Digitisation and analysis of energy data at municipal scale: an application to the municipality of Mendrisio

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Abstract. The concept of Smart Cities has gained significant attention in recent years due to the increasing need for efficient energy management in urban areas. This paper describes a digital platform for the management of energy databases that aims to synchronize, update, and analyze different energy installations and uses in the municipality of Mendrisio according to the Smart City concept. The platform interweaves and compares various energy databases to ensure better efficiency in the use of thermal and electrical energy, as well as optimize the consumption and production of renewable energies. The geodigital platform created is capable of conducting energy assessments for the development of new district heating projects in the municipality and the creation of local energy communities. This paper presents the design and functionalities of the proposed digital platform, highlighting its potential for improving energy management in Smart Cities and facilitating the transition to more sustainable energy practices. The results of this study, financed by Swiss Energy together with Canton Ticino and AIM (Aziende Industriali Mendrisio), contribute to the growing body of research on digital technologies for energy management in urban areas and provide insights for policymakers and urban planners seeking innovative solutions for sustainable energy development.

1. Introduction

The need for sustainable and efficient energy management has become increasingly urgent in recent years [1], [2] and [3]. Municipal, cantonal, and federal governments have been actively investing in the development of energy databases and resources to help them better understand and manage their energy consumption and production. However, it is not enough to simply gather data, it is so essential to analyze and optimize the information collected in a way that ensures efficient and sustainable use of energy resources.

To achieve this goal, it is crucial to adopt innovative technologies and tools, such as digital platforms, that enable local energy planning to make informed decisions [4] and [5]. In particular,

thermal and electrical needs must increasingly rely on sustainable and renewable energy sources, and digital technologies can provide invaluable insights and facilitate the transition to more sustainable energy practices.

This paper aims to present a digital platform for the management of energy databases that follows the Smart City concept. The platform seeks to synchronize, update, and analyze various energy installations and uses in the city to ensure better efficiency in energy use, as well as optimize the consumption and production of renewable energy. The geodigital platform created is capable of conducting energy assessments for the development of new district heating projects in the municipality and the creation of local energy communities.

By presenting this digital platform, we hope to contribute to the growing body of research on digital technologies for energy management in urban areas. We also seek to provide policymakers and urban planners with innovative solutions for sustainable energy development and management.

The project described in the paper is a collaborative effort between various partners who have come together to work towards a common goal. The project has received funding from two significant organizations - Switzerland Energy and the canton of Ticino. In addition to this, the Municipality of Mendrisio has also provided its support by funding the project.

2. Method

During discussions with various partners, the importance of reliable and up-to-date energy databases was emphasized. It was acknowledged that working with inaccurate or outdated data could lead to incorrect conclusions and inefficient use of resources. In Switzerland, every energy database has its own critical points and advantages, and it is essential to compare them to reduce the risk of errors or missing information. The primary objective of this project is to assess suitable areas for the development of new district heating networks based on heat requirements, as well as promoting the creation of energy communities for the installation of new photovoltaic systems.

To achieve these goals, it is essential to have access to accurate and reliable energy data, which can be analyzed using the proposed digital platform. This will ensure that decisions are based on solid information, leading to better energy management and sustainable development practices. A first part of the work involved the selection of the most appropriate energy databases to use and contacting the data managers to ensure their availability. This step was crucial to ensure that the data used for the analysis was reliable and up-to-date. A second part of the project was the creation of an online GIS (Geographic Information System) portal, called GEOME, which the project partners and the Municipality of Mendrisio could use to query the embedded data.

This portal allowed for easy access to the databases and streamlined the data analysis process. The final part of the project focused on the analysis of the data to identify suitable areas for the development of new district heating plants and the creation of new RCP[1]s (energy communities, RCP in Swiss Italian [6]). This involved a comprehensive review of the data to assess heat requirements, available resources, and the potential for the installation of renewable energy sources. The following sections provide more detailed information about each of these stages of the project.

2.1. Analysis and collection of the available databases

To ensure reliable and up-to-date energy data, a list of available databases and their data availability was compiled. The authors relied on their experience in similar works ([7], [8], [9], [10]) and their knowledge of available databases in Switzerland. Municipal, cantonal and federal databases were ordered for inclusion in the list. The databases were evaluated based on the quality and reliability of the data they contained.

The following table shows the databases used in this study and the information they contain:

[1] RCP: Raggruppamento ai fini del consumo proprio

Table 1: List of databases included in GEOME portal

Database name	Level	Information Contained and Used	Accuracy
Federal Register of Buildings and Dwellings (RBD)	National	• Building category • Building surface • Building interval/age • Thermal generator • Thermal source	+
Minergie database	National	• Building category • Building surface • Certification year • Thermal generator • Thermal source	++
Control of heating systems (ConComDat)	Cantonal	• Building category • Burner year • Burner power • Thermal source (fuel)	++
Cantonal incentives for heat pumps	Cantonal	• Subsidy year • Thermal source	++
Cantonal database for geothermal BHE[2] and wells	Cantonal	• Thermal source • Permission year	-
Municipal building permits	Municipal	• Thermal source • Permission year	+
Installations of the municipal energy company	Municipal	• Thermal source • Power (photovoltaic, heat pump, gas burner) • Permission year	+
Electricity consumption of the municipal energy company	Municipal	• Year electric consumption (for big users also hourly consumption)	++
Gas consumption of the municipal energy company	Municipal	• Year gas consumption	++
Gas network	Municipal	• Length and track	++

It is important to highlight that all the databases used in this study provided information associated with buildings (EGID) and their entrances (EDID)[3]. In cases where such information was not available in databases, the address or the municipal fund was used to identify the building. Cross-referencing the different datasets was essential to ensure accurate and reliable analysis. Therefore, having access to information about the physical location of buildings was critical in allowing the databases to be effectively compared and analyzed. Without this information, it would not have been possible to fully exploit the potential of the available data for the analysis of local energy installations, consumption, and production. To ensure accuracy and reliability of the data used in the analysis, the authors made efforts to correct any missing or incorrect data in the databases. In cases where information was

[2] BHE: Borehole Heat Excanger

[3] For more information about EDID and EGID see https://www.bfs.admin.ch/bfs/it/home/registri/registro-persone/armonizzazione-registri/egid-ewid.html

missing or incorrect, such as missing house numbers or incorrect street spellings, the authors attempted to correct the data manually. This was done to ensure that the data used in the analysis was as complete and accurate as possible. Although manual data correction can be time-consuming, it is an important step in ensuring the reliability of the analysis. This approach was taken to minimize the impact of errors and improve the accuracy of the results.

As shown in the table presented earlier, the authors found that some databases were not completely reliable in terms of the information they contained. For example, census errors, changes in energy sources not reported, and census being conducted in different years were some of the challenges encountered. Therefore, the authors prioritized the use of data acquired from more reliable sources, such as the Minergie database, combustion control database, and cantonal incentives database. This allowed for a more streamlined flow of information and ensured that the analysis was based on the most accurate and reliable data available. Based on these databases, a georeferenced portal was created where each building could be queried, providing a more efficient way to access and analyze the data. This approach was taken to ensure that the analysis was based on the most reliable data available, while still making use of all available information.

2.2. Creation of the GIS portal GEOME

After the data was collected and verified, the authors incorporated the information from the various databases into a georeferencing program GEOME for the city of Mendrisio. This program was designed to be accessible and consultable by all project partners, providing a common platform for data analysis and sharing. The program allows project partners to interact with the data in real-time, providing a more efficient way to query and analyze the information. This approach was taken to ensure that all project partners had access to the same information, allowing for better collaboration and decision-making.

Fig. 1: Logo of the GEOME project and portal

Using the georeferencing program developed for the project, it is possible to query each building in the municipal area of Mendrisio and obtain information based on the most reliable data sources available. As mentioned earlier, some databases were prioritized due to their reliability and accuracy, and the program takes this into account when presenting information about each building. However, the program also allows for querying of other databases, and users with administrative rights can suggest changes or correct data that may be inaccurate. This interactive approach provides a more

collaborative way of working with the data, allowing for continuous improvement and refinement of the information available. By allowing users to suggest changes and corrections, the program can be continuously updated to ensure that it reflects the most accurate and reliable information available.

An example of the georeferencing program in action can be seen with the SUPSI building in Mendrisio. As a Minergie-certified building, the program offers information about this certification when the building is queried.

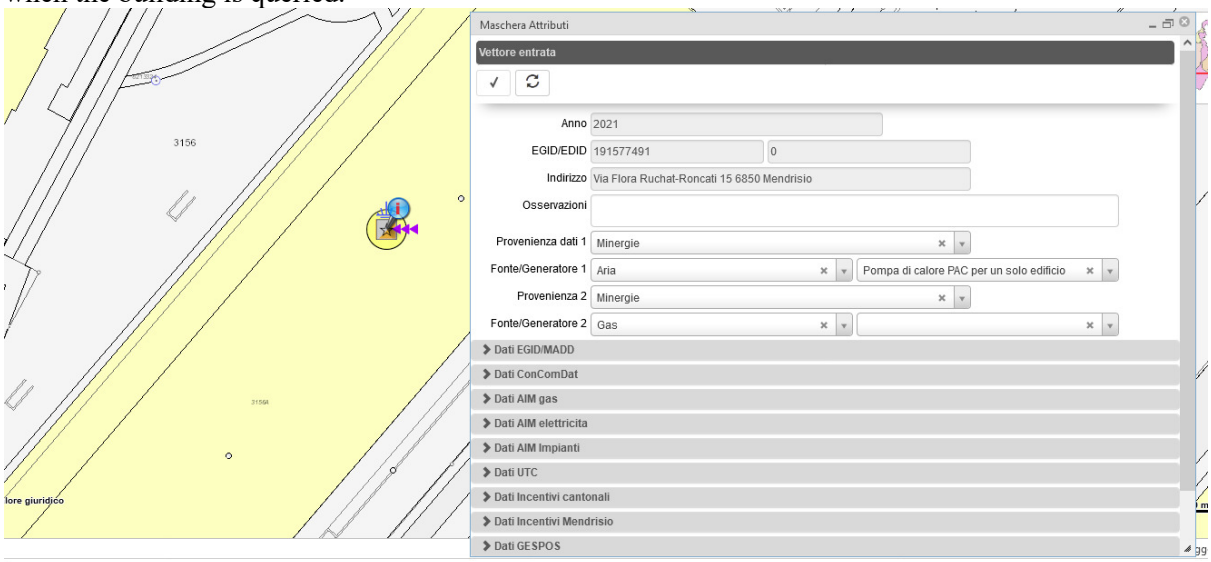

Fig. 2: Example of querying a building with the list of databases (priority for Minergie data)

Additionally, the program uses various icons to represent different types of information, such as heat generators, photovoltaic systems, and energy sources. This visual representation of the data makes it easier for users to quickly identify relevant information and make informed decisions based on this information. The use of icons also helps to streamline the data presentation process, making it more accessible and user-friendly.

2.3. Energy data analysis

In order to identify suitable areas for new district heating plants, the energy requirements of each building in the municipality were analysed and assessed. This involved examining the current heating systems in use, their efficiency, and the potential for introducing renewable energy sources such as heat pumps, solar thermal systems, or biomass boilers. The analysis also took into consideration the urban form of the municipality, identifying areas with a high density of buildings and potential for shared heating systems. The results of this analysis were used to identify priority areas for the development of new district heating plants, taking into account both the technical feasibility and economic viability of such projects.

In parallel with the analysis of suitable areas for district heating plants, the project also focused on the creation of new energy communities (RCPs). These are groups of consumers who come together to jointly produce, manage, and consume their own energy, often using renewable energy sources. The project will take into account factors such as the availability of suitable building roofs for photovoltaic installations, local energy demand, and the willingness of the community to participate in such projects. The aim is to encourage the creation of local energy communities, which not only help to reduce energy consumption and greenhouse gas emissions, but also promote social cohesion and community engagement.

2.3.1. District Heating.

For the evaluation of new district heating plants in the Municipality of Mendrisio, the thermal densities on the territory are initially calculated using GEOME. The program allows for the variation of areas between 100 hectares and 50 hectares to identify the densest areas. The heat thermal needs are evaluated on a theoretical level, taking into consideration the heat indices described in [9] and [10]. However, there is the option to manually modify the heat thermal needs of building, based on more reliable information obtained from the databases. GEOME also allows the drawing of hypothetical heating networks on the identified dense areas. Buildings within a radius of a few meters, which is definable by the user, can be associated with the heating network. Once the buildings are associated, it is possible to remove them from the network if they do not meet certain criteria set by the user, such as exclusion of heat pumps or installations after a certain year. Finally, GEOME calculates the total themal demand for the network by dividing it by the length of the network. This is an interesting indicator, which is considered significant if it exceeds around 2 MWh/m [11]. The intention is to evaluate and deepen the analysis in certain districts of Mendrisio, such as Rancate, Meride, Arzo, Besazio, etc.

2.3.2. Energy communities (RCPs).

In the case of evaluating new RCP installations in the municipality of Mendrisio, the GEOME software is used to calculate electricity densities over an area of 50 hectares. These densities are based on data monitored by the local energy company. The software also allows the possibility of coupling these densities with the presence or absence of large consumers, defined as those with an annual consumption greater than 100 MWh. This information can be useful in identifying potential sites for new RCP installations. In addition to electricity densities and large consumers, the presence of already installed photovoltaic systems or suitable roofs can also be taken into account in identifying potential areas for new RCPs. This information is obtained by de different databased integrated and also visualizing the “solar roof” layer [12]. Overall, the evaluation of new RCP installations in the municipality of Mendrisio involves analyzing a combination of factors such as electricity densities, large consumers, and the availability of suitable rooftops for photovoltaic installations, in order to identify the most suitable areas for new energy communities.

3. Results

While the project is currently ongoing and definitive results are not yet available, some preliminary analyses have been conducted focusing on the potential for district heating and RCPs. In this chapter, the initial findings of the project are presented.

3.1. District heating results

The following figure displays a visual representation of the calculation of heat demand densities across the entire Mendrisio municipal area. The different shades of dark colors in the figure are used to represent varying levels of heat densities, where darker shades indicate higher heat densities. The purpose of the figure is to provide a clear and easy-to-understand visual representation of the heat demand densities throughout the municipality, which can be used to identify areas suitable for the creation of new district heating plants.

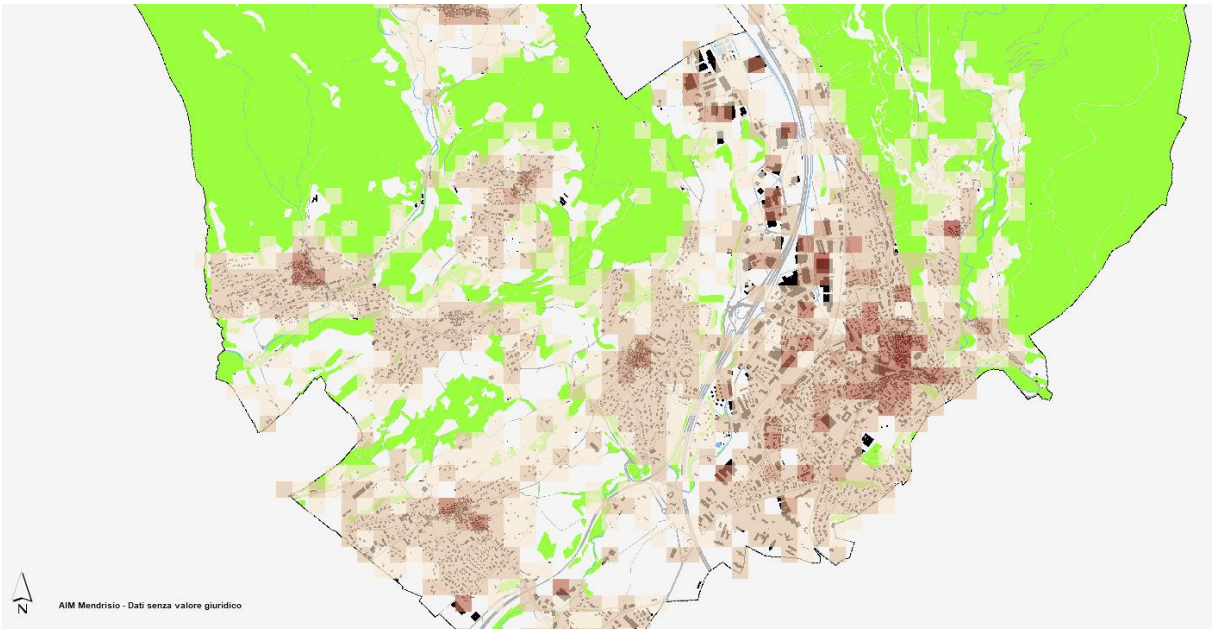

Fig. 3: Mapping of the heat thermal density of the Mendrisio area

The following image shows the Meride neighborhood. The calculation of the rasters is changed to a 50-meter one, which increases the resolution of the heat demand density calculation. The image provides a more detailed view of the heat demand densities in the Meride district, which can be helpful for drawing a district heating.

Fig. 4: Heat thermal density mapping of a neighbourhood in Mendrisio (Meride)

A district heating network was finally designed by associating the buildings within a radius of 10 meters. However, it is also possible to exclude certain buildings with singularities, such as those with a new heating system or heat pumps. For the preliminary calculation, all buildings were considered.

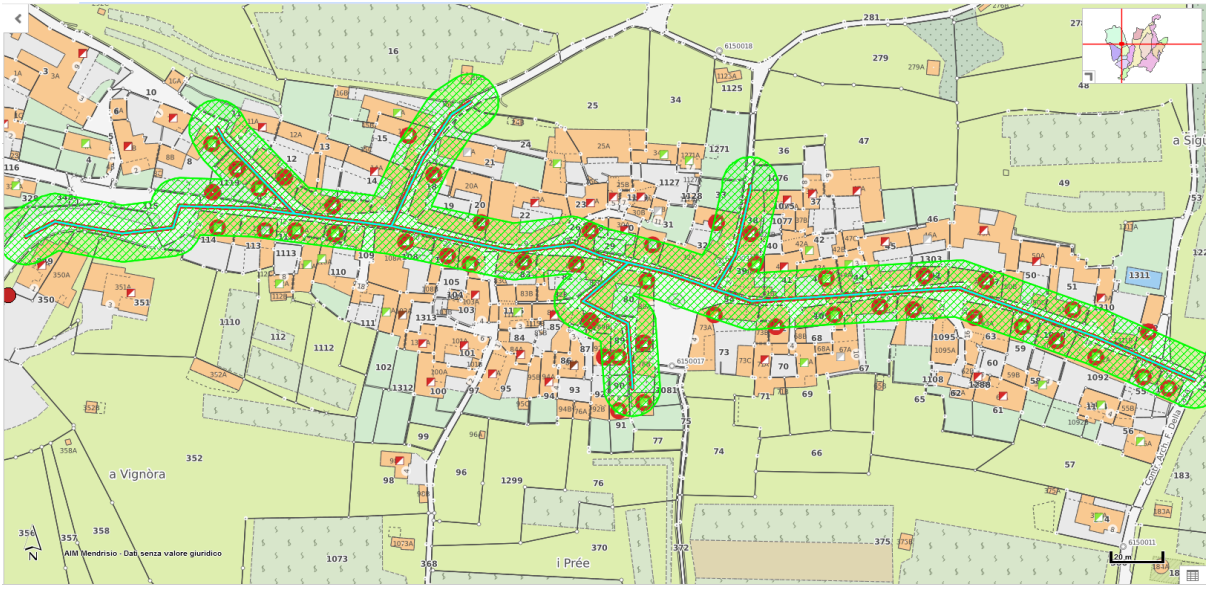

Fig. 5: Drawing of the district heating network with a 10m buffer for connected buildings

The following table presents a summary of the key information obtained from the GEOME portal used in the project. This table provides an overview of the various outputs, as well as the number of buildings, length of heating network, and the total heat demand associated with each density range. By summarizing this information, it becomes easier to understand the overall heat demand distribution across the municipality, which can help identify areas where district heating plants could be most beneficial.

Table 2: Results of the district heating evaluation in a Mendrisio neighborhood (Meride)

	Information	**Values**
Network	Total length	632 m
	Tracks parts	214 + 130 + 53 etc. [m]
Buildings	Buffer on the track	10 m
	Energy	2 GWh
	Numbers of buildings	46 -
	Heating system	all
calculation	Linear energy density	3.2 MWh/m

3.2. Energy communities' results

The part related to the evaluation of new energy communication projects (RCPs) is not yet finalized, but various density maps and thinking have been created. These maps allow visualization of energy consumption on 50-meter rasters while filtering out small consumers, large consumers on the free market, and large consumers not on the free market. These density maps are useful for identifying areas and buildings with higher energy consumption, and therefore areas with greater potential for implementing RCPs. The image shows an example of such a map, specifically the density of small consumers in the area. The darker colors on the map indicate higher densities of small consumers. The sun icon shows the presence of a photovoltaic system.

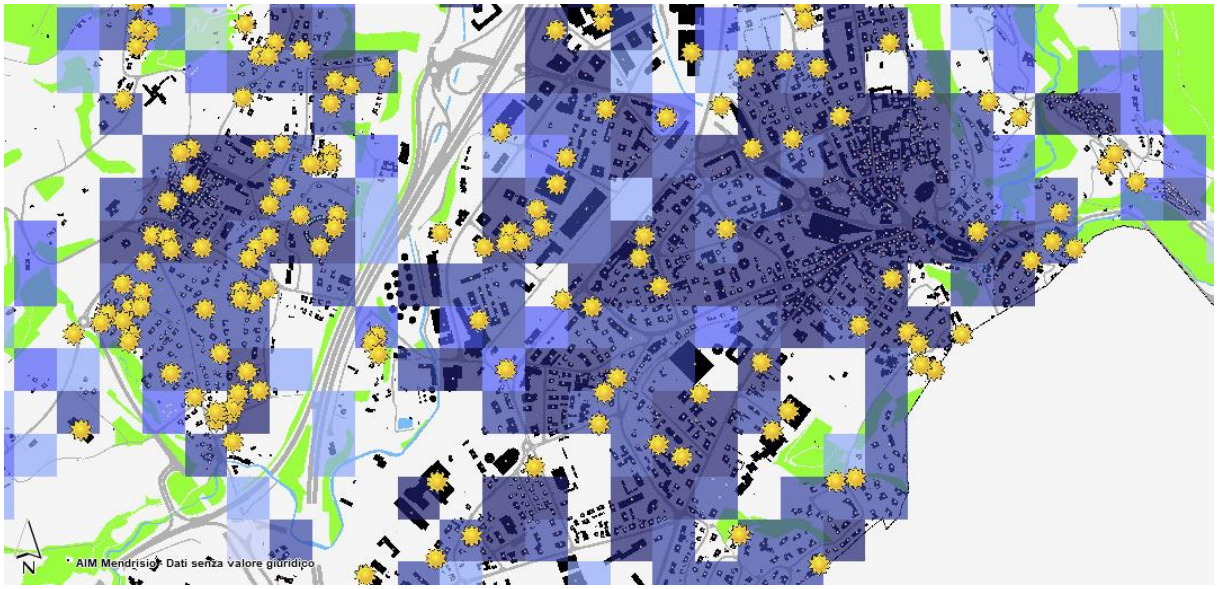

Fig. 6: Mapping of electricity densities in the Mendrisio area (small consumers)

The authors of the work have refrained from providing more specific information on the density intervals and the presence or absence of large consumers in order to protect the privacy of the individuals or entities involved. This is a common practice when working with data that may contain sensitive information, such as electric consumptions. By not providing specific details, the authors aim to maintain confidentiality and respect the privacy of those involved, while still providing valuable insights and information on energy consumption and potential opportunities for energy efficiency improvements.

4. Conclusions and discussion

Despite the fact that the project is ongoing and no final official results have been reached, the initial analyses have demonstrated promising potential. The aim is to provide the municipality of Mendrisio and its municipalised electricity company (AIM) with a quick-to-use digital tool that allows them to find opportunities to improve energy efficiency and promote the use of renewable energy sources, supporting the objectives of sustainability and energy planning in the area.

The project is achieving successfully its goal of identifying areas with high energy consumption and evaluating opportunities to improve energy efficiency in the municipality of Mendrisio. By georeferencing and mapping energy sources and installations, the project has enabled the identification of areas suitable for the creation of new district heating plants and new self-consumption communities, thereby promoting the use of renewable energy sources and reducing costs for citizens and businesses.

Overall, the project represents a significant step towards achieving energy efficiency and sustainability in the municipality of Mendrisio. By using data-driven solutions and innovative technology, the project has demonstrated the importance of taking a proactive approach towards reducing energy consumptions and promoting renewable energy sources. It is hoped that the findings and recommendations of this project will be used to guide future energy planning initiatives in the region, and inspire other communities to adopt similar strategies for achieving greater energy efficiency and sustainability.

The collaboration of the different partners has allowed for the pooling of resources, knowledge, and expertise, enabling the project to make substantial progress towards its goals. The project has been able to take advantage of the diverse perspectives and experiences of the different partners to create a comprehensive and innovative platform that is designed to improve energy efficiency in the municipality.

The funding received from Swiss Energy and the Canton of Ticino is fundamental in the success of the project. This funding is critical in ensuring that the project can achieve its objectives.
The Municipality of Mendrisio's funding support has been equally essential, showing the interest of an interested stakeholder in the sector. As the project's primary beneficiary, the municipality's funding has helped to ensure that the project meets the local energy planning objectives and is tailored to the specific needs of the municipality. The project enables the team to create a digital tool that is user-friendly and accessible, allowing for the identification of opportunities for energy efficiency improvements and the promotion of renewable energy sources.

Aknoledgements

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