INVESTMENT SPECIFICATION FOR THE INTEGRATION OF AN ENERGY STORAGE IN HUC OF CUNEO

D.T2.1.2	Version 3 30/09/2020

Title	INVESTMENT SPECIFICATION FOR THE INTEGRATION OF AN ENERGY STORAGE IN HUC OF…
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Authors	Marco Piacenza, Fabio Pellegrino, Silvia Agnello
Contributors	Mauro Cornaglia
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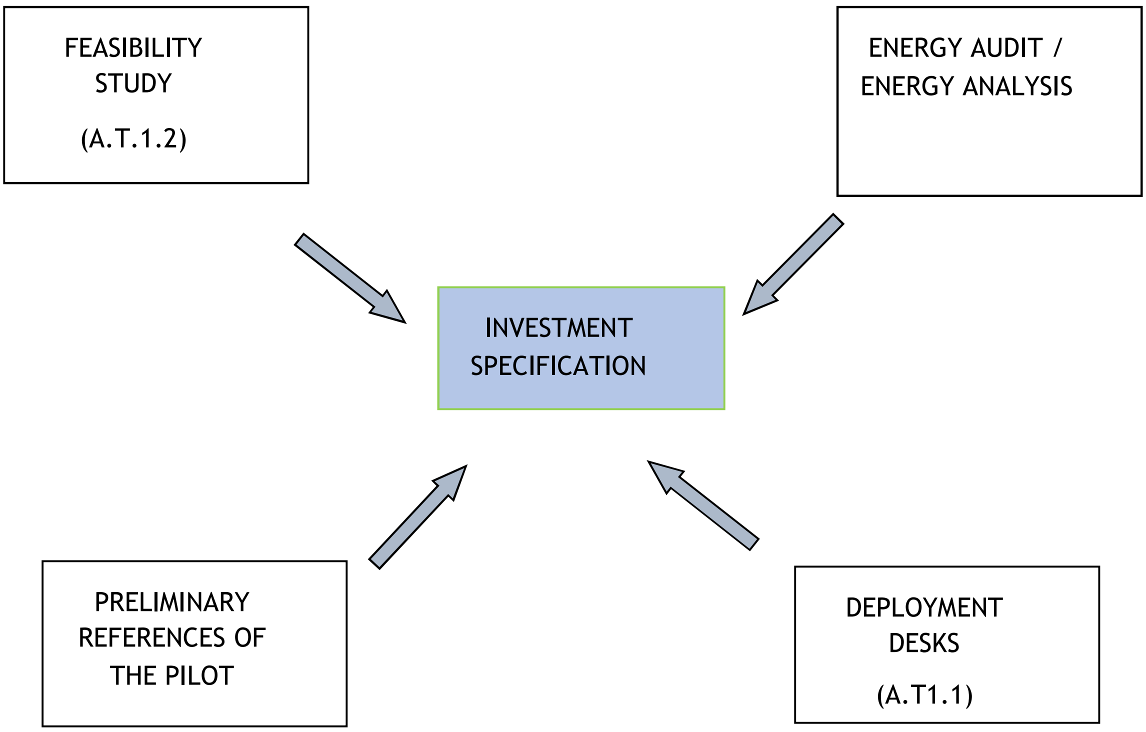
Summary

1. INTRODUCTION

The investment specification document (pre-investment concept) includes all the aspects to be evaluated before starting with investments and procurement procedure, including also the aspects already included in preliminary project design steps and energy audit where available.
Each pilot has filled-in this document to ensure that all relevant aspects will be considered in the procurement of the identified storage solution.

The investment specification is linked and should include the outcomes and contributions of other documents and project results (see also the figure below):

- Deployment desk outcomes, including expectations of stakeholders supporting the pilots (A.T1.1)
- Feasibility study of the pilot (A.T1.2)
- Results of the application of the Energy Management System (EMS) tools in the storage planning and design (A.T3.1)
- Monitoring of Key Performance indicators (KPIs) specified for pre-investment stage (paragraph 2 of template for HUC pilot action report, D.T2.2.1)
- Existing preliminary projects of reference for the pilot investment
- Existing energy audit / analysis of consumption for pilots



INITIAL SITUATION AND CONTEXT

1.1. Localization of the storage

The storage will be installed next to the sloping elevator, located in the city of Cuneo. The elevator is entirely located within the territory of the Municipality of Cuneo, inside the urban perimeter area, and was built by the Municipal Administration as a permanent public transport system linking the free car parking area serving the sport facilities near the Gesso stream with the city centre, with the purpose of relocating the parking area for regular users outside the historic centre of the city (see figures 1 and 2).

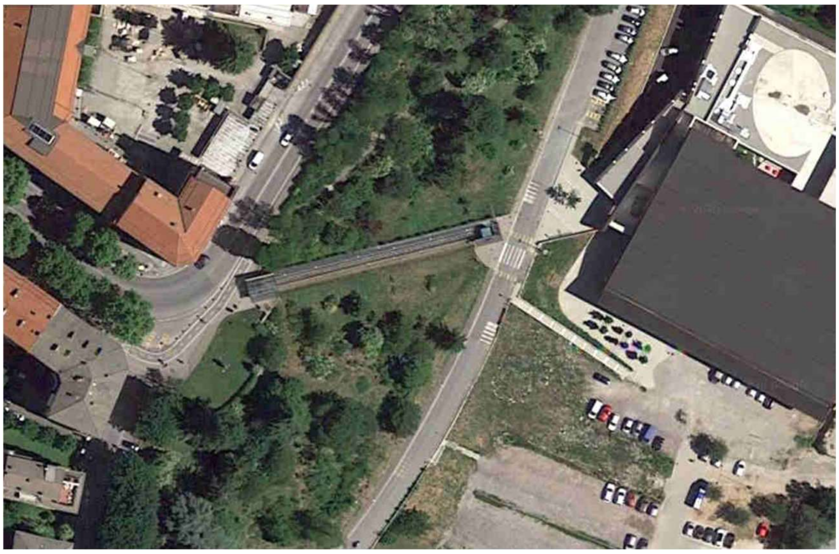


Figure 1: Aerial view of the area. Source: Google Earth

Figure 2: Inclined lift to the city centre of Cuneo

TECHNICAL DATA

Year of manufacture/opening	2009
Cabin capacity	26 people (allows the transport of people with reduced mobility and the transport of bicycles) DUE TO CURRENT EMERGENCY COVID-19 THE CAPACITY IS REDUCED TO 4 PEOPLE.
Lower station altitude	510,59 m
Top station altitude	538.06 m
Runway total length	65 m
Height difference	27.47 m
Cabin speed	1.6 m/sec
Ride time	45 sec
Max number of rides	48 rides/hours

ENERGY EFFICIENCY PROJECT

The project includes the realization of a new system for the production and storage of electrical power, integrated with the drive of the inclined elevator, as well as the construction of a small photovoltaic field along the system runway to supplement the amount of electrical energy that is produced by the elevator during some operating phases. This is actually a single integrated system, made up of several distinct elements, which also require some construction works for support. The individual functional units can be schematically represented as follows:
- changes to the drive of the inclined lift to include an energy recovery module for the energy generated by the driving machine equipped with interface for the connection with the storage;
- construction of a new photovoltaic field to integrate the electricity produced by the lift, through the installation of panels along the existing enclosure above the counterscarp wall of the lift runway, on the northern side of the infrastructure;
- installation of a storage unit, consisting of a dedicated battery pack and related electronic equipment for the control and modulation of incoming and outgoing electrical energy (storage);
- construction of a new technical room, next to the top station of the inclined lift, to house the storage unit and the electronic control and command equipment of the system;
- installation of underground cable ducts for electrical cables running from the photovoltaic field to the technical compartment and from there to the underground engine room of the inclined lift.

1.2. Actual energy users that the storage will serve

The management of the system exploits a technological communication network and the entire infrastructure is connected not only to the system operator’s network, but also to the municipal information network via optical fibre. The system includes 13 security cameras video surveillance and remote control.
The power supply is currently provided by the low-voltage network distributor and the connection point is located a short distance from the lift. The distribution of the power supply to the system is carried out downstream of the general electrical panel installed in the technical room underneath the top station.
The elevator is entirely powered by the power grid without the use of renewable energy.
The system is equipped with some technical solutions designed to maximize the power supply at engine start up and optimize consumption.
The lighting of the runway at night uses low power consumption LED technology lamps.
In 2018, the power consumption from the national grid was 18,226 kWh with a cost of Euro 3,584.12).

Active power kWh *Reactive power kWh* *Max drawn power kW*

Codice Prodotto: SCRPI_AUFIR01_1712FX									Descrizione: **Ascensore inclinato**				
Codice Utenza: C00022876									Matricola misuratore: 08E5F552100430504				
		Energia Attiva kWh				Energia Reattiva kVARh				Potenza max prelevata kW			
		F1	F2	F3	TOT	F1	F2	F3	TOT	F1	F2	F3	TOT
2020	Gennaio	714	263	348	1'325	0	0	0	0	4	4	4	4
	Febbraio	626	319	422	1'367	0	0	0	0	5	5	5	5
	Marzo	685	372	500	1'557	0	0	0	0	5	5	5	5
	Aprile	560	277	427	1'264	0	210	224	434	4	4	4	4
	Maggio	666	302	399	1'367	0	0	0	0	5	5	5	5
	Giugno	604	299	383	1'286	1	0	0	1	5	5	5	5
	Luglio	679	324	406	1'409	0	0	0	0	4	4	4	4
	Agosto	711	329	406	1'446	0	0	0	0	5	5	5	5
	Settembre	674	366	406	1'446	0	0	0	0	5	5	5	5
	Ottobre	782	343	363	1'488	0	0	0	0	5	5	5	5
	Novembre	711	318	404	1'433	0	0	0	0	6	6	6	6
	Dicembre	644	289	473	1'406	0	0	0	0	5.44	5.44	5.44	5.44

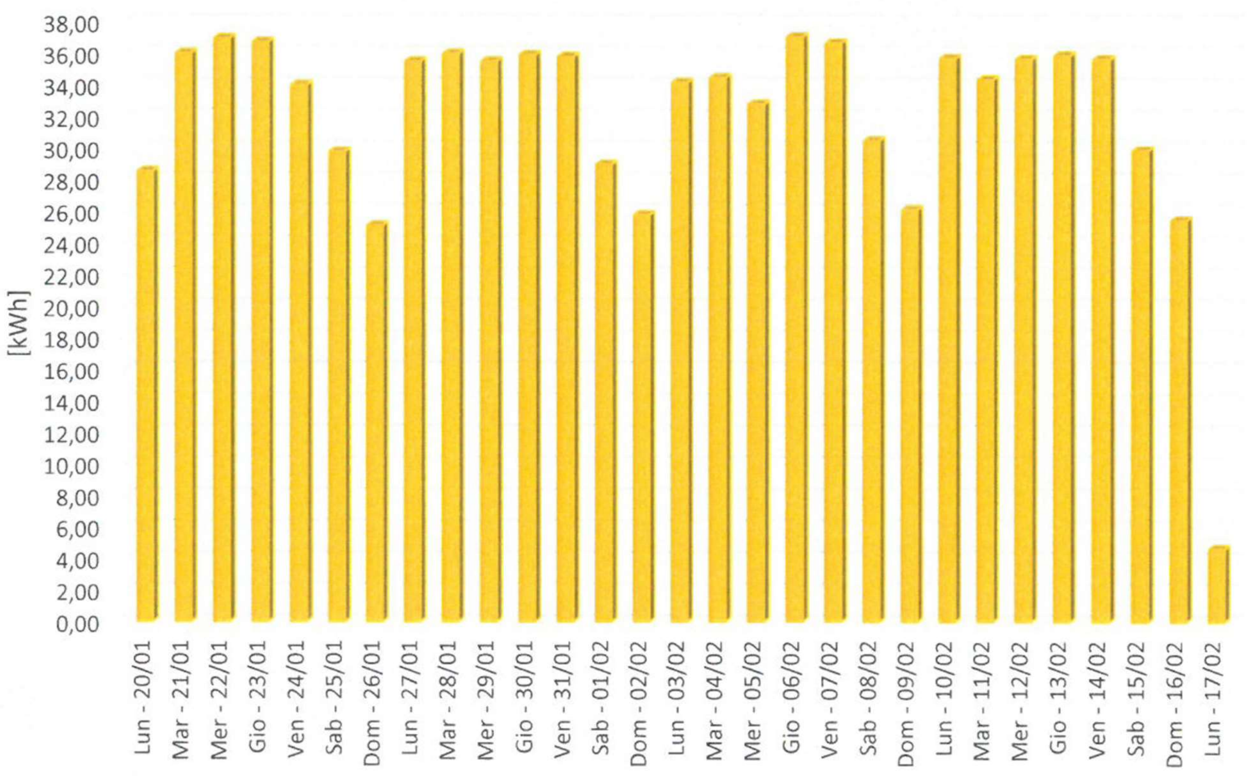
1.3. Actual energy use and energy balance

ELECTRIC POWER SUPPLY - TECHNICAL DATA

Power supply mode: low voltage
Power available: 20kW
Power supply specifications: three-phase + neutral (3Ph+N)
Operating voltage: 400 V (phase-phase) – 230 V (phase-neutral)
Rated frequency: 50Hz

POWER CONSUMPTION ANALYSIS

The following chart shows the overall trend of power consumption recorded in a typical month (from 20/01/2020 to 17/02/2020):



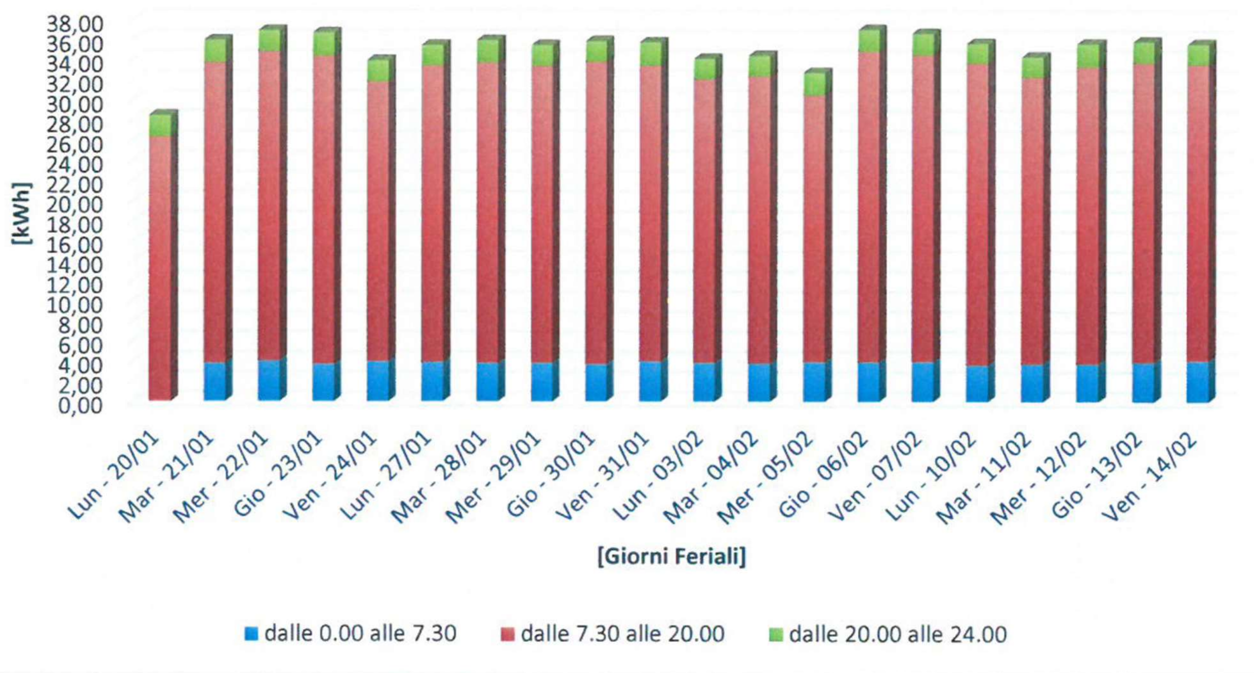
The average daily consumption was 33.01 kWh distributed as follows:

- Monday 33.46 kWh
- Tuesday 35.19 kWh
- Wednesday 35.21 kWh
- Thursday 36.38 kWh
- Friday 35.51 kWh
- Saturday 29.76 kWh
- Sunday 25.58 kWh

Below is the trend of daily power consumption split according to the opening hours of the panoramic elevator to the public. Our analysis will consider separately:

1) weekdays
2) Saturdays
3) Sundays

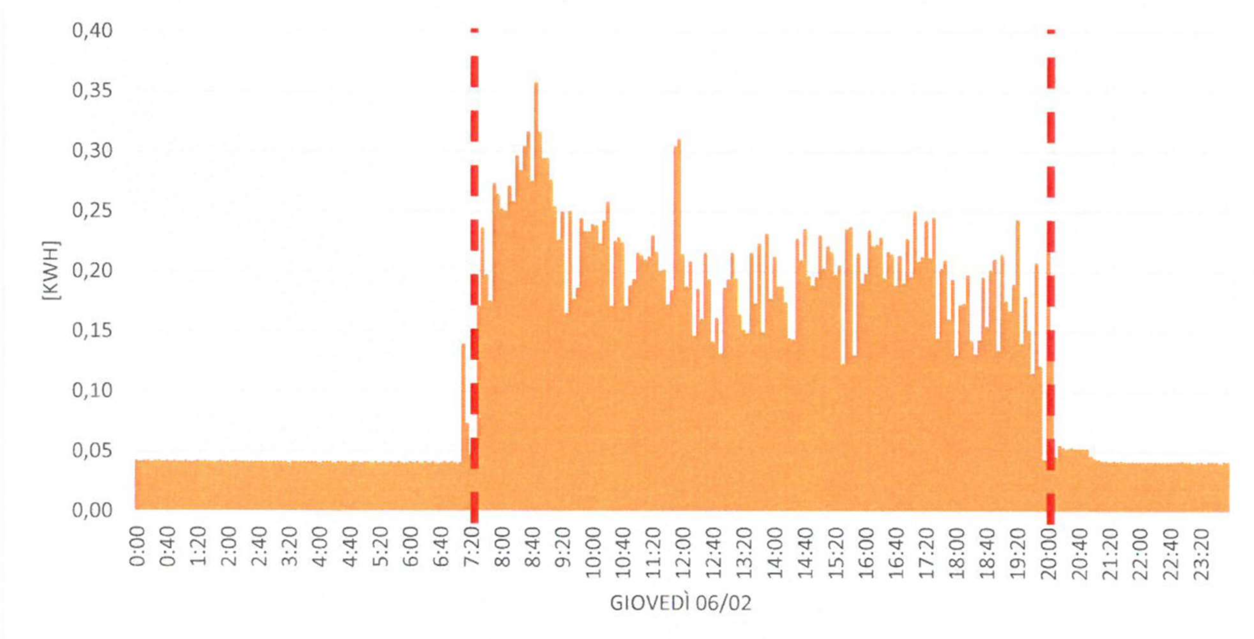
1) weekdays (Monday-Friday; opening hours 7.30 a.m. – 8.00 p.m.)



[Weekdays]

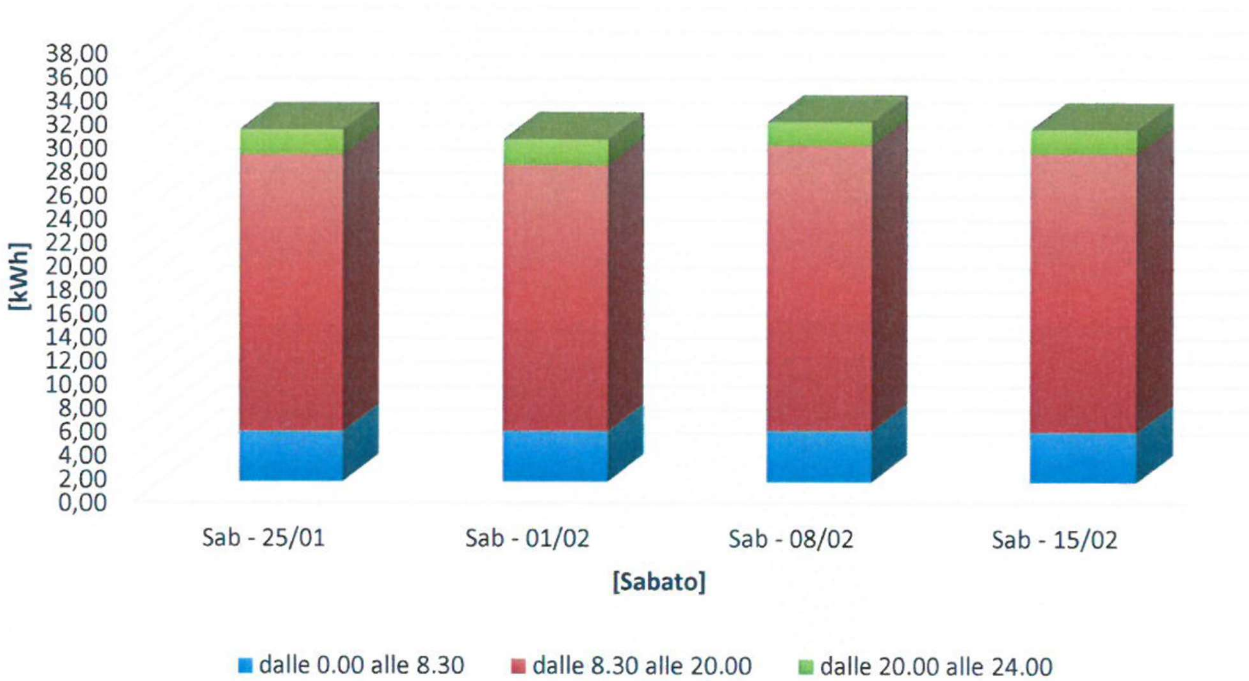
From 0.00 to 7.30 a.m. from 7.30 a.m. to 8 p.m. from 8 a.m. to 12 p.m.

The following diagram shows the trend over the 24 hours of a typical weekday (Thursday, February 6, 2020).



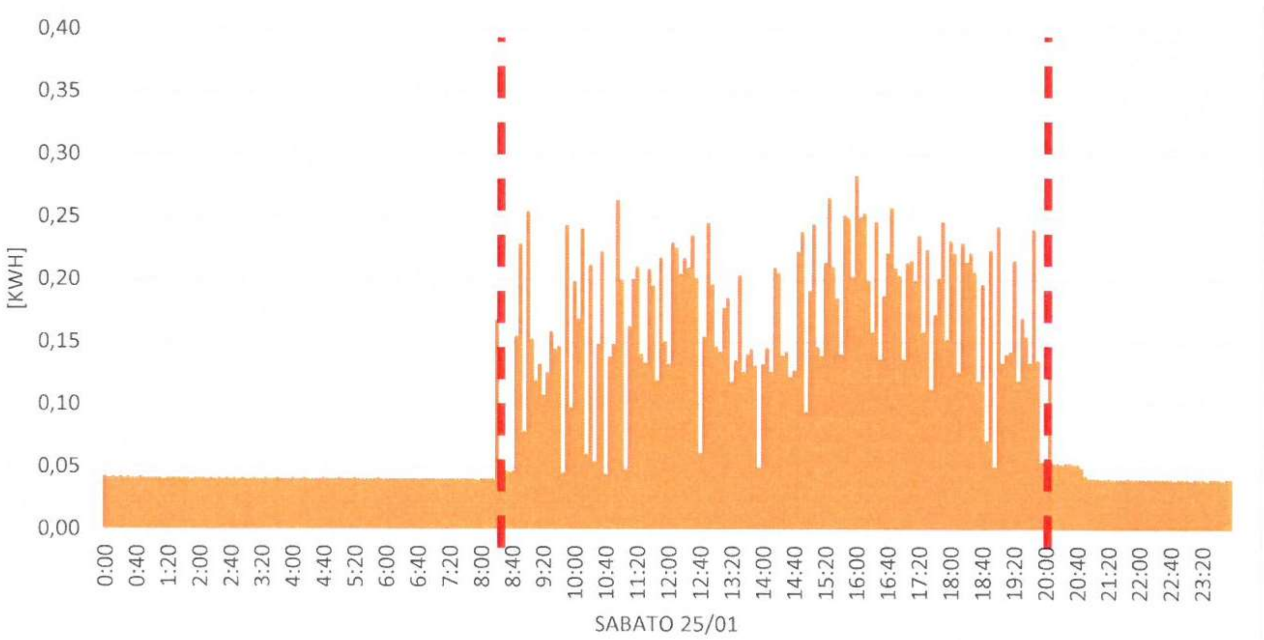
THURSDAY 06/02

2) Saturday (opening hours: 8.30 a.m. - 8.00 p.m.)



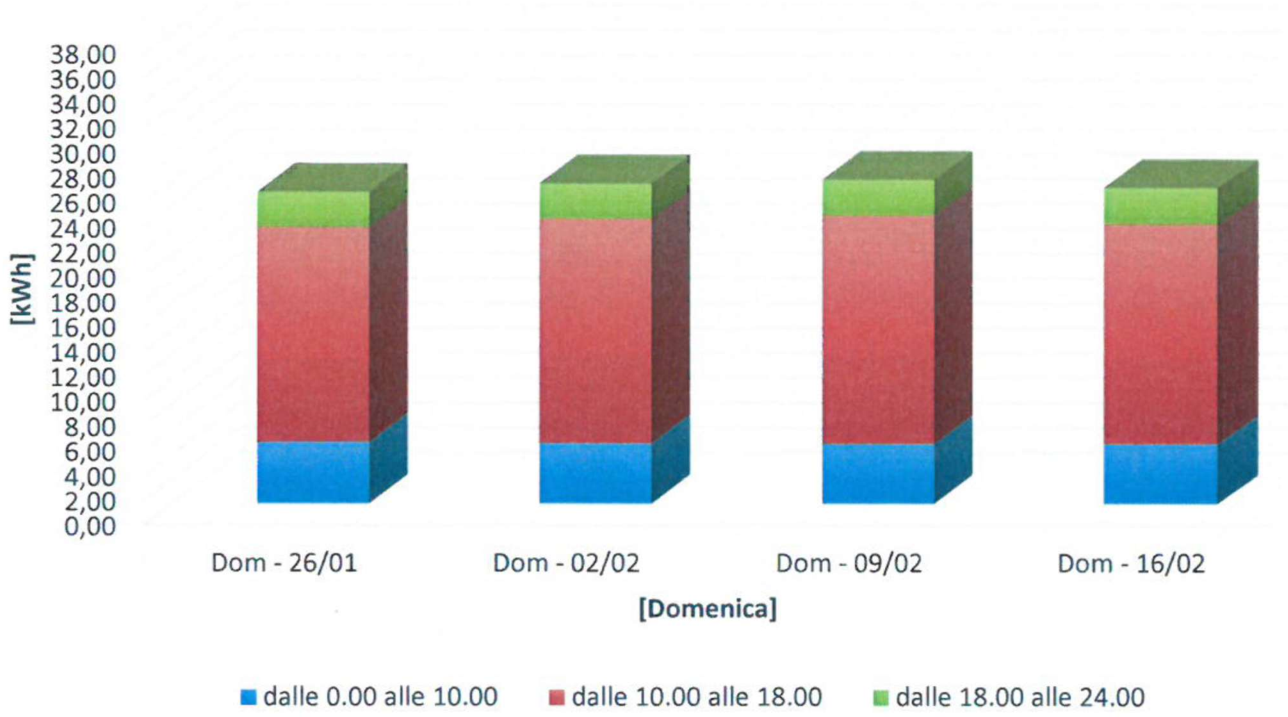
[Saturday]

From 0.00 to 8.30 a.m. *from 8.30 a.m. to 8 p.m.* *from 8.00 a.m. to 12 p.m.*



[Saturday 25/01]

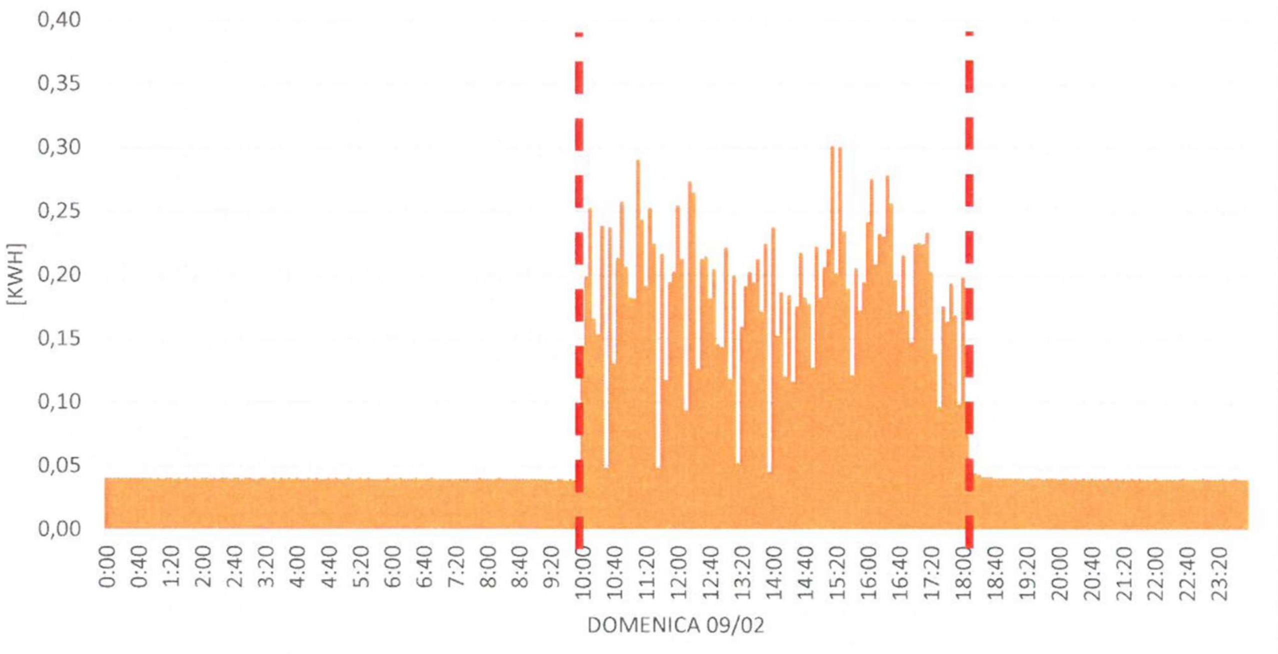
3) Sunday (opening hours: 10 a.m. - 6 p.m.)



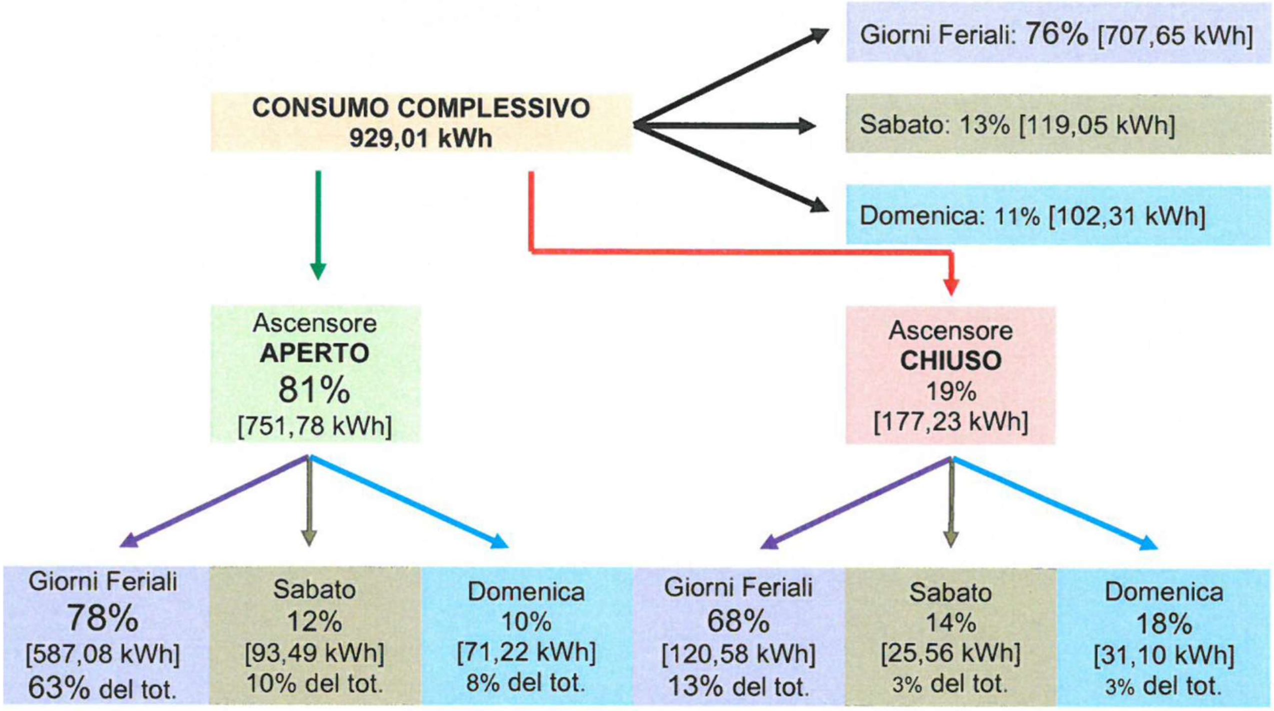
[Sunday]

from 0.00 to 10 a.m. from 10 a.m. to 6 p.m. from 6 a.m. to 12 p.m.

The chart below shows the trend over the 24 hours of a typical Sunday (February 9, 2020).

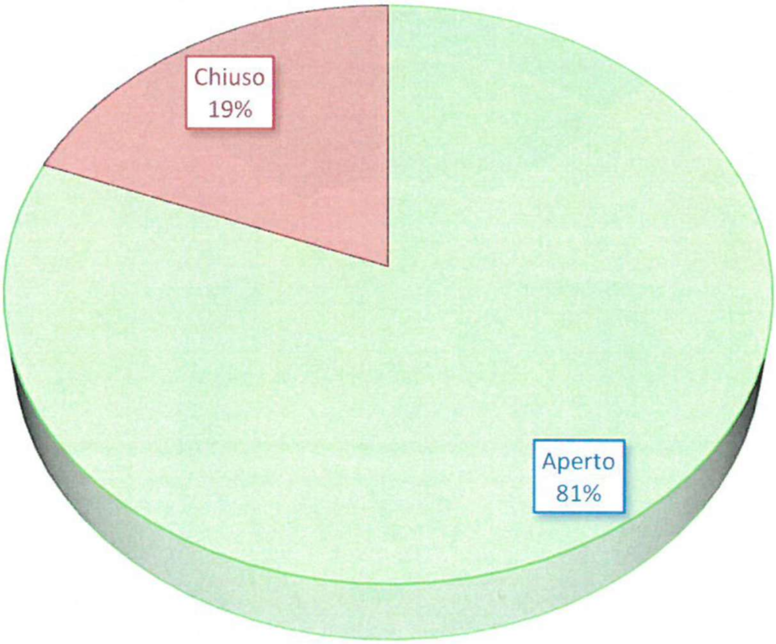


Overview of power consumptions:



CONSUMO COMPLESSIVO	*TOTAL CONSUMPTION*
Giorni feriali	*Weekdays*
Sabato	*Saturday*
Domenica	*Sunday*
Ascensore APERTO	*Elevator OPEN TO PUBLIC*
Ascensore CHIUSO	*Elevator CLOSED TO PUBLIC*

The following chart show the breakdown of the data reported in the previous block diagram.



The percentages shown in the chart and in the block diagram refer to the total power consumption in a typical month.

POWER ABSORPTION

The trend of the power absorption of the system is related to the various phases of operation and to the load carried by the cabin.

The elevator operating phases are:
1) Cabin stationary at the top station with counterweight mass at lower end
2) Cabin moving towards the lower station and counterweight mass moving uphill
3) Cabin stationary at the lower station with counterweight mass at top end
4) Cabin moving towards the top station and counterweight moving donwhill

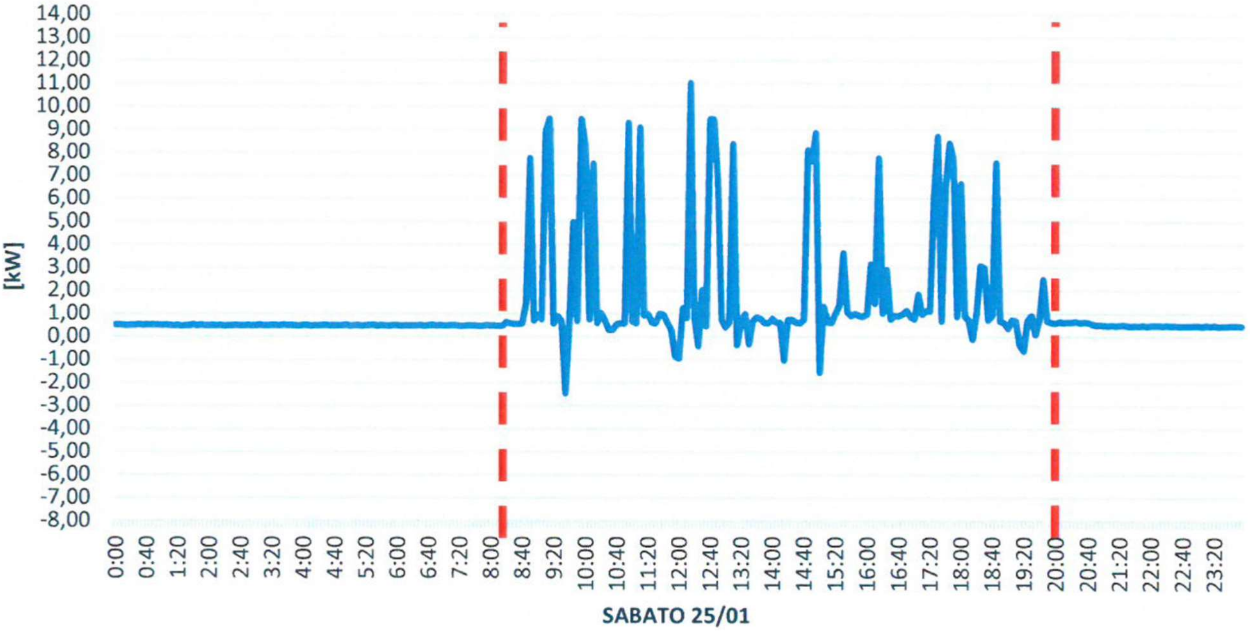
In phases 1 and 3 the system power consumption is close to zero (minimum absorption required to power the system management services and the lighting of cabin interior, cabin access platforms and, in the dark hours, elevator service lighting).

In phase 2, the power absorption depends on the load that is carried in the lift cabin. If the cabin is empty or there are only a couple of people, the lift consumption is higher due to the need to move the counterweight uphill. In this situation there is a maximum peak of 10kW which then drops rapidly to 6 - 5 - 4 kW to reach zero when the cabin stops.
The situation is different when the cabin load increases as the cabin weight "helps" to win the weight of the counterweight, therefore reducing energy consumption.

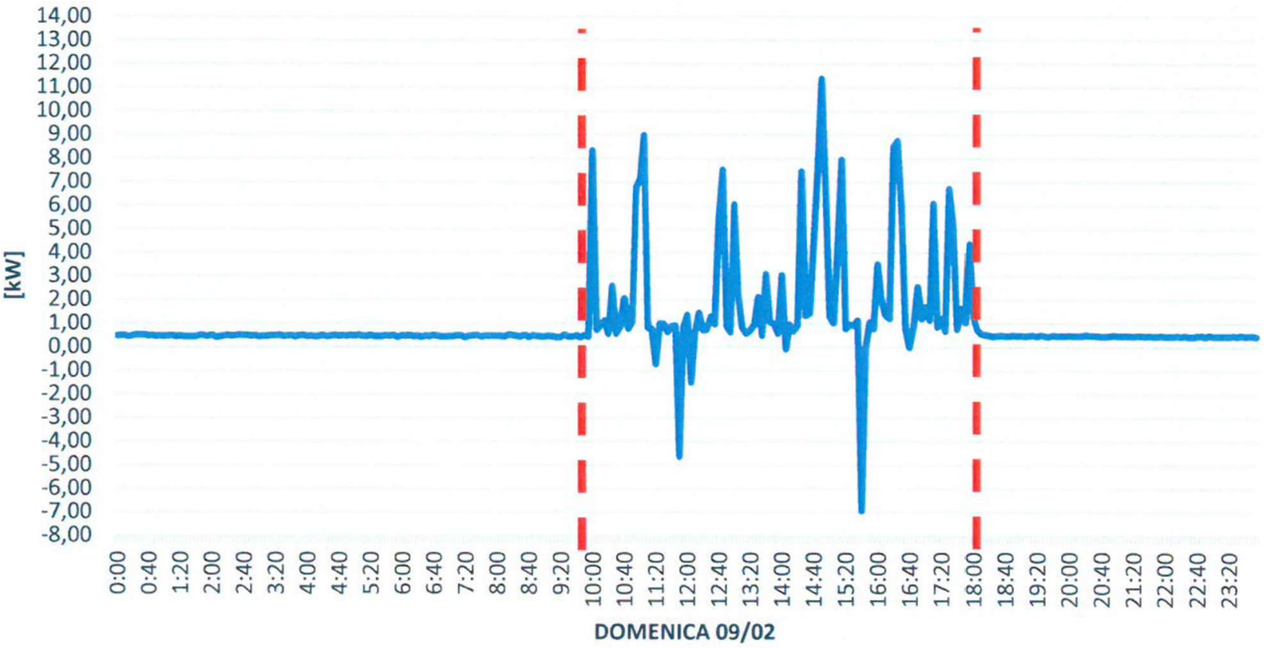
As for phase 2, also in phase 4 power consumption depends on the load carried by the lift cabin: there is no consumption (indeed there is power generation) when the cabin moves up empty or with a couple of people. As the load increases the absorption also increases, although it tends to be lower than when the empty cabin is moving downhill.

The chart below shows the trend over the 24 hours of a typical weekday (Thursday, February 6, 2020).

The chart below shows the trend over the 24 hours of a typical Saturday (January 25, 2020).



The chart below shows the trend over the 24 hours of a typical Sunday (February 9, 2020).



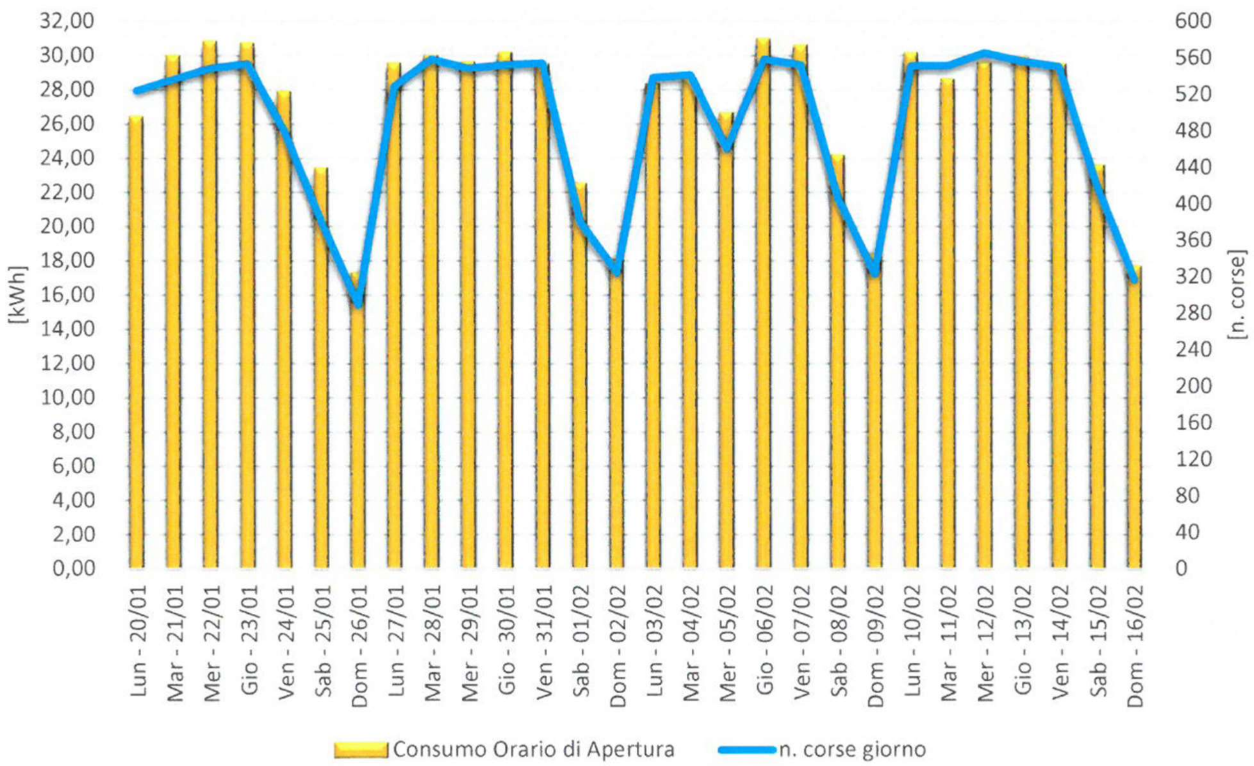
USE OF THE PANORAMIC LIFT

For a comparison between power consumption and the number of daily rides, we have considered the period between January 20 and February 16, in which the elevator performed 13,637 trips.
On average, the number of daily rides is 487, distributed as follows:

- Monday 535
- Tuesday 547

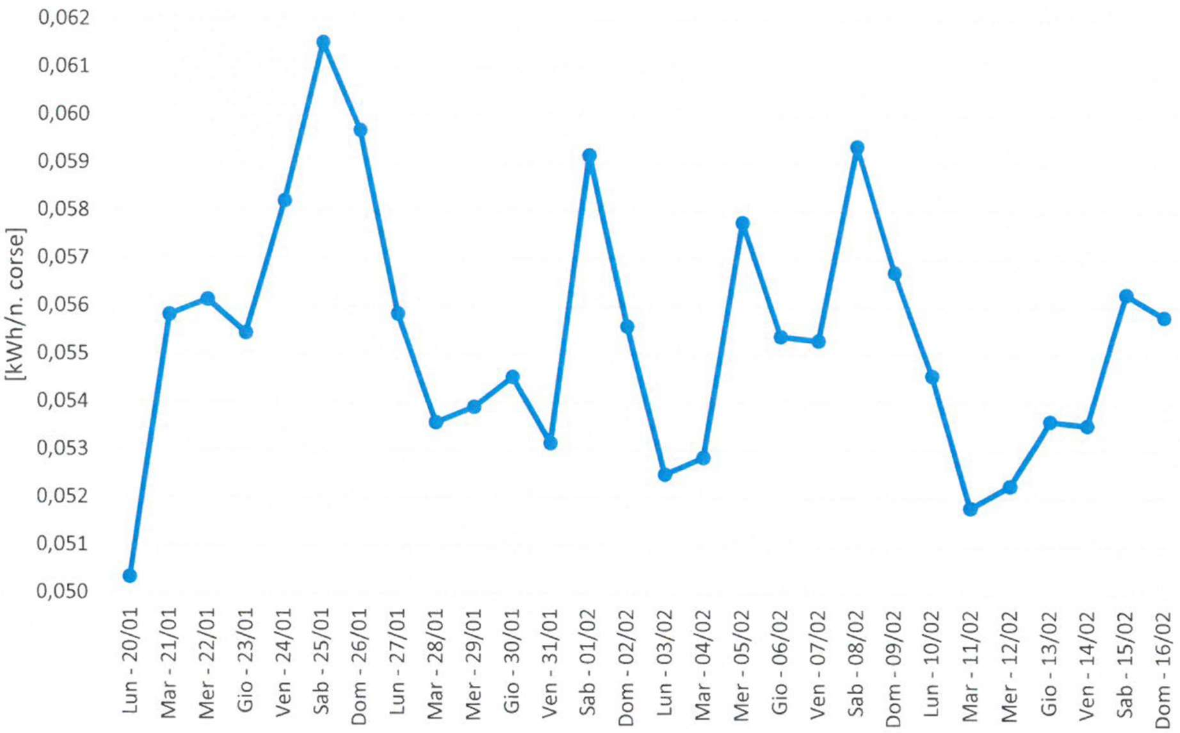
- Wednesday 530
- Thursday 555
- Friday 534
- Saturday 396
- Sunday 313

The following bar chart shows the power consumption trend recorded during the public opening hours of the elevator compared with the daily number of trips made.



Consumption during operning hours *N. of rides per day*

The ratio between the electrical kWh consumed by the system and the daily number of trips, gives the overall energy performance index represented in the diagram below:

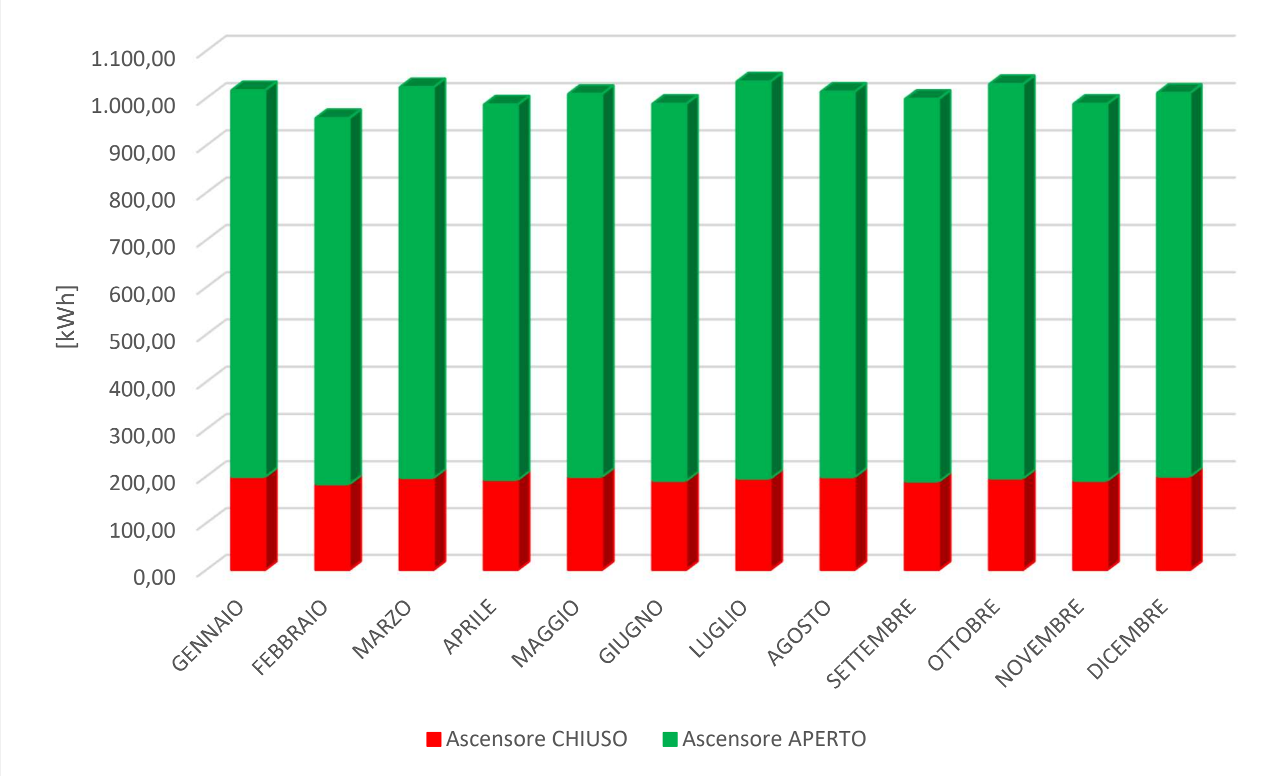


From the data obtained and represented in the diagram we can estimate the average power consumption required for each elevator ride.
On average, a single ride consumption is 0.055 kWh/ride, distributed among the various days of the week as follows:

- Monday → 0.053 kWh/ride
- Tuesday → 0.054 kWh/ride
- Wednesday → 0.055 kWh/ride
- Thursday → 0.055 kWh/ride
- Friday → 0.055 kWh/ride
- Saturday → 0.059 kWh/ride
- Sunday → 0,.057 kWh/ride

ANNUAL CONSUMPTION

The bar diagram below shows the overall power consumption trend in the 12 months of a typical year and makes a distinction between the opening hours to the public and the closing time.



Elevator OPEN to public *Elevator CLOSE to public*

2. CONSTRAINTS AND REFERENCE STANDARDS

2.1. Technical standards

2.1.1. Technical and quality requirements

- Law n.186 of 01-03-68 (Construction and realization of electrical materials and installations in a workmanlike manner)
- Ministerial Decree n. 37 of 22-01-08 (Regulation concerning the enforcement of article 11-quaterdecies, paragraph 13, letter a) of Law n. 248 of December 2, 2005 for the coordination of the provisions on systems installation inside buildings) and subsequent amendments and additions.
- CEI 0-21 (Reference technical rules for the connection of active and passive users to the LV electrical utilities - and subsequent variants)
- CEI 17-13/1 (Low voltage switchgear and controlgear assemblies - LV switchboards). Part 1: Type-tested assemblies (AS) and partially type-tested assemblies (ANS))
- CEI 17-13/2 (Low voltage switchgear and controlgear assemblies - LV switchboards). Part 2: Particular requirements for busbar trunking systems)
- CEI 64-8 and following variants (Power installations with rated voltage not exceeding 1000V AC and 1500V DC).
- IEC EN 61936-1 (CEI 99-2) (Power installations exceeding 1 kV a.c. Part 1: Common rules)
- CENELEC EN 50522 (CEI 99-3) (Earthing of power installations exceeding 1 kV a.c.)
- Guide CEI 11-37 (Guide for the implementation of earthing systems in user energy systems powered at a voltage greater than 1 kV)
- CEI 20-13 (Cables with extruded rubber insulation for rated voltages from 1 to 30 kV)
- CEI 20-38 (Rubber insulated cables which do not propagate fire and generate low levels of toxic and corrosive gases Part I - Rated voltage Uo/U not exceeding 0.6/1 kV)
- CEI 20-45 (Elastomeric compound insulated cables, fire resistant, non-fire propagating, halogen-free (LSOH) with rated voltage Uo/U not exceeding 0.6/1 kV)

- IEC EN 60079-10-1 (CEI 31-87) (Explosive atmospheres Part 10-1: Classification of areas. Explosive gas atmospheres)
- IEC EN 60079-14 (CEI 31-33) (Explosive atmospheres Part 14: Design, selection and installation of electrical systems)
- CEI 31-35 (Guide to the classification of areas with explosion hazard due to the presence of gas in application of IEC EN 60079-10-1 (CEI31-87))
- Construction Products Regulation 305/2011/EU

2.1.2. Required certifications

The installation contractor shall produce and provide the following documents:
- User and Maintenance Manual, including recommended maintenance schedules;
- Declaration certifying all tests and inspections carried out and relevant results;
- Declaration of Conformity in accordance with the Ministerial Decree n. 37 of 22/01/2008 and subsequent amendments and additions;
- Certification issued by an accredited test laboratory for conformity to IEC EN 61215 for crystalline silicon modules and to IEC EN 61646 for thin-film modules;
- Certification issued by an accredited test laboratory about the conformity of the DC/AC converter to the standards in force and, in particular, to CEI 11-20 when the integrated converter interface is used;
- Guarantee Certificates for the equipment installed;
- Full guarantee for the complete system and its operating performance.

2.2. 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 might hinder the realization of the works. The public land on which the infrastructure will be built already hosts a permanent transport system on which we shall intervene by integrating photolvoltaic panels on the existing fencing, with no changes to the layout of the transport system.
The impact resulting from the presence of photovoltaic panels is inherent in the choice of the technological system, which however allows to optimize the use of energy needed to operate the inclined lift, with positive implications on the environmental sustainability of the infrastructure. However, an attempt has been made to mitigate the visual impact by reducing the original size of the photovoltaic array and limiting it to an area along the lower part of the runway, thus significantly reducing the cone of visual perception of the panels from the areas located on the right bank of the River Gesso.
The building site is located beyond the 150 m buffer zone from the River Gesso, but falls within the boundaries of the River Park Gesso and Stura (Galassini), so it is within a nature conservation area under Legislative Decree 42/204. In this regard, in the course of the preliminary investigation of the final project we have obtained the required landscape authorization.

2.3. Energy production license legislation

Pursuant to Legislative Decree no. 112 of 31 March 1998 and Regional Law no. 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 MWt, including plants powered by renewable sources as per Legislative Decree 387/03. 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 28/2011 or after simple notification to the municipality responsible for the territory.
The interventions that can be carried out by means of PAS or communication are shown in the following table.

Fonte	Condizioni da rispettare			Regime urbanistico / edilizio
	Modalità operative / di installazione	Ulteriori condizioni	Potenza	
Fotovoltaica	1) Impianti aderenti o integrati nei tetti di edifici esistenti con la stessa inclinazione e lo stesso orientamento della falda e i cui componenti non modificano la sagoma degli edifici stessi 2) La superficie dell'impianto non è superore a quella del tetto su cui viene realizzato	Gli interventi non ricadono nel campo di applicazione del decreto legislativo 22 gennaio 2004, n. 42 e s.m.i. recante Codice dei beni culturali e del paesaggio, nei casi previsti dall'articolo 11, comma 3, del decreto legislativo n. 115 del 2008	-	Comunicazione
	Realizzati su edifici esistenti o sulle loro pertinenze	Realizzati al di fuori della zona A) di cui al decreto del Ministro per i lavori pubblici 2 aprile 1968, n. 1444	0-200 kW	Comunicazione
	1) Moduli fotovoltaici collocati sugli edifici 2) Superficie complessiva dei moduli fotovoltaici dell'impianto non superiore a quella del tetto dell'edificio sul quale i moduli sono collocati	Nessuna	-	PAS
	Nessuna	Nessuna	0-20 kW	PAS

Source Conditions required

	Operating/installation modes	Other conditions	Power	Town planning/building regulations
PV	1 Systems in contact or integrated in the roofs of existing building having the same roof pitch inclination and orientation and components that do not change the building shape. 2 The system surface area does not exceed theat oft he roof where it is installed	The works do not fall within the scope of Legislative Decree No. 42 of January 22,3004 and subsequent amendments, containing the Code of Cultural Heritage and Landscape, in the cases provided for by art. 11, paragraph 3 of Legislative Decree n. 115 of 2008		Communication
	Built on existing buildings or relevant properties	Built outside zone A) referred to in the decree of the Minister for Public Works no. 1444 of April 2, 1968.	0-200 kW	Communication
	1 PV modules located on buildings 2 Total surface area of PV modules does not exceed that of he building on which the modules are installed	None		PAS
	None	None	0-20 kW	PAS

3. STORAGE DESCRIPTION AND REQUIREMENTS

3.1. Product technical specifications

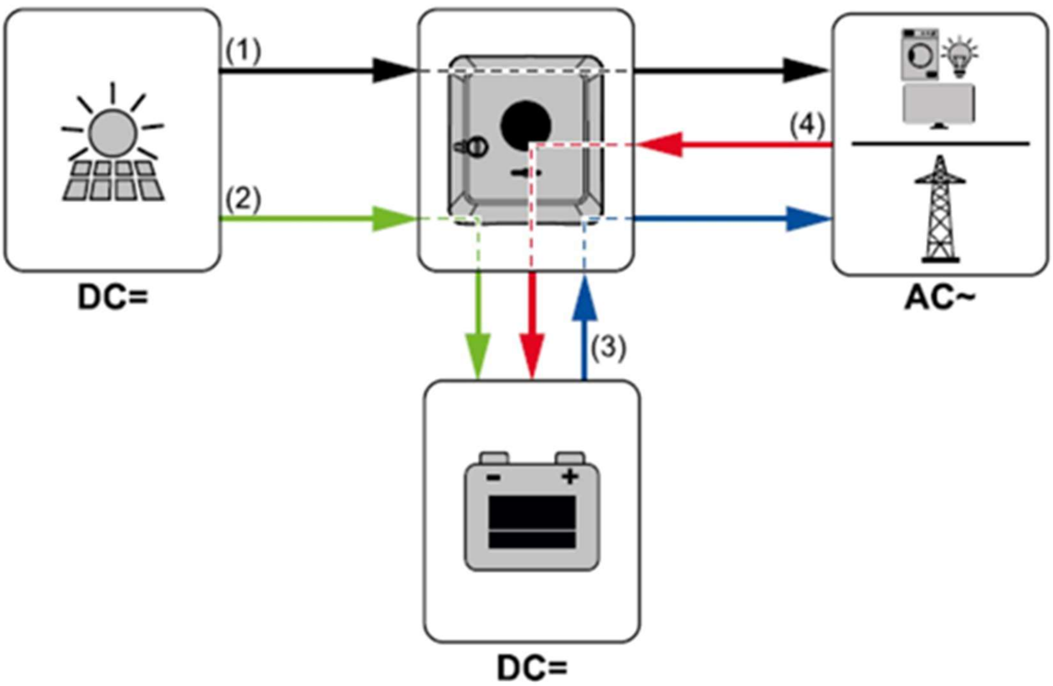
3.1.1. Storage technical requirements

A specific storage unit consisting of a battery pack, with electronic controls and commands, will be supplied and installed in order to enable the storage of the electrical power produced by the inclined lift and the backing photovoltaic field, and to make it available to the elevator system drive when necessary. Since it must be able to supply alternating current power to the user, the storage unit must be equipped with an inverter for DC to AC conversion. This type of device for energy storage is a “hybrid inverter”.
Following the spreading of photovoltaic systems and the greater flexibility required by these systems both for exchange operation and as "stand alone" systems, according to the requirements of power intake and/or continuity of operation, several products of this type are made available on the market for standardized power capacities, easily scalable through parallel connections. Thanks to a standardization of the equipment, the size of this storage - consisting of the inverter and its battery packs - was reduced to enable installation in small rooms or even on the wall. The inclined lift energy efficiency project will use 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 inclined lift drive, when working in power generation mode.

The battery pack will use 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 will be composed of 7 modules with rated capacity of 2.76 kWh/53 Ah for a total capacity of 19.32 kWh.
The storage unit will be connected to the inverter on the production side while charging/discharging is managed by the internal logic 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 will also accumulate the energy produced by the elevator when operating with unbalanced cabin and counterweight loads.

3.1.2. Configuration and relation of the storage with the grid and RES production plant

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 a 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 draw 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 utilities or stored in a battery and - if the utilities are fully charged and non-operating - fed into the grid.
As soon as the energy provided by the solar modules becomes insufficient, the elevator system draws 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:



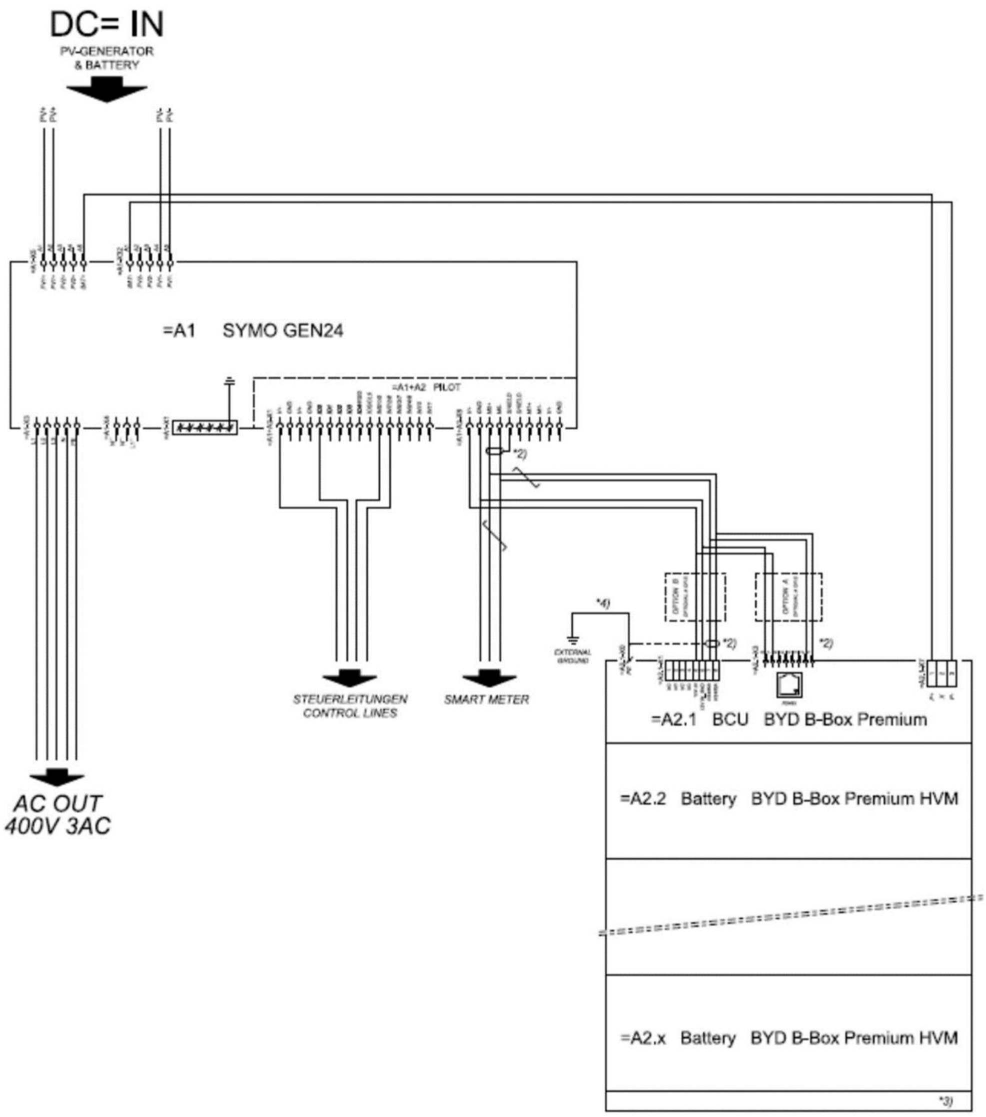
Description of energy flows:

(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 battery (storage) systems there are various conditions of operation related to energy flows:

1. . Normal operation: power is stored or drawn according to load requirement;
2. . Low battery: the battery has reached the minimum charge level specified by the manufacturer or set in the system configuration. The battery cannot be used any further until a new charge is made.
3. . Forced charging: the inverter recharges the battery to maintain the minimum level specified by the manufacturer or set in the system configuration.

Wiring diagram:



3.2. Performance requirements

SIMULATED ANNUAL POWER GENERATION FROM PV

The photovoltaic generator will consist of "monocrystalline" modules with 30 W rated power.

No. of modules:	26
Rated power	340 Wp
Cells:	Monocrystalline silicon cells
Open circuit voltage V_{OC}	41.36 V
Short circuit current I_{SC}	10.46 A
Voltage V_{MP}	34.63 V
Current I_{MP}	9.82 A
Efficiency:	16.33%
Size:	1,689 mm x 996 mm x 35 mm
Total panel area	1.689 mm x 996 mm x 26 = 45 m²

POWER CONVERSION SYSTEM.

The power conversion system consists of 1 static converter (inverter) with the following characteristics:

Input Pmax (d.c.):	15 kWp
Input Pmax (a.c..):	8 kVA
Permissible input voltage (d.c.)	80/800 V – 1000 V max
Max input current (d.c.):	25 A (12.5 A per MPPT)
Efficiency:	97.1 %
Weight:	25 kg

STORAGE UNIT

The storage unit consists of 7 modules with rated capacity of 2.76 kWh/53Ah for a total capacity of 19.32 kWh

Rated capacity of each module:	2.76 kWh
Battery module connection:	7 modules in series
Total rated voltage:	160/700 V
Max charge current:	22 A
Max discharge current:	22 A
Max charge/discharge power:	7.8 kW

3.3. Minimum project targets

Rerport in this paragraph about the calculation of the following KPIs, as described in D.T2.1.1.

In particular, for each KPI report about:

- The initial situation before the pilot investment (**baseline**)
- The **minimum target expected** thanks to the installation of the storage by the pilot action.

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

Status quo:

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

Background:

- Electrical energy consumption referred to the year 2018.

Target (prediction):

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

Background and assumptions:

- Predicted savings considering the self-consumption of electricity produced by PV system.

KPI2: External energy cost 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	Cost of the energy supplied by external sources
Input parameters & Calculation	Calculation method: 1. External thermal/electrical energy cost[1] 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 $E_{c,tot}$ [kWh] 3. External thermal/electrical cost of peak power taken from external sources 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 P_{peak} [kW] 5. Calculation of Key Performance Indicator: $KPI_2 = \Sigma\, [C_E(E_{c,i}) + C_P(P_{peak})]$
Measurement Unit	[€](tax included)
References	-

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

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

Background and assumptions:

- Average cost of the electrical energy supplied by external sources 2018 was considered equal to 0,20 [€/kWh]

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

Background and assumptions:

- Average cost of the electrical energy supplied by external sources 2018 was considered equal to 0,20 [€/kWh]

KPI3: Yearly CO_2 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** [tCO_2/kWh], e.g IPCC emission factors 3. Calculation of Key Performance Indicator: $\mathbf{KPI_3 = E_{c,tot} \times EF}$
Measurement Unit	[tCO_2]
References	Covenant of Mayor: http://www.eumayors.eu/IMG/pdf/technical_annex_en.pdf

Status quo:

$\mathbf{KPI_3 = E_{c,tot} \times EF}$ = 18,226 MWh_e × 0,483 t CO_2/MWh_e = 8,8 [tCO_2]

Background and assumptions:

- **EF** for consumed electricity = 0,483 [tCO_2/MWh_e]
- $\mathbf{E_{c,tot}}$ = 18,226 [MWh_e]

Target (prediction):

$\mathbf{KPI_3 = E_{c,tot} \times EF}$ = 12,226 MWh_e × 0,483 tCO_2/MWh_e = 5,9 [tCO_2]

Background and assumptions:

- **EF** for consumed electricity = 0,483 [tCO_2/MWh_e]
- $\mathbf{E_{c,tot}}$ = 12,226 [MWh_e]

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 $E_{self\text{-}RES}$ [kWh] 2. Total thermal/electrical energy consumption of the pilot system for one-year E_{TOT} [kWh] 3. Calculation of Key Performance Indicator: $KPI_4 = [E_{self\text{-}RES}/ E_{TOT}] \times 100\ \%$
Measurement Unit	[%]
References	Deliverable D.T3.2.4 "Validation report and establishment of the autarky rate tool & the checklist"

Status quo:

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

Background and assumptions:

- There is no self-production of a local RES system → $E_{TOT} = E_{c,tot}$.

Target (prediction):

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

Background and assumptions:

- $E_{self\text{-}RES}$ = 6.000 [€]

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: $KPI_5 = E_{self\text{-}RES}$
Measurement Unit	[kWh]
References	-

Status quo:

$KPI_5 = E_{self\text{-}RES} = 0$ [kWh]

Background and assumptions:

- **See KPI_4.**

Target (prediction):

$KPI_5 = E_{self\text{-}RES} = 6.000$ [kWh]

Background and assumptions:

- **See KPI_4.**

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	-

Status quo:

$KPI_6 = N_{no\_interrupt} / N_{tot} \times 100\ \% = 99$ [%]

Background and assumptions:

- N_{tot} = 4317,38125 [h], average value of the last 8 years (2012-2019)
  - The slope elevator is operated the whole year.
- $N_{no\_interrupt}$ = 4295,19375 [h], average value of the last 8 years (2012-2019)
  - The hours with interruption of the service taken into account are only those ones related to electric system failures

Target (prediction):

$KPI_6 = N_{no\_interrupt} / N_{tot} \times 100\ \% = 99$ [%]

Background and assumptions:

- It is assumed that the number of interruptions/discomforts are not reduced by the integration of storage system in the future.

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 $P_{peak,month}$ [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	-

Status quo:
KPI_7 = 5 [kW]

Background and assumptions:

	Peak	[kW]
$P_{peak,January}$	4	[kW]
$P_{peak,February}$	5	[kW]
$P_{peak,March}$	5	[kW]
$P_{peak,April}$	4	[kW]
$P_{peak,May}$	5	[kW]
$P_{peak,June}$	5	[kW]
$P_{peak,July}$	4	[kW]
$P_{peak,Augus}$	5	[kW]
$P_{peak,September}$	5	[kW]
$P_{peak,October}$	5	[kW]
$P_{peak,November}$	6	[kW]
$P_{peak,December}$	5,44	[kW]

<u>Target (prediction):</u>

KPI_7 = 5 [kW]

Background and assumptions:

- No reduction in absorbed power is foreseen.

KPI8: Profitability

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	No
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	-

Status quo:
Not applicable.

Target (prediction):
KPI8 = NPV / I0 = -0,71 [-]

Background and assumptions:

- I0 = 95.000 [€]
- Rt = 1.388 € [€] → Difference between net cash outflow (cost for energy before investment) and net cash outflow (cost for energy after investment) plus the economic valorisation of the energy fed into the grid assumed to be constant over the entire period
- t = 20 [a] → The number of time periods is assumed to be 20 years according to the technical life of the pilot (defined in KPI9)
- i = 0 [%] → internal rate
- NPV = -67.245 [€] → Net Present Value after t time periods

KPI9: Stimulation of the local economy

Applicability for objects of assessment

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

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	-

Status quo:
Not applicable.

Target (prediction):
$KPI_9 = (CAPEX+OPEX) * r / K = 0{,}48$ [-]

Background and assumptions:

- *CAPEX* = 96.356,99 [€]
  - Estimated costs of planned measures on the basis of the offers obtained from vendors
- *OPEX = 0 [€]*

In case of our pilot the Operation and Maintenance costs are not calculated, because it is about reducing the cost of energy supplied from external distributer

3.4. Life cycle costs

A breakdown of the economic framework of the energy efficiency investment for the Cuneo elevator is provided below:

Upset price for technical room works	€	31.435
Upset price for photovoltaic array works	€	23.053
Upset price for electrical systems and equipment works	€	16.333
Construction site preparation and safety equipment	€	1.462
Contingencies and work on a time-and-materials basis	€	72
Electrical drive upgrade	€	2.440
Designing, works management, security, accounting	€	7.210
INARCASSA (4%) for designing, works management, security, accounting	€	288
VAT (22%) on designing, works management and accounting	€	1.650
Bid management	€	723
Tender and advertising costs	€	250
Static testing	€	952
GSE procedure	€	1.903
VAT on works	€	7.228
TOTAL	€	95.000

A maintenance schedule for the structural parts of the project is available. With regard to electrical and electronic equipment, reference should be made to the directions provided directly by the device manufacturers according to the product certifications supplied by the selected supplier.

3.5. Process related specifications

3.5.1. Timeframe

Activity/Phase	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21
Executive design								
Tenders								
Execution of works								
Connection to the grid								
Final testing								
Verification of performance								

3.5.2. Environmental management

The inclined lift energy efficiency project will lead to the realization of a 'stand alone' model operating independently of the public power grid, allowing greater operational flexibility and responding to the most recent guidelines for the optimization of energy resources.

The sizing of the entire storage system and photovoltaic array was based on the maximum nominal power of the inclined lift and on the requirement to install the panels along the system runway. When choosing

the type of solar panels, we opted for "monocrystalline" modules, consisting of monocrystalline silicon crystals oriented in the same direction. Due to their higher yield, monocrystalline modules need a smaller surface area to generate the same amount of energy. This solution allows to minimize the surface of the photovoltaic array to be built along the runway, thus reducing its environmental impact. The total surface area of the panels in this project is about 42-45 m^2, providing a nominal peak electric power generation of about 8.84 kW.
The battery pack will use 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 key benefits of LiFePO4 batteries are high thermal resistance, ageing resistance, higher peak current and the use of iron, which, unlike cobalt, has a lower environmental impact.

3.5.3. Additional activities

MONITORING

Consumption monitoring sessions will be scheduled following the completion of the project. The planned energy data monitoring system allows to track and monitor the energy consumed, produced and self-produced by the elevator. This can be done through the acquisition of energy data from specific energy meters installed in the electrical system. The recorded data are sent periodically (daily, weekly and monthly) via email in .csv format to be analysed and archived.
The monitoring system architecture is as follows:

- data is collected from a gateway located in the company's Lan network;
- data reading devices, positioned along the power lines of the machines, transmit the data to the gateway via Modbus RS485 network;

The gateway collects all the information from the Modbus RS485 port and transmits it periodically via email in .csv format for remote energy management and data processing.

MAINTENANCE INSPECTIONS AND CHECKS

Below is a list of the periodic inspections and checks to be carried out on the electrical system:

- Safety circuit breakers;
- Earth resistance;
- Equipotential bonding connections.

The installation being subject to annual inspection by the authorized body (USTIF), these tests are carried out during these tests independently of the legal requirements in force.

4. RISK ASSESSMENT

4.1. Risk assessment for the work execution phase

Before delivery and commissioning, the electrical installation contractor must carry out the necessary tests to ensure compliance of the electrical system with the standards.
The tests to performed by the installer shall be carried out in compliance to the directions contained in the CEI 64-8/6 standard, and are grouped into:

- visual examination,
- tests.

Visual examination is a general visual inspection of the electrical system to assess its workmanlike execution, without the use of instrumental tests.
As for the tests, the following measurement shall be carried out:

- continuity check of PE conductors and equipotential conductors;
- earth resistance and fault loop impedence;
- step and touch potential;
- insulation resistance to earth.

4.2. Risk assessment for the operational phase

The electrical installation contractor shall guarantee all the systems supplied for a duration of 12 months. During such period, the contractor shall be responsible for all repairs, replacements and provision of spare parts that may become necessary as a result of the poor quality of the materials used. The warranty excludes the repairs of any damage caused by the inexperience of the personnel in charge with system operation. During the warranty period, the systems cannot be modified or otherwise tampered with by the customer, or by personnel appointed by the customer, that are not the contractor's authorized personnel. Failing this, the latter will be automatically exempted from warranty obligations for the part of the system that has been tampered with.

5. PROCUREMENT PROCEDURE

5.1. Type of tendering procedure

The contractor for the works shall be appointed by direct award procedure in accordance with art. 1 - paragraph 2, letter a) - of the Decree Law n. 76/2020, after a request for proposals sent to 3 economic operators, previously identified as included in a special list in the acts of the Municipality, with final awarding according to the criterion of the lowest price;

5.2. Eligibility criteria for the procurer

See item 5.1

5.3. Minimum technical specifications

See D. T1.2.1 "Feasability study for implementing energy storages in Cuneo (IT)"

5.4. Procedure and award criteria and scores

See item 5.1

5.5. Communication and publicity requirements

Contractors are requested to respect the branding rules of Interreg Central Europe program.
Specify in the tender documents that the construction sites and final storage installations are requested to include billboards or a plaque with the following information in English or national language:

- Information on the total public financial support received by the project
- contact details of the lead partner (name, address, e-mail and website)
- Project logo
- Description of the main project objective
- Objective of the supported activity including the address of the project website

At least one poster (minimum size A3) has to be placed on the construction or at a place nearby visible to the public.