FINAL REPORT OF THE HUC PILOT ACTION IN CUNEO

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TITLE AND LOCATION of the PILOT action: Cuneo

REPORTING STAGE (tick on the proper option)

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☒ Final

☐ Transnational evaluation

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Authors	Marco Piacenza, Fabio Pellegrino, Elisa Marino (PP07)
Contributors	
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Reviewed by	Katja Karba (PP01), Luca Galeasso, Mauro Cornaglia, Mario Lo Curzio, Graziella Pillari (PP06), Michael Heidenreich (PP05)
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Content

1. SUMMARY

The energy efficiency project for the sloping elevator of the City of Cuneo is part of the pilot actions of the Store4HUC project and 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 impediments in the first procurement process initiated by the Municipality of Cuneo.

Since the project involves the use of energy from renewable sources - more specifically from a small photovoltaic field located in the proximity of the system - 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. However, the completion of the project took place in October 2021, allowing for the provision of useful results for the dissemination of the good practice learned.

This document is intended to provide an overview of the pilot action carried out by the City of Cuneo in terms of both procedure and efficiency gains, based on KPIs calculations for the project. An assessment of the efficiency and effectiveness of the action - also in view of its replicability - requires a medium-long term monitoring capable to provide a comparison with the state of the system before the action was taken.

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 means of public transport and others than conventional cars, encouraging the use of bicycles and ensuring a lower traffic of motor vehicles in the historic city center. Since the elevator is a means of transport widely used by the citizens and since it is also allowed to transport bicycles, it already represents an improvement from the point of view of city traffic: its conversion into a "green" installation is the natural completion of its sustainable character.

2. INTRODUCTION

This document describes the reporting activities of the pilot actions foreseen in the STORE4HUC project.

It describes the monitoring activities that the PP07 has conducted on the pilot implementation and the indicators (KPIs) monitored at different stages:

- Intermediate stage (Mid-term report) – September 2020
- Final stage (Final report) – November 2021
- Transnational evaluation stage – November 2021

It also provides (chapter 3) a summary of the aspects that have been included in the feasibility study and at pre-investment stages in order to re-call the whole planning and implementation chain.

The document in particular has two specific objectives:

- Report on the investment process foreseen of the Italian pilot.
- Monitor other aspects related to the positive impacts and successfulness of the pilot, such as:
  - Results of application of operational and monitoring tools.
  - Adaptations of energy and urban policy frames that are needed.
  - Mapping and adaptation of HUC regulations for the authorization of building integration.
  - Energy storage promotion and replication activities.
  - Follow up - recommendations, improvements.
  - Evaluation of the sustainability of the pilot and risk reduction measures.

3. ASPECTS AND KPIs TO BE MONITORED AT DIFFERENT STAGES

Aspects and Urban KPIs	Chapter in the template	Feasibility study	Pre - investment stage	Mid-term report	Final report	Transnat. evaluation
Technical specifications and performance requirements of the identified storage system		X	X			
Strengths, Weaknesses, Opportunities, Threats (SWOT Analysis)		X				
Initial situation: energy consumption, CO_2 emissions and energy costs			X			
Procurement procedure	4.1		X	X	X	
Installation and integration process	4.2		X	X	X	
Impact of the investment on energy and overall costs	4.3		X	X	X	
Energy management	4.4		X	X	X	
Energy and urban policy frames	4.5	X		X	X	X
Stakeholders' involvement	4.6	X		X	X	X
Transferability of the pilot action	4.7	X		X	X	X
Impact of the pilot action	4.8	x		X	X	X
KPI_1 - External energy needs of the pilot system	4.9.1		X		X	X
KPI_2 - External energy costs of the pilot system	4.9.2		X		X	X
KPI_3 - Average yearly CO_2 abatement	4.9.3		X		X	X
KPI_4 - Autarky rate	4.9.4		X		X	X
KPI_5 - Use of energy from RES	4.9.5		X		X	X
KPI_6 -Security of energy supply	4.9.6		X		X	X
KPI_7 - Power peak	4.9.7		X		X	X
KPI_8 - Profitability	4.9.8		X		X	X
KPI_9 - Stimulation of local economy	4.9.9		X		X	X
KPI_{10} - Other pilot specific KPIs	4.9.10		X		X	X

KPIs are classified in 2 different categories:

- **Pilot specific KPIs**, specifically aimed to measure the performance and the results of the storage investment and the direct benefits of its application. PP7 has identified its pilot specific KPIs, depending on the features of its pilot inventory.
- **Urban KPIs**, identified to measure or evaluate the benefits of the pilot action at urban level or other intermediate levels (for example: municipal properties). PP7 has and will assess the common urban KPIs, which are listed in the table below.

Complete list of KPIs

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 CO2 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	Days without service interruptions/discomforts	[-]
KPI_7: Power peak	Pilot specific	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	[-]

4. PROGRESS REPORT OF THE PILOT ACTION

The pilot action of the City of Cuneo was launched in December 2020 with the publication of a call for tenders for the award of the works related to the energy efficiency intervention on the sloping elevator in Cuneo.

The first tendering procedure hit a snag as none of the three competitors invited to tender submitted a bid, due to some incorrect wording related to the prevailing category of work. As a result, the Municipality of Cuneo had to amend some of the bidding documents for the alignment with the executive project before restarting the process in February 2021. Thanks to the changes made, a bid was submitted and the contract was awarded on an urgent basis for starting the works in April 2021.

Due to the large demand for such items as the photovoltaic panels and the battery storage system, these materials were available to the companies in about 30 days from the given order, and the works could finally start in May 2021. In the first month, structural works were carried out for the construction of the technical room to house the new electrical equipment, including the storage system. In the summer, the required electronic components were delivered and could be installed and connected to the existing system. Meanwhile, the procedures for the qualification of the photovoltaic system and the approval of the supply of renewable energy and on-site energy exchange were started and accomplished in October 2021.

Once the administrative procedures described above have been completed, it has been possible to put the system into operation and to start with monitoring the consumption and performance of the system.

The connection of the components has been made on October 20, 2021 when the operators of E-Distribuzione - the national supplier of electricity from the public grid - replaced the electrical panel, as required to enable the connection of the photovoltaic system to the existing system. The Municipality of Cuneo collected data on consumption for a month (from 20.10.2021 and 20.11.2021) in order to evaluate the performance of the pilot plant. Since this is a system with constant energy consumption over time, it has been possible to make long-term projections depending on the seasonal irradiation data on the photovoltaic panels.

4.1. Procurement 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 since the several lockdowns that Italy faced in spring and early autumn 2020 caused difficulties in managing all phases of the planning process.

The contractor for the works has been appointed by direct awarding procedures in accordance with art. 1 -paragraph 2, letter a) - of the Decree Law n. 76/2020, converted into Law n. 120/2020, after a request for proposals sent to three companies, previously identified as included in a special list of the Municipality, with final awarding according to the criterion of the lowest price.

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 Procurements National Code (Legislative Decree n. 50/2016) that usually regulates public procurements in Italy. The new Decree Law was adopted considering Covid-19 difficulties and to simplify procedures 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.

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.

4.1.1. First public procurement procedure- December 2020

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. The deadline for the submission of offers was set on December 15, 2020 and the entire procedure was carried out on the online platform Sintel e-Procurement. This first tender was not successful as no offers have been received by the municipality.

The main reason for such outcome is to be found in the fact that the contracting authority - based on the indications provided by the project designer in the Special Tender Specifications - had specified “Plant for the production of electrical power" as the main category of the works to be carried out. Indeed, in the process of preparing the offers, some companies had mentioned that the requirements of the specifications would involve also works of a different category whose economic value could be prevalent with respect to those of the main category indicated. Consequently, a new procedure started having the same specifications of the first tender but with “Construction works” mentioned as the prevailing category.

4.1.2. New public procurement procedure- February 2021

Acknowledging the issue that had compromised the successful outcome of the previous procedure, the main category of the works included in the new tender documents has been modified to “Civil and Industrial Buildings", and companies complying the necessary requirements have been invited to tender.

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, pursuant to art. 153, paragraph 1, second sentence, of the General Regulations on Public Procurements (D.P.R. 207/2010). In this case, the Contract Manager expressly indicates in the negotiation minutes that ordered works must be started immediately. 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.

An initial preliminary meeting between the contracting company, the Contract Manager and the City of Cuneo took place on March 12, 2021 and was followed by further visits to the pilot site and meetings. The final awarding took place following the verification of the requirements, which took about a month and was therefore fixed by mid-April.

4.1.3. Timetable for Cuneo pilot

Activity/Phase	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sept 2021	Oct 2021
Tender procedure											
Execution of works											
Connection to the grid											
Final testing											
Verification of performance											

4.2. Installation and integration process

The energy efficiency works for the sloping elevator include:

- A newly built underground technical room, located next to the existing uphill station and designed to house all electrical equipment necessary for the operation of the energy storage system;
- 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 during which service disruptions have been very rare and often not related to the intervention in progress. 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 adjoining the room that houses the operating mechanisms for the elevator, the installation of electrical panels available inside the room 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, thanks to the input of the energy produced by photovoltaic modules and not used or stored by the plant.

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 panels was authorized, the system went into operation and, after testing the constructions, the works were completed.

The integration of the new system for power self-generation from the photovoltaic field required the support of the specialized technician who is normally in charge of the management and maintenance of the system. However, in order for the system to be put into service, it was necessary to obtain the authorizations for connection and to replace the existing electrical panel.

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. However, this is a fundamental part of the monitoring system, without which data cannot not be collected and processed.

No impediment was encountered in the preparation of the worksite, except for a temporary modification of the bike lane that runs alongside the elevator runway and a temporary traffic diversion on the days when bulky materials and components had to be unloaded. No disruption of the elevator service resulted from the realization of the works, except for about 4-5 non-continuous days when works were in progress on the electrical components causing an interruption of the service. However, there has been a quite prolonged disruption in August due to the malfunction of a component of the system not related to the pilot action.

The population of the city of Cuneo was duly informed in the course of the works through press releases about work progress and the Store4HUC project. At the finalisation of the works, the Municipality of Cuneo had to respond to the comment of a citizen who criticized the positioning of photovoltaic panels along the elevator runway, in his opinion unsightly and visually impacting because placed on the escarpment that connects the Rivers Gesso and Stura Natural Park with the city center. The Municipality of Cuneo replied by informing that the visual impact of the panels had already been reduced and that in any case the project had obtained the landscape authorization from the Superintendence.

No other objections or negative comments were received at the municipality.

4.3. Impact of the investment on energy and overall costs

The Investment Specification (D.T2.1.2) for the pilot project in Cuneo, contained the estimated KPI values for the implementation of the pilot action. In particular, KPI number 2 "External energy cost of the pilot system" calculates indirectly the economic impact of the action on an annual basis.

It was estimated in the Investment Specification 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 of the elevator system), 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.

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 won't be totally paid back from a mere economic point of view. It can be assumed that in case such an intervention is made during the construction of a new elevator or funicular, the costs of the investment for the energy efficiency could be lower because, as an example, the costs for the technical room might be strongly reduced because integrated in the construction of the whole system.

From the energy side, the monitoring proved the system to be functional to the goals of the Administration: the expected savings in terms of energy provided by the public grid, have been met during the one-month monitoring phase, as demonstrated by the calculation of KPI #1 with the worst case scenario. In fact, the testing period lasted from October 20, 2021 to November 20, 2021 and was characterized by many rainy and cloudy days (about two thirds of the month were characterized by cloudy days) compared to the rest of the year in Cuneo. The testing was done in two different tranches (see Fig. 1 and 2): the first characterized by more sunny days, the second by more cloudy ones. KPI #1 was calculated taking into consideration the share of energy from external sources of period 2, the worse one, but energy savings proved to be anyway better than forecasted even with such a bad weather scenario.

Fig. 1: Share of energy consumed coming from the grid (red) and produced by the PV (green) in period 20.10.21- 06.11.21

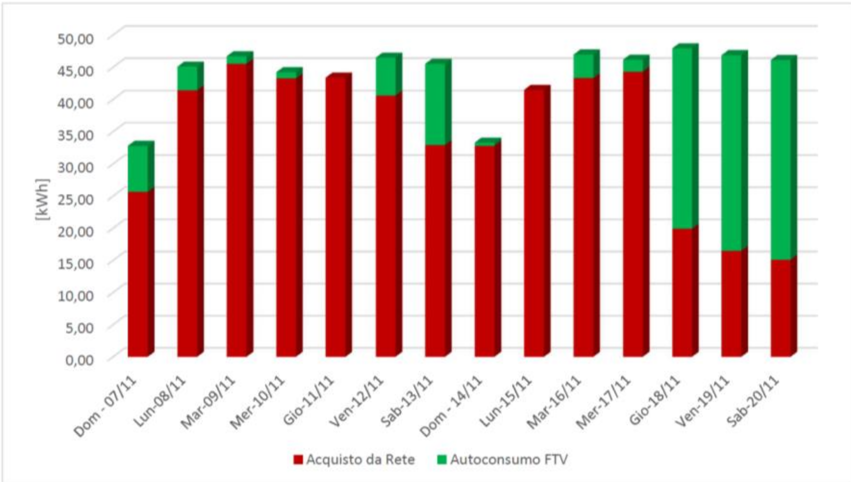

Fig. 2: Share of energy consumed coming from the grid (red) and produced by the PV (green) in period 07.11.21- 20.11.21

However, the average consumption of energy coming from the photovoltaic field has reached the 74% of the total energy needed for the sloping elevator operation in the sunniest day, when some of the energy auto-produced by the photovoltaic field and/or by the elevator auto-production has also been re-introduced to the public grid, because the battery capacity was already full (see Fig. 3).

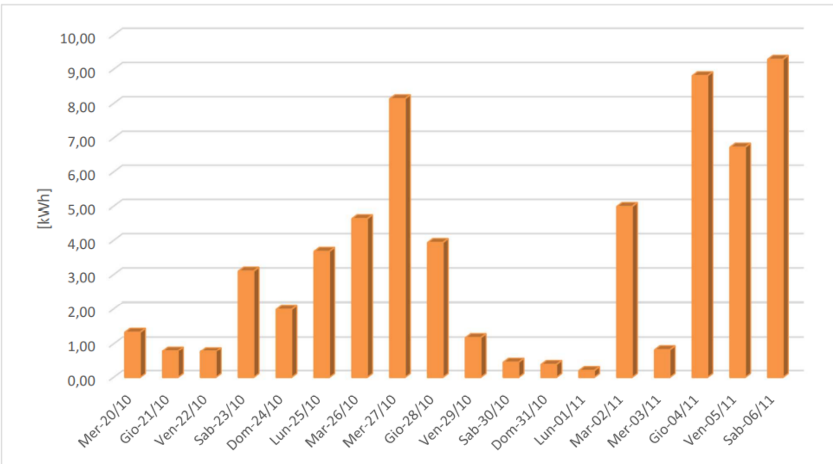

Fig. 3: Share of energy re-inserted in the grid in period 20.10.21- 06.11.21

In average, the energy produced by the PV and used for the elevator functioning for the testing period corresponds to the 31% of the total energy required. In very cloudy days the system used almost 100% of the energy purchased from the public grid, while in sunny days the highest value of energy provided by the PV system has been equal to 74%, as above-mentioned (see Fig. 4). The good results provided by the monitoring were also guaranteed by the storage system that allowed for the use of the renewable energy not directly consumed by the elevator. In sunny days the auto-production was so high to allow also for the re-inserting of the energy in the public grid.

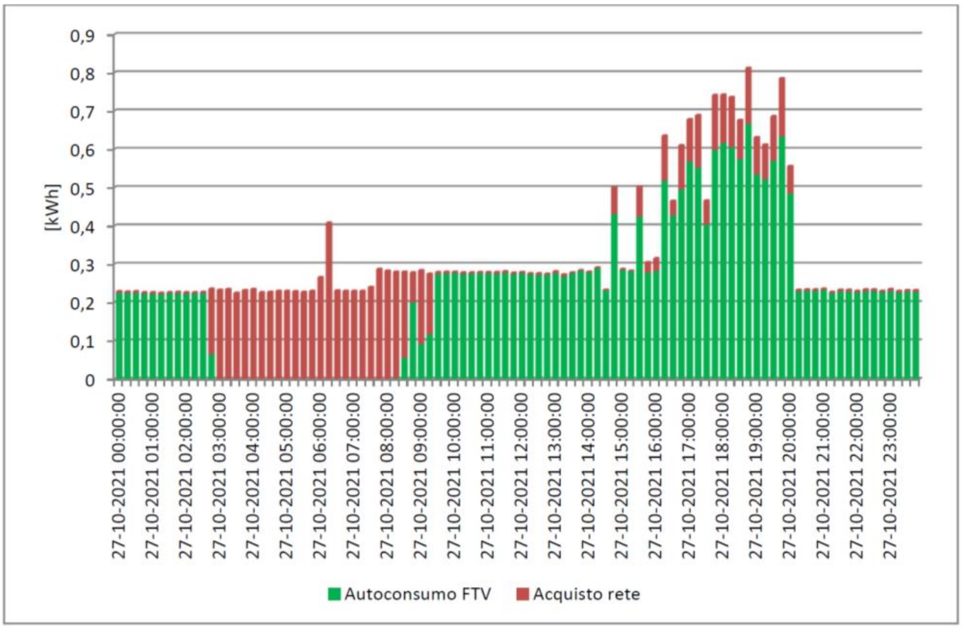

Fig. 4: Share of energy coming from the grid (red) and produced by the PV (green) in the sunniest day of the testing period.

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 (see Fig. 5).

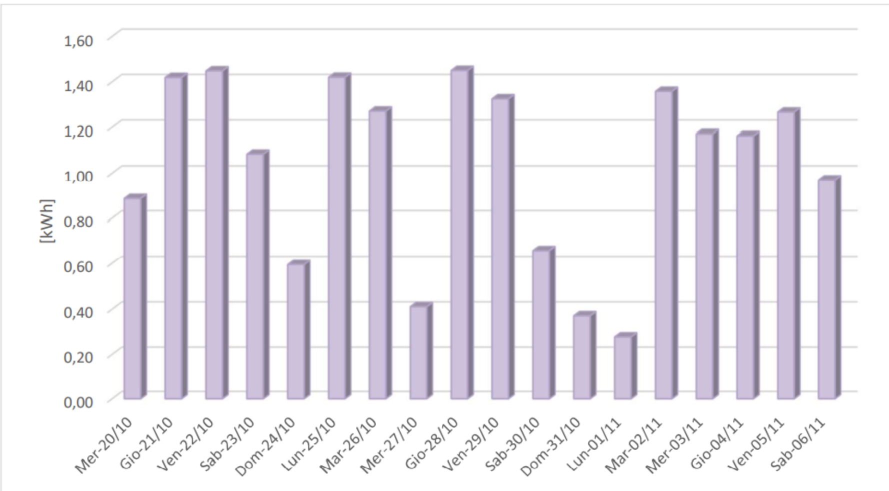

Fig. 5: Share of energy coming from the elevator auto-production in the period from 20.10.21-06.11.21.

The testing has thus shown that the predictions made within the Investment Specification were more positive from the energy efficiency point of view than the real consumption data. More details on the targets reached are available in chapter 4.9 “KPIs- Key Performance Indicators”.

4.4. Energy management

The specific storage unit, consisting of a battery pack with electronic control equipment, has been installed to store the electrical power produced by the sloping elevator and photovoltaic field, and to make it available to the elevator system drive when necessary. Since it must be able to supply alternating currently available solar electricity, the storage unit is equipped with an inverter for DC to AC conversion. This type of device for energy storage is a “hybrid inverter”.

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 battery pack is made of long-life Lithium-Iron-Phosphate batteries, not affected by the critical stability and safety issues that other types of lithium-ion batteries have, and featuring a lower risk of fire that allows easier installation in rooms with no need for special protections. The storage unit is composed of 7 modules with a capacity of 2.76 kWh/53 Ah and in total of 19.32 kWh.

The storage unit has been connected to the inverter on the production side while charging/discharging is managed by the control software of the converter (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 converts the direct current generated by the solar modules into alternating current which is supplied - in synch with the mains voltage - into the public electricity grid. Solar energy can be stored in the battery for future use.

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.

The use of a bidirectional hybrid inverter allows for four different energy flow directions:

1. solar module → inverter (d.c./a.c.) → lift consumption/feed to grid
2. solar module→ inverter (d.c./c.c.) → d.c. battery storage
3. d.c. battery → inverter (d.c./a.c.) → lift consumption
4. grid/lift self-production → inverter (a.c./d.c.) → d.c. battery storage.

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.

4.5. Energy and urban policy frames

For the City of Cuneo, the sloping elevator is a means of public transport that is widely used and has therefore an impact if performed efficiently from the energy consumption point of view.

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.

4.5.1. SECAP, PUMS and "Cuneo for Sustainable Development" Strategic Plan

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.

4.5.2. Building, monument and heritage protection regulation

The investigations carried out on the environmental, hydro-geological, and archaeological feasibility and on urban compatibility of the project did not reveal any significant elements that could have hindered the realization of the works. The public land on which the infrastructure was built hosted already a permanent transport system, on which the photovoltaic panels have been integrated, with no changes to the layout of the transport system.

The building site is located beyond the 150 m buffer zone from the River Gesso, but falls within the boundaries of the Rivers Gesso and Stura Natural Park (Galassini), so it is within a nature conservation area under Legislative Decree n. 42/2004. In this regard, in the course of the preliminary investigation of the final project, the landscape authorization n. 35 has been required and obtained on July 2, 2020, and the number of photovoltaic panels to be installed has been reduced in order to limit the impact on the landscape.

4.5.3. Energy production license legislation

Pursuant to Legislative Decree n. 112 of 31 March 1998 and Regional Law n. 44 of 26 April 2000, the Provinces have been delegated authorisation to build and operate plants for the production of electricity with a capacity of less than 300 MW, including plants powered by renewable sources as per Legislative Decree n. 387/2003. Not all plants powered by renewable sources, however, must be subject to the single procedure of provincial jurisdiction. Interventions below certain thresholds or with characteristics such as to be considered "free building activities" can, in fact, be carried out through the Simplified Qualification Procedures (PAS) of municipal competence pursuant to Legislative Decree n. 28/2011 or after simple notification to the municipality responsible for the territory. The latter is the case for the Cuneo pilot action.

4.5.4. General constraints and opportunities of energy storages installation in HUC

The results of the first Deployment Desk showed that there are no barriers and regulatory constraints concerning protection of architectural and environmental heritage that prevent the installation of energy storages in HUC but 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.

The recommendation arisen from the Deployment Desks and the realization of Cuneo pilot action are the following:

- Ensure the involvement of all stakeholders from the first phases of the project;
- Ensure a strong interaction between local and regional strategic plans for sustainability and the pilot action to create shared interest and greater synergies;
- A strong boost to the installation of energy storages could be given by new incentive policies implemented at regional and national level;
- Carry out upstreaming activities, such as meeting with the national public authorities (bodies) to influence the strategy integration and implementation.

4.6. Stakeholders‘ involvement

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.

Three Deployment Desks have been held up till October 2021, the first on September 12, 2019, in conjunction with the kick-off event, the second on July 9, 2020, and the third on April 27, 2021, jointly with the presentation of two European projects on energy efficiency.

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 Desks 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.

From the point of view of identified challenges, there are not many impediments to the installation of storage systems in historic city centres from an architectural and landscape point of view, except in the case of buildings listed as cultural assets to be safeguarded. Indeed, as the installation of renewable energy sources in these areas is often difficult or even forbidden, storage systems could provide a solution to the decarbonisation of city centres. However, one of the challenges that were identified, which severely limited the deployment of storage systems, is the lack of laws regulating the trade of self-generated energy. This factor greatly affects the dissemination of these technologies and also has a negative impact on the establishment of renewable Energy Communities, which are a very effective tool for promoting storage systems.

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 Desks, 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, is 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.

4.7. Transferability of the pilot action

As mentioned in the previous chapters of this document, the pilot action of the Municipality of Cuneo is a rather peculiar case in the regional but also national scenario. However, the deployment of the pilot action was worthy because of its innovative features - from a technological but also strategic point of view - that are of some interest also for other realities.

To begin with, other cableway transport systems of this type have been found in Piedmont, that could benefit from the experimental action implemented for the sloped elevator of Cuneo. 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.

However, as we speak of the region of Piedmont, it is natural to think of the ski lift facilities that are so widespread in the Western Alps, with a significant impact on CO_2 emissions.

As regards 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.

Therefore, from both a technological and strategic standpoint, this solution can be leveraged elsewhere with excellent benefits. However, a not irrelevant point is the cost of the investment 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.

A viable solution to this type of problem could be sought in the optimization of the investment made, which should cover a greater number of facilities therefore maximizing energy efficiency at several sits. This would make the investment more effective. Not only that, if the action was 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.

The results of the project and the energy efficiency gains will be available after the monitoring phase and will be further disseminated in the following Deployment Desks that will hopefully also involve multiple areas, which are affected by the results of the project. The interest in this type of activities and projects increases in response to measurable benefits and therefore we intend to provide concrete results on the occasion of the next round table with stakeholders.

4.8. Impact of the pilot action

As we have already discussed earlier, 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 urge the local community, as well as local and regional political strategies, about the importance of actions of this type and the input that these can provide to the start of even larger projects, such as the establishment of Renewable Energy Communities, a topic that has been largely discussed during the round tables with the stakeholders and within the partnership.

With regard to the acquisition of know-how, the employees of the City of Cuneo who managed the project work in the Environment and Mobility Department as this is the manager of the elevator on which the action was carried out. As this body is not specialized in projects of this kind - more typically managed by the Public Works Department – they could improve their knowledge of energy efficiency and innovative tools and solutions for improving energy consumption in some facilities of the city. The sloping elevator project - which by virtue of its connotation of pilot project has an experimental character - has represented, even with related difficulties that it has encountered during its implementation, a learning field for the employees of the Municipality of Cuneo who, although experienced in designing at European level, have dealt with the time constraints and the development of "emergency" solutions made necessary by the requirements and the timing of the project.

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.

Through the Cuneo pilot action, the Store4HUC project has also enabled the establishment of a network of organizations involved in the issues addressed by the project, that has brought up shared concerns and reflections and that, thanks also to the participation of the Piedmont Region to a number of round tables, will contribute to expose to the legislators the needs of the territory in terms of enhancement of the policies related to renewable energies and storage systems.

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.

Moreover, in terms of modeling tools implemented as part of the Store4HUC project, this pilot action – just like the other three actions deployed in Slovenia, Croatia and Austria – usefully contributed to testing and improving the Autarky Rate Tool and Module 1 of the Energy Management Tool.

The Autarky Rate Tool has been tested after completion of the first monitoring cycle ended in mid-November 2021, through which it has been possible to assess whether the autarky rate calculated by the tool corresponds to that actually achieved by the plant after completion of the works. The comparison gave some interesting results above all with data from the second tranche of testing: this means that the weather of that period is more similar to the radiation profile used for the ART, while the first period might not be representative of the yearly weather trends for Cuneo. Not only, the own consumption rate calculated by the ART differed from the one emerging from the testing because the ART did not assume that the peak power might be higher than 8 kW, as the testing actually showed. Such a short monitoring period might bias the data, therefore a longer monitoring will allow for a better comparison between the ART and the actually autarky rate of the system.

The second tool, Module 1 of the Energy Management Tool, was tested at the preliminary stage of the pilot project with the purpose to compare the size of the project based on the actual parameters with that assumed at the designing stage. Compared to the Investment Specification data, the EMS tool provided different results which are basically due to the fact that the Investment Specification forecasted a “stand alone mode” of sloping elevator operation, which requires a higher battery and inverter capacity. In fact, it assumes that the system would not depend by the public grid at all, while in the EMS tool it is assumed that the independency from the grid would not be total. This makes the calculation results lower than the ones made within the Investment Specification.

Finally, thanks to the project partnership and to the activities of dissemination of the results of each pilot project, the competence acquired in Italy during the implementation of this action will also be shared with the member states of the Store4HUC project for a deeper know-how about this type of actions. Also, thanks to the numerous contacts of the City of Cuneo with the transalpine regions of France, and the existing collaborations with cross-border bodies and organizations, this competence can be extended beyond the Central Europe territory.

The sustainability of the pilot action will be granted by the fact that the elevator is a means of transport widely used by citizens, so the interest of the Administration is to continue their ordinary and constant management of the plant, because of the high use that the people of Cuneo make of it. The sustainability of the project may also be sought in future interventions of energy efficiency, such as the construction of a second sloping elevator on the opposite side of the city, and/or using the opportunity to improve the energy efficiency of public buildings, activities already in place that could benefit from the experience gained through Store4HUC.

A high degree of continuity to the project would finally be ensured through a new application to the Interreg Central Europe program, with a view to leveraging the know-how acquired during the Store4HUC project and implement it further to expand the scope of application of its results. For example, the focus could be placed on Renewable Energy Communities, a much discussed topic both at national and partnership level.

It is precisely the partnership in the project that has proved 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 substance to its technical and theoretical aspects. The Municipality of Cuneo, in particular 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.

4.9. KPIs (Key Performance Indicators)

KPIs, being yearly values, have been calculated using the monitoring data from one month (20 October 2021 – 20 November 2021) and estimated for the rest of the year, using the radiation profile given by the 2016 version of PVGIS software. A longer monitoring will be run and will last until December 2022, allowing for more precise data by the end of Store4HUC project.

4.9.1. KPI: External energy needs of the pilot system

As can be seen from the monitoring report covering the period from 7.11.2021 to 20.11.2021, 21% of the energy required by the system was produced by the photovoltaic/storage system while the remaining 79% was bought from the public grid. These data can only be considered valid for the month of November.

Considering a daily consumption of 43,77 kWh (data provided by the monitoring report) and constant use of the sloping elevator throughout the year, it can therefore be considered that the energy consumption of the lift for the month of November will be equal to the daily consumption multiplied by the days of the month (30). A monthly consumption of 1.313 kWh is thus obtained, with the following breakdown: 275 kWh (21%) produced by the PV/storage system and 1.038 kWh (79%) purchased from the electricity grid.

To estimate how the energy required by the elevator system can be shared for the other months of the year between self-consumed energy and energy purchased from the electricity grid, it was decided to scale these two values on the basis of the monthly average values of the global horizontal irradiation. The latter was obtained using the PVGIS software for year 2016.

The total energy consumption for the remaining months of the year was calculated by multiplying the daily consumption (43.77 kWh) by the days of each month. Total annual consumption will be 15,976 kWh. This value is lower than the 18,226 kWh considered in the pre-investment status because of the reduced use of the lift due to the pandemic situation.

In this way it was possible to estimate that the energy withdrawn annually from the network, obtained by summing the monthly values, will be equal to 7.431 kWh.

Pre-investment status:

$KPI_1 = E_{c,tot}$ = 18.226 [kWh]

Target (Investment specification prediction):

$KPI_1 = E_{c,tot}$ = 12.226 [kWh]

Measured:

$KPI_1 = E_{c,tot}$ = 7.431 [kWh]

4.9.2. KPI: External energy cost of the pilot system

For the calculation of the total cost of energy withdrawn from the public grid, an average value of € 0.20 / kWh was used, including both the cost of the energy consumed and the cost for the peak power billing.

However, the value considered does not take into account the reduction, due to the presence of PV production, of the energy purchased from the grid and therefore possible variations in the costs on the bill might occur. A more precise calculation of the KPI_2 can be carried out when the electricity billing data will be available in next months when the photovoltaic system will work.

The result are therefore equal to 7.431 kWh * 0.20 € / kWh = 1.486 €.

Pre-investment status:

$KPI_2 = \Sigma [C_E(E_{c,i}) + C_P(P_{peak})]$ = 3.584 [€]

Target (Investment specification prediction):

$KPI_2 = \Sigma [C_E(E_{c,i}) + C_P(P_{peak})]$ = 2.404 [€]

Measured:

$KPI_2 = \Sigma [C_E(E_{c,i}) + C_P(P_{peak})]$ = 1.486 [€]

4.9.3. KPI: Yearly CO_2 emission

CO_2 emissions can be calculated using an EF (Emission Factor) equal to 0.483 tCO_2 / kWh and the annual energy required by the grid calculated in KPI_1.

The final value will be 7.431 kWh * 0.483 tCO_2 / kWh = 3.589/1000 = 3,6 tCO_2.

Pre-investment status:

$KPI_3 = E_{c,tot} \times EF = 18.226\ MWh_e \times 0{,}483\ t\ CO_2/MWh_e = 8{,}8\ [tCO_2]$

Target (Investment specification prediction):

$KPI_3 = E_{c,tot} \times EF = 12.226\ MWh_e \times 0{,}483\ t\ CO_2/MWh_e = 5{,}9\ [tCO_2]$

Measured:

$KPI_3 = E_{c,tot} \times EF = 7.431\ MWh_e \times 0{,}483\ t\ CO_2/MWh_e = 3{,}6\ [tCO_2]$

4.9.4. KPI: Autarky rate

To obtain the percentage of self-consumed energy from photovoltaic system/storage, the data obtained from the calculation of KPI_1, i.e. the annual energy withdrawn from the grid (7.341 kWh) is used, as well as the expected annual electricity consumption, equal to 43.77 kWh/day multiplied by 365 days, namely 15.976 kWh. The difference between these two values, namely 8.544 kWh, will be equal to the annual value of the produced energy from the PV system.

The percentage of self-consumed energy will be equal to the ratio between the self-consumed energy and the annual electricity consumption: 8.544 kWh / 15.976 kWh = 53%.

Pre-investment status:

$KPI_4 = [E_{self\text{-}RES}/E_{TOT}] \times 100\ \% = 0\ [\%]$

Target (Investment specification prediction):

$KPI_4 = [E_{self\text{-}RES}/E_{TOT}] \times 100\ \% = 33\ [\%]$

Measured:

$KPI_4 = [E_{self\text{-}RES}/E_{TOT}] \times 100\ \% = 53\ [\%]$

4.9.5. KPI: Use of energy from RES

The KPI_5 is the annual value of the self-consumed energy, therefore equal to 53% of the total energy required by the system. The result will therefore be 8.544 kWh.

Pre-investment status:

$KPI_4 = E_{self\text{-}RES} = 0\ [kWh]$

Target (Investment specification prediction):

$KPI_4 = E_{self\text{-}RES} = 6.000\ [kWh]$

Measured:

$KPI_4 = E_{self\text{-}RES} = 8.544\ [kWh]$

4.9.6. KPI: Security of energy supply

Not enough data is available at the moment of the delivery of the final report. This KPI will be measured more precisely by the end of the project.

Since the PV-plant came into operation, no interruption/discomfort in terms of operation of local energy consumption system has been registered.

4.9.7. KPI: Power peak

Not enough data is available at the moment of the delivery of the final report. This KPI will be measured more precisely by the end of the project.

4.9.8. KPI: Profitability

The following formula was used to calculate the NPV: $NPV = -I_0 + \sum_{t=0}^{t} [\frac{R_t}{(1+i)^t}]$

The investment cost (I_0) is equal to € 96.356,99, the discount rate (i) is considered equal to 1% and t will be equal to the lifetime of the system (20 years). The annual saving (R_t) is equal to the sum of the valorisation of self-consumed energy plus the valorisation of the energy fed into the network through on-site exchange.

The valorisation of the annual self-consumed energy will be equal to 8.544 KWh * € 0,20/kWh = € 1.709.

From the monitoring data it can be deduced that the energy produced by the photovoltaic system for the month of November is equal to 338 kWh. By scaling this value on the values of the global horizontal irradiation of the other months of the year (same procedure adopted for the calculation of KPI_1), we obtain that the annual energy produced by the photovoltaic system is equal to 10.498 kWh. By subtracting the self-consumed energy (8.544 kWh) from this value, the difference will be the energy fed into the grid, namely 1.952 kWh. Considering a feed-in tariff of 13 cents €/kWh (the same cost considered in EMS Module 1), an annual valorisation of the energy fed into the grid of 253 € is obtained.

The sum of these two values will be equal to € 1.962.

Through the use of Excel it was found that the NPV in the 20th year of life of the plant is equal to € -60.938,4.

Status quo:

Not applicable.

Target (Investment specification prediction):

KPI_8 = NPV / I_0 = -0,71 [-]

Measured:

KPI_8 = NPV / I_0 = -0,63 [-]

4.9.9. KPI: Stimulation of the local economy

Calculation of KPI_9 consisted in the following:

KPI_9 = (CAPEX+OPEX) * r / K = (96.356,99 € € + 0 €) * 1 / 200.000 € = 0,48

Where:

1. Total cumulated expense of the storage installed, calculated as the Investment (CAPEX [€]) + associated Operation & Maintenance costs (OPEX [€]), evaluated on the system technical life, namely 20 years. The OPEX value has been considered negligible, so equal to 0 €;

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. This parameter is considered equal to 1.

4.9.10. Other pilot specific KPIs

No other KPIs have been forecasted for the Italian pilot on the sloping elevator.

5. CONCLUSIONS

The pilot project of the sloped 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 staff of the Municipality has benefited from the project by expanding their know-how and developing both specific skills and more general competence on the management of this type of activity within a European project.

The positive effects of the pilot project of Cuneo and of Store4HUC also extend 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 a first-hand experience 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.

We are confident that from the project, from the round tables and from the future scenarios, new initiatives may arise - also in the form of new applications to European calls - 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, in view of 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 may bring its effects to a wider level.