Lessons Learnt from Case Studies of Solar Energy in Urban Planning

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Solar Heating and Cooling Programme- International Energy Agency
Task 51 “Solar Energy in Urban Planning”

Subtask C – Case Studies and Action Research
Task 51/Report C3 - Lessons Learnt from Case Studies of Solar Energy in Urban Planning

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Subtask topics have been set as an objective within the framework of Solar Heating and Cooling Programme - International Energy Agency T*ask 51 "Solar Energy in Urban Planning".* In the Subtask C Case Studies and Action Research, work on best practice case studies and case stories 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.

The Task 51/Report *C3 - Lessons learnt from Case Studies of Solar Energy in Urban Planning*, is linked to Subtask A, B and D and contains lessons learnt drawn from the Task 51/Report *C1 - Illustrative Prospective of Solar Energy in Urban Planning: Collection of International Case Studies* and Task 51/Report *C2 - National and International Comparison of Case Studies on Solar Energy in Urban Planning*.

SUMMARY

We would like to thank all authors and organisations who contributed to developing case studies for this report. 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 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.

ACKNOWLEDGEMENTS

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1 INTRODUCTION

1.1 Objectives

The main objective of this report is to provide lessons learnt through case studies and their comparison (Subtask C) across the different Subtask topics of Task 51 Solar Energy in Urban Planning. These Subtask topics are:

1. Legal framework, barriers and opportunities for solar energy implementation
2. Development of processes, methods and tools
3. Education and dissemination

Subtask C creates a prospective of urban planning case studies by analyzing the inter-relationship between the variables of the urban surrounding, solar integration technologies, environment, social aspects, aesthetics, methods, approaches, tools and planning process. The analysis contributes to lessons learnt from the case studies and their comparisons in order to develop urban planning guidelines for different target groups.

Specifically, in the Task 51/Report C3, lessons learnt from the case studies are presented and examined primarily through cross country comparisons concerning planning process, research actions, legislation, simulation, education, etc. (Link with Subtask A, B, and D).
This report concludes the work of Task 51/Report C1 and Report C2 by developing a deeper understanding of the case studies by extracting the most relevant lessons learnt which have been organized in nine different topics (see section *2.1 Materials and methods* in this report).

2 METHODOLOGY

2.1 Materials and methods

In the *Task 51/Report C3 - Lessons Learnt from Case Studies of Solar Energy in Urban Planning*, the case studies (Report C1) and their comparisons (Report C2) have been analysed in order to extract the lessons learnt. The lessons learnt are divided into ten categories:

1. Legislation
2. Solar rights and solar potential
3. Daylighting
4. Planning process
5. Approaches, methods and tools (AMT)
6. Education
7. Stakeholders' and researchers' involvement
8. Energy use
9. Economy
10. Visual impact – urban sensitivity and integration quality

Each category includes lessons learnt distributed for the three following environments (fully described in the Report C1):

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

Four target groups have been selected:

1. Citizens
2. Education actors (i.e. students, teachers, researchers etc.)
3. Professionals and stakeholders
4. Politicians and decision makers

In the next pages the different sections composing the templates for lessons learnt, as well as the categories and the target groups will be described in detail.

2.2 Sections of the templates of lessons learnt

The templates of the lessons learnt are organized in different sections which are related to the ten categories selected to organize the findings from the case studies.

Each section is represented by the icons presented in Figure 1 below and graphically in Figure 2 in the next page.

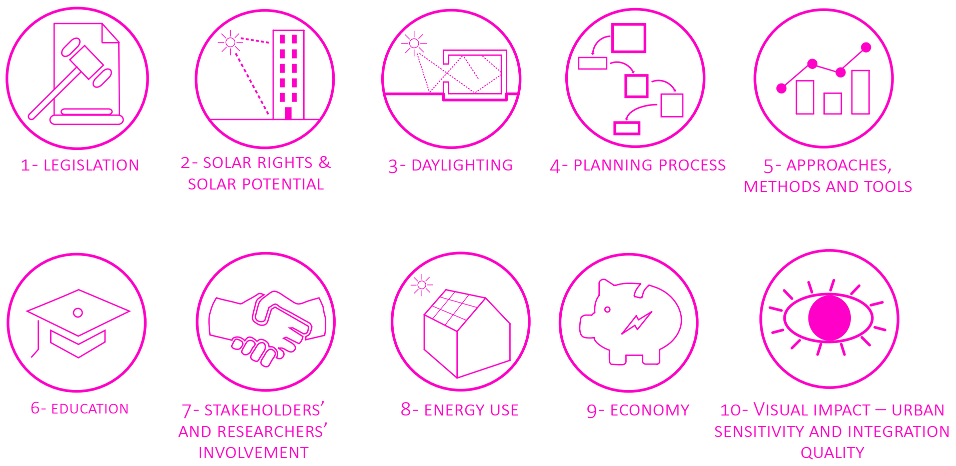
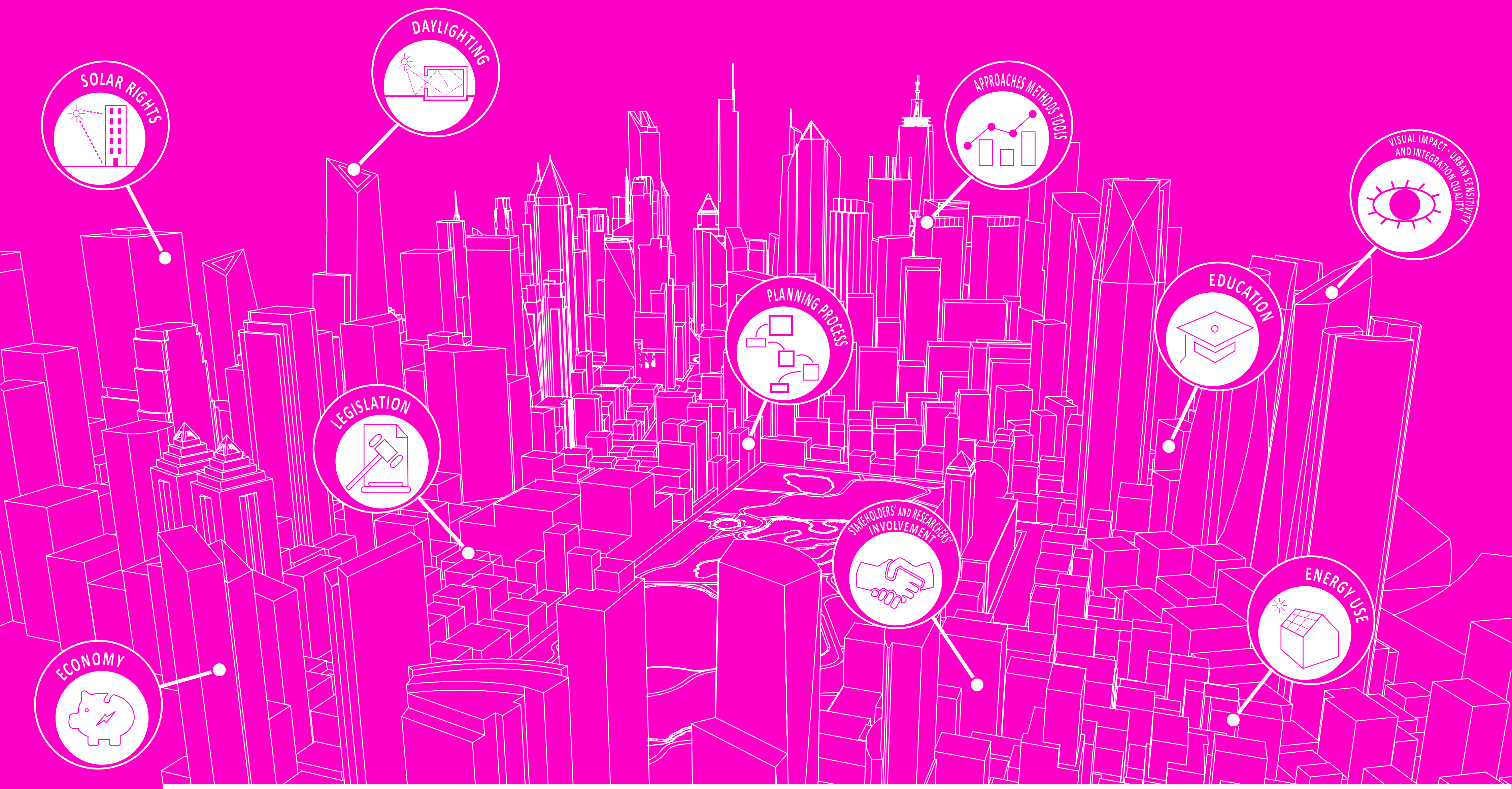


Figure 1 - The categories of the template of the lessons learnt.

The templates have been also developed in order to have links with the different Subtasks and other reports of Task 51. Specifically, the sections are illustrated in Figure 1. The sections "1- Legislation", "2- Solar rights & solar potential" and "3- Daylighting" are linked with the Subtask A *Legal framework, barriers and opportunities*, while the sections "4- Planning process" and "5- Approaches, methods and tools" are linked with the Subtask B *Approaches, Methods and Tools*, and finally the section "6- Education" is linked with the Subtask D *Education and dissemination*.



CATEGORIES of LESSONS LEARNT

Figure 2 - The categories of the lessons Learnt graphically presented in a typical complex urban environment

2.3 Definition of the categories of the lessons learnt

Figure 3 - The organization of the sections related to template of lessons learnt.

TEMPLATES of LESSONS LEARNT

Legislation

Legislation is an influencing factor as a facilitator and inhibitor for solar energy in urban planning.

While many case studies referred to legislation, it was particularly influential on the development of case studies in *Freiham Nord Munich*, Germany; *Lund Brunnshög* and *Hyllie* Malmö, *Frodeparken Uppsala*, Sweden; *Le Albere*, *Agrovoltaico*, Italy; *Agrinergie*, *Ravine Blanche*, *The sustainable city of Beausejour*, *Lyon Confluence*, France; *VerGe project Lugano-Paradiso*, Switzerland; *Sarnia Photovoltaic Power Plant*, Canada.

This section is linked with *Subtask A Legal framework, barriers and opportunities*.

2.4 Description of the categories of the lessons learnt

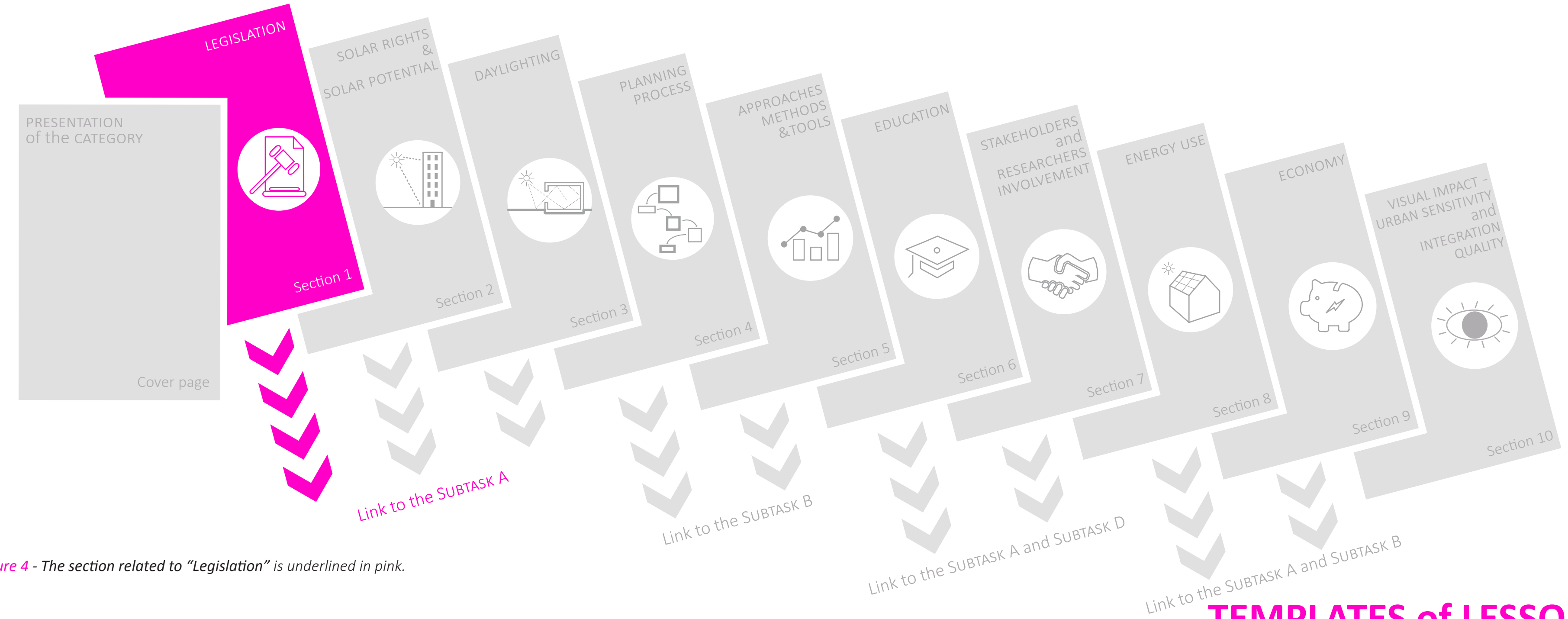


Figure 4 - The section related to "Legislation" is underlined in pink.

TEMPLATES of LESSONS LEARNT

Solar rights and solar potential

Solar rights and solar potential are influencing factors in the definition of urban standards such as distance between buildings, maximum height of the buildings, orientation and properties (i.e. color, albedo etc.) of finishing materials of the façades/roofs. These aspects should be taken into account in good practice in legislating in urban planning given that they could strongly affect the solar accessibility of a building or group of buildings and/or avoid complex shadowing effects which could reduce the potential of energy production from solar systems installed on the building's envelope. This happened for example in the case studies of *Frodeparken Uppsala* in Sweden and *Zero Emission Office Building* in Trondheim, Norway.

This section is linked with *Subtask A Legal framework, barriers and opportunities*.

2.4 Description of the categories

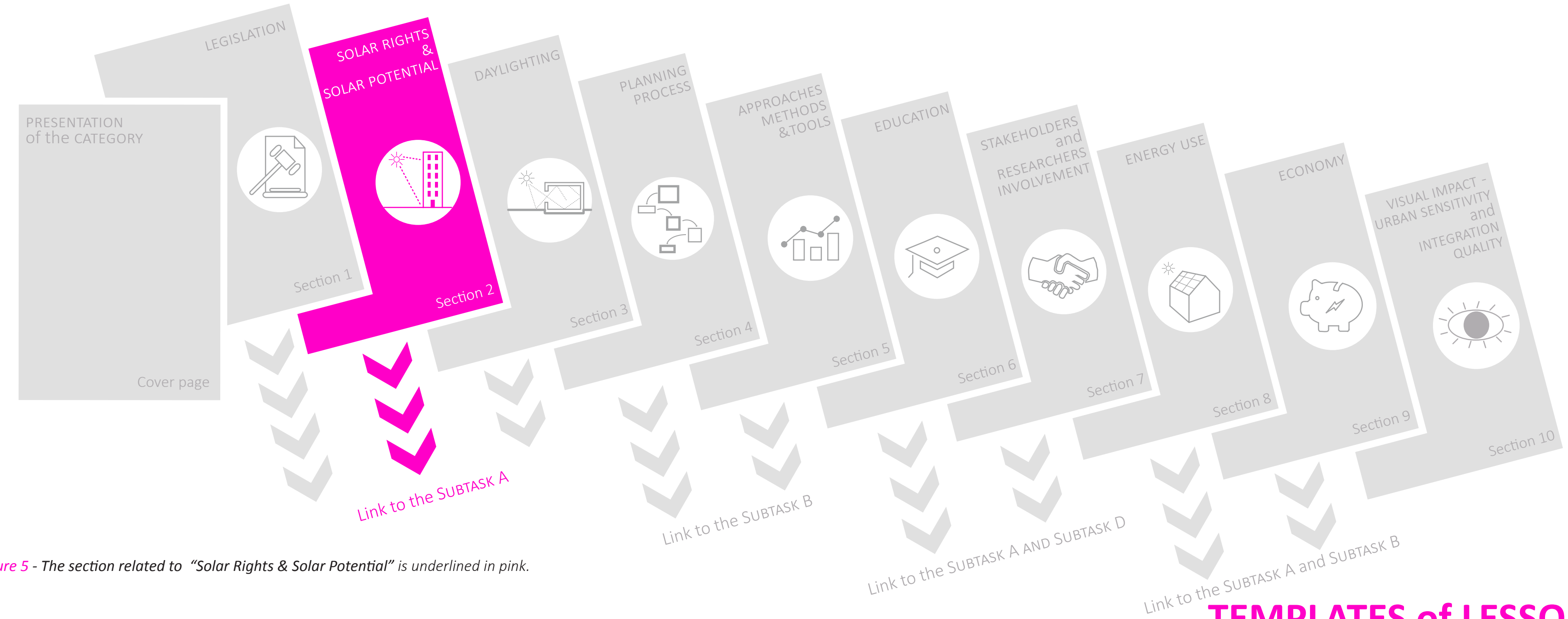


Figure 5 - The section related to "Solar Rights & Solar Potential" is underlined in pink.

TEMPLATES of LESSONS LEARNT

Daylighting

This section describes the lessons learnt from the case studies which during the design process have dealt with the challenge to guarantee solar accessibility and the level of outdoor and indoor illuminance (i.e. Daylighting)

In fact, especially in a complex urban environment, a main challenge is to optimize the minimum level of illuminance in the different inner spaces of the buildings. In that regard, each space has to gain indoor visual comfort according to the specific activity of the users. In the case study of *FredericiaC* in Denmark, specific daylight analyses have been done during the definition of the masterplan.

This section is linked with *Subtask A Legal framework, barriers and opportunities*.

2.4 Description of the categories

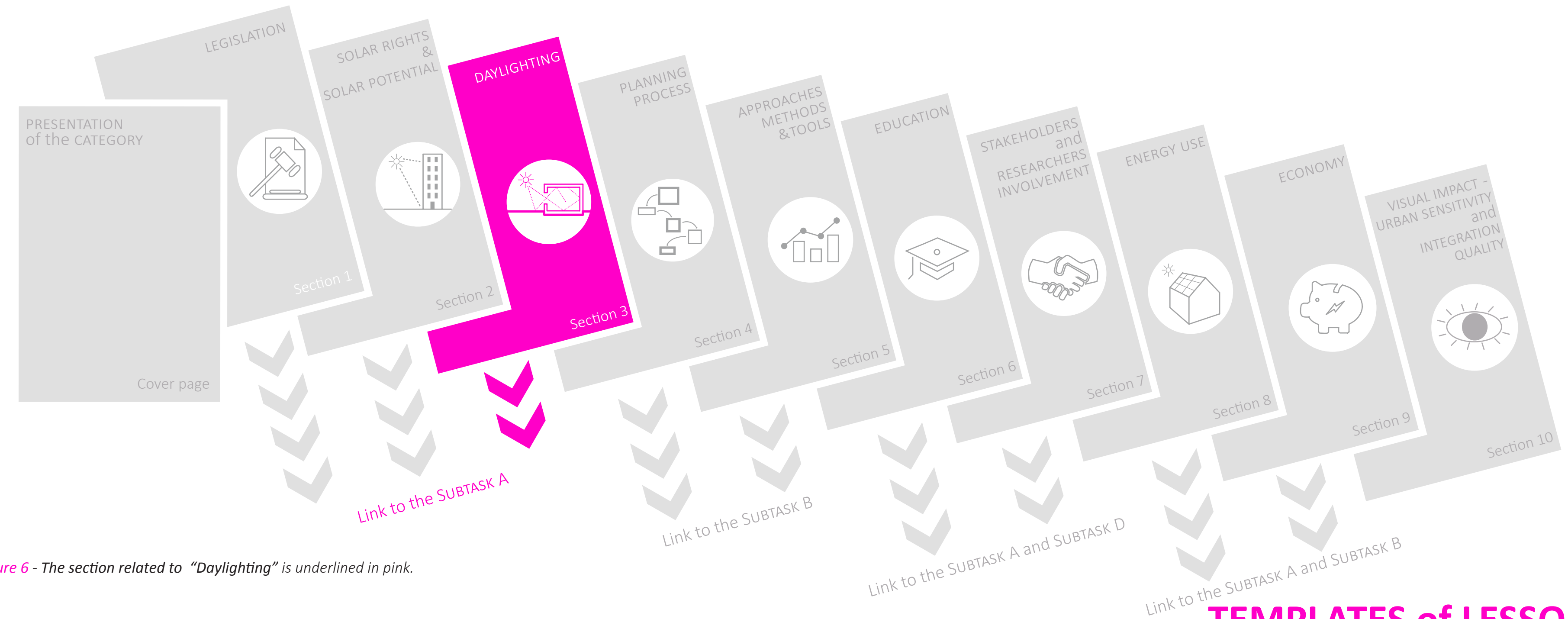


Figure 6 - The section related to "Daylighting" is underlined in pink.

TEMPLATES of LESSONS LEARNT

Planning process

The most positive and negative practices and actions related to the spatial and time scales and stages of urban and landscape planning, barriers and delays in the planning process given by local limitations or bureaucracy have been carried out.

Case studies highlight that the planning process for solar energy is complex with consideration on how solar energy can contribute to the development of the area as well as work within the borders of an allocated area where options for design might be limited. Case studies where the planning process was particularly relevant was illustrated in *Solar District Heating Brædstrup, FredericiaC*, *Gehry City Harbor in Sønderborg* in Denmark; *Lund Brunnshög*, *Malmö Hyllie* in Sweden; and P*hotovoltaic Village in Alessandria*, Italy.

This section is linked with *Subtask B Approaches, Methods and Tools.*

2.4 Description of the categories

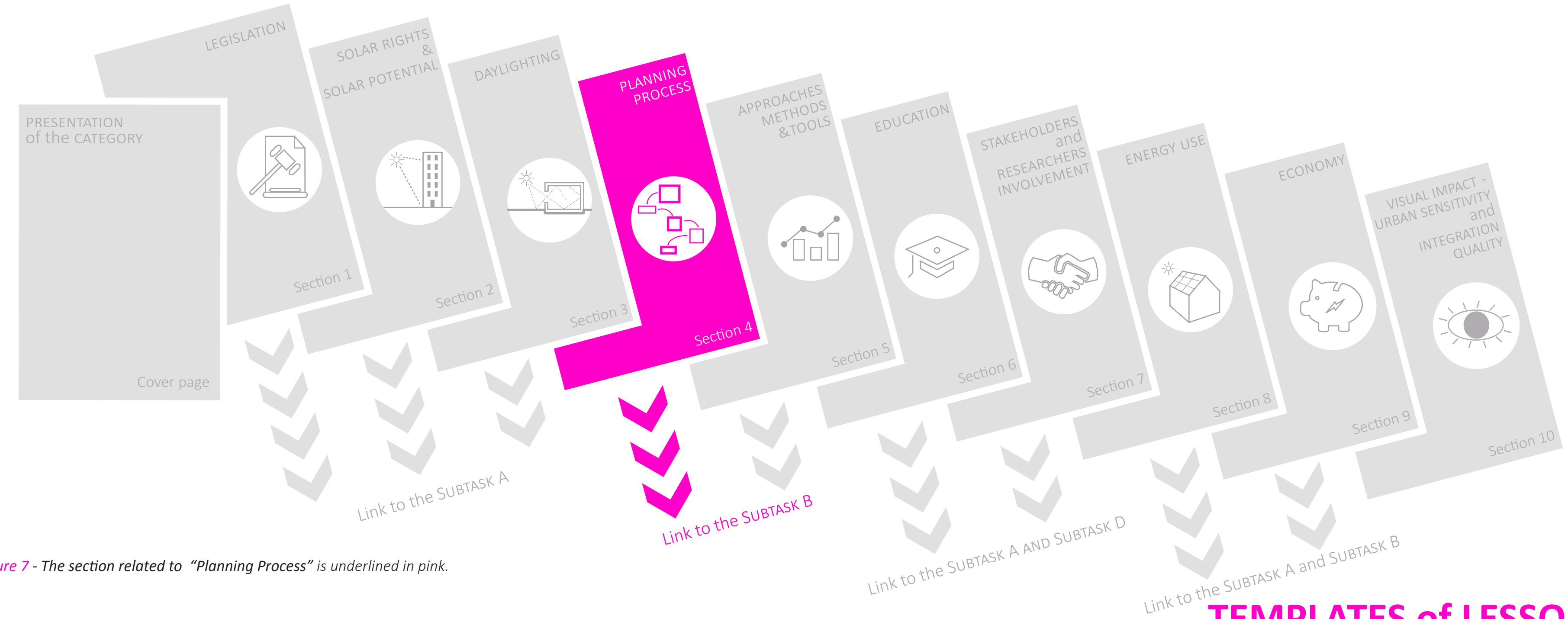


Figure 7 - The section related to "Planning Process" is underlined in pink.

TEMPLATES of LESSONS LEARNT

Approaches, methods and tools

This section presents the lessons learnt during the different phases of the planning process in the following ways:

- 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;
- 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.

The section focuses mainly on the use of approaches, methods and tools in the case studies, such as *aspern+ Die Seestadt Wiens* and *Stadtwerk Lehen* in Austria, and *Residential Plot B45* in China.

This section is linked with *Subtask B Approaches, Methods and Tools.*

2.4 Description of the categories

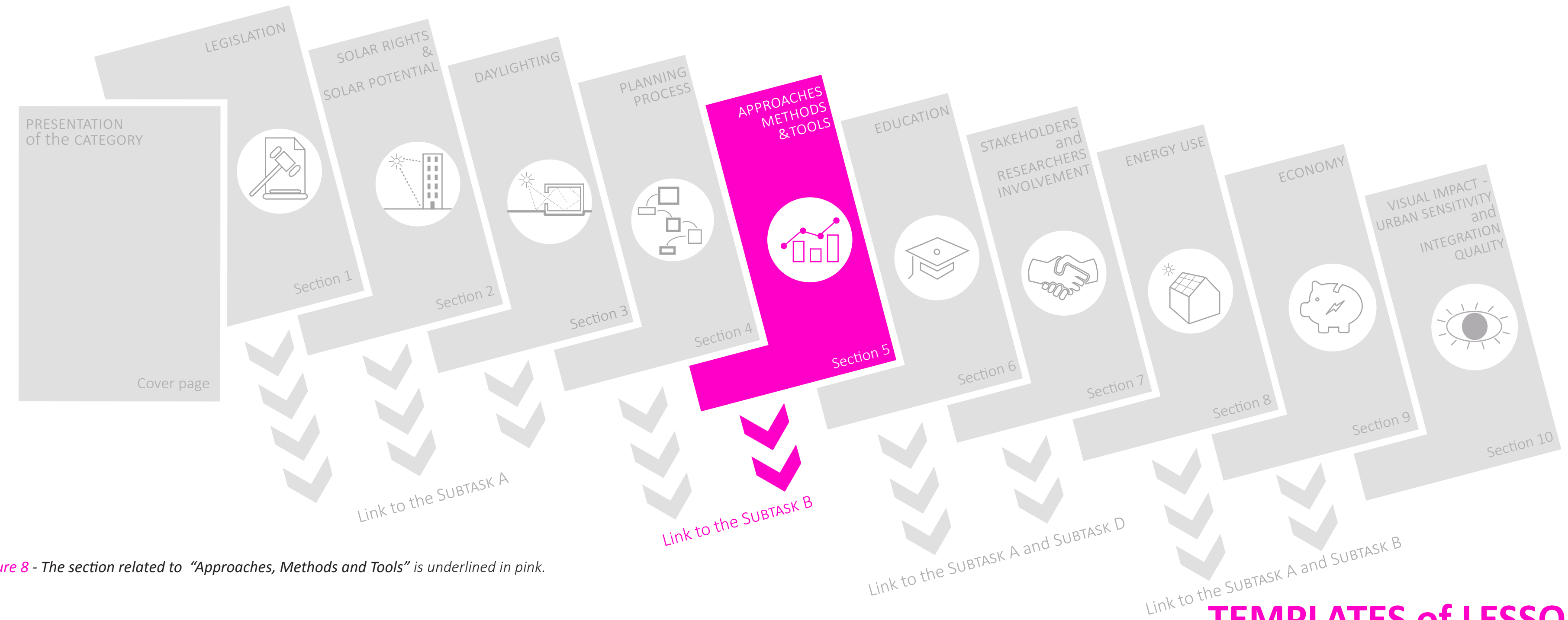


Figure 8 - The section related to "Approaches, Methods and Tools" is underlined in pink.

Education

Education was considered important in ensuring that professionals of urban planning have the knowledge and skill to consider solar as an option as a renewable energy solution in an area in development.

The role of education is particularly emphasized in the case studies of *Øvre Rotvoll* in Norway, while the case study of *Lyon Confluence* in France illustrated the need to raise awareness of solar energy in education.

This section is linked with *Subtask D Education and dissemination.*

2.4 Description of the categories

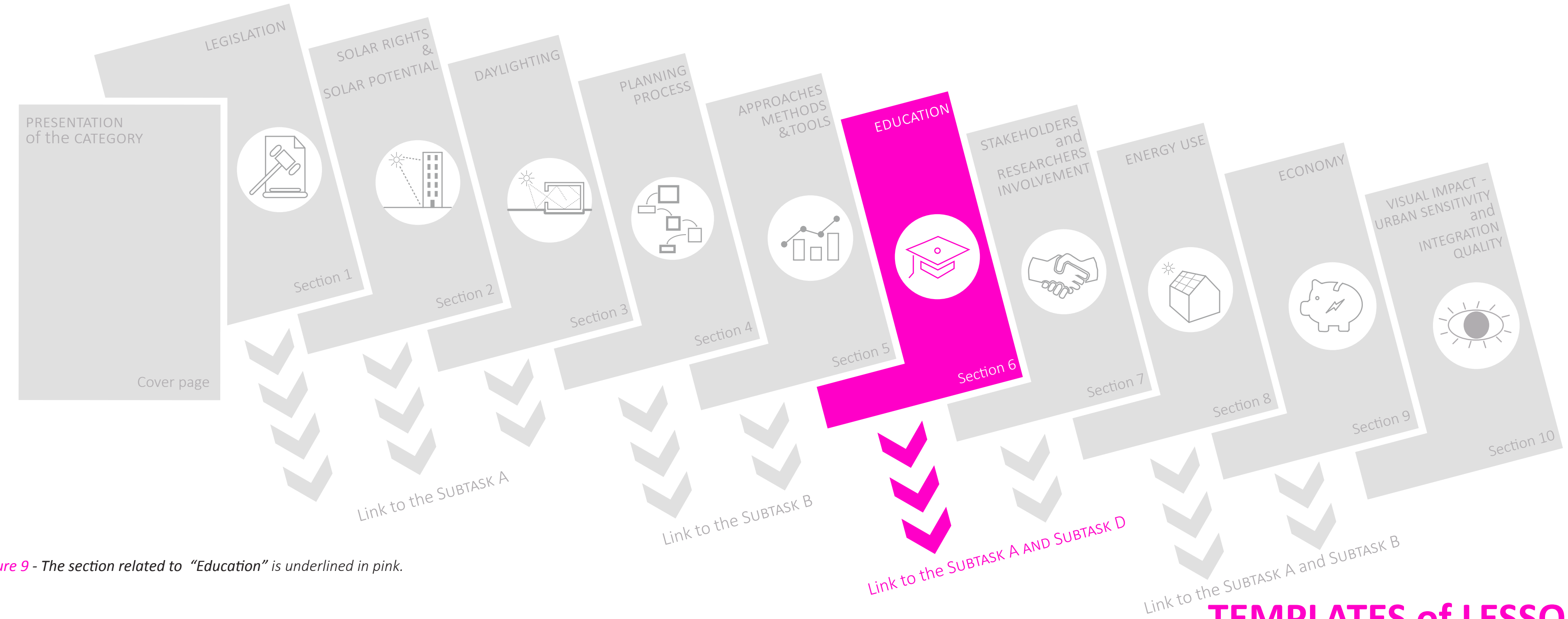


Figure 9 - The section related to "Education" is underlined in pink.

Stakeholders' and researchers' involvement

This section underlines the influencial role of the involved stakeholders and researchers in the most relevant decisions taken during the planning process and how and when they have been involved.

Stakeholders and researchers steered development and potential of solar energy in urban areas. This was particularly emphasized in the case studies of *aspern+ Die Seestadt Wiens*, *Stadtwerk Lehen*, *Graz Reininghaus*, Austria; *FredericiaC* and *Gehry City Harbour in Sonderborg* in Denmark; *Residential Plot B45* in China; *Eco Neighborhood of Ravine Blanche* in France; *Dale* in Norway; *VerGe project Lugano-Paradiso* in Switzerland.

2.4 Description of the categories

Figure 10 - The section related to "Stakeholders' and researchers' involvement" is underlined in pink.

TEMPLATES of LESSONS LEARNT

Energy use

The section highlights relevant energy solar strategies (active, passive or both) or initiatives to implement solar energy approaches (incentives, regional investments etc.). In addition, significantly beneficial energy concepts and solar technologies (specifically photovoltaic, solar thermal and solar gains) to energy use are illustrated through case studies.

For example, in the case studies of *Solar in Halifax Regional Municipality* in Canada and in *Energy Innovation Solar Purchase Group* in Switzerland municipal and public initiatives have substantially increased the number of installations of solar power system as well as the energy production.

This section is linked with *Subtask A Legal framework, barriers and opportunities*. and *Subtask B Approaches, Methods and Tools.*

2.4 Description of the categories

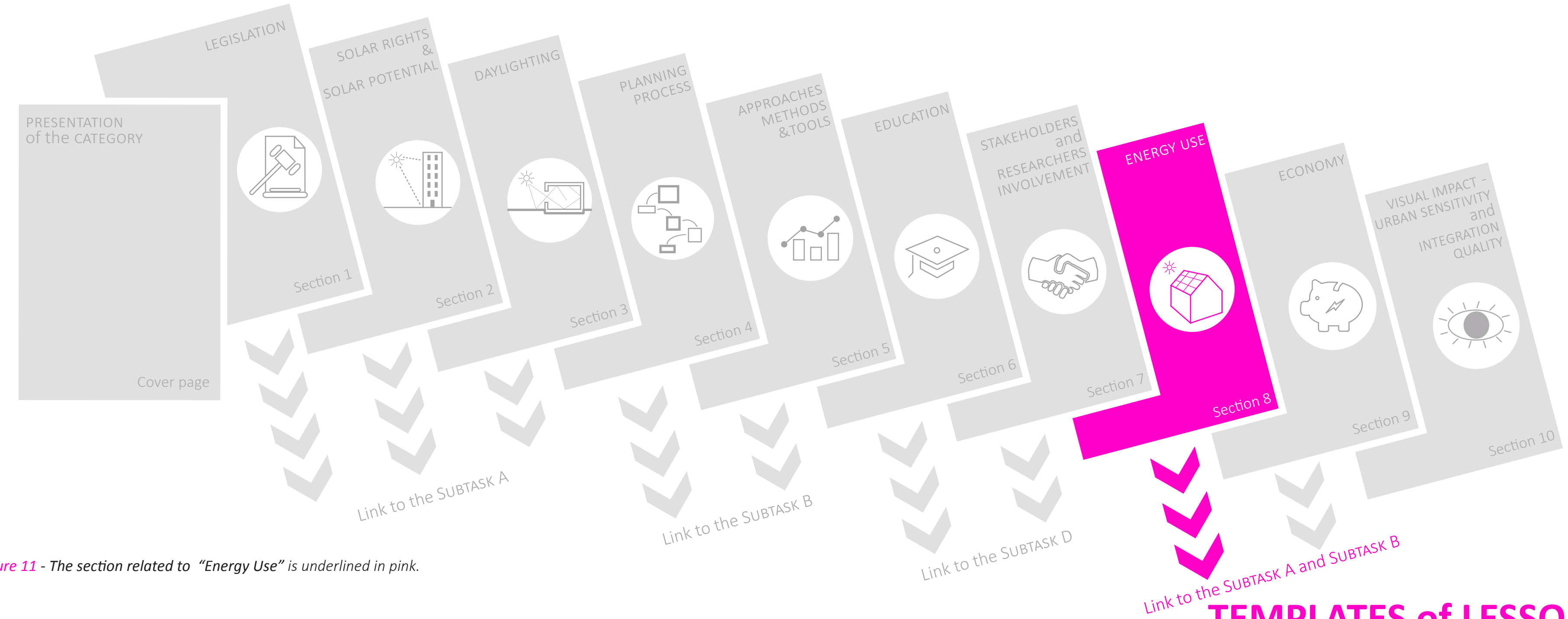


Figure 11 - The section related to "Energy Use" is underlined in pink.

TEMPLATES of LESSONS LEARNT

Economy

The role of economy influences the type of solar energy that can be achieved depending on how much a budget a municipality/building owner has available and the local strategy e.g. *Energy Innovation Solar Purchase Group* in Switzerland.

Economy was influential in many case studies but particularly in the case studies of *Freiham Nord Munich* in Germany; *aspern+ Die Seestadt Wiens* in Austria; *Violino district in Brescia*, Italy; *Solar in Halifax Regional Municipality* in Canada; *Dale* in Norway; *Sarnia Photovoltaic Power Plant,* Canada; *Solar District Heating Brædstrup*, Denmark; *Agrovoltaico*, Italy and *Agrinergie 5*, La Reunion Island.

2.4 Description of the categories

Figure 12 - The section related to "Economy" is underlined in pink.

TEMPLATES of LESSONS LEARNT

VISUAL IMPACT – URBAN SENSITIVITY AND INTEGRATION QUALITY

The last section is related to “Visual impact – urban sensitivity and integration quality”.

As shown by the analyzed case studies (e.g. *Violino District in Brescia* (Italy), *Verge project Lugano Pardiso* (Switzerland), *The Photovoltaic Village in Alessandria* (Italy), *London Solar Community Ontario* (Canada), Le Albere (Italy) and the *Science and Technology park in Berlin Adlershof* (Germany)) the increased use of solar collectors in buildings is necessary but poses major challenges in existing built environments, especially where architectural quality is an issue. The large size of solar systems at the building scale requires careful planning, as they may easily end up compromising the aesthetics of buildings, threatening the identity of entire areas.

In this context, the impact of solar systems on urban environments has been analysed with LESO-QSV, a new method developed at EPFL.

2.4 Description of the categories

Figure 13 - The section related to “Architectural visibility, sensitivity and quality” is underlined in pink.

TEMPLATES of LESSONS LEARNT

2.5 Definition of the target groups

In each section the lessons learnt are numbered in crescent order. The number of each lesson learnt is reported on the related case studies and target groups.

The main target groups have been grouped in four specific categories:

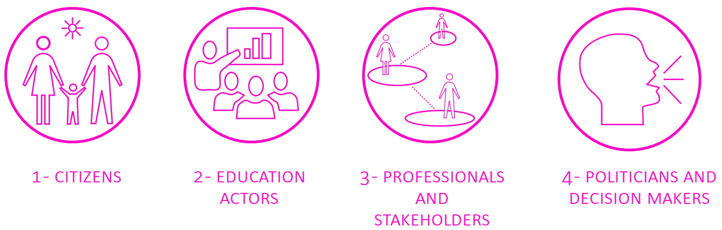
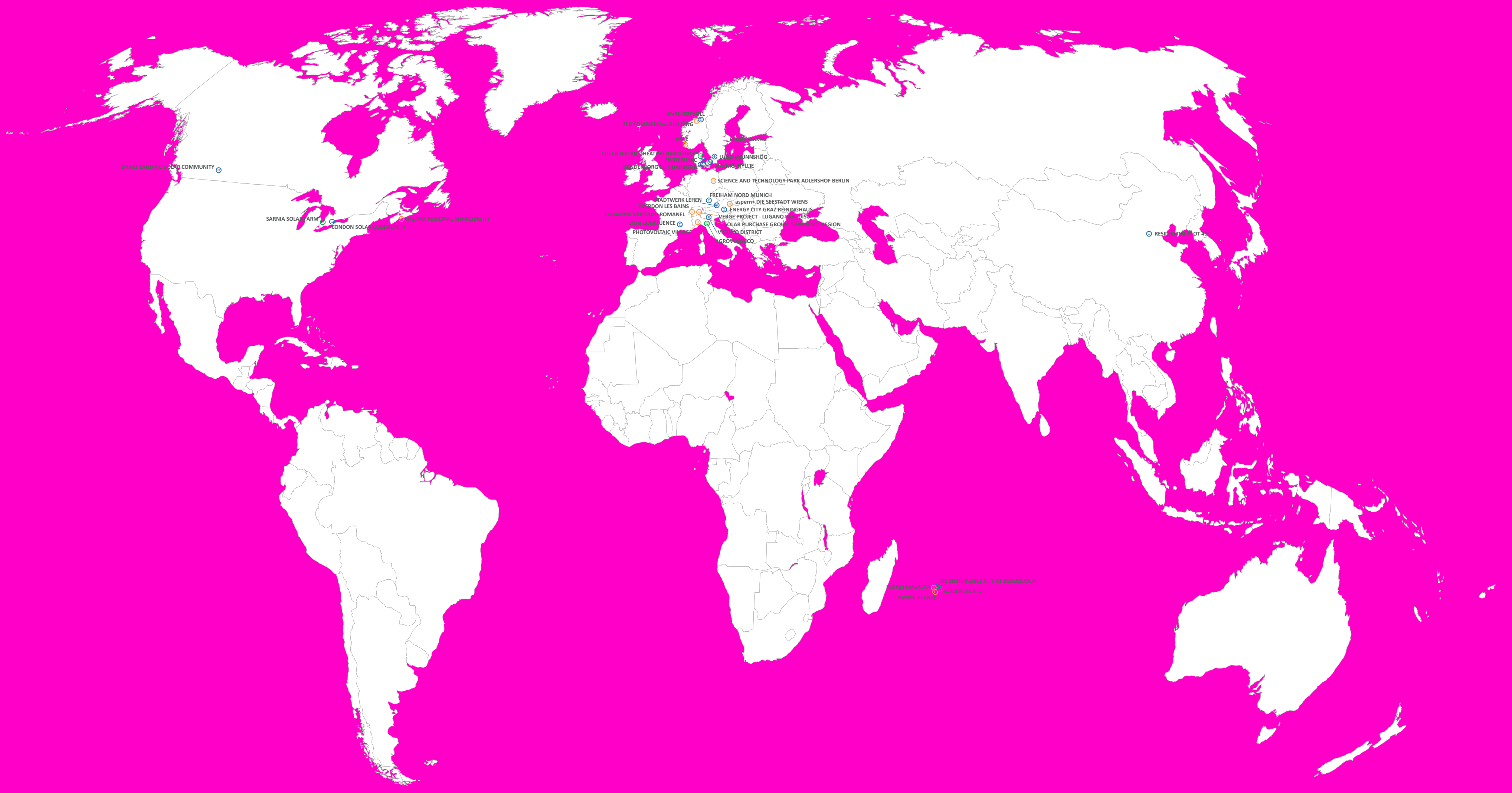


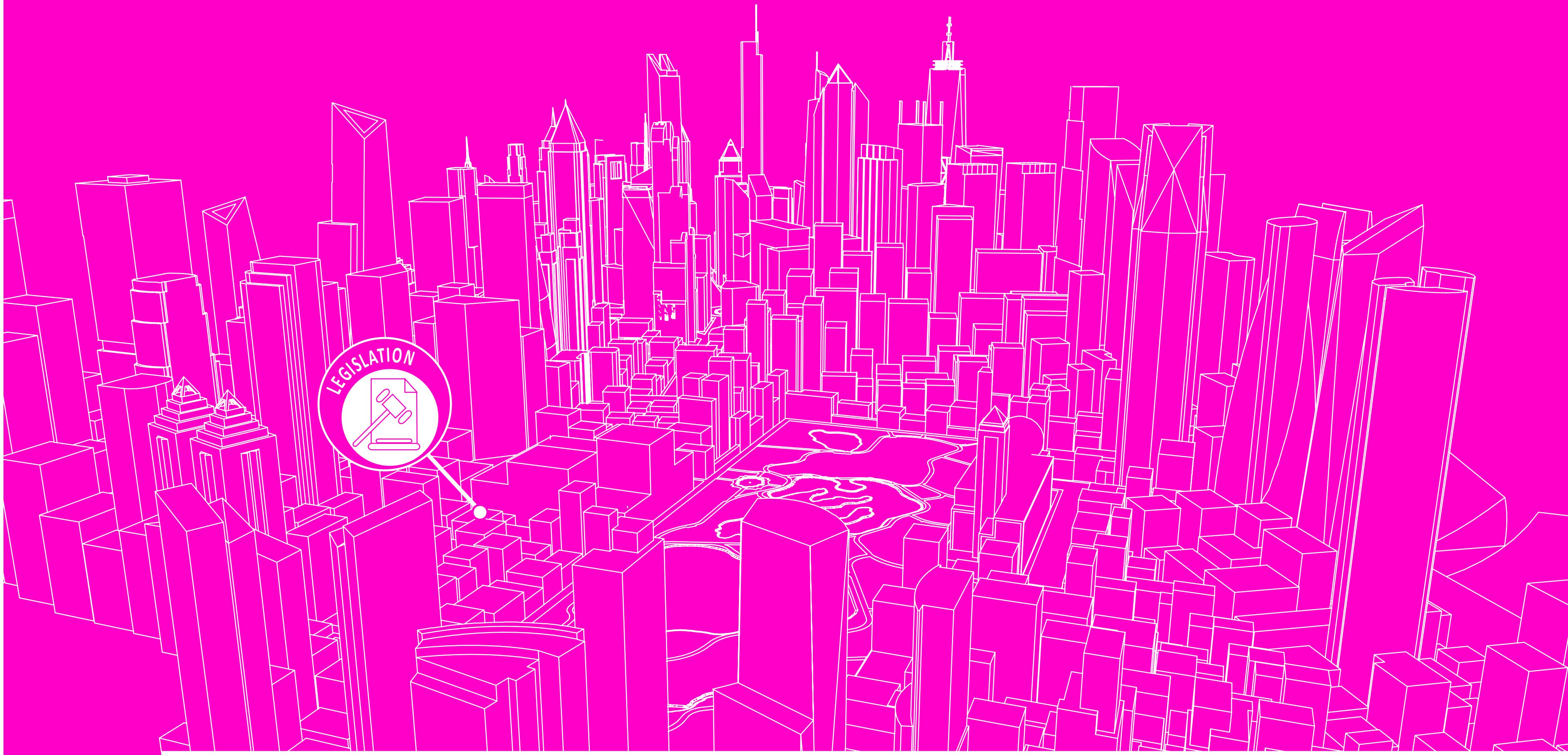
Figure 14 - The categories of the target groups.

3 LESSONS LEARNT FROM THE 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 LEGISLATION



3.1 LESSONS LEARNT IN LEGISLATION

Legislation does not develop solar energy initiatives but can provide drivers to encourage its use in urban planning. Similarly, legislation can also restrict the implementation of solar energy within an urban environment. Legislation played a key influential role in many of the case studies but also there were indications that legislation could go further to incentivize solar energy in urban planning.

NEW URBAN AREAS

The lessons learnt for *legislation* from the case studies of new urban areas are:

1 CONFLICTING ROLE OF LEGISLATION IN SUPPORTING SOLAR ENERGY IN URBAN PLANNING

Several case studies illustrate the conflicting role of legislation, which is both supportive of solar energy in urban planning and contradictory. For example in Germany, the aim of the City of Munich to build the new district Freiham with high sustainability standards is linked to a series of trade-offs and conflicting goals. The reason for this is associated with a local ecological criteria agreed with the municipal energy supply company. This agreement stipulates CO_2 emissions toward climate neutrality by 2050. The stipulation includes a minimum building energy standard, efficient HVAC systems, low energy construction material etc. However, the local high ground water level means that all building roofs must be flat. All of this restricts solar system solutions.

2 TECHNICAL TOOL FOR MANAGING POLITICAL DECISIONS TO IMPLEMENT SOLAR ENERGY

A more technical solution for managing political decisions to implement solar energy in new buildings is a tool called SAFAR, illustrated in the Swedish case studies of *Lund Brunnshög* and *Malmö Hyllie*. This development has led to a focus on both voluntary initiatives, (like BREEAM which includes solar energy), but also to a search for instruments which fit into the legal framework that local administrations currently have.

3 ROLE OF LEGISLATION TO SET TARGETS FOR RENEWABLE ENERGY

The Italian case study of Le Albere demonstrates the role of national legislation on energy planning which sets targets for renewable energy production by 2020 without defining any specific target with regard to the implementation of solar energy. 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.

1 **FREIHAM NORD MUNICH** GERMANY

2 **LUND BRUNNSHÖG** SWEDEN

2 **MALMÖ HYLLIE** SWEDEN

3 **LE ALBERE** ITALY

TARGET GROUPS

2

1 2 3

NEW URBAN AREAS

The lessons learnt for *legislation* from the case studies of new urban areas are:

4 THE INFLUENCE OF LOCAL POLITICAL COMMITMENT TO SUSTAINABLE DEVELOPMENT, SOCIAL INVOLVEMENT AND PUBLIC/PRIVATE PARTNERSHIP

The French case study of *Lyon Confluence* demonstrates that a strong local political commitment to sustainable development, social involvement, and public/private partnership can lead to high energy performance and replicable urban regeneration projects in two large cities of contrasting character. Recommendations from this study is that legislation should be available to adopt a range of consistent measures for simplification and clarification of solar energy legal and administrative framework, especially solar BIPV.

4 LYON CONFLUENCE FRANCE

5 URBAN PLANNING REGULATION AS INSTRUMENT FOR SOCIAL INVOLVEMENT

In France, the case study of *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 the units are subsidized public housing with high architectural quality. The developer contractor initiated an original approach for advocacy planning in which the residents were incorporated in the planning process in a participatory way. A crucial aspect for the urbanization of an ecological sensible site is the resident's enthusiasm and openness to agreement of an eco-citizen project. Amenities (schools, sports complexes, health and community centre, post office, car park silo, etc.) and services (welfare office, police station, urban park etc.) are part of the project and provide all facilities on the scale of the catchment area while bringing economic activity.

THE SUSTAINABLE CITY OF BEAUSÉJOUR - FRANCE 5

TARGET GROUPS 5 4

EXISTING URBAN AREAS

The lessons learnt for *legislation* from the case studies of existing urban areas are:

6 *LEGISLATION REQUIREMENTS FOR ENERGY TARGETS*

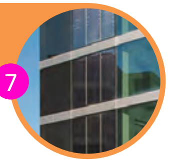
The case study of *Eco Neighborhood of Ravine Blance* illustrates how in accordance with French legislation requirements, the Regional Plan for Climate, Air & Energy of Reunion Island has a set of five major quantitative targets that comprises to achieve self-sufficiency in 2030 and to provide 50 - 60% of homes with solar-powered hot water.

6 THE ECO NEIGHBORHOOD OF RAVINE BLANCHE - FRANCE

7 *URBAN DENSIFICATION VS SOLAR AVAILABILITY*

Verge project - Lugano Paradiso case study in Switzerland illustrates how urban densification policies influence the energy demand, the solar availability of existing buildings and the heritage protection of buildings. Local development regulations can support measures enabling better exploitation of solar and daylighting resources.

VERGE PROJECT LUGANO PARADISO - SWITZERLAND 7



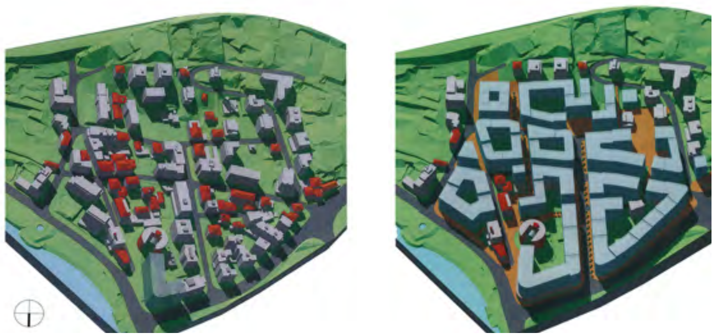


Figure 14 - Current status (left) and new status (right) when New Master Plan will be implemented. Source: © Planidea SA and Lugano Paradiso Municipality City Center area of Paradiso)

TARGET GROUPS

6 7

LANDSCAPE

The lessons learnt for *legislation* from the case studies of landscape are:

8 ***HOW TO OVERCOME RESTRICTIONS IN LEGISLATION WITH SOLAR SOLUTIONS***

Landscape solar projects have offered creative opportunities to overcome restrictive legislation. The dual use of land for food production and solar energy in *Agrovoltaico*, Italy, and *Agrinergie*, Reunion Island, illustrated how restrictions of legislation can be overcome to implement ground mounted PV set by local governments.

9 ***LOCAL GOVERNMENT TO INCENTIVIZE THE USE OF SOLAR***

Incentives set by local government encourage the use of solar by developers. In Canada, the use of a Feed in Tariff in *Sarnia Photovoltaic Power Plant* launched by Ontario Power Authority in order to stimulate smaller distribution connected projects (≤ 10MW) resulted in high ambitions for developers in their projects to qualify for the lucrative price of $420/MWh for a 20 year long contract.

Figure 15 - Aerial view of the Sarnia Solar Project (Photo: © Daniel J Bellyk)

AGRINERGIE 5
FRANCE
8

8
AGROVOLTAICO
ITALY

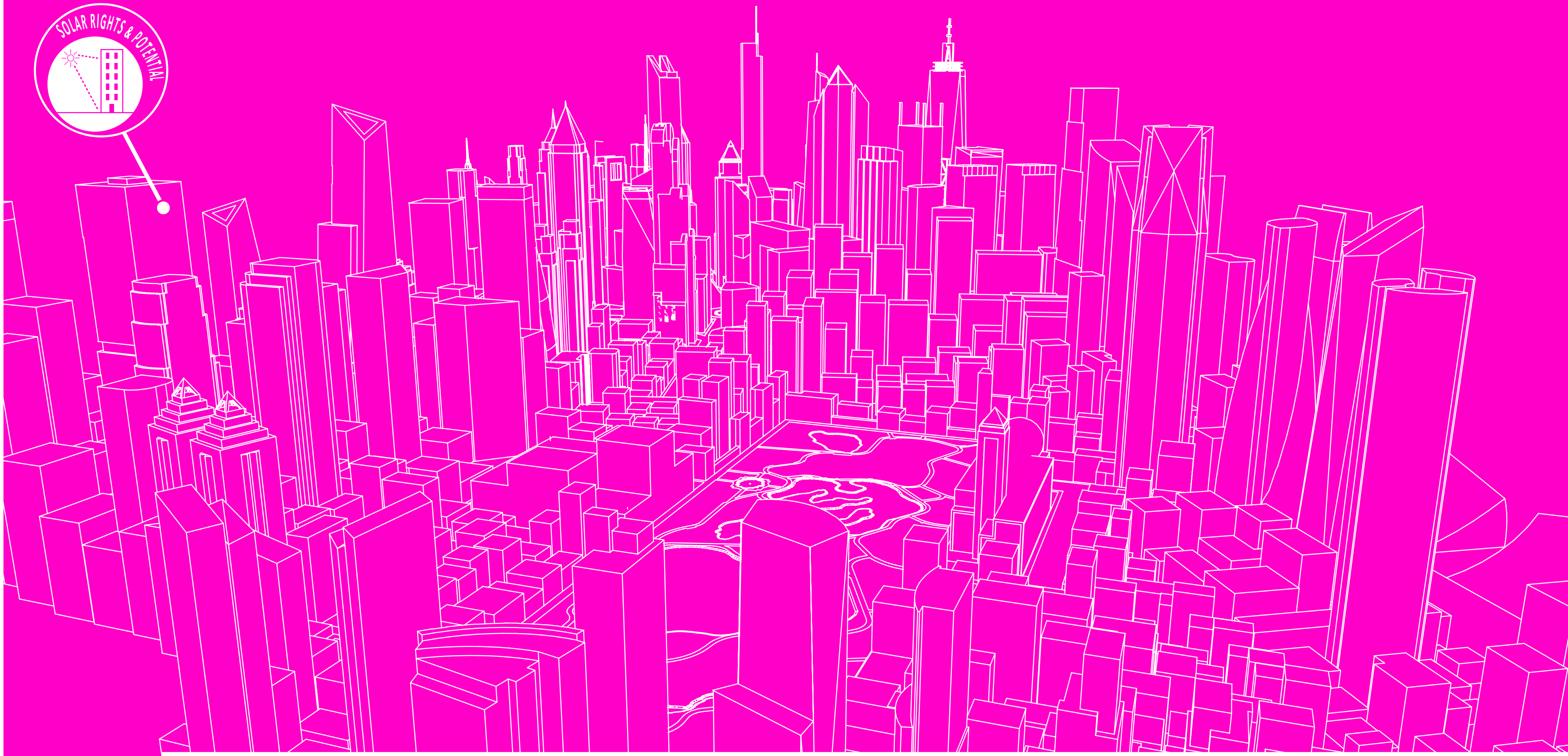
9
SARNIA PHOTOVOLTAIC POWER PLANT - CANADA

TARGET GROUPS

8 9

8 9

3.2 SOLAR RIGHTS and SOLAR POTENTIAL



3.2 LESSONS LEARNT IN SOLAR RIGHTS AND SOLAR POTENTIAL

Buildings in an urban environment have challenges to gain access to solar energy due to the overshadowing effects of surrounding buildings and such an issue needs to be considered at an early point of urban planning.

NEW URBAN AREAS

The lessons learnt for *solar rights and solar potential* from the case studies of new urban areas are:

VIOLINO DISTRICT IN BRESCIA
ITALY

1 *IMPORTANCE OF PRELIMINARY STUDY TO PRESERVE SOLAR ACCESSIBILITY AND SOLAR POTENTIAL OF BUILDINGS*

The analysis in *Violino District in Brescia*, Italy, proposes technological solutions of measurable qualities (e.g. solar accessbility, daylight level etc.).
Planning of urban development models through affiliated procedures have been applied as the principle of right to light in the design process to each residential unit. In the early design phases of the design process, a color plan was developed to set colors of finishing materials for the façades.

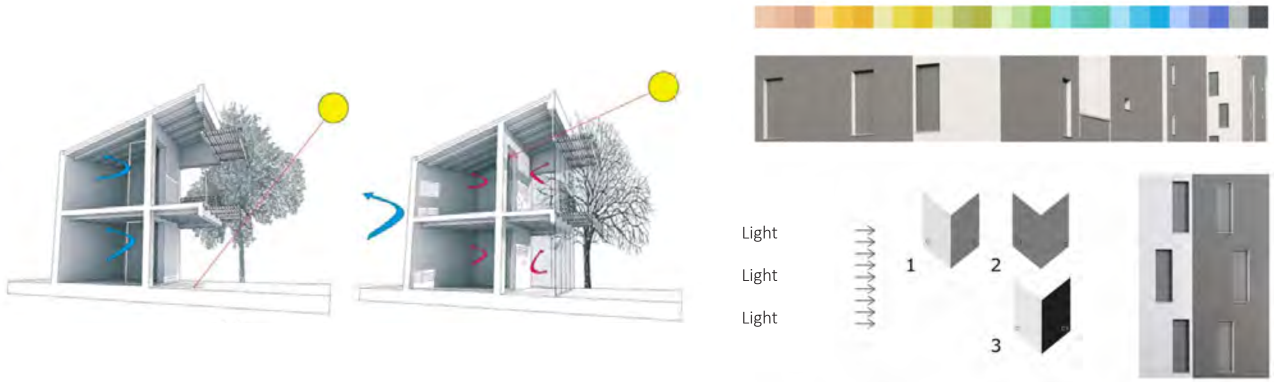


Figure 16 - (Left) Section of the terraced house for solar and ventilation analysis. (Right) Color plan by Jorrit Tornquist. (Source: © Boschi + Serboli architetti associati).

TARGET GROUPS

EXISTING URBAN AREAS

The lessons learnt for *solar rights and solar potential* from the case studies of existing urban areas are:

2

IMPORTANCE OF PRELIMINARY ANALYSES TO ASSESS SOLAR ACCESSIBILITY AND SOLAR POTENTIAL OF BUILDINGS AND AVOID COMPLEX SHADOWING EFFECT

Tools used in *Uppsala Frodeparken*, Sweden and *Zero Emission Office Building*, Norway showed the shadowing effects of planned new buildings on recently built or approved planned buildings. Studies on shadowing effects showed a potential reduction of electricity production in *Frodeparken* by nearly 10% and in Trondheim by more than 45%. The studies highlight how the importance of assessing solar potential in early design stages through the planning process to understand the consequences of shading from surrounding buildings.

UPPSALA FRODEPARKEN
SWEDEN
2

2
ZERO EMISSION OFFICE BUILDING - NORWAY

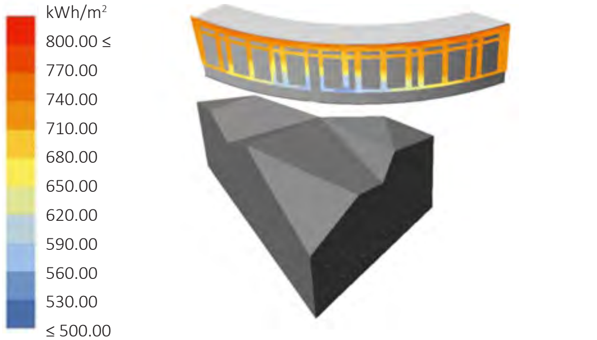


Figure 17 - Screenshot from simulation in Rhino/Grasshopper environment: the solar radiation on the Uppsala Frodeparken resulted to be affected by shadowing on the bottom due to the presence of the Juvelen building in front of it.

Figure 18 - A view of PV system installed on the South façade that resulted partly covered by the shadowing. (Photo: © Carmel Lindkvist)

TARGET GROUPS

2 2 2

3.3 DAYLIGHTING

3.3 LESSONS LEARNT IN DAYLIGHTING

Buildings in an complex urban environment have challenges to guarantee an adequate level of solar accessibility in order to gain indoor visual comfort with good level of daylighting.

NEW URBAN AREAS

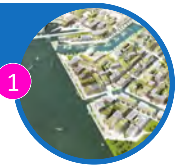
The lessons learnt for *daylighting* from the case studies of new urban areas are:

1

OPTIMIZE DAYLIGHT REQUIREMENTS FOR ANY SPECIFIC DESTINATION OF USE

In *FredericiaC,* Denmark, daylight analyses using the Window to Wall Ratio factor (WWR) have been conducted in order to identify whether it would be possible to achieve good daylight conditions for the actual plan. The key findings ensured that the daylight conditions for the various buildings (offices, apartments, houses, retail etc.) would meet all the daylight requirements for the respective buildings.

FREDERICIAC
DENMARK



Very good daylight conditions, achieved with 30% glass on the Façade
Very good daylight conditions, achieved with 50% glass on the Façade
Special measures needed to achieve good daylight conditions
Poor daylight conditions. Not possible to achieve a daylight factor of 2%

Figure 19 - Daylight levels on façades in the final development plan. (Source: © DEM & Esbensen A/S).

TARGET GROUPS

1

1

NEW and EXISTING URBAN AREAS

The lessons learnt for *daylighting* from the case studies of new and existing urban areas are:

2

EFFECTIVENESS OF DAYLIGHT ANALYSES IN THE EARLY DESIGN STAGE

The case studies from Switzerland (*Yverdon-les-Bains* and *Romanel-sur-Lausanne*) showed how simulation tools can help improve the solar energy and daylight performance from the early design stage. They also showed how some typical design objectives are conflicting (e.g. daylight and built density), making a necessary trade-off between them.

ROMANEL-SUR-LAUSANNE
SWITZERLAND

YVERDON-LES-BAINS
SWITZERLAND

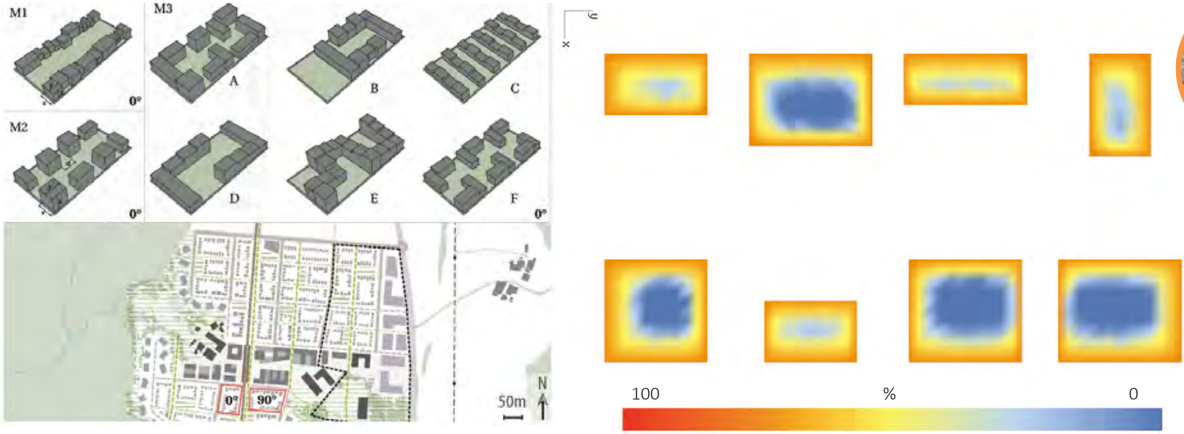


Figure 20 - Case study of Romanel-sur-Lausanne: (Left) Example plots (framed in red) on which the design variants created from M1 and M2 and the specific M3 designs (top) could be located. (Right) Daylight autonomy map for a design variant of type M2 assessed in the study. (Author: © Emilie Nault)

TARGET GROUPS

EXISTING URBAN AREAS

The lessons learnt for *daylighting* from the case studies of existing urban areas are:

2

EFFECTIVENESS OF DAYLIGHT ANALYSES IN THE EARLY DESIGN STAGE

SINFONIA
ITALY

In the case study of Sinfonia in Italy, daylight analyses tested different configurations providing indications for visible light transmission of the window (Tvis) and solar reflectance of finishing materials (Refl) in order to guarantee the minimum mean daylight factor (MDF ≥ 2 %) and to comply with legislation. The use of daylight analysis enables the investigation of mean daylight factor (MDF), which defines the daylight levels inside apartments.

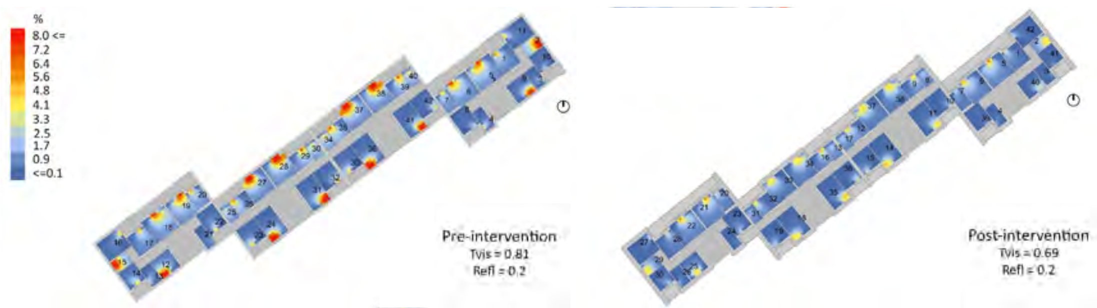
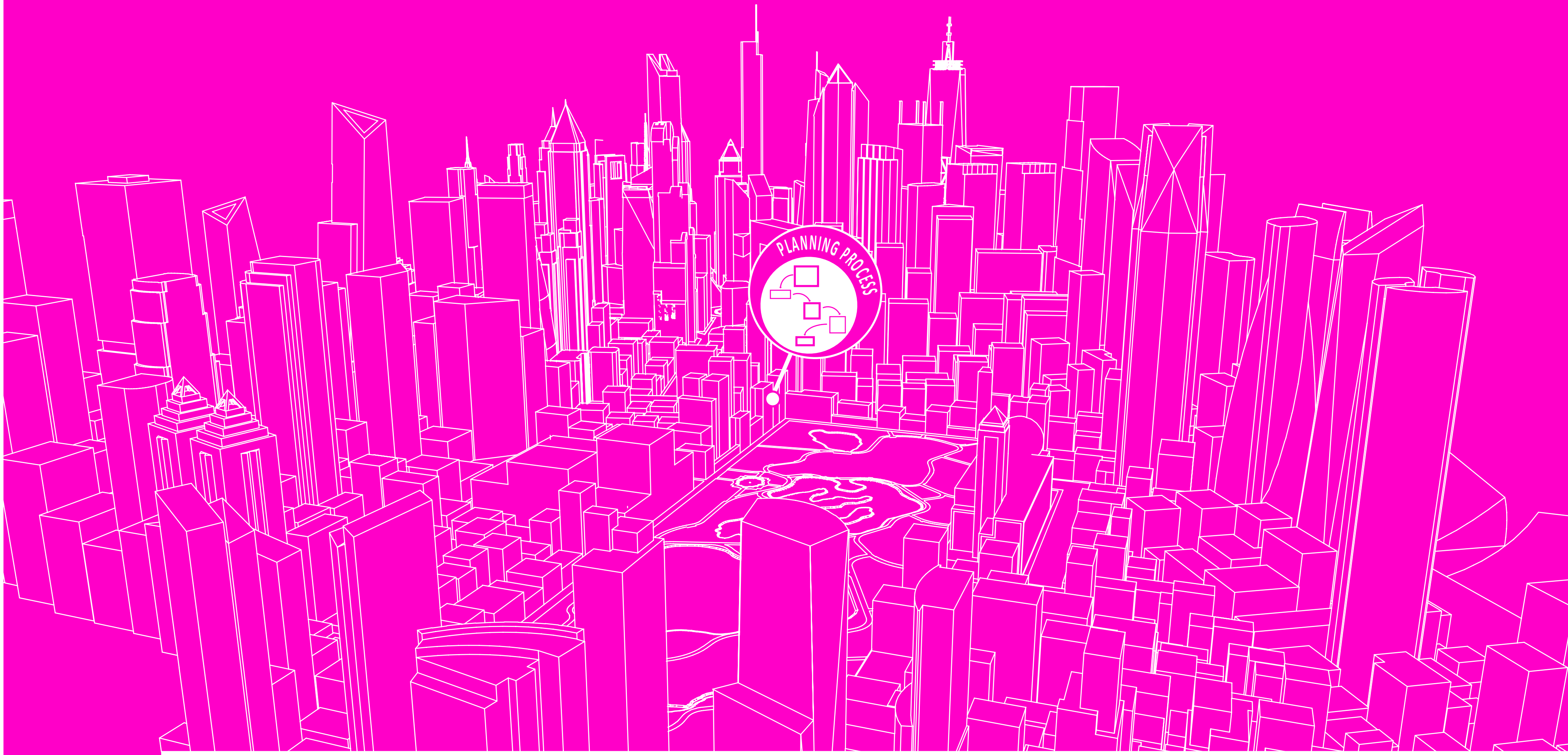


Figure 21 - Daylight analysis for the first floor of the Building South. Tvis: visible light transmission of the windows - Refl: reflectance value of the finishing materials of the loggia´s floor and window sills. (Source: © Eurac Research)

TARGET GROUPS

3.4 PLANNING PROCESS



3.4 LESSONS LEARNT IN THE PLANNING PROCESS

In order to exploit solar energy in the planning of an urban environment, two important steps are the assessment of solar potential and the evaluation of the use of solar design principles. This examination should include local conditions and context; in particular the scale of the area, options for design layouts and technical knowledge.

NEW URBAN AREAS

The lessons learnt for the *planning process* from the case studies of new urban areas are:

1 TIMELINE AND BUREAUCRACY FOR INTEGRATING SOLAR ENERGY INTO THE PLANING PROCESS

The Danish case studies of *FredericiaC* and *Gehry City Harbor in Sønderborg* and the Swedish case studies, *Lund Brunnshög* and *Malmö Hyllie* are examples which illustrate that the initial step to evaluate solar energy in an urban environment is to consider the potential of how solar energy contributes to the area. The next step is to ensure how solar potential is transferred into the physical installation of solar energy systems. This requires design solar experts. These studies also show that routines built into the planning process ease the development of solar energy in an urban environment but due to the involvement of many different departments of city administration, the process becomes slow.

Figure 22 - (on the left) PV-panels implemented on roofs in FredericiaC project (Source: © KCAP); (on the right) A scenario of PV installation in a building in Lund Brunnshög (Author: © Jouri Kanters)

TARGET GROUPS

EXISTING URBAN AREAS

The lessons learnt for the *planning process* from the case studies of existing urban areas are:

THE PHOTOVOLTAIC VILLAGE
ITALY

2

2

LIMITATIONS FOR PHOTOVOLTAIC INSTALLATIONS

There are limitations on existing areas using a photovoltaic system as exemplified in the case study of *The Photovoltaic Village Alessandria* in Italy. Houses included in the village at Alessandria were not a deep renovation and the designer had a limited range of design options, thus needed to work within the confines of the existing building enclosure's geometry and materials. *The Photovoltaic Village in Alessandri*a offered great opportunities in terms of available outdoor public spaces; however, the designers only made minimal use of outdoor areas for photovoltaic installations.

Figure 23 - (on the left) Pedestrian public area covered by PV. (Source: © Municipality of Alessandria); (on the right) The PV panels installed on façade of the row houses of the district (Source: © PierFranco Robotti).

TARGET GROUPS

2

2

LANDSCAPE

The lessons learnt for the *planning process* from the case studies of landscape areas are:

THE SOLAR DISTRICT HEATING BRÆDSTRUP - DENMARK 3

3 *LOCAL CONDITIONS, CONTEXT OF DESIGN AND TECHNICAL KNOWLEDGE FOR LARGE-SCALE SOLAR PLANTS*

The Danish case study of the *Solar district heating in Brædstrup* shows how large-scale solar thermal plants are best suitable in towns with an existing district heating network. In this situation, the solar thermal plants are a cost-competitive technology to substitute a share of the heat production from natural gas boilers. However, local conditions and context are fundamental for this competitiveness to take off. These local conditions and contexts are aided by the following:

- 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.

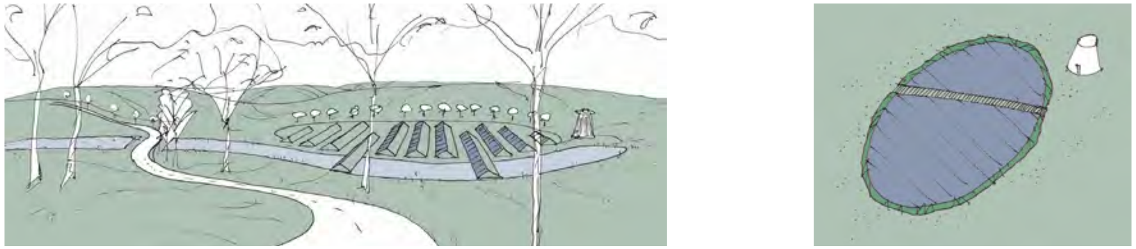
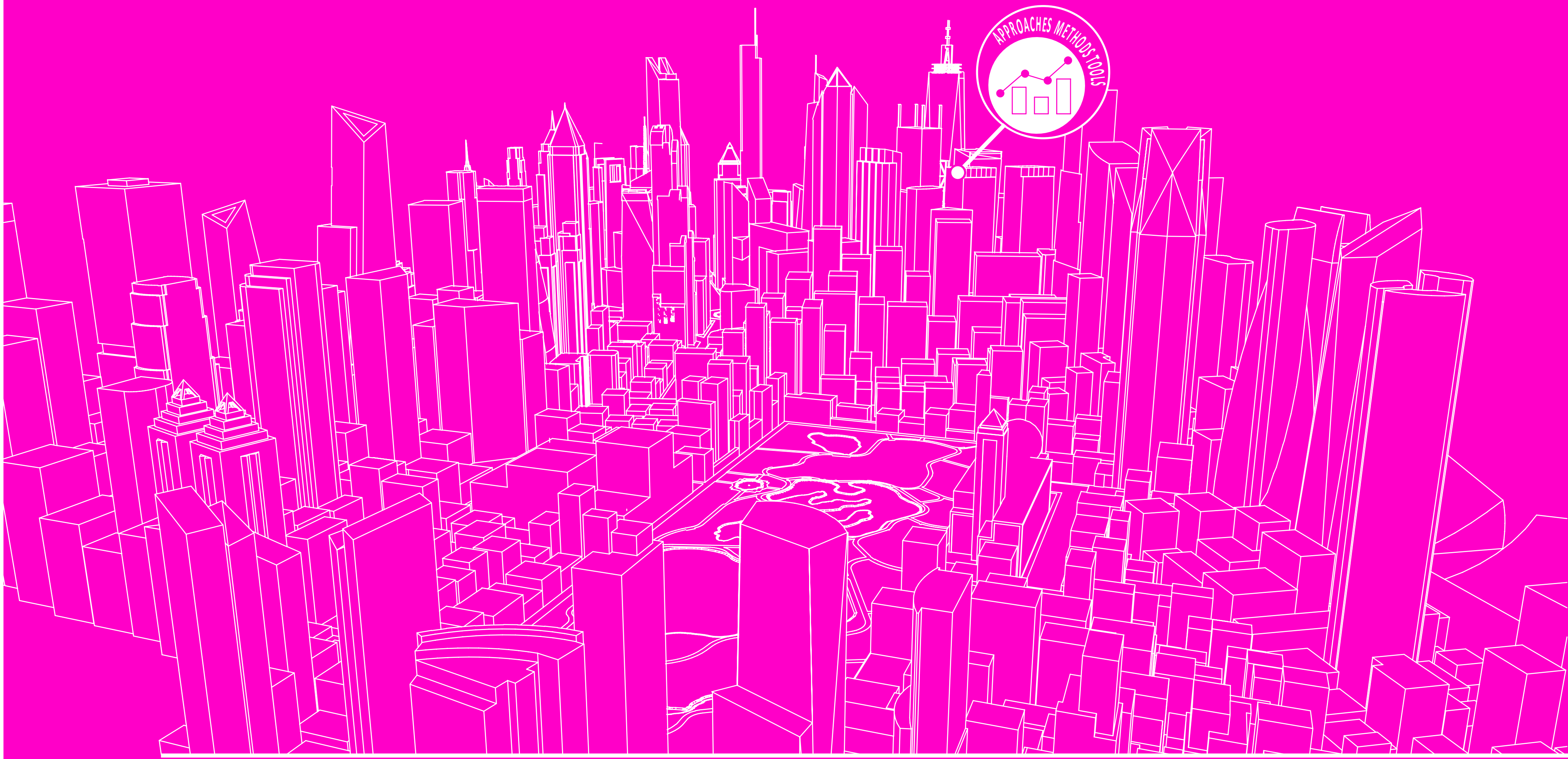


Figure 24 - Examples of drawings from the local municipality as inspiration to alternative layouts of the solar collector area promoting access and attractiveness of the area. (Source: Municipality of Horsens) (Source: © Postmedia Network)

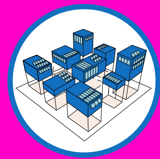
TARGET GROUPS 3 3

3.5 APPROACHES, METHODS and TOOLS



3.5 LESSONS LEARNT IN APPROACHES, METHODS AND TOOLS

This section provides a brief overview of a selection of the Approaches, Methods and Tools (AMTs) used within the different case studies involved in Task 51. AMTs provide solutions for the specific problems and challenges faced within solar energy in urban planning. This section presents an overall overview of the specific use of simulation tools, new analyses' methods and innovative approaches to address single and/or multiple aspects. It also outlines approaches to decision making taken by stakeholders and researcher during the entire planning process.



NEW URBAN AREAS

The lessons learnt for *AMTs* from the case studies of new urban areas are:

ASPERN+ DIE SEESTADT WIENS
AUSTRIA

1 *AMT CAN COVER DIFFERENT DIMENSIONS AND TOPICS*

The AMTs in the case study of *aspern+ Die Seestadt Wiens* allowed to cover the following dimensions:

- *Social*: Human;
- *Technical*: Soil, water, air and climate;
- *Environmental impact*: Landscape, animal and plant habitat;
- *Land use*: Property and cultural assets.

Methods/Tools
Environmental Impact Assessment

Approach
Planning and monitoring

2 *AMTs CAN OPTIMIZE HIGH LEVEL OF STANDARDS*

Ensure compliance with high ecological, environmental, urban planning and construction standards during all phases of development.

Method/Tools
Examples include: Total Quality Building Assessment, regular screenings by the Aspern Advisory Board and the mandatory requirements rooted in the Zoning Plans.

Approach
Control instruments

TARGET GROUPS

NEW URBAN AREAS

The lessons learnt for A*MTs* from the case studies of new urban areas are:

3 *AMTs allow to achieve various energy and design criteria*

The AMTs in the case study of *aspern+ Die Seestadt Wiens* contributed to meet various criteria which included energy efficiency of the built fabric, sustainable mobility and urban design concepts and integration of energy from renewables.

Methods/Tools

- Quantitative and qualitative criteria focusing on the energy efficiency and energy generation (including energy from renewable energy sources).
- Energy demand and energy generations simulation
- Solar accessibility analysis for shadowing studies.

Approach

Scenarios for alternative energy concepts.

4 *AMTs facilitate and improve the dialogue between different actors involved in the project*

In *aspern+ Die Seestadt Wiens* the use of AMTs increase cooperation and skilled negotiation between numerous public and private actors. In *Ørestad*, the AMTs facilitate solar energy as a commonly integrated part of urban planning.

Methods/Tools

Co-creation and participation programs in *aspern+ Die Seestadt Wiens* and storytelling in *Ørestad*.

Approach

Include citizens and relevant actors in the development in *aspern+ Die Seestadt Wiens* and stakeholder engagement in *Ørestad*.

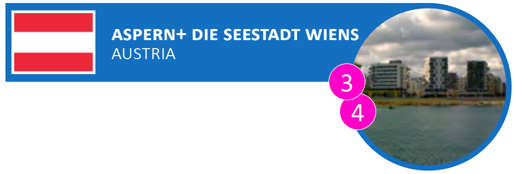


Figure 25 - Overshadowing simulation for aspern Seestadt Masterplan. (Source: ©Austrian Institute of Technology - AIT)

TARGET GROUPS

NEW URBAN AREAS

The lessons learnt for AMTs from the case studies of new urban areas are:

5 *AMTs SUPPORT THE EVALUATION OF THE PROJECT GOALS*

In the case study of *Stadtwerk Lehen* the monitored measures of energy balance data help to evaluate project goals, such as specific heat demand and solar fraction.

Methods/Tools

Monitoring for the whole system (solar, district heating, micro-net; including 300 measuring points) installed as well as a monitoring system with different types of feedback for selected apartments.

Approach

Monitoring after completion.

STADTWERK LEHEN
AUSTRIA

6 *AMTs SUPPORT TO DEVELOP SUSTAINABLE DESIGN AND ENERGY SOLUTIONS*

The AMTs in the case study of *Graz Reininghaus* in Austria have supported the development of a design based approach to meet energy demand.

Methods/Tools

Expected thermal and electric energy demand modelled in dynamic energy simulation tools such as TRNSYS (Transient System simulation program) and the elaboration of data in MATLAB. Degrees of energy autonomy and energy self-sufficiency for the city district calculated in different scenarios.

Approach

Development and evaluation of different scenarios for future energy supply of the district.

GRAZ REININGHAUS
AUSTRIA

TARGET GROUPS

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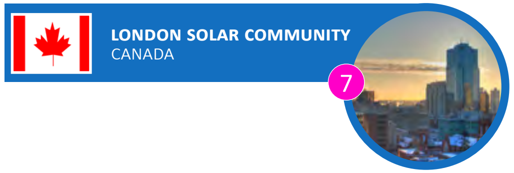
NEW URBAN AREAS

The lessons learnt for *AMTs* from the case studies of new urban areas are:



7 *AMTs SUPPORT STAKEHOLDERS IN DEVELOPING SOLAR LAYOUTS*

In the case study of *London Solar Community* in Canada, AMTs have supported stakeholders to understand the effect of specific layouts in relation to the solar access on the site, and therefore on the potential of passive and active design within the community.

Methods/Tools

- EnergyPlus
- HOT2000
- RETScreen International
- HOT2XP
- HOT2EC

Approach

Performance analysis of various layouts of the neighborhoods

Figure 26 - Electric charge station parking covered by PV panels. (Source: © west5)

TARGET GROUPS

7

NEW URBAN AREAS

The lessons learnt for A*MTs* from the case studies of new urban areas are:

8 *AMTs SUPPORT CO-SIMULATION APPROACH*

Use of different simulations to meet heating requirements.

Methods/Tools

A TRNSYS model built to simulate each part of the collection, storage, and energy distribution systems. Building heating loads 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 predicted using detailed ESP-r simulations, driven by Canadian Weather for Energy Calculation (CWEC) data.

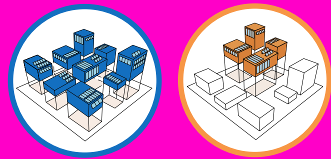
Approach

Co-simulation approach

Figure 27 - Solar system installation in different parts of the buildings' roofs (Source: © www.dlsc.ca)

TARGET GROUPS

8 8



NEW and EXISTING URBAN AREAS

The lessons learnt for *AMTs* from the case studies of new and existing urban areas are:

9 *AMTs TO ENSURE LIVING QUALITY, COMFORT ENERGY EFFICIENCY AND LIMITED ENVIRONMENTAL IMPACT*

In the *Residential Plot B45* in China and in *Flores Malacca*, Reunion Island, the AMTs have been used to ensure living quality, comfort, energy efficiency and limited environmental impact. The impact of solar collectors installed on top of the roof provides rich and flexible arrangement to gain simultaneous solar radiation. In *Le Albere*, Italy, the AMTs have been used to integrate energy efficiency and active solar systems with an innovative architectural design in terms of concept, forms and materials.

Methods/Tools

In *Residential Plot B45*, China

- Microclimate control simulation of wind environment developed with Phoenics2009, air pollution simulation with SCREEN3, noise simulation with Cadna/A, light environment simulation with SUNSHINE-V 3.0.
- Feasibility layout and 3D modeling of site planning simulated and optimized with SketchUp.
- Building energy efficiency calculation tools are: PKPM- PBECA V1.0, Regulated Indicator Calculation Sheet
- Planning residential illumination simulated by SUNSHINE-V 3.0 with measuring and reporting means.

In *Le Albere*, Italy

- BIM software for both building design and energy considerations.

In *Flores Malacca*, Reunion Island

- Environmental approach to urban planning at all stages of the urban development project.

Approach

High sustainability norms in zoning criteria as directive to solar assessment and integration for bio-climates and urban environment (*Residential Plot B45*); Sustainable green-oriented design (*Le Albere*); Solar assessment and integration in extreme climates (*Flores Malacca*).

RESIDENTIAL PLOT B45
CHINA
9

FLORES MALACCA BUILDINGS
FRANCE
9

LE ALBERE
ITALY
9

TARGET GROUPS

9

9

NEW URBAN AREAS

The lessons learnt for *AMTs* from the case studies of new urban areas are:

10 *AMTs FOR OPTIMIZATION OF SOLAR SYSTEM*

A set of solar simulations have been conducted in order to optimize the utilization of solar systems and daylight.

Methods/Tools

- Computer simulations and analyses of possibilities for utilizing solar energy, daylight and solar access to urban areas.
- Simulations of solar gains using the Rhino software package. Electricity production from PV-panels were calculated using PV-SYST.
- Daylight access studies were based on a method using the Window to Wall Ratio factor (WWR).

Approach

General design guides for implementation of solar and daylight in urban planning.

11 *AMTs TO IMPROVE THE IMPLEMENTATION OF PV PRODUCTION*

The support of AMTs allowed a high implementation of PV for production of electricity

Methods/Tools

Simulations were 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 and daylight access as well as attractive outdoor climate conditions regarding solar access to public spaces.

Approach

Analyzing the solar irradiance on roofs and façades for various schemes of the masterplan.

FREDERICIAC
DENMARK

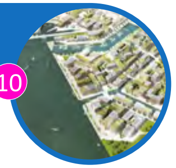


Figure 28- - Solar incidence on originally proposed scheme (Source: © Dansk Energi Management & Esbensen A/S)

GEHRY CITY HARBOR IN SØNDERBORG - DENMARK

TARGET GROUPS

NEW URBAN AREAS

The lessons learnt for AMTs from the case studies of new urban areas are:

12 ***AMTs to evaluate the impacts of different characteristics of urban form***

In the *Residential Plot B45*, the AMTs have been used to to show relative impacts of different characteristics of the urban form: orientation, buildings' arrangement and façades' shape.

12

LYON CONFLUENCE
FRANCE

Methods/Tools

- Using SOLENE software, solar simulation and sky view factors over the of blocks façades;
- Bioclimatic method adopted to study phenomenon (sun, wind, light, and acoustics) separately.

Approach

Consideration of building proximity in urban densities to examine different ambiences in terms of natural light and solar access.

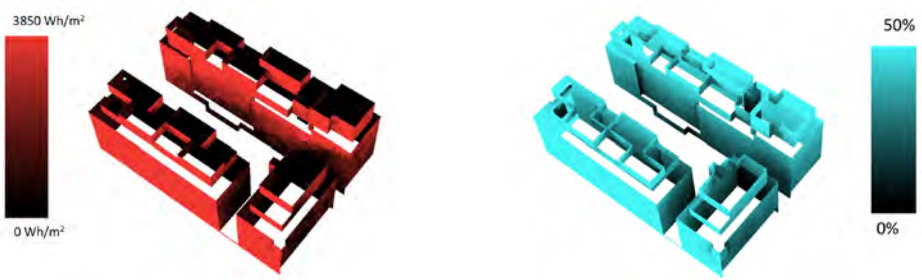


Figure 29 - (Left) Calculation of the cumulated solar energy received by a first phase block of Lyon Confluence over the 31st March day using SOLENE. (Right) Calculation of the façades' sky view factor of a first phase block of Lyon Confluence using SOLENE (Author: © M. Musy)

TARGET GROUPS 12 12 12

NEW URBAN AREAS

The lessons learnt for A*MTs* from the case studies of new urban areas are:

13 *AMTs for solar potential calculation and energy production*

The AMTs in the Swedish case studies of *Lund Brunnshög* and *Malmö Hyllie* calculate the potential amount of energy production by means of Solar Thermal or PV systems and the required energy needed in buildings, which can be produced by solar energy.

LUND BRUNNSHÖG
SWEDEN

MALMÖ HYLLIE
SWEDEN

Methods/Tools

- Solar Factor or SAFAR assesses the design of a zoning plan through computer simulation;
- Radiance simulations.

Approach

Defines the ratio between the suitable area on a building and the floor.

In *Øvre Rotvoll* case study in Trondheim, solar analyses outline the urban design guidelines by evaluating the effect of the finishing materials created by three factors - orientation, reciprocal distance and reflectance values. Analyses of these three factors were conducted successively on the masterplan. This approach to analyses was taken to optimize the layout of the district, to verify the validity of the urban guidelines and to localize the most suitable surfaces for installing solar systems.

ØVRE ROTVOLL
NORWAY

Methods/Tools

DIVA-for-Rhino

Approach

Definition and application to the case study of urban design guidelines outlined on the results of solar potential analyses.

TARGET GROUPS

13 13 13 13

EXISTING URBAN AREAS

The lessons learnt for A*MTs* from the case studies of existing urban areas are:

13 *AMTs FOR SOLAR POTENTIAL CALCULATION AND ENERGY PRODUCTION*

In the case studies of *Uppsala Frodeparken,* Sweden, and *Zero Emission Office Building*, Norway, solar potential analyses on the building envelope in an unobstructed and urban context scenario have been conducted to study overshadowing effect created by the urban surrounding. In *SINFONIA*, Italy, the solar analyses were run to test different configurations of solar systems on the roof and evaluate the solar potential on the façades.

Methods/Tools

In *Zero Emission Office Building*, Norway:

- First level: solar mapping analyses with Diva for Rhino;
- Second level: overshadowing analysis and localization of the most radiated surfaces with Diva for Rhino.
- Third level: the energy production with photovoltaic system was calculated using PV syst.

In the *Uppsala Frodeparken*, Sweden:

- Sketch-up model imported into Rhino and Grasshopper environment and radiation study with the plug-in Ladybug have been conducted.

In *SINFONIA*, Italy:

- Analyses performed with Radiance´s plug-in for Rhinoceros to evaluate the irradiation values on solar systems to be installed on the roof. For the analyses of the solar systems, a genetic algorithm has been applied to maximize the irradiation and minimize the overshadowing on the panels.

Approach

Dynamic simulation tools were used in all case studies to perform solar potential analyses to evaluate the current situation and the proposed alternatives. In addition, for the *Norwegian Zero Emission Office Building*, data on modules and inverters from the real system are used in the simulations.

UPPSALA FRODEPARKEN
SWEDEN
13

13
ZERO EMISSION OFFICE BUILDING - NORWAY

SINFONIA
ITALY
13

TARGET GROUPS

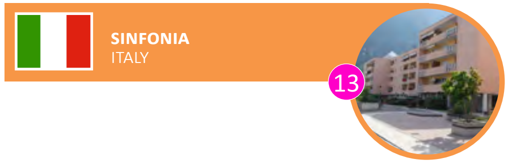
13 13 13 13

EXISTING URBAN AREAS

The lessons learnt for A*MTs* from the case studies of existing urban areas are:

13 *AMTs FOR SOLAR POTENTIAL CALCULATION AND ENERGY PRODUCTION*

In the case study of *SINFONIA* in Italy, solar analyses were used to evaluate three hypotheses for the building envelope retrofit in collaboration with energy consultants, designers, owners, researchers, and technicians.



Methods/Tools

- Numerical simulations and test in laboratory

Approach

Integrated Design Process.

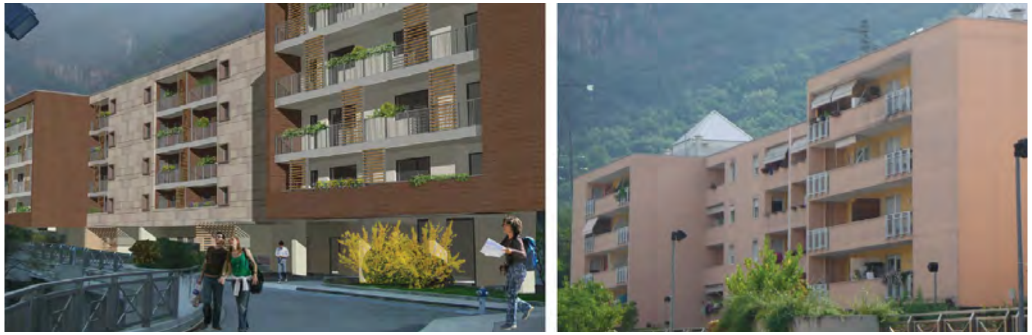


Figure 30 - (Left) North Building: render of the project. (Image: © Studio Mellano & ARCH+MORE); (Right) North Building: current status. (Photo: © Eurac Research)

TARGET GROUPS

13 13 13 13

EXISTING URBAN AREAS

The lessons learnt related to *AMTs* from the case studies of existing urban areas are:

14 *AMTs for citizens involvement*

The AMTs in the German case study of *Science and Technology Park of Berlin Adlershof* were used to include citizens and relevant actors in the development and to increase cooperation and skilled negotiation between numerous public and private actors.

Methods/Tools

Consultancy, co-creation and participation programs.

Approach

Local energy manager, local development company.

15 *AMTs to encourage innovative and efficient concepts*

Acceleration of new developments and pushing towards innovative and energy efficient concepts.

Methods/Tools

- Considering concepts instead of highest offer when selling plots. Owners are bound to build or sell their plots.
- Find innovative solutions for an urban energy concept using state of science instead of state of the art.
- Cooperation with universities and private companies.

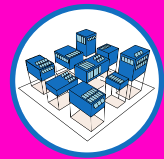
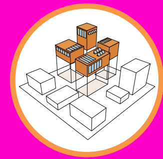
Approach

Urban development measures and research projects.

Figure 31 - Impressions of PV systems in Science and technology park of Berlin Adlershof (Photos: © Margarethe Korolkow)

TARGET GROUPS

14 15 14 15

NEW and EXISTING URBAN AREAS

The lessons learnt for *AMTs* from the case studies of new and existing urban areas are

16 THE USE OF AMTs TO EVALUATE DIFFERENT URBAN DESIGN ALTERNATIVES FOR SOLAR ENERGY AND SOLAR ACCESSIBILITY

In the case studies of *Yverdon-les-Bains and Romanel-sur-Lausanne,* Switzerland*,* the use of AMTs allowed the evaluation of a large number of parametrically-generated design variants based on the typologies defined in or considered for the master plan in order to optimize the solar energy and daylighting potential.

Methods/Tools

- Use of simulation and examination of several criteria to analyze the solar potential (e.g. daylight, active and passive solar) of early designs.

Approach

Performance assessment of neighborhood design variants from master plans.

17 THE USE OF AMTs TO LOCALIZE THE MOST SUITABLE AREAS FOR SOLAR INSTALLATION IN EXISTING URBAN AREAS

In the case studies of *Dale,* Norway, the AMTs were used to localize the optimum position of solar cells.

Methods/Tools

- The analysis assisted in showing how the proposed solutions fit with the municipality's energy and climate plan. Buildings were analysed using PV Syst.

Approach

Using tools to influence integration of solar systems into planning.

ROMANEL-SUR-LAUSANNE
SWITZERLAND
16

16
YVERDON-LES-BAINS
SWITZERLAND

17
DALE COMMUNITY
NORWAY

TARGET GROUPS

16 17 16 17 16 17

EXISTING URBAN AREAS

The lessons learnt related to *AMTs* from the case studies of existing urban areas are:

18 *AMTs USED TO EXPAND THE MARKET OF SOLAR INSTALLATIONS AND RECOMMENDATION FOR SOLAR ENERGY*

In the case study of *Solar in Halifax Regional Municipality* in Canada the AMTs have been used to determine the suitability of facilities, open areas to solar energy generation and to develop recommendations for using solar energy technologies in the energy mix.

Methods/Tools

- Solar suitability assessment of high-resolution solar resource mapping of areas based on satellite-derived solar resource data and LiDAR-based digital elevation model of the area. Fisheye imagery processing technology was used for consideration of obstructions to sunlight on the campus buildings, roofs and walls as well as on the open spaces.
- For residential applications in *Halifax Regional Municipality Solar City* Program in the areas not covered by LiDAR survey, a combination of tools were used for solar suitability assessment including Pictometry's high resolution aerial oblique imagery tools and Green Power Labs' Solar- Rating Online tool.

Approach

Solar City Program used a toolset to assess solar suitability of candidate houses and related business cases for solar system deployment and to select applications with best economic outcome.

SOLAR IN HALIFAX REGIONAL MUNICIPALITY - CANADA 18

TARGET GROUPS 18 18 18

EXISTING URBAN AREAS

The lessons learnt for A*MTs* from the case studies of existing urban areas are:

19 ***AMTs to exploit external environmental conditions, solar energy and daylight***

In the case study of *Verge project Lugano Paradiso* in Switzerland, AMTs have been used to establish aspects that compromise the full exploitation of the external environmental conditions. AMTs were also used to examine the availability of solar energy and daylight to use passive strategies for thermal conditioning. Finally, the AMTs were used to determine, where possible, corrective measures when negative impact on the status quo.

VERGE PROJECT LUGANO PARADISO - SWITZERLAND 19

Methods/Tools

- Combination of numerical methods, 3D simulations programs with photo processing image methods along with sun-path diagrams to analyze solar availability (active and passive solar).
- To assess solar irradiation, shadow effects, daylight, and the real impact of new and existing buildings in energy performances of existing buildings, simulation tools as 3D Ecotect, Daysim RADIANCE and BES-Tenergy software have been used to evaluate the different scenarios.
- Processing image software (ImageJ) in combination with HORIcatcher instrument developed by Meteotest to evaluate obstructions to sunlight and sky view factors (SVF). With a digital camera and a spherical convex mirror, the real horizon in an urban area was used to calculate limitations of the sunshine duration and irradiation due to obstacles in current urban status with in-situ mesurements. These three-dimensional projections have been compared with the same urban area in the future scenario to check differences.
- To assess human comfort differences in the area, bioclimatic charts and diagrams allows calculating the ideal “comfort zone” corresponding to an specific location, in this case Lugano-Paradiso.

Approach

Proposal of methods to assess solar radiation, daylighting availability and Sky-View Factor (SVF) modification in complex urban environments.

TARGET GROUPS 19 19 19

LANDSCAPE

The lessons learnt related to *AMTs* from the case studies of landscape areas are:

20 AMTs FOR MULTI-OBJECTIVES APPLICATIONS

In the case study of *Sarnia photovoltaic power plant* in Canada the AMTs have been used to evaluate: (i) the plant's energy performance; (ii) optimization of the layout and design of landscape; (iii) for costing and financial evaluation; (iv) for the assessment of drainage requirements and design of the site drainage infrastructure; (v) to enable contractors to work with the structure and module mounting techniques to accelerate learning and help to provide better construction cost estimates and (vi) to enable neighbours of the project to evaluate the visual look of the arrays and potential reflections from the arrays.

20 SARNIA PHOTOVOLTAIC POWER PLANT - CANADA

Methods/Tools

- PVSYST software (i)
- CAD (ii)
- First solar software (iii)
- Hydrological software (iv)
- Sandbox (v)
- Dummy array (vi)

Approach

Use of different simulation tools for multi-objectives applications.

TARGET GROUPS

20 20 20

LANDSCAPE

The lessons learnt related to *AMTs* from the case studies of landscape areas are:

20 *AMTs FOR MULTI-OBJECTIVES APPLICATIONS*

In the case studies of *Agrienergie 5* in France and *Agrovoltaico* in Italy the AMTs have been used for the experimentation for growing open field food and producing energy by PV systems which benefit in creating shadow as well.

AGRINERGIE 5
FRANCE
20

20
AGROVOLTAICO
ITALY

Methods/Tools

In Agrinergie 5 in France:

- PV greenhouses panels integrated in the roof.

In Agrovoltaico in Italy:

- A sun-tracking system.

Approach

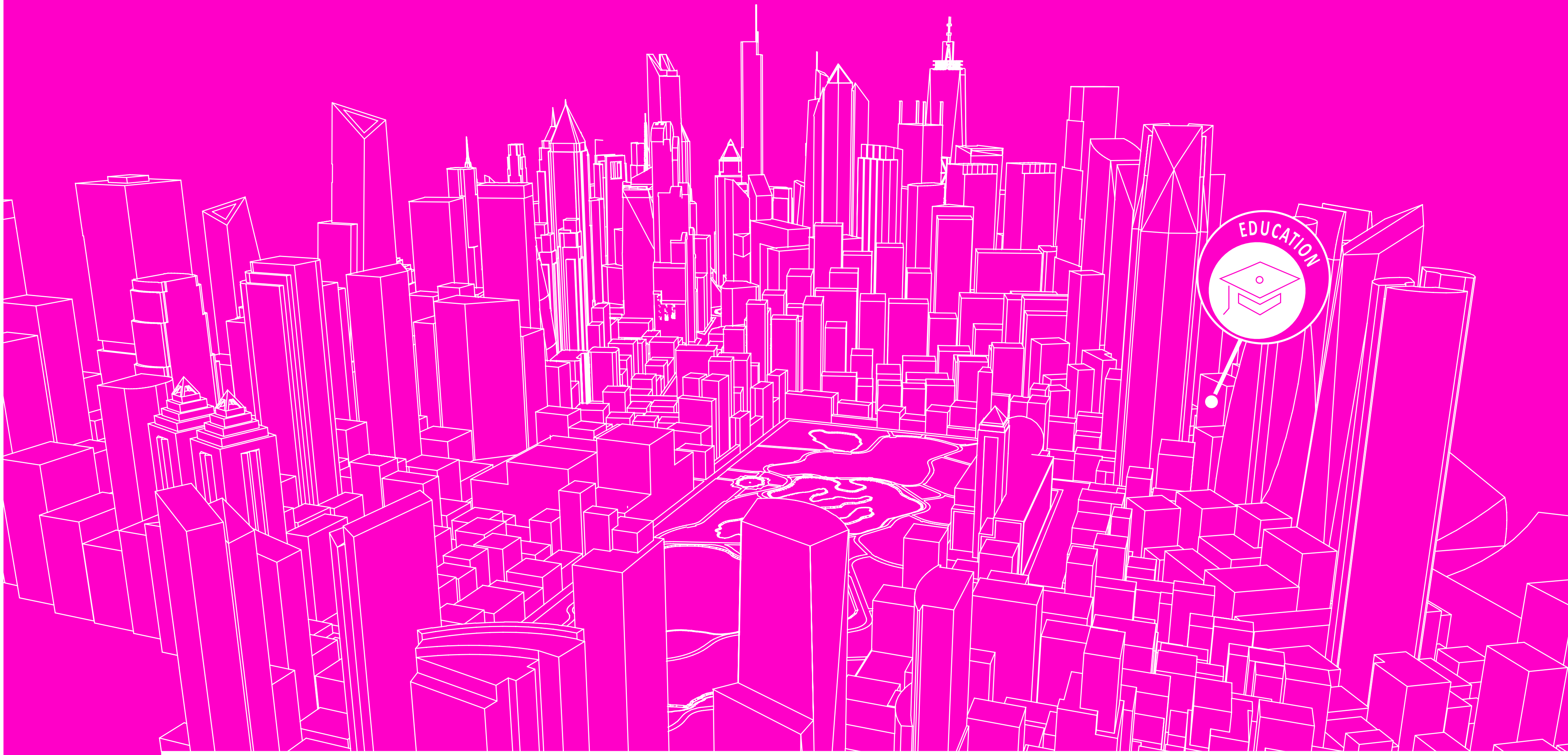
Dual use of land.

Figure 32 - (Left) Inner view of the farmer working in the greenhouse covered by PV system in Agrinergie 5. (Source: © akuoenergy); (Right) Threshing machine in action under the PV track system. (Photo: © REM)

TARGET GROUPS

20 20 20

3.6 EDUCATION

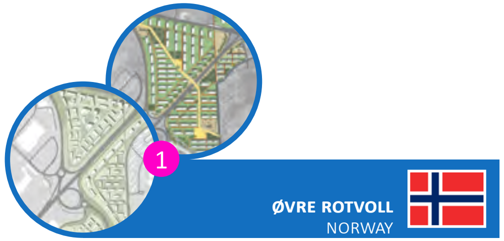


LESSONS LEARNT IN EDUCATION

Developing future professions involved in urban planning to consider solar energy as a renewable solution for urban planning is important practice that needs to be integrated in the educational programmes at all levels. Educational setting in Norway and Germany demonstrate approaches on how to incorporate solar energy in urban planning in university education programmes. There was also evidence based within the case studies on the importance of having educated professionals within this area in order to make informed decisions. More information on education in solar energy in urban planning is available in the Task 51/ Report D1 Part 1.

NEW URBAN AREAS

The lessons learnt for *Education* from the case studies of new urban areas are:



1 SOLAR ENERGY APPROACHES IN THE EDUCATIONAL PROGRAMMES

Two educational case studies demostrated the integration of solar energy in urban planning in courses in two universities located in Germany (University of Wuppertal) and Norway (Norwegian University of Science and Technology).

The course included the development of different approaches and methods to evaluate solar potential with students using a new planned urban site at *Øvre Rotvoll* in Norway.

In Germany, an approach was developed to include energy sustainability of the district as well as the infrastructure and the social impact of the proposed design. They examined solar optimization, improvement of public transport and distribution of public facilities and shops.

In the case study of NTNU and University of Padua, a single criteria method was applied to design a masterplan in which the solar potential is maximized in each area of the district. The approach considered the influence of aspect ratio h/w and orientation and the positive effect on the solar radiation due to the reflections of the different finishing materials.

The findings for *Øvre Rotvoll* planning illustrated the importance of including different design parameters in sustainable design process; the usefulness of analogue and digital tools for supporting all phases of the design process; the consideration of solar systems integrated into the building envelope early in the design process to create energy efficient districts. The studies were done in an educational setting but the findings had real practical applications, which were provided to the local Norwegian municipality for use in their decision making if they so wish. These cases demonstrate the potential to link education on solar energy to real practices in urban planning.

TARGET GROUPS

1 1

NEW URBAN AREAS

The lessons learnt for *Education* from the case studies of new urban areas are:

2 *SOLAR ENERGY APPROACHES IN THE EDUCATIONAL PROGRAMMES*

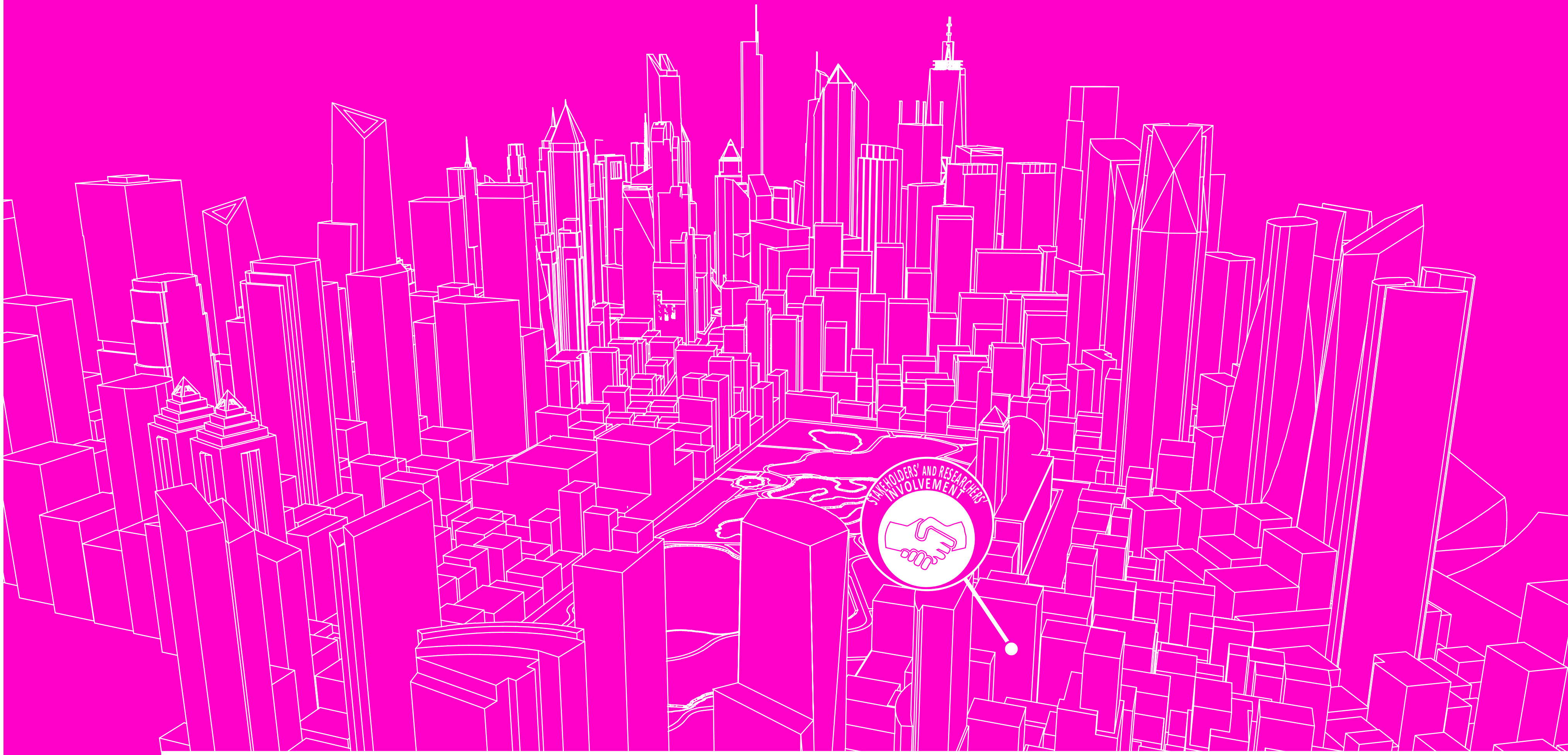
In France, the case study of *Lyon Confluence* illustrated the need to raise awareness and to develop education campaigns towards general public on solar energy in urban planning. This case advocates the necessity to open architecture courses to technical issues given by engineers and to develop a cooperative culture between architects and engineers in design teams – which could be started within an educational context between students of different practices.

2 **LYON CONFLUENCE** FRANCE

Figure 33 - Lyon Confluence second phase. South towers and their masking impact. (Left) The project (Herzog & Demeuron). (Rigth) Simulation with SOLENE (Author: © M. Musy)

TARGET GROUPS 2 2 2

3.7 STAKEHOLDERS' and RESEARCHERS' INVOLVEMENT



3.7 LESSONS LEARNT IN STAKEHOLDERS' AND RESEARCHERS' INVOLVEMENT

A holistic approach to all relevant stakeholders of urban planning including citizen engagement is crucial in building agreements, understanding and achieving solutions for solar energy in urban planning. This ensures a more representative approach which increases the chances of reaching ambitious goals and overcoming barriers in developing solar energy in urban planning.

NEW URBAN AREAS

The lessons learnt for *Stakeholders' and researchers' involvement* from the case studies of new urban areas are:

1 *THE COMPETENCES AND THE INTERESTS OF STAKEHOLDERS AND RESEARCHERS HAVE A RELEVANT IMPACT ON THE DEVELOPMENT OF A PROJECT*

Open-mindedness is important for both researchers and those responsible for urban planning and its implementation. *aspern+ Die Seestad*t case study in Austria, highlights the importance of the early involvement of all the relevant stakeholders representing urban planning and energy planning in order to be able and embed innovative concepts from research into reality.

Integration and agreements among diverse stakeholders is a common theme in two Austrian case studies. In the case study *Stadtwerk Lehen,* realistic goals were set and a quality assurance agreement was signed by all parties, which included ambitious quality goals concerning energy efficiency, renewable energy, ecology, mobility and social factors. The agreement on this interdisciplinary approach continuously followed in order to guarantee a successful implementation of ambitious energy goals. Similarly, the case study of *Graz Reininghaus*, illustrates collaboration of interdisciplinary project team and interaction with a complex network of investors, planners, energy suppliers, interested representatives and locally-based companies. This collaboration initiated a lot of innovative ideas and concepts underpinned in their realization in first milestones.

There is also a need for a clear understanding of solar energy amongst stakeholders as illustrated in Danish case studies. The case studies of *FredericiaC* and *Gehry City Harbour*, illustrate that it is crucial that the developer/land owner as well as the complete design team consider solar and daylight optimization at an early stage in 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.

ASPERN+ DIE SEESTADT WIEN'
AUSTRIA

1

STADTWERK LEHEN
AUSTRIA

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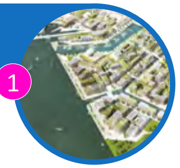
GRAZ REININGHAUS
AUSTRIA

FREDERICIAC
DENMARK



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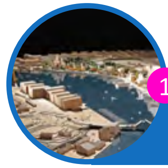

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GHERY CITY HARBOUR
DENMARK

TARGET GROUPS

1 1

NEW AND EXISTING URBAN AREAS

The lessons learnt related to *Stakeholders' and researchers' involvement* from the case studies of new and existing urban areas are:

1

THE COMPETENCES AND THE INTERESTS OF STAKEHOLDERS AND RESEARCHERS HAVE A RELEVANT IMPACT ON THE DEVELOPMENT OF A PROJECT

In the *Photovoltaic Village in Alessandria*, Italy, the methodological definition of the intervention process started with the definition of the role of actors and their coordination and continuous checks in all phases in order to increase cooperation among actors both public and private. Essential is the role of the municipality among the institutional authorities or other bodies involved.

The *Residential Plot B45* based in China included urban planners and architects working with engineers, consultants, solar product/ construction/ supervisory companies simultaneously, which resulted in a solution for the layout of SWH system in tower buildings that did not compromise on aesthetics in proportion, texture and perspective. Participation of multi-stakeholders at early stage is important for new urban area development because final users are unknown.

In France, in the case study of *Eco Neighborhood of Ravine Blanche*, a multi-stakeholders governance approach with an agreement between the main influential stakeholders involved in the planning process has been tested. A Steering Committee with representatives of all interested stakeholders and decision makers worked on clear and common 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. Public consultation and information campaign have played a pivotal role in the 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.

THE PHOTOVOLTAIC VILLAGE
ITALY

1

RESIDENTIAL PLOT B45
CHINA

1

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THE ECO NEIGHBORHOOD OF RAVINE BLANCHE - FRANCE

TARGET GROUPS

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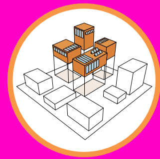

EXISTING URBAN AREAS

The lessons learnt related to *Stakeholders' and researchers' involvement* from the case studies of existing urban areas are:

1 *THE COMPETENCES AND THE INTERESTS OF STAKEHOLDERS AND RESEARCHERS HAVE A RELEVANT IMPACT ON THE DEVELOPMENT OF A PROJECT*

In Norway, the case study of *Dale Community* demonstrated the challenges of integrating a wide variety of stakeholder influences coming from both local, regional and EU perspectives as well as different interest groups.

In Switzerland, the *Verge project Lugano Paradiso* case study illustrated how local contributors who include researchers, urban planning consultants, the Municipal Technical Office, architects and a building heritage owner work together. Researchers analyzed the different urban densification scenarios (old and new Master Plan scenarios) to investigate the real impacts of the new urban pattern and buildings' shapes on the energy behavior of existing buildings by considering solar radiation and daylighting availability along with sky-view factors. The importance of using comparable examples, working collaboratively with planners and municipalities as well as convincing community members in order to explain specific aspects of the research results in a comprehensible way, increased public acceptance to better implement new urban changes.

1 **DALE COMMUNITY** NORWAY

VERGE PROJECT LUGANO PARADISO - SWITZERLAND 1

TARGET GROUPS

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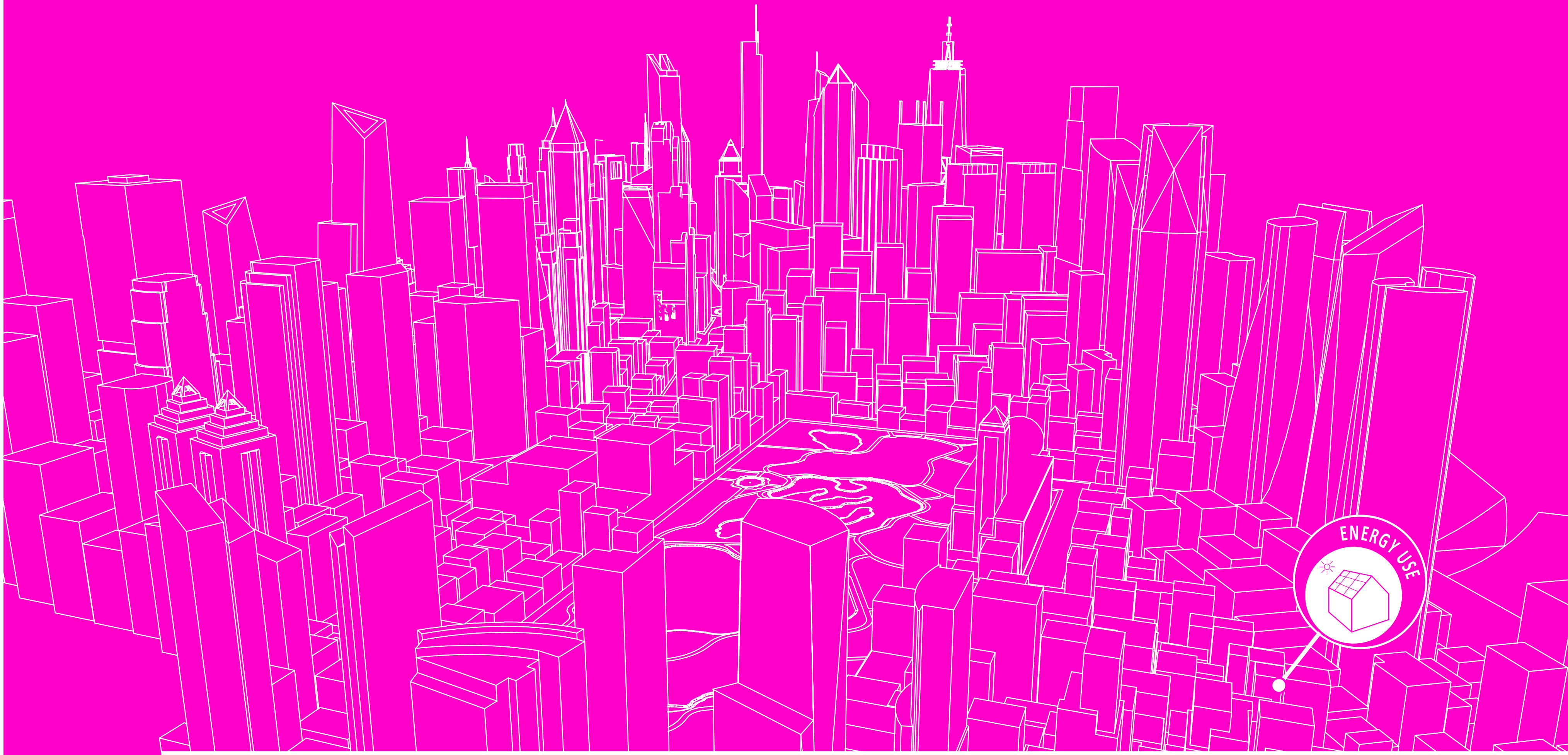
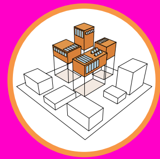
3.8 ENERGY USE



3.8 LESSONS LEARNT IN ENERGY USE

Energy strategies (active, passive or both) or energy initiative (incentives, regional investments etc.) as well as energy concepts and specific solar technologies (Photovoltaic, Solar Thermal and solar gains specifically) are aspects that impact the energy use of the final users. Specific technical and non-technical actions have been undertaken by private and public initiatives in order to implement the energy use in some case studies.



EXISTING URBAN AREAS

The lessons learnt for *Energy use* from the case studies of existing urban areas are:

1 *Implementation of new urban planning strategies for energe use*

In Switzerland, the case study of *Verge project Lugano Paradiso,* evaluated the implementation of new urban planning strategies on the energy behavior of existing cultural protected buildings in the area. A detailed verification of energy flows, energy requirements for thermal conditioning and energy demand were made in one of these protected buildings, as example. This energy analysis was performed considering the two different urban simulations scenarios (before and after the implementation of the new Master Plan) by using dynamic energy simulation tools that allowed to estimate modifications of the total annual amount of primary energy for heating and cooling (kWh/m² yr) and of the building operational costs.

VERGE PROJECT LUGANO PARADISO - SWITZERLAND

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TARGET GROUPS

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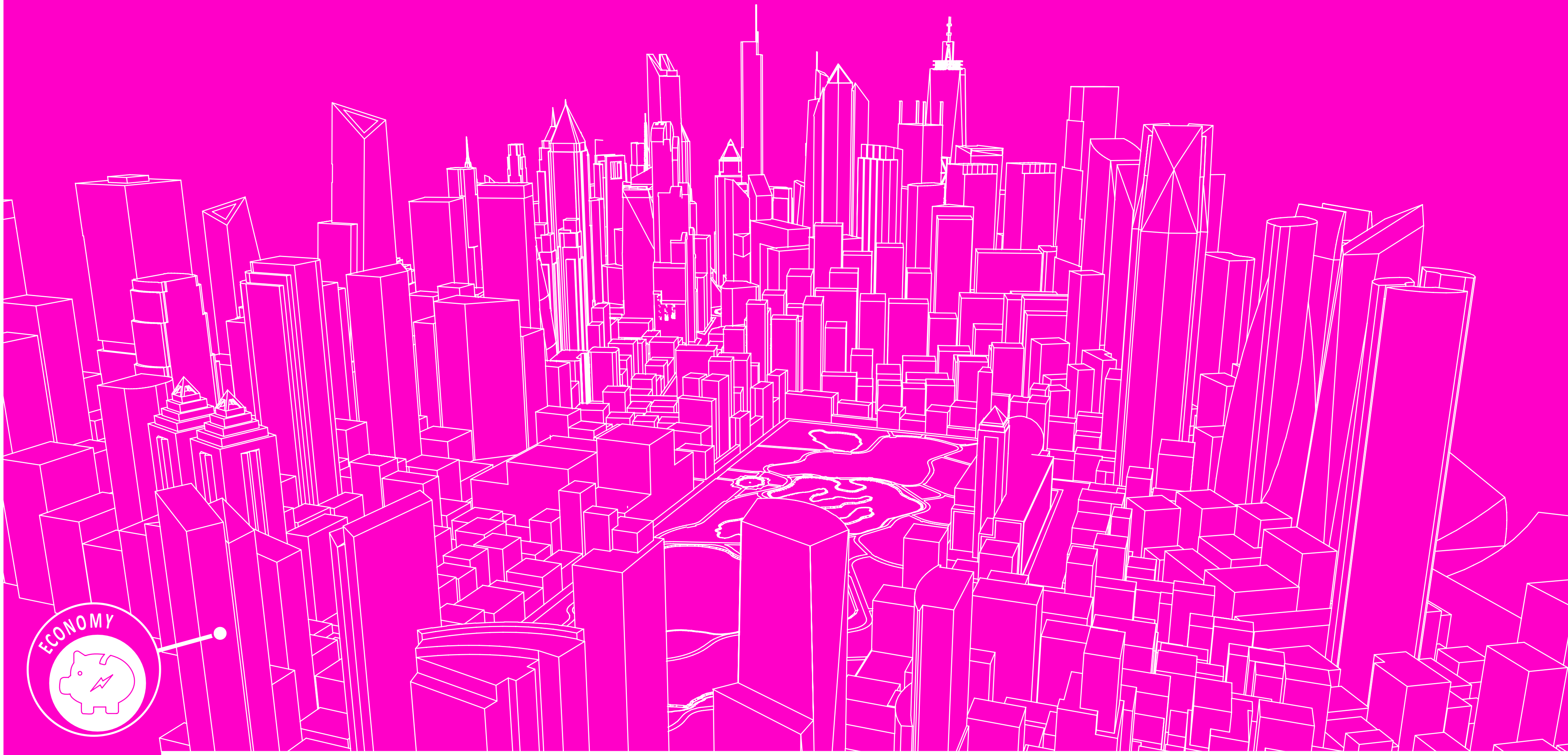
3.9 ECONOMY



LESSONS LEARNT IN ECONOMY

Economy is considered as influential in developing what kind of solar energy solution can be implemented. Some of the factors for consideration include affordability of urban areas; the energy market; available financial incentives; financial benefits of introducing solar as a single solution or an integrated solution and business opportunities through the use of solar.

NEW URBAN AREAS

The lessons learnt for *Economy* from the case studies of new urban areas are:

1

SOLAR ENERGY AND INVESTORS' ATTRACTION

German, Austrian and Swedish cities cannot prioritize a specific renewable energy source over others. Economically, while cities want to attract private investors and in parallel, to promote affordable rents and ownership costs, imposing solar panels on every building roof becomes unfavorable in terms of economic and political benefits. Both *Freiham Nord Munich*, in Germany and *aspern+ Die Steestadt Wiens*, Austria, stress for the provision of PV or solar thermal panel integration in buildings, which has put additional strain on the financing and affordability of the dwellings. Developing solar solutions that meet the planning authority's objective of affordable dwellings need consideration.

In Italy, *Violino District in Brescia* illustrated the willingness to develop sustainable urban projects as well as compare costs of such requirements, with those corresponding to standard requirements of economic and council housing.

Figure 34 - Chimney of the heating plant of Freiham, including PV modules. (Photo: © Stadtwerke München)

ASPERN+ DIE SEESTADT WIENS
AUSTRIA
1

LUND BRUNNSHÖG
SWEDEN
1

FREIHAM NORD MUNICH
GERMANY
1

VIOLINO DISTRICT IN BRESCIA
ITALY
1

TARGET GROUPS

1

1

Existing urban areas

The lessons learnt related to *Economy* from the case studies of existing urban areas are:

1

Solar energy and investors' attraction

The Solar City Program in Halifax Regional Municipality in Canada, is a case study which promoted a participatory approach allowing for engagement of property owners and citizens. The engagement aided the accumulation of support for the energy market and helped in overcoming misconceptions regarding solar energy. The Power Purchase Agreement financial system used in this case study is the only financing option used by customers. Halifax model demonstrates that other financial models are possible but for small and medium size property owners it was found that the multitude of financing options made the program complicated.

A new Swiss energy strategy called *Energy Innovation Solar Purchase Group* supports professionals active in the energy field and researchers who work directly with local communities to facilitate solar group purchases and providing support through the procurement process. This initiative has motivated many small property owners to realize their own installation, while reducing investment costs.

In the Norwegian case study of *Dale*, in order to alleviate cost the use of solar needed to be considered alongside an overall energy concept coupled with other technical building equipment 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. The initial energy solution included economic calculations which resulted in no profitability as a singular entity, however a second solution which incorporated energy exchange with the grid, became profitable.

Solar in Halifax Regional Municipality - Canada

1

Energy Innovation Solar Purchase Group
Switzerland

1

1

Dale community
Norway

Target groups

1

1

LANDSCAPE

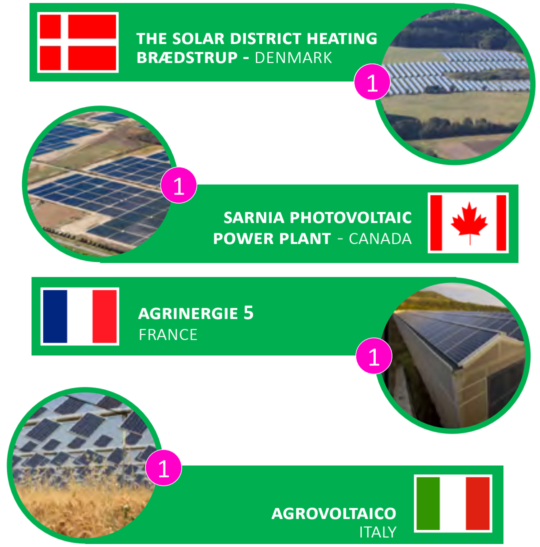
The lessons learnt for *Economy* from the case studies of landscape areas are:

1

SOLAR ENERGY AND INVESTORS' ATTRACTION

Conclusions from *Sarnia Photovoltaic Power Plant*, Canada and *Solar District Heating Brædstrup*, Denmark, recommended the use of agricultural land as opposed to urban land, as a cheaper alternative to generate energy from large scale solar energy production and stressed the need for economic incentives to district companies to invest. The proposed dual use of land recommended in Sarnia and Brædstrup, was demonstrated in the case studies of *Agrovoltaico*, Italy, and *Agrinergie 5*, Reunion Island, based on food production and solar energy.

Figure 35 - 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)



TARGET GROUPS

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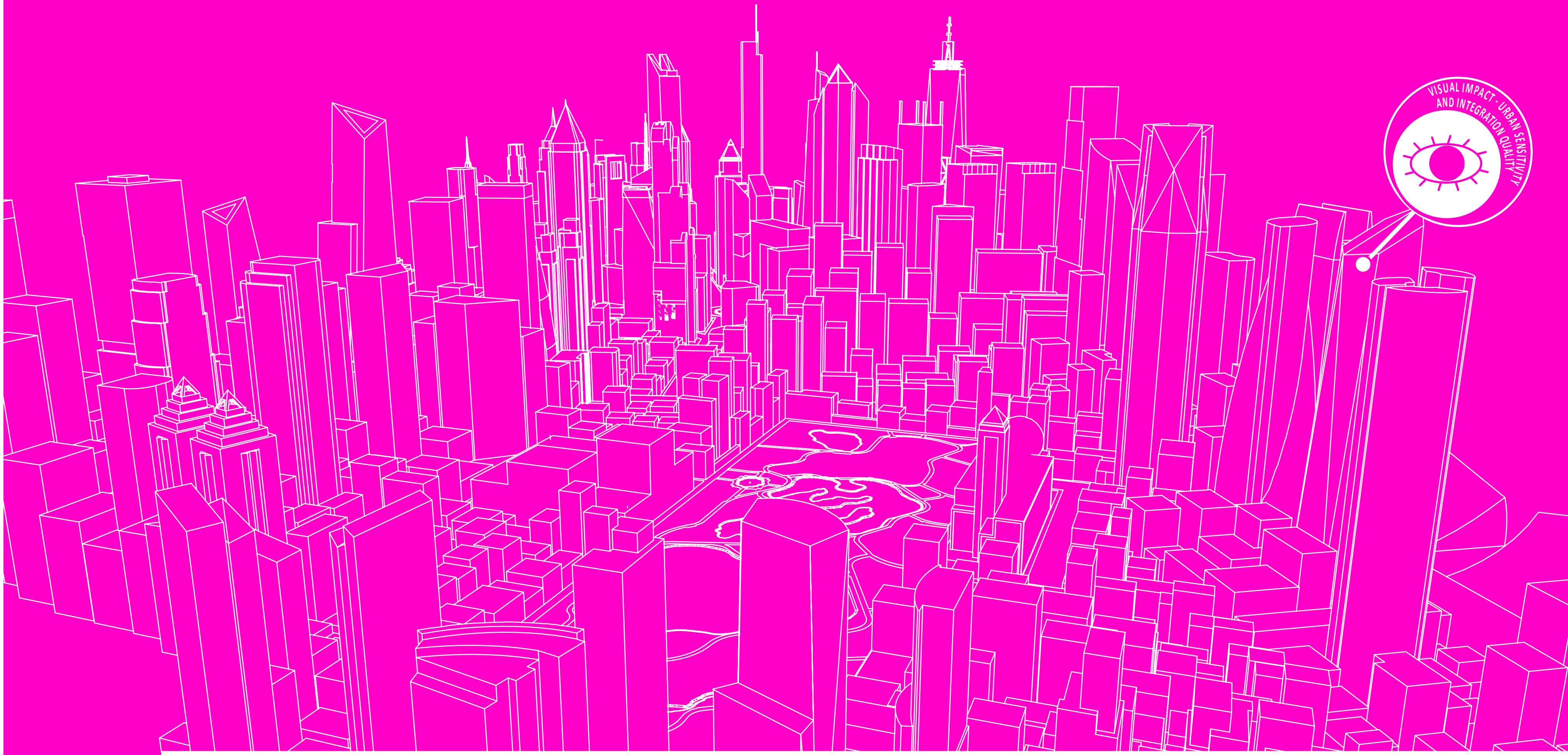

3.10 LESSONS LEARNT IN VISUAL IMPACT – URBAN SENSITIVITY AND INTEGRATION QUALITY

The LESO-QSV method on *Visual impact – urban sensitivity and integration quality* aims to :

- Clarify the notion of architectural integration quality and proposes a simple evaluation method, based on a set of three criteria derived from previously published work.
- Support authorities to set and implement local acceptability requirements, introducing the notion of architectural "criticity" of city surfaces (LESO-QSV acceptability)
- Propose a way to tailor solar energy policies to local urban specificities by mapping the architectural "criticity" of city buildings surfaces, and crossing this information with the city solar irradiation map (LESO-QSV crossmapping), representing a more realistic usable solar potential of these surfaces [1][2].

NEW AND EXISTING URBAN AREAS

The lessons learnt for *Visual impact – urban sensitivity and integration quality f*rom the case studies of new and existing urban areas are:

1 USING THE LESO-QSV METHOD AS SUPPORT INSTRUMENT TO PRESERVE THE QUALITY OF EXISTING URBAN AREAS

The LESO-QSV method can support authorities to preserve the quality of existing urban areas while still promoting solar energy use. The vision underlining the approach is that solar integration is possible even in delicate contexts provided that the integration quality matches the quality of its environment. If this requirement cannot be met, it may be better to postpone the operation, as poor integrations usually end up just discouraging new users. By contrast, if well designed, good examples in delicate contexts can be among the strongest driving forces for solar refurbishment. The QSV method helps to define appropriate local levels of quality, and to identify the factors needed to initiate smart solar energy policies, able to preserve the quality of existing urban contexts while promoting solar energy use. In that regard, the case studies of *Violino District in Brescia* (Italy) and *Verge project Lugano Pardiso* (Switzerland) are emblematic examples.

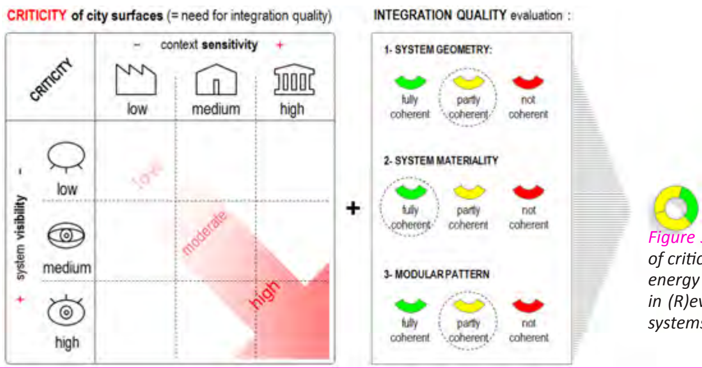

Figure 36 - Criticity of city surfaces in relation to architectural integration quality (on the left); Definition of level of criticity of the installed active system (on the right). (Source: [1] Munari Probst, M. C.; Roecker, C.; (2015). Solar energy promotion & urban context protection: LESO-QSV (Quality-Site-Visibility) method, 2015 PLEA Architecture in (R)evolution, Bologna, IT. [2] Munari Probst MC, Roecker C "Urban acceptability of building integrated solar systems: Leso QSV approach", in proceedings ISES 2011, Kassel, Germany, 2011

DRAKE LANDING SOLAR COMMUNITY CANADA 1

VERGE PROJECT LUGANO PARADISO - SWITZERLAND 1

1 **THE ECO NEIGHBORHOOD OF RAVINE BLANCHE** - FRANCE

VIOLINO DISTRICT IN BRESCIA ITALY 1

TARGET GROUPS

1 1

NEW AND EXISTING URBAN AREAS

The lessons learnt for *Visual impact – urban sensitivity and integration quality* from the case studies of new and existing urban areas are:

2 *USING THE LESO-QSV METHOD TO SET CRITERIA FOR ARCHITECTURAL INTEGRATION QUALITY AND CRITICITY*

The LESO-QSV method clarifies the notion of architectural integration quality and proposes a simple evaluation method. This helps authorities set and implement local acceptability requirements by introducing the notion of architectural "criticity" of city surfaces (LESO-QSV acceptability). The concept of "criticity" is defined by the *Sensitivity* of the urban context where the solar system is planned or proposed, combined with its *Visibility* (close and remote) from the public domain. The more sensitive the urban area and visible the system (high "criticity"), the higher the needed quality. In practice, authorities can set the desired integration quality levels considering local specificities (topography, political and social orientations, available energy sources, city identity image, etc.). In that regard, the case studies of new and existing urban areas such as *The Photovoltaic Village in Alessandria* (Italy), *London Solar Community Ontario* (Canada), *Verge project Lugano Pardiso* (Switzerland) and *Le Albere* (Italy) are emblematic examples.

Figure 37 - *System geometry: view of the PV systems integrated in the roofs from the terrace of the MuSe (Photo: © Silvia Croce).*

THE PHOTOVOLTAIC VILLAGE
ITALY
2

LONDON SOLAR COMMUNITY ONTARIO
CANADA
2

SCIENCE AND TECHNOLOGY PARK BERLIN ADLERSHOF
GERMANY
2

LE ALBERE
ITALY
2

TARGET GROUPS

2 2

NEW AND EXISTING URBAN AREAS

The lessons learnt for *Visual impact – urban sensitivity and integration quality* from the case studies of new and existing urban areas are:

3 Using the LESO-QSV method to tailor solar energy in urban planning

Additionally the method proposes a way to tailor solar energy policies to local urban specificities by mapping the architectural "criticity" of city buildings surfaces, and crossing this information with the city solar irradiation map (LESO-QSV crossmapping), representing the solar potential of these surfaces [1][2]. A process to automatically establish the visibility of the surfaces in the 3D models of cities is currently being developed at EPFL LESO-PB Laboratory, as part of a PhD thesis work [4]. The information related to surface visibility should not only consider the purely physical visibility from the public domain, but should also take into account the hierarchy of the different points of view in relation to their importance for the perceived city identity (the view from a major city square being usually more crucial than the one from a secondary parking lot). Possible crossed graphic representations of insolation and criticity are currently under development in the Laboratory, for the different planning scales [3][4].

Figure 38 - *LESO-QSV Planification: crossmapping tool (sun availability/surface Criticity) © MC Munari Probst)*

[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] Munari Probst MC, Roecker C "Urban acceptability of building integrated solar systems: Leso QSV approach", in proceedings ISES 2011, Kassel, Germany, 2011

[3]Florio, P., Roecker, C., Munari Probst, M. C., Scartezzini, J.-L.; "Visibility of building exposed surfaces for the potential application of solar panels: a photometric model", 2016 UDMV Workshop, Liège.

[4] Florio, P., Schüler, A., Munari Probst, M. C., Scartezzini, J.-L.; "Visual prominence vs architectural sensitivity of solar applications in existing urban areas: an experience with web-shared photos.", CISBAT 2017, Lausanne.

Data from: (roof irradiation) http://www.uvek-gis.admin.ch/BFE/sonnendach/?lang=fr
(ISOS) https://data.geo.admin.ch/ch.bak.bundesinventar-schuetzenswerte-ortsbilder/PDF/ISOS_4397.pdf

TARGET GROUPS

3 3

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 61 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

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For more information on the IEA SHC work, including many free publications, please visit www.iea-shc.org