to give visual unity to all the edifices. The roofs surfaces consists mainly of two materials: large opaque portions covered by zinc sheets and transparent glass parts supported by a metallic structure. The PV panels are fully integrated in this system. Their disposition follow the same steps of the modular structure of the struts. The BiPV systems installed on the façades repeat the pattern of the glass openings.
The silver colour of the modules is fully coherent with the architectural concept of the district and with the appearance of the zinc-coated surfaces on the roofs.

Figure 8 - North view of the science museum MuSe. The PV are integrated in the top surfaces of the roofs (Photo: © Silvia Croce).

Figure 9 - Perception of the PV systems installed on the zinc roofs and on the façades from the public park (Photo: © Silvia Croce).

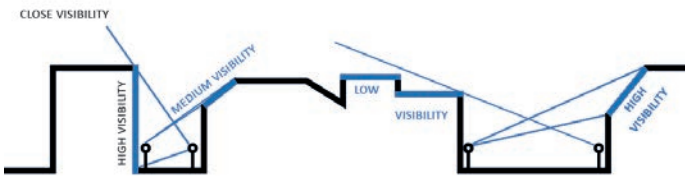


Figure 10 - Different levels of visibility of city surfaces from public domain.

CRITICITY

	HIGH	MEDIUM	LOW
CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	●	○
REMOTE VISIBILITY	○	○	●
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

Michelin factory was a symbol for Trento in the industrial era. It was located outside the historical centre of the city, but in the late 20th century the city expanded its boundaries, and the factory was included in the urban area. Today, the district is constrained between two barriers to the East and West: the railway, separating the area from the town's nearby historical centre, and the river Adige. A new underground was constructed for a section of Via Sanseverino, which acted as an urban boundary between the area itself and the river, in order to reconnect Le Albere with the river´s natural environment. The northern and southern edges of the district border with urban areas without any historical or architectural value. The only exception is Palazzo delle Albere, a renaissance villa-cum-fortress located at North. Therefore, the context sensitivity is evaluated as medium.

SYSTEM VISIBILITY

From a neighborhood perspective, the visibility of the PV systems varies from high to low depending on their position. The systems installed on the façades and on the glass surfaces of the tilted roofs are highly visible both from the internal roads and pathways and from the open area of the park. Portions of these systems are also visible from the roads bordering the district. In contrast, the visibility of the PV modules installed on the zinc roofs is low from the urban canyons in the district, while, from the courtyards and from the park, they are perceived as a geometric pattern.

The height and the dimensional scale of the buildings, 4 to 5 floors high, are comparable to those of the city´s historic center and the existing industrial structures. Therefore, the remote visibility of the systems from Trento´s urban area is low. The sparkling effect of the sun reflection on the modules is perceptible from the hills surrounding the city.

References: [6] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

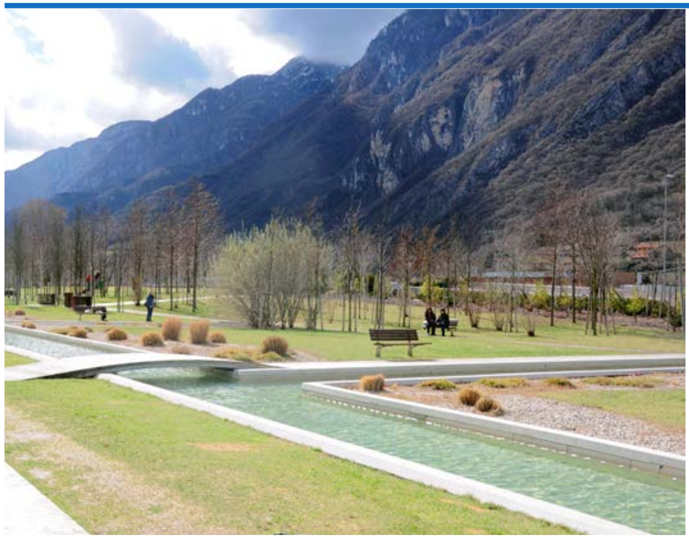


Figure 11 - The public park on the East area of the district. (Photo: © Silvia Croce)

Figure 12 - Green public spaces in the district. (Photo: © Silvia Croce)

Figure 13 - Interior spaces of the MuSe. The museum acts as one of the cultural attractive poles of the area. (Photo: © Silvia Croce)

ENVIRONMENTAL IMPACT

The project of Le Albere had sustainability as an integral part of the design. Local materials, such as wood and stone from the Trentino area, have been chosen in order to guarantee a low environmental impact.

The design of the district aimed at preserving the natural features of the area. The edifices are concentrated in the east part of the lot, in order to leave as much space as possible for the public park facing the river Adige. The park, including autochthonous species and water arrangement, creates an ecosystem aimed at improving the air quality and the outdoor comfort. Traffic in the urban fabric is restricted to residents, taxis and public transport and numerous pedestrian walkways cross the whole area.

Furthermore, the MuSe and the university library have received LEED Gold certification, and the residences and offices, built with passive standards, have obtained a level B CasaClima classification (i.e. energy efficiency certification).

ECONOMIC IMPACT

The urban renewal intervention was entirely managed by the Iniziativa Urbana (now Castello Srg) company, consisting of banks, insurance companies, trade and industry associations. At the completion of the work, the Province of Trento, using the purchase of future asset formula, has acquired the museum. A similar financial solution is planned for the university library. The new underground of the street on the west side of the district (Via Sanseverino) was a public work paid by the Municipality.

The total investment cost of the project is 350 million Euro.

The BiPV system costs are the following:

- Total cost €: 1 800 000;
- €/m^2: 552;
- €/kWp: 6 450.

SOCIAL IMPACT

One of the main project's goals was the urbanization of the district, which, in the past, for social and cultural reasons was marginalized with respect to the rest of the city. For giving back to the area its urban role, a range of different structures (such as residences, office buildings, shops, cultural venues and recreational areas) has been included in the design of the area. The public park attracts the citizens for recreational purposes, while the presence of the university library and of the MuSe, the new Science Museum, reinforces the cultural identity of the district. The museum, together with the Palazzo delle Albere (today the Modern and Contemporary Art Museum), attracts the public and confirms the vocation of the area for culture and recreation.

During the planning process for Le Albere, the public meetings organized by the Municipality with the participation of the architect Renzo Piano have always attracted a large number of citizens, showing the interest of the whole city of Trento for the project.

Sustainable design of the district

"In Le Albere district, the buildings use one third of the energy needs of a traditional building: 40-50 kWh/(m^2 a) instead of 150. With the PV panels we produce 0.6 megawatt. For us, these are not technical data, but especially a strong and important message of all our intervention. Not only we consume less, but also we produce a great part of our energy needs. If the earth is vulnerable, it is our responsibility to create new solutions for preserving its resources."
- Renzo Piano [7]

A strong green-oriented vocation has guided the entire design process of the district. The use of BIM software has integrated the design of the buildings together with energy modelling and considerations on internal and external comfort conditions.

In the advanced design phase, the software Solergo has been used for the design of the PV systems as support for the technical, economical and management phases.

Result and discussion

The case study of Le Albere, in Trento, demonstrates the possibilities of pursuing high energy efficiency and integrating active solar energy systems in the design of innovative projects in terms of concepts, forms and materials. Furthermore, the aesthetic results obtained in the district shows the potentialities of the use of PV systems as both functional and architectural elements.

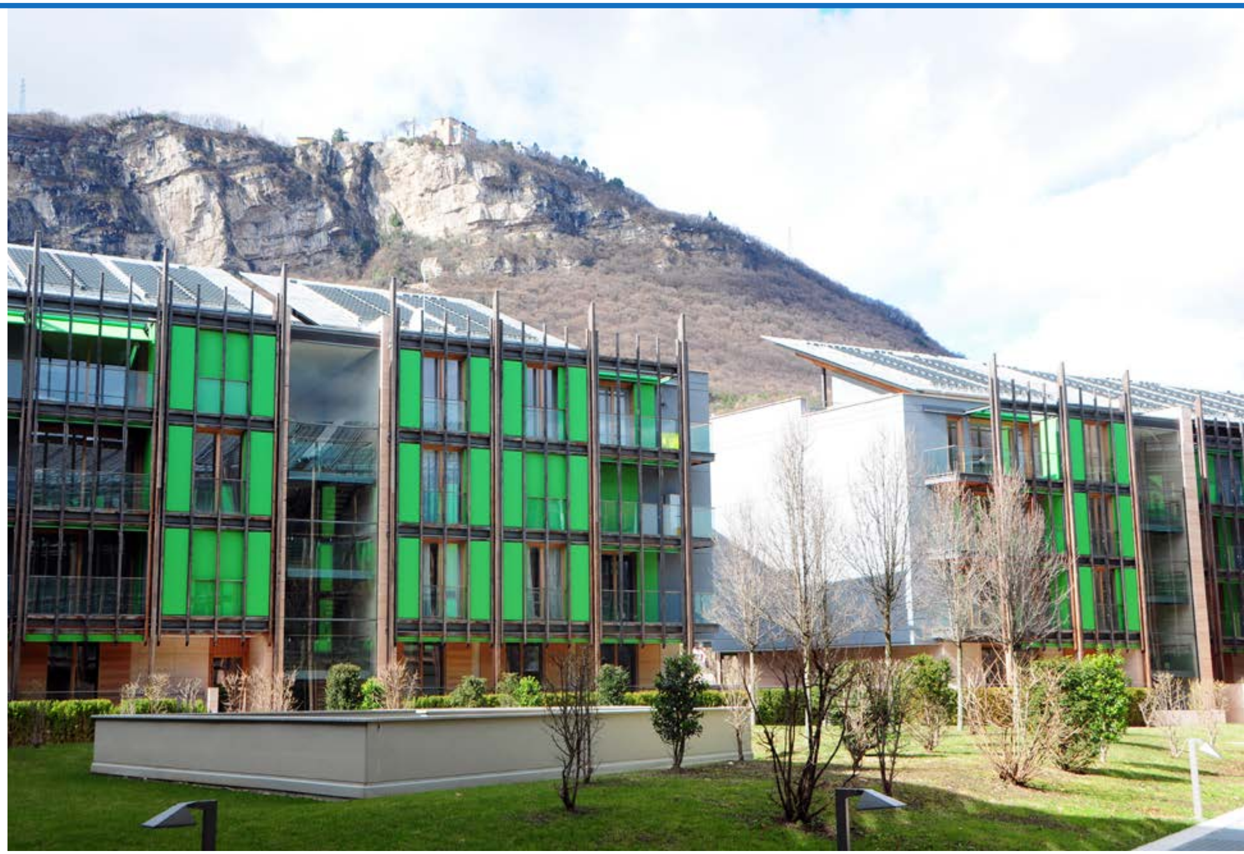


Figure 16 - View of the residential buildings from one of the courtyards of the district. (Photo: © Silvia Croce)

References: [7] Dinacci M. L., Marcantoni M. (2011). Le albere. Il quartiere green di Renzo Piano. IASA.

Lessons learned and recommendations

Figure 15 - On the front: the MuSe and its greenhouse; on the back: the buildings of the residential-commercial district. (Photo: © Silvia Croce)

Figure 16 - BiPV systems on the façades of one of the office building. (Photo: © Silvia Croce)

LESSONS LEARNED

The project of Le Albere provides some important lessons related to the integration of energy issues to spatial planning. Energy efficiency and eco sustainability have been set as the key guideline of the entire project, taking into account both the integration of RES production and minimization of the environmental impact.

Furthermore, the case study shows the possibilities in using the PV systems to contribute not only to covering the energy consumption of the district, but also to the building aesthetic. The presence of the PV modules is declared, making them visible as a characteristic feature of the project instead of hiding or camouflaging them.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- Importance of including sustainable development principles in urban renewal projects;
- Significant role of brownfield development as component of an energy sound planning strategy at urban scale;
- Integration of different renewable energy sources for guaranteeing the energy provision of urban districts;
- Aesthetic potentialities of BiPV systems as unifying features in urban renewal or new urban development projects.

TARGET GROUPS

- Decision makers
- Municipalities
- Urban planners
- Architects
- Developers
- Owners/Clients

PUBLIC AND EDUCATION ACTIVITIES

The case study is included in the book “BiPV in the Trentino Alto Adige Region – The beauty of power generation”, Eurac (2017)


(Photo: © Silvia Croce)

ARCHITECT

RPBW- Renzo Piano Building Workshop

OWNERS

Castello Srg S.p.A.

STAKEHOLDERS

SET Distribuzione, Municipality of Trento, Trentino Network, Dolomiti Energia Group

CONSULTANTS

Favero & Milan; Manens Intertecnica; Associazione PAEA; Müller BBM; Dia Servizi; M.Vuillermin; A.I.A. Engineering; Ingegneri Consulenti Associati; GAE Engineering; Atelier Corajoud-Salliot-Taborda, E.Skabar; Tekne; Twice/lure

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CASE STUDY AUTHORS

Silvia Croce, Daniele Vettorato (Eurac Research)

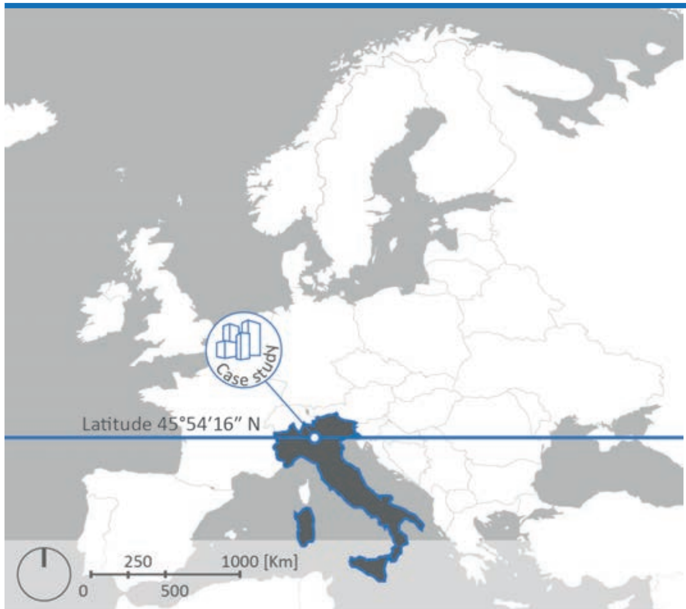
RESEARCH ORGANIZATIONS

eurac research

VIOLINO DISTRICT IN BRESCIA

ITALY

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Italy
Location: Brescia (Lat. 45°54′16″N; Lon. 10°21′18″E)
Climate: Warm Temperature Climate (Cfb) [1]

AREA OF INTEREST

Legislation and technology

NATIONAL AND LOCAL CONTEXT

The framework of Italian legislation on urban and energy planning is characterized by a hierarchical approach stretching from the national level downward to the regional, provincial and municipal level.

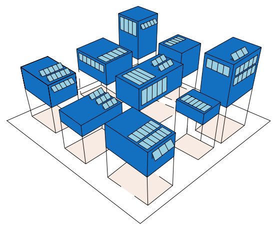
Violino district in Brescia has been developed thanks to the decision of the Brescia Municipal Council to develop a new urban local plan for social housing and to organize a competition [2] [3] for realizing a public residential area characterized by energy savings criteria.

ABOUT THE CASE STUDY

Violino district is an urban district located in the city of Brescia and it was developed in accordance to sustainable principles, merging the needs for low-cost housing with the needs for energy and environmental sustainability. The area was completed in 2006.

Definition of environment:
New Urban Areas

Site area: 48 450 m^2
Building area: 14 880 m^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Palumbo, M, Scognamiglio, A. (2010). Forms of Energy #5- Quartiere Violino, Brescia, Domusweb.
[3] Villa, D.; (2012). Un quartiere per comparti, Progetti di Architettura 1, n. 488, pp. 20-27

Figure 1 - Southern façade of the terraced houses. (Photo: © Alberto Mucciaccia)

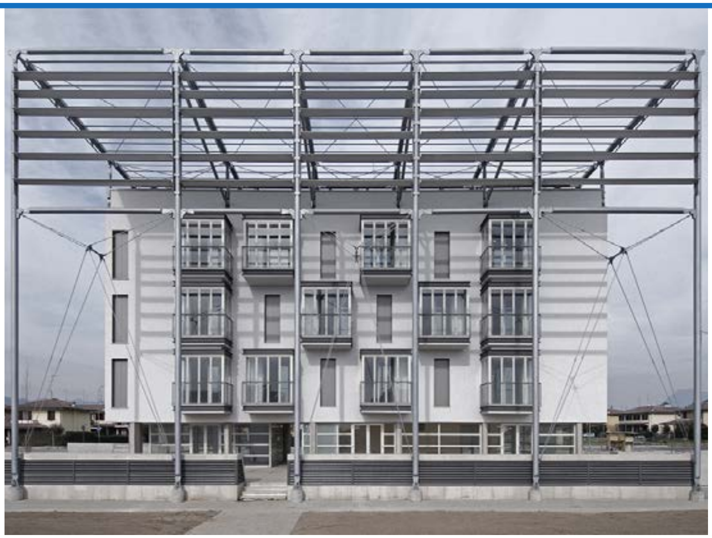


Figure 2 - Southern façade of the multifamily house. (Photo: © Fabio Cattabiani)

Figure 3 - The public space of connection between multifamily and terraced house (Photo: © Alberto Mucciaccia)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the project are:

- Violino district represents the result of a competition established by Municipal Council of Brescia for realizing a public residential area characterized by sustainable approach and energy savings criteria;
- Orientation of each building aimed at gaining of solar radiation.

ISSUES AND CHALLENGES

The competition established by the Brescia Municipal Council was aimed at the development of project proposals about "*new ways of living and environmental sustainability of housing developments*". The main challenges were described in the call for tenders:

- Adequate urban quality able to develop relations in the neighborhood;
- Constructive technical performance able to ensure sustainable urban development in connection with the use of renewable energy sources;
- The quality enhancement of the social housing.

Other challenges were represented by the established form of lots and by the building and planning prescriptions.

DECISION STRATEGIES

The call for tenders required the submitted proposals to be in compliance with the quantifiable quality requirements. It then expressed the will to "measure" the quality and sustainability of the project, and to compare the costs of these requirements with the standards required for the economic and social housing. In particular, according to the established procedure, preliminary projects were evaluated by assigning a score, based on the conformity of construction and performance quality requirements (for example, thermic, acoustic, hygrometric insulation, etc.). This made it possible to physically separate the standard costs from those related to the introduced quality innovations.

The planning process

The Violino district was born thanks to the decision of the Brescia Municipal Council to establish a competition for realizing a social housing project characterized by holistic sustainable approach.

In 2000, a new plan for social housing neighborhood for Violino district was approved. Then, the municipality of Brescia purchased the area and established a competition for project proposals in 2002. The winning project was designed by Boschi+Serboli Architetti Associati, Studio Associato Cigognetti Piccardi Vitale and the architect Francesco Bardelli. The construction works started in 2004 and they finished in 2006. Violino district has been recently involved in the Smart Domo Grid Project [4].

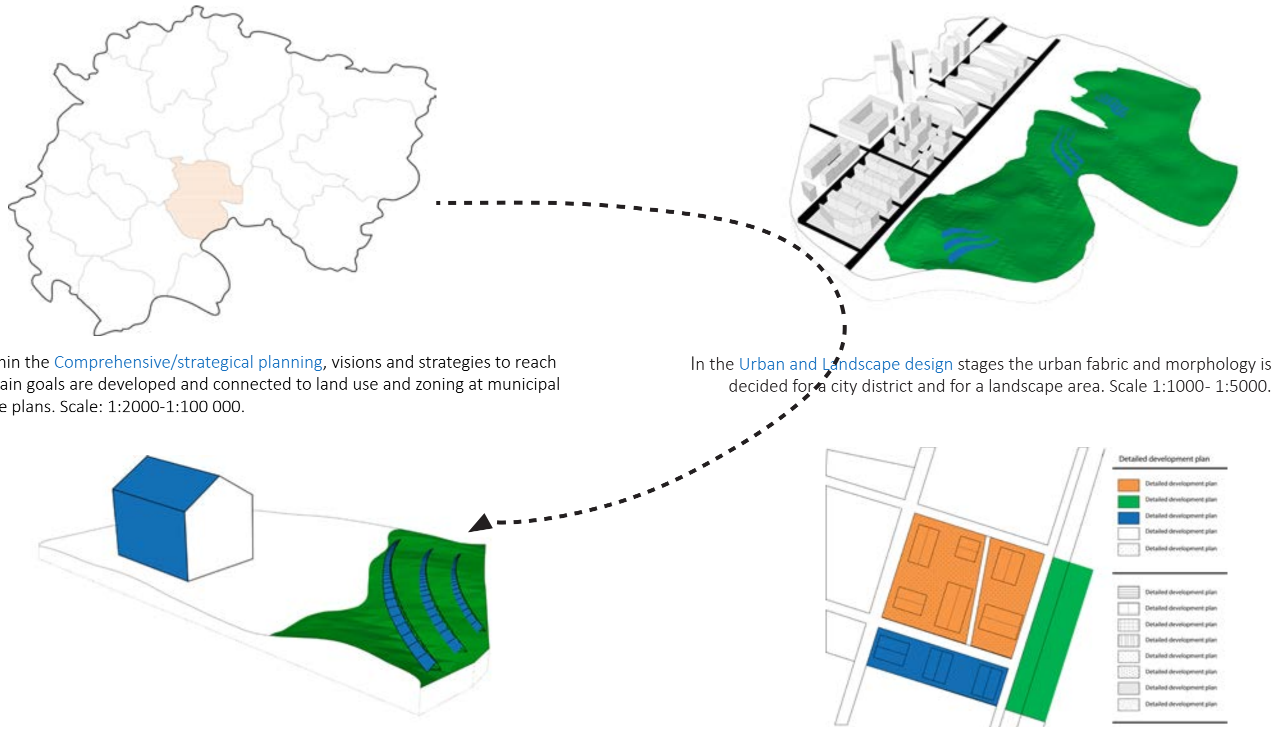
Within the goals of Violino district project, a holistic sustainable urban development is envisioned, including the use of renewable energy sources.

Brescia Municipal Council set the competition. The architects who designed the urban and technological solutions had to be able to achieve the competition goals.

The initiator of the project was the Brescia Municipal Council. Architects, installers and consultants have been involved in developing the process. Finally, local cooperatives and constructive companies realized the area.

The social rental housing was equal to 25% of the built residential area. The project was financed with funds from the Lombardy Region which was allocated to the municipality of Brescia. The Azienda Lombarda Edilizia Residenziale (A.L.E.R.) funded implementation of the Regional Program for public housing which provides financing for 80% of standard costs.

As for rental housing social rent, equal to 25% of the built residential area, the project was financed with funds from the Lombardy Region allocated to the municipality of Brescia and from A.L.E.R. for the implementation of the Regional Programme for public housing which provides a financing for the 80% of conventional costs [5].



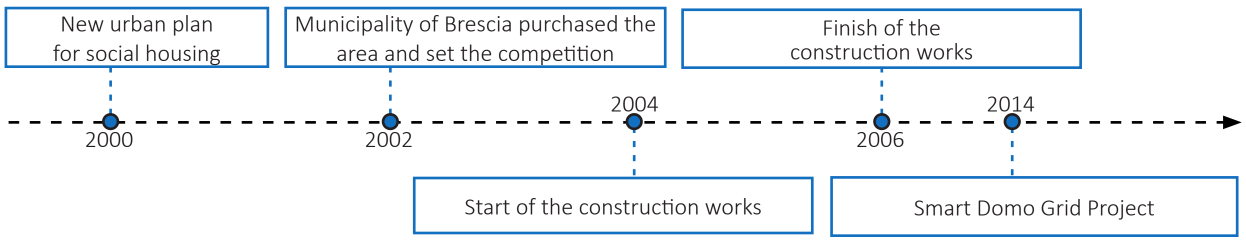
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [4] Dones, M., Smart Domo Grid: Brescia Smart city del future, Informazione tecnica, Magazine Dario Flaccovio.
[5] Granata E., Lainati C., Novak C., a cura di, (2006), Metamorfosi di uno storico quartiere di immigrazione. Osservazioni sui recenti mutamenti del Carmine di Brescia. Iniziativa Comunitaria Equal Fase II. p. 79.

ENERGY CONCEPT

Figure 5 - Aereal view of the BiPV system on the roof of the 112 terraced houses (Source: © BAMSphoto - Basilio)

SUMMARY

The whole neighborhood was designed in order to benefit from climatic conditions (i.e. sun, wind, etc.) in accordance with bioclimatic architectural principles. It consists of 114 energy efficient buildings, which are connected to the district heating system.

TECHNOLOGY

Each building of the neighborhood is oriented in order to gain from solar radiation both for passive uses (i.e. natural lightening) and for active use (i.e. installation of solar systems). Indeed, 112 terraced houses are provided with a BIPV system for the production of electricity, as well as the two multifamily houses.

- Type of system: BIPV systems (polycrystalline)
- Area: 1 210 m^2 (terraced houses: 1 120 m^2, multifamily houses 90 m^2);
- Orientation and inclination: south, 30°.

SOLAR ENERGY AND ENERGY SYSTEM

112 terraced houses are provided with their own BIPV roof system of about 1,3 kWp and the two multifamily houses are equipped with BIPV system of about 11,7 kWp.

In detail, each terraced house provided with BIPV system is characterized by:

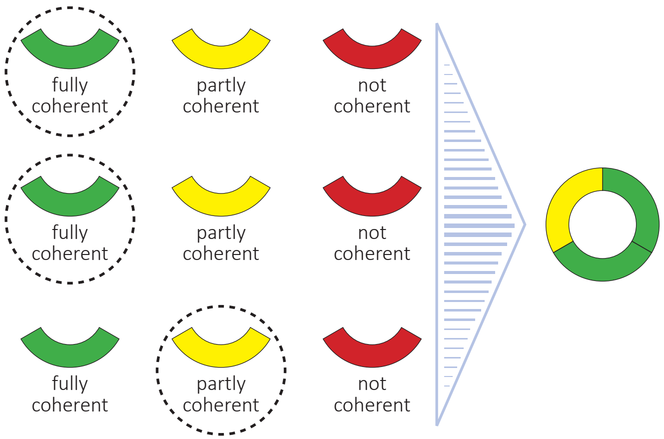
- Energy production: 1 300 kWh/a;
- Power of the system: 1,3 kWp;
- Energy demand/consumption: 3 000 kWh/a

Figure 6 - System geometry of PV implementation. (Photo: © Fabio Cattabiani)

Figure 7 - System modular pattern (Photo: © Fabio Cattabiani)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	1 - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	2 - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	3 - MODULAR PATTERN



COMMENTS

The system applied on the roof of the terraced houses is perceived as integrated and it is coherent with the global building design logic.

The colors of the envelope and those of the modules partially match but the modular pattern reveals many gaps and does not give the impression of a uniform surface.

References: *[6] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 8 - Violino village view of the PV systems integrated on the roofs (Photo: © Fabio Cattabiani).

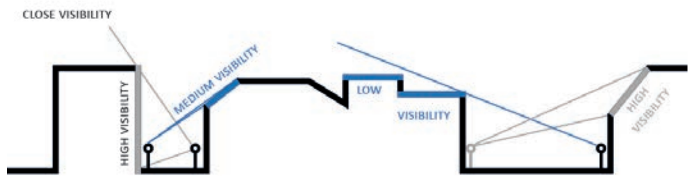


Figure 9 - Different levels of visibility of city surfaces from public domain in Violino district.

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	**HIGH**	**MEDIUM**	**LOW**
CLOSE VISIBILITY	○	●	○
REMOTE VISIBILITY	○	●	○
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

In consideration of the fact that the buildings do not have any historical value, neither there is the presence of monuments or meaningful elements, the zone can be considered at medium sensitivity.

SYSTEM VISIBILITY

The BiPV system installed on the flat roofs of the terraced house resulted in very low close visibility, while the the ones integrated in the tilted roofs, hereby analyzed, are visible.

Due to that, the area is completely flat the remote visibility is not relevant except for the residents in the apartment blocks close to the 112 terraced houses, from where all the PV systems installed on flat roofs are visible.

References: [6] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 10 - Violino village view from the coverage of the building through the shading (Photo: © Alberto Mucciaccia).

Figure 11 - First unit of the terraced house. (Photo: © Alberto Mucciaccia)

Figure 12 - South Side of the two multifamily houses. (Photo: © Fabio Cattabiani).

ENVIRONMENTAL IMPACT

In accordance with bioclimatic principles, the urban area was developed in order to gain from solar radiation and winds. In addition to this, the neighborhood is equipped with different water networks: a drinking water supply network, a non-drinking water supply network for the irrigation of public and private gardens, a waste-water disposal network and a rain water disposal network for avoiding risks of flooding.

ECONOMIC IMPACT

The project was financed with public funds with the aim of creating housing to be given a permanent social rent lease. For some housing, accommodation was reserved to favor particular categories of the demographic-precisely 26 dwellings for the elderly and 12 dwellings for young couples.

SOCIAL IMPACT

As required in the call for tenders, the project envisions also public pedestrian paths able to connect private open spaces, in order to facilitate socialization activities.

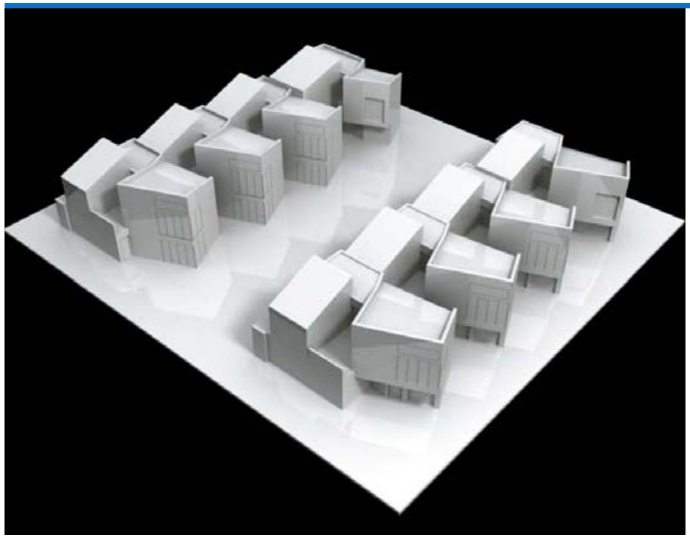


Figure 13 - Study of type terraced view from South. (Source: © Boschi + Serboli architetti associati)

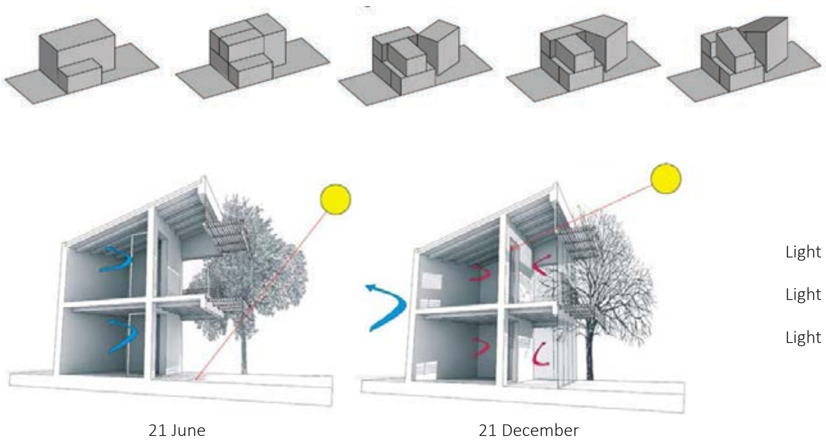


Figure 14 - (on the top) Volumes' composition; (on the bottom) Section of the terraced house. (Source: © Boschi+Serboli Architetti Assocciati)

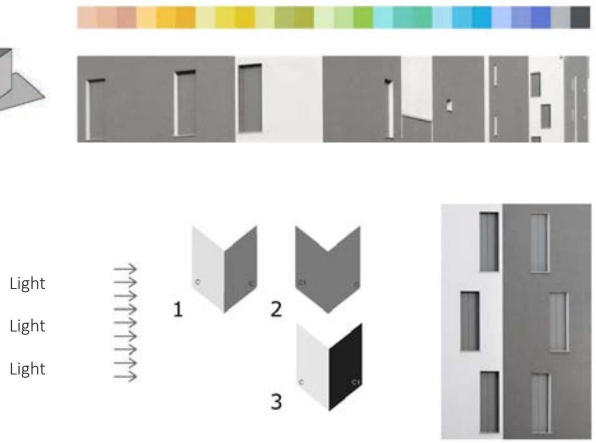


Figure 15 - Color plan by Jorrit Tornquist. (Source: © Boschi + Serboli architetti associati).

OPTIMIZED UTILIZATION OF PV

The design decision came from the application of the principle of guaranteeing to each residential unit the "Sun's right". A colors' study was carried out: Figure 15 shows the alternative colors chosen for the terrace and for the buildings. This study obtained the result of a greater integration with the environment than was previously possible. The color design lightens the perception of the repetitiveness of the terraced type; moreover, each unit is identified by a color available in three shades degrading. In this way, the different incidences of the solar rays during daytime hours highlights the volumetric articulation of the units. The perception of the composition of the buildings changes, which therefore allows various light conditions of the day.

The breakdown comes from the internal functional distribution and from a hypothesis of time spent inside the rooms. To the south are exposed individual rooms on the first floor and the living room on the ground floor. These rooms are considered the most used. To the north are service rooms such as bathrooms and stairs and to the west is the kitchen and the master bedroom. The greenhouses have been painted with dark tones to increase the effect of sunlight uptake in winter.

IN RELATION TO THE SCALE

The bioclimatic aspects, the study of interactions between the building and external conditions, the color, the green areas, the walking trails, the habitability, the integration and the search for identity in a peripheral area have influenced the entire design process and led to the definition of the final result.

MONITORING OF PV SYSTEM

Starting from 2007, monitoring has been performed, by the ASM (Azienda Servizi Municipalizzati) now a2a Group, the largest Italian multi-utility company, in order to check the performance of PV systems and evaluate the amount of energy produced by PV systems and the amount of energy that is fed into the grid [7].

SMART GRID DOMO PROJECT

Smart Domo Grid Project [4][8] was aimed at testing a smart system for enhancing energy efficiency and reducing the cost of energy consumption. The smart system integrates the traditional electric grids, electronic meters, PV systems and smart appliances (i.e. household appliances). In particular, 21 families have been involved in the experiment. Each family has been provided with an energy management application that measures the energy consumptions and provides insights on how to minimize the consumptions. In such a way, users can plan to use household appliances in the most convenient period and handle overload thanks to an alert system. The project has been performed from 2014 to 2015 involving the electrical society a2a SpA (project initiator), the Politecnico of Milano (technical partner) and Whirlpool (appliance provider).

RESULT AND DISCUSSION

In the period in which the survey was carried out, of the 112 systems installed 93 are activated and 65 have at least 100 working days, of which 54 of them are installed in already inhabited utilities. Photovoltaic systems installed in housing units of Violino district have recorded during the reporting period an average daily production between 3.64 kWh and 5.33 kWh, with an average value of 4.54 kWh.

Figure 16 - Aereal view of the context area around the Violino district (Source: © BAMSphoto - Basilio)

References: [4] Dones, M., Smart Domo Grid: Brescia Smart city del future, Informazione tecnica, Magazine Dario Flaccovio.
[7] ASM S.p.a. (2007). Report 1- PDZ A/19 VIOLINO.
[8] www.euinnovate.com/

Figure 17 - West side of the terraced house. (Photo: © Alberto Mucciaccia)

Figure 18 - Southern façade of the terraced houses. (Photo: © Alberto Mucciaccia)

Figure 19 - West side of multifamily house and terraced house. (Photo: © Alberto Mucciaccia).

LESSONS LEARNED

The project aimed at reaching the environmental and the social and economic sustainability (bioclimatic approach and high energy efficiency).

- To achieve the conditions of hygrothermic comfort, it is necessary to simultaneously work on the building's shape, on the construction techniques and on the technological systems, in order to exploit its passive behavior.
- To optimize the efficacy of the bioclimatic planning (solar exposition), the building's sun exposition should be improved.
- To use greenhouses especially during winter as they slowly release heat. They should be implemented because they become a natural system of temperature regulation.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

The use of heating systems based on irradiance instead of on convection do not allow for an excessive humidity drop and do not cause the raise of dust.

The comfort level of the inside spaces can be achieved introducing temperature control systems and diversifying their functions according to spaces' needs.

It is recommended to use an adjustable and silent ventilation system that reduces the risks of condensation and that guarantees air exchange, both in the cases of terraced and multi-family houses, especially where no natural air exchanges occur.

TARGET GROUPS

- Municipalities
- Urban planners
- Architects
- Developers
- Project managers
- Final receivers such as: members of cooperatives, public housing applicants and sales operator.

(Photo: © Alberto Mucciaccia)

DEVELOPER

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Studio Associato Cigognetti Piccardi Vitale
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Brescia Building Council

STAKEHOLDERS

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La Famiglia rurale di Cadigliano Soc. Cop. a r.l.
La Famiglia Violino Due soc. cop. a r.l.

RESEARCH ORGANIZATIONS

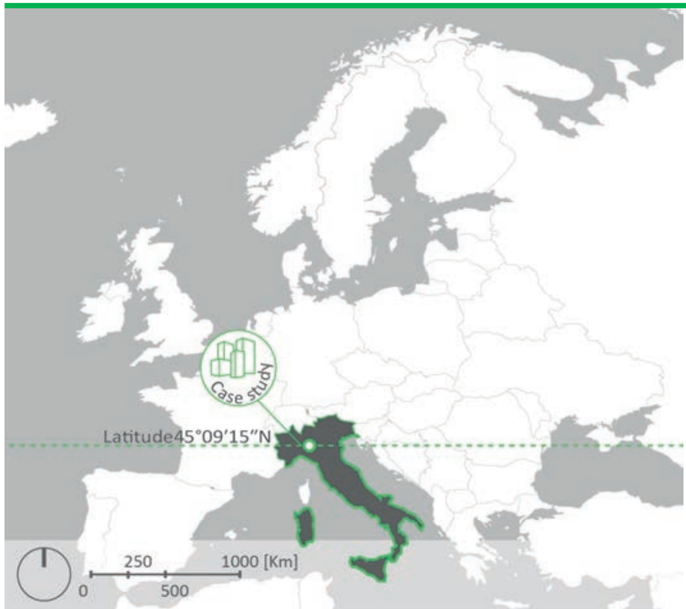
Università degli Studi di Padova

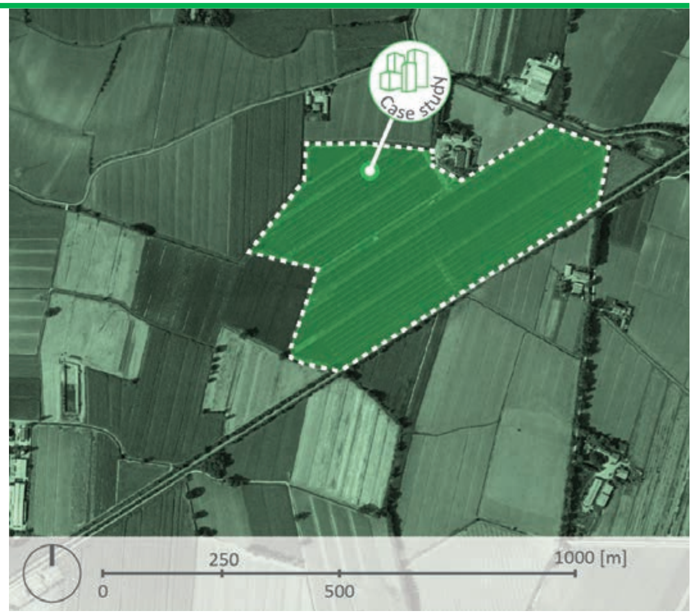

(Photo: © Revolution Energy Maker REM)

AGROVOLTAICO

ITALY

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Italy

Location: Monticelli d'Ongina

(Lat. 55°97'16"N; Lon. 9°92'97"E)

Climate: Warm Temperature Climate (Cfb) [1]

AREA OF INTEREST

- Targets and goals
- Legislation and technology

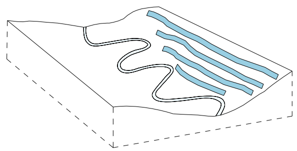
NATIONAL AND LOCAL CONTEXT

The system is located in an area (47 000 km²) called 'Pianura Padana', in Northern Italy. This is an alluvial area that mainly corresponds to the river Po's basin. From a morphological and hydrogeological point of view it is a homogeneous territory, placed about 100m above sea level. It includes several regions such as: Piemonte, Lombardia, Emilia-Romagna and Veneto.

Given the abundant presence of water, and the many channels, the area is particularly suitable for agricultural uses. The flat morphology of the land is in an area also very suitable for solar technologies, e.g. photovoltaics (low engineering costs for the installation, i.e. foundations works and supporting).

ABOUT THE CASE STUDY

The system was built in 2012. At that time the opposition of the public to the installation of photovoltaics (especially large systems) on ground in agricultural areas was very strong. The national legislation had already stopped the incentives for systems whose nominal power was 1MW or higher, and local authorities could set restrictive regulations for the installation of solar technologies. This project is an example of design conceived so as to achieve a double use of land, which is keeping the agricultural function, while producing energy.



Definition of environment:
Landscape PV

Site area: 21 000 m^2
System area: 21 000 m^2

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Issues, challenges and decision strategies

Figure 1 - Threshing machine in action under the PV track system. (Photo: © REM)

Figure 2 - View of the PV track system during the first crop. (Source: © REM)

Figure 3 - Aerial view of the solar plant in landscape. (Photo: © REM)

HIGHLIGHTS OF THE CASE STUDY

The 3.2MWp project is the result of the initiative of a private developer (Revolution Energy Maker, REM), which wanted to find a reliable solution for installing on ground photovoltaics without penalizing the agricultural productive capacity of the land. REM (with own funds, initial investment 2,5 M€) funded a collaborative work with many industrial partners. Moreover a scientific partner was hired (the Institute of Agronomy, Genetics and Field crops from the Catholic University of Sacred Heart of Piacenza), and the local authorities were consulted for succeeding in a design that could meet all the desired requirements.

The system is now patented (Agrovoltaico) and it can be used in other environments where the double use of land is a requirement for the installation of solar.

References: [2] Delibera n.28 del 6 Dicembre 2010 della Regione Emilia Romagna

ISSUES AND CHALLENGES

The main issue was the need to circumnavigate legislation that did not allow building on ground large PV systems (more than 1 MWp) in agricultural areas [2]. This was done through an innovative design of the system. The PV modules are suspended on a cable structure, so the land can be used for crops and only about 2 % of the total land area is used by the structure of the system (according to the regional regulation less than 10 % can by occupied by the system). In order to balance the low density of power of the system (if compared to the one of a standard on ground PV system), a double axis sun-tracking device has been used. The chosen design allows the movement of trucks needed for production and harvesting processes (modules are placed at 5 m from the ground). The low density of the modules only slightly reduces the amount of solar radiation available on the ground. Losses in terms of maze production is about 1 % of conventional crops.

DECISION STRATEGIES

The developer, REM, through collaboration with a scientific partner, and through a cooperation with the local authorities (Soprintendenze) developed a design which was able to satisfy the requirements imposed by the regulations.

THE PLANNING PROCESS

This project replies to the need of installing photovoltaics in on agricultural land, without penalizing the agricultural productivity. It is a typical example of double use of land, which is understood as one of the main strategies to reduce significantly the impact of large on ground photovoltaic systems.

The scale of the planning process includes the landscape as well as the architectural scales; the plot of the project is included in the planning legislation of the Regione Emilia Romagna. This legislation [2] prohibits the realization of PV systems on agricultural areas when bigger than 1 MWp.

The main aim of the project is conceiving a design that could overcome soft barriers for on ground PV due to legislation or to the opposition of the public. In particular the ecological impact was reduced. In terms of visual impact, the low density of the system is able to guarantee meeting the requirements of the regional regulation (less than 10% land area occupation ratio); the materials used are mainly recyclable (90%).

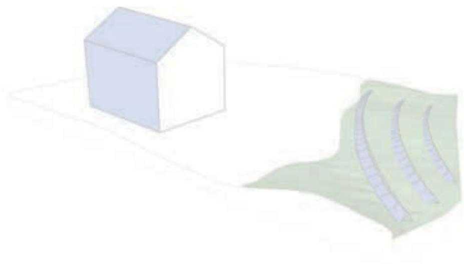
The initiator of the project is a private company, REM. They looked for industrial and scientific partners so as to develop a reliable design of the system.

The researchers involved performed simulations of the crop production, considering the presence of photovoltaic modules (dynamic shadows on the soil), and the consequent reduction in the photosynthesis conversion.

The investment was private (REM). Initially is was about 2.5 M €. After the realization of 3 systems in different locations in Italy, the value of the satellite activities is about 30 M € with about 700 people involved.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

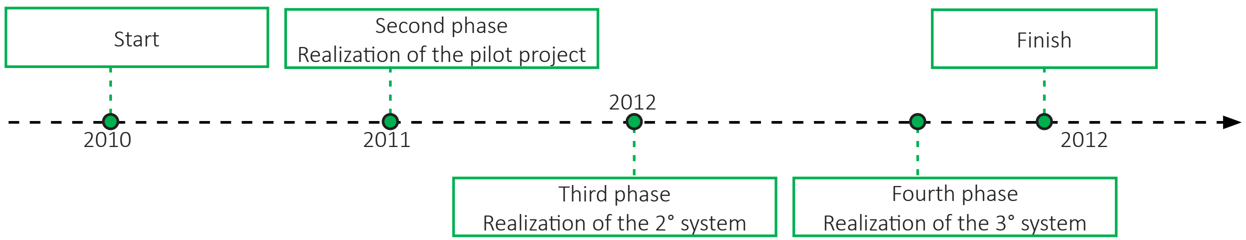
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [2] Delibera n.28 del 6 Dicembre 2010 della Regione Emilia Romagna

Solar Landscape

Figure 5 - The spatial system as a whole (Pattern) (Source: [3])

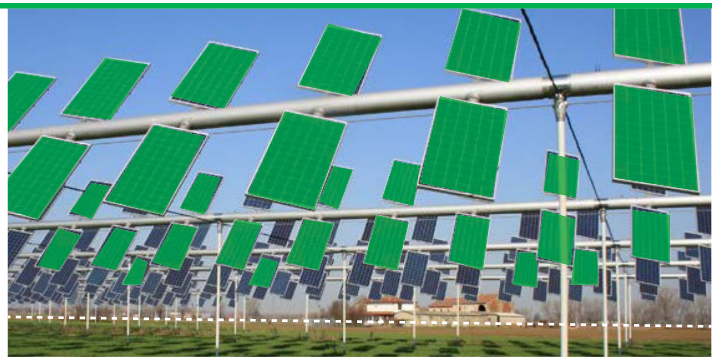


Figure 6 - The photovoltaic space (Source: [3])

Figure 7 - The "pore" space (Source: [3])

FORMAL FUNCIONAL FEATURES

PATCH - PATTERN - EDGES/BORDERS

Patch type

Small		○	Large	●
Straight borders		●	Convoluted borders	○

Grain type

Small patches		●	Large patch	○

Pattern

Porous		○	Dense	●

Pattern type

Stripes	Parallel	●	Not parallel	○
Island	Uniform patches	○	Varied patches	○
Random		○		

Edge/Borders

Continuous		●	Discontinuous	○

SOLAR SYSTEM

TECHNOLOGY AND PRODUCTION OF TOTAL AREA OF MODULES

1. Energy features

Nominal power:	3.2 MWp
Number of modules:	11 535
Technology:	280 Wp Polycrystalline Solartech
Density of power:	3.2 MWp / 171 140 m^2
Land use intensity:	N/A
Normalized yearly energy generation:	1 506.4 Mwh/a

2. Engineering features

The height of tracking PV panels is 5 m connected with each other through an innovative wireless communication controll system.

3. Spatial features

Modules:	Height: 0.5 m; Width: 1.0 m; Area: 13.57 m^2; Color: Blue Tilt angle:double axis sun tracking; Height from the ground: 5 m
Borders:	None;

SOLAR SYSTEM SPACE

PATCH AREA

Connectivity

There is no enclosure around the solar field, people/animals access the area or walk through; there is no discontinuity between the ground where the solar field is placed and the surrounding landscape. These were specific requirements by the local authorities.

Functions

The original function of the land underneath the surface of the modules was crops. It is still cultivated since the intervention maze. There has been no change in the land use function.

Other features

Supporting systems and foundations: steel structure with poles and cables for supporting the modules; precasted concrete poles.

References: [3] Scognamiglio, A. (2016). 'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision, Renewable and Sustainable Energy Reviews, pp 629-661

Site potential

Figure 8 - Threshing machine in action under the PV track system. (Photo: © REM)

LANDSCAPE FACTOR

SENSITIVITY	LOW	HIGH
Landform	●	○
Landscape pattern and complexity (patches and grain)	●	○
Land use	○	●
Land cover	○	●
Settlement and man-made influence	○	●
Historic landscape character	○	●
Distinctive landscape features	○	●
Inter-visibility with adjacent landscapes	○	●
Sense of remoteness/tranquility	○	●
Sense of openness/enclosure	○	●

LANDSCAPE PRESERVATION (SOFT BARRIERS)

The landscape area of the project is valuable because of the evidence of the man made work to transform a very humid area into a productive land for agriculture. Thanks to the flat morphology of the land and to the abundant presence of water, the value of land for agricultural uses is very high. The landscape has cultural value as the product of a long human transformation.

With respect to renewables, in some areas it is forbidden to install solar technologies (see singular regional zoning for renewables).

MULTI-FUNCTIONALITY

The system itself does not perform any other function than producing energy; nevertheless it can be considered an example of double use of land (agriculture and photovoltaics).

Figure 9 - Irrigation system in action under the PV track system. (Photo: © REM)

IMPACT CATEGORY	IMPACT - BURDEN	ALLEVIATION, MITIGATION STRATEGIES, DESIGN APPROACHES
Land use	The system is designed so as that the original land use is preserved.	
Visual impact	The visual impact of the system is very low, thanks to the accurate design and to the porous pattern of the system.	
Environmental impact	The entire system is made of safe, non-polluting and fully recyclable materials (for example the recycled and untreated aluminium of trackers), whose installation guarantees an easy removal at the end of the life cycle (25/30 years).	The local authorities required no mitigation or alleviation strategy, since the overall ecological impact of the system is low.
Public awareness and participation	Along the design phase a close collaboration has been ensured with the local authorities so as to succeed in a good design.	

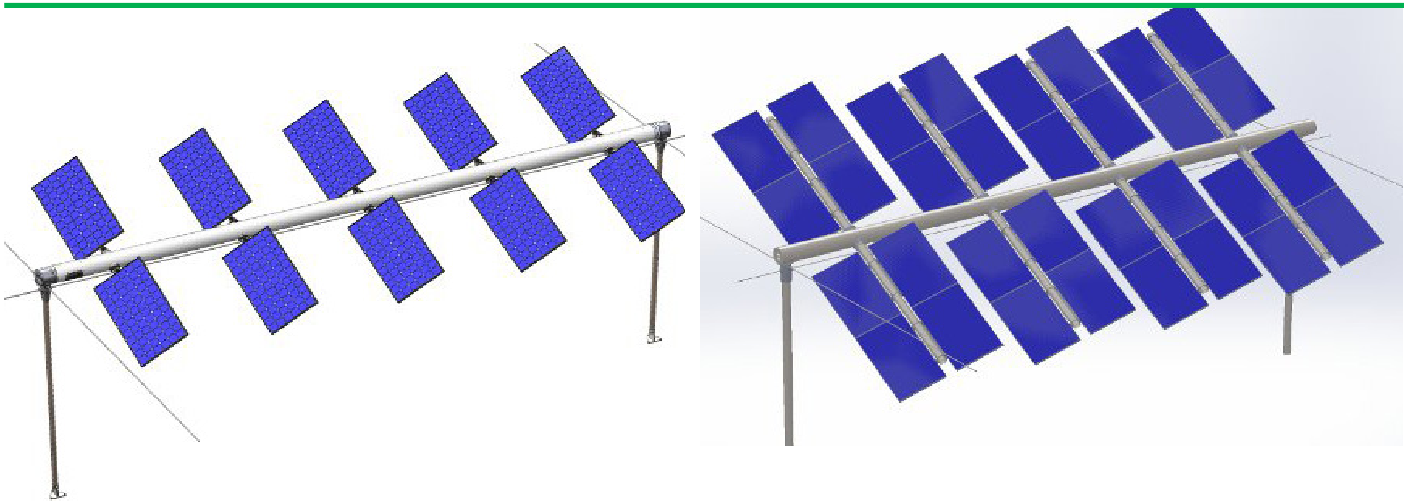


Figure 10 - Scheme of the sun tracking system 01 (on the left) and 02 (on the right) (Source: © remtec.energy)

SYSTEM TECHNOLOGY

REM Tec has worldwide patents on this technology. The height of the park is up to 5 m, allowing a very low impact from the shadow on the growth of agricultural species. The height allows easy mechanized agriculture.

Well knowing the impact on the growth of agricultural species, through a cooperation with the University of Piacenza, REM Tec has developed a tracker family allowing to achieve the optimum design for energy and for food production [4].

SUN TRACKING SYSTEM 01

- 2.5 to 4.35 kW peak per tracker
- 10 panels installed each tracker
- Tracker length 12 m
- Height 4-5 m

SUN TRACKING SYSTEM 02

- 8.64 to 10.46 kW peak per tracker
- 32 panels installed each tracker
- Tracker length 12 m
- Height 4-5 m

References: [4] www.remtec.energy

Lessons learned and recommendations

Figure 11 - Threshing machine in action under the PV track system. (Photo: © REM)

Figure 12 - Tractor in action under the PV track system. (Photo: © REM)

LESSONS LEARNED

- Large photovoltaic systems are a matter of landscape design
- A good design can overcome soft barriers such as legislation and regulation.
- The ecological impacts of on ground large PV systems can be greatly reduced thanks to the double use of land.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- The cooperation between industrial, scientific, and policy subjects was key to the success of the project.

TARGET GROUPS

- Developers
- Local authorities
- Industries
- Farmers

PUBLIC AND EDUCATION ACTIVITIES

Several presentations on the occasion of conferences.


(Photo: © REM)

ARCHITECT, DESIGNER AND DEVELOPER

REM Revolution Energy Maker staff

CONSULTANTS

Many industrial and scientific consultants. Among the others, for crops efficiency: Institute of Agronomy, Genetics and Field crops from the Catholic University of Sacred Hearth of Piacenza.

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ENEA
Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

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3.8 NORWEGIAN CASE STUDIES

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Silvia **Croce**
University of Padova
Institute for Renewable Energy, EURAC Research

25 **ZERO EMISSION OFFICE BUILDING**
Existing urban area

26a 26b **ØVRE ROTVOLL SUSTAINABLE MASTERPLAN**
New urban area

27 **DALE COMMUNITY**
Existing and new urban area

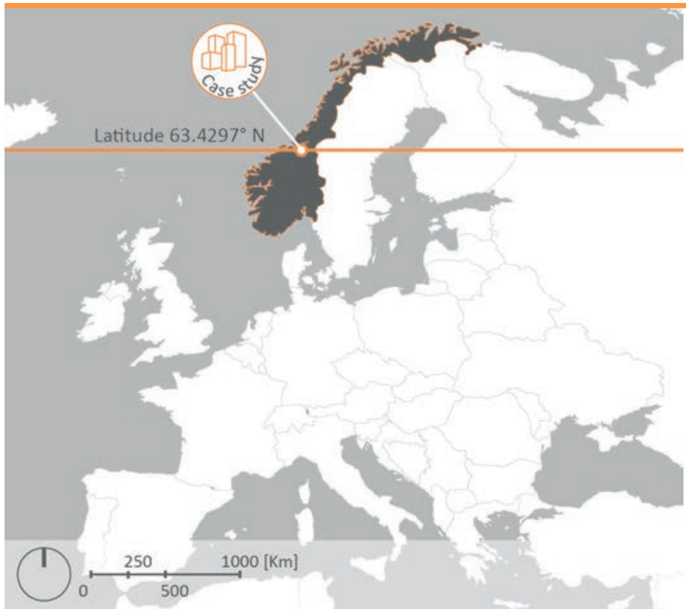
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

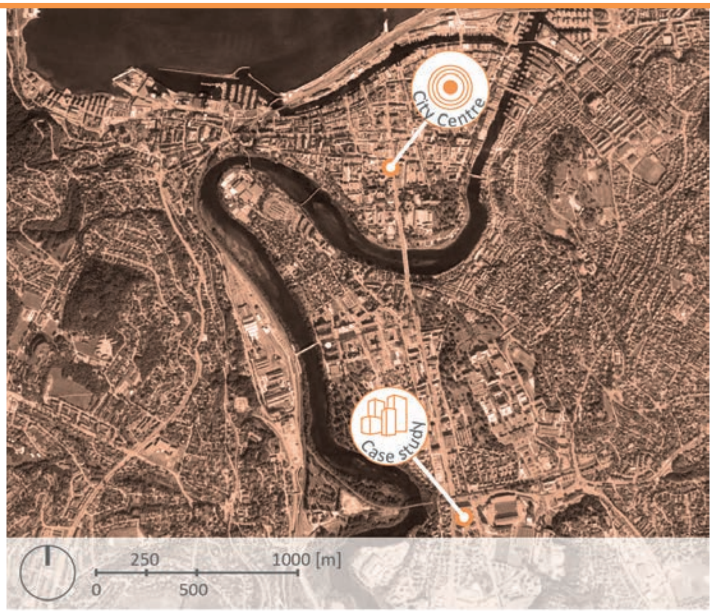
Photo: © Glen Musk, Adresseavisen

ZERO EMISSION OFFICE BUILDING

NORWAY

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Norway
Location: Trondheim (Lat. 63,4297°N; Lon. 10.3933°E)
Climate: Subarctic climate (Dfc) [1]

AREA OF INTEREST

Legislation and technology

NATIONAL AND LOCAL CONTEXT

The number of solar energy installations is increasing in Norway, however due to increased attention to energy efficiency in buildings, more and more solar energy installations are now being added to buildings. A number of larger-scale solar energy projects were realized in Norway in the last years Oseana Culture Center, Campus Evenstad,and Powerhouse Kjørbo.

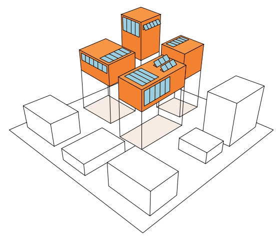
Also in the city of Trondheim the interest on solar installations is improving. One of the most important future project is constituted by the new Trondheim Spektrum: it will be a large facility with a large roof surface cover by solar panels. When it will be built, it will become the largest solar park in Norway. This system will be a major priority when the municipality will look at both the use and production of energy [2].

ABOUT THE CASE STUDY

The building located in Lerkendal district in Trondheim has the ambition to be the first Zero Emission Office Building in Norway. It was completed in 2012.

Definition of environment:
Fill-ins and densification district in the existing urban area

Site area: 4,000 m^2
Building area: 11,000 m^2
Area density:-



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Article available at: http://www.adressa.no/nyheter/trondheim/ Access: 26.01.2016

Figure 1 - North view of the office building in Trondheim, Norway. (Photo: © Gabriele Lobaccaro)

Figure 2 - South view of the students' blocks. (Photo: © Gabriele Lobaccaro)

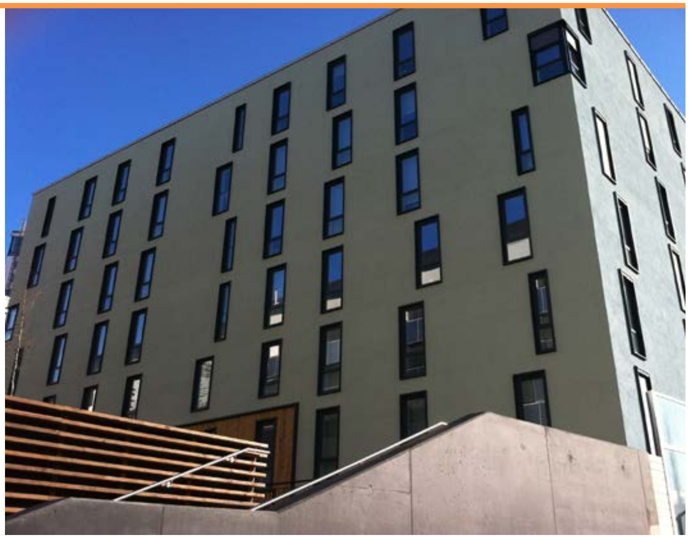


Figure 3 - North view of the office building in Trondheim, Norway. (Photo: © Carmel Margaret Lindkvist)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- Net zero commercial building;
- Building integrated photovoltaic panels;
- Subject of significant overshadowing by urban surrounding;
- Examine solar rights during planning processes in urban areas.

ISSUES AND CHALLENGES

The low sun angle at high latitudes presents challenges for solar energy in urban areas in Northern Europe; Changing rules caused prohibition of PV panel installation on roof; The façade integrated PV system is subject of overshadowing by urban surrounding; Not considering the impact of building heights on the solar building in the planning process. There is quite a narrow focus on buildings with no consideration of how surrounding areas can impact on energy efficient targets achieved through the implementation of a solar solution. Buildings with solar components integrated on façades and roofs are vulnerable by the shading from other buildings. The impact of new buildings has to be taken in consideration in order to guarantee the optimal solar accessibility and right of light to the existing buildings. [3]

DECISION STRATEGIES

Legislation does not consider the broader aspects of solar energy that is relevant in development of urban areas as illustrated in the Norwegian cases. After this case studies, the local regulation has been changed, by abolishing the prohibition of installing solar system on the roofs in that area of the city.

References: [3] Good, C. S., Lobaccaro, G., & Hårklau, S. (2014). Optimization of solar energy potential for buildings in urban areas- a Norwegian case study, Energy Procedia, 166-171.

The planning process of the case study was complex and the discussion was mainly focused on the place where the PV system should be installed and the impact of the surrounding buildings on it.

The construction of the building started in 2010 and was complete in 2012. Other buildings impacted the solar energy of the case. These buildings came after and were partially planned in parallel. It is an interesting case as highlights how planning decisions do not consider solar energy production.

The goal was to study the impact of surrounding buildings on solar energy performance.

The urban regulation in that area did not allow to install solar system on the roof.

Those involved in the case are planning department, architects and end user of the building.

This is a completed building so researchers are evaluating how the planning process resulted in a reduction of solar energy in this Trondheim case. The conducted analyses demonstrated that the impact of the urban surrounding, due to the complex oveshadowing effect, influences the solar radiation on the BiPV South façade, reducing more than 40% of its solar potential.

During the construction, some detailed Simi calculations were done to get financial statements under 84 kWh/m^2 [4]. The total cost of the project was equal to NOK 220 million.

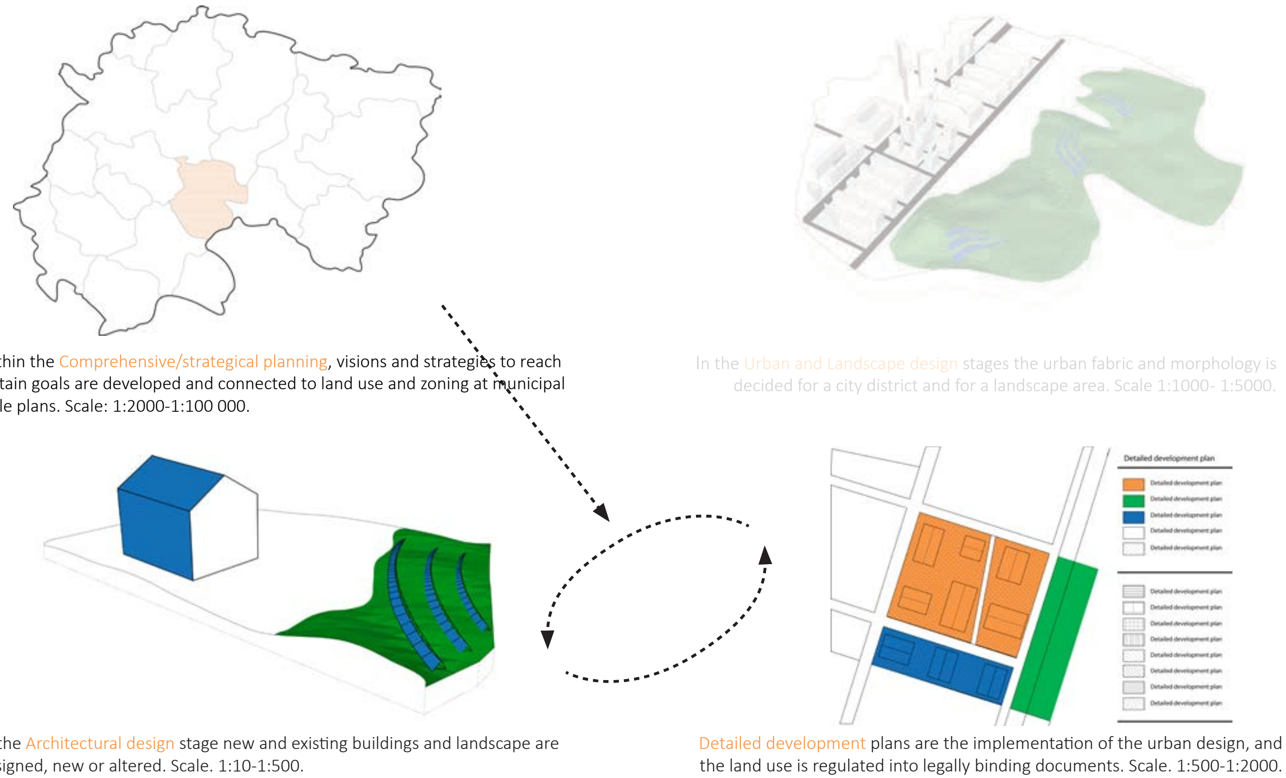
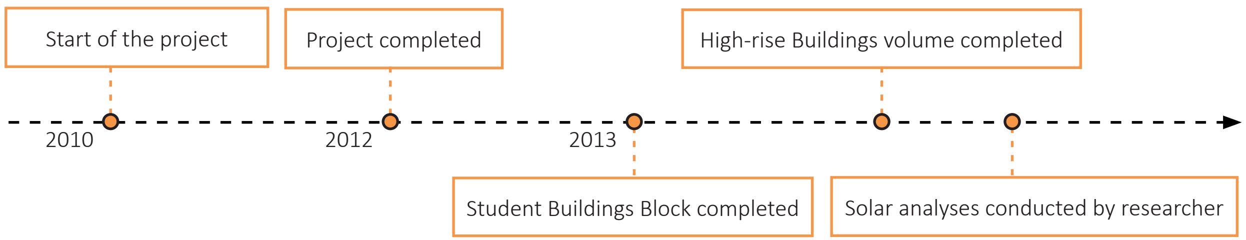


Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [4] Article available at: www.bygg.no/article/95448 Access: 26.01.2016

Figure 5 - A view of PV system installed on the South façade of the building shaded by the student block in front of it. (Photo: © Carmel Lindkvist)

Figure 6 - South view of the BiPV facade of the office building in Trondheim, Norway. (Photo: © Carmel Lindkvist)

SUMMARY

The building is connected to district heating plants, power grids and also has its own production of electricity in a solar system. Total building area 11 000 m^2 of which 7 300 m^2 must meet energy class A.

TECHNOLOGY

The building presents a Building Integrated Photovoltaic system installed on the South and the West façades. The PV system consists of 121 modules, arranged in nine strings for total 203 m^2.
The power of the system is equal to 27.2 kWp.

ENERGY SYSTEM, ENERGY DEMAND, ENERGY PRODUCTION

Legislation does not consider the broader aspects of solar energy that is relevant in development of urban areas as illustrated in the Norwegian cases. After this case studies, the local regulation has been changed, by abolishing the prohibition of installing solar system on the roofs in that area of the city.

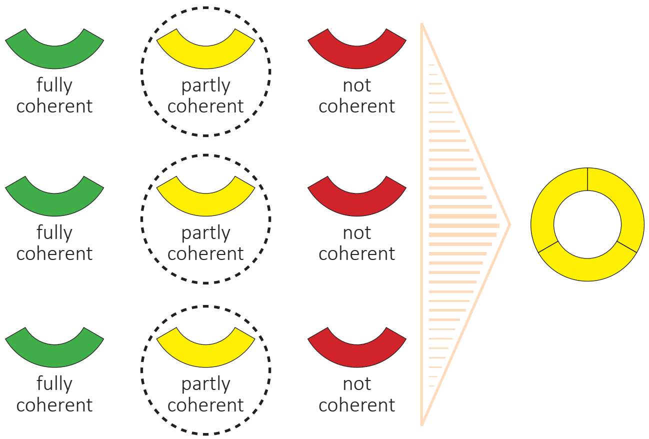
References: [3] Good, C. S., Lobaccaro, G., & Hårklau, S. (2014). Optimization of solar energy potential for buildings in urban areas- a Norwegian case study, Energy Procedia, 166-171.
[4] Article available at: www.bygg.no/article/95448 Access: 26.01.2016

Figure 7 - System geometry (Photo: © Gabriele Lobaccaro)

Figure 8 - View of the BiPV facade (Photo: © Carmel Lindkvist)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	**1** - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	**2** - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	**3** - MODULAR PATTERN



COMMENTS

The system covers a rectangular portion of the façade; the layout is symmetrical along the longitudinal axis of the white cladding. Nevertheless, the architectural composition logic is not completely clear. The blue solar cells contrast with the clear color of the underlying façade, reminding somehow of other dark parts of the building envelope. However, the design logic is difficult to understand, for instance making it difficult to perceive the opening of part of the windows placed on this façade. The modules match the horizontal and vertical spacing between windows, but the encapsulating frame reveals that they are not always coherent with the window opening modularity.

References: *[5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 9 - *Criticity of city surfaces in relation to architectural integration quality [5]*

Figure 10 - *A view of PV system installed on the South façade of the building. The PV panels resulted partly covered by the shadowing of the new student block built one year later. (Photo: © Carmel Lindkvist)*

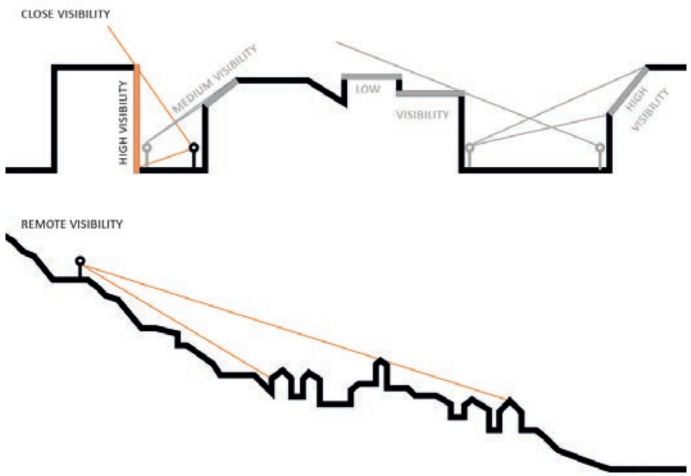


Figure 11 - *Different levels of visibility of city surfaces from public domain*

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	●	○
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	●	○	○

CONTEXT SENSIBILITY

The zone surrounding the building is a recent urban development that includes several typologies, but it is particularly devoted to collective residential (hotels, student house blocks). Buildings located in this area are mainly newly built simple blocks.

SYSTEM VISIBILITY

The district being a new development, is equipped with wide roads and many pedestrian areas.

Concerning the specific case of the analyzed building, the installation was highly visible before the new construction. After the intervention the façade is still visible from a close perspective, but less from a far viewpoint.

However, also remote visibility is still possible, from the hill on the west part of the city of Trondheim (Bymarka, Byåsen) from where the PV panels installed on the west façade are still well visible.

References: [5] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Figure 12 - Top view from the South of Lerkendal district. (Photo: © Fredrik Valde Anthonisen and Edvard Schreiner Sjøblom)

ENVIRONMENTAL IMPACT

The outdoor South side of the area is built on p-cellar. The presence of the trees creates a stay space in human scale between buildings. In order to get enough soil volume for planting large trees, boxes of 1 m height have been used. They work as benches while the area has a twofold function: on the one hand, as pedestrian traffic regulation and on the other hand as a living area. The retaining wall in concrete and slate staircase down to Holtermannsveien has the purpose to screen the building and the outdoor area from the traffic noise [6].

ECONOMIC IMPACT

During the construction, some detailed Simi calculations were done to get financial statements under 84 kWh/m^2 [6]. The total cost of the project was equal to NOK 220 million.

SOCIAL IMPACT

Any activity in order to consider the social impact has been used during the urban process and the case study definition.

References: [6] Tegn_3 website available at: www.tegn3.no/prosjekter/energibygget/ Access: 26.01.2016

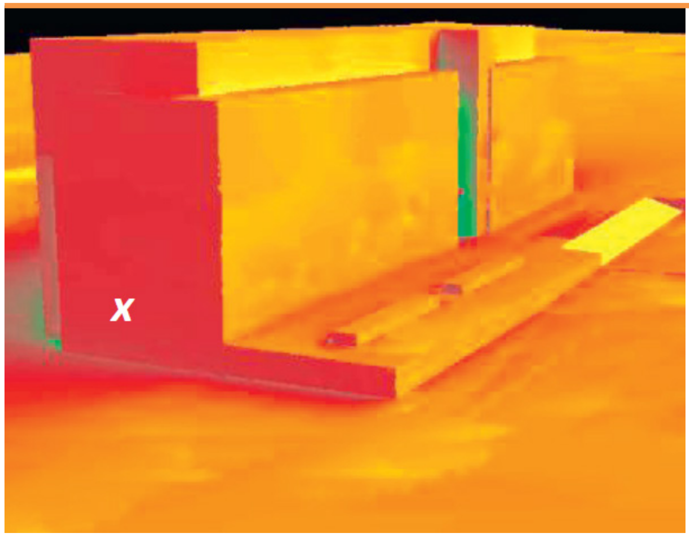


Figure 13 - Solar mapping analysis of the South façade in the unobstructed scenario (Picture: © Gabriele Lobaccaro)

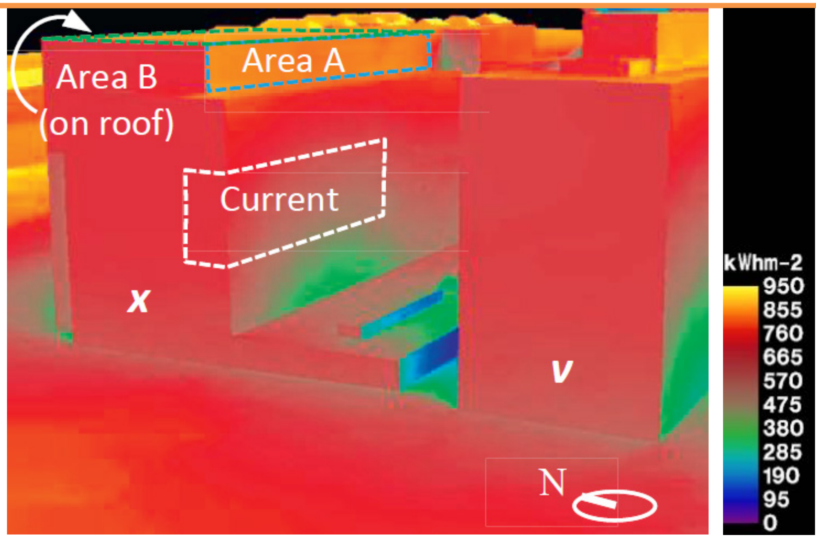


Figure 14 - The visualization of the current PV area (in dashed white line), area A (in dashed blue line) and area B (in dashed green line) (Picture: © Gabriele Lobaccaro)

ANALYSIS

1. Solar potential analysis of the building envelope in an unobstructed scenario;
2. Solar potential analysis of the building in its urban context in order to study the overshadowing effect created by the urban surrounding and localized the parts of the building receiving the highest solar radiation;
3. Optimize the solar energy potential of the building, using a multi-level simulation approach;
4. Analysis of the energy production of two different solar technologies (solar thermal and PV).

EVALUATION

A set of analyses using dynamic simulation tools were used to perform a three-level analysis of the solar potential of the building, in order to propose improved alternatives to the current system. Data on the modules and inverters from the real system are used in the simulation [3].

Three different levels of analyses have been conducted for evaluating the solar potential and energy production:

- First level: solar mapping analyses with Diva for Rhino;
- Second level: overshadowing analysis and localization of the most radiated surfaces with Diva for Rhino.
- In the third level of analysis, the calculation of the energy production with photovoltaic system was calculated using PV syst.

  While Third level: calculation of energy production with Polysun.

RESULTS

In all scenarios, the solar energy systems contribute with a quite small fraction of the building energy demand. The solar thermal systems have a significantly higher output than the PV systems, and the roof mounted solar thermal system contributed with the highest fraction of the building energy demand (9.1 %).

The results of the estimated energy production of the system (200 m^2) calculated from the solar radiation analyses are summarized below.

SCENARIO	PV [kWh]	ST (kWh/ a)	ENERGY DEMAND COVERED [%]	
Current	18 340	-	2.0	
Area A	18 340	43 580	PV 3.1	ST 7.3
Area B	24 340	54 390	PV 4.1	ST 9.1

References: [3] Good, C. S., Lobaccaro, G., & Hårklau, S. (2014). Optimization of solar energy potential for buildings in urban areas- a Norwegian case study, Energy Procedia, 166-171.

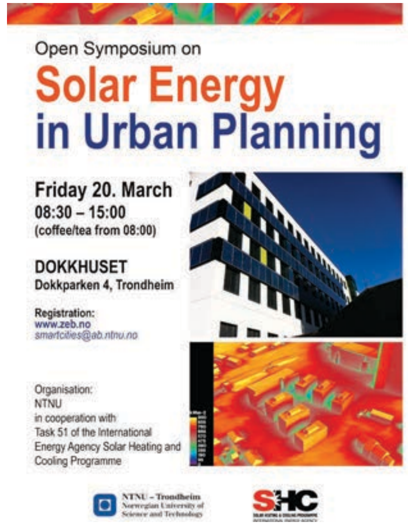


Figure 15 - Flyer of the public open symposium on" Solar energy in Urban Planning" (Author: © Ole Tolstad)

LESSONS LEARNED

- As right of light becomes more commonly discussed in Scandinavia, legislation needs to reflect the reality of solar access in urban environments.
- Planning and building design needs to include solar access rights of individual buildings in order to move toward not just sustainable buildings but sustainable districts.
- New considerations over urban legislation regarding solar rights and access have to be improved.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- Conduct analysis from the early design phases.
- A dialog between researchers, owners and stakeholders is very important.
- Revise the urban regulations in terms of right of lights, solar accessibility and integration of solar components.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects

PUBLIC AND EDUCATION ACTIVITIES

Open Symposium on *"Solar energy in Urban Planning"*- Friday 20. March 2015, Trondheim.

References: [3] Good, C. S., Lobaccaro, G., & Hårklau, S. (2014). Optimization of solar energy potential for buildings in urban areas- a Norwegian case study, Energy Procedia, 166-171.

ARCHITECT, DESIGNER AND DEVELOPER

Tegn 3

CONSULTANTS

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STAKEHOLDERS

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NTNU
Norwegian University of Science and Technology

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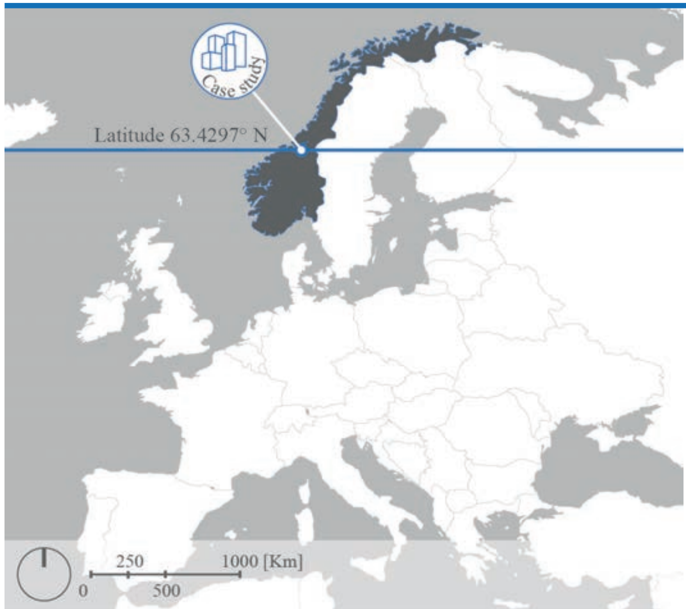
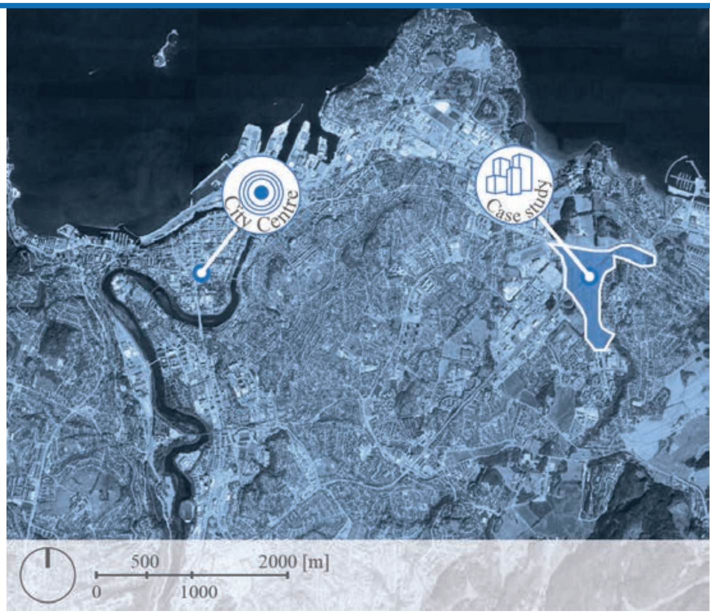
ØVRE ROTVOLL - SUSTAINABLE MASTERPLAN

NORWAY

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Norway
Location: Trondheim (Lat. 63°42′97″N; Lon. 10°39′33″E)
Climate: Subarctic climate (Dfc) [1]

AREA OF INTEREST

Targets and goals and Planning process

LOCAL CONTEXT

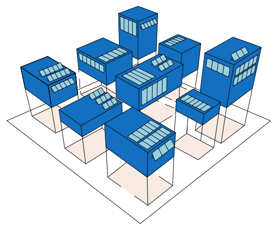
The analysed site is located in a coastal area near Trondheim. The aim of the strategic masterplan for Øvre Rotvoll is to develop a health-promoting, energy-efficient, climate-resilient neighbourhood. To achieve a sustainable settlement, the following criteria should be included: Environmental friendly infrastructure; the use of renewable energies; consideration of social and economic concerns.

ABOUT THE CASE STUDY

In a design seminar, master students of the urban design and research institute at the University of Wuppertal generated a sustainable masterplan proposal. The main focus of the planning process was to optimise solar energy potentials.

Definition of environment:
New Urban Areas

Site area: 275 000 m^2
Building area: 109 000 m^2
Area density: 0.4



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Figure 1 - Distances to bus stops and bus route, foot and bike paths. (Source: © BUW Siems/Simon with Master students, year 2014/15, Seminar ES1)

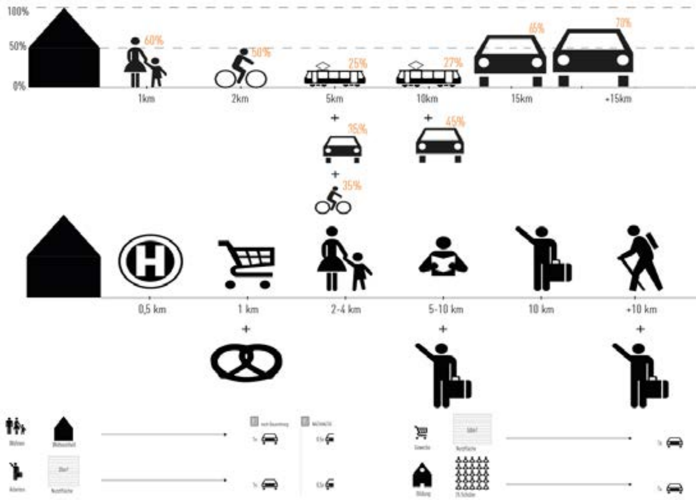


Figure 2 - Distances to amenities. (Source: © BUW Siems/Simon with Master students, year 2014/15, Seminar ES1)

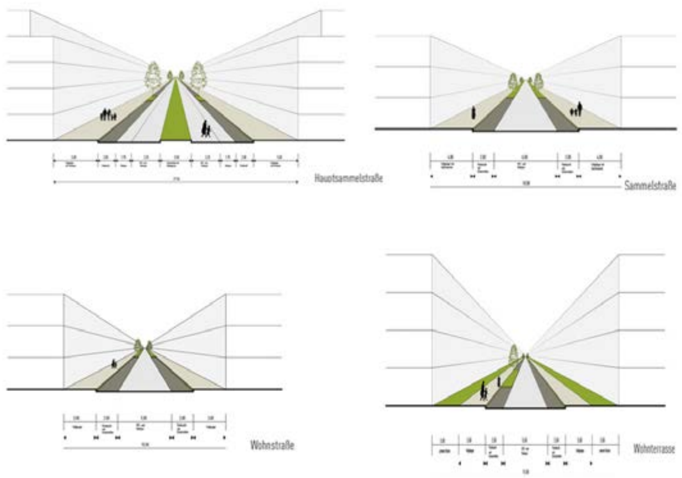


Figure 3 - Regulations for street sections. (Source: © BUW Siems/Simon with Master students, year 2014/15, Seminar ES1)

HIGHLIGHTS OF THE CASE STUDY

Seminar design approach: to generate the sustainable parameters and to apply these to the design process, all urban layers such as technical, traffic, green and social as well as typology and open spaces were taken into consideration.

The design process focused on the public transport as a valid sustainable access to the site. In order to make this happen, bus and tram's stops were placed in a 200 meters radius of each housing plot, so that the distances to the various public transport stops were as close as the parking places for private cars.

ISSUES AND CHALLENGES

To supply the new living area with daily and weekly amenities, the students evaluated and developed in their design approach shops and other public facilities. This was generated through different methods (e.g. diagrammatic relation drawings) and applied afterwards in the overall masterplan strategy (Figure 1).

The students took also the needs of parking within the building areas for housing and business into consideration. They calculated the necessary areas for the stationary traffic in square meters for each usage. The students suggested a more sustainable approach to the accessibility strategy. This included the proposition that the individual traffic should be reduced to 0.5 car parking spaces per housing unit (Figure 2).

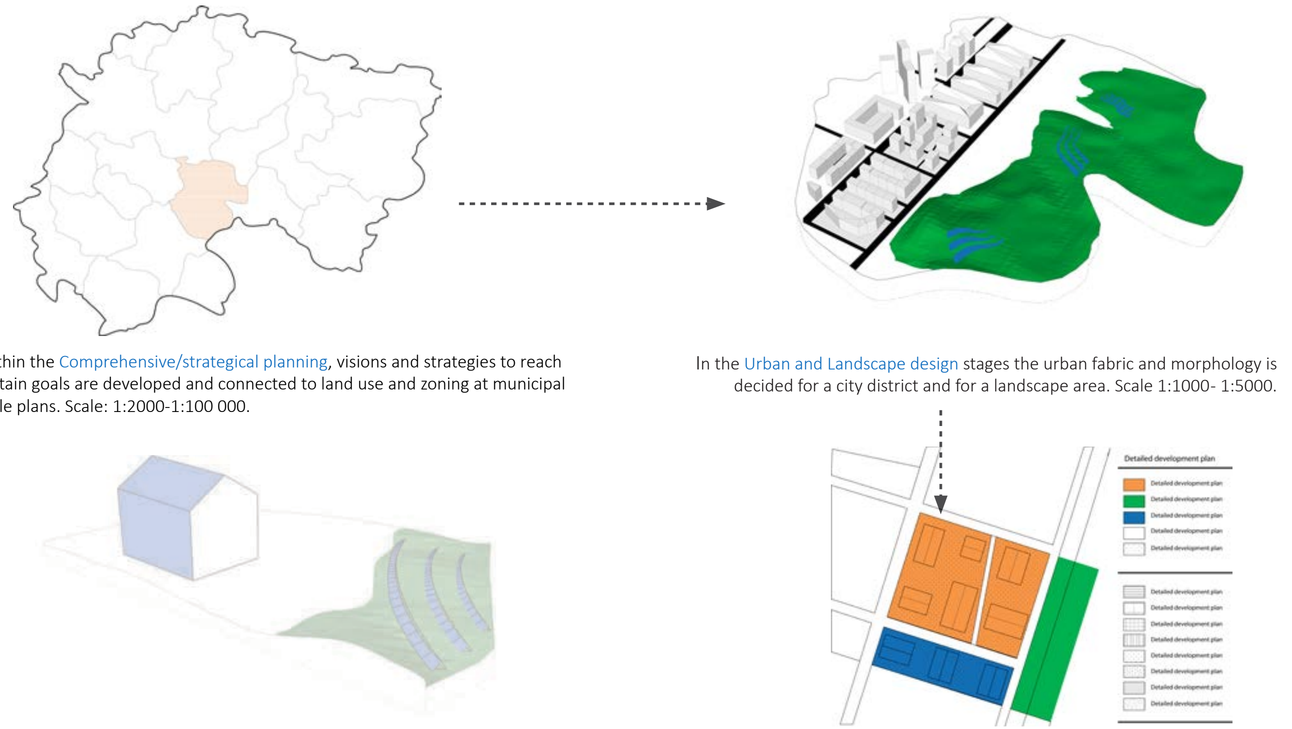
DECISION STRATEGIES

For an environmental infrastructural approach of the masterplan strategy, the distance regulations (German RAS Q, regulations for street sections) for the urban structure had to be taken into account. From this premise, the students generated more sustainable street sections for the primary and secondary roads with a high quality of open spaces, pedestrian and bike paths as well as lanes for public and individual transport (Figure 3). This decision and outcome of the new design regulations underlined the design process to create appropriate distances for the following solar energy strategy plan.

The planning process

The starting point of the students' research for creating the masterplan strategy was to analyse the infrastructural, energetic and social impact to the urban structure and holistic approach. Therefore, the process started with the analysis and the evaluation of the existing main traffic infrastructures. The students created a framework around the existing infrastructure and planned public transport stops. In a 200 meters radius grid, the areas for the planned building units were defined and placed in the urban fabric of the site. This strategy generated five different areas for mixed use purposes. The efficiency of the public transport relied on the infrastructural design strategy of the primary and secondary roads as well as on the new pedestrian paths in the middle of the urban quarter, which defines the backbone of the planning site. The main existing road was noisy because of the accumulated individual transport. The students did plan and design landscape integrated acoustic barriers in order to minimize the sound of the traffic. After the students created the optimised sections for the different street layout, the distances needed to be calculated with a digital platform in order to optimise the solar potentials.

The designed typologies proposal followed the solar energy criteria and did improve the structural approach to the whole masterplan. Social parameters were taken into account once the phase of finding the solution for the typologies was complete. The students evaluated and defined the social parameters and generated a sustainable open and communal space strategy plan. The final masterplan integrated at the end of the process all sustainable criteria as environmental, social, economic and infrastructural concerns; therefore, a holistic masterplan strategy was generated for the site.



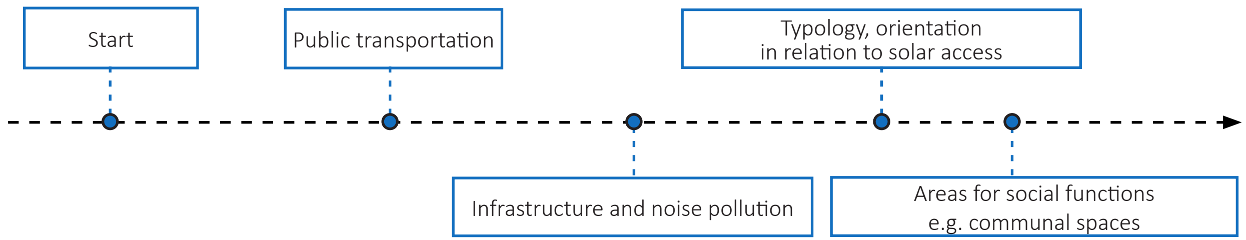
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: © White Arkitekter)



Energy concept

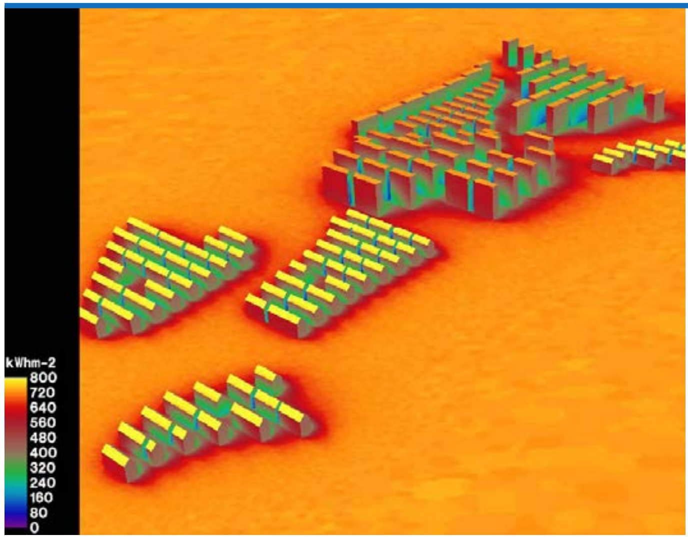


Figure 5 - Solar irradiation per year (DIVA 4 Rhino). (Source: © Katharina Simon)

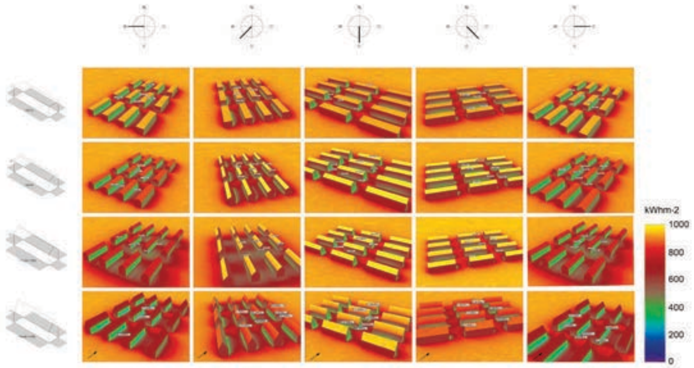


Figure 6 - Comparison of solar irradiation for different roof types and orientations. (Source: © Katharina Simon)

Figure 7 - Exemplary orientation of residential buildings showing the main façade and entrance situation. (Source: © Katharina Simon)

SUMMARY

The usage of solar potentials is the main objective of the generated urban structure. The south orientation of most of the planned typologies facilitate the implementation of PV panels on roofs and on the main façades. The evaluation shows that especially for residential buildings the pitched roofs reach the best solar irradiation. An optimised distance between the buildings allows the integration of solar thermal systems in the façade. The density of the office building area is higher than of the residential site. The office buildings are planned with flat roofs and more floor levels than residential buildings. This aspect has a relevant effect on the urban density and on solar accessibility .

OPTIMIZATION PROCESS

The matrix shown in Figure 6 describes the optimisation process with the software tool DIVA for Rhino3d. Exemplary buildings with different roof types and different orientations have been investigated. The best solar impact is assessed for the south oriented building with a 30 degree pitched roof. The distance between the buildings was set by multiplying the height of the building for 0.8 factor. The worst solar impact was measured for the East or West orientation with a 60 degree pitched roof.

Figure 7 shows the south orientated residential buildings with the main façade and general entrance situation. In the design process balconies can be planned in the south orientated façade which give the possibility for the integration of solar thermal systems.

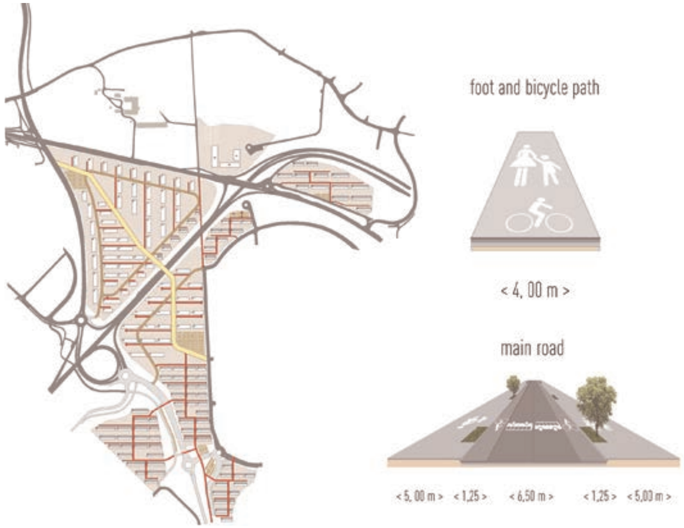


Figure 8 - Infrastructure public transport plus foot and bike path. (Source: © BUW Siems/Simon with Master students, year 2014/15, Seminar ES1)

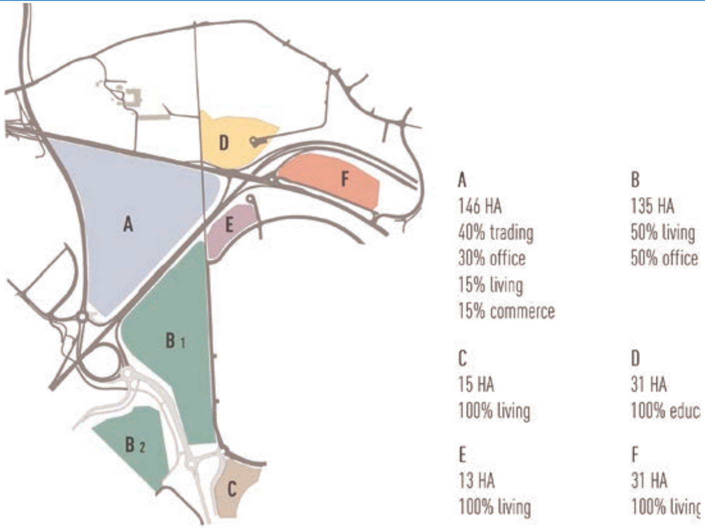


Figure 9 - Building areas. (Source: © BUW Siems/Simon with Master students, year 2014/15, Seminar ES1)

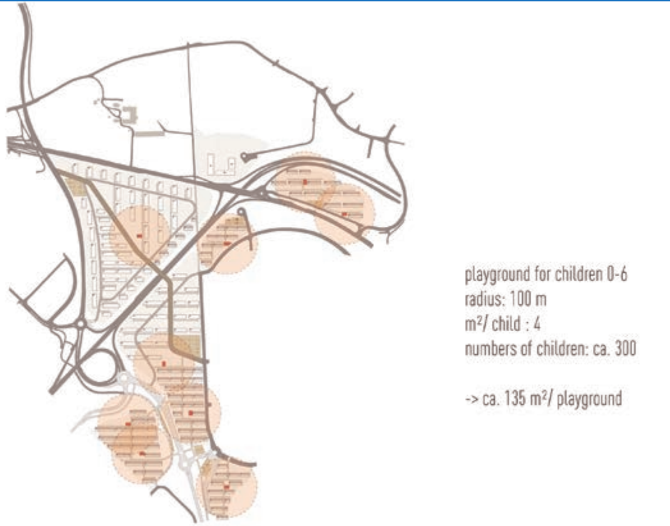


Figure 10 - Communal spaces e.g. parks, playgrounds. (Source: © BUW Siems/Simon with Master students, year 2014/15, Seminar ES1)

ENVIRONMENTAL IMPACT

The relevant environmental impacts of the design development of the case study were created through the traffic infrastructure and the solar structural potentials. Therefore, the students created sustainable, infrastructural solutions in relation to the urban fabric with the possibility of solar energy usage in the chosen typologies, such as solar energy potentials for photovoltaic and solar thermal on the roof and on the façade systems.

In order to make the new urban quarter more sustainable, the public transport accessibility and the high quality of the street sections were most relevant for the design process. Therefore, the right distances from the housing units as well the business units to the public transport including the right frequencies during the peak and off-peak times throughout the day needed to be provided as part of the masterplan strategy.

ECONOMIC IMPACT

For the economic approach, the students evaluated in various design proposals the right amount of density and height of the buildings in the different sub-areas of the district and therefore the used typologies in the masterplan strategy. Relevant for the design process and the final masterplan was the concept of mixed used areas of residential and commercial units and utility services to create a district with a “short distance walk”. The mixed used area approach made the overall building areas feasible and the generated concept reduce the need for individual transport accordingly.

SOCIAL IMPACT

The social impact of the masterplan strategy: The students analysed all social aspects of the site development and generated a digital script for all relevant social facilities in comparison to its users. For each building area, the most social impact was taken into consideration and applied to the design process. Figure 10 shows the planned playground for children and youth centers for teenagers as one layer of the urban fabric. The parameter in the created script analysed and evaluated the distances to communal- and public facilities in relation to the housing units and the educational institutions such as schools and kindergardens. For young and elderly people the script evaluated necessary communal facilities in order to generate a sustainable “open space programme” for these generations.

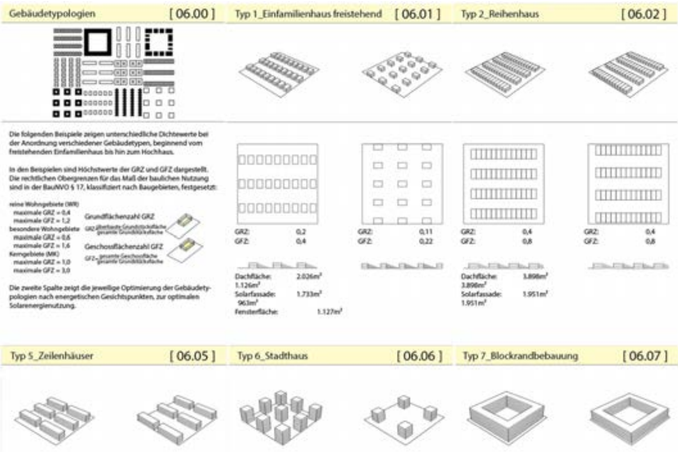


Figure 11 - Typology in relation to solar planning. (Source: © BUW Siems/Simon with Master students, year 2014/15, Seminar ES1)

Figure 12 - Analogue planning tools: irradiation disk for solar energy. (Source: © BUW Siems/ Simon with Master students, year 2014/15, Seminar ES1)

Figure 13 - Planning with artificial sun. (Source: © Katharina Simon)

DESIGN STRATEGY

During the design process we are working with analogue and digital tools in order to support and assess the proposed planning. Especially for developing a sustainable settlement various aspects should be considered. Analogue tools such as “the irradiation disk for solar energy” and the “typology / density cards” illustrated in Figure 11 and Figure 12 help to develop optimised urban projects.

Figure 11 shows an extract of different typologies, which assess the solar impact on roofs and façades. Depending on the density of building agglomerations and building height, the solar irradiation varies. The comparison of different typologies in relation to solar impact, gives an overview on the possibilities to implement solar energy systems in the urban context.

Figure 12 and Figure 13 show further analogue tools, such as the irradiation disk for solar energy or the artificial sun. The disk for solar energy demonstrates the relation of solar impact on roofs depending on the building orientation. The artificial sun (Figure 12) allows the analyses of shading in a physical 3D model in order to give a first idea for solar optimisation at an early stage of the design process.

In seminars by Bachelor and Master students at the University of Wuppertal digital software tools are also used. These tools e.g. DIVA for Rhino 3D are applied in contrast to the described analogue tools during the later planning process. This depends on the fact that a detailed digital 3D model is needed.

Most digital tools work with 3D models that allow the generation of a precise image of existing urban structures. They act as planning aids, graphically depicting shadowed areas and solar radiation totals for a residential area or a district in the form of false-colour imaging. But for use as a decision aid for practicing planners, especially urban planners, all tools display significant deficits. At the moment, all the tools are designed more for energy planners than for urban planners. The lack of interfaces to tools commonly used in urban planning, such as GIS- Systems, hampers practical use. Geoinformation systems are a preferred tool of urban planners because they allow a digital compilation of space-related data in the form of a geometric representation, sometimes in 3D, and linked to numerical databases.

Figure 14 - Design tutorial. (Photo: © Julia Siedle)

Figure 15 - Final presentation of the design project. (Source: © Julia Siedle)

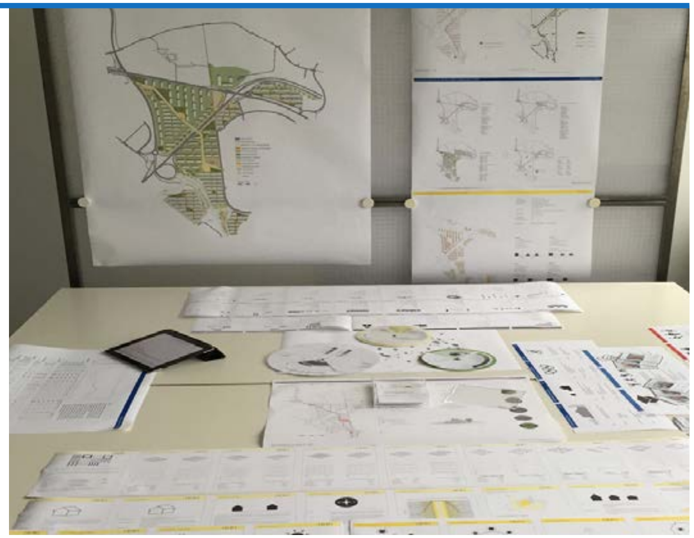


Figure 16 - Final site plan of the design project and the used analogue tools. (Photo: © Tanja Siems)

LESSONS LEARNED

At the end we could see that for a sustainable design process the importance to include each of the described parameters is relevant to the overall design approach.
Missing in the design process were for instance the other energy sources e.g. biomass which changes the urban structure based on the maximal length of possible energy grids. Particularly in students´ work at universities the mix of analogue and digital tools strengthen the understanding of dealing with various planning aspects. The usage of analogue and digital tools supports the students from the early design phase to the later one.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

Currently there are not many existing seminars and course for students which are specifically focusing on solar energy in urban planning at universities.
Most of the courses are taught in the disciplines as architecture, engineering as well as environmental science which are using the principle of solar energy for technical and design purposes only at the building level. The knowledge of implementing solar energy on an urban scale has to be strengthened in the future in the tertiary education. A satisfactory integration of the research results in education is currently one of the biggest challenges.

TARGET GROUPS

Seminar for Master students, here the sample of the Urban design and planning seminar called “ES1 experimental urban research”.

(Source: © University of Wuppertal, Katharina Simon)

RESEARCH INSTITUTION

University of Wuppertal (Bergischen Universität Wuppertal - BUW)

ACKNOWLEDGEMENTS

BUW Master students, year 2014/15, Seminar ES1.

COURSE INFORMATION

Course name: Urban design and planning seminar "ES1 experimental urban research"
Module description: The focus of the urban design seminar lies within identifying the importance of orientation and design systems for a sustainable development of urban projects. Analysis, evaluation and representations of economical, ecological and social interactions between buildings, urban structures, infrastructure and technically related city systems.

CASE STUDY AUTHORS

Tanja Siems, BUW; Katharina Simon, BUW.

RESEARCH ORGANIZATIONS

University Wuppertal, Institute for urban design and research

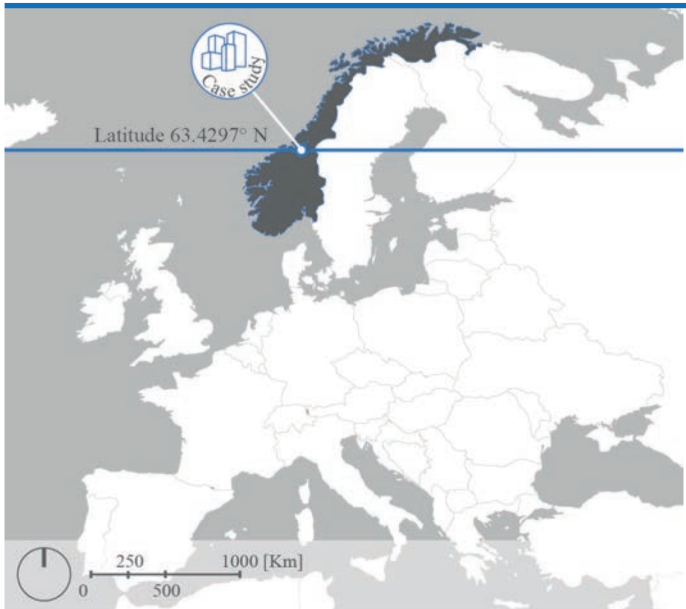
BERGISCHE UNIVERSITÄT WUPPERTAL

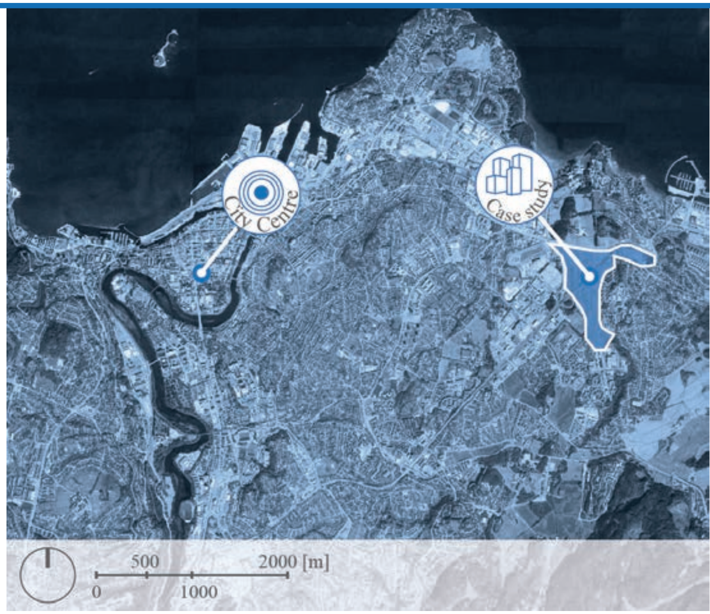
S U
städtebau + urban scape

ØVRE ROTVOLL - SUSTAINABLE MASTERPLAN

NORWAY

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Norway
Location: Trondheim (Lat. 63°42'97"N; Lon. 10°39'33"E)
Climate: Subarctic climate (Dfc) [1]

AREA OF INTEREST

Targets and goals and Planning process

LOCAL CONTEXT

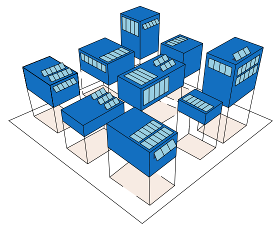
The Norwegian government is actively involved in the promotion of the energy efficiency in the building sector, however, there are no requirements in its energy standards which specifically refer to solar technologies. Furthermore, there is a general lack of standardization with regard to solar accessibility and right of light both at national and municipal level.
However, the number of solar energy installations has been growing in the last years. Oseana Art and Culture Center, Campus Evenstadand and Powerhouse Kjørbo are some of the main examples of building with integrated PV systems. There is an increased interest in Trondheim on solar installation. Meaningful examples are the Powerhouse Brattørkaia [2] and the project for the new Trondheim Spectrum [3], a large facility building with an energy strategy focused on the use of solar systems.

ABOUT THE CASE STUDY

Øvre Rotvoll is a new urban development area, located in the East part of Trondheim. The district aspires to become a new strategic development area according to the energy targets of the net-zero energy neighbourhoods.

Definition of environment:
New Urban Areas

Site area: 255 000 m^2
Building area: 60 000 m^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Article available at: brattora.no Access: 01.06.2016; [3] Article available at: www.adressa.no

Issues, challenges and decision strategies

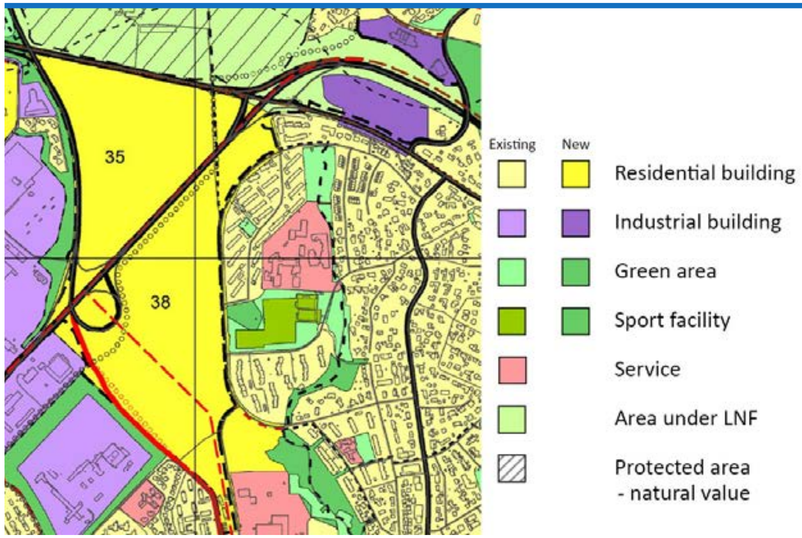


Figure 1 - Zoning for Øvre Rotvoll's area from Municipal Masterplan 2012-2014 (Source: © Trondheim Kommune [3])

Figure 2 - Definition of the six sub-areas composing the new district of Øvre Rotvoll (Author: © Silvia Croce)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case are:

- Definition of urban design guidelines in Nordic climate with regards to solar exposure and solar potential and their validation by applying to a real case study;
- Use of solar potential analysis to optimize the entire district morphology and localize the most suitable surfaces for installing solar integrated systems;
- Implementation of the renewable energy production from the early design phases of an urban district.

ISSUES AND CHALLENGES

- General lack of standardization in Norway, with regard to solar accessibility and solar exposure
- Lack of Norwegian standards regarding the installation of solar systems on the building envelope
- Challenges for the use of solar systems in urban areas in Northern European countries (e.g. long darkness period in winter and the low sun angle at high latitudes)
- Overshadowing effect and influence of the surrounding buildings on solar systems installed in urban areas
- Importance of considering the solar potential of the building envelope at the point of the early design phases.

DECISION STRATEGIES

A literature review has been conducted over Norwegian urban and energy standards [4][5] and municipal planning in Trondheim [6], in order to identify the guidelines to follow during the study and identify where legislation is lacking. Trondheim's residential districts have then been analysed in order to individuate the frequent building typologies and their characteristics. The outcomes of the study, as well as the zoning for Øvre Rotvoll's area proposed by Trondheim's municipal plan [6], were used as a base for the design process.

References: [4] Kommunal- og moderniseringsdepartementet, (2008). Plan- og bygningsloven (Planning and Building Act).
[5] Kommunal- og moderniseringsdepartementet, (2008). TEK10 – Forskrift om tekniske krav til byggverk (Regulations on technical requirements for building works).
[6] Trondheim Komune (2012). KPA- Kommuneplanes arealdel 2012-2024. Available at: trondheim.kommune.no Access: 2.09.2015

The planning process

The planning process focused on implementing the renewable energy production with solar systems from the early phases of the masterplan design.

Firstly, two typical building typologies (row house and high rise apartment block) and their dimensions were individuated by an urban analysis conducted on Trondheim's residential districts. Secondly, the building volumes were used for conducting sets of solar parametrical analysis using Diva for Rhino. Thirdly, the results were transferred into Nordic climate urban design guidelines with regard to solar exposure and solar potential. These guidelines were at the base of the design process of the masterplan, which was then optimized in order to maximize the solar potential of the building surfaces.

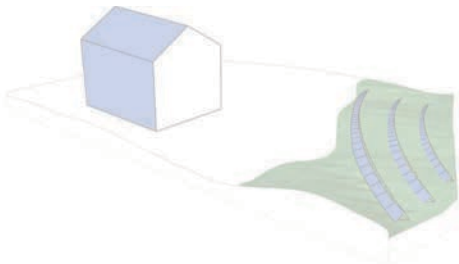
There were two goals:

- Propose a solar optimized masterplan for Øvre Rotvoll;
- Propose a design method in which the principles of solar accessibility and solar optimization are applied from the early design phases and are the bases for the whole design process.

The researcher worked on the case study, partly at NTNU and partly at University of Padova, as part of the development of a master thesis.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: © White Arkitekter)

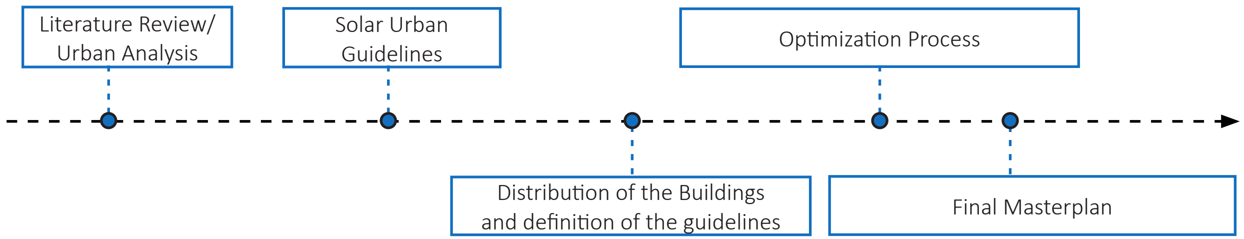


Figure 4 - Masterpla for Øvre Rotvoll.The building colored in orange correspond to sub-area B1. (Author: © Silvia Croce)

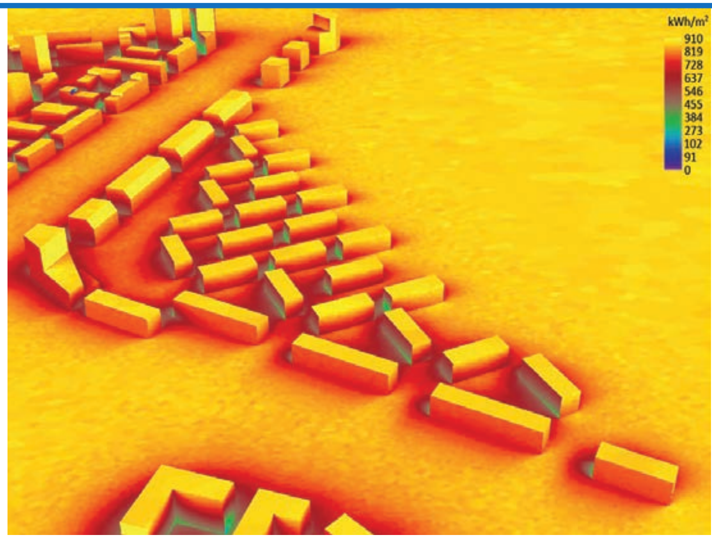


Figure 5 - Solar map of sub-area B1. Solar potential analyses were used for individuating the surfaces suitable for installing solar systems. (Author: © Silvia Croce)

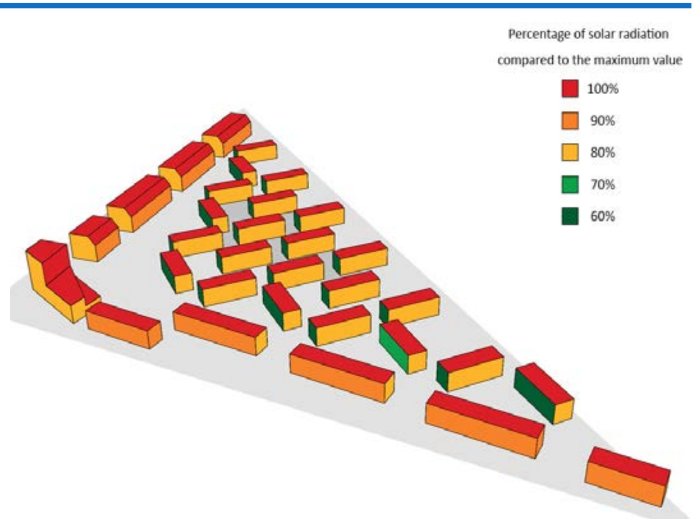


Figure 6 - 3D view of sub-area B1. The roofs and all the colored surfaces of the facades are suitable for installing solar systems. The different colors correspond to different percentages of solar radiation. (Author: © Silvia Croce)

SUMMARY

The design of the masterplan and its optimization process aimed to maximize the solar potential of each area of the district, consequently maximizing the surfaces suitable for installing solar systems integrated into the buildings' envelope.

TECHNOLOGY

The energy optimization of the district was conducted through only the use of active technologies, both PV and ST. The potential energy production was estimated by considering the installation of the solar systems integrated on the flat roofs and on the vertical facades at South, South-East and South-West. The contribution of the vertical facades to the total energy production was calculated in different scenarios, depending on the percentage of solar potential compared with the maximum value.

The total area covered by solar systems can vary from 5 850 m^2 (only surfaces with 100% of the maximum solar radiation) up to 48 500 m^2 (surfaces with 60% to 100% of the maximum solar radiation).

ENERGY SYSTEM, ENERGY DEMEND AND ENERGY PRODUCTION

Considering all the buildings belonging to the Norwegian Energy Class A, the total primary energy demand of the entire district is 26 500 000 kWh per year. Depending from the contribution of the vertical facades, the energy production with building integrated solar systems can cover up to 56% of the total primary energy demand for the entire district (maximum total energy production: 14 800 000 kWh per year).

The primary energy demand for DHW, equal to 6 200 000 kWh per year, can be covered entirely by using 17 % of all the surfaces suitable for installing solar thermal systems.

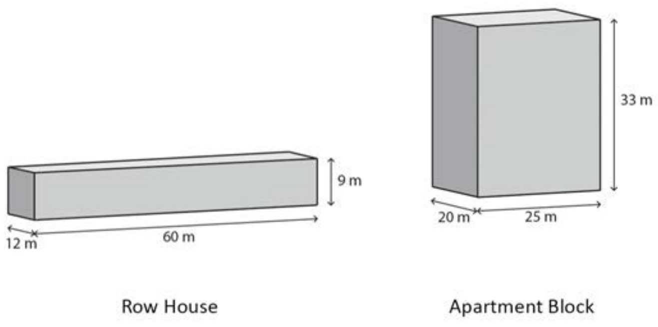


Figure 6 - Dimension of the two building typologies emerged from the literature review. The volumes were used in the parametric study that led to the definition of the urban design guidelines. (Author: © Silvia Croce)

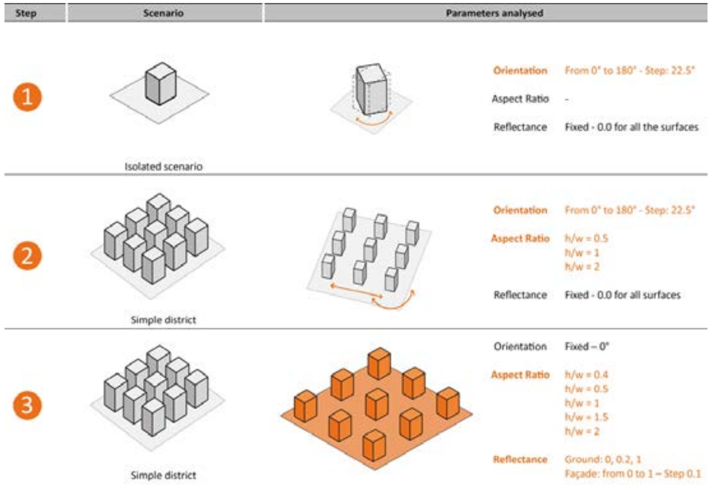


Figure 7 - Steps of the parametric study and parameters analyzed for each of them. (Author: © Silvia Croce)

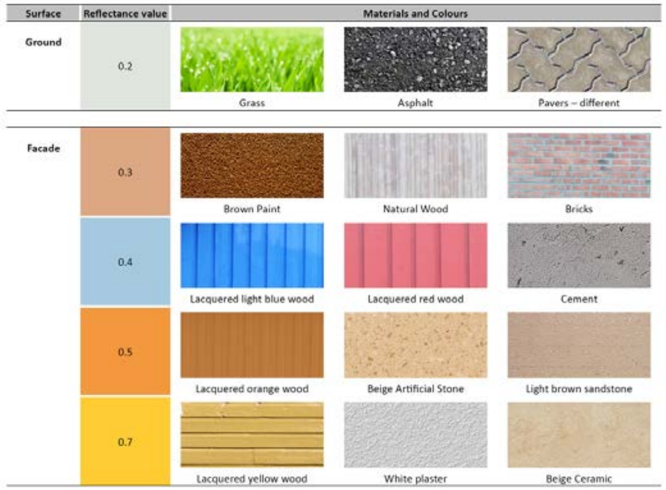


Figure 8 - Some of the materials suggested for the surfaces of the masterplan. The definition of the material had a key rolein increasing the indirect solar radiation. (Author: © Silvia Croce)

DESIGN STRATEGY

1. Solar potential analysis of the building envelope in (i) unobstructed scenario and (ii) simple district;
2. Urban design guidelines in Nordic climate with regards to maximizing the solar potential, outlined on the results of the previous analysis;
3. Definition of the masterplan based on the guidelines;
4. Solar potential analysis for optimizing the layout of the district and localize the most suitable surfaces for installing solar systems;
5. Analysis of the energy production of two different solar technologies (solar thermal and PV).

URBAN DESIGN GUIDELINES

A parametric study was conducted first on isolated building and then on simple district of nine identical buildings for both the building typologies considered (row house and apartment block). Solar potential analyses were carried out with Diva for Rhino in order to evaluate the effects created by orientation, reciprocal distance and reflectance values of the finishing materials.

The observed analytical relations were transferred into urban design guidelines in Nordic climate with regards to solar exposure and solar potential. The guidelines show, for different aspect ratios (height of the building/distance between buildings), how the distribution of the buildings in a district is able to maximize the solar irradiation on the building envelope and how different finishing materials can have positive effects on total solar radiation due to their reflections.

OPTIMIZATION PROCESS

Solar analyses were carried out on the masterplan, both during the design process, for optimizing the layout of the district, and at the end of it, to verify the validity of the urban design guidelines and to localize the most suitable surfaces for installing solar integrated systems in the building envelope.

Firstly, the solar potential of the building's envelope was calculated in the initial configuration without any reflectance contribution. The results were compared to the values obtained for the unobstructed scenario. The exposure of the facades were then modified for exploiting as much as possible the contribution given by the mutual solar reflections from the urban surrounding and the solar reflectance of the facades. The facades' materials were chosen in order to increase the indirect solar radiation reflected by the neighboring buildings.

RESULTS AND DISCUSSION

The design of the Øvre Rotvoll's masterplan validates the urban design guidelines and proposes a new approach for architects and urban planners in which solar accessibility and solar optimization underlie the design process at its early phases.

The results obtained confirm the validity of the approach proposed:

• The optimization process increases the overall solar potential of the district up to 26 % from the initial configuration;

• The choice of the solar reflectance values based on the urban guidelines' recommendations shows that all the building's solar radiation values are equal or higher than the ones in the unobstructed scenario. The contribution of solar indirect radiation reflected by surrounding surfaces produces an increment of 22 % in the total solar potential of the district.

By following the urban guidelines it was possible to avoid the shadowing on all roof surfaces, also the ones located behind taller buildings. In this way, all the roofs in the district have the maximum solar potential (i.e. 874 kWh/m^2 a) and all the facades toward South, South-East or South-West are suitable, totally or in part, for installing solar systems.

Figure 9 - 3D view of the masterplan. The different colors correspond to different values of reflectance for the surfaces materials. (Author: © Silvia Croce)

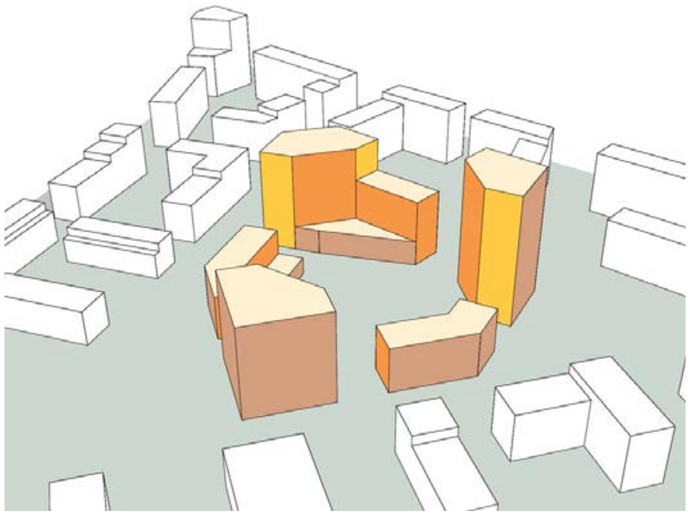


Figure 10 - Central Court in sub-area A: definition of the materials reflectance. (Author: © Silvia Croce)

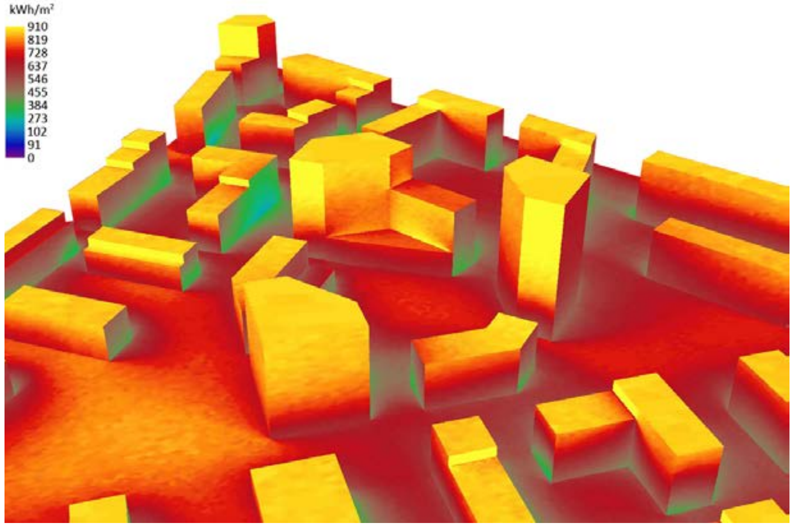


Figure 11 - Central Court in sub-area A: solar map after the optimization process. (Author: © Silvia Croce)

LESSONS LEARNED

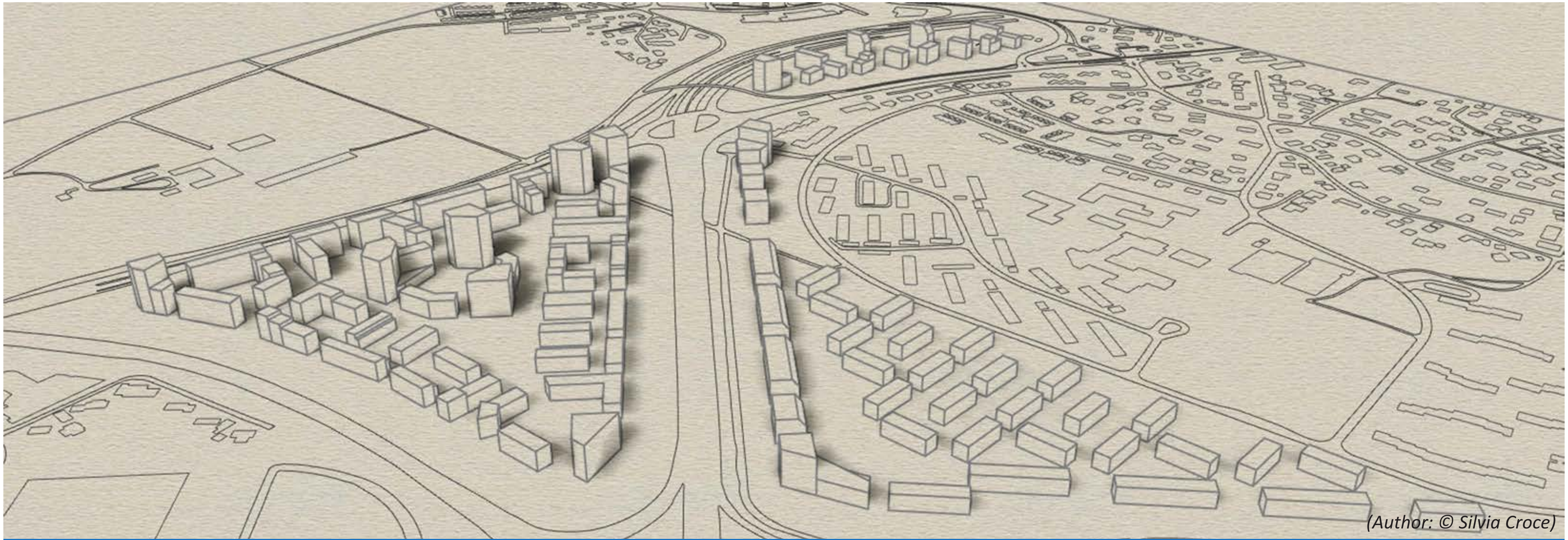
- The solar potential analyses can be used for developing solar design recommendations, which in turn can be a useful methodology to follow in the design and optimization of an urban district;
- The use of the guidelines, in combination with the optimal solar orientation, permits to design a district with the awareness of the solar potential of its buildings;
- Solar urban recommendations for Nordic climate and geographical conditions can partly cover the lack of legislation that regulates the use of renewable energy in Norway.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

- The integration of solar systems into the buildings envelope should be considered at the early phases of the design process in order to create energy efficient districts;
- Implement the legislation that regulates the use of renewable energy and provide guidelines for solar accessibility, right of light and integration of solar systems.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects


(Author: © Silvia Croce)

RESEARCH INSTITUTION

Norwegian University of Science and Technology (NTNU)

Università degli studi di Padova (UNIPD)

COURSE INFORMATION

The result of the research presented in the case study is contained in the author’s master thesis for the MsC in Building Engineering and Architecture at University of Padova.

The thesis is titled “Solar potential optimization in urban planning in extreme cold climate conditions. Design guidelines for solar accessibility and solar design for developing the masterplan of Øvre Rotvoll neighbourhood in Trondheim (Norway).”

CASE STUDY AUTHORS

Silvia Croce, UNIPD

RESEARCH ORGANIZATIONS

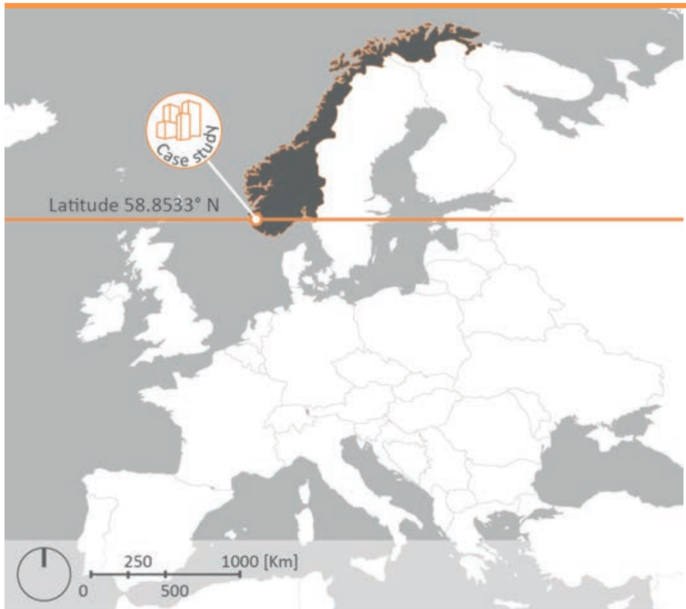
Università degli Studi di Padova

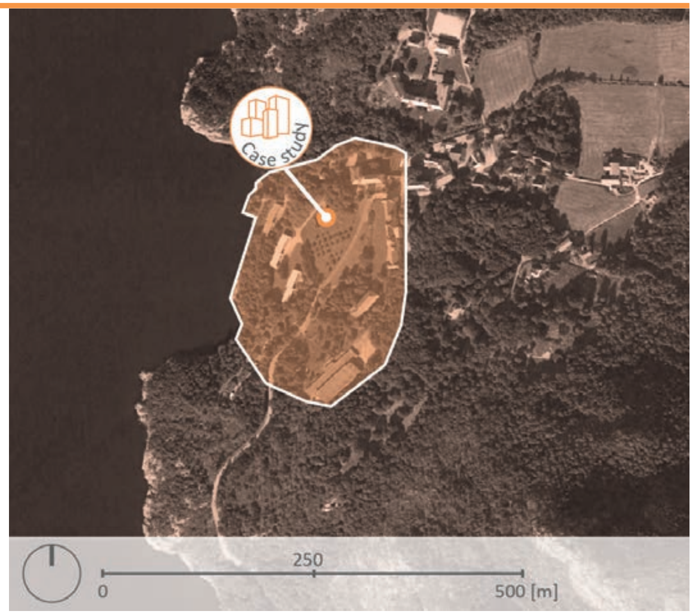
NTNU
Norwegian University of Science and Technology

DALE COMMUNITY

NORWAY

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Norway
Location: Sandnes (Lat. 58,8533°N; Lon. 5.7329°E)
Climate: Subarctic climate (Dfc) [1]

AREA OF INTEREST

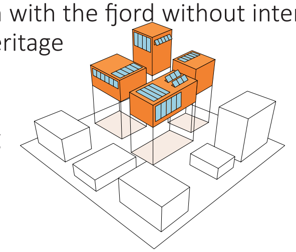
Legislation and technology

NATIONAL AND LOCAL CONTEXT

Dale is located approximately 7-8 km from the city of Sandnes and 20 km from Stavanger . Dale is a culturally heritage area with the historic building of an old mental institution building (FG) situated on a fjord called the Gandsfjord. Between 2008 and 2014, Dale planned to introduce 10 763 m^2 of space which constituted sixty new apartments and one floor for commercial purpose; PV-panels for six multi-residential buildings and the construction of 31 379 m2 of new buildings (in total 159 residential units) [1]. During this time Dale was part of a EU project framework CONCERTO/ PIME's which stipulated the use of renewable energies [2].
In June 2014 a political decision was made to halt plans.

ABOUT THE CASE STUDY

The energy solution needed to align with the long term plans of this cultural significant area. In 2013 a combination of heat pump and PV panels was decided in order to be able to take advantage of the natural surroundings of Dale as it is next to a fjord (the Gandsfjord) which is relevant to develop a renewable heat base. This solution allowed good integration to the landscape of the area by combining the solution with the fjord without interfering with the locally protected heritage requirements in Dale.



Definition of environment:
Densification district in the existing urban area and refurbishment of existing buildings.

Building area: 1 142 m^2

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] PIME'S Project Periodic Report (2013) CONCERTO communities towards optimal thermal and electrical efficiency of buildings and districts, based on MICROGRIDS

Figure 1 - East view if the main building of Dale – Protected mental institute. (Photo: © Carmel Lindkvist, 2014)

Figure 2 - West view of the main building of Dale – Protected mental institute. (Source: © KOKO architects)

HIGHLIGHTS OF THE CASE STUDY

Maintaining the cultural heritage and the history of the Dale area was a high priority in its development and has been outlined in a ten-year, 2007-2017, municipal plan. The energy solution needed to align with the long term plans of this cultural significant area. The energy ambitions were 90-95% renewable energy in the district. In 2013 a combination of a sea water heat pump, PV panels and a small hydro plant was decided. The reason for this choice of solution was to take advantage of the natural surroundings of Dale as it is next to a huge heat basis (the Gandsfjord). This solution was viewed as the best choice for a renewable energy solution. In 2014, planning was halted in Dale and due to start again in 2025. The reasons were primarily economic.

ISSUES AND CHALLENGES

Solar energy performance was limited due to poor access to sunlight in the morning. Modules were simulated as embedded in the ceiling with little added ventilation. Specific performance from the heat pump/PV solution was between 750-790 kWh/m2 a. The solution performance was considered low, but acceptable [3].

If installed max area PV modules heat supply would be nearly completely renewable [4]. However, even if the use of solar energy was supported by the EU project PIME'S, the solution to use solar energy was not considered profitable. To alleviate cost, the use of solar needed to be considered alongside an overall concept, with other technical equipment of buildings for optimum use. PV solar power delivered to energy exchange was preferred as it was considered more cost efficient to use power from the grid than supplementing with solar power.

DECISION STRATEGIES

Different stakeholders involved in the planning process had to adhere to local decision making plans. Dale received funding from the EU project PIME'S which stipulated the solution to be based on solar energy. Dale Eiendomsutvikling AS were a company formed to lobby for decisions on Dale and manage communication of Dale development plans. Rogaland Fylkeskommune (county council) who owned Dale and who were part of the planning approval process in deciding the agenda for planning meeting with the political board. Within PIMES, Dale was managed by the Rogaland Fylkeskommune and Sandnes municipality. Other stakeholders influencing planning decisions for Dale included solar energy consultants, architects and engineers, research institutes.

References: [3] Solcelle skisseprosjekt (Multiconsult report), March 2013: Technical report on combined heat pump/PV solution for Dale
[4] Multiconsult rapport varmeforsyning PIMES Dale, April 2013: Report on combined heat pump/PV solution for Dale.

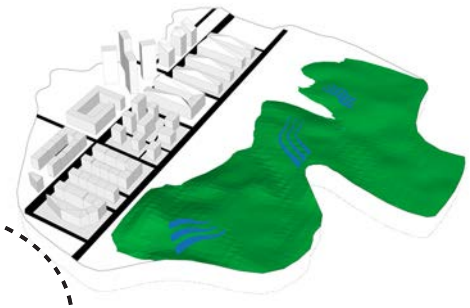
THE PLANNING PROCESS

Dale Eiendomsutvikling AS, Rogalnd fylkeskommune and Sandnes kommune were part of the EU's CONCERTO program (PIME'S) which stipulated a solar solution as a condition of participation. Dale Eiendomsutvikling AS had a clear strategy for the implementation of PIME`S, which was about 5-10% of the total planned units. Sandnes municipality agreed to support Dale Eiendomsutvikling AS PIME'S application but stipulated that development of Dale could only happen in the PIMES funded area. The solution is PV combined with heat pump, using the fjord as an energy source.

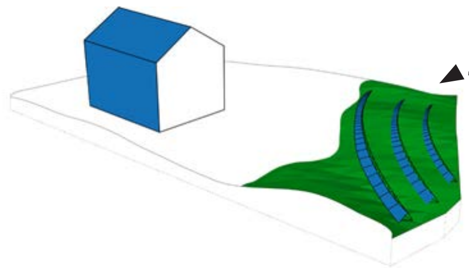
Solar solutions were prioritized in Dale due to its participation in PIME'S in 2009 [2]. Economic calculations were highlighted as necessary consideration of the solution which resulted in illustrating how PV panels for residential blocks could produce energy at 40% of the cost compared to solar heating panels. In 2013, the solution, developed by Multiconsult, was approved. It was an integrated system of sea-water basin with a heat pump and a PV power which had scope to be added to the grid. In 2014, Rogaland Fylkeskommune decided to halt planning Dale because Sandnes municipality required a road to be built linking Dale to Sandnes which was expensive. It was decided to prioritize planning to another area in Sandnes. Only the PIME'S funded area received planning and the rest of Dale is expected to be developed between 2030-2040.

Researchers worked with Dale Eiendomsutvikling AS. Information was gathered through interviews with key stakeholders, document analysis and internet searches .

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.



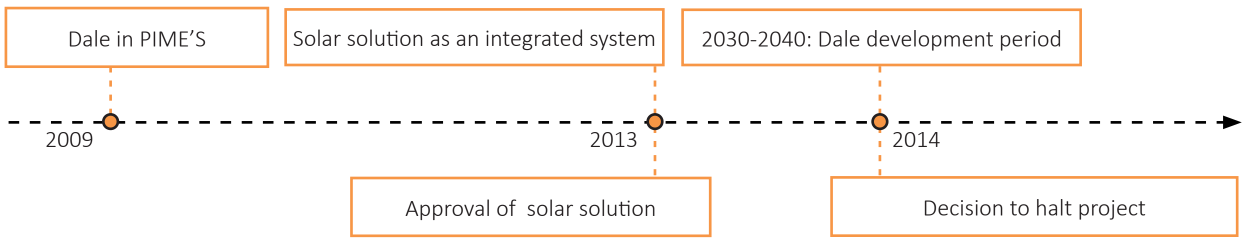
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 3 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [2] PIME'S Project Periodic Report (2013) CONCERTO communities towards optimal thermal and electrical efficiency of buildings and districts, based on MICROGRIDS

Energy concept

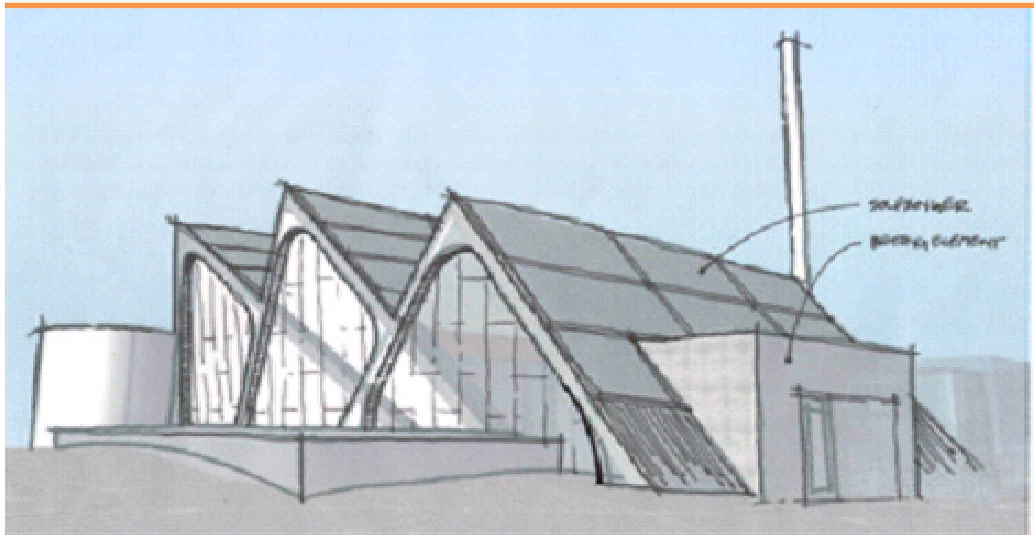


Figure 4 - Multiconsult presentation, Energy solution in Vitale Dale, May 2014 (Source: © Multiconsult)

ENERGY STRATEGY

A sustainable micro-grid system was a requirement for Dale to meet future needs. PIME'S set the restriction that the solution had to be solar. Dale considered PV installation and solar thermal in combination with the fjord for energy. In developing a solar solution, the solar consultant had to consider cultural/heritage restrictions, building heights, shadow of surrounding buildings and the horizon. Architects had the flexibility to make changes to the buildings if needed.

The main building in Dale was under local heritage protection which prohibited panel installation on the roof and the façade. In 2012, the Multiconsult was asked to do economic calculations as the initial solution did not allow for a return on investment. After 2012, the plan changed to be six new apartment buildings with PV on the roofs.

The roofs could not be flat which was an advantage for solar. The approved solution was an integrated system- sea-water basin combining heat pump with PV power connected to the grid. In 2014, the solar consultant's report, illustrated how PV panels for the residential blocks will produce energy at 40% of the cost compared to solar heating panels. This solution was approved.

Figure 5 - East view of the refurbishment intervention of the main building of Dale (Source: © KOKO architects, 2014)

ENVIRONMENTAL IMPACT

The consideration of the environmental impact steered the overall development solution towards a solar/heat pump solution. The specific CO_2 factors recommended for the concept has the lowest greenhouse gas emissions related to heat supply in buildings.

ECONOMIC IMPACT

The economic impact can be considered within (i) the energy solution associated with PIME'S project and (ii) the wider development of Dale. (i) The energy solution included economic calculations which would result in no profitability as a singular entity but when combined in an overall concept incorporating energy exchange with the grid. (ii) In 2014, Rogaland Fylkeskommune who owns the 45 000 acres, decided to sell Dale as they believed the property would progress in the hands of a professional developer. This decision was based on the huge investment required in Dale which was too costly from an owners perspective and in terms of the primary duties of a county council [6]. Heavy maintenance required which had not been done for 35 years. Added to this cost associated with the property is the expense of having to meet the requirement of Sandnes municipality to build a road to link Dale to Sandnes.

SOCIAL IMPACT

The decision making process occurred over a long period of time. The process highlighted the necessity of involving diverse stakeholder groups to meet social, economic and environmental demands for a non-standard solution which was required in Dale.

The approved solution facilitated in meeting all demands from the Dale Eiendomsutvikling AS, Rogaland Fylkeskommune, heritage department and PIMES. It was an economically viable PV/heat pump integrated solution which used the natural resource of the area's environment – the fjord as well as met the demands of local heritage requirements.

References: [6] www.nrk.no/

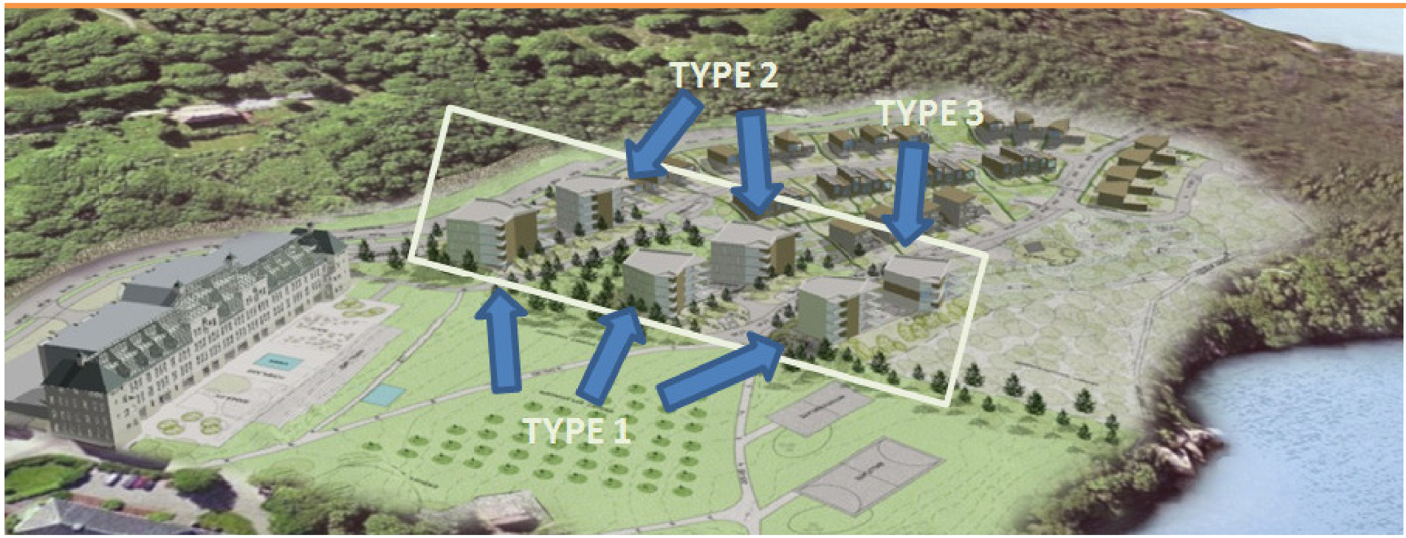


Figure 6 - Detail from a current situation map of Dale and indication of types of new buildings (Source: © Siv Helene Nordahl, Multiconsult)

SUMMARY

The energy concept in Dale was influenced through the funding of PIMES' which stipulated a solar energy solution. There were some environmental challenges in integrating this concept as there was poor access to sunlight in the morning, the heritage department limited the positioning on PV on protected buildings, . Tthe solution had to be economically viable and blend into the environment of the area. The developed solution was an integrated system of sea-water basin with a heat pump, taking heat from the fjord and a PV power with scope to be added to the grid. In such a solution, the aforementioned challenges were addressed as opportunities to create an overall energy efficient concept design.

TOOLS

Dale is 7 km from Sola airport which has ground measurements of temperature and precipitation, but not on solar radiation. Meteonorm generates weather forecasts for locations and calculated the average annual solar radiation on a horizontal surface in Dale to be 876 kWh/m^2 a [3]. Værdatabasen (Weather database) is generated on the basis of satellite data. DIVE Analysis was used to assess buildings for cultural landscape and calculations for energy production.

A simulation tool called T-sol (thermal calculation) was used to design a solar district heating in the early stages of Dale which was later dropped. PV Syst was also used.

SCENARIOS

The tools influenced the integration of solar into planning. DIVE analysis assisted in showing how the proposed solution fit with the municipality's energy and climate plan [5].

Buildings were analysed using PV Syst. The presence of the hill down by the sea was also taken into account in the simulation. The municipality had not allowed to design flat roof in that area, therefore it was decided to tilt the surfaces of the roofs on two angles 10 degrees and 30 degrees. The optimal tilted angle was 40 degrees. However, given the environment obstacles, the shape of the buildings (type 1, type 2 and type 3 in Figure 6) and the availble surfaces on the roof faced on the South, these angles were the best to maximize the solar potential and the energy production by respecting the urban regulations.

References: [3] Solcelle skisseprosjekt (Multiconsult report), March 2013: Technical report on combined heat pump/PV solution for Dale
[5] Detaljregulering for del av GNR95 BNR1, Daleplan 2008: detailed regulation plan approved by Sandnes municipality

Lessons learned and recommendations

Figure 7 - West view of the project facade of the main building of Dale. (Source: © KOKO architects)

LESSONS LEARNED

The case highlights the complexities in planning development with high energy ambitions which include solar energy in a cultural significant area. The landscape set restrictions on the project but the landscape was an integral part of the solution in using the fjord as part of coupling the heat pump with solar PV panel. The solar solution was not cost effective alone in comparison to the grid, but incorporating it in the overall solution meant that heat supply would be nearly completely renewable. Having a renewable energy mindset was integral capability in driving energy efficiency in this project over a long period of time.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

Being part of an EU project enabled an increased focus on solar and was influential in the target for energy efficiency as it needed to be in line with the objectives of the wider PIMES project. There were a lot of diverse knowledgeable stakeholders involved in shaping the energy solutions, developing energy calculations, creating targets for environmental impact and developing a non-standard solution for the project. While decisions occurred over a number of years, not having a developer involved to act on decisions was a barrier for decisions going further than the planning process.

TARGET GROUPS

- Urban developers
- Municipalities
- Urban planners
- Politicians
- Researchers

PUBLIC AND EDUCATION ACTIVITIES

Open Symposium on *"Solar energy in Urban Planning"*- Friday 20. March 2015, Trondheim.

References: [3] Good, C. S., Lobaccaro, G., & Hårklau, S. (2014). Optimization of solar energy potential for buildings in urban areas- a Norwegian case study, Energy Procedia, 166-171.

(Photo: © Carmel Lindkvist, 2014)

ARCHITECT, DESIGNER AND DEVELOPER

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STAKEHOLDERS

Sandnes Municipality, PIME'S Partners, Dale residents

RESEARCH ORGANIZATIONS

NTNU
Norwegian University of
Science and Technology

ACKNOWLEDGEMENTS

The authors wish to thank KOKO architects, Dale Eiendomsutvikling AS, Multiconsult, Rogaland Fykleskommune who provided information, data and the materials.

3.9 SWEDISH CASE STUDIES

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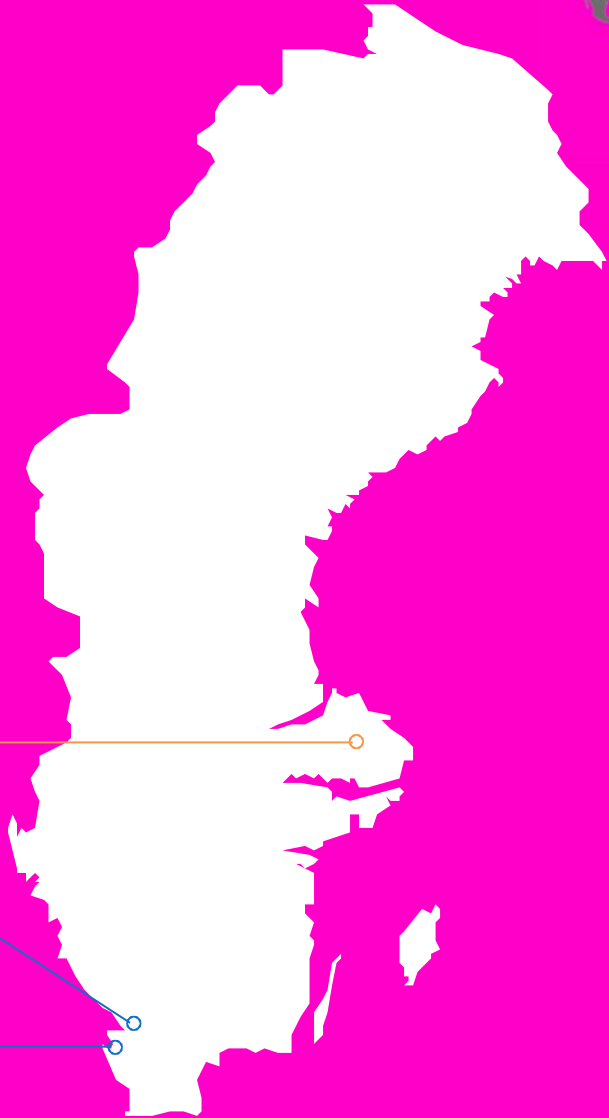
Maria **Wall**
Energy and Building Design
Lund University



28 **UPPSALA FRODEPARKEN**
Fill-ins and densification district in the existing urban area

29 **LUND BRUNNSHÖG**
New development area

30 **MALMÖ HYLLIE**
New development area

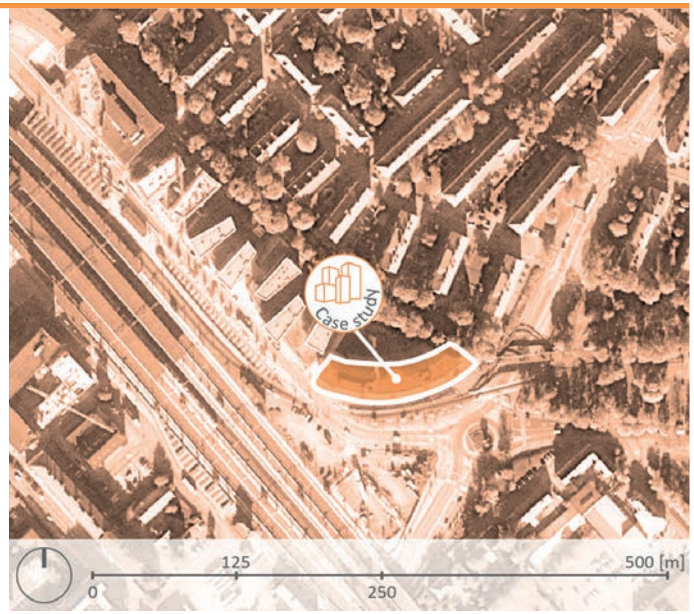
SWEDEN

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

UPPSALA FRODEPARKEN

SWEDEN

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Sweden
Location: Uppsala (Lat. 59°85′86″ N; Lon. 17°65′27″ E)
Climate: Warm humid continental climate (Dfb) [1]

AREA OF INTEREST

Legislation and technology

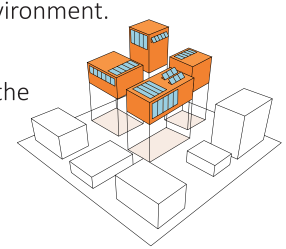
NATIONAL AND LOCAL CONTEXT

Swedish planning is regulated on a local municipal level where many decisions that affect solar energy implementation are taken such as local environmental policies, goals and targets as well as land-use and more detailed urban design. Issues related to solar energy are generally not considered in urban planning even though the market, especially for PV, is growing rapidly.

Uppsala is the fourth largest city and one of the fastest growing cities in Sweden. The city has ambitious goals for reduced climate impact. There are several ongoing projects in the city with high environmental profile from single buildings to large scale urban districts. Uppsala has a solar map for existing buildings.

ABOUT THE CASE STUDY

Frodeparken is an ambitious project that has the largest solar façade on a residential building in Scandinavia. It was initiated through an architectural competition in 2009 and finished in 2013. The same year another competition was held on a plot just south of Frodeparken which raises questions regarding solar rights and how the design of a new building can consider solar energy installations in an urban environment.



Definition of environment:
Fill-ins and densification district in the existing urban area

Site area: approx 10 000 m^2

References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Figure 1 - Frodeparken. (Photo: © Thomas Zaar, White Arkitekter, 2013)

Figure 2 - Competition submission for Juvelen with Frodeparken in the background. (Source: © Utopia, 2013).

Figure 3 - Part of shading study of Frodeparken with a generic volume on the site of Juvelen (Source: © White Arkitekter, 2010)

HIGHLIGHTS OF THE CASE STUDY

The highlights of the case study are:

- Solar rights or sometimes referred to as right to light is becoming increasingly important to deal with in urban planning due to the rapidly growing market for solar energy systems in buildings.
- Even in dense urban areas buildings will be designed or retrofitted with solar energy systems in mind. Especially in new developments, the future surrounding environment is often unknown and the effect may be that solar energy systems installed today can be shaded in the future and thus lose power output.
- The challenge for urban planners and developers is to deal with these cases in a coherent manner over time as they most certainly will occur more frequently.

ISSUES AND CHALLENGES

Sunlight and shading is often considered during the planning process but the planning and building act does not state anything in particular about it. Usually a shading study is part of the process in order to analyze how a new building will affect sunlight on the neighboring buildings, but in general shading studies do not consider the effect on a PV system.

Also, there are no cases found in Swedish courts where a detailed development plan or building permit has been appealed due to shadowing of an existing PV system. Therefore it is difficult to predict how a court would interpret the matter according to existing regulation. If there were court decisions it could be used as a precedent for future similar cases.

DECISION STRATEGIES

In the municipal documents for Frodeparken the text implies that there have been some investigations about PV's on the site but it is not stated anywhere that it is a purpose of the plan. In the competition program for Juvelen, the project across the street, Frodeparken is mentioned but not to in regard to potential shadowing effects of the PV system.

Fortunately, in this case the upcoming development of the neighboring plot was known of because the detailed development plan for Juvelen was already in use. Calculations of the power output from PV façade therefore took into account a shadowing volume.

THE PLANNING PROCESS

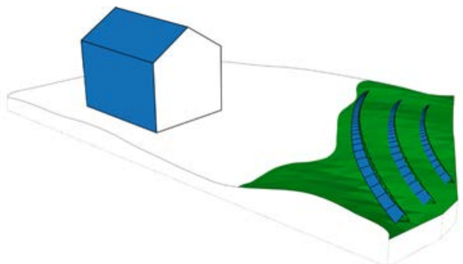
Frodeparken is an ambitious project that has the largest solar façade on a residential building in Scandinavia. The project was initiated through a competition in 2007 which White Arkitekter won. It was in the proposal from White that the idea of a large PV façade was first thought of. Later in the process a separate company was involved in the technical issues relating to the solar façade. Since the existing land-use regulation did not permit a building such as Frodeparken, the municipality had to deliver a new detailed development plan for the site which regulates building heights, floor area etc. The detailed development plan was approved in 2009 and in 2013 Frodeparken was finished.

The same year, 2013, another competition was held for a neighboring plot just south of Frodeparken. The new competition had high ambitions and asked for "the most sustainable building in Scandinavia". The proposal "Juvelen" designed by Utopia was awarded the win. In this case an existing detailed development plan from 2004 contained land-use regulation that was fitting for Juvelen although a small change had to be approved in 2015. In 2016 the building permit for Juvelen was approved.

Since the plan for Juvelen existed before Frodeparken was designed, a shading study was done for Frodeparken that included a generic volume on the site for Juvelen. This study was then used by the company doing energy calculations for the PV system and the theoretical output from and unobstructed façade was reduced by about 10 % to account for the building that would later be called Juvelen.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



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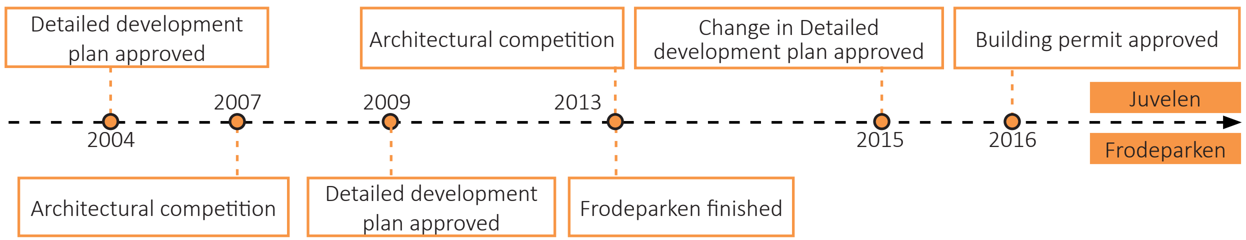
Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: © White Arkitekter)



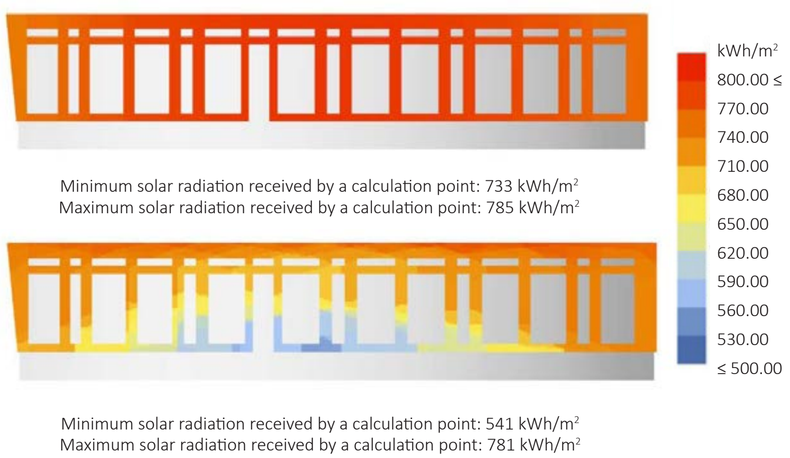


Figure 5 - (on the top) Simulated solar radiation with an unobstructed façade; (on the bottom) Simulated solar radiation with considering the effect of Juvelen on the façade.

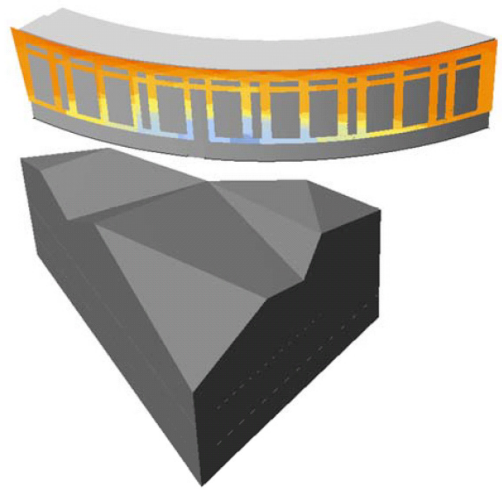


Figure 6 - Screenshot from simulation in Rhino/Grasshopper with context building

MONITORING

The developer or Frodeparken has monitored the power output of the PV façade since construction was finished and has stated that it produces about 10 % more than expected i.e. calculated for. Since Juvelen is not yet finished the shadowing effect of the PV façade on Frodeparken cannot be monitored yet but the overproduction matches the assumption that was made in the design process – that the shadowing effect from the future building on the site of Juvelen would reduce power output by 10 %.

EVALUATION

A radiation study has been done comparing the situation before and after the new building, based on the design in the winning submission for the competition for Juvelen. The result shows that the annual radiation differs from 766 kWh/m^2 a (before new building) to 695 kWh/m^2 a (after new building). This implies that the new building cause a reduction of the annual electricity production by nearly 10 %. These results also compare to the calculations made by the developer.

Simulations were made from a sketch-up model that was imported to Rhino and Grasshopper and the radiation study was made with the plugin Ladybug.

LESSONS LEARNED AND RECOMMENDATIONS

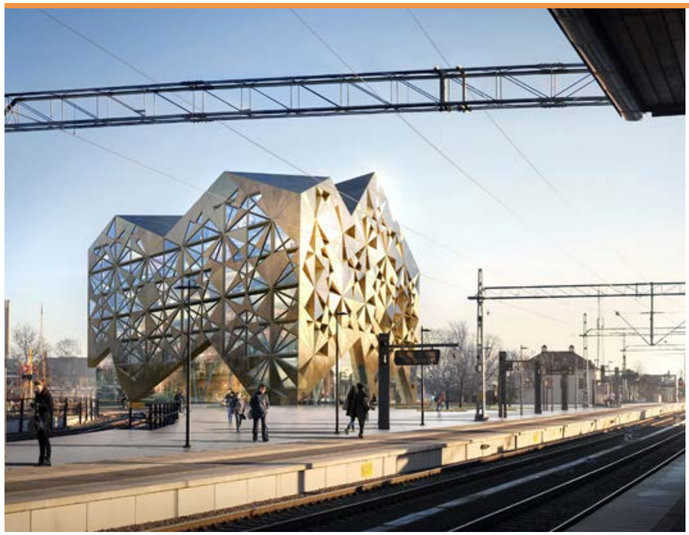


Figure 7 - Competition submission for Juvelen seen from train station (Source: © Utopia)

Figure 8 - Competition submission for Juvelen with Frodeparken in the background. (Source: © Utopia, 2013).

Figure 9 - Night view of the Frodeparken ***(Photo: © Thomas Zaar, White Arkitekter, 2013)***

LESSONS LEARNED

In dense urban areas it is important for developers to have a clear idea of the future surrounding development to be able to invest in large scale solar facades.

Advanced radiation studies can be important to investigate the effect of surrounding buildings but common sense and assumptions made from shading studies can prove to be just as useful.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

Planning authorities in municipalities need to have strategies for dealing with solar energy systems in urban environments. There is a need for more knowledge on how Swedish planning legislation relates to solar rights – if there are cases where the shadowing of a solar energy system could be cause for appeal of a detailed development plan or building permit. At the same time urban planning is a complex process were many aspects need to be weighed against each other. Since solar energy installations are expected to grow rapidly situations may arise where such installations become a barrier for future developments which in turn could decrease social acceptance for solar technologies.

TARGET GROUPS

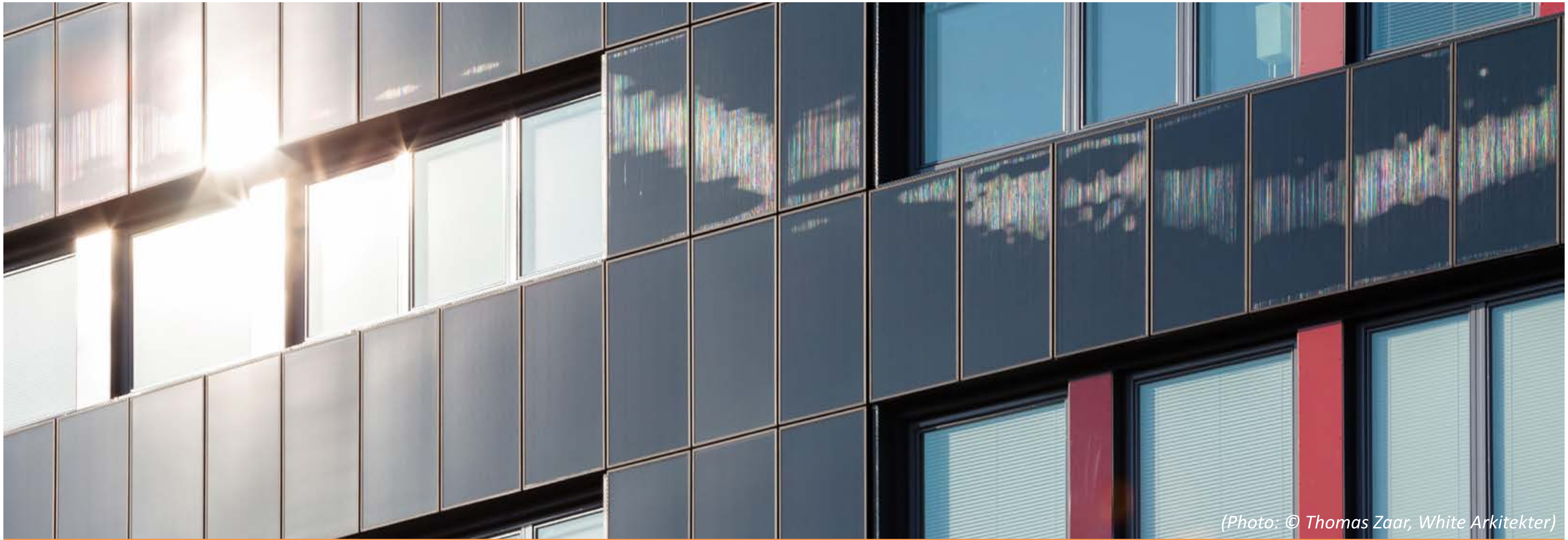
- Urban designers
- Urban planners
- Architects
- Developers
- Building permit officials

PUBLIC AND EDUCATION ACTIVITIES

Public seminar, Toronto, 28 September 2014: Experiences from Building Integration of Solar Energy in Urban Setting;

Open Symposium on *"Solar energy in Urban Planning"*- Friday 20. March 2015, Trondheim;

Public seminar, Stockholm, 04 July 2016: Solenergi I täta städer (Solar Energy in dense cities).



(Photo: © Thomas Zaar, White Arkitekter)

ARCHITECT, DESIGNER AND DEVELOPER

White arkitekter

CONSULTANTS

Direct Energy

CASE STUDY AUTHORS

Johan Dahlberg, Mats Åberg and Marja Lundgren, White arkitekter

OWNERS

Uppsalahem

STAKEHOLDERS

Uppsala municipality
Utopia

RESEARCH ORGANIZATIONS

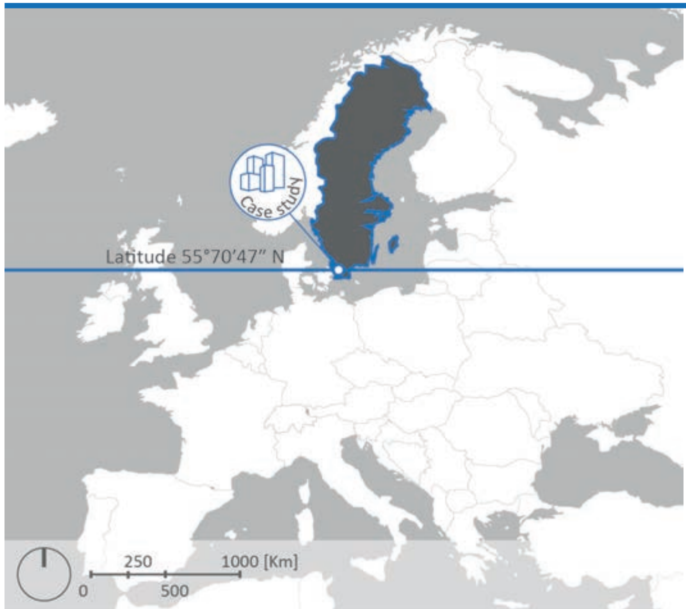
white

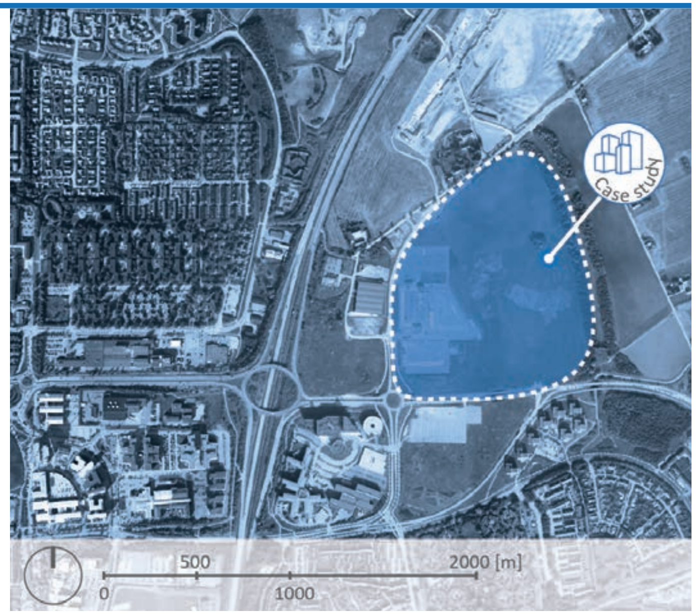
Source: (© White Arkitekter)

LUND BRUNNSHÖG

SWEDEN

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Sweden
Location: Lund (Lat. 55°70′47″N; Lon. 13°19′10″E)
Climate: Warm temperate, fully humid, warm summer (Cfb) [1]

AREA OF INTEREST

Targets and goals

NATIONAL AND LOCAL CONTEXT

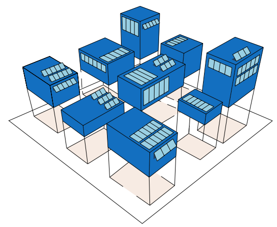
A major part of the urban planning process is done at municipal level at the urban planning department. However, due to a change in legislation, Swedish city administrations have limited possibilities to ‘force’ the installation of solar energy system in new buildings. Therefore, they are left to the ‘willingness’ of real estate developers to install solar energy systems.
Brunnshög will house not only 50 000 people, but also one European research centre (ESS) and other research related functions.

ABOUT THE CASE STUDY

Lund Brunnshög wants to house the world’s leading research facilities, be a European model for sustainable urban development and a regional destination for science, culture and recreation.

Definition of environment:
New Urban Areas

Site area: 2 500 000 m^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Issues, challenges and decision strategies

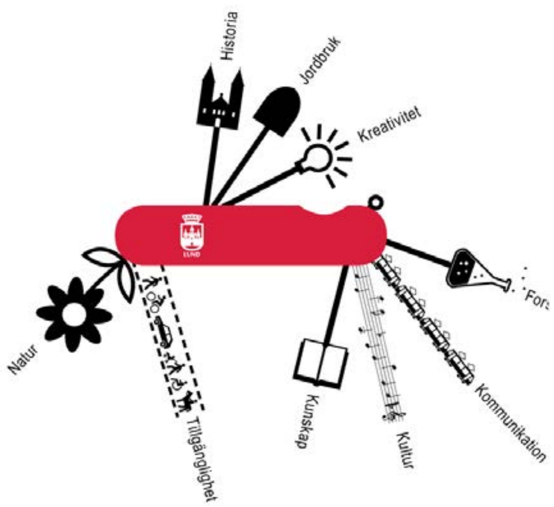


Figure 1 - Elements of Lund. (Source: © Lunds kommun)

Figure 2 - First stage of development. (Source: © Atkins)

HIGHLIGHTS OF THE CASE STUDY

Lund Brunnshög wants to be an attractive urban district and world leading in innovation and research environment. Amongst other aspects, Lund Brunnshög wants to be a European model for sustainable urban development.

ISSUES AND CHALLENGES

With the development of the new European research centre (ESS) and the international laboratory Max IV, Lund is expanding towards the North East.

Embedding these research plants into a mixed urban district with different functions is the vision of the new district.

These research plants have a high power demand but their excess heat will be used in the local urban district heating network to supply domestic hot water (DHW) and space heating for Brunnshög. Therefore, much focus will be on the production of electricity locally to complement the energy supply in the area.

DECISION STRATEGIES

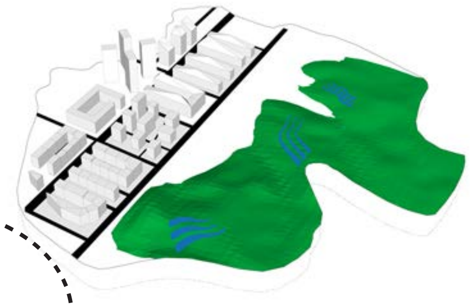
1. Solar energy is mentioned as one of the possibilities to produce on-site energy in vision documents.
2. A first solar potential analysis was performed to analyse how much solar energy could be produced in the entire urban plan.
3. A more detailed solar potential study will be performed on smaller-scale levels.

The planning process

The municipality of Lund started planning already in the 2000s but the first zoning plan was approved in 2011. The whole planning process is divided in several phases to keep the process manageable. The first phase consisted of the planning of a district with mainly residential and office buildings, while on the North of that district, the first building was constructed; the research lab MAX IV. The realization of this first phase will deliver important input for the other phases. When it comes to energy-efficiency and renewable energy production, the urban planning department has hosted many meetings where future interested real estate developers discuss how they could tackle sustainability issues, for example the production of on-site renewables.

A tram line connecting the central station to the new area is also planned.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.



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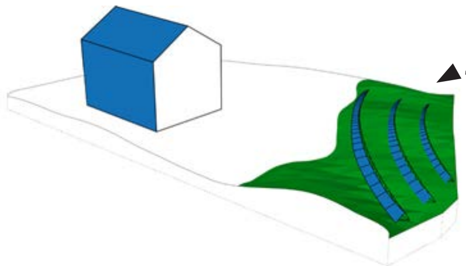

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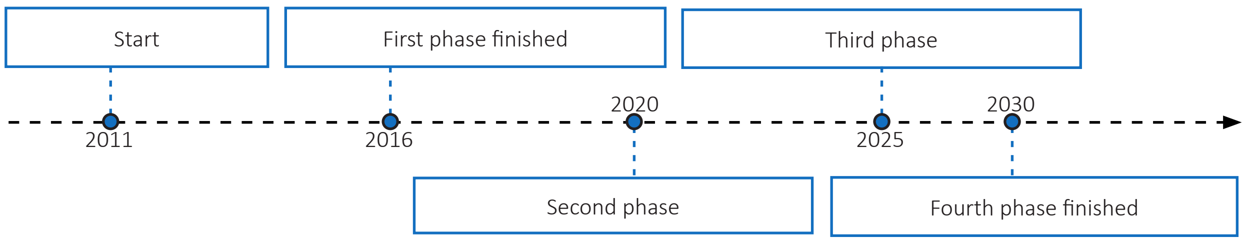


ENERGY CONCEPT

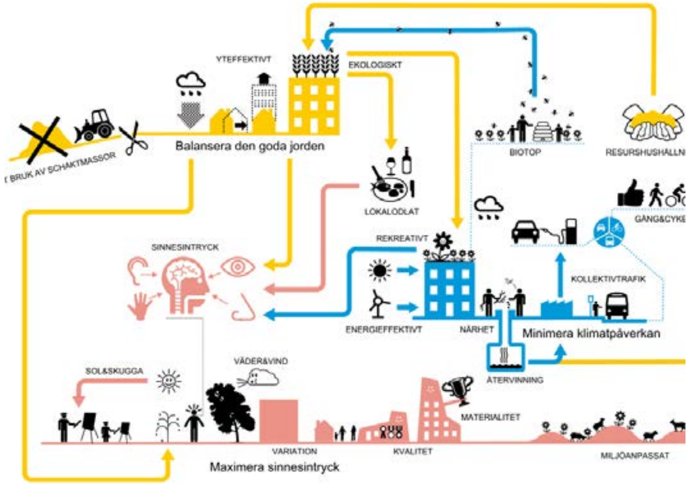


Figure 4 - Elements of Lund. (Source: © Lunds kommun)

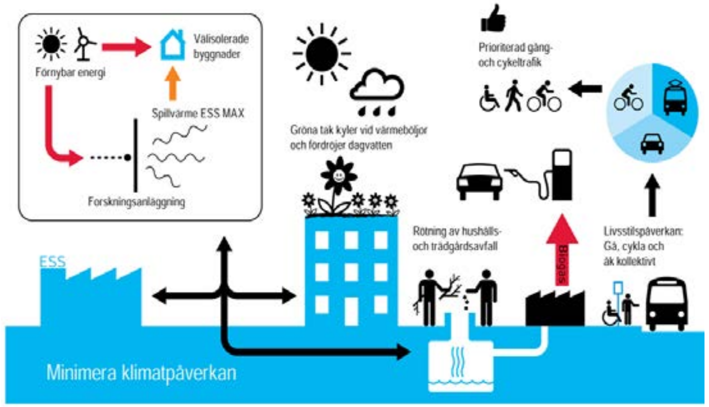


Figure 5 - First stage of development. (Source: © Atkins)

SUMMARY

The sustainability concept of Brunnshög consists of three core areas:

(i) how can we reduce the climate impact;

(ii) how can we balance building on fertile soil;

(iii) how can we create a stimulating urban environment that enhances the human senses?

The first area is addressed by having an extensive public transport system, using renewable energy sources and by making the area attractive so people will not travel much. The second area is tackled by multiple land-use (for example urban gardens on roofs tops) and high density. The third area is tackled by varying the built environment. Solar energy is considered to be part of the 'reduction aspect', but there are no quantitative targets set.

TECHNOLOGY

The planned buildings will be highly energy effective and part of the roof is planned to be a green roof.

In this case study, only the generation of electricity by means of PV is considered.

The large research plant ESS MAX will produce a significant amount of excess heat which will be inserted into the urban district heating network. Since all buildings will be connected to this urban district network, solar thermal is considered not to be feasible in the neighbourhood.

Figure 6 - Vision (Source: © Anna Klara Lundberg)

ENVIRONMENTAL IMPACT

In the very early stage of the planning process and on a very high scale, an environmental impact analysis for solar energy has not been performed.

ECONOMIC IMPACT

The city of Lund works closely together with the local utility company (Kraftringen). It is in the interest of this company to test new business models for future energy consumers. New solutions that are being developed are:

- how does the exchange work between the grid and the producers financially?
- Is there a maximum of energy that can be inserted into the grid?
- How can we solve the fact that owners of apartments do not own the roof on the building?, etc.

These legal issues have to be solved before a solar energy system is set up. In this case, the utility company also was interested in selling their own solar energy products.

SOCIAL IMPACT

Regular workshops were held with the real estate owners of the first phase of the project. In some of these common meetings, the real estate owners were offered help to analyse their buildings for their solar potential.

Several exhibitions for the general public were held to show how Lund Brunnshög will be developed and how sustainability is part of that.

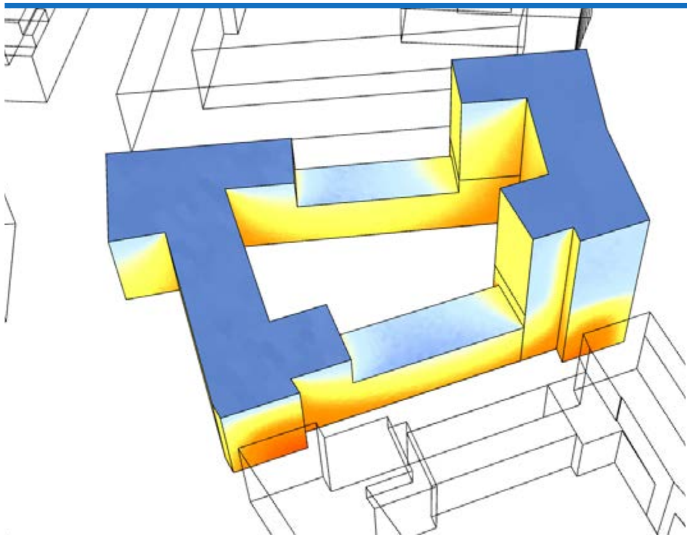


Figure 7 - Annual solar irradiation on the building envelope (Author: © Jouri Kanters)

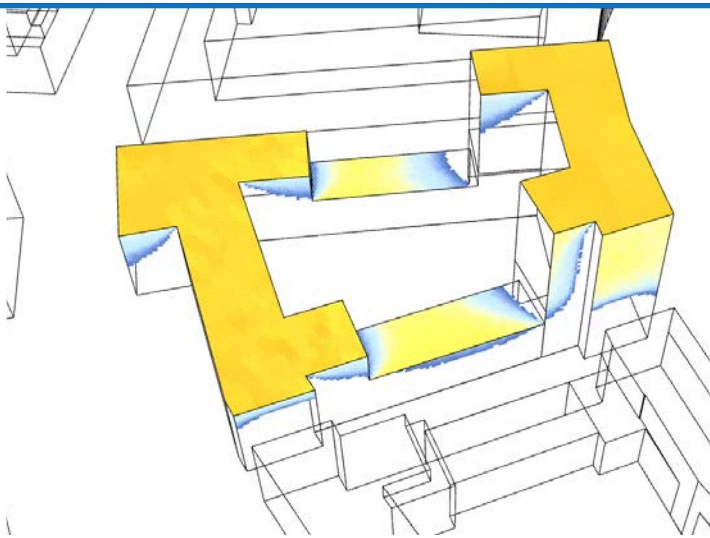


Figure 8 - Masking the areas that receive a higher solar irradiation than a preset threshold. (Author: © Jouri Kanters)

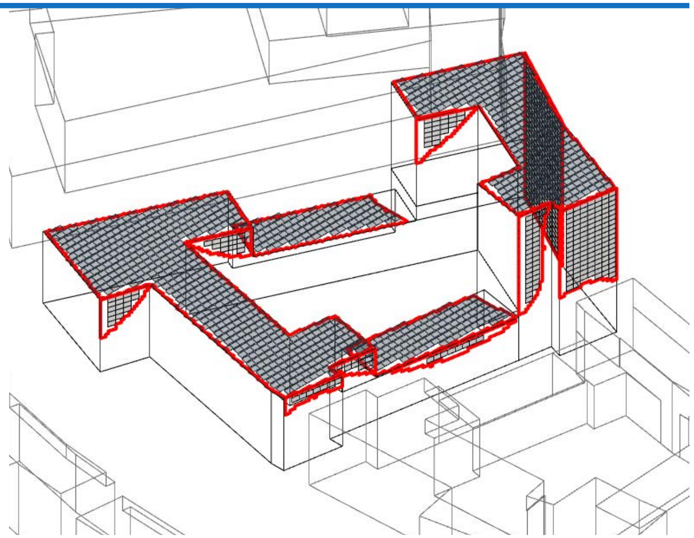


Figure 9 - Setup of a possible PV system on the suitable areas of the building envelope. (Author: © Jouri Kanters)

STRATEGY

The urban planning department of Lund provided a 3D model (Sketchup) of the planned development to the researchers of Lund University. Unnecessary buildings and landscape elements were removed and the clean model was imported into Rhino.

An annual solar energy analysis was performed with the software program Radiance. This simulation provided how much energy could potentially be generated, as well as it showed which parts of the building envelope were qualified as “suitable”; i.e. those surfaces that received a certain threshold irradiation (in this case, 650 kWh/m^2 a).

This was particularly valuable for the city administration to have a first estimation to which extent the urban district could be self-supporting on solar energy.

Many buildings in the zoning plan are designed with flat roofs. A returning question is how to make best use of the available roof area. Should the solar energy system be installed as building-added system with a certain inclination and row distance or can the roof inclination be adapted?

One approach in this project was to perform first an annual solar analysis of the whole building, then filter those surfaces with a payback time under 25 years. Then, a script was produced that could simulate how a PV system could look like with a certain inclination and row distance. Finally, a simulation was performed to analyse how much energy could be produced by the system.

MAXIMIZING THE ENERGY PRODUCTION

An often-discussed question in the workshops with future real estate developers is how a future solar energy system would look like and what a good size is seen in the framework of the current legal conditions. Both questions are not that straight-forward to answer. During some workshops, the involved researchers had analysed one building as an example and used this to discuss how the system would look like (which parts of the building envelope, row distance, inclination, etc).

Figure 10 - Production, Electricity consumption and coverage area in two different scenarios (Author: © Jouri kanters)

Lessons learned and recommendations

LESSONS LEARNED

Due to changing legislation, it is also necessary to change the approach towards real estate developers, since they are one of the key players in the Swedish urban planning process. Instead of setting additional demands, we tried to work by collaborating with different stakeholders in society, making it as easy as possible for all involved stakeholders to invest in solar energy.

New in this project is how the urban planners can design the zoning plan to create the best 'geometrical boundaries' for solar energy.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

It has become clear that not only energy should be discussed, but also how this translates to different stakeholder's interests. It might be more interesting to use different metrics for different stakeholders.

TARGET GROUPS

- Real estate developers
- Urban planners, architects
- Engineers

DEVELOPER

Urban planning department of the city of Lund

STAKEHOLDERS

City of Malmö, potential real estate developers

CASE STUDY AUTHORS

Jouri Kanters (Lund University, Sweden)

OWNERS/CLIENTS

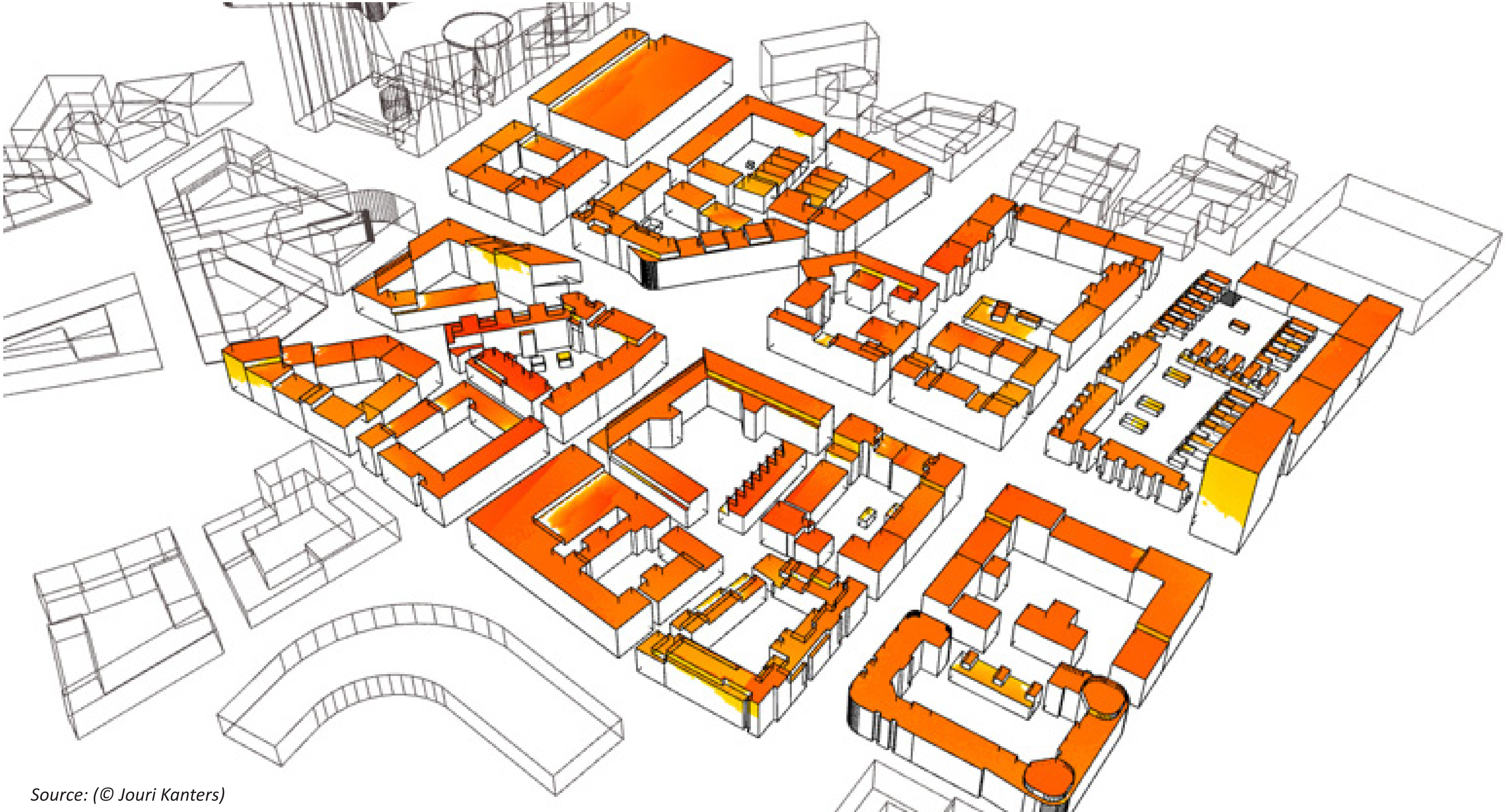
City of Lund

RESEARCH ORGANIZATION

Lund University

ACKNOWLEDGEMENTS

Lund University would like to thank the Swedish Energy Agency for the financial support.

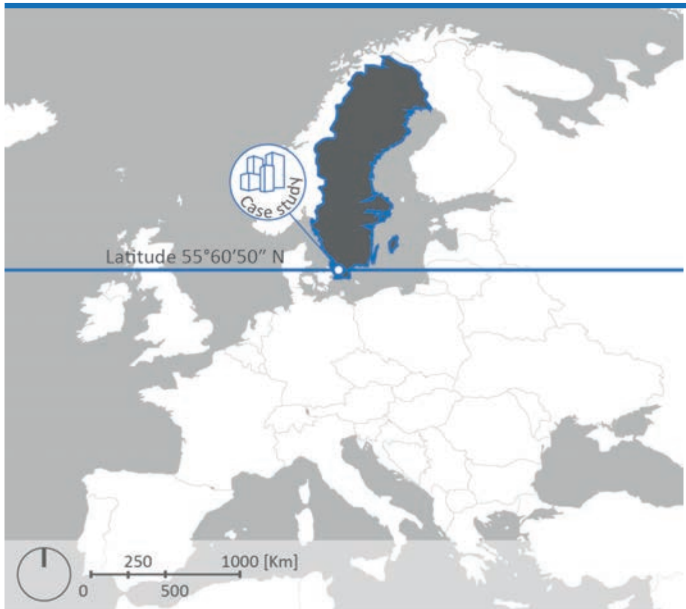


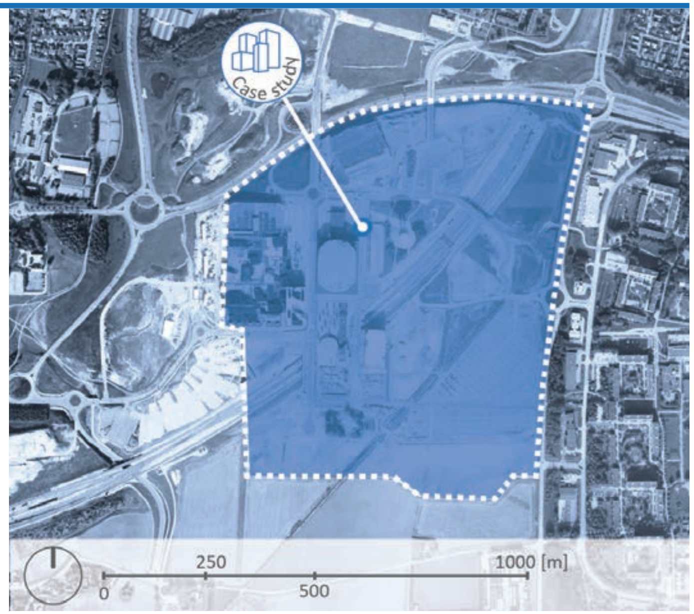
Source: (© Jouri Kanters)

MALMÖ HYLLIE

SWEDEN

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Sweden
Location: Lund (Lat. 55°60′50″N; Lon. 13°00′38″E)
Climate: Warm temperate, fully humid, warm summer (Cfb) [1]

AREA OF INTEREST

Targets and goals

NATIONAL AND LOCAL CONTEXT

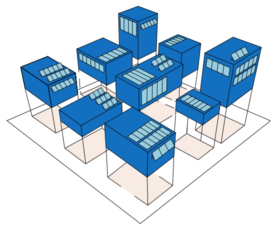
Malmö Hyllie has been pointed out by the local authorities to be the region's most climate smart urban district. A 'solar neighbourhood' has been assigned to become a testbed for solar energy. Solar energy is considered to play a significant role as a local, renewable energy source. However, due to a change in legislation, Swedish city administrations have limited possibilities to 'force' the installation of solar energy system in new buildings.

ABOUT THE CASE STUDY

On the large scale of the Hyllie development, solar energy has been discussed throughout the whole planning process. To study the possibilities of solar energy on the building level, the project 'solar neighbourhood' was started in cooperation with Lund University.

Definition of environment:
New Urban Areas

Site area: 500 000 m^2
Area density: FSI: 0.2- 2.0



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Issues, challenges and decision strategies

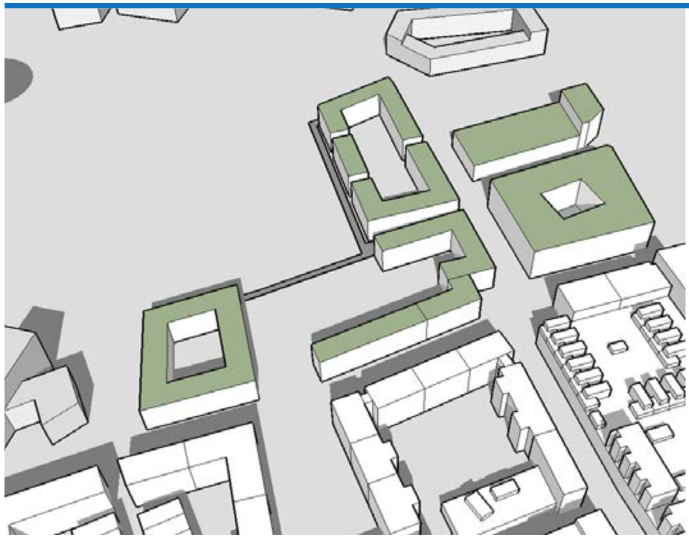


Figure 1 - Top view of the solar neighbourhood. (Source: © Malmö Stad)

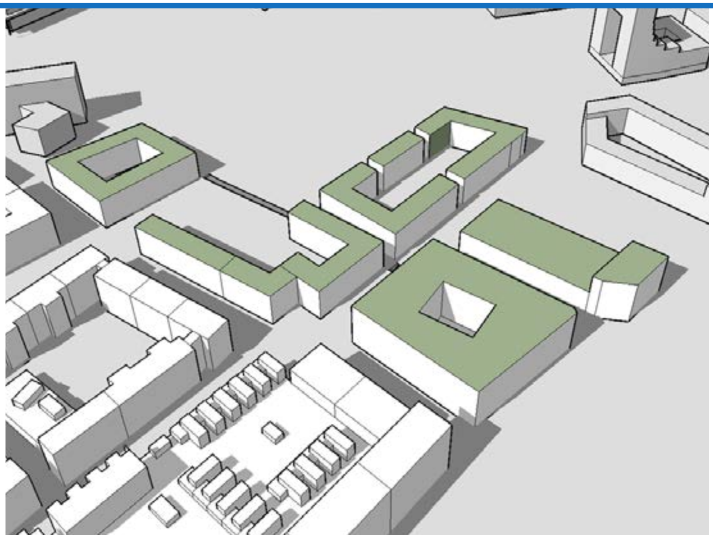


Figure 2 - Top view of the solar neighbourhood. (Source: © Malmö Stad)

Figure 3 - Top view of the solar neighbourhood. (Source: © Malmö Stad)

HIGHLIGHTS OF THE CASE STUDY

Hyllie has set the goal to be the region's most climate smart urban district with various energy targets both by saving energy as well as producing renewable energy.

The production of solar energy has been considered as one of the main elements in the energy/climate strategy in Hyllie. Therefore, Lund University has been involved from the beginning, assessing the solar potential first on the total district scale; later with more detailed analyses at smaller scale.

ISSUES AND CHALLENGES

One of the biggest challenges concerning solar energy has been the constant change of legislation during the course of the planning process. In the first phase of the development, legislation made it possible to put additional energy demands on new buildings (including solar energy). From the 1st of January 2015, this is not possible anymore.

This caused a shift of focus for the city administration. Instead of focusing on setting additional demands on future real estate developers, the city started to put much effort on convincing real estate developers interested in solar energy as well as trying to create good conditions for solar energy on the buildings (e.g. less shading objects, special roof forms, etc).

DECISION STRATEGIES

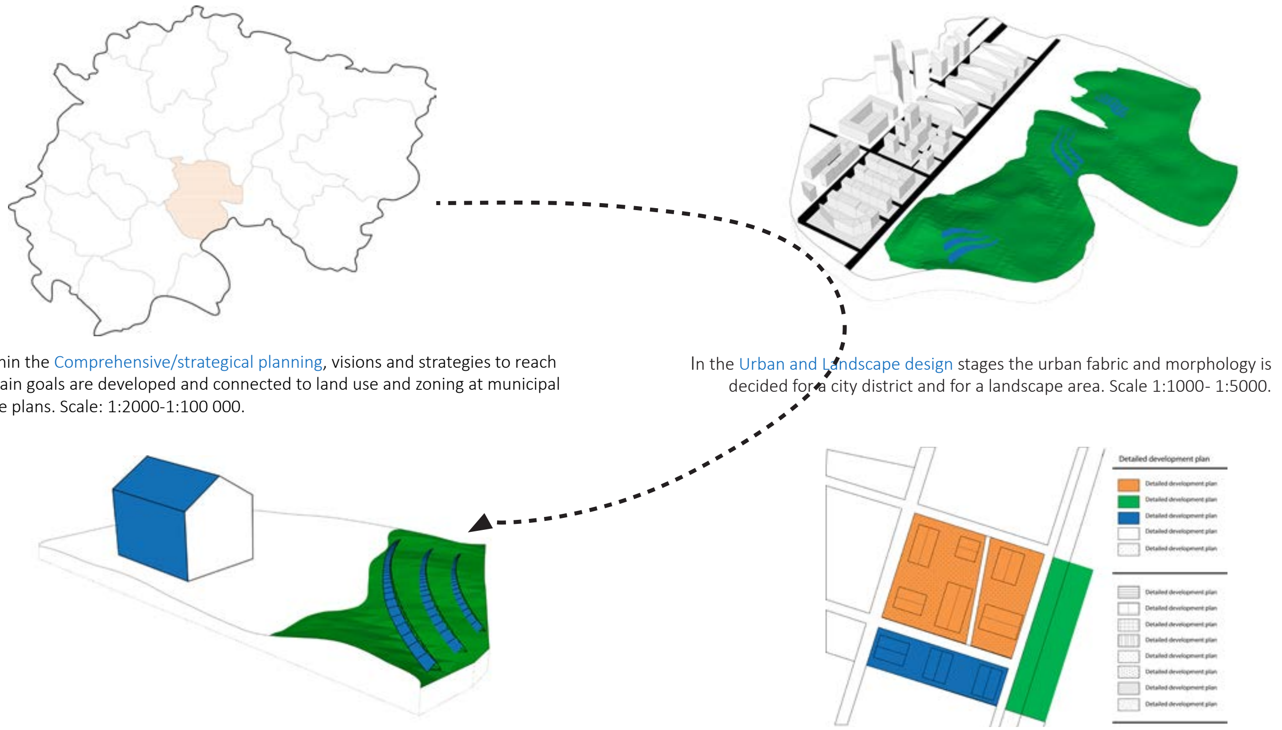
First, the largest scale was addressed and analysed how solar energy could contribute to the production of local energy. Then, a more detailed analysis was performed mainly on building level.

The planning process

Malmö Hyllie has been focus for the extension of the city of Malmö for decades. After the good responses of BO01 – a sustainable district in Malmö built in 2001, the city decided to continue on this track and appointed Hyllie to be 'climate smart'. Specific quantitative goals when it comes to solar energy have not been set, except for the notion that it should be considered and is preferred. The city of Malmö works quite close together with the local utility company to test the possibilities of introducing a smart grid, where solar energy could play an important role.

Already from the beginning of the planning process, the city's urban planning department has been in contact with researchers from Energy and Building Design at Lund University. The involved researchers have supported discussions about solar energy and have performed several solar analyses of all buildings that are going to be developed. Discussions were also based on previous research work [2].

From the first solar analyses, particular smaller blocks of buildings have been appointed where the integration of solar energy will be studied more in detail together with the urban planning department, the future real estate developers and building owners.



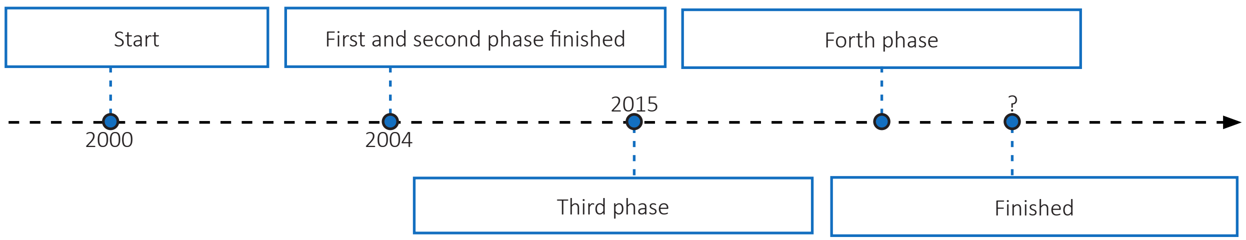
Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.

At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [2] www.solarplanning.org

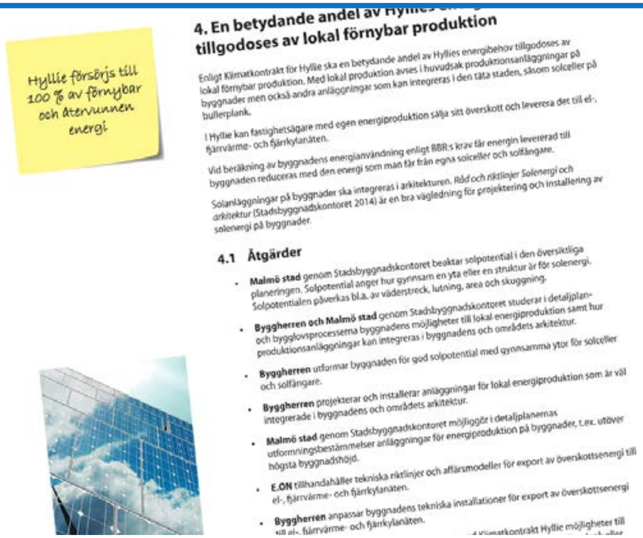


Figure 5 - Extract from Hyllie's environmental programme. (Source: © Malmö Stad)

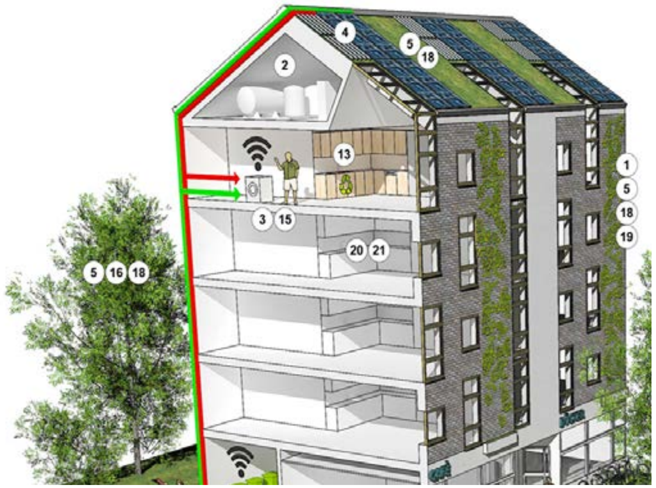


Figure 6 - Extract from Hyllie's environmental programme. (Source: © Malmö Stad)

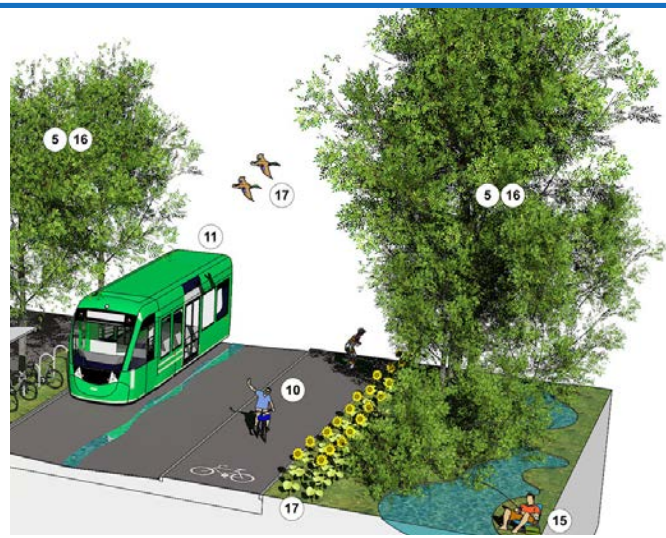


Figure 7 - Extract from Hyllie's environmental programme. (Source: © Malmö Stad)

SUMMARY

As in many other Swedish cities, an extensive urban district heating network delivering heat for space heating and domestic hot water (DHW) is available in Malmö and will be extended into Hyllie. It has been seen that it is very hard to compete financially with solar thermal against the urban district heating network. Therefore, the focus in Hyllie will be on the production of electricity with PV. One of the goals in Hyllie is to produce a considerable part of the electricity on-site with PV.

FROM ANALYSIS TO PRACTICE

Throughout the planning process, several solar potential studies were carried out. In the early stages, a solar potential study of the whole urban development of Hyllie was carried out, to get a rough idea of how much energy could theoretically be produced as well as on which surfaces. To do so, those surfaces that received an annual solar irradiation larger than a present threshold were considered to be suitable, others were omitted. On those suitable areas, it was considered that either PV or ST was installed (although the main focus was on PV).

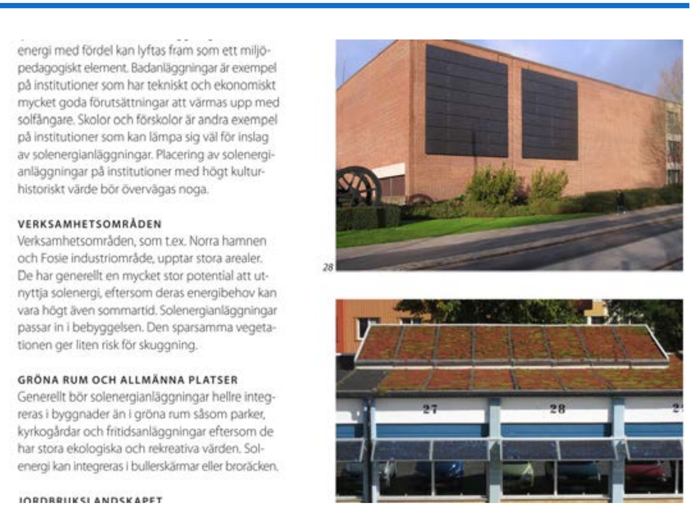
The simulated output also provided data for the discussion to which extent the buildings could be self-supporting concerning energy.

In the recent development project 'solar neighbourhood'; five different buildings were in the focus for the implementation of solar energy. Here, the municipal urban planning department tried to work already in the design phase of the buildings to create the best conditions for solar energy. Partly the placement of buildings was considered to avoid shading, but also the shape of the roofs was studied to maximise the production and to enable a better building integration of solar energy.

Environmental, economic and social impacts

Figure 8 - Visualisation of Hyllie. (Source: © Malmö Stad)

Figure 9 - Guidelines for implementing solar energy in buildings. (Source: © Malmö Stad)



energi med fördel kan lyftas fram som ett miljö-pedagogiskt element. Badanläggningar är exempel på institutioner som har tekniskt och ekonomiskt mycket goda förutsättningar att värmas upp med solfångare. Skolor och förskolor är andra exempel på institutioner som kan lämpa sig väl för inslag av solenergianläggningar. Placering av solenergi-anläggningar på institutioner med högt kultur-historiskt värde bör övervägas noga.

VERKSAMHETSOMRÅDEN

Verksamhetsområden, som t.ex. Norra hamnen och Fosie industriområde, upptar stora arealer. De har generellt en mycket stor potential att ut-nyttja solenergi, eftersom deras energibehov kan vara högt även sommartid. Solenergianläggningar passar in i bebyggelsen. Den sparsamma vegeta-tionen ger liten risk för skuggning.

GRÖNA RUM OCH ALLMÄNNA PLATSER

Generellt bör solenergianläggningar hellre integ-reras i byggnader än i gröna rum såsom parker, kyrkogårdar och fritidsanläggningar eftersom de har stora ekologiska och rekreativa värden. Sol-energi kan integreras i bullerskärmar eller broräcken.

Figure 10 - Guidelines for implementing solar energy in buildings. (Source: © Malmö Stad)

ENVIRONMENTAL IMPACT

The implementation of solar energy is seen as a significant contribution of locally produced renewable energy. However, no quantitative goal is set.

ECONOMIC IMPACT

The city of Lund works closely together with the local utility company (Kraftringen). It is in the interest of this company to test new business models for future energy consumers. New solutions that are being developed are:

- How does the exchange work between the grid and the producers financially?
- Is there a maximum of energy that can be inserted into the grid?
- How can we solve the fact that owners of apartments do not own the roof on the building?, etc.

These legal issues have to be solved before a solar energy system is set up.

SOCIAL IMPACT

Several meetings where held where all important actors participated; interested real estate developers, urban planners, researchers, utility company etc. The city informs its citizens through several platforms about the development of Hyllie.

Figure 11 - Simulation of annual solar irradiation. (Author: © Jouri Kanters)

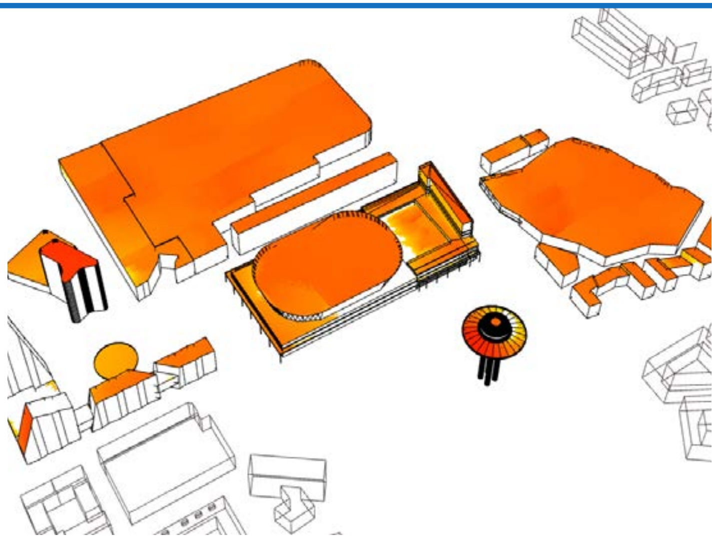


Figure 12 - Simulation of annual solar irradiation. (Author: © Jouri Kanters)

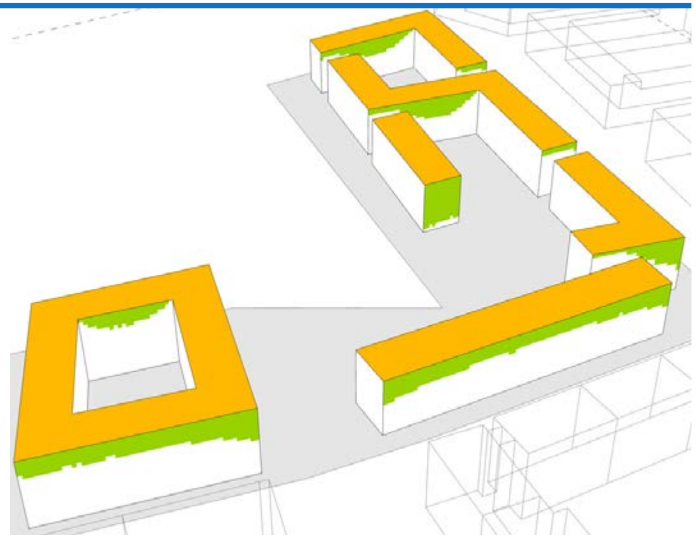


Figure 13 - Simulation of annual solar irradiation. (Author: © Jouri Kanters)

STRATEGY

The urban planning department of Malmö provided a 3D model (Sketchup) of the planned development to the researchers of Lund University. Unnecessary buildings and landscape elements were removed and the clean model was imported into Rhino.

An annual solar energy analysis was performed with the software program Radiance. This simulation provided how much energy could potentially be generated, as well as it showed which parts of the building envelope were qualified as 'suitable'; i.e. those surfaces that received a certain threshold irradiation (in this case, 650 kWh/m^{2}yr) (The coloured surfaces in Figures 11-13).

This was particularly valuable for the city administration to have a first estimation to which extent the urban district could be self-supporting on solar energy.

In the 'solar neighbourhood' project, a very first and rough annual solar analysis was performed in a similar way as the earlier performed analysis. The goal was the same; to identify the amount of energy that can be produced and to see which surfaces are suitable. This analysis provided a foundation to discuss how solar energy can be more building integrated. The discussion mainly focused on how flat roofs should be used; either installing as building added installations or, preferably, within the roof if the roof would have a very small inclination.

TOWARDS NEW METRICS FOR SOLAR ENERGY

While many real estate developers are interested in discussing the amount of produced energy, it might also be useful to discuss other aspects of installing solar energy.

An annual solar analysis without a context is often hard to use in the decision process. Figure 14 shows the analysis of one building with different metrics and adaptations. The standard annual solar irradiation provides an overview of how the annual solar irradiation is distributed over the building. The second column shows when only those surfaces are filtered which receive more than 50% of the maximum solar irradiation.

Perhaps a more suitable way is to look at the payback time (third column), where the irradiation has got an economic value and is recalculated as payback time in years. The coloured surfaces show a payback time under 25 years.

Another metric could be whether an investment is profitable or not. By adapting the inclination of the roof, the PV could also be more building integrated.

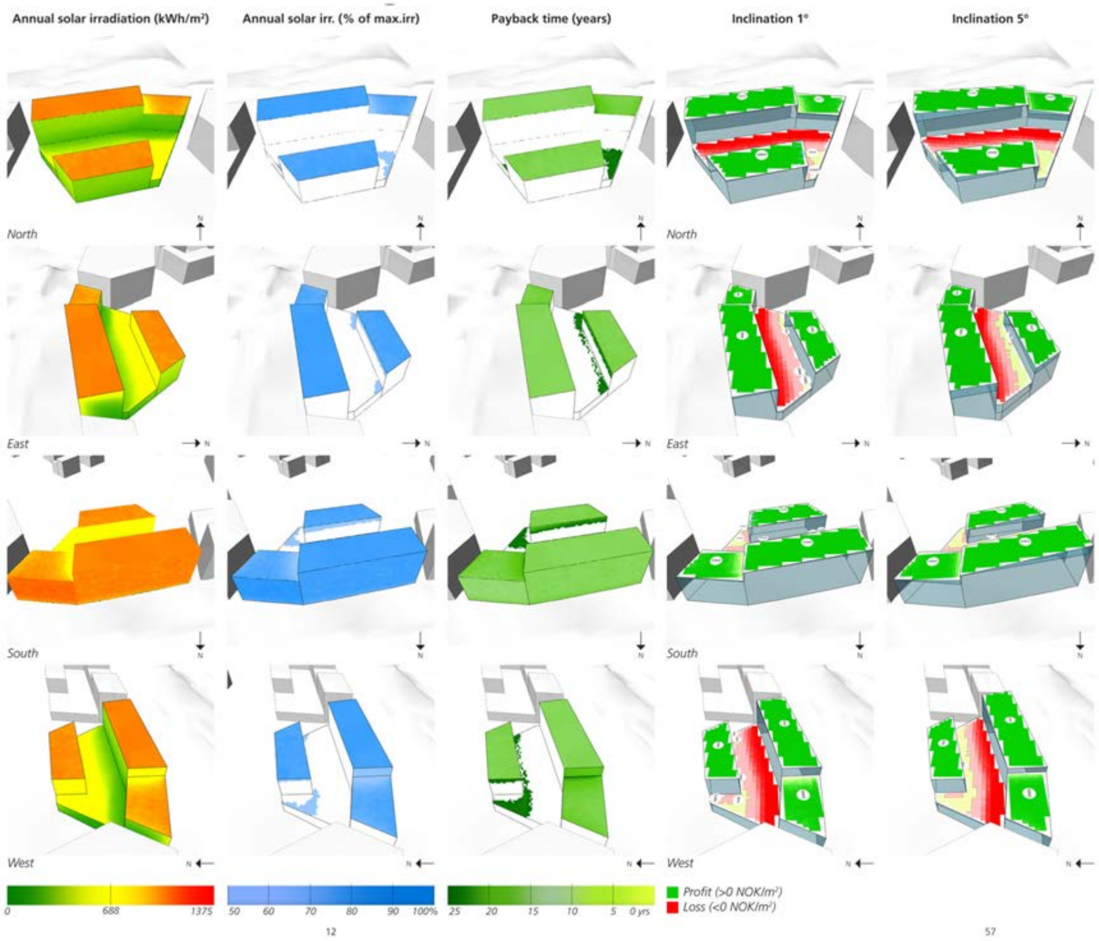


Figure 14 - New metrics for solar energy. (Author: © Jouri kanters)

Lessons learned and recommendations

Figure 15 - Exhibition of Hyllie. (Source: © Malmö Stad)

Figure 16 - Visualisation of Hyllie. (Source: © Malmö Stad)

LESSONS LEARNED

Due to changing legislation, it is also necessary to change the approach towards real estate developers, since they are one of the key players in the Swedish urban planning process. Instead of setting additional demands, we tried to work by collaborating with different stakeholders in society, making it as easy as possible for all involved stakeholders to invest in solar energy.

New in this project is how the urban planners can design the zoning plan to create the best 'geometrical boundaries' for solar energy.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

It has become clear that not only energy should be discussed, but also how this translates to different stakeholders' interests. Already in the early design phase, it would be beneficial to perform an analysis of how much energy can be produced, but also to highlight the financial balance of installing solar energy in more relevant metrics for the different stakeholders (for example costs vs revenue etc).

TARGET GROUPS

- Real estate developers
- Urban planners, architects
- Engineers

(Source: © Malmö Stad)

DEVELOPER

Urban planning department of the city of Malmö

STAKEHOLDERS

City of Malmö, potential real estate developers

CASE STUDY AUTHORS

Jouri Kanters (Lund University, Sweden)

OWNERS/CLIENTS

City of Malmö

RESEARCH ORGANIZATION

Lund University

ACKNOWLEDGEMENTS

Lund University would like to thank the Swedish Energy Agency for the financial support.

3.10 SWISS CASE STUDIES

SWISS TEAM

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Swiss BiPV Competence Centre

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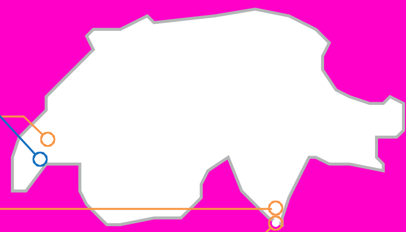
Institute of Applied Sustainability to the Built Environment (ISAAC)
Swiss BiPV Competence Centre

31 **ROMANEL-SUR-LAUSANNE, PDLi NORD-LAUSANNOIS**
Existing urban area

32 **YVERDON-LES-BAINS, PDL GARE-LAC**
Existing urban area

33 **VERGE PROJECT LUGANO PARADISO**
Fill-ins and densification district in the existing urban area

34 **ENERGY INNOVATION SOLAR PURCHASE GROUP**
Existing urban area



SWITZERLAND

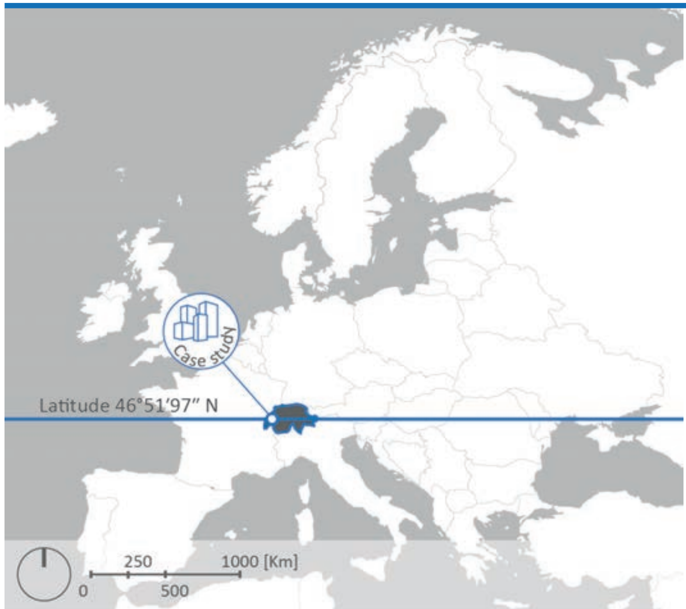
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

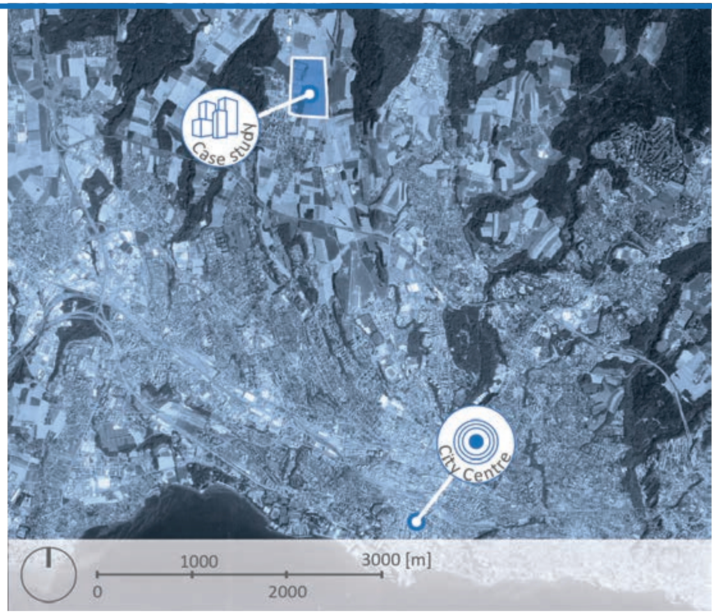
Source: (© Urbaplan)

ROMANEL-SUR-LAUSANNE, PDLi NORD LAUSANNOIS

SWITZERLAND

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Switzerland
Location: Romanel-sur-Lausanne
(Lat. 46°51′97″N; Lon. 6°63′23″E)
Climate: Warm temperate, fully humid, warm summer (Cfb) [1]

AREA OF INTEREST

Planning process

NATIONAL AND LOCAL CONTEXT

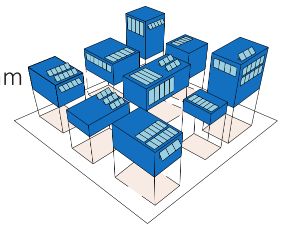
The project's status, as of the time of this study, corresponds to the early planning phase of developing the Plan Directeur Localisé Intercommunal (PDLi, structure plan), a planning instrument subject to the cantonal regulations (Canton of Vaud). This document lays down the general goals related among others to solar energy which are, in this case, the promotion of good daylight autonomy and passive solar gains as well as the installation of active energy production solar systems.

ABOUT THE CASE STUDY

This case study was conducted in collaboration with a local urban design firm (Urbaplan) in the context of a doctoral research project. The goal was to investigate the passive solar performance – quantified by the daylight autonomy and heating need – of different neighborhood designs to support the firm in specifying favorable typologies and guidelines during their task of elaborating the structure plan

Definition of environment:
New Urban Areas with mixed program
(60% residential, 40% commercial)

Site area: 9 504 m²
Building area: 6 500- 18 000 m²



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263

Figure 1 - Schematic master plan of the area. (Source: © Urbaplan)

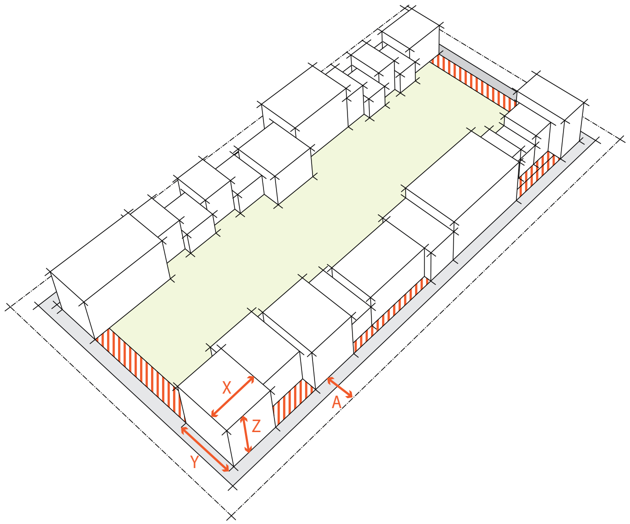


Figure 2 - Base case design M1 - Adjacent blocks. IUS: plot ratio. (Source: © Urbaplan)

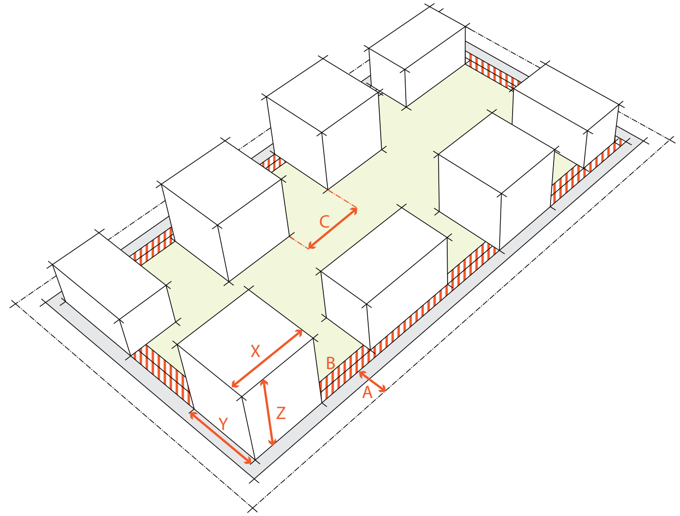


Figure 3 - Base case design M2 – Detached blocks. IUS: plot ratio. (Source: © Urbaplan)

HIGHLIGHTS OF THE CASE STUDY

In collaboration with the urban design and architecture firm Urbaplan based in Lausanne, Switzerland, this study was conducted to support the elaboration of the Plan directeur localisé intercommunal (PDLi) of a project located in Romanel-sur-Lausanne, a community located north of the city of Lausanne [2].

Results, transmitted to the Urbaplan team, were initially intended to be used as support for deciding on the base case typology and general guidelines to adopt in the PDLi. However, their use was restricted due to some limitations stated later on and results were mainly used as communication material during public events.

ISSUES AND CHALLENGES

The two main objectives of the study were:

- Explore the morphological diversity generated by a parametric modeling of design alternatives starting from basic urbanistic rules related mainly to the dimensions.
- Explore the impact of density, measured through the plot ratio (indice d'utilisation du sol, IUS), and compactness, measured by the floor area to envelope surface ratio, on the performance, both between variants of a same typology and between the different typologies (Figures 2- 4).

Challenges were faced when trying to 'translate' the outcomes of the study in order to make them useful to the concerned planners and designers, as further discussed in the following sections.

DECISION STRATEGIES

At this early planning phase, strategies must be defined through planning instruments such as the PDLi, required by law [3]. These strategies concern general guidelines toward achieving the goals in terms of energy and solar performance, although these remain general at this stage. The interest of the study lies in the exploration of diverse building shapes and urban morphologies, to highlight the effect of these geometrical features on specific performance criteria, evaluated through established metrics as opposed to broad brush design heuristics or simplified analyses such as sun path diagrams. Such methods do not allow discriminating at a high resolution level between specific and possibly very similar design alternatives. In the present study, variations concern the grid orientation and the height, depth and width of buildings, affecting also their relative positioning.

References: [2] Urbaplan (2014). Plan Directeur Localisé Intercommunal Lausanne-Vernand – Romanel-sur-Lausanne. V.1.3.
[3] Grand Conseil du Canton de Vaud (2011). Loi sur l'aménagement du territoire et les constructions (LATC).

THE PLANNING PROCESS

This study was conducted on a sector (plot of land) part of a broader development project, in turn falling within the planning process of the Lausanne North region termed Schéma Directeur du Nord Lausannois, SDNL (see timeline on the right) [4]. Our intervention occurred during the elaboration of the strategic plan (PDLi), which lays down future development principles to be respected in subsequent, more detailed planning instruments [2].

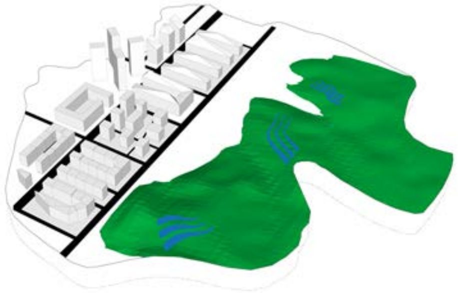
The initiators of the overarching SDNL project are the authorities of the cities of Lausanne and Romanel-sur-Lausanne. The urban firm in charge of the PDLi, Urbaplan, launched this collaborative study.

Although current solar-related targets remain abstract at this planning stage, there was a will to incorporate such considerations as demonstrated by the present case study, which aimed at assessing and comparing early phase design alternatives with respect to their heating need and daylight autonomy. The focus was on individual plots containing a minimum of 8 buildings, possibly to be replicated in North-South and East-West alignments at a larger scale.

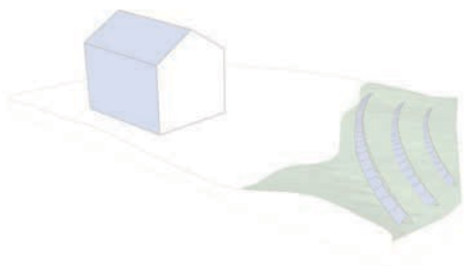
Based on the scope and aims of the study conducted by the author in collaboration with the urban firm, a series of neighbourhood designs were modelled and simulated to obtain the data necessary to conduct the analysis.

The outcome was presented in the context of a public consultation event. However, the contribution of this study for defining the guidelines of the PDLi remained limited, due to the academic nature of the research and reservations from stakeholders.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.



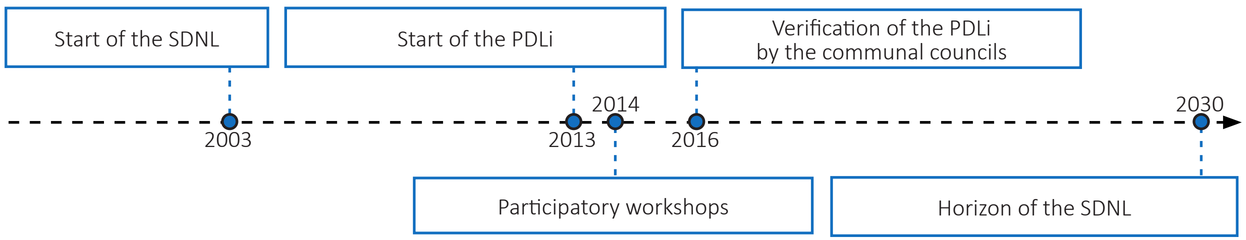
In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: ©White Arkitekter)



References: [2] Urbaplan (2014). Plan Directeur Localisé Intercommunal Lausanne-Vernand – Romanel-sur-Lausanne. V.1.3.
[4] SDNL (2007). Le Nord Lausannois en projet. .

Figure 5 - Example plots (framed in red) on which the design variants created from M1 and M2 and the specific M3 designs (top) could be located. (Author: © Emilie Nault)

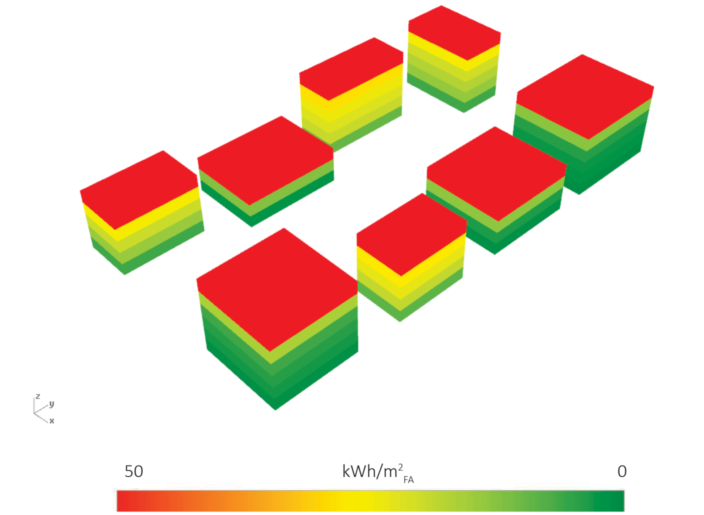


Figure 6 - Average heating need per floor (thermal zone) for a design variant of type M2 assessed in the study. (Author: © Emilie Nault)

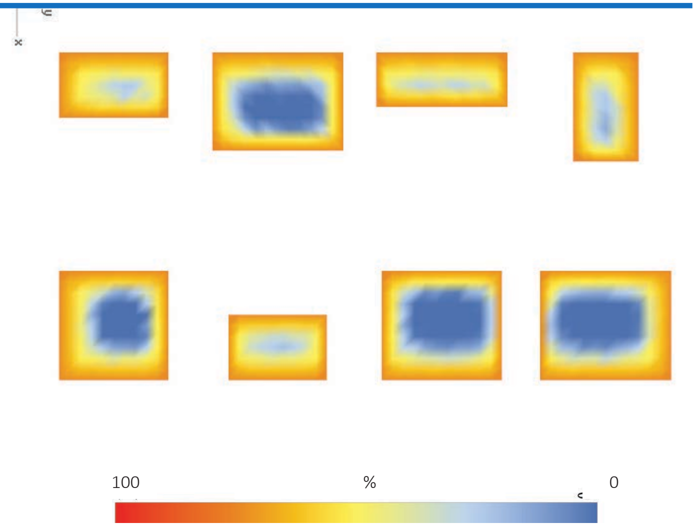


Figure 7 - Daylight autonomy map for a design variant of type M2 assessed in the study. (Author: © Emilie Nault)

APPROACH

The study was conducted through a parametric modeling and simulation workflow based in Rhino and Grasshopper and other tools [5]. From a base case design provided by Urbaplan (Figure 5), a series of variants corresponding to adjacent (M1) and detached (M2) blocks were generated by varying each building's dimensions. M2 was eventually split into M2/A and M2/B, each spanning a different height range. In addition to these groups, six specific designs (M3), conceived by the urban firm, were assessed. A 0° (North-South) and 90° (East-West) alignment were simulated, corresponding to the plots on which the hypothetical designs could be implemented (see framed examples in figure). The EnergyPlus weather file for Geneva was used in the simulations [6].

SIMULATIONS

Two types of simulations were conducted:

(i) a thermal simulation via Archsim, a Grasshopper plug-in and front-end of EnergyPlus, and (ii) a lighting simulation via DIVA-for-Grasshopper, a plug-in and front-end of Radiance/Daysim. Results consisted in (i) the overall annual heating need per floor area, computed from the simulation outputs obtained for each floor (thermal zone) of each building (Figure 6); (ii) the spatial daylight autonomy (sDA), computed at the ground floor level over all buildings using the output daylight autonomy (Figure 7). With all simulation settings equal between the designs (e.g. glazing ratio, materials), these results allow comparing the effect of the building shape and relative positioning on the performance metrics, used here to represent the passive solar potential of the designs.

IN RELATION TO THE SCALE

The need to generate and evaluate a large quantity of design alternatives, each holding multiple buildings, created the need to adopt flexible tools for both the modeling and simulations. Moreover, it was essential to consider the inter-buildings effect at the meso-scale, e.g. the shading from the surroundings on each building's performance. As such, custom Matlab and Grasshopper scripts were developed to automate the process, including randomly sampling the possible building dimensions (x, y, z), parametrically modeling the windows (with a fixed window-to-wall ratio) and thermal zones, and computing the overall neighborhood performance. The extensive work required to put this workflow in place highlights the need for meso-scale adapted tools, facilitating early-phase performance assessment.

References: [5] Archsim, DIVA: Jakubiec, A., & Reinhart, C. F. (2011). DIVA 2.0: integrating daylight and thermal simulations using Rhinoceros 3D, DAYSIM and EnergyPlus. In Proceedings of BS2011 (pp. 2202–2209). Sidney, Australia: IBPSA., Grasshopper; Rhino; EnergyPlus: Crawley, D. B., Pedersen, C. O., Lawrie, L. K., & Winkelmann, F. C. (2000). EnergyPlus: Energy Simulation Program. ASHRAE Journal, 42, 49–56., Radiance: Ward-Larson, G., & Shakespeare, R. (1998). Rendering with radiance: the art and science of lighting visualization. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., Daysim.

[6] Energyplus weather data climate (https://energyplus.net/weather).

RESULTS AND DISCUSSION

Results were presented to the urban firm through various graphics and numerical values. Trends were highlighted e.g. between the heating need and compactness (measured for the whole design). A comparison was done between the different base case series - M1 vs M2/A vs M2/B vs M3 – as well as within the variants of a same group e.g. the 144 designs of M1. Figure 7 shows a synthetic view of the results: the spatial daylight autonomy (sDA) against the heating need, for each design in each case and orientation according to the color- and marker-code. Designs falling near or on the Pareto front represent optimal solutions presenting a high sDA (note the reversed y-axis) and/or low heating need.

Trends can be identified. For example: M1 designs (adjacent blocks) are more spread and have a higher heating need than the M2 designs. The six M3 variants have the lowest daylight performance. Such observations highlight the need to incorporate energy considerations early in the design process of neighborhood projects, as the building typology and layout strongly condition the passive solar potential.

LIMITATIONS AND SUBSEQUENT WORK

These results are intrinsically linked to the simulation settings applied, which were later found to contain some inadequate values (e.g. high U-values not representative of current norms [7]), due to the use of plug-ins in their early development status and the overlooking of their default values. Results are hence not generalizable. This was also demonstrated through work conducted afterwards with different energy simulation settings, showing a different ranking between the M1 and M2 case designs. However, the general methodology remains a valid and useful approach for bringing energy considerations into the design process.

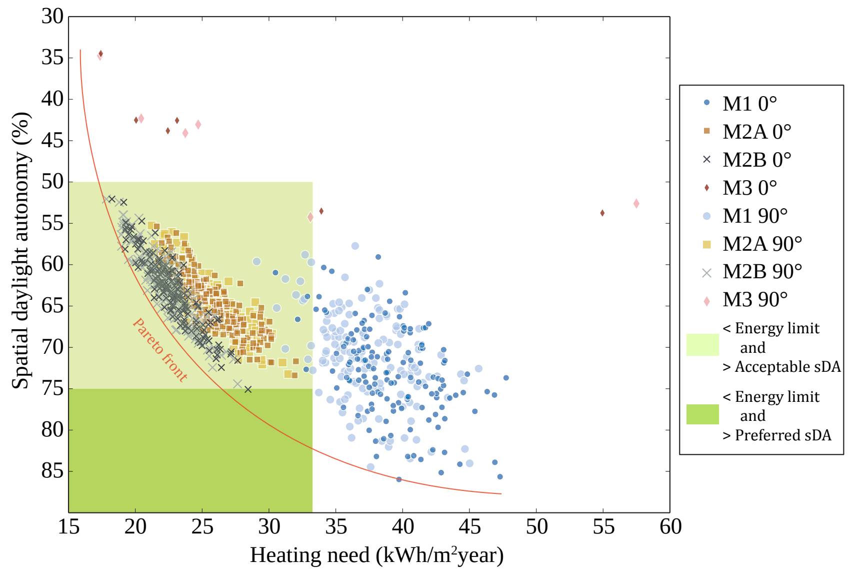


Figure 8 - Multi-criteria assessment of the design variants. Green areas delimit the zones respecting the energy limit, calculated from the SIA norm [7], and sDA targets, defined in [8]. (Author: © Emilie Nault)

References: [7] SIA. (2009). SIA 380/1 Thermal Energy in Buildings. SIA Zurich.
[8] IESNA. (2012). IES LM-83-12 IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE) (IESNA Lighting Measurement No. IES LM-83-12). New York, NY, USA.

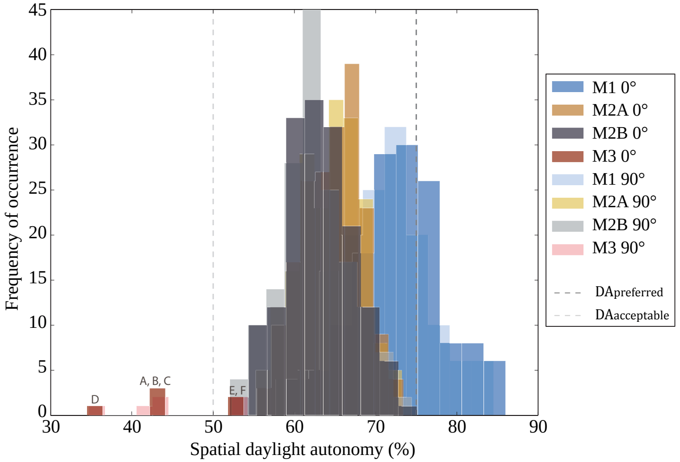


Figure 9 - *Histogram of the spatial daylight autonomy for each case series. (Author: © Emilie Nault)*

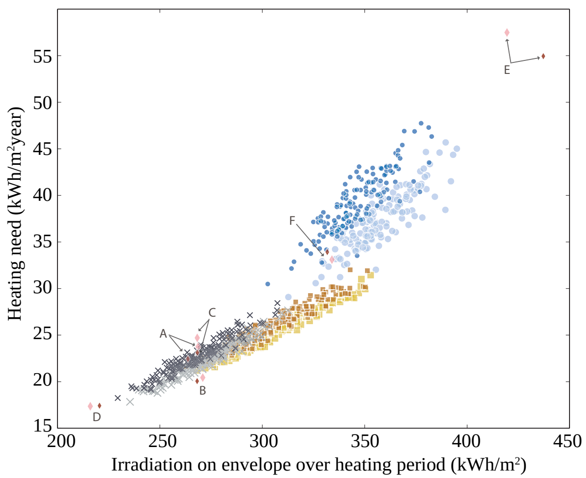


Figure 10 - *Heating need against the floor-area-normalized envelope irradiation cumulated over the heating season. (Author: © Emilie Nault)*

Figure 11 - *Poster with elements from the study, presented at a public exposition [10]. (Source: [10])*

LESSONS LEARNED

We observe a significant difference in the performance of the various designs, emphasizing the relevance of conducting this type of analysis when fixing morphological guidelines. For example, in terms of daylight autonomy (Figure 9), there is a spread even within designs of a same typology, which hold very similar configurations. The study also looked at quantities often used as 'performance indicators'. For example, the irradiation collected on the buildings envelope (Figure 10). A positive correlation is shown with the heating need; more irradiation leads to higher heating needs, a trend opposite to what is often assumed. This behavior is in fact caused by the compactness.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

The use of rules-of-thumb is restricted at the meso scale, considering the complex interactions which rather demand for case-specific analyses.

Results of this study also highlight the need to carefully assess the effect of each design decision, as early as possible in the planning and design process.

Moreover, a multi-criteria approach should be adopted, since optimizing only for one performance metric may be to the detriment of another (e.g. heating need versus sDA in the present case – see Figure 8).

TARGET GROUPS

All parties involved both in the development of strategic and master plans as well as those making use of such instruments should be supported by adequate methods and tools to conduct similar studies. The relevance of including energy and solar considerations in the early planning and design process also concern design competitions at different scales.

Results can be useful to support urban decision-making as well as communication with other actors such as stakeholders, engineers and the general public.

PUBLIC AND EDUCATION ACTIVITIES

This study's report was included in the annex of the structure plan [9]. Information extracted from the report was also presented at a public exposition under the theme "Energy optimization" [10].

References: [9] Urbaplan. (2015). Plan Directeur Localisé Intercommunal Lausanne-Vernand- Romanel-sur-Lausanne. Cahier 2- Annexes. V.1.3. SDNL, City of Lausanne.

[10] Urbaplan. (2014). PDLi poster collection. Presented at a public exposition in November 2014.

DEVELOPER

Urbaplan

CONSULTANTS

BBHN; BG; FRANÇOIS KUONEN; VOGT; bcph

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RESEARCH ORGANIZATION

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

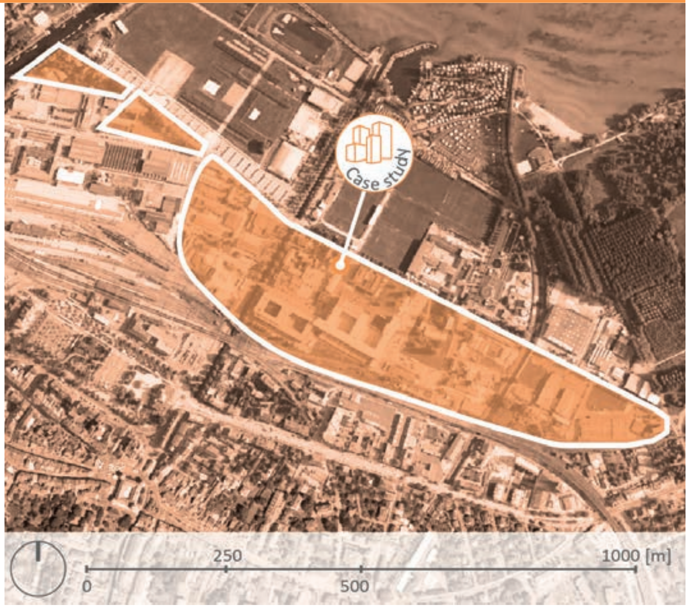
ACKNOWLEDGEMENTS

The authors would like to thank Urbaplan for the opportunity to conduct and publish this study.

YVERDON-LES-BAINS, PDL GARE-LAC

SWITZERLAND

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Switzerland
Location: Yverdon-les-Bains
(Lat. 46°77′85″ N; Lon. 6°64′12″ E)
Climate: warm temperate, fully humid, warm summer (Cfb) [1].

AREA OF INTEREST

Planning process

NATIONAL AND LOCAL CONTEXT

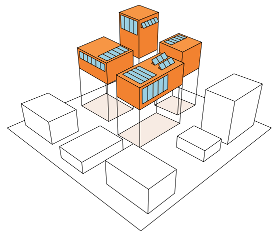
This case study is located in the Canton of Vaud, and was hence developed according to the local planning instruments, i.e. the Plan Directeur Localisé (structure plan), which is the strategic planning document intended for smaller areas, usually corresponding to a neighborhood.

ABOUT THE CASE STUDY

This case study is based on a research project [2] developed on an actual master plan [3] for the renewal of a brownfield area (Gare-Lac district of Yverdon-les-Bains). This project has studied how the possible variants of building shape influence the building performance (active and passive solar) and the built density.

Definition of environment:
Existing urban fabric

Site area: 982 095 m^2
Building area: 254 640 m^2
Area density: 1.7



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263
[2] Peronato, G. (2014). Built density, solar potential and daylighting: application of parametric studies and performance simulation tools in urban design. Master's thesis. Venice: Università Iuav di Venezia.
[3] URBAT (2014). Plan directeur localisé Gare-Lac. Rapport. Yverdon-les-Bains: Service de l'urbanisme et des bâtiments (URBAT).

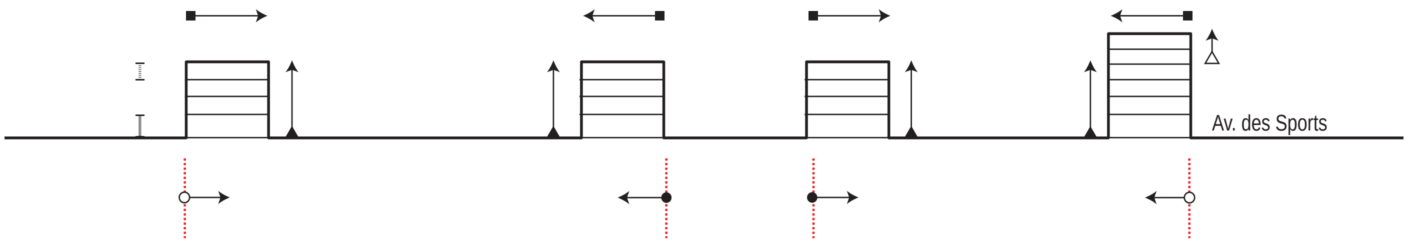


Figure 1 - Schematic of the parametric model. (Source: © Giuseppe Peronato)

HIGHLIGHTS OF THE CASE STUDY

The intent of the research project was the evaluation of a large number of parametrically-generated design variants based on the open courtyard typology defined by the master plan in order to optimize the solar energy and daylighting potential. In particular, we calculated the active solar energy, the building energy needs for space heating and cooling as well as the spatial Daylight Autonomy.

ISSUES AND CHALLENGES

The master plan fixes some ambitious goals for the new development, in terms of energy performance. However, most of these goals are set as requirements for the design at the building and building-envelope scale. The developed research was hence focused on the potential energy improvements that can be still obtained just by varying the sizes of the building typology set by the master plan.

From an energy point of view, the master plan aims at the development of a sustainable neighborhood achieving the objectives of the 2000 Watts Society [4] by integrating renewable energy sources and developing high-performing buildings. In the master plan documents, a 100% coverage of the domestic hot water (DHW) needs was estimated by the coverage of 4% of the rooftops with solar collectors. While the rest of the roof surfaces considered as suitable for PV panels allowing the coverage either of 100% of the urban lighting needs or 10-15% of energy needs of the future households. However, most of the actual planning decisions consist in energy requirements for the future buildings based on the local normative standards and labels (i.e. SIA and Minergie®). The open block typology was selected in the master plan as it was considered appropriate for daylighting and passive heating, but this assumption was not proven by simulations during the planning phase.

This research did not question this choice, but rather tried to verify how variations of this typology could allow some of the goals to be reached. In particular, built density and daylighting were considered as decision constraints for selecting the acceptable design variants.

References: [4] SuisseEnergie (2014). Concept pour l'établissement du bilan de la société à 2000 watts. Zurich : SuisseEnergie, Ville de Zurich, SIA.

This master plan defines the main strategies of the renewal of this central sector of the city in order to accommodate about 3800 new inhabitants and 1200 work places in 14 new buildings.

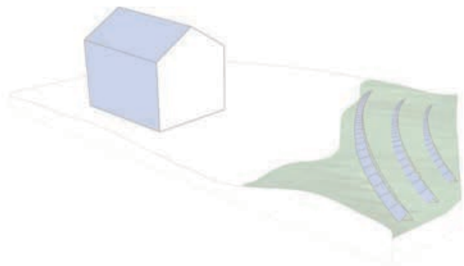
The plan was developed as part of a strategic planning phase. It was defined according to the higher-level plans, i.e. at the canton and the municipality scale, and it has to be further refined by a land use plan whose process started in 2014.

The research proposes a link between the planning and the design phase. At the same time, design studios at Ecole polytechnique fédérale de Lausanne (EPFL) investigated on possible different urban forms, that were lately evaluated in a multicriteria approach, including solar potential indicators [5].

Even if researchers and students were not directly involved in the planning phases, the outcomes of the design studio and research projects held at the EPFL will be hopefully integrated in the next phases of the planning and design process.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 2 - Definition of planning process (Illustrations: ©White Arkitekter)

References: [5] Rey, E. (2015). Urban Recovery. Lausanne: PPUR.

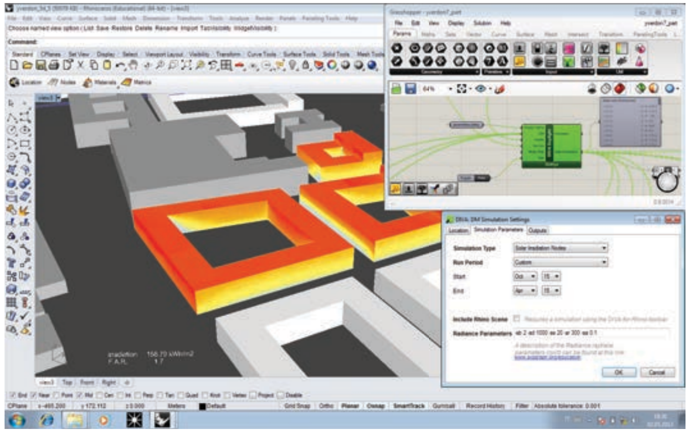


Figure 3 - Simulation interface. (Source: © Giuseppe Peronato)

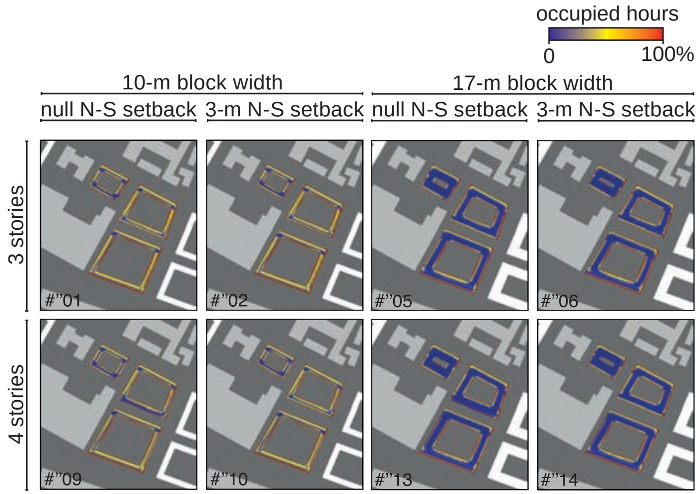


Figure 4 - Spatial Daylight Autonomy of eight notable design variants. (Source: © Giuseppe Peronato)

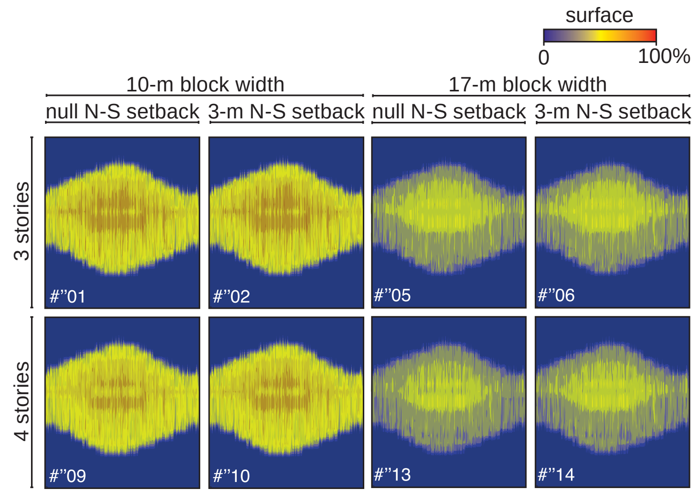


Figure 5 - Temporal Daylight Autonomy of eight notable design variants. (Photo: © Giuseppe Peronato)

METHODOLOGY

The case-study application involved the evaluation of several design alternatives, generated by the variation of building dimensions, using different metrics calculated on the basis of climate-based simulations run in Radiance/Daysim and EnergyPlus through the DIVA-for-Grasshopper interface.

Geometric modifications were equally applied on all buildings through the variation of design parameters within the range of values prescribed by the master plan (i.e. building height), or those considered representative of possible design choices (width and setback).

768 design variants were obtained by combination of the parameters defining the height and the horizontal layout of the building blocks.

The evaluation of the performance was carried out based on four indicators: energy needs for space heating and cooling, potential for solar energy production, spatial Daylight Autonomy ($sDA_{300/50\%}$) and Floor Area Ratio (FAR). The minimum built density of FAR 1.7 as defined in the master plan was set as a minimum requirement for defining the acceptable design variants. Comprehensive plots and false-color maps (Figure 3, 4, 5) are proposed as visualization techniques to represent the solution space and inform the decision makers [6].

IN RELATION TO SCALE

Due to the computational cost related to the large number of buildings to be simulated, the analyses are limited to only three buildings while taking into account their surrounding context in terms of shading and reflections. For similar reasons, only 32 design variants, defined by combination of the maximum and minimum values of each design parameter, were simulated for hourly illuminances.

References: [6] Peronato, G; Nault, E.; Cappelletti, F.; Peron, F.; Andersen, M. (2015). A parametric design-based methodology to visualize building performance at the neighborhood scale, Proceedings of BSA 2015, 351–358. Bolzano/Bozen: Bozen-Bolzano University Press.

LIMITATION AND FUTURE WORKS

The main limitations of the methodology are linked to the computational cost of simulations, in particular those of interior illuminances, as well as to the assumptions made for the metrics calculation. Further work should be done to implement the proposed workflow in an interactive design-support system and to verify its effectiveness in a usability study.

RESULTS AND DISCUSSION

This case-study was used to develop and test a parametric design-based methodology conveying the relative effectiveness of different neighborhood-scale design alternatives according to a wide range of building performance indicators. As the case-specific outcome, when choosing two design constraints (minimum spatial Daylight Autonomy and Floor Area Ratio) and two objectives (minimization of building energy needs and maximization of active solar energy production), three Pareto-optimal design variants were finally found.

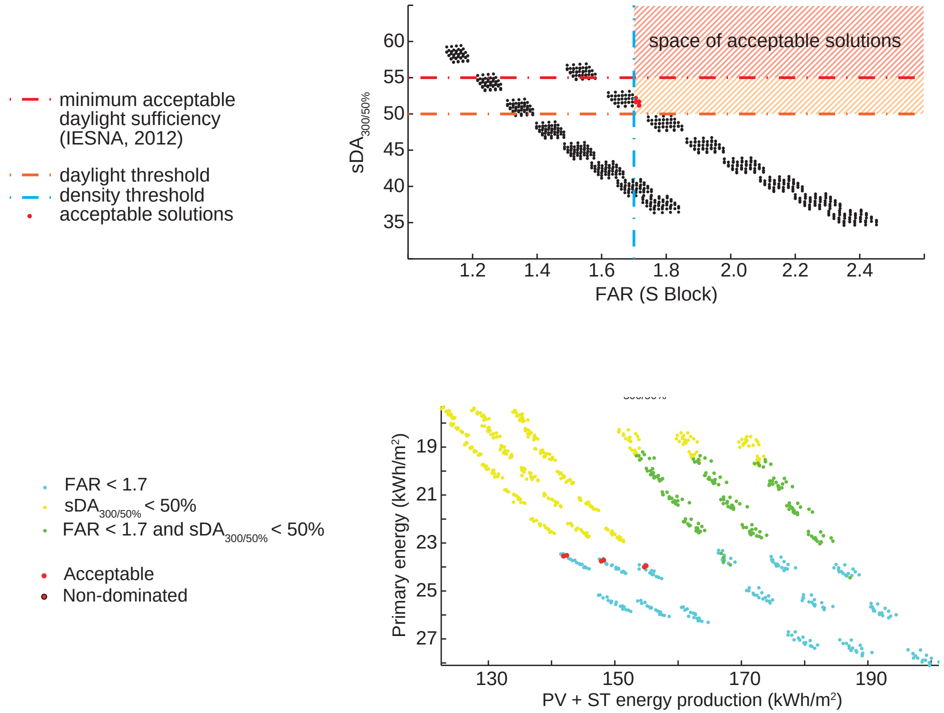


Figure 6 - Decision plots: constraints (above) and optimization goals (bottom). (Source: © Giuseppe Peronato)

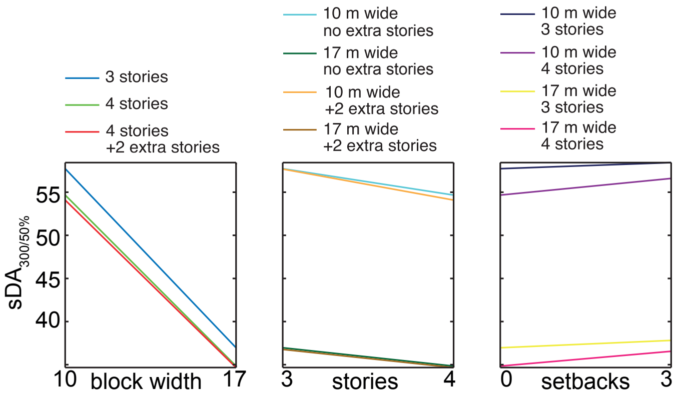


Figure 7 - Sensitivity of the spatial Daylight Autonomy (sDA300/50%) to parameter changes. (Source: © Giuseppe Peronato)

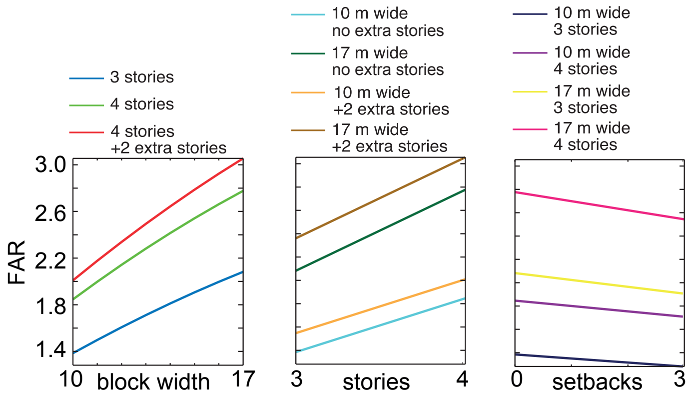


Figure 8 - Sensitivity of the built density (FAR) to parameter changes (Source: © Giuseppe Peronato)

Design variant	NS setback [m]	EW setback [m]	Block width [m]	N. of stories	N. of extra stories
#145	0	0	11	4	0
#146	1	0	11	4	0
#401	0	0	11	4	1
#402	1	0	11	4	1
#657	0	0	11	4	2
#658	1	0	11	11	2
Min-max	**0-3**	**0-3**	**10-17**	**3-4**	**0-2**

Figure 9 - Table of acceptable solutions. The last row show the range of values that was considered in the parametric study. (Photo: © Giuseppe Peronato)

LESSONS LEARNED

The search for optimized solutions resulted in a very limited number of acceptable solutions. This is due to the fact that the two constraints - daylight and built density - were clearly opposing goals.

The acceptable solutions reach these minimum values thanks to low block width and setback values while having the maximum number of stories. The other parameter (number of extra stories) was found non influent, as all combinations of this parameter are included in the acceptable solutions.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

The results of the simulations are difficulty generalizable and the main of the research was the development of a methodology that can be replicated in different situations and locations. However, it can be assumed that similar results can be achieved with similar conditions (e.g. climate, building typology). By looking at the slope of the curves in Figures 7 and 8 indicating the sensitivity of the building performance indicator, it can be noticed that the block width and the number of stories provide a similar increase to the built density. Conversely, the block width has a much greater negative effect on the spatial Daylight Autonomy. In this sense, we can argue that in these conditions, the building height is a better parameter to consider to provide high density than the block width.

TARGET GROUPS

The developed methodology is targeted to urban designers and architects working at the definition of the urban form and of the building typology in neighborhood-scale designs.

PUBLIC AND EDUCATION ACTIVITIES

Prof. E. Rey's design studios at the EPFL: "Urban Lakeside" and "Urban Regeneration" (http://last.epfl.ch/studio-last); Exhibition: "Urban Lakeside", Yverdon-les-Bains, Aug 21 – Sep 20, 2013


(Photo: © Nicolas Strambini, EPFL ENAC IA LAST)

ARCHITECT

BAUART Architectes et Urbanistes SA

OWNERS*

SBB-CFF-FFS, Société coopérative Fenaco, Sables et graviers La Poissine SA, Travys SA, La société de navigation des lacs de Neuchâtet et Morat

*These people/design firms/companies were not involved in the research project, but only in the development of the master plan.

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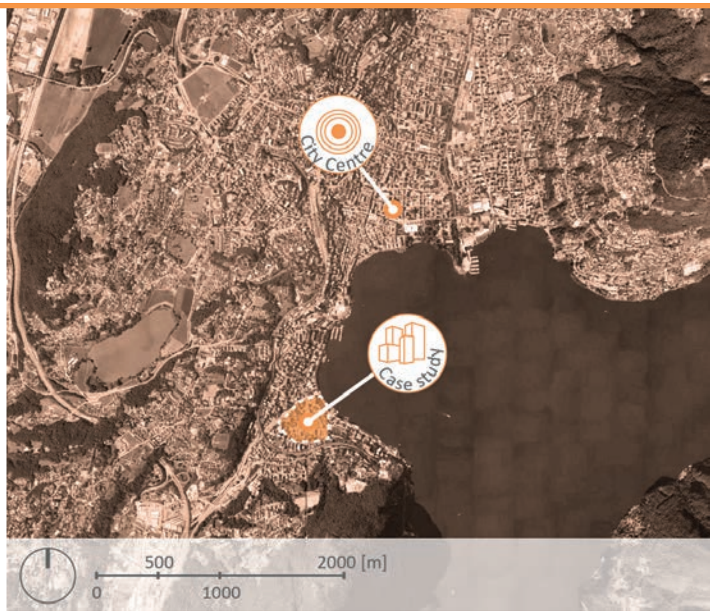
(Source: © Planidea SA and Lugano Paradiso Municipality City Center (CC) area of Paradiso - current status and new status when New Master Plan will be implemented)

Overview



GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Switzerland
Location: Lugano Paradiso (Lat. 46°00’37” S; Lon. 08°95’00” E)
Climate: Temperate Oceanic (Cfb) [1]

AREA OF INTEREST

Planning process

NATIONAL AND LOCAL CONTEXT

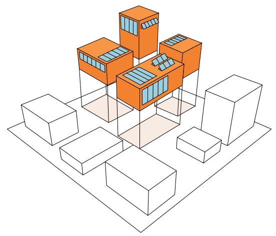
Since the 2011, Switzerland decided to withdraw from the use of nuclear energy. As a result new “Swiss energy strategy 2050” [2] was defined emphasizing the importance to increase the energy supply from renewables while reducing the energy demand in consumption sectors, with specific focus on the construction sector. Urban densification and the conservation of soil have been supported through strategies and regulations at a national and federal level [3] but at the same time a new “Model for energy requirements at Swiss Cantonal level” presumes the future obligation to install at least 10 Watt/m^2 of PV in new buildings (today voluntary). It is very common in Switzerland to apply for a MINERGIE label [4] which is a quality label for new and refurbished low-energy-consumption buildings.

ABOUT THE CASE STUDY

The area of study is located in Paradiso municipality, part of Lugano’s settlement. It is a district which is undergoing a very fast urban densification process. At an urban level in the Canton Ticino, urban densification strategies are underlined among the objectives of the Piano Direttore Cantonale (Flächennutzungsplan) [5].

Definition of environment:
Fill-ins and densification district

Site area: 240 000 m^2
Building area: 330 875 m^2
Area density: 1.38 inhabitant/m^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263; [2] Energy Strategy 2050. Swiss Federal Office of Energy SFOE; [3] Swiss Federal Council, Sustainable Development Strategy 2016-2019, 27th January 2016; Swiss Federal Council, Agglomerationspolitik des Bundes 2016+; [4] Label Minergie, Swiss energy standar for buildings [5] Cantonale Richtpläne. Rechtskräftiger Richtplan (2013). Richtplanung Kanton Tessin

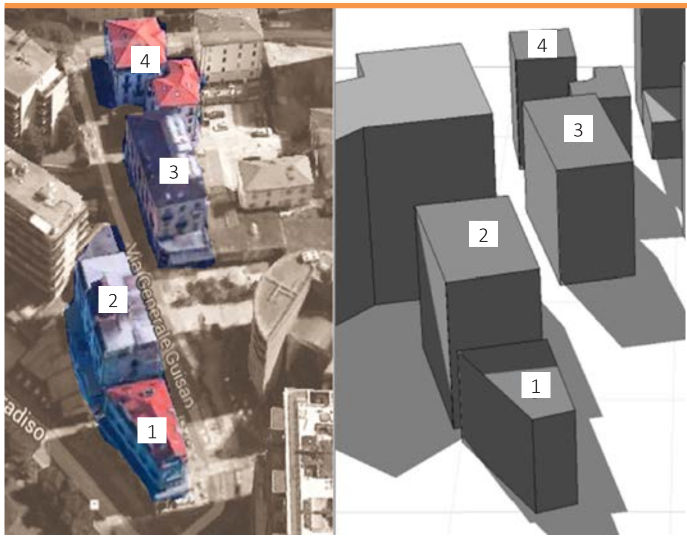


Figure 1 - Main protected heritage buildings in the area: B.1. Palace Riva Paradiso (A4905); B.2. Palace G. Guisan Street, Hotel Victoria (A4906); B.3. Palace G. Guisan Street (A4907); B.4. Palace Geretta –G. Guisan Street, Posthotel Simplon (A4908).

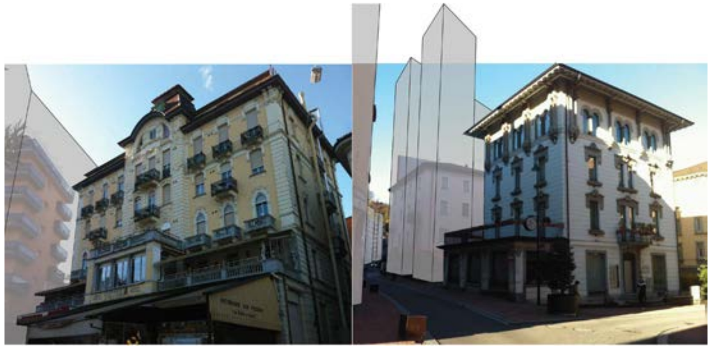


Figure 2 - New Paradiso Master Plan scenario: the white masks show the visual impacts of new building closed to protected cultural monuments in the area. To the right Hotel Victoria Palace A4906 (2); to the left Palace A4908 (3). (Photo: © Cristina Polo)

Figure 3 - New Paradiso Master Plan already implemented: To the right, Palace A4905 (1); to the left, Oratory of Geretta A4901 (5). (Photo: © Cristina Polo)

HIGHLIGHTS OF THE CASE STUDY

Urban densification policies can influence the energy demand, the solar availability of pre-existing buildings and the heritage protection of buildings. In Switzerland, the new Master Plan (MP) of Paradiso Municipality (Piano Regolatore, PR) [6] will change the urban density of the city center area allowing three or four plan levels of the buildings to be raised which are currentlyseparated by narrow streets, to increase to eight floors, without modifying the width of street layout. Main highlights of this project are:

- Urban densification policies and protected buildings;
- Energy efficiency and solar PV potential in dense urban areas;
- Solar rights, solar availability and daylighting.

ISSUES AND CHALLENGES

Main challenges:

- Sensitive and valuable heritage cultural monuments valorization;
- Integration of renewable energy, such as solar, on urban context closed to heritage buildings;
- To assess the effects of new planning processes considering the effects of dense settlements on energy efficiency and the energy supply.

DECISION STRATEGIES

In densely built-up areas it is important to consider factors such as the buildings' geometry and height, the materials and colors, as well as the distance between the buildings themselves (size and morphology of the roads), as factors that can affect the solar radiation absorption and reflection. In the same way, urban shape also depends on the specific conditions of the local place and the climate.

These aspects are not always taken into account in the urban planning process. It would be necessary to enlarge the scale of analysis and to move to urban planning and design scales, which would better allow to consider buildings shape, orientations and density. It allows to detect possible cumulative effects limiting both, the access to sunlight or solar gains and the possibility of equipping buildings with solar renewable systems.

References: [6] Paradiso Master Plan, implementing rules.- Update 07.2012. NAPR. Art. 33- IV Sectoral Standards for Building Zones (Norme di attuazione del piano regolatore di Paradiso.- II-. Aggiornamento 07.2012. NAPR. Art. 33- IV Norme settoriali per le zone edificabili. Art. 33)

The planning process

The new Master Plan (MP) of the area (detailed plan of the common center, PPCC) was published in May 2011 and endorsed by the State Council in June 2012. It defines maximum volumes footprint to nine floors and contiguity mandatory. It is a district that is undergoing a very fast urban densification process, by changing the open urban sprawl towards infill with closed and compact urban fabrics.

This comprehensive/strategical planning (PPCC) which came into effect in August 1997, replaces the previous municipal planning instrument dating back to 1979 [6].

The goal was to study the impact of surrounding buildings on energy performances of cultural and protected buildings.

The new MP does not take into consideration solar systems or solar passive strategies.

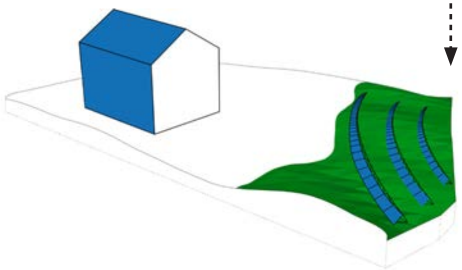
Local contributors involved in the case are urban planning consultants, the Municipal Technical Office, architects and a building heritage owner.

Researchers analysed the different urban densification scenarios (old and new MP) to investigate the real impacts of the new urban pattern and buildings' shapes on the energy behaviour of existing buildings by considering solar radiation and daylighting availability along with sky-view factors.

Urban planning modifications are being supported by private and public funds.

Within the Comprehensive/strategical planning, visions and strategies to reach certain goals are developed and connected to land use and zoning at municipal scale plans. Scale: 1:2000-1:100 000.

In the Urban and Landscape design stages the urban fabric and morphology is decided for a city district and for a landscape area. Scale 1:1000- 1:5000.



At the Architectural design stage new and existing buildings and landscape are designed, new or altered. Scale. 1:10-1:500.

Detailed development plans are the implementation of the urban design, and the land use is regulated into legally binding documents. Scale. 1:500-1:2000.

Figure 4 - Definition of planning process (Illustrations: © White Arkitekter)

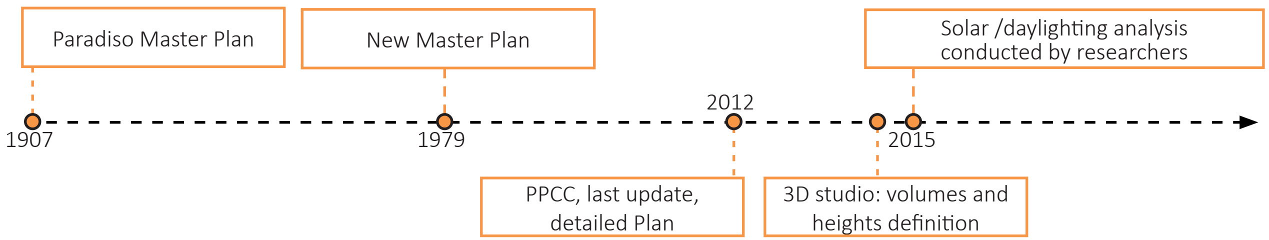


Figure 5 - Screen shoot of the solar Cadaster of Ticino platform OASI. (Source: © Environmental Observatory OASIS platform, Federal Office of Topography Swisstopo)

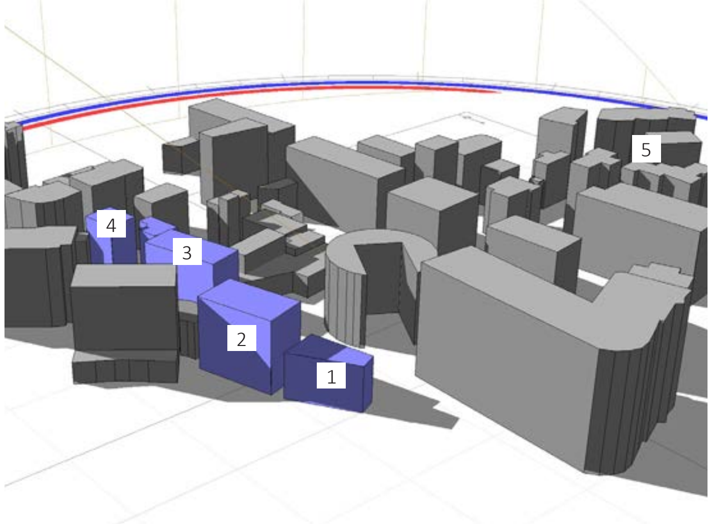


Figure 6 - Paradiso Case Study: current urban status 3D simulation. The blue buildings (1-5) are the existing cultural monuments protected in the area. (Source: © SUPSI)

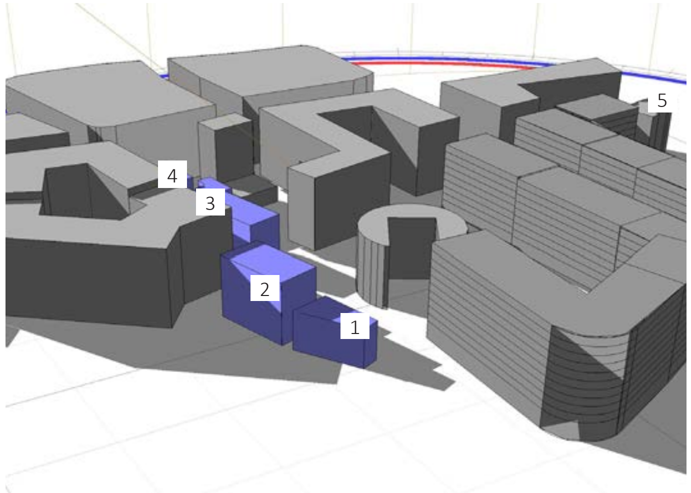


Figure 7 - Paradiso Case Study: future urban status (new Master Plan, MP) when new master plan will be fully implemented, 3D simulation. The blue buildings (1-5) are the existing cultural monuments protected in the area. (Source: © SUPSI)

SUMMARY

Within the VerGe project, two main aspects have been taken into consideration to be analyzed:

- The conflict between the urban transformation towards densification with the energy performances of the architectural and cultural inheritance that pre-exist in the area;
- The expected technological development of renewable energy sources (RES) in this area due to the future obligation to install at least 10 Wp/m² (floor area) of PV in new buildings, as reported in the new "Model for energy requirements at Swiss Cantonal level", is currently only voluntary.

Regarding photovoltaic technologies, the research was keen to stress the impact of such technologies if they are not properly integrated into the building environment especially when they are close to historic and cultural monuments.

SOLAR ENERGY DESIGN

The solar potential for both solar passive and active solutions have been investigated. The solar potential assessment for renewable solar energy has being conducted by using the solar Cadaster of Ticino provided by the Environmental Observatory OASIS platform in Switzerland [7] and also by using simulation tools like PVSOL.

The roof area of buildings suitable to install PV in the City Centre of the urban area is 166 000 m² in the current planning situation, 330 000 m² in the new MP. The PV potential, in the present status, assumes the use of all the roofs surface available in the area while in the future scenario it has been necessary to consider also the facade surfaces well exposed to solar radiation (to comply with the obligation of 10 Watt/m² of PV), due to the high densification.

ENERGY SYSTEM AND TECHNOLOGY

Results highlighted that the estimated PV percentage for electrical supply is almost equal for the current and the future situations when the new urban MP will be completed (28 % and 30 %, respectively). The main differences in the two scenarios are that a high PV density (Wp/m²) in the second case impacts on PV system visibility.

The estimated annual PV production in the current situation (Old MP) is 1 240 MWh/a (electrical energy density 27 kWh/m² a). The estimated annual PV production in the future situation (New MP) is 2 900 MWh/a (electrical energy density 29 kWh/m² a). The estimated annual electrical demand in the current situation is 4 415.5 MWh/a; in the future situation is 9 890 MWh/a [8].

References: [7] Environmental Observatory OASIS (Osservatorio Ambientale della Svizzera Italiana) < http://www.ti.ch/oasi>
[8] Polo López C. S., Frontini F., Bouziri S. (2015). Urban densification and energy performance of existing buildings: a case study. Proceedings of the scientific conference CISBAT 2015, Lausanne, Switzerland, pp 943-948.

Architectural Quality - system Visibility - context Sensibility

Figure 8 - System geometry [9] (Source: © deltaZERO deAngelis Mazza and associates) (on the left); Example of BIPV façade flat roof integration in the urban existing environment of Lugano-Paradiso. NZEB Delta Zero residential building, Lugano, Tessin Canton (CH). (Source: © deltaZERO, de Angelis-Mazza architects) (on the right)

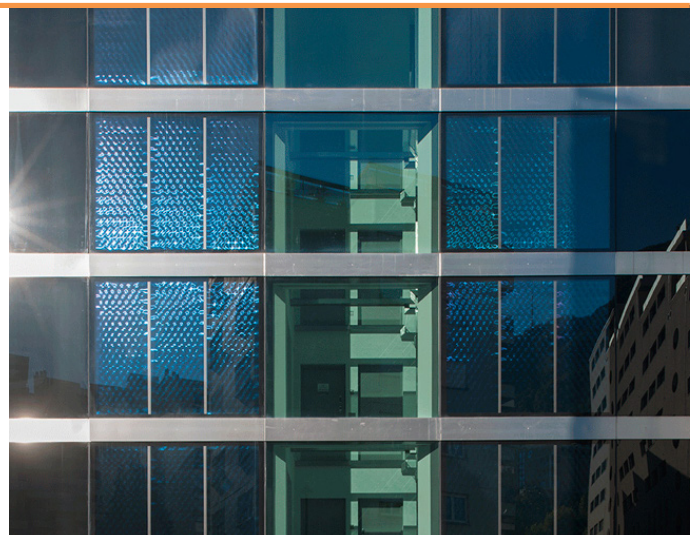
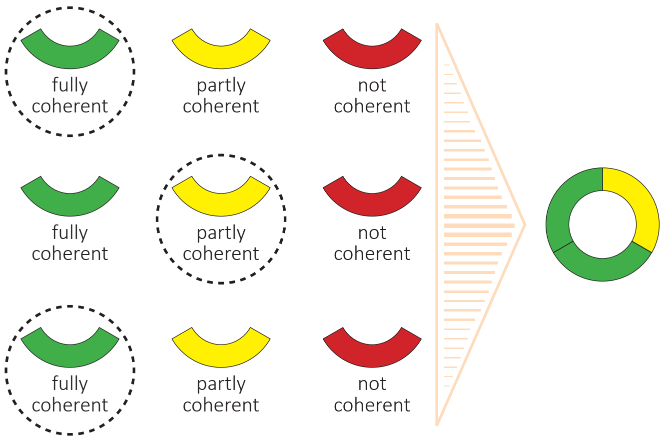


Figure 9 - System modular pattern [9] (Source: © deltaZERO deAngelis Mazza and associates)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	**1** - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	**2** - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	**3** - MODULAR PATTERN



References: *[9] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

COMMENTS

This case studio put the emphasis on the visibility impacts of PV installations in urban areas with historical monuments of cultural significance. The high PV density (10Wp/m^2) imposed by the future legislation, in dense areas, involves integrating RES even in façades. Due to the high visibility, BIPV solutions will be desirable. DeltaZERO NZEB building represents a good example of solar renewable integration in Lugano-Paradiso. BIPV and solar thermal panels are integrated both onto the flat roof and south façade. Solar collectors are covering two vertical bands coherent with the global façade design, revealing a more matte and opalescent appearance next to the corner towards a more translucent and reflective look for the central glazed part. No joints are visible and collectors' frames are integrated with the façade structure. Solar PV panels on the roof and not visible from the street, are opaque supported by a metal structure fixed with clamps.

Figure 10 - View of the deltaZERO building (Source: © deltaZERO deAngelis Mazza and associates)

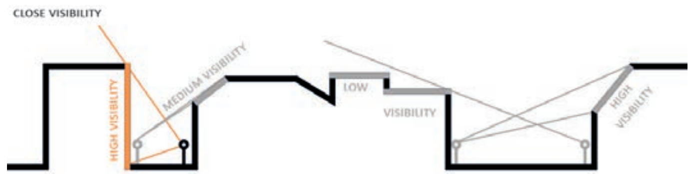


Figure 11 - Different levels of visibility of city surfaces from public domain.

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	●	○	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	●	○	○
REMOTE VISIBILITY	○	○	●
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

The analyzed area of this case studio includes several historic and cultural protected buildings. The deltaZERO building is located in an area of Paradiso not immediately close to the historic buildings, protected by the new master plan. The building has been built in a slightly elevated position with respect to Lugano-Paradiso city center. This part of the city is not affected by the process of urban transformation and densification of the city center, but it is an intensive and dense residential area.

SYSTEM VISIBILITY

PV systems on the flat roofs of these tall new buildings are almost invisible from the close perspective and the intervention may be acceptable due to its low visibility from the public domain. However, remote visibility would be considered from the panoramic viewpoints existing in the area.

By contrast, due to the high visibility of the new constructions close to the existing protected cultural buildings, in the case of façade surfaces, BIPV solutions would be desirable, considering materials, colors and patterns compliant with the surrounding environment.

References: [9] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

Environmental, economic and social impacts

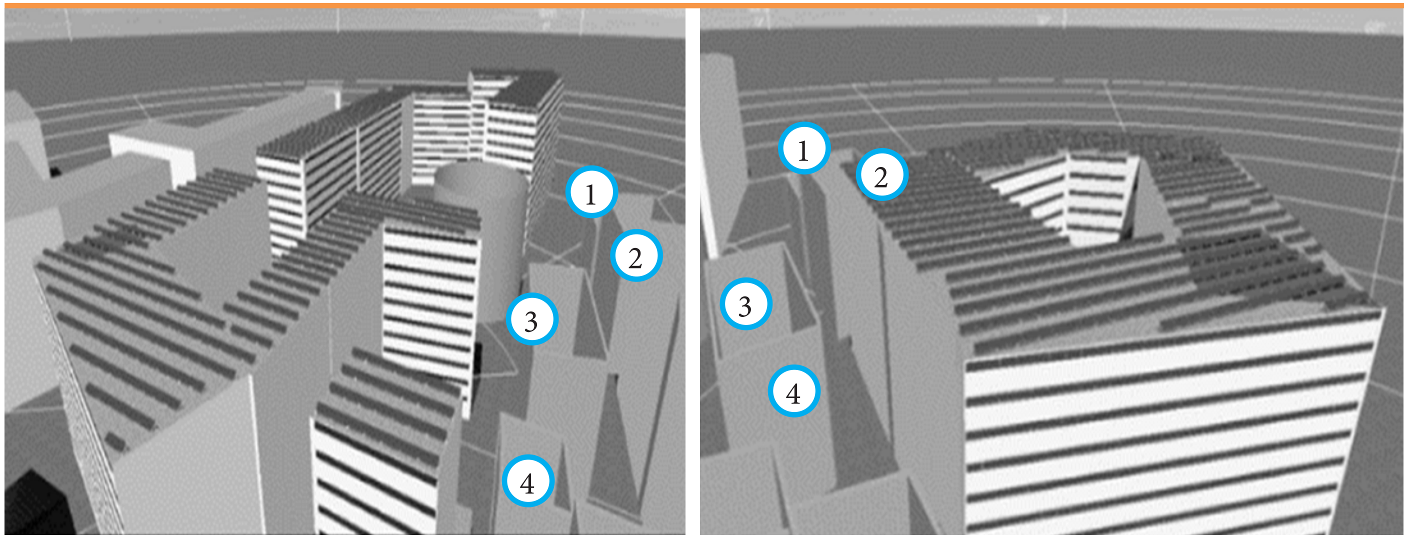


Figure 12 - Paradiso city core, solar potential analysis conducted with PVSol software. Pictures represent possible impacts of PV installations, if not well integrated, considering roofs and façades of new building, to fulfil the obligation to install at least 10 Wp/m2 (GFA) in the future scenario. Numbers are the protected buildings in the area. (Source: @ISAAC-SUPSI).

Figure 13 - Example of complete BIPV façade and roof integration in an urban existing environment: Palazzo Positivo Gasser residential renovated building, Chiasso, Tessin Canton (CH). Plus Energy House and Swiss Solar Award 2014. (Source: © ISAAC-SUPSI)

ENVIRONMENTAL IMPACT

The environmental impact has not been considered during the urban process and during the case study definition. The densification process would be also a positive example from the point of view of sustainability, if considering factors such as: 1) the lower environmental impact due to greater exploitation of the soil and the minor use of free soil; 2) the higher percentage of public spaces, and pedestrian areas; 3) the decreases in car commuting by changing the urban mobility and urban accessibility, resulting in lower energy consumption, lower air pollution levels; 4) the complex activities and mix uses planned (office/residential/tertiary); 5) the expected less energy expenditures in compact built areas than a sprawling, mono-functional city; 6) the green zones & recreation areas proximity; 7) minor per capita use of resources, and production of emissions and waste, etc.

ECONOMIC IMPACT

One protected building has been studied in detail to set the economic impact considering the changes in its energy performances [10]. Energy efficiency assessment has shown that the thermal heating energy demand is growing from the actual to the future situation of about 8.5 %. Conversely, during the summer, the cooling demand decreases as a consequence of the decrement of direct solar irradiance of about 66%. The influence of new constructions will increase the energy consumption and it has been estimated that the total operational cost of the energy systems of this building could increase by 7.21 %, that implies an extra cost of about 1 524.35 €/a [11]. If more severe climatic conditions are considered such as different building orientation layouts or a higher ratio between opaque and transparent surfaces, the impact could be higher.

SOCIAL IMPACT

Any activity in order to consider the social impact has been used during the urban process and the case study definition. With this large urban transformation of the city center. Paradiso expected a big revitalization of the area, with new economic activities, strengthening the tourism and business sectors with new employment alternatives.

The proper integration of solar systems is important to intensify social acceptance towards new technologies even in proximity to protected buildings.

References: [10] Sala M, S. Polo López C. S., Tagliabue L. Ch., Frontini F., De Angelis E. (2015). The energy performance evaluation of buildings in an evolving built environment: an operative methodology. Energy Procedia (2016) Volume 91, June 2016, Pages 1005-1011. Proceedings of the 4th International Conference on Solar Heating and Cooling for Buildings and Industry (SHC 2015), Istanbul, Turkey.

[11] The costs assumed for the economic evaluation are: 1.20 €/m³ of methane for the heating boiler, which produces 9 593 kWh/m³, and 0.06 €/kWh of electricity used for cooling purposes.

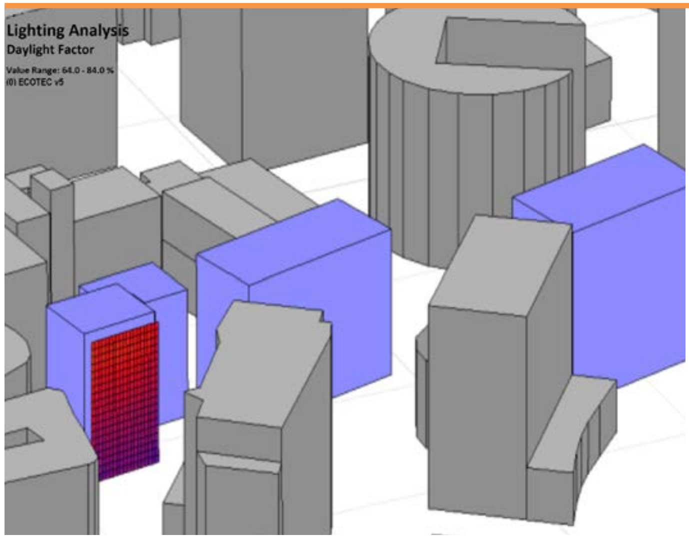


Figure 14 - Example of Ecotect daylighting analysis (Building 4) calculated for the current master plan scenario (Old MP) and the same approach has been used in the new master plan scenario (New MP). (Source: © SUPSI)

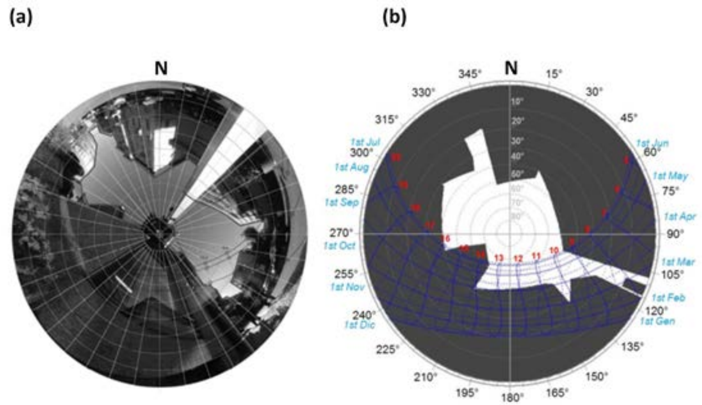
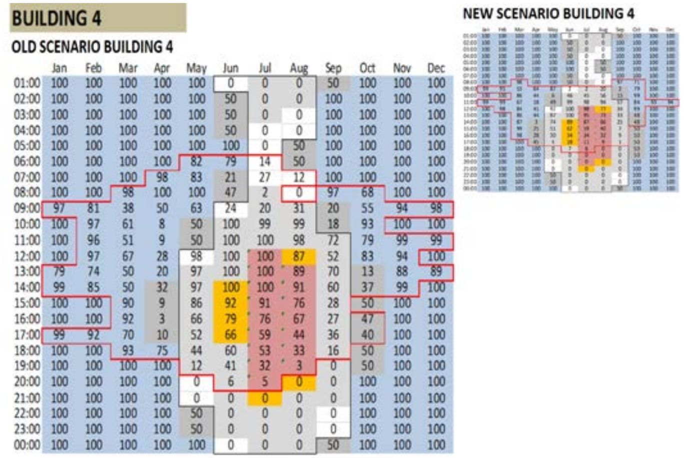


Figure 15 - Sky-factor assessment for building n. 3. Palace G. Guisan street (A4907) through photographic method, different steps in the image processing: (a) Image for the actual situation, Old MP; (b) software simulation New MP. (Source: © SUPSI)



BUILDING 4

OLD SCENARIO BUILDING 4

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
01:00	100	100	100	100	100	0	0	0	50	100	100	100
02:00	100	100	100	100	100	50	0	0	100	100	100	100
03:00	100	100	100	100	100	50	0	0	100	100	100	100
04:00	100	100	100	100	100	50	0	0	100	100	100	100
05:00	100	100	100	100	100	100	0	50	100	100	100	100
06:00	100	100	100	100	82	79	14	50	100	100	100	100
07:00	100	100	100	98	83	21	27	12	100	100	100	100
08:00	100	100	98	100	100	47	2	0	97	68	100	100
09:00	97	81	38	50	63	24	20	31	20	55	94	98
10:00	100	97	61	8	50	100	99	99	18	93	100	100
11:00	100	96	51	9	50	100	100	98	72	79	99	99
12:00	100	97	67	28	98	100	100	87	52	83	94	100
13:00	79	74	50	20	97	100	100	89	70	13	88	89
14:00	99	85	50	32	97	100	100	91	60	37	99	100
15:00	100	100	90	9	86	92	91	76	28	50	100	100
16:00	100	100	92	3	66	79	76	67	27	47	100	100
17:00	99	92	70	10	52	66	59	44	36	40	100	100
18:00	100	100	93	75	44	60	53	33	16	50	100	100
19:00	100	100	100	100	12	41	32	3	0	50	100	100
20:00	100	100	100	100	0	6	5	0	0	100	100	100
21:00	100	100	100	100	0	0	0	0	0	100	100	100
22:00	100	100	100	100	50	0	0	0	0	100	100	100
23:00	100	100	100	100	50	0	0	0	0	100	100	100
00:00	100	100	100	100	100	0	0	0	50	100	100	100

Figure 16 - Isopleth map with CBA bioclimatic chart zones in different colors. Black line identified the period where shade is necessary to prevent overheating; red line represent the average percentage of shading due to the surrounding buildings. (Source: © SUPSI)

STRATEGY AND METHODOLOGY

To investigate the impact of urban densification in the energy behavior of existing buildings and in particular on the heritage cultural monuments, four protected buildings in the area were selected and the following aspects have been identified as main parameters to assess the energy impacts:

- Solar irradiation analysis and potential for solar passive strategies (current and future master plan scenario);
- Sky factors modification in an urban context;
- Human comfort evaluation considering the heritage buildings;
- Daylighting and illuminance levels modification;
- Energy efficiency modification of protected heritage buildings;
- Assessment of solar potential for renewable solar energy in the urban context.

This study identifies and proposes simple methods to assess solar radiation, daylighting availability and Sky-View Factor (SVF) modification, in complex urban environments using a combination of numerical methods, 3D simulations programs with photo processing image methods (Figure 14). To assess solar irradiation and shadows changes and the real impact of new and existing buildings, simulation tools as 3D Ecotect software has been used to evaluate the different scenarios along with Sun-path diagrams. A more accurate analysis was performed by using the HORIcatcher instrument developed by Meteotest. With a digital camera and a spherical convex mirror, the real horizon in an urban area (three-dimensional projections of the surrounding urban space) has been registered in order to calculate limitations of the sunshine duration and irradiation due to obstacles.

Then a processing image software (ImageJ) has been used to analyze the current urban status (Figure 15).

For the assessment of the human comfort differences in the area, bioclimatic charts and diagrams, have been considered for calculating the ideal “comfort zone” corresponding to the specific location of Lugano-Paradiso [12]. This study was performed in order to establish the aspects that compromise the full exploitation of the external environmental conditions and the possibility of using passive strategies for thermal conditioning. The results can be simplified and represented in an Isopleth map (month by month, hour by hour) that could be compared with the same type of diagram showing the results of the dynamic analysis of the solar irradiation simulation made with the Ecotect software for the old MP and the new MP (Figure 16).

References: [12] Average statistical data from Federal Office of Meteorology and Climatology – MeteoSchweiz

By comparing the situation before and after, when the urban transformation will be definitely performed and the new MP completed, it has been possible to calculate the percentage of solar obstruction (sunshine/shading) in each analysed building, due to the presence of the nearby buildings in the surrounding area.

RESULTS AND DISCUSSION

Results show that for Building 1 and 2 there are not significant differences on the façades in terms of solar radiation availability, mainly because the surrounding urban area has been already modified. The greatest impacts have been observed in Buildings 3 and 4, as more changes are detected in their surroundings area in the future scenario. Particularly in the case of Building 3, for almost all façades (north-east, south-west, north-west or south-east) the situation worsens by increasing the percentage of shade from 10% to 15%, in all cases.

In the summer period although the discomfort predominates, in some cases (Building 3 and 4) the comfort increases slightly for the new MP scenario while only in Building 1 the percentage of thermal comfort time exceeds the discomfort. In winter time, however, for all buildings, the thermal comfort decreases while discomfort increases.

The extraordinary urban modification which will take place in the area will not only affect parameters related to solar radiation or the indoor and outdoor thermal comfort, as we have seen so far, but also will have an impact on issues related to sky-view factors (SVF) and the daylighting and visual comfort. Results have shown (Figure 17) that a significant alteration of the SVF values throughout the urban area studied occurs. General conditions also in the current case are not very good regarding daylighting availability (DF), as buildings in the neighborhood are already high and there are so many obstructions. In any case the future situation will clearly worsen the current situation in this sense [13].

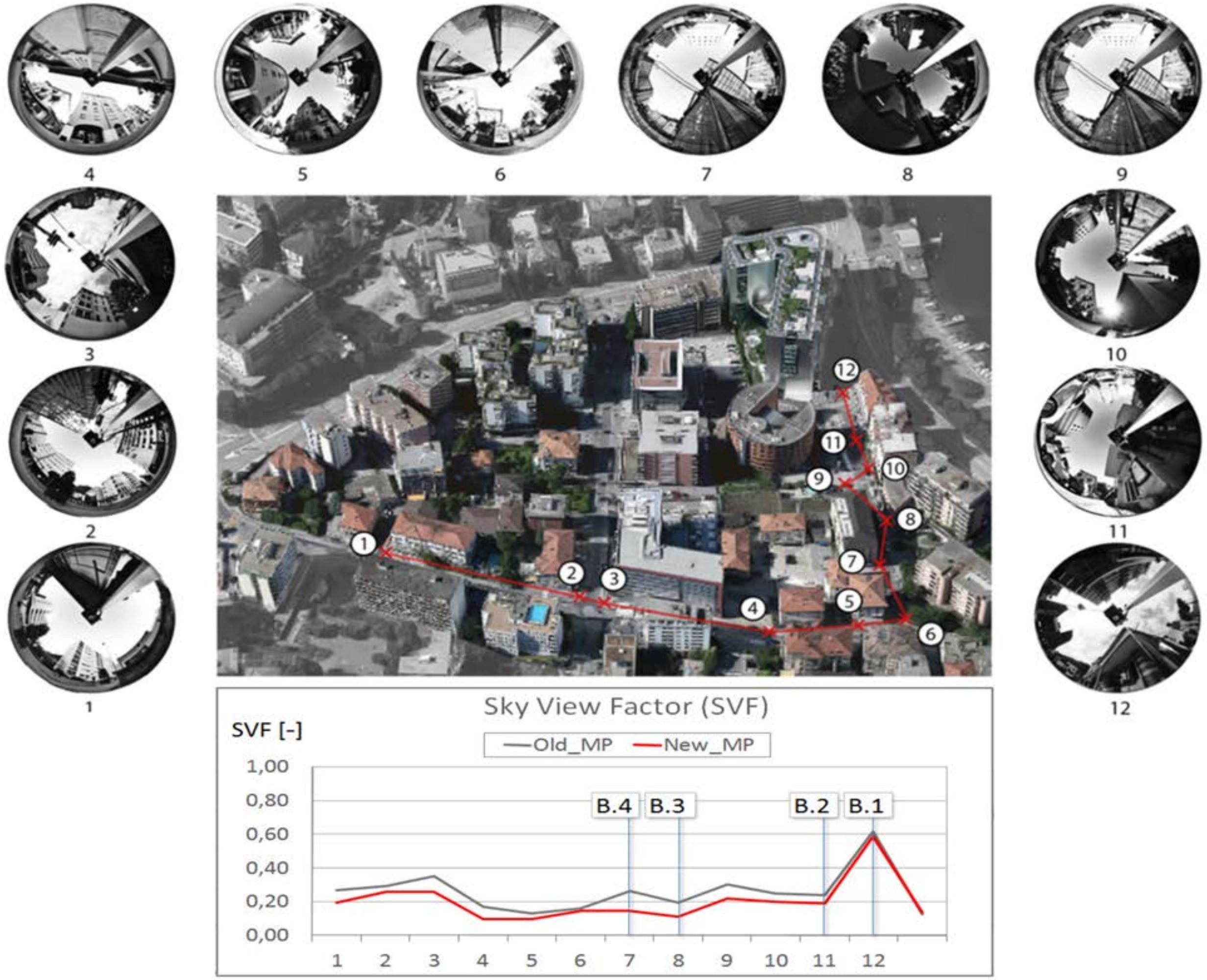


Figure 17 - Pictures taken on site: a site inspection for data collection was carried out, covering the significant points of the urban area and taking as reference the studied historical buildings (Buildings 1-4). (Source: © SUPSI)

References: [13] Polo López C.S., Sala M., Tagliabue L. Ch., Frontini F., Bouziri S. (2015). Solar Radiation and Daylighting Assessment Using the Sky-view Factor (SVF) Analysis as Method to Evaluate Urban Planning Densification Policies Impacts. Energy Procedia (2016) Volume 91, June 2016, Pages 989–996. Proceedings of the 4th International Conference on Solar Heating and Cooling for Buildings and Industry (SHC 2015), , Istanbul, Turkey.

Figure 18 - Mid-term workshop with the stakeholders involve in the project. (Photo: © SUPSI)

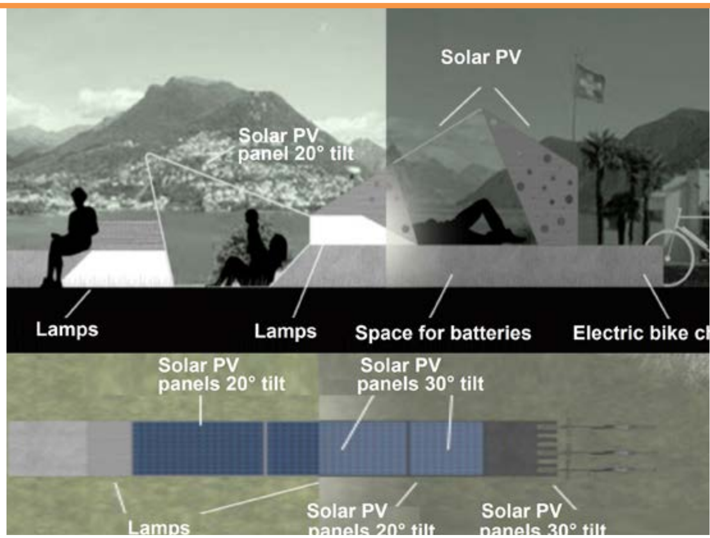


Figure 19 - Seminar with students regarding "Integration of renewable technologies in the urban context". Urban solution furniture integrating solar PV panels. R676 Course, authors: Manini Yvana L. and Mazzetti Stefano. (Source: © SUPSI)

Figure 20 - Example of BIPV integration in an urban furniture element, Chiasso, Tessin Canton (CH) developed by Agere SA. (Photo: © Cristina Polo).

LESSONS LEARNED

- Local development regulations can support measures to better exploit solar and daylighting resources;
- Planners and researchers together can help communities enact standards related to solar exploitation;
- It is important to develop specific codes to eliminate uncertainty around where solar systems may or may not be allowed to mitigate any potential negative impacts.
- Finally, it will be important to use comparable examples; to work in collaboration with planners and the municipalities and to convince the community members in order to explain specific aspects of the research results in a comprehensible way that will help for greater acceptance of public to better implement new urban changes.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

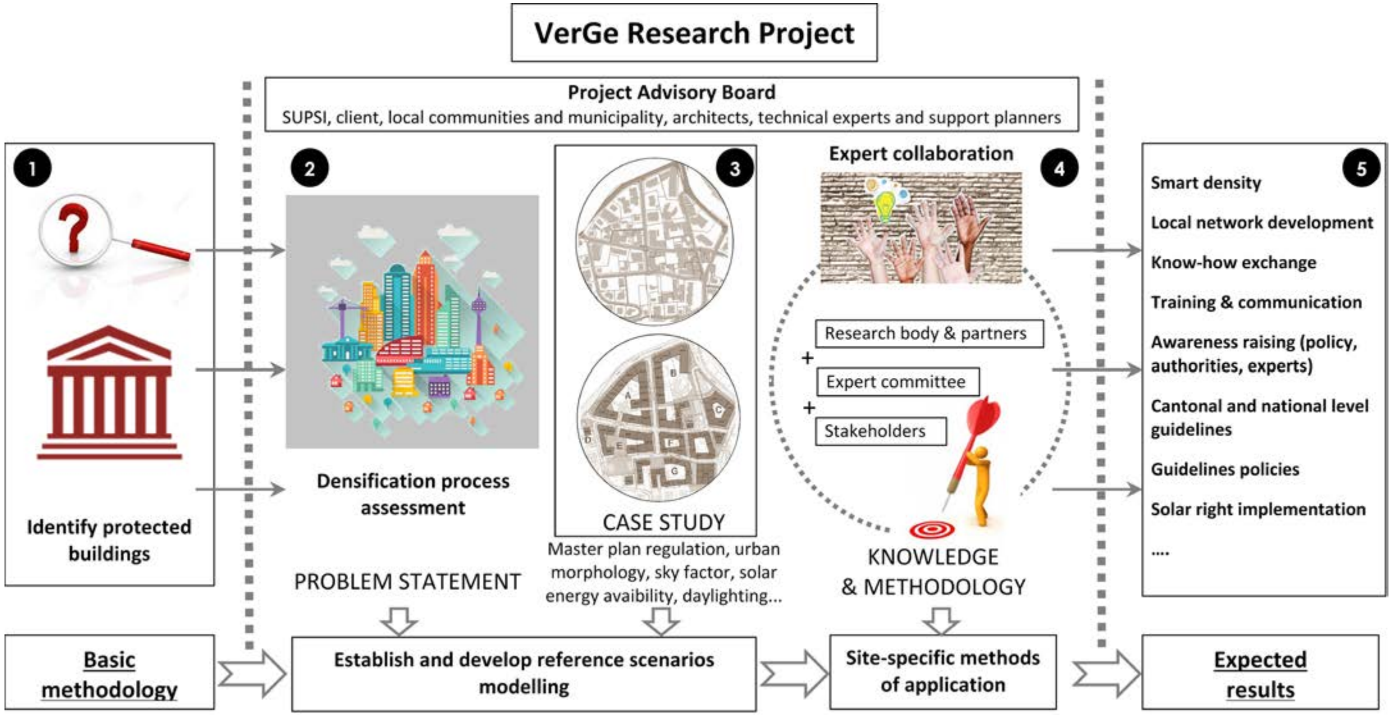
- To anticipate the possible change of the rules in force today for the future and establish solar rights in the planning process for those buildings that cannot benefit from the energy policies due to protection constrains;
- To generate debate on solar energy issues and renewable solar supply potential to promote the acceptability to the solar photovoltaic technologies as measure and to consider building integrated photovoltaic products (BIPV) as a resource to better integrate renewable energy in the surrounding buildings closed to protected heritage;
- To enhance the cultural heritage studying visibility impacts in order to define guidelines, rules or ordinances suitable to the urban area to avoid impacts on the protected heritage.

TARGET GROUPS

- Urban decision makers
- Municipalities
- Urban planners
- Architects
- Students

PUBLIC AND EDUCATION ACTIVITIES

Lecture on "Photovoltaics in historical and city core contexts" in life-long learning programs held in SUPSI: CAS, Certificate of Advanced Studies in rehabilitation and Real Estate Management. October 2014, Lugano; Seminar with students "Integration of renewable technologies in the urban context", R 676 Course: Architecture and solar. SUPSI Bachelor of arts in Architecture.



(Source: © SUPSI)

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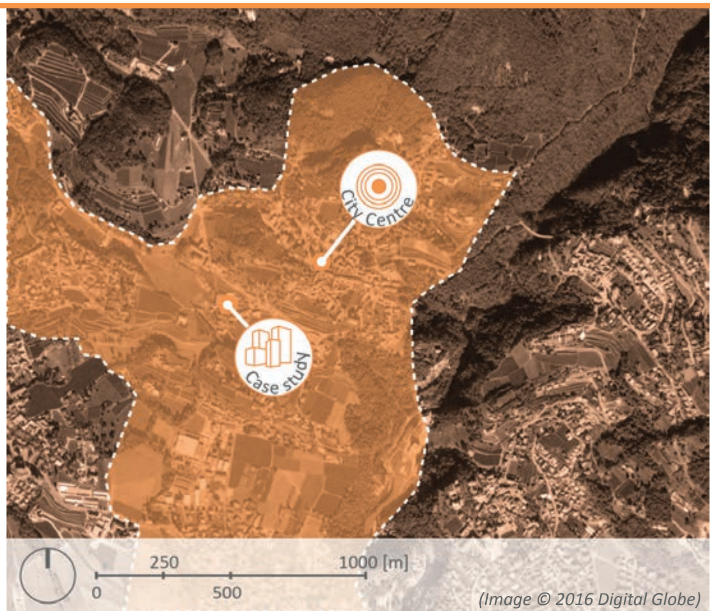
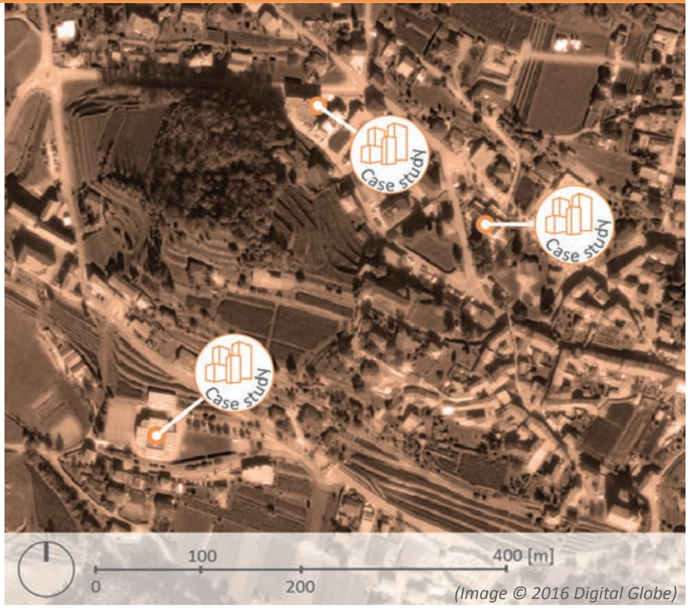
(Source: © SUPSI)

ENERGY INNOVATION SOLAR PURCHASE GROUP

SWITZERLAND

Overview





GEOGRAPHICAL AND CLIMATE INFORMATION

Country: Switzerland
Location: Castel San Pietro (Lat. 45°86’16” N; Lon. 9.00’68” E)
Climate: Temperate Oceanic (Cfb) [1]

AREA OF INTEREST

Targets and goals

NATIONAL AND LOCAL CONTEXT

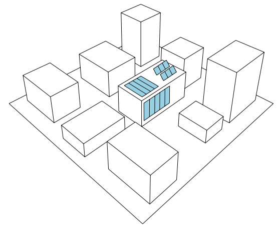
Since 2011, Switzerland decided to withdraw from the use of nuclear energy. As result a new “Swiss energy strategy 2050” [2] was defined emphasizing the importance to increase the energy supply from renewables while reducing the energy demand in consumption sectors, with specific focus on the construction sector. In 2014, the new “Model for energy requirements at Swiss Cantonal level [3]” was approved, which introduced the obligation to install at least 10 Watt/m^2 of PV in new building. This requirement is not yet applied by the Swiss cantons. In the Canton Ticino, new buildings have to be built so that renewable energy will cover at least 20% of the energy needed for heating and hot water production.

ABOUT THE CASE STUDY

The four municipalities of Breggia, Castel San Pietro, Morbio Inferiore and Vacallo created in 2012 a solar thermal purchase group and, successively, in 2014, a photovoltaic purchase groups to promote and manage renewable solar installations. These municipalities are located near the south border of Switzerland in a region called “Ge neroso” with a high solar potential.

Definition of environment:
Existing urban fabric

Site area: 41 160 000 m^2



References: [1] Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World Map of the Köppen-Geiger climate classification updated, Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263;
[2] Energy Strategy 2050. Swiss Federal Office of Energy SFOE
[3] Conférence des directeurs cantonaux de l’énergie (EnDK). Modèle de prescriptions énergétiques des cantons (MoPEC), edition 2014.

Figure 1 - View of the PV panels installed on the roof of one of the house in the Castel San Pietro (Photo: © SUPSI)

Figure 2 - Blazons of the four municipalities.
(source: © the respective municipal chancelleries)

HIGHLIGHTS OF THE CASE STUDY

Four towns located on the slopes of Monte Generoso (Breggia, Castel San Pietro Morbio Inferiore and Vacallo) launched, in collaboration with University of applied sciences and arts of southern Switzerland (SUPSI), two "solar" purchase groups (purchasing goods collectively). This initiative has allowed to motivate many small property owners to realize their own installation, while reducing the investment costs.

- 35 solar thermal installations
- 50 photovoltaic installations
- Price reduction for solar thermal up to 50%
- Price reduction for photovoltaic abt. 15-20%

ISSUES AND CHALLENGES

Although property owners are key players of the energy policies, they are not easy to reach and motivate. Moreover between local and regional authorities, administrative logistic coordination is often challenging. Technical and economic aspects are also a source of confusion and frustration for the property owner considering how difficult it is to get clear and objective information about technical aspects linked to the solar technology, the performance, as well as legal, economic and regulatory aspects.

- Choosing the right technology
- Comparison of prices and services
- Economic feasibility

DECISION STRATEGIES

Main objectives:

- To offer the opportunity to buy and carry out solar installations at a more advantageous price compared to an individual purchase;
- To offer a neutral consultancy, reliable and professional;
- To offer quality products and services for all;
- To promote the local authority's image as a forefront municipality, in line with the 2050 Energy Strategy of the Confederation;
- To endorse and activate the local economy by supporting local employment and job creation in the companies actives in the solar market at regional level.

The process of the initiative

The collective approach has multiple benefits for both the citizens who adhered to the program and the local authority, respectively the region, which promotes it.

In November 2012 the municipalities of the “Generoso” region organized the first informative meeting for the “solar thermal” phase, in January 2014 started the “photovoltaic phase”. Both phases went on for about 1 year.

The set-up of a solar purchase group for thermal and photovoltaic systems has as the main objective to promote locally the realization of these installations, concretely contributing to an increased use of renewable energies, to the protection of the environment and in general to the shift in energy policy.

The Federal Council’s new strategy focuses on the consistent exploitation of the existing energy efficiency potentials and on the balanced use of the potentials of hydropower and new renewable energy sources.

Local contributors are the four municipalities of Breggia, Castel San Pietro, Morbio Inferiore and Vacallo and their citizens.

The SUPSI assisted by two firms active in the energy field (consultancy and planning) have managed and coordinated the two solar purchase groups.

The realization of solar installations is supported by public funds.

Figure 3 - Definition of planning process (Illustrations: © White Arkitekter)

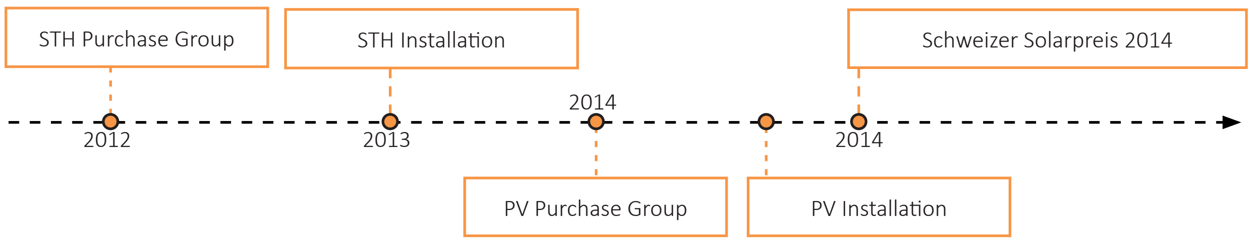


Figure 4 - Logo of the cross-border cooperation program between Italy and Switzerland. (Source: © Programma di cooperazione transfrontaliera INTERREG)


Creato un gruppo di acquisto intercomunale di impianti solari fotovoltaici

Innovazione energetica

Vacallo, Morbio, Breggia e Castel San Pietro avranno il ruolo di coordinatori. L'offerta vincente sarà scelta da chi aderirà al progetto.

Tre serate pubbliche

I Comuni coordinano e informano, i cittadini scelgono

Figure 5 - The solar purchase group was the subject of several newspaper articles and of a couple of TV reports. (Source: © La Regione 22.11.2013)


Energia solare **Acquisto di gruppo**

Iniziativa di quattro Comuni per la promozione di impianti fotovoltaici

FINANZIAMENTI
Il progetto è finanziato dai fondi Interreg, alimentati dalla Confederazione e dall'UE.
(Foto Crinari)

November 22, 2013 Powered by TECNAVIA

Copyright © 22/11/2013 Corriere del Ticino 7:56 am

Figure 6- The solar purchase group had a good media feedback. This newspaper article appeared on one of the main newspaper of the region. (Source: © Corriere del Ticino 22.11.2013)

SUMMARY

This project was initially aimed at promoting the spread of photovoltaic systems of the municipal territory of Castel San Pietro. Then, thanks to the cross-border cooperation program Italy - Switzerland 2007/2013 "Energy Innovation" [4] it has been extended to promote other purchasing groups in the Generoso region (Breggia, Castel San Pietro, Morbio Inferiore and Vacallo) and is also considering solar thermal system.

TECHNOLOGY

Over 300 property owners attended the informative meetings. The two solar purchase groups have always been supported by professionals active in the energy field and by researchers from SUPSI. Each participant was then able to individually define the installation details along with the selected solar installer. The selected installers were chosen by the group of volunteers and needed to have an office in Ticino.

On the roofs of the Generoso region were installed [5]:

- In 2013, 35 solar thermal plants with a total surface of 220 m^2.
- In 2014, 50 photovoltaic installations with a total nominal power of abt. 350 kWp.

AWARDS

This project was awarded the Swiss Solar Prize 2014, as best practice, not only in the optic of an excellent collaboration between different local authorities, but also for the involvement of property owners in the chosen area.

It has been a successful initiative that has had a large media appeal and prompted others towns in Ticino to follow the same good example.

References: [4] Interreg Programma di Cooperazione trasfrontaliera Italia Svizzera 2007-2013. Progetto Innovazione Energetica
[5] Solar Agentur. Publikation 24. Schweizer Solarpreis 2014, pp 26-27.

Figure 7 - System geometry [9] (Source: © SUPSI)

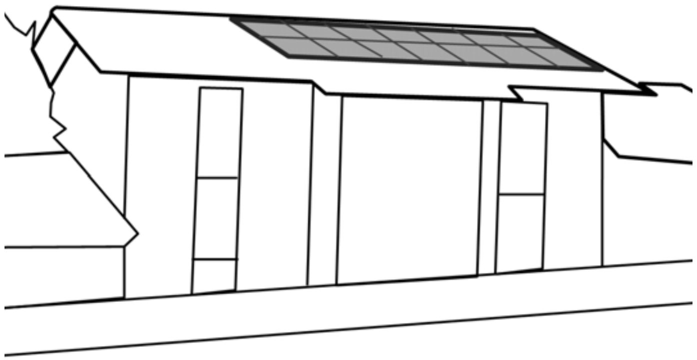
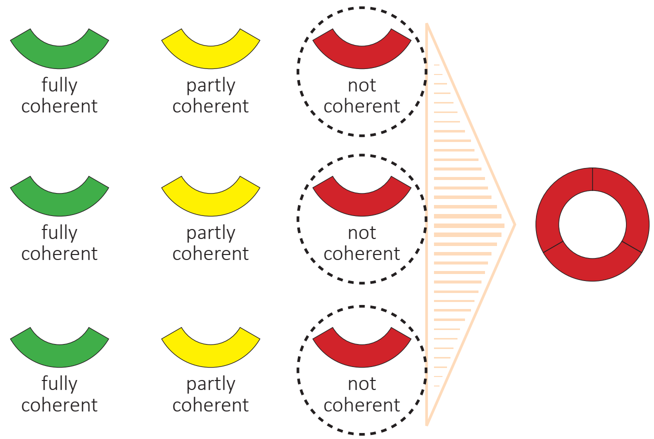


Figure 8 - System materiality [9] (Source: © SUPSI)

ARCHITECTURAL INTEGRATION QUALITY*: EVALUATION OF INTEGRATION QUALITY OF THE SOLAR SYSTEMS INSTALLED

FIELD SIZE / POSITION	**1** - SYSTEM GEOMETRY
VISIBLE MATERIALS SURFACE TEXTURE COLOURS	**2** - SYSTEM MATERIALITY
MODULES SHAPE / SIZE JOINTS	**3** - MODULAR PATTERN



COMMENTS

The solar systems are not considered integrated in the buildings. Usually, only BAPV o BAST (building added photovoltaic and solar thermal) installations have been performed, where energy systems overlap to the construction (roofs) that already exists. System geometry and modular pattern of solar modules have complied which stated in the Federal Law on Spatial Planning (*Bundesgesetz über die Raumplanung*, RPG) and the respective Spatial Planning Ordinance [7]. For this reason, the following aspects has been fulfilled: seen from the front and from above, it does not protrude beyond the surface of the roof; the module surface has a low degree of reflection and it presents itself as a. compact surface. Solar modules are coplanar with the slopes of roof, respect the shape and roof line, they are grouped compactly.

References: *[6] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.
[7] 700 Legge federale sulla pianificazione del territorio, LPT del 22 giugno 1979 (Stato 1° gennaio 2016)

Figure 9 - View of PV panels installed on the roof. (Surce: © SUPSI)

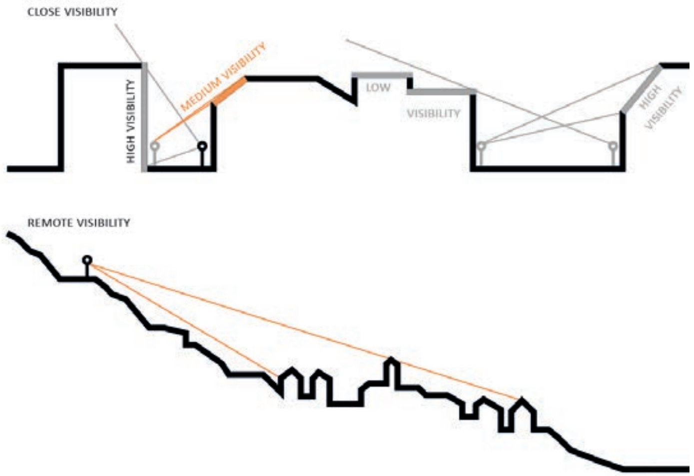


Figure 10 - Different levels of visibility of city surfaces from public domain.

CRITICITY

CONTEXT SENSITIVITY	HIGH	MEDIUM	LOW
URBAN AREA SOCIO-CULTURAL VALUE	○	●	○
SYSTEM VISIBILITY	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	●	○
REMOTE VISIBILITY	○	●	○
Visibility before modification (if relevant)	HIGH	MEDIUM	LOW
CLOSE VISIBILITY	○	○	○
REMOTE VISIBILITY	○	○	○

CONTEXT SENSIBILITY

Most solar systems have been carried out in not densely built urban areas or areas outside the city center.

SYSTEM VISIBILITY

PV systems were integrated in the roof of small buildings, usually single family detached homes or small apartment blocks.

Solar systems on the pitched roof are quite visible from the close perspective but the facilities are not too large. With regard remote visibility, the installations have also been distributed in a large area of the territory, not concentrated in a single point, so the intervention may be acceptable. Solar systems have not represented a negative factor in terms of visual impact in the surrounding area and therefore any specific authorization released by the competent authorities has not been necessary. However, BIPV and BIST (Building Integrated Photovoltaic and solar thermal systems) solutions would be desirable, considering materials, colors and patterns compliant with the surrounding environment, but the cost of installation would surely be greater.

References: [6] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT.

ENVIRONMENTAL, ECONOMIC AND SOCIAL IMPACTS

Figure 11 - First informative meeting of the solar thermal purchase group. (Source: © SUPSI)

ECOENERGIE

Castel San Pietro e il suo "Gruppo di acquisto solare"

Castel San Pietro, primo comune in Ticino a promuovere attivamente e localmente l'energia rinnovabile attraverso un Gruppo di acquisto solare.

A fine 2011 Castel San Pietro ha dato avvio, in collaborazione con l'Istituto Sostenibilità Applicata all'Ambiente Costruito (ISAAC) della SUPSI al progetto "Gruppo di acquisto solare". L'iniziativa, volta a promuovere la diffusione di impianti fotovoltaici sul territorio comunale, ha permesso di riunire tutti i proprietari immobiliari interessati a questo tipo di installazione e di realizzare 14 nuovi impianti, per un totale di 51.2 kWp di potenza installata.

Nascita e caratteristiche del progetto

Figure 12 - Informative publication to promote citizen participation to Solar purchasing group initiative. Ecoenergie magazine, management and public services topic - September 2013 (Source: © Nerio Cereghetti, Michela Sormani SUPSI-DACD-ISAAC)

ENVIRONMENTAL IMPACT

Solar technology allows not only to produce renewable energy but also to reduce heating and electricity costs while preserving as much as possible our environment and territory.

A neutral consultancy by professionals with a recognized experience in the energy/solar field allows objectively evaluating the offers and choosing the best, weighing both technological and financial aspects.

ECONOMIC IMPACT

The project "Solar Purchase Group" allows us to realize solar installations at a fair price with quality and safety guarantees.

This project was financed by municipalities and a cross-border cooperation program Italy – Switzerland whose aim is to create the conditions for developing energy and environmental policies focusing on sustainability. The project was supporting the municipalities in the energy planning and its technical and economic feasibility, in order to actually implement the planned measures and the integrated actions of energy management.

SOCIAL IMPACT

This initiative consents to acquire a solar system with the buying power of a group of purchasers and with the accompaniment of the public authorities and technical partners, specialist on the subject.

Progetto: gruppo d'acquisto solare termico (acqua calda sanitaria)

28 novembre 2012, ore 20:00

presso il Centro Scolastico di Castel San Pietro

Figure 13 - *The flyer was sent to the inhabitants of the four municipalities. (Source: © SUPSI)*

Gruppo di acquisto di impianti solari fotovoltaici:

per un maggiore impiego delle energie rinnovabili

Mercoledì 15 gennaio 2014, ore 20.00

Figure 14 - *Flyer for the presentation meeting of the solar photovoltaic purchase group. (Source: © SUPSI)*

STRATEGY

A "Solar Purchase Group" offers first of all a neutral, reliable and professional consultancy by experts in the field with the aim of helping propriety owners with the technical and financial evaluation of bids for solar installations. An overview of different possibilities is presented to the participants: methods and timing to get financial incentives from federal, cantonal or local sources.

It is a concrete support measure to the citizens within the implementation of innovative methods which are in line with the cantonal and federal energy policy objectives where the development and promotion of renewable energies is a priority [8], providing also the support of industry experts. Moreover, those kinds of projects promote the local economy thanks to the involvement of installers who are active in the region.

The quality of the products and services is also guaranteed thanks to a single tender for the supply and installation of several solar plants.

Every participant has the autonomy to sign, without any constraints, their own contract with the company who won the call for tenders.

IN RELATION TO SCALE

As a customer, this kind of "purchase group" allows each person to strongly position themselves on the building and/or energy market. Acting as a collective and not individually, and with the support of competent and neutral experts in the specific field, enables to acquire a greater negotiation power. Most of the solar installations that have been realized thanks to this project are "domestic-sized"

This initiative was undoubtedly a success. Focusing on the photovoltaic purchase group, of the 180 property owners who attended the first information meeting, 40% actually realized a photovoltaic installation on their home. This was undoubtedly encouraged by several novelties that in 2014 have regarded the PV sector (simplified administrative procedures, new incentives at Cantonal level).

References: [8] Energy Strategy 2050: In 2007 the Federal Council based its energy strategy on four pillars: energy efficiency, renewable energies, replacement and new construction of large power stations for electricity production (also nuclear power stations), and external energy policy. The first set of measures for the development of renewable energies considers a feed-in remuneration system, investment subsidies, support for existing large-scale hydro-electric power stations, approval procedures to be shortened and simplified and a national interest of protection and use (protection of nature and the landscape).

RESULTS AND DISCUSSION

The first informative meeting had the aim of introducing the “Solar Purchase Group”, the proceedings of the project and to provide an overview of the technical and economic aspects of solar energy (thermal or photovoltaic depending on the type of purchase group) [9].

Home owners had the possibility to actively participate in a group of volunteers who, in collaboration with the consultants, evaluated the tenders. In the case of the “Photovoltaic Purchase Group”, the volunteers requested an offer to the eight companies located in the south of Ticino that are listed in the official reference list of solar professionals [10]. The volunteers also decided the origin of the modules (Switzerland).

On this basis, the photovoltaic consultant compiled the technical specifications which were sent to the installers selected by the group of volunteers.

The group of volunteers, with the help of the consultants, selected the best offers elaborating some positive and negative notices. Some additional information was also required: number of employees, number of apprentices, years of experience, references, etc.

All the information was presented in a second public meeting. The attendees selected by voting three companies that will present themselves and their offers at the last meeting.

During the last public event these companies were able to reach the home owner and propose to them an onsite visit and a personalized offer based on the directives specified in the tender. A standard contract and a check list with all the information and verifications to carry out before, during and after the installation, were also provided.

Figure 15 - First informative the informative meeting of the photovoltaic purchase group. (Source: © SUPSI)

References: [9] www.ecomuni.eu/; www.enermi.ch/
[10] www.solarprofis.ch/.

Figure 16 - Brusadelli family, 3.5 kW, Castel San Pietro. (Photo: © SUPSI)

Figure 17 - New solar thermal installation. (Source: © SUPSI)

Figure 18 - New solar thermal installation. (Source: © SUPSI)

LESSONS LEARNED

This experience will bring a greater efficiency in the use of the technology and better integration of the solar installations [11]. The aim of the project was not to promote the installation of innovative products and technology. The purpose of a solar purchase group is very practical, almost ordinary. Given the right information and the needed support, it should be possible to install the largest possible number of solar plants that are correctly planned and executed (for example using certified products or turning to experienced installers). Through the involvement of the region's companies there is a direct promotion of the local economy. Furthermore there is also a direct and positive effect on the electricity production from local renewable sources.

SOLUTIONS, RECOMMENDATIONS AND SUGGESTIONS

The promotion of a participatory approach allows for greater involvement of property owners. With their support and their trust is actually possible to intervene convincingly on the energy market and eventually overcome the old perceptions regarding to solar energy.

TARGET GROUPS

- Twon councils
- Citizens
- Costumers associations
- Environmental group

References: [11] Cereghetti, N. (2013) Castel San Pietro e il suo "Gruppo di acquisto solare". Castel San Pietro, primo comune in Ticino a promuovere attivamente e localmente l'energia rinnovabile attraverso un Gruppo di acquisto solare. Ecoenergie magazine, management and public services topic- September 2013, pp 11-13.

(Source: © SUPSI)

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Comune di Castel San Pietro
Comune di Morbio Inferiore
Comune di Vacallo

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of Southern Switzerland

SUPSI

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SHC CHAPTER

4

4.1 IEA Solar Heating and Cooling Programme

The Solar Heating and Cooling Technology Collaboration Programme was founded in 1977 as one of the first multilateral technology initiatives ("Implementing Agreements") of the International Energy Agency. Its mission is "to enhance collective knowledge and application of solar heating and cooling through international collaboration to reach the goal set in the vision of solar thermal energy meeting 50% of low temperature heating and cooling demand by 2050.

The members of the IEA SHC collaborate on projects (referred to as "Tasks") in the field of research, development, demonstration (RD&D), and test methods for solar thermal energy and solar buildings.

A total of 59 projects have been initiated, 51 of which have been completed. Research topics include:

- Solar Space Heating and Water Heating (Tasks 14, 19, 26, 44, 54)
- Solar Cooling (Tasks 25, 38, 48, 53)
- Solar Heat or Industrial or Agricultural Processes (Tasks 29, 33, 49)
- Solar District Heating (Tasks 7, 45, 55)
- Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52, 56, 59)
- Solar Thermal & PV (Tasks 16, 35, 60)
- Daylighting/Lighting (Tasks 21, 31, 50, 61)
- Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)
- Standards, Certification, and Test Methods (Tasks 14, 24, 34, 43, 57)
- Resource Assessment (Tasks 1, 4, 5, 9, 17, 36, 46)
- Storage of Solar Heat (Tasks 7, 32, 42, 58)

In addition to the project work, there are special activities:

- SHC International Conference on Solar Heating and Cooling for Buildings and Industry
- Solar Heat Worldwide – annual statistics publication
- Memorandum of Understanding – working agreement with solar thermal trade organisations
- Workshops and seminars

4.2 Country members

Australia
Austria
Belgium
Canada
China
Denmark
European Commission
France
Germany
Italy
Mexico
Netherlands
Norway
Slovakia
South Africa
Spain
Sweden
Switzerland
Turkey
Portugal
United Kingdom

4.3 Sponsor Members

European Copper Institute
ECREEE
Gulf Organization for Research and Development
International Solar Energy Society
RCREEE

For more information on the IEA SHC work, including many free publications, please visit www.iea-shc.org