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CREATION OF EXPERIMENTAL URBAN INDICES IN ORDER TO ESTIMATE THE ENVIRONMENTAL PERFORMANCE OF URBAN/BUILDING REGENERATIONS

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Abstract

Identifying indices to measure the multiple environmental effects of urban transformations is the battle line for the urban planners. To tackle this need the Municipality of Modena (Italy) has defined a set of parameters focused on three main phenomena: the urban heat island, energy requirements and hydraulic risk. The indices are capable of measuring the effects, vouching for the achievement of the planning targets and estimating the benefit-cost ratio. The paper describes the pilot actions of the CE program's project UHI realized in the framework of the Plan of Urban Redevelopment of the *Villaggio Artigiano* (POC.MO.W, Modena).

Keywords

urban heat island • urban environmental indices • environmental sustainability • urban planning

Introduction

The high level of complexity of urban regeneration intervention is determined by a mix of reasons, mostly related with the challenge to share and somehow synchronize the needs of different interested parties. In this case more than in others, the 'ideas' must be generated in an open-minded environment where the awareness would allow the viewpoints of the different counterparts to converge. Regeneration and reuse, in par-

ticular, of urban areas and buildings can play a prominent role in containing the urban sprawl, however, they require significant effort, because they should be carried out according to the principles of environmental sustainability and resiliency.

There is a call for delivering innovative urban processes and assigning a new role to the decision making process. The focus is shifting towards innovative experiences and propositions and there is a quest to translate

them into new patterns for urban planning, affecting jointly sustainable development and social preservation (Capucci & Puglisi 2013).

The municipality of Modena embarked on a path aimed at the requalification of an urban area called *Villaggio Artigiano*. The area is not a gray field, but an existing and operative productive tissue in the Modena suburbs: it was created in the 1950s as a craft village and nowadays it is surrounded by residential growth around the city center.

In this framework the planners must interact with all the aspects of urban complexity, trying to mitigate not only the environmental impact of urban development but the crisis effects on the existing enterprises.

The challenge is to manage the interaction of the economical, social and cultural aspects which led to the existing texture, targeting the set up of a new and somehow alternative production system.

Tools to overlap the contest complexity are needed, creating a new system of 'good practice' which is easy to read and understand.

The overall strategy is based on double step logic: to strengthen the awareness of the citizens of the environmental issues, mainly related to the urban heat island, and to set up a panel of tools to support the willingness to protect the environmental and climatological constraints.

Having defined and set up actions to achieve the first two step, the Municipality is now facing the challenge of defining 'the fuel' to run the engine, or the incentive system to support the purposes of the owners and the builders.

The Villaggio Artigiano in west Modena

The village is a sort of 'craft production island' created after the war by the mayor Mr. Corassori, who wanted to launch economic improvements in Modena.

In 1953 the idea become reality: the municipality found an area of 15 ha in west Modena between the railway and the via Emilia and in less than 6 years the *Villaggio*

Artigiano was there with 74 new enterprises. Two main areas of 60 lots were immediately assigned, so the Village was enlarged to 800,000 m² and 200 enterprises (Fig. 1).



Figure 1. The Village in the 1960s

Source: archives of the Municipality of Modena.

The Village was firstly located in the open country, but today it is a rather central location in the structure of the town. Looking at an aerial picture, the Village today is a triangle among two main streets and the railway (Bologna-Milano) which will be closed in the near future.

The location has interesting aspects: it is close to the historical center of the town, it has good road connections with the extra-urban network, it is in the middle of a project of requalification of the west part of the town, with the closure of the railway that will allow the construction of new and more functional roads (Fig. 2).

The Village is an example of territorial identity, of a model 'Modello Modena' that has made the economic fortune of the town, and is also an important part of our social history. The village represents a safe bet of an entire generation able to overcome the destruction of the last war and to develop one of the most wealthy productive districts in Italy.

The Village has economic and business value: it was what we call today a 'start up'

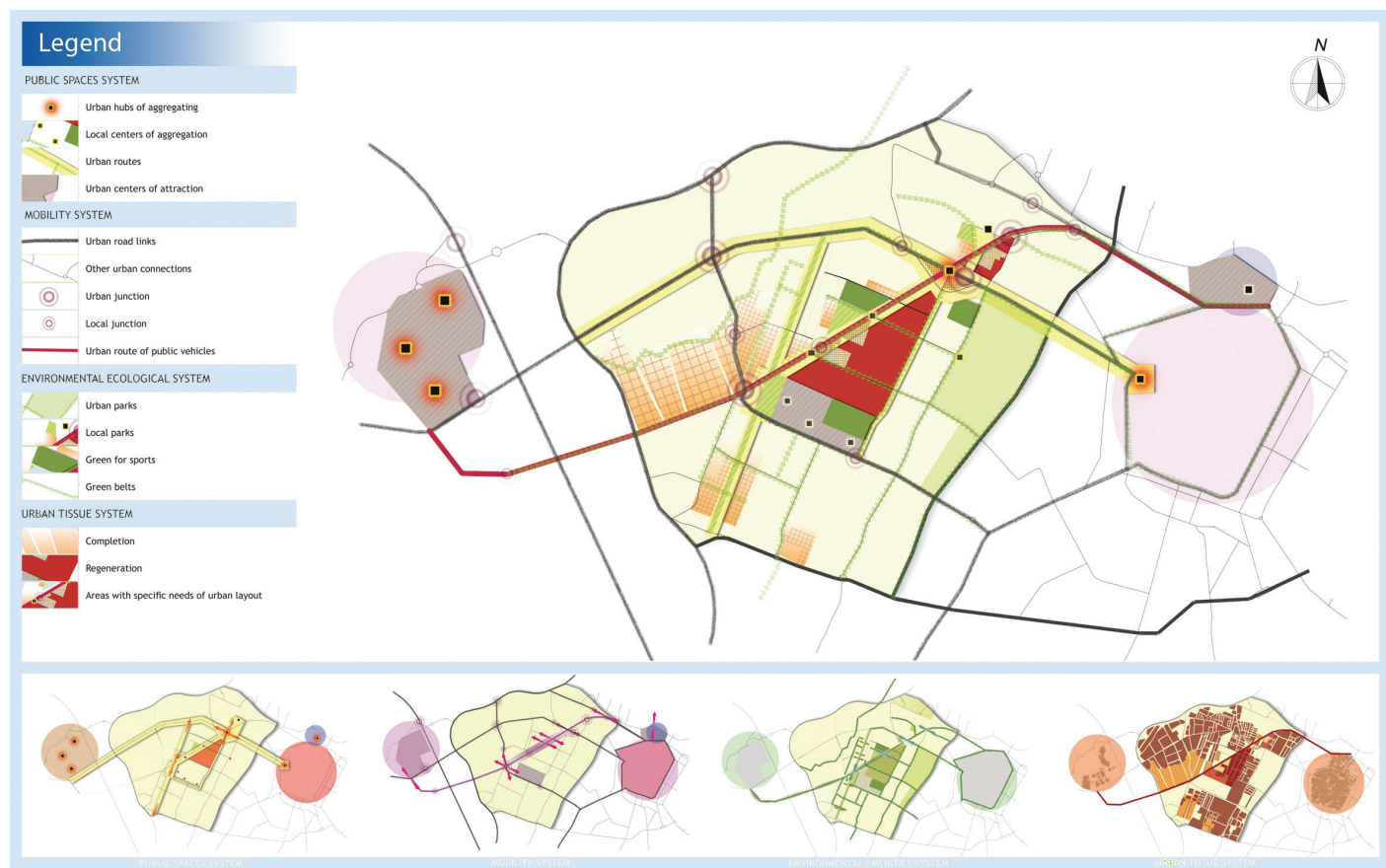


Figure 2. Concept Plan of the future redevelopment of the west area of Modena. Area of the *Villaggio Artigiano*: ‘Urban tissue system’ identified as ‘Regeneration’ and ‘Areas specific needs of urban layout’

Source: Modena, City’ Public Administration, Assessorato alla Pianificazione e Gestione del Territorio.

project. For this reason, local people consider the area as part of the identity of the town to regenerate and value. Even more so, when one considers that the village is a vital place, because, especially in the early settlements, there was also the possibility to build the house close to the shed to minimize the cost of living and transportation.

Today it is still an active area with different technological craft businesses that spontaneously replaced the traditional craft enterprises. It is hoped, therefore, that it may also become a district of the local creativity (*Creatività modenese*) holding together the inheritance from the past and the modern attitude.

The guidelines for the transformation promote regulatory interventions and projects able to allow the transformation in loco, increasing the functional mixture among production (which is still prevalent), services and housing (also considering new housing models like atelier). The adaptive capacity of the texture of the area is a strength that enables the requalification through the re-use of the existing buildings and roads, saving soil and increasing the functional mixture and functional mobility (Modena 2014).

The administration started the regeneration route with the approval of a Plan of Urban Redevelopment of the Village (*Piano operativo di riqualificazione Urbana per il Quadrante di Modena Ovest* – next refers as Plan) aimed at drawing up regulatory standards for the Village area, directly feasible through urban planning. These encourage the re-use of buildings, without disrupting the singular architectural texture, also introducing non-productive facilities (previously not allowed) like commerce, services, housing, fostering a requalification strongly oriented to energy saving and environmental well-being.

The Plan also includes demolition followed by reconstruction of a new building, while maintaining the shape of the previous one, thus preserving the system of dimensional and volumetric relationships that characterizes the Village, achieving a new building organism that continues and updates the typical evolutionary process of the 'Craftsmanship Village'.

At a later time, a second step will be to promote the delocalization of those high environmental impact enterprises, nowadays located in the Village.

Environmental analysis

Modena is a town of about 179,500 inhabitants located in Northern Italy, in the so-called 'Pianura Padana', the Po Valley. The climate is characterized by cold, rainy, foggy and moderately snowy winters, and hot summers. On average, the temperature reaches minimum values at dawn and maximum during mid-afternoon. Since 2001, an absolute maximum of 38.7°C and a minimum of -10°C have been detected. The urban area of Modena is warmer than the rural area. In agreement with the classic trend of Urban Heat Island, the differences in temperature occur more at night, especially in the summer.

Many different Italian, European and world cities have standard procedures to evaluate the environmental urban impact. In Modena, the municipality began to explore the theme in cooperation with technical professional Orders. The environmental performances assessment was elaborated with the contribution of the Order of Doctors of Agronomy and Doctors of Forestry of Modena using the B.A.F. procedure (Biotype Area Factor) firstly used in the 1990s in Berlin and today it has become a standard for other urban realities (*Landschaft Planen & Bauen*, Becker Giseke Mohren Richard 1990).

The motivations leading to the study of this urban index are varied: the possibility to have an instrument to assess mitigation and environmental restoration and landscape preservation; microclimate and atmospheric air improvement; soil control and hydric equilibrium; improvement of green areas and animal habitats; improvement of the human living environment; aesthetic and quality improvement of every single building and even of an entire block.

Within the B.A.F. procedure, mitigation and environmental restoration instruments are the application of technologies to manage

and reuse rain water, the realization of green surfaces with the introduction of technologies to realize green roofs and vertical gardens and the implementation of traditional green areas.

From the first proposal, which was an important starting point of reflection, there have been many insights, mostly resulting from the interaction with the territorial cooperation project called UHI – Urban Heat Island (Modena municipality was in partnership with the Region Emilia Romagna and ARPA Emilia Romagna); the *Villaggio Artigiano* in Modena was a pilot area for implementation and assessment of mitigation strategies.

The UHI project aims to assess the heat urban island phenomenon. The insights studied during the UHI project from the specific working group have contributed to the analysis of wider intervention criteria than those proposed by B.A.F. with also some original aspects.

The further refining of the analysis of environmental quality indices and procedures existing at national and international level, allowed for the summary and putting together of all the various positive aspects of the existing models.

At the same time, thanks to the technical support coming from partnership within the UHI project, to the technical departments of the Municipality of Modena and to collaboration with the University of Modena (Faculty of Engineering, Department EELab), it was possible to better understand and analyze the various factors that affect the environmental characteristics of a building (Bonazzi et al. 2013).

These insights led the Modena municipality to carry out a different method for experimental calculation, which is able to point out environmental performances of a construction project through the use of indices which can estimate physical phenomena and which is based on scientific/technical aspects and procedures already defined by laws or municipal regulations.

Thanks to the collaboration with ARPA (within the UHI project) some meteo-climatic evaluations were carried out to highlight the

correlation between the output of the indices and the real environmental performance of construction projects and to analyze the benefits brought from a number of possible solutions that can be adopted in a project scenario.

Thanks to the collaboration with Democenter Foundation (within UHI project) the experimental indices were presented in the med Program project REPUBLIC-MED (REtrofitting PUBLIC spaces in Intelligent MEDiterranean Cities) as an urbanistic/technical instrument to estimate the heating island.

Experimental indices arrangements

A recurring characteristic of the existing procedures aimed at estimating the environmental performance of a building is to provide an assessment, and in some cases a measure, of the quality of the proposed intervention, within an environmental profile (in the broad sense), providing instruments and calculation methods that are simple and of immediate use.

The evaluation is based on the achievement of minimal performance levels, leaving wide freedom of choice of the materials/intervention to use in a specific building tender.

Attention to environmental aspects together with more traditional 'technical' instruments can play an important role in the requalification and regeneration of our cities. This regards both the adoption of urban and environmental innovative regulations and the adoption of technologies and solutions that increase the sustainability and environmental comfort.

The main objective of the Plan is to allow a renewal of the housing stock in the Village, through comprehensive requalification. Given the new environmental context in which the Village is included, the Plan has been realized to encourage high performance interventions, in order to ensure, besides urban redevelopment, the environmental redevelopment of the area.

The positive experiences of other cities were analyzed in order to define suitable procedures for incentives, and different existing indices were tested to estimate the improvements that can be obtained with a redevelopment project. Starting from the 'B.A.F. – Biotype Area Factor' city of Berlin (Germany), other indices were then analyzed: the 'Green Space Factor', city of Malmö (Sweden), the 'Green Factor', Seattle (USA), the 'Rie – Riduzione Impatto Edilizio' Bolzano and Bologna (Italy) (Berlin.de 2014; Bologna 2014; Bolzano 2014; Malmö 2014; Seattle 2014).

The deepening of such approaches, already operational and tested, led to the definition of most important environmental aspects to be considered in the redevelopment project of the site and therefore best practices to implement in order to reduce the building's impact.

This made it possible to highlight the principal valuable aspects to be included in the guidelines for the *Villaggio Artigiano*, fostering a new experimental approach.

Gathering together technicians from the municipality and professional technicians, particularly within the UHI project, the specific environmental themes were analyzed, and they ended up with the first structuring of the indices to be used in the Plan with both the function of guidelines' synthesis and evaluation instrument.

The indices came about from the need to provide dynamic evaluation instruments able to guide the requalification projects without over loading them.

Therefore, to calculate the indices, the municipality developed software that implements the algorithms and sets up the parameters and calculation procedures. This instrument has an easy user interface and can rapidly elaborate data entry. Even if the algorithms feed the indices' complexity, leading to much more complicated processing than that developed from similar existing indices, the data entry phase approach has remained unchanged and remains extremely user friendly.

One of the main aspects of the method used by the Municipality is to be able to analyze all the surfaces of a lot (courtyard area, vertical walls and roofs) considering all the materials that can be used ('green' and 'not green'). Another important aspect is the ability to elaborate output with a physical unit, that can estimate the magnitude of specific real phenomena. Another, further important aspect of the indices is to be able to put together the simplicity of an urban index with the scientific analysis of the complex physical processes that characterize the environment. The approach is both a typical urban approach, focused on defining simple, direct and quick to use evaluation tools, and a scientific approach, characterized by accurate and precise assessments. The result is a method which can maintain scientific rigor and to limit oversimplification of the land planning point of view.

Structure of experimental indices

For the calculation of the indices, it is usually necessary to know the different kinds of materials/interventions in the lot and their width. By applying different coefficients to each material/intervention, it is possible to obtain a number proportional to its 'environmental quality'; through the use of a simple calculation algorithm, these numbers allow us to obtain a synthesis of the characteristics of a specific lot (Capucci & Puglisi 2013; Modena 2014).

To guarantee an appropriate performance standard in the redevelopment project, a value of the index no lower than a certain threshold has to be achieved.

The common characteristic of the indices is to give a simple and prompt calculation method, aimed at designing a lot without rigid patterns and based on the achievement of minimum performance levels, with freedom in choosing materials/interventions to be used. These procedures are a concrete approach already in use in the last few years in building design, promoting the environmental sustainability (Tab. 1).

When elaborating the indices, an attempt was made to gather together the valuable elements of those procedures, the ones able to improve the environmental characteristics within a urban requalification, making a synthesis of the types of interventions which guarantee the best environmental performance and the best procedures established to provide incentives for redevelopment projects¹.

Table 1. Valuable elements of existing procedures (by Bonazzi & Rizzo 2014)

Positive urban intervention	
• Green elements in courtyards, on the roofs or on the walls • Intervention like cool pavement, cool roofs, cool walls • Permeable paving or roofing • Trees or bushes • Collection and reuse of rain water	
Procedures for incentive	
• Adopt incentives to improve high performance interventions • Adopt procedures to highlight the quality/price ratio of every intervention • Realize bonus elements to improve the landscape quality • Integrate the indexes with a list of proceedings and solutions to describe how to face specific problems	

Types of intervention

The analysis of possible achievable solutions within the building intervention (in the existing scenario and in the project scenario) and the analysis of the physical and technical characteristics of the materials led to a catalogue of possible interventions: 20 different possible actions to refurbish the existing buildings

¹ Standard Methods of characterization and certification of the 'cool' solutions, with high solar reflectance, are being developed by the European Cool Roof Council (<http://coolroofcouncil.eu>). Specific actions for information and training on these solutions will be promoted to Modena from the MAIN Project – Matériaux Intelligents, MED Programme cofinanced by the European Union.

or construct new buildings (Capucci & Puglisi 2013; Modena 2014) (Tab. 2).

Table 2. Types of intervention implemented in the software

Courtyard area	
1	Gardens/flower beds
2	Trees/bushes
3	Permeable pavement
4	Lawn driveway
5	Cool pavement (with high sun reflectance)
6	Standard pavement (concrete, ...)
7	Gravel
Vertical walls	
8	Vertical green creeper
9	Vertical garden
10	Ventilated
11	Cool wall (light colour plaster coat - white or light yellow)
12	Plaster coat (dark colour)
13	Bricks
Horizontal ceilings/roofs	
14	Green roof
15	Cool roof (white colour)
16	Cool colour pitched roof (medium colour)
17	Integrated pv
18	Pitched roof (with tiles)
19	Other cover (light colour)
20	Other colour (dark colour)

Indicators of environmental impact

To estimate the environmental quality of an intervention, an approach based on technical and scientific consistencies was defined, identifying appropriate measurement units and highlighting the environmental performance based on indicators that predict tangible, physical phenomena.

Some consolidated procedures were implemented, accepting some approximations, to simplify data entry by the user.

To evaluate the environmental performances of an intervention, the analysis of the possible environmental phenomena that are influenced by the building process was made.

A synthesis of those aspects led to the identification of three main environmental aspects: the urban heat island effect (outside the building), the energy requirements (inside the building) and the hydraulic risk (outside the lot). The first is related to the properties of building materials to accumulate heat from solar radiation and then release it, determining an increase of the temperatures (including the overnight minimum temperature) more evident during the summer; the second is related to the properties of building materials to reduce/increase the energy consumption due to heating and air conditioning; the third is related to the properties of building materials of having impervious horizontal surfaces that can cause an uncontrolled outflow and subsequent increase of flood in urban basins.

The technical analysis of those aspects led to the identification of three different indicators, able to estimate each phenomenon. The indicators have been used to derive different calculation procedures, one to estimate the urban heat island, one to estimate the energy requirements and one to estimate the hydraulic risk.

Analysis of the urban heat island phenomenon

In days with anticyclonic regime at high altitude and strong stability on the ground, there is a vertical profile of temperature characterized by a thermal inversion (thermal inversion on the ground – countryside). The heat released from the buildings tends to counteract the vertical thermal inversion without breaking it completely (thermal inversion at high altitude – city), creating an air dome whose maximum height is placed in the most densely built-up area.

The inversion layer creates a barrier that prevents the mixing of vertical atmospheric air over the atmospheric available layer. This creates an urban heat island, which, therefore, depends on the season, on the geographic position of the city and on its characteristics.

The 'dome' keeps the heat and is responsible for the increase in temperatures (including the overnight minimum).

On building's surfaces, the presence of materials with low ability to reflect solar radiation (i.e. characterized by low values of solar reflectance, defined as the ratio of reflected radiation and total incident radiation) under the effect of strong irradiation causes high thermal loads on the affected surfaces.

If these surfaces belong to a building with poor thermal insulation (i.e. with high thermal transmittance), they will overheat and will release heat into the atmosphere, even up to the night, contributing to a rise in the air temperature and therefore to the urban heat island phenomenon (overheat of urban area compared to country areas).

The ability of materials to reflect solar radiation (due to a high solar reflectance), to release the absorbed heat toward the high atmosphere (due to a high thermal emissivity) and to insulate (due to a low thermal transmittance) allows, at the same time, for the reduction of heat entry into the buildings (in summer time) and the containment of thermal dispersions from the inside to the outside (in winter time); this limits the conditioning energy need during the summer and the heating energy need during the winter, ultimately contributing to energy savings.

The methodology to analyse the phenomenon was implemented in the software thanks to collaboration with Modena University – EELab Department².

The methodology is able to combine the physical characteristics of the materials (solar reflectance, thermal transmittance and thermal emissivity) with the incident solar radiation to obtain a value to express the energy transmitted through a generic surface (kWh/m²) in a certain period of time.

The index related to the urban heat island measurement is called 'RATE': Reduction

² EELab is the Energy Efficiency Laboratory of the Mechanical and Civil Engineering Department of the University of Modena and Reggio Emilia, Italy, <http://www.eelab.unimore.it/site/en/home.html>.

in the Absorption of Thermal Energy. Every type of pavement, wall and roof was studied in order to identify specific performance parameters (solar reflectance, thermal transmittance and thermal emissivity). To evaluate the different irradiation conditions of roofs and walls (for these the azimuth angle was considered) the energy value per surface unit indicated in the UNI regulation was taken. The loss of energy caused by the shading of building volume was considered to evaluate the irradiation of courtyards.

To take into account the thermal energy absorbed by vegetal elements (trees and bushes, used for photosynthesis and during evaporation and transpiration) a percentage reduction of the thermal energy absorbed by the vegetation was applied.

Also the shaded area, due to tree leaves, was considered in order to reduce the amount of energy passed to the courtyard area. The analysis of the building volume includes an estimation of the energy absorbed by the windows, considering the type of windows and the presence of shielding elements to protect from solar radiation.

Calculation of the 'Rate' to estimate of the urban heat island phenomenon

The data required to elaborate the index describe an ante-operam condition (existing scenario) and a post-operam condition (project scenario). The procedure in the software asks for the sequential elements (Tab. 3).

Table 3. Data required to elaborate the urban lot

Data required to elaborate the urban lot
• Square meters of existing area (same data for project area) • Square meters of covered surface of both areas – existing and project scenery (that can be different) • Average height of buildings (in both sceneries) • The length of a side of the building (in both the sceneries) • The orientation of the building (in both sceneries)

With those data, the building lot is reduced to a simple geometric lot: in the existing scenario and in the project scenario, the building volume is a cuboid in the middle of an 'equivalent' courtyard area, where the distance between the side of the building and the border is equal on each of the 4 sides.

It is necessary to simplify the geometry so as not to overload the index with too many inputs; this doesn't exclude ulterior implementations.

After the identification of the interventions characterizing the existing scenario, and which have to be done on the project scenario, it is necessary to input the surface dimension of each intervention to the software. It is possible to indicate the dimensions of different types of surface on each wall (so to calculate the energy transmitted to the walls considering different irradiation conditions). To simulate the presence of trees, it is necessary to input in the software their total number. To evaluate the thermal transmittance of every single wall and roof, it is necessary to input the year of building (from 1960 on).

After data input, it is possible to calculate the index. Then, the thermal energy absorbed from all the surfaces of the lot is calculated (kWh/time) in both the existing and the project scenarios. The ratio between energy and the lot's surface gives the ultimate value of the index.

The output allows the estimation of the improvement achieved: the quality of an intervention can be underlined based on the index value and on its consequent class group; by measuring the reduction of the absorbed thermal energy (kWh/time) in the project scenario compared to the existing scenario, it is possible to evaluate the improvement of the environmental performances (Fig. 3A, 3B and 4).

The calculation model is based on the assumption, according to which, the urban heat island phenomenon is related to the fraction of solar radiation absorbed by urban surfaces, which then causes the overheating of the surfaces and of overhanging air: it is assumed that the radiation reflected to the upper atmosphere by the surfaces, the

re-emitted infrared radiation to the upper atmosphere and the radiation disposed of by green surfaces through evapotranspiration, do not contribute to the urban heat island.

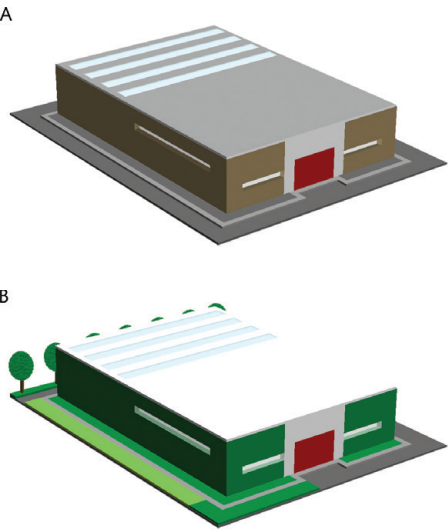


Figure 3. Comparison between an existing scenario (A – built lot: courtyard area with standard pavement; walls with plaster coat of dark colour; roof with dark colour) and a project scenario (B – courtyard area with gardens, trees and standard pavement; walls with vertical green creeper in the two visible side of the picture and light colour plaster coat in the other two; cool roof)

Source: Bonazzi & Rizzo 2014.

The calculation model uses the following formulas, which calculate the energy absorbed by the irradiated surface during the summer time (June, July, August)³.

Energy absorbed by a generic irradiated surface:

$$= \sum_m \left[r \cdot (1 - \cos \vartheta) / 2 + s \cdot (1 - r) \cdot \frac{h_r \cdot (1 - \cos \vartheta) / 2 + h_c}{h_r + h_c} + (1 - e) + \tau \right] \cdot \frac{I_m \cdot \Delta t_m}{1000}$$

[kWh/m²]

Nomenclature:

Symbol	Quantity	[SI unit]
I_m	average daily solar irradiance in the calculation period (month)	[W/m ²]
Δt_m	duration of the calculation period (days in month)	[h]
e	solar radiation disposed of by a green surface through reflection and evapotranspiration	[%]
τ	total solar transmittance of the windows	[%]
r	solar reflectance	[%]
ϑ	inclination of the irradiated surface to the horizontal	[rad]
h_c	convection coefficient	[W/(m ² K)]
h_r	radiation coefficient	[W/(m ² K)]
s	selective coefficient	[0, 1]

³ Author: Alberto Muscio, EELab Department of Engineer 'Enzo Ferrari', University of Modena and Reggio Emilia, Italy.

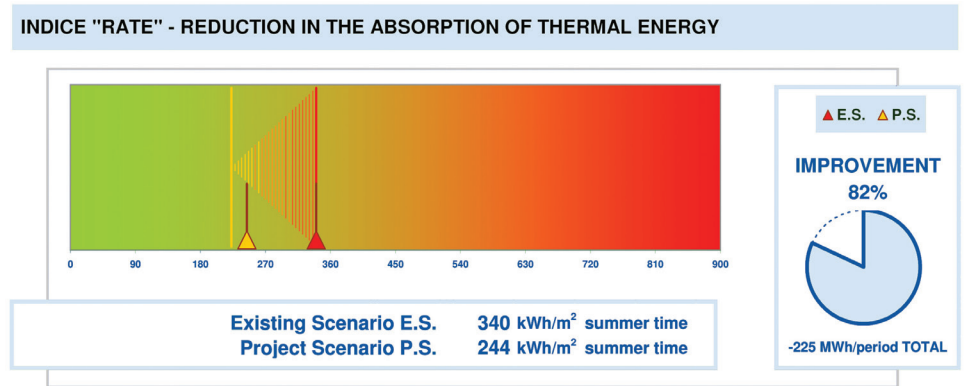


Figure 4. Comparison between the existing scenario and the project scenario

Source: Bonazzi & Rizzo 2014.

For non-horizontal surfaces ($\vartheta > 0$), it is assumed that the solar radiation reflected towards the ground, as that emitted in the thermal infrared towards the ground, are completely absorbed by surrounding urban surfaces, and ultimately transferred to the air, thereby contributing to the creation of urban heat island.

For green surfaces (courtyard area, walls or roofs), opaque surfaces (courtyard area, walls or roofs) and windows (walls or roofs), the following values apply (Tab. 4).

Table 4. Values of the coefficients for each type of surface (by Muscio)

Type	R	S	E	T
Green surfaces	0	0	0.7 horizontal surface 0.6 vertical surface	0
Opaque surfaces	$0 < r < 1$	1	1	0
Windows	$1 - \tau$	0	1	$0 < \tau < 1$

Note that $hc \approx hr$ with calm air, ambient temperature and ordinary surfaces, consequently:

Energy absorbed by a generic irradiated surface:

$$= \sum_m \left[r \cdot (1 - \cos \vartheta) / 2 + s \cdot (1 - r) \cdot \frac{(1 - \cos \vartheta) / 2 + 1}{2} + (1 - e) + \tau \right] \cdot \frac{I_m \cdot \Delta t_m}{1000} \quad [\text{kWh/m}^2]$$

Introducing the above values (Tab. 4) into the formula, it is possible to obtain valid expressions for individual cases (green surfaces, opaque surfaces, windows) as shown below.

Formula for green surfaces:

$$= \sum_m (1 - e) \cdot \frac{I_m \cdot \Delta t_m}{1000} \quad [\text{kWh/m}^2]$$

Formula for opaque surfaces:

$$= \sum_m \left[r \cdot (1 - \cos \vartheta) / 2 + (1 - r) \cdot \frac{(1 - \cos \vartheta) / 2 + 1}{2} \right] \cdot \frac{I_m \cdot \Delta t_m}{1000} \quad [\text{kWh/m}^2]$$

Formula for windows:

$$= \sum_m [(1 - \tau) \cdot (1 - \cos \vartheta) / 2 + \tau] \cdot \frac{I_m \cdot \Delta t_m}{1000} \quad [\text{kWh/m}^2]$$

The parameters are developed on the basis of UNI technical rules (UNI/TS 11300-1 or UNI EN ISO 13790 for calculation of building thermal behavior, and UNI 10349 for standard atmospheric data) and based on the characteristics, inclination and orientation of the types of intervention chosen by the user (Libbra et al. 2013).

The approach adopted in the implementation of the experimental indices, in line with that used for existing indices, identifies the lot as a single object without considering the urban surrounding, which leads to an extreme simplification. The use of the indices cannot be considered apart from the urban context of the intervention. The data produced are therefore supported by other elements coming from the analysis of the urban context. To complete this phase there is a list of guidelines to support the project job which consider different structures (i.e. lot street side, lot among other lots with similar height).

This way, it is possible to consider phenomena like the urban canyon or the air circulation system, giving the planner another instrument to better choose the best type of intervention.

Indices as guidelines to plan and incentive methods

After the index is calculated, it is possible to modify the set of type of interventions to obtain a better result and compare the new project scenario with the others and

choose the best one that gives higher environmental value.

The types of intervention considered in the indices, are therefore a functional synthesis of the planning guidelines which are able to give quickly and accurately both support for architectural planning and an evaluation of general impact. To further improve the analysis connected to planning, the software has a dynamic table that shows the impact from every single intervention within the building project. The indices can improve not only the support tools already described, but can also estimate the costs of the different interventions, therefore considering the cost/benefit ratio and enabling the choice of the best intervention possible for a certain economic resource.

The analysis of the building indices is aimed at gaining a valuable method that, using the evaluation of environmental benefits, could estimate the reward to be given to requalification projects. The municipality is considering the use of the indices within the redevelopment plan of the Village, so as to regulate rewards linked to the achievement of valuable solutions from the environmental point of view. This approach aims to promote not only solutions that can foster the value of a single lot, but also of an entire block, ameliorating the urban landscape and its usability both in terms of environment and perception. To give the incentive or bonus, the promoting subject has to demonstrate the intention to actually realize the type of intervention used to calculate the indices.

In this regard there will be, for each type of intervention, some binding aspects to obtain the reward or bonus. In the case of gardens in the yards, it will be compulsory to also build an automated watering system, in the case of green walls or roofs it will have to demonstrate the presence of a gardening maintenance contract for a certain period of time.

Conclusions

Intensive land use and resources in general, characterized the development of contempo-

rary cities and was due to a quick and radical change in society and of the economic system. The wrong perspective, to have an infinite availability of land and continuous economic development led to radical urban and territorial transformations.

At the same time, the collapse of Europe's industrial and manufacturing economy has left two different wounds in urban tissue, inner city areas blighted by unemployment, riddled with poor housing and socially excluded from more prosperous districts.

Inner city regeneration was a dominant topic in urban policies in the 1980s and in 1990s not only for reusing brownfields and vacant lands but also to contrast social diseases, unemployment and poverty.

Many of these projects failed in different countries and in different cities because of a lack in rules and management tools. A modern urban planning approach seeks to order and regulate land use in an efficient and sustainable way. In doing so, the governmental unit can plan aiming at fulfilling community needs and protecting natural resources. But a win-win option must be based on a conscious will to take part proactively to the process. Citizen awareness, tools to assess the effect of the actions implemented and an incentive system need to be the driving logic.

This is the reason why the European Commission, as well as many countries, introduce new goals and new strategies for urban policies and pay more attention to urban renewal guidelines aimed not only at sustainability but also to social enhancement. This is a real turn in planning and building interventions, a new approach to regeneration policies and a new concern about recovery strategies. The CoR, during the annual plenary session of the 9th and 10th of June 2010, express an official opinion on the role of urban regeneration (UR) in the future of urban development in Europe and stated: "The Committee of the Regions stresses that urban renewal policies should form the basis for an appropriate model, with a broad base of activities covering forms of intervention ranging from

regeneration of urban spaces to rehabilitation of existing housing stock” Committee of the Regions, 2010.

The municipality of Modena began many years ago a plan of intervention aimed at the requalification of a portion of the urban territory that represents a piece of history of the town itself. In this context, urban planning is making an effort to promote the re-building of the area, preserving the peculiarities. Functional and easy to use procedures were defined to create indices to evaluate the environmental performances to reward the best environmentally valuable urban interventions. The innovative mixture of instruments proposed by the municipality to better re-use the territory and to estimate the environmental restoration achieved with the urban interventions, is a starting point to give the planner flexible and easy to use instruments.

The urban indices represent an experimental approach with huge potential, only waiting to be used in future urban requalifications. The indices give a calculation method that aims for a free planning of the lot, based on the achievement of minimum performance standards, introducing innovative elements as the ability to analyse all the surfaces of a lot (courtyards, walls, roofs) considering the characteristics of the materials, as the ability to elaborate a physical output and to combine the simplicity of a typical urban index with the complexity of a scientific analysis of the processes characterizing the context.

In a situation in which the attention to environmental issues is even more linked with the urban matter, where urban planning has continuously new issues concerning many different regulations or environmental approaches,

it is more and more important to understand how to keep an overall view able to permit urban planning to analyze and manage the whole intervention.

The method elaborated by the municipality is based on the hypothesis that the overall view can be possible by defining clear working lines that, after having ‘understood’ the complexity of the topics, allows the planner to foster creativity, freeing them from the need to dwell on specific technical aspects.

The analysis of environmental indices that outline and estimate the physical complex phenomena is moving in this direction and is an experimental approach focused on the definition of instruments able to support a decisional process where urban planning and environmental sustainability are both protagonists.

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