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Urban densification and energy efficiency in smart cities: The Verge project (Switzerland)

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ABSTRACT

The issues of building densification and land conservation are much debated in local development policies and are related to the rational use of local environmental and climate resources.
The paper proposes a critical interpretation of the research project that ISAAC Institute of SUPSI University (Switzerland), carried out on these themes by analyzing a case in the municipality of Lugano Paradiso.
The project analyses the effect of the urban transformation in terms of energy and solar access.
The proposal of the case study was aimed at highlighting the importance of quantifying precisely all the consequences that local planning strategies can have on energy and environment so as to be able to assess their real impacts and define sustainable criteria and possible improvement actions.
This project belongs to a collection of case studies presented by the IEA SHC TASK 51 SOLAR ENERGY IN URBAN PLANNING, addressing how the planning process has been developed, how the stakeholders have been involved, which instruments have been applied, which energy technology and environmental impact have been addressed and what the role is of the researchers during the entire process

1. INTRODUCTION

The International Energy Agency (IEA) was established in 1974 as an autonomous agency within the framework of the Economic Cooperation and Development (OECD) to carry out a comprehensive program of energy cooperation among its 25 member countries and the Commission of the European Communities. The Solar Heating and Cooling Programme was established in 1977, one of the first Programmes of the IEA.

The main objective of SHC Task 51 (duration May 2013-April 2017) is to provide support to urban planner, authorities and architects to achieve urban areas, and eventually whole cities, with architecturally integrated solar energy solutions (active and passive) that contribute a large fraction of the renewable energy supply in cities. Results will include processes, methods and tools to assist cities with developing a long-term urban strategy.

One way to attract interest from planners is to present them with case studies of successfully implemented solar projects. So the group has collected 34 case studies of different countries which are divided into: New urban areas; existing urban areas; landscapes.

SHC Task 51 is divided in four Subtask: Legal framework, barriers and opportunities for solar energy implementation (subtask A); Development of processes, methods and tools (subtask B); Best Practice case studies and case stories (subtask C); Education and Dissemination (subtask D). Subtask C provides recent examples from real applications across the world; 34 cases from Austria, Canada, China, Denmark, France, Germany, Italy, Norway, Sweden and Switzerland have been gathered, which is indicative of the state of the art of leading developments in the planning of solar energy in new and existing urban areas as well as landscape.

The cases should inspire others responsible and influential on urban planning to consider solar energy as well as be made aware of issues that must be addressed, such as solar rights or heritage concerns.

Once the information for each case study was collected, it was decided to use a unique template to present the data. For that purpose, a standard template was developed and built up taking into account the possible differences of case studies and their similarities. Templates were made flexible but with a common structure for consistent outcomes across studies.

Template are divided into the following sections: Overview; Challenges, Issues and Decision Strategies; The Planning Process; Energy Concept; Architectural Visibility, Sensitivity and Quality; Solar Landscape; Solar Potential; Environmental, Economic and Social Impacts; Approaches, Methods and Tools; Lessons Learned and Recommendations.

Verge Project, case study of Lugano Paradiso, is analyzed within the subtask C considering urban planning case studies as case stories by analyzing the inter-relationship between the variables of the urban surrounding, solar integration technologies, environment, social, aesthetics, methods, planning processes, approaches and tools.

2. VERGE PROJECT - A CRITICAL INTERPRETATION

The paper proposes a critical interpretation of the “Verge Project” a research project that ISAAC Institute of SUPSI University (Switzerland), carried out on these themes by analysing a case in the Municipality of Lugano Paradiso (Switzerland).The Verge (Städtische Verdichtung und Energie Verhalten der Bestehenden Gebäude) Research Project aimed to investigate how urban modifications, in particular, urban densification policies, could influence the energy demand, the conservation level and the solar availability of pre-existing buildings as well as the impact on the perception and visibility of the protected heritage.

Figure 1. Lugano Paradiso Municipality – City center area

Figure 2. City Center Area of Paradise – current status and new status when New Master Plan will be implemented

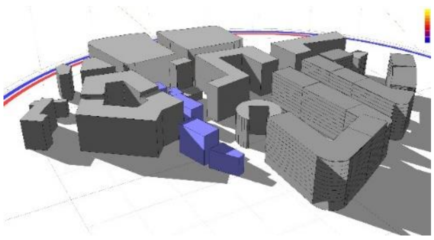

Figure 3. Paradiso Case Study: current urban status 3D simulation. The blue building are the existing cultural monuments

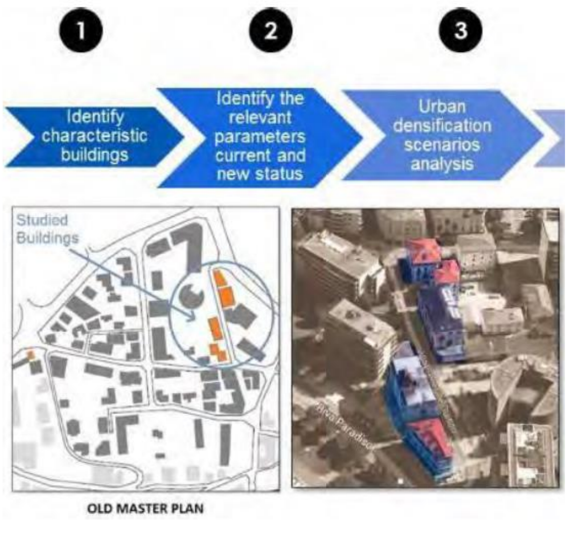

Figure 4. Process development scheme of Verge research – project

The Lugano District is undergoing a very fast urban densification process changing its open urban sprawl into infill, with a closed and compact urban fabric, as defined in the new master plan regulation.

To investigate the impact of urban densification on the energy behaviour of existing buildings and, in particular, on the sensitive and valuable cultural heritage monuments, simulation and photographic diagnostic tools were used. The information analysed provided basic design guidelines for urban planners or public and private institutions, responsible for the protection of cultural assets, with the purpose of seeking a new way to best utilize the methodology proposed considering solar access rights and becoming aware of the real problems caused by urban sprawl.

The presentation of the case study is done following the Template set by the Task 51 research group for the critical interpretative reading of all the projects.

It is believed that analyzing the case through the categories of the proposed Template it is possible to highlight the most important aspects significant of the project in relationship to the correlation between solar energy and urban densification.

Overwiew - Since 2011, Switzerland decided to withdraw from the use of nucleary energy, as a result new “Swiss Energy Strategy 2050” was defined emphasizing the importance to increase demand in consumption sectors, with specific focus on the construction sector. Urban densification and conservation of soil have been supported through strategies and regulations at a national and federal level, but at the same time a new “Model for energy requirements at Swiss cantonal level” presumes the future obligation to install at least 10Watt/sq.m. of PV in new buildings (today voluntary). At urban level in the Canton Ticino, where the study area is located, urban densification strategies are underlined among the objectives of the *Piano Direttore Cantonale*.

Issues, Challenges and Decision Strategies - Main challenges of the Verge project are:

- Sensitive and valuable heritage cultural monuments valorization;
- Integration of renewable energy, such as solar, on urban context closed to heritage buildings;
- To assess the effects of the new planning processes considering the effects of dense settlements on energy efficiency and the energy supply.

The planning process - The new Master Plan of the area was published in May 2011 and endorsed by the State Council in June 2012. It defines maximum volumes foot-print to nine floors and contiguity mandatory. It is a district that is undergoing a very fast urban densification process, by changing the open urban sprawl towards infill with closed and compact urban fabrics.

Energy concepts - Two main aspects have been taken into consideration to be analyzed:

- The conflict between the urban transformation toward densification with the energy performances of the architectural and cultural inheritance that pre-exist in the area;
- The expected technological development of renewable energy sources (RES) in this area due to the future obligation to install at least 10Wp/sq. m. (floor area) of PV in new buildings, as reported in the new “Model for energy requirements at Swiss Cantonal level”.

Architectural Quality – System Visibility – Context Sensibility - This case studio put emphasis on the visibility impacts of PV installations in urban areas with historical monuments of cultural significance. The high PV density (100Wp/mq) imposed by the future legislation, in dense areas, involves integrating RES even in façade. Due to the high visibility, BIPV solutions will be desiderable. Delta ZERO NZEB building represents a good example of solar renewable integration in Lugano-Paradiso. The delta ZERO building is located in an area of Paradise not immediately close to the historic buildings, protected by the new Master Plan. This part of the city is not affected by the process of urban transformation and densification of the city center, but it is an intensive and dense residential area.

Environmental, Economic and Social Impacts - The environmental impact has not been considered during the urban process and during the case study definition. The densification process would be a positive example from the point of view of sustainability, if considering factors such as: minor use of free soil; higher percentage of public spaces;the change of urban mobility and urban accessibility resulting in lower energy consumption, lower air pollution levels; the green zones and recreation areas proximity; minor per capita use of resources, and production of emissions and waste, etc..

One protected building has been studied in detail to set the economic impact considering the changes in its energy performances.

The proper integration of solar system is important to intensify social acceptance towards new technologies even in proximity to protected buildings.

Strategy and methodology - To investigate the impact of urban densification in the energy behavior of existing buildings and in particular on the heritage cultural monuments, four protected buildings in the area were selected and following aspects have been identified as main parameters to assess the energy impacts:

- Solar irradiation analysis and potential for solar passive strategies (current and future master plan scenario);
- Sky factors modifications in an urban context;
- Human comfort evaluation considering the heritage buildings;
- Daylighting and illuminance levels modification;
- Energy efficiency modifications of protected heritage buildings;
- Assessment of solar potential for renewable solar energy in the urban context.

The study identifies and proposes simple methods to assess solar radiation, daylighting availability and Sky-View Factor (SVF) modifications, in complex urban environments using a combination of numerical methods, 3D simulations programs with photo processing image methods. By comparing the situation before and after, when the urban transformation will be definitely performed and the new MP completed, it has been possible to calculate the percentage of solar obstruction (sunshine/shading) in each analyzed building, due to the presence of the nearby buildings in the surrounding area.

Lessons learned and recommendation

- Local development regulations can support measures to better exploit solar and daylighting resources;
- Planners and researchers together can help communities enact standards related to solar exploitation:
- It is important to develop specific codes to eliminate uncertainty around where solar system may or may be allowed to mitigate any potential negative impacts:
- Finally, it will be important to use comparable examples; to work in collaboration with planners and the municipalities and to convince the community members in order to explain specific aspects of research results in a comprehensive way that will help for greater acceptance of public to better implement new urban changes.

3. CONCLUSIONS – LESSONS LEARNT FROM VERGE-PROJECT

The work of the Task 51, after analyzing the various case studies, including the Verge project, concludes with the drafting of some conclusive considerations on the lessons derived from the interpretation and comparison of the case studies. Task 51 identifies some specific aspects to which the projects analyzed have made a contribution. The project in particular was considered an example of reference with respect to the following aspects: Legislation; Approaches Methods and Tools; Stakeholders'/Researchers'; Energy Use; Visual Impact – Urban Sensitivity and Integration Quality.

With regard to *Legislation,* the case study illustrates how urban densifications policies influence the energy demand, the solar availability of existing buildings and the heritage protection of buildings. Local development regulations can support measures enabling better exploitation of solar and daylighting resources.

With regard to *Approaches, Methods and Tools*, in the case study AMTs have been used to establish aspects that compromise the full exploitation of the external environmental conditions; were also used to examine the availability of solar energy and daylight to use passive strategies for thermal conditioning; finally were used to determine, where possible, corrective measures when negative impact on the status quo.

With regard to *Stakeholders'/Researchers' involvement*, the competences and the interests of stakeholders and researchers have a relevant impact on the development of a project. The case study illustrated how local contributors who include researchers, urban planning consultants, the Municipal Technical Office, architects and a building heritage owner work together. The importance of using comparable examples, working collaboratively with planners and municipalities as well as convincing community members in order to explain specific aspects of the researcher result in a comprehensible way, increased to better implement new urban changes.

With regard to *Energy Use*, the case study evaluated the implementation of new urban planning strategies on the energy behavior of existing cultural protected buildings in the area. A detailed verifications of energy flows, energy requirement for thermal conditioning and energy demand were made in one of these protected buildings, as example. This energy analysis was performed considering the two different urban simulations scenarios (before and after the implementation of the new MP) by using dynamic energy simulation tools that allowed to estimate modifications of the total annual amount of primary energy for heating and cooling (kWh/sq.m. yr) and of building operational costs.

Finally, with regard to *Visual Impact – Urban Sensitivity and Integration Quality*, using the LESO-QSV method as support instrument to preserve the quality of existing urban areas while still promoting solar energy use. The vision underlining the approach is that solar integration is possible even in delicate contexts provided that the integration quality matches the quality of its environment. The QSV method helps to define appropriate local levels of quality, and to identify the factors needed to initiate smart solar energy policies, able to preserve the quality of existing urban contexts while promoting solar energy use.

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