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1. COMMON GUIDELINES FOR SELECTING RECs/NBS IN MARGINALIZED AREAS

Stakeholders leading REC/NBS initiatives must comprehensively assess these four dimensions by conducting a thorough background analysis. This analysis should:

1. Align with applicable legal frameworks.
2. Verify spatial planning for renewable energy installations, such as photovoltaic panels or wind turbines.
3. Analyze microclimatic factors, including Urban Heat Island (UHI) effects.
4. Assess the social composition and identify Energy poverty hotspots.

1.1 Regulatory framework analysis

The regulatory framework is summarized in a Normative Dashboard tailored to each pilot country. This dashboard should be expanded for additional countries adopting this policy. Each Normative Dashboard includes:

- EU Level: A unified regulatory framework guiding REC implementation.
- National Level: Country-specific adaptations to ensure relevance and compliance.

1.1 Spatial planning and technical design analysis

Spatial planning should identify critical infrastructure and local conditions to determine the optimal location for renewable power plants. Key steps include:

- Studying the regulatory and planning context and evaluating constraints from the current urban master plan.
- Conducting a preliminary technical feasibility analysis, considering site selection criteria, photovoltaic system specifications, and grid connectivity.
- Performing spatial analysis and mapping to estimate energy productivity and assess the potential benefits of renewable installations.

1.2 Urban Heat Island and microclimate factors

This analysis should identify UHI effects and microclimatic factors at the neighborhood level to guide the integration of RECs with nature-based solutions (NBS). Key considerations include:

- Conducting temperature mapping to evaluate UHI impacts.
- Analyzing surface characteristics, green spaces, water bodies, building densities, and heights.
- Assessing variables such as temperature, humidity, wind patterns, and other climatic factors that influence neighborhood-level energy performance and resilience.

1.3 Social composition analysis

This analysis aims to identify energy poverty hotspots and understand the social composition of target neighborhoods. Key steps include:

- Profiling the demographic and socioeconomic characteristics of the population.

- Assessing energy expenditures, fuel usage, and access to energy resources.
- Identifying vulnerable groups based on income levels, energy costs, and housing conditions.

2. NORMATIVE DASHBOARD

2.1 Normative Dashboard Spain

Normative Framework

Spain hasn't still promoted a full transposition of European Directives about Energy Communities (EU 2018/2001 and 2019/944). However, Energy Communities have been partially introduced in Spanish law, introducing Renewable Energy Communities as a new subject of the electricity sector (modification of article 6 from Spanish law 24/2013, 26th December, on the Electric Sector).

The definition of RECs comes literally from the EU definition, lacking further elaboration on what each term means ('The renewable energy communities, which are legal entities based on open and voluntary participation, autonomous and effectively controlled by partners or members who are located in the vicinity of the renewable energy projects that are owned by said legal entities and that these have developed, whose partners or members are individuals, SMEs or local authorities, including municipalities and whose primary purpose is to provide environmental, economic or social benefits to their partners or members or to the local areas where they operate, instead of financial gains').

Nevertheless, a draft version of the Royal Decree developing the figures of Renewable Energy Communities and Citizen Energy Communities was made available by the Ecological Transition Ministry for public consultation and proposal of amendments in April 2023, still waiting to be enacted. Even if relevant and various stakeholders submitted numerous amendment proposals, it can be expected that the core part of the provisions will not vary too much.

Besides specific provisions for Energy Communities, significant advancements have been made in the field of self-consumption of renewable energy, which has become the main activity of Energy Communities up to now.

Main advancements in self-consumption of electric energy:

Royal Decree 900/2015, of October 9, regulating the administrative, technical and economic conditions of the modalities of supply of electric energy with self-consumption and production with self-consumption, developed for the first time the provisions contained in Law 24/2013, of December 26, of the Electric Sector, whose article 9 regulates the self-consumption of electric energy.

Subsequently, Royal Decree-Law 15/2018, of October 5, on urgent measures for the energy transition and the protection of consumers, has meant an important boost to self-consumption, making a profound modification of its regulation in Spain so that consumers, producers, and society as a whole can benefit from the advantages generated by this activity.

As a result, Royal Decree 244/2019, of April 5, regulating the administrative, technical, and economic conditions of self-consumption of electrical energy, was approved. This almost entirely repeals Royal Decree 900/2015, of October 9, and introduces important modifications. The figure of collective self-consumption is introduced, in which several consumers are supplied with electrical energy from production facilities close to and associated with consumption facilities. Likewise, different types of self-consumption are introduced, allowing the supply of surpluses so generation facilities can, in addition to supplying energy for self-consumption, inject surplus energy into the transport and distribution networks.

From a broader perspective, Energy Communities are mentioned in several strategic plans and working lines from the Ministry. The National Integrated Energy and Climate Plan 2021-2030 (NECP) expressly provides for citizen participation mechanisms in various measures. In measure 1.1. Development of new electricity generation facilities with renewables, through local participation in renewable generation projects; in measures 1.2. Demand management, storage, and flexibility, and 1.4. Development of self-consumption with renewables and distributed generation through the promotion of citizen participation; in “Measure 1.6. Framework for the development of thermal renewable energies” through the development of renewable energy communities linked to air conditioning networks; in measure 1.14. Promotion of the proactive role of citizens in decarbonization through citizen participation in the definition of local, regional, and national energy policies and, finally, in Measure 1.13. Local energy communities aim to facilitate the participation of citizens, SMEs, and local entities in the energy transition.

Finally, at a regional level, a Law 6/2022 on Climate Change and the Ecological Transition of the Valencian Community has been enacted. It introduces the following point on self-consumption and Energy Communities:

- Valencian public administrations will preferably promote renewable energy self-consumption energy communities.

And regarding public procurement for establishing “rights of use of surface”:

1. Public administrations may establish a right of surface on assets owned by them in favour of cooperatives, renewable energy communities or legally constituted citizen energy communities for the development of renewable energy generation or energy storage projects.

2. The right of surface for this purpose may only be granted through a public tender reserved for this type of entities.

Local normativity document list

- Royal Decree 244/2019, of April 5, regulating the administrative, technical and economic conditions of self-consumption of electrical energy.
- Royal Decree-Law 23/2020, of June 23, approving measures in the field of energy and other areas for economic recovery.
- National Integrated Energy and Climate Plan (NECP) 2021-2030
- Draft version of Royal Decree developing the figures of Renewable Energy Communities and Citizen Energy Communities

Local (region/city) rules or normativity

Law 6/2022 on Climate Change and the Ecological Transition of the Valencian Community

Members

According to the only official definition about RECs (article 6 from Spanish law 24/2013) partners or members can be:

- Individuals

- SMEs
- Local authorities, including municipalities

According to the draft version of the Royal Decree developing the figures of Renewable Energy Communities and Citizen Energy Communities, groups or associations of individuals, SMEs, or local authorities may also be partners or members of renewable energy communities, as long as they meet their basic principles on openness, democratic control etc. and whose effective and financial limits are not higher than those established for SMEs (annual turnover or total annual balance sheet does not exceed 10 million euros).

Association

Currently there’s no provision on specific required legal forms for Energy Communities. Nonetheless, several grant programmes driven from the Spanish Ministry and its public body IDAE (Institute for Energy Diversification and Savings) aimed at fostering the creation and supporting Energy Communities at the national level (CE-Implementa) require beneficiaries (which can have any legal form) to meet the basic principles of EC definitions, also having at least five members.

Waiting for an effective final transposition, the requirements set out in these calls serve as a reference or “soft law” to guide stakeholders on how to set up energy communities.

In practice, and according to various and comprehensive legal studies from different institutions, it is widely accepted that the legal forms of association and cooperative are ideal and easily comply with principles that any Energy Community should follow according to current regulations at European and National levels.

Furthermore, considering the most likely scenario in the near future, this chapter will also include some of the potential provisions contained in the draft version of Royal Decree, developing the figures of Renewable Energy Communities and Citizen Energy Communities. Regarding its legal form, it includes the following provisions both for RECs and CECs:

- [RECs or CECs] may adopt any of the legal forms provided for in the legal system that have their own legal personality, provided that they are guaranteed to be compatible with the requirements established in this chapter.
- The statutes of [RECs or CECs], understood as the internal regulations of the community itself that govern its own operation, must comply with the requirements of the regulations applicable to the corresponding legal form and must include the principles and requirements regulated in this chapter. The corporate purpose contained therein must also be consistent with the provisions of the definition of [RECs or CECs].

Implants and technical requirements

There is no specific provision or limitation regarding the type and size of installations that can be owned and operated by Energy Communities as long as they are based on renewable energy in the case of RECs.

However, in practice, multiple and very important barriers prevent ECs from developing or participating in projects with high installed power, given their associated technical, administrative, and legal constraints.

Focusing on collective self-consumption linked with PV installations, which is the most common case, RECs usually limit themselves to installations of maximum 100 kWn installed power to avoid problems with the registration and legalization of the plant, the management of the surplus energy (simplified compensation modality is only eligible for installations below 100 kWn) and other administrative steps that make it difficult for citizen-led initiatives with no necessary expertise on the energy field to thrive.

Detailed information on the technical and administrative requirements for promoting self-consumption from renewable sources can be found in Royal Decree 244/2019. Among the different typologies of self-consumption projects, collective self-consumption with simplified compensation of surplus energy is the most suitable for RECs. The most important requirements are as follows:

- Associated consumers must be within a radius of 2km from PV installations
- At least one consumer must be internally connected to the PV plant
- Consumers must entitle their energy contracts to prepare and send an "Energy Sharing Agreement" including allocation coefficients to be applied for each consumer.

Benefits

Again, there is little elaboration (on law) about the activities that Energy Communities can develop. According to IDAE, mainly:

- Generation of energy from renewable sources.
- Providing energy efficiency services (including, for example, building renovations).
- Supply, consumption, aggregation, and storage of energy and potentially distribution.
- Provision of electric vehicle charging services or other energy services.

As for advantages, also according to IDAE:

- They provide citizens with fair and easy access to local renewable energy resources and other energy or mobility services, and they can benefit from investments in them.
- Users can take control and have greater responsibility for self-provisioning their energy needs.
- Investment opportunities are created for local citizens and businesses.
- Offering communities the possibility of creating income that is generated and remains in the local community, increasing the acceptance of local renewable energy development.
- Facilitating the integration of renewable energy into the system through demand management.
- Environmental benefits.
- Social benefits: local job creation and promotion of social cohesion and equity

Focusing on the REC format, which is more suitable in the context of the EnerCmed project, the main provisions foreseen in the draft version of Royal Decree developing the figures of Renewable Energy Communities and Citizen Energy Communities regarding requirements.

2.2 Normative Dashboard Croatia

Normative framework

In the Croatian legislation, there are two basic types of energy communities: energy communities of citizens (EZG), which are defined by the Law on the Electricity Market (OG 111/2021, 83/2023, ZOTEE) and communities of renewable energy sources (ZOIE) and their kind of subset, consumers own renewable energies that work together, defined by the Law on renewable energy sources and high-efficiency cogeneration (Official Gazette 138/21, 83/2023, ZOIEiVUK). In Croatia, EZG is a legal entity entered in the register of EZG at the Croatian Energy Regulatory Agency (HERA) for the performance of appropriate energy activities that are under the control of members or owners of shares and whose members/owners of shares are, among others, LGUs, natural persons, micro and small enterprises and whose place of residence, business premises or business premises is in the territory of the Republic of Croatia. EZG can participate in the production, supply, consumption, aggregation, storage of energy, energy efficiency services or charging services for electric vehicles or provide other energy services, and it operates based on the Act on Financial Operations and Accounting of Non-Profit Organizations (Official Gazette 121/2014, 114/ 22).

In the register of the Croatian Energy Regulatory Agency, not a single association (the only formally possible form of association) dealing with the energy activity of organizing the energy community of citizens, which is non-profit, has been registered to date. Obtaining HERA's license is necessary to obtain the status of an energy community, which is intended as a non-profit, while energy cooperatives are a more informal form of for-profit organization. (HERA register: https://www.hera.hr/hr/html/registar_dozvola.html).

ZOIE can produce, consume, store, and sell renewable energy, among other things, through renewable energy purchase contracts and can share renewable energy produced in production units owned by it. ZOIE can be a legal entity that is based on open and voluntary participation, independent and under the actual supervision of shareholders or members located near the projects of renewable energy sources that this legal entity owns or develops, whose shareholders or members are natural persons, small and medium-sized enterprises or JLRS and whose primary purpose is to provide environmental, economic or social community benefit for its shareholders or members or for the local areas in which it operates, rather than financial gain.

Consumers of own renewable energy acting jointly are a group consisting of at least two consumers of own renewable energy acting jointly and located in the same building or residential complex, provided that they are connected to the low-voltage line of a common medium-voltage distribution substation. The decision to conclude a contract on self-supply in a multi-apartment building with a supplier is made by the co-owners of the building based on a minimum majority of the votes of the co-owners of the building, which is calculated by the co-ownership parts, and a person authorized to conclude the contract is determined among the members of the co-ownership community.

Although a positive and significant step forward was made with the introduction of energy communities into the Croatian national legislation, there is considerable room for further removal of administrative barriers.

Thus, for example, for EZG, it is necessary to form an association or cooperative, with elaborated statutes and other segments in accordance with the Law (entry in relevant registers, etc.). It is necessary to establish a management and operational structure, which includes bookkeeping, opening a business account, and collecting EUR 2,655. After that, it is necessary to start the registration process for the performance of EZG's energy activities at HERA, for which it is necessary to pay an additional EUR

1,000. In addition, EZG must establish a website, business premises, and other professional and technical capacities, of which it is particularly important to highlight the obligation of EZG to have a permanent employee based on an employment contract. In order to meet all the conditions for small and medium projects, which should be the most important when it comes to energy communities, it is not possible to ensure the profitability of the investment. It is not possible to provide funds for one employed person by investing in, for example, a solar power plant of 65 kWp. Proving professional, technical, and financial ability for small projects where the primary shareholders/members are natural persons, small and micro-entrepreneurs, and public sector representatives is challenging and often unachievable.

Also, the Law recognizes the need and obligation of the so-called of sharing key within the energy community, but at the same time, the competent authorities do not currently have the necessary software at their disposal. Several projects of energy communities with simple, so-called, with a static sharing key that does not require software, but for now, it is unknown how these projects will be realized in practice.

Currently, the regulated prices of electricity, gas, and thermal energy from heating plants for a significant range of consumers, most of whom are potential members of EZGs, represent a barrier to establishing energy communities. Regulating energy prices affects the profitability of investments in renewable sources and energy efficiency, reducing citizens' interest in investing.

Intending to start the scene of energy communities in Croatia, Regional Energy and Climate Agency Northwestern Croatia (REGEA) is implementing three EU projects: SHAREs financed through the Horizon Europe program, through which three pilots will be established in Karlovac, Samobor, and Zabok, and the LOOP and ConnectHeat projects, co-financed through the LIFE program, through which will also test and develop civil energy models for electricity and heat. Through the SHAREs project, an internet platform on energy communities in Croatia was developed, available at www.energetske-zajednice.hr

Local normativity document list

Many other laws and regulations apply to the establishment and operation of energy communities of citizens, renewable energy communities and energy cooperatives. In addition to general laws and regulations, specific documents relevant to their establishment, work, management, and operations are listed below:

- Croatian Parliament, 2012, Energy Law, Official Gazette 120/2012
- Croatian Parliament, 2015, Renewable Energy and High-Efficiency Cogeneration Law, Official Gazette 100/2015
- Croatian Parliament, 2012, Act on the Regulation of Energy Activities, Official Gazette 120/2012
- Croatian Parliament, 2014, Energy Efficiency Act, Official Gazette 127/2014
- Croatian Parliament, 2013, Electricity Market Act, Official gazette 22/2013
- Croatian Government, 2016, The Decree on Amendments to the Law on Renewable Energy Sources and Highly Effective Cogeneration, Official Gazette 123/2016
- Croatian Government, 2007, Regulation on the Minimum Share of Electricity Produced from Renewable Energy Sources and Cogeneration Whose Production is Incentivized, Official Gazette 33/2007
- Croatian Government, 2011, Decree on Amendments to the Regulation on the Minimum Share of Electricity Produced from Renewable Energy Sources and Cogeneration Whose Production is Incentivized, Official Gazette 8/2011

- Croatian Government, 2017, Decree on Subsidies for Renewable Energy Sources and Highly Effective Cogeneration, Official Gazette 87/2017
- Croatian Government, 2013, Tariff System for the Production of Electricity from Renewable Energy Sources and Cogeneration, Official Gazette 133/2013
- Ministry of Economy, 2015, Ordinance on the Use of Renewable Energy and Cogeneration, Official Gazette 88/2012
- Croatian Government, 2007, Regulation on the Minimum Share of Electricity Produced from Renewable Energy Sources and Cogeneration Whose Production is Encouraged, Official Gazette 33/2007
- Croatian Government, 2013, Ordinance on Subsidies to Promote the Production of Electricity from Renewable Energy Sources and Cogeneration, Official Gazette 128/2013
- Croatian Government, 2013, Tariff System for the Production of Electricity from Renewable Energy Sources and Cogeneration, Official Gazette 133/2013
- Croatian Government, 2007, Regulation on the Establishment of a Guarantee of Origin of Electricity, Official Gazette 84/2013
- Ministry of Economy, 2013, Ordinance on Obtaining the Status of an Incentivized Electricity Producer, Official gazette 132/2013
- Croatian Government, 2014, Ordinance on Amendments of the Regulation on the Establishment of a Guarantee of Origin of Electricity, Official Gazette 20/2014
- Ministry of Economy, 2014, Ordinance on Permits for Performing Energy Activities and Keeping the Register of Issued and Seized Licenses for Carrying out Energy Activities, Official Gazette 88/2015
- Ministry of Economy, 2015, Ordinance on Amendments of the Ordinance on permits for performing energy activities and keeping the register of issued and seized licenses for carrying out energy activities, Official Gazette 114/2015
- Rulebook on permits for the performance of energy activities and keeping a register of issued and revoked permits for the performance of energy activities
- Law on Associations
- Law on Cooperatives
- Law on financial operations and accounting of non-profit organizations
- Decision on the amount of fees for the performance of energy activities regulation
- Rulebook on general conditions for network use and electricity supply

Local (region/city) rules or normativity

Only the national normative framework applies.

Members

- Citizens (YES)
- Public entities (YES)
- Authorities (YES)

Role	min	max
Producer/ Prosumer	**1**	-
Consumer	**1**	-

Total	**2**	**-**

Association

Two basic types of energy communities are the following:

1. Energy communities of citizens (EZG), which are defined by the Law on the Electricity Market (OG 111/2021, 83/2023, ZOTEE) and
2. Communities of renewable energy sources (ZOIE) and their kind of subset, consumers own renewable energies that work together, defined by the Law on renewable energy sources and high-efficiency cogeneration (Official Gazette 138/21, 83/2023, ZOIEiVUK).

Benefits

The pilot will contribute to the achievement of strategic goals focusing on energy transition, climate change adaptation and resilience. As well, realization of the pilot will increase the capacity of the partner and public authorities involved in setting up energy communities and in defining it as a model to influence the marginalized groups better well-being.

The REC planned to be applied in Pula will be focused on the group most exposed to energy poverty risk, social benefit users, and single persons who are beneficiaries of the guaranteed minimum fee. Through a social program, they receive compensation in the amount of EUR 53 per month, which is insufficient to cover their monthly living expenses. Because of that, this category is at the very edge of poverty. Users are located in condominiums scattered throughout the city, mainly situated in the detected neighborhood of Monte Zaro. In the city area, it is estimated that there are at least 200 such users. The neighborhood is characterized by the deterioration of buildings, narrow streets, and traffic jams, which are mostly the characteristics of smaller Mediterranean towns that, after the decline of a certain economic branch, turn to tourism.

The REC model planned for Novigrad is conceived as a solution to the problem of constantly raising prices in the homes for older adults who are faced with low-income status. Usually, these kinds of users are situated in public homes for older adults. In the Region of Istria, there are 513 current users of such accommodation. It is well known that the needs are much higher, given that the county's population has entered a deep aging process, and a significant share of that population cannot cover basic living costs with their pension income. Waiting lists for such accommodation in some cities exceed 10 years. According to the Population census from 2011, in the Region of Istria, the share of the population over 60 years old makes up 24% of the total population. Accommodation of that type is available in 4 cities across the Region. Novigrad is one of those locations under the direct jurisdiction of the Region. The income status of the targeted group is additionally threatened due to an increase in electricity prices. Namely, the increase in electricity prices affects the increase in their accommodation prices.

2.3 Normative Dashboard Italy

Country normative framework

The evolution of renewable energy communities and self-consumption configurations in Italy is characterized by a series of legislative and regulatory measures aimed at aligning with European directives, promoting self-consumption, and ensuring the sustainable integration of renewable energy sources.

The national regulation implemented the European Directive Red II in the first phase through the enactment and conversion into law of Legislative Decree 162/19 ("Milleproroghe Decree"). In particular, the art. 42-bis of the Milleproroghe Decree had introduced a provision of a transitional nature to regulate a first experimental phase of REC configuration, which included plants powered by renewable sources with a power not exceeding 200 kW each and a limited aggregation perimeter of the plants to those belonging to the same secondary transformation substation.

Subsequently, in December 2021, Italy transposed the European directives RED II (Renewable Energy Directive II) and IEM (Internal Electricity Market Directive) through Legislative Decrees 199/2021 and 210/2021. These decrees laid the foundations for promoting and developing renewable energy communities and self-consumption configurations.

Legislative Decree 199/2021 made the requirements concerning the sizing, age, and connection of the systems established by Milleproroghe Decree less stringent, such as electricity production plants from renewable sources for a total power of no more than 1 MW (compared to the previous 200kW), a limited aggregation perimeter of the plants belonging to the same primary transformation substation (the previous boundary was secondary transformation substation).

Legislative Decree 210/2021 incorporated aspects of the IEM, focusing on creating a more integrated and efficient electricity market, facilitating the participation of RECs in the energy market, and ensuring fair and equitable access.

In August 2022, ARERA (the Regulatory Authority for Energy, Networks, and Environment) initiated Consultation 390/2022 to refine self-consumption configurations. This consultation aimed to define regulatory parameters and technical specifications for different self-consumption models, including individual and collective configurations. It sought to enhance the economic viability of self-consumption by addressing tariff structures, grid interaction, and incentives, as well as gathering feedback from stakeholders to ensure practical and effective regulatory frameworks.

In November 2022, the Ministry of Ecological Transition (MASE) launched a consultation to revise existing regulatory measures. This revision aimed to update and streamline regulatory provisions to remove barriers and promote the expansion of RECs and self-consumption configurations, incorporate feedback from previous consultations and adapt to evolving market and technological conditions and enhance coordination between different regulatory bodies.

In December 2022, ARERA issued Resolution 727/2022/eel, establishing the Integrated Text of Diffuse Self-consumption (TIAD). This document consolidated various regulations related to self-consumption into a single coherent framework, including all systems for widespread self-consumption: groups of self-consumers acting collectively in buildings and condominiums, energy communities, and individual self-consumers on the public network. The TIAD provided clear guidelines for the implementation and management of self-consumption systems, including technical standards, administrative procedures and economic incentives.

The regulatory landscape for Self-consumption Configurations for Renewable Energy Sharing (CACER) has been finally defined with the MASE (Ministero per l'Ambiente e la Sicurezza Energetica) Decree of 7 December 2023 n. 414 (hereinafter the CACER Decree) came into force on 24 January 2024. The CACER Decree introduced a new set of incentives for self-consumption configurations, offering financial incentives to support the initial setup and ongoing operation of CACER. The aim was to reduce economic barriers associated with renewable energy installations and to encourage investment in innovative technologies and practices that enhance efficiency and sustainability.

On January 30, 2024, a revision of the TIAD technical rules was initiated. This revision aimed to update technical standards and guidelines to reflect technological advancements and changes in the energy market. It sought to address issues identified during the implementation of the initial TIAD guidelines, ensuring more effective and efficient self-consumption systems.

On February 23, 2024, the Energy Services Manager (GSE) issued operational rules to facilitate the practical implementation of policies and incentives related to self-consumption configurations. These rules provided detailed procedures for accessing incentives, connecting to the grid, and managing energy production and consumption. The GSE ensured compliance with national and European regulations, supporting the transparent and efficient operation of CACER. Additionally, guidelines were provided on best practices and operational strategies to maximize the benefits of renewable energy systems for community members.

An important note is related both to art. 6 "Cumulation of the incentives", paragraph 1, of the CACER Decree, and to the Operational Rules, point 1.2.1.6 "Cumulation of the incentive tariff", which specify that the incentives can be cumulated with capital contributions (CAPEX) to the maximum extent of 40% of the eligible investment costs (design, purchase of equipment and construction costs). In the occurrence of CAPEX contribution exceeding 40%, as in the case of EU-funded projects, the premium rate to the self-consumed energy will not be recognized.

In conclusion, despite the limitations related to the "Cumulation of the incentives", the Italian regulatory framework for renewable energy communities and, more in general, self-consumption configurations has evolved significantly with the introduction of key legislative and regulatory measures between December 2021 and February 2024. These measures aimed to align with European directives, promote self-consumption, and create a supportive environment for developing renewable energy communities, contributing to the country's transition towards a more sustainable and decentralized energy system.

Local normativity document list

- (Dic 2019) D.Lgs. 162/19 (Milleproroghe)
- (Dic 2021) *RED 2 & IEM reception.* D.Lgs 199/2001 & D.Lgs 210/21.
- (Aug 2022) *Self-consumption configurations.* Consultazione ARERA 390/2022.
- (Nov 2022) *Revision.* Consultazione MASE DM
- (Dic 2022) Integrated text of diffuse self-consumption (TIAD). Delibera ARERA TIAD 727/2022/eel
- (24/01/2024) Incentives D. MASE 414/23
- (30/01/2024) TIAD technical rules revision.
- (23/02/2024) Operational rules GSE.

Local (region/city) rules or normativity

For Genoa City, only the national normative framework applies.

Members

- Citizens (YES)
- Public entities (YES)
- Authorities (YES)
- Research institutes (YES)
- Religious entities (YES)
- Small-medium companies (YES)
- Big companies (NO)

Role	min	max
Producer/ Prosumer	1	-
Consumer	1	-
Total	2	-

Association

In Italy, different configurations for self-consumption groups (CACER) have been defined:

- **Renewable energy community (REC):** must be constituted as a legal entity such as recognized associations, foundations (non-profit entities), or corporations (for-profit entities).
- **Collective self-consumption group (CSC):** constituted by statutes.
- **Remote individual self-consumption group (ISC):** constituted by statutes.

Plants and technical requirements

Type of implant: solar, wind, geothermal, etc.

Additional technical requirements:

To access the incentives provided by the CACER Decree, renewable energy plants must comply with the following requirements:

- The membership to configurations of RECs, Self-Consumer Groups or Remote Self-Consumer;

- The production facilities and the Point Of Delivery (POD) of each CACER member shall be connected under the same primary substation to which the configuration refers;
- The realization by means of new construction or upgrading of existing plants;
- A maximum power of 1MW;
- The operativity since 16 December 2021, for RECs only, after the regular establishment of the Community;
- The non-involvement at implementing hydrogen-related projects with greenhouse gas emissions of more than 3 tonnes of CO_2 equivalent per tonne of H_2;
- The compliance with the requirements of the DNSH (Do No Significant Harm) principle, as specified in the Rules;
- The components must be new if photovoltaics, while for plants other than photovoltaics is also expected to use regenerated components.

Benefits and requirements

CACER configurations are a way to organize collective and citizen-driven energy actions, and they are seen as a key step to put citizens at the heart of the clean energy transition and set a framework to empower consumers to get actively involved and benefit from clean energy.

REC has value-driven concepts that primarily aim to provide environmental, social, and economic benefits to the community members or the local areas where they operate, such as:

- reduced carbon emissions and sustainable energy production, hampering reliance on fossil fuels;
- Energy Independence, communities gain greater control over their energy supply, enhancing resilience against energy market fluctuations;
- cost savings and revenue generation, since surplus energy can be sold back to the grid, generating additional income for the community.

In this regard, the CACER Decree provides for two incentive measures:

- the incentive tariff, which is valid on the share of energy for renewable energy plants, which are included in consumption configurations. The tariff may be requested until the thirtieth day following the date of achievement of an incentive power quota of 5 GW, and in any case no later than 31 December 2027.;
- a capital contribution from the resources of the "Piano Nazionale di Ripresa e Resilienza" (PNRR), up to 40% of the eligible costs, for the development of energy communities and collective consumption configurations, whose installations are located in municipalities with a population of less than 5000 inhabitants. Requests for access to the contribution must be sent no later than 31 March 2025 and all plants eligible for the contribution must enter into operation within 18 months from the date of admission to the contribution and in any case no later than 30 June 2026. The measure will last until June 30, 2026, to accomplish a total power of at least 2 GW, within the PNRR's financial resources allocation of 2,2 billion euros.

To operate legally and effectively in Italy, CACER configurations must comply with specific requirements and regulations. These requirements align with national and European Union directives to promote sustainable energy practices and community involvement.

1. Different configurations must be established through an autonomous legal entity by statute or act of constitution, which essential elements are:

    - the main purpose is to provide environmental, economic or social benefits at the community level to its members and to the areas in which it operates, and not to obtain financial profits;
    - the members or supervisors are individuals, SMEs, associations with legal personality under private law, local authorities, research and training bodies, religious bodies, third-sector and environmental protection authorities, local administrations contained in the ISTAT list, located in the territory of the same municipalities in which the production plants held by the RECs are located;
    - the community is autonomous and has open and voluntary participation;
    - the participation in the community provides for the maintenance of the rights of the end customer, e.g. the right to choose the seller, to quit at any time, remaining in the event of early withdrawal;
    - a delegated subject responsible for the allocation of shared electricity has been identified;
    - any excess premium tariff amount will be allocated only to consumers and/or used for social purposes benefitting the territories where the sharing plants are located.
2. A request of access must be submitted for widespread self-consumption to the National managing authority GSE – Energy Services Operator o Manager).

3. Preliminary feasibility request can be submitted (optionally).

A CACER configuration can manage more than one sharing configuration. The REC must then be proprietary, i.e. have the availability and control of all the production/UP plants that are part of the configuration. The latter condition may be fulfilled by an agreement signed between the Parties.

EnerCmed Interreg Euro-MED Co-funded by the European Union

2.4 Normative Dashboard Greece

Normative framework

Energy Communities were introduced in Greek legislation by Law no. 4513/2018. They are currently regulated under Law no. 5037 / 2023 on the transposition of the European Directives 2018/2001 and 2019/944.

The legislation provides for three (3) types of Energy Communities:

- Renewable Energy Communities (RECs)
- Citizen Energy Communities (CECs)
- Energy Communities under Law no. 4513/2018 (established until 01/04/2023)

RENEWABLE ENERGY COMMUNITY (REC)

Eligibility for participation:

- Natural persons with full legal capacity, including civil servants.
- Local and regional authorities, associations of local and regional authorities, as well as enterprises that are fully (100%) owned by local and regional authorities.
- Small- and medium-sized enterprises (SMEs).
- Agricultural cooperatives and civil cooperatives under Law 1667/1987.
- Non – for- profit legal entities under public or private law.

Locality criterion:

- At least fifty percent (50%) plus one (1) of the members must have proximity to the area where the REC operates and the RES Project is being developed.

A REC must have a minimum of thirty (30) members, or:

- Twenty (20) members, if the REC is established in an island municipality with a population of less than three thousand one hundred (3,100) residents, according to the last census.
- Fifteen (15) members, if at least fifteen (15) participants are SMEs.
- Three (3) members, if one of them is local/ regional authority and the other two members are either enterprises that is fully (100%) owned by a local or regional authority or local / regional authority.

Renewable Energy Communities (RECs) operate within one region and carry out at least one of the following activities: production, consumption, storage and sale of energy from renewable sources.At least seventy percent (70%) of each financial year' surplus is retained by RECs as extraordinary or special reserves and is allocated, by decision of the general assembly, in accordance to the activities and as provided by the statutes.

CITIZEN ENERGY COMMUNITY (CEC)

Eligibility for participation:

- Individuals with full legal capacity, including civil servants.
- Local and regional authorities, associations of local and regional authorities, and enterprises that are fully (100%) owned by local and regional authorities.

- Legal entities under public or private law
- Agricultural cooperatives and civil cooperatives under Law 1667/1987.

Locality criteria

- At least fifty-one percent (51%) of CEC members must have proximity to the RES project or to the CEC's area of operation.

A CEC must have a minimum of thirty (30) members, or:

- Twenty (20) members if the REC is established in an island municipality with a population of less than three thousand one hundred (3,100) residents, according to the last census.
- Fifteen (15) members, if at least fifteen (15) members are legal entities under public or private law.
- Three (3) members, if all three are local or regional authorities; or if one of them is local or regional authority and the other two members are enterprises fully (100%) owned by a local or regional authority or local/regional authority.

Citizen Energy Communities (CECs) are active within one or more regions. They are required to carry out at least one of the following activities: production, self-consumption or sale of electricity from renewable sources, storage, distribution and supply of electricity, cumulative representation, provision of flexibility and balancing, as well as provision of energy efficiency, electric vehicle charging, and other energy services to its members. At least seventy percent (70%) of each financial year's surplus is retained by CECs as extraordinary or special reserves and is allocated, by decision of the general assembly, in accordance with the activities and as provided by the statutes.

ENERGY COMMUNITIES UNDER LAW no. 4513/2018 (established until 01/04/2023)

Eligibility for participation:

- Natural persons.
- Legal entities under public law, except for local and regional authorities.
- Legal entities under private law.
- Local authorities (within the same Region) and regional authorities.

locality criteria

- 51% of the EC members are expected to have local ties with the district within which the EC has its headquarters. In case of members-individuals these ties shall be demonstrated by a) ownership rights or, b) by the right to use (usufruct) of immovable property within the district of EC, or c) by being residents of the area
- Regarding the island region of the country, the law considers that many islands, especially in the Aegean Sea, are not connected to the mainland's infrastructure. Therefore, they tend to rely heavily on fossil fuels, and during peak season, the costs of energy consumption are soaring. Hence, the law aims to facilitate the island regions' energy autonomy based on renewable energy sources by prescribing special clauses for them1.

The minimum number of members of an EC is: a) five in case the members are public law legal entities, except for local authorities, or private law entities or individuals, b) three in case the members are legal persons of public or private law or physical persons, as long as two at least are local authorities, c) two in case the members are only local authorities of the first tier of island regions of the country with less than 3.100 habitants according to the latest census".

Energy communities are required to carry out at least one of the following activities:

- Production, storage, self-consumption or selling of electric or thermal or cooling energy from renewable energy sources,
- Management (such as collection, transport, processing, storage or distribution) of the raw materials for the production of electricity or heat or cooling energy from biomass or bioliquid or biogas
- supplying its members with electrically operated vehicles or vehicles using alternative motor fuels surplus distribution

1. the “not-for-profit EC”
    - allocating at least 10% of the surplus to the legal reserve of the EC
    - the rest of the surplus is prohibited from being distributed to members
    - For the EC which consists of local authorities only, as well as the EC in which local authorities participate as members in island regions with less than 3.100 habitants, the surpluses – party or totally – may be allocated for local collective activities associated with the energy sector

2. The “for-profit EC”
    - allocating at least 10% of the surplus to the legal reserve of the EC
    - the rest of the surplus can be distributed to members as long as the EC consists of at least 15 members (or 10 members in island regions with less than 3.100 habitants) and 51% of the members are physical and not legal persons.

Local normativity document list

- 2018: Law no. 4513/2018: Energy Communities founding law
- 2023: Law no. 5037/2023: Transposition of Directive 2018/2001 on the promotion of the use of energy from renewable sources and Directive 2019/944 on common rules for the internal market for electricity, and introducing an institutional framework for RECs and CECs.
- 1986: civil cooperatives under Law 1667/1986

Local (region/city) rules or normativity

For PatrasCity, only the national normative framework applies.

Members

	EC	REC	CEC
CITIZENS	YES	YES	YES
LOCAL&REGIONAL AUTHORITIES	YES	YES	YES
SMEs	NO	YES	NO
Agricultural&civil cooperatives	NO	YES	YES
Legal entities underpublic or private law	YES	NOT FOR PROFIT	YES

Association

In Greece, the installation of REC plants and storage systems to meet own needs by applying virtual net-metering is allowed for:

(a) local and regional authorities;

(b) those registered in the Register of Farmers and Agricultural Holdings for installations of agricultural holdings and agricultural uses;

(c) Renewable Energy Communities, Citizen Energy Communities, and Energy Communities under Law no. 4513/2018, to meet the energy needs of members who are exclusively domestic consumers or farmers registered in the Register of Farmers and Agricultural Holdings, the energy needs of citizens living below the poverty line and households affected by energy poverty, as well as to meet the energy needs of local and regional authorities.

Virtual net-metering for RECs, CECs, or Energy Communities under Law no. 4513/2018 refers to the offsetting of the electricity produced by RES or CHP plants of CECs, RECs, or EnComs under Law no. 4513/2018 with the electricity consumed in installations of the aforementioned Communities' members; consumers living below the poverty line; and households affected by energy poverty. In order to apply virtual net-metering (and subject to the regulations concerning the proximity of members), these Energy Communities may install production plants in any Region, regardless of where the consumption installation or the seat of the community is located, and the latter are not all required to be in the same Region.

Implants and technical requirements

Type of implant: solar, wind, geothermal, biogas, biomass, High-Efficiency Electricity-Heat Cogeneration.

Concerning renewable energy technologies, the majority of energy community projects concern photovoltaic installations. Among requests for commercial projects at low-medium voltage (HEDNO), a small number (23) concern wind farms, biogas, biomass, and CHP plants, with a total requested capacity of 43.5 MW (1% of total capacity requested by commercial projects). Ten (10) of these requests are for wind farms with a capacity of 31.6 MW, which have not been electrified, while only one (1) 500 kW biogas project has been electrified in Epirus. Virtual net-metering projects include only photovoltaic systems.

Power: max. 2 GW – for all self-production projects (**Law no. 5037/2023**)

Date of installation: 2021-2024

Additional technical requirements:

Map of RECs activable in the pilot projects in Greece.

REGION	**NUMBER OF ACTIVE RECs**
1. Attica	171
2. Central Greece	113

3. Central Macedonia	333
4. Crete	90
5. Eastern Macedonia and Thrace	125
6. Epirus	62
7. Ionian Islands	25
8. North Aegean	4
9. Peloponnese	77
10. South Aegean	12
11. Thessaly	180
12. Western Greece	187
13. Western Macedonia	294

Region of Western Greece

- one of the 13 regions of Greece: the secondary local government organization that covers the northwestern part of the Peloponnese and the western part of Central Greece
- It occupies an area of 11,336 sq.km. and its permanent population amounts to 648,220 inhabitants, according to the 2021 census by EL.STAT. Its largest city and capital is Patras.
- Recommended by 3 Regional Units: Achaia, Etoloakarnania, and Ilia, with a total of 19 Municipalities.

Non–profit RECs in the Western Greece Region

The Region of Western Greece, along with 26 Local Land Reclamation Organisations and 2 General Land Reclamation Organisations, 11 municipalities, 4 water supply companies, and 9 other legal entities of Western Greece Region, formed 7 Renewable Energy Communities

- 4 with the partnership of 11 Municipalities, 4 water supply companies, and 9 other legal entities of Western Greece Region,
- 3 with the partnership of 26 Local Land Reclamation Organisations and 2 General Land Reclamation Organisations,

The Region of Western Greece proceeded with all the necessary actions and procedures in order to attract the interest of the collaborating entities, analyze their energy needs, and capture the whole project :

- Founding General Assemblies of all RECs, signing of Statutes, election of the Board of Directors, and Supervisory Boards (November 2021)

- Submission of the articles of association and the supporting documents to GENERAL COMMERCIAL REGISTER for issuing VAT number and starting work, and

- environmental impact studies, division of plots - issue of topographical maps

A large photovoltaic park of approximately 118 MW with a total estimated generated energy of 198,000,000 kwh per year is planned to be built in the area of Messolonghi, within an area of 1,300 acres (granted for free to the Region of Western Greece and the aforementioned 7 Energy Communities to implement their project, by the Ministry of Rural Development), which will cover their energy needs using virtual net metering—the largest virtual energy offsetting project with a photovoltaic park in the whole of Europe.

The project concerns and affects more than 306,000 residents from 11 municipalities, 139,000 professional farmers, and their families. Free farmers from the unaffordable energy costs, the accumulated debts to the Public Power Corporation, and the chronic problem of power supply at the water supply pumping stations

With the small percentage of excess electricity, after the virtual energy netting and the coverage of the energy needs of both the Municipalities, their Legal Entities, the Local Land Reclamation Organisations and General Land Reclamation Organisations of the Region of Western Greece the demands on electricity of our proven economically vulnerable fellow human beings can be met. It is estimated that more than 5,000 households will be included, giving economic aid to our fellow citizens.

There is an excellent reduction in the percentage of emitted pollutants (CO_2) through the production of electricity from photovoltaic plants. The estimations are close to absolute and amount to 98.9% of the existing situation for the entire project (from 152,217 to just 1,733 CO_2 units).

THE FINANCIAL PLAN: the financing scheme includes 25 million euros from the Territorial Operational Program of Western Greece and the rest from the Energy Performance contract.

The project is under the application approval procedure.

Benefits

The pilot will contribute to achieving strategic goals focusing on energy transition, climate change adaptation, and resilience. Also, the realization of the pilot will increase the capacity of the partner and public authorities involved in setting up energy communities and defining it as a model to influence the marginalized groups' well-being.

The REC planned to be applied in Pula will be focused on the group most exposed to energy poverty risk, social benefit users, and single persons who are beneficiaries of the guaranteed minimum fee. Through a social program, they receive compensation in the amount of EUR 53 per month, which is insufficient to cover their monthly living expenses. Because of that, that category is at the very edge of poverty. Users are located in condominiums scattered throughout the city, mainly situated in the detected neighborhood of Monte Zaro. In the city area, it is estimated that there are at least 200 such users. The neighborhood is characterized by the deterioration of buildings, narrow streets, and traffic jams, which are mostly the characteristics of smaller Mediterranean towns that, after the decline of a certain economic branch, turn to tourism.

The REC model planned for Novigrad is conceived as solution to a problem of constantly raising prices in the homes for elderly people that are faced with low-income status. Usually, this kind of users are situated in the public homes for elderly people. In the Region of Istria it is estimated that there are 513 current users of such accommodation. It is well aware that the needs are much higher, given that the population of the county has entered in a deep aging process and a significant share of that population cannot cover basic living costs with their pension income. Waiting lists for such accommodation in some cities reach up event to 10 years. According to the Population census from 2011, in the Region of Istria the share of the population over 60 years old makes 24% of the total population. Accommodation of that type is available in 4 cities across the Region. Novigrad is one of those locations under the direct jurisdiction of the Region. Income status of the targeted group is additionally threatened due to electricity prices increase. Namely, the increase in electricity prices affects the increase in the prices of their accommodation.

3. SPATIAL PLANNING

3.1 Spatial Planning Spain

Purpose:

The present document consists of a preliminary screening of potential locations for PV systems according to project goals and municipal space availability and suitability. The analyzed spots have been screened considering the following factors:

- The building or space must be owned by the municipality itself or a municipal entity.
- The building or space must enable a combined solution of PV and NBS, which is in line with the EnerCmed project goals.
- The building or space must have some social/community use to amplify the impact of the intervention.
- Previous experience in past projects and/or municipal initiatives. Also, check future plans for the examined installations, if applicable.
- Heritage protection.
- Grid voltage connectivity.

Scope:

The analysis considers municipal buildings present in the neighbourhoods of Nazaret and Malvarrosa, in terms of PV potential, use, grid connectivity (medium/low voltage) and other factors. The shown list is not exhaustive, as many locations have been rapidly discarded mainly due to low PV potential or heritage protection.

The analysis doesn't consider open public spaces such as parks, squares, car parks or streets as their involvement in the project would imply complex permitting processes and close coordination between multiple municipal delegations. This decision has been made to avoid foreseeable delays in the project implementation.

Methodology:

The above-mentioned list of buildings and their different features and indicators is based on a previous technical feasibility study contracted with an expert partner in the frame of the H2020 POWER UP project. The study methodology is based on GIS and 3D modeling and access to real consumption data from DSOs platform when available.

The study included working sessions and input from different municipal departments.

City Overview

Urban Masterplan Summary:

Both Malvarrosa and Nazaret have conflicting backgrounds in terms of urban planning. While Nazaret suffered big changes because of the new port facilities, losing its beach and starting a process of degradation, Malvarrosa neighbours and grassroot organization could be able to stop some urban plans which foresaw a complete transformation of the current fisherman's type of edifications and environment.

Nonetheless, both neighbourhoods and specially Malvarrosa have been more carefully considered during the last years in terms of urban planning by decision-makers, developing particular special plans which foresee more green areas, new public facilities and continuous renovation and retrofitting plans for public-owned buildings. These plans are, however, still under definition, with constant modifications and pending advancements in administrative procedures. The current phase does not provide a clear view about the urban plan to be considered when planning the EnerCmed project implementation.

Nevertheless, the studied spots can be considered independent from the masterplan guidelines that focus more on public space. Additionally, EnerCmed is considered well aligned with the current municipal policies on energy transition and greening of spaces being Valencia the European Green Capital 2024. This gives us a positive framework for proposing the EnerCmed planned infrastructure investments in municipal facilities.

Existing Critical Infrastructures:

Here is the list of buildings which have been assessed:

Building name	Neighbourhood	Type/Use	PV Potential	Energy Demand	Grid connectivity
Biblioteca del Mar	Nazaret	Library	130 kWp	57 MWh/year	MV
CEIP Ausiàs March	Nazaret	School	64 kWp	42 MWh/year	LV
Centro de Fauna Exótica	Nazaret	Exotic animals shelter	100 kWp	51 MWh/year	LV
Escuela Infantil Gent Menuda	Nazaret	Infant school	54 kWp	19 MWh/year	LV
CMSS Nazaret	Nazaret	Social Services Delegation	60 kWp	42 MWh/year	MV
Centro Municipal de Juventud Nazaret	Nazaret	Youth Municipal Centre	45 kWp	Unknown	MV
Polideportivo Nazaret	Nazaret	Sports Centre	781 kWp	570 MWh/year	Unknown
CMSS Malvarrosa	Malvarrosa	Social Services Delegation	60 kWp	51 MWh/year	LV
Pabellón Malvarrosa	Malvarrosa	Sports Pavilion	288 kWp	55 MWh/year	LV
CEIP Malvarrosa	Malvarrosa	School	100 kWp	26 MWh/year	LV
CEIP Ballester Fandos	Malvarrosa	School	65 kWp	Unknown	LV
Museo Blasco Ibáñez	Malvarrosa	Museum	21 kWp	37 MWh/year	LV

Regulatory and Planning Context

Here, we should distinguish between rooftop use for PV plants and land use for NBS intervention.

When it comes to the installation of PV, there is a local normative that regulates all the requirements that any PV installation should fulfill, regardless of the owner of the roof. Additionally, each building and even district has its own typology and “urban code” which defines additional requirements such as setbacks, panel orientation, and integration in the building's existing infrastructure… when applicable. Each case can be directly consulted with the Urban Department of the municipality, which gives all the indications.

When the building has some heritage protection, the Heritage Commission must approve the project. This is a particularly long and difficult step that will be avoided in the EnerCmed frame.

Permitting Requirements: Outline the necessary permits and approvals needed for PV installations on public buildings.

The permitting process heavily depends on who is asking for permits. If the municipality wants to promote the installations, the permitting is based on internal agreements between the affected departments.

If a municipal (but external) institution (such as VCE) takes the lead, the process would be similar, but municipal departments should sign an extra formal agreement to assign the use of the rooftop to an external body.

Finally, when a third party such as a Renewable Energy Community, wants to access the municipal roof, a public tender must be launched to procure the right to use the public roof. However, based on previous legal analysis, there is an open window for direct assignment to RECs based on solidarity principles, only targeting vulnerable households as beneficiaries.

If we speak of public schools, an additional permit should be obtained from the Regional Government, regardless of who the promoter is. The reason is, while the land and the school buildings are owned and maintained by the municipality, it is the Regional Government, through its Education Department who manages the facilities, as a consequence of how competences are split in our country,

Environmental Impact Considerations: Identify any environmental regulations or assessments required to install PV systems.

Any PV installation promoted in the city should fulfill some environmental requirements regarding the treatment of waste derived from the installation works. These standard requirements should be reflected in the installation project submitted to the municipality's licensing service.

Only promoters of huge PV plants on land must submit particular environmental impact studies, which will not be the case within EnerCmed.

Technical Feasibility Assessment

Site Selection Criteria: Define the criteria for selecting suitable sites for PV installations, such as roof size, orientation, shading, and structural integrity.

The site selection has considered multiple factors, not all of them from a technical approach.

The first requirement is to have a PV potential between 30 and 120 kWp. 30 kWp is considered to be the minimum size to have enough potential for launching a powerful energy community, while 120 kWp (100 kWn at inverter level) is the upper threshold considered in normative to avoid complex permitting with main authorities and a more difficult management of the plant. The same thing applies to the grid connection voltage, which must be *low voltage* to avoid extra costs of grid adaptation.

Secondly, the building must include some open space available to integrate NBS. Additionally, buildings with a social/community use and well perceived by citizens must be prioritized to ensure maximum social impact.

All these criteria lead to the selection of public schools as a first choice. Moreover, the social particularities of the families attending these schools must be considered. The two selected schools CEIP Ballester Fandos and CEIP Ausiàs March are within two of the most deprived areas in the target neighbourhoods, with high grades of migrant and low-income families involved. In addition, both schools have a strong community movement, with various NGOs and grassroots organizations. That could pave the ground for establishing energy communities with high social impact.

PV System Specifications: Provide technical details on the proposed PV systems, including panel types, capacity, and expected energy output.

Previous feasibility studies have already considered multiple factors when estimating the PV potential of each of the municipal buildings.

The study made by expert partners considered the following methodology for calculating the PV potential:

Evaluation of production

The model for calculating photovoltaic potential has several distinct parts: 3D model of the city, sizing, and production. Each of the sections is described in detail below.

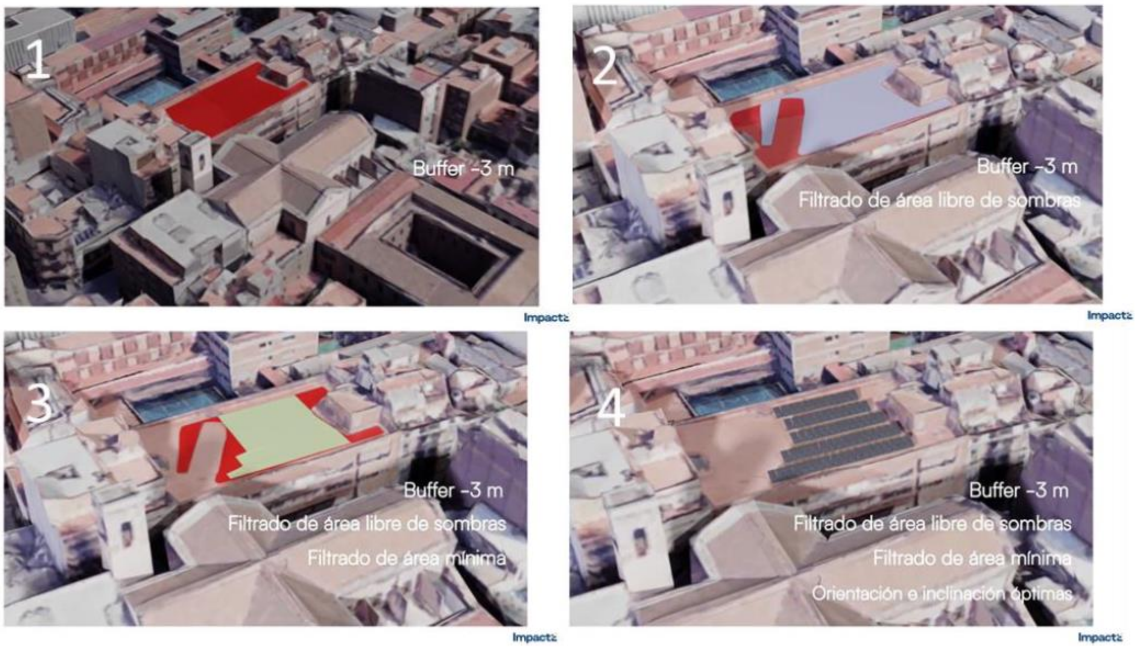
Geographic information is used to calculate with the greatest precision, taking into account the geometries and obstacles of the urban area studied. On the one hand, the installation is modeled taking into account the maximum levels given the entire available roof surface.

3D model of the city

The first step is creating a 3D model of the study area. This is achieved by using proprietary algorithms for identifying, classifying, and analyzing spatial information from spatial data from open sources, through which we obtain a digital twin that includes both the geometry and the possible obstacles inherent to these elements (elevator, air conditioning equipment, railings, etc.). In addition to the buildings and associated elements, the trees are modeled and included in the interaction analysis in the feasibility study due to the potential impact of projected shadows.

Sizing

Once the digital twin has been obtained, the next step is to obtain the interesting surfaces for having photovoltaic installations and their optimal design. First, the areas of interest are obtained.



Areas of interest

- Select the areas of interest that the facilities may have.
- Leave a safety zone with respect to the edge, to avoid installing lifelines and facilitating maintenance.
- Project the shadows of the obstacles that the installation sees (adjacent buildings, trees, chimneys, etc.), to eliminate the areas where installing panels would not be interesting.
- Regularize the area obtained, removing the conflictive areas where panels would not fit.
- Choose the representative point of the surface in which the shadows of the installation will be calculated.

Through this process, the useful square meters of each surface and the representative point of the area are obtained.

Production

In the previous model, the useful square meters of the roof surface and the shadows projected on the representative point are obtained. In this module, both the number and the optimal inclination and orientation of the panels on the useful surface that maximizes the energy generation of the installation are obtained. With this, the incident radiation is obtained, and its annual electrical generation is achieved (hour by hour). In addition, the optimal installation is obtained, given the consumption of the building itself.

Knowing the orientation and inclination of the studied surface, the minimum distance that must be left for safety between panels and the shadow profile, the possible distributions of the panels on it are obtained. To determine the inclination, number of panels, and orientation, these variables are optimized with proprietary algorithms to maximize their energy generation.

In this way, the maximum installable kWp, the radiation curve they receive in each hour of the year (kWh/m2), and the maximum density of panels on the said surface (kW/m2) are obtained. Finally, with the power obtained, the radiation curve, and the design characteristics of the installation, the maximum hourly electricity generation curve that the designed installation could generate is obtained. The nominal power is limited to 100 kWp so as not to change the self-consumption mode and to be able to form the energy communities.

Grid Connectivity: Assess the capacity of the local grid to accommodate the additional power generated by the PV systems.

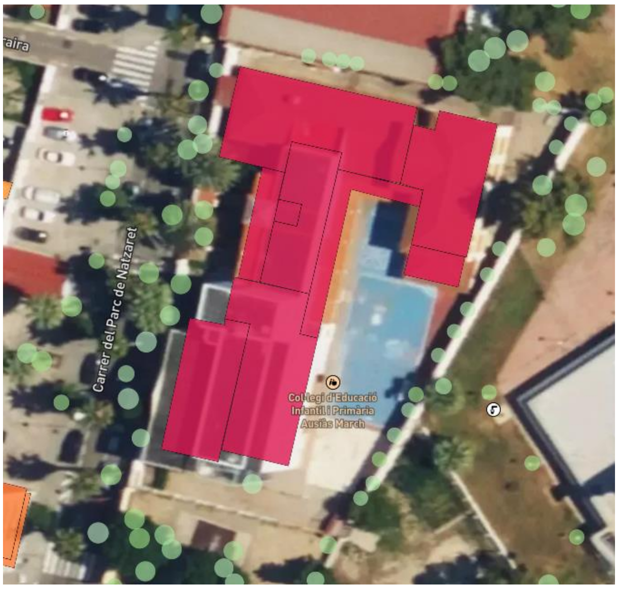
Once the building is selected, this should be assessed in the next step. However, the grid's voltage level in each location has been considered to avoid additional barriers. The connection points will be consulted with the DSO of the area to have clear technical-economic conditions for each case.

Spatial Analysis and Mapping

GIS Mapping: Utilize Geographic Information Systems (PVGIS) to map the locations of critical infrastructures and potential PV installation sites. European Communities, 2022. PVGIS Photovoltaic Geographical Information System. EU Science Hub. https://re.jrc.ec.europa.eu/pvg_tools/en/

You can find below screenshots from the recently launched solar map of the city, showing the two chosen public schools:

CEIP Ballester Fandos



CEIP Ausiàs March

Energy Production and Savings

The estimated maximum energy production would be:

CEIP Ballester Fandos: 90.020 kWh/year

CEIP Ausiàs March: 89.950 kWh/year

This production estimation was obtained from a specific study on municipal buildings, with more accurate estimations than the solar map.

The associated cost savings cannot be estimated until a decision is made about the share of energy assigned to the school. It can already be said that the % of energy dedicated to reducing the cost of municipal energy bills is not the main goal of the installation, which should be reaching as many vulnerable households as possible.

Spatial Compatibility: Evaluate the compatibility of proposed PV installations with the existing urban landscape and future development plans.

The preliminary PV proposed installations would comply with all regulations and adapt to the urban.

3.2 Spatial Planning Croatia

City: Novigrad
Location: Home for elderly Novigrad (Dom za starije osobe Novigrad)

Area of interest. Source: Google maps

Introduction
Purpose
Audit objective
The objective of the audit is to detect a transnational-conceived applicative model for the emergence energy & climate positive neighborhoods, which is based on the integration of REC for the energy transition of marginalized people and complementary climate mitigation interventions based on Nature Based Solutions in the pilot neighborhoods, combining three key drivers:

(1) Presence of urban public infrastructures (parking, schools, port) where installing PV system,

(2) Presence of people exposed at energy poverty risk and

(3) Urban heat island sharp phenomena.

The action aims to activate at least 1 REC in the detected marginalized neighborhood and to implement a REC – complementary investments in Nature Based Solutions within the targeted neighborhood, to directly mitigate the urban heat wave phenomena during peak demand of energy for cooling and indirectly improve the livability and urban regeneration of port hinterlands.

Analysis of the spatial planning requirements for the pilot intervention realization and expected potential impacts

In the past, Novigrad was recognizable as a small fishing town, but it is now a port city on the west coast of Istria.

Article 217 of the Spatial Development Plan of the City of Novigrad (Official newspaper of the City of Novigrad - Cittanova no. 1/08, 4/11, 4/11-refined text, 6/11-correction, 07/14, 09/14-refined text, 08/15, 10/20 and 2/21), underlines necessity for using renewable energy sources “as much as possible that will improve the ecological condition of the covered area, which implies the use of gas or alternative energy sources (solar energy, wind - outside the restricted area of the protected coastal area of the sea, etc.)”.

Considering that the aim of the pilot activity is: (1) the establishment of an EC to reduce energy poverty and on the other hand, (2) the application of NBS solutions in the analyzed district that will contribute to the reduction of the heat island, the subject of this analysis is the residential area Bikokere, where the Home for the elderly Novigrad is located.

The conditions for the arrangement of the Bikokere residential settlement are defined by the Urban Development Plan "UPU Bikokere".

Article 39 UPU Bikokere allows the use of renewable energy sources, solar photovoltaic panels, smaller energy units for electricity production, and thermal energy that can be used to heat and cool individual buildings. According to it solar photovoltaic panels can be placed on the roofs of buildings or as a cover over parking areas, provided that they do not endanger the static stability of the building.

Given that no planned public green areas are within the area (defined by Article 40 of the UPU Bikokere), implementing the NBS solution at the location in question is desirable.

Scope

Combining both aims of the pilot intervention, the Home for elderly Novigrad located in Bikokere resident settlement is defined.

Within the Article 56 in the Spatial Plan Layout of the City of Novigrad, important areas and buildings recognized by the County of Istria, are the buildings of social activities: elementary school, primary school, health center, buildings of science and culture and social welfare buildings.

Among listed, the Home for the elderly Novigrad is located in the area of UPU Bikokere and is the only public building of importance in the area covered by this plan.

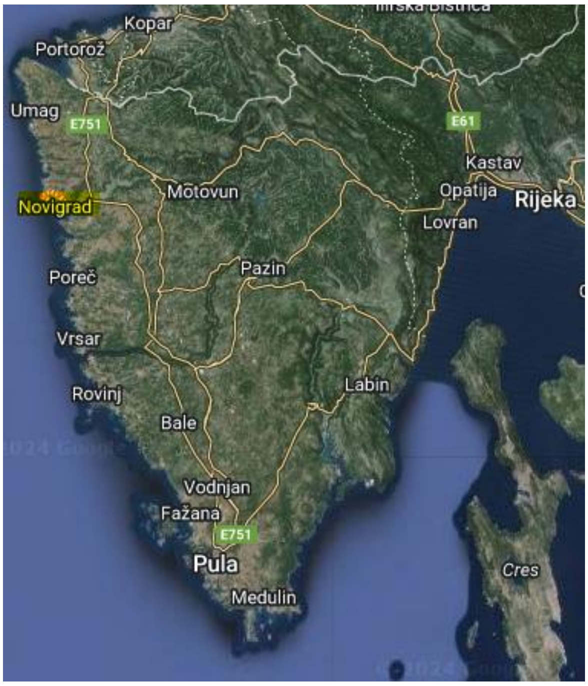
Methodology

Data was provided from the official documents, strategies, and plans, and consultations were made with the local authorities.

City Overview

Urban Masterplan Summary

The pilot intervention is located in the City of Novigrad, on the Istrian peninsula's west coast.



Pula location. Source: Google maps

Novigrad has retained its medieval structure and layout, with narrow, winding streets. In its spatial plan, the long-term basis for the space arrangement is established per the goals and tasks of the City social and economic development.

SPATIAL DEVELOPMENT PLAN OF THE CITY OF NOVIGRAD - CITTANOVA is published in the Official newspaper of the City of Novigrad - Cittanova no. 1/08, 4/11, 4/11-refined text, 6/11-correction, 07/14, 09/14-refined text, 08/15, 10/20 and 2/21.

The plan covers the area of the City of Novigrad with an area of about 26.22 km2, which according to the 2011 census had 4,325 inhabitants (2021 census - 3,889 inhabitants).

In the final spatial distribution of individual purposes and activities, the Plan has foreseen measures that direct the development in space with the aim of:

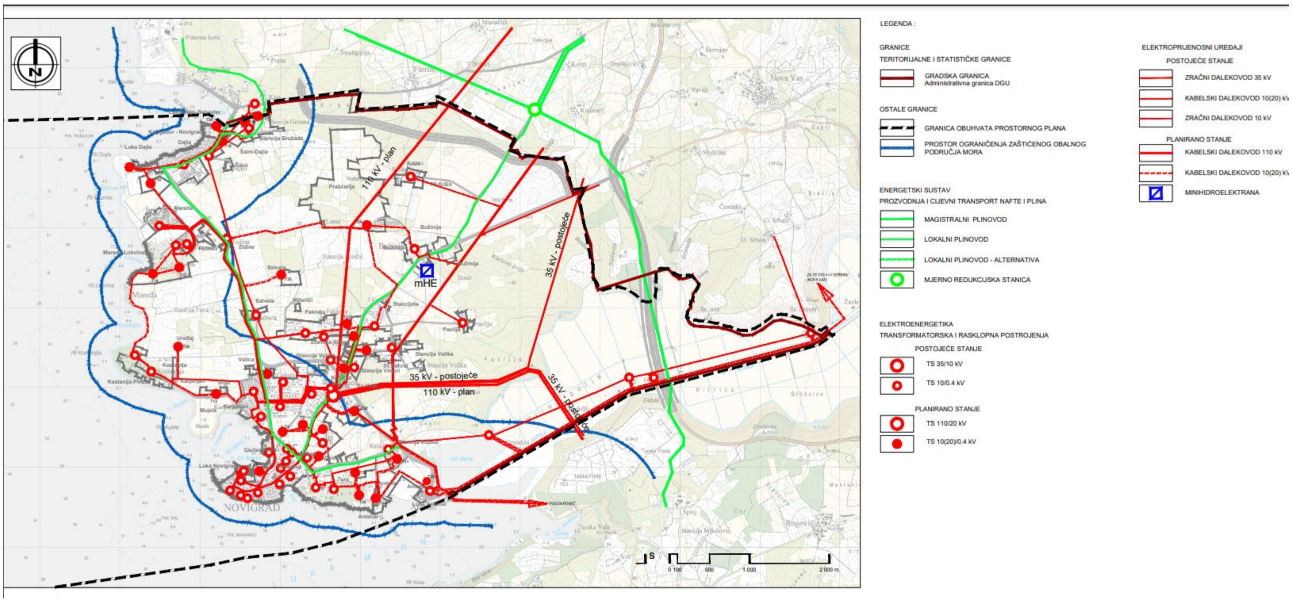
- better use of natural (especially coasts) and created (especially cultural assets), values of individual spatial units,

- determination of the size, structure, quality and capacity of the tourist offer, in accordance with the limit of permissible loading of the coast,

- rationalization of the areas of the construction area, in accordance with the provisions of the Spatial Plan of the County of Istria (SN of the County of Istria 2/02, 1/05, 4/05, 14/05 – revised text, 10/08, 7/10, 16/11, 13/12 , 9/16 and 14/16 - consolidated text) and the Spatial Planning Act (OG 153/13 and 65/17),

- precise determination of the regime for the protection of water, forests, other particularly valuable parts of nature, agricultural soils, architectural heritage and all natural and civilizational values.

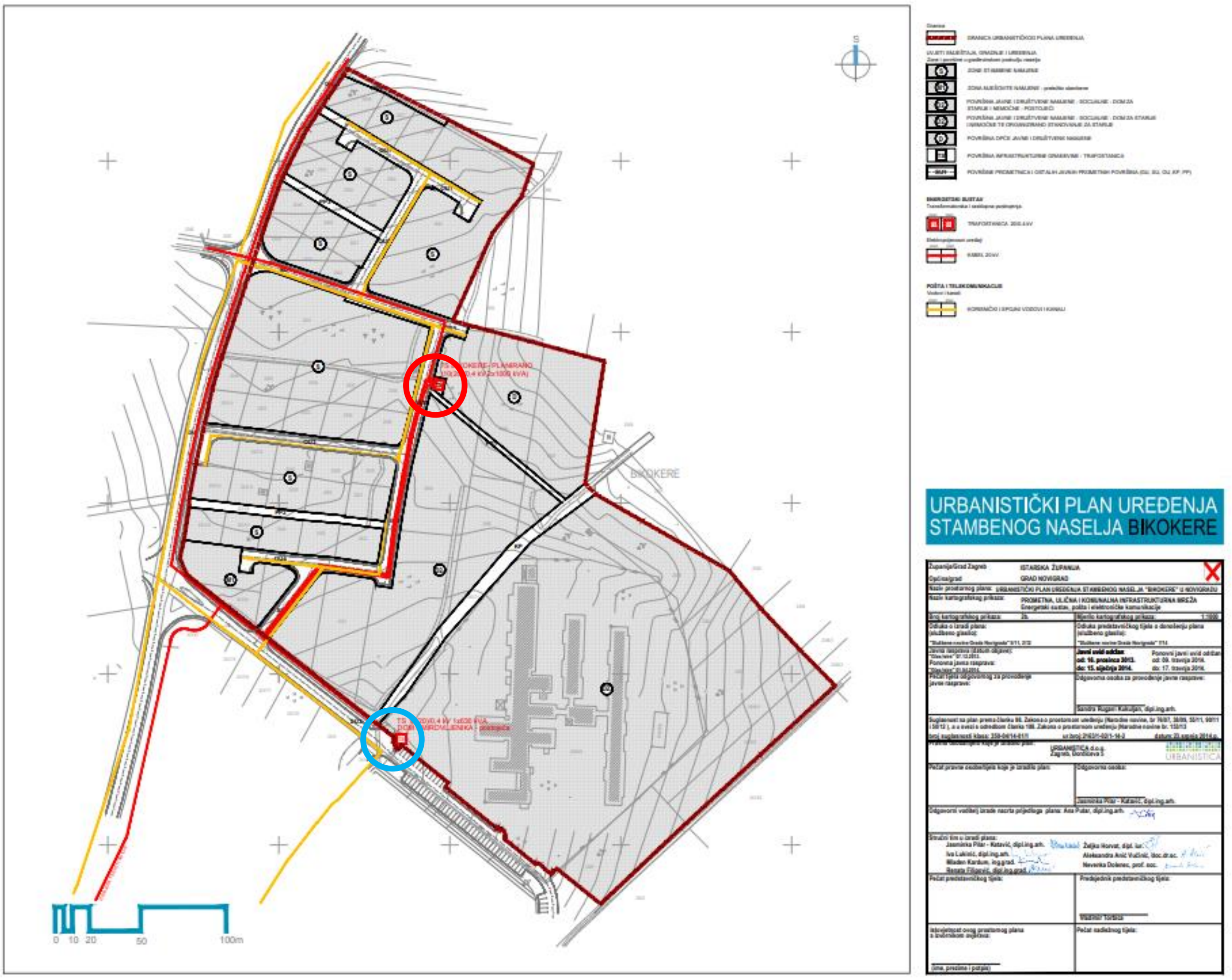
Existing Critical Infrastructures – Energy Infrastructure



Existing Critical Infrastructures. Source: [*Model (novigrad.hr)*]

The plan above shows locations of the important energy infrastructure: gas pipelines (green line), transformer and switching facilities (red dots), transmission lines (red line), and mini-hydroelectric power plant (blue square).

From the point of view of the important energy infrastructure in the targeted neighborhood Bikokere, in its central part, next to the area for general public and social purpose, the area of the infrastructural building - substation (TS) is foreseen (red circle), i.e., the building area is provided part of the substation, in such a way that it has direct access to the public vehicular and pedestrian area (collection street - SU 2). The existing substation (TS) is marked within the blue circle.



Critical infrastructure detail. Source: UPU Bikokere

Current energy consumption and infrastructure condition at the located site

The building where the integrated photovoltaic power plant will be installed covers 6.256 m2 of usable building area and provides accommodation for 253 users. The facility is used 24 hours a day. In total, the building consumes about 1.500.000 kWh per year, of which 258.000 kWh is consumed from electric energy.

Godišnja potrošnja - 2021. (01.2021. - 12.2021.)

Kategorija: Zgradarstvo, Javna rasvjeta, Vozila

Kat.	Grupa energenata	Energent	Mjerna jedinica	Potrošnja	Potrošnja [kWh]	Trošak [€]	Emisija CO_2 [t]
	Električna energija	Električna energija	kWh	258.265,00	258.265,00	36.125,29	60,643
	Grijanje	UNP	kg	2.260,88	28.984,49	2.641,33	7,561
	Grijanje	Loživo ulje ekstra lako	l	118.252,18	1.206.797,42	71.237,93	361,520
	Voda	Voda	m³	6.792,00	0,00	18.561,51	1,523
					1.494.046,92	128.566,06	431,248

Godišnja potrošnja - 2022. (01.2022. - 12.2022.)

Kategorija: Zgradarstvo, Javna rasvjeta, Vozila

Kat.	Grupa energenata	Energent	Mjerna jedinica	Potrošnja	Potrošnja [kWh]	Trošak [€]	Emisija CO_2 [t]
	Električna energija	Električna energija	kWh	258.273,00	258.273,00	36.114,24	60,645
	Grijanje	UNP	kg	2.785,83	35.714,32	4.229,76	9,317
	Grijanje	Loživo ulje ekstra lako	l	119.022,00	1.214.242,92	131.090,90	363,751
	Voda	Voda	m³	12.881,00	0,00	34.231,45	2,888
					1.508.230,25	205.666,35	436,601

Godišnja potrošnja - 2023. (01.2023. - 12.2023.)

Kategorija: Zgradarstvo Javna rasvjeta Vozila

Kat.	Grupa energenata	Energent	Mjerna jedinica	Potrošnja	Potrošnja [kWh]	Trošak [€]	Emisija CO_2 [t]
	Električna energija	Električna energija	kWh	243.632,00	243.632,00	46.464,01	57,207
	Grijanje	UNP	kg	2.991,38	38.349,47	3.488,77	10,005
	Grijanje	Loživo ulje ekstra lako	l	134.942,63	1.376.662,61	137.352,48	412,407
	Voda	Voda	m³	13.199,00	0,00	11.470,49	2,960
					1.658.644,08	**198.775,74**	**482,578**

Energy consumption. Source: ISGE – www. Isge.hr

The energy report for the building detected that the outer envelope of the building does not deviate significantly from the permitted heat transfer coefficients. The ceilings towards the attic and the floor above the engine room have lower heat transfer coefficients than allowed.

The external walls have 3 cm of thermal insulation in their composition, and the heat transfer coefficients of the external walls are higher than allowed. The floors on the ground are designed as floating and have 4 and 6 cm of thermal insulation in their composition, and their heat transfer coefficients are higher than the permitted ones. However, given that thermal insulation is installed on these construction parts and that the heat transfer coefficients do not deviate significantly from the permitted ones heat transfer coefficient, the proposal is not to seek improvements in the thermal properties of these parts of the outer envelope only for the reason that these interventions would require disproportionately higher costs than gains.

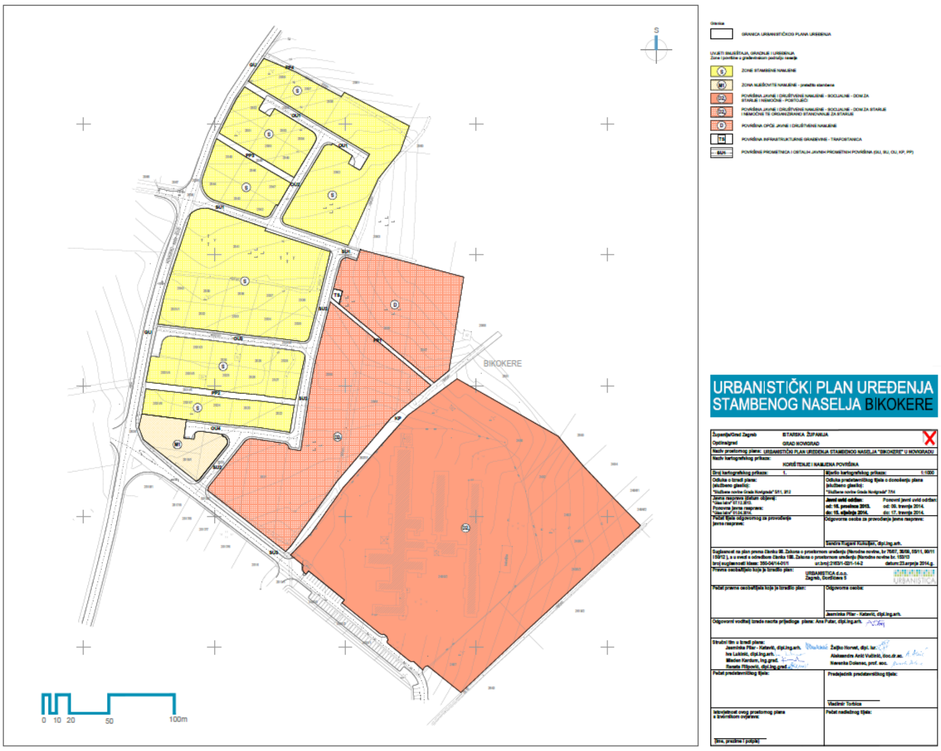
It was observed that old wooden windows and doors and new aluminum windows and doors have a significantly higher heat transfer coefficient than allowed. Built-in openings have a heat transfer coefficient of 3.0 W/m2K, significantly higher than allowed. The energy certificate proposes improvements to mechanical and electrical systems' energy properties, including installing a photovoltaic power plant.

Regulatory and Planning Context

Zoning and Land Use Regulations

Relevant zoning laws, land use policies and building codes that impact the installation of PV systems are the following:

- Regulatory and planning context
- Spatial Planning Act (Official Gazette 153/13, 65/17, 114/18, 39/19, 98/19, 67/23)
- Law on Construction (OG 153/13, 20/17, 39/19, 125/19)
- Ordinance on simple and other buildings (Official Gazette 112/2017)



Zoning and Land Use Regulations. Source:UPU Bikokere

The above map defines the surfaces for public and other purposes as follows:

- residential zones (S),
- zone of mixed-predominantly residential use (M1),
- area of public and social purpose - social - home for the elderly and infirm – existing (D21),
- area of public and social purpose - social - home for the elderly and infirm organized housing for the elderly (D22),
- area of general public and social purpose (D),
- area of infrastructure building - substation (TS),
- surfaces of roads and other public traffic surfaces (GU, SU, OU, KP, PP).

Permitting Requirements - Necessary permits and approvals needed for PV installations on public buildings

The installation of an integrated photovoltaic system with 50 kW power is planned on location. It is necessary to determine the bearing capacity of the roof structure. Preparation of the main project and issuance of the Electric power consent are required. The main project must comply with the special conditions. No additional permits are required since the implementation falls under the Order on simple and other buildings and works (NN 112/17, 34/18, 36/19, 98/19, 31/20, 74/22). Expert supervision is required for PV installation.

Environmental Impact Considerations

There are not environmental regulations or assessments are required for the installation of integrated PV systems.

Technical Feasibility Assessment

Site Selection Criteria

Build detail. Source: Google maps

The retirement home building in Novigrad is a split-level building consisting of three interconnected units stretching north-south. The roof is slanted, and it is built mainly on two roofs that are oriented towards the west and the east. The western and central wings also have parts with more water, some parts of which are oriented to the south or north. Parts of the roof with an east/west (equal surface area) or south orientation can be used to install a photovoltaic power plant. Vegetation on the plot is relatively low. The plot has no buildings in the immediate vicinity, so there is no potential overshadowing problem. The following pictures show the sun's movement at the location in question.

Sun movement 21. 6.

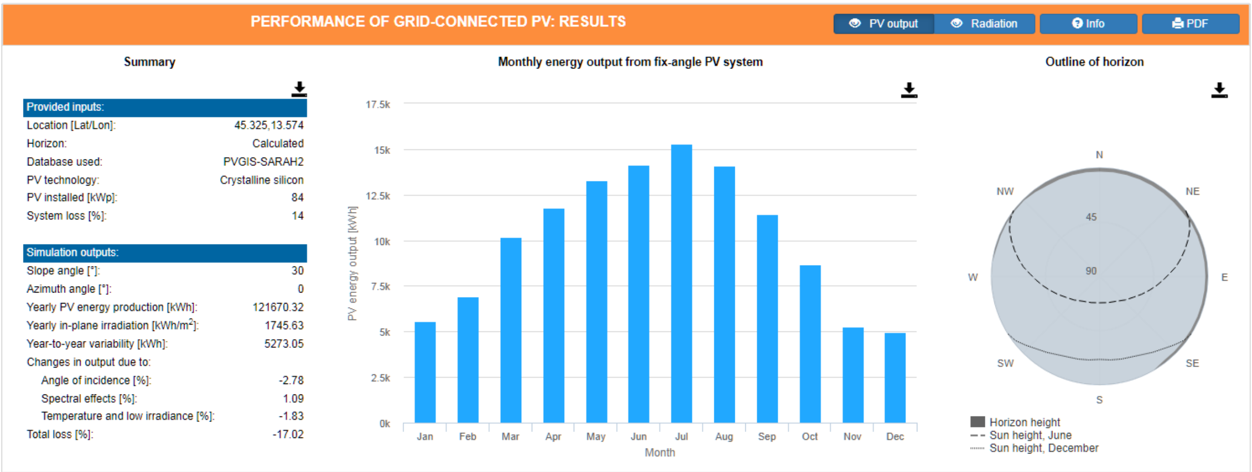
Sun movement 21. 12.

The approximate area of east-facing roofs is 1,250 m2, west-facing roofs 1,250 m2, and south-facing roofs 500 m2. In total, a power plant with a capacity of approximately 500 kW can be installed on all surfaces (east - 208 kW, west - 208 kW, south - 84 kW). Such a power plant could produce approximately 604,000.00 kWh annually.

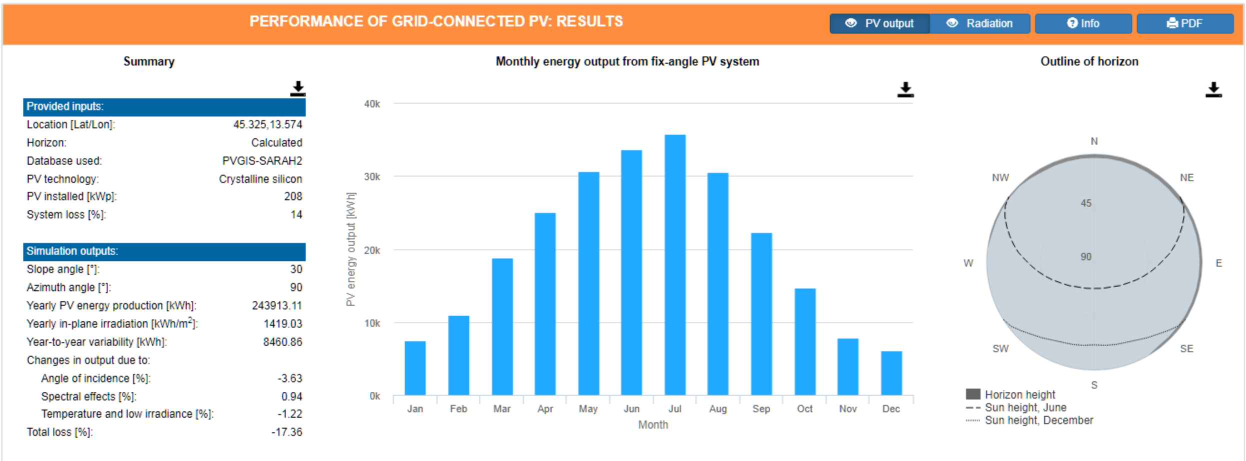
Possible panel positions

Below can be found the possible panel position and the estimated performance.

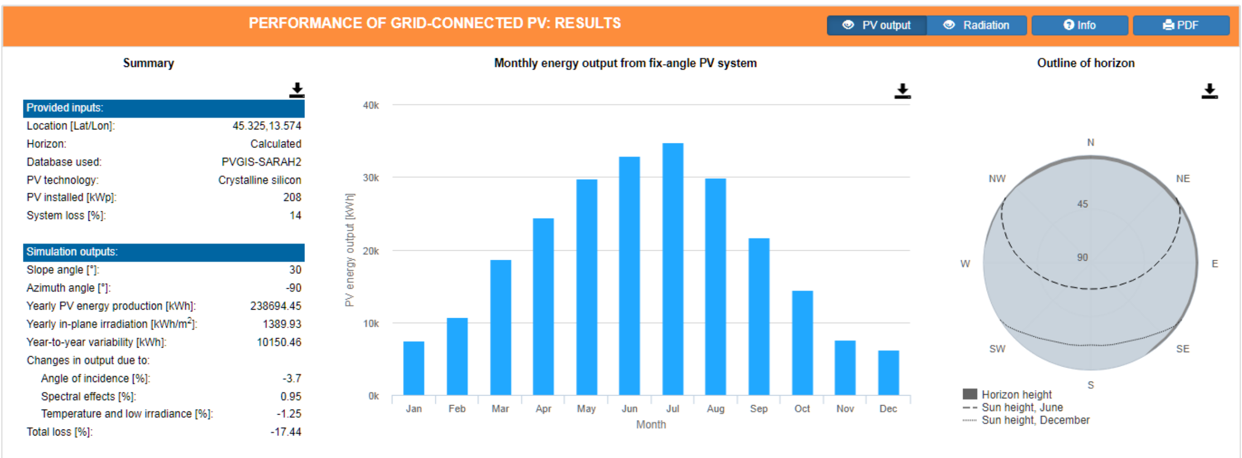
Panels position



Power plant - south side

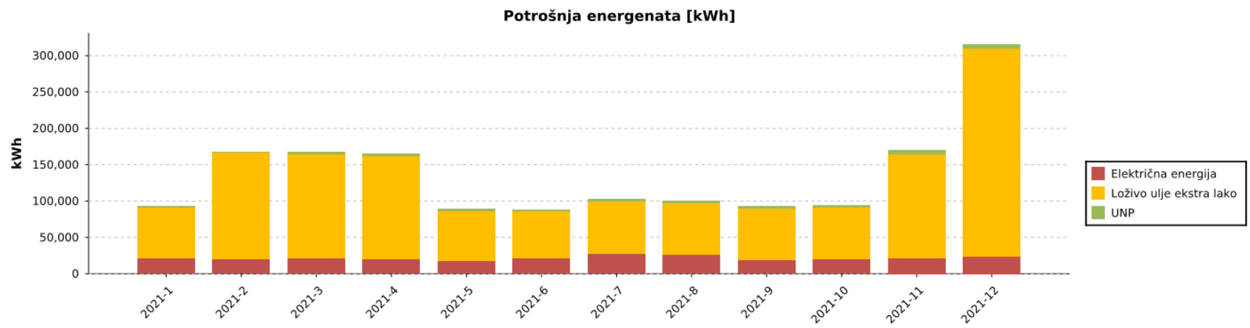


Power plant - west side



Power plant - east side

Annual electricity consumption in the building is approximately 258.000,00 kWh. Electricity consumption is relatively evenly distributed throughout the year. The mentioned consumption would be approximately met by a power plant installed either on the west or on the east side of the roof.



Electricity consumption

When maximizing the facility's production potential (installation on the east, west, and south sides), photovoltaic power plants would fully satisfy the facility's electricity needs except in all months except January, November, and December. A surplus is created and transferred to the network in all other months.

	Siječanj	Veljača	Ožujak	Travanj	Svibanj	Lipanj	Srpanj	Kolovoz	Rujan	Listopad	Studeni	Prosinac	Ukupno
Potrošnja električne energije (kWh - 2021)	21.245,00	19.510,00	21.279,00	19.184,00	17.931,00	21.792,00	27.610,00	26.333,00	18.899,00	20.295,00	20.839,00	23.348,00	258.265,00
Proizvodnja električne energije (kWh - istočna strana 208 kW)	7.426,29	10.754,14	18.634,96	24.446,24	29.729,94	32.886,78	34.821,53	29.932,56	21.695,84	14.478,84	7.605,04	6.281,68	238.693,84
Proizvodnja električne energije (kWh - zapadna strana 208 kW)	7.489,83	10.948,16	18.859,06	25.067,06	30.692,05	33.604,78	35.727,63	30.499,82	22.272,60	14.714,74	7.904,75	6.132,63	243.913,11
Proizvodnja električne energije (kWh - južna strana 84 kW)	5.581,18	6.913,30	10.172,42	11.798,48	13.301,04	14.116,28	15.293,49	14.108,01	11.453,31	8.673,23	5.276,60	4.982,99	121.670,33
Razlika (predano mreži)	-747,7	2192,3	16215,02	30329,3	42490,99	44699,56	42939,16	34099,38	25069,44	8898,58	-5329,21	-10933,69	229923,13

When building a power plant on the eastern or western side, the production and consumption of the facility are approximately equalized on an annual basis, but significant amounts of energy are still delivered to the grid in certain months.

East side

	Siječanj	Veljača	Ožujak	Travanj	Svibanj	Lipanj	Srpanj	Kolovoz	Rujan	Listopad	Studeni	Prosinac	Ukupno
Potrošnja električne energije (kWh - 2021)	21.245,00	19.510,00	21.279,00	19.184,00	17.931,00	21.792,00	27.610,00	26.333,00	18.899,00	20.295,00	20.839,00	23.348,00	258.265,00
Proizvodnja električne energije (kWh - istočna strana)	7.426,29	10.754,14	18.634,96	24.446,24	29.729,94	32.886,78	34.821,53	29.932,56	21.695,84	14.478,84	7.605,04	6.281,68	238.693,84
Razlika (predano mreži)	-13.818,71	-8.755,86	-2.644,04	5.262,24	11.798,94	11.094,78	7.211,53	3.599,56	2.796,84	-5.816,16	-13.233,96	-17.066,32	-19571,16

West side

	Siječanj	Veljača	Ožujak	Travanj	Svibanj	Lipanj	Srpanj	Kolovoz	Rujan	Listopad	Studeni	Prosinac	Ukupno
Potrošnja električne energije (kWh - 2021)	21.245,00	19.510,00	21.279,00	19.184,00	17.931,00	21.792,00	27.610,00	26.333,00	18.899,00	20.295,00	20.839,00	23.348,00	258.265,00
Proizvodnja električne energije (kWh - zapadna strana)	7.489,83	10.948,16	18.859,06	25.067,06	30.692,05	33.604,78	35.727,63	30.499,82	22.272,60	14.714,74	7.904,75	6.132,63	243.913,11
Razlika (predano mreži)	-13.755,17	-8.561,84	-2.419,94	5.883,06	12.761,05	11.812,78	8.117,63	4.166,82	3.373,60	-5.580,26	-12.934,25	-17.215,37	-14351,89

If one wants to completely avoid switching to the grid, installing a power plant with a capacity of approximately 120 kW on the west side of the roof is necessary.

	Siječanj	Veljača	Ožujak	Travanj	Svibanj	Lipanj	Srpanj	Kolovoz	Rujan	Listopad	Studeni	Prosinac	Ukupno
Potrošnja električne energije (kWh - 2021)	21.245,00	19.510,00	21.279,00	19.184,00	17.931,00	21.792,00	27.610,00	26.333,00	18.899,00	20.295,00	20.839,00	23.348,00	258.265,00
Proizvodnja električne energije (kWh - zapadna strana - 120 kW)	4.321,02	6.317,37	10.882,12	14.464,30	17.710,37	19.388,06	20.611,15	17.596,28	12.849,15	8.488,72	4.559,25	3.537,55	140.725,34
Razlika (predano mreži)	-16.923,98	-13.192,63	-10.396,88	-4.719,70	-220,63	-2.403,94	-6.998,85	-8.736,72	-6.049,85	-11.806,28	-16.279,75	-19.810,45	-117.539,66

The investment value of such a power plant (120 kW) would be €144.000,00, and the annual savings would be € 28.016,00.

PV System Specifications

Resources have been secured to realize the EnerCmed pilot intervention in Novigrad for the realization of a 50 kW photovoltaic power plant. Considering that the analysis determines the need to install the PV plant of a higher capacity (around 120 kW), an attempt will be made to secure additional funds for its realization.

The following will analyze the specifications of the 50 kW photovoltaic power plant.

Electricity consumption is relatively evenly distributed throughout the year and ranges around 20.000 kWh per month. Taking into consideration the electric consumption of the building and predicted monthly electricity production, in the case of 50 kW PV installation, the building would ensure its self-sufficiency by around 40%.

Monthly PV energy and solar irradiation

Month	E_m	H(i)_m	SD_m
January	3460.2	84.3	946.5
February	4139.4	103.2	743.6
March	5810.9	148.9	845.0
April	6389.1	170.1	710.8
May	6925.7	187.9	703.0
June	7103.9	198.0	430.2
July	7627.4	215.4	357.0
August	7185.9	201.7	507.6
September	6136.2	166.4	522.3
October	4912.5	127.2	526.3
November	3142.7	78.6	694.3
December	3086.7	75.5	576.5

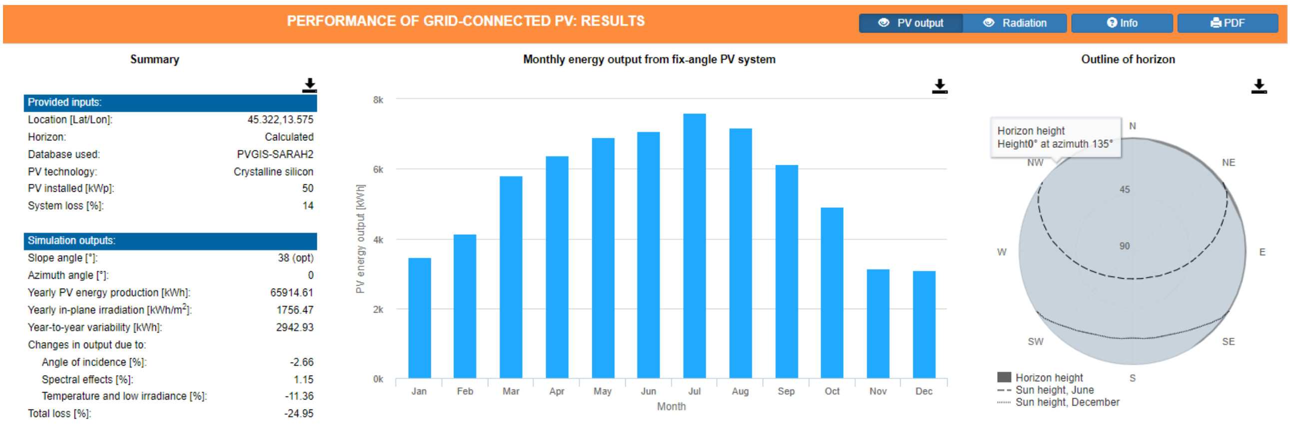
E_m: Average monthly electricity production from the defined system [kWh].

H(i)_m: Average monthly sum of global irradiation per square meter received by the modules of the given system [kWh/m²].

SD_m: Standard deviation of the monthly electricity production due to year-to-year variation [kWh].

Source: PVGIS - https://re.jrc.ec.europa.eu/pvg_tools/en/

On the annual basis PV plant will generate production of 65,914.61 kWh per year.



Source: PVGIS - https://re.jrc.ec.europa.eu/pvg_tools/en/

Grid Connectivity

According to the connection rules of the Croatian Electric Power Company, a photovoltaic power plant with a power of up to 100 kW is connected to its own connection point, while a power plant with a power equal to or greater than 100 kW is connected to a nearby substation. In the case of the construction of a 50 kW photovoltaic power plant, it will be connected to measuring point 1177500263. In the case of constructing a power plant with a power equal to or greater than 100 kW, an Elaboration of the optimal technical connection solution will be requested.

Spatial Compatibility

The neighbourhood where the PV plant will be located is not subject to specific landscape constraints concerning this type of intervention. Therefore, no significant impacts on the urban and spatial environment are expected.

City: Pula

Introduction

Purpose

Audit objective Objective of the audit is to detect transnational-conceived applicative model for the emergence energy & climate positive neighborhoods, which is based on the integration of REC for energy transition of marginalized people and complementary climate mitigation interventions based on Nature Based Solutions in the pilot neighborhoods, combining 3 key drivers:

(1) Presence of urban public infrastructures (parking, schools, port) where installing PV system,
(2) Presence of people exposed at energy poverty risk and
(3) Urban heat island sharp phenomena.

Aim of the action is to activate at least 1 REC in the detected marginalized neighborhood and to implement a REC – complementary investments in Nature Based Solutions within the targeted neighborhood, to directly mitigate the urban heat waves phenomena during peak demand of energy for cooling and indirectly improve the livability and urban regeneration of port hinterlands.

In case of relevance, the competent city department is requiring that the evaluation of the potential photovoltaic system impact on the public infrastructure is included in the main project.

Spatial planning requirements

In the Spatial plan of the City of Pula the guidelines are determined for the protection of natural values during planning measures for the use of solar energy.

For the purposes of electricity and/or thermal energy production, it is possible to realize interventions for the use of thermal solar energy, such as photovoltaic solar energy, in individual units and buildings.

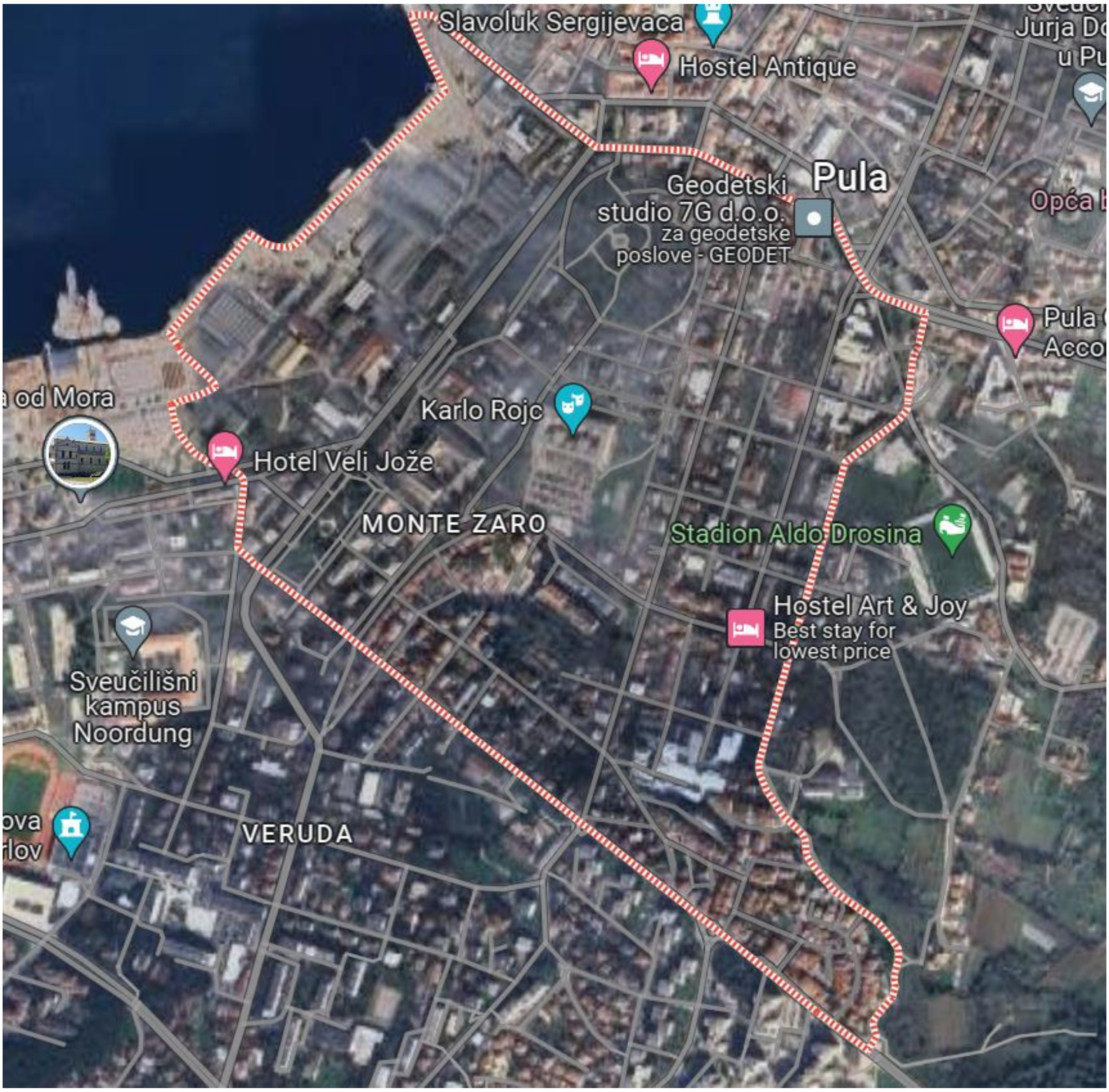
Solar power plants can be planned for existing and planned production zones. In doing so, priority should be given to existing zones with existing communal infrastructure and roofs of existing buildings in those zones. When locating them, it is necessary to avoid areas of distribution of endangered and rare habitat types, protected and/or endangered species of flora and fauna (especially ornithon-fauna), and take into account the characteristics of water resources and landscape elements individual areas, and especially the target species and habitat types of the area of the ecological network of the Republic of Croatia and possible cumulative impacts of several planned/built solar power plants.

Due to the impact on water resources (direct use of water, water pollution, etc.) no solar thermal power plants are planned in the area covered by the Plan.

Scope

Monte Zaro is a city district and one of the local boards of the City of Pula. The Monte Zaro Local Board includes the district of the same name located on an area of 323,720 m² with 3,502 inhabitants. The population density is 10,818.0 inhabitants/km².

Monte Zaro is bounded to the north by the Old Town and Kaštela, to the east by Gregovica and Pragrande, to the south by Monte Rizzi, to the southwest by St. Polycarp, and to the west by the Arsenal.



Neighborhood boundaries of the city district Monte Zaro. Izvor: Google maps

A significant number of the important public infrastructure is situated in the targeted area of the city district Monte Zaro:

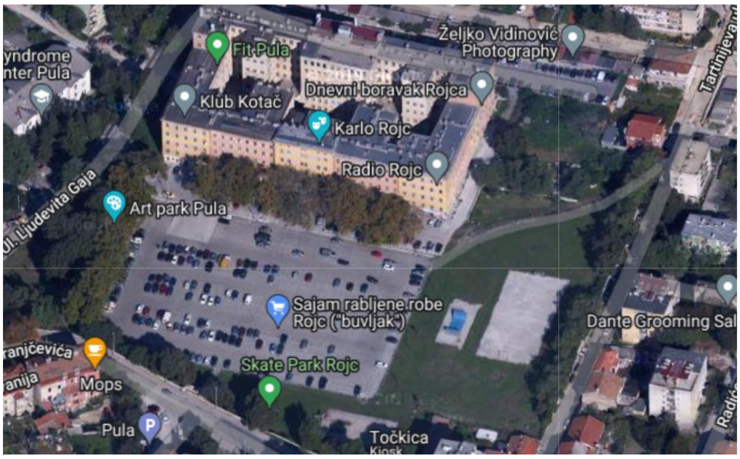
One community centers: Karlo Rojc Community Center, Down Syndrome Center, COOworking space.

Three schools, one faculty and one home: School of upbringing and education, Elementary school Monte Zaro, School of Economics, Faculty of Informatics, Home for Upbringing.

Other important national regional offices: Croatian Health Insurance Fund, Land Registry Department of the Municipal Court.

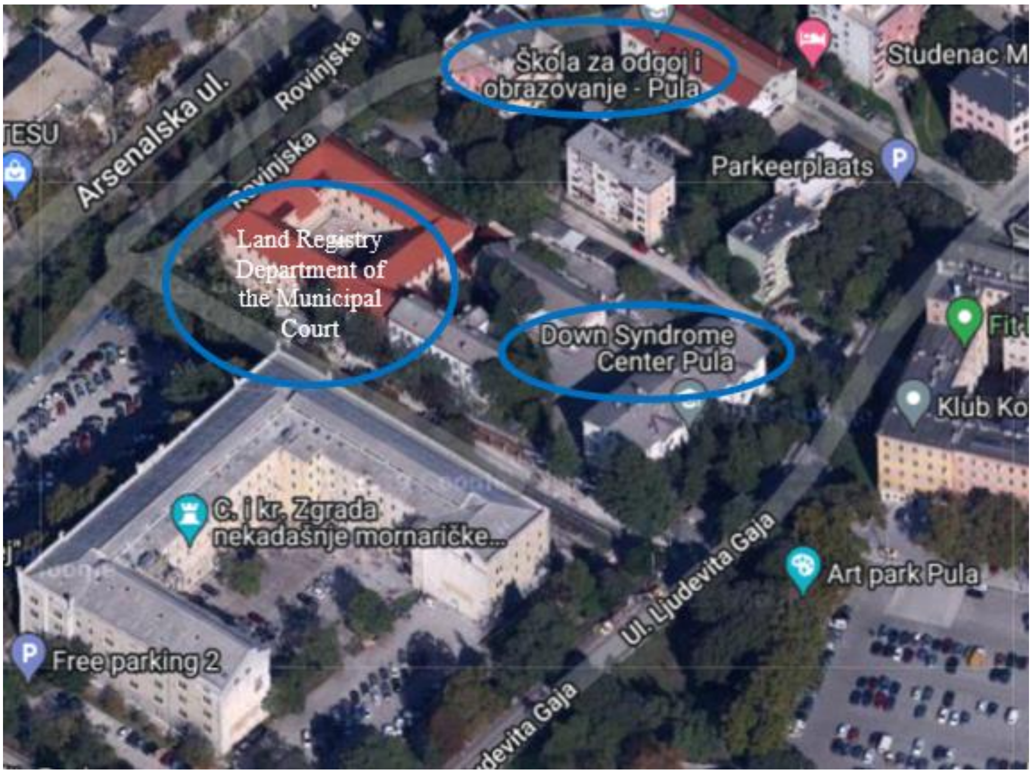
One park Park Monte Zaro and one sport center Patinaggio Sports Center.

The locations of the most important ones are shown in the images below.

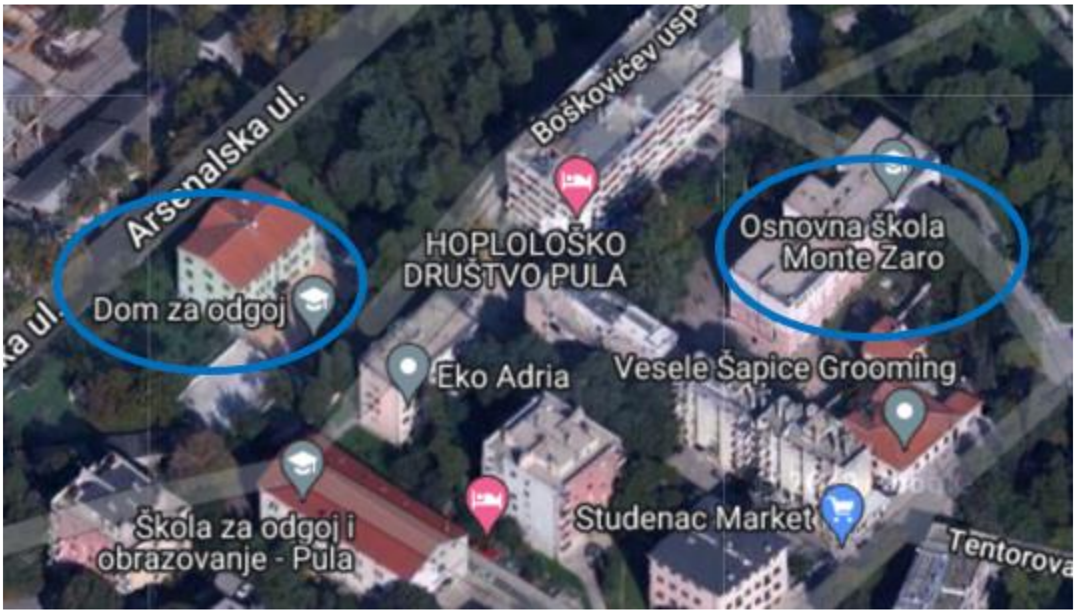


Karlo Rojc Community Center

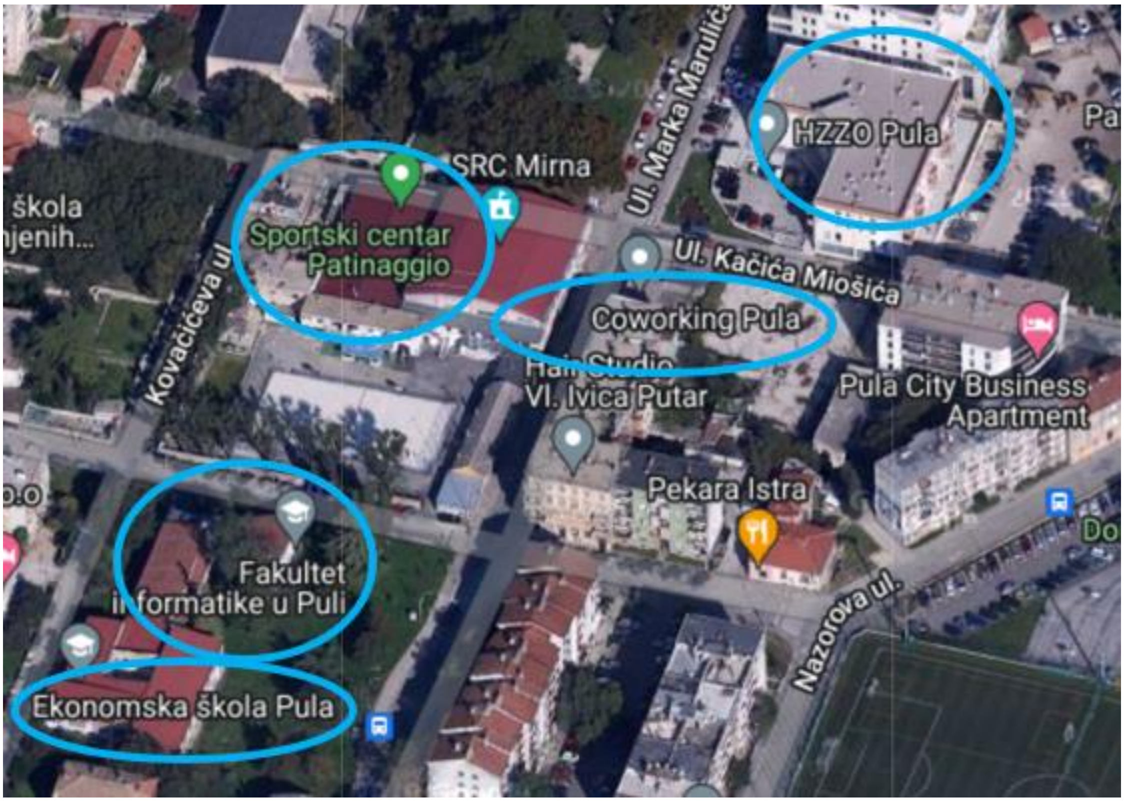
The City uses the former Karlo Rojc barracks to accommodate numerous civil society associations in the fields of culture, sports, social welfare and health, care for people with special needs, care for children and the elderly, ecology, humanitarian work, technical culture, national minorities and the activities of associations arising from the Homeland War.



School of upbringing and education, Down Syndrome Center, Land Registry Department of the Municipal Court

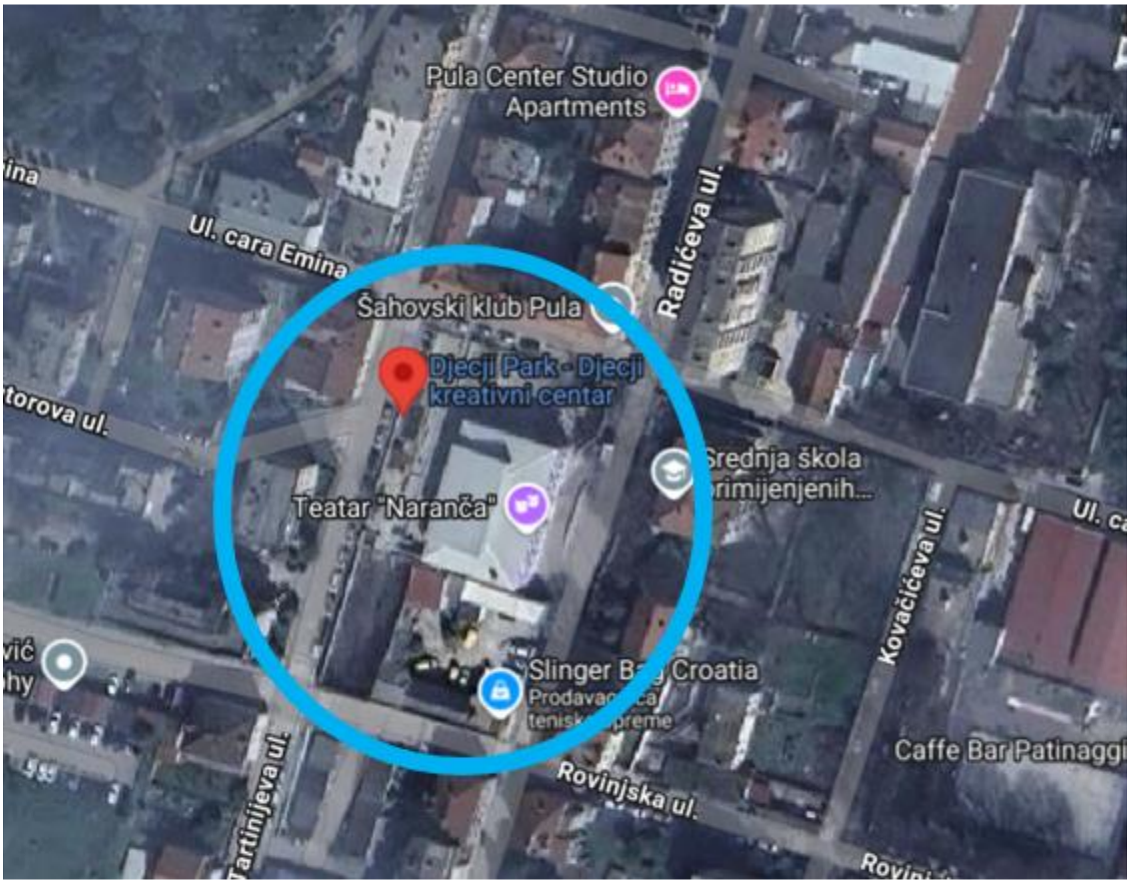


Home for Upbringing, Elementary school Monte Zaro



Croatian Health Insurance Fund, Patinaggio Sports Center, School of Economics, COOwirking space, Faculty of Informatics

Listed objects, except the Children's Creative Centerare, are or located within the protected historical complex, or have some kind of protection defined by the city responsible department, or require the roof replacement for the installation of the photovoltaic system, or ownership issues have not been resolved. This makes them fully disqualified from the further analysis.



Children's Creative Center

Location: Dječji kreativni centar - Centro creativo per bambini. Source: www.pula.hr

The Children's Creative Center carries out activities for children and young people. In 2019. and 2020. building was energy refurbished. Among relevant interventions, the roof was entirely replaced, which makes the building adequate for installing a photovoltaic system.

The children's creative center is located at 22 Radićeva Street in Pula. The purpose of the building is NSZ2 - school and faculty buildings, kindergartens, and other educational institutions. The energy audit of the building was carried out on October 14, 2020. A budget analysis was carried out, and a report was prepared on the energy inspection of the building. The building has an unheated basement, heated ground floor, and first floor. The net area of the heated part of the building is 1,138.39 m2, while the gross area of the heated part is equal to 1,421.10 m2. The subject non-residential building is free-standing; it is not in contact with neighboring buildings. The building has a rectangular floor plan consisting of an unheated basement, a heated ground floor, and the first floor. The object was built in 1930. The building houses the Center for Creative Activities of Young People with different spaces for creative activities, a library, classrooms for music, dance, and various workshops, a large hall for performances and productions, corridors, offices, and sanitary areas. The building underwent an energy refurbishment. Thermal insulation was installed on the external walls, the ceiling towards the attic, and the ceiling of the basement, it was replaced old external carpentry with new PVC carpentry, old lighting fixtures were replaced with new energy ones with more efficient LED lighting fixtures and the building's heating system was reconstructed. Work was carried out inside the building, including the reconstruction of rooms and installations and the arrangement of the outdoor space around the building.

The building's premises are heated using three new gas condensing boilers located in the basement of the building. New heating elements, such as aluminum radiators with different numbers of radiators, were installed in the battery. Radiator batteries are equipped with a radiator valve, a valve with a thermal head, a breather, and a drain tap. The radiators are suspended on standard radiator suspension accessories. Heating medium space has hot water. The water for heating is heated by a gas condensing boiler, with the LAS system (air/flue) for vertical passage through a flat roof. The gas device is independent of the air from the room in which it is located. The temperature regulation of the heating supply line is sliding according to the outside temperature. Energy for heating is natural gas.

The rooms are cooled with external and internal air conditioning units. Energent, which is used for cooling, is electrical energy.

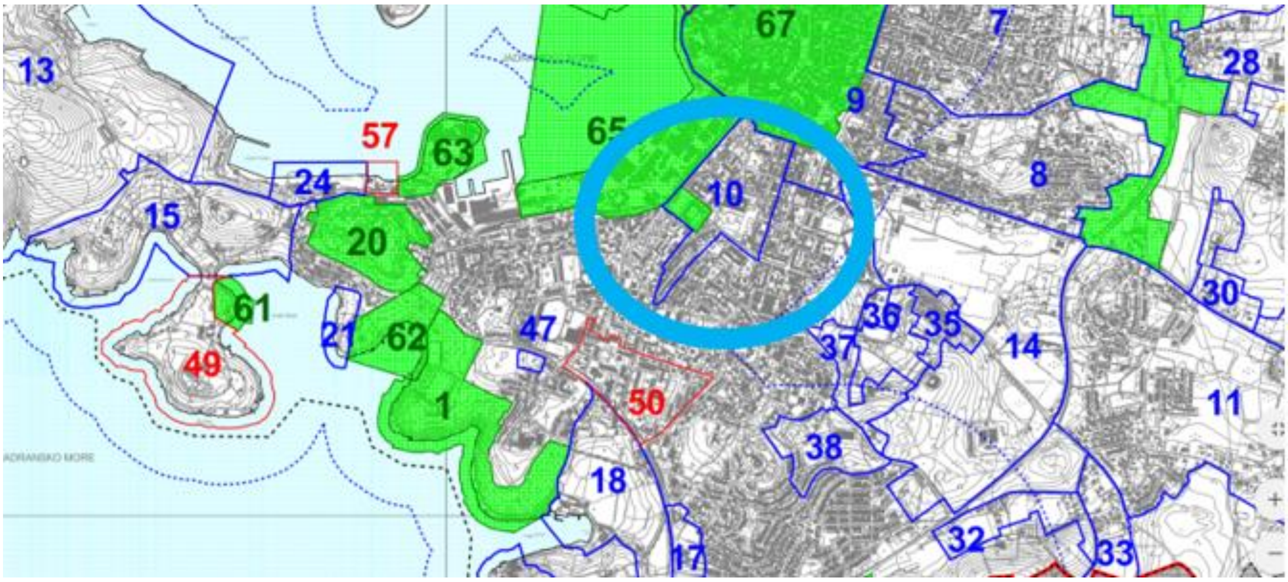
The preparation of domestic hot water is carried out using a new heat pump for domestic hot water with an integrated with a 300 liter tank and integrated regulation, for operation with ambient air. Heat pump and the hot water tank is located in the basement of the building. It is an energy source for the preparation of domestic hot water electrical energy. The coefficient of performance of the heat pump (COP) is 3.7. Domestic hot water is heated using air from the installation room. Condensate forms inside the heat pump module, which is drained into sewerage. The heat pump is connected to hot and cold water, and the recirculation line on which the recirculation is installed pump.

Low and high current systems are installed in the building. Lighting fixtures installed for lighting corridors, children's playgrounds, and the accompanying rooms have LED lighting fixtures. LED ceiling lights with sensors. External LED lighting has been installed on the building. Lighting control is done with switches located next to the entrance door of each room without the possibility of central lighting control. Placed inside the building is anti-panic lighting.

Electricity is used for various devices (computers, printers, ...). The cooling of the rooms was carried out with external and indoor air conditioning units. The energy used for cooling is electricity. On the sloping roof of the building, lightning rods have been installed to protect against lightning strikes. The building has a fire alarm system for fire protection and a new video surveillance system. Inside the building, a new system of electrical installations was carried out (distribution of weak and strong current, network installation, video surveillance system, and sound system). A new LED has been installed in the performance hall reflectors.

The supply of cold sanitary drinking water to the building of the object is made from the public water supply network of the operator - water distributor Vodovod Pula d.o.o., Radićeva ulica 9, 52100 Pula. Water from the water supply system is used in the building for sanitary, drinking, and domestic hot water needs. Water consumption is paid according to the monthly reading of water consumption at the water meter for the entire facility. The water in the facility building is used for sanitary needs, such as sanitary units and kitchens. From consumers, sanitary units have cisterns and sinks. All sanitary items are made of ceramics. In the tea room, a sink is used in the kitchen. Fittings at all spouts are hand-made. Domestic hot water is prepared with a heat pump and a hot water tank located in the basement. It was performed inside the building hydrant network.

Pilot intervention is located in the city district of Monte zaro.



Boundaries of the city district Monte Zaro

Methodology

Data was provided from the official documents, strategies, and plans, and consultations were made with the local authorities. Consultations with urban planners are not predicted for the analyzed case, as the ones are carried out in certain specific situations, such as when installing panels on historic buildings, etc.

City Overview

Urban Masterplan Summary

According to the General Urban Plan, the area is for public and social use, specifically elementary, secondary, and cultural. The DKC building is located in the immediate vicinity of the existing social center Rojc, the sports center Pattinaggio, and the public green area Monte Zaro, which borders the city's historic core. The existing structure of the surrounding construction is densely built, and the potential for creating additional public facilities is very modest.

Existing Critical Infrastructures

The city does not have data on critical infrastructure in the detected area.

Current energy consumption and infrastructure condition at the located site

Electricity in the facility is used for cooling, HVAC, lighting and, to a lesser extent, powering devices.

The electrical energy in the building is emergent for the preparation of hot water; it was made using a new heat pump for hot water with an integrated tank of 300 liters volume and integrated regulation for operation with ambient air.

The electricity in the facility is used for various devices (computers, printers, etc.), cooling the rooms with air conditioning units, powering the fire alarm system, video surveillance system, sound system, and LED lighting fixtures.

According to the 2020 energy survey, the annual required electricity for lighting is 17,486.41 kWh. According to the same source, the annual electricity consumption does not exceed 26,104.20 kWh, of which 8,617.80 kWh is for electricity needed for cooling.

5. ELEKTRIČNA ENERGIJA	
Godišnja potrebna električna energija za rasvjetu E_L [kWh/a]	17486,41
Godišnja proizvedena električna energija iz OIE na lokaciji zgrade [kWh/a] $E_{EL,\ RES}$	0,00
Projektant dijela glavnog projekta zgrade koji se odnosi na racionalnu uporabu energije i toplinsku zaštitu (kvalificirani elektronički potpis) u pogledu svojstava elektroenergetskog sustava - *za podatke iz poglavlja 5.*	

2.A.4.7. Godišnja primarna energija

Rezultati proračuna godišnje primarne energije E_{prim}

Energent	Svrha / Potrošač	E_{del} [kWh]	Faktor f_p	E_{prim} [kWh]
Prirodni plin	Energija za grijanje	32764,02	1,095	35876,60
Električna energija	Energija za hlađenje	8617,80	1,614	13909,12
Električna energija	Energija za PTV	0,00	1,614	0,00
Električna energija	Rasvjeta 1	17486,41	1,614	28223,06
Ukupno		**58.868,22**		**78.008,79**

Source: Energy inpection of the facility Childrens creative centar, 2020.

Inside the building, a new system of electrical installations was installed (distribution of panels and high currents, network installation, video surveillance system, sound system, ect.).

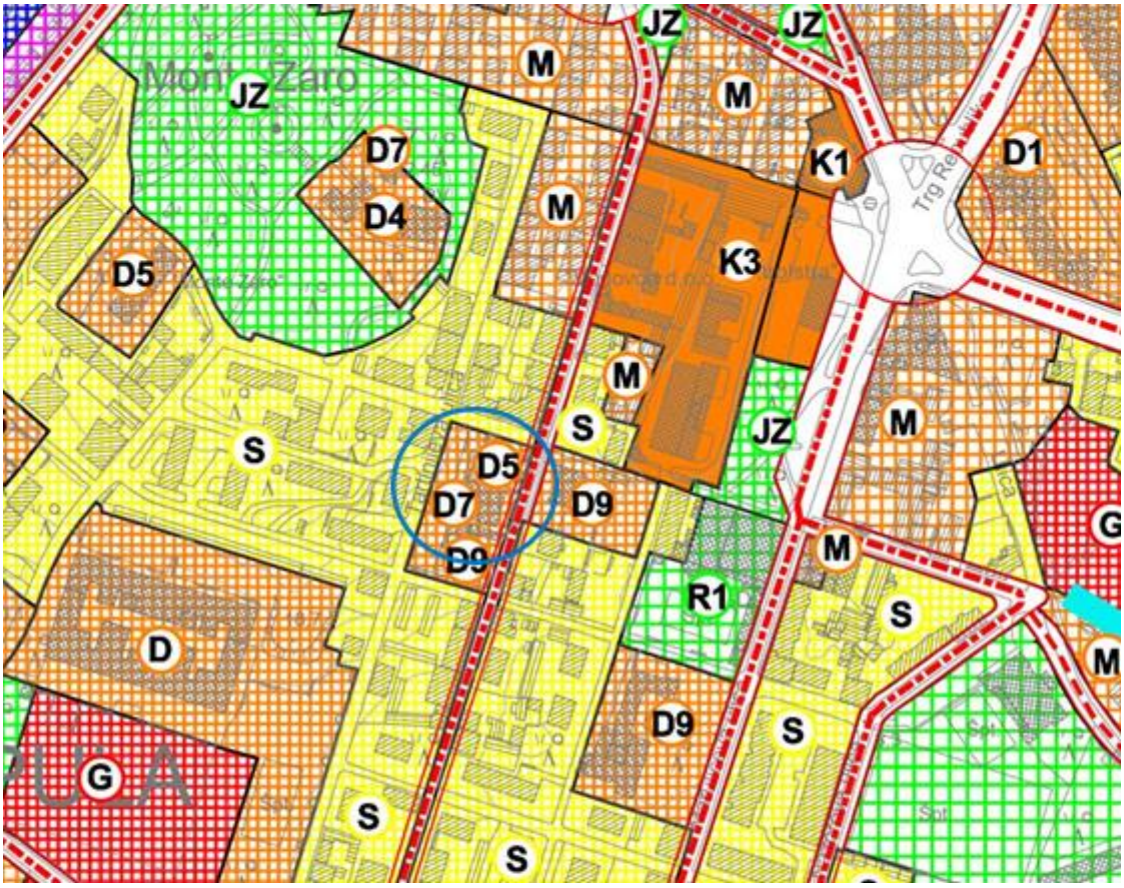
Regulatory and Planning Context

Zoning and Land Use Regulations

According to the General Urban Plan of the City of Pula (Official Gazette No. 5a/08, 12/12, 5/14, 10/14, 13/14, 19/14, 7/15, 9/15, 2/17, 5/17, 9/17, 20/18, 2/19, 5/19, 8/19, 11/19, 8/20, 3/21, 4/21, 6/21 and 16/24) pilot location is sorted as D7- CULTURE and D5 with primary school purpose.

Terms of use that are part of GUP according to the categorization of the arhitectual heritage define the facility in the B – 3 category of protection.

Category B – 3 includes buildings or complexes of ambient value of urban significance, which can be rehabilitated and typologically restored using methods of scientific processing with the possibility of returning buildings or parts of buildings to their original state, which means preserving the original elements of the facade with the possibility of adaptation, and on which the demolition of inadequate of modern additions to the building.



Source: General urban plan (GUP) of the City of Pula

Relevant zoning laws, land use policies and building codes that impact the installation of PV systems are the following:

Regulatory and planning context

Spatial Planning Act (Official Gazette 153/13, 65/17, 114/18, 39/19, 98/19, 67/23)

Law on Construction (OG 153/13, 20/17, 39/19, 125/19)

Ordinance on simple and other buildings (Official Gazette 112/2017)

Permitting Requirements - Necessary permits and approvals needed for PV installations on public buildings

The building regulations that affect the installation of photovoltaic systems are as follows:

Order on simple and other buildings and works (Official Gazette 112/17, 34/18, 36/19, 98/19, 31/20, 74/22 155/23) and legal regulations in accordance with which the Main Projects for a solar power plant for self-consumption with the surplus being fed into the grid:

1. Law on Construction (OG RH153/13,20/17,39/19,125/19)

2. Fire Protection Act (Official Gazette of the Republic of Croatia 92/10)

3. Law on Occupational Safety (Official Gazette 71/14, 181/14 and 154/14)

4. Law on technical regulations for LV electrical installations (Official Gazette 05/10)

5. Technical regulation for lightning action systems on buildings NN no. 87/08, 33/10.

6. Law on Telecommunications Official Gazette of the Republic of Croatia no. 122/03

7. Rulebook on technical conditions for electronic communication

network of commercial and residential buildings (Official Gazette 155/09)

8. Law on technical requirements for products and conformity assessment (Official Gazette 158/03 and 79/07)

9. Law on Standardization (OG 163/03)

Environmental Impact Considerations

Non environmental regulations or assessments are required for the installation of integrated PV systems.

Technical Feasibility Assessment

Children's Cultural Center

The building of the Children's Cultural Center in B - 3 is a category that allows the installation of a photovoltaic system on the roof of the building.

Children's Cultural Center roof

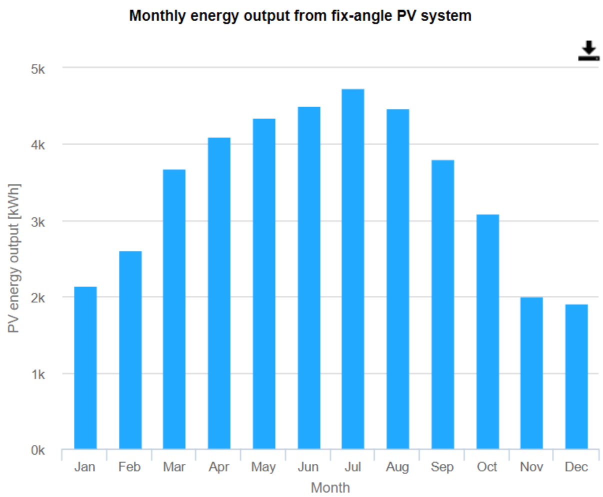
The roof of the building consists of a part of a flat roof and a sloping roof. Heat-insulating roof panels were placed on the sloping roof of the building. Considering that only one small part of it faces south, the photovoltaic power plant will be placed on the surface of the flat roof.

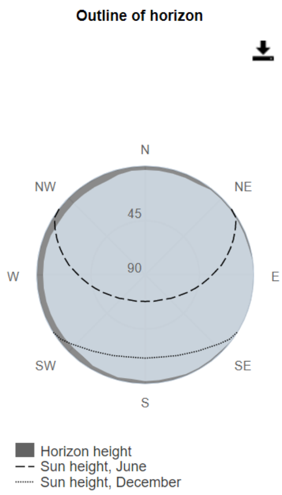
The surface of the flat roof was further analysed, and a little more than 270 m2 is available to install the photovoltaic system, which enables the installation of a maximum power of 45 kW.

Given that the annual electricity consumption does not exceed 26,100 kWh, it will be considered when defining the power of the photovoltaic power plant. The power plant is placed on a flat part of the roof, which enables favorable orientation towards the south.

Summary

Provided inputs:	
Location [Lat/Lon]:	44.864,13.847
Horizon:	Calculated
Database used:	PVGIS-SARAH3
PV technology:	Crystalline silicon
PV installed [kWp]:	30
System loss [%]:	14
Simulation outputs:	
Slope angle [°]:	35
Azimuth angle [°]:	0
Yearly PV energy production [kWh]:	41402.68
Yearly in-plane irradiation [kWh/m²]:	1804.04
Year-to-year variability [kWh]:	1671.33
Changes in output due to:	
Angle of incidence [%]:	-2.66
Spectral effects [%]:	0.93
Temperature and low irradiance [%]:	-9.46
Total loss [%]:	-23.5





Estimated energy production

3.3 Spatial Planning Italy

Introduction

Purpose

With the Sustainable Energy and Climate Action Plan (SECAP), the City of Genoa in 2018 renewed the commitment made in 2010 with the previous Covenant of Mayors initiative, reducing emissions on its territory and embarking on a path to improve its ability to adapt to climate change. Specifically, SECAP has the following goals:

- a reduction of at least 40% in greenhouse gas emissions compared to 2005 levels;
- a share of at least 32% renewable energy (Renewable Energy Directive 2009/28/EC and subsequent updates);
- an improvement of at least 32.5% in energy efficiency (Energy Efficiency Directive 2012/27/EU and subsequent updates).

The Energy Policies of the Municipality are thus addressed to a set of actions, which development is compliant with the objectives of EnerCMed project, in particular:

- improvement of the energy performance of Public Administration properties, including through innovative contractual solutions;
- promotion of energy efficiency in housing and in the tertiary sector, in collaboration with trade associations and stakeholders;
- exploitation of renewable sources of energy, with particular attention to the technologies most integrable in urban environments;
- reduction of energy poverty through targeted services to support the most vulnerable population;
- promotion of efficient, low-emission public transport that optimizes service quality, affordability, and environmental sustainability;
- transition to more sustainable private mobility in terms of both mode of use and impact on the environment.

In this context, the EnerCMed project aims to support the spread of energy communities or other configurations, such as remote Individual Self-Consumption (ISC), as an opportunity to improve access to energy services as well as social aggregation.

Scope

The neighbourhood of Cornigliano, selected as the Pilot site, is located in an area undergoing urban redevelopment after a recent industrial and port-oriented past. It is a highly urbanized area with all the infrastructure and services useful to citizens, such as schools, hospital, sports and accommodation facilities, and social housing. There are also several commercial activities, small neighbourhood businesses and big players (E.g., IKEA, Leroy Merlin, Decathlon etc.). As part of the project, the “Alessandro Volta" middle school, located in Via Cornigliano 9, and "Domenico Ferrero" primary school, located in Via Cervetto 42, were selected as suitable buildings for the installation of photovoltaic systems.

Methodology

The data collection has been proceeded mainly through desk research, using the existing GIS platform managed by the Municipality of Genova (https://mappe.comune.genova.it/MapStore2/#/) and through the consultation of existing projects produced by the Municipality itself (such as previous researches, applications for calls and tenders, etc.). We also leveraged on the specific expertise of internal offices.

City Overview

Urban Masterplan Summary

From the urban planning point of view, the city's Urban Plan (Piano Urbanistico Comunale – PUC) was concluded and became effective in 2015. It establishes land use policies, relevant zoning laws, and specific objectives for the city's development.

According to the Plan, Cornigliano area is included in the following general objectives connected to specific objectives and local actions:

- Spatial re-organization of the city and qualification of the urban image – Promotion of the “compact” city and enhancement of public space – Integrate program of intervention for the Urban Redevelopment of Cornigliano;
- Spatial re-organization of the city and qualification of the urban image – Architectural, landscape, and environmental enhancement of the mobility axes crossing the city – Recovery of the façades of civil homes in the streets of Cornigliano;
- Territory defense and environmental quality – Reduction of air, noise, and light pollution – Reduction of pollutants from urban traffic. Creation of cycle paths;
- Territory defense and environmental quality – Reduction of air, noise, and light pollution – Redevelopment of urban and extra-urban public green areas – Redevelopment of public green spaces. Urban reuse of former ILVA areas (former steel industry plants in Cornigliano).

Existing Critical Infrastructures

In the context of the EnerCMed project, two school buildings were identified as targets for the pilot. Overall, the Genoa Municipality owns more than 200 schools. From the energy performance perspective, the administration aims to improve the performance of the buildings. In particular, the two selected schools fall into energy class "E". About 50% of the schools are classified in “E” energy class.

Regulatory and Planning Context

Zoning and Land Use Regulations

The area where the pilot action will take place is included in the Cornigliano urban planning unit (unità urbanistica), within the local administrative unit of Medio Ponente (Municipio VI) located in the western part of the city of Genova.

Already in the XII – XIII centuries, but especially in the XVII and XVIII centuries, the ancient rural settlement of Cornigliano was dedicated to the holidays of Genoese aristocratic families. Therefore, It was characterized by the presence of a system of Villas, which still constitute a relevant historical heritage. From the beginning of the XIX century, with the expansion of the infrastructural provision and as the industrial revolution progressed, Cornigliano became an important site for the manufactural industry, especially in the textile sector. In the XX century, Cornigliano was a growing urban settlement that officially became part of the Municipality of Genova in 1926. The growing population and the increasing productive vocation made redesigning the urban fabric necessary. New apartment building blocks were constructed, and the road system was redesigned.

The full industrial transformation of the neighbourhood was determined by the “filling” of the seafront and the establishment of heavy industry (steel industrial plants). Over the decades, industrial sector development has totally canceled the relationship of this part of the city with the sea (and also the Polcevera River), compromising its urban quality. Cornigliano neighbourhood developed, then, as a working-class neighbourhood with a very poor life quality despite the presence of quite valuable built heritage (the system of Villas but also the new building blocks showed a certain quality and value). As in many other city areas, due to its morphological characteristics, Cornigliano urban fabric mainly developed in the quite narrow band between the industrial area facing the seaside and the steep hills in the back. The neighborhood suffered from the effects of the industrial crisis, which led to the closing of most industrial installation, mainly dismissed. Today, these industrial plants constitute an unused resource for a neighbourhood still seeking a new identity. From 2003, Cornigliano was included in a reconversion plan of the abandoned steel industry plant's abandoned areas, with the institution of Società Per Cornigliano S.p.A. The Company's objective is to restore the quality and liveability of the neighbourhood. Today, this process, though, is still not complete. The most recent intervention concerns the redevelopment of via Cornigliano, the main commercial street that crosses the neighborhood longitudinally, and the design of a new urban linear park, both walkable and cyclable, in the southern part of the neighbourhood nearby the railway infrastructure.

Within this framework, public services (local schools, library, municipal center), mostly located on the previously mentioned axe of via Cornigliano, are of particular relevance as – in a neighbourhood mostly lacking green spaces and gathering places – they represent meeting places for the residents and significantly contribute to their life quality level.

In terms of schools, the *Istituto Comprensivo Cornigliano* (administrative system of schools of different levels) includes a kindergarten, three primary schools, and a secondary school for a total of approximately 1.000 students.

Considering the two school buildings target of the pilot, from the urban planning point of view, the PUC foresees the following classification:

Secondary school “Volta” in via Cornigliano 9 is classified by the Urban Plan as SIS-S “Territorial and neighbourhood public services”; the school is located in the first part (close to the river edge) of via Cornigliano, the main mobility axe of the neighbourhood, but it is separated from it by a one-floor basement. It is surrounded by mainly residential buildings of no particular architectonical value;

Primary school “Ferrero” in via Cervetto 42 is classified by the Urban Plan as SIS-S “Territorial and neighbourhood public services of historical and landscape value”; Ferrero school is, indeed, located in a quiet historical site of the neighbourhood, very close to one of the historical villas (Villa Serra) and its park. The public services with historical and landscape value must comply, according to the Plan, with the specific level design standards of the AC-US (historic urban system conservation area); generally speaking, “interventions in these areas should pursue the maintenance and enhancement of the architectural, typological and historical-environmental characteristics of the buildings, the surrounding areas, the free and green spaces and the pedestrian and historical paths, restoring the historical formal characteristics of the buildings in the event that they have been altered”. Specific prescriptions on photovoltaic panels are required only in case of pitched roofs, which does not apply to Ferrero school building.

Permitting Requirements

Installing energy production systems from renewable sources is subject to the following procedures: Installation of plants powered by renewable sources, not subject to single authorization or SCIA under Art. 6, c.11 of Legislative Decree 28/2011, are subject to the notice of commencement of work (CIL) pursuant to Legislative Decree 28/2011, Art. 7.

Instead, interventions of construction, operation and modification of electricity production plants powered by renewable sources are subject to Certified Activity Start Signaling (SCIA) under Legislative Decree 387/2003, Art. 12, c.5 if included in the following power thresholds:

photovoltaic plants up to 20KW
wind power plants up to 60 KW
hydroelectric plants with generating capacity up to 100 KW
geothermal plants with generating capacity up to 100 KW
biomass-fired plants with generating capacity up to 200 KW
Biogas-fired plants with generating capacity up to 250 KW

The Municipal Building Regulations[2] prescribe certain facility installation rules (Art. 51, 95, 96, 108). The internal offices of the Municipality handle the project approval and implementation procedures.

Environmental Impact Considerations

The interventions are located in areas adjacent to the aircraft landing cone, during the evaluation phase it may be necessary to require special permits from the Civil Aviation Regulatory Authority (ENAC).

In consideration of the power foreseen PV plants, the authorization procedure does not require any other environmental fulfilments.

Technical Feasibility Assessment
Site Selection Criteria

The sites identified for the installation of the two PV systems are: "Alessandro Volta" middle school, located in Via Cornigliano 9, and "Domenico Ferrero" primary school, located in Via Cervetto 42, both in Genoa's neighbourhood of Cornigliano, as shown in **Error! Reference source not found.**, Figure 1 and Figure 2.

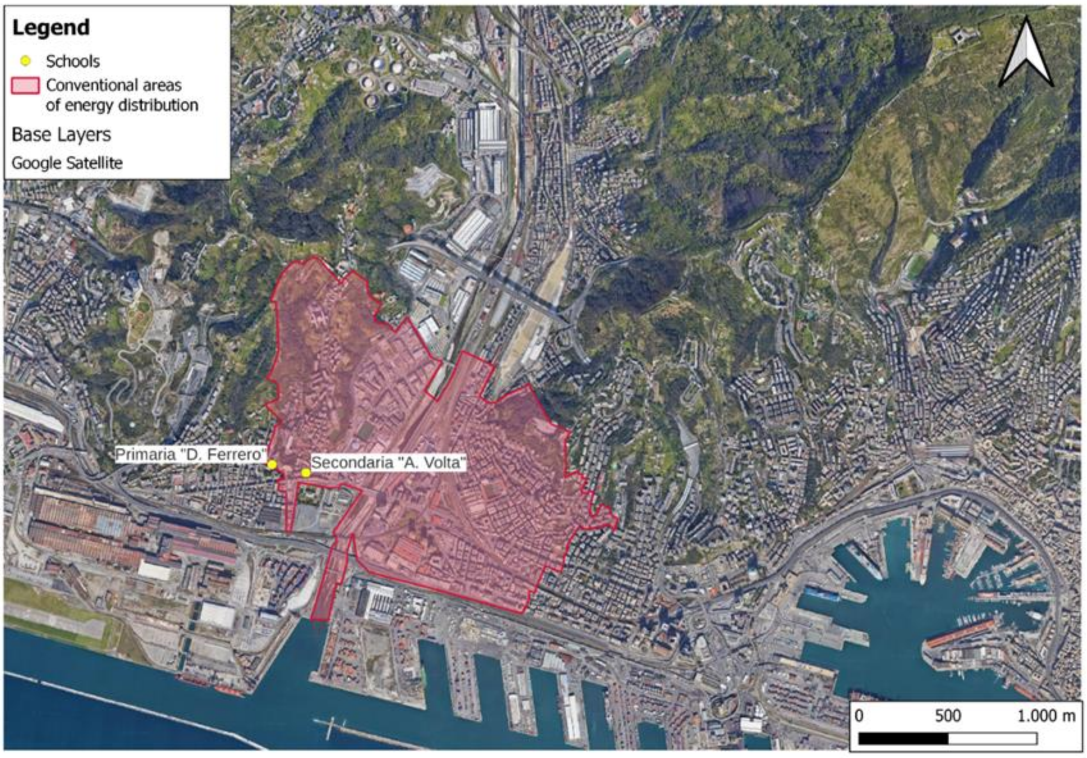


Figure 1: Identification of schools' buildings where photovoltaic systems could be installed.

[2] https://www.comune.genova.it/sites/default/files/2023-11/regolamento_edilizio_2020-dcc-42.pdf

Figure 1: Scuola Volta

Figure 2: Scuola Ferrero

The flat roofs of the buildings housing the two schools, with an area of 440 sqm for Volta and 770 sqm for Ferrero, have excellent exposure without shading and are in good condition. The choice fell on the above-mentioned schools because the buildings are fed from the same Primary Substation, thus, they can be included in the so-called "Remote Individual Self-Consumption" Configuration ("Autoconsumo diffuso"). With this configuration, the energy produced by the plants will be "self-consumed" by the other public buildings in the area. "Self-consumed energy" is defined by the Decree of 7 December 2023 n. 414 (CACER Decree) and under certain conditions it can be subsidized.

To comply with Italian Fire Prevention Regulations, a fire-resistant sheathing has to be placed between the floor slab and the PV panels on the roofs.

PV System Specifications

Plans for the two PV systems are currently being drafted. The following are the data currently defined.

Scuola Volta

Total peak power: 16kWp
Number of panels: 40
Type: single-crystalline silicon
Peak power: 400Wp
Azimuth and shading of panels: -36°, 24°
Number - nominal power of inverter: 1 - 17,5kW
The annual producibility of the plant, calculated with "PV geographical information system" (https://re.jrc.ec.europa.eu/pvg_tools/en/) using the above input data is approx. 20.000kWh/y.

Scuola Ferrero

For this plant, according to Circular Economy Circuit principles, 170Wp single-crystalline silicon panels installed about 10 years ago in a plant being decommissioned will be used.
Laboratory tests could be conducted to define the current peak power of the panels and accordingly size the system on time. Alternatively, data from the technical literature will be used.

At this stage, preliminary plant data are:

Total peak power: 20kWp
Number of panels: 170
Type: single-crystalline silicon
Peak power: 120Wp
Azimuth and shading of panels: 0°, 24°
The annual producibility of the plant, calculated with "PV geographical information system" (https://re.jrc.ec.europa.eu/pvg_tools/en/) using the above input data is approx. 26.000 kWh/y.

Grid Connectivity

The PV systems will be installed on the roofs of buildings located in a densely populated area, close to the port, and characterized by a strong presence of industrial and commercial activities. Since the Power Grid is highly interconnected, it can be of such a power value that the presence of the two PV plants cannot alter its balance.

In addition, considering the type of user and the forecast of its electricity consumption (schools, with activity almost exclusively during daylight hours), it can be reasonably assumed that the energy fed into the grid is only a part of that produced by the plants (production greater than consumption when schools are open, total production when schools are closed).

Spatial Analysis and Mapping

GIS Mapping

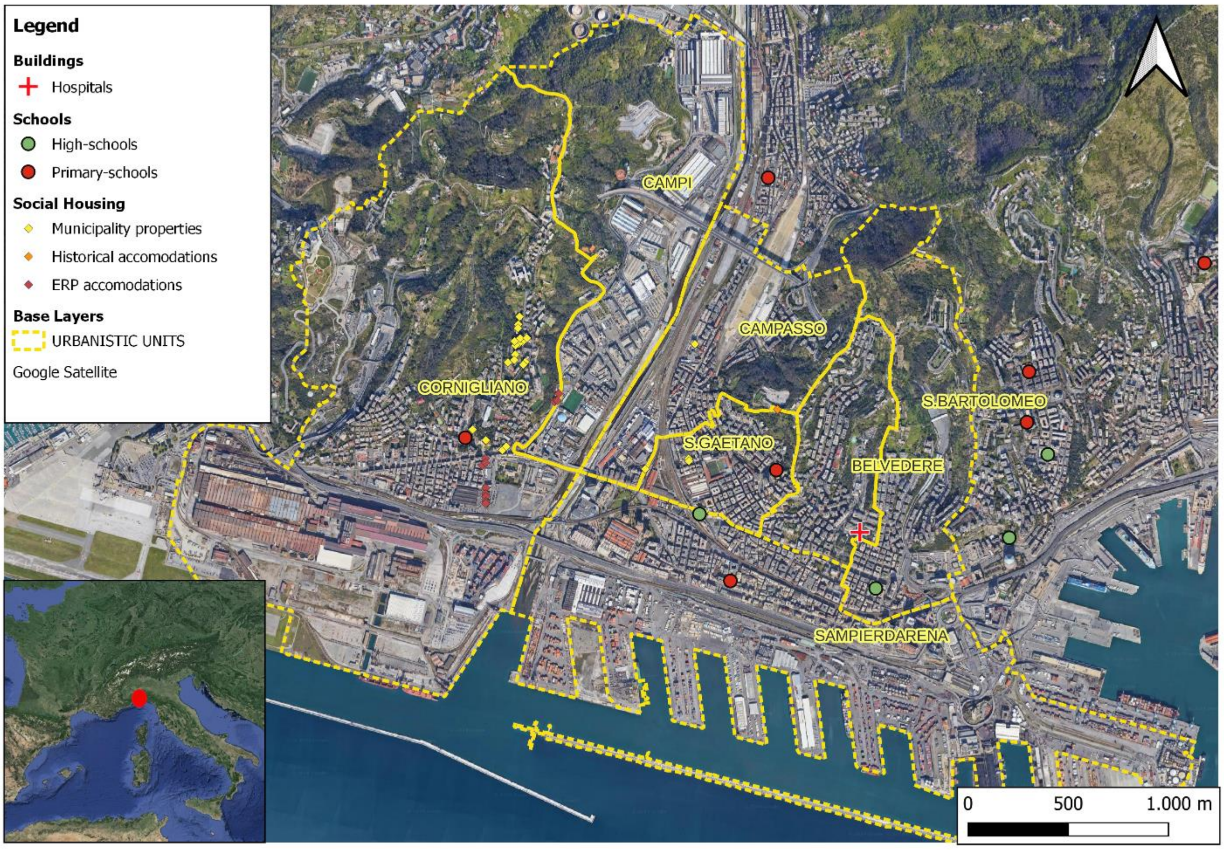
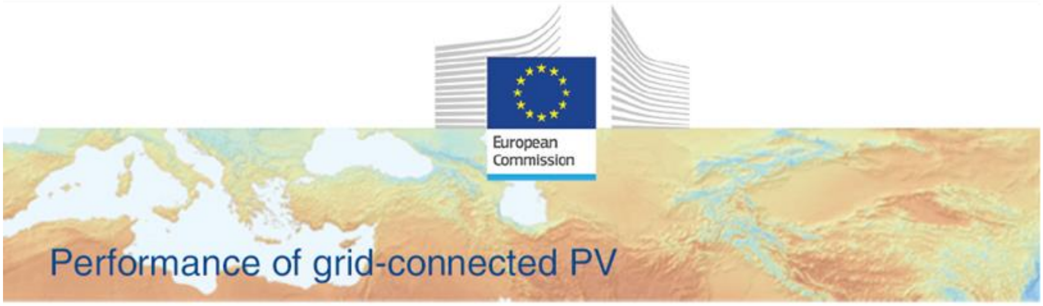


Figure 3: Localization of services on the territory of Cornigliano and neighbouring urban units.

The urbanistic unit of Cornigliano is currently equipped with the main services to citizens. There are also several buildings for social housing, as shown in Figure 3. The area of the district is also strongly characterized by the presence of the port and the retro-port areas, which coexist with the industrial sector, whose spaces host both decommissioned activities and activities still in operation. In Cornigliano and neighbouring urban units, many areas have been identified, through aerial image analysis, as suitable for the installation of photovoltaic systems, as shown in Figure 5.

Figure 4: Obstacle-free areas with a minimum area of 0.1 and 0.4 hectares respectively, with a slope of less than 20 hectares, with compact shape and south orientation, suitable for the installation of photovoltaic systems (source: https://citygreenlight.com/genova-future-city-map/)

From the preliminary analysis in the area of Cornigliano, the two buildings that would be suitable for the installation of photovoltaic systems (as shown in **Error! Reference source not found.**), both belonging to the "Cornigliano" Comprehensive Institute, i.e., the "Alessandro Volta" middle school and the "Domenico Ferrero" primary school, were analyzed with the online software *"PVGIS Photovoltaic Geographical Information System - EU Science Hub (*https://re.jrc.ec.europa.eu/pvg_tools/en/*")* for retrieving a primary performance and productivity assessment.



PVGIS-5 estimates of solar electricity generation:

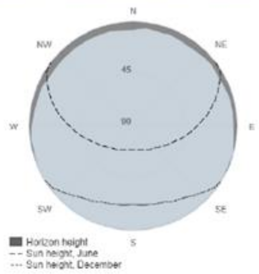
Provided inputs:

Latitude/Longitude:	44.417,8.873
Horizon:	Calculated
Database used:	PVGIS-SARAH2
PV technology:	Crystalline silicon
PV installed:	20 kWp
System loss:	16 %

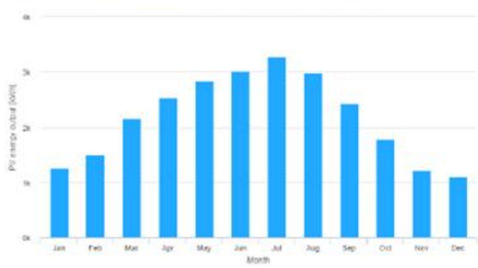
Simulation outputs

Slope angle:	25 °
Azimuth angle:	0 °
Yearly PV energy production:	26095.53 kWh
Yearly in-plane irradiation:	1708.71 kWh/m²
Year-to-year variability:	850.32 kWh
Changes in output due to:	
Angle of incidence:	-2.85 %
Spectral effects:	0.9 %
Temperature and low irradiance:	-7.27 %
Total loss:	-23.64 %

Outline of horizon at chosen location:



Monthly energy output from fix-angle PV system:



Monthly in-plane irradiation for fixed-angle:

Monthly PV energy and solar irradiation

Month	E_m	H(i)_m	SD_m
January	1263.3	77.6	227.7
February	1496.0	93.5	249.8
March	2157.0	136.5	254.5
April	2526.1	163.5	250.0
May	2836.3	187.2	260.8
June	3016.8	203.1	127.6
July	3275.9	223.0	152.9
August	2979.7	202.5	178.9
September	2427.3	161.3	134.1
October	1780.7	114.5	276.1
November	1221.1	76.9	203.9
December	1115.1	69.1	194.1

E_m: Average monthly electricity production from the defined system [kWh].
H(i)_m: Average monthly sum of global irradiation per square meter received by the modules of the given system [kWh/m²].
SD_m: Standard deviation of the monthly electricity production due to year-to-year variation [kWh].

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Figure 5: "Domenico Ferrero" primary school assessed productivity.

European Commission

Performance of grid-connected PV

PVGIS-5 estimates of solar electricity generation:

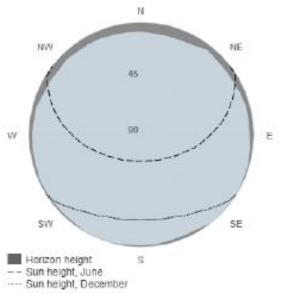
Provided inputs:

Latitude/Longitude:	44.417,8.875
Horizon:	Calculated
Database used:	PVGIS-SARAH2
PV technology:	Crystalline silicon
PV installed:	16 kWp
System loss:	16 %

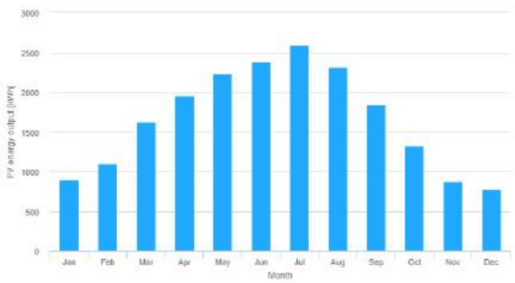
Simulation outputs

Slope angle:	25 °
Azimuth angle:	-39 °
Yearly PV energy production:	19922.8 kWh
Yearly in-plane irradiation:	1634.62 kWh/m²
Year-to-year variability:	647.87 kWh
Changes in output due to:	
Angle of incidence:	-2.98 %
Spectral effects:	0.88 %
Temperature and low irradiance:	-7.35 %
Total loss:	-23.82 %

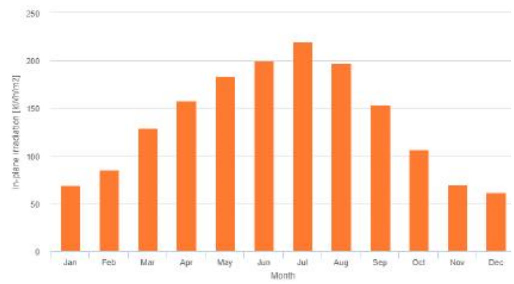
Outline of horizon at chosen location:



Monthly energy output from fix-angle PV system:



Monthly in-plane irradiation for fixed-angle:



Monthly PV energy and solar irradiation

Month	E_m	H(i)_m	SD_m
January	895.5	69.6	154.1
February	1099.0	86.0	175.3
March	1630.1	129.0	193.4
April	1951.4	157.8	195.3
May	2230.3	183.9	207.8
June	2384.2	200.5	96.7
July	2587.0	220.0	119.1
August	2317.9	196.9	149.1
September	1845.5	153.2	108.4
October	1325.1	106.8	197.9
November	878.3	69.7	135.8
December	778.5	61.2	132.4

E_m: Average monthly electricity production from the defined system [kWh].
H(i)_m: Average monthly sum of global irradiation per square meter received by the modules of the given system [kWh/m²].
SD_m: Standard deviation of the monthly electricity production due to year-to-year variation [kWh].

Joint Research Centre

Report generated on 2024/06/12

Figure 6: "Alessandro Volta" middle school assessed productivity.

Production and Savings

The annual producibility of the two PV systems, calculated with "PV geographical information system" (see attached Figure 5 and

Figure 7) using the above input data are, approx.:

Scuola Volta: 20.000 kWh/y
Scuola Ferrero: 26.000 kWh/y.

Considering the total annual producibility, which amounts to 46.000 kWh, and assessing 60% of self-consumed energy on-site, the expected cost savings are allocated as follows:

The self-consumed energy provides cost savings in the bill approximatively of 8.200 €;
The energy produced by PV plants that are not self-consumed and fed into the grid will be remunerated with a fee of about 1.800 € (RID).

Spatial Compatibility

The neighbourhood where the PV plants will be located is not subject to specific landscape constraints concerning this type of intervention. Therefore, no significant impacts on the urban and spatial environment are expected.

3.4 Spatial Planning Greece

Introduction
Purpose

As part of the implementation of the EnerCmed (EUROMED) project, interventions will be made in the building and the surrounding area (courtyard) of the school complex of the 6th High School of Patras, aiming to increase its energy self-sufficiency, reduce its carbon footprint and increase the resilience of the area against the effects of Climate Change.

The interventions will be made in 2 axes, with the installation of a Photovoltaic system (*detailed in the next section*) and the adoption and installation of Nature Based Solutions (NBS) or "nature-inspired and nature-supported solutions that are cost-effective, provide environmental, social and economic benefits and contribute to enhancing resilience".

Unlike conventional solutions, these interventions (plant technicians and others) involve citizens and society in the selection process and are easier to adapt to new conditions. They make a major contribution to addressing (mitigation and adaptation) the impacts of climate change and offer significant long-term benefits.

The main objectives of Ecosystem-Based Solutions are

- enhancing the sustainability of cities
- the restoration of degraded ecosystems
- the management of environmental risks
- the enhancement of human well-being

In line with the central objective of EnerCmed (EUROMED) as a whole, this action will contribute to " Promotion of the concept of energy communities and climate resilient urban planning paradigm in marginalized neighborhoods of port hinterlands of Mediterranean cities”

Scope

The choice of the application site is a school complex characterized by a wide range of ages (different schools), and a variety of social backgrounds (they come from different areas). Also the school's geographical location is close to a mini peripheral road, close to a grove, and the surrounding area is characterized for its population density.

Methodology

The methodology that will be used will be based on GIS tools, which will be used to combine descriptive data (population, statistics, etc.) and agricultural data (land use, urban data, etc.). At the same time, the necessary autopsies will be carried out on the application site and questionnaires will be filled in by the children of the school complex

City Overview
Urban Masterplan Summary

According to the existing urban plan, the application area is classified as a zone of "Protection of the Peripheral Green Areas of Dasillio - Vlatero & Diakou Hill". More specifically, it includes the area of Dasillio - Vlatero up to the small peripheral road and part of the upstream area, which is adjacent to the eastern boundary of the Town Plan. This area is predicted to be subject to building pressures due to its proximity to the urban fabric and the completion of the opening of the small peripheral road. It also contains elements that identify it as a conservation area, such as the hill of Dasillio.

Area of interest

In the area, apart from the school complex, there is a large traffic junction, where the entrance and exit of the city, as well as the mini perimeter road, converge, so this area is distinguished for the intense traffic load. The area is also adjacent to one of the largest forest-urban green spaces in the city. Finally, the area is distinguished by the intense residential development that has taken place in recent years.

Existing Critical Infrastructures

The school complex appears to have a large energy footprint. It has a rudimentary electrical network, which is quite energy-intensive, no building infrastructure that complies with the new environmental regulations, and finally, it is distinguished by the lack of green space within the school complex.

Regulatory and Planning Context
Zoning and Land Use Regulations

Land use according to the General Plan of the Municipality of Patras is classified as Education

Permitting Requirements:

The laws that affect the installation of photovoltaic systems and are relevant to zoning, land use policy and building code are:

- Law No. 4067 Government Gazette A' 79/09.04.2012 (New Building Regulation).
- Law 5069/2023 (Government Gazette 193 A'/28.11.2023)
- "Conditions for building, construction, permitted land uses for data centres, spatial and urban planning regulations, use of Green Fund resources, other environmental and energy provisions and other urgent regulations”
- Law 4759/2020, OFFICIAL GAZETTE 245A/09.12.2020
- RESIDENTIAL DECREE No 59 A' 114/29.06.2018 (Categories and content of land use)
- The institutional framework for the licensing of RES plants in the country is mainly based on Law no. 3468/2006 (Government Gazette A' 129) and its amendments by Law 3468/2006 (Government Gazette A' 129). 4685/2020 (FEK A' 92).

This law classifies projects into two categories:

1. in stations for which a production licence is granted (Article 3 of Law 3468/2006) and
2. to plants exempted from the obligation to obtain a production licence (Article 4 of Law 3468/2006). (Ministry of the Environment, 2020)

For the placement of photovoltaic stations in buildings and for power up to 100 kW, no building permit or approval of small-scale building works is required. For photovoltaic stations with a power of more than 100 kW, approval of small-scale building works and a study of the structural adequacy of the building on which the installation will be made, signed by a licensed civil engineer.

Photovoltaic stations with a power of less than 1 MWp installed on land are exempt from environmental licensing if they are not located in an area of the Natura 2000 network or a coastal location less than 100m from the coastline of the shoreline outside of rocky islets. Otherwise, the stations are classified in Category B according to the Ministry's Decree no. YPEN/DIPA/74463/4562 (Government Gazette 3291 B΄ 2020) and are subject to a P.P.D. In any case, the installation of photovoltaic stations on land requires approval of small-scale building works.

In summary, the following energy permits are required for the licensing of a RES installation:

- Producer's certificate (former production license), which, according to Law no. 4685/2020, replaced the Production Licence to speed up the licensing process. Ahead of the December 2020 application cycle to the RAE, the Regulation on Producer Certificates2 was published (Bee Green, 2021). The opinion body is the RAE and is issued by the Ministry of Environment with exceptions such as for PV parks that require a technical description of the project, the possibility of securing the site's location, etc. If RAE gives a positive opinion (within 4 months), the permit is issued by the Ministry of Environment within 15 days. It is valid for 25 years, but a file for an Installation Permit must be submitted two years after receiving it.
- An installation permit is a complex and time-consuming process, as it requires many intermediate permits and is subject to the opinion of many independent bodies. It includes environmental licensing, a full implementation study for all projects, a study of the connection to the network, etc. It also includes a declaration that the project has been built following the applicable standards and complies with safety rules. Once issued (within 15 days) after submission, it is valid for 20 years.
- An operating permit is required, which is a permit issued after the project is completed. It includes a finding that the project has been constructed per the applicable specifications and

meets safety rules. It is valid for 20 years. A decision by the Minister of Development governs the procedure for issuing an installation permit and an operating licence.

Environmental Impact Considerations

For the environmental licensing of projects and activities of the public and private sector, the provisions of the Amendment to the Decree no. 37674/27-7-2016 (V'2471) of the Minister of Environment, Energy and Climate Change "Classification of public and private projects and activities in categories and subcategories, according to article 1 paragraph 4 of Law No. 4014/2011 (A' 209)', as regards the classification of certain projects and activities of Group 10

For photovoltaics, the limit for exemption from environmental licensing becomes 1 MW (from 500 kW until now) while the limits for larger projects are increased (projects 1-10 MW are now included in category B - with an EPD - and projects >10 MW in category A2). Projects <1 MW in Natura or in a coastal location less than 100 m from the coastline of the shoreline outside of rocky islets are included in category B.

Accompanying projects (e.g., roads, interconnection network) follow the category of the main project. The main project category is followed if storage systems (batteries) are installed at the RES station.

Technical Feasibility Assessment

Site Selection Criteria

A photovoltaic system will be installed in the school complex to produce electricity. The photovoltaic system is located on the roof of the school building. This location has the required surface area for installing the photovoltaic system and the appropriate orientation without prohibitive shading. Also, after a macroscopic visual inspection, the roof can install the photovoltaic system.

PV System Specifications

The photovoltaic system will have a total power of approximately 50kw and consist of monocrystalline silicon photovoltaic panels with a power of 550w (+ 10%) and an efficiency of at least 20% each. In addition, to convert the solar power system to electricity, the system will have 3 inverters with a power of at least 17kw each.

Grid Connectivity

The assessment of capacity of the local electricity supply network will be evaluated, in consultation with the public electricity supplier, after the installation of the photovoltaic system.

Spatial Analysis and Mapping

GIS Mapping

Geographical Information Systems will be used in an advisory capacity to determine the slope, orientation, estimated production, etc., of the photovoltaic system.

Energy Production and Savings

The potential electricity production will amount to approximately 74000 kWh per year. The electricity price of the electricity provider will determine the cost savings.

Spatial Compatibility

The photovoltaic system is not expected to cause significant aesthetic disturbance to the urban landscape.

4 UHI & MICRO-CLIMATE ANALYSIS

4.1 UHI & Micro-Climate Analysis Spain

Introduction

Purpose

Climate Change and global warming are among the most complex and urgent socio-environmental challenges humanity faces. Characterized by the continuous increase of temperatures, including cities and oceans, this phenomenon is triggering significant global climate changes that have evident consequences for all - from biodiversity loss to water scarcity and food safety or the rise of the sea level. The Mediterranean basin is one of the most affected areas with a constant temperature increase and more frequent and recurrent extreme weather events.

Two complementary strategies exist to address these challenges and work towards a more sustainable and resilient future. On the one hand, **mitigation** is a long-term strategy that focuses on reducing greenhouse gas emissions through the transition to renewable energy sources and conserving and protecting the environment and biodiversity. On the other hand, **adaptation** refers to the preparation and response to the adverse impacts of climate change that are already occurring or are expected in the future.[3] This involves integrating climate considerations at all levels, including city urban planning.

In this framework, the EnerCMed project is particularly relevant as it combines both mitigation and adaptation measures by linking Renewable Energy Communities (REC) and Nature Based Solutions (NBS) to address the impacts of Urban Heat Islands (UHI) in 5 Mediterranean cities. In addition, the project integrates the "Just Transition" perspective, ensuring the involvement of vulnerable communities and households in this process to co-create and design the solutions.

Climate change consequences generate negative impacts that do not affect all people uniformly. The disparity in effects is due to various factors that can influence the vulnerability of communities and individuals, either developing new vulnerabilities or exacerbating and perpetuating existing ones. This is why we need an applied approach to focus at neighborhood level.

This report aims at analysing the area of Poblats Marítims in the city of Valencia - more precisely, the districts of Natzaret and La Malva-Rosa. These two neighborhoods, which are close to the port and the sea, have both high levels of energy poverty and poorly isolated houses, combined with high temperatures and humidity levels.

This document will review the UHI effects and micro-climate factors at the neighborhood level to inform the integration of RECs with nature-based solutions.

Scope

The target area is the 11th district of Valencia, Poblats Maritims. More concretely, we will focus on Natzaret and La Malva-Rosa, two deteriorated neighbourhoods close to the port and the sea with high vulnerability and heat index levels.

[3] Fair Local Green Deals Report (2024): "Practical guide of actions fighting the heat - Framed in the revision of the Valencia Climate Agreement", Municipality of Valencia, Valencia Climate and Energy Foundation, Paisaje Transversal

Methodology

The city of Valencia is aligned to sustainable development with the adoption of the Climate Agreement and the Valencia Urban Agenda 2030, which establishes, among their objectives, the goal of achieving a healthy and sustainable city. In addition, Valencia has achieved the title of European Green Capital 2024.

In this sense, the municipality is making an effort to participate in projects addressing UHI, NBS, and energy poverty. Through the Valencia Climate and Energy Foundation, it is also involved in mapping, analysis, and study to monitor the heat, the UHI and the potential to build climate shelters through the Green Urban Data report. Regarding NBS, we will take the opportunity of the recently launched report from the Grow Green European project and Fair Local Green Deals, both with the participation of Valencia Climate and Energy Foundation and the Municipality of Valencia. Finally, we will also consider the open data from the Municipal Statistics Office and the AEMET agency.

Neighborhood Overview

Geographical Context

Poblats Maritims is the easternmost area of the city, on the edge of the seaside. Here we can find the neighbourhoods of Natzaret and La Malva-Rosa

Map 1: Location of Natzaret neighbourhood

Map 2: Location of La Malva-Rosa neighbourhood

Both areas arose as maritime and fishing neighborhoods with unique features and lifestyles. They are considered working-class neighborhoods. Natzaret was originally made up of humble houses of fishermen and port workers. On the other hand, La Malva-Rosa neighborhood is the union between the sea and the orchard, surrounded by old ditches, which makes it a very humid area. There are still vestiges of this heritage such as the traditional houses and constructions, making it very difficult to improve isolation, efficiency systems and renovation.

Urban Heat Island (UHI) Effect Analysis

Temperature Mapping

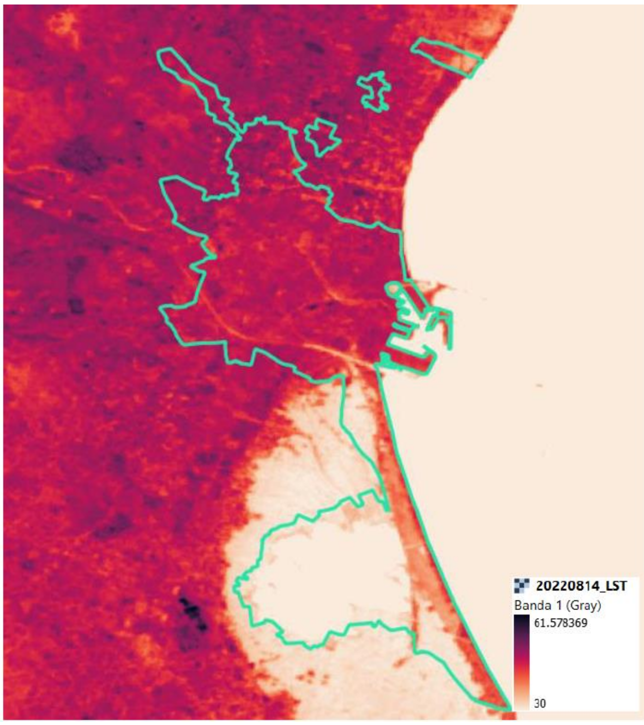
In the case of Valencia, the city's greatest impact on the climate is the heat island effect. This is a multicausal phenomenon caused, among other factors, by the high heat capacity of some construction materials, the release of heat in cities (road traffic, lighting, domestic activities, air conditioning, etc.), and the effectiveness of drainage systems, which evacuate water quickly, preventing it from evaporating from the ground and thus, making a cooling effect on the surface. In fact, there are nights in Madrid, Barcelona, and Valencia with thermal differences of more than 5 °C and some close to 8 °C, between the center of the city and their peri-urban space[4].

According to the Köppen criteria for climate classification, we can consider the city of Valencia as a mild Mediterranean climate, transitioning between Mediterranean and warm semi-arid climates. The city has a network of air quality and temperature monitoring and control stations across 10 points. Even though there are general tendencies at city level, we can state that even within the city there are significant temperature differences that allow us to even talk about micro-climate spots.

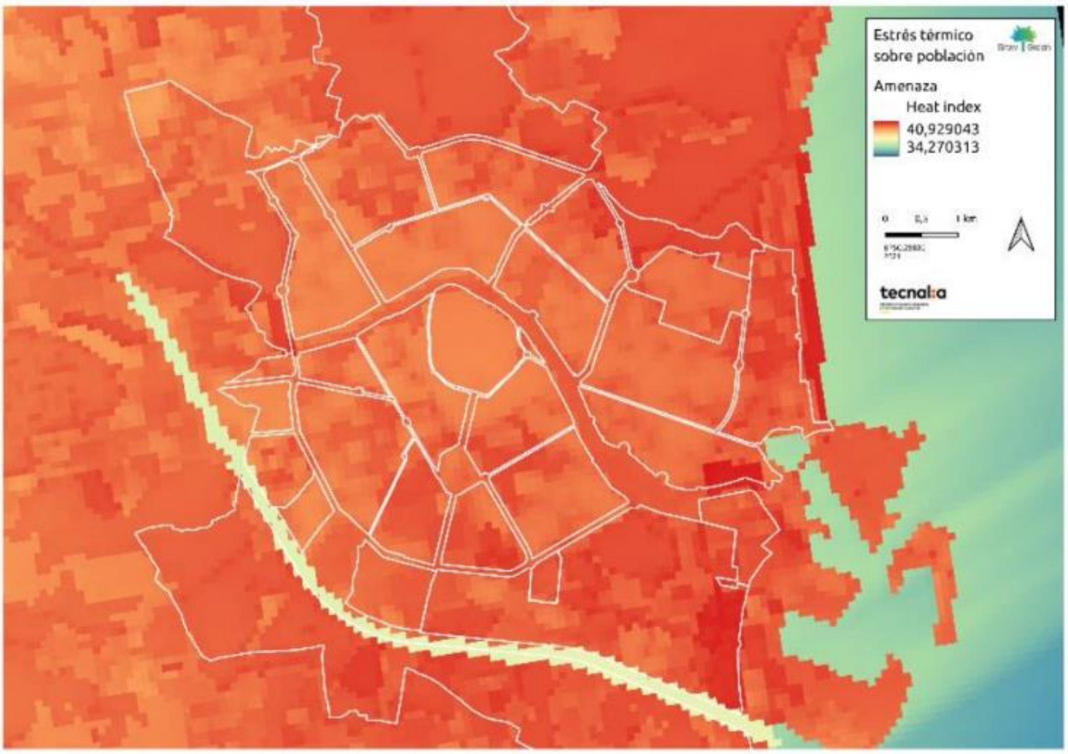
In Valencia, summer heat waves and UHI are a huge concern. The Valencia Clima i Energia Foundation has conducted an exhaustive study and mapping of the evolution of temperatures and heat waves to

[4] Núñez Peiró et al. (2016): " Towards a Dynamic Model for the Urban Heat Island of Madrid", Universidad Politécnica de Madrid, https://oa.upm.es/40144/

identify potential spaces for climate shelters. The 14th of August 2022 was the warmest day of that year. On the following map, we can state the huge temperatures and the risks of thermal stress overpopulation in the following map from NASA's Landsat 9 sensor.



Map 4: Surface temperature (ºC) from Landsat 9 sensor - 14/8/22. Source: EarthExplorer (DR15) and Green Urban Data & VCE, 2022



Map 5: Thermal stress threat over population in the city of Valencia. Source: GrowGreen, 2022

Temporal Analysis

If we look at the data offered by the monitoring stations across the city, we can state the temperature evolution from 1981-2010, among other interesting values such as humidity and rain levels.

València, Viveros
AEMET Periodo: 1981-2010 - Altitud (m): 11

AEMET 1981 – 2010	Enero	Feb	Marz	Abril	Mayo	Junio	Julio	Ago	Sep	Oct	Nov	Dic	Año media
T media	11.8	12.5	14.4	16.2	19.0	22.9	25.6	26.1	23.5	19.7	15.3	12.6	**18.3**
T max	16.4	17.1	19.3	20.8	23.4	27.1	29.7	30.2	27.9	24.3	19.8	17.0	**22.8**
T min	7.1	7.8	9.6	11.5	14.6	18.6	21.5	21.9	19.1	15.2	10.8	8.1	**13.8**
Precipitación media (mm)	37	36	33	38	39	22	8	20	70	77	47	48	**475**
Humedad relativa %	64	64	63	62	65	66	67	68	67	67	66	65	**65**

Figure 1: Evolution of temperatures in Valencia, Viveros AEMET Station 1981-2010 Source: Green Urban Data and VCE Report, 2022

The hot season lasts about 3 months, from June to September, and the average daily maximum temperature is more than 27°C. The warmest month of the year in Valencia is August, with an average maximum temperature of 30 °C and minimum temperature of 22 °C. The cool season lasts around 4 months, from November to March, and the average daily maximum temperature is less than 19°C. The coldest month of the year in Valencia is January, with an average minimum temperature of 6 °C and a maximum of 16 °C.

However, this is slightly changing. In the summer of 2022 - a record year of heat waves, high temperatures, and extreme heat and drought events - several days reached more than 35 degrees combined with high humidity levels - sometimes more than 70% - due to the closeness to the sea.

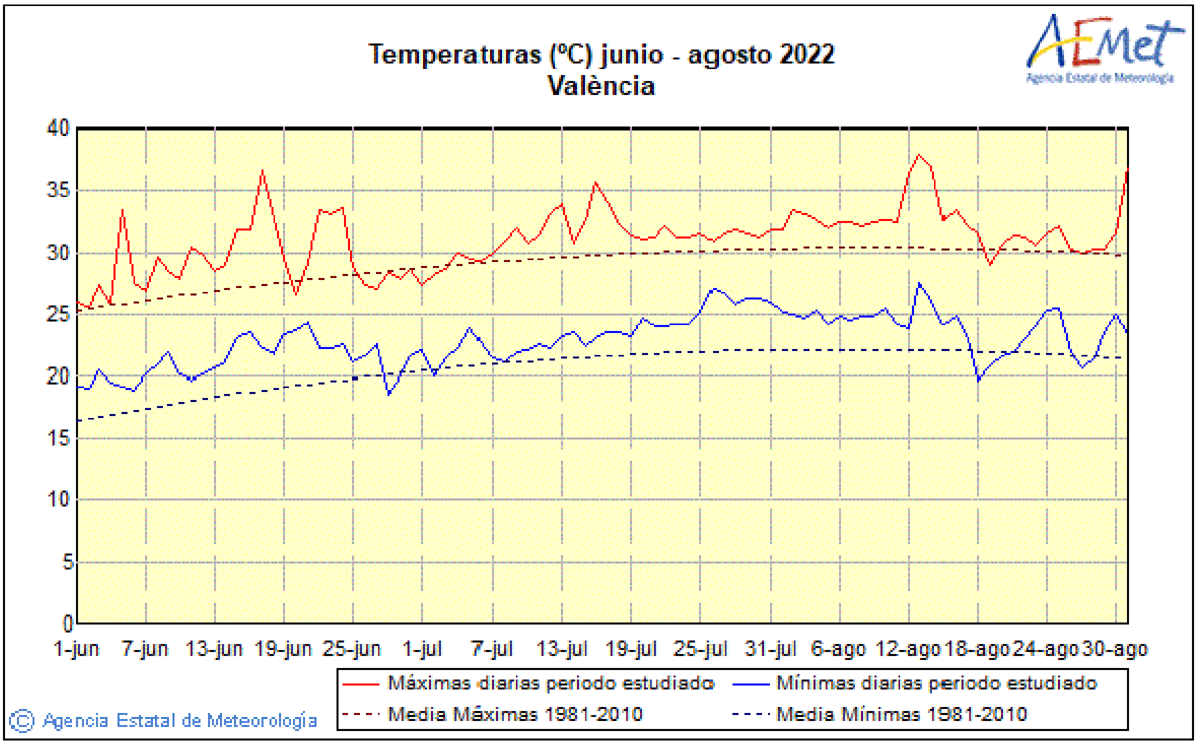


Figure 2: Max and min temperatures June - August 2022 in Valencia city Source: AEMET

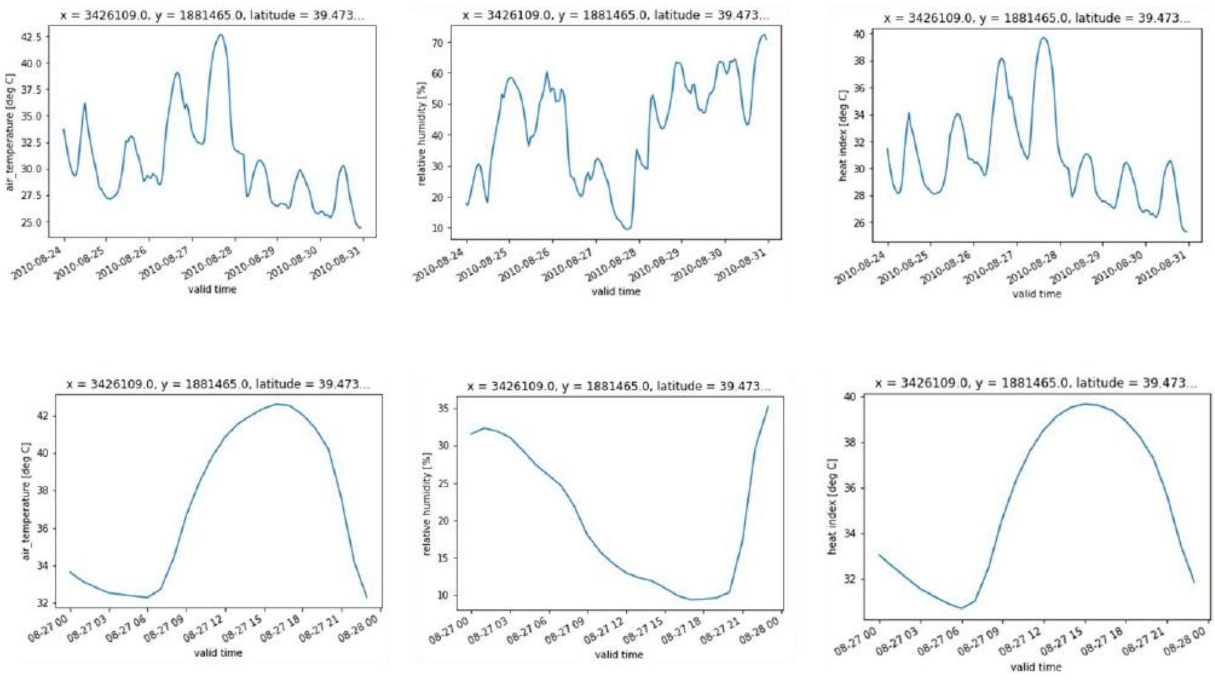


Figure 3: Thermal sensation in Valencia Source: TECANLIA, 2021 and GrowGreen, 2023

It is also worth mentioning the progressive increase of the minimum temperatures and the consequent reduction of the range between maximum and minimum temperatures - particularly noticeable during nighttime hours. This can lead to thermal stress, lack of sleep, anxiety, health problems, and even mortality. In fact, Valencia is among the Spanish cities where heat waves have the greatest impact on mortality, mainly due to high temperatures at night and sudden and unexpected rises[5].

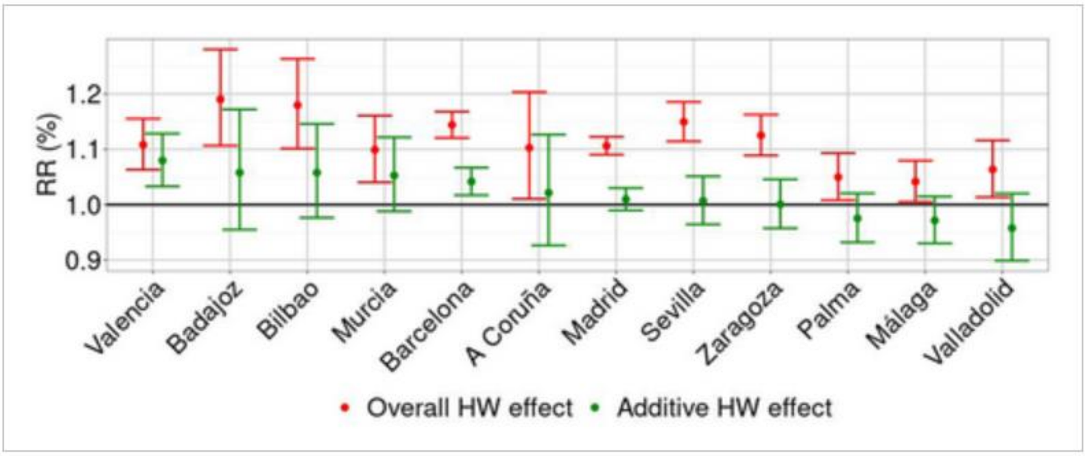
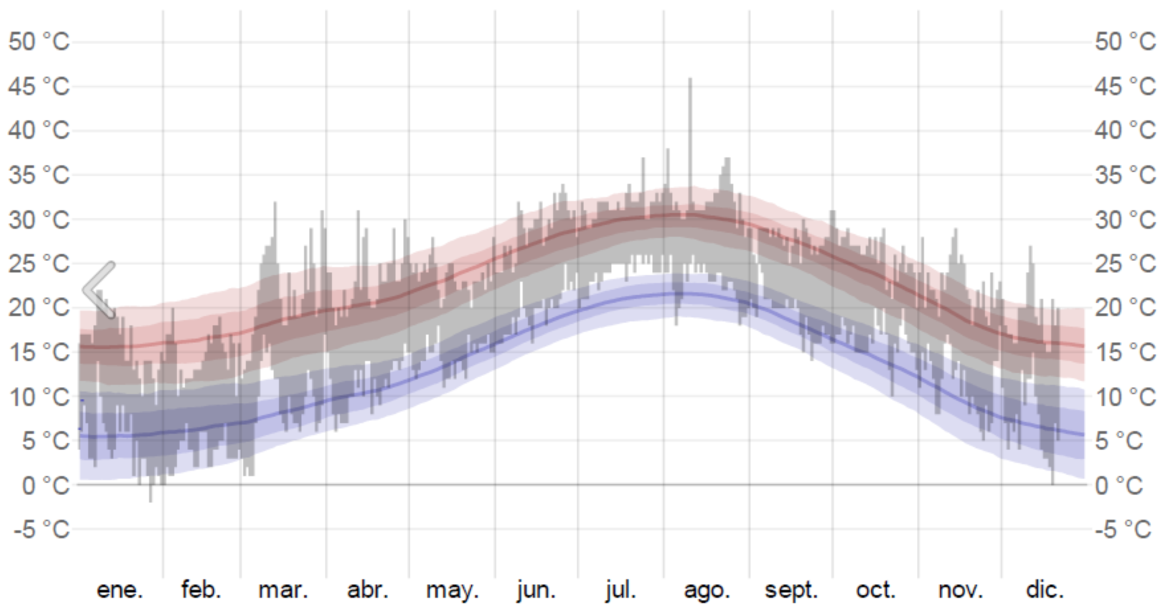


Figure 4: Relative risk (RR) associated with the Heat Waver occurrence derived from the overall HW effect model (YHW, red points) and the additive HW effect model (YTmean+HW, green points) Source: Centro de Estudios Ambientales del Mediterráneo (CEAM)

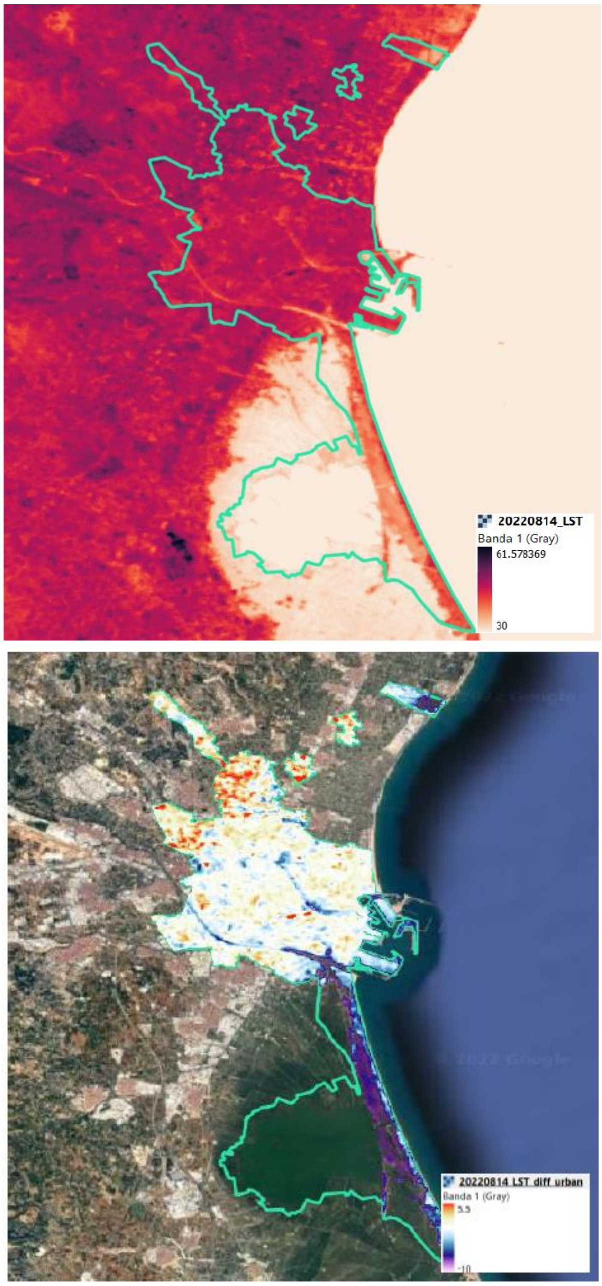


[5] Paredes Fortuny (2024): "Geographical Patterns in Mortality Impacts Due To Heatwaves of Different Characteristics in Spanish Cities", Geo Health, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2024GH001092

Figure 5: Historic temperature data in Valencia 2023 Source: Weather Spark and Fair Local Green Deals & VCE report

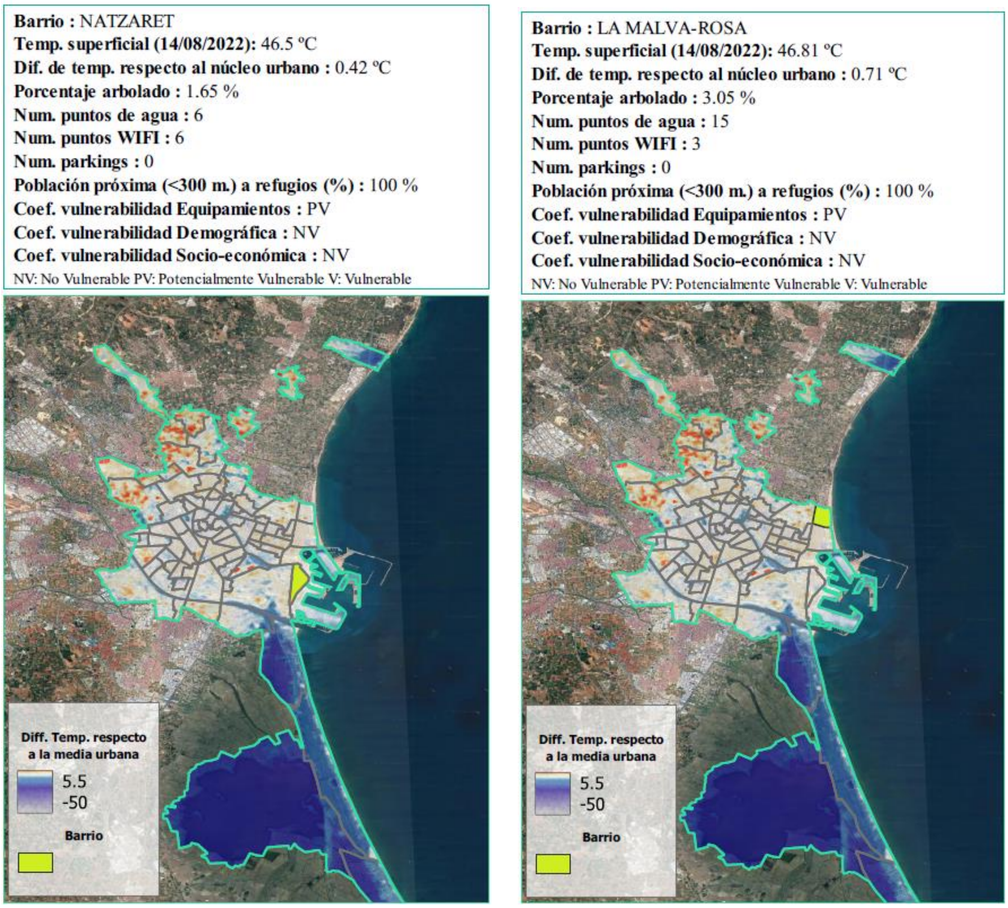
Spatial Distribution:

We can compare the difference between the temperatures in the previous image and the average of the urban area. This map comparison provides information about the warmest and coolest areas above that average. This data source allows us to determine the neighborhoods with the highest temperatures during a heat wave and conduct a detailed study of more specific areas.



Map 6: Comparison between surface temperature and differences to the urban average 14/8/22. Source: EarthExplorer (DR15) and Green Urban Data & VCE, 2022

Regarding Natzaret and La Malva-Rosa, as already mentioned, both neighbourhoods are close to the sea and the port. If we continue analyzing the 14th of August 2022, we can state Natzaret had a surface temperature of 46.5°C and a difference of temperature of 0.42ºC within the urban center, whilst La Malva-Rosa had 46.81°C and 0.71°C



Map 7: Differences to the urban average temperature in Natzaret and La Malva-Rosa. Source: EarthExplorer (DR15) and Green Urban Data & VCE, 2022

Micro-Climate Factors

Surface Characteristics:

The area of interest is mainly characterized by its closeness to the sea and the port. There are car roads, asphalt, and cycling roads. In the case of Natzaret there are also wastelands that people usually use to park their cars.

Green Spaces

According to the previous maps, Natzaret has 1.65% of tree-lines space, while La Malva-Rosa has 3.05%. This is a relatively low number compared to other neighbourhoods with 9%-12% of trees.

Map 8: Natzaret, trees, pools, beach and public spaces that could be climate shelters (schools, libraries, youth centers…)Source: Green Urban Data & VCE, 2022

Map 9: La Malva-Rosa, trees, pools, beach, and public spaces that could be climate shelters (schools, libraries, youth centers…). Source: Green Urban Data & VCE, 2022

Regarding the effects of vegetation, the most affected element is solar radiation. The main influence of trees is determined by their specific variables, which vary depending on the species: leaf area index, leaf biomass density, crown distribution, size, and color of leaves, among others.

Trees in urban areas are important for (1) microclimate regulation, (2) urban hydrology, and (3) air pollution reduction. The presence of native trees is also important, as they can better adapt to weather conditions.

According to the Green Urban Data report on climate shelters in Valencia, trees can lower, as an average temperature 9.8°C degrees.

Map 10: Tree stock according to the municipal register
Source: Source: Green Urban Data & VCE, 2022

Building Density and Height:

Both neighbourhoods do not have very high buildings but more like houses with one or two floors and single-family homes. Most of them are inefficient constructions and unrenovated houses facing serious problems of humidity, mold, and dampness, making it very difficult to keep the house at an adequate temperature in summer and winter. This impacts street shadowing and house cooling as most houses, especially top floors, receive direct sun radiation.

Water Bodies

The predominant water body is the Mediterranean Sea. Both neighborhoods are located by the seaside, which helps lower temperatures thanks to the sea breeze.

At this stage, it is also worth noting that humidity levels are quite high in Valencia, with around 65% values throughout the year. This is particularly important as humidity can raise the heating feeling in our body and generate discomfort, especially at night. The following graph shows discomfort caused by humidity. July and August have the highest values, reaching “unbearable” and "oppressive" feelings.

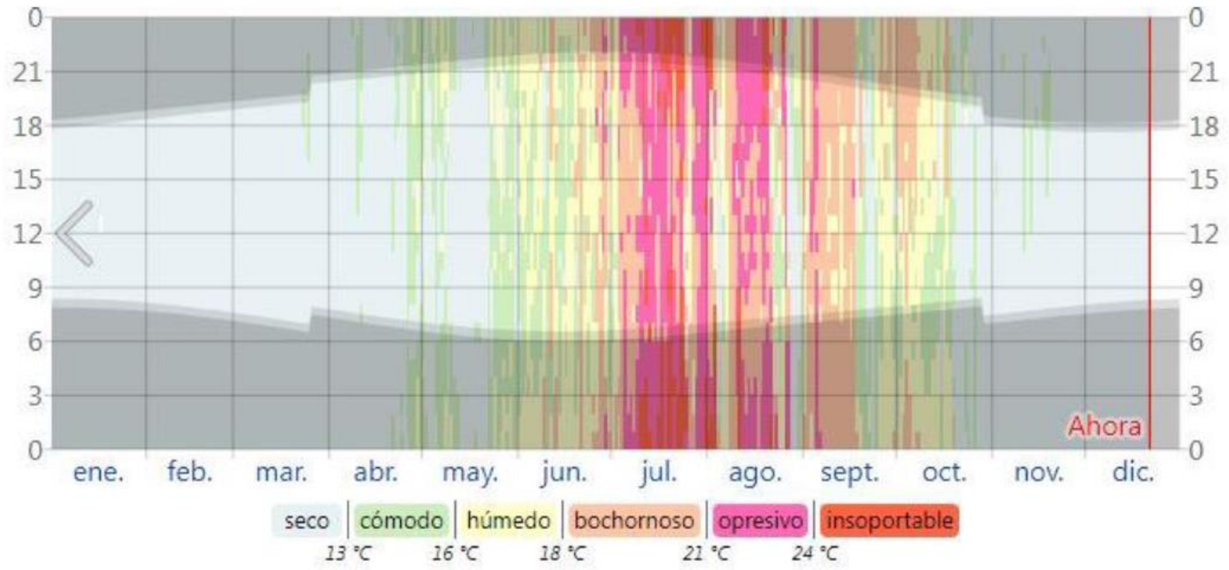


Figure 6: Discomfort caused by humidity in Valencia 2023
Source: Weather Spark and Fair Local Green Deals & VCE report

Wind Patterns

During Valencian summer, the predominant winds are called “Levante”, which have an east and southeast direction, with a variable speed. These winds and breezes can improve the comfort within the city in summer by lowering the temperature naturally. In winter, this trend reverses, and the predominant winds are called “Western” winds, which come from the West. These are warmer and drier, which helps raise temperatures.

The following graph shows the percentages of the wind direction in the city of Valencia.

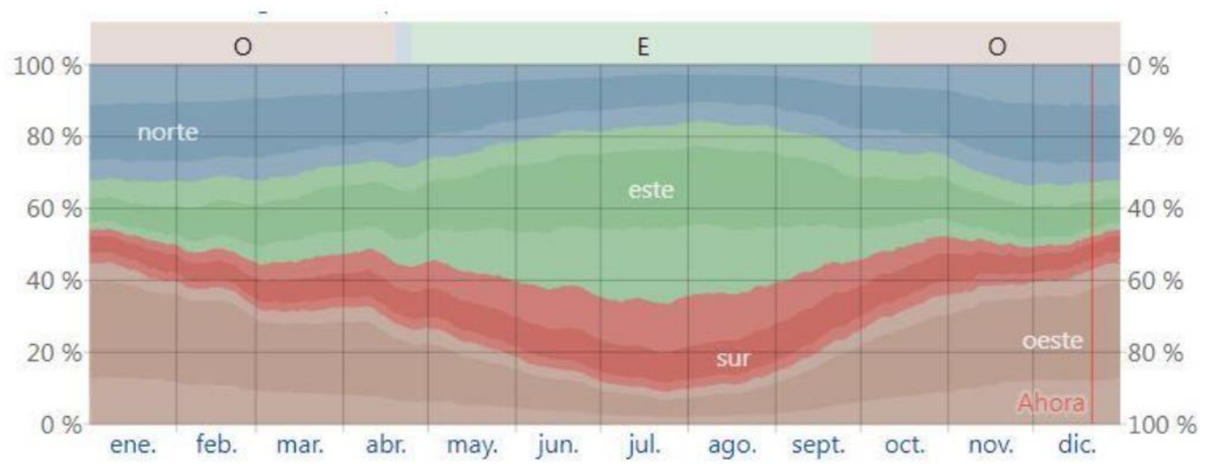


Figure 7: Wind direction in Valencia, 2023. Source: Weather Spark and Fair Local Green Deals & VCE report

Hourly, we can see how the Levante wind is concentrated during daytime hours, while at night, the regime is more variable and presents a predominance of the Western wind. In the following Wind Rose we can see the difference in the direction and intensity of the wind at different times of the day during summer. The symbol on the left represents the speed and direction at 1:00 p.m. (noon), while the one on the right shows it at 12:00 p.m. (night). This impacts having the so-called “torrid or tropical nights”. The main problem comes when Western winds come during summer, as they can raise temperatures in a very significant way.

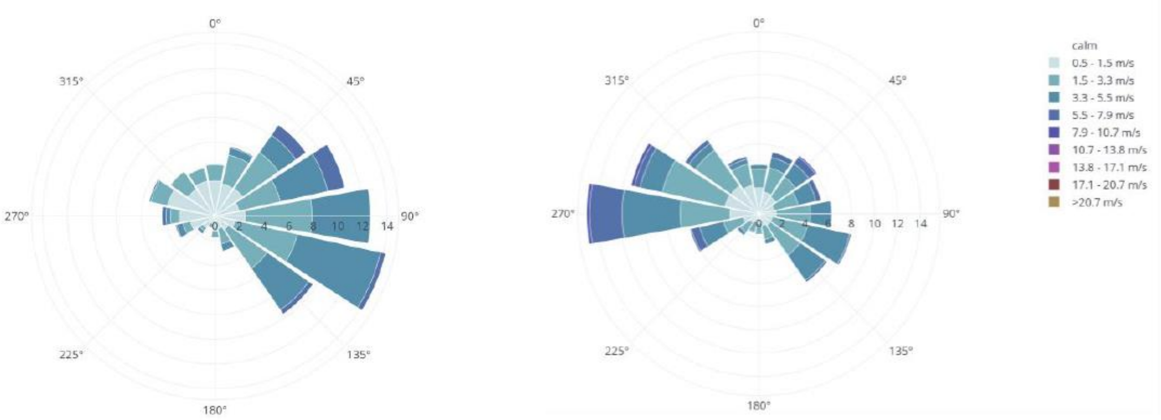
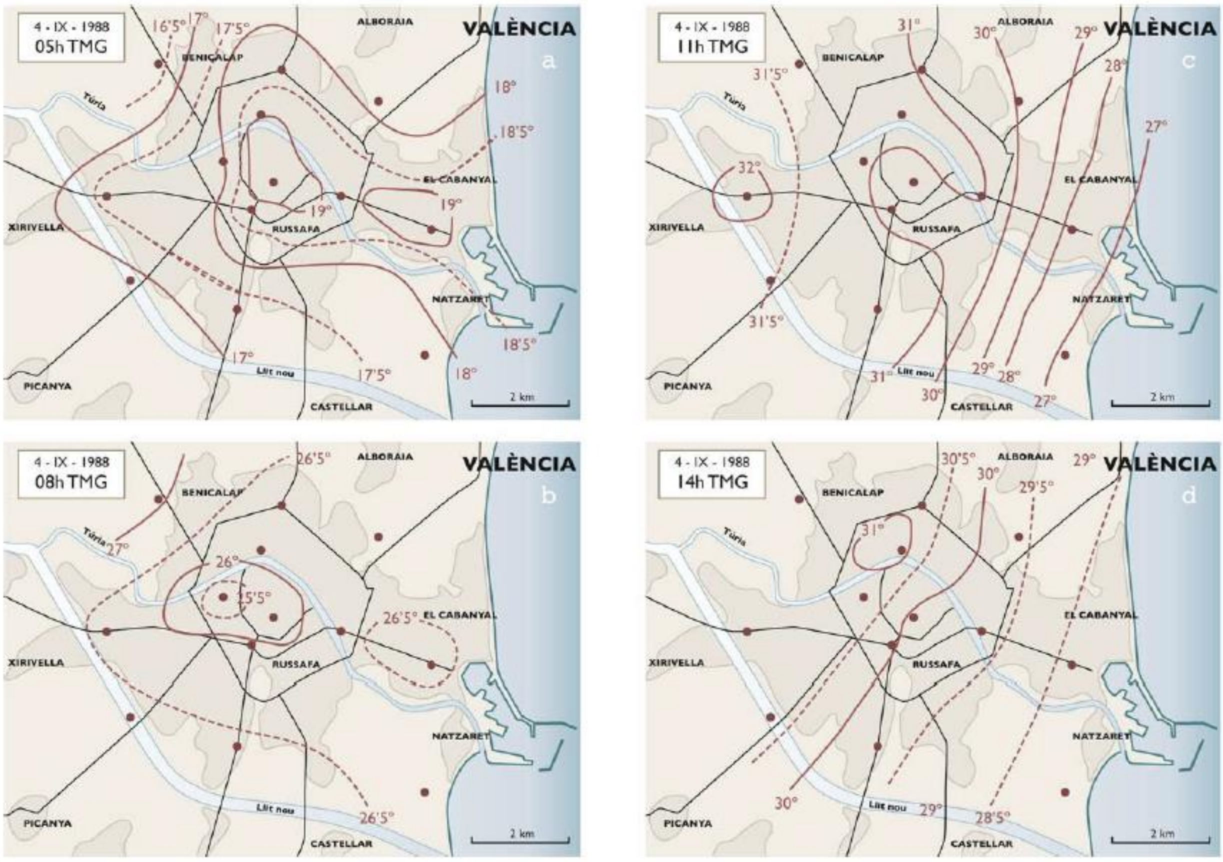


Figure 8: Wind Rose between 13:00-24:00h in June-August, Valencia. Source: CBE Clima Tool

In Valencia, the heat island phenomenon is worsened by tropical nights (more than 20°C) and torrid nights (more than 25°C). In the following maps, we can check some climate variations due to UHI and breeze flow.



Map 11: Evolution of thermal patterns in Valencia during a day with breeze. Source: Perez Cueva, Revista métode (2001), https://metode.es/revistas-metode/monograficos/clima-y-confort-en-las-ciudades-la-ciudad-de-valencia.html

These alterations mark notable environmental differences within the city through the progressive heating of the breeze, starting from original temperatures that are almost always comfortable. This overheating is greater in its urban route than in the countryside. Since the predominant breezes come from the southeast, the northwest part of the city has the maximum urban routes of the breeze. There, the temperature increases with respect to the coastal neighborhoods, regularly reaching about 4 °C, enough to go from conditions that are on the edge of comfort in the maritime neighborhoods to almost oppressive conditions in the west of the city.

Energy Use and Cooling Demand

Residential Energy Consumption

According to the 2M indicator (AIEOLUZ 2023) in 2021, 21,16% of Valencian households allocated more than double the median percentage of annual income to purchasing energy for housing.

As already explained, most houses are inefficient constructions, and unrenovated houses face serious problems of humidity, mold, and dampness, making it very difficult to keep an adequate temperature inside, both in summer and winter. In addition, according to the PD index - perceptions based on statements - (AIEOLUZ, 2023), 32,68% of Valencian households are both really cold in winter and really warm in summer inside their houses. They state that their access to energy negatively affects their daily life. In fact, according to the municipal barometer, 70% of families cut back on consumption at the expense of reducing well-being.

Cooling Technologies

Urban Heat Islands have negative impacts that affect people in different ways. These can increase existing vulnerabilities not only for individuals but also for communities. In the case of Natzaret and La Malva-Rosa, the best example is how people live in old buildings and houses, in many cases without air conditioning. If we compare them with other neighborhoods, they also have limited access to quality green spaces. This clearly impacts on how to copy with the heat and increases the risk of heat-related **illnesses**

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4.2 UHI & Micro-Climate Analysis Croatia

Introduction

Purpose:

The primary goal of the analysis is to identify UHI (Urban Heat Island) effects and micro-climate factors at the neighborhood level. The term "urban heat island" refers to cities getting much warmer than their surrounding rural landscapes, particularly during the summer. This temperature difference occurs when cities' unshaded roads and buildings gain heat during the day and radiate that heat into the surrounding air. As a result, highly developed urban areas can experience mid-afternoon temperatures that are 8°C to 12°C warmer than surrounding vegetated areas. [6]

High population density, energy use, and closely built structures that restrict airflow further intensify the heat. This temperature increase can lead to higher energy demands, health risks, poor air quality, and even changes in local weather patterns.

The environmental characterization of Pula city shows the factors that influence the reccurance of the UHI effect, such as the distribution of rural and urban areas, presence of bodies of water and green areas, and the demographic picture of the city.

Scope:

The City of Pula is located in the southern part of the Istrian peninsula in Croatia, bordered by the Adriatic Sea. The geographic boundaries of Pula include the surrounding coastal areas and extend inland. While (our study area) Monte Zaro is a specific neighborhood within Pula, it does not have official geographic boundaries as it is more of a local reference to an area surrounding a hill (Monte Zaro). It is an especially interesting area due to its proximity to the sea and coastal characteristics.

Two types of temperature data can be analyzed to measure the effects of urban heat islands (UHI) on air temperature and land surface temperature (LST). Atmospheric UHI is based on air temperature measurements. To assess this, scientists use ground-based sensors that directly measure the air temperature in urban and surrounding areas. Surface UHI relies on land surface temperatures, reflecting the ground temperature or surfaces like buildings and roads. Land surface temperature is measured using remote sensing technologies, such as satellites or airborne sensors, which can detect the heat emitted by these surfaces from above.

Methodology:

Copernicus is the Earth observation component of the European Union's Space program developed by the European Union (EU) and the European Space Agency (ESA). It provides accurate, timely, and easily accessible information to improve the management of the environment, understand and mitigate the effects of climate change, and ensure civil security.

ESA has developed a new family of satellites, called Sentinels, specifically for the operational needs of Copernicus. Currently, two complete two-satellite constellations, Sentinel-2 and Sentinel-3, are in orbit, plus two additional single satellites, Sentinel-5P and Sentinel-6 Michael Freilich. The environmental

[6] Urban Heat Islands | HEAT.gov - National Integrated Heat Health Information System

information obtained by the Sentinel satellites consists of thermal, optical, and high-frequency radar images useful for atmospheric, oceanic, and terrestrial-monitoring.

The two Sentinel-3 satellites, used in this analysis, launched on 16 February 2016 and 25 April 2018, providing data for services relevant to the ocean and land. Images provided by The Sentinel-3 (S-3) since 2017 are appropriate for studying the surface UHI (SUHI) effect.[7] Sentinel-3 mission's main objective is to measure the sea surface topography, the sea and land surface temperature, and the colour of the ocean and land surface. To achieve this goal, Sentinel-3 has a combination of different instruments on board. The most important instruments are the Ocean and Land Colour Instrument (OLCI), the SAR Radar Altimeter (SRAL) and the Sea and Land Surface Temperature Radiometer (SLSTR). Sentinel-3 SLSTR L1B temperature images were analysed in this work using data from May 2016 onwards.

Neighborhood Overview

Geographical Context:

Pula is the largest city in Istria County, Croatia situated at the southern tip of the Istrian peninsula in northwestern Croatia. It is the seventh-largest city in the country. It is known for its many ancient Roman buildings, the most famous of which is the Pula Arena, one of the best-preserved Roman amphitheaters. The city has a long wine-making tradition, fishing, shipbuilding, and tourism. It was the administrative center of Istria from ancient Roman times until superseded by Pazin in 1991. The city lies on and beneath seven hills on the inner part of a wide gulf and a naturally well-protected port (depth up to 38 m) open to the northwest with two entrances: from the sea and through Fažana channel. The city is a popular tourist holiday destination in the summer because it is surrounded by the countryside nearby (Brijuni National Park) and the Adriatic Sea, enabling activities such as sailing, fishing, and cliff diving. Today, Pula’s geographical area amounts to 12,760 acres, 10,280 on land and 2,510 at sea. City has medieval characteristics, such as narrow and small streets. During the winter, the area is mostly residential, containing office buildings, different stores in the city center, and more residential houses in rural areas.

The pilot area Monte Zaro is a hilly area in Pula that is located 28 m above the sea level and the majority of area is taken up by residential buildings, except Monte Zaro Park, rich in vegetation usually used for recreational purposes.

[7] ESA - Introducing Copernicus

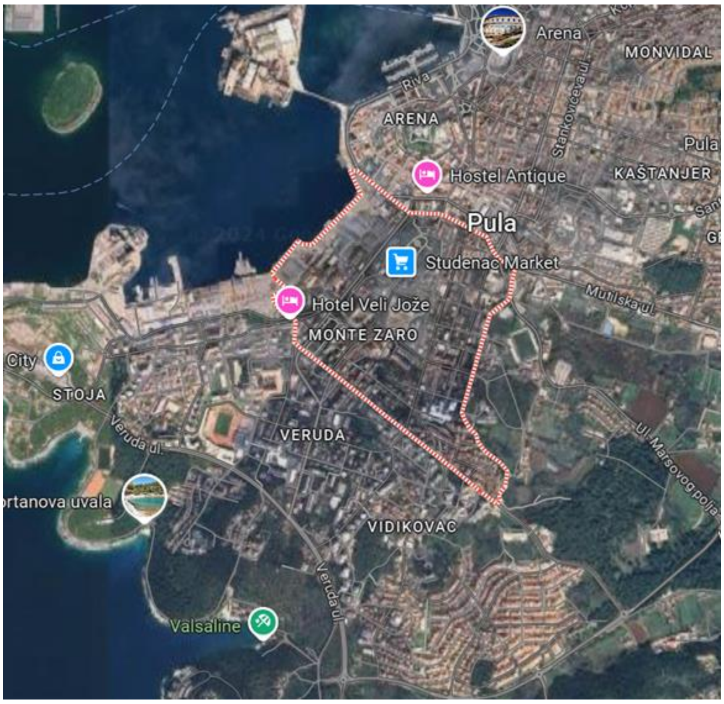


Figure 7. Monte Zaro district, Pula; source: Google Maps

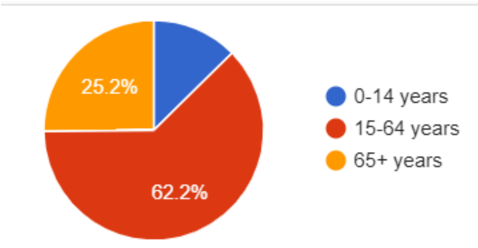
Demographics:

As of the 2021 census, Pula had a population of approximately 52,411 residents. The overall population density in Pula is around 1,000 inhabitants per square kilometer (km²). However, this can vary within different parts of the city, with central urban areas being more densely populated than the outskirts.

Monte Zaro is part of the central urban zone of Pula, which generally has a higher population density compared to suburban areas Monte Zaro covers an area of 323,720 m², with a population of 3,502 residents. The population density is 10,818 inhabitants per square kilometer.

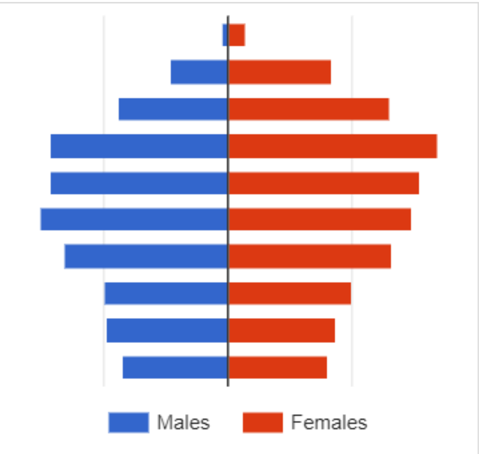
The age distribution in **Pula**, like in most cities, is divided into key demographic groups: **children, working-age adults, and the elderly**. According to the latest census data (2021), Pula's population reflects trends seen in much of Croatia, with an aging population and a declining birth rate.

Here's an overview based on these trends:



Age Groups (C 2021)	
0-14 years	6,580
15-64 years	32,502
65+ years	13,138

Figure 8. Demographics of Pula, source:https://www.citypopulation.de/en/croatia/admin/istra/3590__pula/



Age Distribution (C 2021)	
90+ years	486
80-89 years	3,261
70-79 years	5,442
60-69 years	7,790
50-59 years	7,451
40-49 years	7,478
30-39 years	6,569
20-29 years	4,979
10-19 years	4,640
0-9 years	4,124

Figure 9. Age distribution in Pula; source: https://www.citypopulation.de/en/croatia/admin/istra/3590__pula/

In Pula, living costs are relatively moderate compared to many Western European cities. The average monthly net salary is around 900 – 1,100 € per month, slightly lower than the average monthly net salary in Croatia (around 1,300 €)[8]. Living costs can vary slightly with the tourism season, as summer months bring higher activity and prices in the area.

Urban Heat Island (UHI) Effect Analysis

Temperature Mapping:

According to analyzed data from the Pula Airport meteorological station from 2008 to 2021, it is recorded how the area is subjected to strong heatwaves during the summer. The most precipitation was in the autumn period, with the highest precipitation in November. The lowest precipitation is in the summer, with the lowest values in July and August and the highest temperatures in the summer. Therefore, the summer season will be analyzed in further research.

God.	mjesec												Sr. god.
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2008	8,1	7,3	9,7	13,4	18,2	22,1	24,1	24,4	18,5	16,4	11,8	8,1	**15,2**
2009	5,9	7,1	9,8	15,3	19,6	20,5	23,9	25,1	21,2	15,0	12,2	7,2	**15,2**
2010	4,9	6,8	8,8	13,7	16,9	21,1	24,8	23,2	18,9	14,0	12,5	6,4	**14,3**
2011	6,5	6,7	10,0	15,9	18,2	21,7	22,9	24,9	22,9	15,0	11,0	9,3	**15,4**
2012	6,1	2,8	11,6	12,7	17,0	22,8	25,3	25,5	20,9	16,5	13,4	7,4	**15,2**
2013	7,6	5,9	8,4	13,8	17,1	21,0	24,9	24,6	20,1	16,2	11,9	9,4	**15,1**
2014	10,2	10,5	11,7	14,4	16,7	22,0	22,4	22,8	19,2	16,8	14,3	8,9	**15,8**
2015	7,9	6,2	9,5	12,5	18,1	22,1	26,8	25,7	20,5	15,8	11,7	8,8	**15,5**
2016	7,2	10,1	10,2	14,3	16,9	21,5	25,0	23,9	21,7	15,3	12,0	7,6	**15,5**
2017	3,3	8,6	11,7	13,3	17,6	23,2	24,7	25,9	18,9	15,7	11,1	7,5	**15,1**
2018	9,0	4,9	8,5	15,8	19,9	22,2	24,8	26,2	21,3	17,6	12,8	8,0	**15,9**
2019	4,9	8,1	11,0	13,2	14,5	22,8	23,5	24,4	19,4	16,2	13,5	8,8	**15,0**
2020	7,4	9,3	9,5	13,5	17,3	20,7	24,1	25,8	21,2	15,2	11,0	9,2	**15,3**
2021	6,3	8,4	8,5	10,7	15,7	23,3	25,6	24,4	20,8	14,4	11,8	6,9	**14,7**
Sr. mj.	**6,8**	**7,3**	**9,9**	**13,7**	**17,4**	**21,9**	**24,5**	**24,8**	**20,4**	**15,7**	**12,2**	**8,1**	**15,2**

[8] https://podaci.dzs.hr/2024/en/76866

Figure 10.Average monthly and yearly air temperatures (°C) in Pula 2008.-2021.; source:Meteoblue

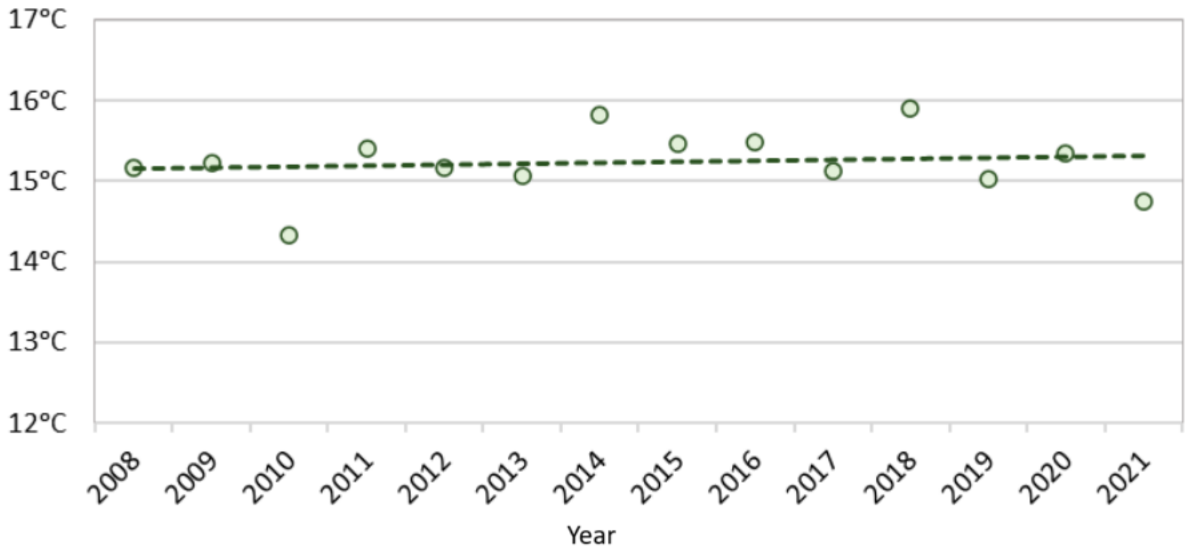


Figure 11. Trend of average annual air temperatures (°C) for Pula from 2008 to 2021, source: Meteoblue

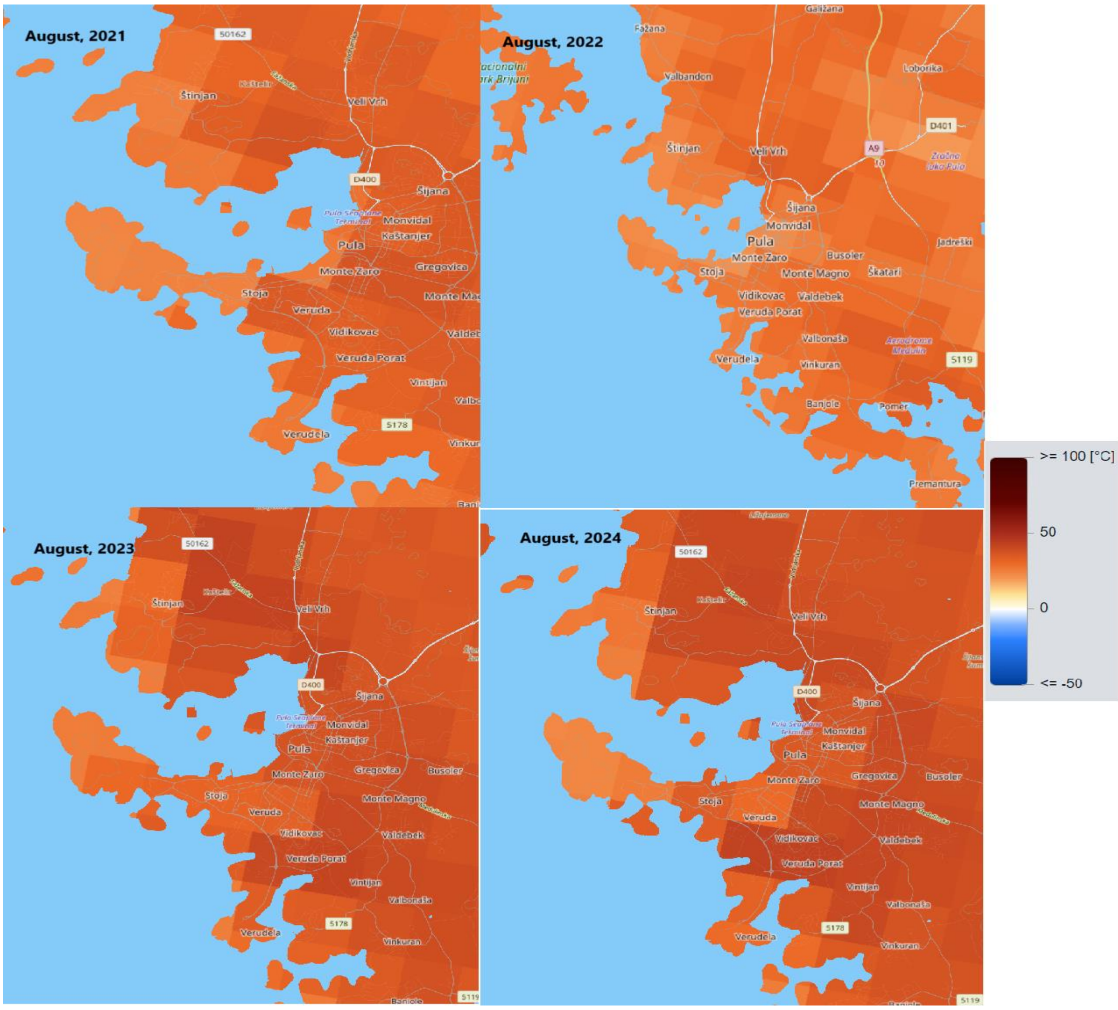


Figure 12. S-3 Thermal IR fire emission bands, by S-3 showing daily temperature of different August days from 2021.- 2024.

Regarding the temperature satellite measurements, the images of S-3 from the Copernicus program, as shown in Figure 6, represent the thermal infra-red fire emission bands (F2 Channel), and it is useful for high-temperature monitoring at 1 km resolution. Despite the relatively limited resolution, it is possible to note that temperatures are the highest in the coastal areas and the valley floors, where the major port places are present. Monte Zaro district is located in an area that shows higher temperatures than those in surrounding areas, creating the urban heat island effect and heat pockets.

The temperature rises significantly from 2021. to 2024., it is assumed that summers will be warmer and warmer, and the heat island effect (UHI) is expected to be even more visible and extreme in the near future.

Precipitation[9]

According to the data for the amount of precipitation for the location of Pula from 2008 to 2021, the most precipitation was in the autumn period, with the highest amount of precipitation in November. The lowest precipitation is in the summer period with the lowest values in July and August, as shown in Figures 7, 8. Precipitation decreases every year, as shown in Figure 9.

God.	Mjesec												Uk. god.
	1	2	3	4	5	6	7	8	9	10	11	12	
2008	86,7	40,0	85,2	72,9	47,5	51,9	6,9	21,5	9,3	30,9	144,2	199,3	**796,3**
2009	97,4	77,9	97,3	62,3	12,3	25,3	19,7	38,8	48,5	36,7	165,1	136,9	**818,2**
2010	192,4	85,5	53,0	55,7	53,3	94,6	18,3	21,6	105,2	58,0	193,7	130,7	**1.062,0**
2011	19,8	37,5	127,7	27,6	48,4	34,2	40,2	0,1	12,2	125,4	31,7	51,9	**556,7**
2012	36,7	33,0	0,5	64,3	71,1	18,0	1,8	3,8	47,6	73,9	176,9	108,1	**635,7**
2013	85,7	82,6	124,9	34,9	78,4	6,8	0,6	20,3	45,7	85,7	151,0	9,3	**725,9**
2014	107,0	112,7	47,1	30,7	40,8	13,0	100,0	14,5	90,3	11,9	128,4	57,1	**753,5**
2015	34,8	108,4	46,4	25,8	32,9	15,7	2,1	44,2	45,3	139,3	31,7	0,2	**526,8**
2016	89,8	123,8	48,8	41,4	81,7	49,0	4,3	13,7	44,1	46,4	100,7	1,4	**645,1**
2017	13,1	71,9	27,3	53,1	35,3	18,9	2,9	3,1	114,0	21,9	104,1	48,7	**514,3**
2018	44,8	143,2	100,9	23,3	45,8	79,2	8,0	27,8	8,0	67,0	133,4	20,4	**701,8**
2019	17,2	18,3	30,3	69,8	93,9	6,6	33,9	2,5	59,5	16,7	141,9	115,2	**605,8**
2020	31,1	1,2	30,8	3,4	19,9	53,5	6,9	36,4	112,8	114,1	27,2	134,8	**572,1**
2021	84,7	35,6	11,3	87,2	27,5	1,9	26,9	11,8	16,8	17,8	80,5	57,8	**459,8**
Sr. mj.	**67,2**	**69,4**	**59,4**	**46,6**	**49,2**	**33,5**	**19,5**	**18,6**	**54,2**	**60,4**	**115,0**	**76,6**	**669,6**

Figure 13.Average monthly precipitation (mm) for Pula from 2008. to 2021.

[9] program_klimatske_promjene-ozon_pula_konacna_verzija_srpanj.pdf

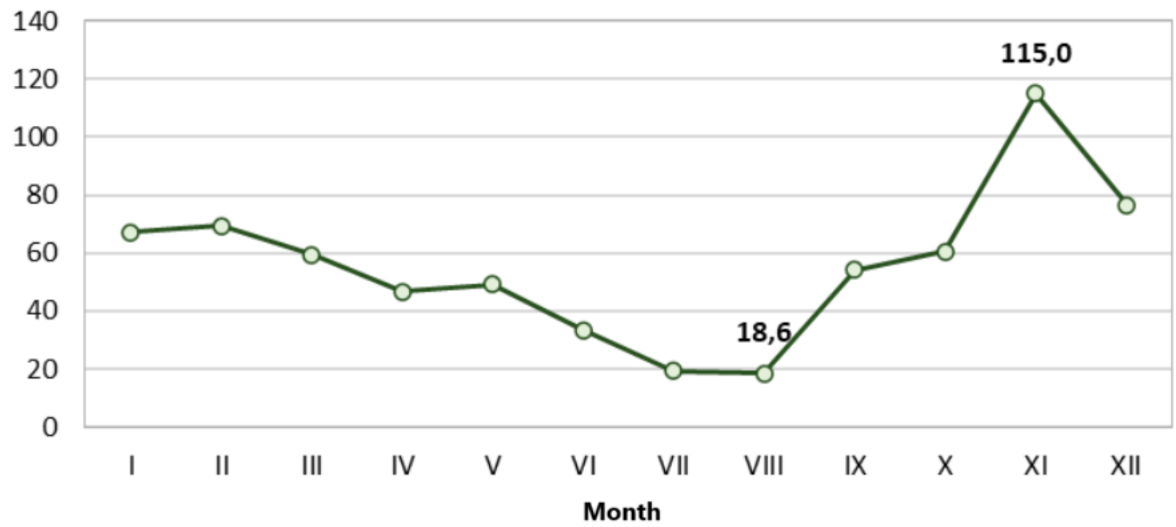


Figure 14. Annual distribution of monthly precipitation (mm) for the location of Pula from 2008. to 2021.

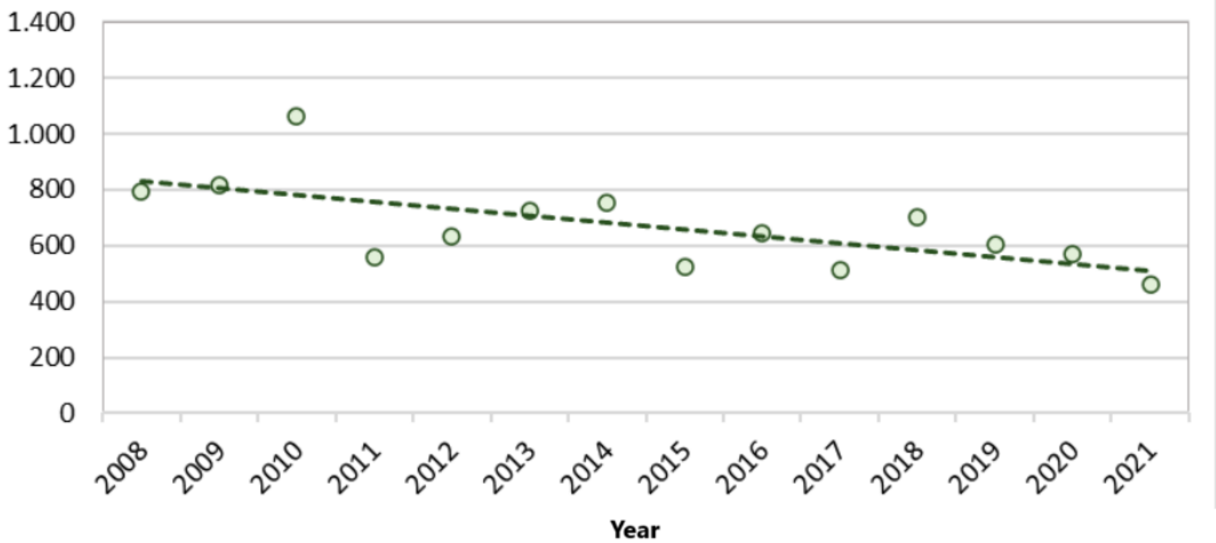


Figure 15.Trend of total annual precipitation (mm) for the location of Pula from 2008.to 2021.

Rain cools surfaces due to evaporation. As the water on surfaces evaporates after precipitation, it pulls heat from the surrounding air, lowering the temperature. In urban areas, where concrete and asphalt surfaces dominate, evaporation can significantly reduce air temperatures, at least temporarily. Surfaces such as asphalt and concrete that dominate in the city tend to trap heat. When rain cools down these surfaces, accumulated heat decreases, which reduces nighttime temperatures in urban areas, reducing the contrast between temperatures in urban and rural areas. The effect of precipitation is more visible during winter and autumn periods when precipitation is more frequent, and temperatures are naturally lower. In summer, precipitation often increases the relative air humidity, sometimes further enhancing the feeling of warmth, especially when air circulation is restricted due to tall buildings and narrow streets. Rainwater quickly runs off in cities due to the intensive sewage network and many impermeable surfaces like asphalt and concrete. Thus, the precipitation helps reduce the heat, but its effect can be limited, especially in dense urban areas.

Temporal Analysis:

The urban heat island (UHI) effect is at its peak in summer and winter. By analyzing different times during the year, it is possible to note that the UHI effect is most visible during August when the temperatures are the highest, as shown in Figure 10.

Although there is no data on when the UHI effect is most visible in Pula city during the day, according to the data on temperature peaks and analyses, it can be concluded that the UHI effect is highest during the evening and nighttime, specifically from sunset to just before dawn. In the daytime, direct solar heating affects both rural and urban areas, reducing their temperature difference. Thus, the UHI effect is less pronounced during peak sunlight hours (roughly from 10 a.m. to 4 p.m.) because the sun is heating all surfaces intensely.

The temperature differences are the highest due to the accumulated heat that radiates from urban areas and waste heat produced by the AC systems, vehicles, and factories.

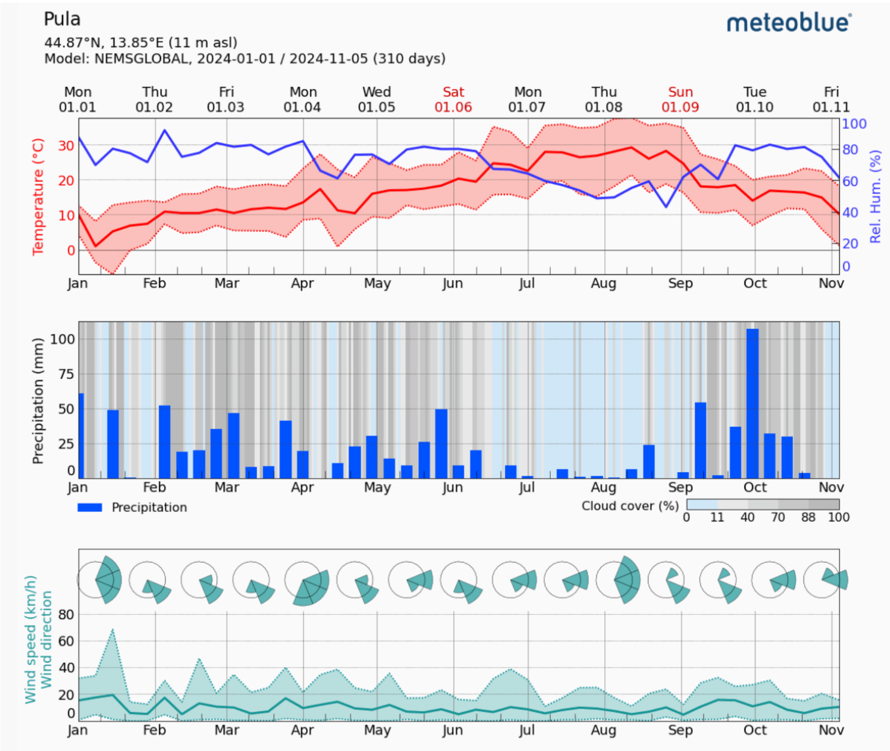


Figure 16. Weather analysis during the year 2024.; source: Meteoblue

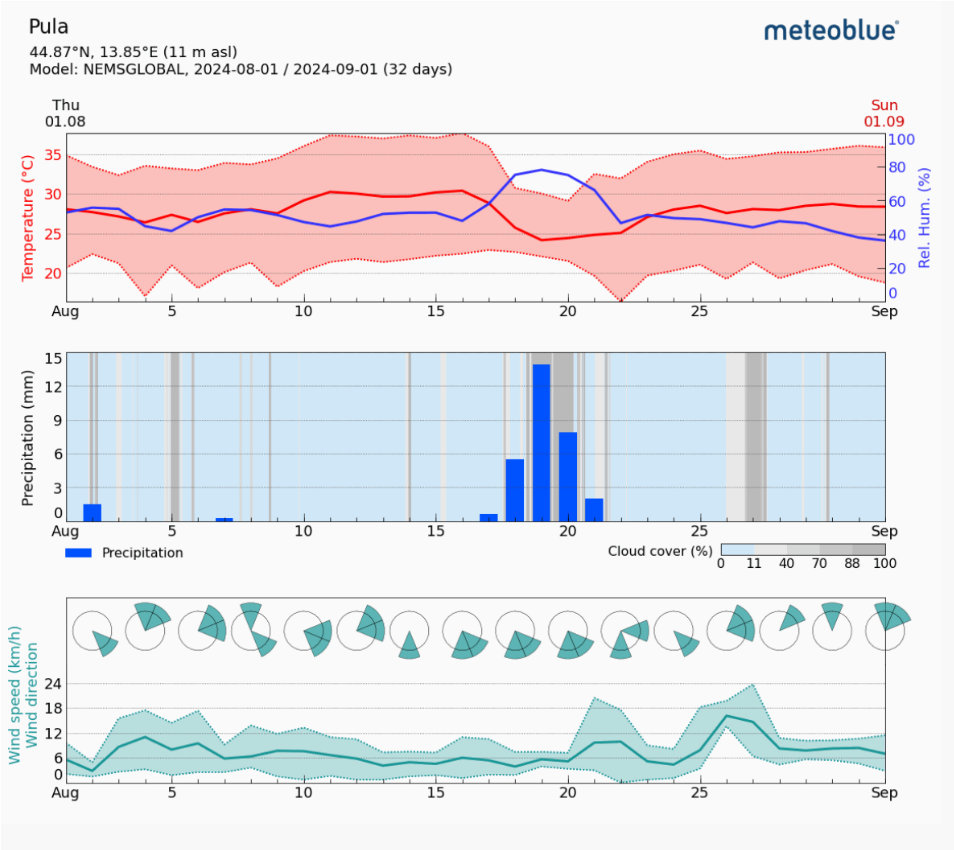


Figure 17. Weather analysis for August, 2024.; source: Meteoblue

The summer period was chosen for UHI effect analysis because it is the season when the most harmful effects have been noted during the past. As shown in weather analysis in Figure 10 and Figure 11, summer 2024 has peak temperatures (>30 °C) in August, with the lowest precipitation during 2024. These conditions cause dangerous and harmful effects to human health and nature, especially for people living in cities during heat waves.

Heat islands contribute to higher daytime temperatures, reduced nighttime cooling, and higher air pollution levels. These, in turn, contribute to heat-related deaths and heat-related illnesses such as general discomfort, respiratory difficulties, heat cramps, heat exhaustion, and non-fatal heat stroke. Sensitive populations such as older adults, young children, and low-income populations (due to poor housing conditions) are particularly at risk during these events.[10]

[10] https://www.epa.gov/heatislands/heat-island-impacts

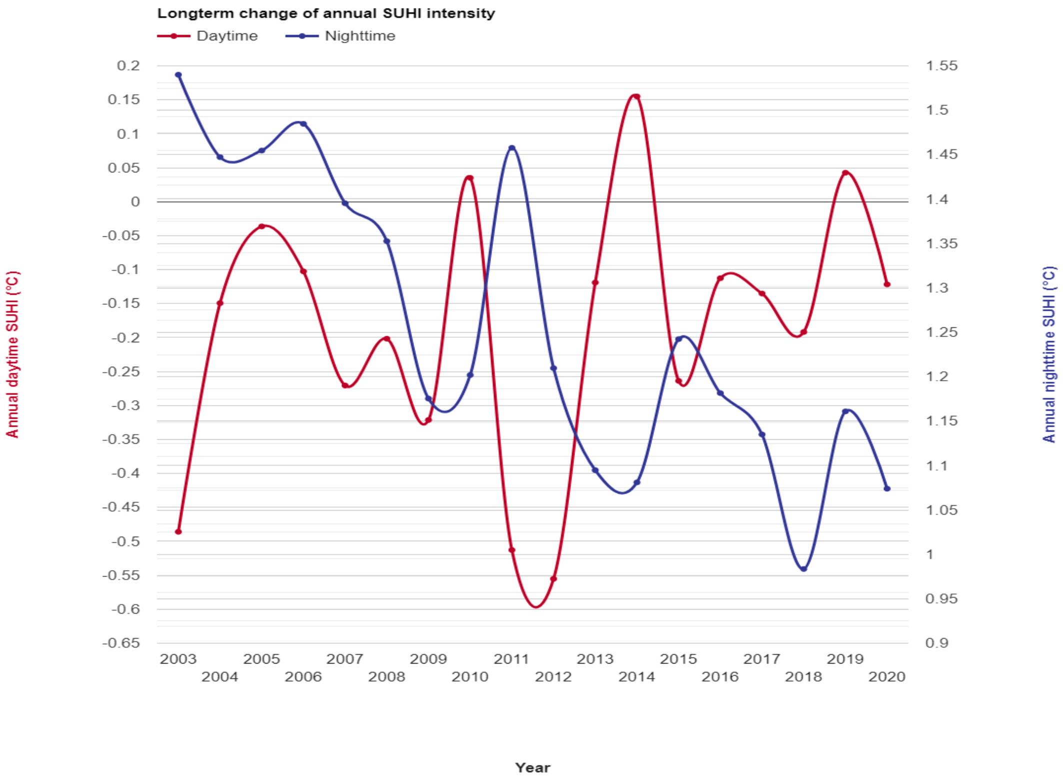


Figure 18. Longterm changes of annual Surface Urban Heat Island (SUHI) effect; source: https://yceo.users.earthengine.app/view/uhimap

Analysis results:

Annual daytime SUHI: -0.19 °C

Annual nightime SUHI: 1.26 °C

Summer daytime SUHI: -0.24 °C

Summer nighttime SUHI: 1.33 °C

Winter daytime SUHI: -0.21 °C

Winter nighttime SUHI: 1.36 °C

Figure 12 shows the long-term intensity of the UHI effect for both daytime and nighttime periods between 2003 and 2020. Both characteristics show a slight drop after 2015. could indicate a minor improvement in mitigating the effect; however, the UHI will continue to intensify due to global warming and constant temperature rise.

Spatial Distribution:

The Global Surface UHI Explorer is used to map the area of interest. The Global Surface UHI Explorer is an interactive web app to monitor urban heat island (UHI) intensities of practically all urban clusters on Earth. The app is built on the Google Earth Engine platform and allows users to query the UHI data of urban areas using a simple interface.

Figure 13 shows the average SUHI effect for the daytime and nighttime in the summer of 2020. It shows how port areas in Pula have higher temperatures than the rural area (around 2 to 3 degrees during the day and 3 to 4 degrees during the night). The differences between daytime and nighttime occur due to concrete and asphalt accumulating heat during the day and containing it during the night (these materials take longer to cool) which is why the nighttime UHI is more pronounced than daytime UHI.

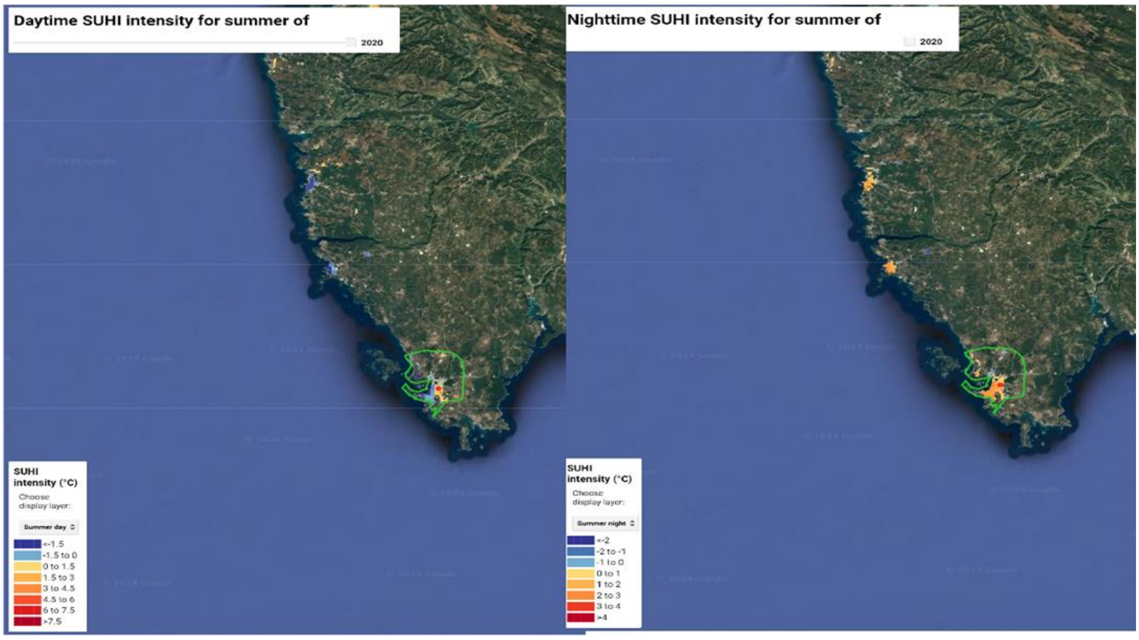


Figure 13. Daytime and nighttime SUHI comparison for the summer of 2020; source:https://yceo.yale.edu/research/global-surface-uhi-explorer

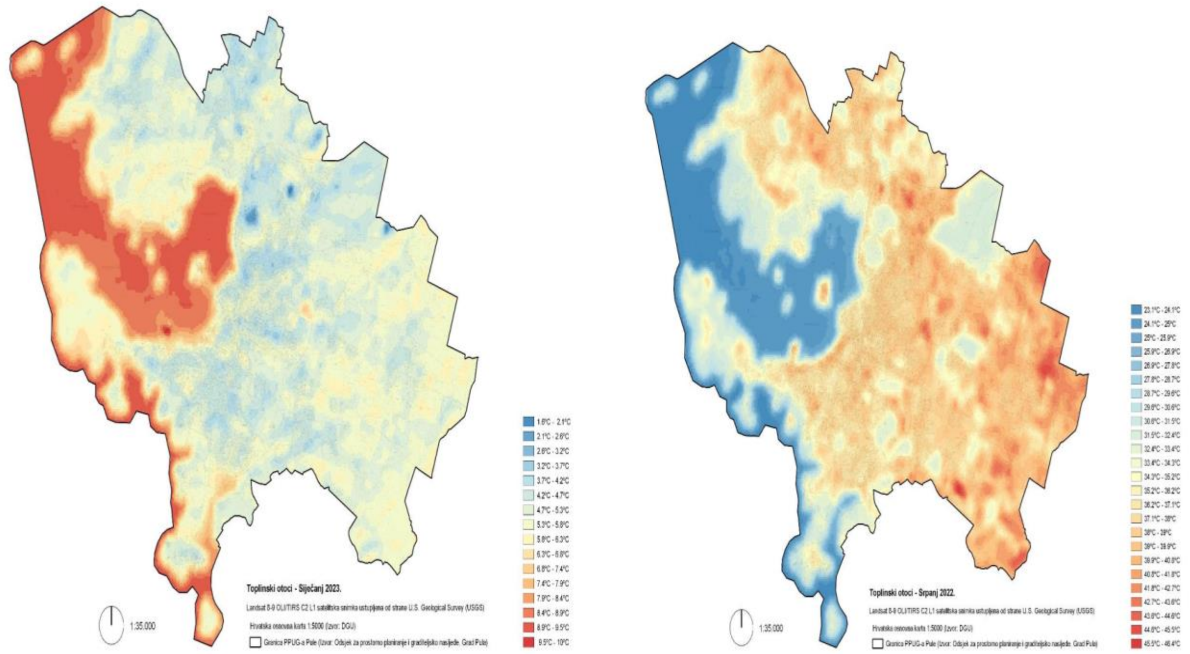


Figure 19.Urban Heat Island for a) Janary 2023 and b) July 2022,source: https://www.pula.hr/media/filer_public/e4/c9/e4c913f7-06fe-4a44-a611-04da1839a400/strategija_zelene_urbane_obnove_grada_pula_pola_do_2030_godine_sazetak.pdf

According to the analysis of heat island for January, the sea has higher temperature than the mainland- the highest sea temperature is 9°C. Winter heat islands coincide with summer as shown in Figure 14- the highest temperatures on the mainland were recorded in the area of the Pula City Mall shopping center (7°C), in the area of the football field next to the Aldo Drosina stadium and along the Uljanik Stadium (6°C). Smaller heat islands are also represented by arable land, meadows, and pastures (6°C). Among the cooler point locations, the city cemetery on Monte Ghiro (2°C), the Bauhaus building (1.6°C), the Veli Vrh primary school (3.6°C), the Vidrijan quarry and the quarry near the Valtura penitentiary (2°C and 3°C).

The temperature of arable land, meadows, and pastures is higher than that of forest areas and areas overgrown with thickets by about 2.5°C.

For the period of July 2022, the highest temperature was recorded in the Uljanik shipyard, in the area of production and business halls, and in the area of meadows and arable land(Corine Land Cover Map for reference, Figure 15). As expected, the lowest temperatures were recorded in parks, forests, and public areas where trees are planted.

Micro-Climate Factors

Surface Characteristics:

Most Pula surfaces around the pilot area are made of asphalt and concrete, which retain and accumulate heat during the day, contributing to the urban heat island effect, especially during summer. These surfaces cool down slowly during the night, retaining heat in the urban area. Urbanized areas are mostly located in ports, along with some industrial commercial buildings as shown in Figure 15.

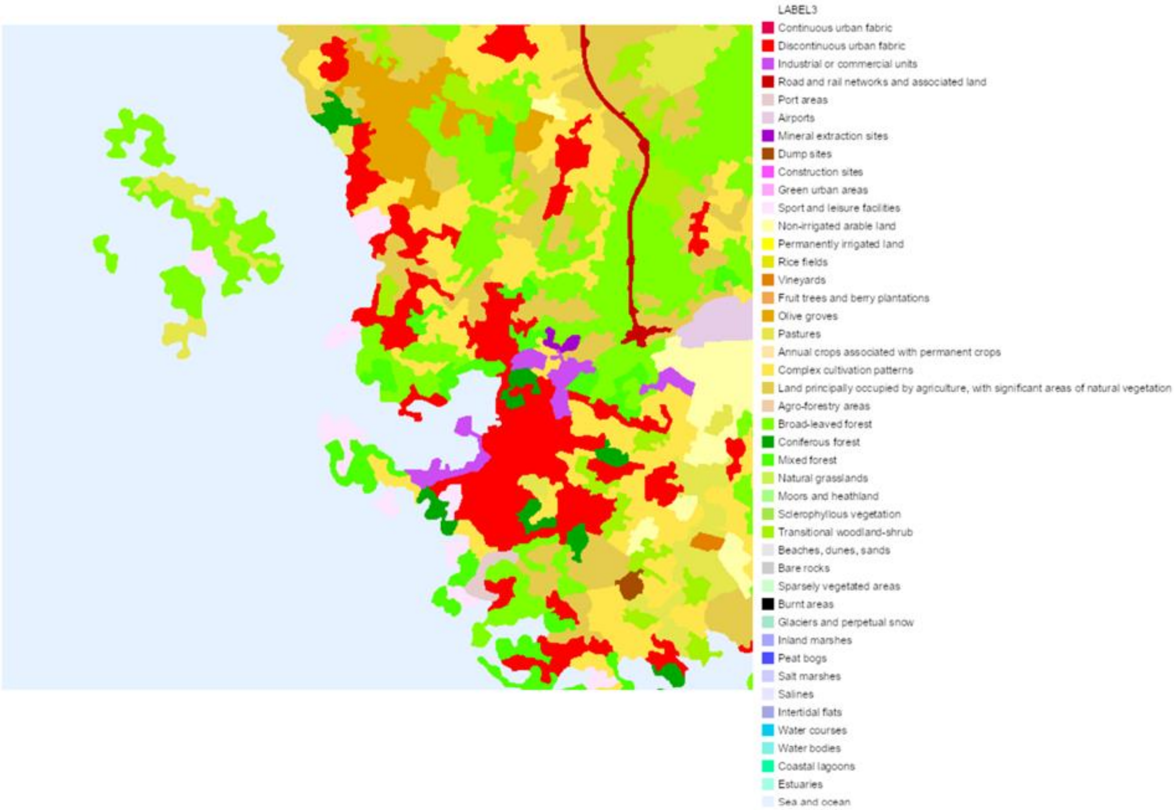


Figure 15. Corine Land Cover Map (2018);source: CLMS

Green Spaces:

On the example of the City of Pula, the existing green infrastructure consists of forests (Šijana Forest,Busoler), protective green areas, public green areas, parks, memorial cemetery (Naval Cemetery), NBS systems, squares, tree alleys, bicycle lanes, pedestrian paths and point locations such as art parks, children's playgrounds, dog parks, urban gardens and locations on which exercise equipment is installed. About 67 children's playgrounds are under the management of the company Pula Sport d.o.o., which takes care of the maintenance and arrangement of children's playgrounds. The rest are children's playgrounds located within kindergartens, tourist resorts and shopping centers; thanks to their large number, the city of Pula bears the title of Child Friendly City. Abandoned and poorly used spaces and buildings of the city represent the potential for applying NBS solutions. Using the existing built infrastructure reduces the need to construct new areas of grey infrastructure. The area of the Uljanik shipyard also represents a huge potential for the circular economy and amplifying city green infrastructure network. A separate group consists of green infrastructure, like rainwater gardens and underground retentions. These NBS solutions are related to the water sector, resolving the problem of more rational use of rainwater, improving living conditions in cities, and mitigating the consequences caused by climate change. Pula used to have flooding problems in the past, so roundabout raingardens and green oasis across the city (Trg Kralja Tomislava) have been introduced, soaking up the excess water (locations shown in Figure 16). In addition to working on the drainage system, soil quality, plants are also planned. For example, sage and lavender are planted along the edge, where water is least retained, and ornamental grasses are planted in the middle, which can withstand up to three months of drought and moisture.

Bike trails and hiking trails represent infrastructure that encourages citizens to recreate, therefore reducing the use of motor vehicles and thus reducing the emission of harmful gases into the atmosphere.

Urban gardens have an additional impact on biodiversity, lower emissions of harmful gases into the environment, encourage organic farming, and promote more sustainable food consumption. [11]

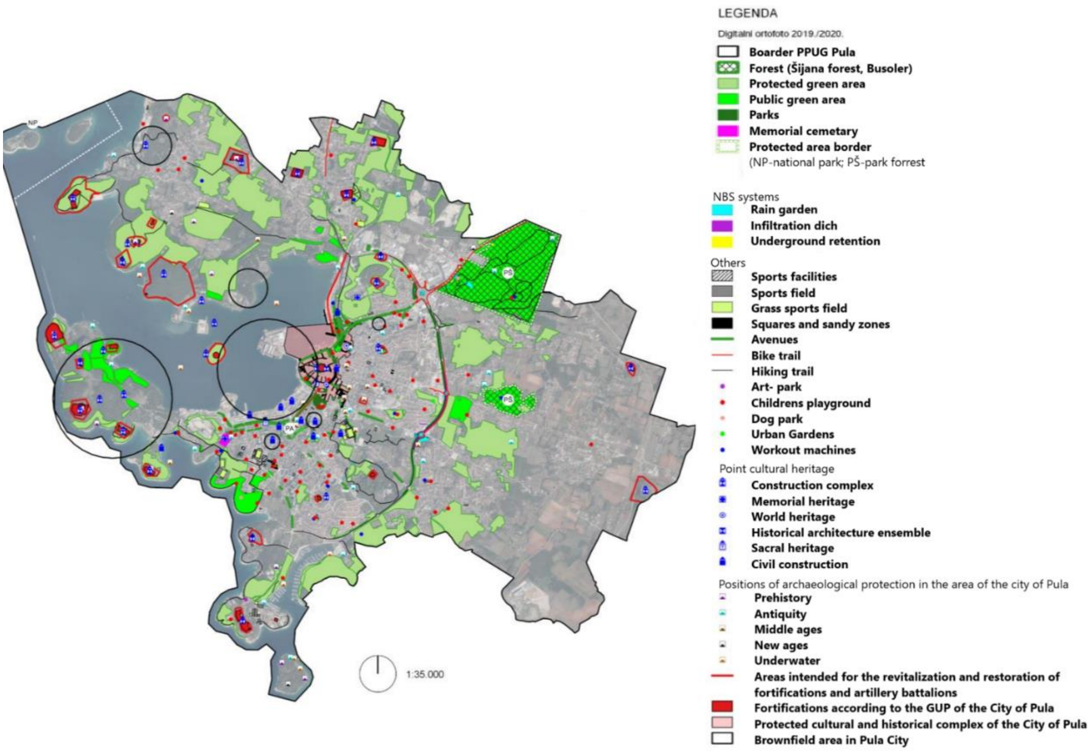
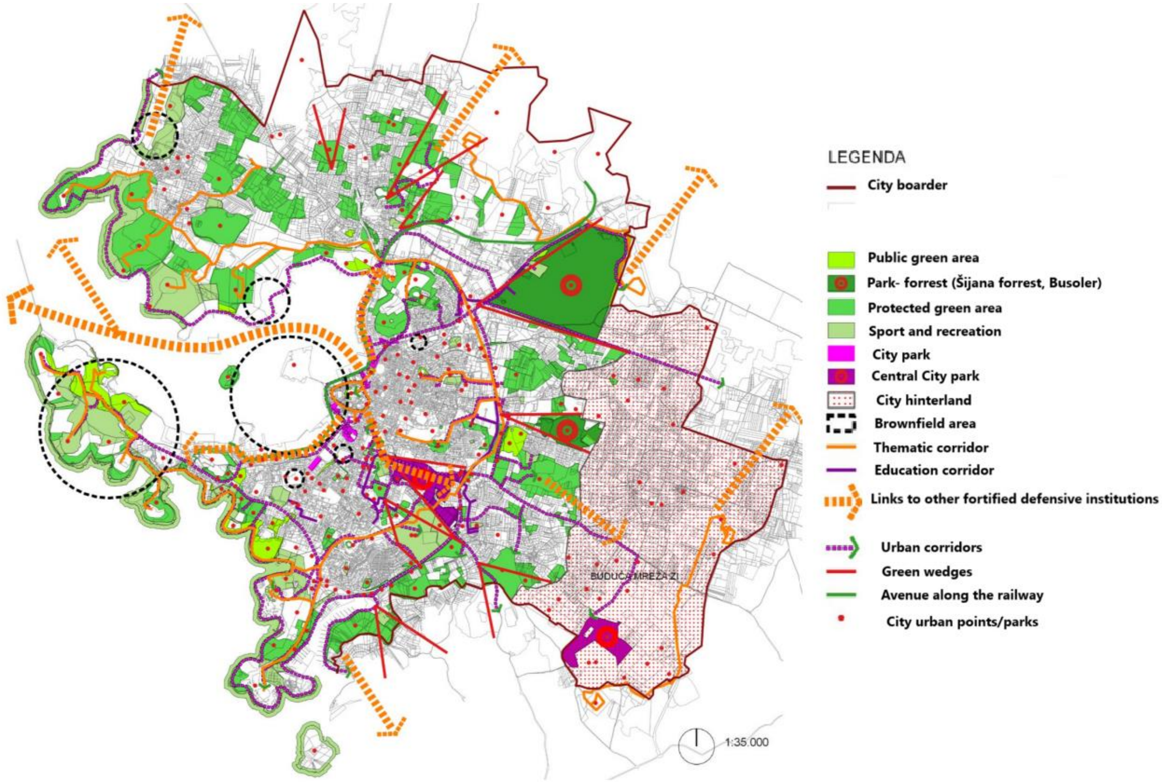


Figure 20. Pula city digital ortofoto 2019/2020, source:https://www.pula.hr/media/filer_public/e4/c9/e4c913f7-06fe-4a44-a611-04da1839a400/strategija_zelene_urbane_obnove_grada_pula_pola_do_2030_godine_sazetak.pdf



[11] STRATEGIJA ZELENE URBANE OBNOVE GRAD PULA-POLA

Figure 21. Green infrastructure network of Pula City; source: https://www.pula.hr/media/filer_public/e4/c9/e4c913f7-06fe-4a44-a611-04da1839a400/strategija_zelene_urbane_obnove_grada_pula_pola_do_2030_godine_sazetak.pdf

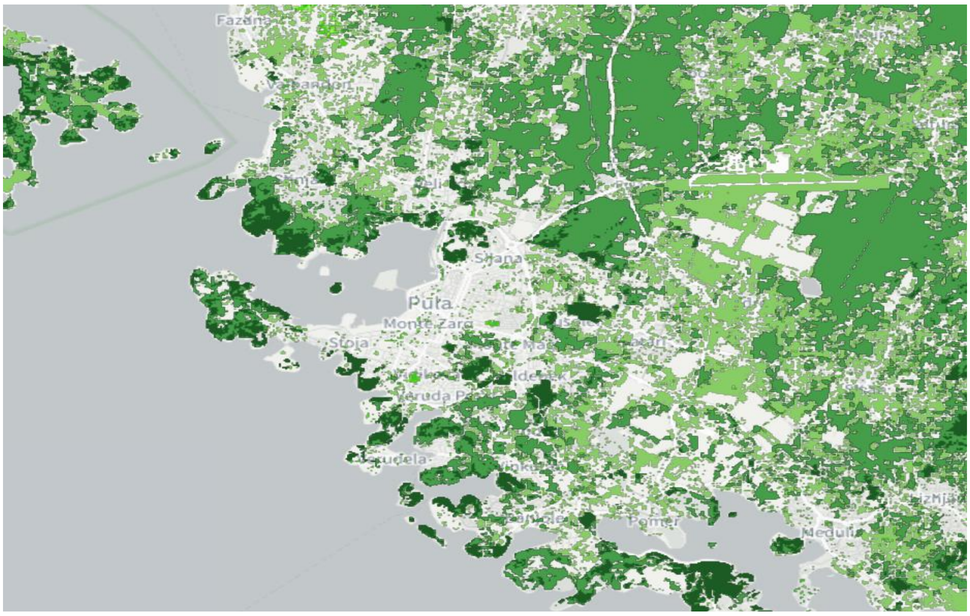


Figure 22. Distribution of green spaces, including parks, gardens and street trees, source: CLMS

Monte Zaro Park is a part of Monte Zaro district and has tree alleys, grassy areas and various vegetation. Trees provide shade, reducing the temperature in close proximity. Grass and other low vegetation have a significant effect on lowering soil and air temperature. They reduce temperature by evaporation, acting as natural cooling systems in the urban area. However, in port areas, the UHI effect can overcome the natural cooling effect of the sea and trees. The urban hinterland (locations shown in Figure 17) is currently and undefined suburban area with a quarter of agricultural, smaller forest areas and degraded habitats with the largest heat islands. From the urban hinterland, larger inflows of rainwater and surface water are generated toward the city itself, and drinking water sources are endangered, which is why the urban hinterland needs to be recovered. In the first phase, approximately 100 ha (out of 900 ha of rocky terrain) were reconciled, which could be rehabilitated by afforestation by 2030.

Building Density and Height:

Building height on average in Pula is around 12-15 m, with high building density (> 5 or more floors), creating an impervious layer that can lower airflow and support heat accumulation, especially during the summer, creating heat pockets. The rural areas surrounding the city consist of smaller buildings and detached houses, as shown in Figure 19 and Figure 20. Figure 19 shows how build-up is concentrated mostly in port area, lowering air flow and contributing to the UHI effect, while Figure 20 shows how impervious layers are distributed in the area. The impervious layer is created when asphalt, concrete, and other materials that do not absorb water are used, and it is usually the most dense in urban port areas as shown in Figure 20.

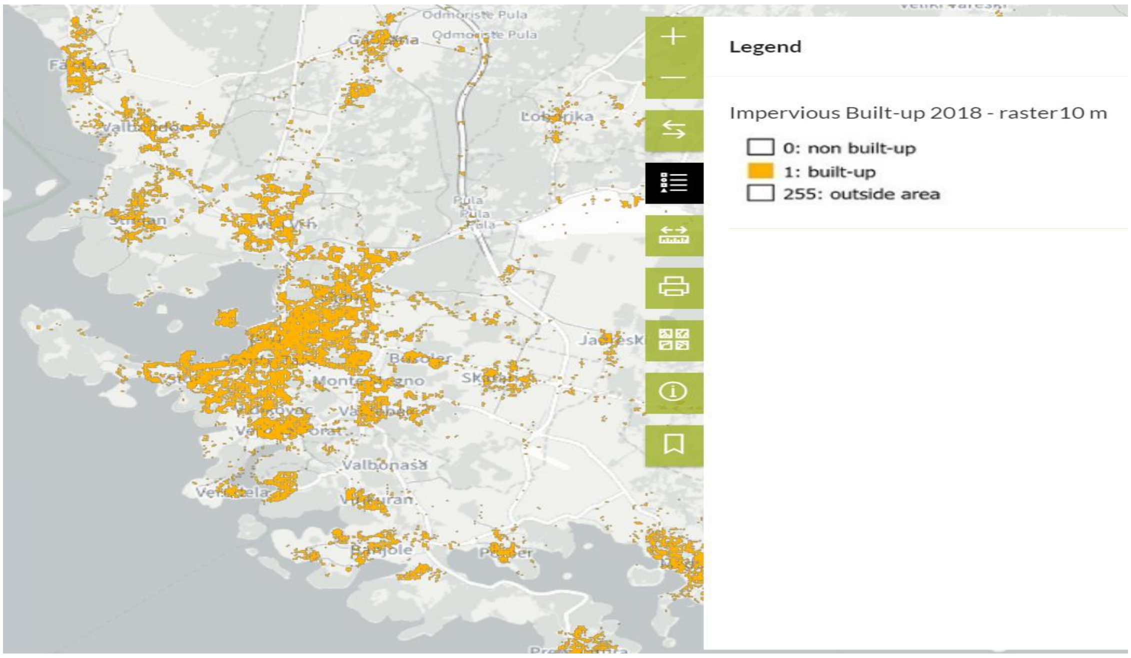


Figure 23.Buildings distribution, source:CLMS

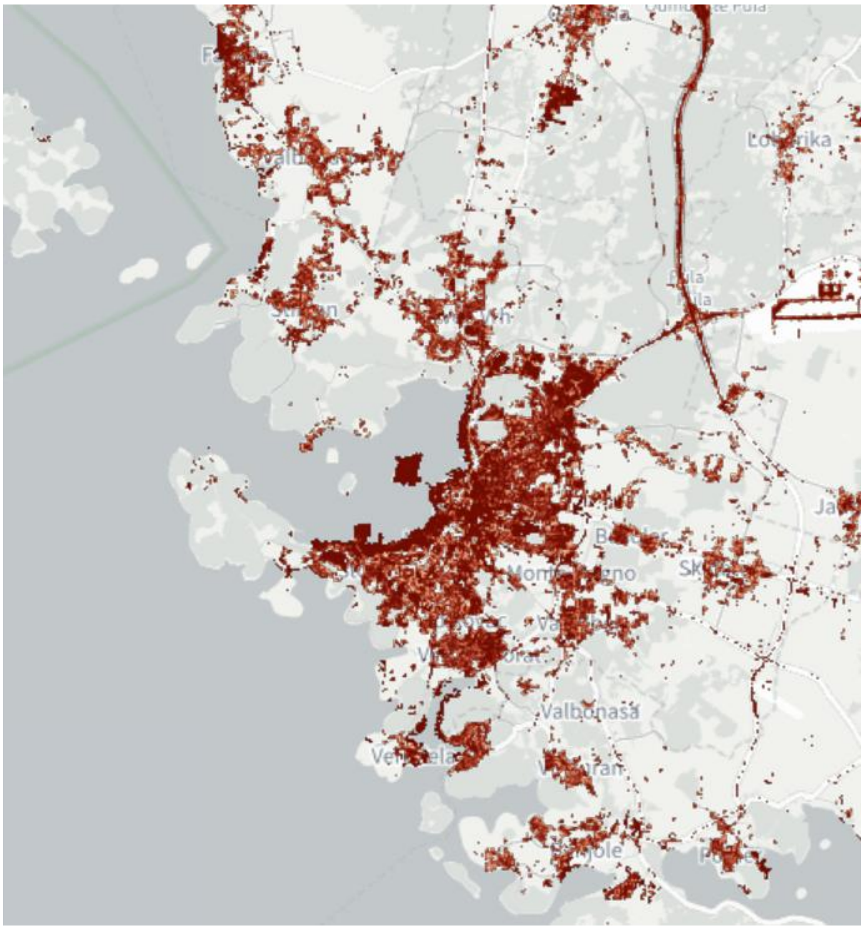


Figure 24. Imperviousness density, source: CLMS

Water Bodies:

The main body of water close to Pula is the Adriatic sea. The sea proximity helps regulate temperature in the area, keeping the area warmer during the winter and cooler during the summer, however in port areas such as Pula, high-rise buildings and industrial facilities can restrict the flow of fresh air from the sea toward the city.

Wind Patterns:

Characteristic winds are bura, jugo and maestral. Bura blows from north to south, bringing dry and clear weather, while jugo is a warm wind that brings rain. Maestral is a light wind that blows in the summer from sea to land.

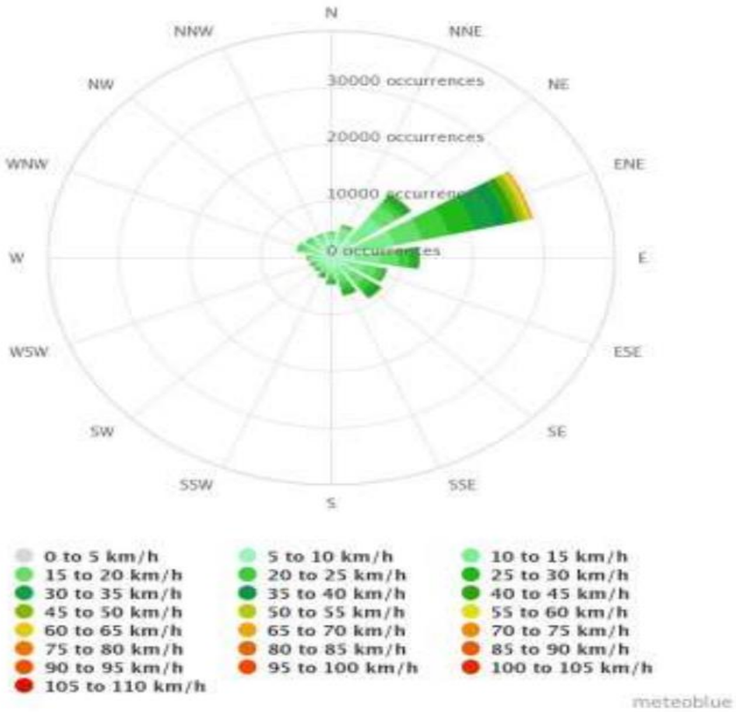


Figure 25. Wind rose for Pula 2008-2021, source:https://www.pula.hr/media/filer_public/44/8f/448fcc76-a5c6-4912-aa96-2bec2116c736/program_klimatske_promjene-ozon_pula_konacna_verzija_srpanj.pdf

According to the wind rose for the location of Pula in the period from 2008 to 2021, the most dominant winds are from the direction of the Northeast.[12]

Energy Use and Cooling Demand

Residential Energy Consumption:

The analysis of energy consumption in buildings refers primarily to the actual consumption in public, residential, and commercial buildings. Based on the analysis of the impact studies, it is found that in average, the cooling load of typical urban buildings is by 13% higher compared to similar buildings in rural areas.[13]

Category	Public	Residential	Commercial and Service	TOTAL

[12] program_klimatske_promjene-ozon_pula_konacna_verzija_srpanj.pdf
[13] https://www.sciencedirect.com/science/article/abs/pii/S0378778814005593

Area (m²)	80,703	1,926,015	2,355,212	4,361,930
Electricity Consumption (kWh/year)	1,912,482	105,891,926	160,426,200	268,230,608
Light Fuel Oil Consumption (kWh/year)	929,09	63,363,943	93,024,006	157,317,039
LPG Consumption (kWh/year)	0	14,080,876	20,672,001	34,752,878
Natural Gas Consumption (kWh/year)	2,258,396	34,916,937	46,293,813	83,469,046
Wood Consumption (kWh/year)	0	63,363,943	93,024,006	156,387,949
Other Sources (Production) (kWh/year)	0	844,853	1,240,320	2,085,173
TOTAL (kWh/year)	5,099,969	281,617,525	413,440,026	700,157,520

Table 1. Residential energy consumption, 2017. ,source: https://www.pula.hr/media/filer_public/b8/42/b8424a1d-286e-4be5-bc5f-2371ec19335f/seap_pula_revidirano.pdf

Based on the data in Table 1, it is evident that residential and commercial sectors have the highest overall energy consumption, which is expected given the large area and number of commercial buildings. The residential sector follows this, and then the public sector with the lowest consumption, as shown in Figure 22. The largest amount of energy is consumed through electricity and wood, while other sources like LPG and natural gas contribute a smaller portion of the total consumption.

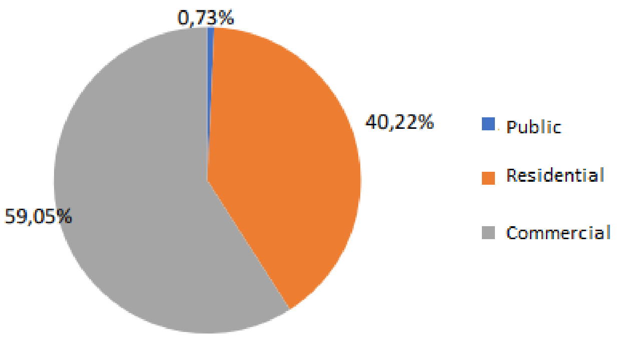


Figure 26. The share of total energy consumption in buildings in the city of Pula by sector, source: https://www.pula.hr/media/filer_public/b8/42/b8424a1d-286e-4be5-bc5f-2371ec19335f/seap_pula_revidirano.pdf

Cooling Technologies:

Most common methods of cooling the environment in homes are air conditioners, which can produce additional waste heat by releasing the heat outside. Air conditioners produce waste heat about 1.3 times the amount of cooling energy produced depending on the efficiency of the AC system.

Nature-Based Solutions (NBS)

The City of Pula has great potential for establishing a permanent network of green infrastructure. The great potential of green infrastructure lies in the connection of existing green area, and the significant potential for the development of green infrastructure should be highlighted by the construction of green (pre)gardens, roofs, and facades in buildings. Pula already has some natural-based solutions implemented, like rainwater gardens on roundabouts, as shown in Figure 24, and green oases around the city. Pula is the first city in Croatia to implement rainwater gardens, which are generally formed to hold and soak rainwater temporarily.

Figure 23. Rain water garden on a roundabout in Pula city center, source: https://www.index.hr/vijesti/clanak/pula-nagradjena-za-prilagodbu-klimatskim-promjenama-zasto-drugi-zaostaju/2477897.aspx

Novigrad

Introduction

Purpose:

The primary goal of the analysis is to identify UHI (Urban Heat Island) effects and micro-climate factors at the neighborhood level to inform the integration of RECs with nature-based solutions. The term “urban heat island” refers to cities getting much warmer than their surrounding rural landscapes, particularly during the summer. This temperature difference occurs when cities’ unshaded roads and buildings gain heat during the day and radiate that heat into the surrounding air. As a result, highly developed urban areas can experience mid-afternoon temperatures that are 8°C to 12°C warmer than surrounding vegetated areas. [14]

High population density, energy use, and closely built structures that restrict airflow further intensify the heat. This temperature increase can lead to higher energy demands, health risks, poor air quality, and changes in local weather patterns.

The environmental characterization of Novigrad city shows the factors that influence the reccurance of the UHI effect, such as the distribution of rural and urban areas, presence of bodies of water and green areas, and the demographic picture of the city.

Scope:

Novigrad is located on a small peninsula on the western coast of Istria. Novigrad has retained its medieval structure and layout, situated on a peninsula with narrow, winding streets and small shops. Bikokere district, where PV powerplant is planned, is a residential neighborhood close to the city center in a more residential and quiet area, allowing access to natural and urban amenities. In contrast, the sports and recreational district Marketi, where the NBS is planned, is located near Bikokere, the nearest heat island to the pilot location district.

Two types of temperature data can be analyzed to measure the effects of urban heat island (UHI) on air temperature and land surface temperature (LST). Atmospheric UHI is based on air temperature measurements. To assess this, scientists use ground-based sensors that directly measure the temperature of the air in urban and surrounding areas. Surface UHI relies on land surface temperatures, which reflects the temperature of the ground or surfaces like buildings and roads. Land surface temperature is measured using remote sensing technologies, such as satellites or airborne sensors which can detect the heat emitted by these surfaces from above.

[14] Urban Heat Islands | HEAT.gov - National Integrated Heat Health Information System

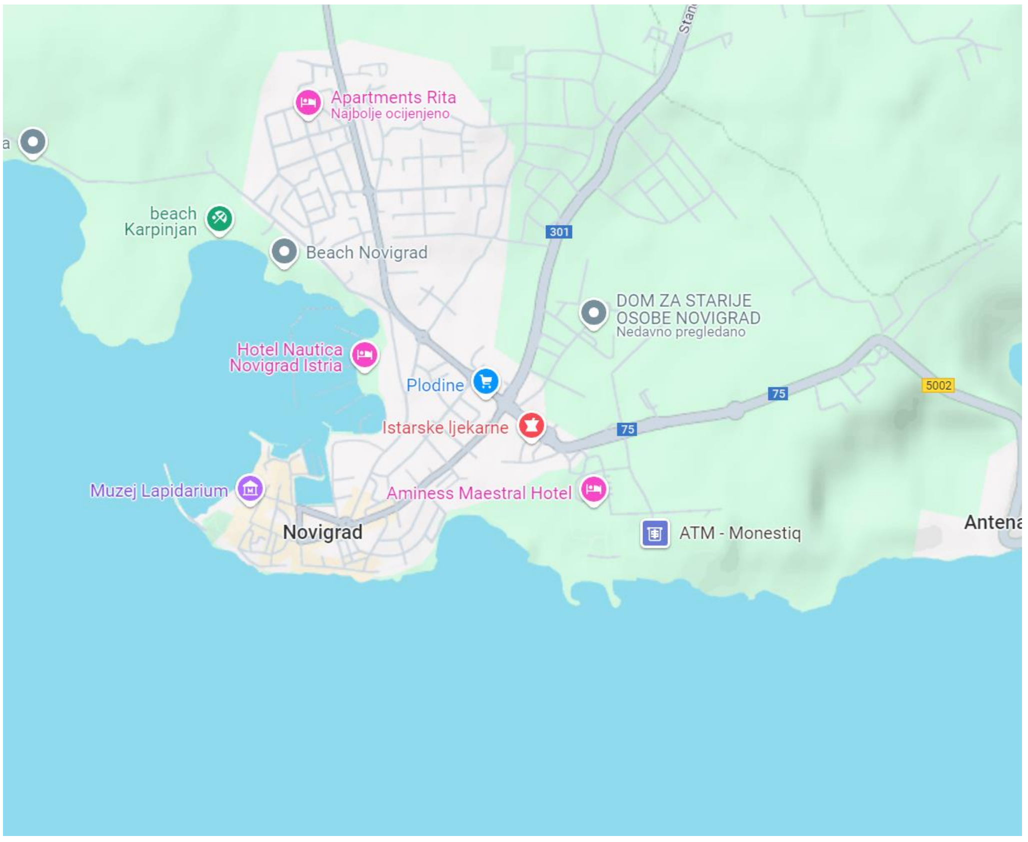


Figure 27.Novigrad city, source: Google Maps

Methodology:

Copernicus is the Earth observation component of the European Union's Space program developed by the European Union (EU) and European Space Agency (ESA). It provides accurate, timely, and easily accessible information to improve the management of the environment, understand and mitigate the effects of climate change, and ensure civil security.

ESA has developed a new family of satellites, called Sentinels, specifically for the operational needs of Copernicus. At present, two complete two-satellite constellations, Sentinel-2 and Sentinel-3, are in orbit plus two additional single satellites, Sentinel-5P and Sentinel-6 Michael Freilich. The environmental information obtained by the Sentinel satellites consists of thermal, optical, and high-frequency radar images useful for atmospheric, oceanic and terrestrial monitoring. The two Sentinel-3 satellites, which is used in this analysis, launched on 16 February 2016 and 25 April 2018, providing data for services relevant to the ocean and land. Images provided by The Sentinel-3 (S-3) since 2017 are appropriate to study the surface UHI (SUHI) effect.[15] Sentinel-3 mission's main objective is to measure the sea surface topography, the sea and land surface temperature, and the colour of the ocean and land surface. To achieve this goal, Sentinel-3 has a combination of different instruments on board. The most important instruments are the Ocean and Land Colour Instrument (OLCI), the SAR Radar Altimeter (SRAL) and the Sea and Land Surface Temperature Radiometer (SLSTR). In this work Sentinel-3 SLSTR L1B temperature images were analysed with data available since May 2016 onwards.

Neighborhood Overview

[15] ESA - Introducing Copernicus

Geographical Context:

Novigrad is a town in Istria County in western Croatia. Novigrad is set on a small peninsula on the western coast of Istria, 2 km north of the mouth of the river Mirna and some 25 km south of the border with Slovenia. Novigrad has retained its medieval structure and layout, situated on a peninsula with narrow, winding streets and small shops. The fortifications belong to the medieval era: the town wall still stands with its battlements and two round towers. There are examples of secular architecture from the time of the Venetian empire, such as the town loggia and several houses built in Venetian Gothic style. The church was built in the 15th and 16th centuries on the foundations of the 8th-century Basilica of Saint Pelagius.[16]

Bikokere lies on the western edge of Novigrad, bordered by the river Mirna on one side and low-rising hills on the other, located 11 m above sea level. It's proximity to both the city center and rural area enhances its appeal as a more residential and recreational area. This is where the elderly citizen housing is located. The terrain is slightly sloped, with flat areas near the river Mirna. The district's architecture is a mix of mid-century modern apartments, newer residential blocks, and detached family houses.

Sports and recreational center Marketi is a district in Novigrad, located near the Bikokere district where a sports center is located, presenting the city's recreational area. The district has a parking area that has 277 parking places one electric car charging station. This parking area is the closest urban heat island to the Bikokere neighbourhood.

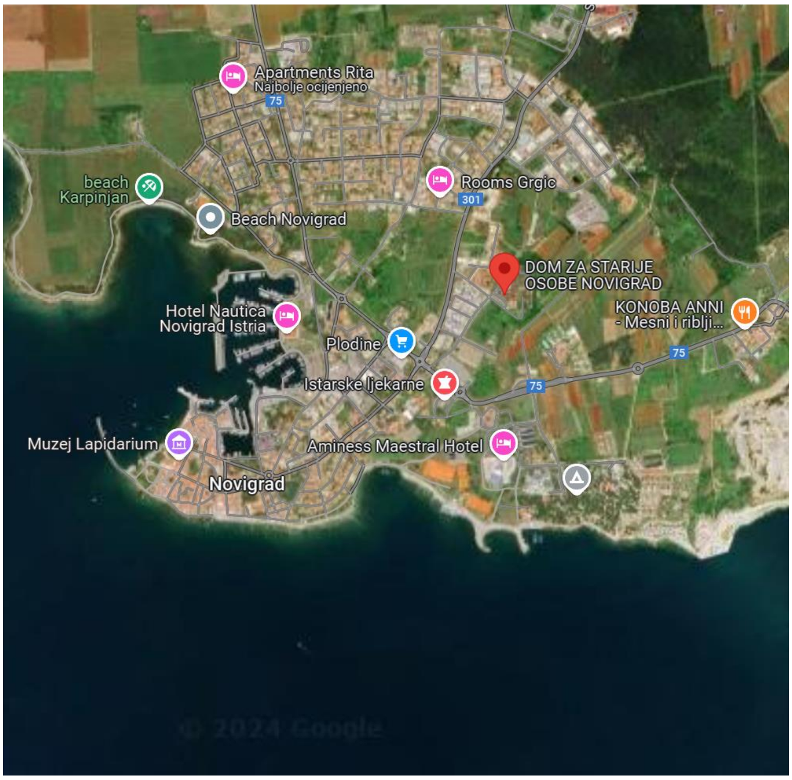


Figure 28. Novigrad city sattelite view, source: Google Maps

16 https://en.wikipedia.org/wiki/Novigrad,_Istria_County

Figure 29. Bikokere district, Novigrad 2, Novigrad city; source: Google Maps

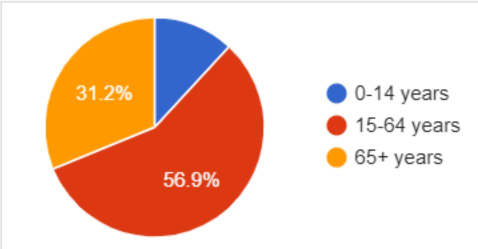
Figure 30.Marketi sports and recreational center

Demographics:

According to the 2021 census, Novigrad had a population of around 3,889 residents, counting the people living in surrounding villages.

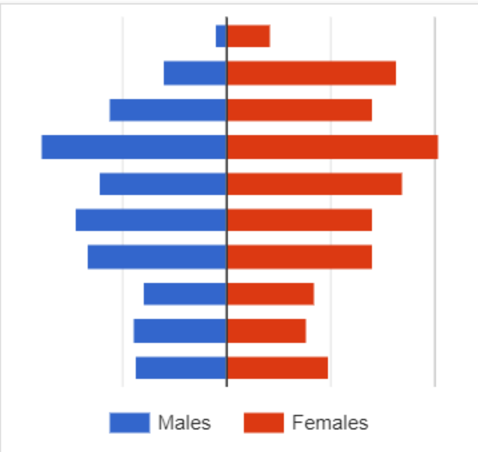
Novigrad's population density is lower, with an average of 531.4 inhabitants per square kilometer (km²). There are no specific, publicly available statistics on the population density for the Bikokere and Marketi district in Novigrad. Like many smaller neighborhoods in Croatian cities, detailed population and density data are often not published at the neighborhood level but for the city as a whole.

Like in most cities, the age distribution in Novigrad is divided into key demographic groups: **children, working-age adults, and the elderly**. According to the latest census data (2021), Novigrad's population reflects trends seen in much of Croatia, with an aging population and a declining birth rate.



Age Groups (C 2021)	
0-14 years	272
15-64 years	1,305
65+ years	715

Figure 31. Demographics of Novigrad, source: https://www.citypopulation.de/en/croatia/istra/novigrad/182917005__novigrad/



Age Distribution (C 2021)	
90+ years	54
80-89 years	225
70-79 years	254
60-69 years	383
50-59 years	293
40-49 years	287
30-39 years	275
20-29 years	165
10-19 years	168
0-9 years	188

Figure 32.Age distribution in Novigrad; source:https://www.citypopulation.de/en/croatia/istra/novigrad/182917005__novigrad/

In Novigrad, living costs are relatively moderate compared to many Western European cities. The average monthly net salary is around 900 – 1,100 € per month, slightly lower than the average monthly net salary in Croatia (around 1,300 €)[17]. Living costs can vary slightly with the tourism season, as summer brings higher activity and prices. Fishing has been present in Novigrad since ancient times, and this town has inherited its fishing tradition throughout its long and rich history. Many people are engaged in beekeeping, olive growing, viticulture, and tourism.

[17] https://podaci.dzs.hr/2024/en/76866

Urban Heat Island (UHI) Effect Analysis

Temperature Mapping:

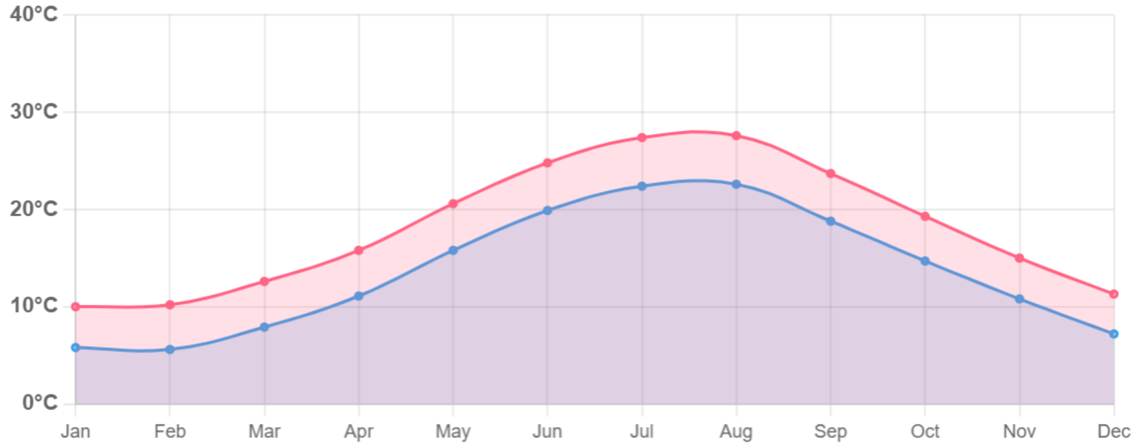


Figure 33. Average High and Low Temperature in Novigrad for 2023.;source: https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,novigrad-istria,Croatia

According to analyzed data for the year 2023., it is recorded how the area is subjected to strong heatwaves during the summer. As shown in Figure 7, the most precipitation was in autumn, with the highest precipitation in September, October, and November. The lowest precipitation is in the summer period with the lowest values in July and August, as shown below in the Temporal Analysis chapter.

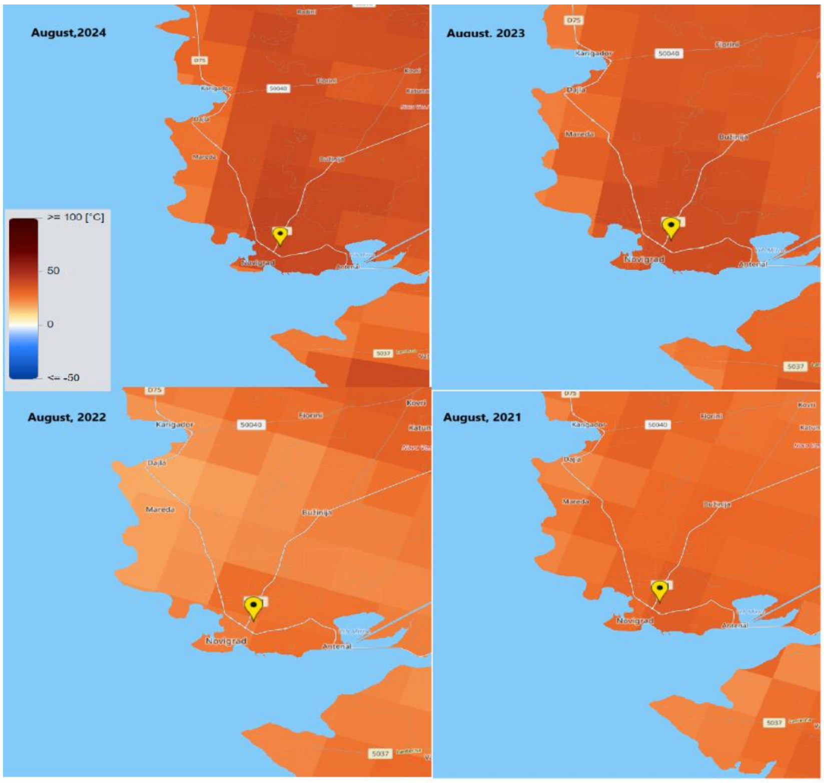


Figure 34. Thermal IR fire emission bands, by S-3 (F2 Channel) showing daily temperature of different August days from 2021 to 2024.

Concerning the temperature satellite measurements, the images of S-3 from the Copernicus program, as shown in Figure 8, represent the thermal infra-red fire emission bands (F2 Channel), and it is useful for high-temperature monitoring at 1 km resolution. Despite the relatively limited resolution, it is possible to note that temperatures are the highest in the coastal areas and the valley floors, where the major port places are present. Bikokere and Marketi districts are located in an area with higher temperatures than those in surrounding areas, creating the urban heat island effect and heat pockets.

The temperature rises significantly from 2021. to 2024., it is assumed that summers will be warmer and warmer, and the heat island effect (UHI) is expected to be even more visible and extreme in the near future.

Temporal Analysis:

Urban heat island (UHI) effect peaks in summer and winter. By analyzing different times during the year, it is possible to note that the UHI effect is most visible during August when the temperatures are the highest, as shown in Figure 9.

Although there is no data on when the UHI effect is most visible in Pula city during the day, according to the data on temperature peaks and analyses, it can be concluded that the UHI effect is highest during the evening and nighttime, specifically from sunset to just before dawn. In the daytime, direct solar heating affects both rural and urban areas, reducing their temperature difference. Thus, the UHI effect is less pronounced during peak sunlight hours (roughly from 10 a.m. to 4 p.m.) because the sun is heating all surfaces intensely.

The temperature differences are the highest due to the accumulated heat that radiates from urban areas and waste heat produced by AC systems, which are the most common technologies used for cooling/heating.

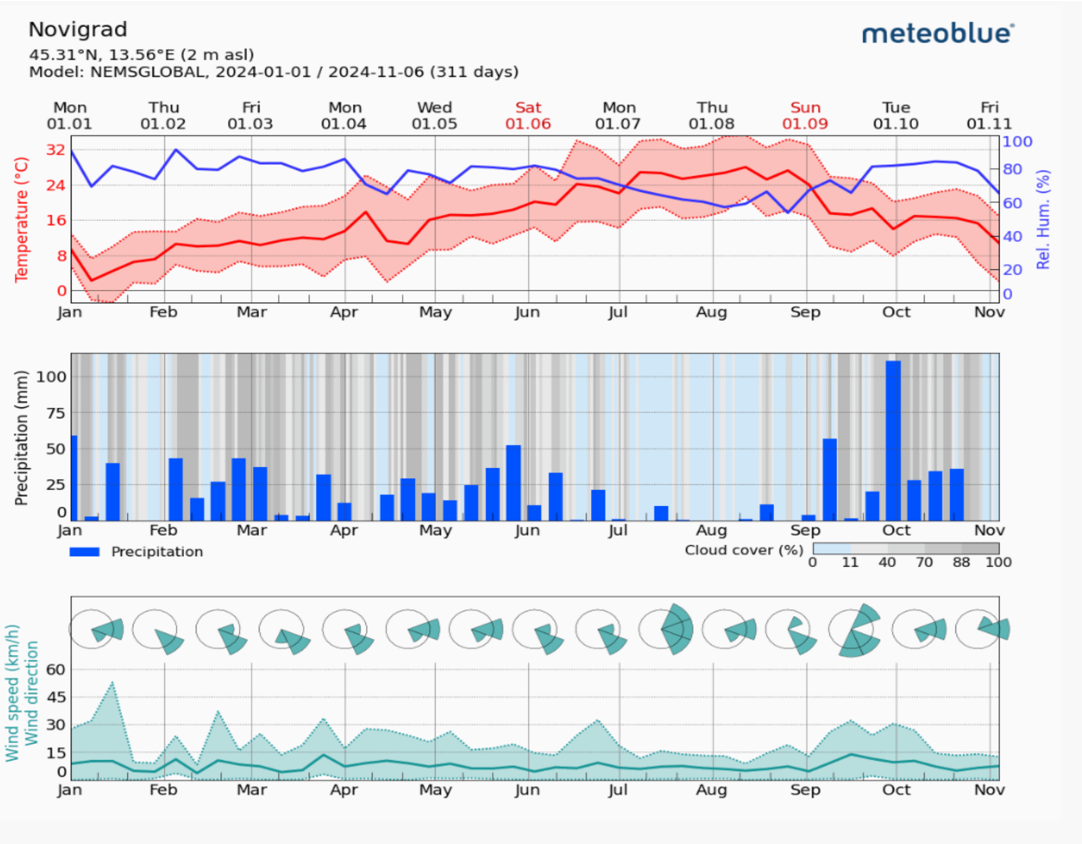


Figure 35.Weather analysis during the year 2024.

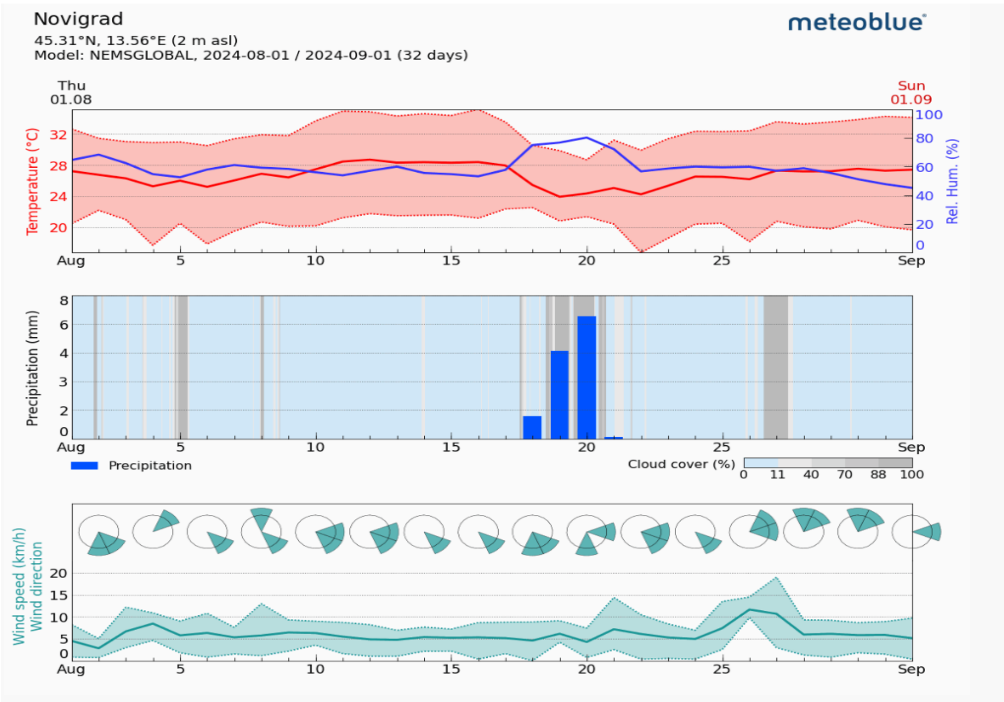


Figure 36.Weather analysis during August 2024.

Peak temperatures in August are from August 10th to August 15th reaching above 30° creating the most noticeable urban heat island effect as seen on Figure 9.

The summer period was chosen for UHI effect analysis because it is the season when the most harmful effects have been noted. As shown in weather analysis in Figure 9 and Figure 10, summer 2024. had peak temperatures (>32 °C) with the lowest precipitation in August during the year 2024. These conditions cause dangerous and harmful effect to human health and nature, especially for people living in cities during heat waves.

Heat islands contribute to higher daytime temperatures, reduced nighttime cooling, and higher air pollution levels. These, in turn, contribute to heat-related deaths and heat-related illnesses such as general discomfort, respiratory difficulties, heat cramps, heat exhaustion, and non-fatal heat stroke. Sensitive populations such as older adults, young children, and low-income populations (due to poor housing conditions) are particularly at risk during these events.[18]

With reference to Figure 8, rain cools surfaces due to evaporation. As the water on surfaces evaporates after precipitation, it pulls heat from the surrounding air, lowering the temperature. In urban areas, where concrete and asphalt surfaces dominate, evaporation can significantly reduce air temperatures, at least temporarily. Surfaces such as asphalt and concrete that dominate in the city tend to trap heat. When rain cools down these surfaces, accumulated heat decreases, which reduces nighttime temperatures in urban areas, reducing the contrast between temperatures in urban and rural areas. The effect of precipitation is more visible during winter and autumn periods when precipitation is more frequent and temperatures are naturally lower. In summer, precipitation often increases the relative air humidity, sometimes further enhancing the feeling of warmth, especially when air circulation is restricted due to tall buildings and narrow streets. In cities, rain water quickly runs off due to the intensive sewage network and impermeable surfaces like asphalt and concrete. Thus, the precipitation helps reduce the heat, its effect can be limited, especially in dense urban areas like Novigrad.

Spatial Distribution:

As seen in Figure 11, the Bikokere and Marketi neighborhoods are located in an area that shows higher temperatures than those in the surrounding Novigrad areas, creating the urban heat island effect. Altough no precise data is available on Novigrad UHI hotspots, Meteoblue's Global Heat Monitor shows us how port spaces are warmer than rural areas surrounding them. This effect is extreme during the summer when temperatures are higher, therefore contributing to the UHI (Urban Heat Island) effect.

[18] https://www.epa.gov/heatislands/heat-island-impacts

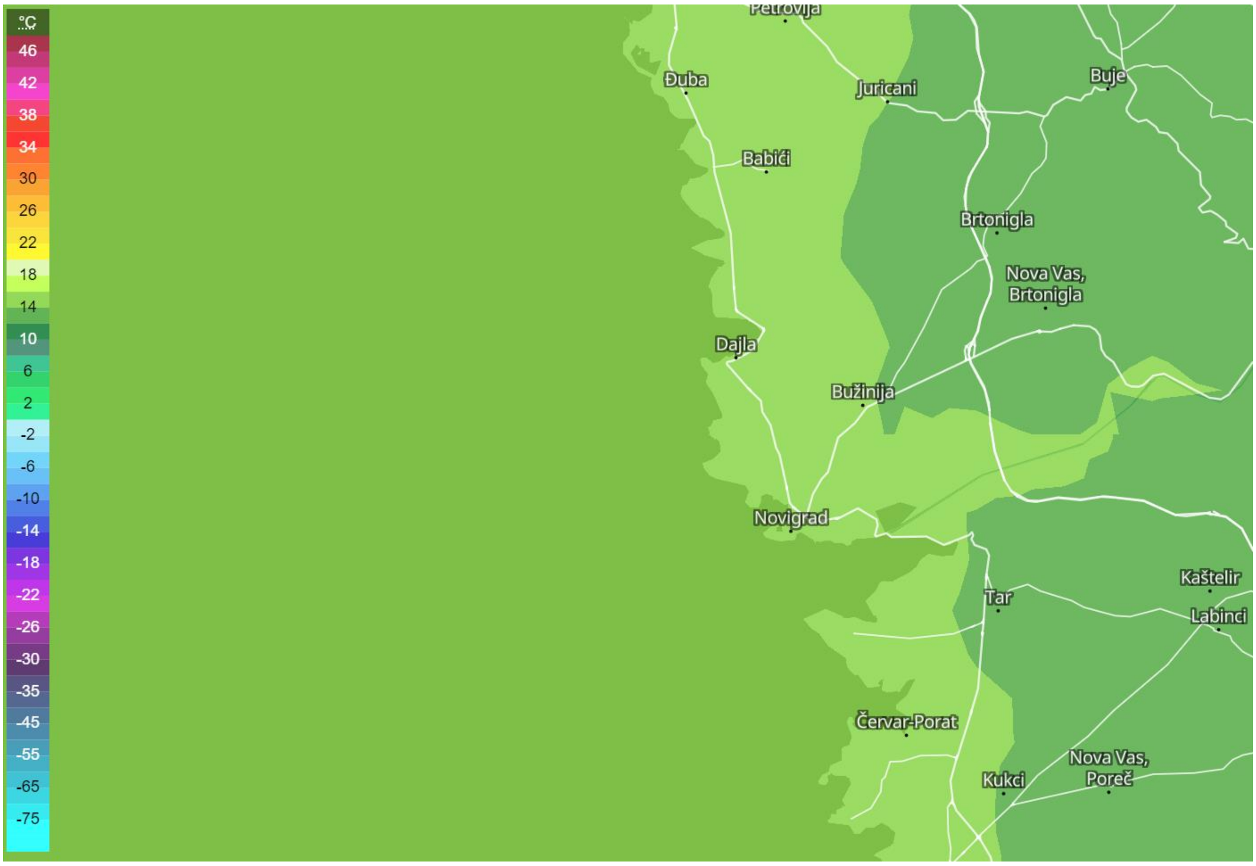


Figure 37.Uban Heat Map for the date 10.11.2024.; source: Meteoblue

Micro-Climate Factors

Surface Characteristics:

Most surfaces in Novigrad are made of asphalt and concrete, which retain and accumulate heat during the day, contributing to the urban heat island effect, especially during summer. These surfaces cool down slowly at night, retaining heat in the urban area. Urbanized areas are mostly located in port areas and some industrial commercial buildings, as shown in Figure 12.

Figure 38. Corine Land Cover Map (2018);source: CLMS

Green Spaces:

Novigrad green spaces include parks, forest parks, avenues, hedges, flower beds, lawns, groups or individual trees, children's playgrounds, playgrounds, pots with ornamental plants, green areas along roads in settlements and outside settlements, next to residential buildings and public buildings as well as the airspace above them. Some green areas in the city are Lapidarij- green area, Mareda raoundabout, Šaini roundabout, Stancijeta Park and Park Novigradskih Ribara.

Novigrad does not yet have any “Green Renewal Strategy” documents, but the city is planning to have one in the future. Novigrad city utility company Neapolis d.o.o has started creating a register of green infrastructure. The city has a total of 41,496 m^2 under irrigation, and the area od maintained parks is 92,000 m^2.

Bikokere district is a part of Novigrad and has tree alleys, grassy areas and various vegetation. Trees provide shade, reducing the temperature in close proximity. Grass and other low vegetation have a significant effect on lowering soil and air temperature. They reduce temperature by evaporation, acting as natural cooling systems in the urban area, however in port areas the UHI effect can overcome the natural cooling effect of the sea and trees. Unlike Bikokere, Marketi sports zone does not have many green areas, as it is mostly residential area with buildings, sports center and a parking lot.

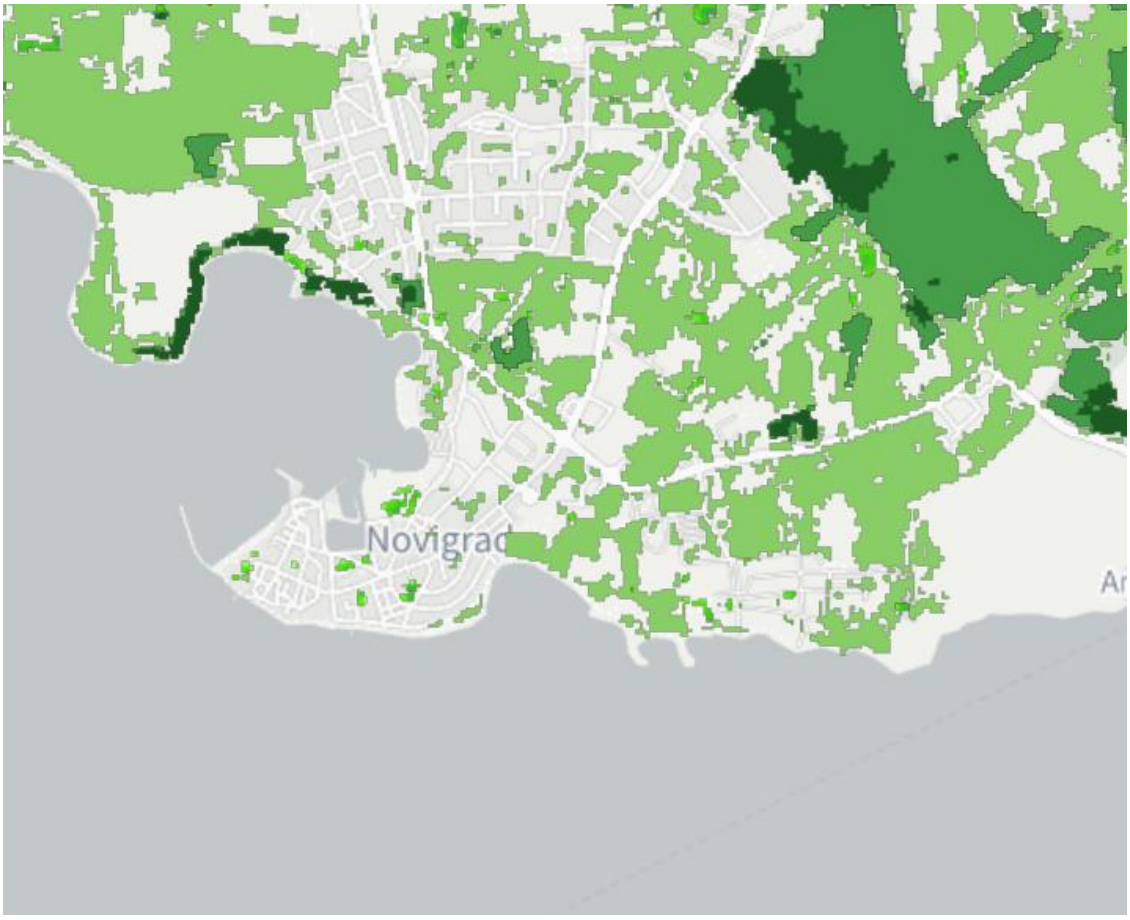


Figure 39. Distribution of green spaces, including parks, gardens and street trees

Building Density and Height:

Building height in Novigrad on average, is around 12-15 m (>5 or more floors) , with high building density in the port area, creating an impervious layer that can lower airflow and support heat accumulation, especially during the summer, creating heat pockets. The rural areas surrounding the city consist of smaller buildings and detached houses, as shown in Figure 14 and Figure 15. Figure 14 shows how build-up is concentrated mostly in port area, lowering airflow and contributing to the UHI effect, while Figure 21 shows how impervious layers are distributed in the area. The impervious layer is created when asphalt, concrete and other materials that do not absorb water are used, and it is usually the most dense in urban port areas as shown in Figure 15.

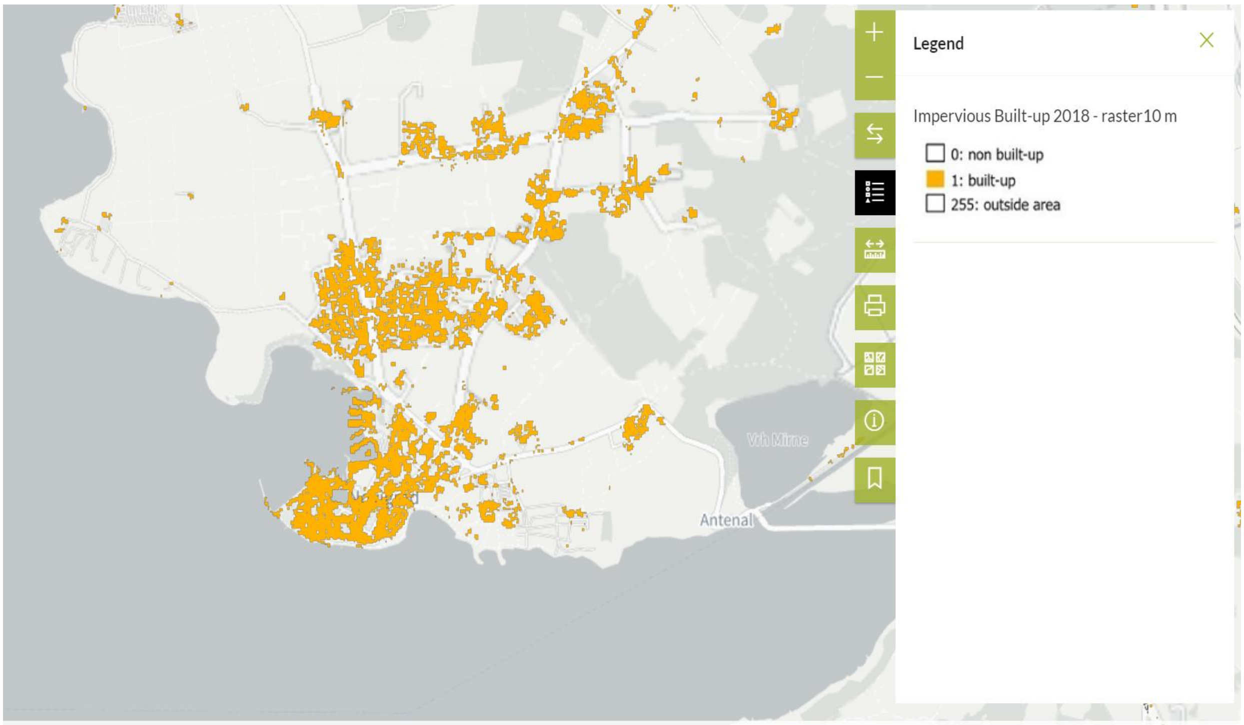


Figure 40. Buildings distribution, source: CLMS

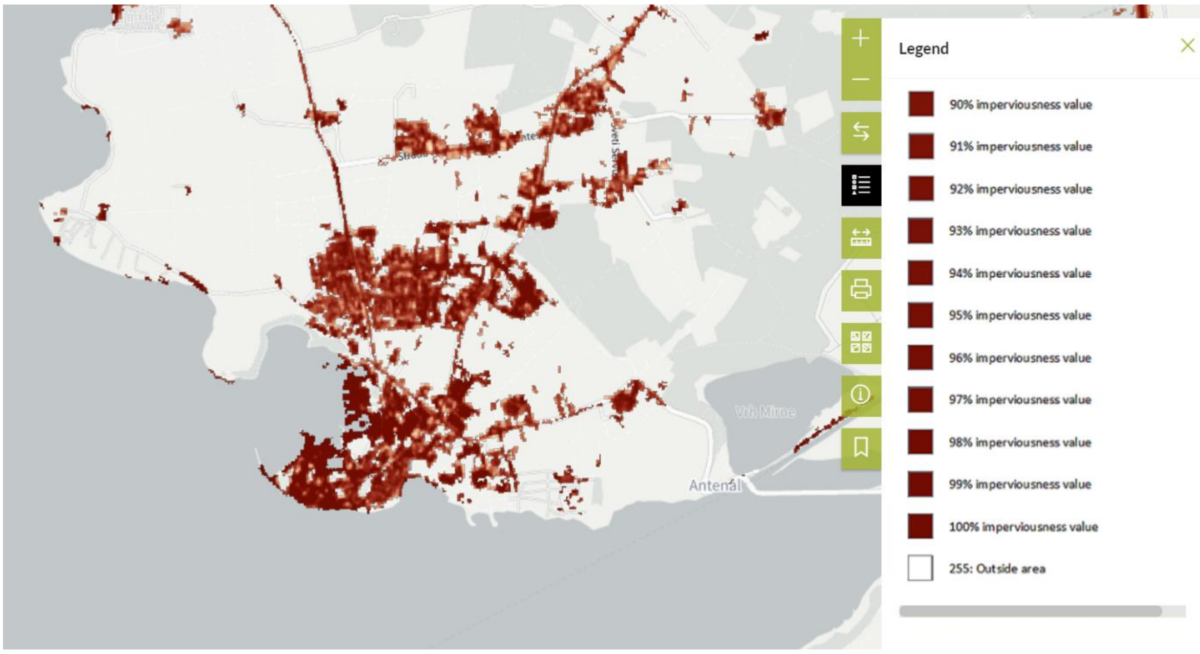


Figure 41. Imperviousness density; source:CLMS

Water Bodies:

The main body of water near Novigrad is the Adriatic Sea. The sea proximity helps regulate temperature in the area, keeping the area warmer during the winter and cooler during the summer, however, in port areas such as Novigrad, high-rise buildings and industrial facilities can restrict the flow of fresh air from the sea toward the rural area.

Wind Patterns:

Characteristic winds are Bura, Jugo, and Maestral. Bura blows from north to south, bringing dry and clear weather, while jugo is a warm wind that brings rain. Maestral is a light wind that blows from sea to land in the summer. According to data found on Meteoblue, as shown in Figure 16, the most dominant wind values are in January and are from the east/northeast direction.

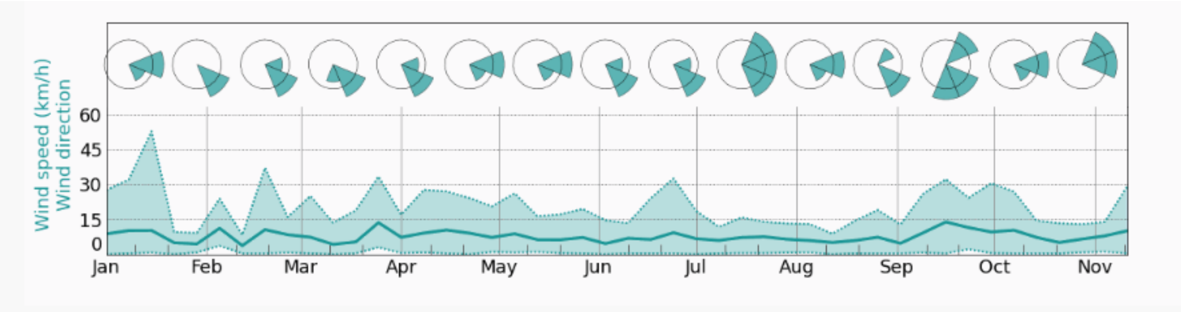


Figure 42.Wind patterns for 2024., source:Meteoblue

Energy Use and Cooling Demand[19]

Residential Energy Consumption:

Energy Source	Buildings	Transport	Public Lighting	Total per Energy Source	Share per Energy Source %
Electric Energy	26,893	-	760	27,653	30.75%
Gasoline	-	29,053.19	-	29,053.19	32.31%
Diesel	-	10,898.78	-	10,898.78	12.12%
LPG	2,805	645	-	3,45	3.84%
Heating Oil	10,093	-	-	10,093	11.22%
Wood	8,538.12	-	-	8,538.12	9.49%
Pellets	245	-	-	245	0.27%
Total	48,574.12	40,596.97	760	89,931.09	100%
Share of Each Sector %	54.01%	45.14%	0.85%	100%	

Table 2. Total energy consumption in the area of the city of Novigrad-Cittanova in the reference year 2019

[19] https://novigrad.hr/media/2022/04/SECAP_Novigrad_1-1.pdf

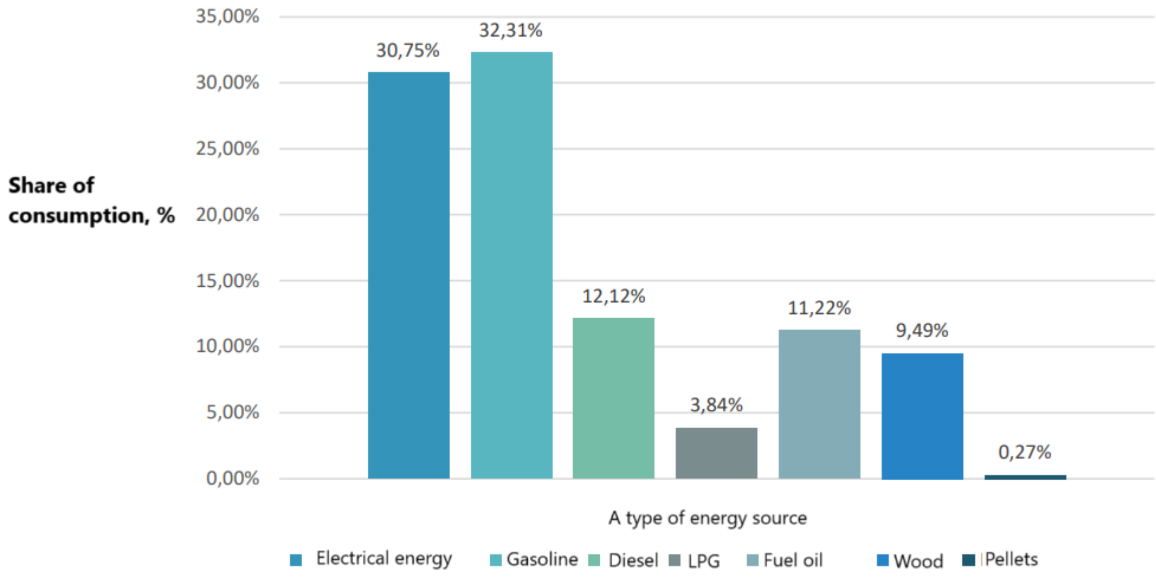


Figure 43. Share of energy consumption in total consumption in 2019

Based on the analysis of the impact studies, it is found that, on average, the cooling load of typical urban buildings is 13% higher compared to similar buildings in rural areas. While the UHI effect is at first most prominent around coastal areas, long-lasting high temperatures during the summer present a danger to areas further away from the city center.

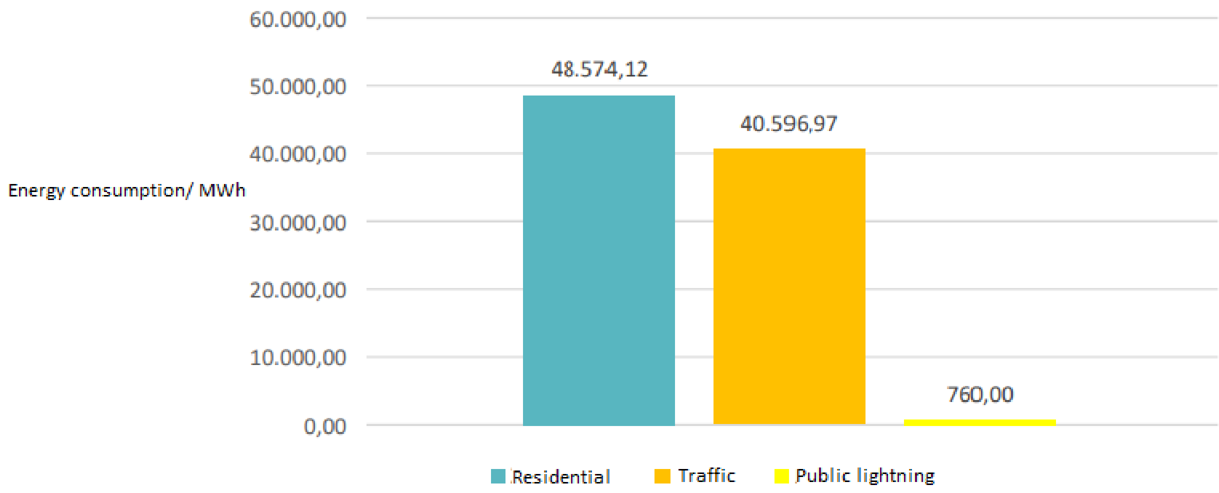


Figure 44.Energy consumption in 2019., by sector

The sector with the highest energy consumption is the building sector (55%), followed by transport (around 45%) and, to a lesser extent, public lightning based on data in Table 1 and Figure 18. The most common energy source is gasoline, followed by electricity, diesel, fuel oil, while the least used is wood, LPG and pellets. Diesel and gasoline account for over half of total consumption, as seen in Figure 17.

Building Sector	Electric Energy	LPG	Heating Oil	Wood	Pellets	Total	Total %
Residential Buildings	12,259	1,246	3,716	7,583.12	199	25,003.12	51.47%
Tertiary Sector Buildings	14,634	1,559	6,377	955	46	23,571	48.53%
Total	26,893	2,805	10,093	8,538.12	245	48,574.12	100%
Total %	55.36%	5.77%	20.78%	17.58%	0.50%	100%	

Table 3.Energy consumption in the building sector/MWh in 2019.

The building sector consists of three subsectors of the following total areas (m^2):

- Subsector of buildings owned by the City: 1,547 m^2
- Residential buildings (households): 201,438.19 m^2
- Buildings of tertiary activities (service buildings): 116,937.08 m^2

In total energy consumption in the residential sector, electricity has the highest consumption, followed by fuel oil, wood, LPG and pellets as seen in Table 2.

Cooling Technologies:

Most common methods of cooling the environment in homes are air conditioners, which can produce additional waste heat by releasing the heat outside. Air conditioners produce waste heat about 1.3 times the amount of cooling energy produced depending on the efficiency of the AC system.

4.3 UHI & Micro-Climate Analysis Italy

Introduction

Purpose

The climatic phenomenon of Urban Heat Island (UHI) affects urban districts with higher temperatures than the surrounding rural areas, caused by urbanization and industrialization processes. It represents one of the main anthropogenic alterations of Earth's environment. It is considered one of the major ecological problems in the 21st century due to rapid urbanization and global warming, with dramatic effects on human health and well-being, rising energy consumption, and increased mortality rates. Identifying and managing UHI contributing and mitigating factors is an open challenge, addressed through urban development strategies and urban planning policies to make cities inclusive, safe, resilient, and sustainable[20].

Therefore, the environmental characterization for the city of Genoa is presented, showing the factors that influence the recurrence of the UHI effect, such as the distribution of rural and urban areas, the presence of bodies of water and a brief meteorological characterization. The city's demographic characteristics and the district involved by the project are also presented. Finally, a recent study on the urban heat island effect for the city of Genoa is presented.

In recent years, the city of Genoa has been strongly committed to work on UHI mitigation and developing Nature-Based Solutions, especially by participating in several projects with a European or National relevance.

As regards adaptation to climate change and especially UHIs, the following projects can be mentioned:

CLIMACTIONS promoted from 2019 and financed by the Italian Ministry of Health, the project was carried out at a local level by the Liguria Region, the University of Genoa and the Municipality of Genoa. It aimed at improving knowledge concerning the effects of heat waves on the health of most vulnerable citizens. To do so, the health impact associated with high temperatures and the UHI effect were estimated by integrating the data and methodologies already developed within the "National Operational Plan for the Prevention of the Effects of Heat" with population data and innovative environmental indicators. An innovative aspect of the project is represented by the collaboration between epidemiologists, who evaluated the impact of such phenomena on human health and urban planners, who analysed urban spaces by identifying the most critical sub-areas at a territorial level. Local case study for the city of Genoa was the Municipio VI (Sestri and Cornigliano neighbourhoods).

ReMED, an Interreg-EuroMed project started in 2024 and led by the University of Malta. ReMED will develop, test and validate climate change adaptation solutions and measures to support cities in the Mediterranean space. The project focuses on resilience and adaptation and has the aim of equipping cities with new and effective tools that will increase the capacity of public authorities to implement effective risk assessment (especially related to UHI) and management measures of climate change effects at different scales, from the building to the city. Genoa, through the participation of the Municipality, is one of the territories in which the project will be developed.

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20 https://www.researchgate.net/publication/354320765_Analysing_the_Surface_Urban_Heat_Island_Effect_with_Copernicus_Data

As concerns Nature-Based Solutions:

UnaLab (https://unalab.eu/) is a Horizon 2020 project which was developed between 2017 and 2021; it involved the city of Genoa as a demonstrator site. Its aim was to implement and demonstrate co-created, innovative, replicable and locally attuned nature-based solutions to enhance the climate and water resilience of cities. In Genoa, the Municipality, with the support of technical partners among which the University of Genoa, created a new urban park in an area located in a very dense neighbourhood (Lagaccio district), formerly occupied by old military barracks; the creation of the Gavoglio park, developed with the use of nature-based solutions, aimed at restoring some kind of naturalness in a highly urbanized area suffering of hydrogeological problems.

NBS EDUWOLRD (https://nbseduworld.eu/) is a Horizon project started in 2022 and led by European Schoolnet; the general objective of NBS EduWORLD is to raise awareness among civil society on the benefits of Nature-Based Solutions, to increasingly support the transition towards a sustainable future. The project therefore has a strong educational value and aims to spread knowledge and training at different levels, involving students, teachers, trainers, educators, professionals and citizens. The Municipality of Genoa is involved as a "second level" city in which the educational models/tools developed by the project will have to be developed based on the experiences of the partners and the "first level" expert cities, as well as on the specific needs of the context.

GreenStorm is a project funded JPI Urban Europe PED Call and started in 2024. The main local partner in Genoa is the University of Genoa, while the Municipality participates as a co-applicant; GreenStorm targets nature-based solutions designed to manage stormwater with a specific focus on climate adaptation, resilience of urban vegetation, but also enhanced social benefits. The project will assess, by modelling and testing, the benefits and performances of such NBS in the case of extreme climate events (high intensity rainfall, drought, heat waves, frost/thaw). Co-creation workshops with relevant stakeholders (professionals and citizens) will support the actual implementation of NBS in the chosen participating cities.

URCA! Urban Resilience to Climate Change (https://prinurca.wordpress.com/) is a research project with national relevance developed from 2021 by the University of Genoa; it aims to promote urban resilience to climate change through the implementations of innovative and sustainable urban drainage systems, based on NBS, to mitigate hydrological risk and improve liveability of the urban environment. The project involves a strong participation of citizens and local communities that were consulted and actively involved in the different phases. The Municipality of Genoa supports the project with its patronage.

Scope

The data are related to the Municipality of Genoa (MGE). The most significant aspects will be focused on the back-port areas, particularly the Cornigliano district.

Methodology

The workflow described derives from a Chapter of a recent publication on the process of Electronic Government and the Information Systems Perspective 10th International Conference, EGOVIS 2021, Virtual Event, 27-30 September 2021[21].

UHI may be quantified from the air temperature or from the land surface temperatures (LST). The atmospheric UHIs are assessed with in situ sensors or model data which provide air temperature information, while the surface UHIs (SUHI) are measured by airborne or satellite remote sensing platforms that detect LST.

In particular, satellites provide thermal LST data with high spatial and temporal coverage, allowing the employment of such data for urban planning and surface temperature-based heat island effect monitoring.

Through a constellation of six Sentinel satellites, the Copernicus Programme, developed by the European Space Agency (ESA) and the European Union (EU) following the Open Data strategy, provides free data and information derived from Earth Observation (EO) satellite images, covering Europe and almost all of Earth. It aims at supporting the environmental and health protection policies of European public administrations and promote economic growth in Europe. The environmental information obtained by the Sentinel satellites consists of thermal, optical, and high-frequency radar images useful for atmospheric, oceanic and terrestrial monitoring.

The Sentinel-3 (S-3) thermal images delivered since 2017 by the Programme are appropriate to study the SUHI phenomenon as provide ready to use LST measurement[22].

The SUHI intensity is computed as the LST difference between an urban and its surrounding rural area. Copernicus LST data are measured by the SLSTR S-3 sensor, whose mission is characterized by a two-satellites (S-3A in orbit since 2016, S-3B since 2018) constellation; the main objectives are to support the ocean forecasting systems, the environment, and the climate monitoring with the measurements of sea surface features (*e.g.* topography and colour), land surface colour and the LST. The spatial resolution of this band is 1 km^2, and the revisit time of S-3 on the area of interest is one day.

The UHI calculation process also integrated Copernicus data with other Open Data sources. On the one hand, to delimit the study area, vector layers that describe the provincial boundaries and the contour lines were used, provided by the Geoportal of the Liguria Region [23] , which allows free access to the updated and structured catalog of geo-referenced regional map data.

Furthermore, CORINE Land Cover map layer[24] (2018) provides geographical information on land cover at a 100 m spatial resolution with different land cover categories, it is used for the determination of rural surfaces and rural areas.

In this work n. 40 S-3 satellite images were analyzed (images are accessible in the Copernicus Browser[25]). The acquisition period spans from June 21st and September 22nd 2020, during the summer

[21] https://link.springer.com/book/10.1007/978-3-030-86611-2
[22] https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-slstr

[23] geoportal.regione.liguria.it
[24] land.copernicus.eu/pan-european/corine-land-cover
[25] https://browser.dataspace.copernicus.eu/

season. From thermal LST satellite images, through the use of open software, including SNAP[26] and Q-GIS[27], was calculated the rural mean temperature background for the summer season 2020 at night and day.

Owing to Genoa's very complex morphology in the distribution of urban agglomerations, for the highly variable orography and proximity to the sea, the different areas of the municipality have different average temperatures due to the altitude thermal gradient. It was, therefore, necessary to select the rural areas below a given elevation, to avoid temperature-affecting factors.

To calculate the average background rural temperature two criteria were considered: i) the non-overlapping and non-adjacency with urban areas, as defined by Corine Land Cover 2018; ii) the altitude to lower values at 140 m above sea level, which represents the altimetric belt where most of the urban agglomerates are present, as shown in **Error! Reference source not found.**.

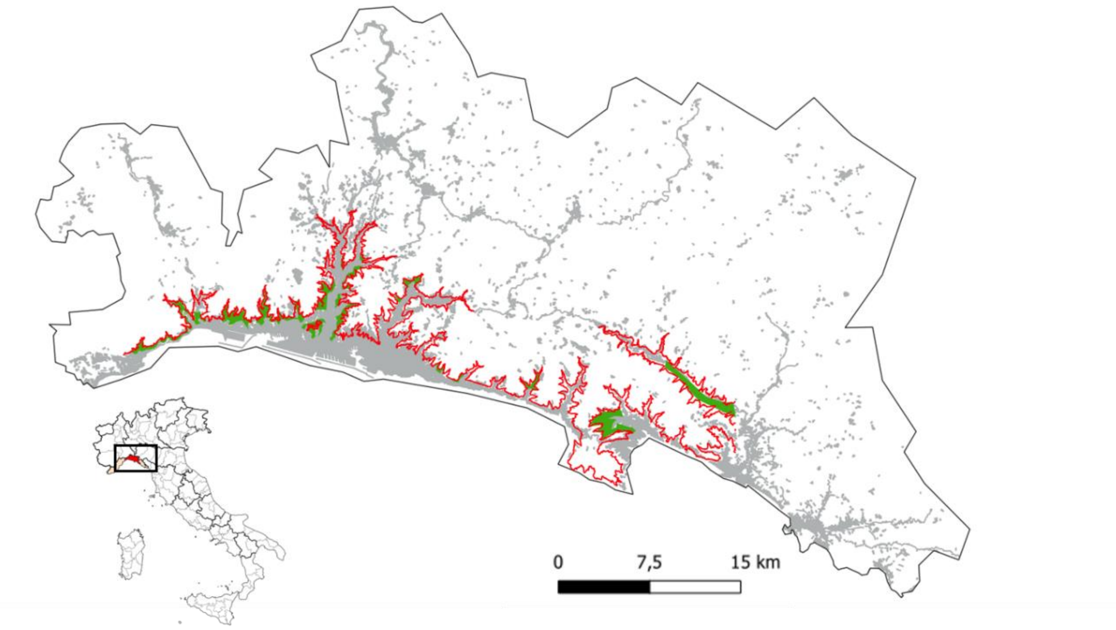

Figure 1 - Sample rural areas for the background rural temperature retrieval in the AOI: Sample rural areas (Light Green) are selected owing to the height above sea level (< 140m, red line) in absence of impervious surfaces (grey areas).

Once the rural areas were selected, the mean monthly temperature value for rural areas was retrieved to derive the average day and night monthly SUHI, following equation:

SUHI = AOI LST – Background Rural Temperature

Neighborhood Overview

Geographical Context

Genoa is the largest and most densely populated urban agglomeration in the Metropolitan Area, with more than 560.000 inhabitants: the Mediterranean Sea and the steep hills of the hinterland narrow the territory. Over the centuries, its natural landform has undergone upheaval due to human activities, such

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26 step.esa.int/main/toolboxes/snap

27 qgis.org/it/site/

as modifications of the drainage network, excavations and filling, and building and street constructions, which particularly intensified during the economic boom after World War II.

The territory of the Municipality of Genoa extends for 240,28 km^2 and about 30 km along the coastline. The municipal territory has numerous valleys that descend towards the sea from the Ligurian-Po watershed, with mountain reliefs at altitudes between 400 and 1200 meters high, located between 6 and 10 km from the sea.

The orography of the metropolitan area locates Genoa among the Italian metropolitan cities with the greatest variety of climate types. Specifically, the coastline presents the greatest climate differentiation, while the most densely populated areas are more sensitive to thermal and hydrological fluctuations.

The pilot area of Cornigliano presents some critical issues visible on a territorial and urban level, which are also reflected in the social dimension, demographic and economic dynamics exacerbate problems.

The vehicular and railway mobility infrastructures are abundantly present in Cornigliano and in the adjacent area of Sampierdarena: the A7 (Milan-Genoa) was the first motorway in Italy, Lungomare Canepa, built in addition to the Guido Rossa, the so-called railway connection Terzo Valico dei Giovi which currently sees some crucial zones used as construction sites and material storage areas. All these infrastructures have the characteristic of being elevated and, therefore represent a double barrier, physical and visual.

The environmental values of the area are hardly noticeable and inaccessible: this applies to the sea, the river, and the hills. Furthermore, compared to a consolidated residential urban fabric of relatively small blocks, some industrial, logistical and service functions have inserted themselves into this fabric, deeply tearing it apart. This is the case of the AMT vehicle depots and the various warehouses dedicated to the logistics of large companies located between the hill and the Polcevera in Cornigliano. The port contributes significantly to designing a context mostly represented as industrial and logistical. In fact, the port piers and the road surface developed starting from the 1930s, overlooking the sea and enclosing it a few hundred meters beyond the line that still bears the name Lungomare. The Port Authority and various entities such as public purpose companies and industrial operators are signing agreements, commitments and programs with the Municipality of Genoa to redevelop large areas abandoned by industrial production and, reorganize the road system, and restore liveable spaces to residents.

Demographics

The population of Genoa is 564.657 inhabitants (reference year 2023), the population density is approximately 2.350 inhabitants per square kilometer, varying significantly between different neighborhoods. The city's territory includes densely populated urban areas and less inhabited hilly and coastal areas.

Cornigliano is home to around 13.800 inhabitants. The population density is high compared to the city average, with numerous condominiums and houses concentrated in a relatively small area. In recent years, the neighborhood has seen a diversification of its population with the arrival of immigrants from different parts of the world, contributing to a rich and varied cultural mosaic.

Municipality of Genoa																						
	0-4 years	5-9 years	10-14 years	15-19 years	20-24 years	25-29 years	30-34 years	35-29 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years	65-69 years	70-74 years	75-79 years	80-84 years	85-89 years	90-94 years	95-99 years	>= 100 years	Total	Average Age
Female	8.223	9.535	11.065	11.833	12.386	13.248	14.382	14.282	15.309	19.355	23.326	24.731	22.996	19.900	18.148	18.543	16.246	12.393	6.660	1.933	269	294.763	50,7
Male	8.820	10.184	11.675	13.003	13.936	14.923	15.125	14.924	15.081	18.524	22.216	23.172	20.396	17.286	15.149	14.333	10.897	6.926	2.700	563	61	269.894	46,7
Total	17.043	19.719	22.740	24.836	26.322	28.171	29.507	29.206	30.390	37.879	45.542	47.903	43.392	37.186	33.297	32.876	27.143	19.319	9.360	2.496	330	564.657	48,8

	0-4 years	5-9 years	10-14 years	15-19 years	20-24 years	25-29 years	30-34 years	35-29 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years	65-69 years	70-74 years	75-79 years	80-84 years	85-89 years	90-94 years	95-99 years	>= 100 years	Total	Average Age
VI Medio Ponente																							
Female	956	1.104	1.152	1.246	1.240	1.408	1.543	1.567	1.577	1.973	2.371	2.494	2.314	1.975	1.771	1.871	1.602	1.195	632	175	28	30.194	49,7
Male	1.043	1.159	1.231	1.430	1.464	1.720	1.680	1.723	1.750	2.054	2.331	2.343	2.095	1.723	1.513	1.401	1.099	689	225	36	5	28.714	45,5
Total	*1.999*	*2.263*	*2.383*	*2.676*	*2.704*	*3.128*	*3.223*	*3.290*	*3.327*	*4.027*	*4.702*	*4.837*	*4.409*	*3.698*	*3.284*	*3.272*	*2.701*	*1.884*	*857*	*211*	*33*	*58.908*	*47,7*
Cornigliano																							
	0-4 years	**5-9 years**	**10-14 years**	**15-19 years**	**20-24 years**	**25-29 years**	**30-34 years**	**35-29 years**	**40-44 years**	**45-49 years**	**50-54 years**	**55-59 years**	**60-64 years**	**65-69 years**	**70-74 years**	**75-79 years**	**80-84 years**	**85-89 years**	**90-94 years**	**95-99 years**	**>= 100 years**	**Total**	**Average Age**
Female	264	272	275	281	313	336	364	401	367	457	531	557	518	430	390	389	284	225	114	32	6	6.806	47,8
Male	246	329	308	352	407	508	456	444	466	535	526	526	515	424	332	278	199	133	34	9	1	7.028	43,5
Total	510	601	583	633	720	844	820	845	833	992	1.057	1.083	1.033	854	722	667	483	358	148	41	7	13.834	45,6

Figure 2- Resident population by five-year age class in the Municipality of Genoa, VI Medio Ponente and Cornigliano (reference year 2023).

The neighborhood of Cornigliano is configured as a high-density neighborhoods and is characterized by a high number of residents of foreign origin. The average population density of the Municipality of Genoa is 2.350 inhabitants per square kilometer, while the average population density of Cornigliano is 3.660 inhabitants per square kilometer, therefore 55% higher than the city average.

The age distribution of the Genoese population is characterized by a growing number of older adults, reflecting a common trend in many Italian cities. Approximately 27,6% of the population is over 65 years old, while young people under 20 years old represent approximately 15%.

The age distribution in Cornigliano partly reflects the distribution of the rest of the city, with a significant presence of elderly people; approximately 23,7% of the population is over 65 years old. However, there is also a good representation of young families and children; young people under 20 years old represent approximately 16,8%.

The average income in Genoa is relatively high compared to other Italian cities, but significant disparities exist between different neighborhoods. The income level in Cornigliano and in the adjacent area of Sampierdarena is the lowest in the city, reflecting the economic difficulties related to the post-industrial transition. Unemployment is a significant problem, especially among the less qualified population segments.

The data relating to the years 2011 and 2020 are listed below.

YEAR 2011*

Cornigliano: 17.367 € (3rd lowest in the Municipality)

Sampierdarena: 20.082 €

The average income in the Municipality was around 23.000 €.

* *Statistical Area of the Municipality of Genoa* http://statistica.comune.genova.it/pubblicazioni/download/redditi/redditi%202011.pdf

YEAR 2020**

Cornigliano: 17.035 € (lowest value in the Municipality)

Sampierdarena 18.134 € (3rd lowest in the Municipality)

The average income in the Municipality was 22.131 €.

*** "Secolo XIX" elaborations of Ministry of Economy and Finance data.*

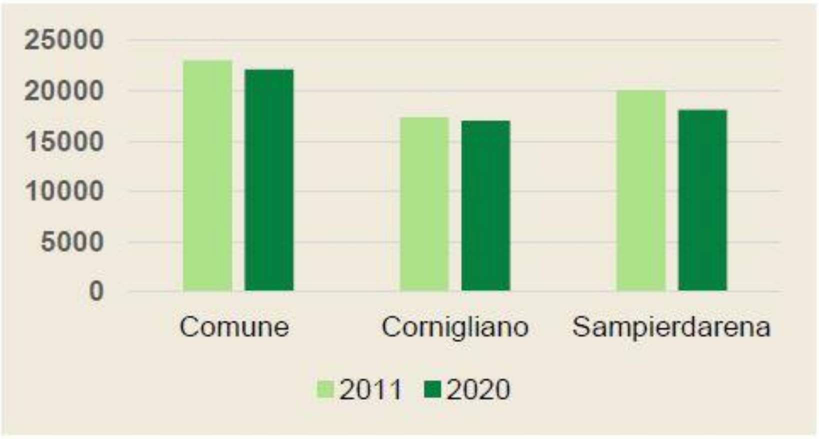


Figure 3 - Average income for year 2011 and 2020.

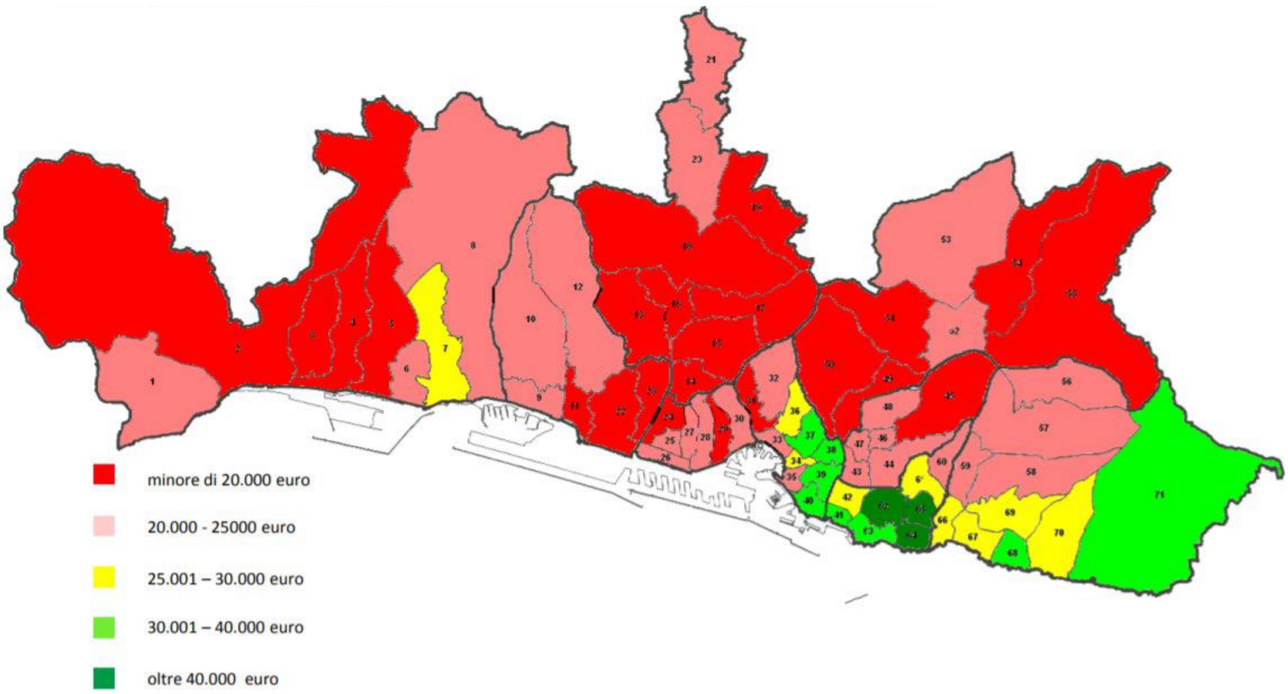


Figure 4 - Distribution of income in the Municipality of Genoa for year 2011.

Urban Heat Island (UHI) Effect Analysis

Temperature Mapping

In Genoa, based on daily meteorological data collected at the weather station of Airport C. Colombo di Genova Sestri Ponente and provided by the Regional Agency for the Protection of the Ligurian

Environment (ARPAL), it emerges that 2022 was characterized by two aspects: average high temperatures and generally low rainfall.

During 2022 in fact, the cumulated rainfall amounted to 488,6 mm, compared to 1.097 mm in 2021 (-609 mm; -55.5%). However, local strong episodes have been linked to thunderstorms or related phenomena (such as hailstorms, tornadoes, and storms).

The thermometer never fell below zero in 2022, and the average of the minimum temperatures recorded in Genova Sestri Ponente was 15.1 °C, while the average of the maximum temperatures reached the value of 20.5 °C, the absolute max value of 37.5 °C was detected on July 18. In Genoa, the intense summer heat coincided with a long anticyclonic phase with weak winds and a mainly calm sea for several weeks. Only in the last months of the year did some more structured Atlantic systems fail.

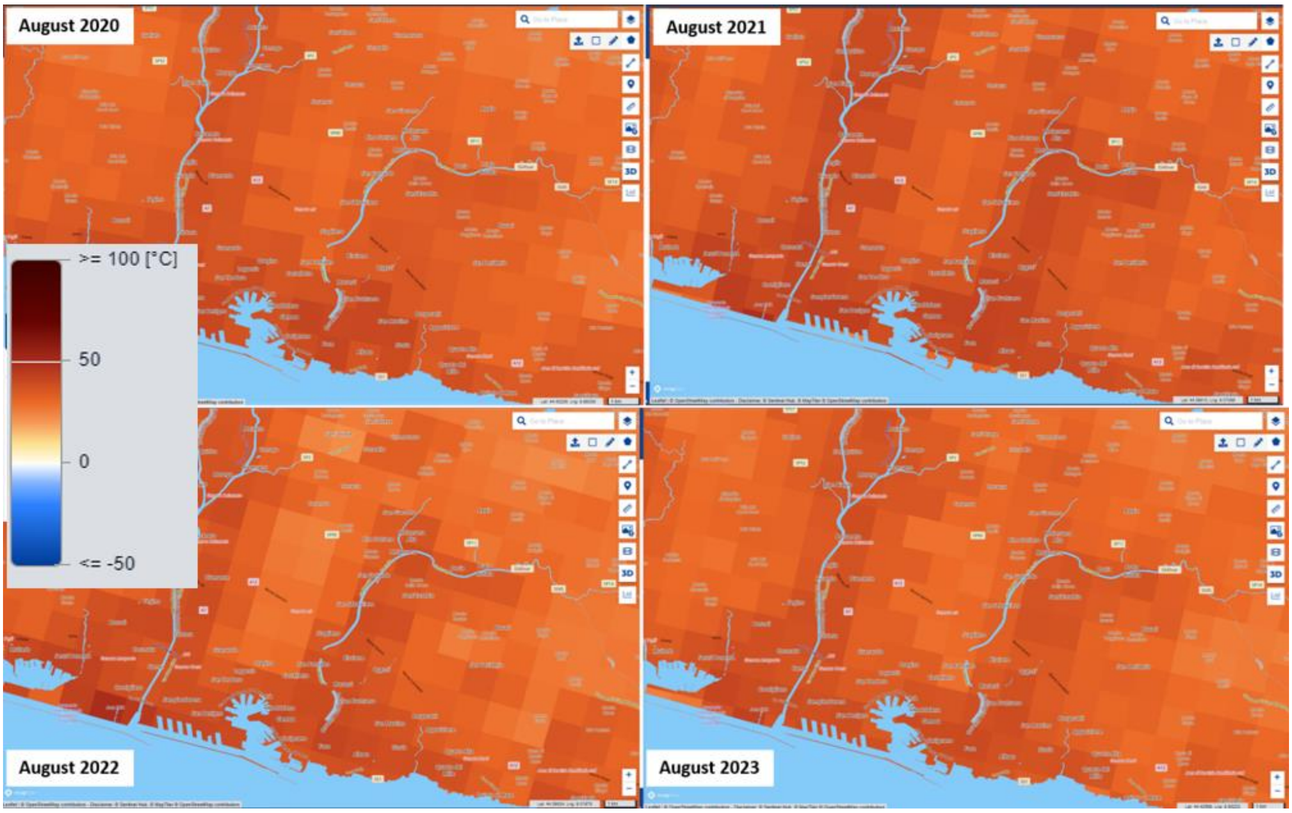


Figure 5 - S-3 Thermal IR fire emission bands, by S-3 (F2 Channel) showing daily temperature of different August days from 2020 to 2023.

Concerning temperature satellite measurements, the images of S-3 from the Copernicus program, as shown in Figure 5, represent the thermal infra-red fire emission bands (F2 Channel), and it is useful for high-temperature monitoring at 1 km resolution. From the images of S-3, despite the relatively limited spatial resolution, it is possible to note that the coastal areas and the valley floors, where the major urban nuclei are present, are the hottest.

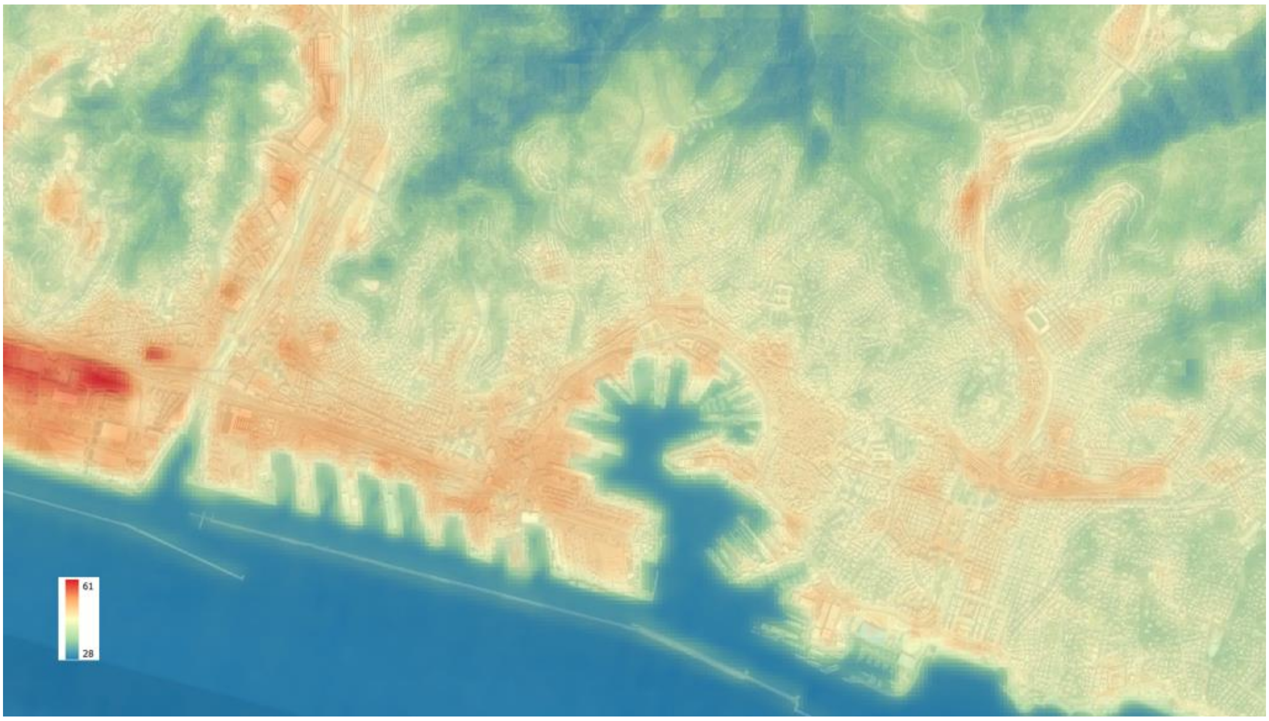


Figure 6 - Land Surface Temperature (LST) map of Genoa on 26/06/2023, derived from Landsat 8 satellite. Temperature is in celsius degrees and refers to the ground surface. Urban surfaces are much hotter than vegetated surfaces[28]. (Landsat Level-2 Surface Temperature Science Product by courtesy of U.S. Geological Survey).

NASA's Landsat 8 program provides much higher spatial resolution temperature maps (100 m), which represent in greater detail urban areas that at the same time of day have very different temperatures, as shown in Figure 6.

Temporal Analysis

Table 1 shows the average values of several years for the maximum and minimum temperatures, recorded in the weather station of Airport C. Colombo di Genova Sestri Ponente (ARPAL): in 2022 the highest values for both max and min were recorded along the ten-year series.

Temperature data		
Year	**Max. averages**	**Min averages**
2012	19,5	14,0
2013	18,9	13,4
2014	19,7	14,5
2015	20,3	14,7
2016	19,9	14,1
2017	19,8	14,1
2018	20,1	14,6
2019	19,9	13,9
2020	19,5	14,2
2021	19,0	13,8
2022	20,5	15,1

[28] https://www.cimafoundation.org/news/isole-di-calore-tra-modelli-previsionali-e-citizen-science/

Table 1 - Temperature data recorded at Airport C. Colombo, Genoa.

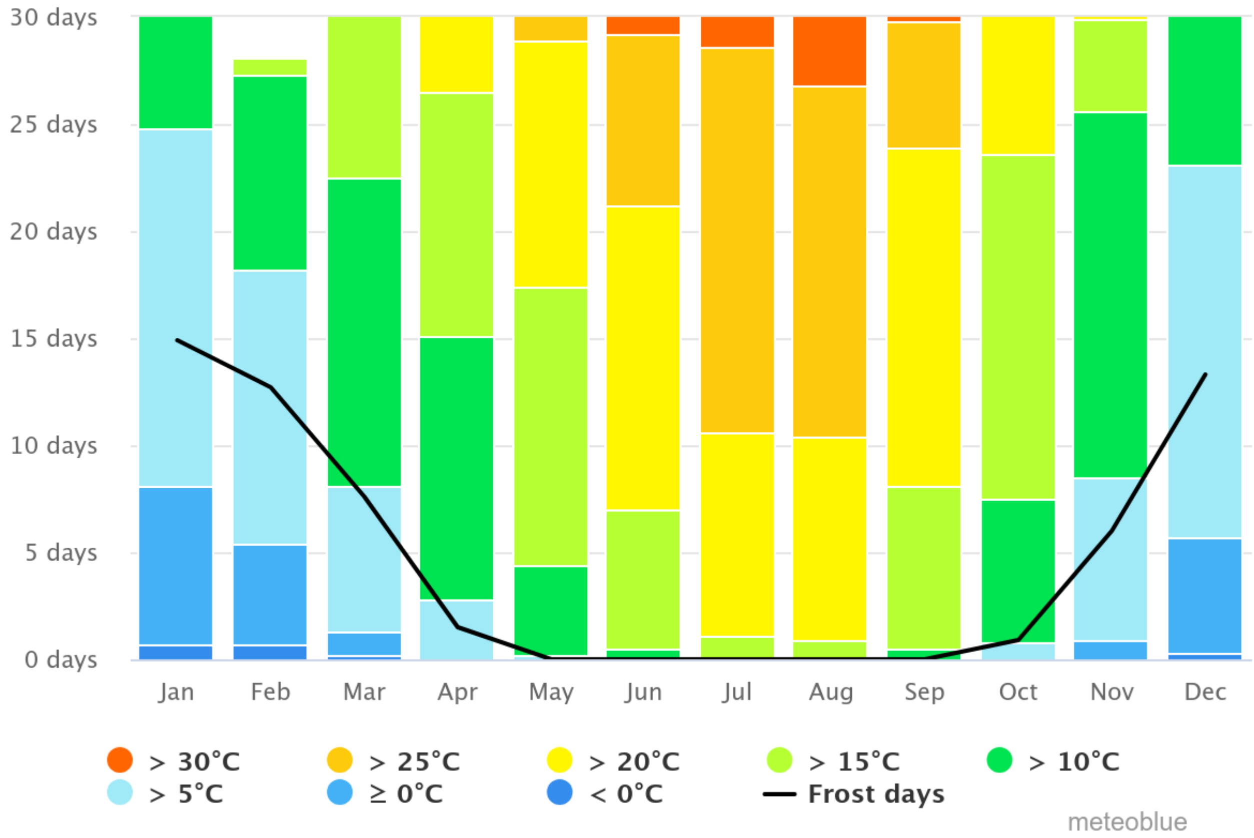


Figure 7 - The maximum temperature diagram for Genoa displays how many days per month reach certain temperatures.

As for the entire territory of the city during the last 30 years, Figure 7 shows what is the distribution of the days in different heat bands: in the period between June and September, the greatest number of days with higher temperatures is recorded. The summer period was chosen for the analysis of the UHI effect because it is the season where this has the most harmful effects.

Spatial Distribution

Figure reports the resulting average SUHI effect for day and night in the summer 2020. It shows Genoa urban areas where the difference in temperature to the surrounding rural area is on average, higher (up to 4 degrees during the day) during the summer season. The differences between the daily and nightly seasonal patterns are mainly due to the nature of the SUHI effect: active solar radiation on the Earth's surface increases the LST of particularly reflective surfaces, such as large urban areas during the daytime, thus raising maximum values. The nightly SUHI owing to the absence of active solar radiation, is less intense in term of temperature variations but more widespread[29]. Positive anomalies in temperature variation are detectable in the urban areas.

[29] https://www.mdpi.com/2072-4292/12/17/2713

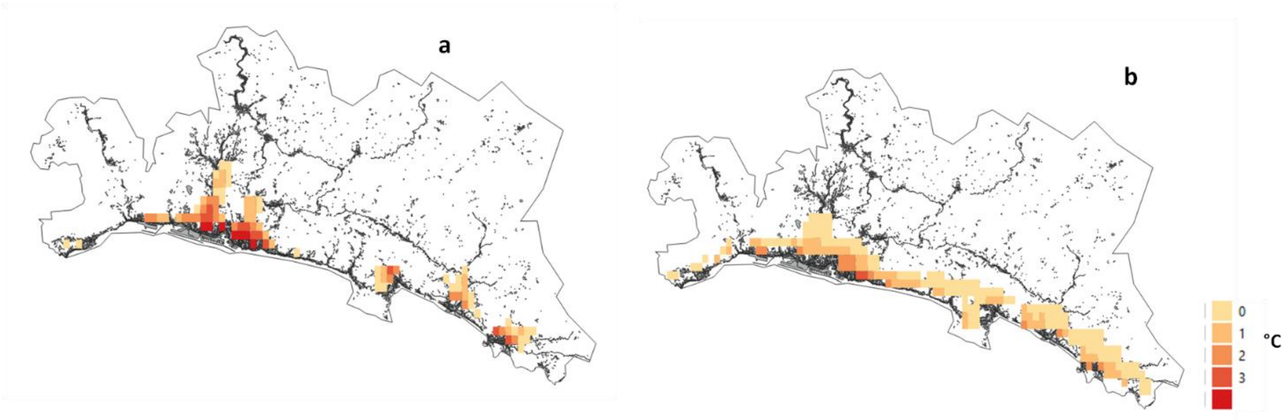


Figure 8 - SUHI daily (a) and nightly (b) average for summer 2020 in Genoa metropolitan area.

Figure reports the same behaviour, where the SUHI trend along Genoa's coastline is shown concerning land cover classes, urban or rural; a wide variability in the seasonal daily trend is detectable.

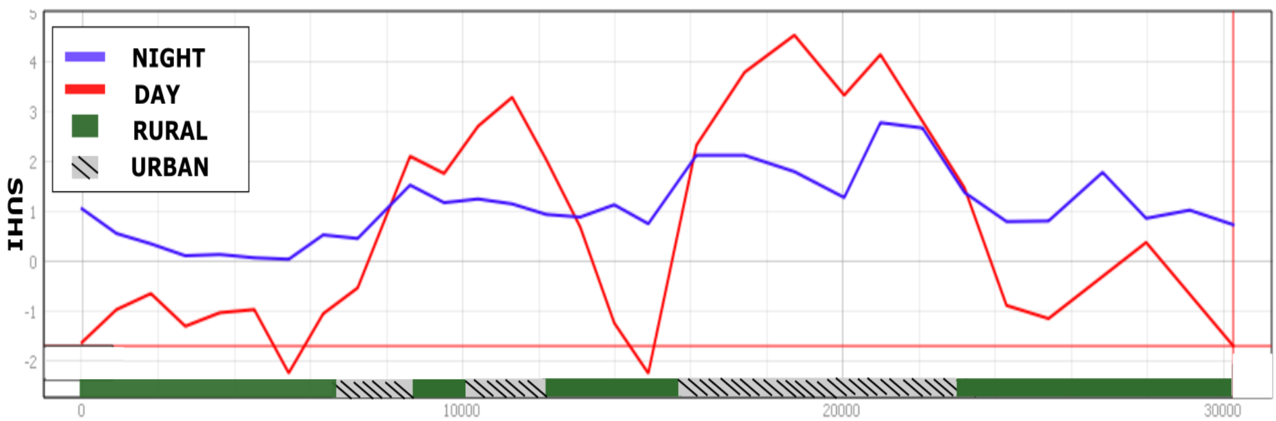


Figure 9 - Daily (red line) and nightly (blue line) SUHI seasonal profile for summer 2020 along Genoa central coastline (1 km wide, 30 km long), in relation to urban (grey) and rural (green) land cover classes (Corine Land Cover) of the same profile.

Micro-Climate Factors

Surface Characteristics

The urbanized areas of the Municipality of Genoa develop exclusively along the coast and in the valley bottoms, where most of the territory is urbanized and occupied by buildings, as shown in Figure 10.

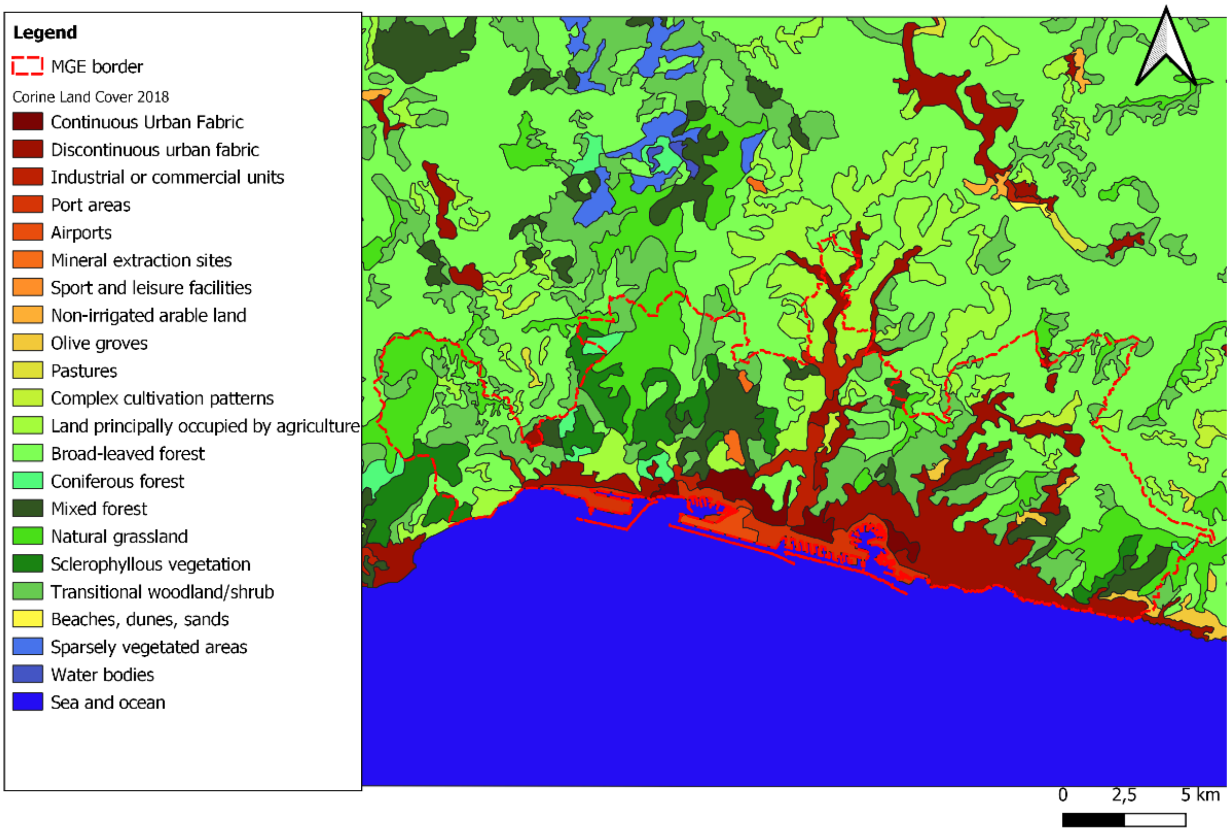


Figure 10 - Corine Land Cover Map (2018), source CLMS.

Green Spaces

The Genoese urban area includes large urban green surfaces and protected natural areas, creating a context in where, in the face of a significant presence of population, efforts have been made to preserve the green areas thanks to conservation and protection interventions.

From the analysis of ISTAT environmental data appears that in the year 2021 in the Municipality of Genoa the surface area of green areas (urban green areas and protected natural areas) amounts to approximately 75.079.458 m^2, of which 84% is made up of protected natural areas (63.102.195 m^2), while the remaining 16% is represented by urban greenery (11.977.263 m^2). The surface of the latter includes the areas of "historic greenery" and "large urban parks" (i.e. the green surfaces protected by the Cultural Heritage Code) for 13,1%, the "equipped greenery" areas for 8,1%, cemeteries for 4,1%, those of "street furniture" for 3,0%, "uncultivated green areas" for 1,7%, "school gardens" for 0,8%, outdoor sports areas for 0,3% and botanical and urban gardens for 0,1%. Wooded areas represent 68.8% of total urban greenery.

The usable urban greenery represents a surface area equal to 3.521.962 m^2, corresponding to 6,2% (ratio between urban green areas and the average resident population of the year). Accessibility to urban green spaces is not homogeneous in the municipal area: a higher percentage of the population has green spaces available within 300 meters of their home in the city center areas, while decidedly low values are recorded in the hinterland, especially along the course of the Bisagno.

There are also two protected areas, the largest one called “Beigua”, classified as a protected area of interest, and “Parco delle Mura”, classified as a protected area of local interest.

The hills and woods behind the neighborhoods guarantee a statistical balance because, as is known, in many neighborhoods the green areas that are immediately urban and usable by all citizens remain few and not sufficient. The urban area with high population density is mainly concentrated in coastal areas and near the rivers and their drains, representing one of the main fragilities of the territory concerning the climatic danger of extreme rainfall. A crucial element of fragility is represented by the limited diffusion of urban greenery and its poor accessibility, which does not guarantee an improvement in the permeability of the urban structure and is not suitable or sufficient to deal with the increasingly widespread heat waves in Liguria and Genoa.

The Municipality of Genoa adopted the strategic document for city's green infrastructure “Genova Green Strategy”, aimed at analyzing existing and increasing public green spaces through the organization of Genoa's public spaces. It is a document that establishes a series of objectives aimed at increasing permeability of the soil, reduce heat islands, mitigate environmental risks and redefine the relationship between city and nature, redesigning city greenery to combat climate change by exploiting the ability of plants to absorb carbon dioxide released into the atmosphere. This is a series of projects which involves the planting of new trees (in urban contexts but not only) and the reduction of soil waterproofing which is among the primary causes of hydrogeological instability.

Building Density and Height

Figure and Figure show the areas most affected by the presence of impervious buildings and surfaces. Buildings in the central areas of most neighborhoods of the city reach significant heights (> 5 or more floors). In peripheral areas and on the border with rural areas there are smaller buildings, often consisting of detached houses.

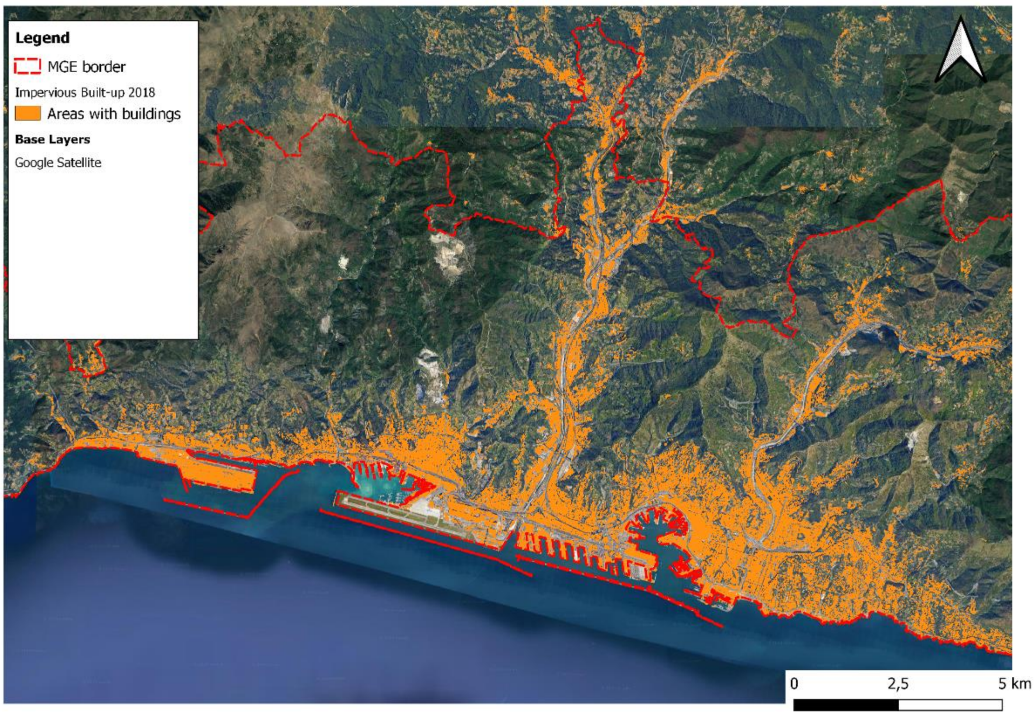


Figure 11 - Buildings distribution, source CLMS.

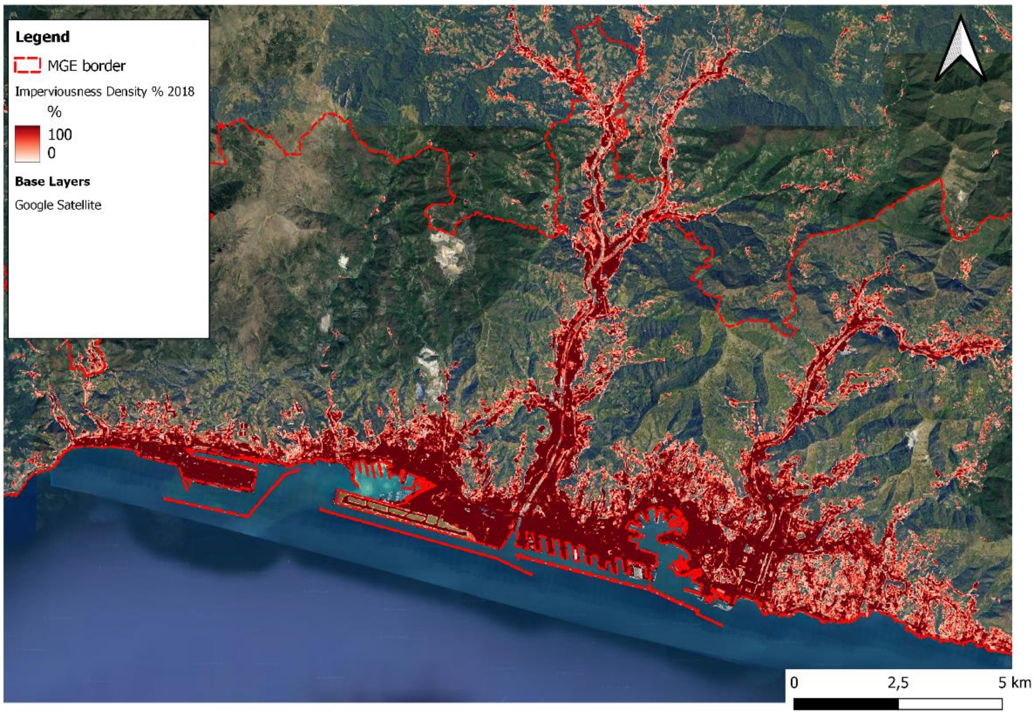


Figure 12 - Imperviousness density, source CLMS.

Water Bodies

The main body of water in the vicinity of the city of Genoa is the sea, which mitigates the temperature changes during the warmer and colder periods. However, the mitigating effect is reduced by the fact that most of the coastal areas of the city are affected by the presence of the port, and therefore, closed basins with limited thermal exchange, especially during the summer season. In fact, these waters tend to heat up reducing the mitigating capacity. In the city, there are also two large streams, which are subject to large seasonal variations in flow and are often dry during the summer.

Wind Patterns

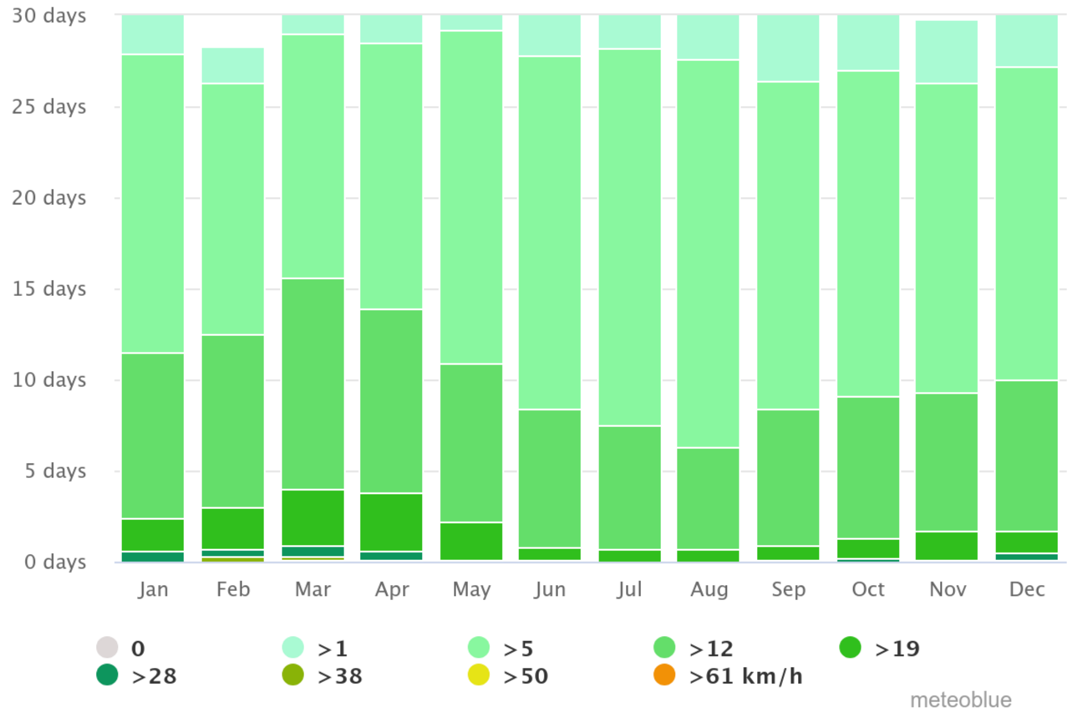


Figure 13 - The diagram for Genoa shows the days per month, during which the wind reaches a certain speed[30].

[30] https://www.meteoblue.com/

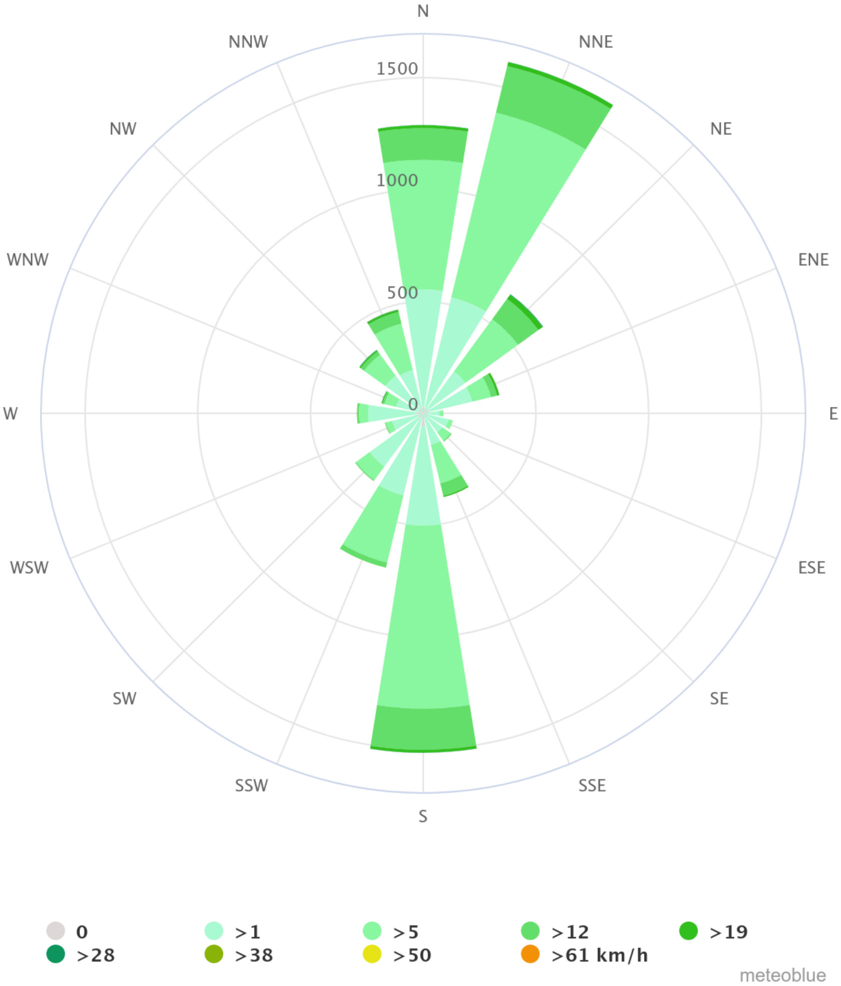


Figure 45 - The wind rose for Genoa shows how many hours per year the wind blows from the indicated direction[31].

In Figure and Figure 45 are reported the prevailing directions of the wind and the distribution of intensity in the various months of the year. In summer the average wind intensity is lower than other periods of the year, this factor contributes to increase the heat island effect.

Energy Use and Cooling Demand

Residential Energy Consumption

The available data about consumption of the residential sector date back to 2018 and out of a global total of 2.099.326.186 kWh amounts to 577.696.245 kWh. Updated data have been requested to the Distributor (e-Distribuzione). When they become available, the data will be updated.

Cooling Technologies

[31] https://www.meteoblue.com/

The most commonly used air-conditioning technology at the residential level is the use of direct expansion chillers (split/multisplit system). In residual cases, controlled mechanical ventilation (CMV) technology is also present. The COP usually is between 4 and 5.

Nature-Based Solutions (NBS) [32]

The national regulation promotes the implementation of Nature Based Solutions in the urban context. Ministerial Decree 23/6/2022 "*Minimum environmental criteria*" (CAM) for public contracts, contains the specific paragraph *2.3.3 Reduction of the summer heat island effect and air pollution* with criteria that must be respected with regard to surfaces to be used for greenery.

[32] https://documents1.worldbank.org/curated/en/502101636360985715/pdf/A-Catalogue-of-Nature-based-Solutions-for-Urban-Resilience.pdf

4.4 UHI & Micro-Climate Analysis Greece

Introduction

Purpose

The study area is characterized by the presence of a densely populated area, Patras Port a mini-perimeter road and three significant forested areas: 1) Dasyllio, 2) Eschatovouni, 3) Kavoukaki. By examining these factors, critical information is gathered to aid in effectively integrating Renewable Energy Communities (RECs) with nature-based solutions. These findings will inform strategies to mitigate Urban Heat Island (UHI) effects, enhance local climate resilience, and promote sustainable urban development through the symbiotic relationship between RECs and natural ecosystems.

Satellite image from the area of interest and surrounding area

Solar energy absorptivity coefficients (α) and thermal radiation emissivity coefficients (ε) for urban and rural surfaces.

Είδος επιφάνειας *SURFACE TYPE*	Συντελεστής απορροφητικότητας ηλιακής ενέργειας (α)[1] **SOLAR ENERGY ABSORPTIVITY COEFFICIENT**	Συντελεστής εκπομπής θερμικής ακτινοβολίας (ε) ***THERMAL RADIATION***
Άσφαλτος ***(Asphalt)***	0,05 – 0,20	0,95
Τσιμέντο ***(Concrete)***	0,10 – 0,35	0,71 – 0,91
Αστικές περιοχές ***(Urban Areas)***	0,10 - 0,27	0,85 – 0,96
Χώμα (υγρό προς ξηρό) ***(Soil {Wet-soil- Dry Soil)***	0,05 – 0,40	0,98 – 0,90
Γρασίδι ***(Grass)***	0,16 – 0,26	0,90 - 0,95

An area's urban planning and zoning significantly affect the atmospheric temperature within urban areas. Factors such as land coverage ratio, building density coefficient, maximum allowable building height, and other urban planning regulations are crucial in shaping the urban environment and the amount of incident solar radiation at the urban level. (Manni, 2020), (Voordeckers, D. st al., 2021)

The configuration of these volumes results in solar radiation being absorbed by building envelopes during the day, while during the night, the release of radiation back into the atmosphere is inhibited. Additionally, this specific urban layout restricts airflow and natural ventilation in cities, as the gaps created are insufficient for wind circulation. (Loughner et al., 2012)

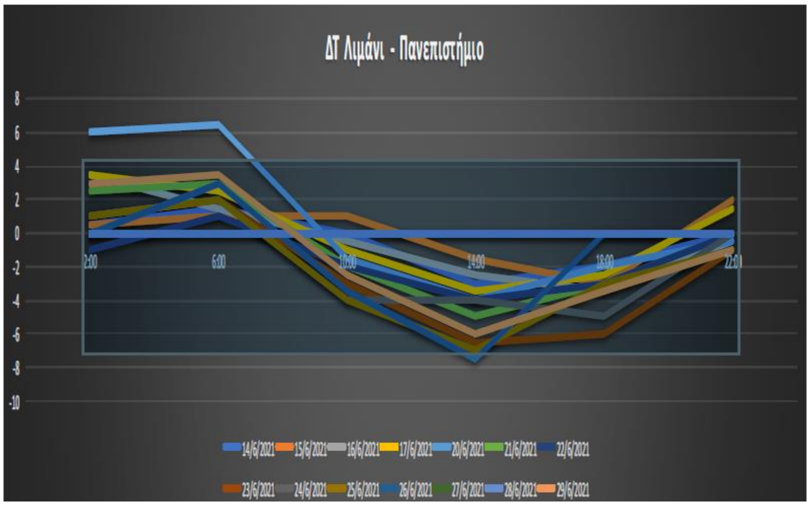
Human activities taking place within the area of interest, such as transportation, heating, and cooling of buildings, are responsible for generating additional heat. This accumulated heat, combined with incident and trapped solar radiation, exacerbates the Urban Heat Island (UHI) effect (Shahmohamadi et al., 2011).

The following table shows the percentage of built-up area (urban environment) relative to the total area of the geographic basin of the urban agglomeration for the three largest cities in Greece.

	Ποσοστό οικοδομημένης έκτασης ως προς το σύνολο επιφάνειας γεωγραφικής λεκάνης πολεοδομικού συγκροτήματος	
Αθήνα	***(Athens)***	66,15%
Θεσσαλονίκη	***(Thessaloniki)***	53,08%
Πάτρα	***(Patra)***	37,70%

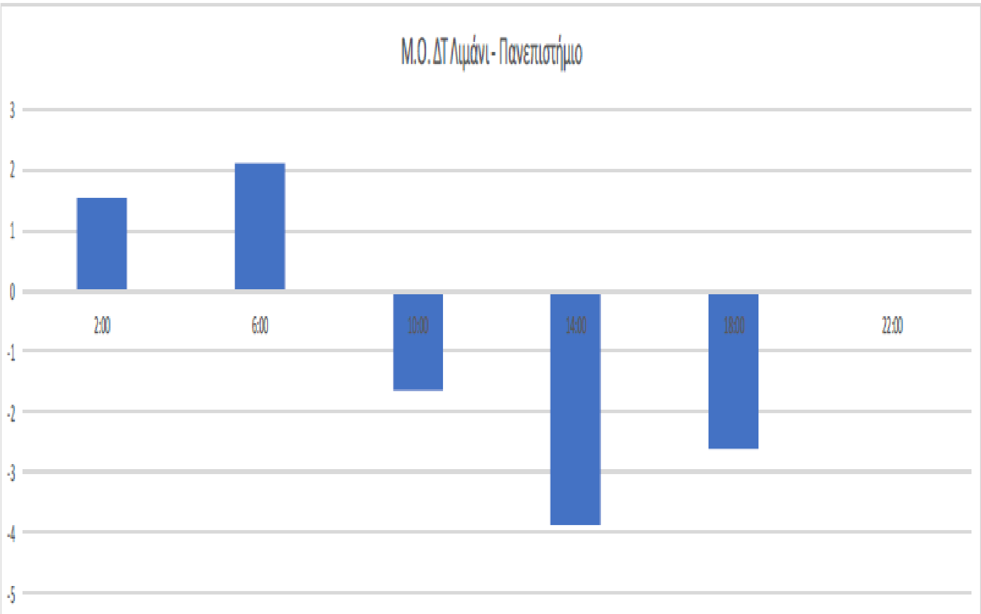
Percentage of built-up area relative to the total geographic basin area of the urban agglomeration. (Αβδελίδη, 2010)

The network of meteorological stations at the National Observatory of Athens provides us with accurate measurements regarding temperature variation in the entire area of interest.



Temperature difference variation between the Port and the area of interest [*https://www.meteo.gr/Gmap.cfm*](https://www.meteo.gr/Gmap.cfm)

The diagram shows that the average temperature at the Port is higher than the average temperature at the Interest area during the time intervals of 02:00 and 06:00. Specifically, during these periods, the temperature difference ranges from 1.5 to 2.0°C. However, later in the day, at 10:00, 14:00, and 18:00, the average temperature at the Port is lower than the average temperature at the University, ranging from 1.6 to 4°C. Finally, at 22:00, there is essentially no temperature difference between the two areas. This indicates that the UHI (Urban Heat Island) effect appears in the early morning hours, from 02:00 to 06:00, because the heat accumulated in the impervious building materials of the urban environment after sunset is emitted with a delay into the atmosphere, simultaneously warming the air layers in contact with these surfaces, thus creating a warmer microclimate in the area.



Average temperature difference between the Port and the area of area of interest, https://www.meteo.gr/Gmap.cfm

Scope

Neighborhoods around the Patras pilot intervention has specific characteristics social, demographic etc.

Neighborhood Overview

Geographical Context

The area of interest is classified as urban. It is distinguished by the intense residential development, while at the same time, due to the nodal element, located at the entrance and exit of the city, there is a strong traffic presence.

Demographics

The demographic information concerning the entire city of Patras based on the 2011 census data are:

TOTAL	Unmarried	Married, cohabiting and separated	Widows and widowers from a civil partnership	Divorced and persons divorced from a civil partnership
213.984	96.703	98.211	13.022	6.048
percentage %	45,19	45,90	6,09	2,83

TOTAL	Holders of a doctoral or postgraduate degree / Graduates of University - Polytechnic, TEI, ASPAITE, higher vocational and equivalent schools	Graduates of post-secondary education (IEK, Colleges, etc.)	High school graduates (General, Ecclesiastical, Vocational etc.)	Graduates of third grade high school and graduates of vocational schools	Primary School Graduates	They dropped out of primary school, but they know how to read and write	Unclassified (persons born after 1/1/2005)
213.984	39.685	7.024	64.355	25.368	41.714	21.739	14.099

EnerCmed Interreg Euro-MED Co-funded by the European Union

percentage %	18,55	3,28	30,07	11,86	19,49	10,16	6,59

TOTAL	GREEK	FOREINGERS		
		FOREIGN MINISTERS	EU COUNTRIES	NON EU COUNTRIES
213.984	202.870	11.114	2.173	8.941
percentage %	94,81	5,19	19,55	80,45

	MEN		WOMEN	
AGES	NUMBERS	percentage %	NUMBERS	percentage %
0-4	4.245	5,23	3.955	4,58
5-9	3.922	4,84	3.663	4,24
10 -14	4.059	5,00	3.893	4,51
15-19	5.642	6,96	5.720	6,63
20-24	8.129	10,02	8.040	9,31
25-29	6.600	8,14	6.198	7,18
30-34	6.715	8,28	6.294	7,29
35-39	5.942	7,33	6.230	7,22
40-44	5.937	7,32	6.665	7,72
45-49	5.087	6,27	5.934	6,87
50-54	5.052	6,23	5.702	6,60
55-59	4.453	5,49	5.060	5,86
60-64	4.268	5,26	4.649	5,39
65-69	2.952	3,64	3.199	3,71
70-74	3.041	3,75	3.681	4,26

EnerCmed Interreg Euro-MED Co-funded by the European Union

75-79	2.473	3,05	3.123	3,62
80-84	1.526	1,88	2.526	2,93
85+	1.071	1,32	1.800	2,08
TOTAL	81114		86332	

Building Conditions

The heat and the heating system in the house/flat are in the first place (over 10%). Humidity, Heating and Poor insulation all together reach almost 100%.

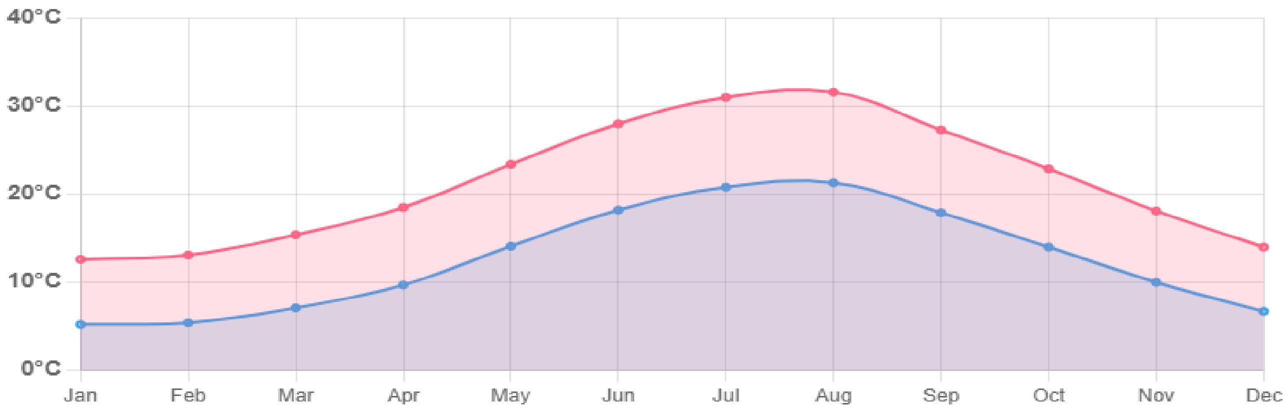
Energy Infrastructure

7.5% say they do not have any type of heating in their house, with the percentage reaching 14% for the "risk group", low-income families and pensioners.

Urban Heat Island (UHI) Effect Analysis

Temperature Mapping

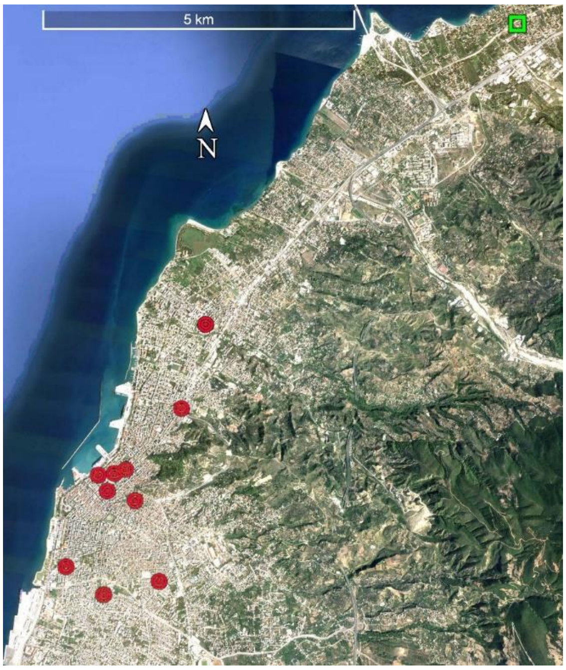
Utilize satellite imagery and/or ground-based temperature sensors to create detailed temperature maps of each neighborhood. Further data will be provided by the Greek Meteorological Service.



The mean minimum and maximum ground temperatures for Patras over the year.

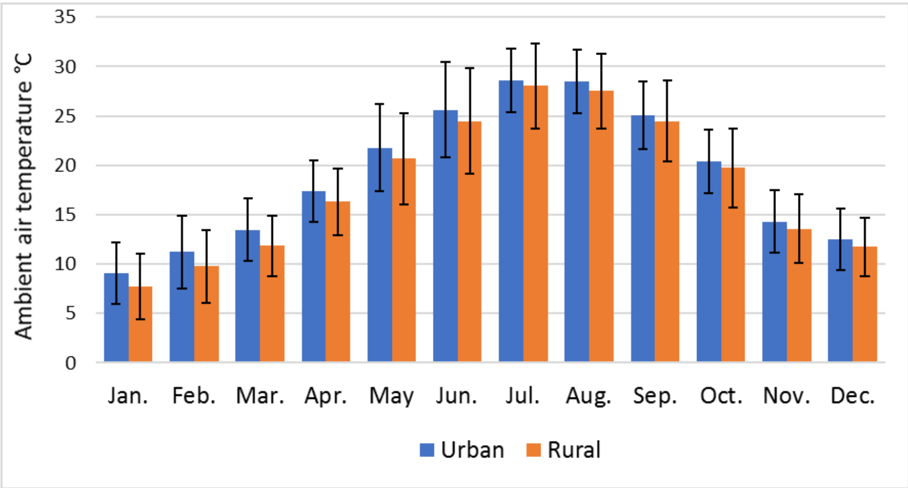
Temporal Analysis

The temperature measurements used were recorded for every hour. The period of data collection for Patras was the year 2018, and that for Kalamata was 2019 and 2020 full years Functional range of devices installed in Patras was −40 °C to + 85 °C, with sensor accuracy of ±0.2 °C, (range from 0°C to 70 °C) and resolution of 0.4 °C.



General view of Patras city. Red circles mark the locations of the ten urban monitoring stations and green rectangle the rural monitoring station (terrain view by Google Earth 2021).

The hourly recorded temperatures of each monitoring station for base temperatures of 18 °C and 26 °C were used to calculate the monthly HDHs and CDHs, respectively, using an equation. The HDHs and CDHs for the urban areas are calculated from the average HDHs, and CDHs collected from corresponding urban stations. The HDDs and CDDs are calculated by dividing HDHs and CDHs by 24. The urban zones of Patras are observed to have 5,495.89 HDHs less than the rural areas, approximating a 19.2% reduction, which is close to the early estimate of 22.3%. Similarly, the CDHs in urban areas are 9% higher than those in rural areas, indicating the UHI effect. January is the coldest month, and previous studies substantiate this finding. July is the warmest month, which contradicts the findings provided, which report August as the warmest. However, the CDHs or CDD statistics for Patras City have not been reported.



Average daily (24 h) ambient air temperatures (°C) for each month for Patras and their standard deviation.

Spatial Distribution:

According to monitoring data in the urban area of the City of Patras has been treated, and temperature variations are extracted.

Two representative cases of UHI are selected and presented for the summer period of 2015 (1/6/15-30/8/15). The first case concerns comparisons between transversal and longitudinal to the sea streets of the town center. As the second case, comparisons between urban and rural areas are selected.

In the 1st case, the temperature variation is for the transversal “Patreos” street and the longitudinal “Korinthou” street. Two sets of data are presented for the longitudinal street, one for the center and another for its ending portion outside the center. According to the monitoring data, the transversal street has lower temperatures than the longitudinal one (even for the outside part).

A comparison is made between the longitudinal "Korinthou" street (urban) and the rural place of "Ag. Vasilios". The upper peaks have quite the same magnitude, while the rural region develops lower down peaks.

As an urban place, the up-town "Pantokratoros" street, which lies near the forest hill of the town, is selected and thus characterized as "sub" urban. Comparison with the rural region of "Ag. Vasilios" indicates that the rural area develops higher daily and lower night temperatures.

In order to understand better this behavior, two more figures are given.

The rural region develops higher daily peak temperatures, always higher than the "sub"urban place and many times higher than the urban place (at the town entrance). The rural night temperatures are always lower than urban and "sub" urban.

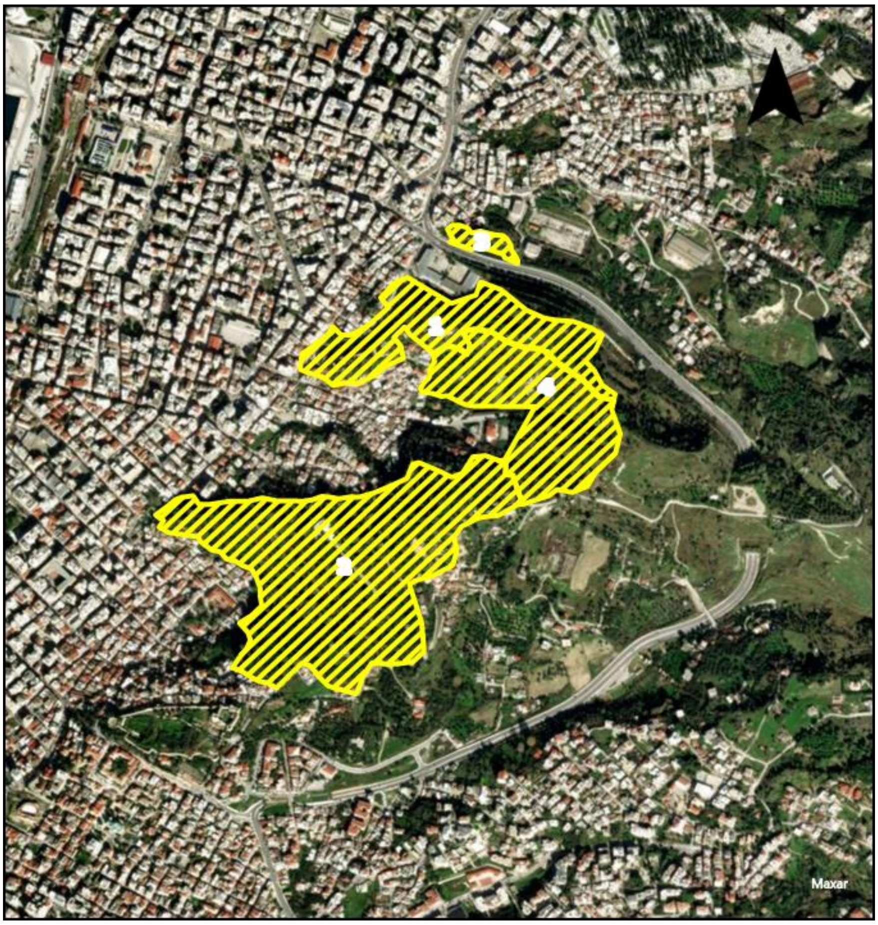
Micro-Climate Factors

Surface Characteristics:

The area of interest is mainly characterized by the concrete used to build the houses. Asphalt is also strongly present due to the neighborhood roads and the mini perimeter. Finally, there are also several large areas of vegetation due to the adjacent woodlands in the area.

Green Spaces

The main green spots in our study area are as follows: 1) Dasyllio, 2) Eschatovouni, 3) Kavoukaki. Several undeveloped areas are not worth mentioning. One of the main characteristics of these three small forests is the grove covering almost their entire extent, mainly consisting of dense clusters of pine trees. Additionally, some characteristic species of bryophytes are worth mentioning, including Barbulavinealis Brid., BryumargenteumHedw., Funaria hygrometricaHedw, and Pleurochaetesquarrosa. The main tree species encountered in these forests are pine trees, upright cypresses, koutsoupies, carobs, false acacias, myrtles, and lentisks. It is also worth mentioning that the Municipality of Patras recently planted around 800 trees of the aforementioned species.(https://kede.gr/patra)



SCALE:1:10.000

Green Spaces

https://gissrvweb.geopatras.gr/publish_t/webapps/dp/

GREEN TOTAL AREA:352.892

AA	AREA
1	68.939
2	197.920
3	5.430
4	80.603

Influence on Local Temperatures

Shade Provision: The dense canopy of the large pine trees provides extensive shade, which helps lower the area's temperatures by reducing direct sunlight exposure.

Evapotranspiration: Pine trees release water vapor into the air through a process called evapotranspiration. This process cools the air and increases humidity, creating a more comfortable microclimate.

Heat Island Effect Reduction: Urban areas often experience higher temperatures due to human activities and infrastructure, known as the heat island effect. The presence of the forest helps to mitigate this effect by cooling the surrounding air.

Microclimate Modification

Temperature Moderation: The forest acts as a natural temperature buffer, reducing extreme temperature fluctuations. It helps keep the area cooler in the summer and slightly warmer in the winter.

Wind Barrier: The forest can serve as a windbreak, reducing the impact of strong winds on the area. This not only makes the climate more pleasant but also helps in preventing soil erosion.

Environmental Benefits

Air Quality Improvement: Pine trees filter pollutants from the air, improving air quality. Theyalsoreleaseoxygen, contributingto a healthieratmosphere.

Biodiversity Support: The forest provides a habitat for various species of flora and fauna, supporting local biodiversity and creating a balanced ecosystem.

Soil Stabilization: The root systems of the pine trees help to stabilize the soil, preventing erosion and maintaining the integrity of the landscape.

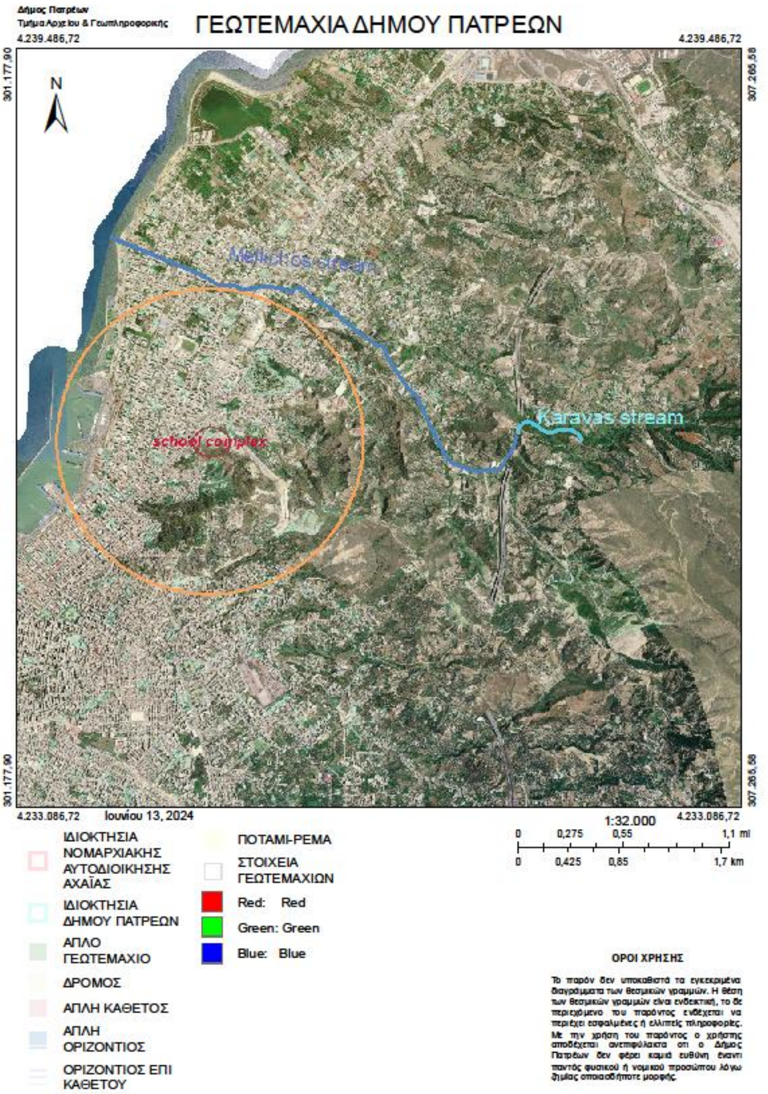
Recreational and Aesthetic Value: The forest offers recreational opportunities and enhances the visual appeal of the area, contributing to the well-being of the local community.(https://www.sciencedirect.com/)

Building Density and Height:

From the topography of the buildings located in the area we can conclude that they are not characterized by particularly high heights due to the fact that the building factor in general in the area allows the construction of buildings up to 3 floors. There are of course cases where 5 floors are constructed, but they are few in the area. Therefore in terms of the height of the buildings the air flow is not particularly affected. On the contrary, however, there is another element that affects air flow and that is the density of building which is very high in this area. There are places where there is sparse building density, but it is too small to affect the general climate.

Due to the construction material of the buildings, concrete, and in combination with the poor air flow in the area, there is a strong accumulation of heat

Water Bodies



Identification of Water Bodies Meilichos River Karavas Stream

Temperature Regulation: Rivers and streams can have a cooling effect on the surrounding areas, particularly during summer. Water can absorb and store heat, which results in lower air temperatures near the river.

Humidity: The presence of water increases the air humidity, making the temperature feel higher in the summer due to the humidity effect.

Microclimate: Creates a microclimate around the riverbed, with cooler temperatures compared to urban areas away from the water. (https://www.sciencedirect.com/)

Heat Dispersion: Although smaller in size, the Karavas Stream also contributes to heat dispersion and creates cooler conditions in its immediate areas.

Evaporation: The evaporation of water from the stream contributes to cooling the air, as evaporation requires heat from the surroundings.

Urban Heat Island Effect: In more densely populated and urbanized areas, such as those around the Karavas Stream, the presence of water can mitigate the urban heat island effect, where temperatures are higher due to the absorption and emission of heat from buildings and roads.(https://www.sciencedirect.com/)

Cooling Effects of Water Bodies

Evaporation and Transpiration: Water bodies contribute to the cooling of the micro-climate primarily through the processes of evaporation and transpiration. As water evaporates, it absorbs heat from the surrounding environment, resulting in a cooling effect.(Hellenic Cadastre. (2024). Geographic data and maps. Retrieved from Hellenic Cadastre).

Thermal Conductivity and Heat Capacity: Water has a high specific heat capacity, which means it can absorb a large amount of heat without a significant rise in temperature. This characteristic helps stabilize temperatures in the surrounding area, reducing the occurrence of extreme heat events.(Hellenic National Meteorological Service. (2024). Climate data for Patras region. Retrieved from HNMS).

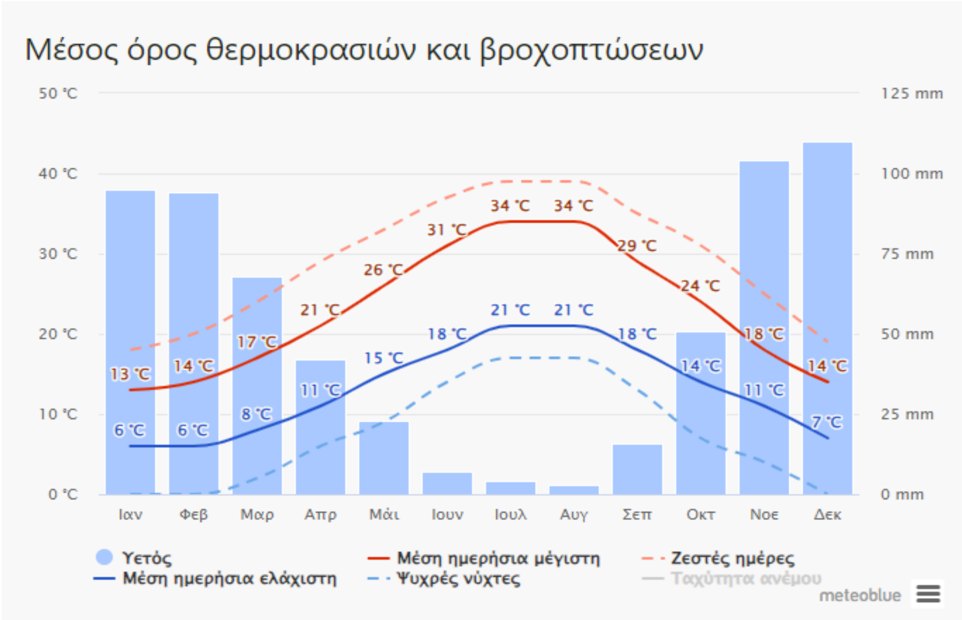
Wind Patterns

In winter in our study area, the three local forests (Dasyllio, Esxatovouni, and Cavoukaki) can act as barriers to cold winds, shielding the region from harsh weather conditions. Winds passing through or around the forests may lose some of their chill, resulting in milder winter temperatures compared to nearby open areas. Additionally, the forests themselves can trap heat during the day and release it at night, creating microclimates within the region.

The presence of the sea also significantly influences the local climate of Patras, being a coastal city. The proximity to the sea moderates temperature extremes, especially during winter, when maritime air masses tend to be warmer than continental air masses. The sea surface acts as a heat reservoir, absorbing solar radiation during the day and releasing it slowly during the night, thus regulating temperature fluctuations along the coast.

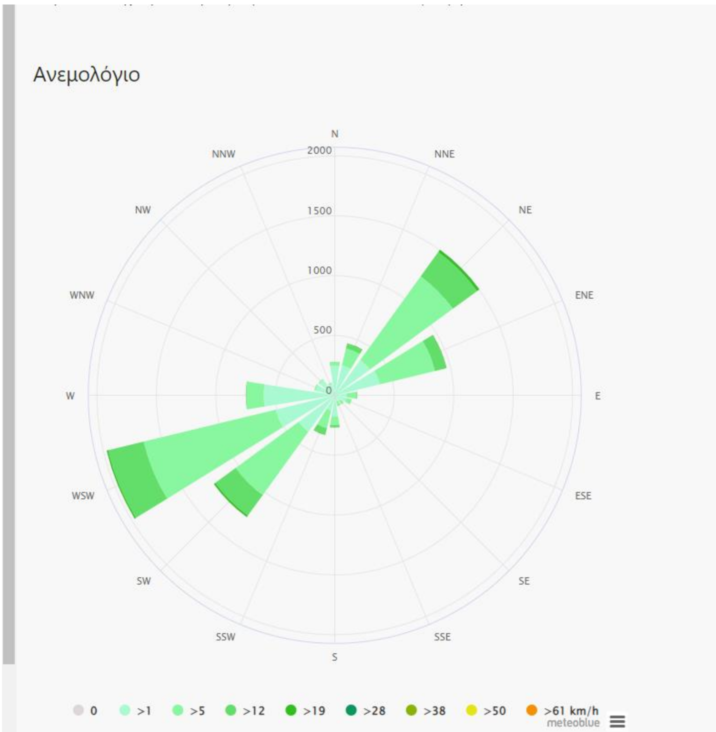
During transitional seasons, such as spring and autumn, the interaction between the forests, the sea, and prevailing winds can lead to dynamic temperature fluctuations. The sea breeze phenomenon, where cooler air from the sea moves inland to replace the warmer air over the land, can moderate temperature changes and influence wind patterns. Depending on factors like leaf cover, tree density, and sea surface temperature, these interactions may enhance or moderate temperature variations, shaping the overall climate patterns in the area.

Overall, the combined influence of the surrounding forests and the sea contributes to the complexity and diversity of the local climate in Patras, affecting wind patterns and temperature distribution throughout the year. Below are three different types of detailed diagrams:



1)Climate Diagram: "Mean Temperature and Precipitation" https://www.meteoblue.com/

The "daily mean maximum" (solid red line) shows the maximum temperature of an average day for each month for Patras. Similarly, the "daily mean minimum" (solid blue line) indicates the average minimum temperature. Warm days and cold nights (dashed red and blue lines) represent the average of the hottest day and coldest night of each month for the last 30 years.(https://www.meteoblue.com/)



2) Wind Rose : Year 2022https://www.meteoblue.com/

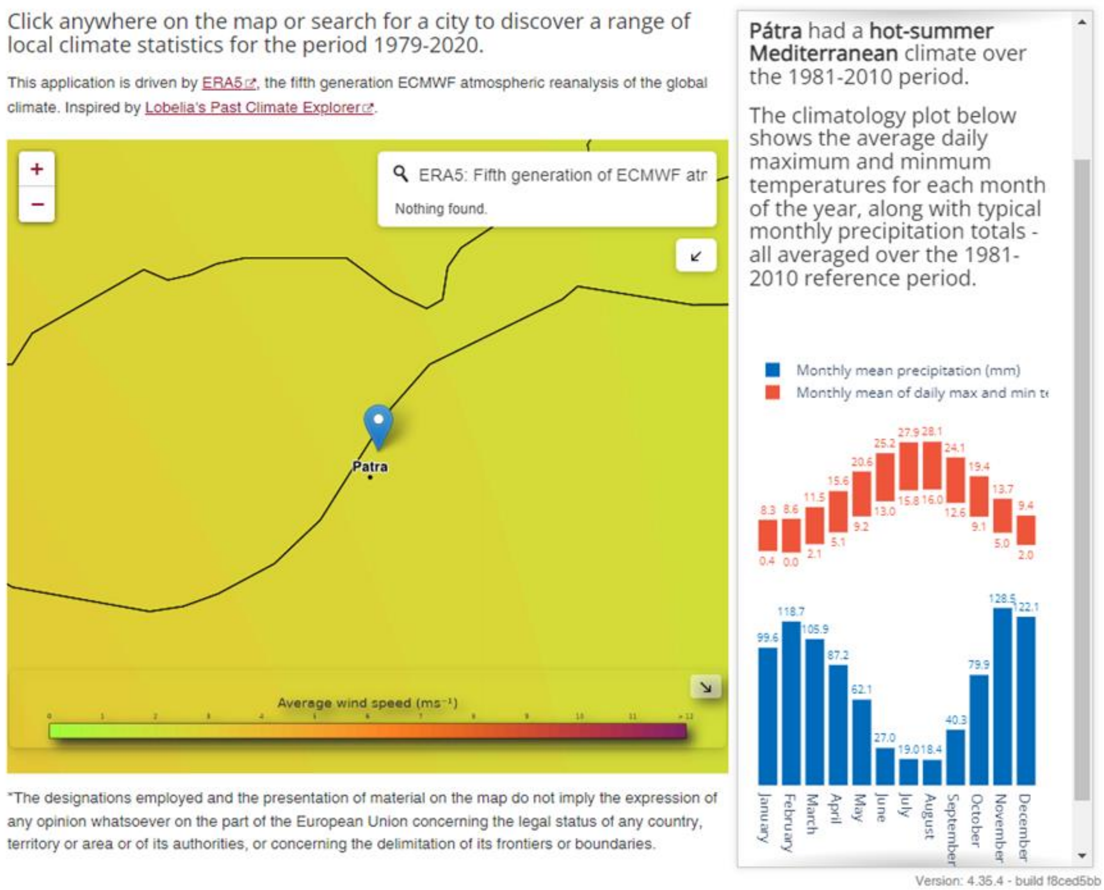
The wind rose for Patras, which shows the number of hours annually that the wind blows from the indicated direction. For example, NW indicates that the wind blows from the Northwest toward the

Southeast. In a region surrounded by three forests, prevailing wind patterns play a crucial role in shaping the local climate and temperature variations throughout the year.

During the summer, winds blowing from the direction of the forests can bring a cooling effect to the area, especially if the forests are dense and well-established. These winds may carry moisture, relieving the heat and contributing to a more moderate temperature regime. However, if the forests are sparse or distant, the prevailing winds might not have a significant cooling influence, and temperatures could remain relatively high.

In winter, these three local forests can act as barriers to cold winds, shielding the region from harsh weather conditions. Winds passing through or around the forests may lose some of their chill, resulting in milder winter temperatures than nearby open areas. Additionally, the forests can trap heat during the day and release it at night, creating microclimates within the region.

The interaction between the forests and prevailing winds can lead to dynamic temperature fluctuations during transitional seasons, such as spring and autumn. Depending on factors like leaf cover and tree density, the forests may either enhance or moderate temperature changes, influencing the overall climate patterns in the area.



3) Atmotmosfairic reanalysis Diagram

Energy Use and Cooling Demand

Residential Energy Consumption

Household space cooling accounts for 4.9 % of total energy consumption in residences. 66,7% of households are using e some system to cool their residence, it uses independent air conditioning units 2-4 months a year, while 30.9% less from 2 months. The electricity authority will seek data on energy use to achieve cooling. Regarding the daily operation of cooling systems, half of households use them on average 3-5 hours, according to the summer months (May to September). The figures concern the major urban centers of Greece (Athens, Thessaloniki, Piraeus, Patras, Larissa, Heraklion, Ioannina, etc.) and are obtained from the energy management authority.

Cooling Technologies

Due to the age of the buildings, for over 10 year old structures, the technology used mainly to achieve cooling in households is air-conditioning with thermal efficiencies for the majority of 9,000btu to 12,000btu. A second commonly used medium is that of the fan. As far as heat pumps are concerned, because they have recently become widely known, they have not yet been installed in many households.

5 SOCIAL COMPOSITION AND ENERGY POVERTY ANALYSIS

5.1 Social composition and energy poverty analysis Spain

Introduction

Purpose

This analysis aims to provide an overview of the concrete socio-demographic features of the two target neighborhoods in Valencia - La Malva-Rosa and Natzaret in the Poblats Marítims neighborhood - and the difficulties in accessing energy across vulnerable households. This will allow us to design better and implement the actions and solutions for the EnerCMed pilot.

Scope

The target area is the 11th district of Valencia, namely Poblat Maritimes. This is the easternmost area of the city, on the edge of the seaside. It is composed of 5 neighborhoods. The study focuses on two of them: Natzaret and Malva-Rosa.

Map 1: Location of Natzaret neighborhood

Map 2: Location of Malva-Rosa neighborhood

Both areas arose as maritime and fishing neighborhoods with unique features and lifestyles. There are still vestiges of this heritage, such as the traditional houses and constructions, making improving isolation, efficiency systems, and renovation very difficult. Both are considered working neighborhoods. Natzaret also has a large group of migrant people residing in.

Regarding La Malva-Rosa, the project will focus on an existing solidarity energy community developed in CEIP Ballester Fandos School for children and primary studies. Being aware of the families' difficulties, the school management has started a process to create and share energy among vulnerable households in La Malva-Rosa with Nature Based Solutions. They are currently at the early stages of the energy community. EnerCMed will foster collaboration with them to speed up this process.

On the other hand, Natzaret is located by the city port, in the southeast of València, quite isolated from the urban center due to its orography. It has different municipal and public services, such as a sports center, a delegation of social services, a public library, centers for elderly people and neighborhood associations. It also has a traditional associative lifestyle and a strong social network with different entities and NGOs working together to improve the image and living conditions in Natzaret. It also has three schools that are very committed and involved in the development of the neighborhood.

It is also worth mentioning that both neighborhoods have a bad reputation among others in the city due to insecurity problems and drugs in the past, despite the efforts of social entities, NGOs, and civil associations to change this image. This has contributed to progressive isolation or marginalization, especially in the case of Natzaret, which is physically poorly connected to the rest of the city.

Methodology

The data collection for this socio-economic and demographic analysis of the two neighborhoods comes mainly from the Municipal Statistics Office in Valencia and their periodic reports, namely:

Ajuntament de València (2022): “Districte 11. Poblats Marítims. Barri 5 Natzaret” Oficina d'Estadística de València

Ajuntament de València (2023): “Districte 11. Poblats Marítims. Barri 3. La Malva-Rosa” Oficina d'Estadística de València

Municipal Population Registration Office open data

Ajuntament de València (2024): Dades estadístiques de la ciutat de València. Num 3 Juliol-Setembre 2024" Oficina d'Estadística de València

The energy poverty data are gathered thanks to the "Energy Vulnerability Report in Valencia and its Action Plan 2023-2030" (2023), drafted by AIEOLUZ Energy Consultancy and the municipal Valencia Climate and Energy Foundation. These are reliable and updated data sources. Finally, we will also consider our own experience working closely with these two neighborhoods on previous projects and initiatives on energy poverty and communities.

Demographic Profile

Population Size and Density:

According to the Municipal Statistic Office and the report for each neighborhood, the evolution of the population size and density for both neighborhoods is as follows:

Neighborhood population evolution	1991	2001	2015	2020	2022
Natzaret	6749	6073	6060	6117	6088
La Malva-Rosa	13544	13458	13496	12915	12925

Neighborhood	Population 2022	Area	Density
Natzaret	6.088	91,7	66,4
La Malva-Rosa	12.925	72,9	177,4

Both have been slightly losing population over the years. La Malva-Rosa has more population density than Natzaret.

Age Distribution:

The age and gender distribution for both neighborhoods in 2022-2023 is as follows:

Natzaret	Total	0-14	15-29	30-44	45-59	60-79	80 +
Total	**6088**	886	1053	1221	1391	1195	342
Men	**2980**	463	534	595	739	534	115
Women	**3108**	423	519	626	652	661	227

La Malva-Rosa	Total	0-14	15-29	30-44	45-59	60-79	80 +
Total	**12925**	1481	1970	2555	2842	3271	806
Men	**6206**	758	1046	1279	1400	1454	269
Women	**6719**	723	924	1276	1442	1817	537

The average age for Natzaret is 43, whilst 46,2 in La Malva-Rosa.

Household Composition

Regarding household composition, it is worth looking at some additional demographic statistics that help us better understand the composition of both neighborhoods and their inhabitants.

First of all, it is worth analyzing the data of the people and their place of birth for both neighborhoods.

Neighborhood	Total	Valencia City	Valencia Region	Other regions Spain	Outside Spain
Natzaret	**6.088**	3.557	267	906	1358
La Malva-Rosa	**12.925**	7.420	788	2.075	2.642

If we deepen into these, according to the Municipal Statistics Office, the migrant people residing in both areas by nationality is as follows:

Neighborhood	Total	EU	Non EU Europe	Africa	North America	Central America	South America	Asia	Oceania and others
Natzaret	**1173**	298	95	227	12	80	341	112	8
La Malva-Rosa	**2118**	667	283	171	36	110	622	224	6

Thus, we can see that the percentage of migrant population (outside Spain) coming to these areas is 19,3% in Natzaret and 16,4% in La Malva-Rosa. These are quite high relative numbers for the city of Valencia, and this is partially explained by the strong social and supportive network operating in the area, which facilitates integration, as well as the lower price of housing compared with the rest of the city.

In addition, we can see that Europeans and South Americans are the largest groups living in. This is explained by the facilities of EU migrants (bureaucracy and legal permissions) and the language (Spanish mainly spoken in South America). These charts do not take into consideration migrant people with irregular administrative situations or not registered in the municipality.

Regarding general civil status data, according to the mentioned reports, Natzaret (2022) has 55% of single people, 35,68% married, 4,75% widowed and 4,58% divorced or separated inhabitants. Moreover, 25,8% of women do not have kids, whilst 74,2% have - among them, 21,4% have one kid, 40% have two children and 38,5% 3 or more.

On the other hand, La Malva-Rosa (2023) has 39,4% of single people, 44,2% married, 8,5% widowed and 7,7% divorced or separated people. Regarding children, 32,88% of women living in La Malva-Rosa do not have kids, whilst 67,12% have - among them, 22,9% have one kid, 48,3% have two children, and 28,8% have 3 or more.This is relevant as we can find, especially in Natzaret, households with many children living in as new families are moving in.

Socio-Economic Characteristics

Income Levels

According to the MIS (Minimum Income Standard), 23,23% of valencian households have an income level that, once energy and housing expenses are deducted, it still remains below the highest minimum insertion income (AIEOLUZ, 2023).

If we take a closer look at the cadastral value of housing in Natzaret and La Malva-Rosa we can see that they are among the lowest in the city (35.000€ or less). Therefore, lower-income people usually can only afford housing in these neighborhoods.

LLISTAT DELS BARRIS SEGONS VALOR CADASTRAL MITJÀ DELS HABITATGES

LISTADO DE LOS BARRIOS SEGÚN VALOR CATASTRAL MEDIO DE SUS VIVIENDAS

35.000 € o menya	De 35.001 a 40.000 €	De 40.001 a 45.000 €	De 45.001 a 60.000 €	Més de 60.000 €
7. 4 la Fontsanta	9. 3 la Creu Coberta	5. 3 Trinitat	17. 3 Carpesa	1. 1 la Seu
4. 3 el Calvari	12. 3 la Creu del Grau	19. 3 Pinedo	8. 1 Patraix	3. 4 Arrancapins
7. 3 Tres Forques	18. 1 Benimàmet	19. 2 Castellar-l'Oliveral	8. 2 Sant Isidre	15. 3 Sant Llorenç
17. 5 Mauella	12. 1 Aiora	11. 4 Beteró	19. 6 el Perellonet	10. 7 Ciutat de les Arts i de les Ciències
11. 2 el Cabanyal-el Canyamelar	5. 2 Morvedre	8. 5 Favara	3. 1 el Botànic	18. 2 Beniferri
15. 1 Orriols	10. 2 En Corts	4. 2 les Tendetes	2. 1 Russafa	6. 4 Ciutat Universitària
11. 5 Natzaret	13. 1 l'Illa Perduda	12. 2 Albors	13. 2 Ciutat Jardí	6. 2 Mestalla
17. 4 les Cases de Bàrcena	9. 2 l'Hort de Senabre	9. 1 la Raiosa	19. 4 el Saler	4. 4 Sant Pau
16. 2 Ciutat Fallera	1. 3 el Carme	12. 4 Camí Fondo	19. 8 Faitanar	17. 6 Massarrojos
19. 7 la Torre	17. 2 Poble Nou	7. 5 la Llum	17. 1 Benifaraig	2. 3 la Gran Via
19. 1 el Forn d'Alcedo	7. 1 Nou Moles	5. 5 Sant Antoni	8. 4 el Safranar	1. 2 la Xerea
9. 4 Sant Marcel·lí	10. 1 Montolivet	16. 1 Benicalap	14. 2 Camí de Vera	12. 5 Penya-roja
7. 2 Soternes	9. 5 Camí Real	8. 3 Vara de Quart	1. 5 el Mercat	1. 6 Sant Francesc
11. 3 la Malva-rosa	11. 1 el Grau	14. 1 Benimaclet	3. 2 la Roqueta	6. 1 Exposició
10. 4 la Fonteta de Sant Lluís	13. 3 l'Amistat	10. 3 Malilla	4. 1 Campanar	6. 3 Jaume Roig
15. 2 Torrefiel		1. 4 el Pilar	10. 6 la Punta	2. 2 el Pla del Remei
5. 4 Tormos		17. 7 Borbotó	3. 3 la Petxina	
10. 5 na Rovella		19. 5 el Palmar	13. 5 la Carrasca	
5. 1 Marxalenes			13. 4 la Bega Baixa	

Source: Real State Cadastre 1-1-2024 & elaboration by Oficina d'Estadística Report (2024)

This, combined with the previous demographic analysis, provides evidence of the progressive deterioration, or even marginalization, of Natzaret and La Malva-Rosa. In addition, both neighborhoods have two dedicated Municipal Social Services delegations, being among the most active in València. Finally, we can also state these neighborhoods' low income levels by analyzing the following indicators.

Employment Status

Both neighborhoods have high unemployment rates. If we take a look at the data provided by the Municipal Statistics Office, we can see the following numbers:

Neighborhood	Total population over 16 y/o	Active*	Not active**	Full-time job	Part-time job***	Unemployed who have worked before	Unemployed looking for 1st job***
Natzaret	4.350	3.020	1.325	1.325	225	1.375	100
La Malva-Rosa	12.115	7.035	5.080	3.765	835	2.160	275

* Population in working age matching the conditions to work, either if they are employed or not

** Population in working age not participating in the labor market (students, pensioners, sick, house tasks…)

*** Might contain deviations

In Natzaret (2022) we have a 48,84% unemployment rate among the active working-age population whilst in La Malva-Rosa (2023) is 34,61%. Not active population values are also worth mentioning being 30,45% and 58,06%, respectively.

Moreover, women rates are significantly higher for "not active" (52% and 59%) and "part-time job" (86,7% and 75,4%) categories, evidencing that in most cases, they also take care of house tasks and/or family members.

Education Levels:

Regarding the education levels, we can state a significant difference between both neighborhoods. Most of the population in Natzaret has a school graduate (or even lower) whilst a smaller percentage of people has a bachelor degree or higher education. In La Malva-Rosa, percentages are more alike between categories, being bachelor or higher education the highest percentage.

EnerCmed Interreg Euro-MED Co-funded by the European Union

Neighborhood	Cannot read/write	Lower than School Graduate	School Graduate	Bachelor or higher education
Natzaret	0,56%	34,47%	40,92%	24%
La Malva-Rosa	0,29%	24,74%	37,19%	37,76%

*Data does not take into consideration population under 18 y/o

Housing and Living Conditions

Housing Types:

As explained in previous sections, both neighborhoods arose as maritime and traditional fishermen.

Natzaret was originally made up of humble houses of fishermen and port workers. Along these traditional houses, we can also find old chalets and summer recreational houses for people coming for summer holidays from the city center or even outside Valencia. Houses with one or two floors and single-family homes are the predominant. Some houses have protected façades or structures, making it difficult to adapt them to newer isolation and energy efficiency systems. After the population growth during the first decades of the XX century, the neighborhood expanded with newer brick buildings. Natzaret's houses usually have humidity, mold, and dampness problems.

Pictures: two traditional constructions in Natzaret and a building for port workers

La Malva-Rosa neighborhood is a union between the sea and the orchard, surrounded by old ditches, making it a very humid area. This neighborhood also arose as a working-class area combined with recreational summer houses due to its proximity to the sea - hosting even famous writer Blasco Ibañez and painter Sorolla.

Here we can find similar one- and two-floor houses and constructions to those in Natzaret, most of them unrenovated. This neighborhood was heavily damaged by the floods of 1957 and many houses were affected. Therefore, the government built new social and public houses, such as Las Casitas Rosas, which is the best example of this architecture. These appear to be deteriorating and inefficient due to poor construction materials and models.


Pictures: Las Casitas Rosas block and La Malva-Rosa façades

Ownership Status:

Due to the progressive marginalization of Natzaret, most of the flats and houses are rented as old owners face trouble finding potential buyers in the market. People living here, especially migrants, are mainly rented as prices are lower than in the rest of the city.

On the other hand, La Malva-Rosa - due to its proximity to the beach - is experiencing a touristification process as private investors and companies are buying houses to renovate them for tourists and "digital nomads" with higher incomes, making it very difficult for neighbors and particular buyers to access the housing market. Because of this, flat rentals here are higher, making people and families living here have to use a really high percentage of their salary to pay their rent if they want to keep the house. This is progressively transforming the neighborhood's habitat structure - all-time residents, new migrant families living in deteriorated buildings and houses vs. tourists and digital nomads with new and renovated houses and flats.

Building Conditions

As already explained, most of them are inefficient constructions and unrenovated houses facing serious problems of humidity, mold and damp, being very difficult to keep the house at an adequate temperature, both in summer and winter. This makes it even a health risk.

Pictures: Humidity and mold in a Malva-Rosa House

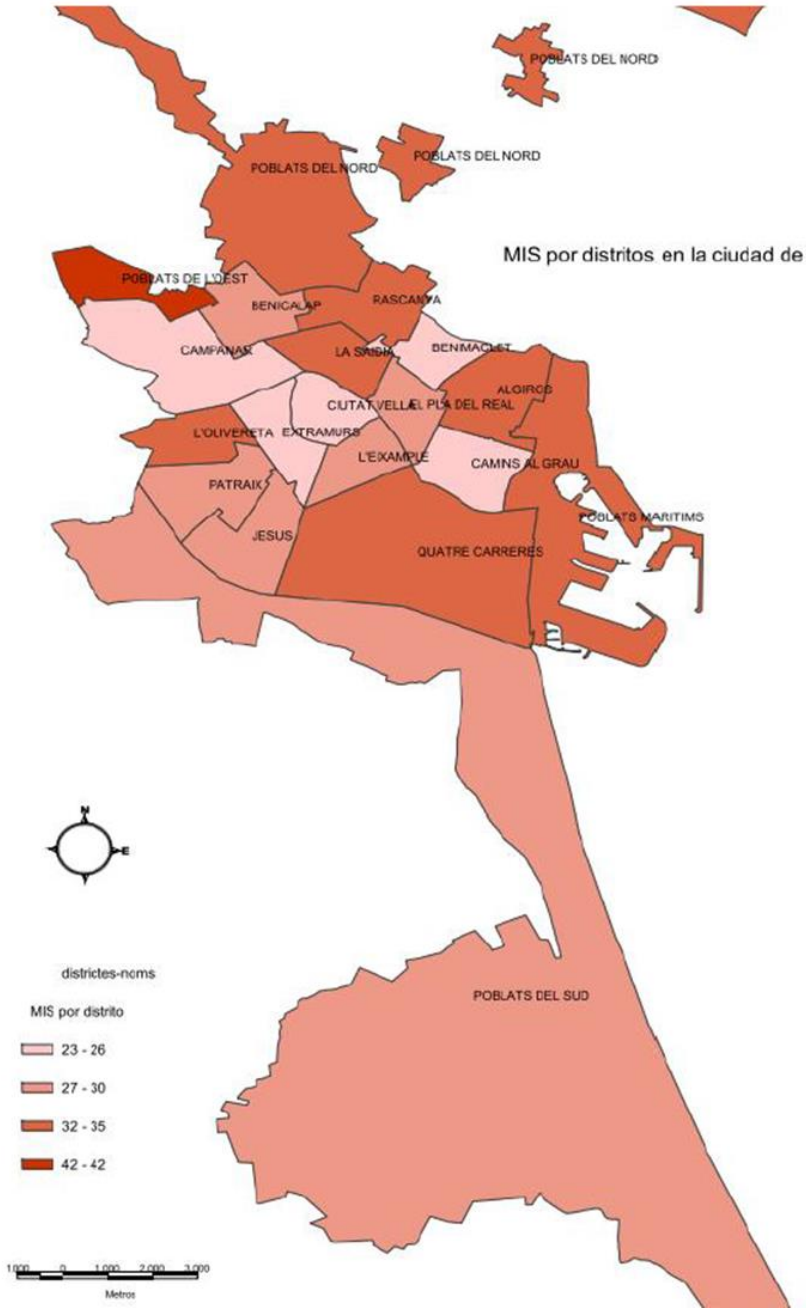
Energy Infrastructure

Most houses are old, unrenovated and inefficient, making keeping an adequate temperature inside hard. Construction materials also face the challenges of fighting against humidity and mold. Wooden windows are present in traditional houses in both neighborhoods. Many people, especially the elderly, still use butane bottled gas for cooking and stoves.

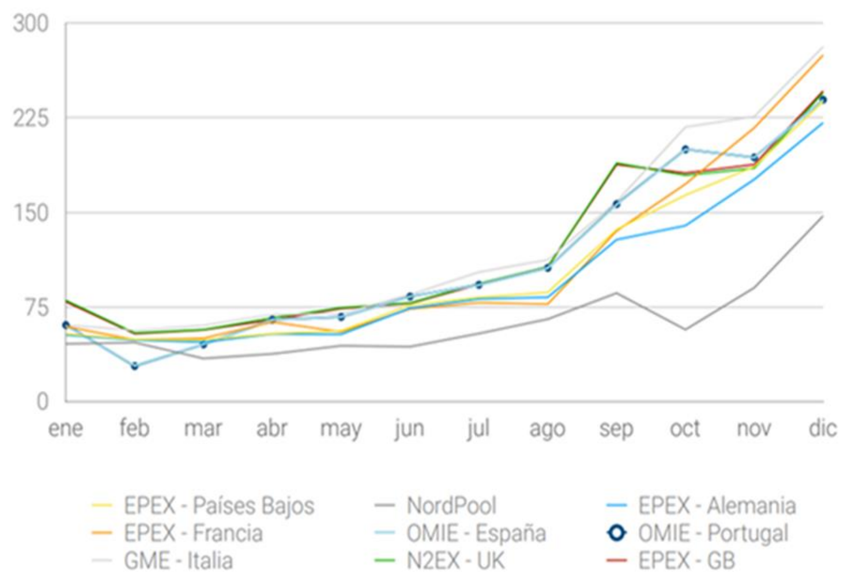
Energy Poverty Assessment

Energy Expenditure

According to the 2M indicator (AIEOLUZ 2023) in 2021 21,16% of Valencian households allocated more than double the median percentage of annual income to purchasing energy for housing. In addition, according to the MIS indicator (minimum income standard), 32,85% of Valencian households are in energy poverty, a 9% increase since 2016.



MIS in Valencian districts. Source: AIEOLUZ report (2023)The data shows that numbers have worsened in all districts. Poblats Marítims (district containing Natzaret and La Malva-Rosa) is one of the most affected ones.



Evolution of the electricity price in Europe 2021. Source: OMIE February monthly report 2022

Prices have also risen due to global events (Covid-19, Russia-Ucraine conflict, climate change). Thus, the government has taken different initiatives to tackle this problem by reducing energy bills, especially for vulnerable families.

The Social Bonus is the best example. This includes a bill discount from 40% up to 80% according to different economic and social features. The Social Bonus has also lowered the income limits so more households can access it. It has also increased payment deadlines and protected from electricity disconnections.

Access to Energy

According to the PD index - perceptions based on statements - (AIEOLUZ, 2023), 32,68% of Valencian households are both really cold in winter and really warm in summer inside their houses. They state that their access to energy negatively affects their daily life. In fact, according to the municipal barometer, 70% of families cut back on consumption at the expense of reducing well-being. This affects not only their comfort at home, but also their physical and mental health, especially for children and elderly people, leading even to stigmatization and isolation.

It is also really significant that, in 2022, the Valencian Municipal Social Services processed 22.48% more aid to cover basic supplies of electricity, water, and gas.

Fuel Use

As already mentioned, houses in Natzaret and La Malva-Rosa are usually old, inefficient, and unrenovated. They suffer much humidity both in winter and summer and generally do not have proper heating and isolation systems.

In many cases they still use bottled butane cylinders to cook and to heat the houses.

Identification of Vulnerable Groups

The most affected by energy poverty in these neighborhoods by their characteristics are:

- Elderly people, specially women
- People with chronic diseases
- Women and single parent families
- Children
- Migrant people
- Unemployed people

Several efforts are being made considering the rise of energy poverty across the city of Valencia.

Both neighborhoods have their own Municipal Social Services Office, which addresses energy poverty cases. As a prevention measure, the Municipal Energy Offices (OSS) and the Social Services have developed an agreement for case referral and information exchange to facilitate tackling energy vulnerability. This assesses households' rights, bills, payment plans, and efficiency measures. The OSS also offers workshops, training, and house interventions.

Other initiatives are:

- The Energy Poverty Plan, which is currently being developed
- The creation of the Municipal Energy Poverty follow up commission, with representatives from all sectors involved
- The update of municipal indicators and statistics to include energy poverty data

Energy poverty mapping

Conversations between València Clima i Energia Foundation and other municipal delegations, especially education, consumer and health, to raise awareness among energy poverty and establish a protocol for energy poverty detection.

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5.2 Social composition and energy poverty analysis Croatia

Introduction

Purpose

The primary goal of the analysis is to identify energy poverty hotspots in the cities of Novigrad and Pula, Istria. This involves understanding where households are disproportionately affected by high energy costs, low energy efficiency, and inadequate access to reliable energy services.

The study aims to:

Identify areas where a significant proportion of household income is spent on energy.

Determine which social groups (e.g., elderly, low-income families, single-parent households) are most vulnerable to energy poverty.

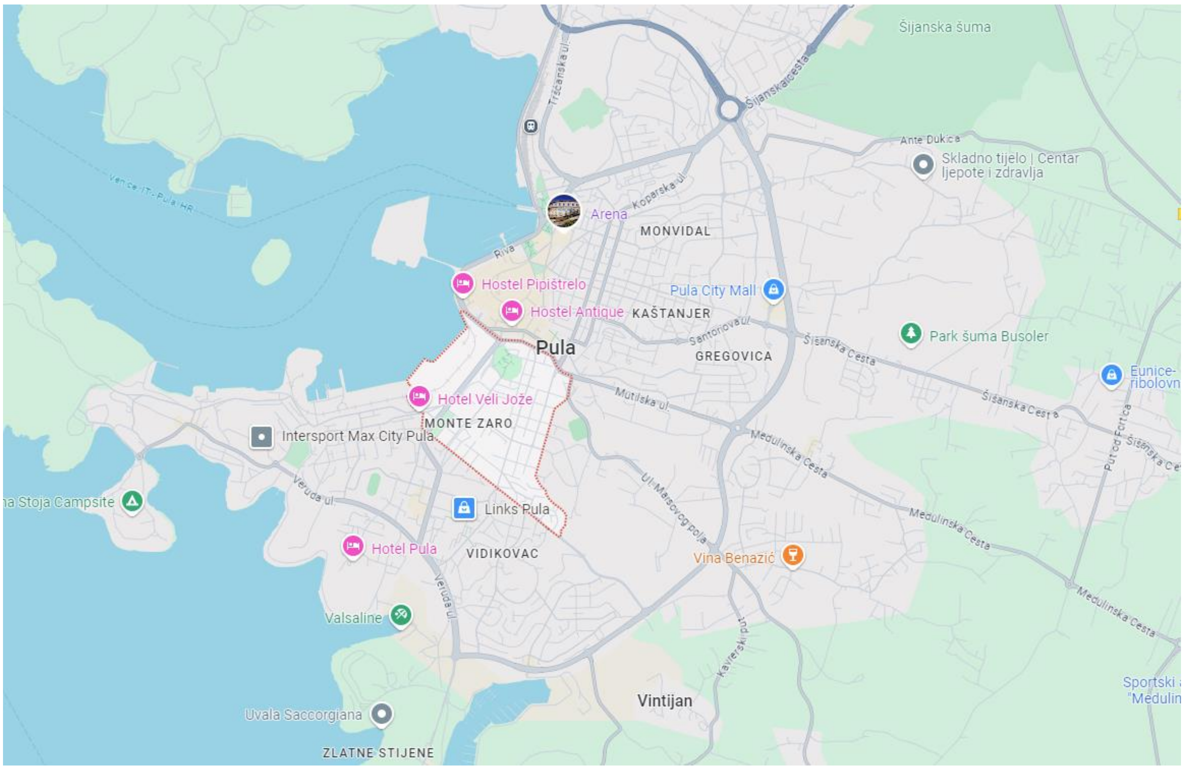
Assess the types of fuel used for heating and cooking, focusing on reliance on traditional biomass or inefficient energy systems.

Provide actionable recommendations to local governments and stakeholders to alleviate energy poverty and promote energy efficiency in these neighborhoods.

By analyzing energy poverty hotspots, the study seeks to improve the quality of life for residents, reduce energy costs, and support sustainable energy initiatives.

Scope

The City of Pula is located in the southern part of the Istrian peninsula in Croatia, bordered by the Adriatic Sea. The geographic boundaries of Pula include the surrounding coastal areas and extend inland. While (our study area) Monte Zaro is a specific neighborhood within Pula, it does not have official geographic boundaries as it is more of a local reference to an area surrounding a hill (Monte Zaro).



The city of Novigrad (Novigrad-Cittanova) is located on the western coast of Istria, Croatia, along the Adriatic Sea. It is a small coastal town known for its medieval architecture, historic charm, and tourism. Our study area is Bikokere, a residential neighborhood located east of Novigrad's city center. The neighborhood is known for being quieter and more residential than the bustling center and is popular for its proximity to both the historic area and the more rural parts of Novigrad.

The methodology for this analysis includes both primary data collection and the use of secondary data sources to ensure comprehensive coverage of energy poverty in Novigrad and Pula. The following methods are used:

- Surveys: A household survey is conducted to gather information about:
- Monthly energy expenditure (heating, electricity, gas),
- Types of energy used for heating and cooking,
- Perceived affordability and access to reliable energy services,
- Energy-saving practices and awareness of energy efficiency programs,
- Interviews: In-depth interviews with key stakeholders, including:
- Local government officials responsible for social services and energy policies,
- Representatives of energy companies that supply electricity and gas to the region,
- Community organizations working with vulnerable groups to understand the impact of energy poverty on daily life,

Secondary Data Analysis: Existing datasets are analyzed to complement the survey and interview findings. This includes:

- Local government statistics on income distribution, housing conditions, and energy consumption,
- National and regional energy price data from energy providers.

Demographic Profile

As of the 2021 census, Pula had a population of approximately 52,411 residents.

The overall density of Pula is around 1,000 inhabitants per square kilometer (km²). However, this can vary within different parts of the city, with central urban areas being more densely populated than the outskirts.

Monte Zaro is part of the central urban zone of Pula, which generally has a higher population density compared to suburban areas Monte Zaro covers an area of 323,720 m², with a population of 3,502 residents. The population density is 10,818.0 inhabitants per square kilometer.

According to the 2021 census, Novigrad had a population of around 4,010 residents.

Novigrad's population density is lower, with an average of 188 inhabitants per square kilometer (km²). Given Novigrad's smaller size and rural surroundings, the density is notably less compared to larger cities like Pula. There are no specific, publicly available statistics on the population density of the Bikokere neighborhood in Novigrad. Like many smaller neighborhoods in Croatian cities, detailed population and density data are often not published at the neighborhood level but for the city as a whole.

Age Distribution

The age distribution in **Pula**, like in most cities, is divided into key demographic groups: **children, working-age adults, and the elderly**. According to the latest census data (2021), Pula's population reflects trends seen in much of Croatia, with an aging population and a declining birth rate.

Here's an overview based on these trends:

Children (0-14 years old)	6.771	12,9%
Working-age adults	32.502	62%
Elderly	13.138	25%

In Novigrad, as in much of Istria and Croatia, the population is influenced by demographic trends such as a low birth rate and an aging population. Based on recent data, including the 2021 census, here's an outline of the age group distribution in Novigrad:

Children (0-14 years old)	503	12,9%
Working-age adults	2.376	61%
Elderly	1.010	25,9%

Household Composition

The city of Pula has diverse household structures, with statistics reflective of both urban and aging population trends common in Croatia. The most recent census data (2021) and other sources provide some insights into average household size - the average household size in Pula is around 2.3 to 2.5 persons per household. This is slightly below the national average in Croatia, which has also been declining due to lower birth rates and the aging population. Many households consist of fewer individuals, reflecting a trend of smaller family units and an increase in single-person households. In Pula, as in the rest of Croatia, single-parent households make up a significant portion of family structures. Although specific numbers for Pula are not always directly available, it is estimated that around 10-15% of households are led by single parents, typically mothers.

Other Household Structures

Single-person households: A significant portion of households in Novigrad consist of single individuals, particularly the elderly. Many older adults, especially widows and widowers, live alone. This structure is increasingly common as the population ages, contributing to the lower average household size.

Couple households without children: Another common household structure in Novigrad, especially among older couples whose children have grown up and moved away (empty-nest households) or among younger couples who have not had children. This is typical for areas with an aging population and declining birth rates.

Extended family households: In some cases, households consist of extended family members, often due to economic factors or the need for caregiving. While more common in rural areas, this structure can be found in Novigrad, where family units may include elderly parents living with their adult children.

Socio-Economic Characteristics

The average monthly salary in Croatia as of 2023 is around €1,100 (gross), with regional differences. Istria, being a coastal and tourism-driven region, has slightly higher average incomes due to seasonal tourism jobs, compared to inland areas. However, Pula has a mix of industries, including tourism, shipbuilding (historically), and services, which causes variability in incomes.

Like many cities, income distribution in Pula follows a pattern where a small percentage of households earn significantly more, while a larger proportion earns below the national average. The wealth gap in Croatia has been slowly increasing, with certain groups, particularly the elderly and those in rural areas, facing higher risks of poverty.

Low-income households in Pula are often found among several key groups:

- Elderly Population: A significant portion of Pula's elderly population, particularly retirees, live on fixed pensions that tend to be lower than the national average salary. Many elderly people in Croatia face financial challenges due to low pensions, and this is reflected in Pula as well.
- Unemployed and Underemployed Individuals: While Pula has a relatively low unemployment rate compared to the national average, some workers are engaged in seasonal or part-time jobs, particularly in tourism. These workers are more vulnerable to income fluctuations and lower wages, especially in the off-season when tourism jobs are scarce.
- Single-Parent Households: Single-parent households are often at higher risk of being low-income due to the challenges of balancing work and childcare. Many single parents face difficulties finding full-time work or must rely on part-time jobs, which can result in lower overall income.
- Workers in Low-Wage Sectors: A large portion of Pula's workforce is engaged in the service and tourism industries, which traditionally offer lower wages compared to other sectors. Additionally, workers in small businesses, retail, and hospitality might earn below the national average.
- Young People and Recent Graduates: Young people entering the workforce, particularly those without higher education, tend to earn lower starting wages. In Pula, younger residents may find entry-level positions in the tourism or service sectors, which typically pay less.

The income distribution and identification of low-income households in Novigrad, like much of the Istrian region, are influenced by the town’s economic structure, which relies heavily on tourism, agriculture, and small-scale industry. Novigrad is a smaller city, and its local economy reflects seasonal employment patterns and a mix of income levels typical of smaller coastal towns. Like many Istrian towns, Novigrad experiences significant income fluctuations due to its dependency on tourism, which peaks during the summer months. Many workers may face underemployment or job insecurity during the off-season, leading to irregular income and increased financial pressure on families during the winter. While some individuals working in skilled positions or tourism management earn higher wages, many hospitality, retail, and seasonal workers typically earn less.

Low-income households in Novigrad can be identified based on several socio-economic factors:

Seasonal Workers and Low-Wage Sectors: Many residents are employed in hospitality, retail, and agriculture, which typically pay lower wages. During the tourist season, employment is high, but off-season work opportunities are limited, leading to irregular income for many workers. Jobs in restaurants, hotels, and related sectors often offer temporary contracts or lower wages, pushing these workers into low-income categories during winter.

Elderly Population: A significant portion of Novigrad’s population is elderly. As in the rest of Croatia, retirees in Novigrad often live on low pensions, which are insufficient to meet living costs, especially for those who previously worked in low-wage sectors. Elderly people living alone or without family support are particularly at risk of falling into low-income brackets.

Single-Parent Households: Single-parent households are often vulnerable to poverty due to the challenges of balancing work and childcare. With limited job opportunities outside the tourist season, single parents in Novigrad may struggle to secure stable, full-time employment, pushing them into low-income categories.

Agricultural Workers: Although agriculture is less dominant than tourism in Novigrad, some residents are employed in small-scale farming. These agricultural workers often have irregular incomes and face financial challenges due to the seasonality of agricultural production and the limited profitability of small-scale farming.

Employment Status

In Croatia, the employment rate for people aged 15-64 is around 66-68%, and Pula aligns with this national average. Employment rates in Pula have been steadily improving in recent years due to increased economic activity, especially in tourism and services, as well as urban development projects. The labor force participation rate, i.e., the percentage of the working-age population that is either employed or actively seeking employment) is estimated at around 70-75% in Pula, which is slightly higher than the national average due to the presence of tourism and related industries.

The employment structure in Pula is diverse, with different industries contributing to overall employment. Some key sectors include:

Tourism and Hospitality: as a coastal city and a major tourist destination, Pula's economy relies heavily on tourism and hospitality, especially during summer. Jobs in hotels, restaurants, travel agencies, and tourist attractions need a significant portion of the workforce. Many of these jobs are seasonal, leading to high demand for workers during peak tourist periods.

Public Sector and Services: Pula, as the administrative center of Istria, has a substantial number of employees in the public sector, including education, healthcare, and public administration. These jobs tend to be more stable than the seasonal tourism jobs.

Manufacturing and Industry: Pula has a history of shipbuilding, which still provides employment, although on a much smaller scale than in previous decades. The city’s Shipyard Uljanik, once a major employer, has recently reduced its workforce. Other industrial activities, such as construction and food processing, also provide jobs.

Retail and Commerce: Pula has a growing retail sector, with large shopping centers and small local businesses contributing to employment in this field. The city's sales, marketing, and customer service roles are common, especially as it serves residents and tourists.

Self-Employment and Small Business: the city has a number of self-employed individuals and small businesses, especially in the sectors of artisanal crafts, food and beverage production, and tourism-related services (e.g., guesthouses tour guides).

The unemployment rate in Pula is generally lower than the Croatian national average. As of the latest estimates from 2023., the national unemployment rate hovers around 7-9%, while Pula’s rate is slightly lower at around 5-7%, thanks to its robust tourism sector and diverse economy. However, the seasonal nature of many jobs in tourism can result in fluctuations in unemployment, with higher rates during the off-season in the winter months.

Like national trends, youth unemployment (ages 15-24) tends to be higher, though it has decreased in recent years. Many young people work in seasonal jobs, and some face challenges finding full-time, stable employment outside of the tourism sector. Pula also has a share of long-term unemployed individuals, particularly among older workers and those with lower levels of education. These individuals may struggle to find employment in sectors that are increasingly demanding more specialized skills.

The employment rates, types of employment, and unemployment rates in Novigrad reflect the town's smaller size and its economic dependency on tourism, agriculture, and small-scale industry. As a coastal town in Istria, Novigrad's employment landscape is shaped by seasonal tourism, and the town experiences fluctuations in employment during the year, with the tourist season heavily influencing the local economy.

Novigrad is estimated to be slightly below Croatian's average employment rate for people aged 15-64, around 60-65%, which is due to the town's smaller population and heavy reliance on seasonal employment. Similar to the national average, the labor force participation rate in Novigrad is estimated at 65-70%, reflecting the participation of working-age residents in both full-time and seasonal employment. The town sees higher labor force participation during summer when tourism activities are in full swing.

The economy of Novigrad is structured around a few key sectors, including tourism, agriculture, and small businesses. Employment opportunities reflect this structure:

Tourism and Hospitality: like many towns in Istria, tourism is the primary driver of employment in Novigrad. A large portion of the town's workforce is employed in hotels, restaurants, bars, travel agencies, and holiday rental services. Tourism-related jobs make up a significant part of the local economy, especially during summer.

Agriculture: Novigrad has a history of small-scale agricultural activities, particularly in olive oil production, wine production, and fishing. While agriculture is no longer the dominant industry, it remains a source of employment, particularly for small producers and family businesses involved in farming, vineyards, and fishing.

Retail and Commerce: the town has a modest retail sector, which includes small shops, local markets, and grocery stores that serve both the local population and tourists. Jobs in sales, retail management, and customer service are common, particularly during the tourist season when the population temporarily swells with visitors.

Small Businesses and Artisanal Production: many residents in Novigrad are involved in small businesses, especially those linked to artisanal crafts, local food production, and tourism-related services. These businesses provide jobs in handicrafts, gastronomy, and cultural tourism.

Self-Employment: a notable portion of the working population in Novigrad is involved in self-employment, either through running small guesthouses, managing restaurants, or offering tourist services. This type of employment is common in towns reliant on tourism and small-scale industry.

The unemployment rate in Novigrad is estimated to be around 7-9%, slightly lower than the national average (which stands at around 7-9% as of 2023), but the rate fluctuates due to the town's seasonal economy.

As is the case across Croatia, youth unemployment (ages 15-24) tends to be higher in Novigrad. Young people often rely on seasonal jobs in tourism, and many face challenges finding full-time, stable employment. Youth unemployment in Istria is typically around 15-20%, but opportunities during the summer months help somewhat alleviate this issue.

Long-term unemployment can affect older workers and those with lower levels of education. Individuals who have previously worked in sectors such as agriculture or low-wage tourism jobs may face difficulties re-entering the workforce, particularly outside the tourist season.

Education Levels

The population's educational attainment in Pula reflects the city's demographic structure and economic development. As one of the larger cities in the Istria region, Pula has a mix of educational levels, influenced by its historical focus on tourism, industry (especially shipbuilding), and its status as an administrative center.

Here is an overview based on the current situation in Pula:

No schooling	161
1-3 grades of basic education	74
4-7 grades of basic education	449
Basic education	5.702
Secondary education	26.193
Professional study	4.796
University study	8.054
Doctorate of science	192
Unknown	19

In recent decades, women in Pula have made significant strides in education; more women are completing secondary and high education than previous generations. Women are particularly well-represented in fields like teaching, healthcare, business administration and tourism management. Men in Pula have historically been more likely to pursue vocational training related to industries like construction, shipbuilding, and mechanical engineering. However, in recent years, more men are pursuing higher education in fields such as information technology, engineering and management.

Regarding Novigrad, the population's educational attainment reflects the town’s size, economy, and regional characteristics. With a focus on tourism, agriculture, and small-scale industries, Novigrad has a population with a mix of education levels, similar to other small towns in Croatia. The educational attainment here is influenced by access to local schools and vocational institutions, with many young residents pursuing higher education in nearby cities. You can see an overview in the table below:

No schooling	14

1-3 grades of basic education	24
4-7 grades of basic education	98
Basic education	588
Secondary education	1.882
Professional study	318
University study	446
Doctorate of science	11
Unknown	5

In conclusion, while vocational training remains Novigrad's most common educational path, higher education is becoming more important, especially for younger generations. Continued investment in skills development and education opportunities will be crucial for supporting Novigrad’s future economic growth, especially in tourism and related industries.

Housing and Living Conditions

The housing types available in Pula vary, reflecting the city’s historical development, population size, economic structure, and a blend of urban, suburban, and rural lifestyles with a focus on both permanent residents and the tourism economy.

Apartments: Predominantly in the city center and suburban areas, particularly in Veruda, Šijana, and Monte Zaro.

Detached Houses: Common in suburban and rural areas like Vidikovac, Veli Vrh, and Štinjan, as well as in coastal regions used for tourism.

Semi-Detached Houses: Found in residential neighborhoods such as Veruda Porat and Štinjan.

Tourism-Oriented Housing: Coastal and historic areas, including Stoja and Verudela, with a focus on short-term rentals and villas.

Public Housing: Primarily on the outskirts, in districts like Šijana and Monte Magno.

Modern apartments and condominiums are growing in peripheral areas, appealing to younger residents and tourists.

The housing in Novigrad illustrates a blend of residential living and tourism, with various options that serve both local residents and visitors. In Novigrad, the types of housing available reflect the town's size, coastal location, and the influence of tourism. Here's an overview of the types of housing and their distribution in Novigrad:

Apartments: Common in the town center and coastal areas, focusing on seasonal rentals.
Detached Houses: These are predominantly found in suburban neighborhoods like Bikokere and rural areas towards Funtana and Brtonigla.

Semi-Detached Houses: Available in residential neighborhoods, appealing to families. Holiday Homes: Concentrated in coastal areas, designed for tourists and seasonal use. Public Housing: Limited availability, primarily on the outskirts as most residential developments in the central areas are privately owned. Modern apartments and villas in growing areas outside the city center.

In Pula, the ownership status of housing varies between renters and homeowners, reflecting broader national trends and local economic conditions. Homeownership is more prevalent in suburban neighborhoods, where families tend to seek larger homes with gardens. In contrast, renters are often concentrated in urban areas, particularly in the city center, where apartments are more accessible. The tourism boom in Pula has shifted some dynamics in the housing market, with a growing number of homeowners converting properties into short-term rentals. This trend impacts the availability of affordable housing for local residents and increases competition in the rental market.

Novigrad has a significant homeownership rate, similar to many smaller Croatian towns. Owning a home is often viewed as a symbol of financial stability and personal achievement among residents. Homeownership is more common in suburban neighborhoods and rural areas surrounding Novigrad, where families prefer larger homes with gardens (like in Pula). Renters are typically found in the town center, where smaller apartments are more accessible and affordable. The strong tourism presence in Novigrad has encouraged some homeowners to convert their properties into short-term rentals. This trend can impact the availability of affordable housing for locals, making it more challenging for them to secure long-term rentals.

Assessing the building conditions in Pula reveals a mix of well-maintained structures and buildings that are in varying states of disrepair. The state of buildings is influenced by factors such as historical significance, age, and economic conditions. There are also many older buildings in need of repair, ranging from minor cosmetic updates to major renovations, which include historical buildings, residential buildings, commercial and mixed-use buildings, vacant and abandoned buildings, public buildings and infrastructure, and some of the urban development projects. Addressing the needs of aging buildings, particularly those in poor condition, will require coordinated efforts from local authorities, property owners, and community stakeholders to ensure Pula remains a vibrant and attractive place to live and visit. Efforts to balance the preservation of historical structures with modern urban development will be crucial for the city’s future growth and sustainability. Assessing the building conditions in Novigrad involves evaluating the state of various types of structures, including residential, commercial, and historical buildings. The condition of these buildings is influenced by their age, usage, and the local economy. It could be said that the conditions are mixed, with many properties in good condition, particularly those that are newer or well-maintained historical structures. However, older buildings also need repair, ranging from minor cosmetic work to significant renovations. Addressing the needs of aging buildings and vacant properties will require collaborative efforts from local authorities, property owners, and the community to ensure that Novigrad remains an attractive place for residents and visitors.

Energy Infrastructure

Pula has a well-developed electrical grid, providing reliable access to electricity for residential, commercial, and industrial users. Hrvatska Elektroprivreda (HEP), the national electricity provider, maintains the electrical infrastructure. The City of Pula does not have an extensive district heating system. However, some areas may have access to localized heating solutions, but most residential buildings rely on individual heating systems.

While there are challenges related to energy efficiency in older buildings, ongoing initiatives, and a growing emphasis on renewable energy opportunities for improvement, the city's future energy strategies will likely focus on enhancing energy efficiency, increasing renewables, and ensuring that all residents have access to affordable energy.

Novigrad has a reliable electrical grid that provides residential, commercial, and industrial users with access to electricity. Hrvatska Elektroprivreda (HEP), the national electricity provider, manages the electrical supply. Most of the town and surrounding areas are well-connected to the electrical grid, ensuring reliable electricity access. In Novigrad, there is a growing interest in renewable energy sources, particularly solar power. Some residents and businesses have begun to install solar panels, supported by local and national incentives for green energy investments. Overall, Novigrad has a well-established energy infrastructure with reliable access to electricity and various heating sources (natural gas, electric heating, and solid fuels).

Energy Poverty Assessment

Energy Expenditure

The proportion of household income spent on energy varies significantly across different income groups. On average, energy costs constitute about 5% to 10% of gross income for most households, with lower-income households facing a disproportionately higher burden. The average cost of electricity in Croatia is about €0.13 to €0.15 per kWh, as energy prices fluctuate, and continued attention to energy affordability and support programs will be crucial to ensure that all households can manage their energy expenses effectively.

Access to Energy

Households in Pula and Novigrad lacking access to reliable and affordable energy services are primarily those that are low-income, vulnerable populations and those living in poor-quality housing. Geographic disparities and barriers to energy services further exacerbate the challenges faced by these households.

Fuel Use:

In Pula and Novigrad, the predominant fuels used for heating and cooking include natural gas and electricity, with a significant reliance on traditional biomass, particularly wood, in certain households. The choice of fuel is influenced by availability, economic factors, and personal preferences. While traditional biomass offers a cost-effective solution, it also poses challenges regarding environmental sustainability and air quality.

Identification of Vulnerable Groups

In Pula and Novigrad, the most vulnerable groups facing energy poverty include elderly residents, single-parent households, low-income families, unemployed individuals, people with disabilities, and those with lower educational attainment. Addressing the needs of these groups is crucial for ensuring equitable access to energy services. Efforts to provide targeted assistance, raise awareness of available resources, and promote energy efficiency can help mitigate the risks of energy poverty and improve overall living conditions for these vulnerable populations.

5.3 Social composition and energy poverty analysis Italy

Introduction

Purpose

As part of the EnerCMed project, which aims to support the spread of energy communities or other configurations, such as remote individual self-consumption (ISC), as an opportunity to improve access to energy services and social aggregation, this analysis has the objective of outlining the characteristics of the social aspects for the Municipality of Genoa and for the areas of the city in which the pilot action will be developed.

Scope

The following data are related to the territory of the Municipality of Genoa, whose borders are represented in the figure, and where available, a specific focus has been placed on the district of Cornigliano, which was selected for the pilot action. In some case data are not available for the city of Genoa, considerations at a general and national level are reported.

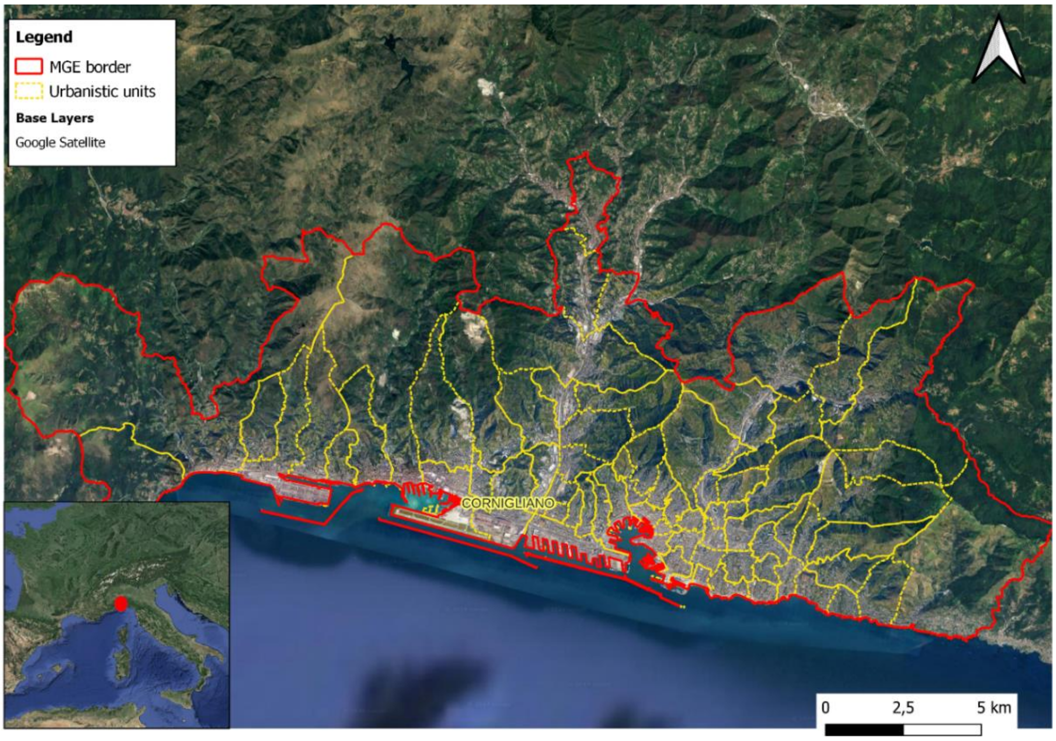


Figure 1 - Territory of the Municipality of Genoa

Methodology

The data collection has been proceeded mainly through desk research, using data from different sources, primarily those provided by the Office of Sustainability, Ecological Transition and Statistics - Special Projects of the Municipality of Genoa. Information was also used from other accredited sources, e.g. ISTAT, and data retrieved from internal planning within the Institution.

Demographic Profile

Population Size and Density

The population of Genoa is 564.657 inhabitants (year 2023), and the population density is approximately 2.350 inhabitants/sq.km, varying significantly between different neighborhoods. The city's territory includes densely populated urban areas and less inhabited hilly and coastal areas.

Cornigliano is home to 13.800 inhabitants and is configured as a high-density neighborhood with many foreign people. The average population density of Genoa is 2.350 inhabitants/sq.km, while in Cornigliano, the value is 3.660 inhabitants/sq.km, 55% higher than the city average.

Municipality of Genoa																						
	0-4 years	5-9 years	10-14 years	15-19 years	20-24 years	25-29 years	30-34 years	35-29 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years	65-69 years	70-74 years	75-79 years	80-84 years	85-89 years	90-94 years	95-99 years	>= 100 years	Total	Average Age
Female	8.223	9.535	11.065	11.833	12.386	13.248	14.382	14.282	15.309	19.355	23.326	24.731	22.996	19.900	18.148	18.543	16.246	12.393	6.660	1.933	269	294.763	50,7
Male	8.820	10.184	11.675	13.003	13.936	14.923	15.125	14.924	15.081	18.524	22.216	23.172	20.396	17.286	15.149	14.333	10.897	6.926	2.700	563	61	269.894	46,7
Total	17.043	19.719	22.740	24.836	26.322	28.171	29.507	29.206	30.390	37.879	45.542	47.903	43.392	37.186	33.297	32.876	27.143	19.319	9.360	2.496	330	564.657	48,8

VI Medio Ponente																						
	0-4 years	5-9 years	10-14 years	15-19 years	20-24 years	25-29 years	30-34 years	35-29 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years	65-69 years	70-74 years	75-79 years	80-84 years	85-89 years	90-94 years	95-99 years	>= 100 years	Total	Average Age
Female	956	1.104	1.152	1.246	1.240	1.408	1.543	1.567	1.577	1.973	2.371	2.494	2.314	1.975	1.771	1.871	1.602	1.195	632	175	28	30.194	49,7
Male	1.043	1.159	1.231	1.430	1.464	1.720	1.680	1.723	1.750	2.054	2.331	2.343	2.095	1.723	1.513	1.401	1.099	689	225	36	5	28.714	45,5
Total	*1.999*	*2.263*	*2.383*	*2.676*	*2.704*	*3.128*	*3.223*	*3.290*	*3.327*	*4.027*	*4.702*	*4.837*	*4.409*	*3.698*	*3.284*	*3.272*	*2.701*	*1.884*	*857*	*211*	*33*	*58.908*	*47,7*

Cornigliano																						
	0-4 years	5-9 years	10-14 years	15-19 years	20-24 years	25-29 years	30-34 years	35-29 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years	65-69 years	70-74 years	75-79 years	80-84 years	85-89 years	90-94 years	95-99 years	>= 100 years	Total	Average Age
Female	264	272	275	281	313	336	364	401	367	457	531	557	518	430	390	389	284	225	114	32	6	6.806	47,8
Male	246	329	308	352	407	508	456	444	466	535	526	526	515	424	332	278	199	133	34	9	1	7.028	43,5
Total	510	601	583	633	720	844	820	845	833	992	1.057	1.083	1.033	854	722	667	483	358	148	41	7	13.834	45,6

Figure 2 - Resident population by five-year age classes in the Municipality of Genoa, VI Medio Ponente and Cornigliano (year 2023)

Age Distribution

The age distribution of the Genoese population is characterized by a growing number of elderly people, reflecting a common Italian trend. Approximately 27,6% of the population is over 65 years old, while young people under 20 years old represent approximately 15%.

Cornigliano partly reflects the age distribution of the rest of the city, with a significant presence of elderly people, approximately 23,7% of whom are over 65 years old. However, there is also a good representation of young families, people under 20 years old represent approximately 16,8%.

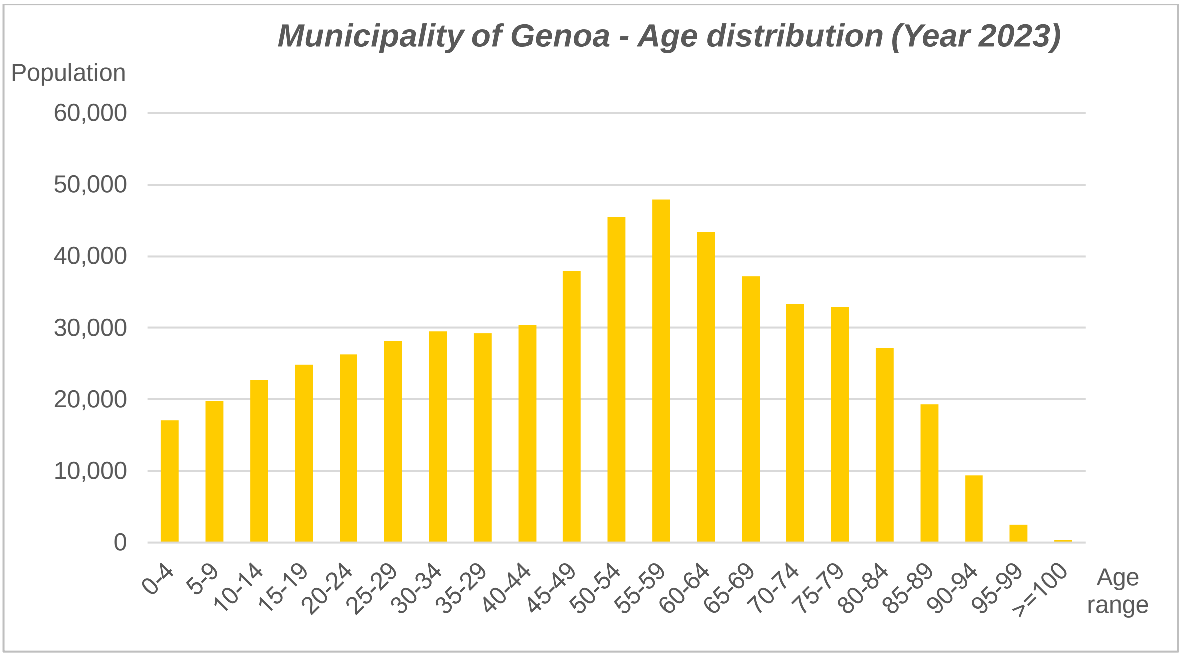


Figure 3- Age distribution of population in the Municipality of Genoa (year 2023)

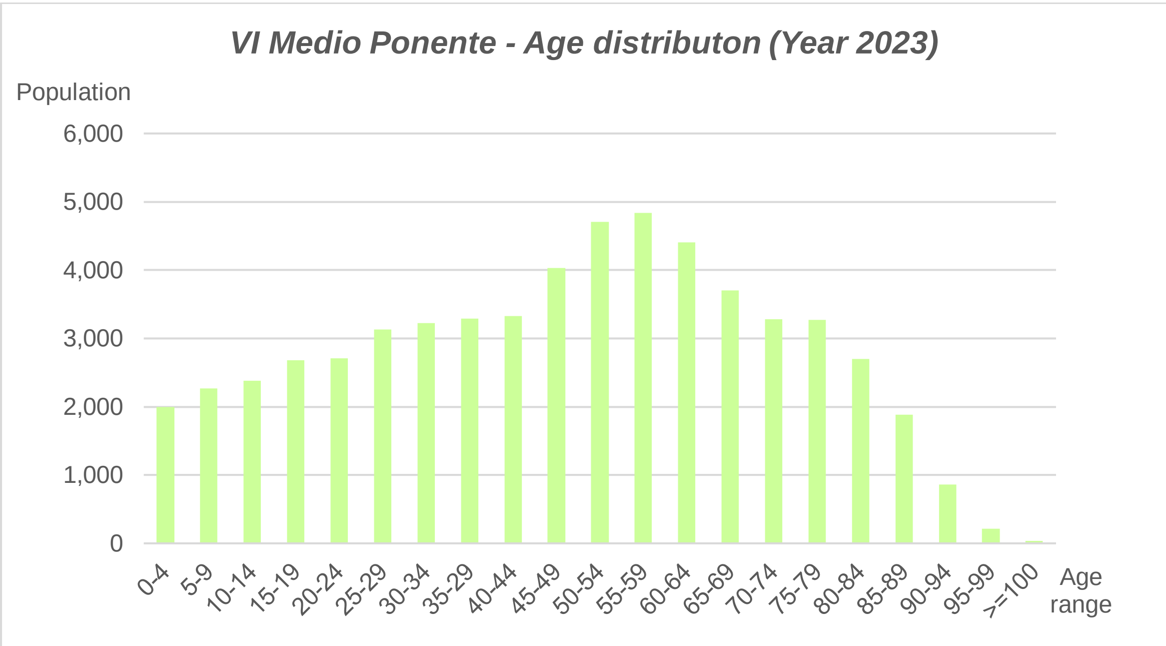


Figure 4 - Age distribution of population in the VI Medio Ponente (year 2023)

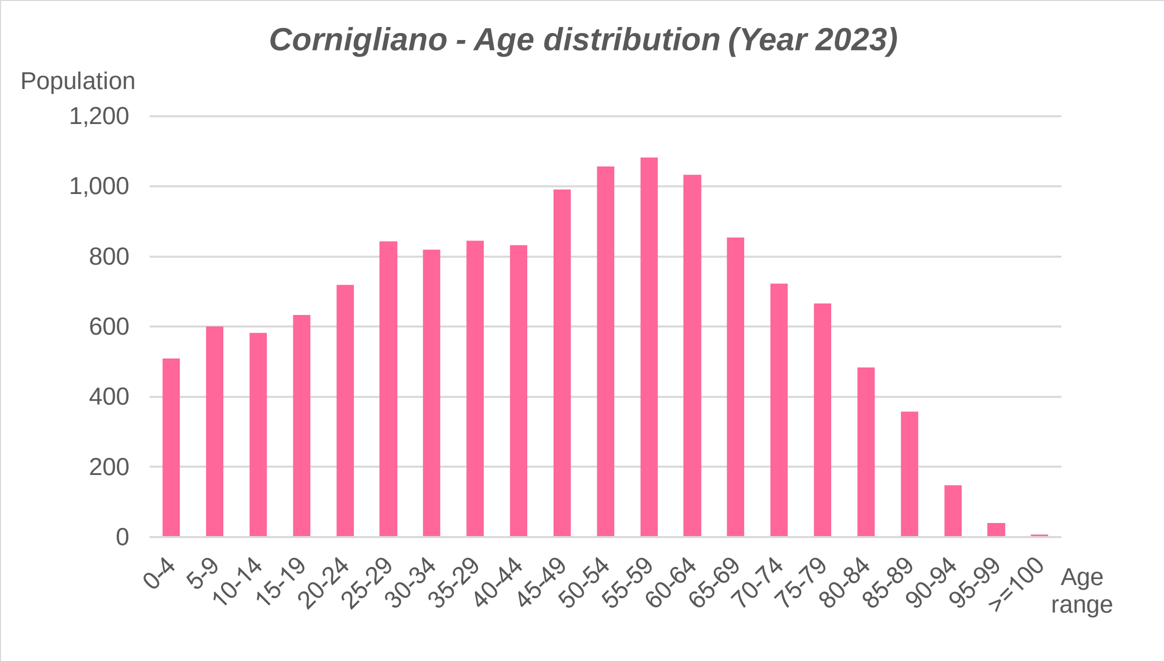
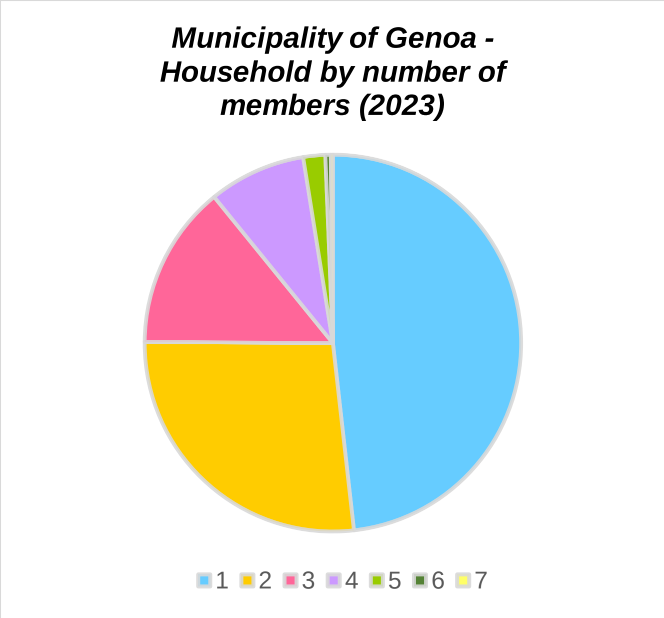


Figure 5 - Age distribution of population in Cornigliano (year 2023)

Household Composition

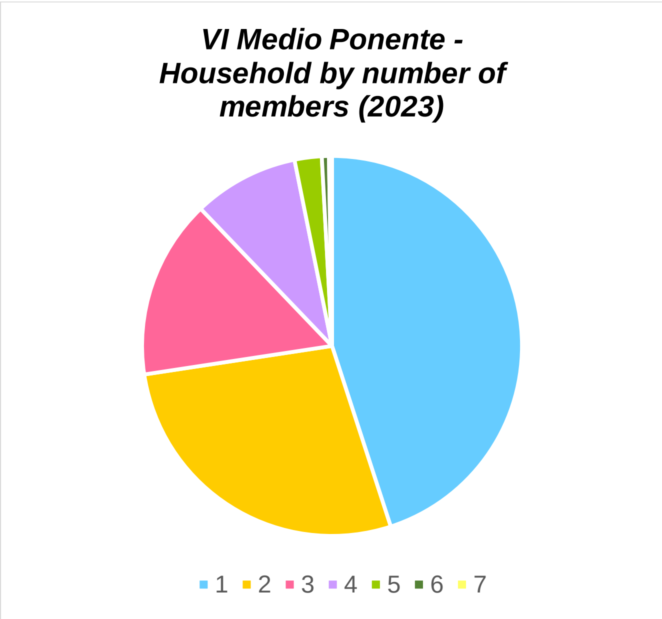
The average size of families in Genoa is 1,91 members per family unit, in Cornigliano the value is 2,06, slightly higher. Many Genoese families are made up of one or two people, and approximately half of the households are made up of only one member. For the city of Genoa the percentage is 48,2%, while for Cornigliano it is 44,6%.



N. of members	N. of household
1	140.812
2	78.525
3	40.984
4	24.342
5	5.505
6	1.365
7	515
	292.048

Figure 6 - Resident families by number of members in the Municipality of Genoa (year 2023)

Average number of household members: 1,91

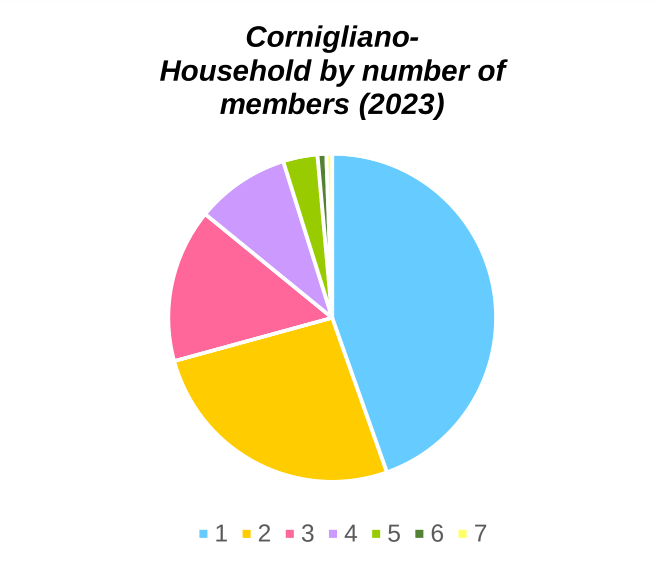


N. of members	N. of household
1	13.156
2	8.070
3	4.458
4	2.627
5	675
6	176
7	76
	29.238

Average number of household members: 1,99

Figure 7 - Resident families by number of members in VI Medio Ponente (year 2023)

N. of members	N. of household
1	2.888
2	1.695



3	981
4	601
5	220
6	56
7	37
	6.478

Average number of household members: 2,06

Figure 8 - Resident families by number of members in Cornigliano (year 2023)

Socio-Economic Characteristics

Income Levels

Data related to the number of taxpayers divided by income classes, average income per capita, and overall income for each income class are reported below.

2018			
Income classes *(€)*	**Number of taxpayers**	**Total income***(€)*	**Average income per capita** *(€)*
< 0 €	40	-136.226 €	-3.405,65 €
0 €	7.223	0	0,00 €
0 - 10.000 €	119.228	555.030.518 €	4.655,20 €
10.000 - 15.000 €	55.425	692.192.709 €	12.488,82 €
15.000 - 26.000 €	130.699	2.674.300.019 €	20.461,52 €
26.000 - 55.000 €	122.034	4.270.006.003 €	34.990,30 €
55.000 - 75.000 €	13.166	838.837.500 €	63.712,40 €
75.000 - 120.000 €	9.574	876.841.766 €	91.585,73 €
> 120.000 €	4.658	1.017.576.633 €	218.457,84 €
Total	**462.047**	**10.924.648.922 €**	**23.644,02 €**

2019			
Income classes *(€)*	**Number of taxpayers**	**Total income***(€)*	**Average income per capita** *(€)*
< 0 €	20	-84.451 €	-4.222,55 €
0 €	9.719	0 €	0,00 €
0 - 10.000 €	120.079	549.699.866 €	4.577,82 €
10.000 - 15.000 €	54.846	685.538.825 €	12.499,34 €
15.000 - 26.000 €	129.295	2.645.984.182 €	20.464,71 €
26.000 - 55.000 €	123.620	4.325.889.241 €	34.993,44 €
55.000 - 75.000 €	13.110	834.243.415 €	63.634,13 €
75.000 - 120.000 €	9.777	894.437.569 €	91.483,85 €
> 120.000 €	4.613	1.005.839.574 €	218.044,56 €
Total	**465.079**	**10.941.548.221 €**	**23.526,21 €**

2020			
Income classes *(€)*	**Number of taxpayers**	**Total income***(€)*	**Average income per capita** *(€)*
< 0 €	43	-350.910 €	-8.160,70 €
0 €	10.826	0 €	0,00 €
0 - 10.000 €	124.293	554.768.315 €	4.463,39 €
10.000 - 15.000 €	49.999	624.721.030 €	12.494,67 €
15.000 - 26.000 €	122.117	2.504.934.407 €	20.512,58 €
26.000 - 55.000 €	119.744	4.190.814.961 €	34.998,12 €
55.000 - 75.000 €	12.709	809.218.461 €	63.672,87 €
75.000 - 120.000 €	9.755	891.588.292 €	91.398,08 €
> 120.000 €	4.540	957.122.231 €	210.819,87 €
Total	**454.026**	**10.532.816.787 €**	**23.198,71 €**

2021			
Income classes *(€)*	**Number of taxpayers**	**Total income***(€)*	**Average income per capita** *(€)*
< 0 €	24	-149.433 €	-6.226,38 €
0 €	10.497	0 €	0,00 €
0 - 10.000 €	113.138	492.579.586 €	4.353,79 €
10.000 - 15.000 €	48.187	603.211.707 €	12.518,14 €
15.000 - 26.000 €	122.481	2.520.955.816 €	20.582,42 €
26.000 - 55.000 €	123.675	4.332.918.179 €	35.034,71 €
55.000 - 75.000 €	13.511	859.449.132 €	63.611,07 €
75.000 - 120.000 €	10.356	951.741.166 €	91.902,39 €
> 120.000 €	5.346	1.161.950.187 €	217.349,46 €
Total	**447.215**	**10.922.656.340 €**	**24.423,73 €**

Figure 9 - Number of taxpayers by income classes, total income and average income in Genoa, years 2018-2021 (Ministry of Economy and Finance)

It can be observed that approximately a quarter of the population falls into the income class 0-10.000 €; similar percentages, slightly higher, can be found for the income classes 15.000-26.000 € and 26.000-55.000 €.

The 10% of the total city income is held by approximately 1% of the city population.

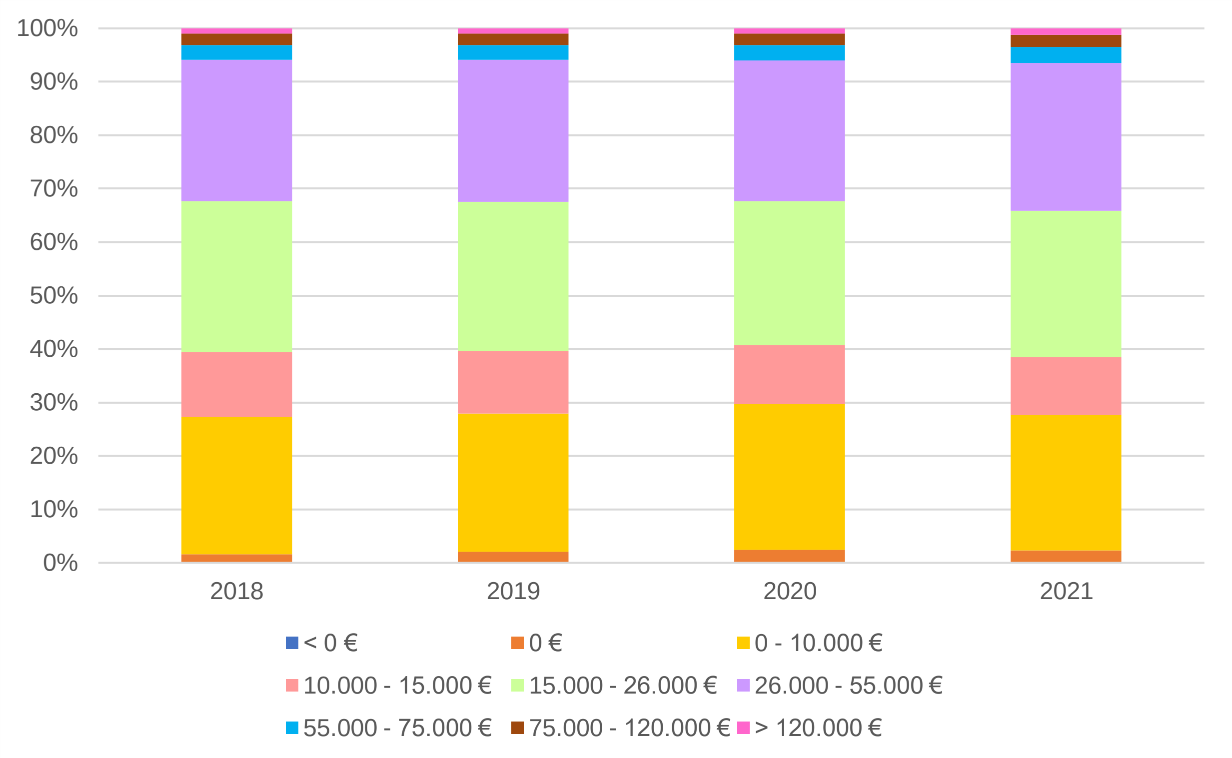


Figure 10 - Population of Genoa divided by income classes (Ministry of Economy and Finance)

Comparing the data, it can be observed that the economic gap has accentuated over time: in 2021, both the number of people in the classes with no income (+45,3% compared to 2018) and the number of people with income > 120.000 € (+14.8% compared to 2018) increased, while the number of people belonging to the classes with intermediate incomes has reduced.

Employment Status

Analyzing the data reported below, it can be observed that during the five years 2018-2022, employment values dropped in 2020, probably due to the COVID-19 pandemic.

Year	Employed *(thousands people)*	Employment rate *(15-64 aged) %*	Unemployed *(thousands people)*	Unemployment rate *(15-74 aged) %*	Non-labor force *(thousands people)*	Inactivity rate *(15-64 aged) %*
2018	230	65,1	23	9,3	96	28,1
2019	226	63,8	26	10,3	97	28,7
2020	221	63,2	21	8,6	104	30,8
2021	224	64,7	20	8,2	98	29,4
2022	233	67,0	17	6,9	94	27,9

Figure 11 - Employed, unemployed, non-labor force and related rates in Genoa, years 2018-2022 (ISTAT)

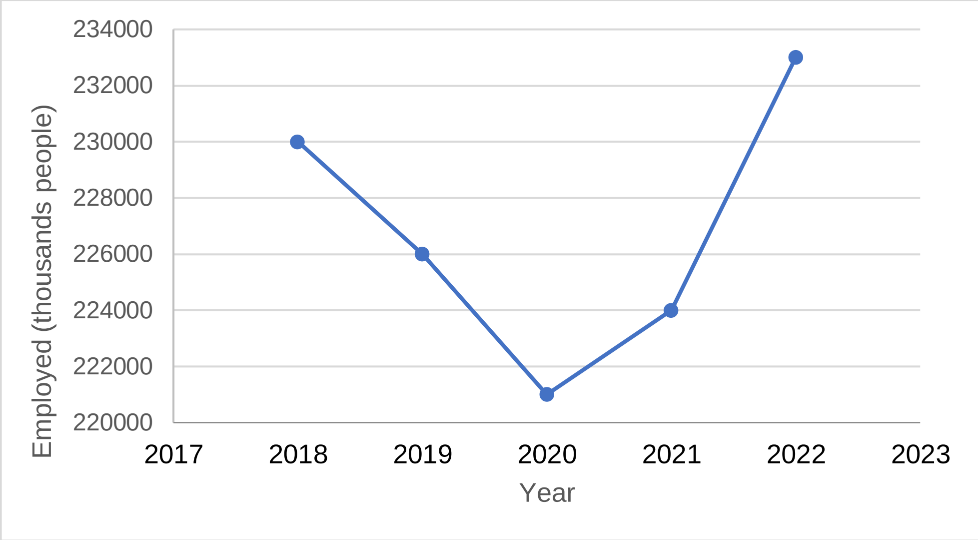


Figure 12 - Number of employed people in Genoa, years 2018-2022 (ISTAT)

Map of Genoa shows how the index of active unemployment in Cornigliano has a high value (1,4) if compared to other neighborhoods.

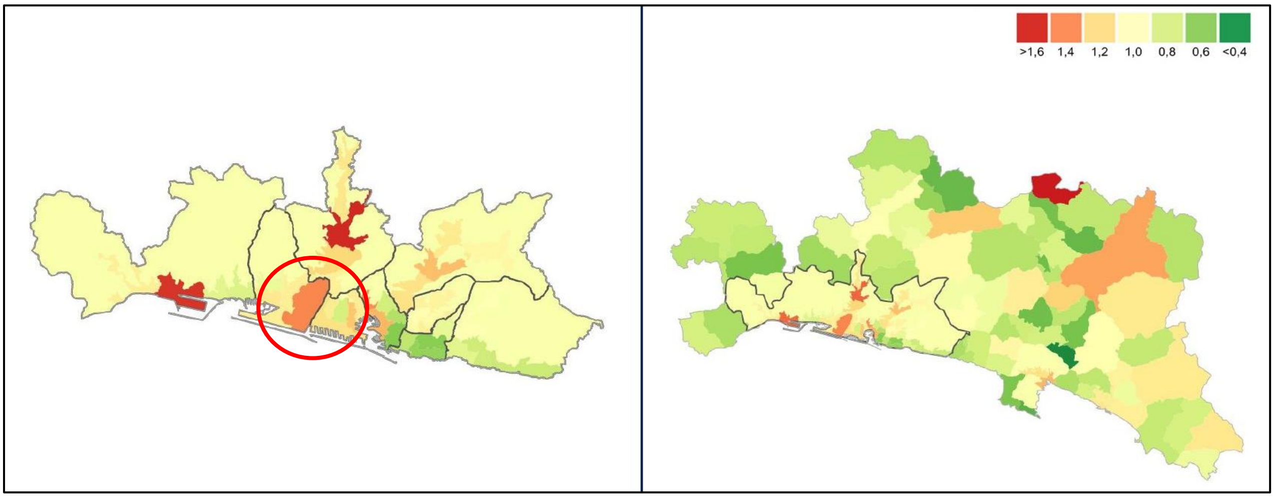


Figure 13 - Map of index of active unemployment for Genoa (left) and Metropolitan city area (right) - NUVAP PovertyMaps 2017

Education Levels

In the Capital Municipalities of metropolitan areas, education levels are generally higher than in the Municipalities that gravitate around these large centers. Below are reported data for 14 Italian metropolitan cities (year 2021), considering residents aged 25-64 years, with a distinction between the metropolitan municipality and the adjacent municipalities of the first and second urban belt, up to the most peripheral areas.

Overall, 43% of people have a secondary school diploma and 24% have a tertiary education qualification (bachelor, master or doctoral level). For the metropolitan area of Genoa, it is observed that in Genoa, 27,2% of residents have a tertiary education level, in the first urban belt 20,5%, and in the second belt, 20,3%.

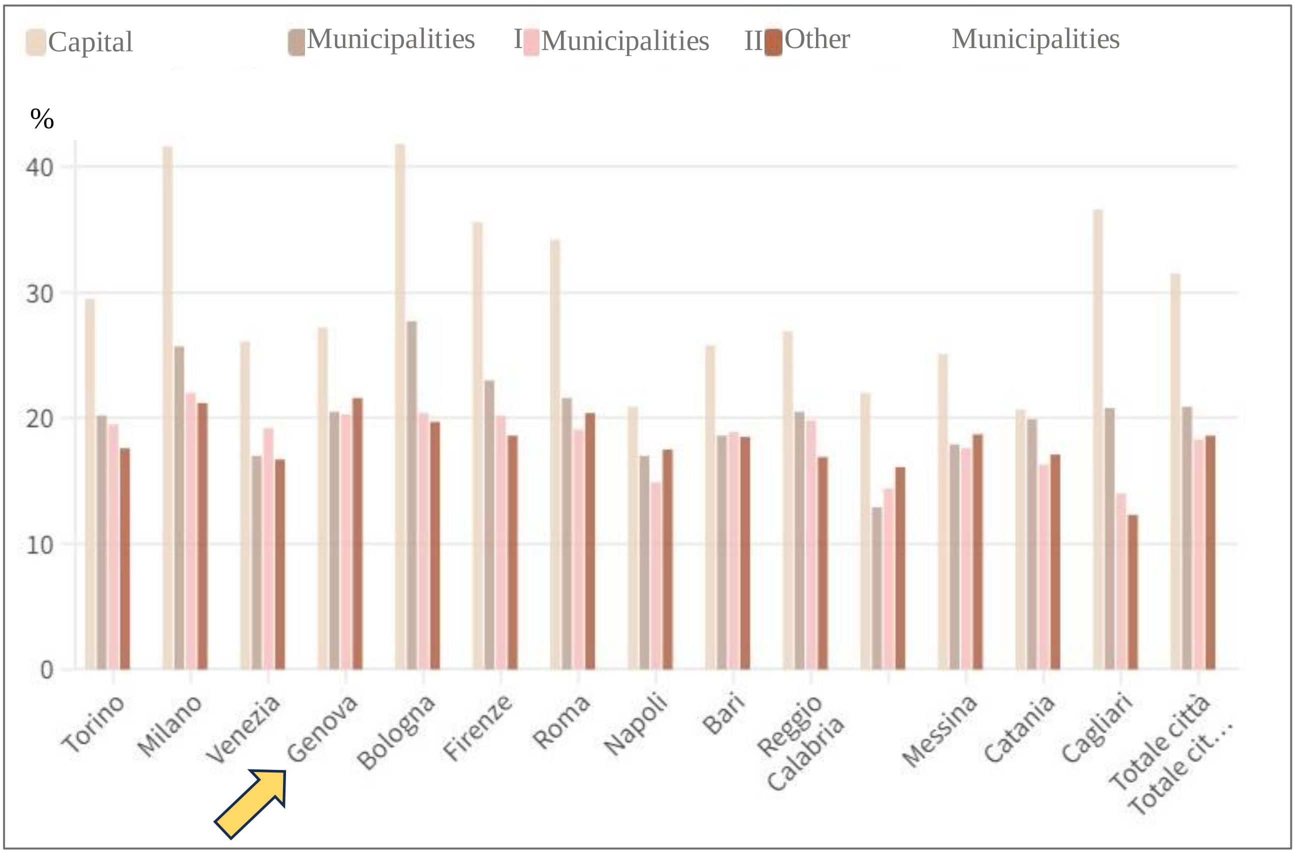


Figure 14 - Population aged 25-64 with a tertiary education level in metropolitan areas, year 2021 (ISTAT)

Map of Genoa shows how the index of low education in Cornigliano has a high value (1,2) compared to other neighborhoods.

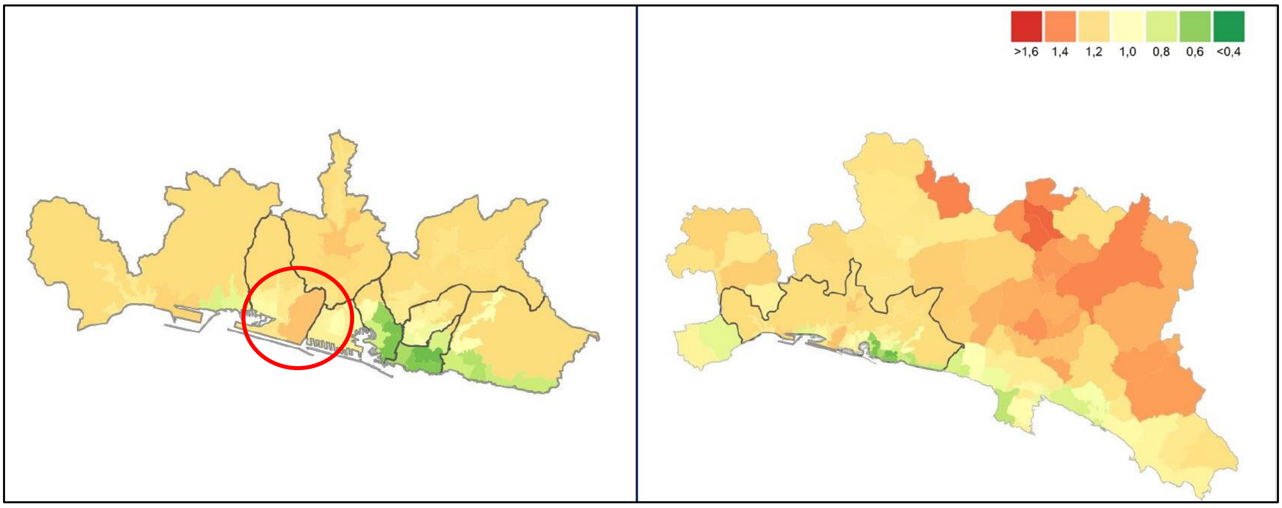


Figure 15 - Map of index of low education for Genoa (left) and Metropolitan area (right) - NUVAP PovertyMaps 2017

Housing and Living Conditions

Housing Types

Considering the city territory's shape, most homes are condominiums of various sizes across the city, with detached homes mainly in hilly neighborhoods like Coronata in Cornigliano.

The PUC (Urban City Plan) analyzes Genoa's building types by local administrative unit. As shown in Figure 16, the most common type in the city and in Cornigliano (Medio Ponente, Municipio VI) is the block, a continuous band of buildings often enclosing a courtyard.

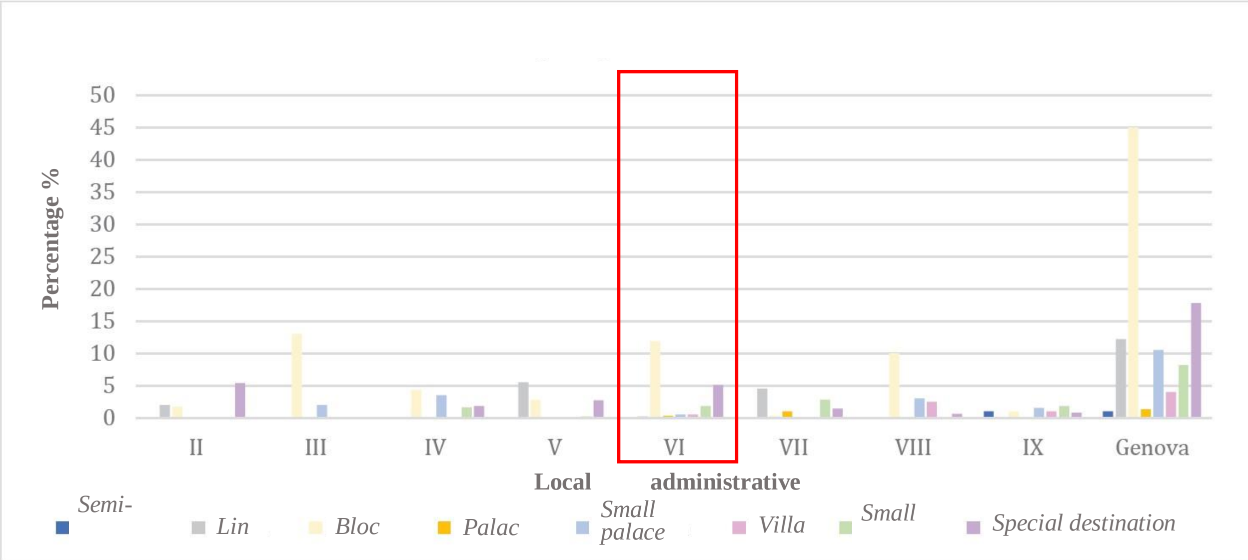


Figure 16 - Building typologies in Genoa

Ownership Status

At a national level ISTAT found that in 2021:

- 18,2 million families (70,8%) are owners of the home in which they live (42,7 million people, 72,5%)
- 5,2 million families (20,5%) live in rent (11,8 million people, 20%)
- 2,2 million families (8,7%) have their home in usufruct or free of charge (4,4 million people, 7,6%).

Building Conditions

Out of a total of 29.668 residential buildings in Genoa, 27.667 were built before the 1970s, accounting for 93% of the total. Of these, almost 13 thousand dates to 1918 and earlier years. This means that these are obsolete buildings that do not have the most modern technologies in terms of energy class.

In the entire region, 76% of buildings are more than 45 years old (199.558 out of 263.468), making Liguria one of the regions with the "oldest" buildings, compared to an Italian average which sees this percentage at 57%.

Energy Infrastructure

The City of Genoa has signed a collaboration agreement, GENOWATT 2026, to enable the city's energy transition as part of the National Recovery and Resilience Plan (PNRR). Key objectives include creating a new primary substation for SkyMetro, doubling 128 secondary substations to boost sustainability (e.g., cold ironing), and upgrading existing electric infrastructure with the latest technology.

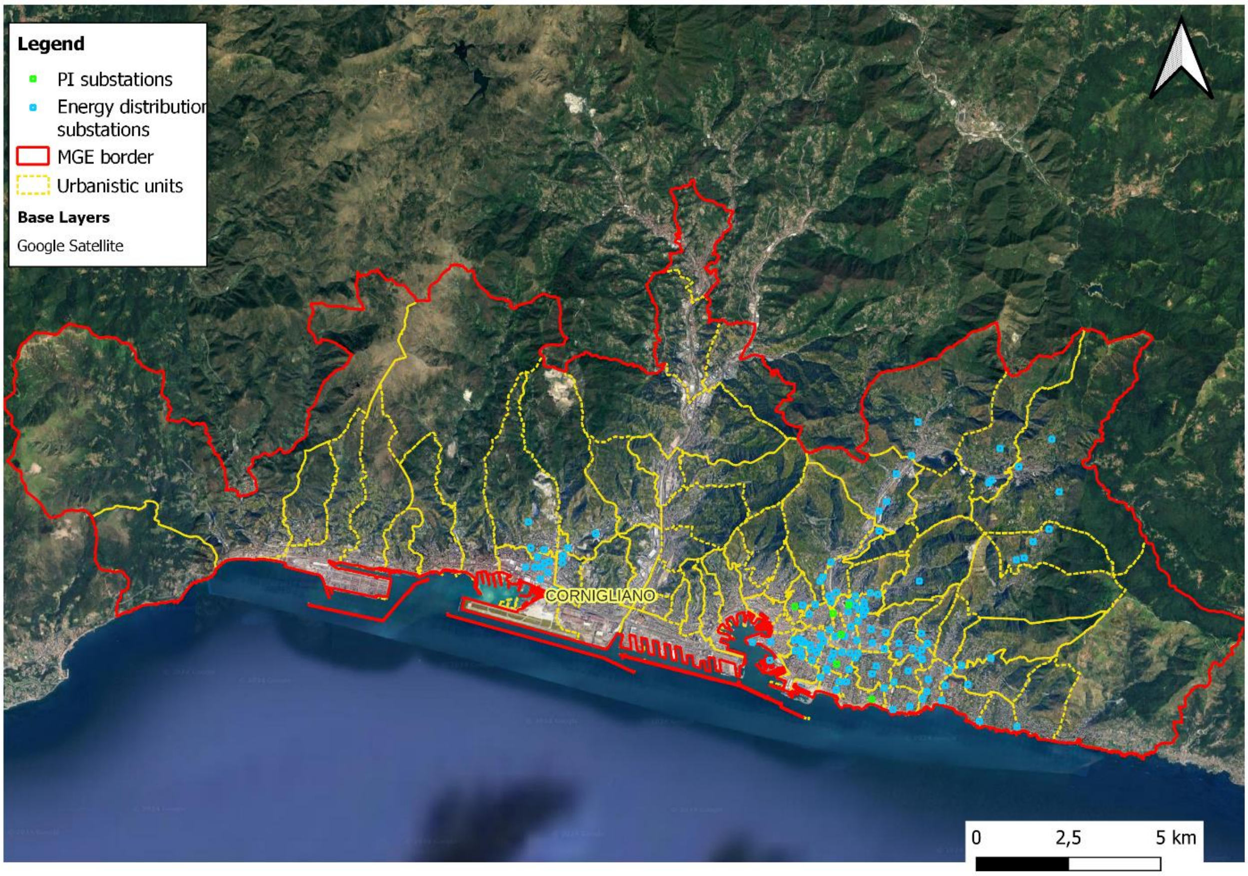


Figure 17 - Existing energy distribution and public illumination substations

Genoa is equipped with a district heating network. The system recovers heat produced in the plant through a boiler and delivers it as superheated water for space heating hot water for sanitary uses and cooling. The plant is located in Sampierdarena, near to Cornigliano, and the 12 km network serves the Fiumara, San Benigno and Campi districts.

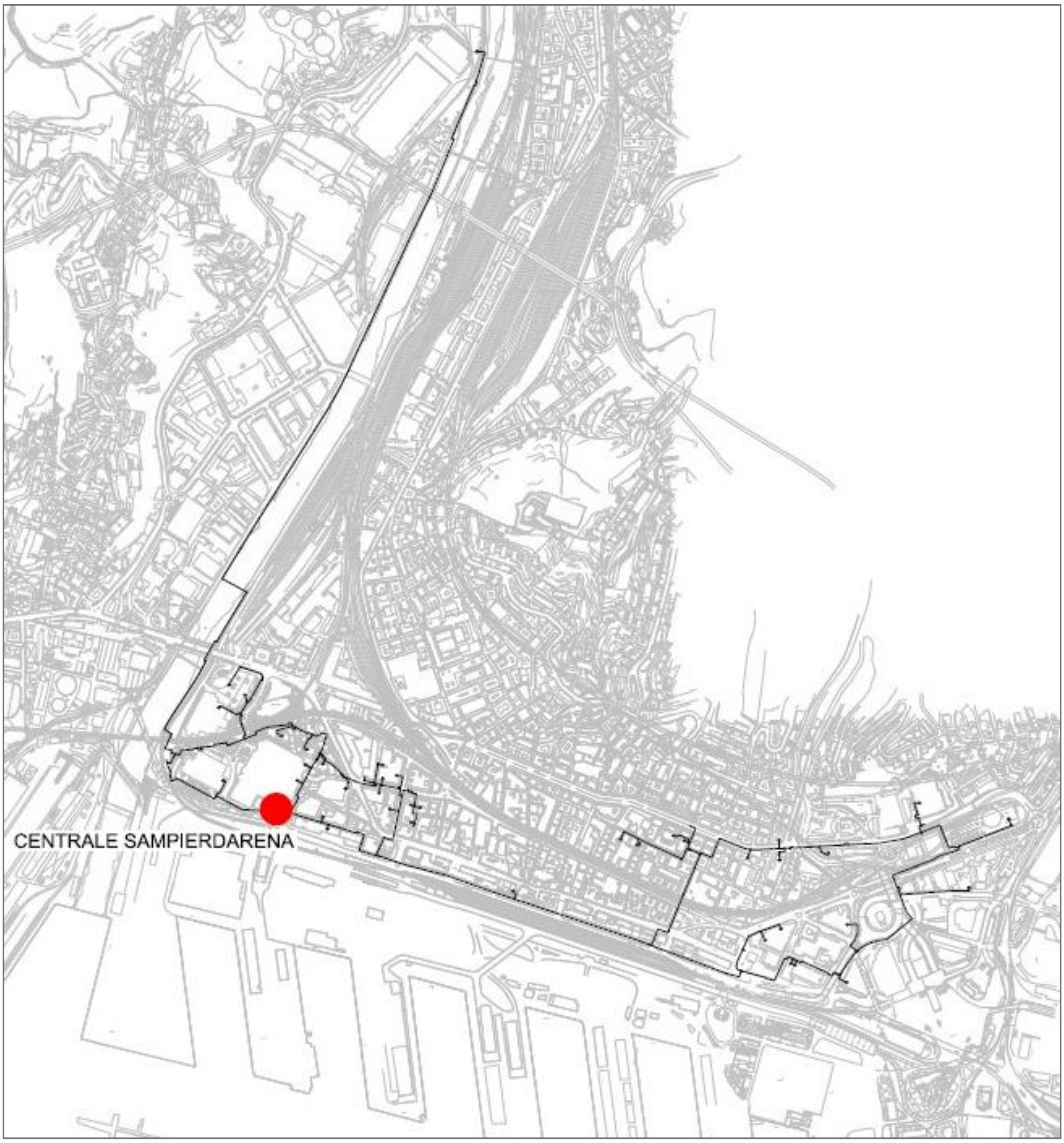


Figure 18 - Map of district heating network of Genoa (IREN)

The energy efficiency of buildings is assessed by the energy performance certificate (APE), which details energy consumption and potential improvements. The APE includes the building's energy performance, global energy performance index (renewable and non-renewable), and energy class (A4 to G). New buildings, property transactions, new leases, and major renovations are mandatory. The APE is also needed to access economic incentives for renovations.

Figure 19 shows that from 2017 to 2024, nearly 85% of residential buildings in Genoa fall into the three lowest energy classes, with 40% in class G.

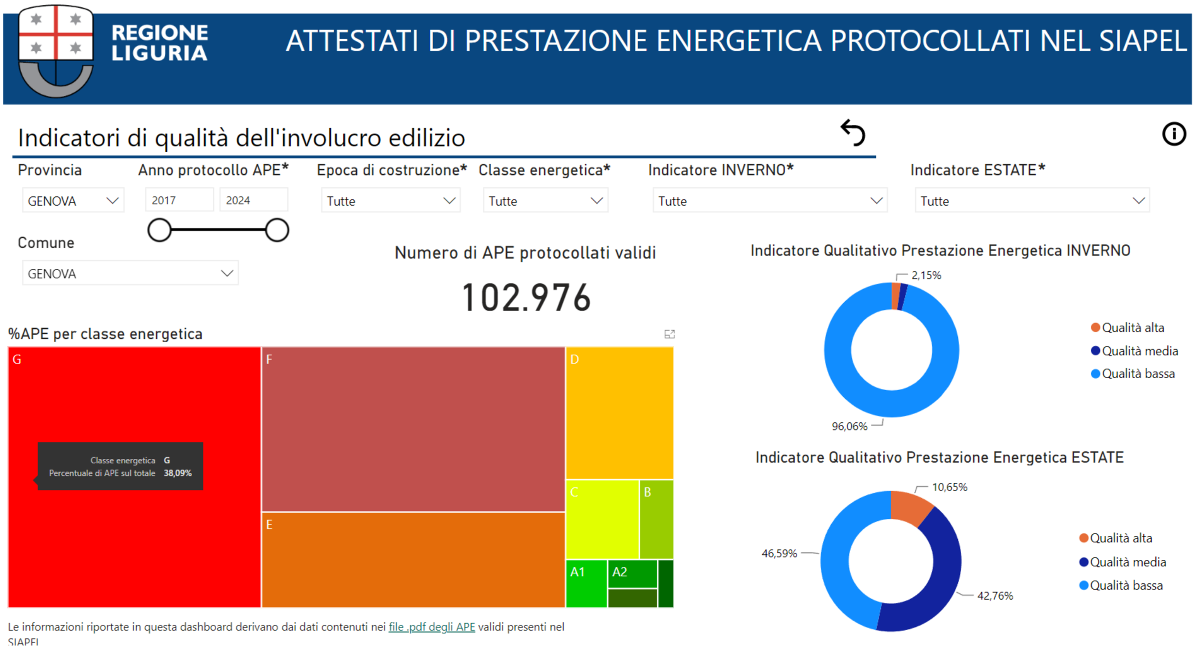
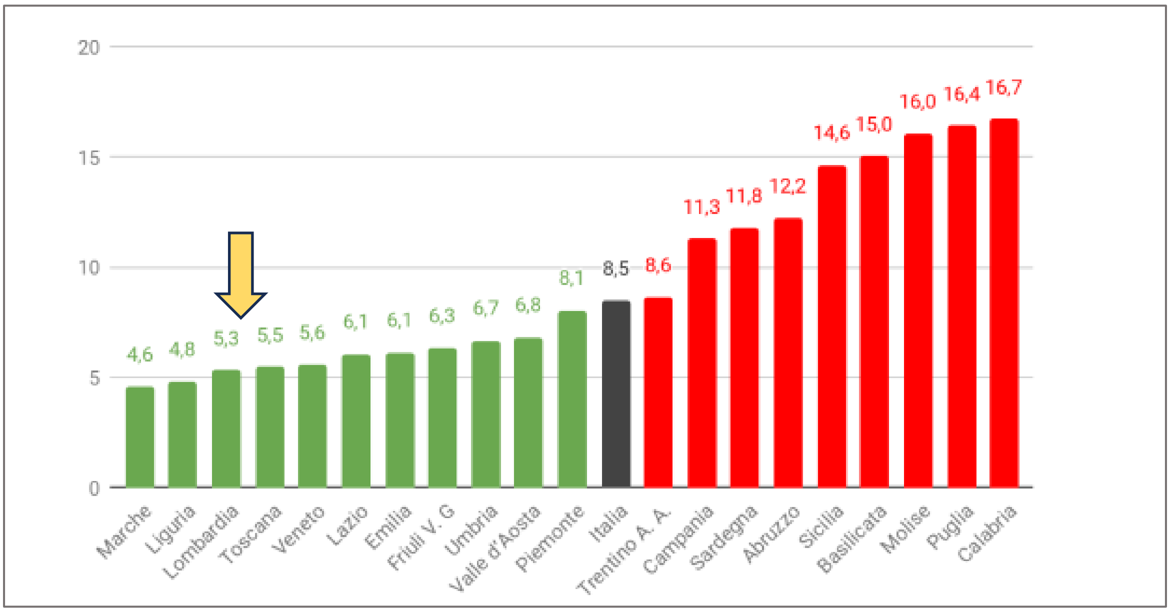


Figure 19 - Data on energy efficiency of buildings in Genoa, years 2017-2024

Energy Poverty Assessment

Energy Expenditure

In 2021, the Italian Observatory on Energy Poverty (OIPE) estimated energy poverty across Italian regions, ranging from 4,6% to 16,7%, with a national average of 8,5%. Liguria reported 4,8%, among the lowest. In 2022, energy poverty affected 2 million households (7,7%), a 0,8% decrease from 2021.



EnerCmed
Interreg Euro-MED
Co-funded by the European Union

	media	errore standard	intervallo al 95%	var p.p. su 2020
01 Piemonte	8,1	0,9	[6,5-9,6]	2,0
02 Valle d'Aosta	6,8	1,4	[4,1-9,5]	-0,5
03 Lombardia	5,3	0,5	[4,5-6,2]	-0,5
04 Trentino A. A.	8,6	1,4	[6,3-11]	1,8
05 Veneto	5,6	0,8	[4,3-6,8]	1,0
06 Friuli V. G.	6,3	1	[4,3-8,3]	0,5
07 Liguria	4,8	0,8	[3,1-6,5]	0,0
08 Emilia Romagna	6,1	1,1	[4,9-7,4]	1,0
09 Toscana	5,5	0,7	[4,2-6,7]	0,0
10 Umbria	6,7	1,6	[3,9-9,4]	0,1
11 Marche	4,6	0,8	[2,9-6,2]	-0,1
12 Lazio	6,1	1	[5-7,2]	0,9
13 Abruzzi	12,2	1,8	[8,8-15,7]	2,1
14 Molise	16,0	3,3	[9,5-22,6]	4,3
15 Campania	11,3	1,4	[9,2-13,4]	0,5
16 Puglia	16,4	2,6	[13,8-19]	5,5
17 Basilicata	15,0	3,4	[8,4-21,7]	-1,3
18 Calabria	16,7	3,3	[11,4-22,1]	1,1
19 Sicilia	14,6	1,8	[11,7-17,5]	-3,5
20 Sardegna	11,8	2,4	[8,1-15,4]	-1,8
Italia	**8,5**	**0,3**	**[8-9]**	**0,5**

Figure 460 - Energy poverty in Italy, year 2021
(https://oipeosservatorio.it/wpcontent/uploads/2022/12/2022_PE_regioni_2021.pdf)

In 2022, energy prices surged, significantly impacting household spending. Italian households' annual energy expenditure rose by 32% from 2021, with the average household spending 1.915 €, about 500 € more than in 2021. Eurostat reported a 50% increase in electricity costs and a 34,7% rise in natural gas prices. Government interventions on final prices mitigated these increases. Although energy costs rose for all households, poorer households experienced a smaller increase compared to those around the median expenditure level.

(https://www.istat.it/it/files//2024/05/Rapporto-Annuale-2024.pdf#page=130)

Access to Energy

At the national level, energy poverty characterizes families in small towns (in municipalities under 50 thousand inhabitants) and suburban areas.

Energy poverty is increasing in families with minors and in those with foreign reference persons.

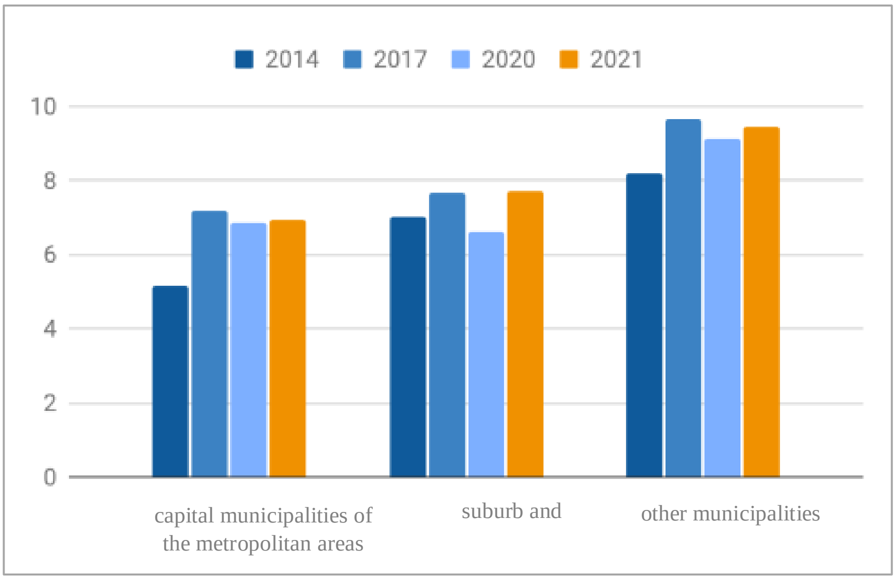


Figure 471 - Italian energy poverty levels

Fuel Use

The only data available refer to the year 2005. The fuel mix analysis for the civil sector in the municipal territory shows that natural gas was the fuel most affecting consumption with a percentage of 61%, followed by electricity at 26%, diesel at 8%, fuel oil at 3%, LPG and heat both with 1%.

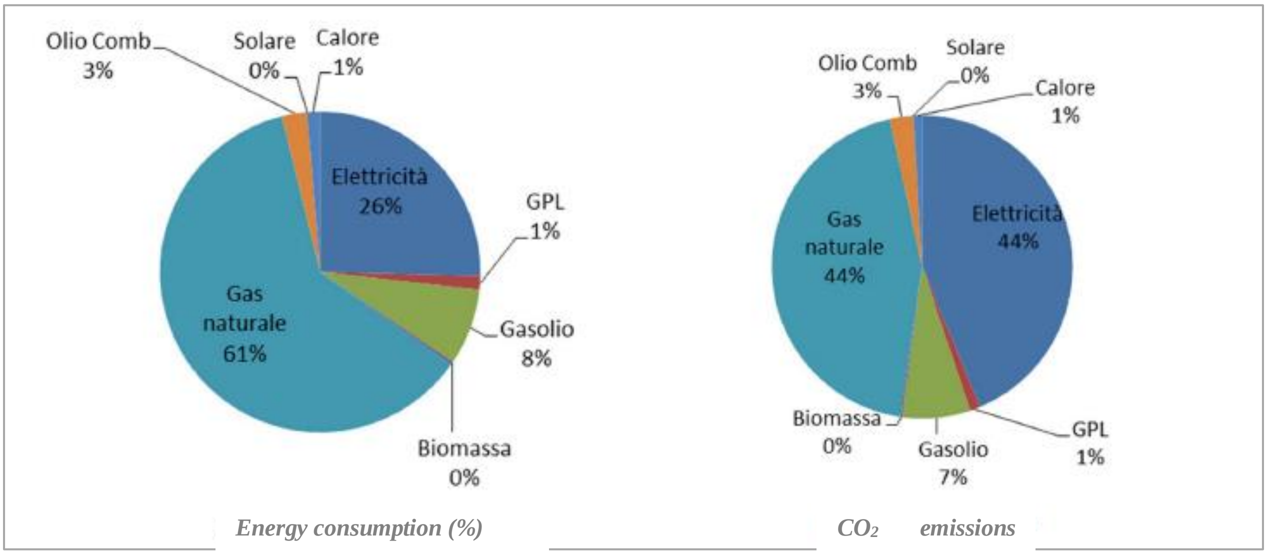


Figure 482 - Energy consumption and CO_2 emissions for the civil sector, year 2005 (IRE spa and UNIGE)

Identification of Vulnerable Groups

Genoa is the oldest city in Italy, so the elderly are presumably the most vulnerable from the point of view of energy poverty. The district of Cornigliano, presenting considerable social problems, can be presumed to be among the city's most sensitive areas concerning the energy poverty.

5.4 Social composition and energy poverty analysis Greece

Introduction

Purpose

The purpose of the present analysis is to identify the relationship that exists between the socioeconomic composition of the target neighborhoods and energy poverty. The correlation will be studied, that is, if one affects or is affected by the other.

Scope

The target study area includes a school complex that houses five secondary schools. It is located between the municipal forest of Dassilio, the city's old port, and a high-traffic road, the mini perimeter road of the city. On the south side of the school complex, there is a hill named Eschatovouni. It is 880 meters from the North Pier of the port, where commercial ships dock, and 1100 meters from the Agios Nikolaos Pier in the southwest, where passenger ships dock. (a map is listed on the last page)

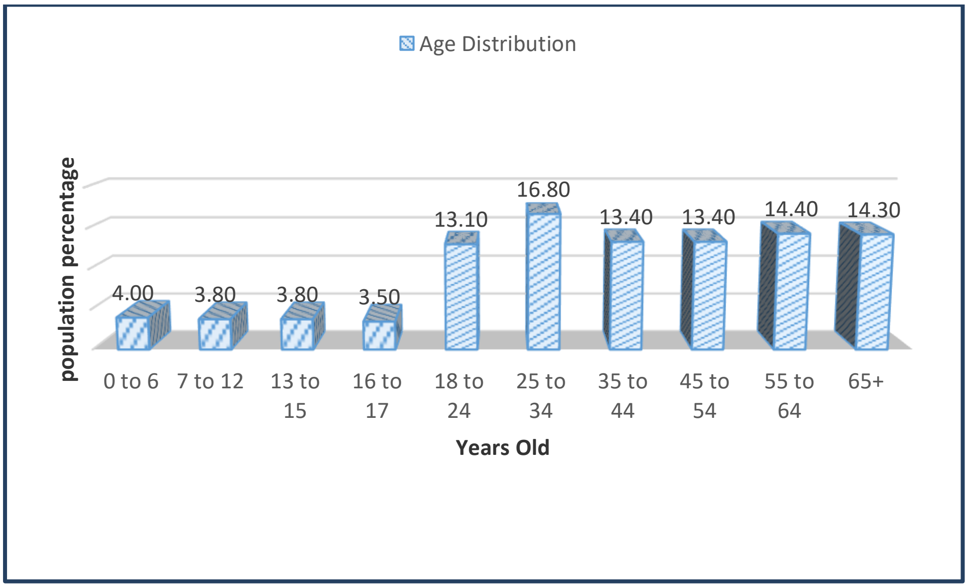
Methodology

The collection of data for the analysis of the object was done through maps available to the Municipality of Patras, the valuable help of the GIS, and observation in the field. The state statistical office provided reliable socio-economic data for the study area. As expected the picture regarding the state obligations is somewhat different; 60% stated that they covered their financial obligations. The exact opposite is true for the "risk group" and for the families with more than six members; only 32% managed to respond.

Demographic Profile

Population Size and Density: Provide statistics on the number of inhabitants and population density in the neighborhood.

Age Distribution: The percentage of men in the community is 49.5% and 50.5% women.



Household Composition

About 1 in 3 households have at least one retired person who lives with them. This percentage is over 40% when we speak about families with 2-3 or more than six members; this shows that pensioners live alone as couples or with their families, which they most probably help financially. 50% of the population is married and 40% are single. The widowers reach 6.5% and 2.3% are divorced.

Socio-Economic Characteristics

Income Levels

3 in 4 households say they did not have difficulty in covering their personal liabilities. Only 55% of the "risk group" adequately covered their financial obligations. This percentage is the same for families with more than six members. About 70% say they cannot cover an emergent yet necessary expenditure of 550 euros. Things are even worse in the "risk group" as the percentage of those who cannot cover an emergent yet necessary expenditure of 550 euros rises to 95%. 31% state they do not have 550 euros, though they declare their monthly income is 1500 € plus. All the incomes from a household's possible sources include "black" incomes together with wages, rents, etc. The percent below 820 euros per month is about 42% since the poverty line is 38%. This might indicate that about four in ten families need some help as they lack survival goods and have low incomes. The percent of families/households located either at risk of poverty or below the threshold is 37.7%. About 1 in 3 households have at least one retired person who lives with them. This percentage is over 40% when we speak about families with 2-3 or more than 6 members; this shows that pensioners live alone as couples or with their families, which they most probably help financially.

The following table shows the percentage of the population that has the corresponding monthly income. 59% of the population has up to 1,000 euros.

3,4%	0€
6,5%	<350€
32,1%	351€-820€
17,0%	821€-1000€
14,7%	1001€-1500€
10,2%	>1500€
16,1%	Does not answer

Employment Status

Regarding the activity, we can see that in total 30% over 18 years old work, 23% are pensioners and students, 11.5% are unemployed and 9.2% are housewives. With a second analysis of the economically active population, we see that the rate of jobless people reaches 29.7%, which is slightly above the average for the whole Borough.

Education Levels:

It is important to note that 30% of the residents have a University degree from at least a Technological Educational Institute (TEI). The majority 37%, are Senior High School graduates. However, among the ages 25-34, the University graduates with a degree from TEI or from a Higher Educational Institute (aka AEI) exceed 40%. Among those who are 55-plus, the number of primary school graduates exceeds 25%.

38.6% have a certificate in a foreign language other than their native language, the percent exceeds 60% at the ages below 34 years and shows that the second language is now a very common phenomenon; however, at the ages 55-plus, this percent falls below 15 %.

The situation is different with the certificates for computer use. Only 18.8% say that it has one. The largest percent, 37.9%, who have an ICT certificate belong to the age group 25-34, and the lowest percent, 2.1%, belong to the age group 65-plus.

Housing and Living Conditions

Housing Types:

85% have houses/flats between 46 and 150 m^2. 13.5% of the population live in less than 45 m^2, while only 3.4% live in bigger houses/flats of 150 m^2. The more members and income a family has, the bigger the house/flat where they live is. 2 out of 3 live in a block of flats while the rest live in a house. A minimum percent of families have a two-story house, but different tenants reside on each floor. As we move away from the center of the municipality of Patras towards the suburbs, the size of the buildings increases.

Ownership Status:

Most of the respondents (35%) reside in homes they own without loans, meaning they either bought them by their own means or inherited them from a relative. We almost have the same percentage for those living in rented houses/flats, whereas half is the percentage of the respondents who bought a house/flat with loans. 13.4% live in houses that still belong to their parents /relatives. It is important to note that among the "risk group" and those whose income is below 820 euros per month, the percentage of people living in rented houses/flats exceeds 45%. The proprietary homes with or without loans are mainly houses around 100 m^2.

Building Conditions

The heat and the heating system in the house/flat are in the first place (over 10%). Humidity, Heating, and Poor insulation all together reach almost 100%.

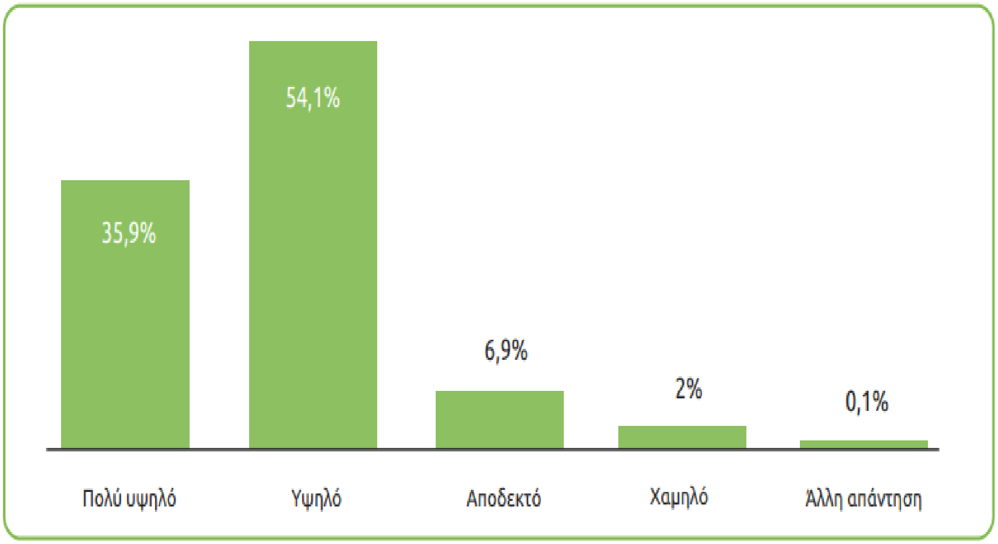
Energy Infrastructure

7.5% say they do not have any heating in their house, with the percentage reaching 14% for the "risk group", low-income families and pensioners.

Energy Poverty Assessment

Energy Expenditure

Cost of energy in Patras Greece in relation to the monthly/annual income.



- Very high 35,9%
- High 54,1%
- Acceptable 6,9%
- Low 2%
- Other answer 0,1%

Impact of energy price increases and which ones have affected you the most

- Electricity (electricity providers) 59,8%
- Heating oil 23,2%
- Natural gas 1,6%

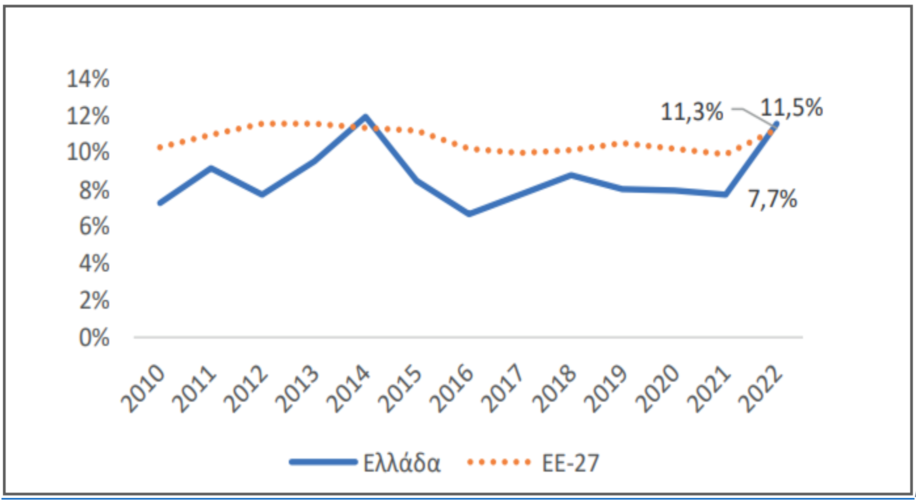
Regarding the cost of provided energy services, the majority of respondents - 90% - believe it is high to very high. Out of this 90%, 36,5% indicate that during the last 24 months, they frequently to very frequently faced difficulties in paying energy bills.

Access to Energy

The increase in energy prices has led to a significant rise in consumer expenditure on energy – to 11.5% of total consumer expenditure in 2021, up from 7.7% in 2020, compared to 11.3%. Household positions in Greece were more favorable in previous years than households in other EU member states, partly due to lower heating needs. However, without a corresponding income increase, households' purchasing power has been significantly constrained. This situation raises distributional issues, as energy expenditures constitute a proportionally higher share of expenses for poorer households.

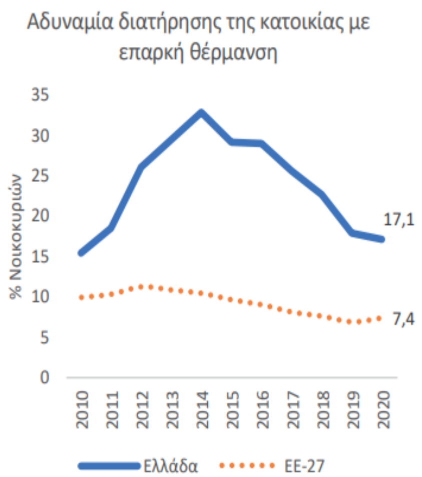
Consumer expenditure on energy

as a % of total consumer expenditure, 2010-2022



https://ec.europa.eu/eurostat

The following charts concern: i) Nability to maintain the residence with sufficient heating. ii) Percentage of households with overdue debts on utility bills.



Increased energy expenditure reflects the pressures many households in Greece face, which cannot maintain adequate heating in their homes. The percentage of these households, consistently estimated to be higher in Greece compared to the EU-27 average, peaked during the economic crisis, reaching 32.9% of total households in 2014 . Since then, there has been a decline, with the figure dropping to 17.1% of total households by 2020, yet remaining significantly higher compared to the EU-27. The same applies to the percentage of households with overdue utility bills, which rose to 42% in 2016 before decreasing to 28.2% by 2020, still well above the EU-27 average of 6.5% in 2020.(https://ec.europa.eu/eurostat)

Fuel Use

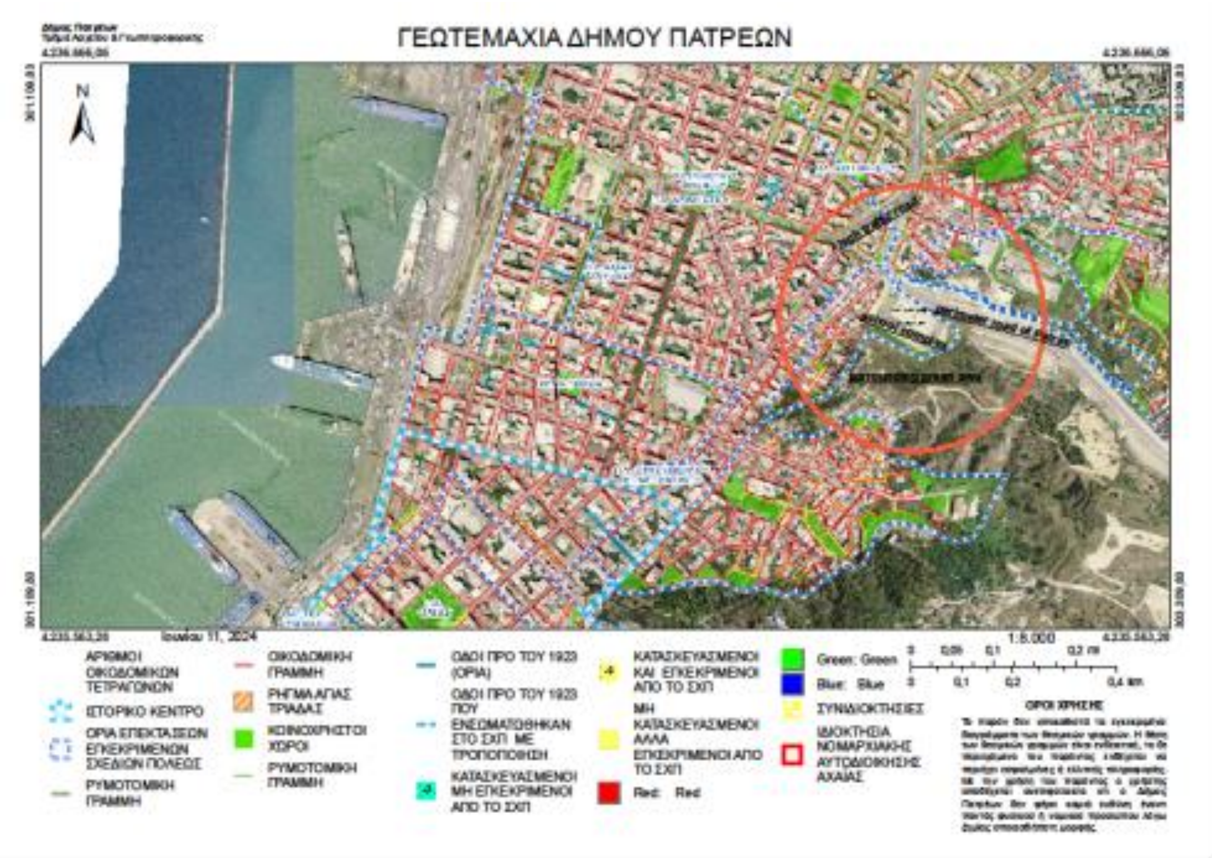
Heating oil exceeds 83.1%, followed by air heaters at 6%, stoves at 4.5%, and fireplaces at 4%. In houses/flats up to 45 m^2 the Air Heaters exceed 10%. The fact that Heating Oil loses 50% of its final use while this percentage goes to heating such as Air Heaters, Stoves, Fireplaces, and Conditioning indicates the dire financial situation. The interesting statistical phenomenon here is that the growth of alternative forms of heating is stronger in the "risk group" and low-income families than in the high-income families, except for the use of fireplaces which the non-"risk group mostly uses". Additionally, it is shocking that 0.3% say they do not use any form of heating.

More than half say that the kind of heating they use- whatever this may be is satisfactory but the percentage of the "risk group" falls to 26%. The air conditioning seems to provide the biggest satisfaction, nearly 76%.

Identification of Vulnerable Groups

3 out of 4 families do not have a person who belongs to the existing categories. Most have elderly 17.7%, people with chronic medical conditions 12.2%, people with disabilities 3.7%, while few have dependents and unvaccinated children/infants. Older people live alone or in families with more than 4 members; they thus help their families or get help.

Map depicting the study area


ΓΕΩΤΕΜΑΧΙΑ ΔΗΜΟΥ ΠΑΤΡΕΩΝ
ΑΡΙΘΜΟΙ ΟΙΚΟΔΟΜΙΚΩΝ ΤΕΤΡΑΓΩΝΩΝ
ΙΣΤΟΡΙΚΟ ΚΕΝΤΡΟ
ΟΙΚΟΔΟΜΙΚΗ ΓΡΑΜΜΗ
ΚΟΙΝΟΧΡΗΣΤΟΙ ΧΩΡΟΙ
ΡΥΜΟΤΟΜΙΚΗ ΓΡΑΜΜΗ
ΣΥΝΙΔΙΟΚΤΗΣΙΕΣ
Green: Green
Blue: Blue
Red: Red
ΟΡΟΙ ΧΡΗΣΗΣ


school complex
Κανακάρη
Α.Σ.ΠΑΙ.Τ.Ε.
2ο Επαγγελματικό Λύκειο
Πανεπιστημίου
easywash Self Service
Crab and go
Google Earth
100 m