

# THE ENERGY TRANSITION OF CTM CAGLIARI



The Clean Bus Europe Platform is financed by the European Union.





## SPEAKERS

### **Luigi Di Stasio – CTM**

Maintenance Manager

Phone: +39 070 2091 348

Mail: [luigi.distasio@ctmcagliari.it](mailto:luigi.distasio@ctmcagliari.it)



### **Francesco V. Caredda – CTM**

Maintenance Engineer

Phone: +39 070 2091 345

Mail: [francesco.caredda@ctmcagliari.it](mailto:francesco.caredda@ctmcagliari.it)



# PROGRAMME



## THE ENERGY TRANSITION OF CTM CAGLIARI

9.20 – 9.30	Welcome	CTM
9.30 – 10.30	<ul style="list-style-type: none"><li>• Introduction</li><li>• Where we were – <i>“from ZeEUS to the present”</i></li><li>• Where we are</li><li>• Where are we going? – <i>“the energy transition of CTM”</i></li><li>• Fleet renewal plan – <i>“from diesel to full electric”</i></li><li>• Focus on 2023-2026 step</li><li>• Future plans</li><li>• Conclusions</li> <li>• Technical visits presentation</li></ul>	Luigi Di Stasio, CTM Francesco Caredda, CTM
10.30 – 10.50	Questions & Answers	

# INTRODUCTION

THE ENERGY TRANSITION OF CTM CAGLIARI





# 1

## INTRODUCTION: The City of Cagliari

- Cagliari is the regional capital of the Italian island of Sardinia, located in the centre of the Mediterranean Sea.
- The city has about **150,000** inhabitants and is the main centre of the *Cagliari Metropolitan City* that includes **23** smaller neighbouring municipalities
- The population of the Metropolitan area is about 480,000 inhabitants.







# INTRODUCTION: CTM in numbers



CTM is a fully public owned company that operates the public transportation in Cagliari's urban area.

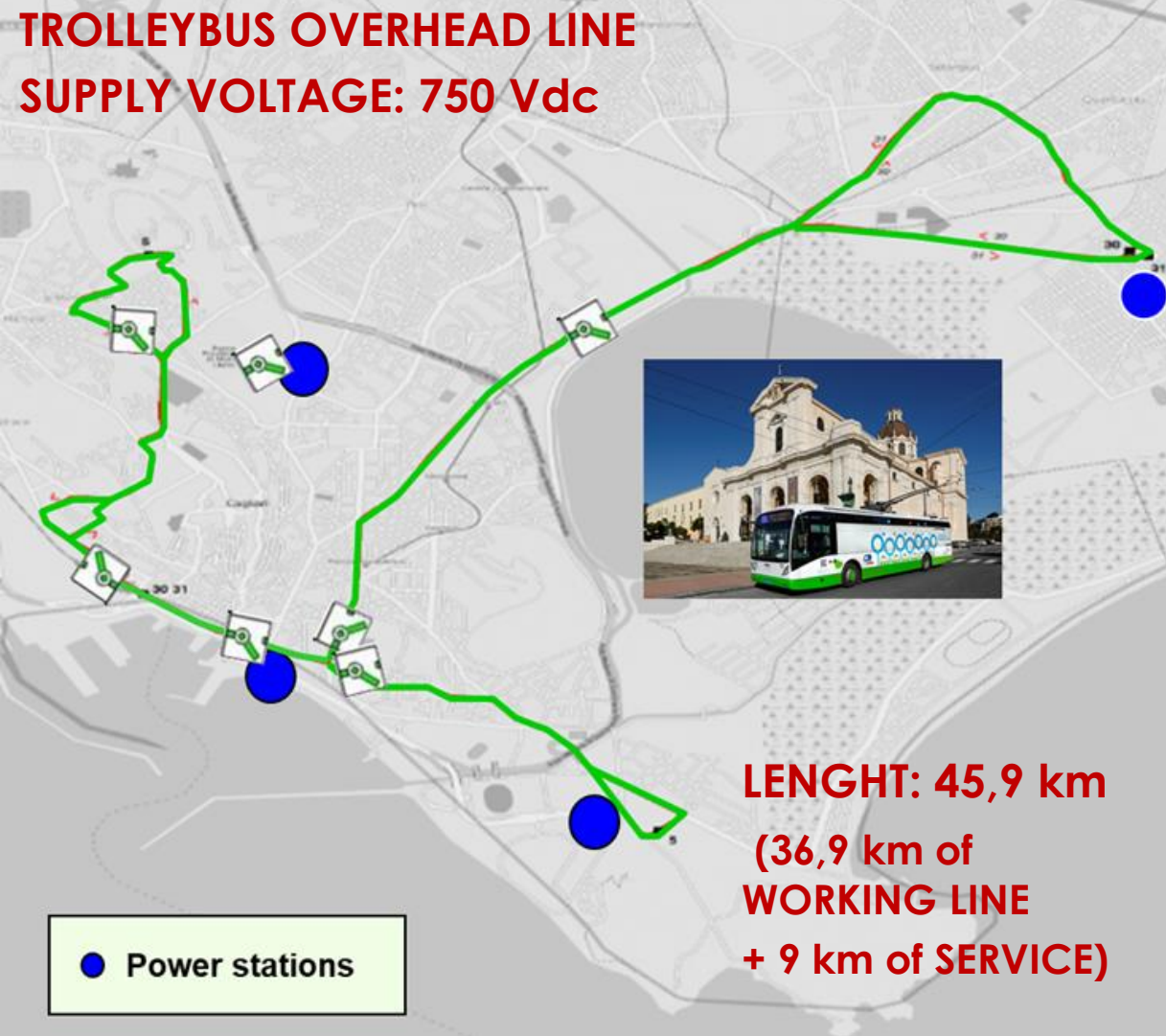
- **Population served:** 385.000 inhabitants
- **Lines:** 32, out of which **3 trolleybus lines**
- **Length of the network:** 434 km
- **Vehicles km/year:** 12.400.000
- **Average Commercial Speed:** 16 km/h
- **Mean frequency (peak hours):** 9 min
- **Bus fleet:** 271 (239 buses, 32 trolleybuses)
- **Fleet average age:** 10,0 years  
(10,2 buses - 8,8 trolleybuses)



THE ENERGY TRANSITION OF CTM CAGLIARI

(Data at December 31<sup>st</sup> 2022)

## OVERHEAD LINE

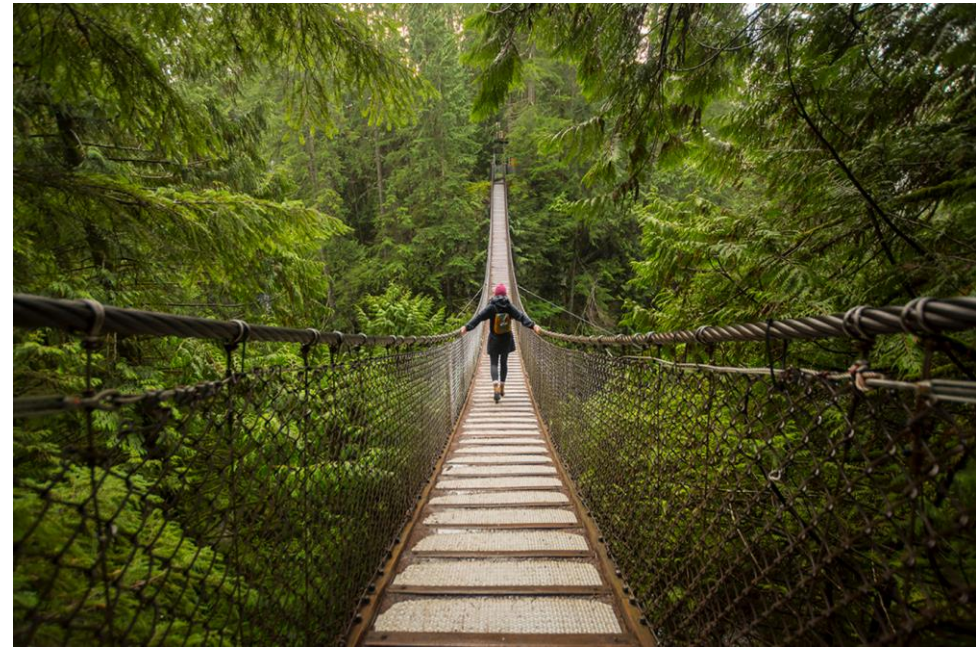


## VEHICLES

	Model	Nr.
	(2012) Solaris Trollino T12	16
	(2016) Solaris Trollino T12 Lithium Titanate Battery (37 kWh)	2
	(2016) Kiepe Van Hool A330T	10
	(2016) Kiepe Van Hool A330T Lithium Titanate Battery (23 kWh)	4
	<b>Total</b>	<b>32</b>

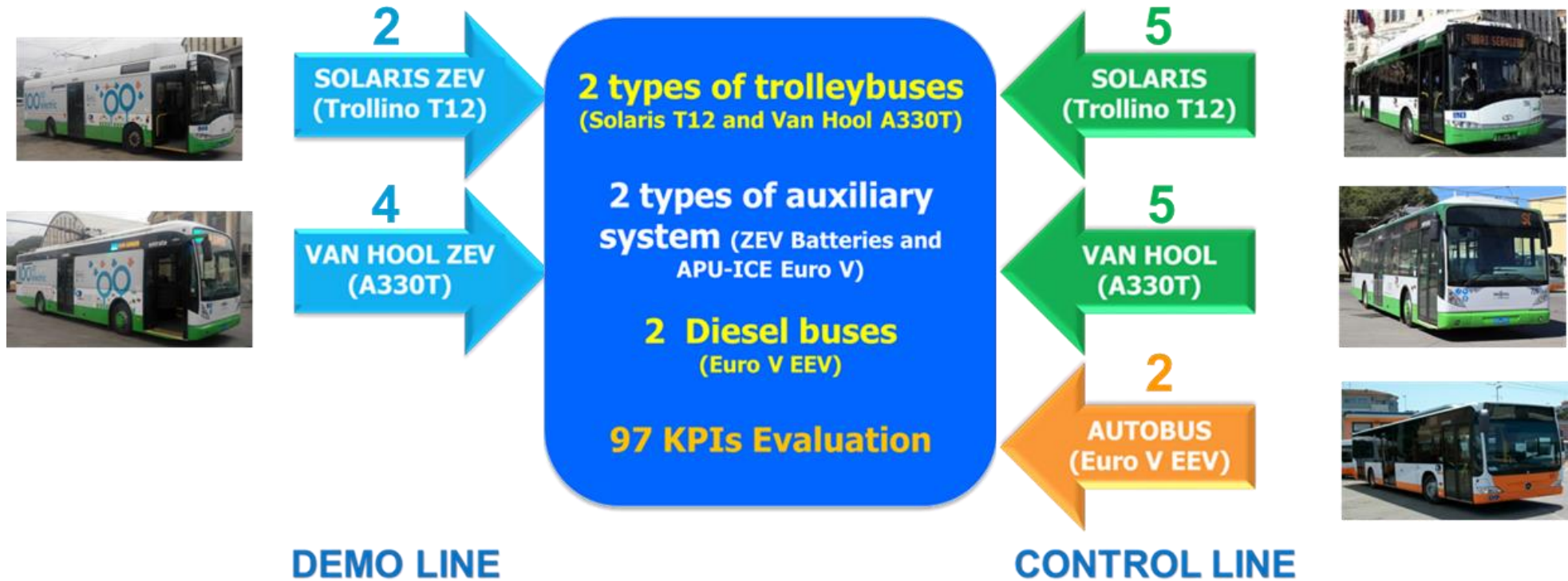


# WHERE WERE WE



## STARTING POINT: ZeEUS Project (2016-2017)

**Main Task:** To experiment the use, in the ordinary scheduled service, of a ZEV trolleybus fleet, powered with innovative technologies to use in the sections without overhead line, in order to evaluate **performance, efficiency, reliability, economic and environmental sustainability.**



**Evaluation process:** during the test CTM is collecting different data that allow to calculate **97 Key Performance Indicators (KPI)**, used to compare the **performance** of different **vehicles**.



# WHERE WERE WE

## STARTING POINT: ZeEUS Project (2016-2017)

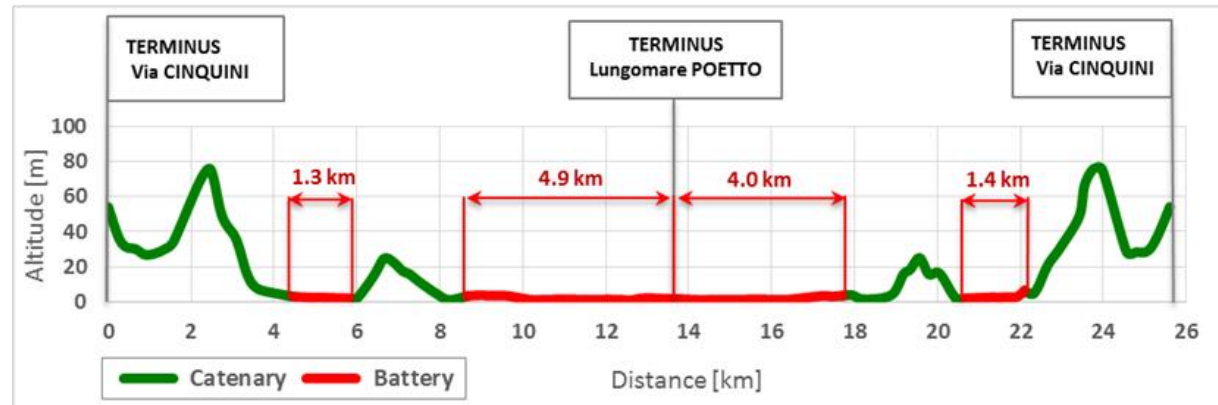
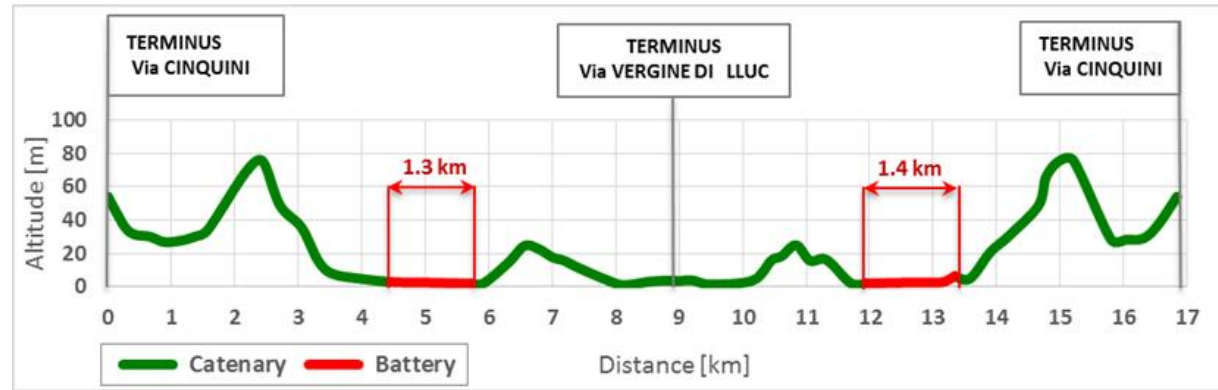


	Winter Configuration	Summer Configuration
<b>Length</b>	<b>16.8 km</b> (round trip)	<b>25.4 km</b> (round trip)
<b>Days of demo operation</b>	296 days	193 days
<b>Number of bus stops</b>	57	83
<b>Average daily travelled distance</b>	180 km ( <b>19%</b> off-wire)	213 ( <b>46%</b> off-wire)
<b>Frequency</b>	8-10 minutes	8-10 minutes
<b>Commercial speed</b>	12.9 km/h	13.6 km/h

Nr. Of Demo test days: **501**  
(from March 2016 to September 2017)

Summer Configuration of Line5ZeEUS still in service today

(Technical Visit Nr.2)





### Phase 1 (December 2020 – June 2021)

Deployment of **3** electric buses (Rampini E60) with plug-in charging



### Phase 2 (February – December 2022)

Deployment of **8** electric buses (Rampini E60) with pantograph charging







## WHERE WERE WE

### Electric buses deployment (2020-2022)



Short e buses (6 m) used to bring electric public service within the historic centre of the city







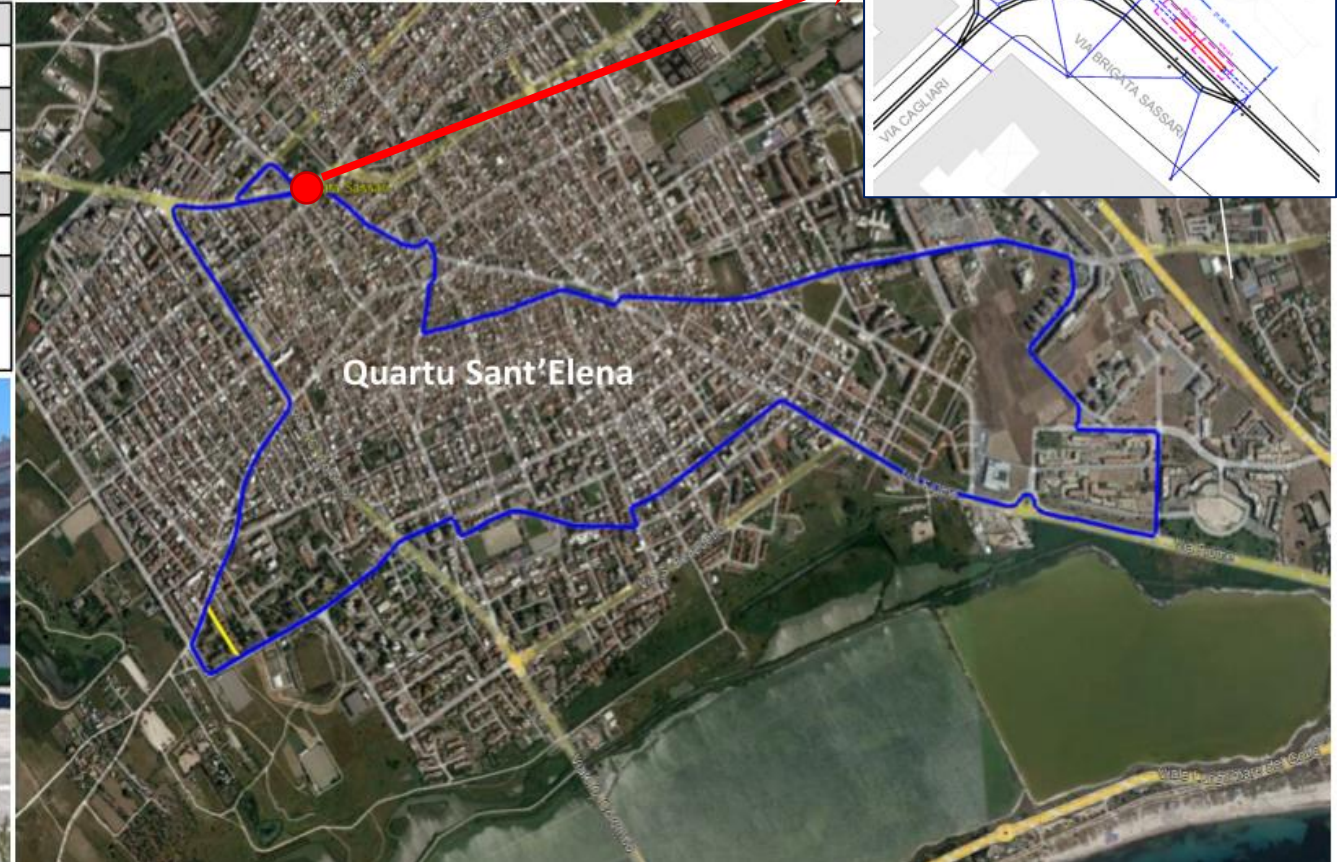
# WHERE WERE WE

## Integration between trolleybus infrastructures - electric buses (2022)



Line 40 is operated by e buses with pantograph (fast charging at terminus - slow charging at depot). Charging at the terminus with pantograph, connecting the electric bus to the existing trolleybus overhead line. [\(Technical Visit Nr.1\)](#)

DATI DI SINTESI - LINEA 40	
Lunghezza di esercizio	9 Km
Mezzi impiegati	3 fino ore 15:30, 2 fino a fine servizio
Operatività servizio	Lun.-Sab. inizio h 5:56 fine h 22:54
Frequenza	13 min in hdp
Media pax trasportati	[19 pax/corsa] periodo invernale
Max coeffi. Occup. a bordo	52%
Produzione chilometrica autorizzata RAS anno 2022	146.857 Km/anno







# WHERE WERE WE

## Expansion of electric lines with trolleybus infrastructures (2016-2022)



TROLLEYBUS



### TROLLEYBUS

Power supply + battery charging system in motion  
40-80 kW



*Extension of trolleybus service, without new wires*

### CATENARY



Connecting device

**TROLLEY POLES ≠ PANTOGRAPH**

### ELECTRIC BUS

Stationary charging system  
20-70 kW



*Extension of the trolleybus infrastructure capabilities*





## WHERE WERE WE

# Expansion of electric lines with trolleybus infrastructures (2016-2022)

**1 infrastructure, 3 ways to use it (traditional trolleybuses, IMC trolleys, Electric buses with pantograph)**



### Overhead Line (37 km)

- 3 Trolleybus lines: 5-30-31/QEX

### Trolleybus service extension (9 km) (ZeEUS Project)

- Line 5ZeEUS (operated from mid June to mid September by trolley-hybrids with In Motion Charging technology) - 2016

### Integration between ebus-catenary (pantograph charging at terminus)

- Line 40 (electric buses) – 2022



*Opportunity* charging from catenary with pantograph to **Line 10**

DATI DI SINTESI - LINEA 10	
Is Guadazzonis - Sant'Ignazio [Km]	6,716
Sant'Ignazio - Is Guadazzonis [Km]	6,142
Lunghezza di esercizio [Km]	12,858
Mezzi impiegati	4 fino ore 16:30, 3 fino a fine servizio
Operatività servizio	Feriali 6:00 - 22:00 Festivi . inizio h 6:05 fine h 21:25
Frequenza	13 min in hdp
Media pax trasportati	[25 pax/corsa] periodo invernale
Max coeffi. Occup. a bordo	69%
Produzione chilometrica autorizzata RAS anno 2022	268.777 Km/anno



LINEA	GIORNI	INIZIO	FINE	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
10	feriali	06:00	22:00				25	13	13	13	13	13	13	13	13	13	16	18	18	18	18	15	
	festivi	06:05	21.25				35	25	25	25	25	25	25	25	25	25	25	25	25	25	24	25	



*Opportunity* charging from catenary with pantograph to **Line 10**



### Overhead Line (37 km)

- 3 Trolleybus lines: 5-30-31/QEX

### Trolleybus service extension (9 km) (ZeEUS Project)

- Line 5ZeEUS (operated from mid June to mid September by trolley-hybrids with In Motion Charging technology) - 2016

### Integration between ebus-catenary (pantograph charging at terminus)

- Line 40 (ebuses), 9 km – 2022
- Line 10 (ebuses), 13 – 2023

**TOTAL: 31 km of more electric lines**  
**+84%**

# WHERE WE ARE



THE ENERGY TRANSITION OF CTM CAGLIARI





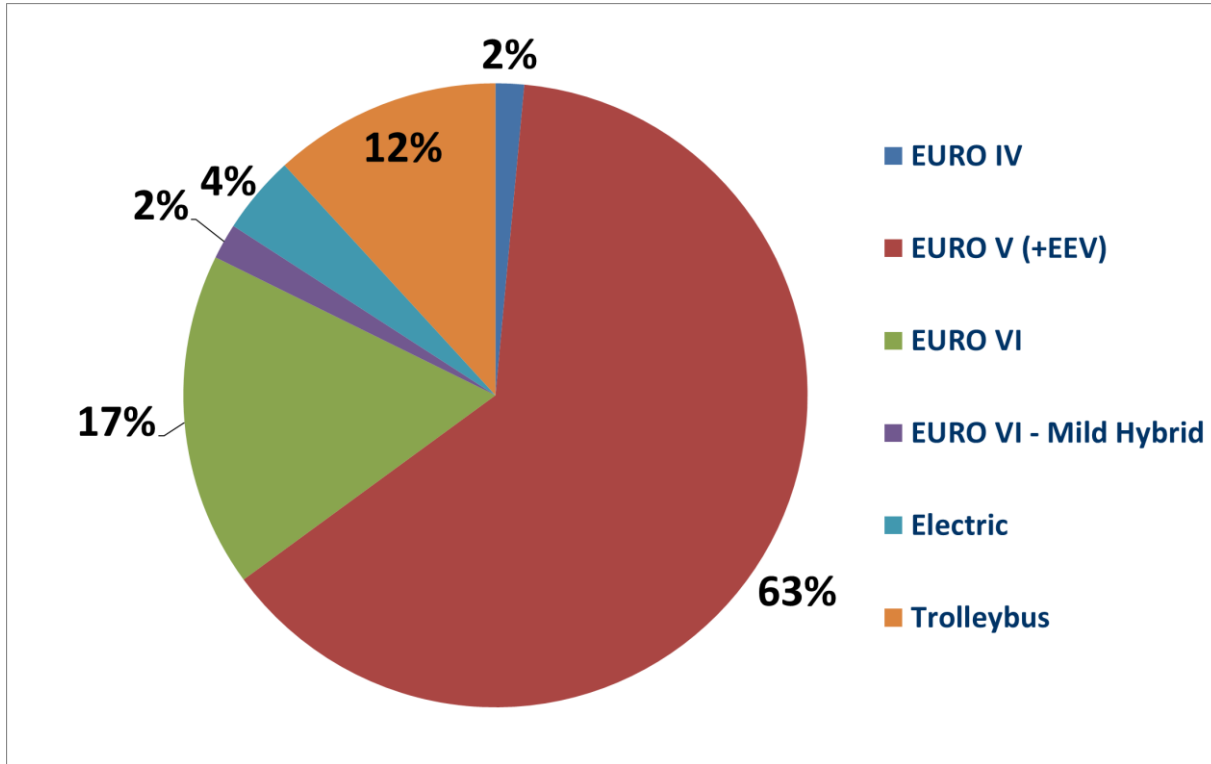


# WHERE WE ARE

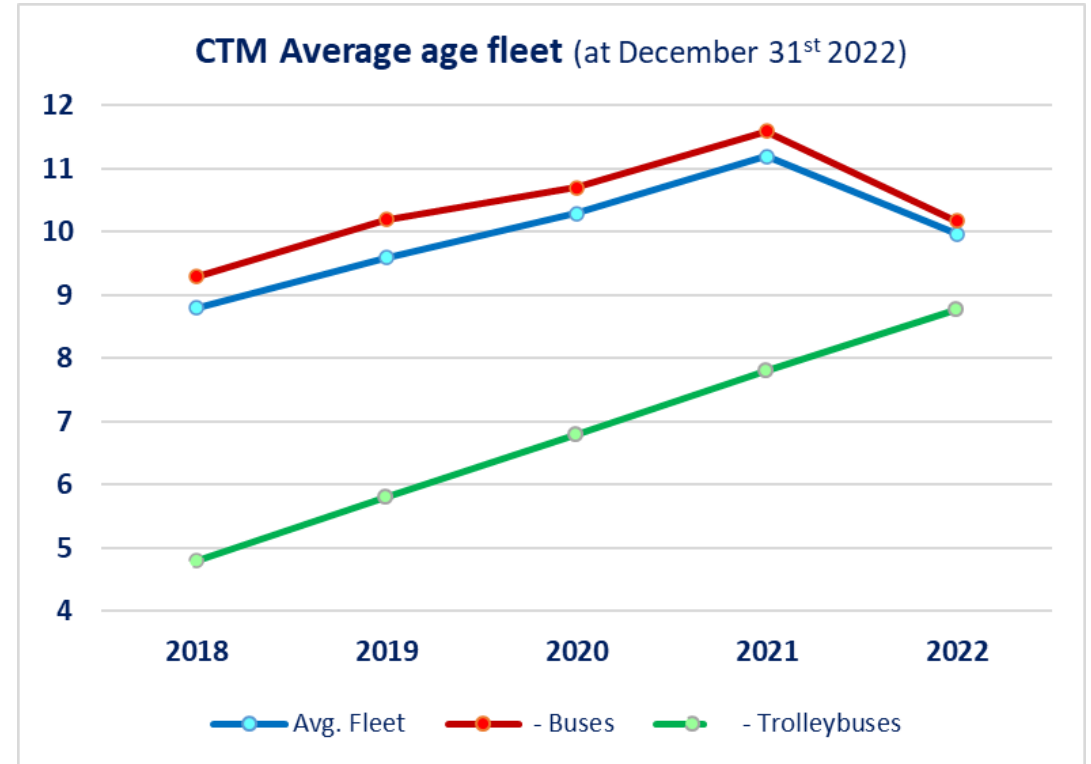
## CTM fleet at the beginning of 2023



### CTM fleet: composition for emission class



### CTM fleet: average age



### CTM fleet:

- 239 buses: 223 diesel + 5 Mild-Hybrid/diesel EURO VI + 11 full-electric (3 plug-in + 8 pantograph)
- 32 Trolleybuses: 6 IMC + 16 with diesel APU



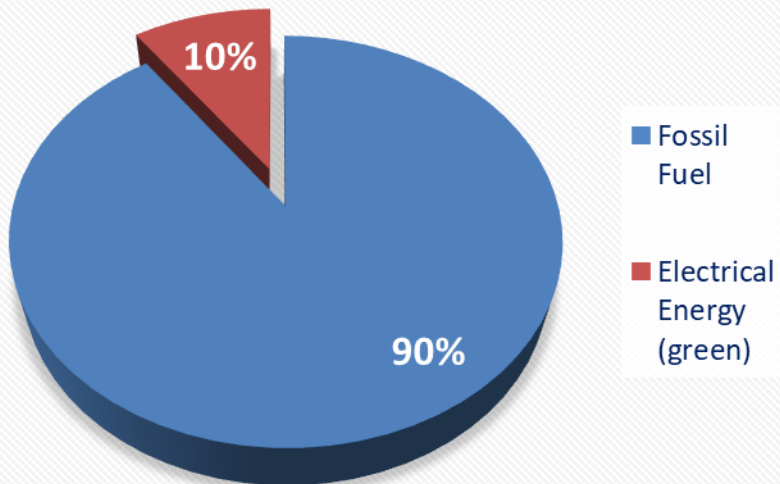
# WHERE WE ARE

## CTM energy consumption in 2022

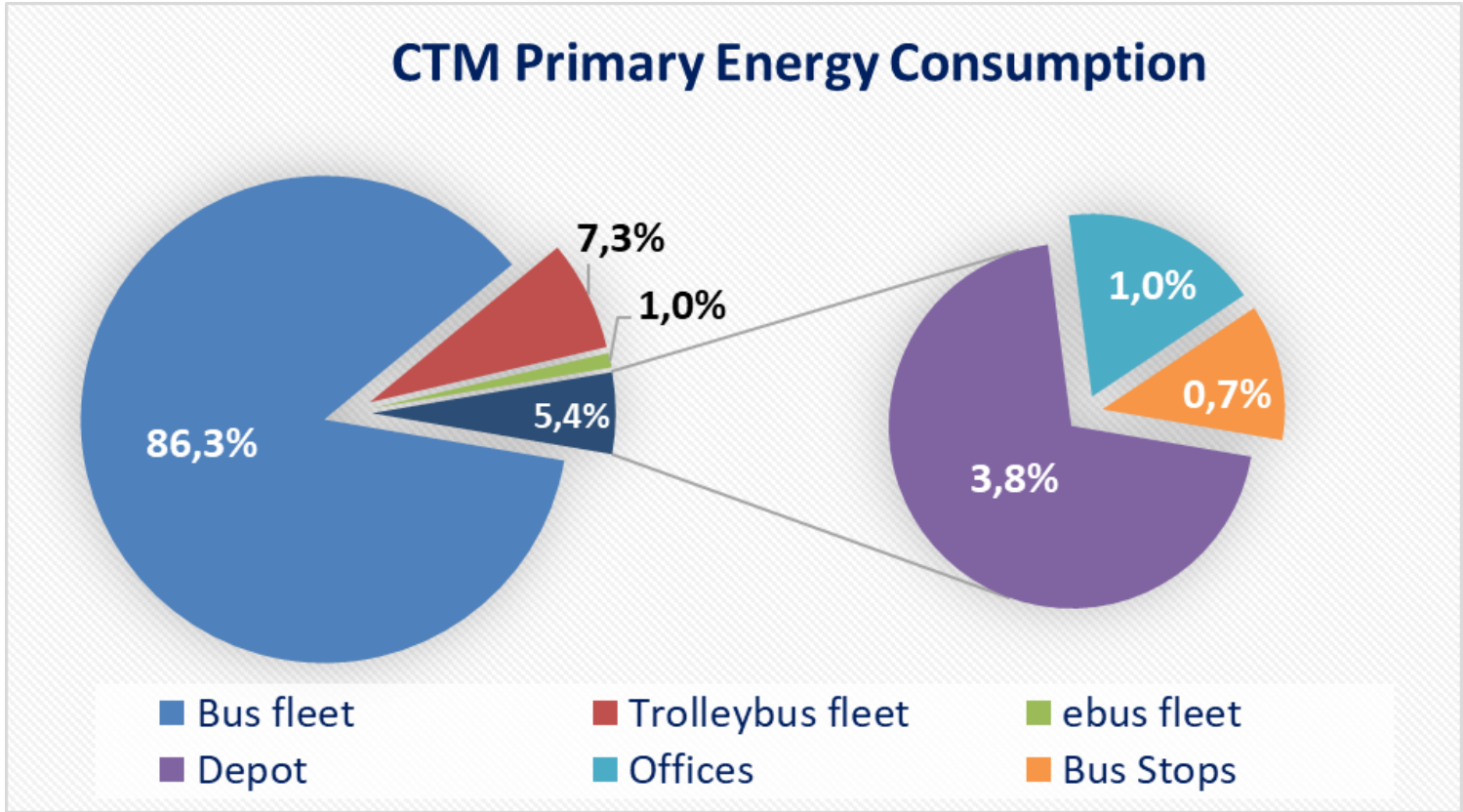


- 2022 Primary Energy consumption: **5.195 toe** (*tons of oil equivalent*)
- The fleet needs about **95%** of the total energy consumption of CTM
- CTM purchase only renewable electrical energy (certified)

### Energy Primary Sources



### CTM Primary Energy Consumption



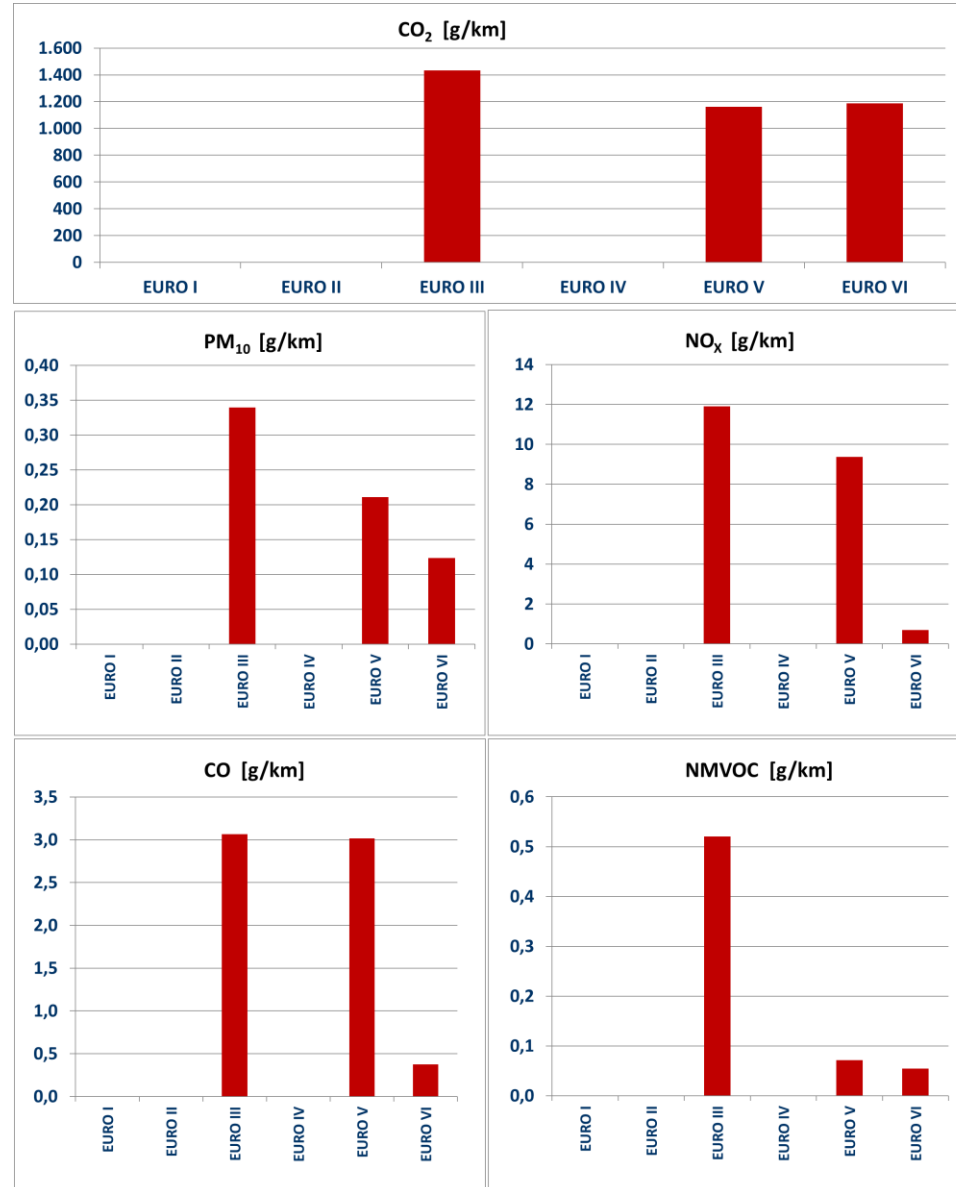
**A Clean Fleet is the Key to energy transition**



## WHERE WE ARE

# CTM fleet atmospheric emissions in 2022

- Atmospheric emissions calculated using COPERT (version 5.4) software.
- “Tank to Wheel” approach.
- PM<sub>10</sub> (particulate) emissions include also tyre and brake wear, road abrasion.



### TOTAL EMISSIONS:

- CO: 31,3 tonne
- NO<sub>x</sub>: 96,4 tonne
- PM<sub>10</sub>: 2,48 tonne
- NMVOC: 0,87 tonne
- CO<sub>2</sub>: 14.273 tonne

### SPECIFIC EMISSIONS:

- CO: 2,35 g/km
- NO<sub>x</sub>: 7,24 g/km
- PM<sub>10</sub>: 0,186 g/km
- NMVOC: 0,065 g/km
- CO<sub>2</sub>: 1.072 g/km



## WHERE WE ARE

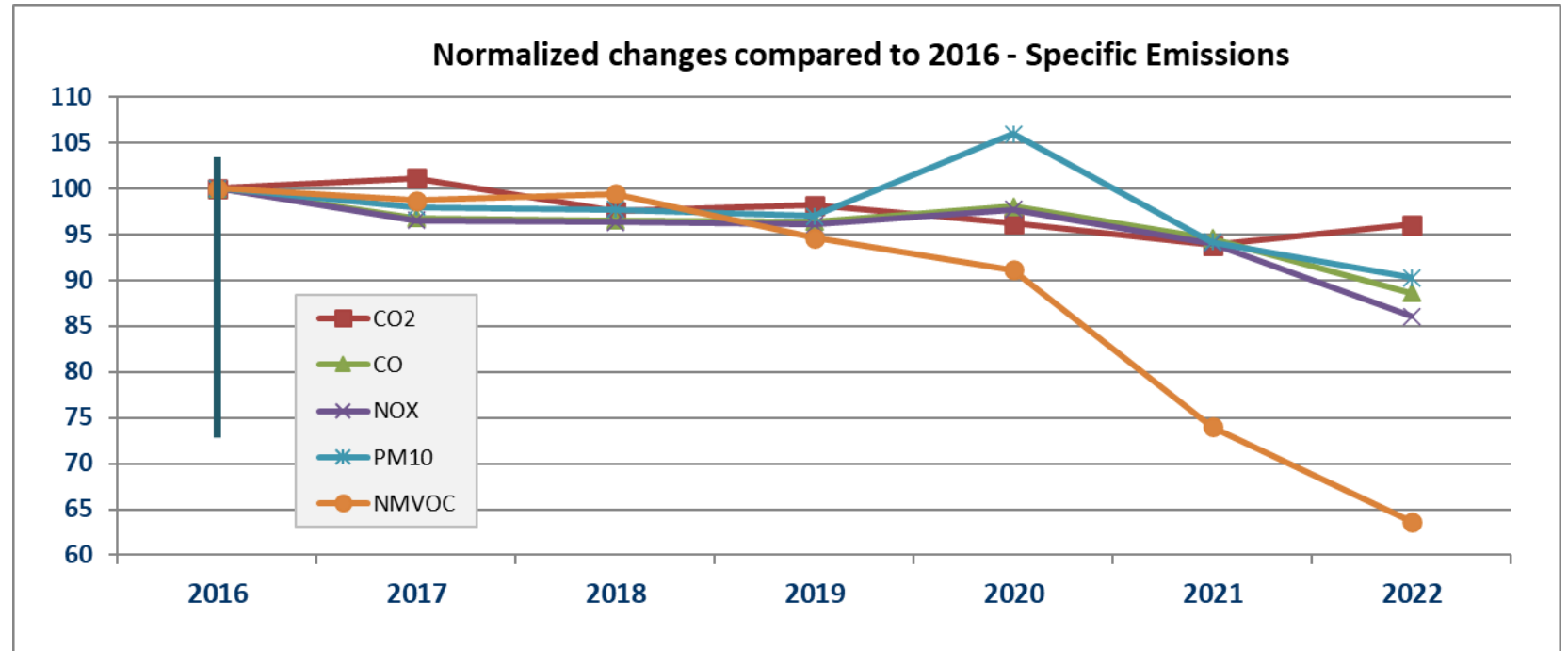
### CTM fleet atmospheric emissions in 2022



#### SPECIFIC EMISSIONS:

##### Percentage change 2016-2022

- CO: -11,4%
- NO<sub>x</sub>: -14,0%
- PM<sub>10</sub>: -9,7%
- NMVOC: -36,4%
- CO<sub>2</sub>: -3,9%



#### Improvements in the last two years due to:

- Fleet renewal (new EURO VI diesel buses - dismissal of EURO III and EURO IV diesel buses)
- Purchase of renewable electrical energy (trolleybus -ebus) from December 2020

# WHERE ARE WE GOING?







***Shifting from a fossil fuel economy to a clean and sustainable one is no less challenging than going to the Moon.***

***... by the way, we already reached the Moon, not the first target.***



## WHERE ARE WE GOING?

*We choose to become a sustainable company for sustainable mobility*

**CLEAN FLEET**  
+  
**CLEAN BUILDINGS**  
+  
**GREEN PROCEDURES**  
=  
**GREEN CTM**



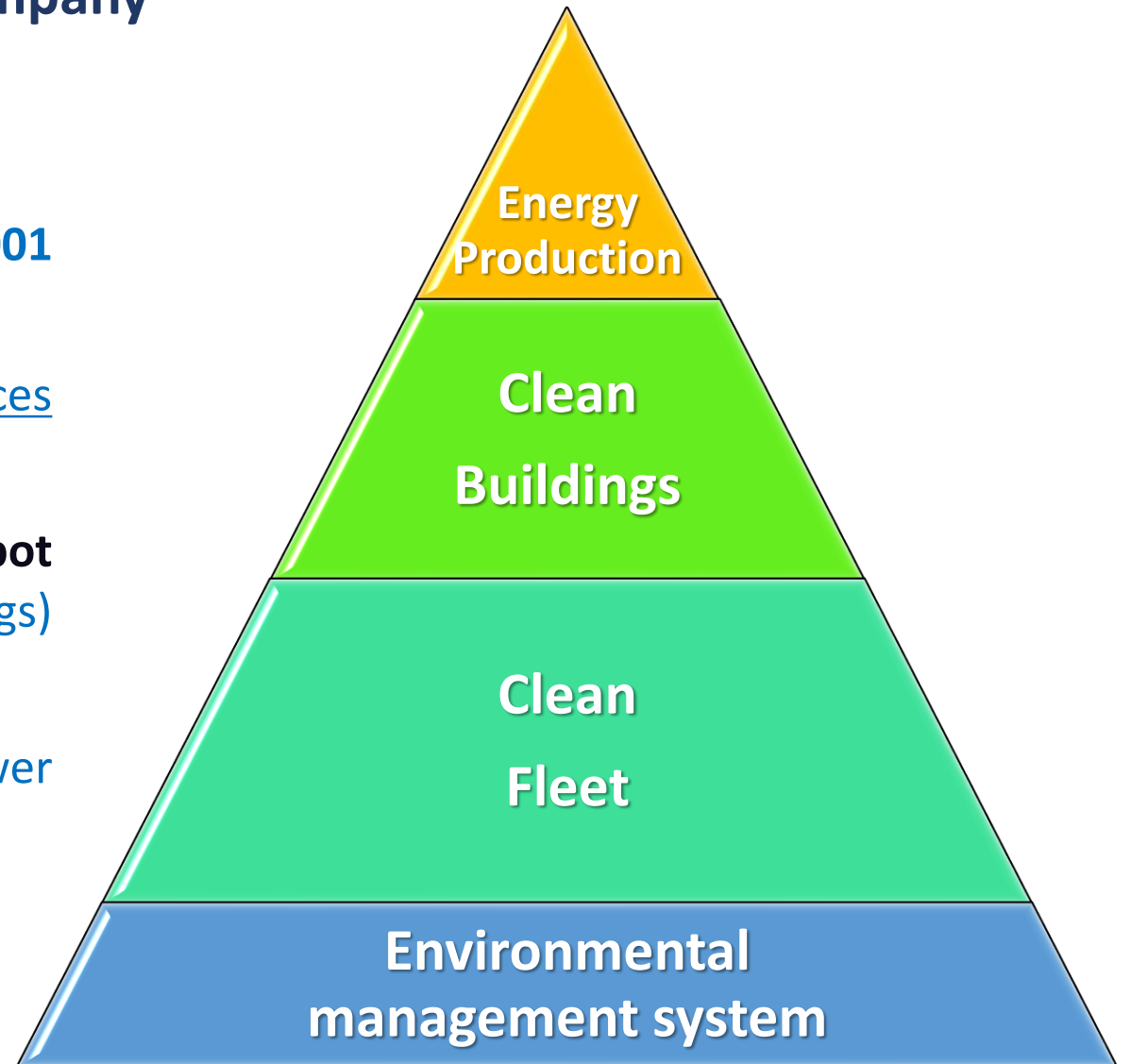




## WHERE ARE WE GOING?

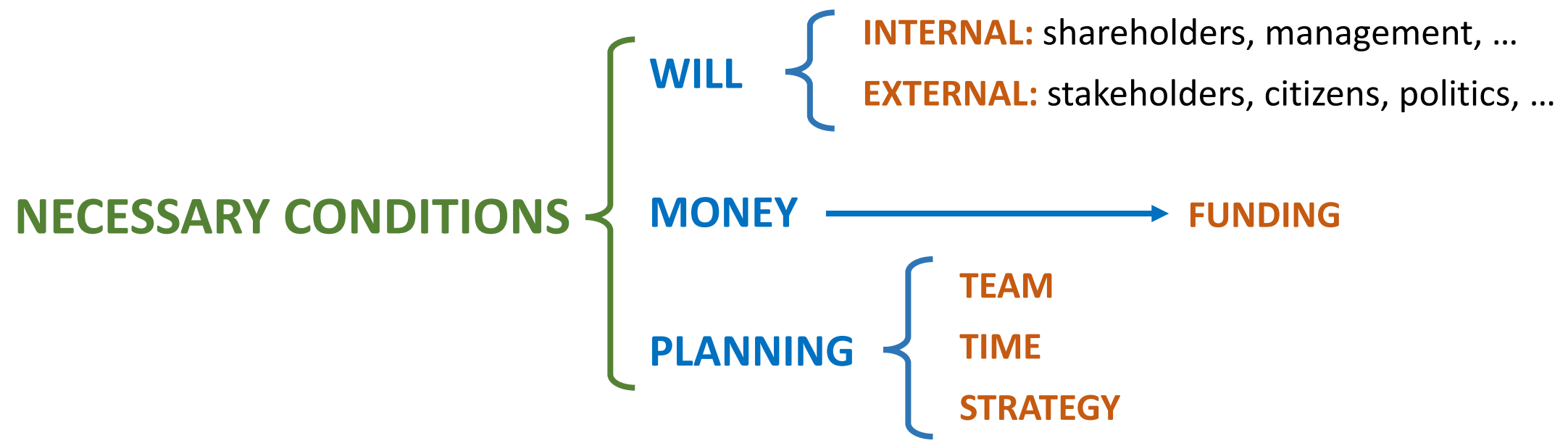
### CTM challenge to become a "green" company

- **Environmental Management System: UNI EN ISO 14001** (already in place since **2022**)
- **Clean Fleet**, powered by renewable sources (electrical energy, green H2, ...) by the end of **2030**
- Retrofitting of the current **depot**, building a **new depot** and new **headquarters** with **ZEB (zero emission buildings)** technologies, by **2030/2035**
- **Energy production** for self-consumption (**PV power plant**), by **2025/2035**



# WHERE ARE WE GOING?

## CTM challenge to become a "green" company

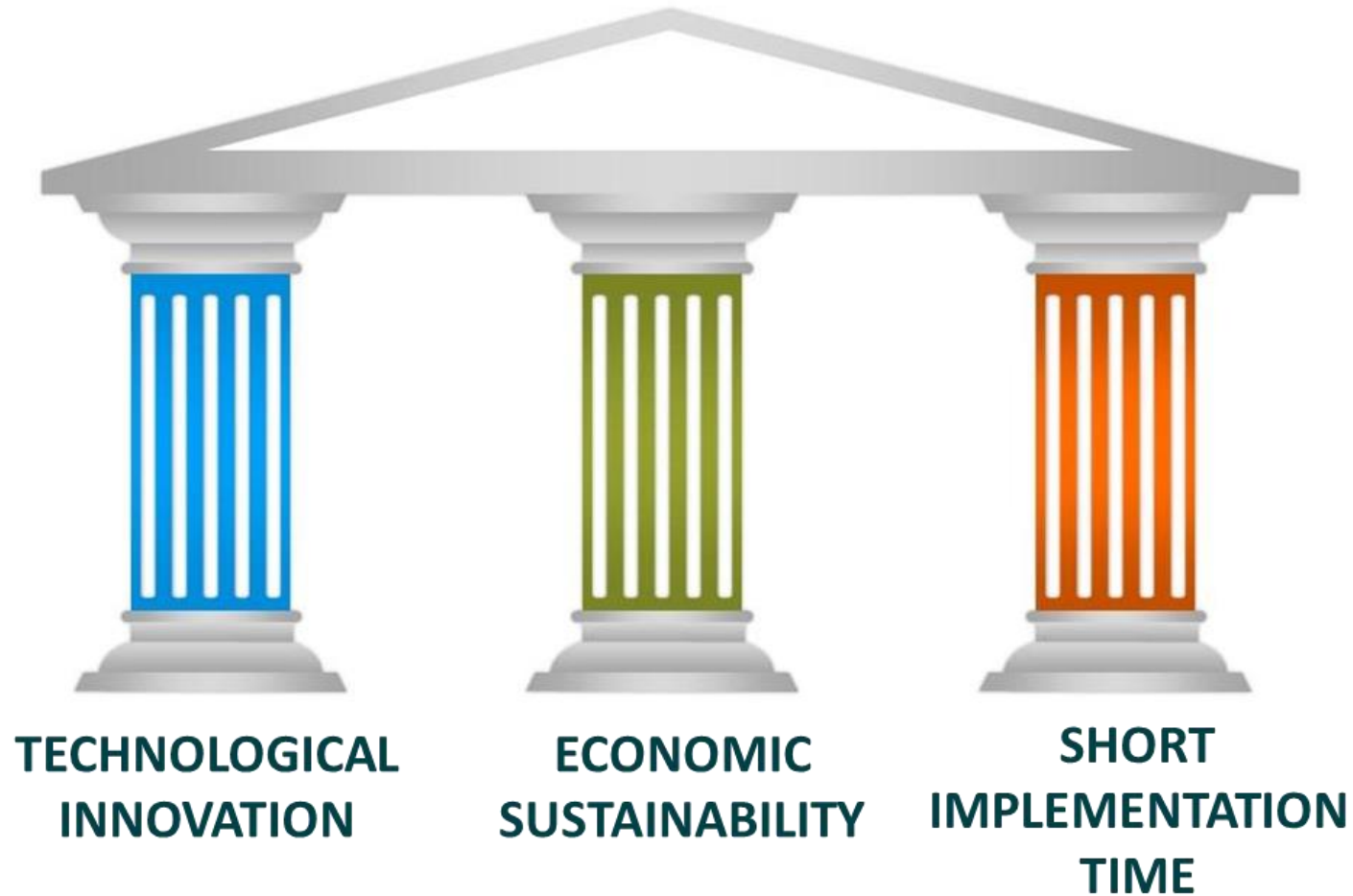




# CTM ENERGY TRANSITION STRATEGY



## The pillars of CTM Strategy



## The lines of action for a Clean Fleet

### Fleet renewal

- Purchase of clean vehicles to reaching an average fleet age of less than 7 years



### Trolleybus system

- Extension and integration of existing trolley network with trolley-hybrids and e buses



### BRT

- Implementation of electrical BRT systems with fast charging solutions





# FLEET RENEWAL PLAN



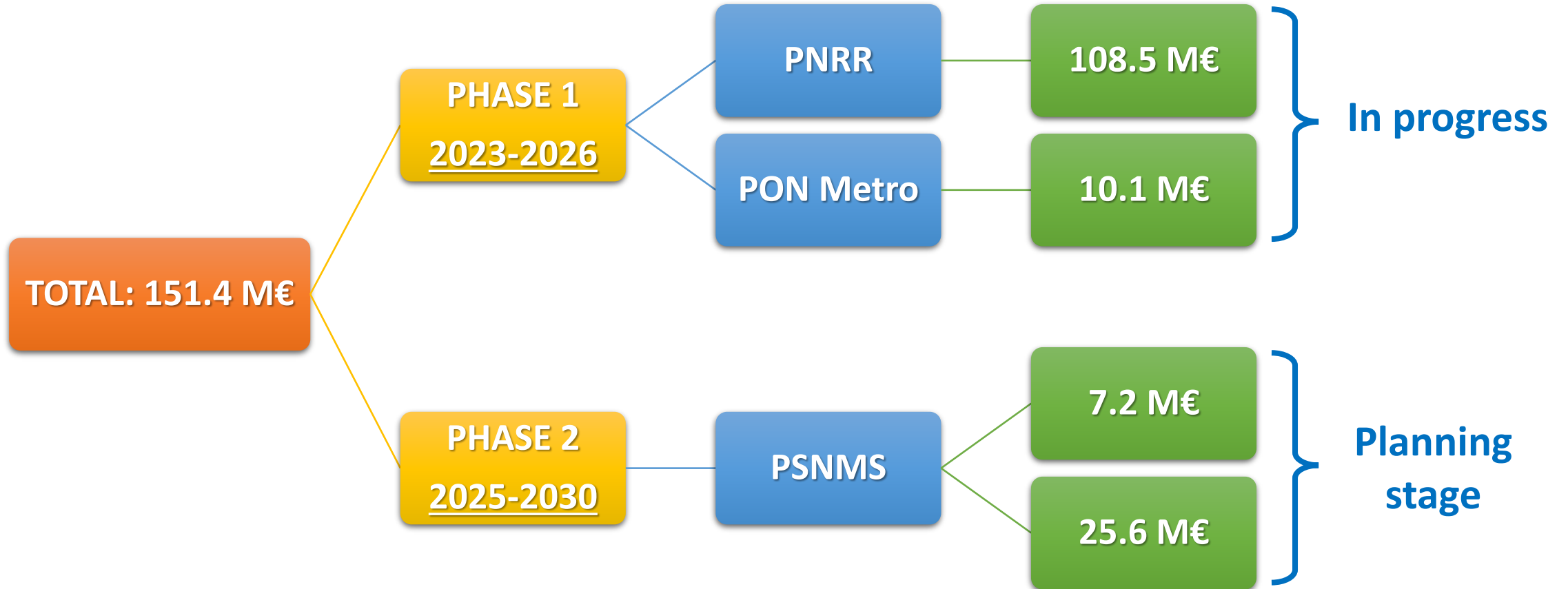
THE ENERGY TRANSITION OF CTM CAGLIARI





# FLEET RENEWAL PLAN: BOUNDARY CONDITIONS

## FUNDINGS AVAILABLE



**Funding for purchase of vehicles and infrastructure (depot adaptation, charging infrastructures)**



# FLEET RENEWAL PLAN: BOUNDARY CONDITIONS

## FUNDING



**72%** of the fundings already available to CTM come from the **PNRR** (*Piano Nazionale di Ripresa e Resilienza - National Recovery and Resilience Plan*), financed by the **Next Generation EU (NGEU)**.



THE ENERGY TRANSITION OF CTM CAGLIARI

### ITALY's Missions

- I. Digitalization, Innovation, Competitiveness, and Culture
- II. Green revolution and Ecological transition**
- III. Infrastructure for sustainable mobility
- IV. Education and Research
- V. Inclusion and Cohesion
- VI. Health



**Mission Target (M2C2):**  
**3000** electric buses by the end of **June 2026**





# FLEET RENEWAL PLAN: BOUNDARY CONDITIONS

## TECHNOLOGIES AVAILABLE



### OLD FLEET RENEWAL PLAN



**1 old diesel bus OUT**



**1 new diesel bus IN**



# FLEET RENEWAL PLAN: BOUNDARY CONDITIONS

## TECHNOLOGIES AVAILABLE



### TODAY'S FLEET RENEWAL PLAN



**1 diesel bus OUT**



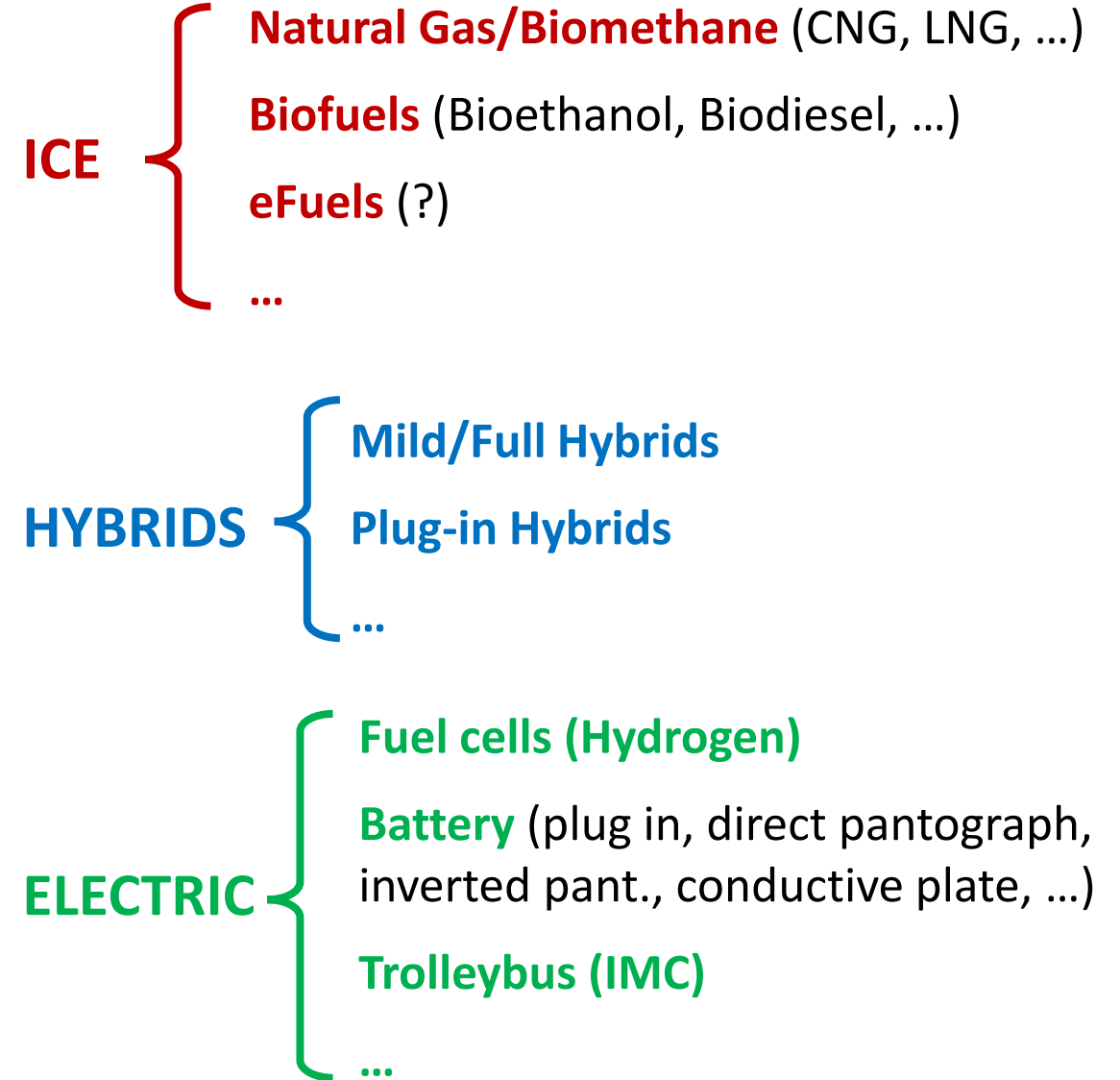
**Different technologies to choose from**

# FLEET RENEWAL PLAN: BOUNDARY CONDITIONS

## TECHNOLOGIES AVAILABLE



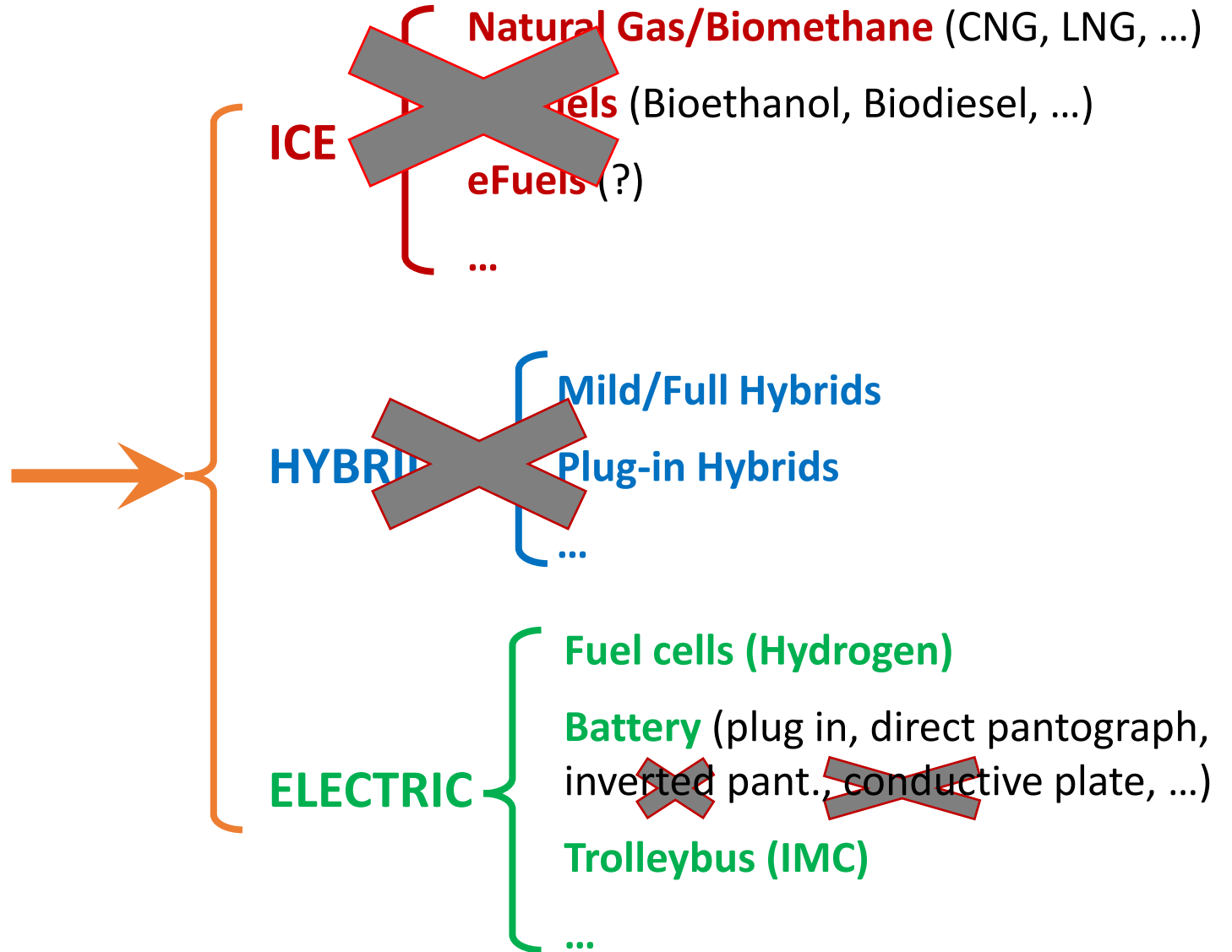
1 diesel bus OUT





### CUT-OFF CRITERIA:

- NATURAL GAS AVAILABILITY
- NO FOSSIL FUELS
- ZERO EMISSION VEHICLES
- SIMPLE CHARGING SYSTEM
- MARKET AVAILABILITY
- IMPACT ON THE CITY
- TIMING
- FUNDING
- ...





# FLEET RENEWAL PLAN: TECHNOLOGIES SELECTED



System Selected	Charging Infrastructure	Vehicle length	Timeline deployment	Future plans
Trolleybuses (battery IMC)	Catenary + fixed charging stations	12-18 m	Already in service (12 m)	Increase (2025-2030)
Battery buses	Plug-in	6 m from 6 to 12 m	Already in service (6 m) 2023-2026	Increase (2026-2030)
	Direct pantograph + plug in	10-12-18 m	2024-2026	///
	Pantograph bottom up (catenary) + plug in	6 m	Already in service	To be decided (based on 2022/24 feedback)
Fuel Cell buses	Hydrogen refuelling station	12-18 m	2025-2027	Increase (2028-2030)



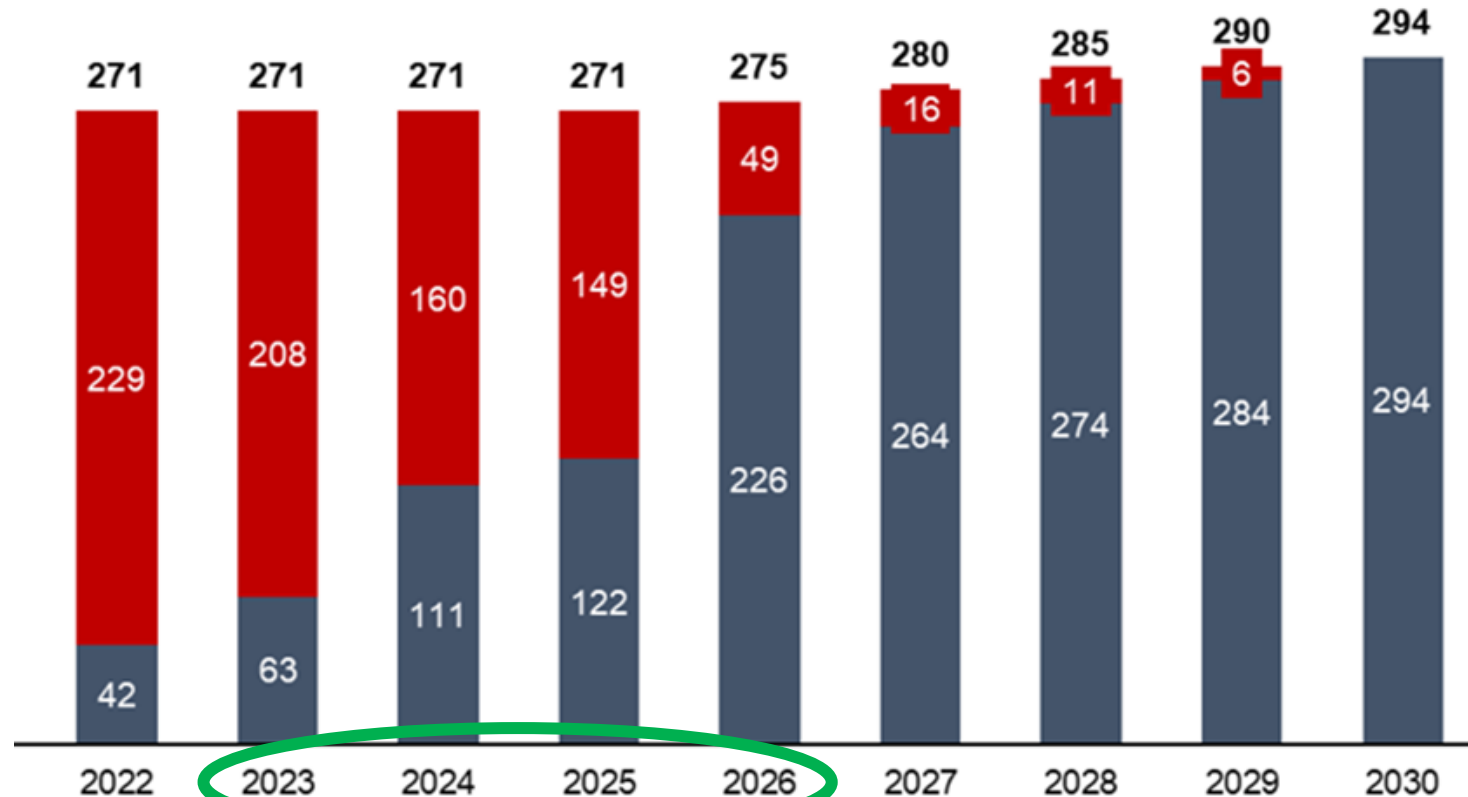
# FLEET RENEWAL PLAN: TECHNOLOGIES SELECTED VEHICLES DEPLOYMENT HYPOTHESIS 2022-2030



The biggest step in fleet electrification will occur between 2023 -2026

More vehicles will be needed to compensate for the shorter distances run by plug-in battery buses

**DIESEL BUSES**  
**ELECTRIC BUSES**  
(including TROLLEYBUSES)

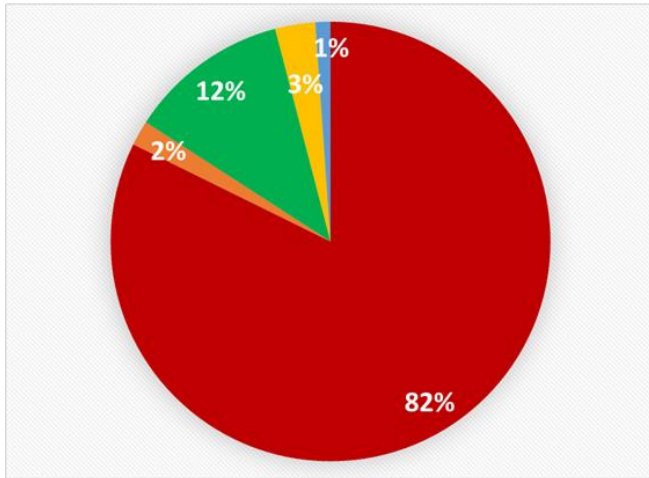




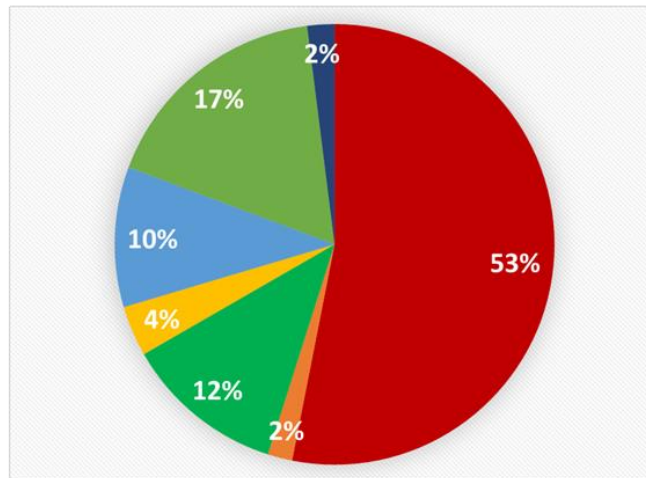


# FLEET RENEWAL PLAN: TECHNOLOGIES SELECTED VEHICLES DEPLOYMENT HYPOTHESIS 2022-2030

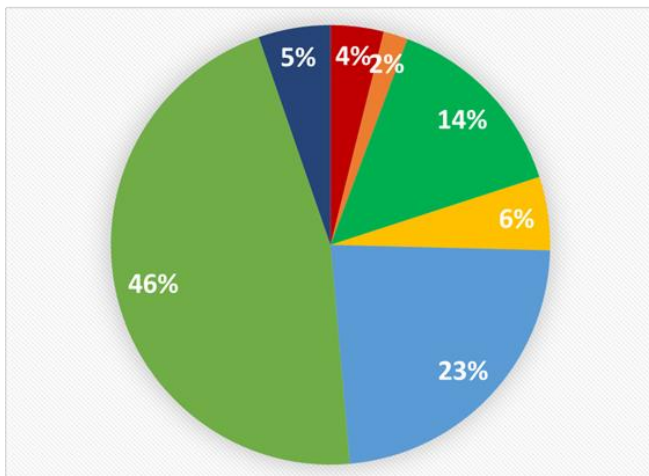
2022



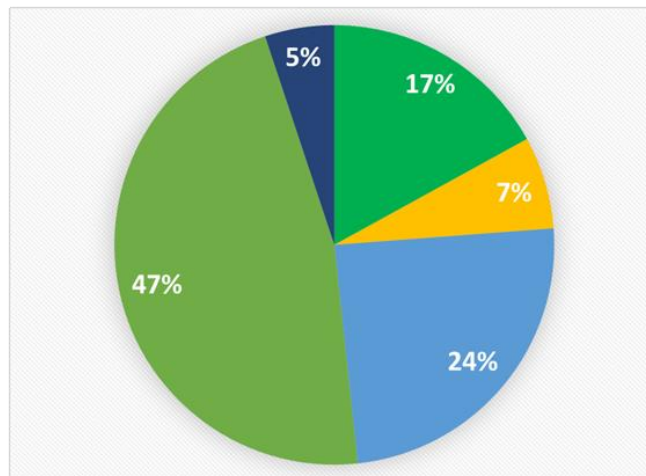
2025



2027



2030



- Diesel
- Mild Hybrids (Diesel)
- Trolleybuses
- Battery buses pantograph - slow charging
- Battery buses plug in - slow charging
- Battery buses pantograph - fast charging
- Fuel cell buses - Hydrogen

# FLEET RENEWAL PLAN FOCUS ON 2023-2026





## FLEET RENEWAL PLAN 23-26



### Funds available: **118.6 M€**

- 108.5 M€ (PNRR)
- 10.1 M€ (PON METRO)

### Vehicles target: **173 bus** (64% of the entire fleet)

- 152 (PNRR)
- 21 (PON METRO)

### Milestones (deployment)

- 31/12/2023: **21 vehicles**
- 31/12/2024: **41 vehicles**
- 30/06/2026: **111 vehicles**

### Technologies selected: **battery bus**

- plug in (slow charging)
- direct pantograph (fast charging)



## CUSTOM-FIT APPROACH



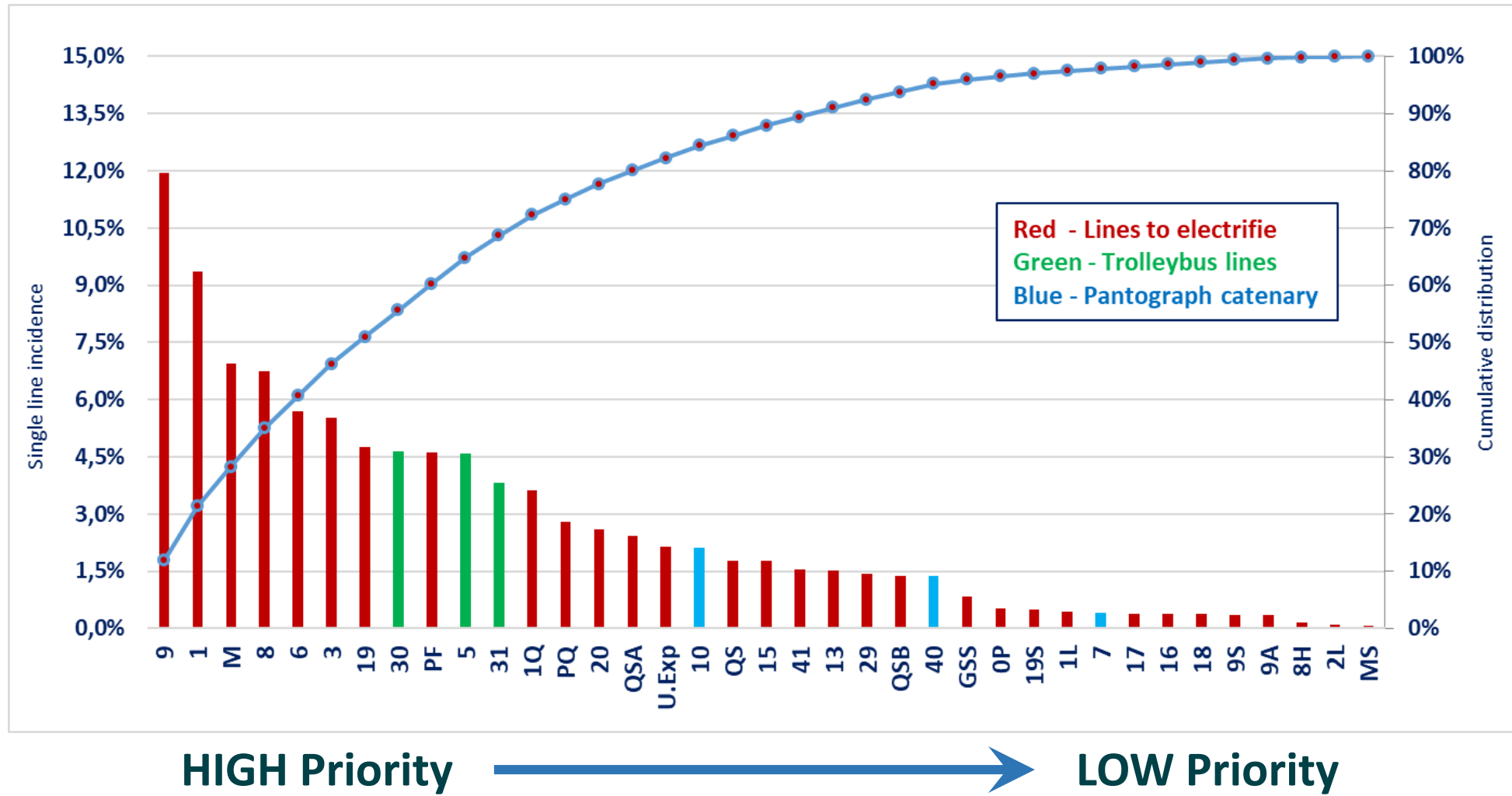


# FLEET RENEWAL PLAN 23-26: SYSTEM ARCHITECTURE

## LINES ANALYSIS



### Which line to electrify first?



**HIGH Priority** → **LOW Priority**



# FLEET RENEWAL PLAN 23-26: SYSTEM ARCHITECTURE

## OVERNIGHT vs. OPPORTUNITY

### Opportunity

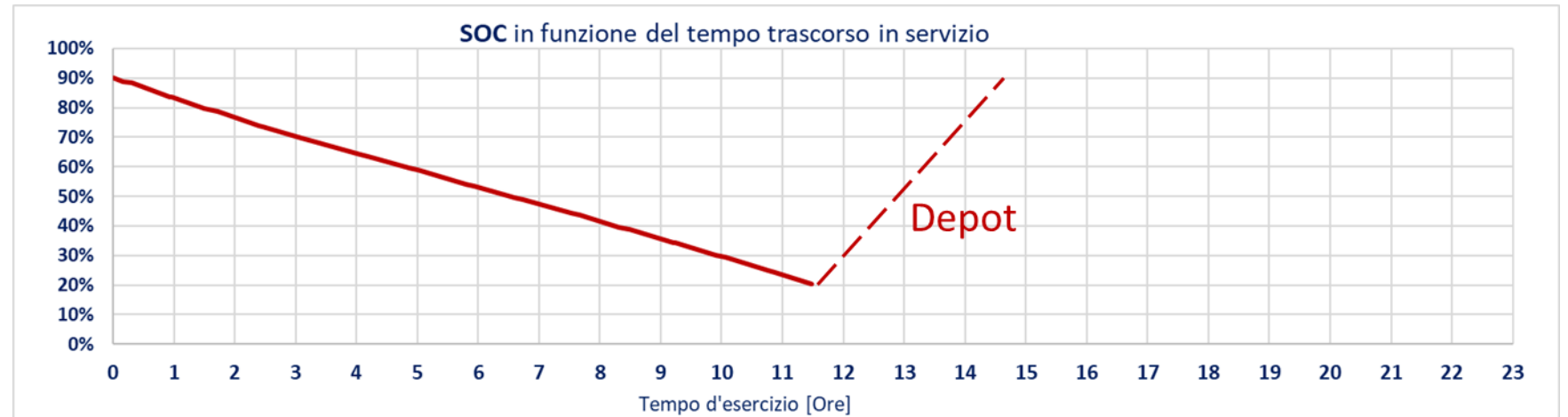
- Fast charging
- Charging at terminus
- High power (>400 kW)
- Low charging times (5-10 minutes)
- Low battery autonomy (max. 100-150 km)

### Battery State of Charge vs. Time



### Overnight

- Slow charging
- Charging at depot
- Lower power (100-200 kW)
- Longer charging times (3-5 hours)
- High battery autonomy (min. 200-250 km)



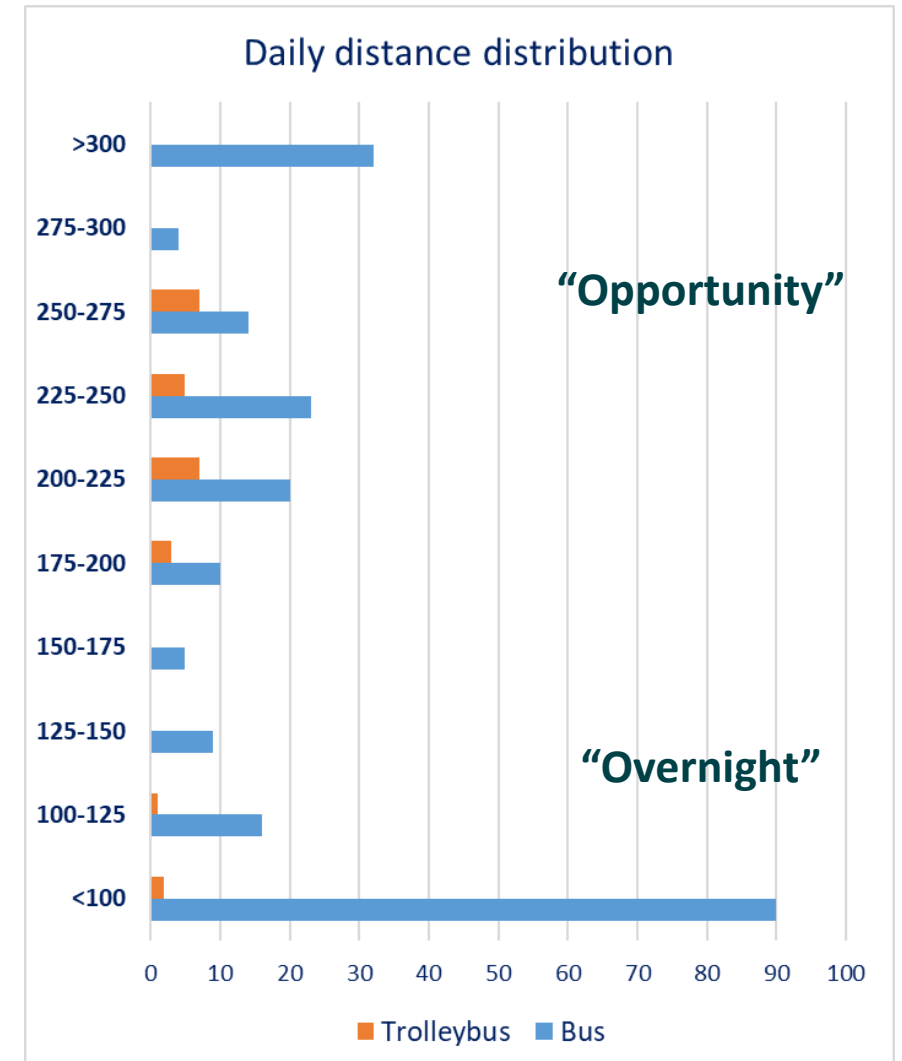
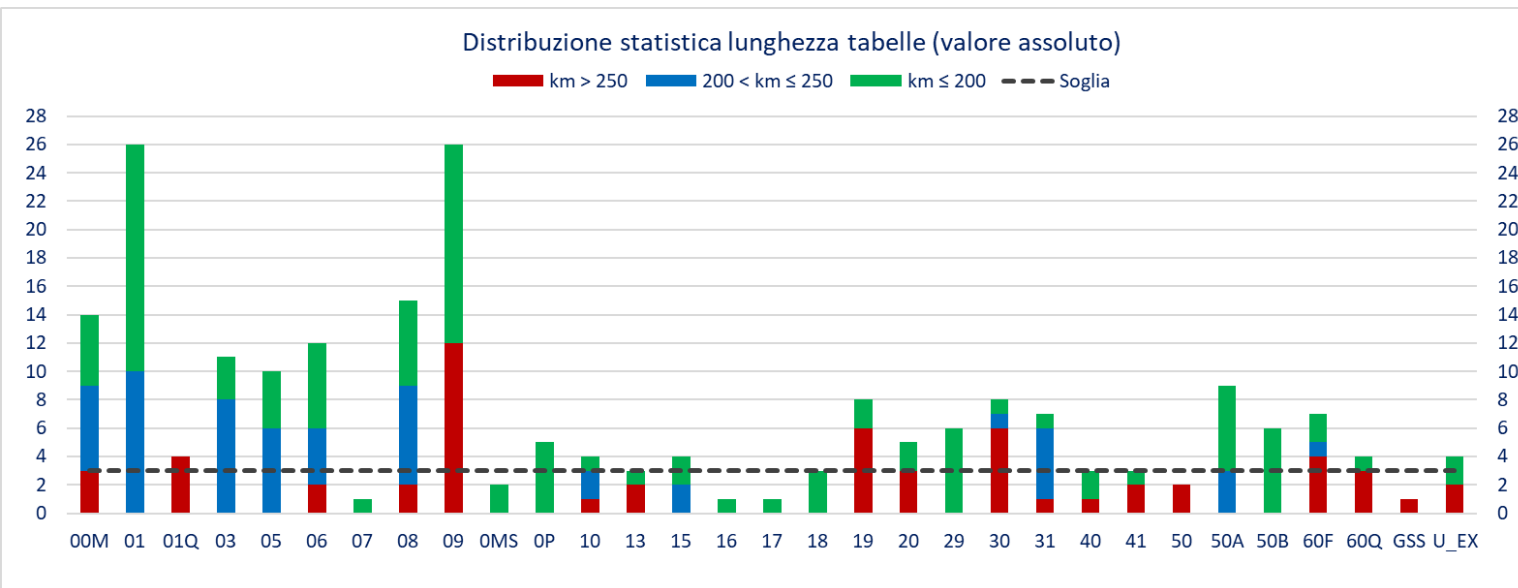


# FLEET RENEWAL PLAN 23-26: SYSTEM ARCHITECTURE LINES ANALYSIS



## BATTERY BUSES: What kind of technology we may choose?

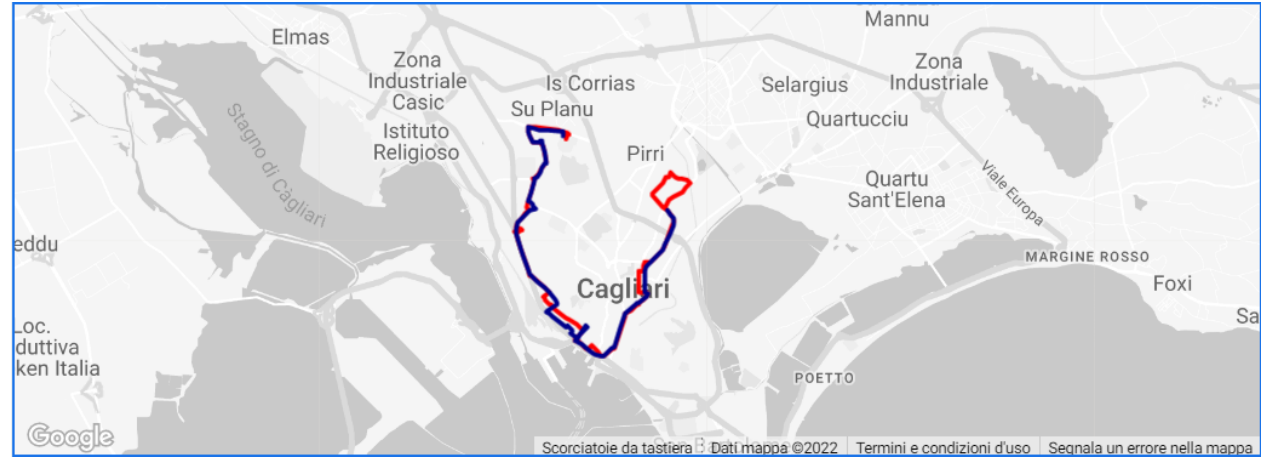
Select between "Overnight" or "Opportunity" charging system.





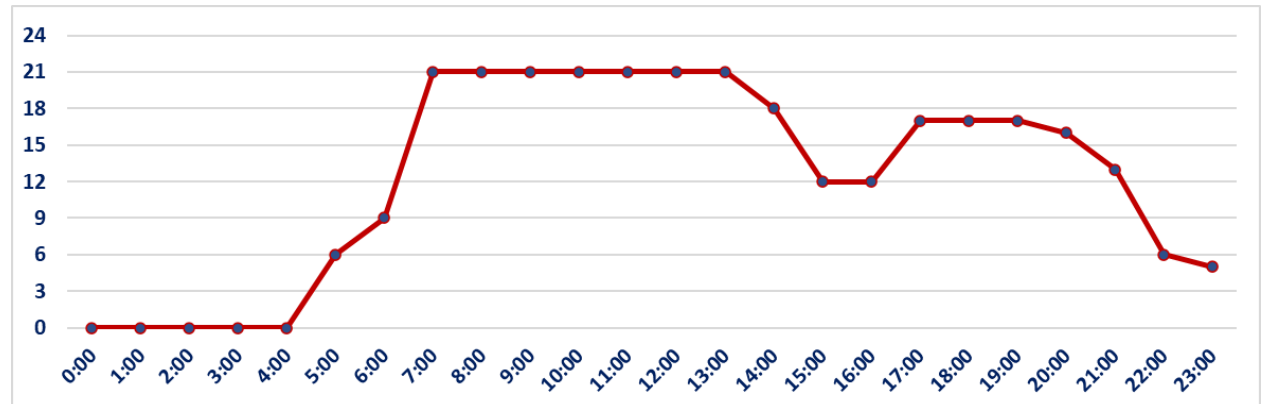
### Analysis of the line in order to assess:

- minimum size of battery packs (autonomy)
- minimum charging power required
- minimum charging time at terminus
- number of charging points
- selection of the best terminus to install the charging infrastructure



Line 1	
Length	24.3 km (round trip)
Vehicles length	12 meters
Max. vehicles in service	21
Commercial speed	13.3 km/h
Daily line distance	3,828 km
CTM's daily production	9.4%

Nr. of buses in service





# FLEET RENEWAL PLAN 23-26: SYSTEM ARCHITECTURE

## SINGLE LINE ANALYSIS

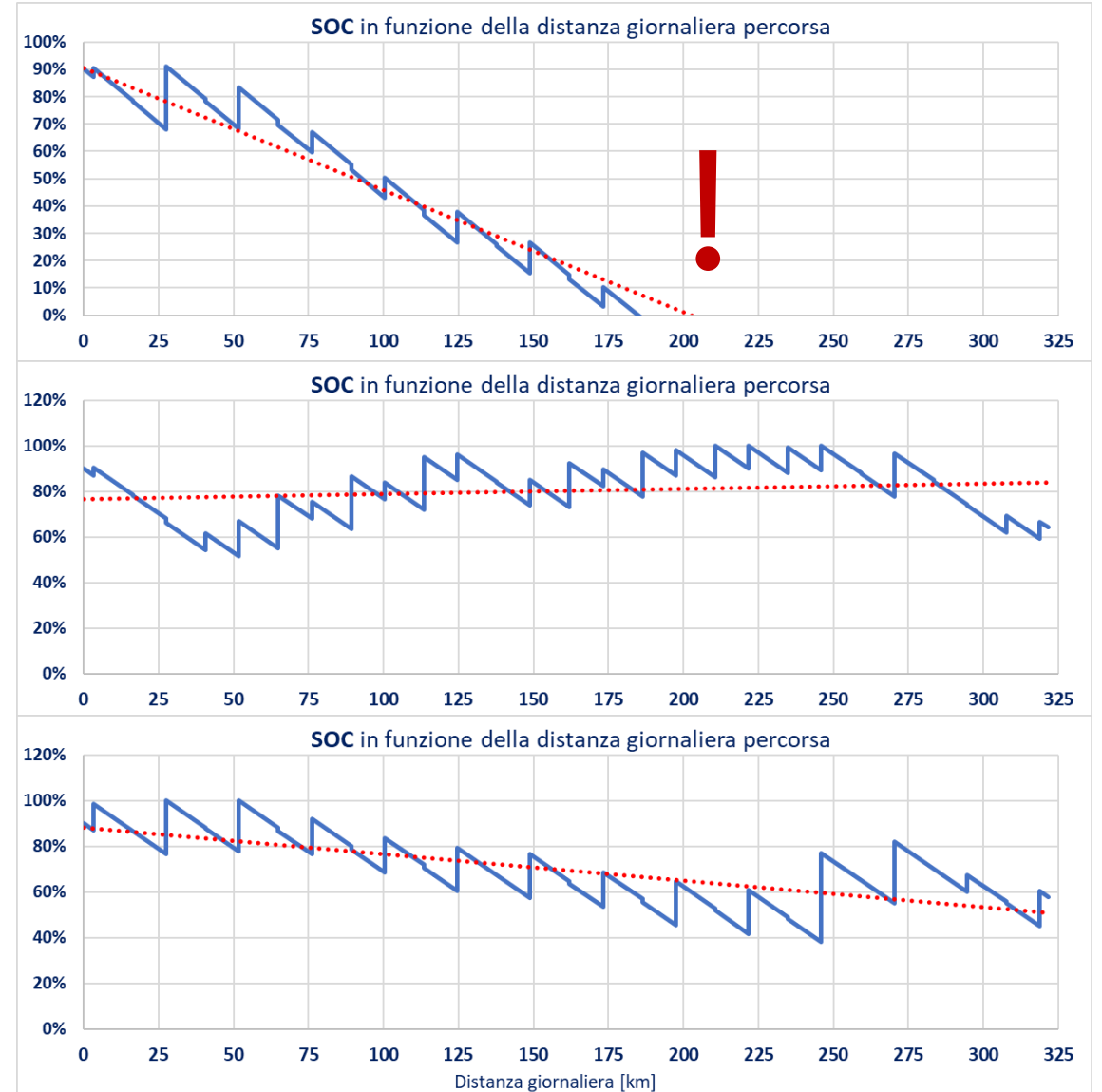


Analysis of the line in order to assess:

- minimum size of battery packs (autonomy)
- minimum charging power required
- minimum charging time at terminus
- number of charging points
- selection of the best terminus to install the charging infrastructure

Line 1 – Results of simulations	
Minimum battery autonomy	110 km
Minimum charging power	500 kW
Nr. of charging terminus	1 (Ospedale Brotzu)
Nr. of charging points per terminus	2
Charging time available	5 minutes
Daily energy charged at terminus	90%
Daily energy charged at depot	10%

### Line 1 - State of Charge simulations





# FLEET RENEWAL PLAN: DEPLOYMENT TIMELINE

## VEHICLES DEPLOYMENT and LINES ELECTRIFICATION



TROLLEYBUS



2023

Partial electrification of **6 lines** with **21 plug in battery buses**.

System architecture:  
*“Overnight”*

2024

Electrification of **Lines 1-9** (about 20% of daily distance).

NEW Line: **Poetto BRT**

**48 ebuses (12-18 m) with direct pantograph**

System architecture:  
*“Opportunity”*

2025-2026

**8 Lines** with **Opportunity** charging at terminus.

**6 Lines** with **Overnight** charging at depot.

**104 ebuses (from 6 to 12 m)**  
(about 75% of daily distance will be electric).





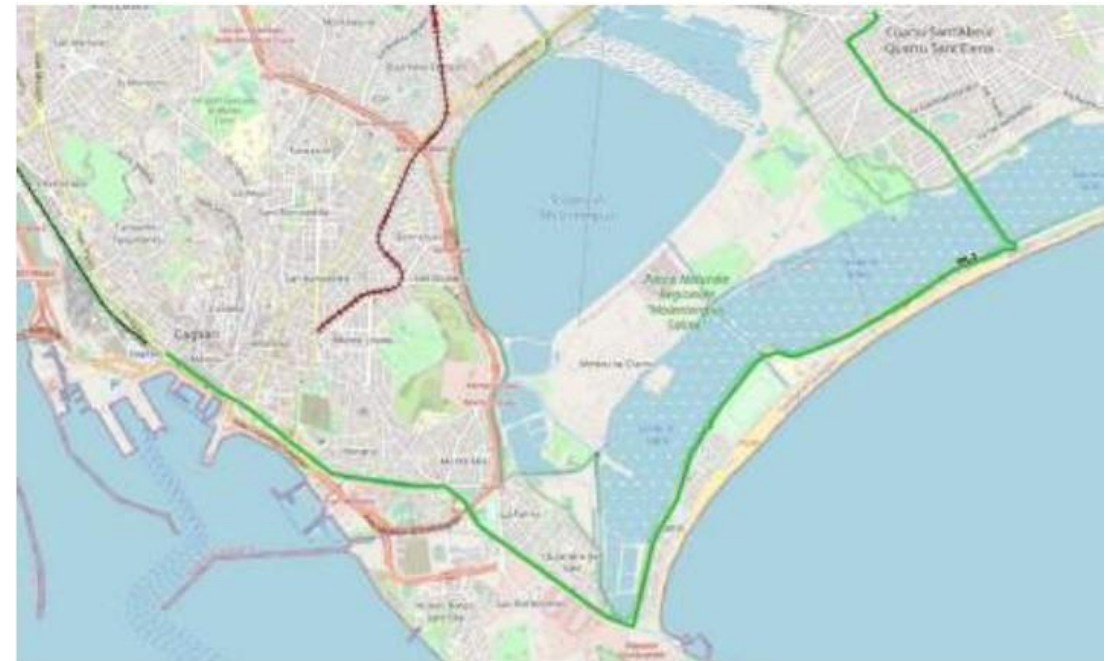
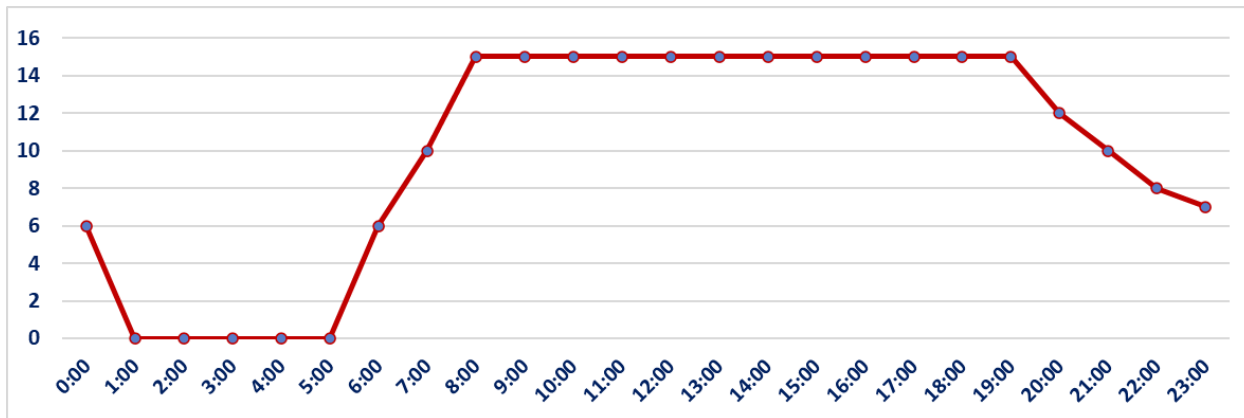
# FLEET RENEWAL PLAN: DEPLOYMENT TIMELINE LINES



## NEW Poetto BRT Line

Line BRT Poetto	
Period of service	Summer time
Length	26.9 km (round trip)
Vehicles length	18 meters
Max. vehicles in service	15
Commercial speed	16.7 km/h
Frequency (peak)	6.5 minutes
Charging technology	Opportunity – “fast” at terminus
Nr. of charging terminus	2 (both terminus)
Stop time at terminus	6 minutes
Daily line distance	3,723 km

- Electric BRT line available during the summer (from mid-June to mid-September)
- Start of operation: summer 2025
- Fast connection between Cagliari and Quartu S.E, passing near Poetto beach



- 1) CTM Depot (2023-2024) [6 MW]**  
 Overnight charging (fast – slow), battery equalization, vehicles maintenance.
- 2) “La Plaia” Hub (2024) [4.5 MW]**  
 Overnight charging (slow), opportunity charging (fast) for 6 lines.
- 3) “Policlinico Univ.” (2026) [2 MW]**  
 Opportunity charging (fast) for 3 lines.
- 4) “Ospedale Brotzu” (2024) [1.5 MW]**  
 Opportunity charging (fast) for Line 1.
- 5) “Brigata Sassari” (2024) [2 MW]**  
 Opportunity charging (fast) for 2 lines.  
 Opportunity charging with pantograph.







# FLEET RENEWAL PLAN: INFRASTRUCTURES DEPOT

## Depot adaptations

- Maintenance of battery packs and charging devices (pantographs) on the vehicles' roofs.
- Safety (fire of battery packs)
- New control center (charging infrastructures monitoring – smart charging)

## Charging infrastructure

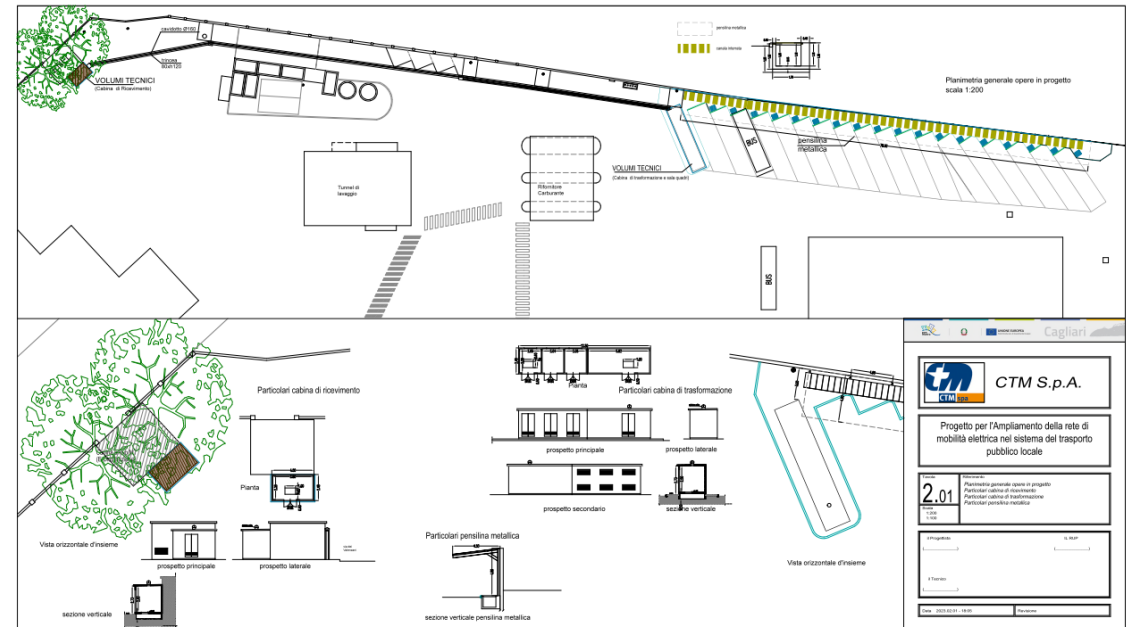
- Plug in chargers (slow) – bus/charger ratio 3:1
- Pantograph (fast)

## Upgrading of the existing 500 kW power station

- AC section: depot
- CC section: trolleybus overhead line

## Building new power stations

- **Phase 1 (2023):** from **500 kW** to 2MW
- **Phase 2 (2024):** from 2 MW to **6MW**





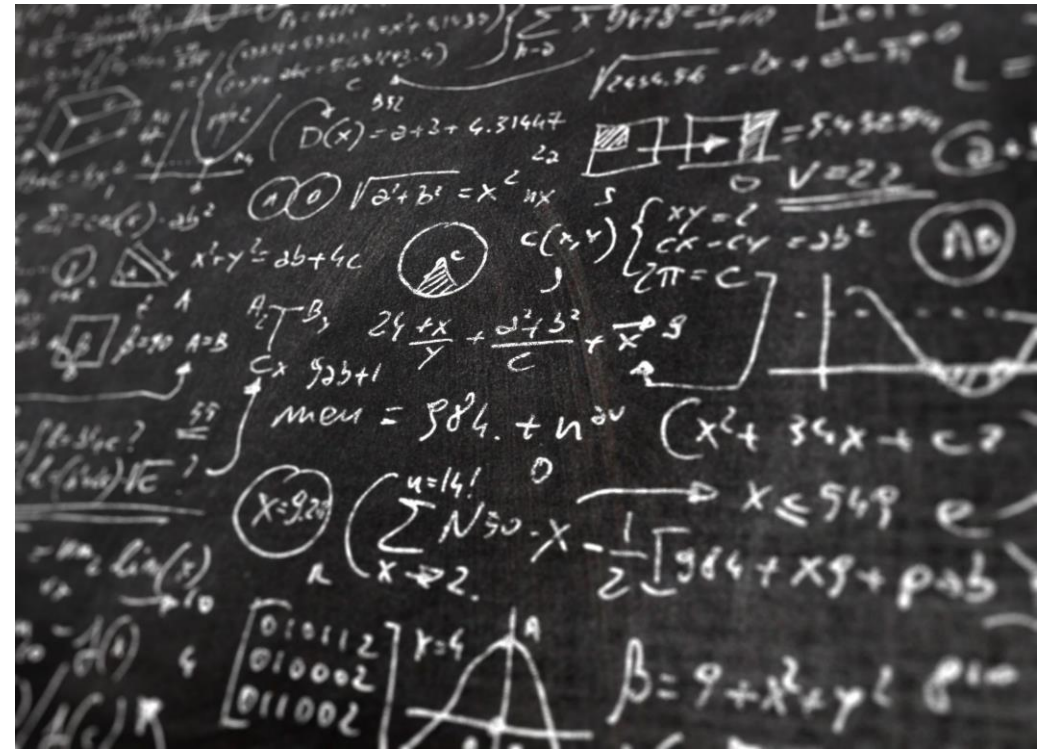
## TRAINING AND INVOLVING PEOPLE IN THE CHANGE PROCESS

### DRIVERS

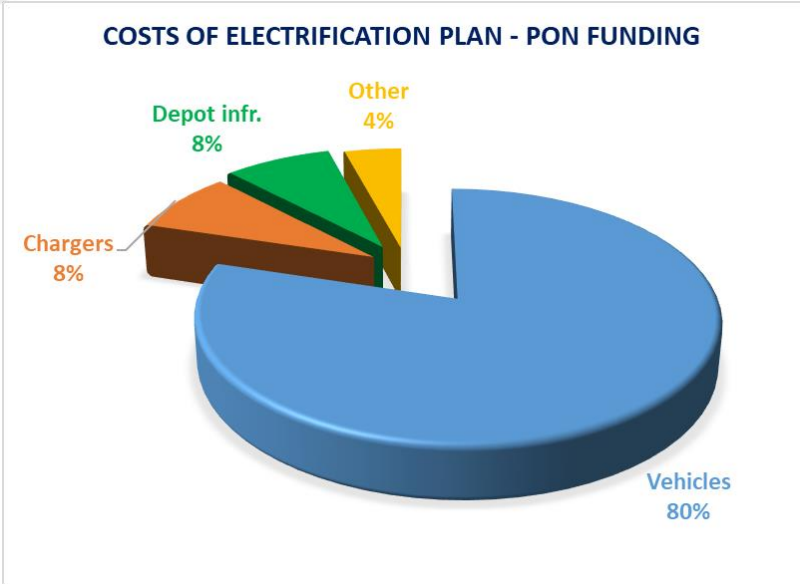
- features of the new vehicles
- charging operation (opportunity charging at terminus)
- efficient use of energy resources (driving style)
- ...

### MAINTENANCE & DEPOT PERSONNEL

- battery system maintenance
- charging infrastructure maintenance
- charging operation (overnight at depot)
- ...

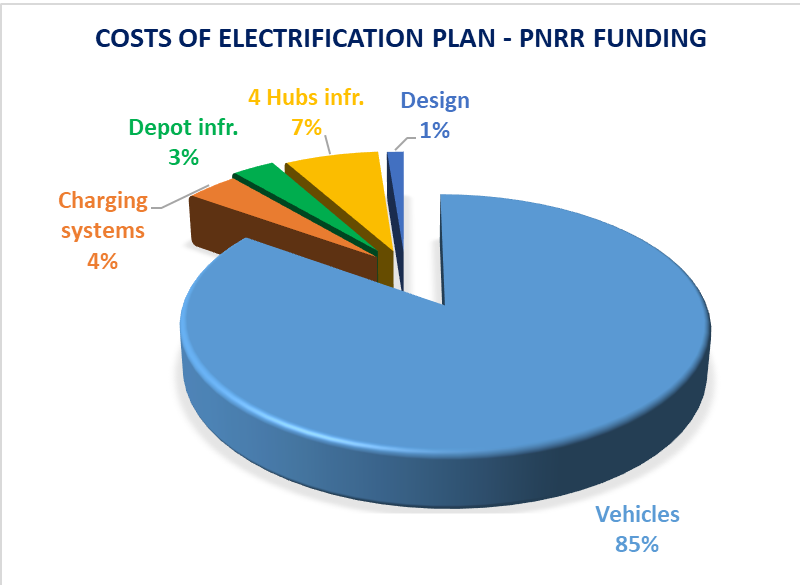


# FLEET RENEWAL PLAN: OVERVIEW



**PON funding: 10.1 M€**

- Vehicles purchase: February-June 22
- Tendering (depot infrastructures): April-May 23
- Vehicles delivery: July 23
- Depot infrastructures realization: October 23



**PNRR funding: 108.5 M€**

- Vehicles purchase: June 23
- Preliminary project: May-June 23
- Tendering (infrastructures - executive project): July-November 23
- Vehicles delivery: September 24 – March 26
- Executive projects: January-May 26
- Infrastructures realization: December 24 – March 26

# FUTURE PLANS



THE ENERGY TRANSITION OF CTM CAGLIARI







## FUTURE PLANS



### DEPLOYMENT OF A SMALL FLEET OF FUEL-CELL HYDROGEN BUSES

**Nr. of vehicles:** 15

**Length of vehicles:** 12-18 meters

**Years:** 2025-2027

**Funding:** PSNMS

**Refueling H<sub>2</sub> station:** outside of CTM depot, using a refueling station in construction near Cagliari

**H<sub>2</sub> production:** renewable sources



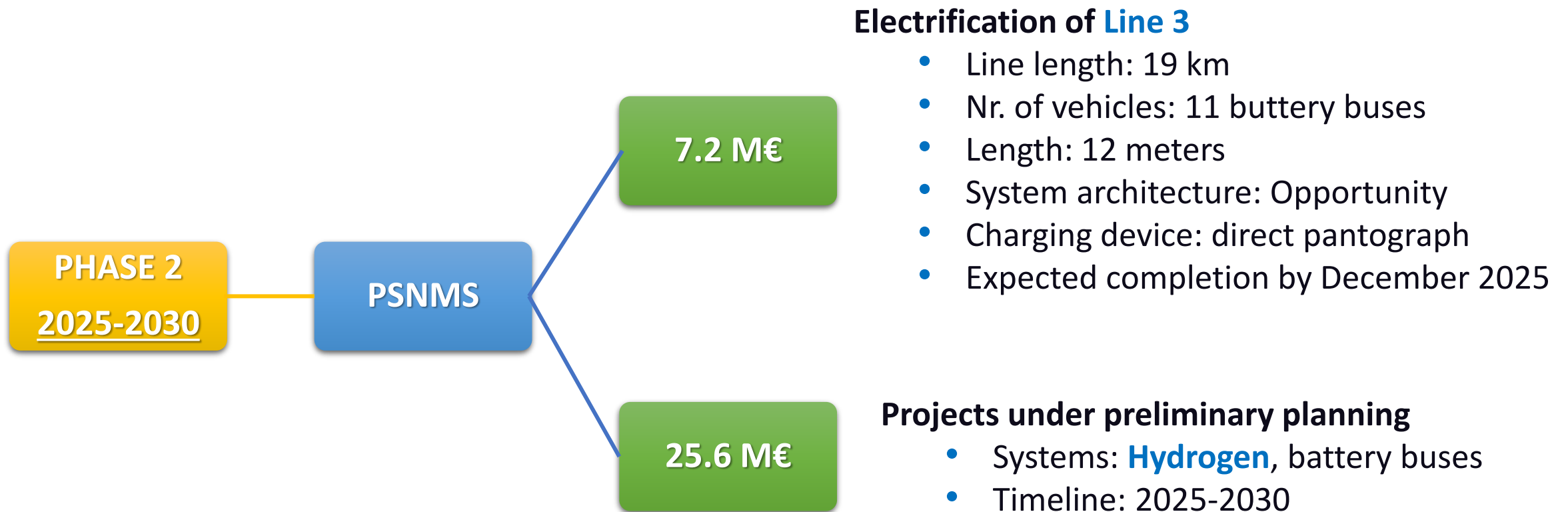
style-photography via Getty Images

THE ENERGY TRANSITION OF CTM CAGLIARI

**If 2025-2027 tests on a small scale gives us positive feedbacks, a full-scale deployment of a hydrogen powered fleet is expected in 2028-2030, with construction of a refueling station.**



## PROJECTS ON FUNDINGS ALREADY AVAILABLE



## EXTENSION OF TROLLEYBUS NETWORK WITH BATTERY-TROLLEYS: LINE 6



Line 6	
Line length	24.8 km (round trip)
Terminus A	S. Elia
Terminus B	Andorra
Vehicles length	12 meters
Max. vehicles in service	10
Nr. Of vehicles needed	12
Commercial speed	14.8 km/h
Daily line distance	2,327 km

**Elevation profile: from A to B (13.2 km)**

**Min: -1 m.a.s.l. - Max: 80 m.a.s.l.**

**Maximum slope: 17.7 %**





## EXTENSION OF TROLLEYBUS NETWORK WITH BATTERY-TROLLEYS: LINE 6



Line 6	
Line length	24.8 km (round trip)
Terminus A	S. Elia
Terminus B	Andorra
Vehicles length	12 meters
Max. vehicles in service	10
Nr. Of vehicles needed	12
Commercial speed	14.8 km/h
Daily line distance	2,327 km

Trolleybus electrification hypothesis Nr. 1	
Line length	24.8 km (round trip)
Overhead line section	from c to d (vice versa)
Overhead line length	9.4 km (38%)

Trolleybus electrification hypothesis Nr. 2	
Line length	24.8 km (round trip)
Overhead line section	c-d and e-f (vice versa)
Overhead line length	12.6 km (51%)

# CONCLUSIONS



## CTM IS PLANNING A FULL ENERGY TRANSITION, AS A COMPANY

- The **energy transition of the fleet** will be completed **by 2030**, with electric clean vehicles.
- The **biggest leap** toward a clean fleet is expected between **2023-2026**.
- Best technical solutions for CTM Cagliari, considering the boundary conditions and the environment in which we operate, are: **plug-in battery buses** (slow charging); **direct pantograph (fast charging)**; **direct pantograph (slow charging by catenary)**; **battery-trolleybuses**; **fuel-cell hydrogen buses**.
- Other than building new charging infrastructure, we are going to **increase the potentiality** of the infrastructure already available (**overhead line**) with two technological solutions:
  - **In motion charging** of battery-trolleybuses
  - Stationary **battery charging** with direct **pantograph**



## CTM IS PLANNING A FULL ENERGY TRANSITION, AS A COMPANY

- **Correct design and sites selection** of charging infrastructures, together with **battery sizing**, are the key factors to achieve the performance required for an **efficient transportation system**.
- A major **renewal** of the **depot** (control center, safety systems, maintenance facilities and equipment, etc.) is necessary to accommodate these technologies.
- With electrification, **fleet renewal** plans are more **complicated** than the past. We deal with a **complex and integrated system** (vehicles - charging infrastructure – depot adaptation – electric power availability – etc.).
- The complexity of the systems involved implicates **high investments costs**. **Public funding** is essential for the energy transition of PT companies.
- Training of drivers, maintenance and depot staff is very important.

# TECHNICAL VISITS







**CTM DEPOT**

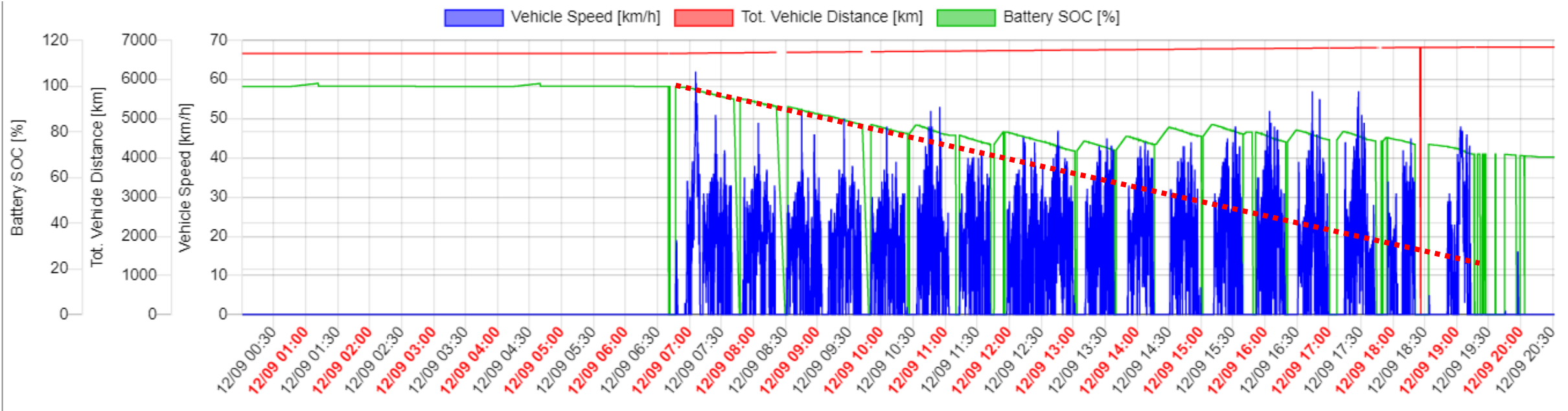


**Brigata Sassari (CTM Point)**



**Electric bus charging with trolleybus infrastructures  
Overnight (Depot) – Opportunity (Line 40)**

## Real data from service: Line 40 - September 12<sup>th</sup>, 2022 Opportunity charging via pantograph at “Brigata Sassari” terminus

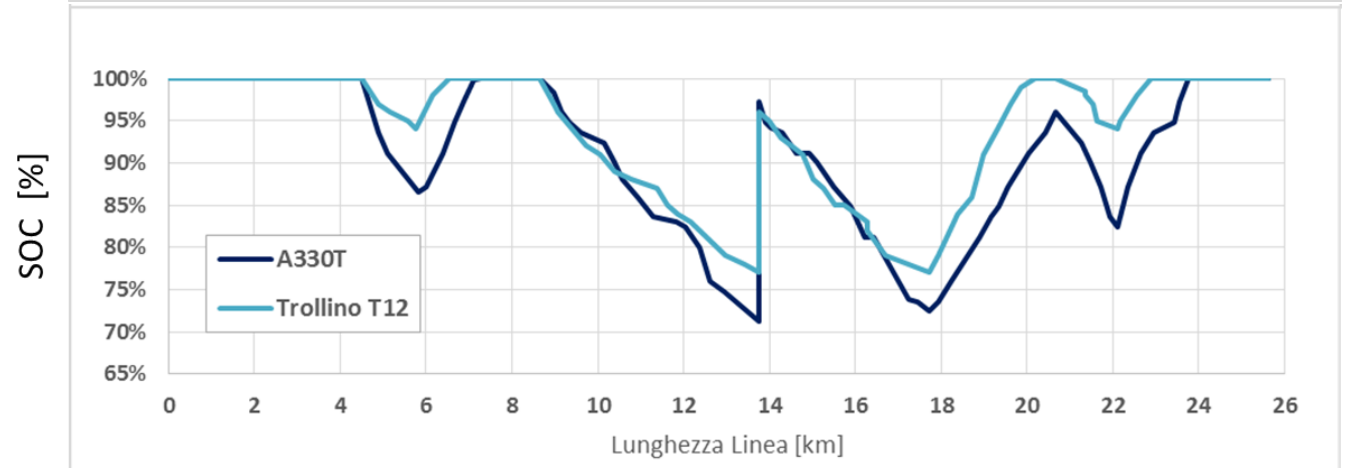
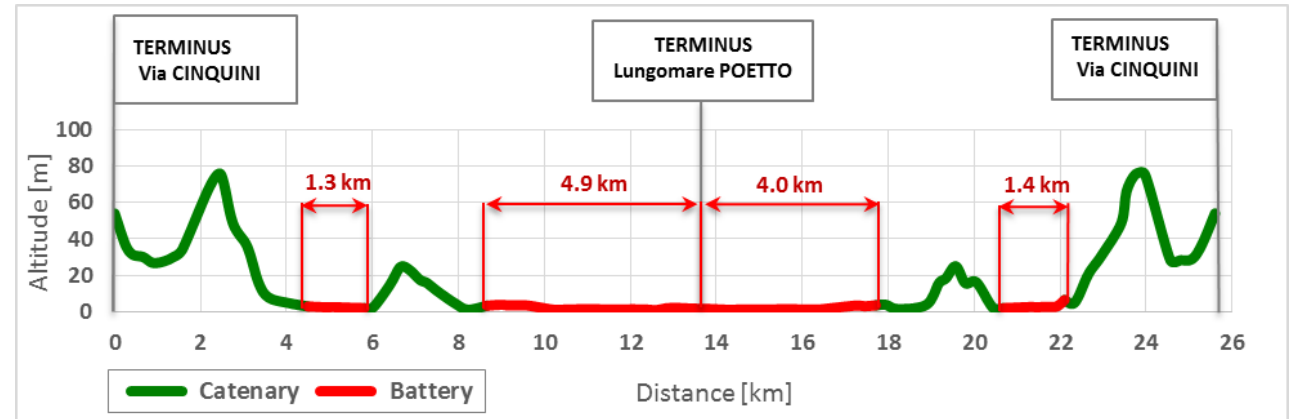


**Final SOC with opportunity charging: ≈70%**  
**Final SOC without opportunity charging: ≈25%**

## Line 5ZeEUS

Length	25.4 km (round trip)
Number of bus stops	83
Average daily travelled distance	213 km ( <b>46% without Catenary</b> )
Frequency	8-10 minutes
Commercial speed	13.6 km/h

**Trolleybus line in operation since 2016, every summer (from mid June to mid September)**





## Poetto charging station

### Technical Data

AC Input		
Voltage	400 (±5%)	V
Frequency	50	Hz
DC Output		
Nominal voltage	750	V
Nominal current	67	A
Electric specifications		
Type of connection	three-phase bridge	
Semiconductor	diode	
Pulse number	6	Nr.
Overload class (IEC 60146-1-1)	I	
Installation	Indoor (IP20)	
Dimensions and Weight		
Length	1000	mm
Width	1000	mm
Height	2200	mm
Weight	400	kg
Operative conditions		
Ambient temperature	0-40	°C
Elevation	≤ 1000	m a.s.l.



# Poetto charging station





# Poetto charging station







Thank You!

# Questions & Answers

