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STÄDTISCHE VERDICHTUNG UND ENERGIE VERHALTEN DER BESTEHENDEN GEBÄUDE

VERGE PROJECT

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1 Methodology and Objectives of VerGe research project

1.1 Introduction

Urban planning determines significantly the possibility to relish solar irradiation in buildings. Solar energy exploitation on existing buildings could be compromised during urban transformation. Dense and compact urban settlements with mixed use provide a complex environment, where solar access and daylight availability can become a scarce commodity with also implications in the urban microclimate and building thermal performance. This is mainly related to the complex dynamic shadowing effects on building surfaces as a consequence of modifying the sky factor, when high-rise buildings increase. In the same way urban densification can influence the building energy demand and building thermal performance, the level of conservation of existing buildings (in particular historical buildings) with also implications in the urban microclimate [1].

The need to accurately quantifying these effects is a key factor for predicting reductions in solar availability to understand the real impacts to drive the corrective measures, if possible.

The urban densification and the conservation of soil, however, as a parameter of environmental and socially sustainable development, in Switzerland and in other EU countries, has being supported and emphasized through strategies and regulations at a national and federal level. At urban level in the Canton Ticino, they are explicitly mentioned among the objectives of the Piano Direttore Cantonale (Flächennutzungsplan) and are underlined in the plan guidelines related to urban densification.

Furthermore, Swiss federal energy policies also emphasize the importance of incrementing the supply of energy from renewable resources, while also reducing the energy demand in consumption sectors, with specific focus on the construction sector. These objectives have become much more relevant since the 2011 Fukushima nuclear station accident, after which principles were defined for a new “2050 energy strategy”. Furthermore, the future obligation to install at least 10 Watt/m² of PV in new buildings (today only voluntary), as reported in the new “Model for energy requirements at Swiss Cantonal level”, presume a “revolutionary” change in the configuration of dense neighborhoods and in the cities themselves.

However, to maximize solar energy exploitation in urban zones it is necessary to ensure its acceptance on an upper level assuring both building and urban context needs regarding the degree of “transformability” of these places. To prevent an arbitrary use of solar energy technology, it is necessary to assess the solar potential (solar photovoltaics, thermal collectors and direct and indirect passive solar systems) and availability for a building in relation with its immediate environment and with its constructive and typological features.

Many issues however are still unknown:

- How are the dynamics of this urban change?
- How to measure the impact of a sprawl urban development or infill compact settlements?
- What will be the real influence on social communities?
- What are the implications for existing buildings during the process? And not least, what can be the impact on the mid-term stationary buildings, and especially on long-term stationary buildings under guardianship, with protection constrains that must be unalterably preserved?
- What does solar energy mean for heritage sites/landscape?

2 Stellungnahme des BFE zum Projekt MuKEN 2014. Publication date: 25.06.2014.
- What does solar access rights mean in terms of new/existing neighbourhoods and building design?

All these questions have been addressed and considered in this project.

1.2 Objectives and methodology

This research project “Städtische Verdichtung und Energie Verhalten der Bestehenden Gebäude”, named VerGe, aims to investigate how urban modifications, in particular urban densification policies, can influence the energy demand, the conservation level and the solar availability of pre-existing buildings but also the impact on the perception and visibility of the heritage protected. Based on this initial insight, the project aims to recognize, understand and analyze different urban densification scenarios, considering the massing of the buildings and other aspects like the sky-view factors or solar radiation impact analysis to investigate if the urban pattern and the building design in the scenarios considered are suitable for preservation and conservation of energy behavior of existing buildings.

This research is based on the analysis of a real case study in Ticino (Switzerland), in the Paradiso municipality, part of Lugano's settlement. 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, as defined in the new master plan regulation.

To investigate the impact of urban densification in the energy behavior of existing buildings and in particular on the sensitive and valuable heritage cultural monuments, simulation and photographic diagnosis tools are used. The usefulness of the information analyzed will serve to provide a basic design guideline for urban planners or public and private institutions responsible for the protection of the cultural assets with the purpose of seeking a new form to best utilize the methodology proposed in the optic of considering the solar access rights becoming aware of the real problems caused by the urban sprawl. Within the project different meetings have been organized between the SUPSI advisory board and different stakeholders (architects, planners, Heritage Science’s specialist) and decision makers (municipalities and public authorities). From the beginning of the project, they have been involved proactively in order: (i) to share the proposals for the urban densification scenarios, (ii) to identify the key-parameters for the assessment of their effects and (iii) to perform a multi-criteria analysis for the comparison of the scenarios on the basis of their effects. Moreover, the project benefits from the collaboration with the IEA Task 51 international expert group.

The research main objectives and methodological process can be summarised as follow:

![Figure 1: Lugano Paradiso development (2003 - 2008 - 2013).](image)
The activities undergo the following steps (a Mind Map diagram that serves to clarify each point and the parameters of study associated to each work package is presented in Annex 1, paragraph A.1):

1. **Identification of characteristic buildings** (cultural protected monuments) already existing in the context of Lugano Paradiso;

2. **Current and new urban transformation status analysis**: Identification of the relevant parameters highly influenced by urban morphology to assess the impact of densification urban policies on existing buildings to be considered during land planning and design scenarios phase (i.e. solar energy access, passive solar gain, daylight access, historical preservation and value, building consumption, visibility and view contact);

3. **Development of different urban densification scenario** based on such parameters. Regarding the technical aspects of this research, urban densification provides a complex environment, where self-shading and overshadowing by adjacent buildings can dominate solar energy potential and daylight availability. Such environments can vary significantly from site to site, depending on their latitude, distances between buildings and the height, among others. Simulation tools, such as Radiance/Daysim or Ecotect software, have been used in order to predict the dynamic effects of surface overshadowing at urban scale. The urban plan in the present and in the future situation (when the New Master plan in the Paradiso area will be implemented) have been analyzed in order to conduct the VerGe process analysis from the initial (preliminary phase) to the late design simulation phases (Master Plan situation). The two considered scenarios have allowed testing the urban planning solutions proposed in the master plan, becoming aware of the conflicts between the existing buildings (in particular protected heritage buildings) and the surrounding public urban areas, in order to understand and assess the urban densification impacts on the energy behaviour and conservation level of existing buildings, through a methodological evaluation process. Such assessment has focused in particular on the exploitation of sunlight and solar energy (both passive and active) in the existing buildings and urban areas: in fact, the great challenge is to identify methods and tools to support the use of solar energy in already urbanized and built areas. In this circumstances the research wants to propose a methodology to assess in advance, already in the design phase, the effect of new urban planning implementation on the behaviour of existing buildings (solar availability and thermal comfort) to know all the impacts on the solar availability and the solar energy harvesting which can negatively affect the energy balance of
the building, its preservation and the renewable energy production (i.e. by the use of Photovoltaic or Solar Thermal systems), if considered.

4. Guidelines, recommendations and theoretical principles definition, based on the case-study results, strategies able to favour effective integration and harmonization of conflicts have been summarized and elaborated at the end of the document.

By doing so, this project allows promoting cross-sectorial synergies between the research/educational advisory board, the Heritage Science’s players, and the stakeholders in order to transfer know-how and competences into municipalities and heritage buildings (HBs) administrators or surveyors to trigger a global change in urban planning operation, considering culture, place, technology and field of knowledge. In this perspective, it is expected that ongoing and future research projects, and on-site novel approaches, would benefit from the VerGe project outcomes.

1.3 Relevance of project results for historic preservation practice

The main expected benefit of the project is to overcome the “lack of knowledge” among architects and urban planners related to the effects of urban planning policies specially linked to the energy consumption and production on buildings on solar and to spread the use of existing and new tools and methodologies into everyday professional activities considering all the scales of the design process (urban, building and energy scale) also in the previous stages in the definition of the new master plan of the cities. The outcomes of the project (set of relevant parameters to be investigated, tools to be used and, guidelines and recommendations to be aware of) will be, in fact, available for the consultation at municipal and cantonal levels and might also become a reference point for professional associations. They will also be directly used within teaching activities (e.g. Bachelor of Arts in Architecture), and in life-long learning programs (post-graduation courses for practitioners) held in SUPSI (Diploma of Advanced Studies in Energy management) but also in other universities.

The collaboration with the Task 51 of the IEA (which bring together many experts from different countries) will spread also the results to the international community. The main objective of Task 51 is to provide support to urban planners, authorities and architects to achieve urban areas and eventually whole cities with architecturally integrated solar energy solutions (active and passive), highly contributing to cities with a large fraction of renewable energy supply, considering also the special case of heritage sites/landscape.

![Figure 3: Task 51 “Solar Energy and Urban Planning” official web](http://task51.iea-shc.org/).

IEA Solar Heating and Cooling Programme (SHC) started in May 2013 to April 2017. SUPSI together with the École Polytechnique Fédérale de Lausanne (EPFL), participate as Swiss member in the round table cross-country discussion about the topics and objectives to be achieved in the task.

Finally, at the local level (case study areas), we expect the activation of a process of empowerment of stakeholders and local authorities, which will hopefully lead to the revision of their land planning and design tools, according to the scenarios developed in the project.
2 Status of the project

2.1 Resources and organization of the project

The project referent for the entire process and to lead the advisory board is the Department of Environment, Construction and Design (DACD) within the University of Applied Sciences and Arts of Southern Switzerland (SUPSI).

The main research unit of the Department for Environment, Construction and Design (DACD) at SUPSI that participate at the project is:

Institute for Applied Sustainability in the Built Environment (ISAAC)

The ISAAC is part of the University of Applied Sciences, Southern Switzerland (SUPSI). The research activities and the scope of the Institute develop mainly on two areas: on one hand, renewable energy and in particular solar and geothermal energy, and on the other hand the rational uses of energy in the construction of ecological and economic criteria.

Other local contributors

- Lugano Paradiso Municipality
  
  Mr. Matteo Mazzi, Deputy Director AAP and Architect UTC, Municipal Technical Office of Paradiso.

- Planidea SA, Ticino company that provides consulting services in the following fields: Urban and territory planning, protection of the environment, mobility management (Ing. Paolo ROGGIANI). Planidea has provided the AutoCAD drawings of the new urban development planning of Paradiso Municipality.

- deltaZERO, de Angelis - Mazza architect. The architectural firm De Angelis Associates, based in Lugano Paradiso, focuses in the design of flexible buildings with low energy consumption and high living comfort, NZEB, net zero energy buildings. These buildings must produce more energy than they consume thanks to renewable energy sources such as photovoltaic and solar thermal systems combined with high-tech systems as geothermal. The architects that, live and work in Paradiso, know the real implications that urban changes are generating in the area and its contribution may be important as stakeholder.

International contributors

- IEA task 51 "Solar Energy and Urban planning". The main objective of Task 51 is to provide support to urban planners, authorities and architects to achieve urban areas and eventually whole cities with architecturally integrated solar energy solutions (active and passive), highly contributing to cities with a large fraction of renewable energy supply, while heritage and aesthetic issues will be also taken into account. The main aim is to encourage cross-country cooperation about this field. (http://task51.iea-shc.org/)

As participant to the IEA task 51 ISAAC-SUPSI will contribute to the different subtask, mainly to the Subtask C: Case studies and action research, with the VerGe project. The VerGe project will be part of the Swiss database of best practice on activities supporting this action research.
2.2 Project plan with milestones

As had been stated in the project definition, the schedule envisages after the first four months a preliminary discussion with stakeholders (municipalities, urban planner and architects) in order to include their comment and wishes in the definition of the scenarios and the relevant parameters. In month 10 a second milestone has been included in order to evaluate the different scenario identified in Task D and E.

A first report has been delivered as schedule in the time plan. Additional time was required to complete the final delivery for the second part, which completes the final project document. In this period a third Workshop with expert and stakeholders has been organized in order to prepare this final report, more details are presented in following paragraphs.

2.3 Workshop with stakeholder

Thanks to the collaboration of the Lugano-Paradiso Municipality, specific meetings have been performed to discuss with the local authorities and the state government officials, about the case study that has been selected for this research. Mr. Matteo Mazzi, Deputy Director AAP and UTC Architect of the Municipal Technical Office of Paradiso, has exchanged information with the advisory board and the researchers, about the urban transformation process that now is in act in the area of Paradiso starring by the new master plan which provides for a significant increase densification in the city center urban area. The specific features of this case study will be described in detail in the following sections of this document.

Other different stakeholders have been attended to these meetings together with local authorities and experts in urban planning. Experts in energy efficiency, solar energy and simulation software of the SUPSI working group together with representative architects and building owners have collaborated to achieve the best results and to gather the inputs collected from all the main part involved in the decision planning process.

The main local contributors were:

- Lugano Paradiso Municipality: Mr. Matteo Mazzi, Deputy Director AAP and Architect UTC, Municipal Technical Office of Paradiso.
- Planidea SA: Mr. Paolo Roggiani, engineer consultant specialized in urban and territory planning, protection of the environment and mobility management. Planidea SA, a consulting services company on Urban and territory planning has provided the research group with the Master Plan drawings that will serve to accomplish with the point 2 of the methodological process: Current and new urban transformation status analysis.
– deltaZERO, de Angelis-Mazza architect: Mr. Stefano De Angelis, architect director of the architectural firm De Angelis Associates, based in Lugano Paradiso, focuses on low energy consumption buildings NZEB.

Furthermore, the project has counted also with the participation of Mr. Alfredo Varisco, owner of one of the protected cultural heritage building studied (Building 3, Palace G. Guisan street, A4907) and real estate developer in the area. This historical building was used as an example to simulate in a dynamic way the energy consumption impacts due to the densification processes and caused by the changes undertaken and implemented with the new plan.

![Figure 4: Mid-term workshop with the stakeholders involve in the VerGe project.](image)

### 2.4 Dissemination activities - Publications

**Conference and articles:**

- Tastk 51 “Solar Energy and Urban planning”. Participation at Subtask C: D. C1 Database of best practice. VerGe project has been presented as case study at 7th Meeting 19th March, 2015 Trondheim, Norway (abstract submission and poster presentation).


**Future Publications:**


  Title: Solar Radiation and Daylighting Assessment Using the Sky-view Factor (SVF) Analysis as Method to Evaluate Urban Planning Densification Policies Impacts.

  Title: The energy performance evaluation of buildings in an evolving built environment: an operative methodology

Title: Existing buildings energy performance change in urban densification processes, a method to assess solar availability in a Swiss case study.

Seminars and workshops:

Lecturer regarding the topic: “Photovoltaics in historical and city core contexts” in the life-long learning programs held in SUPSI (post-graduation courses for practitioners).

b) March 2015: Elective course in the Bachelor of arts in Architecture program held in SUPSI regarding solar energy (R 676 Course: Architecture and solar energy)

The VerGe project was taken as inspiration to develop a specific seminar with students regarding a practical training on the topic “integration of renewable technologies in the urban context and in existing buildings”, to promote the acceptability to the solar photovoltaic technologies in urban areas enhancing the cultural heritage and to generate debate on the energy aspects and supply solar. The results of this seminar represent a different way to take advantage of new urban solutions to promote historical heritage buildings affected by urban transformation policies.
The **urban densification** and the **conservation of soil**, as a parameter of environmental and socially sustainable development, are very current discussion topics about which there are still few scientifically proved bases.

In Switzerland these concepts are also acknowledged by visions and regulations at the federal level together with the importance of increasing energy supply by renewable energy sources and reducing the energy demand in-prims of existing building. National and regional policy strategies on the other hand striving at a minimize environmental impact of new developments by setting the context in which urban planners can develop plans for new and existing urban areas.

The need for high quality densification of urban settlements is gaining momentum also in the public opinion, as recently stated by Schweizer Heimatschutz³, the Swiss Heritage Society, which agreed for a reasonable and sustainable use of the land. In the document published in autumn 2010: "L'aménagement du territoire face à de grands défis / Raumplanung vor grossen Herausforderungen" [1], it has been exposed by what means it is possible to act to follow these goals. The central point is a better organization and an equally better exploitation of areas already built, taking the surplus resulting from the re-insert or re-use of an urban area to exploit the existing potential to curb the disorderly expansion of settlements.

Numerous examples are known of urban evolution of twentieth century's dismissed post-industrial architecture, derelict buildings and degraded city cores that have been managed to convert in new cultural sites, museums, auditoriums, public and private buildings etc. by means of revamping cities to which they belonged to.

In these areas modernity overcomes tradition, the technological process manifests as an element of renewal and transformation that motivates and re-feed the positive change. Heritage of cultural interest, places, artifacts, and buildings as memory of the past that no longer exists, today

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⁴ Source: ARE, Federal Office for Spatial Development ARE (http://www.are.admin.ch)
Degraded and decommissioned, take on a new life with a new appearance and function in the new urban transformation process.

These singular transformations for the revitalization of these places, although if driven by new challenges to the conservation project related to the control of energetic and eco-sustainability aspects could still arouse opposition by the general public and by the authorities in charge to the protection of the cultural heritage.

![Figure 6](image1.png)  ![Figure 6](image2.png)

**Figure 6:** 1) New center Neuhegi-Grüze in Winterthur East. The decommissioned industrial area, Sulzer Winterthur, since 1995 is undergoing an interesting transformation process based on the coexisting presence of new buildings and modern uses in old factories; 2) Zarrotzaurre new master plan commissioned to Zaha HADID architect and part of the urban regeneration of Bilbao (ES). The old factories that have occupied this place, rooted in the city’s maritime past for many decades, will continue to play a role in this new urban plan.

![Figure 7](image3.png)  ![Figure 7](image4.png)  ![Figure 7](image5.png)

**Figure 7:** 1) Area Sulzer Winterthur, Zürich (CH); 2) Basque Country, Bizkaia, Bilbao (ES), New Civic Center; 3) Nationale Nederlanden building of Gehry Partners and Vlado Milunic Architects, placed in the city core of Praga (CZE).

The urban sprawl, dense new master plans or in-fill settlement developments generate an urban transformation which affect specially the existing buildings, which remain in place for a certain period of time (mid-term stationary building) until the new urban plan amends the current situation, or moreover, those protected buildings and unchangeable cultural properties (long-term steady buildings). How do these urban revolutionary changes towards densification appear and impact?
Furthermore, the risks of densification process, anyway, are important if new measures are implemented quickly and without a careful study of the boundary conditions that serve to meet with the qualitative and architectural culture of the place. The interest is also to avoid the opposition of the population towards this transformation.

The Swiss Heritage Society suggests **ten basic rules for a quality densification process** that are:

1. **Consider the identity** and the specific quality of construction;
2. **Respect inventories**;
3. **Safeguard of historical and memories elements**;
4. **Find the optimal densification degree** in compliance of the appearance of a place;
5. **Meet consensus** to foster the acceptance;
6. **Promotion of quality architecture**;
7. **Find suitable function and land utilization** to enhance an area or a neighborhood;
8. **Encourage diversity** to accommodate different functions to minimize the impact of commuting;
9. **Preserves and create free spaces**, for leisure and for cultural and social interrelationships;
10. **Actives tools and land policy** with good public examples that becomes a driving force for the private actors.

Obviously, all of these aspects are important and are a significant starting point. When new areas are planned, different aspects will be taken into account in a first step, for example: the topography of cities and their urban built environment; the separation of the streets, the local climate; building heights; depth of the spaces; the floor area ratio (FAR); the orientation and solar exposures; buildings solar reflection; the outdoor spaces for social relationship design; suitable zoning; etc. The microclimate around a building, establishing through the interaction with other buildings or the natural environment, is a significant factor in the building energy consumption.

These and other aspects are essential also to asses and prepare new and existing buildings for the proper integration of **solar energy strategies (active and passive)** in the existing urban areas. In densely built-up areas, such factors as the specific climate local conditions, buildings’ geometry, the materials and colors, as well as the size and morphology of the roads can affect the solar radiation absorption and reflection, the energy demand and thermal performance of existing buildings, the daylighting and solar availability for passive and active strategies, in order to reduce the energy dependency, as stated by the Swiss Energy Strategy 2050.

Buildings and urban planning have a long time horizon, while new energy policies will increase quickly the potential of using solar energy for a long time ahead. Meantime, the lack of knowledge about rights and laws solar access, which still are not taken into account in current planning policies, can become a development barrier for the coming years.

In this development process, special cases are the **cultural protected monuments**, unchanged and immutable through time, which express their history and their continued right to existence, protected by the regulatory plans and bound by preservation needs and constraints that cannot benefit from an unconscionable urban development. At this point one has to wonder for the impact of this kind of urban transformation and about the real influence on visual perception or “behavior” of pre-existing buildings (especially building with historical value) and their surrounding micro-climate.

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5 Floor Area Ratio (FAR): is the ratio of total net floor area of a building to the total lot area. An FAR describes the intensity of the use on a site.
4 State of the Art

Sustainable development may be defined as development that optimizes the quality of life of people, including future generations, considering both economic and environmental aspects. From this starting point, there is a general consensus among the scientific community on the need for developing compact urban settlements [2]. From the Aalborg Charter\(^6\) (May 1994), the importance of implementing effective policies in land use and planning was recognized, involving a strategic environmental assessment. The emphasis was put on the opportunities offered by dense urban concentrations to provide public transport services and more efficient energy supply, while at the same time, preserving the human dimension of development. Further on the Leipzig Charter and the Toledo Declaration, 2010, point to the need of integrated urban development policies, which promote, among other things, the creation and consolidation of quality public spaces, upgrading infrastructure networks and improving energy efficiency as well as the development of efficient and affordable public transport systems.

In terms of urban planning, five characteristics usually describe the quintessential of compact and complex urban settlements, and that clearly differentiate these from the scattered and diffused urban models. These characteristics, closely linked to each other and would not be related to issues such as energy efficiency or greenhouse gas emissions, are: urban density, building compactness, complexity of uses and functions, accessibility and proximity to services and basic equipment, and mobility in the urban environment. Finally, social cohesion and territorial cohesion is also established as a priority objective of the sustainable city urban model. From this point of view, urban models and city configurations is not developed, therefore, purely from a territorial standpoint, but through a holistic approach, since, as mentioned above, the organization of the territory has a direct influence on both mobility and the management of natural resources, energy efficiency as well as essential aspects of social cohesion and economic development\(^7\). [3].

Many European research projects focuses in Heritage and sustainable development will enable Cities to work together to develop solutions that are new and sustainable to major urban challenges integrating economic, social and environmental dimensions, reaffirming the key role they play in facing increasingly complex societal changes. URBACT [4], financed by the European Regional Development Fund, for example, is a European exchange and learning programme\(^8\) for promoting sustainable urban development. Within the project it has been experimented the use of interactive media tools to elaborate potential uses of existing infrastructure and resources in an urban area, transforming empty properties to allow them adopt new uses, with the aim to densify the existing urban areas. TUTUR project\(^9\) serves to introduce the method of temporary use in urban regeneration to cities by participating in a network that engages an important number of municipal and private economic development agencies, property owners, as well as cultural organizations and architects (and landscape architects, designers) playing a key role in the development of models for interim use and in the establishment of temporary spatial possibilities.

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\(^7\) Marín Cots P. et al. (2012). CAT-MED Sustainable urban models. Work methodology and results. CAT-MED project (Changing Mediterranean Metropolises Around Time) EU project CO-financed by ERDF (project started in 2009).

\(^8\) This program is part of Europe’s cohesion policy: its goal is to help implement the Lisbon-Gothenburg Strategy, which prioritizes competitiveness, growth and employment. The “Gothenburg Agenda” defined during the meeting of European Council held in June 2001 in Gothenburg, complemented the Lisbon strategy by adding an environmental dimension. The Gothenburg agenda is focused on a new emphasis to protect the environment and achieve a more sustainable pattern of development.

Figure 8: Temporary tool www.city-hound used as a generator and incubator of self-organized projects and a testing ground for long-term uses. If anyone knows about empty buildings it is possible to post on city-hound platform to make people think of something to do with them (as example the city of Rome, Italy).

CURE, Creative Urban Renewal in Europe\textsuperscript{10}, reflect about the cities with substantial and valuable heritage with the aim to overcome the aspect linked to the too rigid protection regulations in urban areas that not allow even the most needed adaptation of historic buildings and areas to the requirements of recent times. Even in such cities, however, there might be debates between the contradictory aims of conservation vs. modernization of heritage areas. HerO, Heritage as Opportunity\textsuperscript{11}[5], network provides a worthy complement here in its search to devise integrated systems of cultural heritage management, preserving and developing historic urban landscapes as a key facet of the dynamic multi-functional city. Emphasis will be placed on managing conflicting usage interests and capitalizing the potential of cultural heritage assets for economic, social and cultural activities (Heritage as Opportunity). CTUR and Creative Clusters, Creative Metropoles and CLUSNET [6] projects also make a contribution to this sub-theme on the issue of innovative entrepreneurship in the context of the urban cultural heritage. Qualicities, Quality – Cities [7], for example, is a comprehensive project proposed to the European local historic communities in order to help them improve their outputs. It is based on the assessment and optimization of the local community’s patrimonial assets and has a wider objective to improve their performance, and to satisfy users.

Other example of sustainable urban development’s focuses also in energy efficiency of buildings to propose new solutions and promote new policies for the sustainable renovation of existing cities. In these cases, a participatory processes driven by local administration highlighted the role of the municipalities in urban planning by setting an example of and encouraging sustainable construction practices during rehabilitation of building stocks working with citizens. [8] [9]

At Swiss level through model projects\textsuperscript{12}, the federal government (BFE) supports local, regional and cantonal projects that experiment new approaches to achieve sustainable development of the

\textsuperscript{10} CURE is an EU-funded project (INTERREG IVB NWE) which aims to facilitate triggered growth of the creative economy in decayed urban areas in medium-sized cities in Northwest-Europe. <http://www.cure-web.eu/> [Consulted in April 2015]

\textsuperscript{11} HerO EU-funded project. Organization of World Heritage Cities (OWHC) network. Their main objective of HerO network is facilitating the right balance between the preservation of built cultural heritage and the sustainable, future-proof socio-economic development of historic towns in order to strengthen their attractiveness and competitiveness.

\textsuperscript{12} Model projects on Sustainable development of the territory (2014-2018).
territory. The model projects for sustainable development of the territory are real-scale laboratories where new methods, new approaches and new procedures will be experienced, completing the existing tools for sustainable development of the territory in a targeted way. Priority themes in these project models are: making a centripetal development of settlements; promote spaces not built in agglomerations; create a sufficient and appropriate offer of accommodation; promote the economy in the functional spaces; exploit and use natural resources in a sustainable manner. Among these new model projects for the 2014-2018 it is possible to note those that refer to the development of centripetal settlements actions, specifically, the model projects for a quality densification, the maintenance of the building culture and for the protection of landscapes not built in rural areas on the canton Valais based on the example of the landscaped park Binntal (“Binntal VS, regional Nature Park”).

Previous experiences as the “Sustainable neighborhoods for the agglomeration of Lausanne” (2007-2011) allow to develop the first online open source tool called “Sustainable Neighbourhoods by SMEO”\(^\text{13}\) for the evaluation of processes for each life cycle of a neighborhood (genesis, creation and use). To assess sustainable neighborhoods, SMEO tool allows to take into account important aspects such as requirements, governance, architecture, costs and finances, infrastructure, soil and landscape, the factors of identity, comfort and health, mobility, life in the community, security, water, materials, waste and energy, for example.

Another good example is the project Raum + Schwyz\(^\text{14}\) - Reserves of land for the development of the settlement to the inside (that have been already mentioned in the Foreword) in the canton of Schwyz (2007-2011) to mobilize and use the available reserves in construction zones and to develop the internal reserves as part of the planning process.

Regarding urban densification process, in Switzerland these concepts are also acknowledged by visions and regulations at the federal level (for instance: [10], [11], [12]). In the Canton Ticino, they are explicitly mentioned among the objectives of the Pian Direttore Cantonale (Flächennutzungsplan) and are underlined in the plan guidelines related to urban densification [13], [14], [15]. The need for high quality densification of urban settlements is gaining momentum also in the public opinion, as recently stated by Schweizer Heimatschutz [16].

Last year the Swiss Heritage, for example, awarded the City of Aarau with the Wakker Prize 2014. The capital of the canton of Aargau receives this award for the exemplary implementation of a quality densification that preserves the identity the different neighborhoods.

At the same time, energy policies developed at the federal level stress the importance of both increasing energy supply by renewable energy sources and reducing energy demand in the final consumption sectors, with a special emphasis for the building sector (mainly on the existing building stock, as new constructions account for little more than 1% of the building stock per year). In such a framework, political statements and directives aimed at stronger integration between energy and building sector concerns were developed (see for instance the EU Directive on net energy zero buildings [17]). What is the impact of these measures on existing buildings (especially with historical values)? How will future urban transformation process influence the “behavior” of pre-existing buildings (especially building with historical value) and the surrounding micro-climate?

The actuality of the energy issue has recently brought attention to the possibilities offered by the local climate and conditions of a site to exploit these resources in a passive way and at the same time deepens the search for constructive solutions that meet the requirements of environmental

\[^{13}\text{SméO tool. http://www.smeo.ch/}\]

\[^{14}\text{The Raum method is based on a cooperative and dialogue approach aimed at exploiting the knowledge not only of the local representatives, but also of external experts; the method was used to detect the reserves of soil in settlement areas and besides to understand their quality.}\]
comfort to limit consumption of heating and cooling. Many ancient civilizations have harnessed the sun’s energy to add comfort to living spaces. Already the treatise on architecture written by the Roman architect Vitruvius\textsuperscript{15} (written around 15 BC) invited architects to understand and take advantage of the orientation of the lot with respect to the sun and prevailing winds.

The thermodynamic and meteorological phenomena that determine the "climate" characteristic of a region have been in most cases, the determining factor in the location of the first urban settlements. The ancient city has created its first condition intrinsic and environmental illuminance, landscape, geomorphological, etc. sometimes associated with its natural territory and others in marked contrast with them.

The problem of the density of the building fabric decisively influences, with the orientation and the morphological characteristics of the buildings, the energy and bioclimatic performance of a settlement.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{example.png}
\caption{Examples of various urban settlements, the city of the Middle Ages, the city of the Renaissance, the concept of English garden city (Letchworth), the development of the modern city, Barcelona, Cerdà Plan 1859.}
\end{figure}

Even though different European [18], [19] and national [20], [21] projects already proposed innovative approaches to raise energy efficiency through urban development and the refurbishment of the building stock, effective methods and tools able to evaluate solar energy aspects and support the planning and design process are in fact nowadays still lacking or in prototype stage. [22]

A good orientation of the building in the urban fabric does not ensure all the necessary hours of sunshine. This aspect however is also very important when apply the rule of the "right to the sun" with the right distances between buildings to allow the façades have the right amount of solar in winter time. In the same way factors such as the geography and topography of a place, the type of vegetation or soil characteristics and the built mass around the building, could affect not only the sun and daylight availability but also the local wind regime (wind speed and direction). For example, with cold winds could be problematic low speeds of 0.5 m/s, while in hot and dry areas would be desirable up to speeds of 3 to 3.5 m/s.

\textsuperscript{15} Vitruvius. On architecture, published as Ten Books on Architecture.
Solar rights and Solar access laws already define the proper configuration of buildings' shape, restricting the height of buildings in function of the width of the roads in order to ensure a correct sunlight and solar gain. However past efforts were focused on single new buildings and in particular allowed to get comprehensive understanding of the opportunities of exploiting the sun in buildings in both active and passive ways (see for example[23], [24], [25], [26], [27]). The scientific community is however well aware of the need to enlarge the scale of analysis and to move to urban planning and design scales, which would better allow to take into account the buildings’ shape, orientation and density and to detect possible cumulative effects limiting both the access to sunlight or solar gains, changing the wind path and consequently the micro-climate, and the possibility of equipping them with solar systems.

Moreover the impact on solar energy availability on existing buildings (in particular historical buildings) during urban transformation is still not well understood and is a matter of research. That’s way also the recent decision of the International Energy Agency (IEA) to set up a new working group on “Solar energy in urban planning” aimed at monitoring progresses in such issues, proves the innovation of the research questions we propose. [28]

The use of simulation tools, such as Radiance/Daysim and DiVA [29], [30], [31], 3D models and advanced tools (e.g. daylight and solar potential simulation tools) for the calculation of solar energy potential in this case, has proven to be an effective system to predict the dynamic effects of surface overshadowing at an urban scale. This kind of analysis allow to improve existing model design in order to conduct the process of the project from the initial (preliminary phase) to the late design simulation phases, permitting to test different design solutions, to solve the conflict with existing buildings and existing public areas and to check effects on the surrounding and go back to test a new one scenario with an iterative process. [32], [33], [34]

Some research studies focuses on solar energy and its integration in urban areas develops theoretical models consider different key issues such as: demography, urban form and morphology, built environment, land densities and uses, population growth, suitability, spatial zoning and neighborhood effect applying models from a macro-scale to micro-scale to understand the relationships of these parameters in urban planning process, using Geographic Information Systems (GIS) [35], [36], [37]. The only problem might be the complexity for developing the 3D model and the extremely accuracy in the analysis conducted really not necessary when the scope is to provide Municipalities with a basic tool, method and rules to quickly detect negative/positive energy impacts on a new urban process development.

Other tool16 (used with most common building energy software such us EnergyPlus17) allows quantifying the full microclimatic factors that influence the microclimate around a building in an urban context, considering the interaction with other buildings or the natural environment, which is a significant factor in the building energy consumption. Parameters as solar radiation, long wave radiation, air temperature, air humidity and wind speed are considered in this case. [38]

Instead of this complex kind of analysis there are also more simple methods to estimate some parameters to characterize the correct geometry of urban settlements. These approaches study aspects like sky-view factor using digital cameras with fisheye lens or specific software to analyses the incidence of urban canyon geometry [39].

Another aspect to be study with more detail regards “solar right” laws approach, aspect that will be the subject of a specific paragraph later.

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16 Urban microclimate model ENVI-met. ENVI-met is a three-dimensional microclimate model designed to simulate the surface-plant-air interactions in urban environment. <http://www.envi-met.com/#section/intro>

17 EnergyPlus is an energy analysis and thermal load simulation program. <http://apps1.eere.energy.gov/buildings/energyplus/energyplus_about.cfm>
As stated before, this research project is based on the analysis of a real case study in Ticino (Switzerland), in the Paradiso municipality, part of Lugano's settlement. The key point was to study the main characteristics of the current and future condition of this urban settlement to detect the relevant parameters highly influenced by urban morphology to be considered during urban planning transformations and design scenarios phase.

Lugano-Paradiso, districk of Lugano (Ticino Canton, Switzerland) was once called Calprino and took its current name from a fraction of its territory. A municipality of about 4300 inhabitants, with a varied composition of the population and the presence of important financial, commercial and administrative activities. With an enviable territory overlooking, in the flat section of the shore of the beautiful Ceresio Lake while in the slope part of the territory lies at the bottom of Monte San Salvatore and gives stunning and panoramic views over the prestigious bay of Lugano. Therefore the various areas of the territory are characterized by different land slopes.

The town of Calprino then called Paradiso, was once a town with gardens, orchards, the cultivation of silkworms, the textile-mills (1834 -1889) and, with the opening of the Hotel Panorama (1870) and Bucher-Durrer (1889), start to exploit a tourism potential; also the industry sector with the vassals Brewery (1894). The first traces of human settlement in the territory of Paradise go back to the Romani, while the presence of the Lombards is historically dated towards the end of the century VII. From 1286 to 1513 the town of Paradise, had belonged to the Duchy of Milan and then at that time will be part of the bailiwick of Lugano, governed by the twelfth Cantons.

This area of Lugano has had a strong economic development in recent decades with the result of an increasing population growth and a large building development. in the late nineteenth and early twentieth century, rose there some luxurious buildings and villas, for example, Villa Conca d'Oro, Villa Cirla, Villa Gloria, Villa Apolonia. However, since the early sixty the excessive building development in constant growth and predominantly speculative has radically changed the face of near the lake shore. However, already at the beginning of the century the result of this huge urban

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20) Basilea, Berne, Friburgo, Glarona, Lucerna, Sciaffusa, Soletta, Svitto, Untervaldo, Uri, Zugo e Zurigo.
development was that some valuable buildings, “memory” of the local past, have disappeared especially in the hotel industry.

Paradiso area hosts a long tradition on hotel industry. Some of these buildings are categorized as protected by the urban zoning in the current Regulatory Master Plan. The new Master Plan envisages detailed plans with the purposes of promotion or socio-economic planning of a particular type of construction in this case for tourism promotion of the area.

Figure 11: Postcards from Paradiso Ticino, brochure Hotel Victoria au Lac.

5.1 Urban planning tools and regulation aspects of Paradiso Municipality

The spatial planning\(^\text{21}\) of the territory of the Lugano City is established mainly through a Master Plan. These planning instruments set the balance between built and unbuilt spaces and the buildings destination (offices, homes, shops, bars, restaurants, etc.). In addition, in support of the Master Plan, detailed plans are established. They are specific plans that can meet two main objectives:

- of the area: a more detailed planning of a particular area of the city in order to change and define the urbanism;
- for promotion: undertaken in order to answer the purposes of promotion or socio-economic planning of a particular type of construction.

The territorial management in Paradiso, is especially complex and therefore requires different tools those mentioned so far, and in particular:

1. Detailed Plans area / neighborhood
2. Detailed Plans for Promotion
3. Plans regulators of individual districts with their detailed plans

5.2 Master Plan (PR Piano Regolatore)

In the words of Marco Borradori, Director of the Department of the territory in 2006 and today Mayor of Lugano:

“Organize and manage the land are two fundamental tasks of municipal politics. The criteria and tools to assess the effects of human activity on the soil are provided by the discipline of planning, which helps to resolve conflicts through balancing the various interests at stake and the search for balanced solutions. The City has a central role in territorial development, as it is called in designing the organization of its spaces, define the rules for land use and planning of interventions and the financial resources necessary to achieve the objectives.

The master plan (Piano Regolatore, PR) is the primary tool for land management at the local level and must be constantly adapted to new tasks and changes in society, economy and environment. The pressure on land - the use of which is disputed between functions in competition with each other and hence the origin of conflict - continues to grow. The drive towards the extension of the settlement areas and a greater exploitation of the soil is constant.

On the other hand, fewer financial resources, the uncertainty and risks are reducing the operational capabilities and require careful analysis of choices and financing of development projects. The next generation of PR will have to bend on these issues and promote the existing building zones, encouraging density, the mix of mix of usages and activities searching for planning of quality.”

The Municipal master plan (Piano Regolatore, PR) of Paradiso Municipality originates from the Swiss Federal Law on Spatial Planning dated 22 June 1979 (LPT), the Cantonal Law enforcement LPT on 23 May 1990 (LALPT), the building cantonal Law on 13 March 1991 (LE) and from its Implementing Regulation (RLE).

The current Paradiso Master Plan, which came into full force and effect in August 1997, replaces the primordial municipal planning instrument dating back to 1979. The long gestation of the new PR, lasting nearly a decade, is a testimony to the deepening and the particularity of the contents of the new urbanism, which is not limited to a superficial review of the current plan, but lays the foundation for a radical rethinking of the urban road network and, especially for the core of the country.

With intent of revitalizing the city center, the new PR already underway drives major changes on existing urban development patterns. The proposed project by Arch. Renzo Molina has been enthusiastically accepted by the municipality, especially for the exceptional building potential granted by the detailed plan of the detailed plan of the common center (PPCC)23, with the definition of maximum volumes footprint to nine floors and contiguity mandatory, instead of the traditional division of land parcels.

At the same time this new plan wants to be the basis for the development of tourism quality, to place clear conditions for the protection of environmental values, to protect against the noise pollution produced by the railway and for the planning of the lake shore sector. The new Master Plan is geared towards increased the buildable area and the floor area ratio (FAR), considering the constraints of the township, while keeping constant the total units of settlement (PPCC: 9 floors height; R7 intensive residential area downstream of the railroad; R5 Semi-intensive residential area

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http://www.vlp-aspan.ch/sites/default/files/rpidg_ti_0.pdf
23 Last update of the plan (PPCC), was published in May 2011, endorsed by the State Council in June 5, 2012.
upstream of the railroad). In general, it is envisioned in this plan the regulation of secondary residences, a promotion of primary residences, the maintenance of the hotel industry of quality profile, a corresponding area development both in terms of quantity (development of trade and the primary residence), both from the qualitative point of view (the hotel industry) and an expected significant increase in jobs.

The Master Plan (PR) is a set of prescriptions and predictions that constitute general guidelines for overseeing municipal to regional planning within a stipulated time period.

More specifically - under current building law - the Master Plan is intended to regulate the activities of private and public entities in the development project of the municipal territory, specifying for each part of the territory:

- the criteria for use of funds
- the nature of the construction that there may arise
- the essential characteristics and extent of the works and public facilities
- the immovable things that go to make up the country’s natural beauty and the historical monuments
- the constraints imposed on private

In relation to the theme that concerns us the Article 17\textsuperscript{24} (energy saver, local dimensions, stairs and openings) in Section II. GENERAL BUILDING REGULATIONS establishes measures for energy saving while imposes certain criteria for heating and cooling facilities, health conditions of living spaces (which must receive adequate light and ventilation), the openings and windows sizes, and specifies in general terms the characteristics that must have solar installations. For this purpose, quotes verbatim some of the factors of interest:

II. GENERAL BUILDING REGULATIONS:

Art. 17

3. The installation of solar panels for energy production is possible, provided that the overall dimensions and the main plant components properly contribute to complete aesthetically and architecturally the façades and roof of the building.

4. The spaces intended for habitation must be willing to receive direct light and air.

5. The spaces intended for habitation must have the windows of minimum size equal to 1/8 of the base surface of the spaces.

In Section IV. SECTORAL REGULATION OF THE BUILDING ZONE, more specific rules are defined for each urban area regarding other aspects related to the volumes (volumetric), building heights, size of the roads and also indentations and protrusions in the building envelope. All aspect, that somehow affect the possible use solar (passive, active, natural light, etc.).

5.3 Historical features and cultural monuments in the area of Paradiso

The Civil Protection Consortium of Lugano City, Cultural Heritage Protection Service has surveyed, cataloged and filed - in April 1997- in accordance with criteria and specific parameters, about thirty cultural heritage items public and private (A and B types\textsuperscript{25}) throughout the town of Lugano. For example: have been cataloged, in some areas, streets and buildings (San Martino), chapels and oratories (Geretta Oratory), frescoes, presses, picturesque corners, landscape and characteristic, city park, villas (Cataneo Castle) and rustic complex (Villa the Morchino), an old

\textsuperscript{24} Implementing rules of the Master Plan of Paradiso Municipality (June 2013) – “Norme di attuazione del Piano Regolatore (PR) di Paradiso (Giugno 2013)”.

\textsuperscript{25} PCP Inventory, Protection of Cultural Heritage Category A: Cultural Heritage of national importance, Category B: Cultural Heritage of regional importance.
farm (Guidino Superior) and in the lower part of the City, an architectural construction in Art Nouveau style (Posthotel Simplon).

In Paradiso were not identified assets of national importance. In the classification of cultural heritage, Cattaneo Castle, the Oratory of Geretta, Guidino farm and Morchino complex were categorized as evidence of second degree. These are the most valuable cultural relics in the area, significant testimonies of the past that make up an important historical, religious and cultural center of an era and a great detail of the story of their municipality.

A Starting from 1735, there are several evidences the existence of Morchino, which was then a rural farm whose owners were called Morcaino. Of Guidino area, however, will have testimonies from 1187. The territory of Paradiso, at the foot of Monte San Salvatore, mainly agricultural in ancient times, of which the oldest area was the town of Guidino (eleventh century) with farms, farmhouses, fields where they cultivated corn, namely wheat, rye, millet, with lawns and rhonchi in most grown with vineyard, in Guidino Superior, and in Lower Guidino, woods and forests, wetlands, and the new buildings along the lake.

A cadastral census of 1856, shows the number of houses, cottages, farmhouses, and grottos scattered throughout the territory. It was reported three textile-mills, a furnace and four presses, including two for wine. A land where cattle ranching, does not seem to have had relevance in the local economy, which remains virtually unchanged as long as - in 1873 - with the construction of the railway Lugano-Chiasso, it is split into two parts. Its territory underwent a new transformation with the construction between 1970 and 1971 the motorway exits Lugano-Sud. One hundred years later, Paradiso, has become a city on the outskirts south of Lugano city.

The Section III. SECTORIAL REGULATIONS FOR THE LANDSCAPE of the Master Plan (PR) in the Article 26 describes the sites and picturesque landscapes and views protected by the Canton, while Article 29 defines the cultural Monuments reported on the landscape plan:

II. SECTORIAL REGULATIONS FOR THE LANDSCAPE:

Art. 29

1. The cultural monuments that are reported in the landscape plan are:
- Cattaneo Castle, map n. 555
- Morchino core, map n. 218, 219, 220
- Palace reported in map n. 32 Riva Paradiso
- Palace reported in map n. 34 - Riva Paradiso
- Palace reported in map n. 23E - G. Guisan Street
- Palace reported to map n. 26 - Geretta Street- G. Guisan Street
- Palace reported to map n. 132 - P Boggia Street
- Oratory of Geretta reported in map n. 55 [columns]

The Master Plan states to ban actions that may damage the integrity of the monuments. The owners of these assets have an obligation to provide for their conservation and to refrain from doing an unseemly use.
# Cattaneo Castle

**A4903**

**Brief description:**
Castle Cattaneo, historicizing, of Florentine style medieval polychrome stone with corner turret and garden; 1912. The castle high on three floors and tower, with a covered area of 1000 square meters on a park of 3225 square meters was built by the architect Gino Coppedè (1866-1927) for the owner Emilio Cattaneo Dionisotti in the years 1908-1911. Built on the slopes of Monte San Salvatore in a panoramic area, in a building Florence medieval style, the building is one of the most significant historicist castles in Switzerland and is characterized by the polychrome of building materials such as natural stone and brick.

**Bibliography:**


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# Morchino core

**Villa Antonietti (A4910)**

**Brief description:**
A Starting from 1735, there are several evidences the existence of Morchino, which was then a rural farm whose owners were called Morcaino. The part built on such land is reduced to the historical core (whose origins date back to the twelfth century) and includes several buildings arranged around a courtyard. The building consists of three floors with several spaces. The ground floor had an old press and the launderette. Close to the press was the space for weaving hemp linen and silk. The new house was built by the engineer Alessandro Antonietti in 1928 on the old foundations of the house dating from the fifteenth century destroyed by a major fire. The most interesting elements of the core are the frescoed halls and the oratory dedicated to San Vincenzo de’ Paoli. Then there is a chapel dating back to the eleventh century, and was dedicated to Sant’Abbondio (IV Bishop of Como). A document of 1486 mentions a chapel dedicated to Saint Stephen in “Morchino”. Above the Chapel there was a large rectangular room called “barn” where it was preserved the ancient library with valuable books, antique prints and a multitude of miscellaneous items. In 1997 Mr. Leo Crepaz, owner decided to convert it to a newly created institution, the “Leo and Maria Crepaz Antonietti Foundation, Center Morchino”.

**Bibliography:**

Leo and Maria Crepaz Antonietti Foundation
### Palace Riva Paradiso

**A4905**

**Brief description:**
Three-story office building recently renovated (Ex Hôtel Tivoli. Corner building with a porch topped by a balcony along the front, with beautiful ornamental band under the eaves.

**Bibliography:**
Lugano Inventory ISOS (ISOS Federal Inventory of Swiss Heritage Sites)
<https://dav0.bgdi.admin.ch/isos/Lugano%20(3975)%20rilevamento%20150dpi%202006.pdf>

### Palace Via G. Guisan

**Hotel Victoria (A4906)**

**Brief description:**
The Hotel Victoria, perhaps designed by architect Paolito Somazzi, was opened in 1898 as Hotel San Salvatore, then transformed in the years 1905. The elegant Art Nouveau building, in the early part of the 19th century is a favorite destination for many tourists from the United Kingdom. Lately because of this the hotel took the name of the Queen Victoria and became Hotel Victoria. The building is characterized by the central attic projection with a French type dome.

**Bibliography:**
Lugano Inventory ISOS (ISOS Federal Inventory of Swiss Heritage Sites)
<https://dav0.bgdi.admin.ch/isos/Lugano%20(3975)%20rilevamento%20150dpi%202006.pdf>

### Palace Via Geretta - Via G. Guisan

**A4907**

**Brief description:**
Set of housing buildings of 3, 4 storey, with residential, commercial and hotel activities. The building was built between the end of sec. Nineteenth and early twentieth centuries.

**Bibliography:**
Lugano Inventory ISOS (ISOS Federal Inventory of Swiss Heritage Sites)
<table>
<thead>
<tr>
<th>6</th>
<th>Palace Via Geretta – Via G. Guisan (Posthotel Simplon)</th>
<th>A4908</th>
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<tbody>
<tr>
<td><strong>Brief description:</strong></td>
<td>Building in Art Nouveau style (Ex Posthotel Simplon), today in good state of preservation. House 4 floors, with shops on the ground floor; Neo-Renaissance richly decorated façade of the early century XX. Building of the early twentieth century, adorned with gargoyles, mullioned windows, twin columns. The building was designed by the architect Arnold R. Ziegler for Roeschli in 1914.</td>
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<tr>
<td><strong>Bibliography:</strong></td>
<td>Lugano Inventory ISOS (ISOS Federal Inventory of Swiss Heritage Sites)</td>
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<tr>
<th>7</th>
<th>Palace, Ex-textile mill</th>
<th>A490</th>
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<tbody>
<tr>
<td><strong>Brief description:</strong></td>
<td>Once the industrial district and residential villas overlooking the lake; still readable old plants with gardens. Rural small apartment with 4 floors and a covered pavilion, joined with a wall with archway, part of a country estate. Villa with 3 floors and 4-axis, the central one with a tower within a garden with palm trees; ca. 1930.</td>
<td></td>
</tr>
<tr>
<td><strong>Bibliography:</strong></td>
<td>Lugano Inventory ISOS (ISOS Federal Inventory of Swiss Heritage Sites). 2006</td>
<td></td>
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<thead>
<tr>
<th>8</th>
<th>Geretta Oratory</th>
<th>A4901 OA6218</th>
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</thead>
<tbody>
<tr>
<td><strong>Brief description:</strong></td>
<td>The church of Geretta was built in 1709 and was included in a group of dwellings; rectangular construction in stones and bricks.</td>
<td></td>
</tr>
<tr>
<td><strong>Bibliography:</strong></td>
<td>Inventario delle vie di comunicazione storiche della svizzera. Documentazione IVS, Cantone Ticino classificazione nazionale. Percorso TI 25 Lugano - Figino -/ Càsoro (-/ Porto Ceresio -/ Varese)</td>
<td></td>
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</tbody>
</table>
Figure 12: Location of protected cultural monuments of Paradise Municipally.
5.4 **SWOT analysis**

In order to better understand the urban morphology and solar availability of the area a SWOT analysis has been performed. The SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis is a very common process in strategic planning, providing a framework to categorize a wide range of inputs from technical and other experts in a way that facilitates decision making.

In this analysis, many of the aspects, identified in the SWOT analysis, that make the densification process, a positive example from the point of view of sustainability, have not been fully taken into account because beyond the main objectives of this project. It is clear that the “urban sustainable” concept is very broad, 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 change 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. regarding all these aspects, the New Paradiso Master urban model, is of course a good example sustainable city.

The indicators used in Swiss planning today to measure the complex concept of sustainability differ in their specific orientation and the spatial levels of implementation (cities, cantons) and in many cases have been developed in an ad-hoc manner (City of Zurich Richtplan – Lucerne Canton Ritchplan). These sustainable indicators allow providing flexibility for local and cantonal administrations in identifying sustainable issues and the need to actions.

As example and as already mentioned in the paragraph “State of the art”, in the framework program "Sustainable Neighbourhoods" the Swiss Federal Office of Energy SFOE and the Federal Office for Spatial Development ARE, in collaboration with the Canton of Vaud, the city of Lausanne and Schéma directeur de l'Ouest lausannois (SDOL), have developed the tool "Sustainable Neighbourhoods". Free available on the Internet, this open source software is an aid instrument for the planning, implementation and management of projects for neighborhoods according to the principles of sustainable development.

The tool active in SMEO platform allows evaluating a project based on a number of sustainability criteria, related to environmental, socio-cultural and economic operation. In order to generate the long-term thinking, the tool is structured according to the stages of the life cycle of the neighborhood. The phases of the project evaluated for the district are: planning, master plan, district plan, implementation and use.

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26 Ritchplan (cantonal guidance plan) in Switzerland is a developed plan on cantonal level. The spatial activities and the spatial development of a canton are summarized in the Ritchplan that also defines objectives and guidelines for future development.


Figure 13: SWOT analysis for Paradiso. This analysis helps to better understand the strategic aspects related to the VerGe project in order to propose solutions that maximizes the municipality's strengths, minimizes its weaknesses, takes advantage of opportunities and limits its threats.
5.5 Current and new urban transformation status analysis

The first step of this study includes the analysis of the current situation and the urban transformations envisaged by the municipality with the entry into force of the new Master Plan. The relevant parameters highly influenced by urban morphology that affect energy aspects in buildings have been identified.

When it is necessary to assess solar access in urban planning it is important to consider the interaction of multiple parameters and factors depending on urban morphology and energy aspects. The solar energy potential in urban context available for the integration of passive strategies and active solar systems (photovoltaic and solar thermal) is also a factor that affects the energy consumption of existing and new buildings. In this way, within the city, selected urban units having positive, negative or balanced energy performances may exist.29

A growing urban development that leads to a major transformation of urban planning certainly had to consider economic and social factors; however, at urban level today it is necessary also to investigate the correlations between urban patterns and energy issues. At urban level aspects like: urban morphology, land orography, zoning and uses, proportion of green areas and built environment, densities and neighbourhood relationships, walkable areas, etc. Different aspects and parameters linked to urban morphology and buildings typologies have a direct impact on building energy consumption, mainly on heating, cooling and ventilation performances: volumes, surfaces, streets dimensions, façade orientation, sun obstructions and shadings, etc. These key parameters will allow establishing the “ideal” urban settings scenario to reduce energy dependence on existing buildings and to improve the condition of stationary buildings in the area (medium and long term stationary buildings) as in the case of historic buildings.

The main focus of the methodology proposed is to measure the impact and repercussions of the urban changes on the solar availability and the effects of these measures in the existing historical buildings and cultural monuments, considered in this case as long-term stationary buildings that must remain almost inalterable over the years.

The methodology proposed is explained in detail below:

<table>
<thead>
<tr>
<th>Urban Level Analysis</th>
<th>Building Level Analysis</th>
<th>Energy Level Criteria</th>
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<tbody>
<tr>
<td>• Main parameters: urban morphology and lot patterns; land orography; zoning and uses; urban density; street dimension and profile (height to street width, H/W ratios); settlement units; proportion of green areas and built environment; open public spaces and neighborhood relationships; walkable areas; etc.</td>
<td>• Main parameters: year of construction (construction typologies); current and future uses; prevalent building types; volumes; façade orientation; minimum and maximum height, sun obstructions and shadings; window area distribution (glass/opaque ratio); roof typologies; surfaces and façade materials; etc.</td>
<td>• Main parameters: climate factor, building orientation; building construction types; SOF solar orientation factor; window area distribution; solar gains and daylighting availability; natural ventilation and solar gains; net roof/façade available area for renewables; roof slope and reduction factors and shadings, etc.</td>
</tr>
</tbody>
</table>

**Figure 14:** Workflow diagram – methodology.

---

The workflow shows that for each level of the chain there are some important parameters that influence the energy aspects and the energy balance of a building (consumption and production). From an urban level the specific urban planning significantly determines the possibility to relish solar irradiation in buildings. Solar energy exploitation on existing buildings (in particular historical buildings) could be compromised during urban transformation. To shift the detail at a building level, but always linked to the urban environment, it is necessary to examine the existing and under transformation architectonical situation. This will be done by analyzing the distinctive elements of the surroundings according to building techniques, the year of construction, the materials used, and the morphology of the buildings and so on. All these aspects will finally complete the assessment at the energy level. All levels have a direct impact on medium and long term stationary buildings.

By compare the current situation with the future one (when the New Master Plan in the area will be completely implemented) will allow to establish the main impacts on different aspects such as: solar potential (for solar passive strategies and renewable solar energy installations, RES); daylighting or illuminance levels; sky factors modification on an urban environment; human comfort or cultural building visibility changes due to urban transformation, for example. It also expected that these results will allow establishing a methodology to assess urban planning processes that serves to approach solar rights for protected buildings in a new way.
Urban Level Analysis

The Municipal territory of Paradiso in the master plan is divided into the following areas:

- Center City area with detailed plan -CC
- Intensive residential area - R 17
- Semi-intensive residential area - RS 15
- Special Lakeside Area - SL
- Residential Detail Settlement – RP

In Figure 15, the Zoning plan of the New Master Plan of Paradise is presented. For all these main areas that have been mentioned above an evaluation was made, identifying the following parameters:

- Urban Morphology
- Land-use Coverage Percentage (Building/Street/Open spaces)
- Urban Density %
- Minimum Green areas
- Land-orography (range %)
- Number of settlement unit
- Min. Building Height
- Max. Building Height
- Roof typology
- Façade orientation
- Building envelop requirements
- Protected Buildings Identification for each area
Figure 15: Zoning plan. New Master Plan of Paradiso (Ticino Canton). June 2013
### Table 1. Urban Analysis: Current Status

<table>
<thead>
<tr>
<th>Paradiso Municipality</th>
<th>Urban Morphology</th>
<th>Land-use Coverage % (Building/Street/Open spaces) - Current</th>
<th>Land-use Coverage (Building/Street/Open spaces) - New MP</th>
<th>Urban Density</th>
<th>% Minimum Green areas</th>
<th>Land-orography (range %)</th>
<th>Settlement unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>City Center CC</strong></td>
<td><strong>CC</strong></td>
<td>Buildings: 40.0, Streets: 10.0, Open spaces: 21.0</td>
<td>Min. 40% Primary residences - Max. 30% Secondary residences - Max. 30% Offices</td>
<td>Detailed plan</td>
<td>Detailed plan</td>
<td>1 - 16 %</td>
<td>4800.00</td>
</tr>
<tr>
<td><strong>Semi-Intensive Settlement</strong></td>
<td><strong>RI7</strong></td>
<td>Buildings: 24.0, Streets: 6.0, Open spaces: 69.0</td>
<td>Min. 40% Primary residences - Max. 30% Secondary residences - Max. 30% Offices</td>
<td>1.8</td>
<td>30%</td>
<td>6 - 16 %</td>
<td>3164.00</td>
</tr>
<tr>
<td><strong>Intensive Settlement</strong></td>
<td><strong>RS15</strong></td>
<td>Buildings: 15.8, Streets: 13.2, Open spaces: 71.0</td>
<td>30% Secondary residences - +20% useful floor area building for a minimum area of 3000 sq</td>
<td>1.0</td>
<td>35%</td>
<td>9 - 36 %</td>
<td>2867.00</td>
</tr>
<tr>
<td><strong>Special Lakeside Area</strong></td>
<td><strong>SL</strong></td>
<td>Buildings: 20.0, Streets: 0.0, Open spaces: 80.0</td>
<td>Relevant implementation rules</td>
<td>1.5</td>
<td>35%</td>
<td>29 - 33 %</td>
<td>65.00</td>
</tr>
<tr>
<td><strong>Residential Detail Settlement</strong></td>
<td><strong>RP</strong></td>
<td>Buildings: 15.7, Streets: 3.3, Open spaces: 81.0</td>
<td></td>
<td>1.5</td>
<td>35%</td>
<td>29 - 33 %</td>
<td>65.00</td>
</tr>
<tr>
<td>City Planning Models</td>
<td>PARADISO MASTER PLAN - URBAN ANALYSIS</td>
<td>LONG-TERM STATIONARY BUILDINGS</td>
<td></td>
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<tr>
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<tr>
<td>City Center CC</td>
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<td></td>
<td>Detailed plan</td>
<td>Detailed plan</td>
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<tr>
<td></td>
<td>Min. Building Height</td>
<td>Max. Building Height</td>
<td>Settlemnt unit</td>
<td>Roof typology</td>
<td>Façade orientation (m / n°)</td>
<td>Building envelope requirements</td>
<td>Protected Buildings</td>
</tr>
<tr>
<td></td>
<td>17.50</td>
<td>22.00</td>
<td>276400</td>
<td>Flat / Flat</td>
<td>N 19% E 5% SE 13% SW 5% W 21%</td>
<td>Mandatory continuity of building facades: Max. 1 m. projections and recesses (excluding balconies); Not mandatory continuity faces: Max. 1 m. projections, recesses with limits.</td>
<td>Palace, Riva Paradiso</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
<td>Palazzo Hotel Victoria, Riva Paradiso</td>
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<td>Palazzo, Via G. Guisan</td>
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<td>Oratory of Geretta, Via Geretta</td>
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<td></td>
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<td>A4901, OA220</td>
</tr>
<tr>
<td>Semi-Intensive Settlement</td>
<td>RI7</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.50</td>
<td>17.50</td>
<td>276700</td>
<td>Flat / Flat</td>
<td>N 14% E 11% SE 11% SW 14% W 13%</td>
<td>Mandatory continuity of building facades: Max. 1 m. projections and recesses (excluding balconies); Not mandatory continuity faces: Max. 1 m. projections, recesses with limits.</td>
<td>Cattaneo Castle</td>
</tr>
<tr>
<td>Intensive Settlement</td>
<td>RS15</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>10.50</td>
<td>15.00</td>
<td>300800</td>
<td>Flat / Flat</td>
<td>N 10% E 15% SE 15% SW 10% W 10%</td>
<td>Mandatory continuity of building facades: Max. 1 m. projections and recesses (excluding balconies); Not mandatory continuity faces: Max. 1 m. projections, recesses with limits.</td>
<td>Manzoni Core</td>
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<tr>
<td>Special Lakeside Area</td>
<td>SL</td>
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<tr>
<td>Residential Detail Settlement</td>
<td>RP</td>
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</tbody>
</table>
6.1.1 Main outcomes of the analysis at urban level

As a result of this analysis is important to note the following aspects:

**Center City area with detailed plan – CC:**

The downtown area of the municipality has an urban setting with “warped parallel”30 roads as street pattern. Currently the buildings in this area are freely positioned on the plot with maintaining the alignment of streets in some cases. Building orientation in this case is less determined by the street layout. The geography of the place does not have much slope varying from 16% to 1% next to the lake.

Currently, the proportion of buildings with respect to open spaces (public and private) is important, near to 40% of buildings and 10% for roads, and 50% of open spaces (mainly private 28%). It is the most densely built area of the territory of Paradiso.

House orientations in the area are mainly influence by the street pattern. Façade orientation is equally divided on North-South façades orientations and East-West orientations.

It is expected to important urban transformation in this area by changing the percent of buildable area with tallest closed blocks of buildings and increasing in public walkability of the streets. The area envisages mixed uses. The new master plan provides for a minimum of 40% primary residence and a maximum of 30% on secondary residences, 30% offices.

It is the area with the largest number of protected cultural buildings.

**Intensive residential area - R 17:**

This area is characterized by a “linear and loop” urban morphology. Buildings in this area are freely positioned on the plot, but building orientation is, in this case, determined by the street layout in most cases. The topography of the place does not have much slope varying from 16% to 6%.

Currently, the proportion of buildings with respect to open spaces is only the 24%, 10% for roads, and the 69% are open spaces (mainly private). The new master plan provides for a minimum 30% of green areas.

Façade orientation is not homogeneous, also varying in north-south orientation as well as east-west, northeast-southwest, northwest-southeast. The maximum building height correspond to 22.00 m. and the minimum 17.30 m. that means buildings may have between 5 and 7 floors on average. In general, single-family buildings and have a pitched roof, while the large residential buildings and multi-story buildings have a flat roof.

There is only one protected cultural monument, the A4909 Palace, ex-textile mill, on Boggia Street.

**Semi-intensive residential area - RS 15:**

This area is characterized by an urban morphology like “lollipops on a stick” with an organic pattern with cul-de-sac streets. Buildings in this area are freely positioned on the plot, but building orientation is, in this case, determined by the street layout, determined by its time by the slope of the terrain. The slope of the topography varies from 9% to 36%.

Currently, the proportion of buildings with respect to open spaces is almost the 16%, 13.2% for roads, and the 71% are open spaces. The new master plan provides for a minimum 30% of secondary buildings and a 35% of green areas.

Façade orientation is not homogeneous, also varying in north-south orientation as well as east-west, northeast-southwest, northwest-southeast. The maximum building height correspond to 17.50 m. and the minimum 9.50 m. that means buildings may have between 3 and 5 floors on average. In general, single-family buildings and have a pitched roof, while the large residential buildings and multi-story buildings have a flat roof.

There is only one protected cultural monument, the A4903 Cattaneo Castle.

### Special Lakeside Area – SL:

This area represents a small part of the entire urban plan, but singular because there is the front shore of the lake. It is characterized by a “linear” urban morphology. Building orientation is, in this case, determined by the shore of the lake layout. This motivates relevant implementation requirements developed in a detailed special planning.

Currently, the proportion of buildings with respect to open spaces is almost the 20% while the 80% are open spaces. Façade orientation is mainly northeast-southwest, northwest-southeast.

There are not protected cultural monuments in this area.

### Residential Detail Settlement – RP

This area is characterized by an urban morphology like “lollipops on a stick” with an organic pattern with cul-de-sac streets. Buildings in this area are freely positioned on the plot, but building orientation is, in this case, determined by the street layout, determined by its time by the high slope of the terrain that develops under San Salvador mountain, ranging from 29% to 33%.

Currently, the proportion of buildings with respect to open spaces is almost the 18%, 3.3 % for roads, and the 81% for open spaces. The new master plan provides for low urban density with a minimum 35% of green areas.

House orientations in the area are mainly influence by the sloping terrain. Façade orientation is equally divided on North-South façades orientations and East-West orientations.

There is only one protected cultural monument, the A4910 monument, Villa Antonietti and Morchino Core.

Finally, thanks to this evaluation it has been decided to focus the research on the city center (CC) area. As seen before, this area must undergo a more radical urban transformation towards a dense and compact city center. Also it is the area of the whole territory where the highest concentration of protected cultural monuments occurs.

Currently the open urban pattern, where buildings are freely positioned on the plot, is changing towards closed and dense urban fabrics with tallest closed blocks of buildings with a courtyard inside, as defined in the new master plan regulation.
Figure 16: Spatial urban planning: Left picture shows the current situation and the right one represent the future Master Plan PR urban transformation in the City Center (CC) of Paradiso.

The area is divided in seven sectors (A-G) as shown below:

Figure 17: City Center (CC) urban sectors.

At this point it has been necessary to analyze the area in detail, taking into consideration aspects both from the urban level to the building level to check the interactions of the new urban planning from an energetic point of view.
7 Building Level analysis

Different aspects have been analyzed from the urban level to the building level for each of the sectors:

- **Aspects regarding urban morphology**: street patterns and street profile of each sector, the maximum height of buildings (max. Height to street Width ratio, H:W), the urban density (%), settlement units for each area.
- **Aspects regarding Building configuration and design**: Prevalent building types (uses and construction typologies, year of construction, etc.), orientation, building heights.
- **Aspects regarding building shape and façade materials**: Roof and façade typology and building envelop requirements.

All these aspects previously indicated have many implications from an energetic point of view:

7.1.1 Aspects regarding urban morphology

Traditionally urban patterns depend strongly on climate and are usually designed differently in each climatic zone. Basic concerns are the provision of shading and air movement by alternative means. The urban morphology can moderate the city's microclimate and improve the conditions for the buildings and their inhabitants. Compact settlements are characteristic of hot and dry climates as they provide optimal protection against solar radiation by mutual shading while in warm humid climates the necessary natural ventilation and breezes, require that buildings will be scattered in the plot. However, new urban developments and the requirements for city growth are often in contradiction to traditional urban patterns.

Figure 18: City Center (CC) area of Paradiso - current status and new status when New Master Plan will be implemented (drawings courtesy of Planidea SA)

A dense layout is more characteristic of warm and hot-dry climates where the town structure and the public spaces should thus counteract heat with a shaded and compacted morphology. There should be a close connection between public spaces and residential areas. In the proposed new Master Plan, the buildings are bound together (cluster), by reducing the exposed surfaces. Nine-story buildings with closed courtyards open to the sky, will maximize shade, minimize radiation, will still retain some ventilation and will reduce the effects of cool winds.
Compactness can be achieved by "carpet-planning" layouts with courtyard houses or cluster settlements of high buildings to create suitable patterns, but this kind of urban solution must correspond to local climate needs. The design of the whole urban configuration is important, because the ratio of shaded space to open space to solar radiation affects air temperature significantly.

7.1.2 Aspects regarding building configuration and design

The optimal orientation of a building in a placement must correctly respond to sun and wind exposure. Its design can provide wind protection where required, shading as much as necessary as function of local climate and must also favor natural ventilation by excluding climatically adverse side-effects. Because of these factors, solar radiation, prevailing winds and topography are aspects that must be considered. The radiation intensity on differently oriented surfaces has directly impact with regard to heat gain by solar radiation.

Compact settlements reduce surface areas of heat gain. Protection from solar radiation is particularly important during times of excessive heat. In this situation when buildings are arranged in clusters and dwelling units create like patio areas inside is the best solution for avoiding heat absorption, provide shading opportunities and protection from east and west exposures.

Figure 19: Solar path and prevalent winds in the area, current and new situation diagrams.
Instead, to take advantage of sun-exposure, the larger building dimension should face north and south in this hemisphere (generally, west orientation is the worst: high air temperature combined with strong solar radiation). The optimum orientation for any given location has to be determined in order to achieve the most satisfactory distribution of total heat gain and loss in all seasons.

Housing orientation are determined by street layout and this aspect determine energy consumption for heating, cooling and lighting depending shadows from other buildings and the window area distribution. Besides, building orientation also influence energy production from renewable solar energy (RES).

Likewise, when cooling by ventilation is desired, buildings should therefore be oriented across the prevailing breeze. Prevailing winds in the area come from North-West. This direction often does not coincide with the best orientation according to the sun, but not in this case. Furthermore, it would be necessary to consider also the effect of the lake, and the topography that may also alter the prevailing wind and provide shade at certain time of the day. In our specific case the location of the municipality and its proximity to Lake Lugano certainly influence the local climate. Winds blowing over a water-body can result in a decrease of a few degrees in the ambient temperature. Wind can also be caused by specific direction and conditions in a valley, considering the proximity to Monte San Salvador.

To achieve a reliable air circulation, buildings must be designed for cross-ventilation. Every building creates wind-protected areas and may deflect the wind direction. This may be important for neighboring buildings with closed infill paths where the higher a building is, the deeper is the wind shade area behind it preventing the flow of natural ventilation in the surrounding areas. The grouping of buildings also affects the airflow pattern. Through a narrow passage where buildings are close to each other (street canyon effect) will produce a jet-effect where the funnel situation causes accelerated wind speeds. By contrast in summer conditions the lack of wind (natural air circulation) in urban areas could result in a heat island effect with higher air temperatures as compared to surrounding free scattered urban areas.

The grid pattern maximizes radiation throughout its straight and closer streets, but by orienting the grid pattern diagonally to the east-west axis, would have improved the sun exposure and shade that would be better distributed on the streets; such a grid still supports some dynamic movement of air. However, remain important, the street profiles and the buildings form. Housing patterns are significant and must be planned carefully.

Street profiles have also an impact in global energy efficiency. During the day, high buildings' height to street width (H/W) ratios the urban mass is high, the air circulation decrease and the solar access is limited. In case of low H/W ratios (e.g. lower than 0.5) the air circulation could be also poor as wind velocity would be mostly reduced by the urban texture, but it will be a high solar access with limited shades on street pavement and building surfaces.

7.1.3 Aspects regarding building shape and façade materials

It is known that the shape and volume of buildings should be compacts, because compact volumes gain or lose less heat. In general, the optimum shape is that with a minimum heat gain in summer and a minimum heat loss in winter. A compact "patio" building type, adjoining houses, row houses, and building group arrangements which tend to create a volumetric effect, are advantageous from this point of view. Regarding the volume, an interior courtyard is the most suitable form that can benefit in summer from the microclimatic effects of cool air pools that occur inside. Nevertheless, it is difficult to meet all the different functional and climatic requirements.

The temperature in and around buildings can either be tempered or aggravated by the nature of the surrounding surface. The surface of the surroundings may store and reflect solar radiant heat towards the building, depending on the surface's angle relative to the solar radiation and on the type of surface. The heat exchange between the building and the environment depends greatly on the exposed surfaces. A compact building gains less heat during the daytime and loses less heat at night. Therefore, the ratio of surface to volume is an important factor. The new planning
approach has better surface to volume ratio being more efficient this option from an energy point of view to prevent heat loss.

Building materials are also important in the heat exchange processes. Heat storage and time lag, which provide a balanced indoor climate, take advantage of outdoor temperature fluctuations but also of building finishes and the envelope construction package. Materials reflectivity, absorption and emissivity can regulate the radiation from and to the sky and the surroundings. In many cases building envelopes related these aspects are linked to year period of time construction.

The appropriate design of openings and shading elements according to local climate can also contribute to minimize the building energy consumption (reduce heat losses and conditioning energy use) providing also a good level of daylighting. A good urban planning must to consider that it is not equal the energy needs for east and west façades and also for south or north exposures. Usually the tendency is to limit the protrusions and recesses of the façades in the same way (as in this case) but this limits greatly the possibility to adequately protect the openings of a given façade of the solar overheating.

All these aspects, the variability of environmental conditions, and in particular solar radiation affect the perceived thermal comfort of people.

7.1.4 Main outcomes of the analysis

Particular analyses of the City-Center (CC) area of Paradiso were performed by neighborhoods (subdivisions). This analysis conducted sector by sector (A to G sectors) has served to identify some aspects of interest that will be highlighted hereinafter. The study in detail is presented in the Annex 1. The following figure (Figure 20) summarize the regulatory framework of the aspects analyzed comparing the old master plan with the new one in the area of Lugano Paradiso.
The main different aspects have been analyzed from the urban level to the building level for each of the sectors, which are in the tables:

- Urban Morphology
- Street profile / Maximum Height
- Street patterns
- Urban Density %
- Maximum Height to street Width (H/W ratios)
- Prevalent Building types %
- Number of settlement unit
- Min. Building Height
- Max. Building Height
- Roof typology
- Building design and façade orientation
- Building envelop requirements
- Protected Buildings Identification for each area

Highlighting the aspects related to urban morphology, a comparison of the current status with the New Master Plan (future status) has been made for the whole City Center area (CC). Most of the existing buildings have been built from less than 20 years ago (47%), new buildings and renovations represent a high percentage (21%), buildings built over 20-50 years ago almost the same (19%) and over 50 years old around 12%. Protected buildings in this context account for only 1%. In the future situation all buildings must be rebuilt according to the urban fabric of the new Master Plan remaining only those specially protected as cultural monuments.

While today the area is mainly residential (51%), the non-residential buildings represent a high percentage of the activities in the area (49%), with offices (17%) and services (commercial, tertiary, public or hotels) that represent the other 32%. In the new Master Plan, primary residence represents 40%, offices and services represent the 30% like secondary residence that represent the last 30%.

Urban morphology will change from a free urban pattern with an open structure towards a compact closed courtyards pattern. In the first case, nowadays the percentage of open spaces (61%) regarding the buildable area (26%) is higher, while the roads/streets areas are only the 13% of the total CC area. The new urban plan greatly increase the area occupied by buildings (40%) by reducing the open spaces (50%) public and private while maintain practically intact the streets area (10%).

Roof typologies today are divided by flat roofs (mainly the new buildings or in buildings less than 20 years old) and slopped pitched roofs (mainly in buildings over 20 years old). Buildings orientation depending on streets configurations are almost equally divided by north-south and est-west orientations (about 20% of cases for each one). All the subdivisions (urban sectors) in the area are oriented along both N-S axis and E-W axis.

With regard to building configuration and design, and building shape and façade materials, the analysis reveals that in general, the street profiles significantly change in the new configuration of the Master Plan with building heights reaching up to 29.5 meters from the level of the street. Due to the relationship between the heights of buildings in the area on each side of the streets, for all cases the H/W, height to street width ratio, is quite high, which mean, a poor balance in solar access terms with shading effects on surrounding buildings. This situation is significantly accentuated in the case of the new plan with building heights up to nine plants with H:W ratios up to 2,5 in some cases. There will be a reduction on the potential use of solar passive strategies and with limits on the use of façade surfaces for integrated solar photovoltaic systems. Besides the air circulation in urban areas could decrease in significantly due to the configuration of these urban canyons.

Building orientation as said before are predominantly oriented along N-S or E-W axis which means that well-oriented façades are proportionally equal to those not well-oriented. It would be necessary
to adequately differentiate openings in the different orientations to maximize passive energy gains minimizing energy losses at the same time. Nevertheless, sectors A and D will be mainly oriented by NW-SE axis and sectors B and C will be oriented by E-W axis.

A clear heterogeneity can be observed in the new building construction process.

- **Sector-A:**

Even now in the area there are a high percentage of high-rise multifamily buildings (33.7 %) with also mid and low-rise multifamily buildings (13.4 %) and single-family detached houses (4.5 %). Tertiary (including hotels and commercial) and offices are also present (48.4 %). Building orientation now is free with prevailing south and north façades (20%). In this area only remains a building with volumetric form that must be respected but there is not a cultural monument.

In the current situation, new buildings and renovations or buildings with less than 20 years old have flat roofs with a high inhomogeneity on building envelopes finishes. Façades coatings are often in natural stone or plaster. However, buildings of over 20 or 50 years old usually single-family houses or low rise multifamily houses has pitched roofs with façades covered in plaster and a few and small openings.

- **Sector-B:**

In this sector there is a high percentage of offices (40%) and services, hotels and commercial (31,1%) with a lower percentage of high and mid-rise multifamily buildings (28.9 %). Building orientation now is free with prevailing east and west façades (aprox. 28%). Some buildings in the area have been already built according the New Master Plan (Mantegazza Palace in the corner of Cattori Street, the “Cinque Continenti” Offices building and the Novotel Lugano Paradiso building). In this area there are two buildings protected by the MP (PR) that will be remain for future almost unaltered (A4907, A4908).

New buildings or with less than 20 years old have flat roofs and use all the height available by the PR. The architecture is modern and the façades are covered in Fiber-reinforced concrete (FRC) and metallic panels. High diversity of building envelope materials have been applied (ceramic façade, bricks, stained glass, metal façades, stone claddings, curtain glass walls, etc.). Old buildings (more than 20 years) have pitched roofs and the façades are covered in plaster with the ratio of the opaque surfaces regarding transparent wall surfaces higher compared with new buildings.

- **Sector-C:**

In this sector there are a high percentage of offices (35%) and services, hotels and commercial (22%) with a high percentage of mid-rise multifamily buildings (43.5 %). Building orientation now is free with prevailing north-east and south-west façades (approx. 20%). In future, building orientation will change to east and west mainly. This area has not yet been changed by new urban transformation process. In this area there are two buildings protected by the MP (PR) that will be remain for future almost unaltered (A4905, A4906).

Multi-story residential buildings of recent years have a flat roof with the façades covered by plaster with some balconies. The opaque surfaces are greater than the glass surfaces. Old buildings (more than 20 years) have pitched roofs.

- **Sector-D:**

In this sector there are a high percentage of high-rise multifamily buildings (62 %) and also services, hotels and commercial (38%). Building orientation is free with prevailing north-east and south-west façades (approx. 18%). This area has already been changed by new urban transformation process. In this area there is one building protected by the MP (PR) that will be remaining for future almost unaltered (A4901, OA6218).

The multi-story residential building of recent years that has been built according to the specifications of the new Master Plan of Paradiso uses all the height allowed by the PR. It has a flat roof with the façades are identical on all sides. The ventilated façades are covered with
recyclable and colored fiber cement slabs. There is a large proportion of glazed part with respect to the opaque part of the façade. Old buildings (more than 20 years) have pitched roofs has pitched with only three floors. The façades are covered in plaster, in the renovation one and with small openings. The protected building is a rectangular construction in stones and bricks. It has pitched roof and the openings are very limited and small.

- **Sector-E:**

In this sector there are a high percentage of services, hotels and commercial (29%) with a high percentage of high and mid-rise multifamily buildings (70.9%). Building orientation now is free with prevailing north-east and south-west façades (approx. 28%) and east-west (20%). This area has not yet been changed by new urban transformation process. There is not any cultural monument protected.

Now buildings in this sector were new or renovated or were built over 20 years old. Usually have flat roofs with the façades covered in plaster. There are many openings with few balconies.

- **Sector-F:**

In this sector there are a high percentage of and services, hotels and commercial (32.8%) with a high percentage of high and mid-rise multifamily buildings (62.2%). Building orientation now is free with prevailing north-east and south-west façades (approx. 28%) and east-west (21%). This area has already been changed by the new urban transformation process. There is not any cultural monument protected.

Some new building of the area hosts offices or services (hotels). These buildings usually have flat roofs and the façades are covered in fiber-reinforced concrete (FRC) panels. Some buildings that were built over 20 years old have pitched roofs with the façades covered in plaster.

- **Sector-G:**

In this sector there are a high percentage of services, hotels and commercial (49%), offices (17%) and a high percentage of high -rise multifamily buildings (34 %). Building orientation now is free with prevailing north-east and south-west façades and east-west (25%). This area has already been changed by the new urban transformation process. There is not any cultural monument protected.

In this area there is some new building of the area hosts public institutions. The façades of municipal and public buildings have natural stone cladding. New offices buildings around façades covered with light-colored metal panels. Moreover, other residential buildings in the area and the hotels present a façade with plaster. There is a high inhomogeneity on building envelopes finishes.
8 **Energy Level analysis**

The rational use of energy towards greater efficiency and the reduction of climate-altering gases emissions, the transition towards autonomy and self-sufficiency through renewable energy together with the energy supply issue are aspects need to be considered in the building design but also at urban level. Nevertheless, the urban planning process requires long timeframes that sometimes are in opposition to the rapidity of these changes favored by energy policies at the national and global levels.

As seen before, Lugano Paradiso district is currently undergoing a profound change towards densification of the urban environment with the new master plan now in act. But not always the vision of the different field experts, the stakeholders and the city administration are coincident. Certain measures were imposed for the new urban development and also motivated by stronger economic interests not just environmental, without having into account aspects such as the energy impact of the measures, the visibility of the property protected, raising public awareness towards aspects as environmental issues, etc.

When it is necessary to assess solar access in urban planning it is important to consider the interaction of multiple parameters and factors depending on urban morphology and energy aspects. The solar energy potential in urban context available for the integration of passive strategies and active solar systems (photovoltaic and solar thermal) is also a factor that affects the energy consumption of existing and new buildings. In this way, within the city, selected urban units having positive, negative or balanced energy performances may exist.

The urban pattern and the building configuration, as seen before, can modify certain aspects that are related to the rational use of natural and environmental resources. The opportunity to use the solar radiation, the natural lighting and natural ventilation in order to reduce energy dependency (for heating, cooling and lighting purposes) could be compromised in an urban environment with a fast, dense and excessive development, leaded by different and divergent interests (economic, social, environmental, land development, mobility and transports, tourism, etc.).

All the main parameters studied since now, from urban level to building level (the climate factor; building orientation; building construction types; the solar orientation factor; window area distribution; solar gains and daylighting availability; natural ventilation and solar gains; net roof/façade available area for renewables; solar radiation reduction factors and shadings, etc.) are aspects that not only affect energy consumption and human comfort of a building but also the opportunity to generate energy with solar renewable resources.

The proposed methodology of VerGe project applied to the case study of Lugano Paradiso foresees that the energy impacts must necessarily to be quantified to enable new approaches in urbanism alternatives. The aim has been to assess primarily the impacts on the different aspects listed previously, by compare the current situation now and the future situation when the new urban Master Plan will be completed.

This comparison will enable to prioritize possible solutions by suggesting the possibility to impose corrective policy instruments to equate solar access inequalities due to densification.

The following aspects have been identified as main parameters to valutate this **energy impacts (energy level):**

- **8.1 Solar irradiation (solar passive strategies);**
- **8.2 Sky factors modification in an urban context;**
- **8.3 Human comfort;**
- **8.4 Daylighting and illuminance levels;**
- **8.5 Energy production and consumption** (Solar potential for renewable solar energy, energy efficiency of protected heritage buildings, solar rights assessment).
To explain the effect of the densification process in act in Paradiso city center (CC) area on each parameter mentioned above, both simple and complex simulation analyses have been performed, in order to provide the necessary background to suggest new approaches in urban planning for new directives of future master plans. After the general analysis done so far for the entire downtown area of Paradiso (CC, City Center area and subdivisions), the valuation of the aspects previously highlighted have been focused on the impact assessment on historic/cultural buildings present in the area of study (long-term stationary buildings), due to higher constraints for this typology of buildings and therefore the greatest expected impacts when measures of urban densification will be fully deployed.

However, it is important to stress that the proposed methodology, would allow implementing and replicating of the results to other kind of buildings in the area (medium-term stationary buildings).

Five protected heritage buildings were identified in the area: 1. Palace Riva Paradiso (A4905); 2. Hotel Victoria (A4906); 3. Palace G. Guisan Street (A4907); 4. Posthotel Simplon (A4908); 5) Oratory of Geretta (see Figure 21) but the mainly the study have been focused on the first four ones. As the last one is located in an area where the new plan has been already implemented, many of the studies only consider the urban area where the four first buildings are situated. The impact of the future buildings on the historical heritage has been quantified to understand the change by different points of view. The analysis will compare the current situation and the simulation of the future scenario by assessing solar access and daylighting availability in the area.

Figure 21: Paradiso Case Study, urban transformation towards densification (3D simulation): a) current status; b) future status when new master plan will be fully implemented. The blue buildings and numbers (1-5) are the existing cultural monuments protected in the area.
8.1 Solar irradiation (solar passive strategies)

8.1.1 Methods and tools to assess solar irradiation availability

To assess solar irradiation changes and to analyze the different parameters that quantify energy impacts in an urban context, solar simulation tools have been used to evaluate the different scenarios. Furthermore, there are also more simple methods to characterize the correct geometry of urban settlements that can be used in combination with the simulation analysis made using 3D Ecotect software.

Specific tools have been used to study the urban context and the impacts of the future urban transformation in the area of Paradiso.

The position of the Sun in the sky at any time of the day on any day of the year can be read directly from a Sun-Path Diagram. Sun-path charts or Sun-path diagrams are simple graphical methods to present Sun’s apparent movement. Sun path diagram is a very useful tool not only for early photovoltaic system design phase but also to assess shadow path. The most important geometrical parameters, which describe Earth-Sun relations, include declination (δ), Sun height (α) and solar azimuth (Φ).

There are different Sun-path charts that can be used for different purposes\textsuperscript{31}. It depends of the different types of projection whether they use Polar or Cartesian co-ordinate mapping. In this study, two different sun-path charts have been used.

- The Cylindrical Sun-path chart, for example that is very suitable for architectural design and site/shading analysis. In the Cylindrical Sun-path chart uses the Cartesian coordinate system where each coordinate is given relative to a universal origin point and measured along two perpendicular axes. This typically results in a rectangular-shaped diagram with solar azimuth along the horizontal axis and solar altitude along the vertical axis.

For example, the Orthographic Projection refers to a straight mapping of azimuth and altitude angles onto the X and Y-axis (respectively) of a Cartesian graph. The key to an orthographic projection is that, much like plan view or elevation of a 3D object, the data on each axis are mapped linearly, with no attempt to include modifications from surface incidence or sky luminance. Other sun diagrams (i.e. Waldram Diagram for use in the manual calculation of potential daylight levels in buildings) can take also into account that not all parts of the sky contribute equally to the daylight that arrives at a surface because different sky conditions can result in variations in the distribution of luminance over the sky dome.

\textbf{Figure 22:} Ortographic projection for Lugano. Cylindrical Sun-Path made with Ecotect Software.

\textsuperscript{31} \url{http://wiki.naturalfrequency.com/wiki/Sun-Path/Projections}
- The Polar Sun-Path, using the Stereographic Projection. In the case of a polar sun-path diagram, the solar azimuth is plotted as an angle from North (0-360) whilst the solar altitude is given as the distance from the center (0-90). The Stereographic Projection is a more complex projection in which azimuth lines are first projected back to a reference point located a distance of one radius beneath the circle center. The point where each of these lines intersects the zero axis gives the radial distance. The primary advantage of this method is that it increases the resolution of the diagram at low solar altitudes making it more suitable for the majority of surrounding building overshadowing situations.

![Figure 23: Stereographic projection for Lugano. Polar Sun-Path made with Ecotect Software.](image)

Some parameters could be quickly investigated thanks to these diagrams. First of all, as said before, solar obstructions can be read out directly on the diagrams, as the position of the sun in the sky at any time of the day on any day of the year can be read directly from the Sun-Path Diagrams.

The best way to conceptualize a sun-path diagram such as the one shown above is to liken it to a photograph of the sky. The paths of the sun at different times of the year can then be projected onto this flattened hemisphere. Solar Pathfinder device, for example, is a non-electronic tool that can be used to determine the projected shadow on a point in an urban environment. This analysis serves also to better calculate the solar potential for renewable energy of a site, to determine the solar radiation potential and the sky view factors modification.

![Figure 24: SolarPathfinder device.](image)
A more accurate analysis is possible by using the HORIcatcher instrument developed by Meteotest\(^{32}\). With a digital camera and a horizon mirror (spherical convex mirror) it is possible to register the horizon in the field quickly and efficiently in order to calculate limitations of the sunshine duration and irradiation due to obstacles and serves to obtain three-dimensional projections of the space projected in the mirror dome. Specific software calculates the sun’s orbit, which is put in relation with the horizon. The horizon file recorded can be imported to other tools like Meteonorm\(^{33}\) in order to precisely calculate solar irradiation.

![HORIcatcher instrument](image)

**Figure 25:** HORIcatcher instrument propriety of isaac-supsi.

8.1.2 Application to the case study and results

Thanks to these instruments, a comprehensive study of the urban area of the City Center of Paradiso has been made (Figure 26).

![Site survey with the HORIcatcher instrumentation](image)

**Figure 26:** Site survey with the HORIcatcher instrumentation.

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\(^{32}\) [http://www.meteotest.ch/en/footernavi/solar_energy/horicatcher/]

\(^{33}\) [http://meteonorm.com/]

The results of this site survey will allow having a first estimation on solar urban transformation for each area. To assess the real impact of new and existing buildings in the solar irradiation and shadows it is possible to use the Sun-Paths diagrams. The images obtained with the digital camera can be exported and represented in a Sun-Path diagram.

Some parameters could be quickly investigated thanks to these diagrams. First of all, as said before, solar obstructions can be read out directly on the diagrams, as the position of the sun in the sky at any time of the day on any day of the year can be read directly from the Sun-Path Diagrams.

In particular, an exhaustive analysis is being carried out for each historical building in the area to study the solar obstructions in the current situation and in the future situation. The analyses will be done also at ground level (bottom) where major impacts will be expected and at roof level (top) to assess the differences. Changes in solar irradiation at roof level will have an impact on potential solar active installations, while at ground level, studying the effects on every façade, the major impact will be a chance to exploit passive solar strategies.

Comparing the situation before and after, when the urban transformation will be definitely performed and the new master plan completed it can accurately simulate the percentage of solar obstruction (sunshine / shading) in each building individually studied, caused by the other buildings in the area. Knowing this aspect, it will also possible to determine the amount of solar radiation (Wh/m²) that is modified.

The analysis is being conducted mainly in the sectors C, B, D and F where the highest concentration of protected historic buildings is given.
Figure 28: Sectors C, B of the City Centre of Paradiso area, 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 29: Example of the solar obstruction assessment made for the building 1, Palace Riva Paradiso (A4905): a) Solar irradiation evaluation at ground level - current situation; b) Future situation (new MP), evaluation at ground level; c) Solar irradiation evaluation at roof level - current situation; d) Future situation (new MP), evaluation at roof level.
Figure 29 and Figure 30 show an example of the solar obstruction assessment that has been conducted on Paradiso City Center area using sun-path diagrams. For this analysis Ecotect® Analysis software\(^{34}\) has been used. As can be seen in Figure 29, the current situation (old MP) with regard to the building analyzed -building 1, A4905- do not significantly differ in comparison the future state (new MP), given that, in the B area, the transformation of the new urban plan is already partially in act, with new buildings already built following the directives of the new master plan. The impact of urban modifications only will be determined by evaluating the difference between shadow affected areas before and after.

It has been used it has been used two different sun-path charts: The Cylindrical Sun-path chart that uses Orthographic Projection and the Polar Sun-Path, using the Stereographic Projection. This method is very suitable for architectural design and site/shading analysis. With this second diagram it is also possible to pursue the difference from the old and the new scenarios facade by facade as it possible to see in the next figures (Figure 30, Figure 31, Figure 32, Figure 33 and Figure 34).

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\(^{34}\) [http://usa.autodesk.com/ecotect-analysis/](http://usa.autodesk.com/ecotect-analysis/)
According to this analysis the comparison between the current scenario and the new scenario shows that for building 1 there is not significant differences by façades mainly because the surrounding urban area is already modified with the new parameter of the new Master Plan. On the contrary, there is a greater impact on solar availability reduction on south façade in Building 2 (-14.05% solar reduction), Building 3 (-19.69%) and Building 4 (12.00%) and on east façade in Building 2 (-8.93%) and Building 3 (-12.55%). At the same time an improvement can be seen in the case of Building 2 in the west façade (+33.73% solar path free) relative to the current state.

Figure 31: Impact of shadows by orientations studied for the four case study-buildings using the solar sun path diagram.
For other orientations (see Figure 32), the biggest differences were also found in buildings 3 and 4, particularly in the case of building 3 where for almost all façades (north-east, south-west, north-west or south-east) where the situation worsens, increasing the percentage of shade between 10% to 15% in all cases. Building 2, for example, an improvement have been shown in the façade north-east, by decreasing the percentage of area affecting by the shadows.

Cylindrical Sun-path chart, using also Ecotect software to simulate the urban environment around the buildings in the present and future scenario have been used to compare visually the differences in solar obstructions for each historical building analyzed in the area. The evaluations (Figure 33 and Figure 34) have been done at ground level (bottom) where major impacts will be expected and at roof level (top) of each building to assess the differences. Changes in solar irradiation at roof level will have an impact on potential solar active installations, while at ground level, studying the effects on every façade, the major impact will be a chance to exploit passive solar strategies.

As seen in the following diagrams, justifying the above results, the greatest impacts are observed in Buildings 3 and 4, as more changes are detected in their surroundings area in the future scenario. In these cases, at ground level and mainly in winter time, the situation becomes dramatic with very few hours of sunshine all year round.
Figure 33: Solar obstruction assessment made for the building 1, 2, 3 and 4 at ground level (bottom): Diagrams on the left shows the Orthographic solar sun-path for the current situation (OLD MP), with the projection of the shadows of the surrounding buildings; In diagrams on the right, it is possible to see the changes in for the future scenario (NEW MP).

At roof level (top) of the buildings where hypothetically it could be possible to install a solar renewable energy plant (ever considering cultural heritage constraints) the situation is better. The south slope of roofs in these buildings is not suitable to install a PV plant in any case, as the main orientation is in the axis N-S, with the largest surfaces of their pitched roofs oriented to east and west. Considering this aspect, the lake front area to the northeast, in the case of Building 1 and 2, remains open without obstructions during the year (left side of the diagrams). In the case of Buildings 3 and 4 the obstructions during the year on the roofs sloping to east or west are higher, especially in the winter period, but to the south there are not many obstructions. It would be interesting to study the feasibility of an installation of these characteristics using coplanar photovoltaic modules.

Another aspect to be evaluated in this case it would be the visibility impacts of these PV plants. Since the slope of the roof is not excessive it is possible they are not visible from the street but from a greater visual depth surely if (i.e. scenic routes and views, Monte San Salvatore or from the lake of Lugano).
Figure 34: Solar obstruction assessment made for the building 1, 2, 3 and 4 at roof level (Top): Diagrams on the left shows the Orthographic solar sun-path for the current situation (OLD MP), with the projection of the shadows of the surrounding buildings while in the right, it is possible to see the changes in for the future scenario (NEW MP).

**Recommendations:**

- To assess solar irradiation changes in the urban planning process in order to analyze and quantify the real energy impacts in an urban context to evaluate the different possible scenarios;

Simulation analysis could be made using 3D Ecotect software and Sun-path charts (orthographic and stereographic projection). These tools can be used in combination with special digital cameras with a spherical convex mirror to obtain three-dimensional projections of the space projected in order to calculate limitations of the sunshine duration and irradiation due to obstacles in the urban environment.
8.2 Sky factors modification in an urban context;

8.2.1 Methods and tools to assess sky factors modification

In the same way other parameters have been studied using sun-path diagrams. One of the more universal parameters used to define and characterize the geometry of urban canyons is the sky-view factor (SVF, $\psi_s$), a measure of the degree to which the sky is obscured by the surroundings for a given point. The urban canyon geometry is depended directly by the height, the length and spacing of the buildings itself and have a significant impact on the energy exchanges and on the urban areas temperatures [40]. These energy exchanges, that influence the local microclimate of an urban area, are directly linked with the street profile which depends also of the orientation (N-S; E-W), the sky view factors and the building height to width (H:W) ratio

The sky view-factor is a climate-relevant parameter either on the micro-scale or with respect to urban areas as obstacles and surrounding urban structures can modify the visible horizon and incoming radiation. This parameter represents the ratio of solar radiation received by a planar surface compared with that received from the entire hemispheric radiating environment

In this sense, the sky-view factor represents the ratio of solar radiation received by a planar surface compared with that received from the entire hemispheric radiating environment. The sky can be covered with important reliefs or vegetation (which varies from season to season), from elements of street furniture and also by new buildings. The SVF can be used also to indicate the contribution / absence of solar radiation and natural light in the indoor environment due to obstructions and this therefore, affects the daylighting with implication also on human comfort because the perception and vision of the sky and the natural lighting has directly benefits on human health. [41]

The sky-view factors can be determined using either analytical or photographic methods. Analytical methods use equations as function of the geometry of the site by knowing azimuth angles ($\alpha$) and the associated elevation (in connection with produced shadow) angles ($\beta$) of each elements of the hemispheric environment (surrounding buildings). In this case it possible to assume that the sky-view can be calculated by the following equation:

$$\psi_s = \frac{1}{2\pi} \{(\gamma_1 - \gamma_2) + \cos\beta \left[\tan^{-1}(\cos\beta \tan\gamma_1) - \tan^{-1}(\cos\beta \tan\gamma_2)\right]\}$$

In the above equation (Equation 1) $\gamma_1$ and $\gamma_2$ are the azimuth angles of the walls determined by point of interest. [42]

Otherwise, this parameter could be studied also using digital cameras with fisheye lens or special mirrors [43-44], to project the hemispherical environment onto a circular image plane (HORIcatcher device


38 ImageJ software is an open source image processing program designed for analyze multidimensional images.<http://imagej.net/Welcome>
Figure 35. Sky-factor assessment for building n. 3. Palace G. Guisan street (A4907) through photographic method (different steps in the image processing: a) Photo recorded by HORIcatcher device; b) Image modification in HDR format.

The images obtained with the digital camera can be exported and represented in a Sun-Path diagram. Results obtained by using photographic methods can be compared then with the analysis made with specific 3D software, as Ecotect or Radiance, for example (Figure 36).

Figure 36. Different image processing steps: a) The building environment has been placed in the correct orientation and position; b) Example of the sky-factor assessment made for the building 3. Palace G. Guisan street(A4907): a) Photographic method using digital camera – current status (left) simulation method using 3D software Ecotect – future status (right).
8.2.2 Application to the case study and results

Results obtained by using photographic methods for the urban current status have been then compared with the analysis made using 3D Ecotect polar sun-path diagrams for the future building configuration as seen in the following figure (Figure 37). The comparison among the different evaluation methods has had the objective to verify whether substantial differences exist between them due to the different complexity degree for each assessment, while a photographic method, for example, can be more useful and simple in the evaluation of this particular aspect.

Figure 37. 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.
**Figure 38:** Results of the analysis for SVF for the current scenario (Old Master Plan) and the future (New Master Plan).

<table>
<thead>
<tr>
<th>Building</th>
<th>Old Master Plan</th>
<th>New Master Plan</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.1</td>
<td>60.5</td>
<td>59.1</td>
<td>2.3</td>
</tr>
<tr>
<td>B.2</td>
<td>23.0</td>
<td>18.9</td>
<td>17.7</td>
</tr>
<tr>
<td>B.3</td>
<td>21.1</td>
<td>9.9</td>
<td>53.1</td>
</tr>
<tr>
<td>B.4</td>
<td>24.0</td>
<td>10.8</td>
<td>54.9</td>
</tr>
</tbody>
</table>

**Figure 39:** Results of the comparison of the analysis for SVF values with analytical methods (Johnson&Watson method) and photographic methods (ImageJ software).

<table>
<thead>
<tr>
<th></th>
<th>Old_MP</th>
<th>New_MP</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ImageJ Method</td>
<td>0.61</td>
<td>0.62</td>
<td>-1.1%</td>
</tr>
<tr>
<td>B.1</td>
<td>0.23</td>
<td>0.24</td>
<td>-0.9%</td>
</tr>
<tr>
<td>B.3</td>
<td>0.21</td>
<td>0.19</td>
<td>1.6%</td>
</tr>
<tr>
<td>B.4</td>
<td>0.24</td>
<td>0.26</td>
<td>-2.4%</td>
</tr>
</tbody>
</table>

ImageJ Method | 0.59         | 0.59           | 0.2%      |
| B.1      | 0.19           | 0.19           | 0.1%      |
| B.3      | 0.10           | 0.11           | -1.0%     |
| B.4      | 0.11           | 0.15           | -3.8%     |

- **SVF max. losses [%] _ ImageJ method**

- **SVF**
A site inspection for data collection was carried out (see Figure 37), covering the significant points of the urban area and taking as reference the studied historical buildings. This direct survey in the urban area of Paradiso city center have been made with the aim to state the differences, in percentage, of SVF measured and calculated between the previous-existing status and the future configuration when the new master plan will be implemented.

The SVF is a dimensionless value which varies from 0 to 1 where zero implies the absence of visible sky while the value 1 implies that there are no obstructions, means that all radiation will propagate freely to the sky (Brown & Grimmond 2001).

Results have shown (Figure 38) that a significant alteration of the SVF values throughout the urban area studied occurs. This result is most significant in regard to buildings 3 and 4, which also corresponds to the previous studies conducted so far. In this particular case, the percentage of the sky view factor value decreases of up to more than 50%, from about 21.0-24.0% to 9.0-10.8%over the previous value that corresponds to the current situation. However, it should be noted that in the present situation the SVF values are not already relevant, thus accentuating the situation dramatically when the new regulatory plan will be into action. The comparison between the different methods (Figure 39) of analysis of this factor has shown no significant differences between each other. Both analytical and photographical methods are correct, in this specific case, differences between different analyzed values differs only the 0.1% and 3.8% in the worst case.

Recommendations:
- To consider the sky-view factor (SVF) modification, in planning strategies a measure of the street profile impacts on the energy exchanges;
- To consider together analytical methods that use equations as function of the geometry of the site, sun-paths diagrams and photographic image processing software, in combination with simulation software as simple methods to assess SVF modification.

8.3 Human comfort

8.3.1 Methods and tools to assess human comfort in urban environment

For the assessment of the human comfort differences in the area will be considered bioclimatic techniques for calculating the ideal “comfort zone” corresponding to the specific location of Lugano-Paradiso. Specific bioclimatic studies in order to establish the aspects that compromise the fully exploit the external environmental conditions (climate and location) and the possibility on using passive strategies for thermal conditioning will be performed.

The climatic data used to perform this study refer to the meteorological of Lugano using average statistical data from the Federal Office of Meteorology and Climatology – MeteoSvizzera (MeteoSchweiz) – and based on data measured in the 1961-1990 and 1981-2010 periods. With this meteo data bioclimatic diagrams have been developed. The diagram CBA39, Wellness Adapted Chart (as seen in Figure 40), is a diagram of environmental well-being, developed on the basis of the diagram Victor Olgyay40, incorporating the basic strategies of the diagram Givoni41 specific to the climate and conditions of the site [46]. It also incorporates the latest innovations in

39 Wellness Adapted Chart. CBA developed from Climogramma of Olgyay and Givoni is a result of studies by F. Javier Neila González, architect and professor of the Polytechnic University of Madrid, author of several books including “Bioclimatic architecture in a sustainable environment” (original: Arquitectura bioclimática en un entorno sostenible”).


41 Baruch Givoni, Architect, specialist in bioclimatic architecture, in which publication “Man, Climate and Architecture” of 1969 establishes the relationship between the environmental comfort of the people, the climate and architecture.
the theory of well-being shown recently by ASHRAE. In this diagram we consider not only the parameters of temperature and relative humidity as factors for evaluating comfort but other important aspects such as those due to clothing or activity performed in space analyzed, and the mean radiant temperature of the ambient.

| AREA 1 | Comfort Zone (80% of people satisfied) |
| AREA 2 | Comfort but dry to the health (<10% of dissatisfied) |
| AREA 3 | Comfort but wet for health (less 10% of dissatisfied) |
| AREA 4 | Extended comfort area (only 20% of dissatisfied) |
| AREA 5 | Acceptable comfort area but excessively dry |
| AREA 6 | Acceptable comfort area but excessively wet |
| AREA 7 | Comfort controlled by night ventilation and thermal inertia |
| AREA 8 | Comfort controlled by permanent ventilation |
| AREA 9 | Comfort controlled by evaporative cooling, natural ventilation and thermal inertia |
| AREA 10 | Reach comfort due to solar radiation, passive and sometimes additional heating system |
| AREA 11 | Reach comfort through internal loads |
| Shading Line | Is necessary to shade the windows to avoid overheating |

![Figure 40: CBA chart based on Olgyay bioclimatic diagram, study developed for Lugano.](image)

### 8.3.2 Application to the case study and results

**Interpretation of the CBA Diagram for the case study: LUGANO-PARADISO**

In general, we can say that in the winter months from October to April, we are in the comfort zone, in the area where the lack of heat can compensate for the lack of comfort by taking advantage of solar gain passive solar strategies and internal loads spontaneous. It will be necessary, however, an additional heating system and the support of active systems. It is necessary ensure perfect insulation to prevent heat loss.

In the months of May, June and September the comfort zone is reached (thermal comfort area for 90% of people). During the months of June, July and August, at certain times of the day the comfort zone is also reached but this area correspond to a slightly wet for health (less than 10% dissatisfied). The 4A/4B areas are also interested (20% of dissatisfied, that is at least 80% of people feel good). Especially in the months of July and August where area 7, in the previous graphic is reached, which means that comfort can be controlled with night ventilation and thermal inertia, over this area it is necessary to check indoor comfort ambient conditions by using natural ventilation and evaporative cooling. In all these summer months where shadow black line (Sla, SLb) is crossed, it is essential to properly shade the façades to prevent undesirable overheating, in this situation thermal inertia in the building can affect in a positive way.

These results will be also simplified and represented in an Isopleth map (lines with equal temperature values), hour by hour and month by month. In this diagram it is also possible to associate the areas identified in the CBA chart as seen in Figure 41. In this diagram it is represented during a year-type period the need for radiation to assure comfort (6 blue area); the comfort period for the 80% of people (less than 20% dissatisfied) that correspond to 5 dark grey area; the comfort area for the 90% of people (less than 10% dissatisfied) where shadow is necessary, white area 4; the comfort period for the 80% of people (less than 20% dissatisfied) but where shadow is absolutely necessary, that correspond to 3 light grey area; and the areas out of comfort zone due to excessive heat, the yellow one where it is possible to use natural ventilation.
strategies to restore the comfort status and the red one, where serves a mix of natural ventilation and evaporative cooling, together with active cooling systems to mitigate the excessive heat. The black line identified the period of time during the year where it is necessary to have shadow to prevent rising indoor temperatures in the building, because of undesired overheating caused by an excess of solar radiation.

![Figure 41](image1.jpg)

**Figure 41:** Isopleth map where CBA zones are represented. The black line identified the period of time during the year where it is necessary to have shadow to prevent overheating.

It means that the areas plotted as number 6 and 5 (need of radiation and comfort PPD 20%) to make the most of natural resources and take advantage of solar gains to maintain comfort should not be shaded (0% shade). By contrast, in the areas identified in the above figure as 4.3, 2 and 1 (comfort PPD 10%, PPD 20%, need for ventilation and excessive heat) should avoid excessive overheating due to solar radiation (100% shade, if possible) to maintain comfort.

This graphic has been then compared with the same type of diagram (month by month, hour by hour) showing the results of the dynamic analysis of the solar irradiation simulation made with the Ecotect software for the old and the new urban Master Plan. The program allows evaluating and calculating, for each protected building analyzed, the total average percentage of shading generated by the lack of solar radiation due to the surrounding buildings. The data obtained by simulate each protected buildings were then compared with the bioclimatic analysis described above (e.g. Figure 42 shows the specific analysis performed for Building 1, old Master Plan configuration).

![Figure 42](image2.jpg)

**Figure 42:** Isopleth map showing the average percentage of shading calculated for Building 1.
<table>
<thead>
<tr>
<th>Time</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
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<td>100 100</td>
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</tbody>
</table>
**Figure 43**: Deviation between the absence of solar radiation by shadows in percentage (Old Master Plan and New) and comfort needs.

Applying these methods of analysis previous Figure 43, shows the deviation percentage between the absence of solar radiation due to shadows caused by buildings (negative or positive impacts) in the area of the City Centre of Paradiso for the two main scenarios (Old Master Plan and New). The area delimited by the red line represents solar radiation availability. The numbers (%) in the diagrams indicate how far away, the analyzed scenario is regarding comfort requirements, to match the needs of sun or shade. The shadowing analysis for buildings 1 to 4, in the old and new scenario, has been performed using Ecotect software.

If we consider the graphs at the annual level, percentages obtained in the analysis divided by summer and winter period are shown in Figure 44, the differences are bigger in the morning hours and during the winter time in buildings 3 and 4. It is clear that a dense compact urban environment will be better to achieve comfort in summer because shadows are required, unlike the winter where this situation may be more critical, for this specific climate. The shadowing impact to comfort zone, at annual level, is about 68% in building 1 (minimum) to 72% in building 4 (maximum) in the present scenario (Old MP) while for the future scenario (New MP) varies from 70%, building 1 and 4, to 71% in buildings 2 and 3. In absolute terms between the current and future situation there is not a big difference since in either, the first case or the second one, the shadow requirements to fit human comfort are not being fulfilled properly.

![Figure 43](image)

**Figure 44**: Diagrams shows the shadowing impact (negative impacts) to match human comfort requirements as stated in the bioclimatic study, for both scenarios analyzed (current situation and future situation), considering cultural protected building 1 to 4.

These results demonstrate that for the case of Lugano Paradiso, although the specific climate conditions of this area, that characterized by relatively mild winters, warm, damp summers and plentiful precipitation year-round, dense urban cities could avoid the necessary potential solar gains benefits in winter (due to excessive shadows). Therefore, in the same way for this specific climate, the effect of the shadows is beneficial in summer, allowing avoiding overheating effects inside the buildings due to excessive solar radiation. In other climates, with more severe conditions (e.g. continental or alpine climate with long cold season), the negative effects could be accentuated drastically.

The method proposed here can be used easily to verify the effects of the urban planning strategies in human comfort since early design phase for any climate condition.

In the same way, the ideal comfort zone for the site can be also represented in the solar polar sun-path diagram (see Figure 45 below, 45 a and 45 b). In this way, for example, could be easily seen (visually) and measurable the impacts by extrapolating conclusions of the diagrams when this area will be affected by obstructions of the surrounding environment.
Figure 45: Comfort zone calculated and represented in the solar polar sun-path diagram (stereographic projection) for Lugano area: a) comfort zone for summer time; b) comfort zone for winter time; c) solar obstructions assessment by photographic or analytical methods; d) matching between solar obstruction and comfort needs (in green positive effects in red negative effects to the comfort zone).

Obstructions calculated in previous paragraphs by photographic (current status, old master plan) and analytical (Ecotect simulation for the future status, new master plan) have been plotted over the comfort zone in the sun-path diagram (Figure 45 c). As outlined before in this section, outside the comfort zone drawn in the diagram, solar irradiation is needed, while the comfort zone requires being shadowed to avoid overheating.

When the needs (radiation or shadows to maintain comfort) match the real shadowing effects of the buildings in the urban scenario analyzed is represented in green when there is mismatch, is represented in red. For example, if the comfort zone is being partially shaded by buildings is represented in green (optimal conditions to avoid excessive overheating and to keep welfare conditions) when there is not shadow, it is represented in red. At the same way outside the comfort zone there is a need for solar radiation, when the conditions match the needs, it is represented in green (that means no obstruction with potential useful internal gains) when there is not match, it is represented in red (Figure 45 d).
Figure 46: Comfort zone for summer time and winter time calculated and represented in the solar polar sun-path diagram (stereographic projection) for Lugano area.

The results for all case studies can be seen in Figure 46 and Figure 47. In green Figure 46 color green means that comfort requirements have been fulfilled while red color represents discomfort hours. Visually is easy to see that discomfort is prevalent with respect to comfort, mainly in winter time. The situation gets worse in the new scenario (new MP) especially for buildings 3 and 4. This is normal as this area undergoes greater urban modifications, in the new master plan scenario.
In show the results of the analysis. It could be seen again in Figure 47, where all the results are summarized in the same graphic expressed in percentage that for the summer period although the discomfort predominate, in some cases (building 3 and 4) the comfort increases slightly for the new plan scenario, only in building 1 the percentage of time on comfort exceeds the discomfort. In winter time, however, for all buildings studied the comfort time decreases while discomfort increases.

![Comfort analysis graph](image)

**Figure 47:** Comfort zone for summer time and winter time calculated and represented in the solar polar sun-path diagram (stereographic projection) for Lugano area. Results 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).

As conclusion, the method proposed have put in evidence that when urban transformations occur, changes regarding current status can be considered and assessed as positive or negative impacts, in order to improve not only the general energy efficiency of the buildings but also in the human comfort conditions.

**Recommendations:**
- **To consider local climate resources** as a benefit for energy strategies and human comfort;
- **To consider sun-paths diagrams** as simple methods to assess impacts on solar radiation availability and to verify human comfort issues.
8.4 Daylighting and illuminance levels

8.4.1 Methods and tools to assess daylighting availability in urban environment

The extraordinary urban modification which will take place in the area not only will affect parameters related to solar radiation or the indoor and outdoor comfort, as we have seen so far, but also will have an impact on issues related to the daylighting and visual comfort in the interior spaces, besides the visual impact that new constructions will generate in the urban environment. The pictures below (Figure 48) show the visual effects of the new volumes that built near the protected buildings, some ones already built (pictures a, b) and a mask with the new ones that will be built in future (pictures a, c, d, e and f).

Urban densification effects consequently lead to a reduction in daylighting availability and in this case, the use of simulation tools becomes necessary in order to simulate the daylight modification. The three dimensional model of the urban area have been used in order to calculate and predict the total solar radiation and luminance levels incident on the protected building envelopes studied, taking into account the dynamic effects of adjacent buildings in the urban area, in terms of shadows, mutual reflections and albedo.
Daylighting factors (DF) and illuminance levels have been assessed by using Ecotect software that models the annual amount of daylight in and around buildings and serves for performing lighting simulation evaluation (Figure 49). Ecotect software uses a geometric version of the Split Flux Method (outlined by the UK Building Research Establishment, BRE) for the computational analysis of the Daylight Factor, Furthermore this software allows to export the virtual urban model to other programs as Daysim\textsuperscript{42} RADIANCE\textsuperscript{43} for more complex and physically accurate daylight simulation.

Figure 49: Example of lighting Analysis visualization in Ecotect. Colour coded cumulative luminance levels (cd/m\(^2\)) on the urban current status on the assessed building envelop, façade Est of building 4, Palace Geretta (A4908).

8.4.2 Application to the case study and results

The analysis show, as reported in Table 3,that major impacts at annual level occurs in Building 3 (Palace Via Geretta A4907) and Building 4 (Palace Via Geretta A4908) where differences are more than 10% in the first case and more than 6% in the second case. As seen in previous studies general conditions also in the current case are not very good regarding daylighting availability, as buildings in the neighborhood are already very higher and there are so many obstructions. In any case the future situation will clearly worsen the current situation in this sense.

Table 3. Daylighting factor (DF) results in terms of percentage of DF losses considering the current scenario (Old Master Plan) and the future (New Master Plan).

<table>
<thead>
<tr>
<th>Building</th>
<th>DF max. losses [%]</th>
<th>Old Master Plan</th>
<th>New Master Plan</th>
<th>Deviation</th>
</tr>
</thead>
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<tr>
<td>B.1</td>
<td></td>
<td>88.6</td>
<td>88.7</td>
<td>0.0</td>
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<tr>
<td>B.2</td>
<td></td>
<td>92.9</td>
<td>89.3</td>
<td>3.8</td>
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<tr>
<td>B.3</td>
<td></td>
<td>90.7</td>
<td>80.8</td>
<td>10.9</td>
</tr>
<tr>
<td>B.4</td>
<td></td>
<td>85.4</td>
<td>79.7</td>
<td>6.6</td>
</tr>
</tbody>
</table>

The different buildings levels were also studied to determine where the greatest impact occurs (Figure 50). It is clear that the greatest effects are produced in the lower levels and it is likely that lighting energy consumption will increase in apartments where daylighting is limited. As stated in the new Master Plan there is a high percentage of land uses for this area that envisaged primary housing (40%), secondary housing (30%), and offices (30%) as reported in the previous document (Chapter 6, paragraph 6.1 Preliminary Report) and summarized in this document (Chapter 2, \textsuperscript{42} <http://daysim.ning.com/>.

\textsuperscript{42} Radiance software was developed by the Building Technologies Program in the Environmental Energy Technologies Division of Lawrence Berkeley National Laboratory in Berkeley, California. Radiance software is a ray-tracer that can be used to predict the light levels and appearance of a space prior to construction and is used commonly to predict illumination, visual quality and appearance of different design spaces, and also to evaluate new lighting and daylighting technologies. <www.radiance-online.org/>.
paragraph 2.1). Most absence of direct lighting in the indoor space could condition the segregation of the uses within the building, relegating to the lower and disadvantaged floors, those spaces that do not require continuity exploitation (e.g. secondary housing, etc.).

Figure 50: Daylighting analysis performed with simulation tools, the figure shows variations in Daylight Factor (DF) at different height levels: (a) Building 1 (Palace A4905); (b) Building 2 (Hotel Victoria Palace A4906); (c) Building 3 (Palace A4908); and (d) Building 4 (Posthotel Simplon A4907).

Results indicate, once again, that the greatest differences are shown especially in buildings 3 and 4 as large urban modifications will be expected in the surrounding area, while for building 1 and 2 some urban modifications have already been implemented according to the new master plan. In building 2, from 12 meters’ height to zero (almost equivalent to 4 floors) the differences in daylighting availability, between the current situation and future, are greater than 3%. In building 3, from 21 meters’ height to zero (almost equivalent to 7 floors) the differences in daylighting availability is always greater than 5%, while from 9 meter height (3 floors) this parameter increases to more than 10%. In building 4, nevertheless, from 15 meters’ height to zero (5 floors) results show those differences are greater of 5%. Results of these studies can be used to further investigate the impact of urban densification scenario on lighting energy consumption where daylighting can be strongly reduced. Moreover, these reductions especially for the first floors could be reflected into new possible use of these areas. A further more detailed analysis of this issue has been made with other energy simulation software BESTenergy developed by the Polytechnic of Milan, to assess the impact of some surrounding buildings in the area on the specific case of building 3, aspect that will be shown in the next section in detail.

Recommendations:

- To consider the current scenario and the future scenario (Master Plan) to assess differences in illuminance levels could allow defining and better distributing uses (urban zoning) in the spatial urban structure and inside buildings.
8.5 Production and consumption: energy efficiency and solar energy integration assessment

The main goal of this section is to investigate some aspects regarding solar availability in dense urban environments that affect energy harvesting (passive and active) since this is a fundamental aspect in the energy balance of a building which allow compensates consumption, and to tap into the energy efficiency goals provided worldwide (NEZB) by minimizing also \( \text{CO}_2 \) emissions.

In this case, different aspects have been considered:

1) Effects of urban densification in the energy efficiency of protected heritage buildings

In this case since now it was clear that dense urban policies have a direct impact on energy efficiency measures in terms of solar radiation loss, solar gains decreasing, and provision of daylight availability in the heritage buildings affected by urban modification that still remain unchanged over time. With this aim more detail study has been performed in order to quantify the real entity of these urban changes focusing only in one of the protected buildings, identified as building 3, Palace G. Guisan Street (A4907).

2) Renewal energy integration in the urban context

First of all the goal of this analysis has been to assess the conflict between the urban transformation versus densification along with the expected technological development of RES in this urban area and the architectural and cultural inheritance that pre-exist in the area. Proper integration of these technologies in the urban environment would also help to encourage social acceptance towards the changes and the new technologies, while minimizing the visual impact in close of protected buildings.

8.5.1 Assessment of energy efficiency of protected heritage buildings

As stated in the previous paragraphs, urban dense settlements have great influence in the energy exchanges of buildings in the urban environment. The thermal properties in built-up areas and the lack of effective radiation due to obstructions, affect the net radiation and consequently the temperature pattern in urban areas. The radiation intensity, on differently oriented surfaces, has directly impact with regard to heat gain by solar radiation and the human comfort. As seen before in the urban and building level analysis, the topography of a site, the urban pattern and the building morphology can allow or not to benefit of the local climate in order to favor solar gains or natural ventilation, minimizing the energy consumption. Some studies also have demonstrated the implication of the sky-view factor (SVF) on urban air temperature differences [47]. Alterations of all these factors, as solar radiation, prevailing winds, and shadowing, clearly modify the equilibrium on energy exchanges of the protected buildings because their life cycle is longer than other conventional buildings, although it is not clear the real level of these impacts from a strict point of view, in terms of the conservation of the constructive envelope characteristics.

Anyway these are aspects that must be considered in the energy behavior of these kind buildings to prevent the conservation level can be affected. For this reason, a further more detailed analysis regarding the energy efficiency aspects to assess the impact of some surrounding buildings in the area on the specific case of building 3 (Palace G. Guisan Street, A4907).

The building under study (see Figure 51 and Figure 52) was built between the end of sec. nineteenth and early twentieth centuries. The primarily use is residential and the total gross floor area floor (GFA) amount at 1.515,55 m\(^2\). It develops symmetrically around a stairwell unheated; it houses a pharmacy on the ground floor and two apartments on each floor in the upper levels.

The building is oriented almost exactly north-south but tilted slightly to the west (of less than 10°). Today the building is closed between narrow streets and buildings to the south and east while to the north and west remains open to a public space. It is developed over three floors plus a very simple roof with four slopes inclined and unheated; there is an unheated basement accessible through the central stairwell, also without heating. It has several openings on all fronts and the
main entrances are located across the main street (east), Guisan Street. The windows are small only occupying almost the 30% of the gross area of the façades. The back façade of the building overlooks a public square in the western side that is now under construction following the directives of the new urban plan.

![Figure 51: Selected building, building 3 for a detailed energy analysis of the influence of the densification policies in the Paradiso city center area.](image)

The analysis has been made with an energy simulation software BESTenergy\(^{44}\) developed by the Polytechnic of Milan. The program uses SketchUp as graphic interface and EnergyPlus \([48-49]\) as calculation method as shown in Figure 53. It allows to intuitively performing detailed and complex dynamic simulations of energy performance of buildings. The configuration of the building is defined thanks to a three-dimensional geometric modeler, allowing setting the thermo-physical properties of the all components of building envelope. The software enables a detailed verification of the real behavior of the building in terms of energy flows, requirements, consumption and comfort.

This building has been chosen for a more detailed analysis because it is one of those who suffered the biggest influence of new buildings.

---

\(^{44}\) BESTenergy, energy dynamic computing platform, developed by the Polytechnic of Milan based on the software EnergyPlus 7.1.
The first step was to create a 3D building with their constructive packages, and a model of the urban area, made up of buildings, designed as shading surfaces [50]. Two different simulations have been made: the first with the building in the present context and the second with the building in the future scenario context. The goal is to quantify the possible “damage” brought by the new buildings configuration [51].

![Figure 53](image)

**Figure 53**: Comparison between the models produced describing the existing situation (a) and new urban configuration (b). Detailed 3D model of the building (c).

Through a visual inspection on site and considering the layers of the building envelope compatible with age of the building [52] and its constructional technology, the building envelope has been assumed and simulated as presented in Figure 54: 1,5 cm of plaster outside, internal layer of 40 cm of rock mixed without insulation and 1,5 cm of plaster inside the building.

![Figure 54](image)

**Figure 54**: Construction detail of the stratigraphy of the building package of the façade.

The roof is made of wood, and has a thickness ranging from 20 to 30 centimeters. The slabs of each floor are made with beams and wood paneling also. A windows transmittance value of 5 W/m²K, has been assumed and an overall buildings performance, corresponding the same year of construction and considering the typological characteristics of this time period, is about 166,00 kWh/m²yr. This value has been verified in the simulations. Both simulation (for the current status and the future status) were made with the original 50s construction packet, without considering any building envelop renovation and changes.

The results of the simulation are reported as heating and cooling demand for each floor level, such as to allow the direct evaluation of the different losses of performance in the different season during the year. During the analysis was important to differentiate the levels, to see how the energy demand of the floors are altered differently.
Figure 55: Analysis of energy demand: 
a) red bars in the left graphic represent the annual building heating
energy demand necessary during winter season, differentiated by color intensities for the current situation and
future situation; b) In the same way, the blue bars in the right graphic represents the annual building cooling
energy demand for summer season, also for the current and future scenario.

Figure 55 shows the results of the simulations: during the winter, the energy needs for heating
grow in the future scenario regarding the current one due to the reduction of solar radiation and the
effect mutual shading of surrounding buildings that prevent sunlight and solar gains to the building
analyzed (changes in the internal loads generated by artificial lighting are neglected); during the
summer, the shadow cast by the new buildings expected by the new master plan and now under
construction results in the reduction of the cooling demand.

The results show how the situation changes during the year. During the winter the energy demand
is growing from the old to the new situation, in particular for the taller floors (second and third
floors). Conversely, during the summer, the cooling energy necessary for the building falls: this is a
consequence of the decrement of direct solar irradiance (Table 4).

Table 4. Total consumption estimated during winter and summer in kWh/m² yr. (total conditioned floor space
considered was 1.096 m²).

<table>
<thead>
<tr>
<th></th>
<th>Actual scenario</th>
<th>Future scenario</th>
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<tbody>
<tr>
<td>Thermal energy demand kWh/m² yr</td>
<td></td>
<td></td>
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<tr>
<td>Heating</td>
<td>112,15</td>
<td>122,52</td>
</tr>
<tr>
<td>Cooling</td>
<td>17,62</td>
<td>6,04</td>
</tr>
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</table>

Translating the calculated data to primary energy and dividing the results for the coefficients of
performance, we can calculate the real expenses of the building [53] considering a traditional boiler
for heating and a chiller for cooling; for the heating the coefficient of performance is 0,8; for the
cooling the COP used is 3 (Table 5) [54].

Table 5. Total amount of primary energy consumes during winter and summer in kWh/m² yr.

<table>
<thead>
<tr>
<th>Thermal energy demand kWh/m² yr</th>
<th>Actual scenario</th>
<th>Future scenario</th>
<th>Difference</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>140,18</td>
<td>153,15</td>
<td>12,97</td>
<td>8.47%</td>
</tr>
<tr>
<td>Cooling</td>
<td>5,87</td>
<td>2,01</td>
<td>-3,89</td>
<td>-65.93%</td>
</tr>
</tbody>
</table>
The energy aspect analyzed previously is supported also by an economic analysis in order to estimate the economic damage and the costs due to the new interventions in the close built environment. Changes in energy behavior of the building have been calculated as a variation of the running cost on the case study building as consequences of a new urban configuration. The final step has been to economically quantify these extra energy demands on heating and cooling obtained in the yearly total energy consumption estimation. In this way it has been possible to calculate the effective economic damage brought by the new buildings in the future scenario when the new densification process in the urban area of Paradiso municipality will be completed [55].

To calculate the economic damage of the building regarding heating energy consumption it has been considered that 1 m³ of fuel oil45, lower calorific value of fuels produces an amount of energy equal to 9.6 KWh and costs today approximatively CHF 0.10 each kWh (considering an average price of the last 5 years); regarding cooling energy it has been considered that 1 kWh of electricity today costs 0.22 CHF (Table 6).

### Table 6. Economic damage estimation (*kWh electricity prices references 2015*)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Thermal energy demand [kWh/m² yr]</th>
<th>Final energy yield [kWh/yr]</th>
<th>Economic estimation [CHF/yr]</th>
<th>Difference [CHF/yr]</th>
<th>Difference [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>Heating</td>
<td>140,18</td>
<td>153,637,28</td>
<td>15.363,73</td>
<td>+ 1.421,51</td>
</tr>
<tr>
<td>Future</td>
<td>Heating</td>
<td>153,15</td>
<td>167,852,40</td>
<td>16.785,24</td>
<td>9.25%</td>
</tr>
<tr>
<td>Actual</td>
<td>Cooling</td>
<td>5,87</td>
<td>6.433,52</td>
<td>1.415,37</td>
<td>-930,72</td>
</tr>
<tr>
<td>Future</td>
<td>Cooling</td>
<td>2,01</td>
<td>2.202,96</td>
<td>484,65</td>
<td>-65,76%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Thermal energy demand [kWh/m² yr]</th>
<th>Final energy yield [kWh]</th>
<th>Economic estimation [CHF/yr]</th>
<th>Difference [CHF/yr]</th>
<th>Difference [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>Total</td>
<td>146,05</td>
<td>160,070,80</td>
<td>16.779,10</td>
<td>+ 490,99</td>
</tr>
<tr>
<td>Future</td>
<td>Total</td>
<td>155,16</td>
<td>170,055,36</td>
<td>17.269,89</td>
<td>2.93%</td>
</tr>
</tbody>
</table>

The total operational cost of the energy systems of the building increase by 2.93%, that implies about 490,79 CHF/year. It is normal that historical building that are not refurbished and not energetically upgraded would have an oil boiler as a heating system while the cooling system doesn’t exist. That’s means only heating system will be considered and for this specific case, supposes an increase in thermal energy consumption of 19.656,68 kWh/yr. due to the effects of the new Master Plan implementation. On the other hand, today the current trend to ensure greater user comfort leads to consider the possibility of increasing HVAC cooling systems in summer.

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45 It is normal that historical building that are not refurbished and not energetically upgraded, would have an oil boiler as a heating system. In any case, the calorific value of the oil fuel is similar to natural gas, which could be probable in the case of restored buildings. Today the price of the gas natural (AIL Lugano), varies between 0.70-0.80 CHF/m³ and the price per liter of fuel oil due to contingencies of the economic market remains aligned with that of natural gas and therefore the calculation can be considered meaningful although for other energy vector, 1 m³ of fuel oil43, lower calorific value of fuels produces an amount of energy equal to and costs today approximatively CHF 0.10 each kWh (considering an average price of the last 5 years) [www.migrol.ch](http://www.migrol.ch). This building has been renovated in 2007 changing its thermal heating system to a natural gas boiler.
conditions. This results presented here show that if measures to upgrade this kind of building also with HVAC cooling system will be promoted could be a benefit considering the energy savings on summer period (regarding the same situation in the current status), in a climatic zone such as this.

In this particular case the climate conditions of the site have favored the final results on energy consumption increasing, the climate of Paradiso is characterized by warm temperatures in summer time, so the energy savings are substantial due to obstructions. Nonetheless, the influence of new constructions around the building considered in the analysis is negative overall. In another geographical location (more severe climatic conditions, for example), with different building orientation layouts, or with another ratio between opaque surfaces and transparent surfaces (e.g. medium ratio or larger), the damage would be certainly higher.

There are also some special conditions on this case of study that must be noticed:

- The building is not well-oriented; there is not an optimal façade exposition also to minimize thermal dispersions.
- It is located in a climate characterized by mild summers; it means a higher need for adequate shading to avoid undesirable overheating in these periods and a major need for ventilation and cooling in summer. The existing balconies in the building along with the shading provided by the new buildings in the future scenario contribute in this case in a positive way.
- The transparent surface area ratio of the building is about the 30% of the total opaque area of the building envelope; this ratio value is very low, compared to the average, ensuring a low demand for air conditioning in summer. The high thermal inertia of the building envelops contributes also in a positive way stabilizing indoor temperatures in summer. The absence of isolation by contrast rather enhances the negative effect in the case of winter.
- It is normal that historical building not refurbished and not energetically upgraded can have an oil boiler as a heating system while the cooling system doesn’t exist.

**Recommendations:**

- To consider in the regulatory new master plans measures to check the energy impacts of the urban modification to the heritage protected;
- To provide compensatory measures to favor heritage buildings in order to maintenance their cultural interest or to improve their energy need.
8.5.2 Assessment of solar radiation availability for renewal energy

Within the VerGe project, some aspects related to the possible impacts on the visibility of the protected cultural monument have been analyzed. It has been considered not only the aspects regarding the changes in the perception of protected buildings themselves but also regarding constraints that can delve with the visual impact of solar technologies in sensible urban environments, as there are historic buildings in proximity to the new urban area under development.

The evaluation of the visual impact was considered in the past at local level by some building codes in particular cases or for instance in general “guidelines”\textsuperscript{46} [56]. Some European research project and international initiatives face since today this [57-58]. But nowadays it is necessary to be consistent with the territorial analysis in terms of visual impact when integrating solar technologies in new buildings to ensure the harmonious integration of plans specially for protected environment, both natural and urbanized [59-63].

The goal of this study is to assess the conflict between the urban transformation versus densification along with the expected technological development of RES in this urban area and the architectural and cultural inheritance that pre-exist in the area. Proper integration of these technologies in the urban environment would also help to encourage social acceptance towards the changes and the new technologies, while minimizing the visual impact in close of protected buildings.

![Figure 56: Transformation scenarios of New Paradiso Master Plan, impacts on protected cultural monuments: a) Oratory of Geretta (OA6218, A4901); b) Palace (A4908); c) Hotel Victoria Palace (A4906); d) Palace (A4905). (Photo by Cristina Polo, December 2014).](image)

Today regulations at a national and federal level are pushing to increase the energy supply from renewable energy sources and to reduce the energy demand in new and existing buildings focusing in the NZEB concept. All these aspects along with the obligation to install at least 10 Wp/m\textsuperscript{2} (floor area) of PV in new buildings today only voluntary, as reported in the new “Model for energy requirements at Swiss Cantonal level”, presume a “revolutionary” change in the configuration of dense neighborhoods and in the cities themselves. The new plants, now necessarily integrated into the façades of buildings, will be clearly visible from the streets. Fulfil with these objectives in densely built-up areas may have a significant impact and generate conflicts in areas with cultural heritage buildings.

It will affect both the level of vision and perception of the city itself and with regard the new technologies integration and with regard the visibility of the cultural monument affected by the urban transformations. A harmonious integration of these solar technologies is needed. Thus, new planning policies and building codes and regulations should adjust the good integration and harmonization of these new plants.

\textsuperscript{46} Guidelines of Ticino Canton: “Pannelli solari nei nuclei storici Criteri di posa e di valutazione paesaggistica”. February 2010. Spatial Development Office of nature and landscape, Department of the territory, territorial development and mobility Division.
To assess the potential of solar power in this urban context and near the cultural protected monuments, it will be important to establish a set of criteria relevant with regard to this specific issue (available roof and façade surfaces, PV array installations, shading effects, aesthetics and integration possibilities, acceptance, visibility, etc.). At the same time, the analysis will serve to clarify and deepen on aspects as solar access changes during urban transformation (which is a right to sunlight upon certain building façades) and on aspects, regarding solar rights or solar easement aspects (specifically meant for direct sunlight for solar energy systems).

The solar potential assessment for renewable solar energy has being conducted by using the solar Cadaster of Ticino provided by OASIS platform and also by using simulation tools like PVSOL.

The scope of this analysis is to verify whether is possible to reach the objectives suggested by future Swiss policies in a high dense urban area as this (i.e. a great amount of PV installations in new buildings is expected for future). Thus, it will be possible to know the impacts also in terms of visibility and changes of the urban perception when these technologies are in proximity to protected building.

Figure 57: PV Solar potential analysis for the CC area (Paradiso), analysis conducted with PVSol software. The pictures represent the future urban transformation with new Master Plan.

As first, the solar potential of each the urban area of Paradiso suitable for renewable energy (solar thermal and photovoltaics) have been investigated. For the current status using the solar potential map in Ticino, that is available on the portal of environmental data Environmental Observatory in Switzerland OASI47 (http://www.oasi.ti.ch/web/dati/aria.html), it is possible to “zoom in” the buildings scale to verify solar availability on roofs -from the point of view of insolation- to install solar systems (solar thermal or photovoltaic). In this case the software also takes into account factors that reduce the solar potential availability, such as the inclination and the shadows due to buildings or trees.

Selecting a single item some essential information appears, in particular if interested in photovoltaic system, the possible production of electricity, the investment costs and the annual revenue are indicated. For the new scenario rough estimation will be made depending on available solar radiation on roof and façade surfaces.

Furthermore, depending on building typologies it is also possible to calculate approximately the average annual thermal energy consumption index (kWh/m² yr). This parameter will be useful to understand the solar energy potential of the area and the autarchy ratio of the building (RES production versus energy needs). These parameters are:

47 The solar cadaster shows, on a grid of 20 meters by 20 meters, the annual solar radiation potential throughout the canton Ticino. This varies according to the exposure, altitude, to the hours of sunlight and the local climate. These data allow carrying out specific studies on the potential exploitation of PV on dams, slopes of high mountains and large surfaces.
- Renewable (ST/PV) surface potential (OASI) m²
- Estimated annual PV electricity production, MWh/yr
- Average annual thermal energy consumption Index, kWh/m² yr

It has been roughly estimated the total thermal energy consumption (thermal/DHW) of the buildings in the current state and future state based on statistical information collected and developed at ISAAC [64] by applying average coefficients [kWh/m² yr] of thermal consumption indices as a function of year of construction (more than 50 years; from 20 to 50 years; Max. 20 years; new or renovated buildings) for new and existing buildings. An accurate estimation is complex as energy consumption is not only related to urban morphology but also to other variable factors such as user behavior and constructive and geometrical aspects as well as the use associated to each type of building. New buildings, has been considered very efficient and it has been supposed to have heat pumps for thermal conditioning (equivalent coefficient of performance, COP of about 3).

The total electrical energy consumption [MWh/m² yr], i.e. annual electricity needs in the area, sector by sector for the current state and the future one, has been estimated also by applying the Swiss regulation SIA 380/1:2009 and the SIA 380/4:2006.

The total PV production is being under assessment in a first step with a preliminary estimation provided by OASI platform, solar cadaster of Ticino for the existing buildings, and by using the simulation program PVSOL [49]. In the case of future buildings when the New Master plan will be fully implemented the evaluation considered the future obligation to install 10Wp/m² (floor area) of photovoltaic systems.

Table 7. Energy demand, PV solar potential and global energy balance. The table shows the PV percentage contribution to meet the objectives of a Net-zero Energy settlement.

<table>
<thead>
<tr>
<th>Sectors</th>
<th>CURRENT SITUATION (ACTUAL URBAN PLAN)</th>
<th>FUTURE SITUATION (NEW URBAN PLAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GROSS FLOOR AREA [m²]</td>
<td>THERMAL DEMAND [MWh/yr]</td>
</tr>
<tr>
<td>A</td>
<td>26043.0</td>
<td>1899.5</td>
</tr>
<tr>
<td>B</td>
<td>48'366.0</td>
<td>3'364.1</td>
</tr>
<tr>
<td>C</td>
<td>14'624.0</td>
<td>1'158.8</td>
</tr>
<tr>
<td>D</td>
<td>3199.0</td>
<td>188.0</td>
</tr>
<tr>
<td>E</td>
<td>15'730.0</td>
<td>1'522.9</td>
</tr>
<tr>
<td>F</td>
<td>21'162.0</td>
<td>19'001.0</td>
</tr>
<tr>
<td>G</td>
<td>42'366.0</td>
<td>26'122.0</td>
</tr>
<tr>
<td>Total urban area</td>
<td>165'854.0</td>
<td>12'442.7</td>
</tr>
</tbody>
</table>

1. Considering only the electrical demand
2. Considering electrical demand plus thermal demand

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[49] Dynamic simulation PV program with 3D visualization and detailed shading analysis of roof-integrated or mounted grid-connected photovoltaic systems.
The simulated scenarios consider solar photovoltaic systems fully integrated in the City Centre (CC) district area, where there are several protected buildings. As seen in previous table (Table 7) the results highlighted that the estimated PV percentage for electrical supply is almost equal for the current and the future situations when the new urban Master Plan 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 (see Figure 57 and Figure 58) while transforming the complete urban area appearance. In the hypothesis of covering also the thermal buildings demand, the future situation is better if considering a high-efficient built stock (future average thermal energy density index of 14 kWh/m²yr compared with 77 kWh/m²yr calculated for the present status).

These results show how important is the proper integration of PV technologies in future buildings, especially in dense urban areas through the use of BIPV (Building integrated Photovoltaics) products.

**Recommendations:**

- **To consider building integrated photovoltaic products** (BIPV) as a resource to better integrate renewable energy in the surrounding buildings closed to protected heritage;
- **To study visibility impacts** in order to define guidelines, rules or ordinances suitable to the urban area to avoid impacts on the protected heritage;
- **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.
9 Solar rights assessment

As stated in the beginning of the document (paragraph 5.1) the master plan is the urban programming tool of the activities of spatial impact at the municipal level, that serves to rationally organizing the territory and the harmonious development of the City so that the ground is used with restraint, considering also the best utilization of supply sources and a proper environmental protection, considering for it specific rules of implementation. By detailed planning measures at neighborhood level, it disciplines the conditions of use of a defined part of the township when particular interests and objectives of urban or socioeconomic promotion of the area are necessary, considering also the protection of natural environments, monuments, historic centers or city cores.

Today new energy models to generate energy in a diffuse way are closely connected with renewable energy, where the local energy production used on-site. Solar panels to produce hot water, electricity, or cooling and passive bioclimatic strategies to minimize building energy consumption are possible. This new model on energy generation deployed and the current trends policies are leading to a major change aimed at increasing urban transformation and upgrading of the real estate buildings.

This study shows that urban transformation towards a denser urban context can cause a negative hazard to the existing buildings that have no possibility of change (e.g. historical protected buildings), but also to those buildings that still remain during the slow process of urban transformation. This damage could occur not only from an energy point of view that implies changes on human comfort but also on economic and social aspects as the urban spaces are modified also from a perceptual and visual point of view. All these aspects as seen before can be quantified.

The exploitation of the sun is an aspect which has always been considered from ancient civilizations (Mileto, Olinto and Priene Greek cities or in roman period it is renowned the publication treaty De Architectura of Vitruvio, for example). The thermodynamic and meteorological phenomena determining the “characteristic climate” of a region have been, in most cases, the determining factor in the location of the first urban settlements. Cities, during centuries, arose thanks to this special consideration about the environmental characteristics, of illumination, landscape, geomorphological, etc. conditions, sometimes associated with its natural territory and others in marked contrast with them.

The way that today it is considered the excessive growth of the cities and urban policies towards densification can have an important meaning in the actions to ensure the optimal insolation and the correct use of solar energy systems (solar passive and active systems, daylighting and bioclimatic strategies and so on). The urban and building morphology of city centers, the housing organization and the prevalent building types, today cannot be reconciled with these requirements and with the target that today legislation requires. By contrast, at the same time, in many countries mechanisms such incentives, contributions, tax breaks, accelerated depreciation procedures, low interest loans, etc. have been prepared to encourage installing solar equipment or, more generally, systems designed to exploit renewable energy sources.

Solar rights define the protection access to the sun, alluding to guarantee exposure to sunlight for the different equipment or systems that must transform solar radiation into usable energy (panels, passive systems, etc.). Nowadays, only some states have been set the legal basis of this solar rights easement [65].

9.1 Solar rights application to the case study

In our specific case, could be possible also to think about a compensatory system to the owners or properties (building heritage or cultural monuments protected) harmed in the process of urban transformation in such a way that there will be some kind of benefit. The aim will be not only perceived the negative aspects caused from an energetic point of view but also to consider a possible benefit of real and effective nature (e.g. financial compensation, incentives for improving
the building energy efficiency, incentives pro renovation, the cession of solar energy produced by other real estate in the neighborhood, etc.). With this aim it has attempted to quantify the damage generated by new constructions in the area of Paradiso municipality, generalizing the issue at urban level to try to establish how can be implemented.

Considering this, it has performed a particularized evaluation for the case of study (Lugano Paradiso) of the effect from an energy point of view by quantifying the percentage (%) of solar radiation variation when applying the new master plan. In this case it was consider a reference scenario without obstruction and then it was evaluated from a generic point of view the effect of the height of buildings and the distance of these with respect to a fixed point, considering a grid, a radial frame, which swivel can be positioned anywhere in the urban fabric, allowing to know immediately and intuitively the energy implication effects of the buildings that will be built close to the focal point of the radial pattern considered in the urban environment. To obtain these results Ecotect 3D software has been used.

![Figure 59: Generic method proposed to evaluate the energy impacts of the different building heights in an urban area.](image)

With this approach the aim is to define what are the minimum and maximum impacts of each area of the grid to perhaps establish a proportional relationship of these repercussions with respect to the real area occupied by the buildings (GFA, gross are floor) that impacts to the focal point considered (Figure 59, Table 8 and Figure 60).

The area was divided into trapezoidal segments upon a grid, and it was analyzed a piece at a time. Each segment defines a portion of the new buildings that influence the building studied which is positioned in the focus point. The first analysis was carried out with Ecotect simulation software, which provides the results of all segments analyzed in function of the position (segments A, B, C, D, E, F, G, H) and of the building height (4 m, 10 m, 15 m, 25 m, 30 m, 45 m) considered.

The idea of this reasoning could be to establish an economic fee or compensation to be implemented by the municipality in order to solve the real harm produced to the cultural protected buildings by the action of the new master plan in terms of energy consumption and production disadvantages. For this reason, the real climate of Lugano-Paradiso and the real topography effects have been taken into consideration. As seen in the following figures and table major effects are shown in the South Est area of the grid as local orography (Monte San Salvatore placed to south orientation and the open unobstructed area of lake of Lugano placed towards north orientation) that has a great influence in the local climate condition and in the solar radiation availability.
Table 8. Results of the evaluation in terms of percentage of solar radiation reduction corresponding to each sector and area considered in the grid pattern.

<table>
<thead>
<tr>
<th>Height (m)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3.53%</td>
<td>1.26%</td>
<td>0.43%</td>
<td>0.27%</td>
<td>0.27%</td>
<td>0.35%</td>
<td>0.71%</td>
<td>1.21%</td>
</tr>
<tr>
<td>10</td>
<td>10.19%</td>
<td>5.94%</td>
<td>2.87%</td>
<td>1.92%</td>
<td>1.76%</td>
<td>2.28%</td>
<td>3.88%</td>
<td>5.73%</td>
</tr>
<tr>
<td>15</td>
<td>13.54%</td>
<td>9.19%</td>
<td>4.98%</td>
<td>3.86%</td>
<td>3.60%</td>
<td>4.16%</td>
<td>6.53%</td>
<td>8.60%</td>
</tr>
<tr>
<td>25</td>
<td>16.50%</td>
<td>13.12%</td>
<td>8.11%</td>
<td>6.69%</td>
<td>6.30%</td>
<td>7.06%</td>
<td>9.98%</td>
<td>11.54%</td>
</tr>
<tr>
<td>30</td>
<td>16.94%</td>
<td>14.12%</td>
<td>9.17%</td>
<td>7.74%</td>
<td>7.27%</td>
<td>8.11%</td>
<td>10.95%</td>
<td>12.17%</td>
</tr>
<tr>
<td>45</td>
<td>17.40%</td>
<td>15.54%</td>
<td>10.87%</td>
<td>9.64%</td>
<td>9.07%</td>
<td>9.90%</td>
<td>12.43%</td>
<td>12.78%</td>
</tr>
</tbody>
</table>

![Diagram of grid pattern with solar radiation reduction values]
Figure 60: Visual result obtained by using simulation tools (3D Ecotect software).

The legend associated with the colors of the graphics represent, in percentage terms, the loss of direct illumination and solar radiation of the building studied and positioned in the focus point of the grid caused by new building. It is possible to notice that the higher losses (more than 10%, colors orange and red) are given primarily by two factors: the proximity to the building and the height. It is possible to see also how for lower heights (from 4 to 10 meters) the influence is almost negligible.
Once obtained the generic calculation applied to the specific location of Lugano Paradiso, it has been also assessed the real scenario condition when the new regulatory plan will be implemented to see if the proposed generic method can be used to generalize the evaluation of the solar energy impacts.

It has been chosen to consider the effect of the new building 1 identified in Figure 61 on the protected historical building assessed in the previous paragraph, building 3 (Palace G. Guisan Street, A4907), as seen in Figure 61 and Figure 62).

![Figure 61: 3D visualization of the building studied with more particularized detail.](image)

![Figure 62: Segments of the new building (new building 1) affecting the energy performance of the historic protected building studied.](image)

It is therefore logical that a building that occupies more surfaces that is so close in terms of distance to the historic building studied will result in a loss of direct light and solar availability. The Best Energy software, mentioned earlier, was used again for the simulations. Results were then compared with the generic results obtained from Ecotect (Table 9).
Table 9. Results of the evaluation for the real case of the historic protected building studied (Building 3) considering the energy impacts of New Building 1.

<table>
<thead>
<tr>
<th>Generic analysis (Grid)</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Solar radiation reduction (full segment)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 m</td>
<td>16.50</td>
<td>10.70</td>
<td>4.49</td>
<td>2.27</td>
<td>13.12</td>
<td>8.73</td>
<td>3.13</td>
<td>1.60</td>
<td>5.43</td>
<td>2.46</td>
</tr>
<tr>
<td>30 m</td>
<td>16.94</td>
<td>11.44</td>
<td>5.57</td>
<td>2.90</td>
<td>14.12</td>
<td>10.51</td>
<td>4.26</td>
<td>2.22</td>
<td>6.62</td>
<td>3.17</td>
</tr>
<tr>
<td>28.5 m</td>
<td>16.80</td>
<td>11.21</td>
<td>5.24</td>
<td>2.71</td>
<td>13.82</td>
<td>9.98</td>
<td>9.92</td>
<td>2.03</td>
<td>6.26</td>
<td>2.96</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Particularized analysis (Real building 1)</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>% GFA, gross area floor</td>
<td>25.64</td>
<td>78.50</td>
<td>10.90</td>
<td>83.29</td>
<td>5.76</td>
<td>92.23</td>
<td>62.70</td>
<td>65.98</td>
<td>31.40</td>
<td>13.40</td>
</tr>
<tr>
<td>% Solar radiation reduction (full segment)</td>
<td>16.80</td>
<td>11.21</td>
<td>5.24</td>
<td>2.71</td>
<td>13.82</td>
<td>9.98</td>
<td>9.92</td>
<td>2.03</td>
<td>6.26</td>
<td>2.96</td>
</tr>
<tr>
<td>% Solar radiation reduction (real GAF)</td>
<td>14.19</td>
<td>11.47</td>
<td>10.95</td>
<td>7.84</td>
<td>11.78</td>
<td>13.20</td>
<td>12.37</td>
<td>5.25</td>
<td>14.31</td>
<td>8.87</td>
</tr>
</tbody>
</table>

Finally, to summarize this paragraph, the studies performed has demonstrated that there is a real impact on energy efficiency behavior of the protected building studied. It would be necessary to think about compensatory measures that consider the possibility of improving the energy efficiency of these kinds of buildings to assure the proper maintenance and management of the historical asset.

Other possibility is to promote awareness activities regarding this problematic and considering not only the effects of dense urban environment on the energetical aspects of the heritage buildings but considering also effects on visibility and on possible changes in their scenic and cultural value. With this perspective the VerGe project was taken as inspiration to develop a specific seminar with students regarding a practical training on the topic "integration of renewable technologies in the urban context and in existing buildings". The results are presented below and serve as inspiration of possible alternative measures to promote historical building that suffer the urban desification losing their visibility and value.

9.2 Solar rights in United States, US

Many US states, for example, have already prepared rules of safeguarding access to the sun that are introduced into their national statutes of solar easement [66]. In any case, in American regulations, underlying the constitution of the solar easement cannot in any event arise a reduction in the density allowed or the percentage of the lot which can be occupied by a building or a structure as a result of the urban regulations applicable, at the time in which the proposed subdivision is presented for approval

In US the exploitation of sunlight through the neighboring property can be ensured through the acquisition of an easement (the right to use -the sunlight in this case- through the neighboring property, for a specific purpose), called solar access easement. This term identifies a negative easement, which implies to other adjoining owners not to put on his property in any activity that produces the result of blocking the flow of light reaching the fund of the holder of the solar easement.

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50 California Solar Right Act.
Americans' courts prefer to recognize the existence of easements of light and air if it is based on express agreements, rejecting the doctrine of the English ancient lights. But, nowadays solar systems are also considered by many of these solar easement statutes of the different states (Wisconsin, Minnesota, California, New Mexico, Wyoming, Iowa, etc.) with the specific purpose of preventing the implementation of activities that interfere with the utilization of light by the equipment installed itself. However, in some cases, to get this right, the user (the owner of the solar system) should pay extra taxes to secure the right to use it. Specific cases are those states which ensure also the access to the wind, as in the case of Wisconsin and Minnesota laws. As is intuitive, systems that use wind energy need unobstructed exposure to the wind in order to function.

Urban planners through a regulatory framework, create reciprocal restrictions on individual batches in the area in development, in order to ensure certain objectives (aesthetic uniformity of the area, the homogeneity of assets and activities, etc.). Buyers of individual batches become holders of land with positions both as active as of obligation towards the owners of the other lots, the content of which is determined by the type of tax requirement. Some states are using this form as one of the mechanisms to ensure access to the sun. In other cases, some municipalities have also resorted to "incentive zoning" - e.g. Lincoln City, Nebraska - by virtue of a special order, projects of residential development specially designed to the use of solar equipment can increase by 20% the index of buildable area, floor area ratio (FAR) allowed.

9.2.1 R676 Bachelor elective course (main results)

The results of this seminar are presented here as a new way to enhance the cultural heritage while promoting solar energy at the same time. Urban furniture could be a resource for energy compensate cultural assets but also to promote more visibility of these heritage buildings.

"Architecture and solar energy" is an optional course of 40 hours of lecture, held in the third year of the Bachelor of Arts in Architecture that entitles two training credits.

The aim of the course is to provide participants with the knowledge necessary for the design and architectural integration of solar systems, with particular reference to the technologies of photovoltaics and solar thermal. The concept of BIPV (Building Integrated PhotoVoltaics) have been introduce by showing how photovoltaic technology can and should be considered in all respects part of the building envelope as a resource for the architect and the designer.

Within the course was proposed a practical exercise taking as an example the case study of Lugano-Paradiso considering the different aspects generated by the implementation of the new Master Plan in the urban center of the town and the effect and impact that this new urban development in process has in the historical buildings.

The exercise has allowed to take awareness of the problem in the urban area and to propose different architectural design solutions as elements of the urban furniture incorporating solar pannels to create some educational and cultural paths to enhance the protected historical heritage in the area.

These new functional and didactic paths designed for the new urban area Paradiso had the aim of:

- enhance the cultural heritage, connecting all of the cultural protected heritage existing in the in the whole area of the town hall;

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51 According to this, the law allows the owner of propriety which has received the light through the fund of the nearby neighbor propriety for a certain period of time, to continue exploiting natural lighting (relative to the exploitation of illumination natural within a room), recognizing to him a negative easement that prevents the neighbor can interfere in the enjoyment. In England, the period necessary to acquire this right is 27 years. In America this right had been rejected to promote the growing urban development in certain areas.
generate debate on solar energy issues and renewable solar supply potential;

promote the acceptability to the solar photovoltaic technologies as measure to promote historical buildings.

Furthermore, other aspects linked to the functionality of the new designed solar urban devices have been also considered as the multifunctionality of the elements proposed (shelters, sculptures, elements of illumination, etc.); the solar performance optimizing, considering achieving the maximum energy production; the aesthetics and integration in context (fixing system, materials and finishes); and finally aspects that regards the affordability and the maintenance and management of the systems proposed.

9.2.1.1 Achieved results

Tree different proposal have been presented:

a) The first group of students, by using a flexible PV module proposed a versatile solution that could be used in different urban context closed to the heritage protected buildings as canopy for urban transport bus stop, as benches, as an element of artificial lighting and as media element that contains information of the cultural historical building (Figure 63).

![Figure 63: Urban solution furniture integrating solar PV panels. The element at different heights can integrate various functions, paper bin, electric current charger, lighting, seats, etc.](image-url)
The flexibility of the proposed item allows the proper integration in different urban contexts. Source: R676 Course, authors: Casella Lara and De Lorenzi Francesca.

The designed element can be adapted to the place and context by varying the materials and colors of the photovoltaic element and the support structure. Being modular it can be extended depending on the specific needs (Figure 64).

b) The second group of students, by using a fixed steel structural support imagines a urban solution inspired in the natural environment. The vertical stand holds the PV modules and acts as an element of artificial lighting. The metal structure allows plant growth along its height, with different colors and shapes, so that the element can be better integrated in both urban and natural context. The support base contains a small battery which guarantees the complete autonomy of these lighting elements (Figure 65 and Figure 66).

Figure 64: The flexibility of the proposed item allows the proper integration in different urban contexts. Source: R676 Course, authors: Casella Lara and De Lorenzi Francesca.

Figure 65: Detailed of the steel structural element that support the PV system. The PV system supplies the electricity for the artificial lighting. The integration of the plants besides allowing a better integration in the context had also the intention to give a positive contribution to the reduction of pollution in urban areas.
Figure 66: The map indicates the areas of integration of the urban elements proposed directly related to cultural path connecting the different historic buildings in the area of Lugano-Paradiso. Source: R676 Course, authors: Dragan Bosnjak, Filippo Vegezzi and Rossi Larry.

c) Finally the third group of students chose to design two elements of street furniture: a bench element (Figure 67) with the photovoltaic pannes used to generate electricity for artificial lighting suitable to be integrated into the urban area (urban path connecting cultural monuments) and another element that also incorporates shading surfaces (Figure 68) that allows an electric bicycle parking with also chargers for these bikes and other electronic devices (PCs, phones) for free that best suited to public open spaces, parks, etc.

Figure 67: Detailed of the urban furniture designed as irregular bench with artificial lighting incorporated.
Figure 68: Second furniture element designed. PV modules are integrated in the covering surfaces providing also a protected and shading space to be integrated into open spaces and city squares. Source: R676 Course, authors: Manini Yvana L. and Mazzetti Stefano.

As a conclusion, this exercise with the students has allowed the future architects to be aware of the main problematic implicit in the VerGe project regarding the strong densification process in Paradiso urban area, stimulating the search for alternative energy supply possibilities at citywide scale (not only to building scale) with solutions to be integrated into the surrounding environment with the aim to recover the intrinsic value of cultural heritage in the area. A guided path through the cultural protected buildings using photovoltaic urban elements as landmarks in the urban layout have been suggested to overcome the possible disadvantage that the densification process could generate in this area.

Recommendations:
- **To consider solar rights** in planning strategies to preserve not only the exposure to sunlight for different equipment that transform solar radiation into usable energy (e.g. solar systems) but considering also the proper exploitation and human comfort benefits of sun radiation (e.g. solar gains) or daylighting.
- **To enhance cultural heritage and generate debate on solar energy issues**, also with alternative solutions as solar photovoltaic technologies as measure to promote historical buildings.
10 Final considerations and conclusion

As stated in this research project urban planning strategies determine the possibility to exploit solar irradiation as solar passive/active, daylighting, human comfort, etc., factors that could be compromised during urban transformation. In the same way urban densification can influence the building energy demand and building thermal performance, the level of conservation of existing buildings (in particular historical buildings) with also implications in the urban microclimate. The need to accurately quantifying these effects is a key factor for predicting reductions in solar availability to understand the real impacts to drive the corrective measures, if possible.

A real case study in Ticino (Switzerland), in the Paradiso municipality, part of Lugano’s settlement was selected to be analyzed within VerGe research project. The new urban master Plan Regulation (PR) in the area was modified recently and now is still in act. A thorough study of the whole area of the district has led to choose the City-Center area of Paradiso to perform the methodological approach of the VerGe project defined in Chapter 2. The City-Centre (CC) of Paradiso is currently undergoing a profound change towards densification of the urban environment with new zoning regulations that change in a radical way the urban morphology from an open urban sprawl towards closed and compact urban fabrics, increasing significantly also the heights of the new buildings. [67]

![Figure 69: Lugano-Paradiso City Centre district: a) Aerial view (google earth, 2013); b) Spatial urban planning, current and future urban development (new Master Plan).](image)

The methodology proposed reached the target raised in the project, i.e. to assess properly how urban densification policies influence the energy demand, the conservation level and the solar availability of pre-existing buildings focusing mainly on the major impacts over the protected cultural heritage, that remain unaltered forever, undergoing transformations of the surrounding environment. Next figure (Figure 70) summarize the methodological approach of the project:

![Figure 70: Process development scheme of VerGe research project.](image)
1. Firstly, in VerGe project development, it has been necessary to identify the main buildings representative in this area and stated as cultural monuments by the PR that already exists (Chapter 5, paragraph 5.4 Preliminary Report).

The largest number of protected cultural buildings has been identified in the City-Centre area. Five buildings are already protected by the new Master Plan: 1. - Palace Riva Paradiso (A4905); 2. - Palace G. Guisan Street, Hotel Victoria (A4906); 3. - Palace G. Guisan Street (A4907); 4. - Palace Geretta –G. Guisan Street, Posthotel Simplon (A4908); 5. - Oratory of Geretta (OA6218, A4901).

2. Second part of the analysis has been focused in identifying the relevant parameters highly influenced by urban morphology to assess the real impacts on energy aspects that need to be considered during the analysis of the different land planning scenarios phase.

This approach takes into account three level of analysis from the general aspects (urban level) to particular and detail aspects (building and energy levels). For each level of the analysis some parameters that influence energy aspects and the energy balance of a building (consumption and production) are identified together with the relevant phenomena highly influenced by urban morphology. The specific urban planning significantly determines the possibility to harvest solar irradiation in buildings and solar energy exploitation on existing and new buildings could be compromised during urban transformation. To shift the detail at a building level, it is necessary to examine the existing and under transformation architectonical situations. This analysis has been done by analyzing the distinctive elements of the surroundings according to building techniques, year of construction, materials used, morphology of the buildings and so on. All these aspects will finally complete the assessment at the energy level. All levels have a direct impact on medium and long term stationary buildings (i.e. heritage buildings).

3. Third part of the project process, applied precedent aspects to the different urban scenarios. The study has been included the analysis of the current situation (old master plan scenario) and the urban transformations envisaged by the municipality with the entry into force of the new Master Plan (new master plan scenario).

Hereinafter will be summarized the main outcomes obtained for the urban and building levels of detail applied to the main urban scenarios studied for Paradiso (current urban plan / new urban plan). In the preliminary report these two levels of analysis have been completed.

**Urban Level Analysis:** In the City Centre area (CC) of Paradiso the percent of buildable area and the public walkability of the streets, with tallest closed blocks of buildings up to nine floors will increase in the future. The new master plan sets out for a minimum of 40% primary residence and a maximum of 30% on secondary residences, 30% offices. The downtown area of the municipality has an urban setting with "warped parallel" roads as street pattern and currently buildings are freely positioned on the plot where façade orientation in this case is less determined by the street layout that are equally divided on North-South and East-West. The geography of the place does not have much slope varying from 16% to 1% next to the lake. It is the most densely built area of the territory of Paradiso. Currently, the proportion of buildings with respect to open spaces (public and private) is important, near to 40% of buildings and 10% for roads, and 50% of open spaces (mainly private 28%). As stated in point 1 first, it is the area with the largest number of protected cultural buildings.

**Building Level Analysis:** Different aspects have been analyzed from the urban level to the building level for each of the sectors of the selected area (the Master Plan divides the City Centre core in different building areas, named from A to G), which are: Aspects regarding urban morphology: street patterns and street profiles, settlement unit, the height to street width ratio (H:W) and the urban density (%); Aspects regarding building configuration and design: prevalent building types (uses and construction typologies, year of construction, etc.), orientation, building heights; Aspects regarding building shape and façade materials: roof and façade typologies and building envelop features.
As outcome of this analysis it has been found that street profiles significantly change in the new configuration of the Master Plan with building heights reaching up to 29.5 meters from the level of the street. Due to the relationship between the heights of buildings in the area on each side of the streets, for all cases the H:W, height to street width ratio, is quite high, which mean, a poor balance in solar access terms with shading effects on surrounding buildings. This situation is significantly accentuated in the case of the new plan with building heights up to nine plants with H:W ratios up to 2.5 in some cases. There will be a reduction on the potential use of solar passive strategies and will limit the use of façade surfaces for integrated solar energy systems. Besides, air circulation in the urban area could be reduced significantly due to the configuration of these urban canyons. Building orientation remains predominantly oriented along N-S or E-W axis which means that well-oriented façades are proportionally equal to those not well-oriented. It would be necessary to adequately differentiate openings in the different orientations to maximize passive energy gains minimizing energy losses at the same time.

4. Fourth part of the process project development regards understanding the effects and impacts of urban transformation on energy aspects (energy level analysis).

Energy Level Analysis: When it is necessary to assess solar access in urban planning it is important to consider the interaction of multiple parameters and factors depending on urban morphology and energy aspects. The solar energy potential in urban context available for the integration of passive strategies and active solar systems (photovoltaic and solar thermal) is also a factor that affects the energy consumption of existing and new buildings. In this way, within the city, selected urban units having positive, negative or balanced energy performances may exist.

This document presents a full in-depth details regarding the following aspects:

- Solar irradiation (solar passive strategies);
- Sky factors modification in an urban context;
- Human comfort;
- Daylighting and illuminance levels;
- Energy efficiency and solar energy integration assessment

5. Fifth and final part of the process regards the final recommendations and considerations that have been possible to extrapolate as final results of this methodological process that has been presented before and that can be summarized in the following lines.

Urban policies, local authorities and many communities recognize the economic and environmental benefits of dense urban environments and at the same time global energy stated goals for the next future are pushing for a greater improvement in energy efficiency in the building sector considering also the benefits of local renewable energy, generally, and solar energy, specifically.

This project has put a special emphasis on issues that are important at the time of redefinition of an urban area but also in defining the design of the new constructions, not only because of the implications that this may have on historical buildings and existing in the area in question but also on new buildings to be developed in the future and not least important on the renewable solar installations that can be integrated in these new buildings. Urban environments can vary significantly from site to site, depending on their latitude, distances between buildings and the height, among others. Therefore, since such information is very specific and different from site to site, it becomes difficult to use generic indication.

Regarding the subdivision and urban level, should be important an accurate orientation of the streets and lots and for example by placing the buildings as much as possible close to the northern boundary of the lot. Regarding the building level, should be necessary to consider the orientation, shape and height (e.g. buildings with long axis oriented in order to reduce the shadows cast).
Urban planners and local authorities have a key role in these urban transformations as are in charge of write, amend, and administer standards, policies and incentives that have huge influences on the nature these changes, the timing of future private development as well as what, where and how local resources are used or protected. With this objective planner might to examine zoning codes, building codes, subdivision codes and ordinances and other regulations in order to assess the better way to integrate solar energy aspects, overtaking barriers. Planners have the responsibility to clarify and to help communities for a better understanding on priorities and goals relate to solar energy use [68]. Researchers that investigate these aspects can support planners to achieve this objective plus using public engagement techniques (dissemination and education) to broaden the knowledge. Planners and researchers together can help communities enact standards related to solar exploitation.

In this case, urban planners have the duty to establish restrictions such as to ensure the unobstructed flow of solar energy through the adjacent lots when the parceling and allotment of a particular urban area has been designed, but defining precisely ordinances specifying the standards to determine the exact size and locations of the easement indicating and also the limitations on buildings or structures that could prevent the passage of light through the easement. The legislative provision of the easement must be expressed in measurable terms, such as horizontal and vertical angles measured in degrees, or the times of day of specified date during which there not must be an obstruction of "sunlight"; the indication of the type of obstacle (vegetation or structures) that may prevent the passage of light and a clear explanation of the extent of the restrictions imposed, and furthermore, the terms or conditions in which it can be amended or extinguished.

Specific ordinances to ensure solar rights must provide and protect, as far as possible, the daylighting and sun access in south-facing wall of the buildings during the hours of sunlight, keeping in mind the latitude, topography, microclimate and the existing urbanization and vegetation, besides the uses and densities set up in the area. Following the example of other countries[52], municipalities in the new Master Plans should consider establishing solar access standards for: (a) the orientation of new roads and the lots; (b) the location, the height of the new trees on public roads and other public properties; (c) the intended use and the density of urbanization to conserve energy, and / or facilitate the use of solar energy.

Communities can create incentives by streamlining the approval process, reducing permitting cost, and increasingly flexibility for the incorporation of solar and local energy sources if all aspects have correctly been considerate since the first steps of urban codes. In this case, not only aspects related the correct solar radiation and daylighting availability may be contemplating in the urban regulations or building codes but also it is necessary to take into account the real impacts of the measures proposed in the new urban planning measures although considering the protected cultural monuments already existing.

In this respect and as seen in this study it is important to develop also specific codes to eliminate uncertainty around where solar systems may or may not be allowed to ensure the appropriate locations in order to mitigate any potential negative impacts. To better enact standards regarding this specific topic, baseline considerations are important as clarifying properly the types of solar systems allowed and where to put it with the aim to mitigate as much as possible the potential nuisances associated with solar equipment, as for example the visual impacts and addressing solar access issues.

Municipalities should attempt to provide basic zoning such defining solar energy–related terms; determining whether solar energy systems will be allowed, placed on primary or accessory uses in each zoning district; setting forth height, lot coverage, and setback requirements and describing relevant development standards for solar energy systems such as screening patterns (typologies, 52 “Ordinances solar access; goals, standards” Zoning Enabling Act, Oregon. OR. REV. STAT. 227.190
colors, forms, etc.) and placement (on building or site). Municipalities and urban planners should also tackle solar easement and access requirements as site planning guidelines for lot and building orientation profiles that maximize solar access or thinking about solar-ready development standards easily comprehensible wherein to be applied on buildings are being constructed to allow the future installation of solar energy systems.

In this vision, for example, it would be possible to encourage ground-mounted PV systems on rooftop or roof PV panels to be located on side or rear roof slopes rather than street-facing roof slopes, when possible, for aesthetic reasons, but it is not only the best solution, as BIPV (building integrated photovoltaic) modules could be integrated in new buildings in a better way also considering building façades. It would be also possible to limit the height that rooftop panels may extend above the roofline, or in some cases, exempt solar panels altogether from district height restrictions, as other typical rooftop structures such as chimneys, air conditioning units, antennae or lifts towers.

Furthermore, the new ordinances should also address the system appearance, requiring neutral paint colors, specific forms and shapes according to the building envelope and BIPV systems, with non-active system components, customized for better and greater integration.

Sometimes specific studies could be required (i.e. visibility studies) for screening the correct solutions from public rights-of-way, respecting the viewpoints defined in urban planning or the public spaces closed to the heritage protected, for example. This kind of studies should allow researchers to provide urban planners and municipalities, with the proper instruments to guide new urban developments and to set the new ordinances in order to set better the proper placement and screening considerations, however considering, the effects of requirements on the efficacy of solar panels. This kind of accurate studies would allow some degree of flexibility on ordinances that would be possible to ensure that almost all property owners could exploit solar energy within site and at the same time, establishing measures of the structural constraints to achieve reasonable solar rights.

Visibility impacts, nowadays is becoming a new and promising field of research. Today new tools more and more accurate (3D software, motor engine technologies, photographic processing images) can help to better understand the implications of certain aspects of visibility on human perception, the acceptance of certain facilities or installations, the visual comfort (glare phenomena, high lighting contrasts, etc.), the effect on the historical monuments. Thank to this tools researches can help urban planners and municipalities to integrate the proper mechanisms in urban planning, so that the effect can be corrected or reverse [69-70].

In addition, the new ordinances should also address the system appearance, requiring neutral paint colors, specific forms and shapes according to the building envelope and BIPV systems, with non-active system components, customized for better and greater integration.

Planners should also consider the urban context, such as residential, nonresidential, new developments, infill settlements or redevelopment and especially the protected cultural and natural heritage when establishing such standards, as solar objectives may conflict with other community objectives (i.e., higher-intensity development or dense urban environments) as the research VerGe presented.

Moreover, policies to encourage the spread of solar technologies have to worry about ensuring to all potentially interested parties the opportunity to exploit these technologies, but considering besides that a user will be interested to benefit from the light passing through the neighboring lots in the south without concern not to suffer unnecessary burdens to allow irradiation of adjacent lots to the north. This approach would be a solution to the future goal of "raising awareness" legal instruments to ensure the protection of access to the sun on a large scale.

To finish, solar energy use, in all its forms (passive and active way) not only produces an improvement in energy efficiency in buildings, and if renewable energy production is considered will foster natural resources and reduces air pollution, greenhouse gas emissions, and dependence on fossil-fuel energy sources. To help municipalities to better use this local energy resource,
researchers and planners working together, have highlighted how local development regulations can support measures to better exploit solar and daylighting resources considering the specifics of the site and urban morphology. In the same way, studies like this, could allow better define specific ordinances to either promote or inhibit the installation of solar energy systems in different urban areas, by studying in detail the constraints and effects of the new master plans under development. Researchers after evaluating the effects of existing regulations (in terms of sky-factor modifications, daylighting aspects, effects on solar passive strategies, solar shading and solar radiation availability, etc.) have the possibility to suggest urban planners new solutions, in order that they can then work to remove barriers, create incentives, and draft standards for a better solar energy use in existing and new developments.

To set the better strategies for future master plans, researchers and planners should be important also to consider these basic rules:

1) **Use comparable examples** to identify communities with similar characteristics in terms of size, geography, climate, regulatory framework, development character, and natural and political environment, and review their codes considering the most relevant outputs of the project.

2) **Work in collaboration with planners and the municipalities**, when possible, because there are in charge of writing and administer the ordinance. They provide useful information about the aspect to be modified and the better way to do it.

3) **Convincing the community members** will be important 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 and to suggest new urban regulations to achieve the best way to use solar energy without damaging other existing buildings (e.g. protected buildings) in the area but always ensuring the proper solar right, in any case.
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[28] The new IEA Task “Solar energy in urban planning” was launched in Lisbon in March 2012. SUPSI participated at the workshop for the new task definition


12 Attachements

12.1 Annex 1. Index

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SUBJECT
PROJECT BAULICHE VERDICHTUNG UND DENKMALPFLEGE (VERGE)

TITLE
ANNEX 1
VERGE PROJECT
STÄDTISCHE VERDICHTUNG UND ENERGIE VERHALTEN DER BESTEHENDEN GEBÄUDE

SUPPORTED BY
FOUNDATION FOR THE PROMOTION OF THE CONSERVATION OF THE BUILT HERITAGE.
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PLACE AND DATE
Lugano/Canobbio, 18.12.2015
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A.1. Mindmap VerGE research project

Figure 1. Mindmap VerGe Project. Workflow and parameters of study associated to each work packages (WPs).
### A.2. Urban Level Analysis and Building Level Analysis Assessment

#### A.2.1. Urban Level Analysis: Comparison Current status and New Master Plan – CC City Center area

Table 1. Comparative table of the New Master Plan regulatory status and the current situation status for the whole City Center area.

<table>
<thead>
<tr>
<th>PARADISO MUNICIPALITY</th>
<th>LONG-TERM STATIONARY BUILDINGS</th>
<th>OLD MASTER PLAN</th>
<th>NEW MASTER PLAN</th>
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<td></td>
<td>Street patterns model of city planning</td>
<td>Protected Buildings</td>
<td>Construction types %</td>
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<tr>
<td>City Center CC (CC)</td>
<td>Building with significant architectural and urban value; the new PRG concerns an integral conservation.</td>
<td>1. Palace, Riva Paradiso</td>
<td>Renovation / New building</td>
</tr>
<tr>
<td></td>
<td>Building with significant architectural and urban value; the new PRG concerns an integral conservation.</td>
<td>2. Palace Hotel Victoria, Riva Paradiso</td>
<td>Protected building</td>
</tr>
<tr>
<td></td>
<td>Building with significant architectural and urban value; the new PRG concerns an integral conservation.</td>
<td>3. Palace, Via G. Guisan</td>
<td>New building / Renovation</td>
</tr>
<tr>
<td></td>
<td>Building with significant architectural and urban value; the new PRG concerns an integral conservation.</td>
<td>4. Palace, Via G. Guisan</td>
<td>New building / Renovation</td>
</tr>
<tr>
<td></td>
<td>Building with significant architectural and urban value; the new PRG concerns an integral conservation.</td>
<td>5. Oratory of Geretta, Via Geretta</td>
<td>New building / Renovation</td>
</tr>
</tbody>
</table>

- **Protected Buildings**: Buildings with significant architectural and urban value. The new PRG foresee an integral conservation.
- **Urban Morfology**: Urban density, Roof typology, Façade orientation (m), Land-orientation (range %)
- **Construction types %**: Prevalent Building types %
- **Land-use Coverage % (Building/Street/Open spaces)**: Urban density, Roof typology, Façade orientation (m), Land-orientation (range %)

*According to the new guidelines and trends, new buildings all have a flat roof. Instead, some historic buildings that will be preserved have a pitched roof.*
A.2.2. Building Level analysis: Comparison Current status and New Master Plan - CC City Center area

A.2.2.1. Aspects regarding urban morphology and building configuration and design by sectors.

<table>
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<th>Paradiso Municipality - City Center Area (PRG CC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Table 2.</strong> Paradiso city center area (CC) assessment, from urban level to building level, comparative table of the current and future urban status: Sectors A and B.</td>
</tr>
</tbody>
</table>

**Paradiso Municipality - City Center Area (PRG CC)**

**Table 2.** Paradiso city center area (CC) assessment, from urban level to building level, comparative table of the current and future urban status: Sectors A and B.

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Construction types %</th>
<th>Street profile / Masterplan Height</th>
<th>Building Orientation</th>
<th>Urban Density</th>
<th>Settlement Units</th>
<th>Prevailing Building types - Ficurans (2015)</th>
<th>Roof Topology</th>
<th>Façade Orientation (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. ACTUAL</strong></td>
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<td>New building / Remanence</td>
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<td>&lt;20 years</td>
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<tr>
<td>20-50 years</td>
<td>30</td>
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<tr>
<td>&gt;50 years</td>
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<tr>
<td><strong>B. ACTUAL</strong></td>
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<tr>
<td>New building / Remanence</td>
<td>30</td>
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<tr>
<td>&lt;20 years</td>
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<td>20-50 years</td>
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<tr>
<td><strong>A. FUTURE</strong></td>
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<td>New building / Remanence</td>
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<td><strong>B. FUTURE</strong></td>
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<tr>
<td>New building / Remanence</td>
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<td>&lt;20 years</td>
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<td>20-50 years</td>
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<td>&gt;50 years</td>
<td>10</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Terraced buildings</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The new urban master plan foresees flat roofs with roof garden.
### Table 3. Paradiso city center area (CC) assessment, from urban level to building level, comparative table of the current and future urban status: Sectors C and D.

#### Paradiso Municipality - City Center Area (PRG CC)

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Construction types %</th>
<th>Street profile / Maximum Height</th>
<th>Street pattern</th>
<th>Urban Density</th>
<th>Settled Units</th>
<th>Prevailing Building types %</th>
<th>Roof typology</th>
<th>Façade Orientation (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACTUAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
|             | New building / Renovation 25
> 20 years 75
20-50 years 0
> 50 years 0
Renewed buildings 3 | Street orientation: Free
Building Blocks: Free
Building Avenues: 15-45° | SL: 1-5
EL: 0 | Single-family detached houses: 0
Multi-family low-rise: 0
Multi-family medium-rise: 42% |
Hipped and flat roof
Flat roof |
N 15%
NE 15%
E 15%
SE 15%
S 15%
SW 15%
W 15%
NW 15% |
|             |                       |                                 |               |              |              |                            |              |                       |
| **FUTURE** |                       |                                 |               |              |              |                            |              |                       |
|             | New building / Renovation 25
> 20 years 75
20-50 years 0
> 50 years 0
Renewed buildings 3 | Street orientation: Free
Building Blocks: Free
Building Avenues: 15-45° | SL: 1-5
EL: 0 | Single-family detached houses: 0
Multi-family low-rise: 0
Multi-family medium-rise: 42% |
Hipped and flat roof
Flat roof |
N 15%
NE 15%
E 15%
SE 15%
S 15%
SW 15%
W 15%
NW 15% |
|             |                       |                                 |               |              |              |                            |              |                       |
| **ACTUAL**  |                       |                                 |               |              |              |                            |              |                       |
|             | New building / Renovation 30
> 20 years 50
20-50 years 0
> 50 years 30
Renewed buildings 2 | Street orientation: Free
Building Blocks: Free
Building Avenues: 15-45° | SL: 1-5
EL: 0 | Single-family detached houses: 0
Multi-family low-rise: 0
Multi-family medium-rise: 42% |
Hipped and flat roof
Flat roof |
N 15%
NE 15%
E 15%
SE 15%
S 15%
SW 15%
W 15%
NW 15% |
|             |                       |                                 |               |              |              |                            |              |                       |
| **FUTURE** |                       |                                 |               |              |              |                            |              |                       |
|             | New building / Renovation 30
> 20 years 50
20-50 years 0
> 50 years 30
Renewed buildings 2 | Street orientation: Free
Building Blocks: Free
Building Avenues: 15-45° | SL: 1-5
EL: 0 | Single-family detached houses: 0
Multi-family low-rise: 0
Multi-family medium-rise: 42% |
Hipped and flat roof
Flat roof |
N 15%
NE 15%
E 15%
SE 15%
S 15%
SW 15%
W 15%
NW 15% |

The new urban master plan foresees flat roofs with roof gardens.
### Table 4. Paradiso city center area (CC) assessment, from urban level to building level, comparative table of the current and future urban status: Sectors E and F.

#### Paradiso Municipality - City Center Area (PRG CC)

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Construction types %</th>
<th>Street profile / Maximum Height</th>
<th>Max. Height to street Width, H/W ratios</th>
<th>Street pattern</th>
<th>Urban Density</th>
<th>Settlement Units</th>
<th>Prevalent Building types %</th>
<th>Roof typology</th>
<th>Façade Orientation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A - ACTUAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New building / Renovation</td>
<td>8</td>
<td>Via Sidonea 1.0</td>
<td>Street orientation: N / S, W</td>
<td>0</td>
<td>Single-family detached houses</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 20 years</td>
<td>50</td>
<td>-</td>
<td>Building blocks: Free</td>
<td>6</td>
<td>Multifamily low-rise</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-50 years</td>
<td>38</td>
<td>-</td>
<td>Building orientation: Free</td>
<td>-</td>
<td>Multi-family medium-rise</td>
<td>1.9</td>
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<td></td>
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</tr>
<tr>
<td>&gt; 50 years</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Multifamily high-rise</td>
<td>6.2</td>
<td></td>
<td></td>
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<tr>
<td>Protected buildings</td>
<td>0</td>
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<td>-</td>
<td>-</td>
<td>Office</td>
<td>-</td>
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</tbody>
</table>

#### Paradiso Municipality - City Center Area (PRG CC)

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Construction types %</th>
<th>Street profile / Maximum Height</th>
<th>Max. Height to street Width, H/W ratios</th>
<th>Street pattern</th>
<th>Urban Density</th>
<th>Settlement Units</th>
<th>Prevalent Building types %</th>
<th>Roof typology</th>
<th>Façade Orientation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F - FUTURE</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New building / Renovation</td>
<td>8</td>
<td>Via Sidonea 1.0</td>
<td>Street orientation: N / S, W</td>
<td>0</td>
<td>Single-family detached houses</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 20 years</td>
<td>50</td>
<td>-</td>
<td>Building blocks: Free</td>
<td>6</td>
<td>Multifamily low-rise</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-50 years</td>
<td>38</td>
<td>-</td>
<td>Building orientation: Free</td>
<td>-</td>
<td>Multi-family medium-rise</td>
<td>1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 50 years</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Multifamily high-rise</td>
<td>6.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protected buildings</td>
<td>0</td>
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<td>Office</td>
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<td></td>
<td></td>
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</table>
Table 5. Paradiso city center area (CC) assessment, from urban level to building level, comparative table of the current and future urban status: Sector G.

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Construction types %</th>
<th>Street profile / Maximum Height</th>
<th>Street pattern</th>
<th>Urban Density</th>
<th>Settlement Units</th>
<th>Prevalent Building types %</th>
<th>Roof typology</th>
<th>Façade Orientation [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>New building / Renovation</td>
<td>9</td>
<td>Via delle Scuole</td>
<td>Street orientation: N-S / E-W</td>
<td>15</td>
<td>I.S.: 1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-40 years</td>
<td>20%</td>
<td>1,97</td>
<td>Building blocks: Compact</td>
<td>8</td>
<td></td>
<td></td>
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<tr>
<td>40-80 years</td>
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<td>Building orientation: Free</td>
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</tr>
<tr>
<td>Protected buildings</td>
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<td>17</td>
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</tr>
</tbody>
</table>

ACTUAL

FUTURE

The new urban master plan foresees flat roofs with roof garden.

ML_VerDE Project_en A-7/15 ANNEX 1
### A.2.2.2. Aspects regarding building shape and façade materials

**Table 6.** Paradiso city center area (CC) assessment: Sector A. Current status building tops analysis.

<table>
<thead>
<tr>
<th>Construction types</th>
<th>Description</th>
<th>Opaque/Transparent ratio</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New building / Renovation</strong></td>
<td>All the new buildings, residences and offices, have flat roofs. The maximum height allowed by the PR was usually reached. There is a high dishomogeneity on building envelopes finishes. The coatings are often in natural stone.</td>
<td>2:1</td>
<td></td>
</tr>
<tr>
<td><strong>&lt; 20 years</strong></td>
<td>Buildings for this period have flat roofs and use all the height allowed by the PR. The facades are covered with plaster, they reflect the 1980's style. All the residential buildings have balconies or terraces.</td>
<td>3:1</td>
<td></td>
</tr>
<tr>
<td><strong>20-50 years</strong></td>
<td>All the residential buildings, usually single-family residences, have pitched roofs. Multi-story building have also flat roofs. The heights are modest (2 or 3 plans), the only exception is the hotel in the area which is higher. Multi-story building have also flat roofs. The facades are covered in plaster and the openings are limited.</td>
<td>5:1</td>
<td></td>
</tr>
<tr>
<td><strong>&gt; 50 years</strong></td>
<td>Buildings for this period have pitched roofs and solid walls. They are often residential, the only exception is the cinema, and they are encircled by copious vegetation. The buildings have color plaster facades and the openings are limited.</td>
<td>4:1</td>
<td></td>
</tr>
</tbody>
</table>
Table 7. Paradiso city center area (CC) assessment: Sector B. Current status building topes analysis.

<table>
<thead>
<tr>
<th>Construction types</th>
<th>Description</th>
<th>Opaque/Transparent ratio</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>New building / Rennovation</td>
<td>In this part of the city the buildings are very different. The Mantegazza palace is characterized by a complete glass curtain wall facing the street; several metallic strips separate the floors. The “Cinque Continenti” Offices and Residences building designed by Mario Botta architect (1986-1992) is cylindrical and the facades are covered with brick masonry, the openings are smaller and fewer.</td>
<td>-</td>
<td><img src="image" alt="New building" /></td>
</tr>
<tr>
<td>&lt; 20 years</td>
<td>Buildings for this period has a flat roof and use all the height available by the PR. The architecture is modern and the facades are covered in Fiber-reinforced concrete (FRC) and metallic panels. There are balconies covering all the length of the facades. The opaque surfaces are wider than the glass wall.</td>
<td>5.5:1</td>
<td><img src="image" alt="20 years" /></td>
</tr>
<tr>
<td>20-50 years</td>
<td>These buildings are mostly residential; they have both plane and pitched roofs. The facades are covered in plaster, the openings are regular and they have a normal size. The facades present many balconies.</td>
<td>2:1</td>
<td><img src="image" alt="50 years" /></td>
</tr>
<tr>
<td>&gt; 50 years</td>
<td>The only building older than 50 years has pitched roof and solid walls covered in plaster. The openings are are not numerous, and some have been closed. There are some balconies.</td>
<td>6.5:1</td>
<td><img src="image" alt="Over 50 years" /></td>
</tr>
</tbody>
</table>
Table 8. Paradiso city center area (CC) assessment: Sector C. Current status building tope analysis.

<table>
<thead>
<tr>
<th>Construction types</th>
<th>Description</th>
<th>Opaque/Transparent ratio</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>New building / Rennovation</td>
<td>This is a restoration of a historical building, built more than 50 years ago. It has a simple hip roof. The openings in the facades are double, there are some balconies and a large terrace. On the ground floor there is a porch with an arcade topped by a balcony.</td>
<td>2:1</td>
<td><img src="image1.png" alt="Picture" /></td>
</tr>
<tr>
<td>&lt; 20 years</td>
<td>There is only one building for this period in the area. It is a multi-storey residential building with a flat roof. The facades are covered by plaster and there are some balconies. The opaque surfaces are greater than the glass surfaces.</td>
<td>5:1</td>
<td><img src="image2.png" alt="Picture" /></td>
</tr>
<tr>
<td>20-50 years</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&gt; 50 years</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 9. Paradiso city center area (CC) assessment: Sector D. Current status building types analysis.

<table>
<thead>
<tr>
<th>Construction types</th>
<th>Description</th>
<th>Opaque/Transparent ratio</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>New building / Renovation</td>
<td>There is only one building for this period in the area. It is a multi-storey residential building with a flat roof. This building has been built according to the specifications of the new Master Plan of Paradiso. It uses all the height allowed by the PR. The facades are identical on all sides. The ventilated façades are covered with recyclable and colored fiber cement slabs. There is a large proportion of glazed part with respect to the opaque part of the facade.</td>
<td>1:1</td>
<td><img src="" alt="Picture" /></td>
</tr>
<tr>
<td>&lt; 20 years</td>
<td>This building has pitched roof. It is a building of only three floors. The facades are covered in plaster, the openings are limited.</td>
<td>3.5:1</td>
<td><img src="" alt="Picture" /></td>
</tr>
<tr>
<td>20-50 years</td>
<td>-</td>
<td>-</td>
<td>![Picture]</td>
</tr>
<tr>
<td>&gt; 50 years</td>
<td>This building was built in 1709; it is a rectangular construction in stones and bricks. It has pitched roof and the openings are very limited and small.</td>
<td>12:01</td>
<td><img src="" alt="Picture" /></td>
</tr>
</tbody>
</table>
### Table 10. Paradiso city center area (CC) assessment: Sector E. Current status building topes analysis.

<table>
<thead>
<tr>
<th>Construction types</th>
<th>Description</th>
<th>Opaque/Transparent ratio</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>New building / Rennovation</td>
<td>This building is probably a recent restoration. It is a multi-storey residential building with a flat roof. The facades covered with plaster are different from side to side. The openings are calculated according to the orientation.</td>
<td>3:1</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>&lt; 20 years</td>
<td>Buildings from this period have all flat roofs. They are destined to become residences or hotels. The facades are covered in plaster and there are many openings. There are few balconies.</td>
<td>2,5:1</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>20-50 years</td>
<td>Buildings from this period are typically residential multi-story building with flat roofs. There are many balconies and terraces. The facades are covered in plaster. There is a large proportion of opaque part with respect to the glazed part of the facade.</td>
<td>1,5:1</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>&gt; 50 years</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 11. Paradiso city center area (CC) assessment: Sector F. Current status building topes analysis.

<table>
<thead>
<tr>
<th>Construction types</th>
<th>Description</th>
<th>Opaque/Transparent ratio</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>New building / Rennovation</td>
<td>This is the only new building of the area. It hosts some offices and it doesn’t use all the height allowed by the PR. It has a flat roof and the facades are covered in fiber-reinforced concrete (FRC) panels. This is a corner building with a curved profile of the facade. Openings, which are numerous, establish horizontal lines.</td>
<td>1:1</td>
<td></td>
</tr>
<tr>
<td>&lt; 20 years</td>
<td>Buildings from this period have both plane and pitched roofs. They are typically residential. The facades are covered in plaster and the openings are limited. Some have arcades on the ground floor in correspondence with the existing pedestrian street.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>20-50 years</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>&gt; 50 years</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
**Table 12.** Paradiso city center area (CC) assessment: Sector G. Current status building topes analysis.

<table>
<thead>
<tr>
<th>Construction types</th>
<th>Description</th>
<th>Opaque/Transparent ratio</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>New building / Rennovation</td>
<td>The new buildings have always flat roofs as stated in the New Urban Master Plan. The facades are different. Sometimes the facades are ventilated and they are covered in different kind of materials (natural stone claddings, metal claddings, etc.). There is a high dishomogeneity on building envelopes finishes.</td>
<td>2:1</td>
<td></td>
</tr>
<tr>
<td>&lt; 20 years</td>
<td>Buildings from this period have flat roofs. All the height allowed by the PR is usually reached. The facades are covered in plaster. There are different kind of openings depending on facade orientations. There are some balconies.</td>
<td>5:1</td>
<td></td>
</tr>
<tr>
<td>20-50 years</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>&gt; 50 years</td>
<td>There is only one building for this period in the area. The bottom part of the building is made by massive walls covered by plaster. The bottom part of the building is made by massive walls covered by plaster finishing. The upper part of the facade is covered by a wood coating. It has pitched roof with numerous openings in the facade.</td>
<td>6:5:1</td>
<td></td>
</tr>
</tbody>
</table>

Paradiso Municipality - City Center Area (PRG CC)