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Energy Communities and Requalification - Towards Energy Transition and Self-Sufficiency: A "Challenge" for the Olympic Village

Mariangela Zagaria[1*], Cristian Fiorini[2], Francesco Mancini[2], Carola Clemente[1]

[1] Department of Architecture and Design, Faculty of Architecture, DiAP, Sapienza University of Rome, Roma 00197, Italy
[2] Department of Planning, Design, Technology of Architecture, Faculty of Architecture, PDTA, Sapienza University of Rome, Roma 00197, Italy

Corresponding Author Email: mariangela.zagaria@uniroma1.it

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ABSTRACT

Against the current global climate emergency and energy crisis, one of the most effective tools for reforming the current energy system, while at the same time prompting development based upon sharing and savings are the Renewable Energy Communities (REC). This study proposes assessing the energy consumption of residential buildings in the Olympic Village of Rome, in order to suggest energy retrofits and assess the feasibility for the establishment of an energy community. First of all was performed a preliminary biophysical, bioclimatic, and anthropic analysis of the neighborhood, followed by a building system energy analysis; specifically, were analyzed the technical and plant systems, estimating the incidence of the building envelope's heat losses and the breakdown of consumption. Then were suggested actions aimed at improving those system's performance, with the elaboration of three energy scenarios of differing intensity. Lastly, was performed an analysis on the feasibility of instituting a REC in the area of the Olympic Village. The preliminary results of the research emphasize how the local sharing of energy through the establishment of RECs can generate significant environmental, social, and economic benefits. The model proposed for the Olympic Village case study demonstrates its replicability in numerous settings.

1. INTRODUCTION

The scientific community estimates that the effects of global warming, responsible for extreme weather events, along with the increasing urbanization by the global population, lead to a progressive deterioration of living conditions within cities, from multiple perspectives.

One of the sectors primarily accountable for this situation is the energy sector, whose production and consumption account for more than 75% of greenhouse gas emissions within the EU. Specifically, the most energy-intensive sector is the building sector, considered in its entirety throughout the lifecycle: from initial construction phases to the production and use of construction materials, to the actual utilization of the building until its demolition. It is estimated that the construction sector is responsible for 40% of CO_2 emissions into the atmosphere [1].

In response to this trend, the European Union has sanctioned the European Green Deal, a political-economic intervention mechanism which, employing various strategies directed at decarbonization through the utilization of renewable energy sources (RES), aims to cutting greenhouse gas emissions in half by 2030 and gradually reach net zero by 2050, achieving climate neutrality [2, 3]. Climate neutrality refers to the idea of balancing greenhouse gas emissions and the planet's natural absorption carbon dioxide.

A strategy targeting the reduction of energy consumption in densely populated urban areas involves the establishment of Renewable Energy Communities (RECs) [4].

The European Commission defines RECs as communities of public and private entities that aggregate consumers and producers of energy from renewable sources promoting the local production of energy distributed via smart grids, to promote the electrification of consumption and to produce and share sustainably generated energy.

This community configuration gives multiple benefits. From an environmental perspective, local production of renewable energy minimizes waste and promotes sustainable practices, thereby contributing to the reduction of greenhouse gas. This approach optimizes the utilization of available energy resources, diminishes reliance on traditional sources, and aids in lowering energy bill costs. From a social point of view, it aims to a cooperative approach to energy management, involving citizen in a central role in the energy market. In Italy, the Ministry of Ecological Transition (MASE), with the recent promulgation of the REC Decree on 23 January 2024, has allocated financing for the creation of these communities, promoting the local production of energy distributed via smart grids [5].

This research focuses on this context, analyzing the residential complex of the Olympic Village in Rome. Through a study of energy consumption of this residential complex, an intervention aimed at electrifying energy usage and retrofitting the building is proposed. To achieve this goal, a preliminary assessment of biophysical, bioclimatic, and anthropic factors of the neighborhood was conducted; other steps of this study involve an energy analysis of the building plant system within a selected representative building of the residential complex. This analysis included a detailed study of the technological and plant systems, estimating the impact of heat loss ratio from the building envelope and the breakdown of energy consumption.

Subsequently, specific actions were formulated to enhance the performance of the technological and plant systems, achieved through the development of three energy scenarios of varying intensity. The proposed strategies encompass interventions such as thermal insulation of the building envelope and the complete electrification of energy consumption, complemented by local energy production through the installation of a photovoltaic system.

2. THE BUILDING COMPLEX OF THE OLYMPIC VILLAGE

The intervention forms an integral component of the urban redevelopment initiative undertaken in Rome in preparation for the 1960 summer Olympics. In order to establish the sports city intended to accommodate athletes, the Italian National Olympic Committee (CONI) selected a publicly owned area situated within the plain between the Villa Glori hill and the bend of the Tevere River to the north of the city (Figure 1).

This area already encompassed sports facilities constructed prior to the Second World War, including the Rondinella Stadium, the National Stadium, the Parioli racecourse, and the Villa Glori hippodrome [6].

However, in the post-war period, the area became occupied by illegal settlements established by displaced persons, resulting in the formation of a cluster of shanties known as the "Campo Parioli."

The selection of this area for the construction of the Olympic Village proved to be advantageous not only for the territorial redevelopment of the zone, thereby restoring its previous sporting vocation, but also socially, by providing a substantial number of housing units that, after the Olympics, would be allocated to the Roman population.

The project for the Olympic Village was entrusted by the National Institute for State Employees' Housing (INCIS) to a group of architects consisting of Vittorio Cafiero, Adalberto Libera, Amedeo Luccichenti, Vincenzo Monaco, and Luigi Moretti, the latter serving as the group coordinator [7].

The designated area for the project spans a total of 350,000 m^2, with 70,000 m^2 allocated for buildings and 160,000 m^2 designated for green spaces.

The project involved the creation of 35 buildings, comprising a total of 1,348 apartments of varying sizes, ranging from two to five rooms.

Various types of residential buildings were employed, including single building and double building row houses, closed square courtyard houses, open courtyard houses arranged in a cruciform plan, and building on square plan.

Unlike public residential settlements of the first half of the 20th century, the Olympic Village employed a "canonically" modern architectural language, drawing inspiration from the five points of modern architecture outlined by Le Corbusier [8, 9]. The five points of architecture theorized by Le Corbusier include: the free plan, free facade, raised plan on pilotis, roof garden, ribbon windows. However, it integrated materials, construction techniques, and architectural forms rooted in the Italian tradition. Despite being designed by different architects employing various architectural approaches, the overall complex appears homogeneous through the utilization of common typological and construction elements.

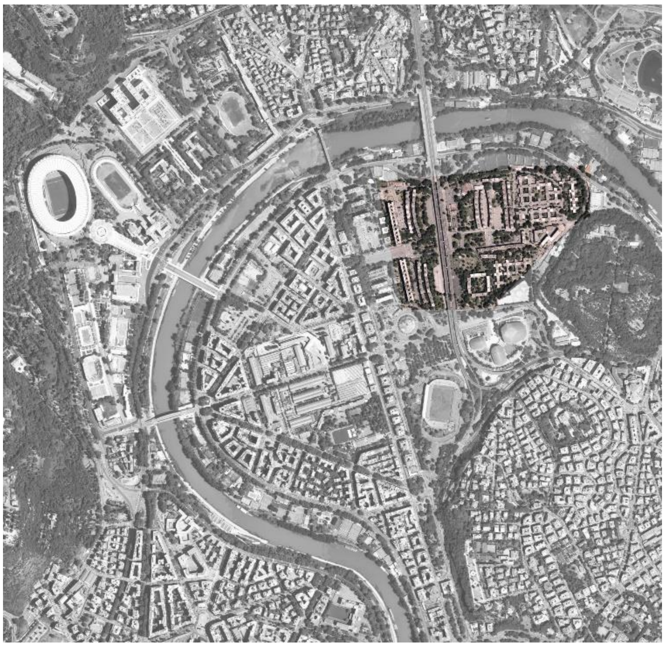

Figure 1. Residential complex of the Olympic Village
Maps data: © Google Earth 2024.

3. MATERIALS AND METHODS

Consultation of the "Villaggio Olimpico di Roma, Viale Tiziano 1958" (archivial file number 144) and the architect "Luigi W. Moretti" holdings at Archivio Centrale dello Stato, as well as a number of inspections, were fundamental for identifying the construction bodies' technological system. Various interviews of the complex's inhabitants were conducted in order to outline the dwellings' occupational profiles and to define, using simulation software, the energy requirement and the impact on the environment.

In this research, the row house situated on the southern side of Piazza Jan Palach was selected as the representative building for the energy retrofit proposal.

The structure, measuring 75.6 metres in length and 10.75 metres in wide, consists of a concrete frame construction spanning four above-ground floors, with a total height of 15.7 m.

The ground floor level is elevated on pilotis and houses the four entrances to the building, granting access to four stairwells, each serving two dwellings on each storey.

The upper three floors collectively accommodate 24 apartments (eight on each floor) with usable areas between 60 m^2 and 90 m^2.

The facades feature a brick curtain wall, alternating with horizontal windows on the Piazza Jan Palach side (west) and loggias on the via Finlandia side (east) (Figure 2). Positioned on the roof, corresponding to each stairwell, are four oval-shaped brick towers serving as clothes-drying areas and technical rooms.

Figure 2. Row house situated on the southern side of Piazza Jan Palach
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The research was structured by conducting a preliminary analysis of the environmental and climatic conditions specific to the area, to evaluating the impact of external factors on the thermal comfort conditions within the housing units. Subsequently, simulations were employed to model user energy consumption patterns, thereby informing the selection of suitable technologies for the revitalization of the complex. Finally, a feasibility study was undertaken to assess the viability of implementing a Renewable Energy Community for the entirety of the Olympic Village.

3.1 Environmental and bioclimatic analysis

In this study, the examined area, including the residential building subject to analysis, was divided into three systems: environmental, anthropic, and bioclimatic. Each system was evaluated to assess its respective energy contribution.

Figure 3. Bioclimatic analysis of the area
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The bioclimatic analysis of the area (Figure 3) was conducted using the simulation software Autodesk Forma, with input data including climatic factors and components of the anthropic and biophysical systems.

The simulation, selecting the days of the winter and summer solstices as representative moments of the year, revealed a microclimatic condition strongly influenced by the components of the two systems. The microclimatic condition is described by parameters such as average air temperature, wind direction and intensity, humidity, direct and indirect solar radiation.

Specifically, the anthropic system encompasses paved open spaces and asphalted neighborhood streets, engendering the "heat island" effect. Moreover, ground-floor commercial activities, through their interruption of the piloted portico space, reduce heat permeability, instigating a "buffering effect."

The combined effects result in a significant temperature increase, which is, however, mitigated by the biophysical system. It is characterized by tall trees and small green areas along the squares, which counteract the “heat island” effect.

Figure 4. Insolation analysis of the area
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During this analysis, a study of insolation was conducted (Figure 4), which is essential for evaluating the impact of solar radiation on the urban tissue. Through qualitative analysis, the absence of shadows cast on any active solar systems plan on the roof was verified. Based on the results obtained, energy retrofit strategies were hypothesized, which included:

- Urban scale, proposing the redefinition of the hierarchy of neighborhood routes, driveways, and pedestrian paths; replacing impermeable pavements (both open and enclosed spaces) with surfaces capable of reducing the heat island effect;
- Architectural scale, intervening on the building envelope with improving technologies aimed at reducing the entry of free solar heat gains during the summer period.

3.2 Current state of the building envelope

The typological and constructive aspect is the element common to the complex’s various residential typologies: the load-bearing structure is constructed of reinforced concrete, with the ground floor distinguished by an open portico supported on piloti. The slabs are in hollow-core concrete cast onsite, while the claddings with double masonry wall are lined on the outside with pinkish yellow bricks. Windows fixtures are in painted metal and of unified measurements across all building units. Lastly, the roofs are flat and accessible, featuring brick towers within which equipment rooms are incorporated [10].

The walls bordering with the exterior and without insulation are 33 cm thick and are of the “cavity wall” type, with full-brick masonry on the exterior side and perforated bricks on the interior side. Similarly, the internal walls between the dwelling and the stairwell, measuring 28 cm thick, and also of the cavity type, are done with perforated bricks lined with plaster on both sides.

The vertical external windows, larger than the standards of the time, were done with metal profiles without seal and feature 2 mm thick glass; the shading systems comprise roller blind with not heat-insulated shutter boxes.

The horizontal envelope elements divided into accessible flat roof slabs and slab over open spaces (on ground floor portico), are constructed of cast on site reinforced concrete, have respective sections of 29.8 cm and 25.5 cm. The former are clad on the outside with layers of asphalt emulsion and tar paper, and prefabricated cement blocks, and on the inside with plaster; the latter are clad on the inside with grit tiles and on the outside with plaster.

Analysis of the existing stratigraphy shows that the thermal transmittance U values of the vertical envelope element vary between 1.20 - 5.12 W/m^{2}K (considering both opaque and transparent portions), while the horizontal envelope element values range between 1.40 - 1.72 W/m^{2}K. These values far exceed the maximum values established by the Ministerial Decree of 26 June 2015, currently in force.

3.3 Analysis of energy consumption

The analysis of thermal and electrical consumption was conducted on the 24 dwellings in the examined building. Energy requirements was developed using the Enea Smart-Sim simulation software and verified during site visits through interviews of the occupants on the use of electrical appliances. The following is the list of the input data used in the calculation sheet for each dwelling:

(1) General apartment data (climatic area, degree-days);
(2) Architectural characteristics (size, orientation, location with respect to the building);
(3) Occupancy profile of each dwelling;
(4) Type of plant systems (thermal and electrical energy production subsystems);
(5) Characteristics of electrical appliances, lighting systems, and equipment in general.

The data obtained for each dwelling were grouped to define the overall yearly framework in terms of energy requirement and CO_2 emissions for the entire building (Table 1).

Table 1. Energy consumption, CO_2 emissions, and energy costs of the standard building (current state)

Electricity Consumption [kWh/year]	73.680
Gas Consumption [m^3/year]	33.144
Primary Energy Consumption [kWh/year]	465.005
CO_2 Emissions [kg CO_2/year]	87.189
Electricity Costs [Euro/year]	19.893
Gas Costs [Euro/year]	33.144

The data reported in the table represent a typical condition for all the complex's buildings, in which: 40% of the heat loss is caused by the vertical opaque component, while 50% of consumption is caused by the environments' heating plant system (Table 2, Table 3).

Table 2. Impact of individual structures on the winter thermal load

Thermal Loss Incidence	
Walls	39%
Windows	25%
Floors	24%
Casings	11%

Table 3. Distribution of consumption (current state)

Distribution of Consumption	
Heating	50%
Other	15%
Washing	15%
Domestic hot water	10%
Kitchen	8%
Lighting	2%

4. ANALYSIS OF RESULTS AND INTERVENTION STRATEGIES

In consideration of what emerged from the energy analysis of the area and of the building, interventions aimed at improving energy performance on the urban and construction scale were hypothesized. At the settlement scale, proposals entail the establishment of a Renewable Energy Community within the Olympic Village residential complex [11]. Meanwhile, interventions at the building scale concentrate on the enhancement of the building envelope and the optimization of building plant systems, in complete compliance with the constraints described by the Carta per la Qualità of the Piano Regolatore Generale [12]. (As observed from the mappings, the area and consequently the building subject to energy retrofitting exhibit significant urban, architectural, and cultural value, qualifying it for inclusion in the elaboration G1a "Quality Charter" article 16 NTA of the current PRG.)

4.1 Intervention strategies and technical solutions for the building envelope

The proposed energy retrofit interventions [13] aimed at increasing the envelope's thermal performance, for the purpose of complying with the relevant regulatory requirements in force (Table 4), relate to:

(1) Insulation of opaque vertical structures;
(2) Insulation of the roof slab;
(3) Insulation of the portico floor slab on pilotis level;
(4) Replacement of windows and insulation of the shutter box.

Table 4. U-values of the building envelope components [W/m^{2}K]

Description	Current State	Project State	Limit Values
External walls	1.21	0.31	0.32
Internal walls	1.18	0.28	0.80
Slabs over open space (portico)	1.72	0.25	0.32
Intermediate slabs	1.40	0.24	0.80
Roof slabs	1.67	0.21	0.26
Windows	5.12	1.53	1.80

The technical solution relating to the insulation of the opaque vertical structures is represented by the insulation in the hollow space obtained through the technique of mechanical blowing with insulation in glass wool flakes. For the roof slabs, intermediate slabs, and slabs on portico, the screed will be redone with thermal insulation and the insertion of the insulation panel in silica aerogel without altering the inter-storey height, already at the limit value of 2.70 meters. For the transparent vertical structures, solutions were considered that comply with the existing size characteristics:

the replacement of the door and window fixtures in secondary aluminium with thermal break, and insulation of the shutter box in polystyrene foam [14, 15].

The choice of insulation materials was conditioned by the insulation properties and by the level of sustainability. Sustainability was achieved by the proper balance between reduced energy requirement and the sustainability values expressed in consumed energy and CO_2 equivalent during the life cycle; It is evident that utilizing a material that on the one hand reduces the building's energy requirement and on the other produces a high level of grey (embodied) energy is a contradiction. Having stated this, the research took place by identifying the products by means of the Minimal Environmental Criteria (MACs), in which there is a concrete, proven assessment of the products' environmental performance throughout the life cycle (Table 5) [16]. Minimal Environmental Criteria (MACs) are environmental requirements defined for the various phases of the purchasing process, aimed at identifying the best product from the environmental standpoint throughout the life cycle, taking market availability into account. They are defined in the context of what was established by the environmental sustainability Plan for consumption in the sector of public administration, and were adopted with Ministerial Decree no. 256 of 23 June 2022.

Table 5. Level of sustainability of the materials employed in the intervention on the building envelope

CAM n. %	% Recycled Raw Material
Silica aerogel	equal to 70%
Glass wool flakes	more than 60%
Cork bio-mortar	more than 14%
Polystyrene foam	from 10 to 60%
Secondary aluminum	equal to 20%

4.2 Intervention strategies and technical solutions for building plant systems

The strategy in the context of the plant system is based on the replacement of traditional plant with plant systems consisting of components that can be coordinated with one another and that exploit exclusively the energy carrier of electricity; therefore, the following was proposed:

(1) Installation of the integrated Building Management System (BMS);
(2) Installation of centralized heat pumps for heating and cooling;
(3) Installation of autonomous heat pumps for production of sanitary hot water;
(4) Installation of a photovoltaic system;
(5) Installation of a point-based controlled mechanical ventilation system;
(6) Replacement of gas with induction ranges;
(7) Replacement of traditional lamps with LED bulbs.

The size of the heat pumps for heating and cooling was determined by calculating the winter and summer thermal loads, while taking account of the interventions on the building envelope.

For the building being analyzed, 8 heat pumps [17], for a total rated thermal input equal to 240 kW, have been identified, placed inside the towers on the roof. The heat pumps for the production of sanitary hot water, having a rated thermal input equal to 1 kW, were positioned inside each dwelling. As relates to the installation of the mechanical ventilation unit, a system distributed in points was chosen, for each environment, hidden inside shutter boxes. The electrification of all the plant systems just described involves increasing electricity consumption; the installation on the roof of photovoltaic panels was therefore assessed. The roof of the typical building offers an absorbing surface equal to 113 m^2; the assessments for the shaded areas, the orientation and inclination of the panels are the same as done for the REC feasibility study. Photovoltaic panel (1046 × 1690 × 40 mm) with 104 solar cells in monocrystalline silicon, rated power of 400Wp with standard efficiency 22.6%. The absorbing surface of 113 m^2 [18] can produce only 28% of the total withdrawn from the grid.

4.3 Elaboration of intervention scenarios

Following the identification of interventions aimed at enhancing the performance of the building envelope and the efficiency of the building plant system, three scenarios have been developed:

Scenario 1: Insulation of perimeter walls and roof + efficiency improvements to the entire building plant system;

Scenario 2: Scenario 1 interventions + replacement of windows;

Scenario 3: Scenario 2 interventions + insulation of the portico floor slab on pilotis level.

Table 6. Comparison among the three intervention scenarios

	Scenarios 1	Scenarios 2	Scenarios 3
Electricity Consumption [kWh/year]	148.272	140.400	122.031
Gas Consumption [m^3/year]	0	0	0
Primary Energy Consumption [kWh/year]	284.832	185.760	144.480
CO_2 Emissions [kg CO_2/year]	64.272	61.296	52.908
Electricity Costs [Euro/year]	40.033	37.908	32.948
Gas Costs [Euro/year]	0	0	0

Comparison between the current state and scenario 3 (Table 6) yields a net reduction of primary energy consumption and of CO_2 emissions by 69 and 40% respectively. The intervention, 96% deductible, allows the yearly expenditure for energy carriers to be reduced by 40%.

For the REC simulation, scenario 3 is taken into consideration, given that the dwellings are more efficient and able to optimize the self-produced energy in the best possible way.

4.4 The Renewable Energy Community of the Olympic Village

In order to minimize the amount of energy withdrawn from the grid and the amount of CO_2 emitted into the atmosphere, a feasibility study for a Renewable Energy Community was developed, with the objective of sharing the electrical energy self-produced by Renewable Energy Sources (RES). The feasibility study consisted of the following phases:

(1) Identifying the member buildings (Prosumers and Consumers) of the REC: two factors are taken into

consideration for the choice of member buildings: the first is the geographical limit identified by the primary substation; the second relates to the type of load; for the latter, buildings have been identified that have energy loads different from the residential type, and therefore the choice fell to school buildings in order to exploit the energy self-produced during their period of inactivity, and vice versa [19, 20]. Decree MASE No. 414 of 7 December 2023 recognizes the key figure of the CER as the prosumer, who is both a producer and consumer. The consumer, on the other hand, is simply the user. In this specific case, the consumer is the residential building that does not have a production system because the height of the roof parapet is not sufficient to make the photovoltaic system "invisible" (Article 16 NTA of the PRG).

(2) Identifying the member buildings yearly average consumption: the total energy consumption values calculated both for residential and for the school complex make reference to requalified structures; for the former, the calculation was elaborated with a performance index (59.1 kWh/m^{2}y) arising from the energy efficiency intervention performed for the typical building, while for school buildings, the S.I.R.E. ENEA simulation software was used, whose index is equal to (12.1 kWh/m^{2}y). Ultimately, the total consumption for the residential complex amounts to 1,382,062 kWh/year, while for the school complex, it is 153,574 kWh/year.

(3) Estimating production from Renewable Energy Source (RES): the yearly production that can be obtained from the photovoltaic systems on the roof was assessed through the computation of the absorbing surfaces, net of the areas of shading (winter solstice). A double simulation was performed with various angles of inclination of the panels: one with a 32° angle (considered optimal given the place's latitude) and the other 10°. For orientations, the attempt was made, to the extent possible, to choose the azimuth angle equal to 0° (southern direction). The choice fell to the second option since it generated a larger absorbing surface: to be precise, 584 m^2 for the residential complex and 753 m^2 for the school complex, with a yearly expected production of respectively 173 MWh/y and 250 MWh/y. Shared energy is defined as the minimum, for each hour, between the sum of the electric energy produced and fed into the grid and the sum of the energy withdrawn. The MISE (Italian Ministry of Economic Development) recognizes a twenty-year incentive for feed-in equal to € 0.05/kWh and one for sharing equal to € 0.11/kWh.

(4) Identifying the REC's Self-Sufficiency Index (SSI): The energy flows consumed and produced by the RES were entered into the RECON ENEA simulation software, which yielded a Self-Sufficiency Index (SSI) of 25%.

(5) Quantification of the revenues produced by shared energy: the same software as in point 4 quantified the economic flows produced by the energy introduced into the grid by the REC's members, and the savings for having avoided withdrawal from the grid.

The simulation provides a hypothesis on the Energy Community in terms of energy self-produced annually, CO$_2$ emissions prevented, investment costs net of tax incentives, and payback period (Table 7, Figure 5).

Table 7. Size characteristics of the photovoltaic field, energy, environmental, and economic indicators of the REC

Electricity Consumption [MWh/year]	1.535
Expected Yearly Production [MWh/year]	423
Photovoltaic System Nominal Power [kWp]	313
Energy Self-Sufficiency Index	25%
Avoided CO$_2$ Emissions [kg CO$_2$/year]	224.000
Local CO$_2$ Emissions [Euro/year]	0
Annual Primary Energy Savings	847
Initial Investment [Euro/year]	390.300
Annual Revenues [Euro/year]	148.640
Payback Period [years]	2.62

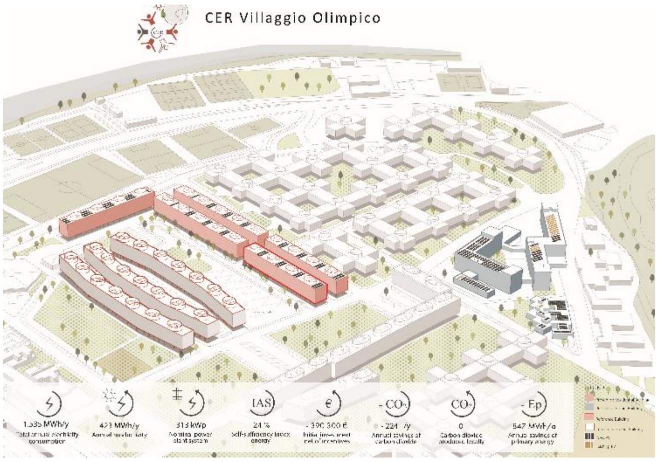

Figure 5. Renewable Energy Community of the Olympic Village
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5. CONCLUSIONS

In conclusion, the following research has demonstrated the possibility of significant improvement and efficiency in the energy system of the residential complex under examination through retrofitting interventions on the building envelope and the plant system.

These proposed actions will also allow electrification of the energy supply systems of the residences and installation of energy production and consumption systems from renewable sources. This will result in zero local CO$_2$ emissions and a reduction in energy demand on the central grid.

These technological and plant innovations constitute the starting point for the creation of a Renewable Energy Community. Subsequently, through the aggregation of multiple users, it will be possible to produce and manage large quantities of flexible loads accumulated during the hours of the day and inject energy surpluses into the grid, thus becoming self-sufficient and actively participating in the national market.

The RECs is certainly a winning model for managing and improving energy systems, advantageous not only in the short term in terms of energy and economic aspects for the individual citizen - thanks to local and autonomous energy production through RES and the simultaneous reduction in the cost of supply on the market - but also on a larger scale and in the longer term [21]. Economically, the Renewable Energy

Community allows for economies of scale capable of engaging on equal terms with stakeholders in the energy market, providing a significant opportunity for small and medium-sized local businesses in the sector and thus contributing to the industrial and employment growth of the area. Socially, citizen involvement in the investigations and operational choices of the system and the network promotes community cohesion and improves territorial and environmental life and awareness regarding sustainability issues [22].

Finally, given the scalability, replicability, and adaptability of the interventions, this research can be configured as a basic model for the study and analysis of other urban districts, representing a valid tool for the promotion and transition to a more sustainable and inclusive economy.

REFERENCES

[1] Council of the EU. (2022). ‘Fit for 55’: Council agrees on stricter rules for energy performance of buildings [Press release]. https://www.consilium.europa.eu/en/press/press-releases/2022/10/25/fit-for-55-council-agrees-on-stricter-rules-for-energy-performance-of-buildings/.

[2] Fetting, C. (2020). The European Green Deal. ESDN Report. ESDN Office, Vienna.

[3] Rifkin, J. (2019). Un Green New Deal Globale. Il Crollo Della Civiltà Dei Combustibili Fossili Entro Il 2028 E L'audace Piano Economico per Salvare La Terra. Milan: Mondadori.

[4] de Santoli, L. (2011). Le Comunità dell’Energia. Rome: Quodlibet.

[5] Ministerial Decree MASE 7 December 2023, n. 414, “Decreto CER (Comunità Energetiche Rinnovabili)” (2024). https://www.mase.gov.it/sites/default/files/Decreto%20CER.pdf.

[6] Spagnesi, G. (2009). Il Villaggio Olimpico di Roma e la cultura architettonica nella città durante gli anni Sessanta. In Luigi Moretti. Architetto del Novecento. Rome: Gangemi.

[7] Talamona, M. (2010). Il Villaggio olimpico. In Luigi Moretti, Razionalismo E Trasgressione Tra Barocco E Informale. Milan: Electa.

[8] Le Corbusier, P., Jeanneret, P. (1937). Les 5 points d’une architecture nouvelle. In Le Corbusier – OEuvres complètes 1910-1929. Les Éditions d’Architecture.

[9] Le Corbusier, Saugnier. (1923). Vers Une Architecture. Paris: Les Editions G. Cres et Cie.

[10] Salvo, S. (2012). Quartieri moderni al Bivio. Il Villaggio Olimpico di Roma fra trasformazione e conservazione. In Il Secondo Progetto. Interventi Sull’abitare Pubblico. Rome: Ed. Prospettive.

[11] Barroco, F., Cappellaro, F., Palumbo, C. (2020). Le Comunità Energetiche. Una Guida per Orientare I Cittadini Nel Nuovo Mercato Dell’energia. https://doi.org/10.12910/DOC2020-012

[12] Rossi, P.O. (2001). La città contemporanea e la “Carta per la Qualità”. Urbanistica, 116: 121-124. https://web.uniroma1.it/qart/sites/default/files/Urb116.pdf.

[13] MISE, MATTM and MIT. (2020). Strategia per la Riqualificazione Energetica del Parco Immobiliare Nazionale. https://www.mimit.gov.it/images/stories/documenti/STREPIN_2020_rev_25-11-2020.pdf.

[14] Arbizzani, E. (2021). Progettazione Tecnologica Dell'architettura. Processo, Progetto, Costruzione. Santarcangelo di Romagna: Maggioli Editore.

[15] De Martin, P. (2021). Manuale Di Progettazione per La Riqualificazione Energetica. Santarcangelo di Romagna: Maggioli.

[16] Ministerial Decree MASE 23 June 2022, n. 256. Criteri ambientali minimi per l'affidamento del servizio di progettazione di interventi edilizi, per l'affidamento dei lavori per interventi edilizi e per l'affidamento congiunto di progettazione e lavori per interventi edilizi. (2022). Gazzetta Ufficiale, 183.

[17] de Santoli, L., Mancini, F. (2017). Macchine per la produzione dell’energia termica e frigorifera. In Progettazione Degli Impianti Di Climatizzazione. Santarcangelo di Romagna: Maggioli.

[18] Casini, M. (2009). Gli impianti da fonti energetiche rinnovabili. In Costruire L’ambiente. Gli Strumenti Ed I Metodi Della Progettazione Ambientale. Milan: Ed. Ambiente, pp. 329-333.

[19] Rossetti, M., Pepe, D. (2014). La Riqualificazione Energetico-Ambientale Degli Edifici Scolastici. Santarcangelo di Romagna: Maggioli.

[20] Pavesi, A.S., Zanata, G. (2013). Edilizia Scolastica Pubblica. Strumenti per La Rigenerazione Del Patrimonio Scolastico in Italia. Santarcangelo di Romagna: Maggioli.

[21] MISE, MATTM and MIT. (2020). Strategia per la Riqualificazione Energetica del Parco Immobiliare Nazionale. https://www.mimit.gov.it/images/stories/documenti/STREPIN_2020_rev_25-11-2020.pdf.

[22] Romano, G., Margani, P., Mancini, F., Battisti, A. (2023). Building a renewable energy community for the tor Sapienza district in Rome. In Conference 78° Congresso Nazionale Ati 2023 - Transizione Energetica: Ricerca E Innovazione per L'industria, Le Comunità Ed Il Territorio. https://iris.uniroma1.it/handle/11573/1699834.