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Sustainable requalification in restricted area: the case study of Flaminio stadium in Rome

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Abstract

The requalification of neglected areas in urban contexts are considered as one of the main challenges to get the targets of environmental sustainability, energy efficiency and life quality currently required for smart cities. The management of deteriorated urban green areas increases human well-being and biodiversity conservation, facilitating the individuation of natural and anthropic risks as well as territorial vulnerabilities. In this context, the paper focused on the Flaminio Stadium in Rome that despite its central position in the city, is located inside a neglected area that could potentially be requalified offering services and facilities to citizens and tourists. This demonstration starts from a status quo study of chosen building and its surroundings in terms of energy analysis. This latter is, then, implemented by a techno-economic study to support its improvement in terms of energy efficiency and sustainability. The economic cost analysis evidences the difficulties to support a requalification cost of global district for the Municipality of Rome.

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Keywords: sustainable requalification; building energy retrofitting; techno-economic analysis; sustainability.

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1. Introduction

In Italy there are about 160.000 sports facilities according with the Ministry of Cultural Heritage and Activity data. In many cases a sport facility is considered as a practical solution for the requalification of a deteriorated urban area and can be integrated to other annexed services for the community for the planning of multifunctional centres.

However, in Italy there are many cases of incomplete sport facilities mainly due to technical causes, failure of contractors, and lack of funds or regulatory constraints. The requalification of neglected areas in urban contexts are considered as one of the main challenges to get the targets of environmental sustainability, energy efficiency and life quality [1] currently required for smart cities. First attempt was made by implementing waste management strategies to give back to the city new energy within its operational cycle [2]. Yet, the management of deteriorated urban green areas increases human well-being and biodiversity conservation, facilitating the individuation of natural and anthropic risks [3,4] as well as territorial vulnerabilities [5]. Furthermore, the requalification of urban green spaces facilitate the natural development of ecological corridors [6] and safety standards for citizens [7]. Another key point is to address carbon emissions reduction deriving from energy production by more efficient systems [8] along with dedicated strategy for air quality improvement [9]. Brownfield areas are generally composed by low-performance buildings which call for hard energy efficiency interventions to comply with regulations in force [10] or upgrade of Heating, Ventilation and Air Conditioning systems for reducing losses and consumption [11,12]. In this context, the paper focused on the Flaminio Stadium in Rome that despite its central position in the city is located inside a neglected area that could potentially be requalified offering services and facilities to citizens and tourists. The stadium is along the Flaminia street, the first street to connect the city of Rome with the North of Italy. Anyway, despite its importance, the area from Porta Flaminia to Ponte Milvio was not urbanized until the XX century, due to the recurring inundations of Tiber River that needed the planning of flood defence interventions [13]. The first important interventions in that area were in the '900 with the edification along the banks of the Tiber River of military garrisons and sportive centres. Subsequently, residential buildings occurred aligned with the modernism and the low cost and low energy performance as well [14]. This situation did not changed until the 1960 Olympic games in Rome, that required new and large construction of sportive facilities, infrastructures, accommodations for athletes and reporters generating the new districts of Flaminio.

Fig. 1. (a) The area of Flaminio with highlighted sport facilities.

Yet, the new transportation infrastructures increased the fragmentation level of surrounding natural habitats [15].

The Stadio Flaminio area is situated along the director of the Flaminia street, it is located in the urban zone Parioli, with a surface of 2,08 m^2, a density population of 10.581,25 inhabitants per Km^2 and an overall population of 22.009 inhabitants in 2015. As shown in Fig. 1, the area of intervention is mostly occupied with sportive services, green and residential areas.The external areas neighbouring the Stadio Flaminio is degraded and the public green in state of neglect. Nevertheless, referring to the structure of Stadio Flaminio there are no particular constraints, despite its elevate architectural value: The global structure is made by reinforced concrete, the shelter is supported by external inclined pillars that they are installed in place. The roof have the drilling with dual function: lightening structure itself and housing lighting equipment. As many large buildings, it plays a key role in 'greening the city' strategies such as photovoltaic generator installation on roof or integrating into the facades [16,17]. It was designed by A. Nervi and P. Nervi and it was inaugurated in the 1959.

Stadio Flaminio provides 42.000 seats of which 8.000 covered ones seats; at first the sportive structure hosted many service as bar, the covered heated pool of 25x10 meters, two rooms for education, two gyms for the fight and the weightlifting, one boxing gym and one gymnastics area. It is very equipped at plants level: 240 projectors placed on 4 metal towers, every tower has 60 projectors, with global power of 425 W; external nighttime lightning for playground to guarantee 300 lux. In the 2008 Rome municipality allowed Rugby Italian Federation to use it for the 6 Nations tournament. Yet, after this event it was decommissioned because for its inadequacy in hosting so huge spectators capacity. Nowadays, the state of deterioration is evident for lack of maintenance of HVAC systems, building envelope. Furthermore, its age of construction entails its entering into a dedicated list of building to preserve [18]. This is the reason why guidelines for historic building refurbishment could be useful for it [19].

2. Materials and methods

Considering the degradation, it is necessary to intervene and a series of measures are proposed in this paper.

Many examples of interventions towards environmental and energy sustainability in other similar facilities are available. Here, a brief overview of them is presented to understand which best practices could be applied to our case study. The analysed interventions are: the Stadium Stamford Bridge, the World Games Stadium, the Stadio Bentegodi and the Juventus Stadium.

Stamford Bridge was the first stadium with integration of Arena Vision LED illumination. This system have the capacity to eliminate repeats flash, the possibility to switch on instantaneously as well as guaranteeing lightning vertical and horizontal values higher compared to other technologies.

Also, in the Juventus Stadium in Turin the Arena Vision LED system was installed, with 396 sets installed on roof and on the gangways of the experts. The use of this technology allows a major efficiency of consumptions and it simplifies maintenance interventions.

Referring to the World Games Stadium, it is the first stadium of the world with entire green electricity supply: Indeed, 8,844 photovoltaic panels are installed on whole ring that surround the tribune. Photovoltaic panels generate 1.1 MWh of electric energy per year. When the stadium is not used, the Taiwan government sells about 1.14 million of kWh per year so to feed the 80% of the energy need of all surrounding areas and to save yearly 660 t of CO_2. A high amount of renewable electricity connected to large facilities like the stadium is already proven to produce Hydrogen [20] to partially green the Natural Gas supply of conventional boilers [21] in large apartment block or small scale dwellings contributing to the building with large PV-dedicated surface as well its surroundings [22].

Bentegodi Stadium of Verona has also a significant photovoltaic roof for sport services, with 13.300 photovoltaic panels totally integrated in the structure. The system produce 1 MWh of clean energy per year, meeting the energy need of 400 families and avoiging 550 tons of CO2 emissions. Beside more-efficient lighting systems, sustainable interventions should address the use of surroundings as well as mobility sector.

CorriMI 2.0 and BikeMI projects of Milan municipality are suitable example of the requalification of external surrounding area: the first implies the requalification of external gym with 7 parks with 10 Km of tracks; the second consists of 140 cycle tracks, 20% on green areas and 80% on urban ones. Another innovative example is the Plastic Road Project of Rotterdam: a clycle way with 100% recycled asphalt, able to work in the temperature range from -40°C to +80°C. This road coating is made by recycled plastic waste. It is composed by a series of prefabricated modules, mainly made by of the plastic bottles and polyethylene terephthalate refuses. This is why it is light allowing a major facility of installation, reducing construction time. This typology of pavement entails the reduction of 1.6 million t of CO_2. So, embodied carbon dioxide emissions should be consider another driver towards sustainability. Based on those studies on the existing and similar requalification interventions, both for dimensions area of intervention and characteristics, the study analyses the possible interventions for a sustainable requalification of the Flaminio Stadium accounting for lighting systems, mobility and economic aspects.

2.1. Air Conditioning plants

Hybrid variable refrigerant flow Mitsubishi Electric System: is the first Variable refrigerant flow hybrid system in the world, cooling and heating with heat recover. Every internal unit can be used independently. Heat recovery ventilation Daikin system multi-zones air conditioning have a variable refrigerating volume that can provide total control of every single zone. It results to be the more complete solution for cooling, heating, ventilation and Hot Water production. There is also the FAU3 Mitsubishi Electric: machine of external air treatment with enthalpy recovery, battery with direct expansion, integrate regulation alimented by ecological refrigerating gas R410A. It guarantees high energety efficiency values since a total recover of heat is available compared to conventional Air Handling Unit. Monoblock Rooftop system at elevate efficiency: this system provides both at the air treatment and centralized thermal and cooling production. The system decentralization allows to eliminate the losses derived to the energy transfer to not occupied zones and it increases the global reliability.

2.2. Lighting plant

The lighting options are:

- Halogen lamps: at the internal bulb there are gases with halogen elements (iodine, xenon or krypton); it entails filament heating at higher temperatures so as to increase efficiency and illuminance.
- Fluorescent lamps: it switches on with electrical discharge generated by the potential difference between the two electrodes inside the gas; fluorescents lamps are more brittle and they emit bright intensity at low temperature. Furthermore, they give lowness levels of infrared and ultraviolet rays with efficiency of 25% and up to 10 years of lifespan.
- LED lamps: the light derives to the photon emissions through diodes fed by an electric circuit. LED lamps have high investments cost but they show long life from 15 up to 20 years as well as implying savings until 80% compared to conventional ones. Their operation does not produce heat and does not emit infrared or ultraviolet rays.

The sustainable requalification interventions of the Flaminio Stadium foresee the choice of one of those solutions to improve the environmental and energy status of the area.

3. The project proposal

The proposed interventions will aim at building a multifunctional stadium including underground structures, gyms, cafeteria and a multi theatre cinema in the surrounding areas. Moreover, a university campus for sport disciplines and two commercial zones are planned, as shown in Figure 2.

Fig. 2. Project proposal for the Flaminio Stadium area.

For the air-conditioning plant of the cinema, the preferred technology solution is Rooftop system because the best temperature and the relative humidity control so as to guarantee the air quality for large number of occupants. Among the other analysed solutions, the Rooftop plant is easy to install, because supplementary pipes are not required, it is possible to integrate free-cooling strategy when $T_e < T_i$ the external air can be used as free source of cooling. Moreover, it is equipped with CO_2 sensors for controlling the external air flow to maintain the air quality.

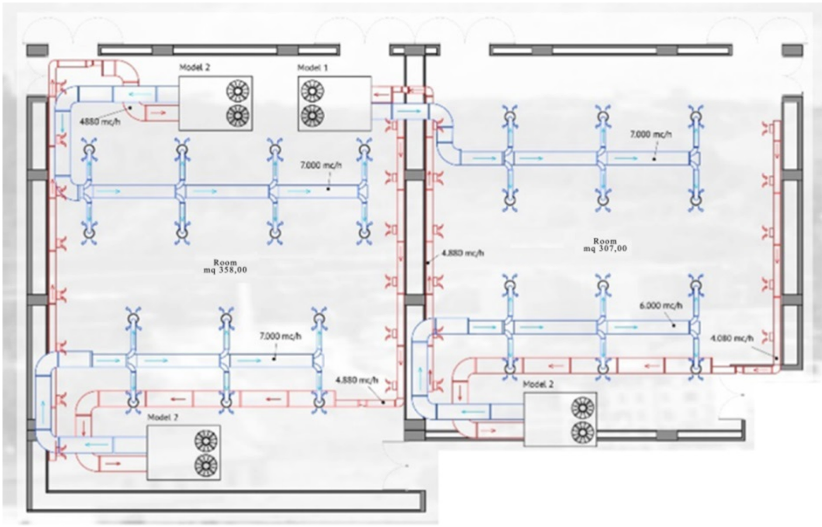

Fig. 3. Rooftop HVAC system and pipes layout

A LED system is the chosen solution for lighting plant: for cinema rooms a LED lamp of 8W power was installed on the ceiling: totally 82 for big rooms and 68 for smaller ones. While, in the foyer LED lamp of 30W were installed: totally, 59 as shown in Figure 4. Renewable integration into existing buildings, especially when intensive consumer is faced in this analysis. The roof of the Flaminio Stadium can offer surface, up to 70%, i.e. 13,200 m² for Photovoltaics installation.

The best technology suitable for integration into the tensile structure is the thin film in amorphous silicon. This membrane is built in Ethylene tetra-fluoroethylene. That material is suitable to be installed outdoor because of its high resistance to corrosion and to high temperature. It is light, transparent and with a lifespan up to 30 years.

The cells thickness of this panels is 50 micron, then the silicon in it is very inferior respect standard panels and this result to be more economic and, even if it has lower efficiency (6%) compared to other rigid solutions, considering the object of intervention, the global plant is able to produce 406.5 kW/h, yearly.

The same surface of roof of the Stadio Flaminio is suitable for collecting rainwater up to about 10.700 m^3 which can be used for irrigation. The surrounding green are, in particular Ankara square, can be involved in the process.

Hence, the requalification intervention also provides the construction of two commercial building beside the large square, equipped with green façade. The module of the green wall is composed by a cage in zinc steel in these there are substrates of plants.

Between metal cage and green wall there are a hallow space to have a good insulation property. This typology of wall can receive different green species, it is easy disassembly and it can be recycled in different way.

In combination with the green façade, cool materials application on pavement was planned to face the Urban Heat Island effect.

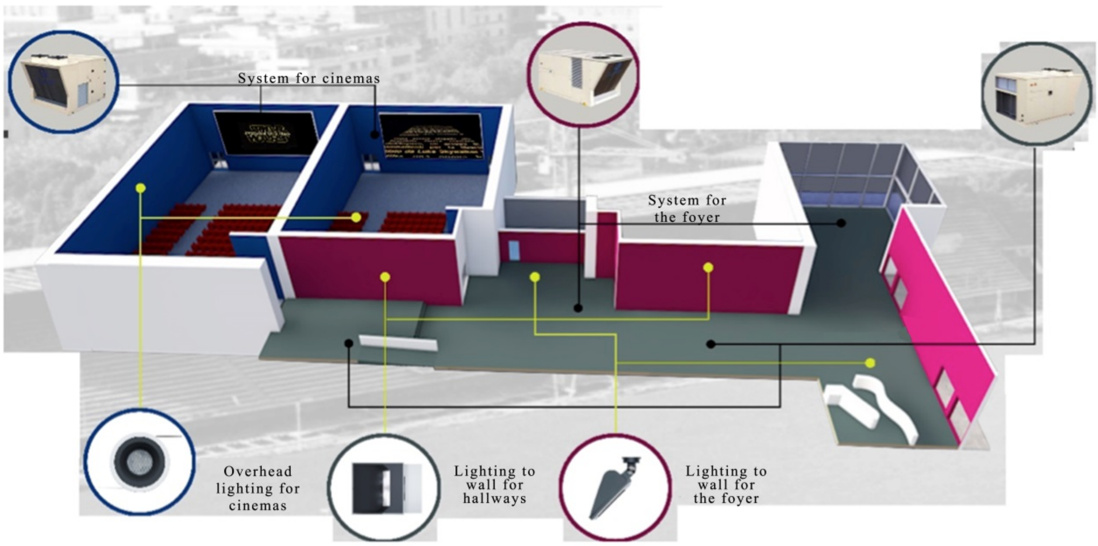

Fig. 4. Lighting system and its allocation.

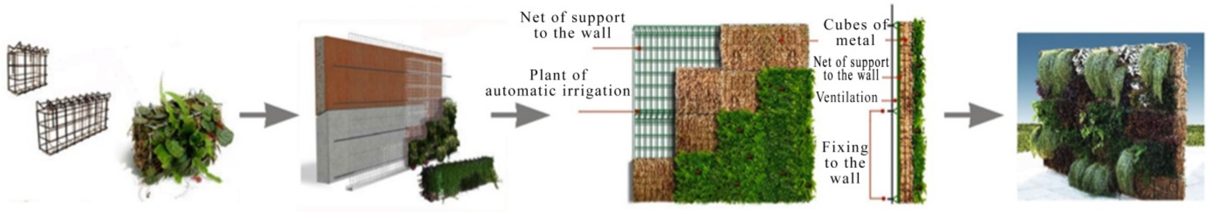

Fig. 5. Details of the green façade.

As mentioned, the LED systems will be applied to public lighting with overhanging photovoltaic cells, the energy produced is accumulated in batteries. Then, a cycle track and a running one, allow to come to this are from public transport stops so as to guarantee the multi-modal mobility integration.

3.1. The economic analysis

Table 1 summarizes all the investment costs associated to those interventions. Huge efforts are requested to Public Administration for improving environmental and energy quality of the area.

The cost of the investment is based on market analysis by comparing the prices of the best companies on the market to the present day, so the cost of each intervention comes from the individual metric calculations elaborated with reference to the relative units of measurement.

$$PPE = \frac{UsualAnnualEnergy}{SavedAnnualEnergy} \quad (1)$$

Equations 1 and 2 show the calculation of PayBack Period in terms of Energy and Emissions to better understand the impact of the applied measures in terms of savings and time required.

$$PPCO_2 = \frac{UsualAnnualEmissions}{SavedAnnualEmissions} \tag{2}$$

Table 1. Summary of interventions and associated costs.

Intervention's description	Investment cost €
Cycle lanes (rainwater system and signage)	153,416.00
Running lane	52,844.00
PV-equipped LED public lighting system	161,205.00
Outdoor sport facilities for garden	8,000.00
Rooftop HVAC system	255,000.00
Indoor cinema rooms LED lighting system	30,000.00
Recycled pavement and installation	362,600.00
Hydroponic solution	14,512.00
Urban furniture	8,186.00
New plants	7,566.00

As in Table 2, the substitution with new technology solutions can be analysed in terms of energy and emission gains when compared with existing installations. It is noteworthy that comparing the energy spent in one year to meet a specific need such as lighting could be compared with the number of years needed to cut this expenditure of 100%, once the new systems is applied. Larger the number of years, smaller the difference between conventional and new solution's consumption. The same comparison is appreciated for CO_2 emissions.

Table 2. Summary of interventions and associated gain in energy and emissions.

Intervention's description	Energy-back period [y]	Emission-back period [y]
Cycle lanes (rainwater system and signage)	-	1
Running lane	-	-
PV-equipped LED public lighting system	4	4
Outdoor sport facilities for garden	-	-
Rooftop HVAC system	8	8
Indoor cinema rooms LED lighting system	5	5
Recycled pavement and installation	6	6
Hydroponic solution	8	8
Urban furniture	-	-
New plants	-	10

This comparison methodology was already used in the expert opinion analysis in the energy field such as [23].

4. Conclusions

The economic cost analysis highlights the constraints to support a global requalification cost for the area by the Municipality of Rome. On the other hand, the benefits related to an overall requalification include significant improvements of environmental quality, social context, and economic value of the buildings.

The social values are more difficult to evaluate in terms of economics. Indeed, the more efficient requalification strategy is the one that considered the whole analysed areas and not only the requalification of its buildings.

Lastly, the identified intervention could be partially covered by economic incentive scheme where available but, it is relevant to set the goal of those strategies such as the actual gains in energy and emissions expenditure to run the area as usual. Unlike other projects, the research presented gives the issue of redevelopment a great deal of importance because it favors and integrates cooperation between different disciplinary sectors, affecting wide areas of work. The introduced parameters allow to evaluate from different perspectives the interventions to apply as well as making an informed choice for a given objective function: energy or emission reduction. Finally, enlarging the study area entails the opportunity to involve wider range of energy consumers and producers in order to feasibly integrate the strategic planning without the risk of narrow sectorial analysis and low actual feasibility.

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