



CLIMATE RESILIENT STRATEGIES BY
ARCHETYPE-BASED URBAN ENERGY MODELLING

Atlas of the typical urban context configuration: resilient and mitigating strategies

DELIVERABLE 4.2

This study was carried out within the «Climate Resilient Strategies by Archetype-based Urban Energy Modelling (CRiStAll)» project – funded by European Union – Next Generation EU within the PRIN 2022 PNRR program (D.D.1409 del 14/09/2022 Ministero dell'Università e della Ricerca), M4C2, I 1.1. This manuscript reflects only the authors' views and opinions and the Ministry cannot be considered responsible for them.

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1. INTRODUCTION

1.1 Purpose

Global climate change leads to increased ambient temperatures, causing buildings to overheat and demand more energy while worsening indoor environmental quality. Urban Heat Island (*UHI*) effects, caused by local warming in urban areas, further exacerbate these challenges. Existing Urban Building Energy Modelling (*UBEM*) struggles to address *UHI* due to limited data on microscale climatic conditions and detailed mapping of urban areas. The CRiStAll project aims to address these gaps by creating detailed climatic datasets and exploring different urban configurations at the microscale.

Under the CRiStAll project, three interconnected research lines are developed. These include:

- (A) building an urban climate model that incorporates the impacts of the Urban Heat Island (*UHI*) at the microscale, as well as the short-, mid-, and long-term (future weather data) consequences of climate change;
- (B) putting the archetype-based Urban Building Energy Model (*UBEM*) into practice using typical urban environment configurations (street canyons);
- (C) evaluating the impact of climate resilience and *UHI* reducing methods in urban locations.

Within Work Package 4, “Resilient and Mitigating Strategies,” which addresses Research Line C, the effect of climate-resilient *UHI* mitigation strategies in urban context configurations will be evaluated across short, mid, and long-term scenarios. Task 4.2, “*Implementation of the strategies in the urban configurations*” focuses on evaluating the effect of the most effective climate-resilient cooling strategies identified in Task 4.1 “*Definition of climate resilient and mitigating strategies*”. The effect strategies to mitigate *UHI* effects are considered both in current weather scenarios as well in future scenarios affected by climate change.

1.2 Deliverable structure

This deliverable is structured into four sections, outlining the analysis and selection of climate-resilient cooling strategies to address Urban Heat Island (*UHI*) effects in both the present and a warming future. Section 1 serves as the introduction, detailing the purpose (1.1), deliverable structure (1.2), and partner contributions to Task 4.2 development (1.3). Section 2 focuses on the description of the selection process of *UHI*-mitigating strategies as among the ones described in deliverable 4.1, Section 3 described the scenarios on which the strategies will be applied reporting the parameters that characterize each scenario. Section 3.1 introduces the approach Section 3.2 describes the urban level scenarios while Section 3.3 presents the building level scenario. Finally, section 4 presents some remarks and comments about the whole process.

1.3 Contribution of partners

Units were in charge for the deliverable, together with the partners analysed the strategies and considered the ones implementable in the contest of the case studies, wrote the initial deliverable draft.

2. SELECTED CLIMATE RESILIENT AND UHI MITIGATING STRATEGIES

Deliverable 4.1 described three main categories of climate-resilient strategies: nature-based solutions (leveraging natural systems), grey solutions (referring to design and interventions in the built environment), and soft solutions (operational and behavioural measures). Different solutions have been described. However, the selection of the mitigation strategies to be adopted must consider the characteristics of the urban environment under study. The scope of this deliverable is to focus on selected strategies, explaining the selection process and the impact that can give to mitigate the urban island effect. The mitigation strategies are described by some parameters driving the simulations in UWG and CitySim tools to assess the outcome of the mitigation approaches. The scenarios that will be presented in Section 3 are therefore generated using the two tools. Urban scenarios depend on the output of UWG tools, while building scenarios are generated using the weather files generated by UWG and processed using the CitySim tool to obtain usable indicators about energy consumption and comfort and health conditions.

2.1 Nature-based solutions

2.1.1 Green infrastructure

Green infrastructure comprises different solutions such as green vertical walls, green roofs and street trees. However, the analysis of the applicability of the solutions on the urban environment led to the selection of the street trees as the sole solution to be investigated. The other two solutions were discarded due to implementation issues. The buildings in the considered urban areas present mainly pitched roofs clearly not usable to develop green roofs. Similar argument has been risen to exclude to the analysis green walls since the buildings vertical walls were considered not suitable for such installation in the considered areas. The selected strategy affects mainly the urban level contributing to lower the temperatures in the area. At the building level it can affect the shading effect and in CitySim can be considered with the insertion of shading areas. The UWG parameter that describes the street trees presence is "*treecover*" which ranges from 0 to 1.

2.2 Grey solutions

For grey solutions, three strategies have been selected: Cool roofs, Reflective Pavements, and Glazing techniques. Solar shading technologies were not considered since they modify the buildings external fabric and they application relies heavily on the municipal regulations. Furthermore, some buildings in the considered areas have historical characteristics and so the implementation of solutions modifying the general aspect of the building are expected to be prohibited. On the contrary cool roofs, reflective pavements and glazing techniques do not substantially modify the building characteristics.

2.2.1 Cool roofs

Cool roofs require only a change of the characteristics of the roof surface and can be easily implemented also in existing buildings using ad hoc coating and paintings characterized by high reflectivity. The effect of this strategy can be added both in UWG using the parameter "*albroof*" and in CitySim "*reflectance*". As for the impact this parameter is of great importance for urban scenarios but can affect also the building scenarios.

2.2.2 Reflective Pavements

The effect of reflective pavements can be tested using both tools for urban and building scenarios. In UWG and CitySim tools the reflective characteristic of pavements is inserted using the “*albstreet*” and “*reflectance*” parameters for UWG and CitySim respectively. These parameters should be selected with accuracy since they can also affect the convergence of the codes. As for the Cool Roofs this parameter affects both type of scenarios.

2.2.3 Glazing technologies

To reduce cooling loads for air-conditioned buildings and to reduce high temperatures for unconditioned buildings it is always important to limit the energy entering the living spaces with solar radiation. As mentioned before, solutions that use external shading devices are not considered, however, glazing technologies offer the possibility to reduce the solar loads using high performance filtering glass types. Almost all manufacturers offer products that reduce the entering solar radiation without jeopardizing the natural light contribution. Window characteristics can be modified in UWG with the parameter “*SHGC*” while in citySim the parameter can be entered as “*g-value*” solar factor of the window. In CitySim also the thermal transmittance of the window can be inserted as “*U-value*” parameter. Glazing technologies are of interest for both kinds of scenarios, also if it is supposed that can affect mainly the building scenario.

2.2.4 Natural ventilation

Natural ventilation is a traditional method used to reduce internal temperatures when the external ones are lower than the internal. Natural ventilation depends heavily on the conformation of the building and external environment. It is typically used during nighttime when external temperatures are lower. At urban level natural ventilation must be carefully evaluated since the effect of the urban canopy increase the temperature during the night respect the open area values, so the efficiency of the ventilation can be reduced. However, natural ventilation increases also the velocity of air increasing the comfort of people inside buildings. It is worth mentioning that natural ventilation is a characteristic of the building and a strategy already used by the users inside the building, so its effectiveness does not depend directly on the implementation of the strategy. However, this effect is heavily influenced by the performance of the urban level strategies that can lower external temperature so increasing the effectiveness of natural ventilation. The ventilation is considered active when there is a sufficient difference between external and internal temperatures described by the parameter Δt . This parameter is of interest for building scenarios only.

After selecting the most suitable strategies for the case studies, the next section outlines the framework for their implementation in the simulation environment, specifying the corresponding parameters and their application at both the urban and building scales.

3. FRAMEWORK FOR STRATEGY IMPLEMENTATION

The framework for implementing resilience and mitigation strategies is defined according to two main criteria. First, the strategies must be applicable to the case studies; for example, green roofs were excluded because the buildings within the defined urban context are mainly characterised by pitched roofs, which makes their implementation unfeasible. The second criterion concerns the

limitations of the *UBEM* simulation tool; for instance, green façades could not be assessed because CitySim does not support their detailed representation.

The table below outlines all candidate strategies, indicates whether they are implemented in CitySim (building scale) or in UWG (urban scale), and reports the parameters that define them.

Table 1. Summary of candidate strategies and implementation framework

Strategies	Implementation in simulations	CitySim	UWG	Value
Street trees	Change the coverage percentage or add trees as shading objects in the model	-	X	<u>Tree coverage:</u> 0.2 in UWG, an optimistic value that is chosen only to show the effect.
Reflective pavements	Assign high-albedo materials	X	X	<u>Solar Reflectance:</u> 0.50–0.80 (from Annex report) 0.70 (be applied in UWG)
Cool roofs, façades	Assign high-albedo materials	X	X	<u>Solar Reflectance:</u> 0.70–0.90 (from Annex report) 0.75, in line with UWG guidelines
Glazing Technologies	Define glazing/window properties: g and U	X	-	<u>Solar factor (g-value):</u> 0.25–0.35 (solar control glazing) <u>U-value (thermal transmittance):</u> - depends on the climate zone
Natural Ventilation	Adjust night ventilation	X	-	<u>Activation schedule:</u> - Ventilation is active when the indoor temperature exceeds the setpoint and the outdoor air is at least 2–4 °C cooler than the indoor air. - The <u>ACH</u> depends on the climate zone and building type and shape (4–8 h⁻¹).
Thermal insulation	Define the components' thermal transmittance	X	-	<u>It depends on the climate zone.</u>

The presented strategies are implemented in simulation scenarios, where different parameters are combined to obtain insights into the effectiveness of the selected mitigation strategies. It is worth noting that the parameters can have an influence at the urban or building level, so two scenarios have been defined.

The first scenario is an urban-scale scenario, and the parameters that characterize the scenario mainly influence microclimate conditions. The main tool used to develop the scenario is UWG. In this context, street tree cover and reflective pavements are implemented.

The value presented must be considered with care; for example, the tree cover value can be considered an indicative value, since the amount of tree cover depends on the current urban layout. Nevertheless, the analysis represents an insight into the potential of dedicated policies. Both strategies considered here require action at the level of urban design and public space management.

The second scenario builds on Scenario 1 by adding building-level strategies, which affect mainly the building energy consumption and the internal conditions, in particular the internal temperature and humidity, which affect the thermal comfort and the health of the people inside the building. In this context, cool roofs, cool facades, glazing technologies, natural ventilation, and thermal insulation are implemented.

In this case, all the strategies must be implemented by building owners or tenants. Nevertheless, the outcome of the simulation gives important information for policymakers and regulatory frameworks. Natural ventilation depends on the building structure and the number and position of openings. An additional problem is noise pollution, since window opening could be limited by the presence of outdoor traffic noise.

4. REMARKS AND CONCLUSION

The implementation of the strategies heavily depends on the performance of the simulation tools used. Particular attention should be paid to the combination of parameters and how they can affect the convergence of solutions. This is an important issue and should always be taken into account when generating the input files for the different tools. Some values cannot be available from standard sources and, so, alternative ways should be implemented in order to generate these scenarios. The UWG tool, for example, requires that the weather files contain the values of the infrared downward radiation, mainly due to the infrared exchange with the sky and cloud cover. However, not all stations record this value, and it should be derived from cloud cover data if available.

The combination of urban-scale and building-scale strategies is an important step to obtain an insight into how the urban canopy affects the energy consumption and comfort of people inside buildings. The study of the strategies is an important step to mitigate the temperature increase, in particular when the effects of climate change can be more pronounced in the near or distant future period.

In this deliverable, only a subset of the technologies presented in the Deliverable 4.1 were considered. This is due to the decision to consider only the implementable solutions with respect to the locations studied in this project. However, if other urban areas are considered, the previously discarded strategies could also be reassessed and implemented.

5. REFERENCES

Resilient Cooling of Buildings Technology Profiles Report (Annex 80) Energy in Buildings and Communities Technology Collaboration Programme. (2024).

A Practical Guide to Cool Roofs and Cool Pavements. (2012).