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1. SUMMARY

In historical urban centres, providing a low carbon energy supply in a style of energy storages is usually very tough, because interventions in this specific area meet strict architectural protection constraints, involve higher implementation costs and often come in conflict with town planning policies. Therefore, one of the main objectives of the Store4HUC project was also to improve and enrich energy and spatial planning strategies targeting historical city centres by focusing on integration of energy storage systems to enhance the public institutional and utility capabilities.

This document is intended to provide an overview of the 4 pilot actions carried out in Weiz (Austria), Cuneo (Italy), Lendava (Slovenia) and Bračak (Croatia) in terms of procedure, performance and efficiency gains, based on KPIs calculations for the project.

This Report describes, for the 4 pilot projects, the launching of the tender procedure, the preliminary energy management steps, the progress of the pilot action, the procurement procedure, the execution of works and construction supervision, the installation and integration process and the impact of the investment on energy and overall costs. It describes also the Energy and urban policy frames as well as the Stakeholder's involvement, the transferability and the impact of the pilot action. The last chapters describe key performance indicators (KPIs) to evaluate the impacts of the pilot actions on different aspects and benefits foreseen by the implementation of energy storages in HUCs.

WEIZ

Even though the Covid-19 pandemic slightly affected the progress of the pilot in Weiz, the construction phase of the storage started in February 2020, and was completed with the installation of the water buffer storage at the end of June 2020. Moreover, in order to raise additional funds to finance the project, the project team successfully applied for a "KEM[1] Thermal Storage" funding.

The installation of the water buffer storage has been considered necessary, because of too high emission loads of the system and in order to increase lifetime of the system, energy efficiency and the use of renewable energy sources The expected energy savings consist in 9 % for biomass fuel, 2 % for grid losses and 12 % for electricity consumption. As described in the following chapters, there is a great potential to implement the planned system in other HUCs, in fact, other regional municipalities have already announced a clear interest on the project results.

The involvement of all relevant institutions and organizations from the beginning was and is very important for the success of the pilot implementation. These took place at the so-called deployment desk meetings, where all stakeholders come together every couple of months, as well as at some other informal meetings in-between whenever necessary. Participation in external events by means of presentations to promote the project results (in Rostock, Vienna, Bolzano, and Graz) are also important measures within the framework of the stakeholder engagement process. In this context, the energy infrastructure companies Fernwärme Weiz and Energienetze Steiermark are going to be increasingly integrated in the future in comparison with the today involvement. A cross-fertilization event organised by the Climate Alliance Styria, with contribution of the W.E.I.Z., was conducted. In addition, at the project's ending, the opening of the storage was organised on the 23rd of July 2021 with a lot of stakeholders attending. Now, the expected impact is monitored.

[1] https://www.energieregion.at/kem/ Klima- und Energie-Modellregion

CUNEO

The energy efficiency project for the sloping elevator of the City of Cuneo represents the Italian pilot intervention.

The project is a case study on the installation of an energy storage system connected to a photovoltaic array on a means of public transport. The innovating aspect of this energy efficiency action lies in the fact that the battery storage system will allow the reuse of the energy produced by the system itself during operation, which in turn will be integrated with the energy produced by a photovoltaic array (thanks to an on-site exchange of the energy that is not consumed or stored in the battery).

The required works were carried out during spring-summer 2021 and consisted of a part of structural construction and a part of installation and electrical adaptation of the new system. The pilot action, including the monitoring of energy consumption, was two months behind schedule due to some issues in the first procurement process started by the Municipality of Cuneo.

Since the project involves the use of energy from renewable sources, it was necessary to apply to the national energy operator (GSE) for the qualification of the system and the authorization for the on-site energy exchange system that is expected to be in place once the works are completed. This administrative procedure proved to be a medium-long term process that strongly impacted on the timely connection of the different parts of the system and consequently on the monitoring plans. Hence, the completion of the project took place in October 2021, allowing the provision of useful results for the dissemination of the good practice learned the last months.

Apart from energy savings and the reduction of greenhouse gases emitted by the installation, the project is part of a wider process of conversion to sustainable mobility implemented by the Municipality of Cuneo, aimed at promoting the use of public transport, encouraging the use of bicycles and ensuring a lower traffic of motor vehicles in the historic city center. Since the elevator is widely used by the citizens and since it is allowed to transport bicycles as well, it already represents an improvement towards sustainability from the point of view of city traffic.

LENDAVA

The implementation of a PCM based latent storage in connection with a geothermal district heating system in the municipality of Lendava represents the Slovenian pilot intervention.

Even though the Covid-19 pandemic also affects the progress of the pilot in Lendava, as physical meetings with the stakeholders were not possible for some times and some works have been delayed, all the required works were carried out successfully. The construction phase of the new pipeline connection started in January 2021 and was completed with the installation of the new PCM based latent storage in February 2021.

The installation of the water buffer storage has been considered necessary, because of too high emission loads of the system and in order to increase lifetime of the system, energy efficiency and the use of renewable energy sources. The expected energy savings during the project preparation phase were calculated as 5,5 % in total, 100 % of fossil fuel reduction and 23 tonnes of CO_2 emissions reduction. There is a great potential to implement the planned system in other HUCs: the pilot in Lendava should therefore serve as an innovative good-practice example over the next few years in protected historic monuments and landscapes and it should lead to a significant increase in the use of renewable energy sources in historic urban centres.

The involvement of all relevant institutions and organizations from the beginning was and is very important for the success of the pilot implementation. These took place at the so-called deployment desk meetings, where all stakeholders come together every few months, as well as at some other informal meetings in-between whenever necessary.

Now, in the last part of the project the pilot promotion is an important measure within the framework of the stakeholder engagement process. In this context, the energy related companies/organisations Petrol – Geoterm, Geological Survey of Slovenia, Local Energy Agency Pomurje and Ekopark d.o.o. to be increasingly integrated in the future. Several cross-fertilization and project/pilot promotion events were organized. In addition, at the project's ending, the opening of the storage was organised on the 22nd of April 2021 in a small circle due to the Covid-19 pandemic situation. Now, the positive effects are monitored.

BRACAK

Bračak Manor was reconstructed and restored in 2017 in accordance with best practices in renewing heritage on the principle of energy efficiency and today is used as central place for organisations, companies and institutions interested in the renewable energy as well as small and medium companies (SME) from other sectors. It also serves as business incubator for young companies with favourable lease of business office spaces. The manor is a protected cultural and heritage monument listed in Register of Cultural Goods of the Republic of Croatia, and it is owned by the Krapina-Zagorje County.

The aim of the Bračak pilot project is the implementation of a central battery (bank) system, installation of a photovoltaic system, and integration of it to an advanced Energy management system (EMS). Bračak Manor is already equipped with wood pellets boiler for heating, micro-CHP for hot water and power production, air-water heat pump system for cooling and heating in transitional periods. Wall insulation is also present on the inside as well as energy efficient windows and doors, efficient lighting system, HVAC system, central EMS for monitoring of heating, cooling and energy consumption, rainwater harvesting for irrigation of green areas, wastewater treatment and electric vehicle charging station. The already existing equipment will be combined with the new ones through an advanced energy management ICT system that will act as a decision support for the system operators instructing how to run the micro-CHP and wood pellets boiler on one-day ahead scale, in the presence of the newly introduced photovoltaic and battery system.

Construction officially started on 28.10.2020, while the introduction to work was done on November 2, 2020. Construction works were completed on 30.06.2021. Due to the need of obtaining a building permit for the installation of the photovoltaic system, whose proceedings lasted more than two months, the start of execution of works was slightly delayed. Also, due to the COVID 19 pandemic, the manufacturer of the designed battery system could not deliver the equipment in due time, so the deadline for the execution of works was extended. The works on the construction of the solar power plant have been completed, and now it is in operation.

2. INTRODUCTION

This document describes the reporting activities of the 4 pilot actions which were achieved in the Store4HUC project.

It describes the monitoring activities that the involved PPs conducted on the pilots' implementation and the indicators (KPIs) monitored at different stages.

The document in particular has two specific objectives:

- Report on the investment process for the pilots.
- Report on the impacts, outputs and lessons learnt from the pilot actions, including:
    - The procurement process, focusing on authorization and installation of the storages in HUCs
    - The results of the stakeholder engagement process
    - The results of the pilots in terms of climate change and environmental related impacts
    - The integration of the pilot actions in the urban and policy frames and adaptations required
    - The envisaged follow-up activities, recommendations and improvements.

3. FINAL EVALUATION OF THE PILOT ACTIONS

According to what has been described in the former chapters, the subchapters below show the course of implementation of the 4 pilot projects. The investment is presented according to the activities planned in the application form. This chapter describes procurement procedures, installation and integration processes, impact of the investment on energy & overall costs, and the energy management upgrade. Additionally, the energy and urban policy frames, the stakeholders' involvement, the transferability of the pilot action and the impact of the pilot actions are discussed.

3.1. Procurement procedures

WEIZ

Type of tendering procedure

In Austria (Weiz), relevant procurement procedures are depending on who is investing according to the national procurement law. The Dorda Brugger Jordis Rechsanwälte webpage provides an overview about relevant laws: For the State (Bund) and public bodies on the central government level, the Federal Public Procurement Law 2006 (Bundesvergabegesetz 2006 – "BVergG 2006") implements Directives 2004/17/EC and 2004/18/EC (aspects on content) as well as Directives 89/665/EEC and 92/13/EEC (review proceedings).

Eligibility criteria and timetable for the procurer

Expected skills are chosen via the analysis of provided references. In addition, a so-called competence matrix is used for the documentation of the agreed responsibilities of all involved project stakeholders and their roles for each work package and responsibility for reaching the expected project results. The monitoring was carried out for one whole year from November 2020 until October 2021. In addition, several dissemination activities were and will be carried out in the last months of the project.

Tender decision-making process

The tender procedure for the thermal storage at pilot Weizberg was prepared and accompanied by DI Johann Haas. In total, there were two separate parts of the tender, one for the construction of the boiler room and one for Installation phase.

The company *Lieb*, as the cheapest bidder, has been selected for the construction of the cement building (boiler room) and the company *Haas*, as the cheapest bidder as well, for the installation.

CUNEO

Type of tendering procedure

The procurement procedure for the works concerning the pilot action was launched in late 2020 because the whole year was impacted by the Covid-19 pandemic, which delayed the planning of the intervention. The executive project was in fact delivered in autumn 2020.

This procedure has been possible thanks to the Decree Law n. 76/2020, converted into Law n. 120/2020, that brought some temporary modifications to the Public Procurement National Legislation. The new Decree Law was adopted considering Covid-19 difficulties and, according to this new regulation, works could be procured directly to one company if valued less than 150.000€. The Municipality of Cuneo decided to require three offers anyway, in order to guarantee the transparency of the tender.

Eligibility criteria and timetable for the procurer

The first tender for the assignment of the energy efficiency works of the Cuneo sloping elevator was published in December 2020, in line with the procedure mentioned above inviting three companies fulfilling the requirements to carry out the works. This first tender was not successful, as the municipality has received no offers. The main reason for such outcome is that the contracting authority had specified “Plant for the production of electrical power" as the main category of the works to be carried out. For this reason, the tender documents have been modified into “Civil and Industrial Buildings", so companies complying the necessary requirements have been invited to tender.

Tender decision-making process

The Municipality of Cuneo finally identified the contracting company (Pianfei Costruzioni S.r.l.) and assigned the works to be carried out as a matter of urgency. This procedure has been put in place to ensure the execution of all works on time, by allowing the contracting company to start ordering the materials in due time and to make all necessary arrangements to set up the construction site.

Works have been temporarily appointed on March 11, 2021 and the final contract signed when the awarding company’s requisites verification was completed, on May 4, 2021. Thanks to the urgent procedure put in place, the awarding company could start ordering the materials even prior to the contract signing, and they have been delivered at the beginning of July, 2021.

LENDAVA

Type of tendering procedure

In Slovenia, relevant procurement procedures are depending on who is investing and on the contract value according to the Slovenian Public Procurement Act - ZJN-3 (Official Gazette of the Republic of Slovenia no. 91/15 and 14/18). Direct purchase is allowed for work contracts below EUR 40.000. Due to the Covid-19 pandemic in 2020, the EUR 40.000 limit was increased to EUR 80.000. In this case, there is not the obligation for Lendava pilot contract (under EUR 80.000) to be posted on the Slovenian Public Procurement portal.

Eligibility criteria and timetable for the procurer

The bidder should submit a completed bid list and cost estimate based on the prepared list of projects/materials/services and sent to the procurer.

The monitoring of the project was carried out from April 2021 until November 2021. In addition, several dissemination activities were and will be carried out in the last months of the project.

Tender decision-making process

The selection criteria in case of Lendava pilot based on the current Slovenian Public Procurement Act (pandemic exceptions included and taken into account) is 100% the price.

On the basis of the prepared investment specifications and the feasibility study, the starting points for the preparation of the public procurement for the infrastructure part of the project was prepared and the bids have been gathered. The procurement process has been carried out in first weeks of August in 2020. The procurer made, with a help of an expert, an inventory of materials / services based on price verification (references, web analytics) and collected 3 bids / offers. The bidder had to submit a completed bid list and cost estimate based on the prepared list of projects/materials/services and sent to the procurer. The construction company has been chosen in the second half of August 2020 and started to gathering the material on the market. Based on the prepared documents the investment includes in the first part the purchase of 2x 65m of pre-insulated pipes and the connection of the public building to the existing geothermal district heating system with all connecting materials. The second part of the investment includes the purchase and the installation of 2 PCM latent storages with all necessary electrical and mechanical parts for energy transmission and measurement.

BRACAK

Type of tendering procedure

The procurement is carried out in accordance with the Public Procurement Act (OG 120/2016) of the Republic of Croatia, internal acts of the Agency and in accordance with the Interreg CENTRAL EUROPE Program Rules, and consists of:

- Procurement for the Installation Project for the construction of a free-standing canopy with a photovoltaic power plant and battery system with integration in the central monitoring system
- Procurement for Execution of works (photovoltaic power plant + battery system + central monitoring system)
- Procurement for the Construction Supervision.

Eligibility criteria and timetable for the procurer

Concerning the Procurement for Execution of works (PV + battery system + central monitoring system), each bidder had to prove her ability to perform professional activities, technical and professional ability, submit a guarantee for the proper performance of the contract, fill in the tender form and attach other documents in accordance with the procurement rules.

Tender decision-making process

Procurement for the Installation Project for constructing a free-standing canopy with a photovoltaic power plant has begun with market research, which was conducted following the Interreg CENTRAL EUROPE Program Rules. As part of the market research, a request for bids was sent to five different design offices and 5 were collected. After the market research was conducted, inquiries for offers were again sent to 5 design offices, and after the evaluation, a contract was signed with the most favorable bidder - Elektrik d.o.o. Since the Law on Protection and Preservation of Cultural Heritage in Croatia prohibits any action that could directly or indirectly changes the properties, shape, meaning, and appearance of cultural property, it was necessary to look for other solutions to accommodate a photovoltaic system. The Conservation department suggested and accepted the construction of a canopy in the parking lot next to the Manor. To achieve that, it was necessary to obtain a building permit and meet special conditions for construction.

The Procurement for Execution of works (PV + battery system + central monitoring system) has begun with market research as well. As a part of the market research, based on the Installation project, a request for bids was sent to 5 different companies and 4 bids were collected. After the market research was conducted, inquiries for offers were again sent to 5 different companies (the deadline for submission of bids was October 9, 2020). After the bid evaluation, a Turnkey Contract was signed with the most favorable bidder - Solaris Pons d.o.o. The execution of works officially began on November 2, 2020. The canopy was built during December 2020 and January 2021.

The contractor requested an extension of the deadline two times (the second until 30.06.2021) due to the unfavourable epidemiological - Covid 19 situation in Europe.

The works on the construction of the solar power plant have been completed, and now it is in operation. The works were not performed within the deadline as defined in Annex II of the contract because no technical inspection was held, that is the conditions of the Contract were for the issued permit to be considered a successful completion of the works. On that occasion, the contractor received an extension until 30.09.2021.

Procurement for the Construction supervision was carried out in accordance with the Croatian Construction Act and Law on Works and Activities of Physical Planning and Construction. As a part of the construction supervision, the following have been contracted: Professional supervision, Design supervision and Coordinator of safety at work. For each of them, inquiries for offers were sent to 3 different companies, and contracts have been concluded with the most favorable bidder.

3.2. Installation and integration process

WEIZ

Before the storage was installed, the heating plant was operated mainly in a disadvantageous partial or low load range due to the lack of a central heat storage tank. In addition, the heating network was used as a thermal buffer to absorb the heat supplied by the boilers: in this way, the heating network was constantly maintained at correspondingly high flow temperatures and unnecessary heat losses of the network (distribution losses) occurred.

The innovation of this project takes place on the storage tank as well as on the system level. On the one hand on the system level by the implementation of a new control with a coherent load management of all system components (boiler plant, central storage, network and decentralised storage at the consumers) by mutual communication of these and by access to the control of the decentralised storage at the consumers. On the other hand, on the storage level with the integration of a central heat storage in the historic monument and landscape protection zone.

One of the main reasons for the lack of a storage tank and other measures to increase efficiency was the location of the heating plant in the historic monument and landscape protection zone of Weizberg, where the church and the parish buildings are protected as a historical monument and a protected site. The constructional requirements were fulfilled by implementing new solution concepts. This project can and should therefore serve as an innovative best-practice facility and as a model for simplified technical and above all economic implementation at other protected sites and lead to a significant increase in the proportion of renewable energy sources in historic city centres.

The building phase started in February 2020. Due to the Covid-19 pandemic the construction work and all planned stakeholder engagement meetings had to stop for some weeks. However, they were completed with the installation of the water buffer storage tank at the end of June 2020. As there were no major problems in the building phase the commissioning of the system has started as planned and was completed almost at the start of the heating season in November 2020. An inauguration ceremony was held in July 21 to officially put the expanded biomass heating plant into operation (the operation was in November 20, but due to COVID 19, an official opening wasn´t possible before summer 21).

Last work during the storage installation

CUNEO

The energy efficiency works for the sloping elevator include:

- A newly built underground technical room, located next to the existing uphill station;
- A photovoltaic field with a peak power of about 8 kWp, consisting of 26 monocrystalline silicon modules placed on metal frames along the runway of the elevator, near the retaining wall of the installation;
- A lithium-iron-phosphate battery storage system combined with a three-phase inverter that allows the exchange of energy between the photovoltaic field, the national grid and the plant, which in turn self-produces energy during its operation;
- The integration of the new electrical equipment into the existing system and its interconnection to the grid.

Works were carried out on the elevator for about four months. The only actual challenge was due to the timing for the delivery of the materials and components required for the electrical installations, which took almost two months and caused an interruption in the work of about three weeks.

In a chronological order, works have been carried out as follows: the underground technical room with the installation of electrical panels and of the battery storage system, the installation and connection of the photovoltaic field, the completion of the technical room with an internal staircase and a metal roofing frame.

The next step after the completion of the works was to carry out the practices for the qualification of the photovoltaic field and the authorization for the on-site energy exchange designed to improve efficiency and reduce the costs for the energy supply from the national grid. This application procedure took quite a long time and, although it was initiated well in advance with the necessary paperwork being prepared in mid-July 2021, it was completed by mid-October 2021. Once the use of energy from the photovoltaic modules was authorized, the system went into operation.

The integration of the new system for power self-generation from the photovoltaic field required the support of the experts. This particular procedure, outsourced to Studio di Ingegneria Brignone from Cuneo, took several months. In addition, an internet connection was installed for the download of the monitoring data collected by the system. Also this operation, carried out by the Data Processing Sector of the Municipality of Cuneo, was rather time consuming due to the summer holiday season that slowed down the operations.

The PV plant installed at the sloping elevator in Cuneo

LENDAVA

The main aim of the pilot project was the replacement of the existing Oil-Fired Boiler in Lendava Library (public building) with a renewable energy source. The building was connected to the existing geothermal district heating network. The building of Lendava Library is the last connection in the geothermal district heating network and the supply is not stable - the supply medium temperature is not constant. The storage selection in the pilot was crucial, to switch to RES. The properly selected storage in this case ensures now the stable supply for end users.

Paraffin cells have been installed as modern and innovative buffer storages, developed to efficiently store heat generated from small irregular energy sources and to require less space compared to regular water storages. Thermal energy storage technologies and geothermal district heating systems have the potential to play a significant role in the transition towards 100% renewable energy systems through increasing system flexibility and overall efficiency, thus reduce CO_2 emissions, increase domestic energy security, and additionally reduce the costs of heating. The storage has been installed in the basement of the building.

Due to the Covid-19 pandemic the construction work and all planned stakeholder engagement meetings had to stop for some weeks in the last quarter of 2020. However, the construction work has been carried out from last 2 weeks in January till mid-February 2021 in two phases:

1. Connection of the building to the existing geothermal district network
2. Installation of the PCM storage tank and all electrical and mechanical components for energy transmission and measurement



Installation of the storage tank with PCM material and all electrical and mechanical components for energy transmission and measurement

With the additional installation of an energy management tool, it was possible to monitor all features that proves the effectiveness of the pilot installations. The monitoring and testing phase started in first half of April in 2021.

A small opening ceremony has been organised on the 22nd of April 2021 in a small circle due to the Covid-19 pandemic situation.

BRACAK

The aim of the pilot project is the implementation of a central battery (bank) system, installation of a photovoltaic system, and integration of it to advanced Energy management system. The already existing systems are combined with the new ones through an advanced energy management ICT system that is built on top of the already existing central monitoring system as a coordination service that optimally exploits all different available assets. The energy management system serves as decision support, so the operators can decide one day ahead how to engage micro-CHP and the wood pellet boiler in the presence of newly installed photovoltaic and battery system.

Photovoltaic system and the battery system are connected to the billing metering point of the Bračak manor where all produced energy is primarily used for own consumption and the surplus is stored in the battery system. If the production of electricity exceeds the needs of Bračak Manor and the capacity of the battery system, then the surplus is delivered to the grid. The distribution system operator, as one of the stakeholders, was informed from the beginning about the implementation of the pilot project and its task was to issue the prior electricity approval required for the connection to the distribution network.

After the public procurement for the execution of works, a Turnkey Contract was signed with the company Solaris pons d.o.o. and the official introduction to the work was held on November 2, 2020. During November, all preparatory and earthworks for the construction of the canopy were carried out, and a steel structure was delivered to the construction site and the construction of the canopy began.

Canopy construction

The colour of the canopy was determined by the conservation office. The roof surface of the canopy is used to install photovoltaic modules. The canopy has a rectangular roof surface and a total of 36 photovoltaic monocrystalline modules with a capacity of 300Wp each is installed on it. This means that the peak power of the photovoltaic system is 36 X 300Wp = 10,8 kWp. Each photovoltaic module has an associated micro inverter to reduce losses from possible shading during the day.

The storage (battery system) is placed in the premises of the Bračak Manor, in the basement next to the stairs. Three-phase battery system has a capacity of 8,0 kWh, together with inverters / chargers and battery management equipment.

3.3. Impact of the investment on energy and overall costs

WEIZ

It is enabled the collection, aggregation and filtering of the energy data and other information that are provided by a wide range of equipment (such as installed meters) and sources mainly responsible for energy production and consumption. The information gathered is afterwards exported to a service layer for enabling peak load reduction, demand shifting, optimum storage exploitation, and consumption forecasting as well as grid flexibility and reliability.

Additional investments are largely due to the implementation of the storage facility in a historic city centre with protected status and listed buildings and the associated difficult and cost-intensive construction requirements. However, these are to be contrasted with the positive environmental effect achieved for protected historical town centres, which is only made possible by this additional investment.

In terms of energy, the water buffer storage is a proven technology and can be considered the most cost-efficient solution compared to other storage technologies due to the high number of charging cycles (almost daily complete charging and discharging of the storage).

CUNEO

In the Investment Specification it was estimated that, considering an average cost of the purchased energy of 0,20€/kWh, the annual saving for the purchase of energy would have been around 2.400 €, out of a total annual operational cost of 3.500 €, because the expected amount of energy from external sources (KPI #1) was forecasted to be equal to 12.226 kWh. Even though the monitoring was run in a very cloudy month (October-November 2021) and calculations of KPI #1 were done on the most cloudy period of the monitoring (with a share of energy from external sources of 79% of the total consumption), KPI #1 is equal to 7.431 kWh, which is a lower value compared to the estimated one. The calculation was done applying the tested November value to the whole year and considering the solar irradiation given by the software PVGIS (2016). Therefore, KPI #2 too is lower than expected and equal to 1.486 €/month.

The benefit from an economic point of view is therefore a saving of about 57% per year, representing a good result in terms of efficiency. The accuracy of this data will be confirmed with a longer monitoring period, which is planned for the whole 2022.

The self-production of the sloping elevator proved to be a small value (on average, 1kWh/day) compared to the total consumption of the elevator and it is likely that it is directly used by the system instead of being stored in the battery.

Another economic aspect of the pilot intervention is given by the calculation of KPI #9, the profitability of the investment: as predicted, the profitability is equal to -0,63, which means that in 20 years the investment will be totally paid back from a mere economic point of view.

LENDAVA

In order to calculate and monitor the impact on energy and costs, a central control system was installed. The testing and monitoring works are already running. It has enabled the collection, aggregation and filtering of the energy data and other information that are provided by a wide range of equipment (such as installed meters) and sources mainly responsible for energy transmission and consumption. The information gathered is afterwards exported to a central service system.

BRACAK

For this pilot project, the execution phase is just finished so the exact impact of the investment on energy and overall costs will be known after few months of operation.

Projected annual production of the power plant is 11,340.00 kWh. In combination with the battery system, all the energy produced is used for the needs of the Bračak Castle. In previous years, the building consumed an average of 24,312.67 kWh of electricity, and now this consumption will be reduced by 11,340.00 kWh or 46.4%. This electricity savings will also generate savings on electricity bills for HRK 23,739.21 per year.

3.4. Energy management

WEIZ

The heat supply of the local heating network with 12 consumers is ensured by two biomass boilers fired with regional wood chips. The largest consumers are a hotel building and the parish of Weizberg. Before the set measures, the plant operated without a storage and without an additional oil or gas boilers as a failure safety system.

The high return flow temperatures of the local heating network had a large optimisation potential. Therefore, optimisation measures (renewal of the heat exchangers, hydraulic balancing, renewal of the control system, etc.) have been carried out at the second largest consumer (Weizberg parish) to reduce the return temperatures. Further optimisation measures (additional heat storage tank and heat exchanger, optimisation of the control system, etc.) have already been implemented for the largest consumer (hotel operation).

In order to enable the implementation of the new control system with a coherent load management through mutual communication of all system components (boiler system, storage tank, network and decentralised storage tanks at the consumers), access to the control system of the decentralised hot water storage tanks at the consumers was necessary. This agreement has already been reached in November 21 with the corresponding consumers by extending the heat supply contract and the maintenance agreement.

As control system of the district heating network and the storage, the MR-12 from the company Schneid was chosen. The control unit MR-12 enables simple and quick adaptation to the conditions of the system to be controlled.

In addition to that, the "Optimal Heat Source Scheduler" which was developed within WP T3, enables the further improvement of the boiler efficiency. With the help of the tool, it is possible to compute the optimal boilers operation for the next day. Needed inputs are the predicted daily heat consumption profile of the consumers (jointly, sum of all consumptions) as well as the admissible starting temperature interval and the flow temperature. In this way, it is possible to re-assure that the qualitative boiler section operation strategy is indeed optimal and, eventually, to quantitatively assess the switch-on/off times for the boilers as well as their operating powers when in 'on' state throughout the day.

The plant operators will be able to enter the planned daily consumption profile in the tool and, based on it, get the profile of boilers operation for the next day; they would then need to schedule on the plant automation system.

CUNEO

The size of the storage installed within the pilot project intervention - consisting of the inverter and its battery packs - was reduced to enable the installation in a small room. The sloping elevator energy efficiency project uses a hybrid inverter with multiple inputs to manage charging operations of both the PV field and the grid, and from the same power supply of the sloping elevator drive, when working in power generation mode.

The storage unit has been connected to the inverter on the production side while charging/discharging is managed by the control software of the inverter. The storage system is intended to optimize direct self-consumption by storing the amount of the energy produced that would otherwise be fed into the grid for later use to limit the peaks of absorption and/or feed the load when the photovoltaic system is not operating. The storage system accumulates also the energy produced by the elevator when operating with unbalanced cabin and counterweight loads.

The inverter automatically monitors the public electricity grid. In the event of abnormal behaviour of the grid, the inverter immediately ceases to operate and interrupts the power supply to the electricity grid (e.g. grid failures, etc.). The inverter operates automatically to track the maximum possible power from the solar modules.

Depending on the operating point, the power generated by the photovoltaic system is either used for the elevator system utilised or stored in a battery and/or, if the storage units are fully charged and not operating, fed into the grid.

As soon as the energy provided by the solar modules becomes insufficient, the elevator uses power from the battery. Power can be drawn from the public grid to charge the battery, or the self-produced energy from the elevator system can be stored.

For the battery (storage) system there are various conditions of operation modes related to energy flows:

- Normal operation: electricity is stored according to the charging status;
- Low battery: the battery has reached the minimum charging level specified by the manufacturer or set in the system configuration. The battery cannot be used any further until it is charged;
- Forced charging: the inverter recharges the battery to maintain the minimum level specified by the manufacturer or set in the system configuration.

The Store4HUC tool (module 1) was applied to define the optimal size and related investment of the battery. Considering that the requirement of stand-alone operation of the lift for a ride, in case of grid failure, represents a relevant issue for the pilot, in the final implementation a bigger size for the battery was planned.

LENDAVA

The principle of operation of the district heating system is as follows: thermal water is pumping from aquifer with the production well, transfer heat through heat exchangers to consumers and then cooled water is injected back into the aquifer.

In some existing facilities, hot-water boilers on standard fuels are installed. They are used as reserve for operation at extremely low temperature and in the events of the district heating system failures.

The total installed heat power of the district heating system is 6.65 MWth with total heating area of 65,000 m². Consumers connected to the district heating system are residential (residential blocks), business (shops and business facilities) and educational (school and gym). All consumers have built-in calorimeters to measure heat supplied by the heat distributor.

Annually the heat consumption of all consumers is approximately 5.000 MWh, which means about 1.500 tons of CO_2 less greenhouse gas emissions, than in the case if the heat would be provided by incineration of 600.000 litres of extra light heating oil.

For what concerns Lendava Library, the current average annual heat consumption is 84.351 kWh on a heated area of 596 m². Together with the electric consumption (32.653 kWh), they have an annual energy consumption of 196 kWh per square meter. Lendava Library produces annually 23,5 tons of CO_2 related to space heating. The connection to the existing geothermal network would reduce this amount to zero.

To achieve optimal heating results, it is necessary to install the optimal size of the heating station with first-class control and regulation equipment. Compact modern heating stations have low heat losses and high energy transfer efficiency with extremely small temperature drops in the transfer from the primary high-pressure part to the secondary heating system. The planned heating station is of the indirect type of compact design with a secondary circuit for heating the building for the temperature regime:

- primary 60°C / 50°C
- secondary 55°C / 45°C at Tout = - 16°C

The heating station is designed as a compact heating station, mounted on a steel frame and with all electrical connections. The elements and pipe connections are insulated as much as possible. It consists of a primary and a secondary part. It is connected to the hot water network (2C) Lendava and implemented in accordance with the technical conditions for connection to the distribution network.

Regarding the *system operating instructions* for the **district heating system** in the geographical area of the Municipality of Lendava the following regulation have to be considered to define the temperature diagram for the hot water system for buildings:

- The maximum flow temperature of the system is 65°C and at outside temperature of -10°C this temperature drops to 60°C and less.
- At outside temperature of 5°C, the distributor provides 50°C temperature. As the tolerance is ± 3°C, a temperature of 47°C can be expected.
- Regarding the data above and due to the additional temperature drop of 2-5°C, a maximum of 45°C on the secondary side is expected.

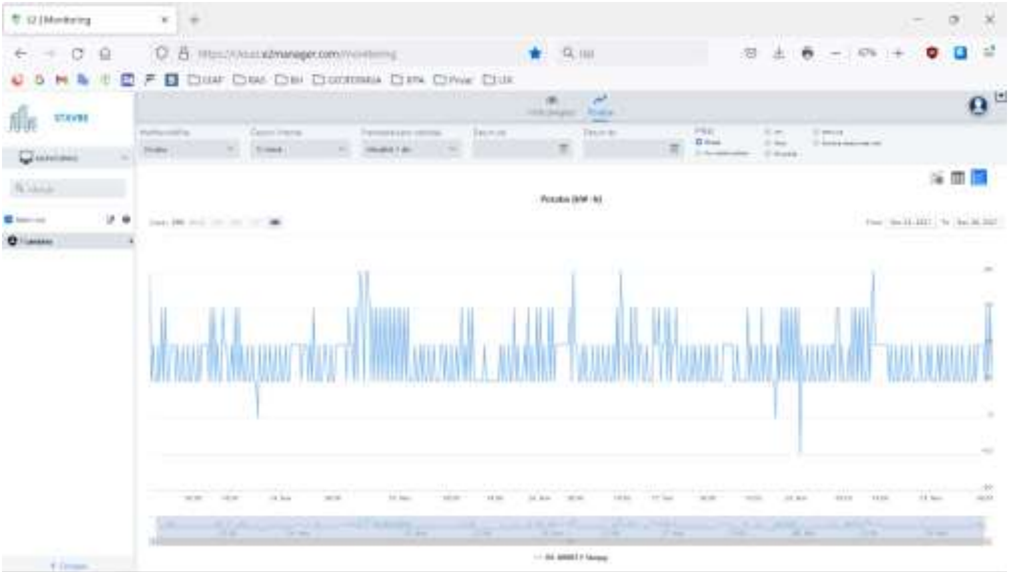
In case of Lendava library, there is a limit related to the operating temperature of the district heating, which is low, and with the required indirect connection to the heating system (the flow temperature will be further reduced by 5°C, taking into account the losses of pipelines).

Latent paraffin storage tanks consist of a classic heating water storage tank filled with balls that have a paraffin filler (PCM). At a temperature withdrawal of 45/30°C, energy can be absorbed during the day, distributed overnight and in the morning.

Unlike a conventional storage tank, a hybrid storage tank has correspondingly high dynamics of energy store and discharge. It also gives a constant outlet temperature in the discharge at over a longer period of time. The stored heat energy can be taken away with a time delay at a certain temperature that does not fall. It is possible to additionally install electrical heater on the tank in a case of a solar power plant on the roof of a building.

The monitoring was carried out from April 2021 until November 2021. The aim of the monitoring and testing phase was to prove (or disprove) the mentioned positive characteristics with numbers. The results are listed in the KPI section.

For the Lendava pilot also the module 2 software tool was adopted to plan the day-ahead operation that exploits the PCM existing in the storage. Especially useful is the day-ahead decision support in operation when there is an interruption of supply or too low geothermal grid temperatures predicted in one part of the day. Then smart using of the storage with PCM can reduce both costs and minimize CO_2 emissions due to evading the heating boiler usage relied on predictive actions that intentionally increase the temperature in the storage prior to the geothermal grid interruption.



Monitoring of the heat consumption in Lendava Library

BRACAK

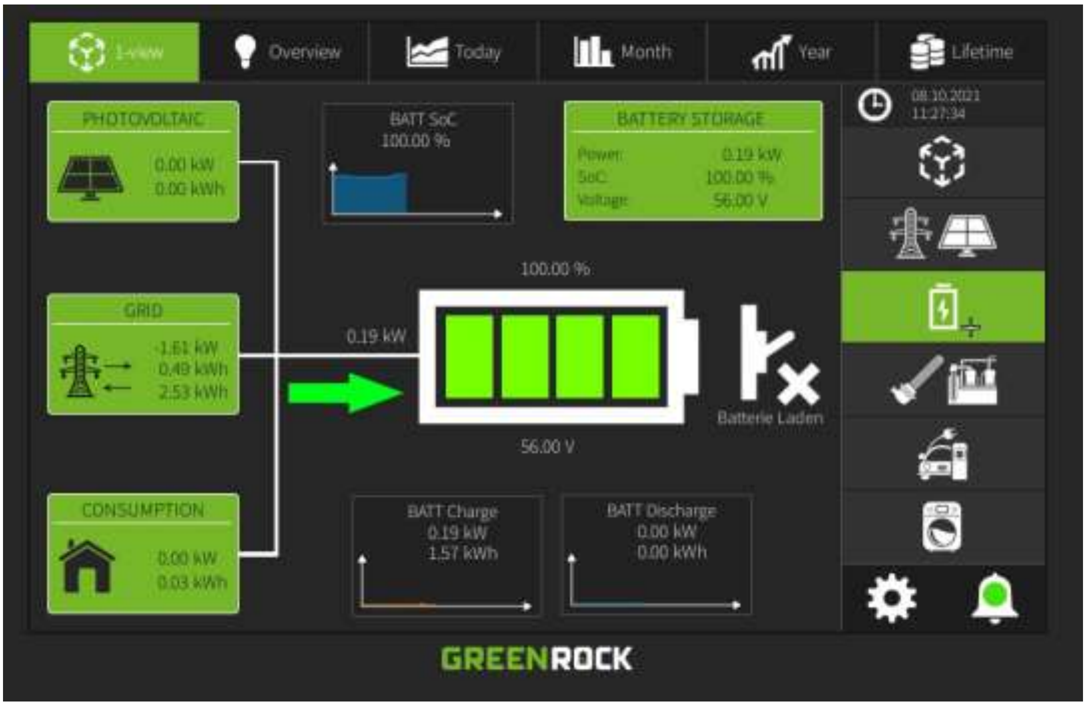
The existing central monitoring system is upgraded, which includes the integration of battery storage system (BESS) and photovoltaic system with all associated equipment needed for a safe and efficient management and monitoring of newly installed systems through the central monitoring system. The system has been reconfigured to enable coordination services that optimally exploit different available assets. With this system, it is possible to monitor all data such as the:

- Current electricity production,
- Battery charge,
- Current energy consumption and
- All other data from the HVAC system and
- The various sensors in the building to maximise energy efficiency.

With these data it is possible to adjust energy flows and to control load management and/or peak shaving. Everything is connected in a way that already existing systems is combined with the new ones through an advanced energy management ICT system. A new photovoltaic and battery management system has been built on top of the already existing central monitoring system. Such a connection allows to have real time data on the operation of all systems (new ones, and existing) and to optimally exploit different available assets. Based on the data collected it is possible to coordinate the energy systems and to predict and manage costs.

Use of Module 1 of the Store4HUC software for assessment of optimal PV+battery system parametrization and optimal battery system yearly operation has shown a rentability of the battery system for 15 or 20 years investment pay-off periods in case of KPI1 or KPI2 optimization criteria, but with a significant subsidy added (e.g. profitability with 60% subsidy was shown). The optimal sizing for KPI2 (yearly cost of energy from external sources) in case of 15-20 years investment pay-off period and 60% subsidy gave a sizing of the battery capacity similarly as chosen on the site.

As regards to module 2, it was shown that smart combination of CHP and wood pellets boiler can provide significant benefits, also depending strongly on the variable tariffs for electricity and gas. This also becomes very important in the coming times of deliberation of energy streams from Russia, when the energy markets may be very lively.



Building management system

3.5. Energy and urban policy frames

WEIZ

Storage technologies are important pieces of the puzzle for a sustainable energy system, as it is also stated in the energy plans of the City of Weiz, the KEM Weiz-Gleisdorf[2] and the Catholic Church of Styria. Hence, the pilot project is fully integrated into the regional climate and energy strategies of the City of Weiz, the KEM Weiz-Gleisdorf and the Catholic Church of Styria.

The municipality of Weiz has set itself the goal of reducing per capita CO_2 emissions by 40 % by 2030 compared to 1990. Although the share of renewables is increasing, especially in the electricity and heating sectors in Weiz, there is an increasing demand in transport, industry and above all in listed buildings and districts.

One of the main customers of the biomass heating plant Weizberg is the parish Weizberg with the basilica Weizberg. The climate and energy strategy of the Catholic Church of Styria was put into effect by Bishop Dr. Wilhelm Krautwaschl on 1 October 2018. The basis for this climate and energy strategy was laid down in the resolutions of the Austrian Bishops' Conference of 11 November 2015.

The higher-level climate and energy model region "Energy Region Weiz-Gleisdorf" pursues an efficient use of the available resources with the goal of 100 % resource use for electricity, heat and mobility through renewable energy sources by 2050. The achievement of these goals also requires an optimization of the existing systems with regard to the local heat expansion, the associated use of storage as well as the increase in energy efficiency.

In this context, the area of the heating plant in the historical city centre of Weizberg is located in a monumental protected area according to the zoning plan. In Austria, the protection of historic sites and monuments in historic urban centres or other districts is subject to the Building and Regional Planning Act of the Federal State and the Austrian Monument Protection Act. In this context, a local image expert in the context of building permits performs the preservation of the local image and of historical monuments in the respective local image protection zones. Structural changes in protected areas therefore require a building permit including a positive assessment of the protected area.

Excerpt from the zoning plan for the focus area Weizberg (Source: zoning plan No. 1.0 - Stadtgemeinde Weiz, as at: 26.09.2019)

[2] https://www.energieregion.at/kem/

The following requirements had to be fulfilled by special structural measures due to the approval situation:

- Implementation of the storage in the building, mostly underground, below ground level
- Utilization of existing buildings to cover the extension and associated restrictions regarding the dimensions of the extension
- Specially adapted design of the visible facades with regard to colour and geometry while complying with the requirements for weather resistance,
- Minimally invasive integration, in order not to influence existing natural conditions such as trees and bushes

CUNEO

The main policy and regulatory frames taken into consideration for the implementation of the pilot action realization were: the legislation on energy production license (Legislative Decree n. 387 of 29 December 2003 and Legislative Decree n. 28 of 3 march 2011); the landscape authorisation (Legislative Decree n. 42 of 22 January 2004). No other particular regulatory constraints have been identified during the setting up of the pilot intervention because the sloping elevator is not a protected heritage building and is located quite at the boundaries of the historic city centre of Cuneo.

The Municipality of Cuneo is highly committed to the reduction of emissions and has demonstrated this commitment by engaging several actions such as:

- Adhering to the New Covenant of Mayors for Energy and Climate;
- Approving the Sustainable Energy and Climate Action Plan (SECAP);
- Issuing the PUMS (Urban Plan for Sustainable Mobility) which constitutes the reference framework for optimal mobility management strategies for the City of Cuneo;
- Endorsing the Strategic Plan “Cuneo for Sustainable Development” which directs local policies towards the implementation of the 17 sustainable development goals contained in the Agenda 2030.

In this framework, the pilot project fits as one piece of the strategic plan of the city and as an example of good practice that could be replicated in the region.

New regulation and law at national level might be developed in the sector of energy trading. The lack of regulation on energy market, based on energy decentralization and peer-to-peer energy trading, limits the spread of energy storages.

In spite of the current regulation on the energy market that does not provide for peer-to-peer trading opportunities, a new system of rules and regulations is currently under investigation and it is likely to change the situation on short to medium-term, promoting the development of Renewable Energy Communities in the territory of the Piedmont Region. For the Cuneo area, the presence of a pilot project already implemented in a historic centre scenario will be an important element to be considered in the decision-making processes that shall be addressed at local level.

LENDAVA

The Lendava Library is located in the centrum of the town near the Evangelical Church and the Lendava Town Hall, where the municipal administration is located.

The location of Public Library in Lendava

HUCs are in Slovenia subject to the building and spatial planning laws of the local community and the Slovenian Preservation of Cultural Heritage Act (2008) which includes movable as well as non-movable and intangible cultural heritage, defining the tasks to be performed by public services concerning the preservation of cultural heritage and its executants.

In 2016, The Ministry of Culture in cooperation with the Ministry of Infrastructure published the *Guidelines for energy renovation of cultural heritage buildings*.

In accordance with the Slovenian Decree on the Classification of Facilities (*Official Gazette of the Republic of Slovenia, no. 37/18, according to Annex 2)* the installation of a thermal substation is classified as an intervention "Maintenance of facilities" for a number of works: installation of devices and installations in, on and next to the facility. This includes also: the installation of new appliances and related installations for heating, cooling, ventilation, domestic hot water and lighting, including the use of renewable energy sources. A building permit is not required for this type of construction work. It is necessary to obtain project conditions and opinions on the PZI (project for the implementation).

Based on the *Register of Slovene Cultural Heritage*, which is under the jurisdiction of Ministry of Culture, the Lendava Library is classified as Profane Building. In 2018, based on the Local Self-Government Act (Official Gazette of the Republic of Slovenia, no. 94/07, 76/08, 79/09, 51/10 and 84/17) and the Cultural Heritage Protection Act – ZVKD-1 (Official Gazette of the Republic of Slovenia, no. 16/08), the Municipality of Lendava has adopted an *Ordinance on the proclamation of cultural monuments of local importance in the area of the Municipality of Lendava*.

In terms of energy supply, the Lendava district heating system is managed by the company PETROL d.d.

BRACAK

In Croatia, different cities have developed or are developing Smart city strategies, and these support the innovative approaches to energy management if proven economically viable. Store4HUC aims to overcome barriers to the adoption of energy efficient technologies and RES, influence policy makers by providing the recommendations and to promote innovation in storage facilities and related energy management in HUC.

The Bračak pilot project will be in line with all legislative frameworks of the Republic of Croatia such as:

- Croatian Energy Efficiency Act (OG 127/2014, 116/18);
- Croatian Construction Act (OG 153/13, 20/17, 39/19);
- Croatian Law on the Protection and Preservation of Cultural Property (OG 69/99, 151/03, 157/03, 100/04, 87/09, 88/10, 61/11, 25/12, 136/12, 157/13, 152/14, 98/15, 44/17, 90/18);
- Croatian Energy Development Strategy;
- Proposal of the Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia;
- National Public Sector Building Renovation Program 2016-2020;
- Fourth National Energy Efficiency Action Plan for the period from 2017 to 2019;
- Proposal of the Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia.

The biggest obstacle to the improvement and greater use of renewable energy sources and energy storages in buildings under cultural heritage is the insufficiently adapted legal framework to new technologies. Croatian Law on the Protection and Preservation of Cultural Property prohibits any action that could directly or indirectly change the properties, like the shape, the meaning, and the appearance of cultural property and it is obligatory to protect and preserve cultural goods in their pristine and original condition, and to pass on cultural goods to future generations. Therefore, the installation of a photovoltaic system on the roof of a building is impossible and for that reason, it was necessary to look for other solutions to accommodate a photovoltaic system. Given the technologies available today, the legal framework needs to be adapted to simplify the procedures for installing energy storages and photovoltaic systems on historical urban sites.

3.6. Stakeholders‘ involvement

WEIZ

The biomass heating plant Weizberg has been operated by 24 innovative farmers for 20 years (founded in 1999). Through the use of regional wood chips, the added value remains in the region. The heating plant supplies twelve objects on the hill of Weizberg, including the elementary school as well as some commercial enterprises and residential buildings apart from the hotel and the parish. Using renewable energy, the guiding principle of the farmer cooperative is "Energy from the region for the region".

The identified stakeholders have been summarized in groups with similar activities.

- WEIZ (employees of WEIZ)
- 4ward Enrgy Research (employees of 4ward Energy Research)
- Technicians (Gerald Hutter (Varicon), Günther Grabner (Innoplan), Johann Haas (Ing. HAAS GesmbH)
- Local authorities in the surrounding of WEIZ, cities and municipalities representatives from Weiz, Thannhausen and Almenland, KEM Weiz-Gleisdorf and the Catholic Church of Styria
- Members of the biomass network
- Researcher and biomass experts (AEE INTEC)

Technicians of technical offices (Günter Grabner, Gerald Hutter, and Johann Haas) are regional experts in planning of biomass storages, EMS devices and energy efficiency measurements. They have gained extra knowledge, and experiences in implementation of renewable energy systems and storages in the envisaged historical urban area.

Other Styrian cities and municipalities have and will be educated about the benefits of energy efficiency and the use of renewable energy sources as well as on storages in buildings under cultural heritage protection.

The members of the biomass district heating systems have been educated how to enable further development of projects dedicated to renewable energy sources on other cultural heritage buildings and have gained knowledge about possible technologies of district heating networks.

The stakeholder involvement process is still ongoing. Participation in external events by means of presentations to promote the project results (Rostock, Vienna, Bolzano, Graz) are also important measures within the framework of the stakeholder engagement process. In this context, the energy infrastructure companies Fernwärme Weiz and Energienetze Steiermark are to be increasingly integrated in the future. A cross-fertilization event organised by the Climate Alliance Styria, with contribution of the W.E.I.Z., was also held in Weiz.

CUNEO

Stakeholders have been involved since the early stages of the Store4HUC project by organising Deployment Desks and sharing updates on the progress of the pilot project and of the whole Store4HUC project.

The participants in the working groups came from different areas of the territories of Cuneo and Turin, since the groups have been jointly organised by the Municipality of Cuneo and Environment Park located in Turin. The participants in the working groups have been clustered according to the following categories:

- Various departments of the Municipality of Cuneo
- Piedmont Region
- Regional and local agencies
- Other local authorities
- Research institutions
- Private entities such as bus companies, electricity providers
- Environmental consultants.

The focus of all Deployment Desk meetings has always been the pilot project, but it has also triggered a broader debate on the opportunity to disseminate good practices, such as the one demonstrated by the energy efficiency intervention on the sloping elevator in Cuneo, and the potential constraints arising from the attempts to replicate them at other sites. Further topics addressed during the meetings include opportunities and challenges of installing energy storages in historic city centres, their contribution to the municipal strategy towards sustainable mobility and the Agenda2030, the incentives available to encourage the spread of such good practice, the contribution of such a project towards the development of renewable energy communities.

The meetings addressed the economic, regulatory and institutional barriers that could affect the dissemination of these technologies, while they also explored the opportunities that the implementation of the pilot project could offer and how the adaptation and mitigation strategies undertaken by various local authorities can promote the dissemination of such a good practice. For example, the adoption of energy storage systems could help improving certain public services, such as urban transport, or could encourage the creation of intermodal charging stations for bicycles and electric vehicles.

The opportunity to integrate the installation of storage systems in historic city centres into the SECAP of the Municipality of Cuneo, was also discussed during the Deployment Desk meetings, involving adaptations to the city plan or defining incentives for the installation of these technologies.

Finally, the opportunity offered by the Piedmont Region to set up renewable Energy Communities - supported by economic contributions, in which oil-free areas are being developed - was also discussed.

The meetings, which were attended by various local and regional parties, are a starting point to develop useful synergies for the future creation of an energy community in Cuneo. However, the regulatory framework is still to be finalised and the current state of affairs does not encourage the spreading of energy exchange systems like the envisaged.

LENDAVA

In the action of the development of the pilot in Lendava three internal stakeholders and eight external ones were identified.

The internal stakeholders are:

- Employees of the municipality;
- Mayor of the municipality;
- Employees of Development agency Sinergija

They have been involved in the project and have been informed via personal meetings, emails or telephone calls.

External stakeholders are:

- Owners of district heating networks;
- Representatives of the municipalities and cities in Slovenia;
- Representatives for cultural heritage protection;
- Local energy agencies.

The communication channels have been similar (also due to the pandemic situation) as for the internal ones.

Public participation in spatial planning and environmental protection processes in Slovenia is regulated by:

- Convention on access to information, public participation in decision-making and access to justice in environmental matters;
- Spatial Planning Act;
- Environmental Protection Act.

This is a legal national frame, but within the EU projects there are no formal/official rules how to involve stakeholders.

BRACAK

In Bračak pilot project seven stakeholders have been identified and clustered in groups with similar activities:

- Pilot site users (employees of REGEA, the regional energy agency, on the pilot site);
- Local pilot experts from REGEA;
- Energy management tool developers – UNIZGFER representatives;
- Owner of Bračak Manor (Krapina-Zagorje County) representatives;
- Local authorities in reach of REGEA, cities and municipalities representatives from the Krapina-Zagorje County area;
- Cultural heritage preservation authorities for the County area;
- Croatian Association of historical towns;
- Distribution system operator for electricity (HEP DSO).

To discuss the potential and execution of the Bračak pilot project at the pilot site of the Bračak Manor (Energy Centre Bračak) n.2 Deployment desk meetings took place. The main objectives of the Deployment desk meetings have been to gather opinions of all relevant stakeholders, present the pilot planning to them, receive their initial feedback, and agree on the next steps related to pilot investment as well as their involvement. The meetings were organized as an open discussion where the planned interventions on Bračak Manor were first explained from the investment point of view (REGEA) as well as the energy management and IT point of view (UNIZGFER). After that, there was a discussion about the Bračak pilot implementation with focus on the related technical and economic barriers. Since the communication was interactive, all the requirements for the construction and execution of the pilot project were agreed together between the stakeholders. Respecting all proposals and suggestions of stakeholders after the meeting, the terms of reference for the installation project were prepared.

3.7. Transferability of the pilot action

WEIZ

The aim of the project was to integrate the planned water buffer tank unobtrusively into the overall picture. It can thus be shown that large thermal energy storage systems will in future also be a technically and economically viable option for the provision of heating and cooling in buildings or districts under preservation order, especially in regard to the integration of renewable energy sources. Only the integration of the central heat storage unit enabled the implementation of a fully integrated, intelligent load management, which led to a significant increase in the flexibility and efficiency of the system.

The integration of a central heat storage unit with a new load management can be made possible, following the Weizer model, in districts under a preservation order and in listed buildings, and therefore in numerous locations, through an off-road integrated construction of the plant and through access to the regulation of the consumers.

The number of cities with historical city centres in Austria currently amounts to 44, with 38,367 protected monuments. Therefore, this innovative integration has a high replication potential.

In the next few years, the plant can and should therefore serve as an innovative best-practice plant and as a model for simplified technical and above all economic implementation at these protected sites and lead to a significant increase in the proportion of renewable energy sources and the economic efficiency of local heating networks.

CUNEO

The pilot action of the Municipality of Cuneo is a rather peculiar case in the regional but also national scenario.

Other cableway transport systems of this type, which could actually benefit from the experimental action implemented for the sloped elevator of Cuneo, have been found in Piedmont. One of these sites is a very similar cableway system that connects the lower and upper parts of the city of Mondovì. Even in the City of Cuneo itself, there is talk of installing a panoramic elevator similar to the one involved in the pilot action, at the other end of the historic center. It is natural to think about the ski lift facilities that are so widespread in the Western Alps, with a significant impact on CO_2 emissions.

In regard to the experience gathered about the integration of energy storage systems in historic urban contexts, the pilot project of Cuneo - as well as the pilot projects carried out in the other partner countries - proved to be the optimal solution for the use of energy produced from renewable sources in urban areas. In addition, the potential for extending the effect of this pilot action to other facilities, such as powering recharging stations for electric bicycles or electric cars, was explored.

However, the cost of the investment is relevant compared to the expected savings. In economic terms, for a facility that consumes a rather small amount of energy, the savings will be equally limited, compared to the investment made. In the absence of external forms of financing, such as a European project, a bank donation, a government subsidy, it seems very unlikely that the investment is considered sustainable, especially in the case of public administrations. Anyway, if the action would be integral part of the development of a Renewable Energy Community, the related investment could be supported by incentives and repaid on a higher level thanks to the multiple benefits that an energy community can give to participants and citizens.

LENDAVA

The investment in an energy storage system in Lendava is the first in the region and at the national level. The storage, which has been installed in the cultural and historic protected building of public library of Lendava, is now representing a decentralized system of thermal energy advancement in the system with paraffin – latent storages. The Municipality of Lendava is one of two Slovenian municipalities that has geothermal district heating.

Pilot paraffin-based latent storages in connection with geothermal district heating system in Lendava is an innovative investment at the national level, such installation has not yet been built anywhere in Slovenia. The investment can serve as an example of good practice in the project area; example of innovative solution of storing renewable energy in an effective way and can be easily transferred to other municipalities/regions/countries.

BRACAK

The battery storage and photovoltaic system, as low carbon energy source, provides a good showcase to the local authorities which benefit in terms of improved energy efficiency and increased use of renewable energy sources and lower energy costs. Bračak pilot project will serve as an innovative good-practice example over the next years, as a model for simplified technical and economic implementation in historical urban sites and will lead to a significant increase in the proportion of renewable energy sources in historic urban centres. The long-term goal is to show innovative materials and technologies in reconstruction as a demonstrative example to other similar historical urban sites and to show that despite of the strict conservation requirements the project of this type can be realised.

At the Deployment desk meetings outputs and knowledge has already been transferred to stakeholders, who represent decision-makers at all levels in the implementation of renewable energy sources in historical urban sites in the Krapina-Zagorje County. Most stakeholders also participate in the process of issuing permits for the installation of storage systems and photovoltaic systems in the county, and this is the first of such projects in this part of Croatia. Given that this is the first pilot in this part of Croatia, stakeholders intend to gain the necessary experience and knowledge. This will allow all processes to be shorter in the future when implementing similar projects. As Krapina-Zagorje County is rich in cultural heritage that needs to be restored and put into operation, this pilot project can pave the way for the restoration of such cultural and historical sites.

Although it is difficult to come to comparative analysis results of interconnection points, the following summary might be helpful for further interregional developments:

Engagement of regional actors and stakeholders among all pilots	Societal Impact
Operational deployment desk groups have been and will be collaborating with relevant energy stakeholders, firms and organisations as well as local/regional authorities. The integration of mentioned local/regional audiences and their networks has been promoted in order to advertise project results.	Providing cost-effective sustainable solutions to interconnect pilots with manifold ownerships and investment budgets in the back. Providing affordable solutions for municipalities (and their citizens) that is payable (even with co-financing now) in future whilst allowing a better understanding

Enhancing the partnership between public & private actors. Involving Municipality services to integrate local stakeholders/social actors through the usual communication channels, also targeting citizens in general.	of reliable hybrid systems (EE+RES+Storage). Performing Local Energy Communities for users to reduce their environmental footprint and saving energy costs by participating.

3.8. Impact of the pilot actions

WEIZ

The envisaged pilot will facilitate the acceptance of the related activities in the neighbourhood or in other interested cities, while providing attractive motives. Hence, smart technologies that take advantage of Weiz as a model will be deployed within the project and abroad. Local authorities are involved in the procurement and communication processes as harbingers providing the necessary permit of the site and for future other projects. Pilot-related socio-economic aspects are investigated during and after the construction work.

The expected energy savings are calculated as follows: 9 % of biomass fuel, 2 % grid losses, and 12 % electricity. The pilot serves as a lighthouse for other municipalities as biomass district heating systems in the context of historical centres are widespread in Styria, one of 9 counties in Austria. Other regional municipalities have already announced a clear interest on the project results e.g. on the CEBC 2020 conference in Graz on 24-01-20 and via usual communication channels.

Dedicated structures for the implementation have been developed in order to fulfil the energy needs of all connected buildings whilst maximising the efficiency of the district heating system. All relevant local institutions have been involved at the early stage of the pilot project and have been informed about amendments due to necessary planning adaptations e.g. from the monumental protection office. The consortium has put a significant effort on making the pilot replicable in other historical cities even with a different local context and culture.

CUNEO

The pilot action deployed for the sloping elevator of Cuneo is an important part of the strategy to strengthen sustainable mobility and of the Strategic Plan for Sustainable Development Cuneo 2030.

The concrete benefits can also be expected at the level of local treasury, thanks to the economic savings that will result, and the reduction of CO_2 emissions due to the use of "clean" energy. However, the pilot action has also another critical function that is to raise awareness to the local community, as well as local and regional authorities, about the importance of actions of this type, for instance in the framework of the establishment of Renewable Energy Communities.

At the local level, the pilot project has also represented an innovative technological model of energy efficiency on a public transport vehicle, allowing both the designer and the professionals and stakeholder groups involved, to concretely observe the results of a project that is in many ways unprecedented. The actual energy efficiency gains have been measured within the monitoring phase that returned concrete and accurate data thus allowing a realistic impact assessment.

This individual pilot action of Cuneo did not require the amendment of any local regulations or the obtainment of any special authorization other than the landscape authorization, so the pilot project in itself does not constitute a trigger for the adoption of new policies or the improvement of existing ones. Rather, this was the starting point for a broader discussion about Renewable Energy Communities, for which the integration of storage systems, for example in historic urban centers, would be of crucial importance. Therefore, the pilot project is a small-scale model of a larger transformation of the territory that extends to the borders of Piedmont and beyond. Through its implementation, it will be possible to draw conclusions from an investment made possible by the Store4HUC project in order to assess its benefits and its replicability elsewhere and on a larger scale.

It is precisely the partnership in the project that has proved to be a major driver for the development of a competence and the search for innovative tools and solutions in the field of energy efficiency. The technical skills of the Store4HUC partners have made an important contribution to the results of the project and the pilot actions have given the substance to its technical and theoretical aspects. The Municipality of Cuneo, in particular in the Environment and Mobility Department, occasionally encountered some difficulties in fully understanding the more technical issues addressed by the partners and the works on the sloped elevator proved to be difficult to manage due to their limited understanding of the electrical aspects. In spite of this, the support of project partners, first of all Environment Park, have been supporting hands to carry out the works and compensate some specific shortcomings of the Municipality employees. The synergy for the completion of collateral works was however important and showed how the success of a project is often determined by a close collaboration between different organizations, each providing a different contribution.

LENDAVA

Due to the COVID-19 pandemic, the construction work and all planned stakeholder engagement meetings were adapted. However, energy experts (for example the Consortium of Slovenian Local Energy Agencies) got valuable and transferable experience in the field of this “new” technology in connection with low temperature geothermal energy. Local authorities have been involved in the procurement and communication processes as harbingers providing the necessary permit of the site and for future other projects. Pilot-related socio-economic aspects are investigated during and after the construction work.

As a result of the connection to RES and newly implemented storage, in accordance with the implemented control and EMS system, the following positive effects have been planned and at the end also achieved:

- Increasing the energy efficiency of the system by changing the heating system from energy un-efficient (old Oil-Fired boiler) to efficient (DHS) → min. primary energy savings → CO_2 saving through lower final energy consumption
- Lower pollutant emissions by changing from fossil to renewable energy source (carbon dioxide - CO_2, carbon monoxide - CO, dust and other greenhouse gas emissions as NOx and CxHy)
- Exploitation of local renewable energy – geothermal energy
- Extension of maintenance intervals → lower maintenance costs (no maintenance on heating system and low maintenance cost on storage)

BRAČAK

Bračak Manor has already been known as a place and an example of how to renovate a building under cultural heritage according to the highest standards of energy efficiency with the use of renewable energy. With the implementation of this pilot project, Bracak Manor (Energy Centre Bračak) will be even more positioned on the map of excellence in energy efficiency. Energy management of the versatile energy systems in the Bračak Manor including heating, cooling, energy production and storage will allow to investigate what are the economically and ecologically most favourable technology mixes on historical sites. Target groups will thus benefit from future renovations of historical urban sites because they will have a good example of which technology is most cost-effective. In addition, stakeholders representing decision makers at all levels in the implementation of renewable energy sources in historical urban sites in the Krapina-Zagorje County will gain additional experience and knowledge that will allow all processes to be shorter in the future when implementing similar projects.

Mutual learning sessions of Store4HUC provided benefit to the participating audiences among the consortium via project meetings and stakeholders via deployment desk meetings. In Bračak the implementation measures have already started and are nearly finished.

3.9. KPIs (Key Performance Indicators)

This paragraph reports on the KPIs identified to evaluate the impacts of the pilot actions on different aspects and benefits foreseen by the implementation of energy storages in HUCs. As already stated in chapter **Errore. L'origine riferimento non è stata trovata.**, the KPIs are classified in 2 different categories:

- **Pilot specific KPIs**, specifically aimed to measure the performance and evaluate the results of the storage investment and the direct benefits of its application, coupled with a suitable control algorithm for their energy management. Each PP must identify its pilot specific KPIs, depending on the features of its pilot investment
- **Urban KPIs**, identified to measure or evaluate the benefits of the pilot action at urban level or other intermediate levels (for example: municipal properties). All PPs are required to monitor these common urban KPIs.

In order to understand the meaning of the implemented indicators, a short introduction to the definition of the parameters referred to energy consumption is necessary.

In the following indicators these parameters have been defined:

- $E_{c,i}$: i-th thermal/electrical energy consumption of the pilot system, supplied by external source for one year [kWh]
- $E_{c,tot} = \sum E_{c,i}$: total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year [kWh]
- $E_{self\text{-}RES,i}$: i-th consumed energy from self-production of local RES system in a year [kWh]
- $E_{self\text{-}RES} = \sum E_{self\text{-}RES,i}$: total consumed energy from self-production of local RES systems in a year [kWh]
- $E_{TOT} = E_{c,tot} + E_{self\text{-}RES}$: total thermal/electrical energy consumption of the pilot system for one year [kWh]

Table 9: *Complete list of KPI´s*

Indicator	Category	Description	Measurement Unit
KPI_1: External energy needs of the pilot system	Pilot specific KPI	Energy consumption supplied by external sources	[kWh]
KPI_2: External energy cost of the pilot system	Pilot specific KPI	Cost of the energy supplied by external sources	[€]
KPI_3: Average yearly CO_2 abatement	Pilot specific / Urban KPI	CO_2 emissions	[t CO_2]
KPI_4: Autarky rate	Pilot specific / Urban KPI	Energy self-sufficiency	[%]
KPI_5: Use of energy from RES	Pilot specific / Urban KPI	RES self-consumed energy, associated to storage	[kWh]
KPI_6: Security of energy supply	Pilot specific KPI	Hours without service interruptions/discomforts	[-]
KPI_7: Power peak	Pilot specific KPI	Average power peak	[kW]
KPI_8: Profitability	Pilot specific KPI	Net Present Value / Investment	[-]
KPI_9: Stimulation of the local economy	Urban KPI	New jobs created calculated through estimation of investment and replicability potential	[-]

KPI1: External energy needs of the pilot system

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Energy consumption supplied by external sources
Input parameters & Calculation	Calculation method: 1. Total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year $\mathbf{E_{c,tot}}$ [kWh] 2. Calculation of Key Performance Indicator: $\mathbf{KPI_1 = E_{c,tot}}$
Measurement Unit	[kWh]
References	Efficiency Valuation Organization, *International Performance Measurement and Verification Protocol*, 2017
References	Efficiency Valuation Organization, *International Performance Measurement and Verification Protocol*, 2017

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [kWh]	**1.833.500**	**18.226**	**84.351**	**138.219,67**
Target (prediction) [kWh]	1.726.607	12.226	80.133	107.811
Status quo (after pilot implementation) [kWh]	**1.812.965**	**7.431**	**69.930**	**126.879,67**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

3.9.1. KPI2: External energy cost of the pilot system

<u>Applicability for objects of assessment</u>

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Cost of the energy supplied by external sources
Input parameters & Calculation	Calculation method: 1. External thermal/electrical energy cost[1] $\mathbf{C_E}$ [€], as function of yearly energy profile of each external energy source 2. Thermal/electrical energy consumption profile of the pilot system, supplied by external sources for one year $\mathbf{E_{c,tot}}$ [kWh] 3. External thermal/electrical cost of peak power taken from external sources $\mathbf{C_P}$ [€], which also includes the contracted power delivery with the external source 4. Sequence of peak powers absorbed from the external sources on yearly basis $\mathbf{P_{peak}}$ [kW] 5. Calculation of Key Performance Indicator: $\mathbf{KPI_2 = \Sigma\, [C_E(E_{c,i}) + C_P(P_{peak})]}$
Measurement Unit	[€]
References	-

[1] This cost must include all expenses related to energy purchasing, energy distribution and transportation, energy meter management, system charges and taxes.

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [€]	**51.338**	**3.584**	**8.460,45**	**9.295,27**
Target (prediction) [€]	48.345	2.404	5.272,93	7.095,27
Status quo (after pilot implementation) [€]	**49.625**	**1.486**	**2.102,42**	**7.707,67**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

3.9.2. KPI3: Yearly CO2 emissions

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	CO_2 emissions
Input parameters & Calculation	Calculation method: 1. Total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year $\mathbf{E_{c,tot}}$ [kWh] 2. CO_2 emission factor to be applied to the energy source **EF** [t CO_2/kWh], e.g IPCC emission factors 3. Calculation of Key Performance Indicator: $\mathbf{KPI_3 = E_{c,tot} \times EF}$
Measurement Unit	[t CO_2]
References	Covenant of Mayor: http://www.eumayors.eu/IMG/pdf/technical_annex_en.pdf

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [t CO2]	**29,34**	**8,8**	**23,53**	**17,25**
Target (prediction) [t CO2]	27,63	5,9	0	15,26
Status quo (after pilot implementation) [t CO2]	**29,01**	**3,6**	**0**	**14,59**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

3.9.3. KPI4: Autarky rate

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Energy self-sufficiency
Input parameters & Calculation	Calculation method: 1. Consumed energy from self-production of local RES system in a year $\mathbf{E}_{self\text{-}RES}$ [kWh] 2. Total thermal/electrical energy consumption of the pilot system for one year $\mathbf{E}_{TOT}$ [kWh] 3. Calculation of Key Performance Indicator: $\mathbf{KPI_4 = [E_{self\text{-}RES/}\ E_{TOT}] \times 100\ \%}$
Measurement Unit	[%]
References	Deliverable D.T3.2.4 "Validation report and establishment of the autarky rate tool & the checklist"

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [%]	**0**	**0**	**0**	**0**
Target (prediction) [%]	0	33	0	8,7
Status quo (after pilot implementation) [%]	**0**	**53**	**0**	**8,2**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

3.9.4. KPI5: Use of energy from RES

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Consumed energy from self-production of local RES systems in a year
Input parameters & Calculation	Calculation method: 1. Consumed energy produced by local RES systems in a year **E** $_{self\text{-}RES}$ [kWh] 2. Calculation of Key Performance Indicator: $\mathbf{KPI_5 = E_{self\text{-}RES}}$
Measurement Unit	[kWh]

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [**kWh**]	**0**	**0**	**0**	**0**
Target (prediction) [**kWh**]	0	6.000	0	12.036
Status quo (after pilot implementation) [**kWh**]	**0**	**8.544**	**0**	**11.340**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

3.9.5. KPI6: Security of energy supply

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Percentage of time without interruptions/discomforts in terms of operation of local energy consumption system without service interruptions/discomforts
Input parameters & Calculation	Calculation method: 1. Number of hours without interruptions/discomforts on yearly basis $N_{no\_interrupt}$ [h] 2. Total number of hours of local energy consumption systems operation on yearly basis N_{tot} [h] 3. Calculation of Key Performance Indicator: $KPI_6 = N_{no\_interrupt} / N_{tot} \times 100\ \%$
Measurement Unit	[%]
References	-

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [%]	**99,23**	**99**	**99**	**99,992**
Target (prediction) [%]	100	99	100	>99
Status quo (after pilot implementation) [%]	**99,65**	**n/a**	**100**	**n/a**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

3.9.6. KPI7: Peak power

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Average yearly peak power delivered from external energy sources
Input parameters & Calculation	Calculation method: 1. Array of monthly peak powers delivered from external energy sources $\mathbf{P_{peak,month}}$ [kW], where *month* goes from January to December [$P_{peak,January}$, $P_{peak,February}$, … , $P_{peak,December}$] 2. Calculation of Key Performance Indicator: $$KPI_7 = \frac{1}{12} * \sum_{month=January}^{December} P_{peak,month}$$
Measurement Unit	[kW]
References	-

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [kW]	**476**	**5**	**22,25**	**10,64**
Target (prediction) **[kW]**	400	5	16,5	8,5
Status quo (after pilot implementation) **[kW]**	**409**	**n/a**	**21,6**	**n/a**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

3.9.7. KPI8: Profitability

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Net Present Value / Investment
Input parameters & Calculation	Calculation method: 1. Calculation of Net Present Value: $NPV = -I_0 + \sum_{t=0}^{t}[\frac{R_t}{(1+i)^t}]$ NPV = Net Present Value [€] I_0 = investment [€] R_t = Net cash inflow-outflows during a single period t [€] t = numbers of time periods i = discount rate or return that could be earned in an alternative investment 2. Calculation of Key Performance: **KPI_8 = NPV / I_0**
Measurement Unit	[-]
References	-

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [-]	n/a	n/a	n/a	n/a
Target (prediction) [-]	2,15	0,71	1,49	n/a
Status quo (after pilot implementation) [-]	**2,35**	**0,63**	**1,99**	**0,78**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

3.9.8. KPI9: Stimulation of the local economy

Applicability for objects of assessment

Pilot specific KPI	-
Urban KPI	X
Thermal energy storage	X
Electric energy storage	X
Only energy storage integrated by RES system	X

Description	New jobs created calculated through valuation of investment and its maintenance and operational costs
Input parameters & Calculation	Calculation method: 1. Total cumulated expense of the storage installed, calculated as the Investment (*CAPEX* [€]) + associated Operation & Maintenance costs ($OPEX$ [€], evaluated on the system technical life: 20 years for electric pilot and 15 years for thermal pilot) 2. Constant K [€], equal to 200.000 €, that represents an empirical factor calculated as the ratio between a generic Company turnover and the number of company employees 3. *r*, equal to the number of the same storage solutions potentially installed in the district/region, considering a mid-term perspective of 5 years after the end of the pilot project. At the pre-investment stage consider this parameter equal to 1 4. Calculation of Key Perfomance Indicator: **KPI_9 = (*CAPEX*+*OPEX*) * *r* / *K***
Measurement Unit	
References	-

PILOT	WEIZ	CUNEO	LENDAVA	BRACAK
Pre-investment status [-]	**n/a**	**n/a**	**n/a**	**n/a**
Target (prediction) [-]	1,5	0,48	0,48	0,316
Status quo (after pilot implementation) [-]	**7,12**	**0,48**	**0,48**	**0,283**

More information and detail about KPI calculation are included in DT 2.2.3, DT 2.2.5, DT 2.2.7 and DT 2.2.9.

4. CONCLUSIONS

The degree of energy self-sufficiency achieved with the implementation of these measures varies in the different pilots depending on the local climatic conditions, type of technology, previous energy consumption, etc. Each demonstration site is combining locally available renewable energy sources with storage units. Even though the used technologies are proven and well established, the way they are combined is innovative and will produce new insights.

Mutual learning sessions of Store4HUC let benefit the participating audiences among the consortium via project meetings and stakeholders via deployment desk meetings.

WEIZ

As with all construction measures at sites listed as monumental and landscape protected, the most relevant challenge for the Weizberg biomass heating plant was to harmonise the additional regulations and requirements of monument and landscape protection with the objectives of the implementation. Due to the special requirements, however, it was possible to apply for KEM funding scheme (Austrian funding scheme for innovative thermal model regions among others) including energy storages in order to raise additional funds to finance the project. In order to be eligible for funding under the "Thermal Storage" pilot programme, the storage system must go beyond the usual state of the art (material, size, temporal use, etc.) and thus exhibit a high degree of innovation and be technically and economically multipliable. As the only project in Austria, it was a good achievement for the Austrian Store4HUC team, as well as its local partners and stakeholders, that the storage expansion project in Weizberg received the "KEM Thermal Storage" funding, with the maximum eligible rate of 45 % of the investment costs.

The construction phase started in February 2020 and was completed with the installation of the water buffer storage at the end of June 2020. All challenges resulting from the implementation of the extension were excellently mastered by the measures taken. During the construction phase, partnerships were established between W.E.I.Z. (Andrea Dornhofer, Rafael Bramreiter), AEE INTEC (Michael Reisenbichler), "Biomasse Heizwerk Weizberg" (Johannes Schinagl & Johann Neuhold), TB Haas (Johann Haas) and the Weizberg parish (Anton Herk-Pickl & Herbert Ederer), which is intended to be continued successfully in future projects and cooperation. As there were no major problems during the construction phase, the commissioning of the system has started as planned and was completed before the heating season 2021 starts. An inauguration ceremony was organised in summer 2021. The expanded biomass heating plant thus initiates an energy-efficient and climate-friendly future for the energy supply at Weizberg and hopefully also at many other places under monument and landscape protection.

CUNEO

The pilot project of the sloping elevator of Cuneo, and the participation of the Municipality in the Store4HUC project have provided a unique opportunity for the city to acquire energy-efficient and clean means of transportation, and to learn about new innovative tools and solutions for the implementation of policies and initiatives aimed at making the territory increasingly energy efficient.

While the direct benefits of the intervention are meant for the public, thanks to the reduced management costs of the sloping elevator and the reduction of CO_2 emissions, also the Municipality staff has benefited from the project by expanding its know-how and developing both specific skills and more general competence on the management of a European project.

The positive effects of the pilot project of Cuneo and of Store4HUC are also extended to other target groups such as the project stakeholders and those who took part in the dissemination and educational events organized by the municipality and by Environment Park. They were able to gain first-hand experiences of how a process of implementing the pilot project works, participate in a network of institutions and organizations at the regional level focused on energy efficiency, exchange opinions, experiences and doubts about the potential development of these issues and the evolution of national legislation on the subject. Stakeholders will be invited to a final round table within the project duration, the 4th Deployment Desk of this project, presenting first results of the monitoring phase and of the testing of the computational tools developed during the project.

New initiatives may arise for the development of innovative technologies and facilities at regulatory level to expand the scope of the outcomes of Store4HUC. As mentioned above, among the topics of high relevance is that of Renewable Energy Communities that could benefit from some of the skills acquired within the Store4HUC project and during the implementation of the pilot action.

However, considering the new European programming and the Italian National Recovery and Resilience Plan, financed by the Next Generation EU funds, which places particular emphasis on the energy transition of the country, any initiative aimed at transforming and enhancing energy efficiency in the cities, as in the case of the Store4HUC project, will be taken into due consideration and will bring its effects to a wider level.

LENDAVA

As with all construction measures at sites listed as monumental and landscape protected, the greatest challenge for the pilot in Lendava was to harmonise the additional regulations and requirements of monument and landscape protection with the objectives of the implementation. Additionally, due to the Covid-19 pandemic situation the construction work and all planned stakeholder engagement meetings had to stop for some weeks in the last quarter of 2020. This situation resulted in the building phase starting in January 2020. Before the construction work, the most important fact was also to find a suitable expert for geothermal district heating in connection with PCM storages and, in parallel, to find a suitable product on the market. However, as said, the construction work has been carried out from last 2 weeks in January until mid-February 2021 in two phases.

During the project, deployment desk meetings were held with stakeholders, creating a working network on the topics related to the pilot (geothermal energy, district heating, EMS tool, local renewable energy, innovative storage solutions, local/national policy on monumental and landscape protected, etc.). These meetings proved to be very useful in laying the foundations for future collaboration involving different actors, from institutions to private companies operating in the energy sector, creating an even wider network thanks to the cross-fertilization events that have been held during the project.

During the project preparation phase, public procurement process and construction phase, partnerships were established between Local Energy Agency Pomurje, Municipality of Lendava, regional Development Agency Sinergija, distributer Petrol – Geotherm, national Geological Survey of Slovenia, Institute for the Protection of Cultural Heritage of Slovenia and the Pomurje technology Park, which will hopefully be continued successfully in future projects and cooperation. Despite the delays due to the pandemic situation, there were no major problems during the construction phase, the monitoring and testing phase will continue independently from the project time plan/milestones and even after the formal project end. The final goal is to optimize the pilot (max. efficiency/min. energy costs/min. emissions), which will serve for a long time as an example of good practice in the project area; example of innovative solution of storing renewable energy in an effective way and can be easily transferred to other municipalities/regions/countries.

In general, the project partners have increased the knowledge and raised awareness related to the topic of low temperature district heating among project partners and especially among the stakeholders, but also beyond the project partnership. It turned out that there is a large interest in the topic (also in areas with no geothermal potential, for example the increasement of efficiency of biomass district heating systems) and that especially public authorities and heat providers as well as grid operators.

While the direct benefits of the intervention are meant for the Lendava public administration, thanks to the reduced energy costs of the newly renovated storage and the reduction of CO_2 emissions, also other stakeholders (for example the Consortium of Slovenian Local Energy Agencies) benefitted from the project. They expanded their know-how and developed both specific skills and more general competence on the management of this type of activity within a European project.

BRACAK

Despite the Covid-19 pandemic and the unexpected lockdowns in Europe and thus in Croatia, the execution of works on the Croatian pilot project is progressing with some delays. As stated in the application form, the risk associated with the investment was the potentially infeasible installation of a photovoltaic system at the Manor. After starting preparations of the implementation of the pilot project and organizing initial meetings with all relevant stakeholders, the conclusion was that in Croatia significant constraints are related to the energy storage, the energy management system, and the installation of the photovoltaic system at locations under cultural heritage protection. The constraints are defined by the Law on Protection and Preservation of Cultural Heritage. The law prescribes the prevention of any action that could directly or indirectly change the properties, form, meaning and appearance of a cultural property. It is also obligatory to protect and preserve cultural goods in their pristine and original design, and to pass on cultural goods to future generations. For this reason, the installation of a photovoltaic system on the roof of a building was impossible to be realized. As a result, a lot of time has been spent for preparing an alternative pilot option and has involved more REGEA staff (PP8) in the planning to find the right solution. Finally, the conservators have agreed on constructing a canopy in the parking lot next to the castle on the same cadastral plot. For building a canopy and for installing a photovoltaic power plant on it, it was necessary to meet special construction conditions and to obtain for a building permit. In addition, it has been necessary to prepare a fire protection study to meet all the requirements of the Fire Protection Act, performed by the REGEA staff.

The public procurement for the execution of works was carried out and the Turnkey Contract for the execution of works was signed, and the agreed price of the works was 55.951,56 EUR including VAT. The main reason for which the total investment is less than the planned 90.000 EUR is that the investment costs for PV installations have decreased considerably within the last two years. During the preparatory phase of the investment the existing building management system, servers and electrical installations were reviewed and considered still usable, in order to reduce the total cost.
The purpose of the photovoltaic system is to produce electricity for the site own needs with the possibility of handing over the surplus to the grid. Combined with a battery system, surplus will first charge the battery and thus increase system efficiency. The expected annual electricity production of the photovoltaic system is 11 MWh. According to the contract, the works on the installation of the photovoltaic system and the battery system, as well as the works on the integration into the energy management system, have been completed during December 2021. The Administrative Department for Physical Planning, Construction and Environmental Protection, Zabok issued on 23.11.2011. Decision (Use permit, CLASS: UP / I-361-05 / 21-01 / 000097, REGISTRATION NUMBER: 2140 / 01-08-5-21-0011 dated 26.10.2021) which became final for the photovoltaic system.

The system testing phase began as soon as the complete system was put into operation. The module from the energy management tool for decision support on using the micro-CHP and wood pellets boiler in the optimal way in the new conditions with installed battery and the photovoltaic system has been integrated. Employees of REGEA will be trained to monitor the system operation such that they can maintain the system in optimal operation and present it as a showcase to different regional, national, and international stakeholders. The Manor is already used as a demonstration centre for good practices in energy renovation of historical sites, and it will still be used even after the project end in a reinforced way.

SUMMARISED

Energy solutions for HUCs in the development of Low Carbon infrastructures such as integration of Photovoltaic or improving the district heating systems with energy storge systems are implemented in order to improve the sustainability of energy production and utilization in the pilots and abroad. The intention is to better match the demand and supply side management. The case study analyses of the given report will not eliminate all missteps, but it may provide the necessary knowledge development and spread. The project results may improve our understanding of how socio-economic perception shapes the adoption of environmental technologies and energy consumption based on empirical data.