Depot adaptations & safety issues for zero-emission buses

Webinar Series

26th January 2023, 11.00-12.00 CET

Lidia León Talavera

Deputy Director of Operations Centers, EMT Madrid

CLEAN BUS EUROPE PLATFORM

UITP

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

Lidia León Talavera
Deputy Director of Operations Centers, EMT Madrid

- Industrial Mechanical Engineer
- At EMT Madrid since 2006, in several positions always linked to bus operation
- Since 2019, representative of EMT Madrid at UITP Bus Committee and leader of the CVT work stream
- Since 2020 Deputy Director of Operations Centres at EMT Madrid.

Programme

Depot adaptations & safety issues for zero-emission buses		
11.00 – 11.05	Welcome & Introduction	UITP

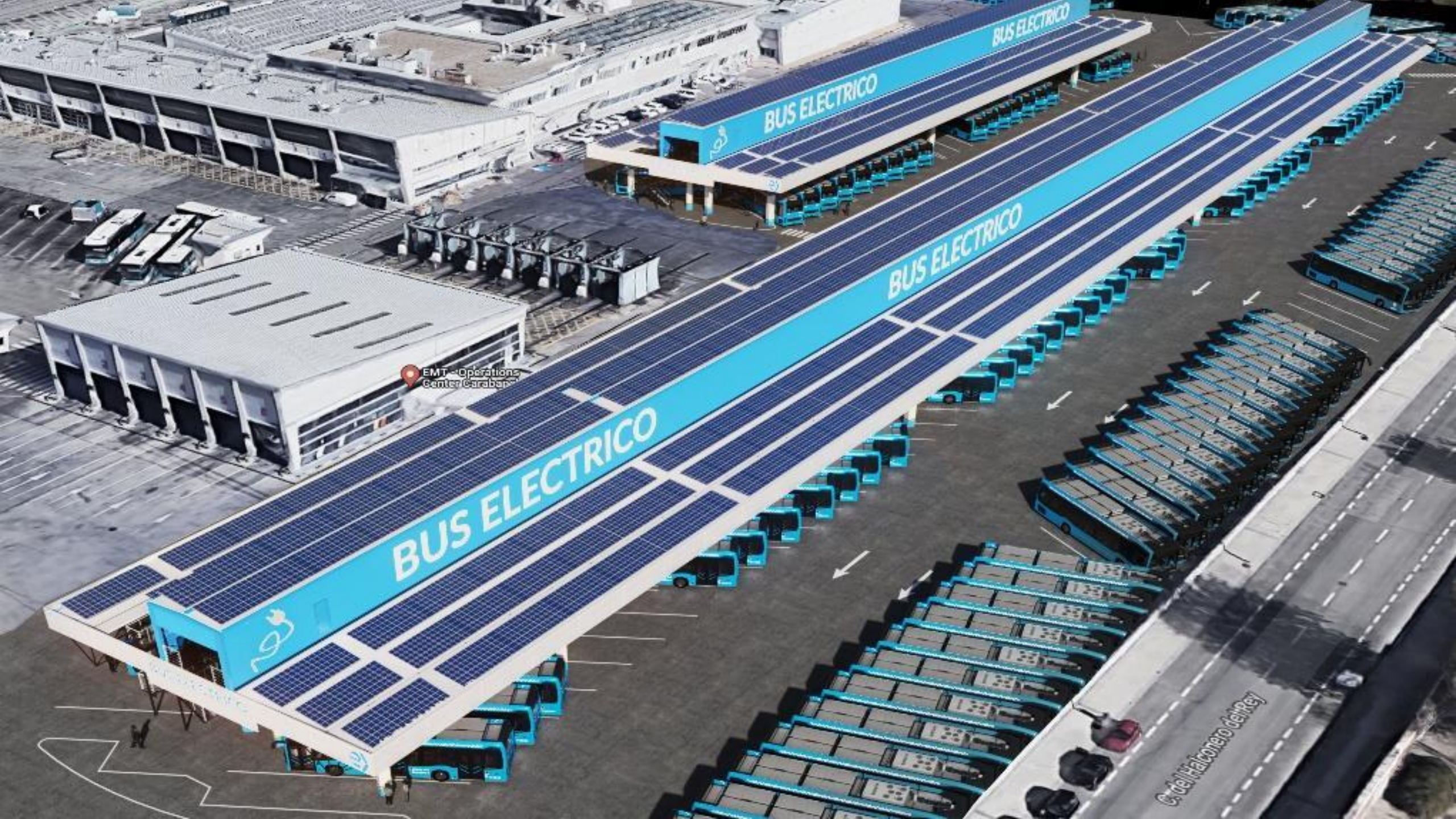
11.05 – 11.50	• EMT MADRID: History, Data and Assets
	• II. INTRODUCTION TO BUS DEPOT ELEMENTS
	• III. PLANNING
	  • Operation structure
	  • Charging Infrastructure
	  • Smart Charging
	  • Safety regulations and standards
	• IV. TOTAL COST OPERATION
	• V.EMT CONCLUSIONS
		Lidia León Talavera, EMT Madrid

11.50 – 12.00	Questions & Answers	

Etiquette for joint discussion

- Participants please mute yourself per default
- You can use the Chat to place your questions, share interesting info or make us aware of any technical issue
- Raise your hand and switch on your camera to ask to have the word
- The session will be recorded.

We count on your valuable contribution for a successful workshop. Thank You!


BUS ELECTRICO
BUS ELECTRICO
BUS ELECTRICO
BUS ELECTRICO
EMT - Operations Center Carabanchel

Depot adaptations & safety issues for zero-emission buses

Lidia León Talavera, Deputy Director Operations Centres, EMT Madrid

Agenda

I. EMT MADRID: History, Data and Assets

II. INTRODUCTION TO BUS DEPOT ELEMENTS

III. PLANNING

- Operation structure
- Charging Infrastructure
- Smart Charging
- Safety regulations and standards

IV. TOTAL COST OPERATION

V.EMT CONCLUSIONS

I. EMT MADRID

History, Data and Assets

EMT Madrid: History, data and assets

EMT MADRID

MUNICIPAL TRANPORT COMPANY OF MADRID

Created in 1947.
Company 100% owned by Madrid City Council.
Service 24/7 all year round.
Operates and manages the whole network of public urban buses in Madrid city.
EMT also provides other public mobility services in the city of Madrid:

- **Since** 2014, managing parking facilities and tow trucks
- **Since** September 2016, the public e-bike sharing system BiciMAD.
- **Since** January 2018, the cable car system

But also managing the segregated bus lanes, bus canopies/shelters advertising exploitation, and Consultancy

EMT MADRID: ASSETS

EMT is the **reference of surface mobility** in the city of Madrid. It counts with 9.923 workers, 7 business lines and 5 Bus Depots that enable the company to provide integrated and client-oriented services that foster a **sustainable and efficient mobility**.

Assets EMT 2022

BUS

2.090 buses (2.090 buses in Dec.-2022 | 100% green fleet)

220 bus lines

372,9M passengers (Dec.-2022))

10.884 bus stops | 3.977,66 km network | 5 bus depots

(Nov.- 2022) BiciMAD

3.681 bikes | 373 BiciMAD Go |

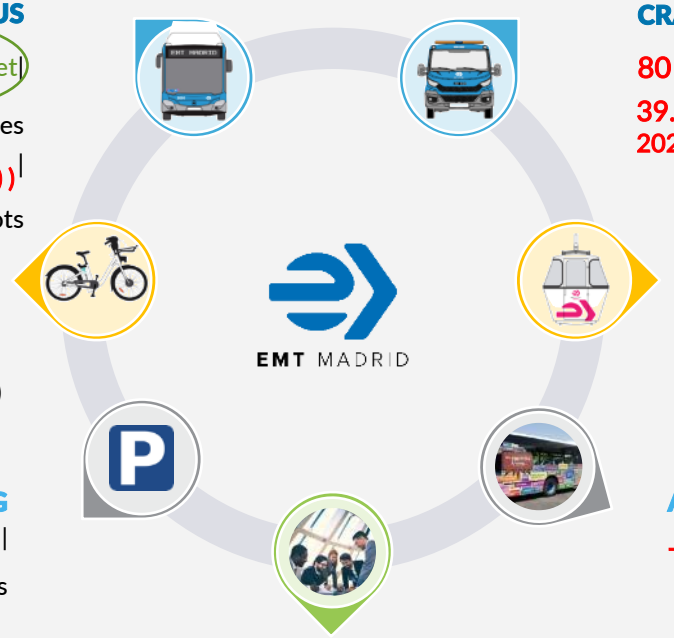
264 bike stations | 15 districts

3,3M rides (2019)

(Dec- 2022) PARKING

28 parking facilities | 1 Mobility hub |

12.530 parking lots



CRANES

80 cranes | 4 bases | 3 depots

39.015 removed vehicles (Dec. - 2022)

CABLE CAR

80 cabins | 2 stations

310.521 passengers (Dec. – 2022)

ADVERTISING

+4.000 bus shelters

CONSULTING

8 technical assistances

6 EU funded projects

Strategic Framework 2021-2025

Strategic Framework for EMT

International roadmap transferred to the local level

Sustainable Development Goals (SDG)

European Green Deal

Next Generation Funds

MADRID 360 Sustainability Strategy

Sustainability Strategy Madrid 360 reflects Madrid's commitment to:

- the SDGs and the decarbonisation objectives of the European Green Deal, and
- the reduction of carbon dioxide emissions in the city by 6.5% is marked as a key objective.

MADRID 360 new SUMP

Plan de Movilidad Sostenible

July 2022. Completes and develops the strategy measures

EMT Madrid Strategic Plan 2021-2025

EMT Strategic Plan 2021-2025 aims to reinforce the Company as:

- the reference of sustainable mobility in the city,
- 100% free of diesel and with clear progress in the decarbonisation of the fleet.

Strategic Framework for EMT Madrid

Strategic Plan EMT 2021-2025

Corporate Goals

The corporate objectives characterize the general purpose in **transversal objectives** for the entire company, focused on **sustainability**, the **client**, **economic profitability** and **digital transformation**.

- Move towards a **green, decarbonised company** that takes advantage of the benefits of the **circular economy**
- **Strengthen customer orientation** with an **excellent** service of general interest
- Guarantee **financial sustainability and business growth** through **new businesses and services**
- Promote the **digital transformation** of EMT and the improvement of **efficiency** in the provision of mobility services

Strategic Framework for EMT Madrid

Strategic Framework for EMT Madrid

Main Strategic Projects

Operations

2030 Bus Development	Design of the new **bus model**, **with technological improvements** deployed on board to improve the quality, efficiency and safety of the service.
On-demand bus pilots and **autonomous driving**	Prospecting and development of pilots to **promote innovation and international positioning** of the company, offering new services to users.

Infrastructures

Bus Depots of the future: La Elipa and Las Tablas	Design and construction of the Bus Depots of the future to **optimize the operation of current services** and enable the provision of new services.
Parking lots as mobility infrastructures	Transformation of infrastructures to support the **sustainable mobility of the future**, promoting EMT Madrid's role as a mobility agent.
Photovoltaic panels installation	Installation of more than **40,000 m² of photovoltaic panels** to improve infrastructure sustainability and facilitate the **transition to a decarbonized and efficient EMT**.

Strategic Framework for EMT

Strategic Plan EMT 2025

Investment planned: € 1.000M for the next 5 years

534M €
Buses Acquisition

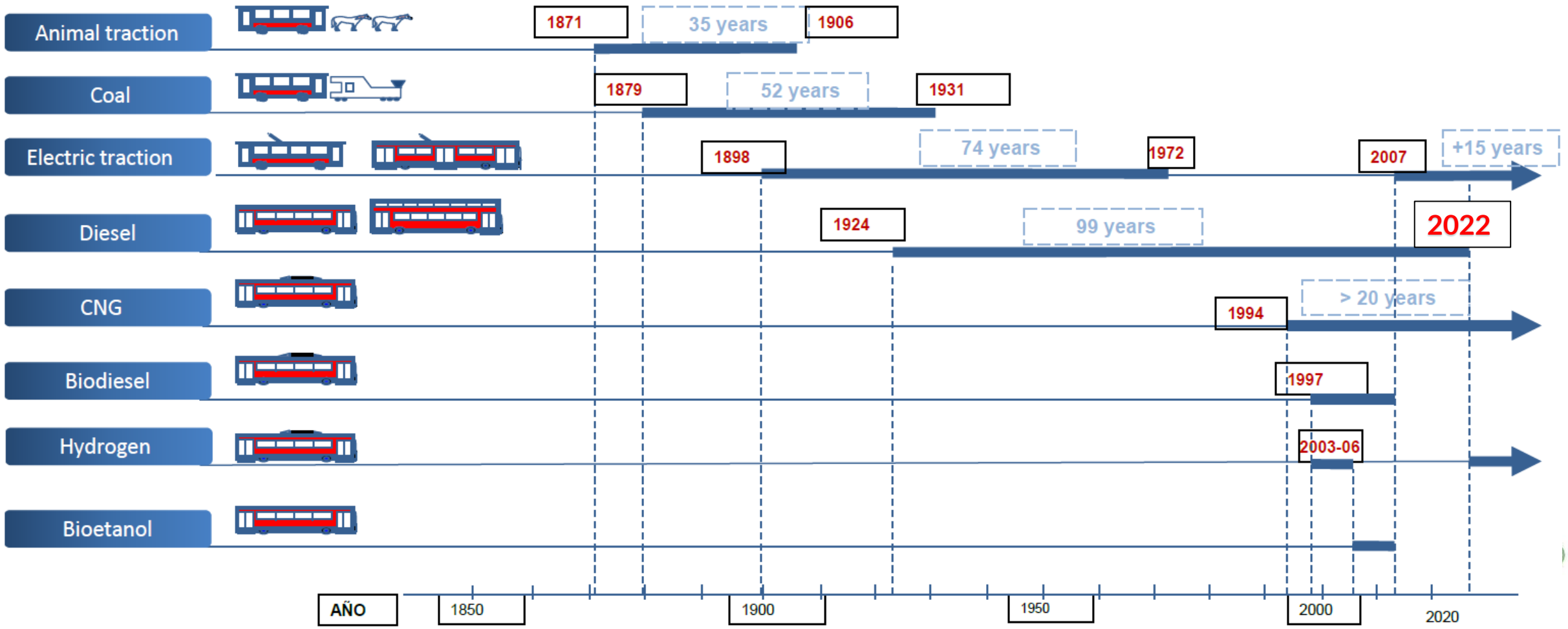
131M €
Construction

158M €
Installations

177M €
Other investments

€	2021	2022	2023	2024	2025	TOTAL
Buses acquisition	112.132.900	108.584.200	81.403.900	116.284.200	116.284.200	534.689.400
Constructions	200.000	17.692.900	45.155.800	52.655.800	16.050.000	131.754.500
Installations	4.124.744	29.523.188	50.675.800	55.255.800	18.650.000	158.229.532
Other investments	25.362.310	59.719.861	45.038.420	23.000.495	24.064.208	177.185.292
TOTAL INVESTMENT	**141.819.954**	**215.520.148**	**222.273.920**	**247.196.295**	**175.048.408**	**1.001.858.724**

EMT MADRID: PREVIOUS FLEET EVOLUTION



EMT MADRID: TRANSITION DIESEL – CNG / CNG – BATTERY ELECTRIC

FROM DIESEL TO CNG

1. EMT **has already done a full transition from DIESEL to CNG (1994-2022)**

   a) Over more than 20 years, EMT has been purchasing CNG buses.

   b) **Since 2010** EMT has not purchased **any diesel buses**

2. IMPLEMENTATION PROCEDURE

   a) Transitory adaptations of depots as testing ground

   b) **New depot 100% GNC in 2010** based on previous experience in other depots

FROM CNG TO ELECTRIC

1. EMT started with its first fully electric e-bus in 2007 (microbuses).
2. First 12 m long fully electric e-bus in 2018 (first public trials in 2017)
3. Expected transition to a **fully decarbonized fleet up to 2035** (Today at 8%; by 2027 will be at 34%)

EMT MADRID: ELECTRIFICATION OF BUS FLEET

Fleet evolution

Current e-fleet

- ✓ Total e-buses in service: 180
- ✓ 19 bus lines 100% electric

	2020	2021	2022	2023	2024	2025	2026	2027
Diesel	388	196						
GNC	1.552	1.678	1.829	1.744	1.661	1.561	1.451	1.351
Hybrid	47	47	17	17				
Hydrogen				10	10	10	20	20
Electric	81	179	254	329	429	529	629	729
Total	2.068	2.100	2.100	2.100	2.100	2.100	2.100	2.100
% electrifiation fleet	3,9%	8,5%	12,1%	15,7%	20,4%	25,2%	30,0%	34,7%

Composition fleet evolution in EMT at the end of the year (unities). Source: EMT Madrid.

Strategic decision: no diesel fleet renewal (2010)

C.O. de Sanchinarro, 2010: First 100% CNG bus depot in Europe

Currently, 100% Green fleet

Short-medium term 2020-2023

50 e-buses /year In 2022 and 2023 : 75

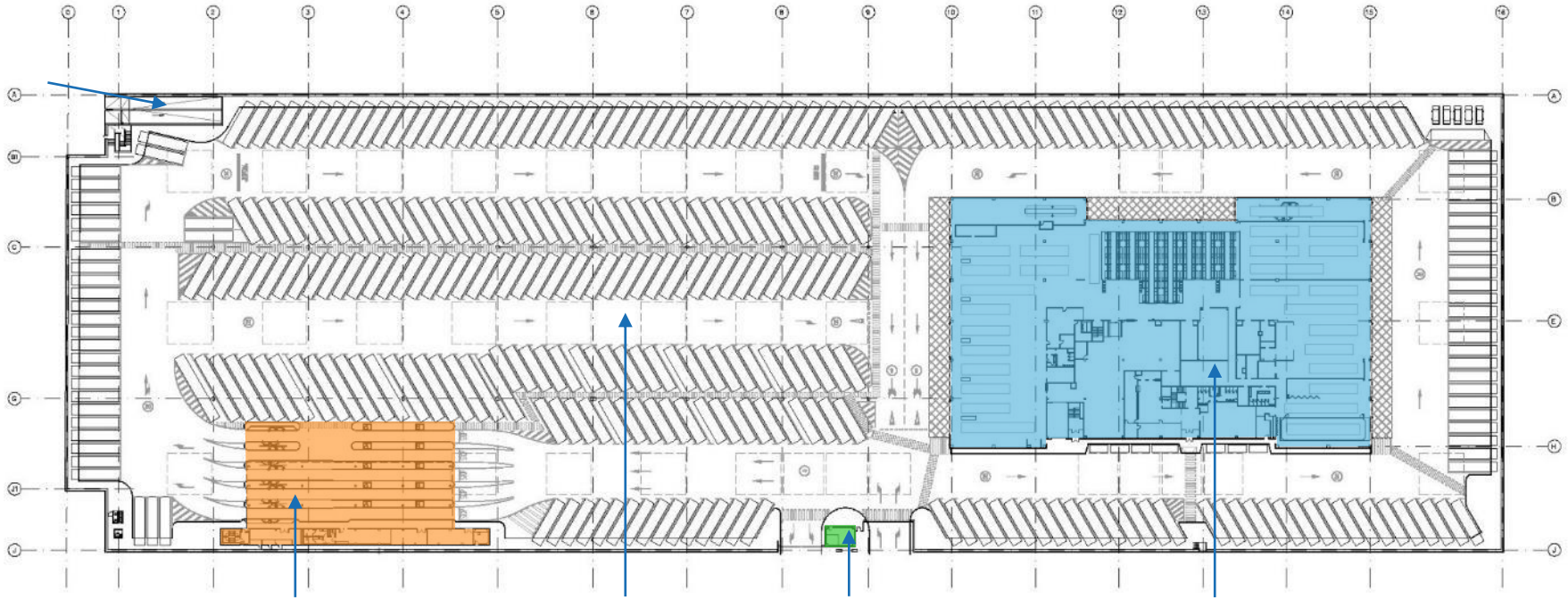
Long term 2024-2028

100 e-buses /year

II. INTRODUCTION TO BUS DEPOT ELEMENTS

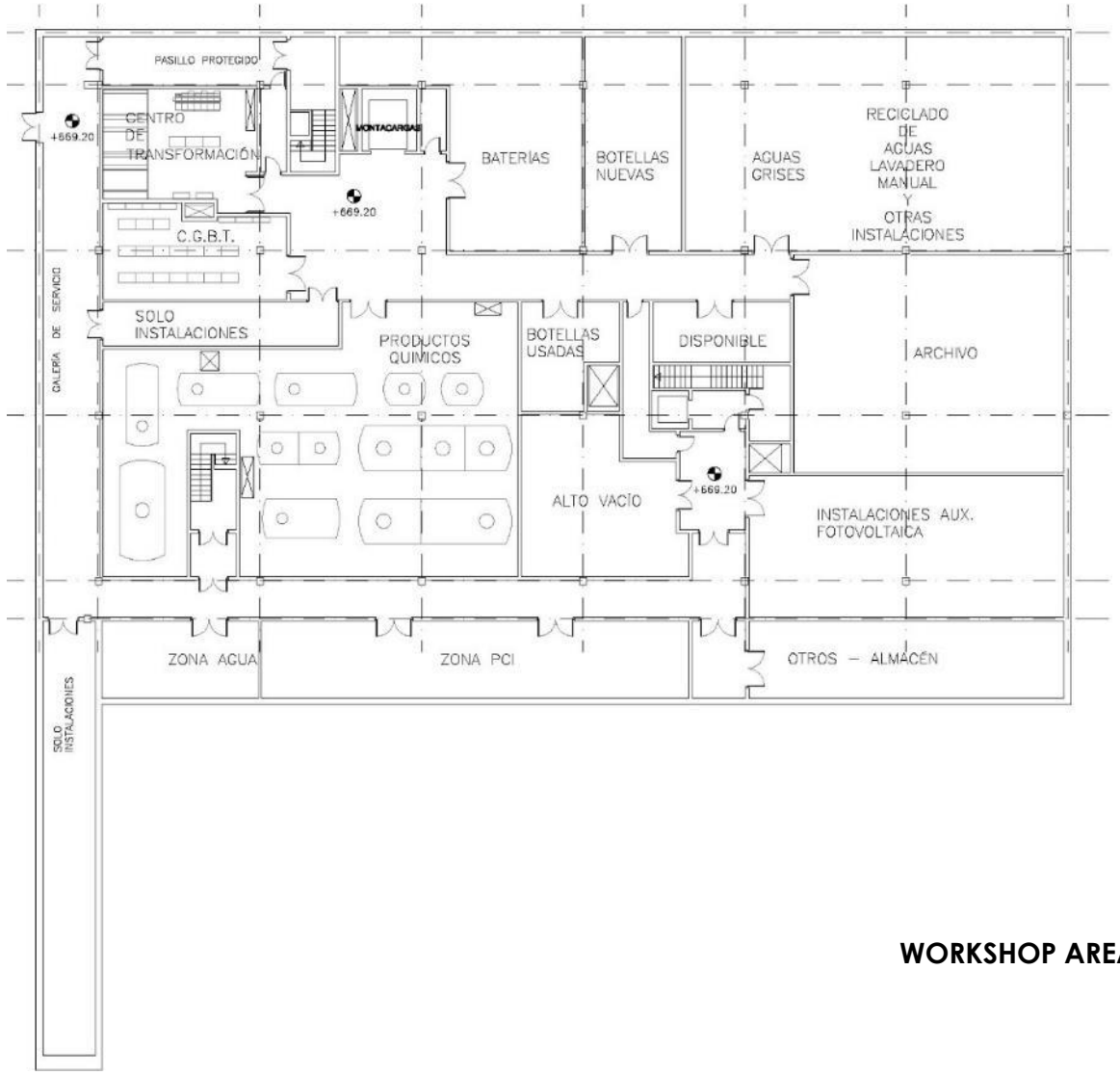
Based on our brand new la Elipa bus depot

Parking Access (for employees and visitors)



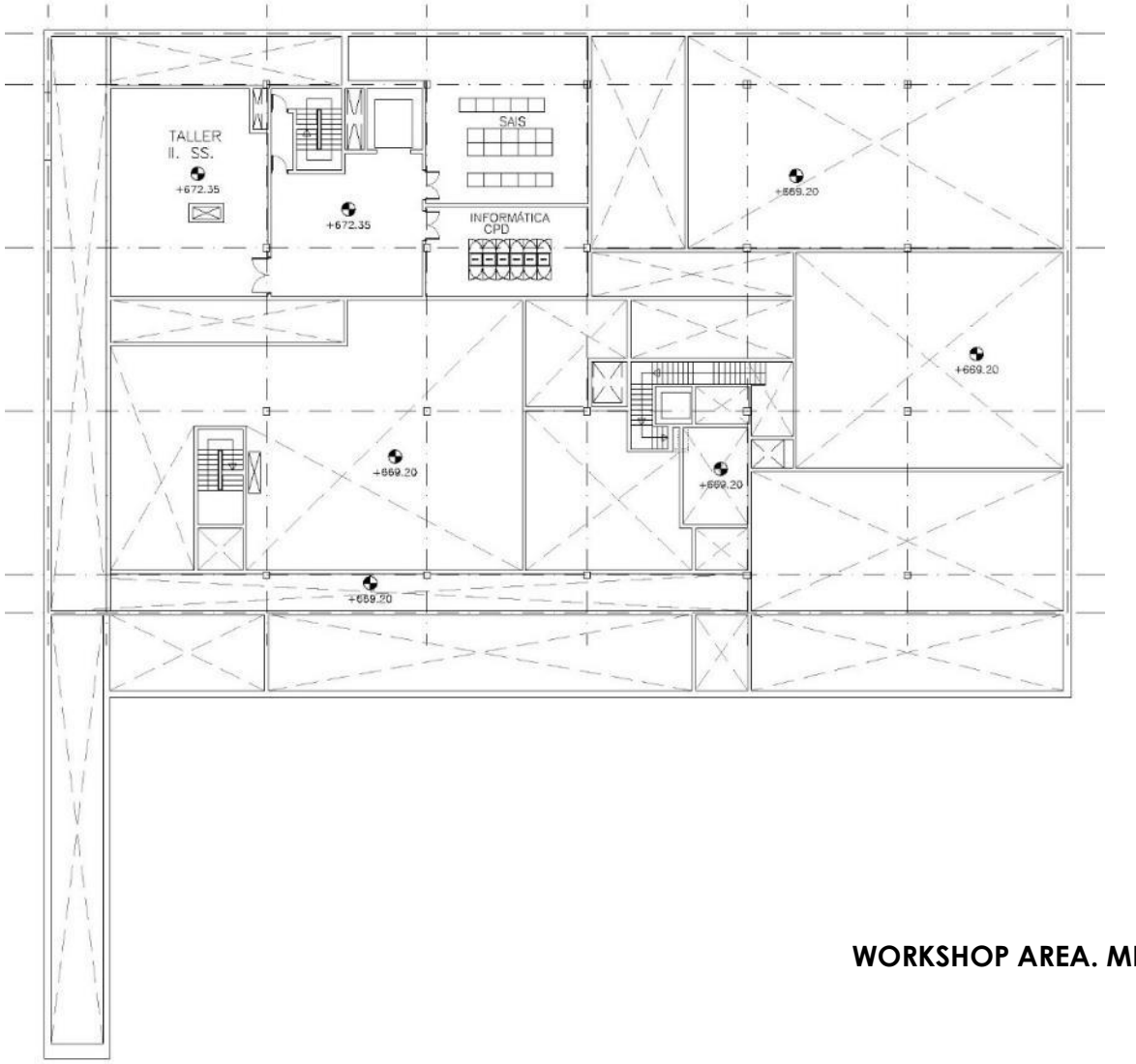
CENTRO DE OPERACIONES DE LA ELIPA
(EMT MADRID)
Ground floor

Based on our brand new la Elipa bus depot



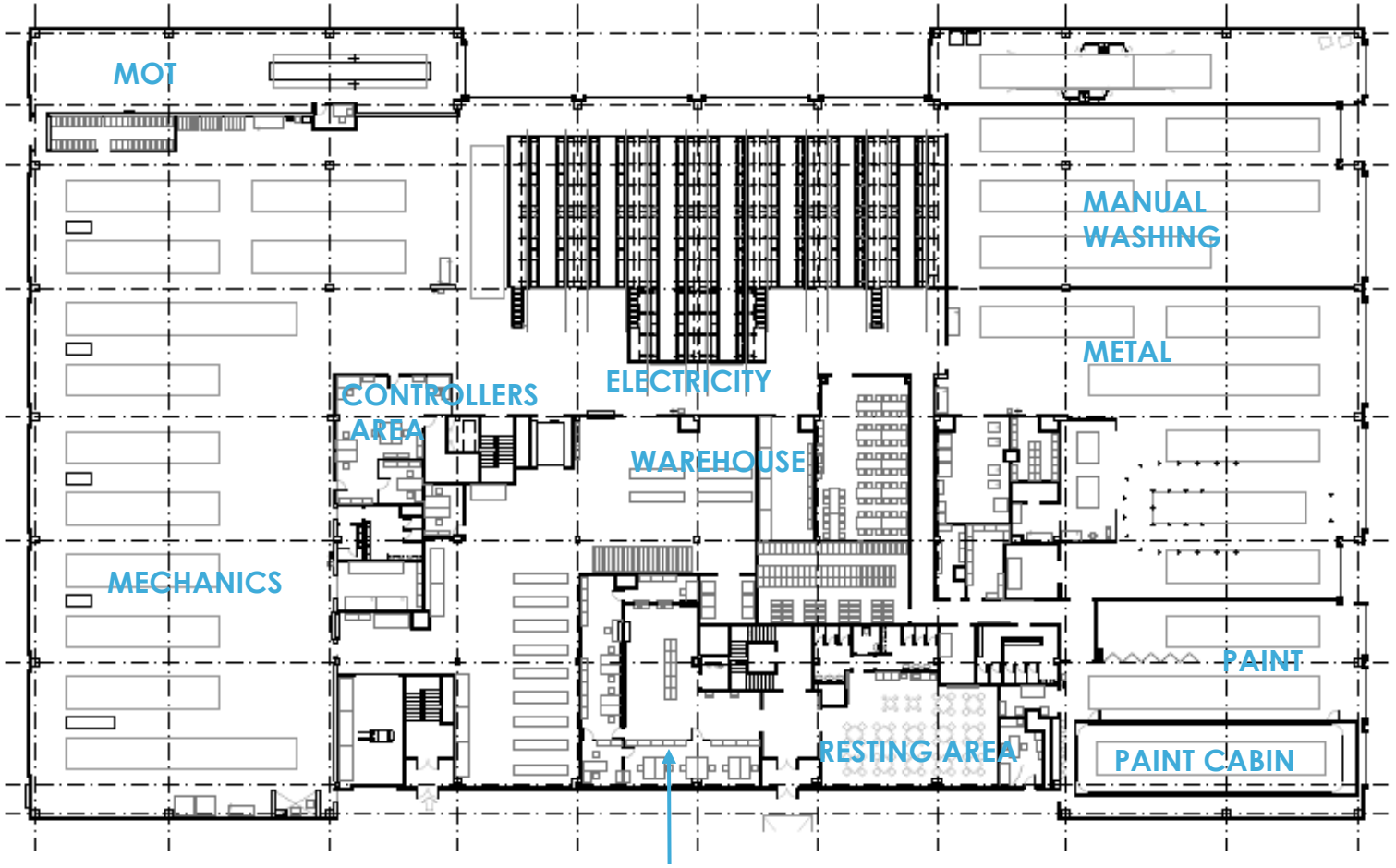
WORKSHOP AREA. UNDERGROUND FLOOR)

Based on our brand new la Elipa bus depot



WORKSHOP AREA. MEZZANINE FLOOR

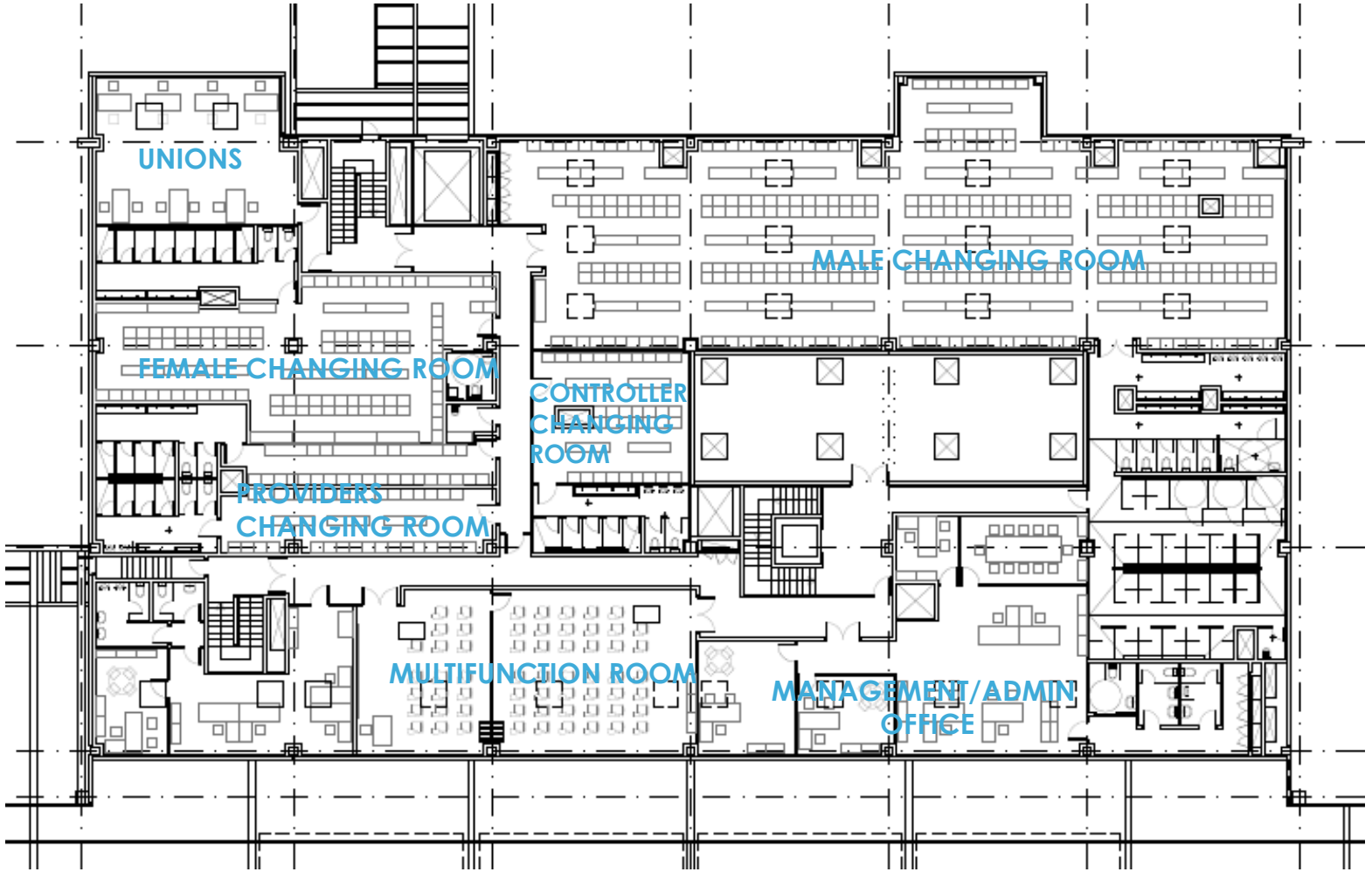
Based on our brand new la Elipa bus depot



WORKSHOP BUILDING: GROUND FLOOR

SURFACE OF WORKSHOP: 6,180 M2

Based on our brand new la Elipa bus depot



WORKSHOP BUILDING: FIRST FLOOR

III. PLANNING

III.I. OPERATION STRUCTURE

E-BUSES OPERATION STRUCTURE

Fleet Provider

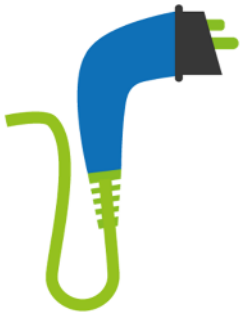
- Bus Provider
- Chargers Provider
- Training
- Maintenance during warranty period

Supply Contract

EMT MADRID

Energy Provider

Services Contract



What does EMT do?

- Bus Operator
- Maintenance fleet
- Training workforce
- Installation and Maintenance of charging infrastructure

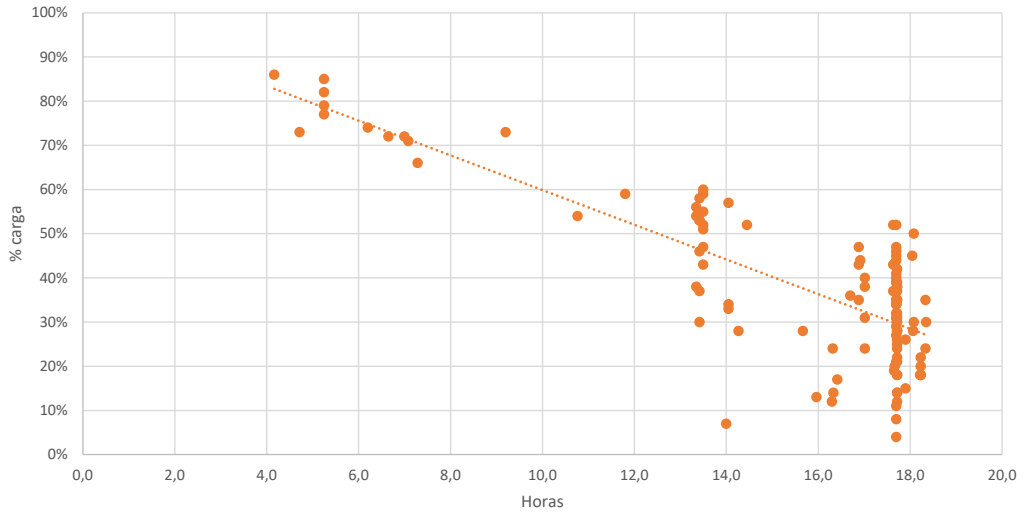
Aspects to consider for e-bus operation

About the service provided

- Charging processes
- Autonomy conditioned by:
  - Weather
  - Use of air-conditioning systems (very relevant in consumption)
  - Decreasing based on use

Substantial difference between range estimates and operational values.

- Influence of driving. Driver training is essential and needs to be regular.
- Systems to monitor driving patterns in range-limited vehicles are essential as a means of detecting training needs.
- Influence of routes. Effectiveness of energy recovery system



In-service unloading process

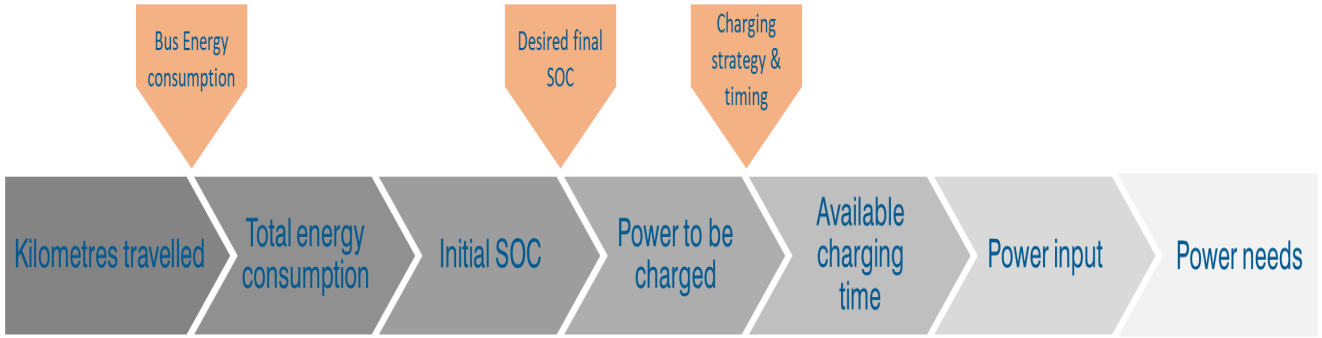
III. PLANNING

- III.II. CHARGING INFRASTRUCTURE

CHARGING INFRASTRUCTURE

Inputs:

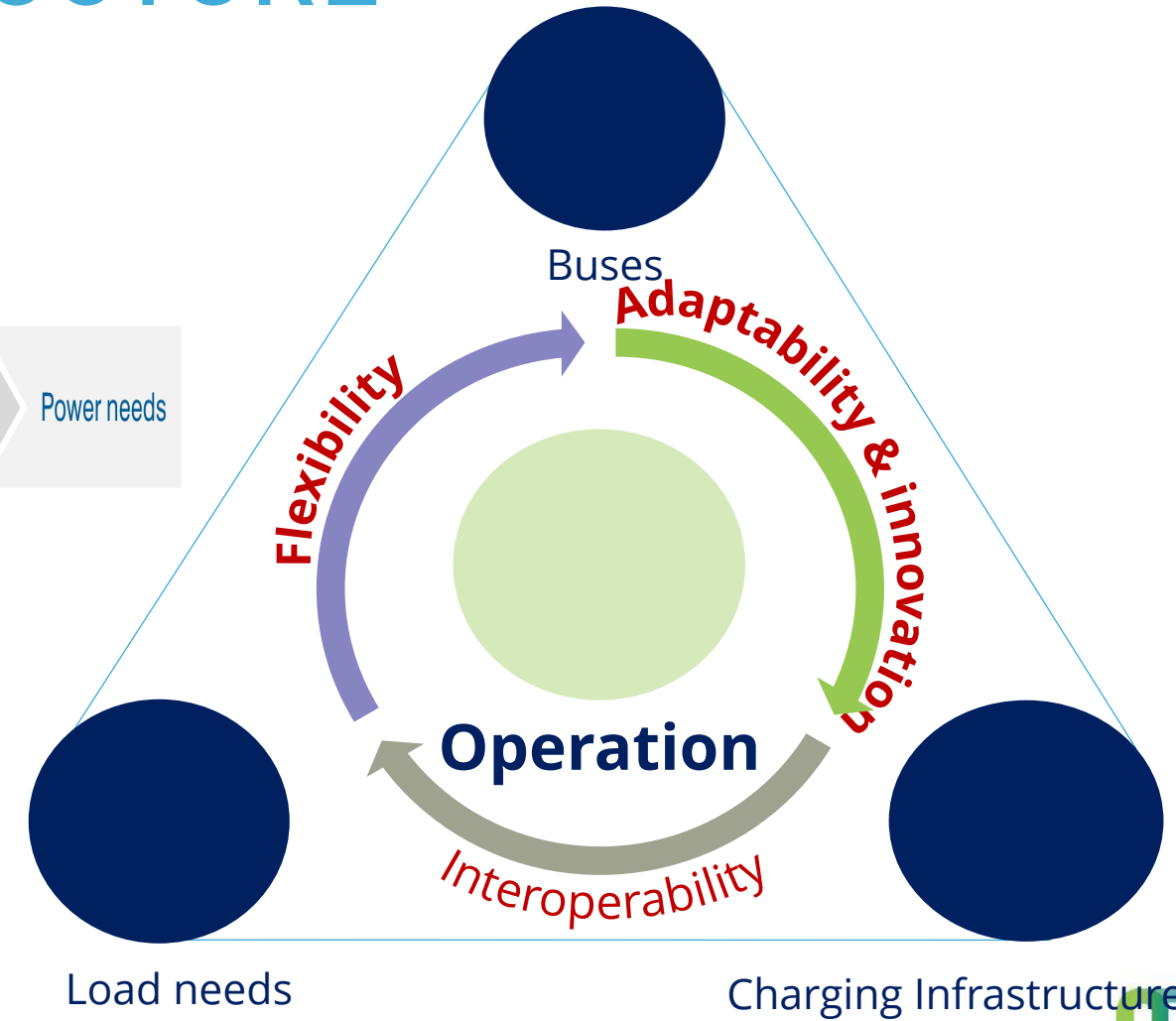
- Operational analysis



- Characteristics of new buses

Outputs:

- Election of charging solution
- Definition and optimization of charging strategies
- Depot adaptations



CHARGING SYSTEMS EVOLUTION IN EMT MADRID

INDUCTION OPPORTUNITY CHARGING

5 Vehicles

Since 2018

Opportunity charging on final lane

PLUG IN CHARGING

138 Chargers

Since 2007 minibuses (25)

Since 2018 standard (113)

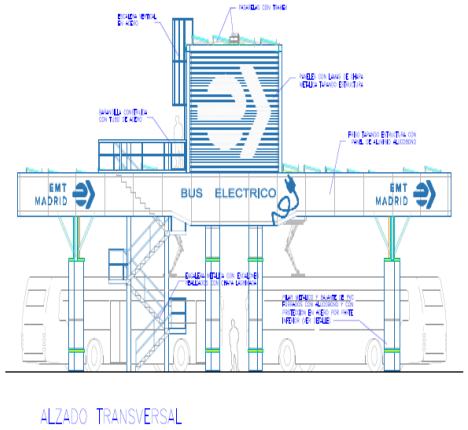
INVERTED PANTOGRAPH

176 pantographs

4 in test project

52 in 2022

118 in 2023



SMART CHARGING & NEW DEPOT

New Depot

318 inverted pantographs

Smart Charging

Optimizing charging power and cost

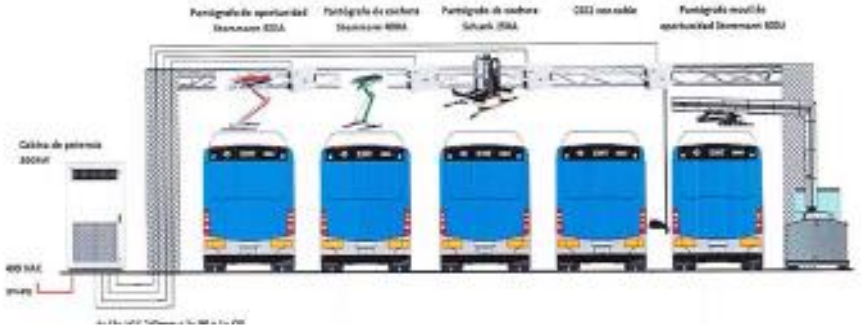
OPPORTUNITY CHARGING: INDUCTION PILOT

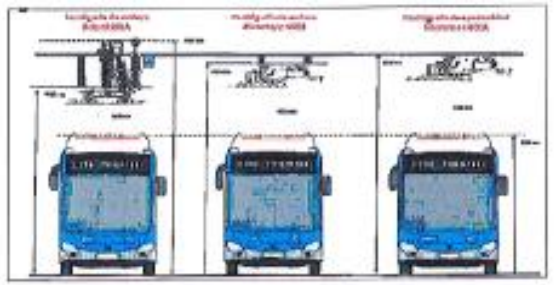
- Since 2018
- Retrofit of 5 hybrid buses from CNG to electric
- Certain limitation of energy storage on board
- Opportunity charge on the two ends of the lane (100 kW) and by wire charging in depot
- Not be further developed because the technology is not providing adequate performance for EMT operations

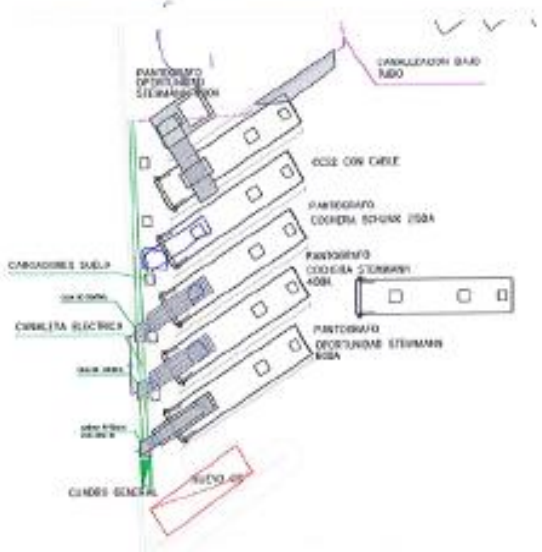
PLUG-IN CHARGING

- Since 2007
- 138 chargers
- 25 with 80 kW of power for minibuses
- 113 between 80 and 120 kW of power for standard buses

Inverted pantograph chargign (Test Project)







About charging infrastructure facilities

Installed power requirements

- Variations in contracted power require long management times.
- Electrification needs to be analysed globally. The necessary transformation centres require space and locations that allow for complex growth.

Location of chargers. Increased space requirements

- Conventional fleet parking spaces (herringbone in our case) clash with the provision of 1 charger/bus.
- The space requirements of the charging systems themselves and the guarantee of their physical security reduce the available parking spaces.
- The presence of large-diameter wiring and charging connectors makes it necessary to think about load-bearing elements and, in any case, the appearance of risks.
- Solutions such as pantographs imply the elimination of some but not all of these factors.

i.e. The new Fuencarral bus depot transformation centre will supply 50 chargers of 80KW

About workshops facilities

Requirements for working **at heights**:

- Batteries are largely located on the roof. This implies an additional need for workshop height.
- At present, this is less of a constraint, given that the CNG and air-conditioning works previously made it necessary to take initiatives to solve the problem.

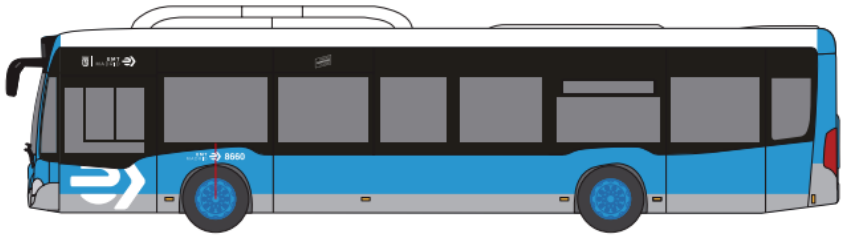
Requirements for **battery movement and storage**:

- Batteries, for the time being, have a limited life. Warranties shorter than the usual amortisation periods imply replacement works of high and heavy elements.
- Positions adapted to these jobs are required.
- Batteries are expensive elements with delivery times that generate immobilizations that are difficult to assume.
- Reducing these lead times involves stocking equipment that requires unusual storage conditions.
- The vehicle's allocation for medium/high voltage work implies the use of larger workshop spaces or specific work areas.

About maintenance equipment at workshops

For **preventive** reasons, the use of insulated tools specially designed for working under voltage is mandatory. These are expensive tools which deteriorate easily.

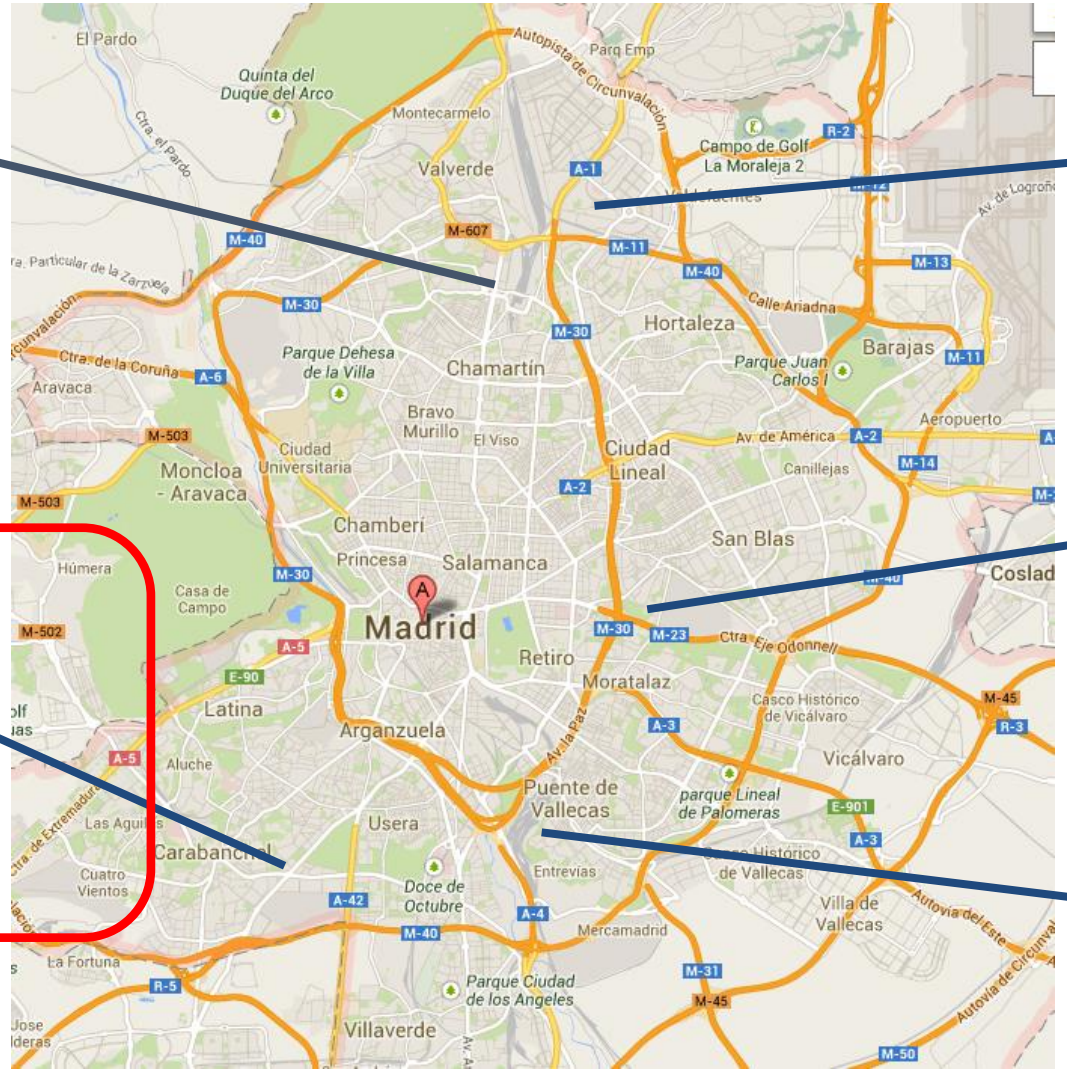
- Not many jobs require their use.
- It is advisable to rationalise their use through training
- It is necessary to acquire what is needed after study
- As in so many areas of life, it starts with exaggeration (the manufacturers themselves contribute to this excess in their maintenance manuals) and that is why the decision on what to equip oneself with and to what extent must be considered.



Depots adaptations

EMT Bus Depots

Fuencarral Bus Depot



Sanchinarro Bus Depot

La Elipa Bus Depot

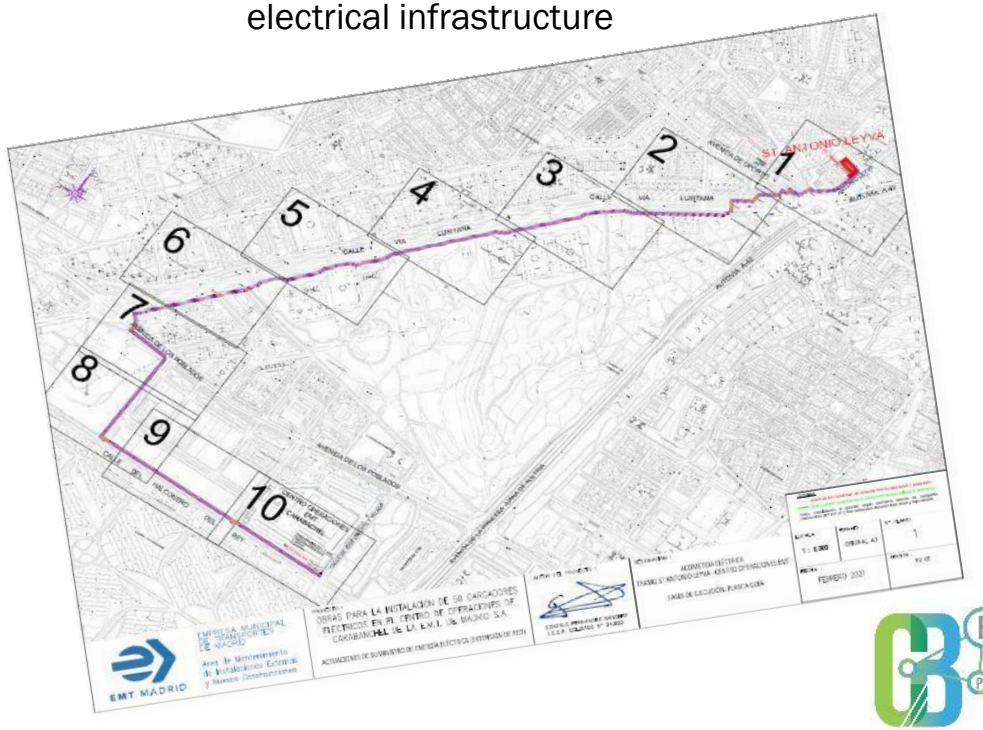
Carabanchel Bus Depot

Entrevías Bus Depot

CURRENT DEPOTS ADAPTATIONS: CARABANCHEL

Proyect along four years 2021/2023 for 220 chargers:

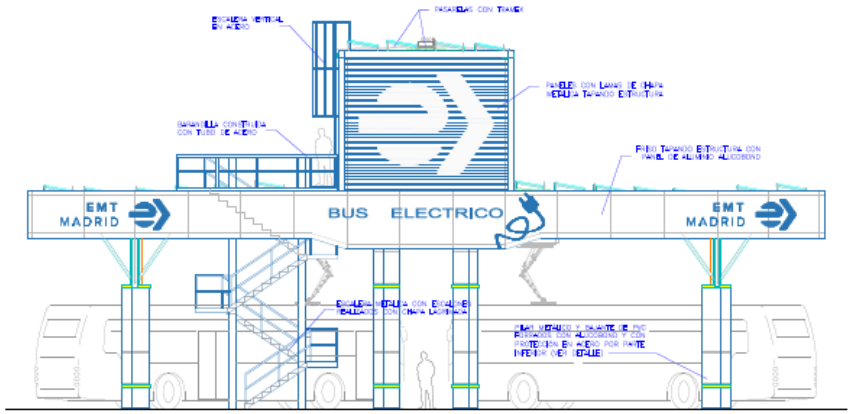
- Obtaining the necessary energy supply: 15MW
- Purchase of recharging elements: Chargers and Pantographs
- Execution of civil works and design and construction of the necessary electrical infrastructure



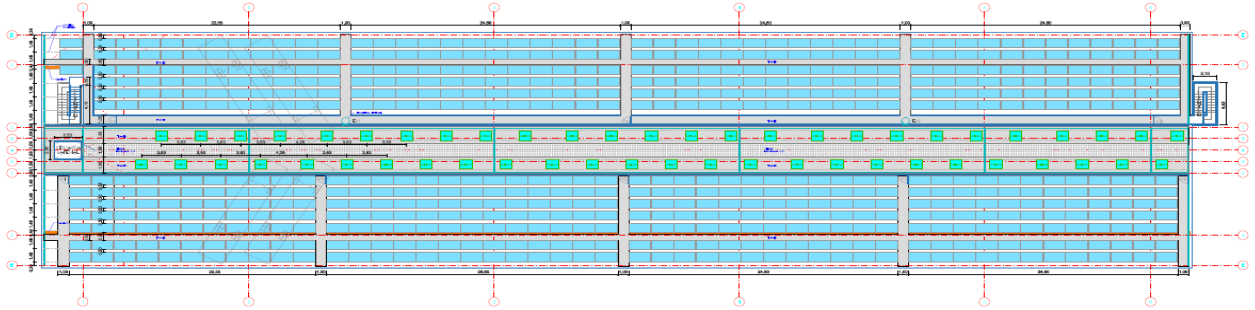
CURRENT DEPOTS ADAPTATIONS: CARABANCHEL

INVERTED PANTOGRAPH CHARGING

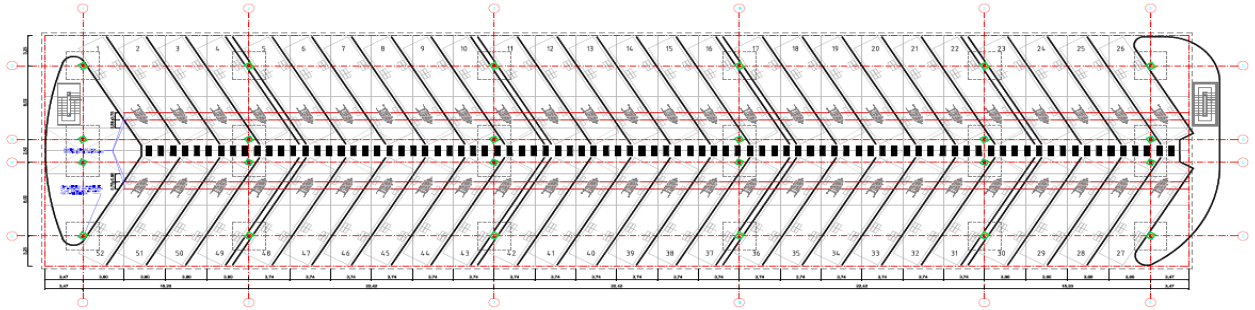
- In construction since June 2022
- 52 chargers of 100 kW in 2022
- 118 chargers up to 300 kW in 2023
- Infrastructures had been designed for chargers from 275 kW up to 865 kW
- Photovoltaic panels on the roof



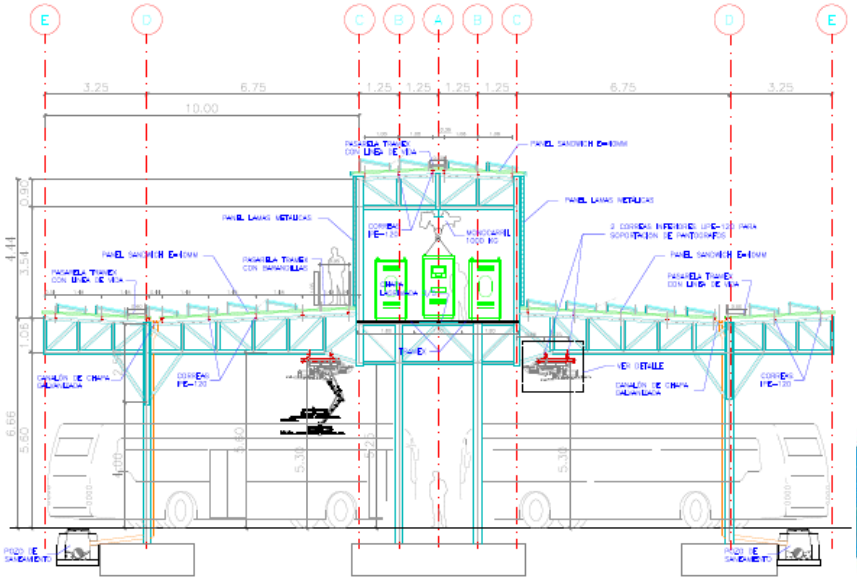
ALZADO TRANSVERSAL



PLANTA CARGADORES Y FOTOVOLTAICA



PLANTA PANTOGRAFOS



SECCIÓN TRANSVERSAL

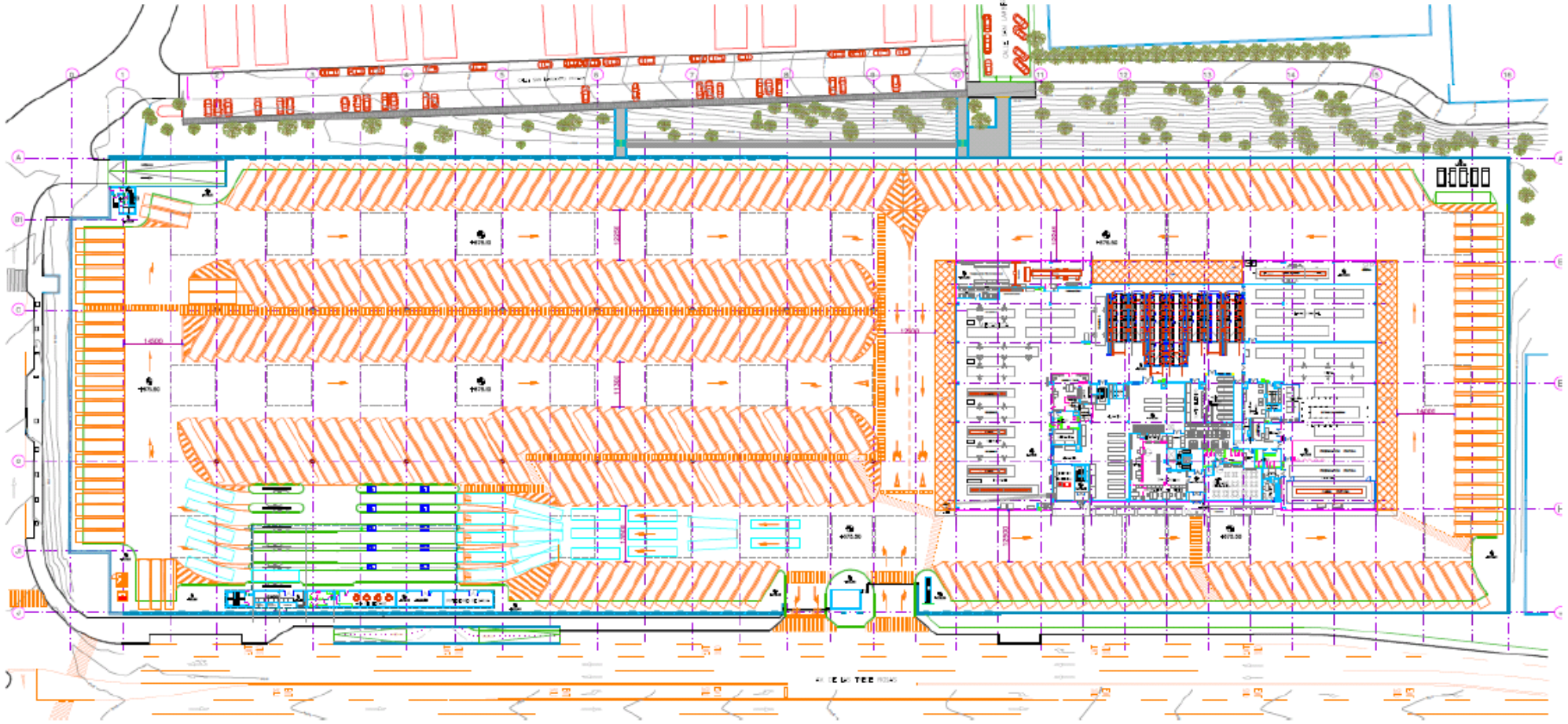
NEW ELECTRIC LA ELIPA BUS DEPOT: its origins

1971/2022

NEW ELECTRIC LA ELIPA DEPOT: ACTUAL STATE

NEW ELECTRIC LA ELIPA DEPOT: FORECAST STATE

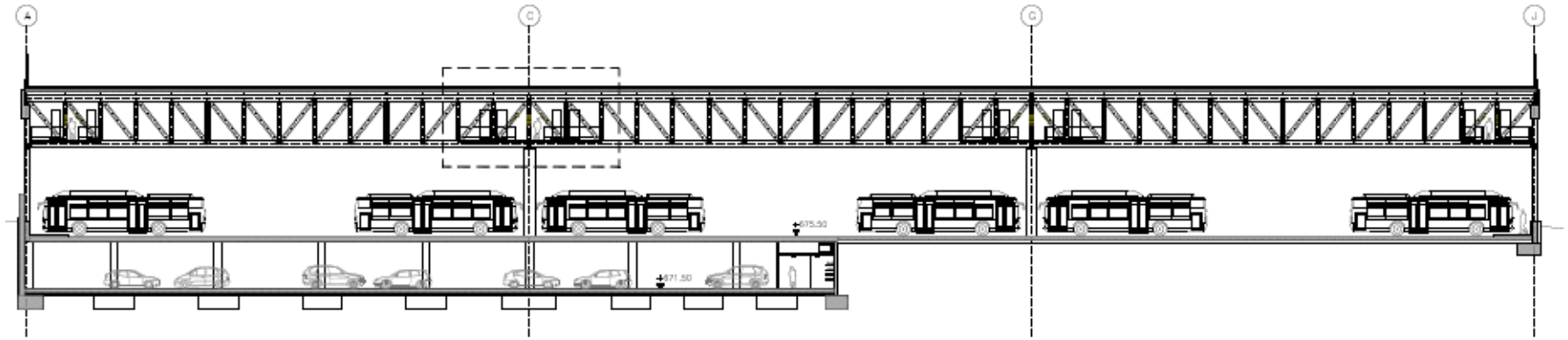
Overnight charging by 318 inverted pantographs – 100% electric La Elipa Depot

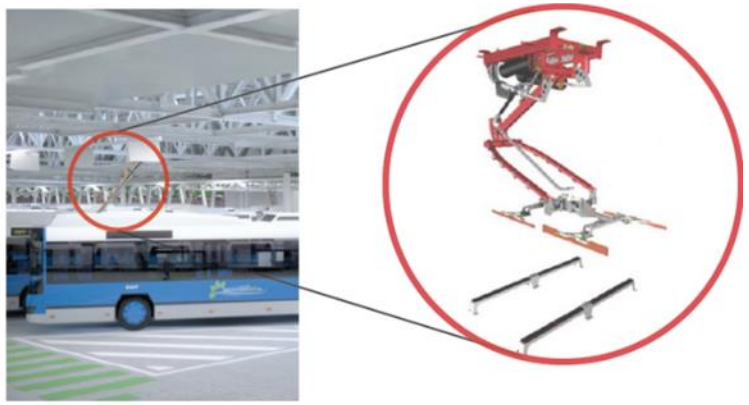


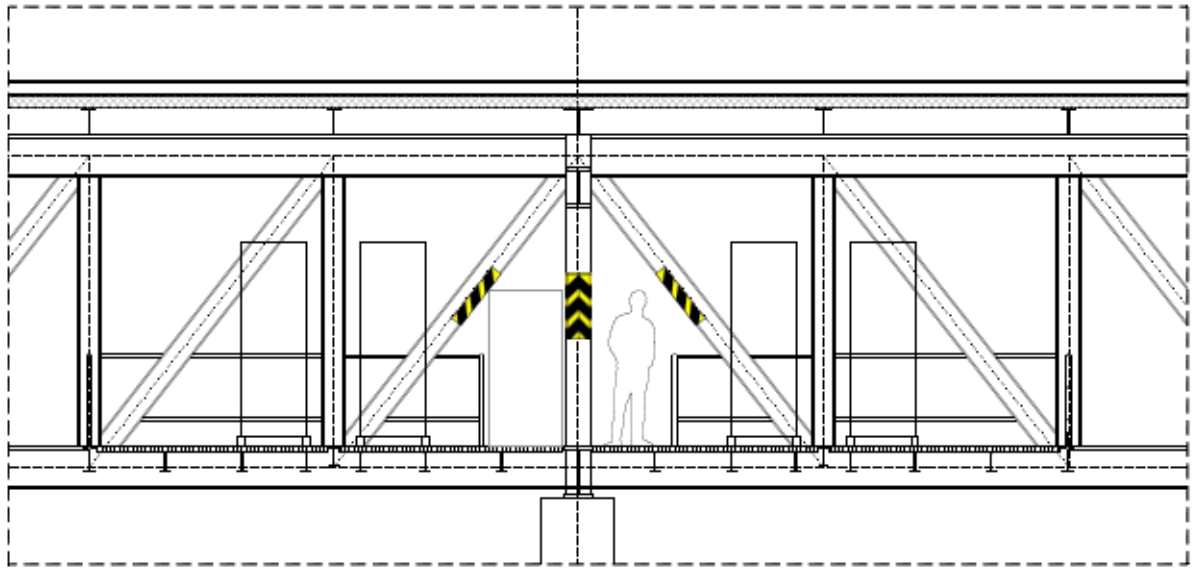
NEW ELECTRIC LA ELIPA BUS DEPOT

- ✓318 **ebuses**
- ✓ **Inverted pantograph** charging
- ✓Designed **with sustainable environmental criteria**
- ✓Biggest roofed e-bus depot in Europe
- ✓**Green facade**
- ✓Reduction of greenhouse gas (GHG) emissions: **minimizing the affections to the neighborhood**
- ✓Use of renewable energy sources: photovoltaic panels in the ceiling that generate **2MW**
- ✓**Photocatalytic roof (decontaminating NOx effect 30,000 m2)**

NEW ELECTRIC LA ELIPA BUS DEPOT





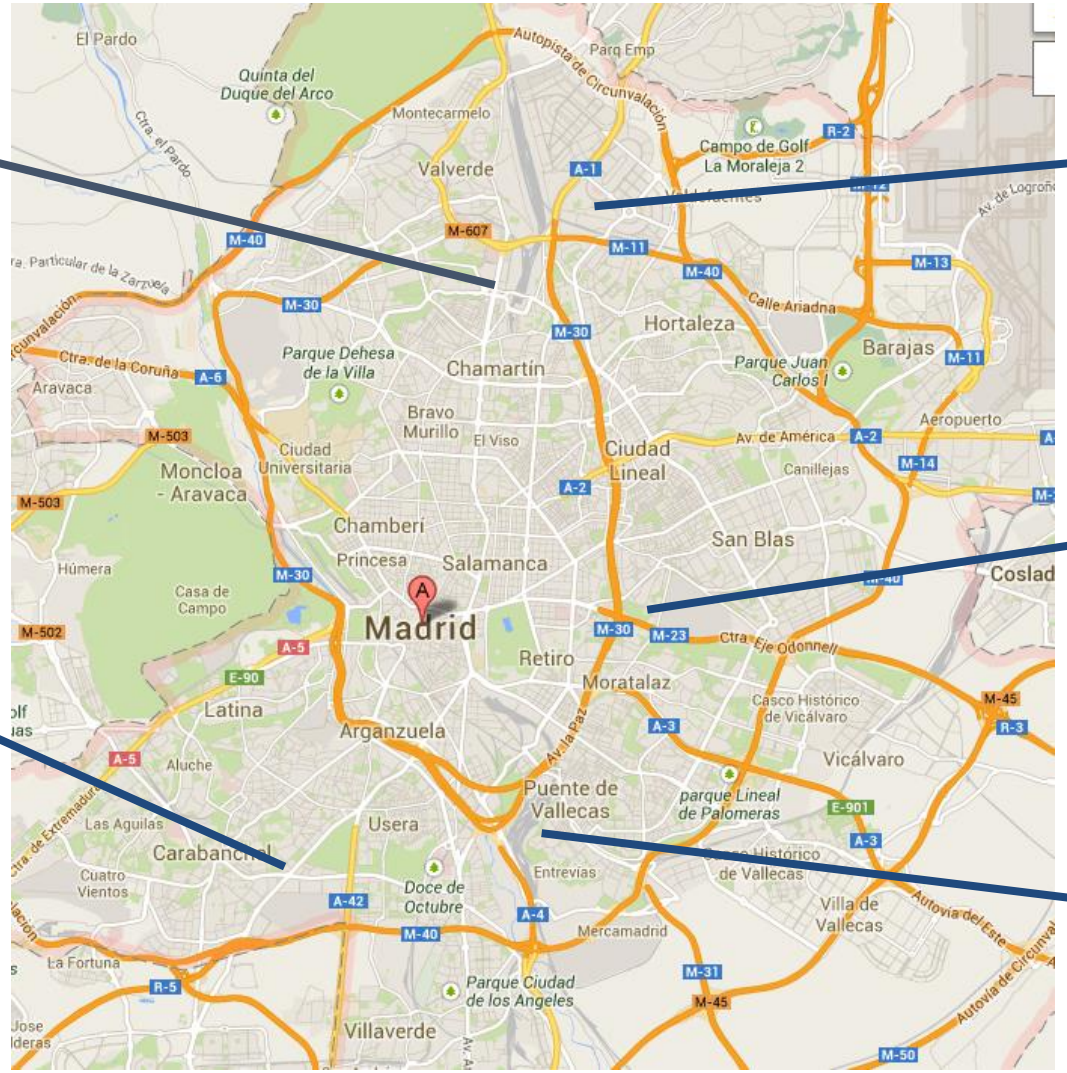


NEW ELECTRIC DEPOT LA ELIPA

- Video of the works in la Elipa Depot: https://youtu.be/o3fWF5xlAdw

Depot adaptations: Entrevías

Fuencarral Bus Depot



Sanchinarro Bus Depot

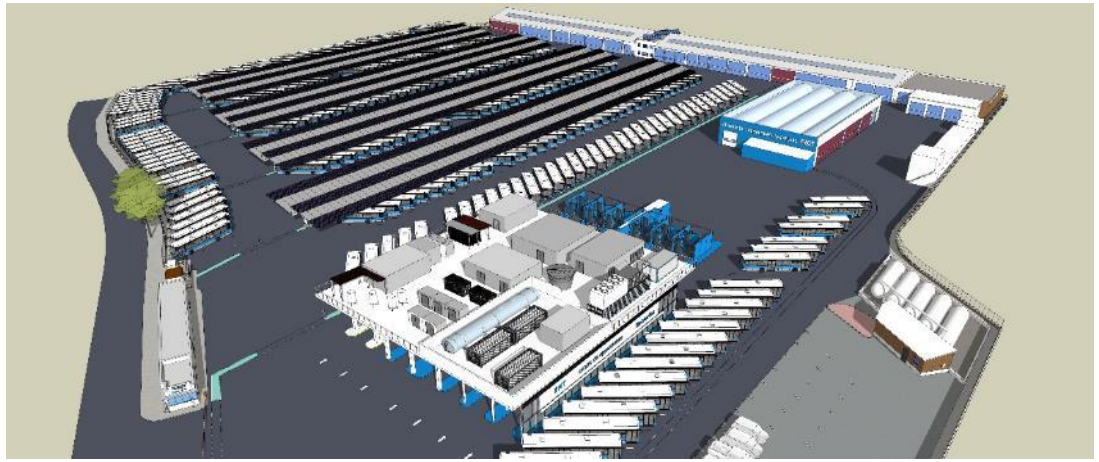
La Elipa Bus Depot

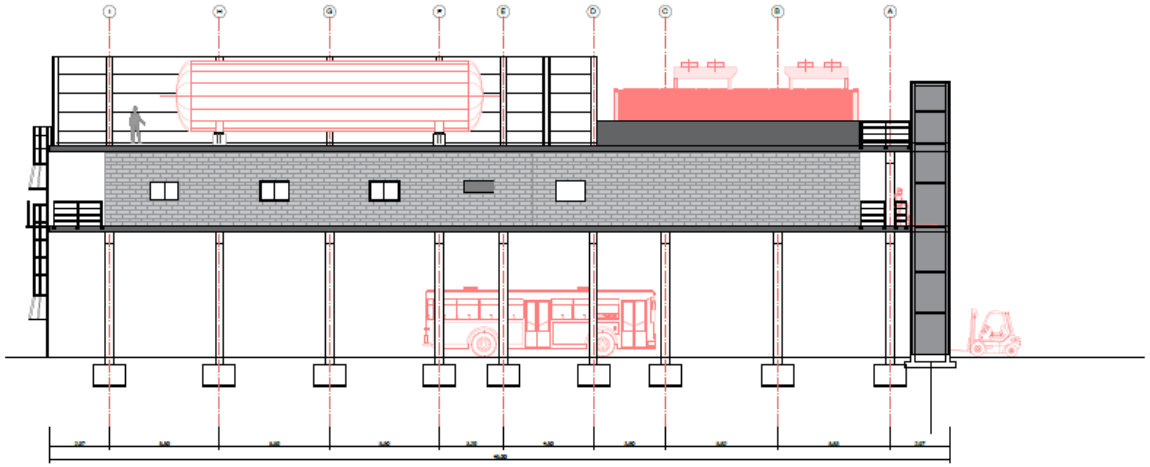
Carabanchel Bus Depot

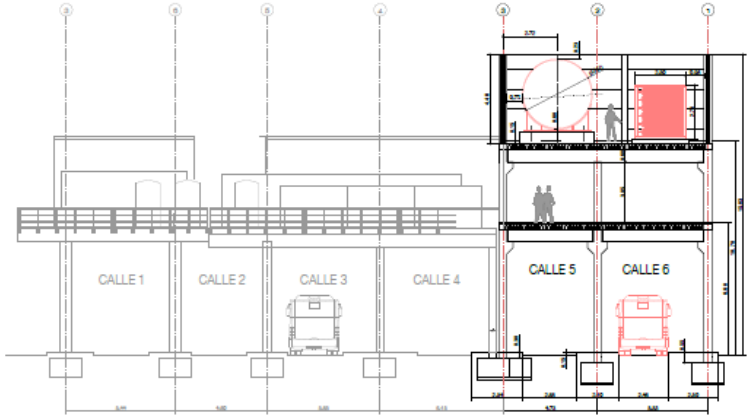
Entrevías Bus Depot

ENTREVÍAS BUS DEPOT: Green Hydrogen

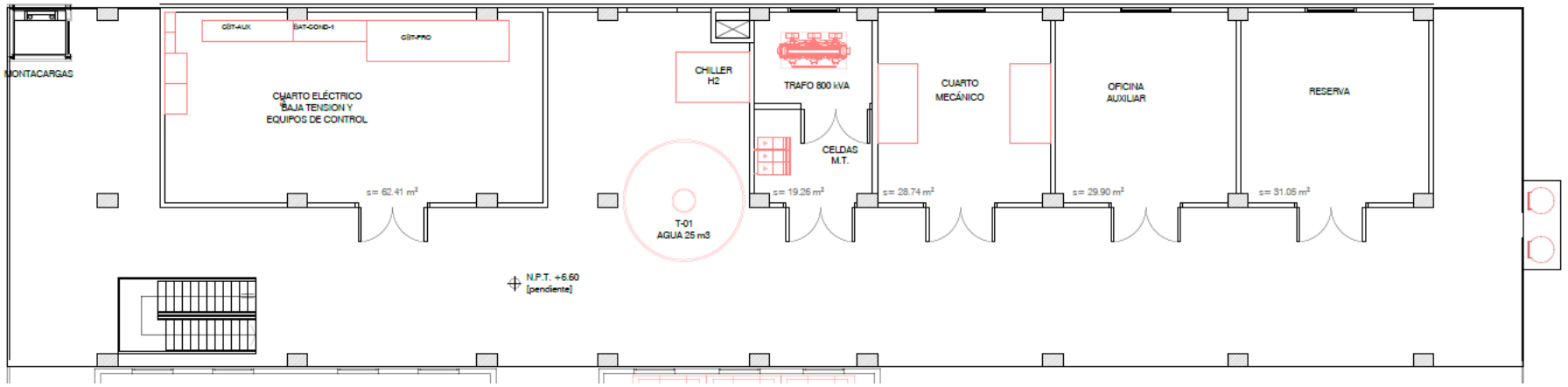
Hydrogen station



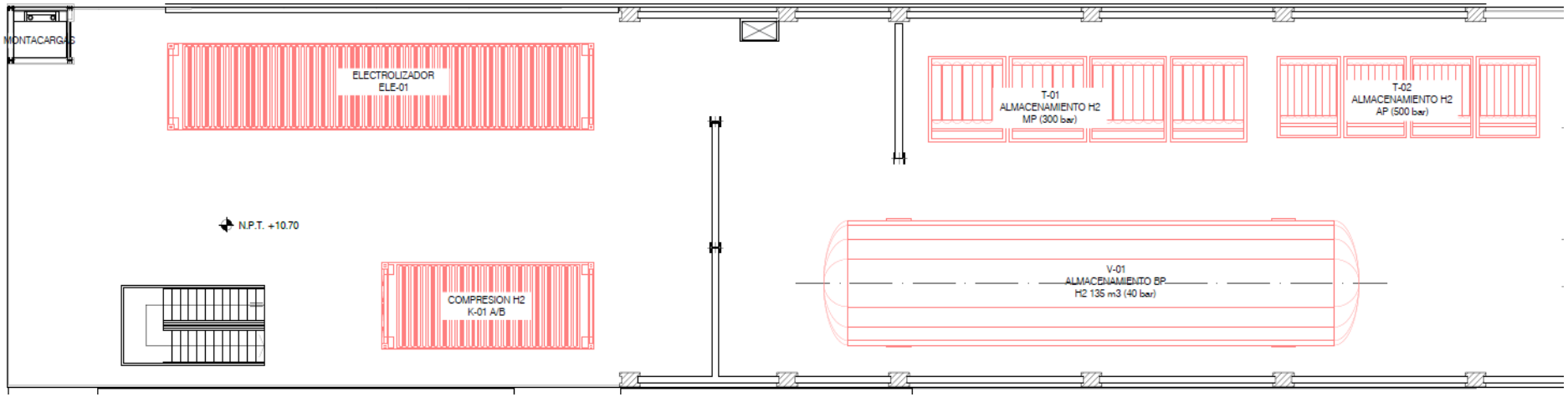




- ✓ Hydrogen station for 10 buses in the Entrevías Depot
- ✓ Photovoltaic panels on roofs for the production of 2 Mwh
- ✓ Hydrogen production equipment by electrolysis with the capacity to produce up to 18 kg of H2/h (73 ton H2/year)
- ✓ Maximum storage system of 1,013 kg of H2
- ✓ Date for operation: December/2023
- ✓ Total investment €17.2 million (including buses)

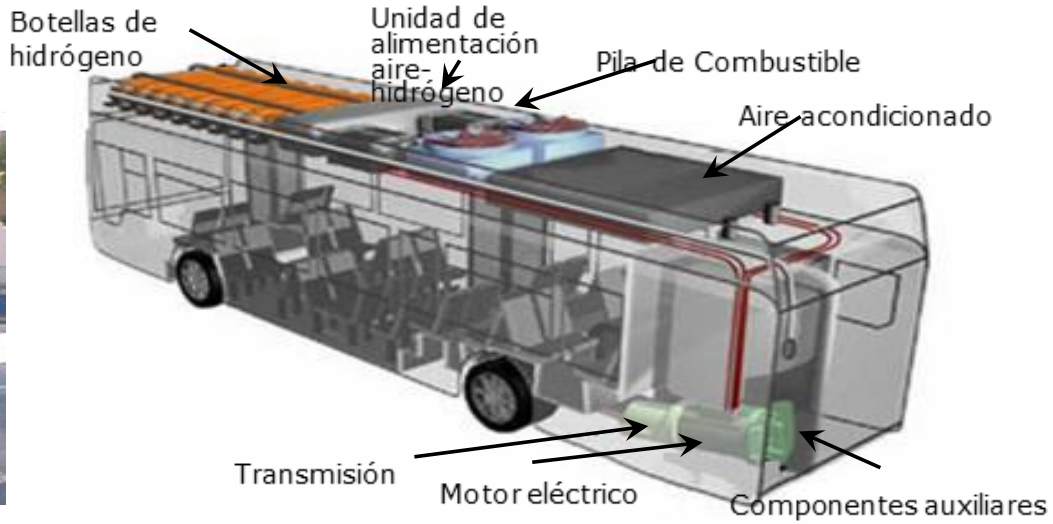


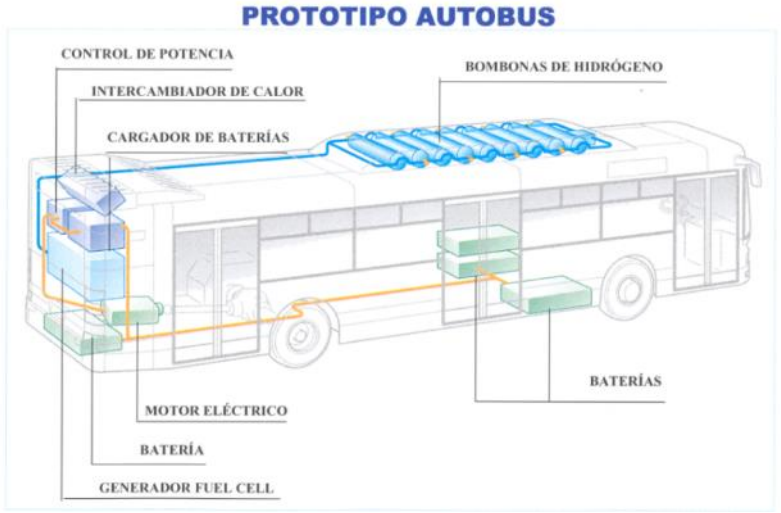
1st Floor



2nd Floor

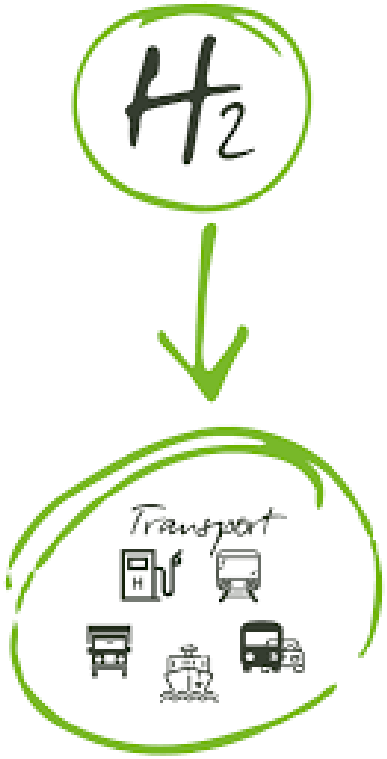
BACKGROUND: CUTE and CITYCELL projects





USE of H_2 IN TRANSPORT: Fuel cell bus, some figures

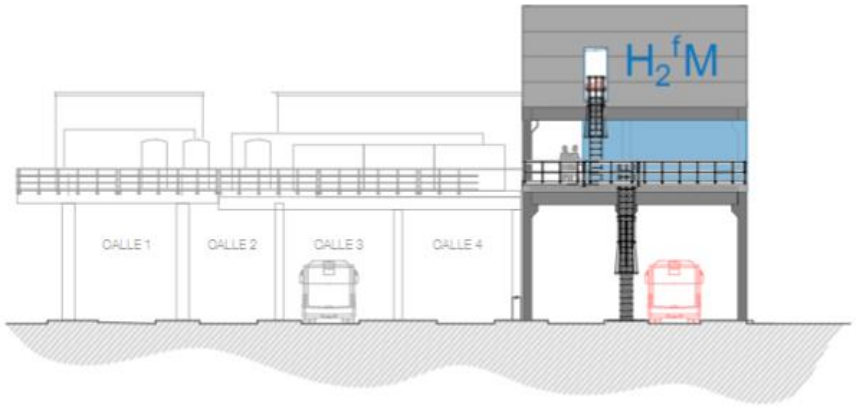
1. In a hydrogen fuel cell bus, there are **also batteries** (or capacitors). The fuel cell and the batteries or capacitors provide energy for the operation of the vehicle.
2. The **efficiency** of the fuel cell is **up to 65%.**
3. The fuel cell has an estimated **lifetime of 7 years**.
4. The **range is similar** to that of an **internal combustion bus**.
5. **Filling** the hydrogen tanks of the bus takes **10 minutes**.
6. Pressure is **350 bar, 75% more** than CNG compressors.
7. Batteries or capacitors supplement the power of the battery when needed and provide a place to store the **energy recovered from braking**.

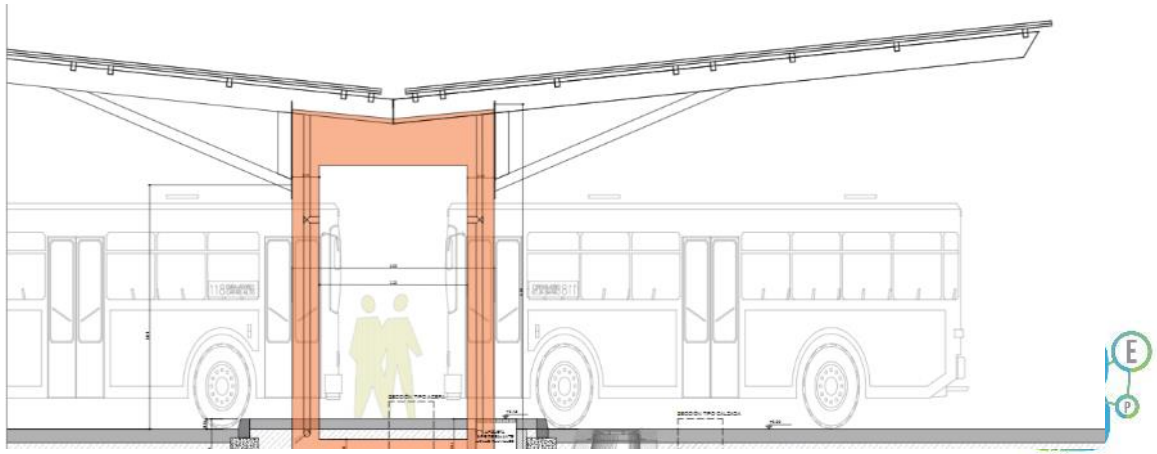


ENTREVÍAS BUS DEPOT: Green Hydrogen

Integrated Hydrogen Cycle at Entrevías Bus Depot 2021-2023

GNC Refuelling station





FUEL CELL BUSES: PROS & CONS

Advantages

- Zero emissions for urban traffic with green hydrogen
- Hydrogen fuel cell buses can replace a conventional vehicle:
  - Fast charging process: comparable to refuelling times of diesel vehicles (approx. 10 minutes)
  - High operational range: 300 - 400 km or more.
  - No loss of passenger capacity
- Energy recovery during deceleration and braking.
- “Low energy cost if the hydrogen comes from a chemical process”

FUEL CELL BUSES: PROS AND CONS

Disadvantages

- Environmental
  - Production from fossil fuels, producing CO, CO2 and other GHG
  - Production by electrolysis. Hydrogen is green only if using renewable energy sources
- High investment
  - Vehicles 30% more expensive than conventional battery electric ones
  - High cost of fuel cells, with a shorter lifetime than the vehicle
  - High cost of on-board storage systems: 350 bar cylinders for hydrogen storage, with very high containment requirements
- High maintenance costs: Need to adapt workshops and refueling area to meet hydrogen requirements
- Low efficiency of hydrogen as an energy carrier:
  - Water electrolysis: 75% efficiency
  - Compression and storage: 90% efficiency
  - Electrolysis of the battery: 50% efficiency

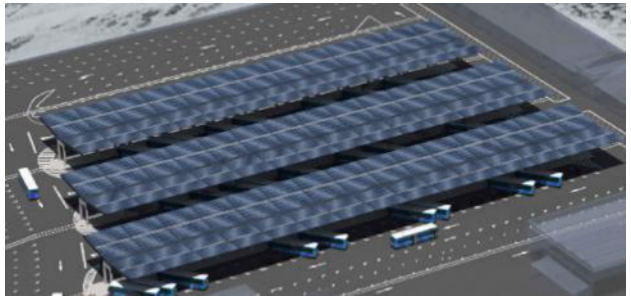
EMT H_2 PROJECT

"Integral project for the implementation of hydrogen buses on regular urban public transport bus lines in the city of Madrid"

- EMT's **commitment**
- Project **aligned with the 'Green Deal',** launched by the European Commission for Clean Hydrogen.
- **Positioning of EMT** as a national and international benchmark in the use of H2 in public transport.
- The project covers the **entire cycle**: from the **generation of electricity** through **renewable** energies for the production of **green hydrogen**, to the **refueling** of the same in Fuel Cell buses at an EMT Operations Centre (C.O. Entrevías).
- Project developed **entirely in EMT facilities**.
- Project draft in 2020. EMT agreement (oct 2020) with the **National Hydrogen Centre (CNH2)**: Expert advice and technical assistance

EMT H_2 PROJECT: SIZING

1.- Energy supply



Photovoltaic pannels on parking track to obtain Green Hydrogen→ Around 2 MW energy production

2.- H_2 production

H2 production station, with more than 400 kg H_2/day

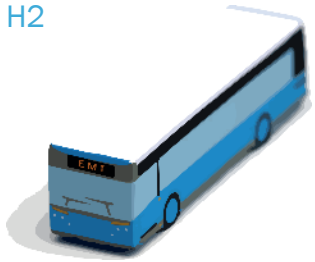
Storage system with a máximum capacity of around 550 kg of H2 (3 tanks at 40, 300 and 500 bar)

2 Compressors up to 500 bar

H2 Fueling station: 2 dispensers at 350 bar.

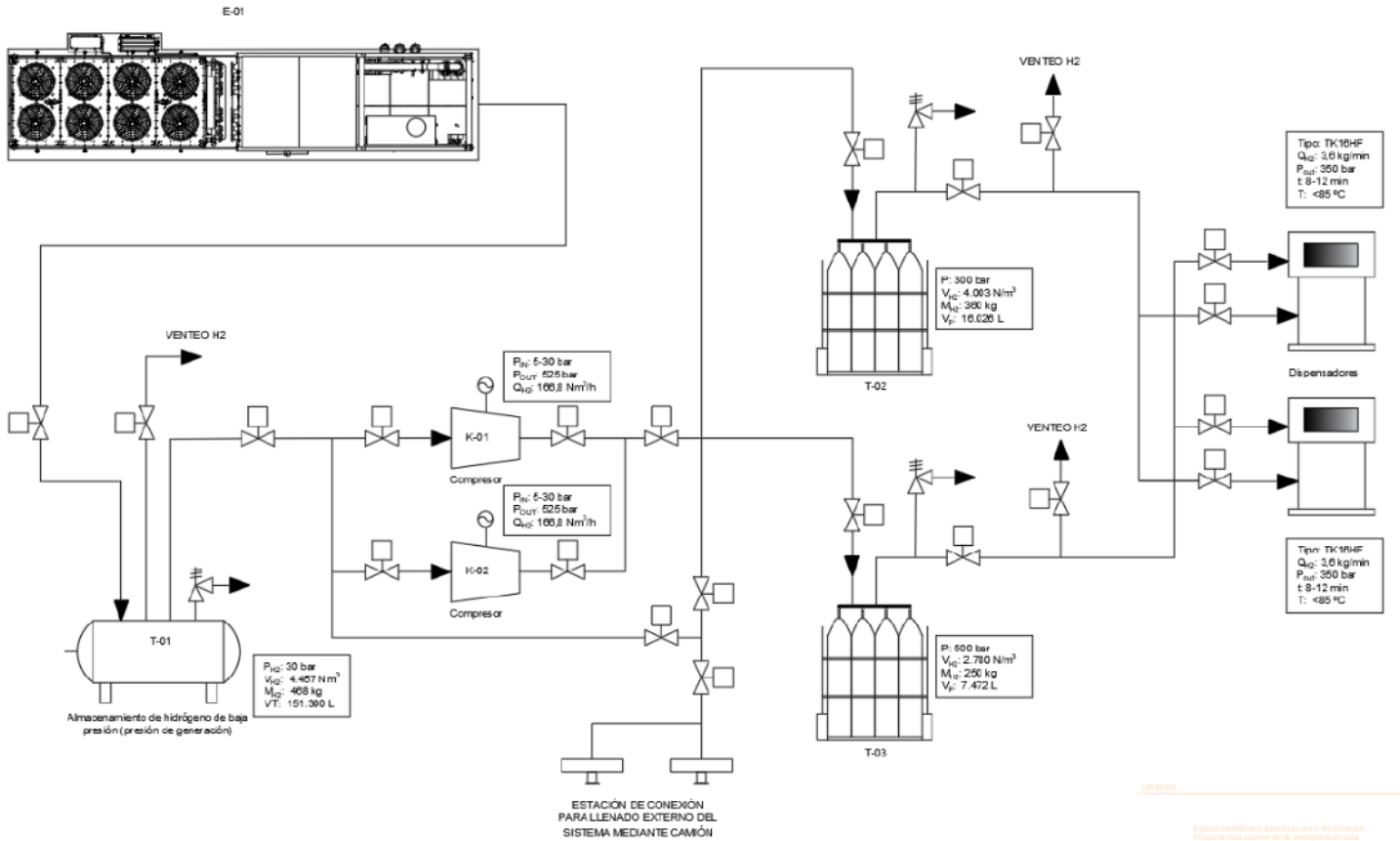
3.- H_2 buses

Purchase an addition of 10 H2 buses in the EMT fleet



Solution

Building works will start shortly



3,8 M€ funding (out of 7,6 M€)

EUROPEAN UNION
European Regional Development Fund

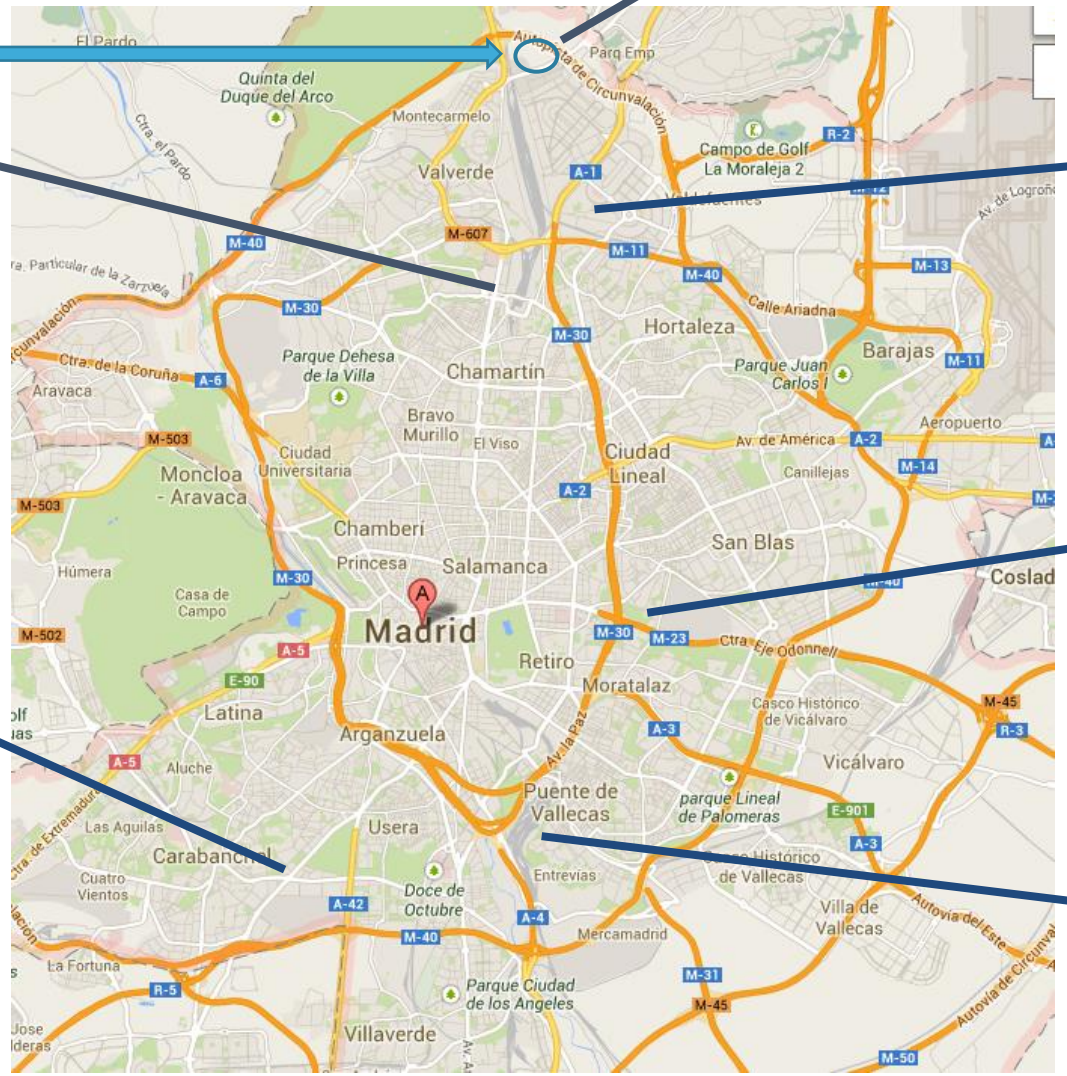
NEW ELECTRIC DEPOT ENTREVIAS

Watch out the video Entrevias Depot:

- https://youtu.be/B5Kx-AGK3KE

New depot: Las Tablas

Fuencarral Bus Depot



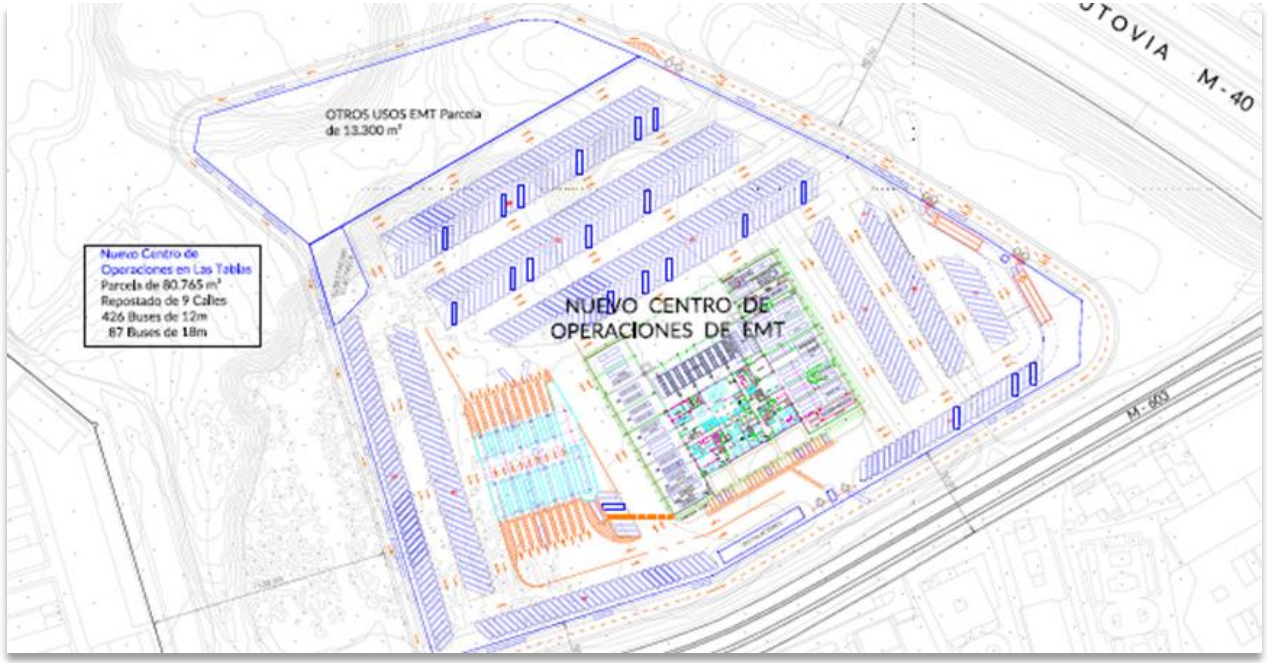
Sanchinarro Bus Depot

La Elipa Bus Depot

Carabanchel Bus Depot

Entrevías Bus Depot

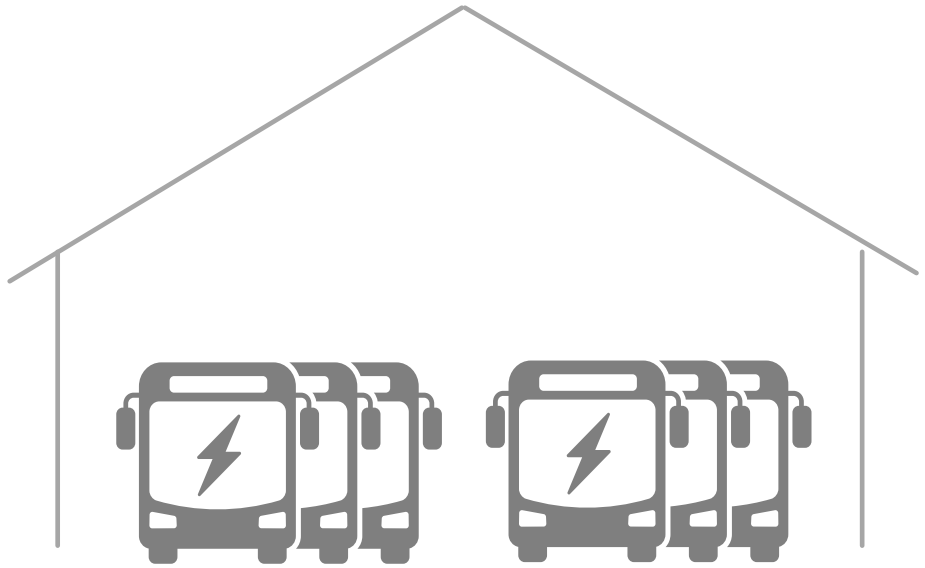
Las Tablas New bus depot



- ✓ Design of a 9,200 m2 Depot with a “H” shaped building
- ✓ 100% low emission fleet (electric and CNG)
- ✓ 663 buses parking area (660 std and 63 articulated)
- ✓ E-charging system by inverted pantograph and photovoltaic cover
- ✓ The use of photocatalytic materials for the roof of the garage building, to reduce greenhouse gas emissions
- ✓ **€150 million investment**

Las Tablas New bus depot

CURRENT DEPOTS ADAPTATIONS



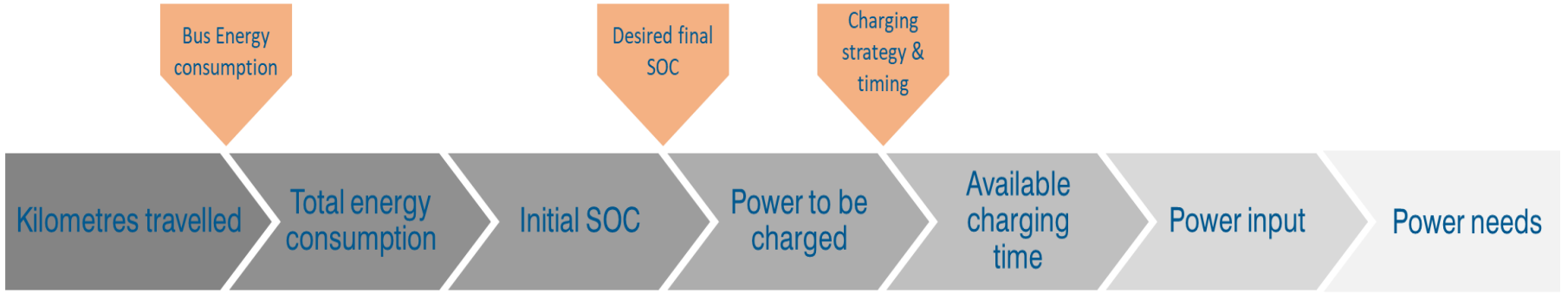
CHALLENGES

- ✓Coexistence of different technologies (GNC, battery electric…) and suppliers (batteries, chargers…)
- ✓Training EMT workforce in battery electric propulsion
- ✓Guarantee grid supply
- ✓Workshop adaptations

III. PLANNING

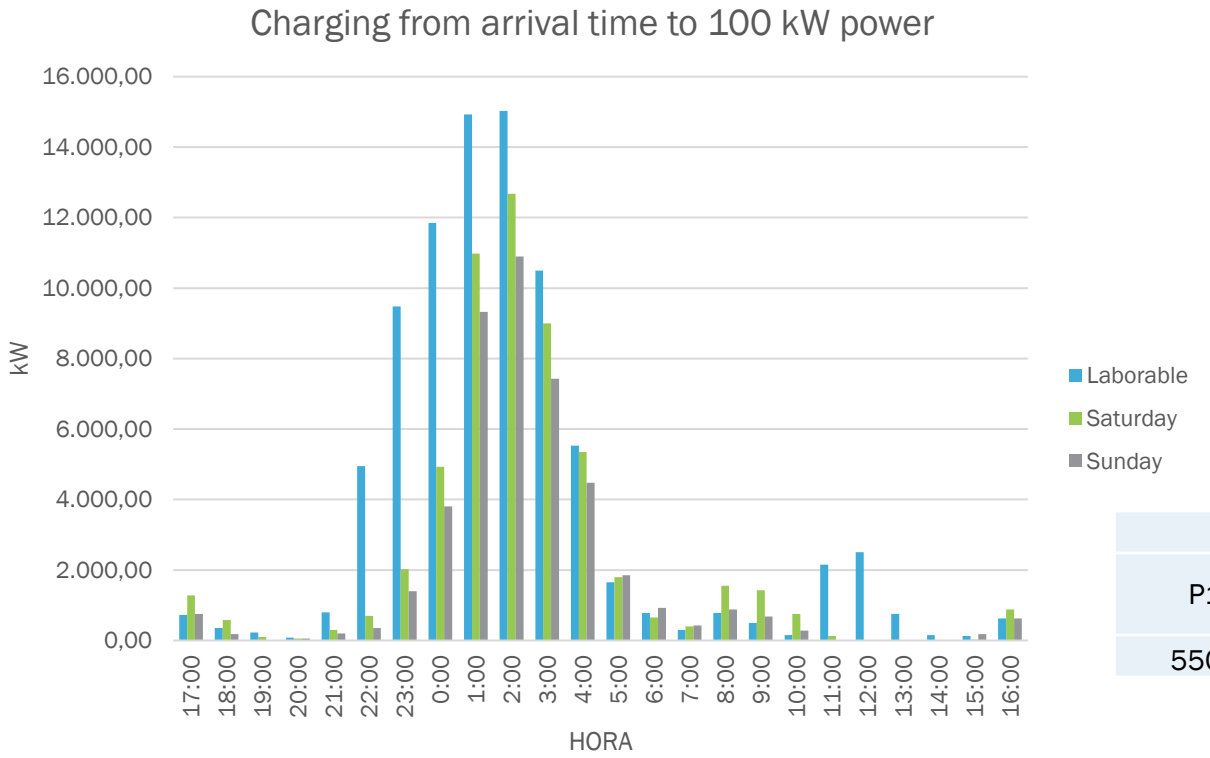
- III.III. SMART CHARGING

ESTIMATING ENERGY NEEDS: OPERATIONAL ANALYSIS



Linea	CC	Orden	Salida	Turno	Encierro	Horas en Servicio	Horas en CO	km totales 2 turnos	P.consumida (1,5kWh/km)	T.recarga horas (150kWh)	H. INICIO CARGA	HORA FIN CARGA (04:00)	HORAS CARGA
77	5	1	5:39	5	10:40	5:01	3:14	140,784	91,79	0,6119	10:45	13:45	3:00
77	5	2	13:54		20:37	6:43	9:03		119,39	0,79594	21:00	4:00	7:00
77	6	1	5:51	6	22:03	16:12	7:48		312,63	2,08422	22:30	4:00	5:30
77	7	1	6:01	7	20:27	14:26	9:34		284,61	1,89737	20:30	5:00	8:30
77	8	1	6:11	8	20:38	14:27	9:33		281,46	1,87641	21:00	5:00	8:00
77	9	1	6:15	9	23:27	17:12	6:48		339,82	2,26545	23:30	5:00	5:30
77	10	1	6:29	10	21:06	14:37	9:23		284,61	1,89737	21:30	5:00	7:30
77	11	1	6:38	11	0:42	18:04	5:56		367,42	2,44949	1:00	5:00	4:00
77	12	1	6:45	12	0:54	18:09	5:51		364,28	2,42853	1:00	5:00	4:00

ESTIMATING ENERGY NEEDS: OPERATIONAL ANALYSIS. WITHOUT SMART CHARGING



	Annual cost
0	4.416.414,23 €

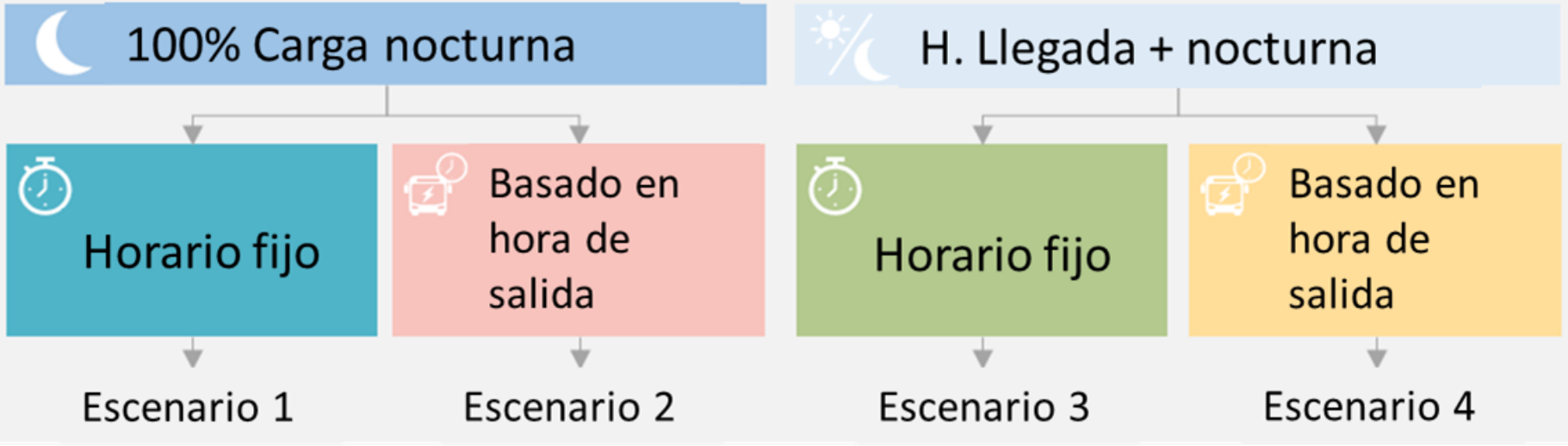
HIRED POWER (kW)					
P1	P2	P3	P4	P5	P6
5500	12500	12500	12500	12500	15500

Annual power consumed (kWh)							
Fare periods	P1	P2	P3	P4	P5	P6	TOTAL
Energy charging	833.291,67	2.255.569,44	1.399.980,56	1.803.991,67	1.426.883,33	17.595.625,00	**25.315.341,67**
Energy C.O.	115.840,00	141.279,00	126.250,00	144.377,00	56.604,00	687.984,00	**1.272.334,00**
Energy Photovoltaic	69.442,73	85.108,65	75.348,08	85.834,65	32.953,80	119.847,75	**468.535,65**
Total Energy	879.688,94	2.311.739,79	1.450.882,48	1.862.534,02	1.450.533,53	18.163.761,25	**26.119.140,02**

ESTIMATING ENERGY NEEDS

Estrategia de Recarga

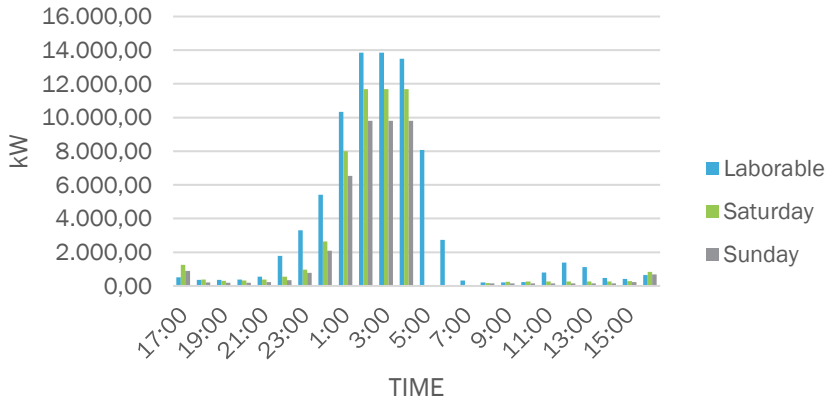
Carga en depósito



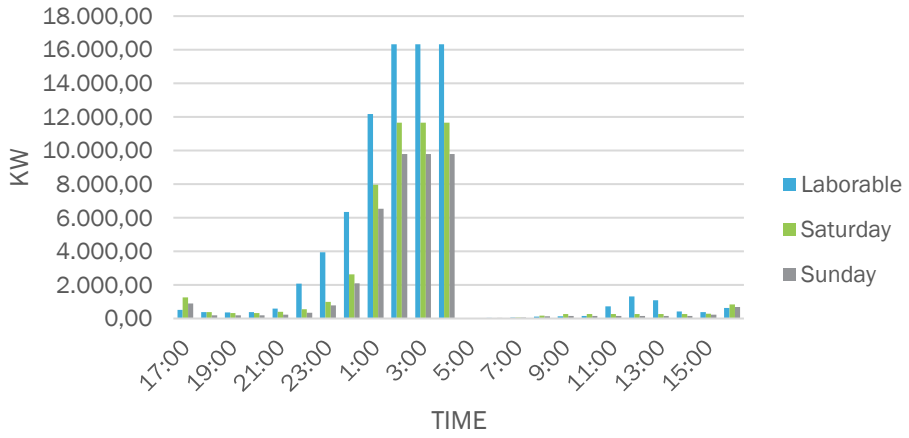
ESTIMATING ENERGY NEEDS:

OPERATIONAL ANALYSIS. WITH SMART CHARGING

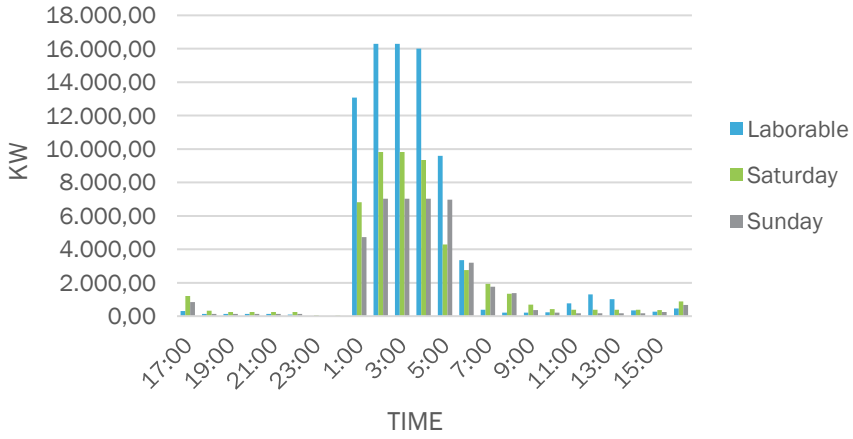
1.- Charging from arrival time up to one hour before departure time



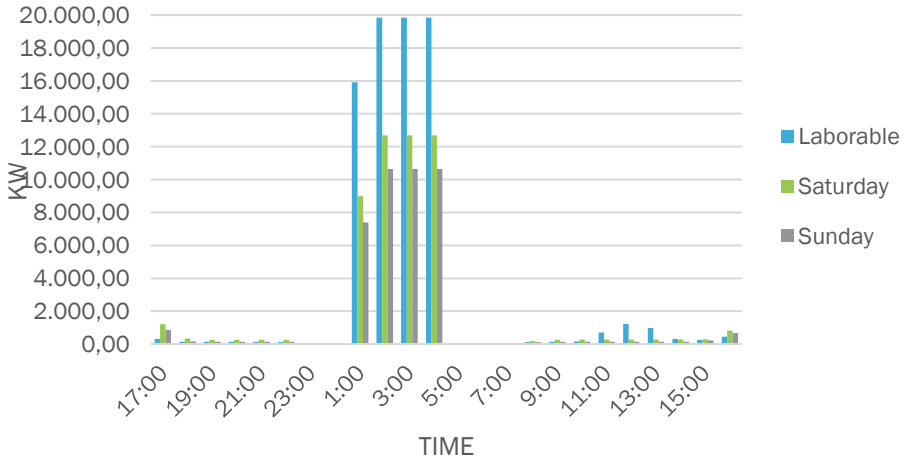
2.- Charging from arrival up to 04:00 AM



3.- Charging from 0:00 AM up to one hour before departure time



4.- Charging from 0:00 AM up to 04:00 AM



	Annual Cost
0	4.416.414,23 €
1	3.902.771,75 €
2	3.944.895,72 €
3	3.711.294,89 €
4	3.711.945,81 €

ESTIMATING ENERGY NEEDS: OPERATIONAL ANALYSIS. WITH SMART CHARGING

		ANUAL COST	POWER NEEDS (KW)	BATTERIES LIFE	DISPONIBILITY
0	Without Smart Charging	4.416.414,23 €	17.000	LOW	VERY HIGH
1	Arrival - Departure	3.902.771,75 €	14.500	VERY HIGH	HIGH
2	Arrival – 04:00 AM	3.944.895,72 €	17.000	MEDIUM	LOW
3	0:00 AM - Departure	3.711.294,89 €	17.000	MEDIUM	MEDIUM
4	0:00 AM - 04:00 AM	3.711.945,81 €	20.500	LOW	LOW

SELECTING CHARGING TECHNOLOGY
STUDY OF ALTERNATIVES

Requerimientos	Cable	Inducción		Conducción	
		Estático	Dinámico	Pantógrafo tradicional	Pantógrafo invertido
Permita desvincular la compra del autobús de la infraestructura de carga.	✗	✗	✗	✓	✓
Sea un sistema de "cargador universal" que permita a cada autobús aparcar en cualquier plaza de aparcamiento independientemente de la marca.	✗	☑	☑	✓	✓
Permita la carga a diferentes niveles de potencia.	☑	✓	✓	✓	✓
Sea apto para la carga en depósito.	✓	✓	✗	✓	✓
Sea automático, de modo que no requiera una conexión manual.	✗	✓	✓	✓	✓
Permita un "sistema inteligente de gestión de la carga" para optimizar la potencia consumida y minimizar los "picos" de potencia.	☑	✓	✓	✓	✓

✓ Cumple ☑ Cumple de forma limitada ✗ No cumple

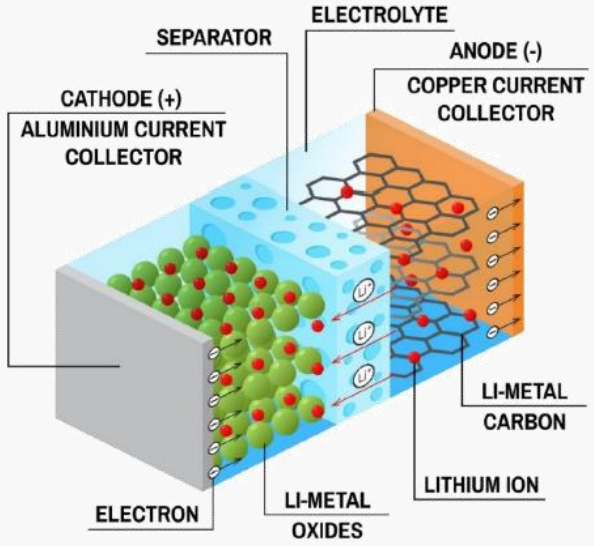
SELECTING CHARGING TECHNOLOGY STUDY OF ALTERNATIVES

- Conductive charging is, according to the study, the best option for big fleet os public e-buses
- Thanks to the maturity of the market, and a growing catalogue of solutions, inverted pantographs (panto-down) have more advantages tan the traditional panto (panto-up)
- Inverted pantographs are also the best suited for EMT needs and requirements
- Preinstalation of the compatible racks with inverted pantographs on the ceiling of e-buses is an advantage for the adoption of this technology and the homogeneization of EMT fleet

III. PLANNING

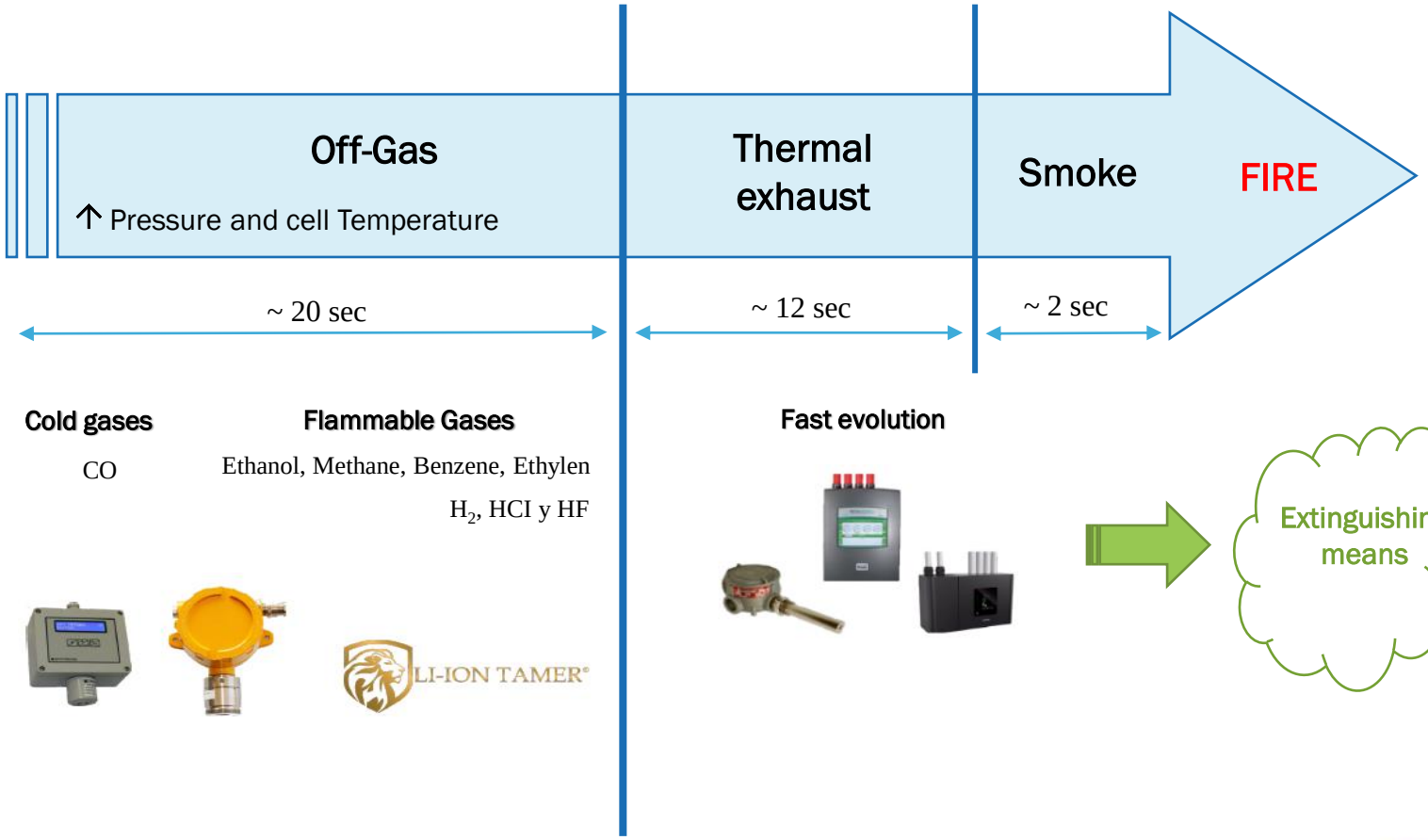
- III.IV. SAFETY REGULATIONS AND STANDARDS

RISKS OF ION-LITHIUM BATTERIES



ELECTROLITO INFAMABLE

- ↑ Pressure and cell temperature
- Electrolyte decomposition
- Electrochemical reaction and release of flammable gases



FIRE EXTINGUISHING MEANS

MALOS AGENTES:

- Polvo
- Espuma
- Agua

Sistemas de Extinción por inundación:

Fase "Thermal runaway"

- Gases Inertes / Novec 1230 (15,2%)
- Aerosoles

Sistemas de Encapsulado:

- Solución acuosa / F-500

F-500 ESPAÑA | AGENTE ENCAPSULADOR

Temperature reduction: 600°C in few seconds

HEAT ABSORPTION	WATER:	F500 (1%):	F500 (3%):
	6,624,702 KCAL/HOUR	**21,164,604 KCAL/HOUR**	**65,493,812 KCAL/HOUR**

What is F-500?

- Is a water based additive (fresh – salted)
- Classified as multi-purpose suppression agent (UL)
- Flammable liquid spill control agent
- Bioremediation facilitator (EPA)

Fire suppression

- Reduction of surface tension
- Reduction of heat quick and permanent:

Powerful cooling and increased penetrating effect

- Reduction of toxic gases:

Encapsulating agent that can envelop/contain flammable fuels and gases, thereby inhibiting their oxidising effect and reducing the impact of toxic gases

IMPLEMENTATION CHARGING INFRASTRUCTURE IN CARABANCHEL (BEB)

As outdoor canopies, regulation indicates that prescriptive protection is based on hydrants, fire extinguishers and alarm buttons.

As **additional safety measures** to protect infrastructure and rolling stock:

- Automatic fire extinguishers by sprinklers and encapsulating additive F500
- Flammable and toxic gases detection systems
- Detection system and fire alarms by specific detectors and infrared thermal cameras
- Portable fire extinguishers (extinguishers with minimum regulatory efficiencies and trolley extinguishers with F500 additive tested for lithium battery fires)

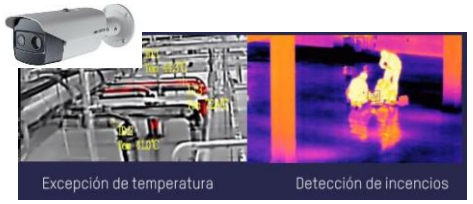
Criterio	Riesgo	Caudal Rociadores nominal (lpm)	Aditivo F-500 (3%)	Reserva de F-500 a 30 min	Depóstito atmosférico	Dosificador FIre-DOS
UNE 12845 y Bomberos Barcelona (*)	ROII	972	30	900	1000	1000

It has been decided to design it according to the standard UNE 12845 adapted to the protection against fire supply in the infrastructure

BUS CANOPY: Surface = 2,650 m2

1 Unit
ATMOSPFHERIC FOAM CONCENTRATE TANK
1.000 LITRES
With additive F-500 3%

18 Units ANALOGUE OPTICAL DETECTOR
18 Units CARBON MONOXIDE DETECTOR
18 Units METHANE/ETHYLEN DETECTOR



6 Units HEATPRO THERMAL CAMERAS
With bi-spectral lens optical/thermic for the control of the battery and bus pantograph

- 6 Units EXTINGUISHER 5kg CO_2
- 6 Units EXTINGUISHER 6kg powder
- 8 Units EXTINGUISHER TROLLEY 50L WATER WITH ADDITIVE F-500

320 Units
AUTOMATIC SPRINKLERS ½" K=80 (Homologated FM/UL), TARED 93º (bulb) HANGING. QR

Safety procedures for employees when interacting with charging infrastructure

1 - Preparation
- Remove metallic elements
- Prepare the necessary PPE (personal protection equipment) and check it
- Check measuring elements (they are the right ones and they work)

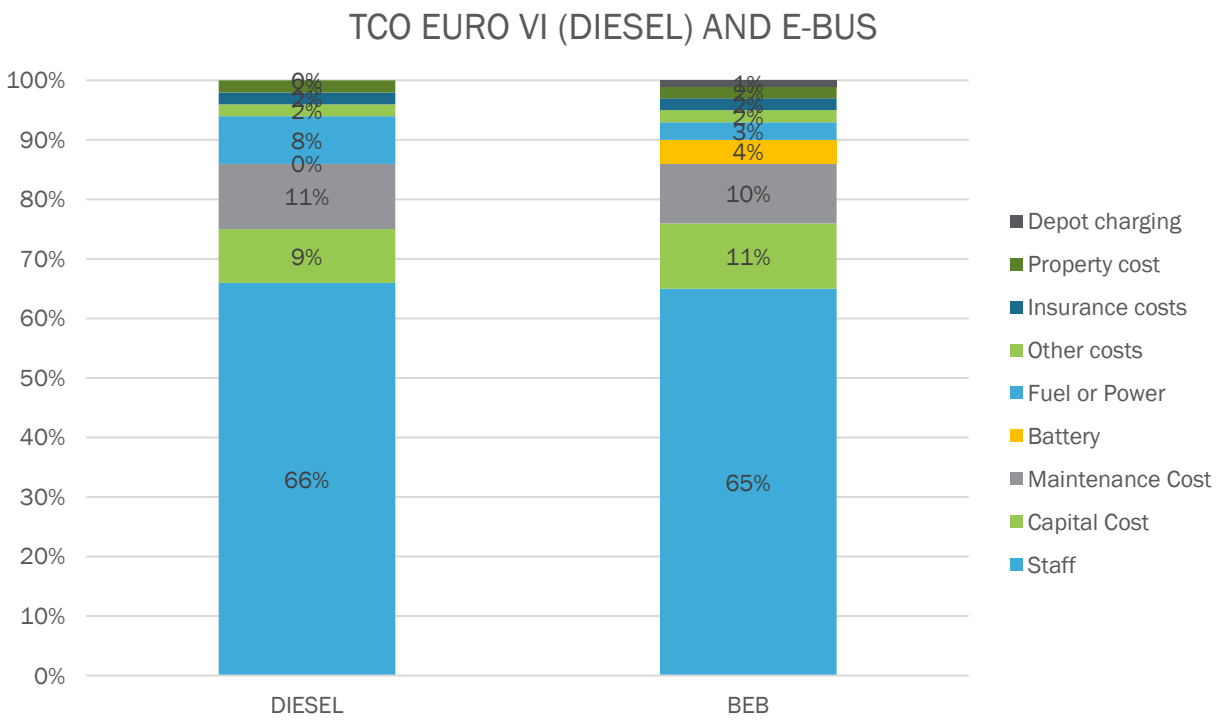
2 - Signpost and protect
- Warning signs
- Delimitation of work area
- Disconnection of high voltage. Removal of fuses or relays.
- Measurement of absence of voltage

3 - Use of PPE and suitable tools.

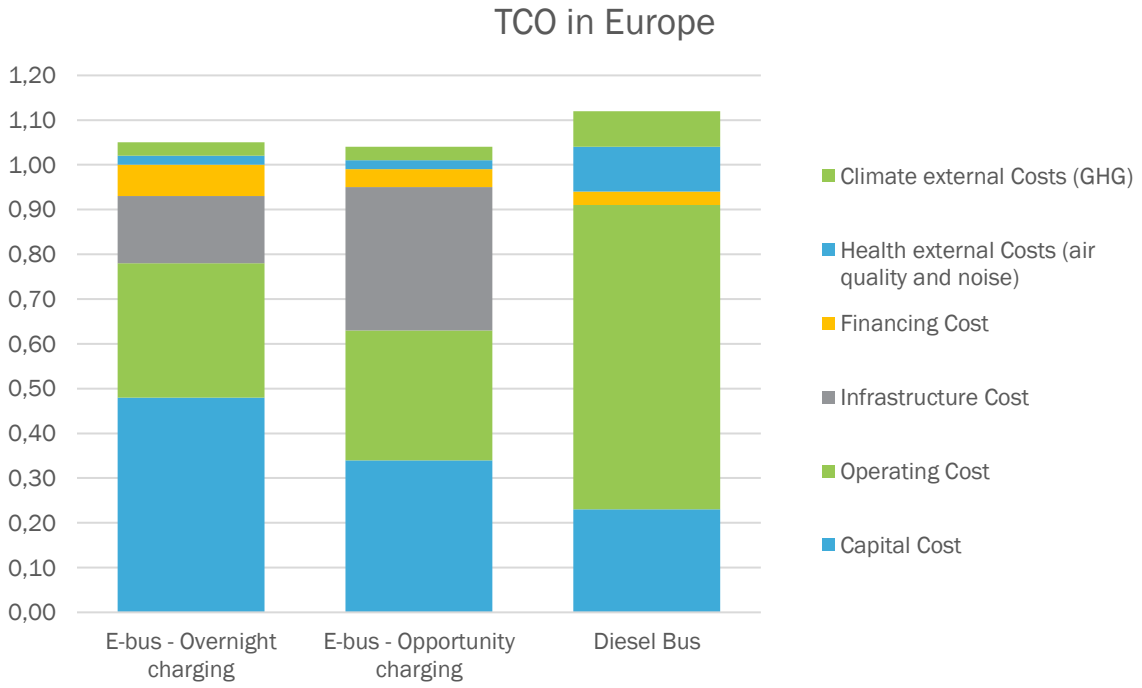
4 - Powering up by reverse process.

IV. TOTAL COST OPERATION

TOTAL COST OPERATION: EXAMPLES

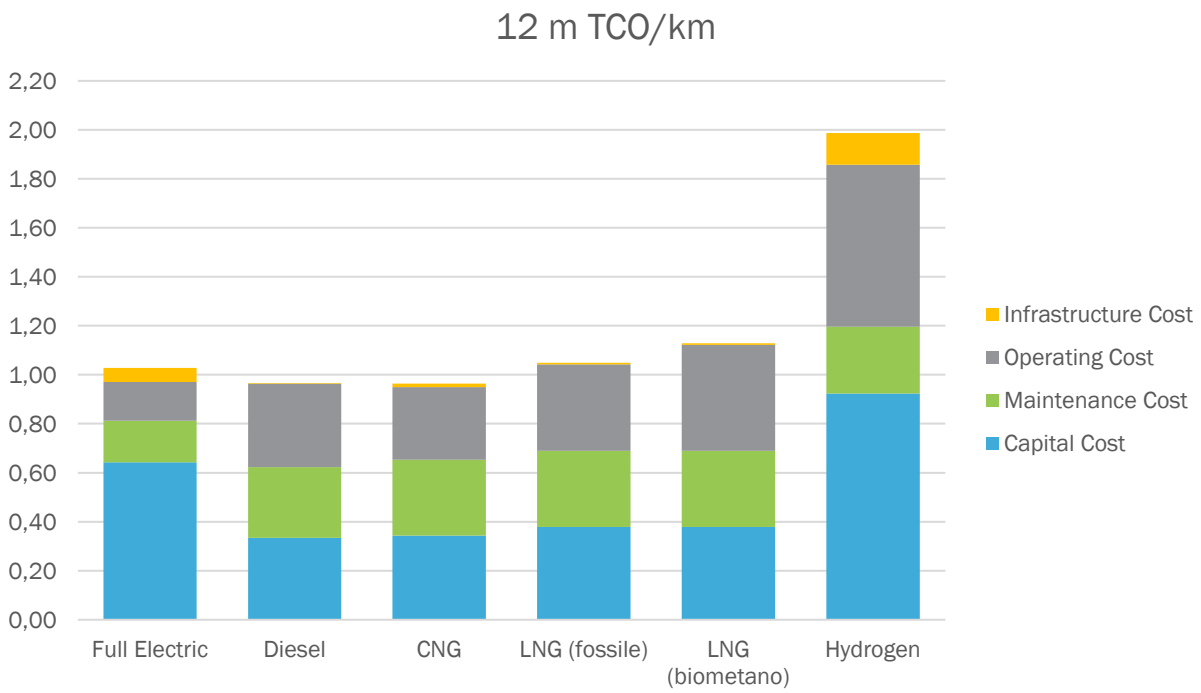


Comparation of TCO between Euro VI diesel and e-bus (UK assumptions). Source: Going electric. A Path to Zero Emission Buses (European Bank for Reconstruction and Development Policy Paper) and TIL analysis for the EBRD.

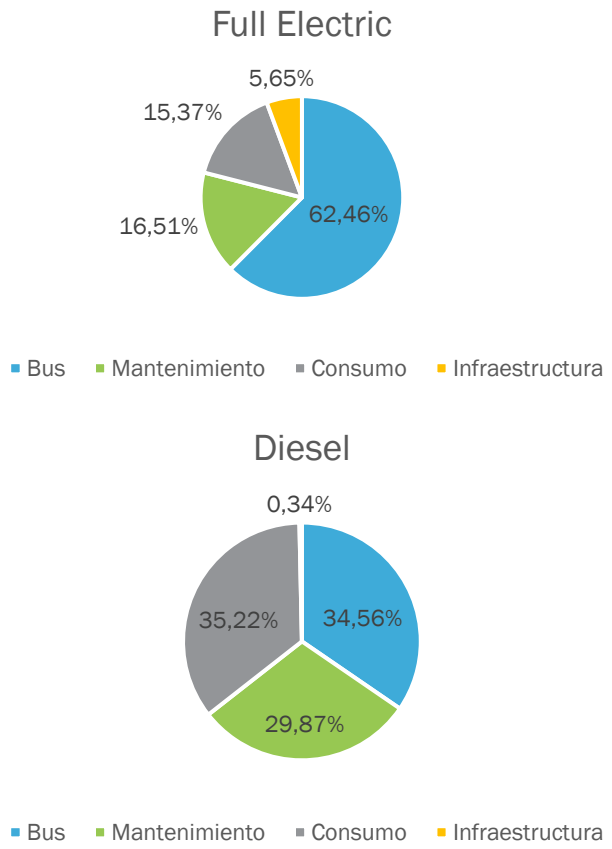


8-year TCO calculation, daily distance traveled of 250 km, excluding driver costs, in 2018, in Europe (€/km). Source: Transport and Environment (2018)

TOTAL COST OPERATION: EXAMPLES

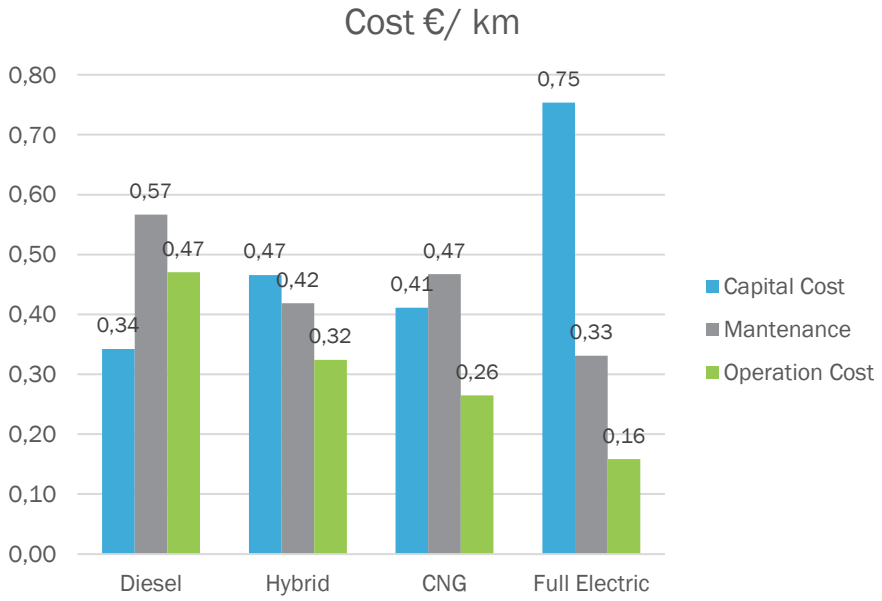


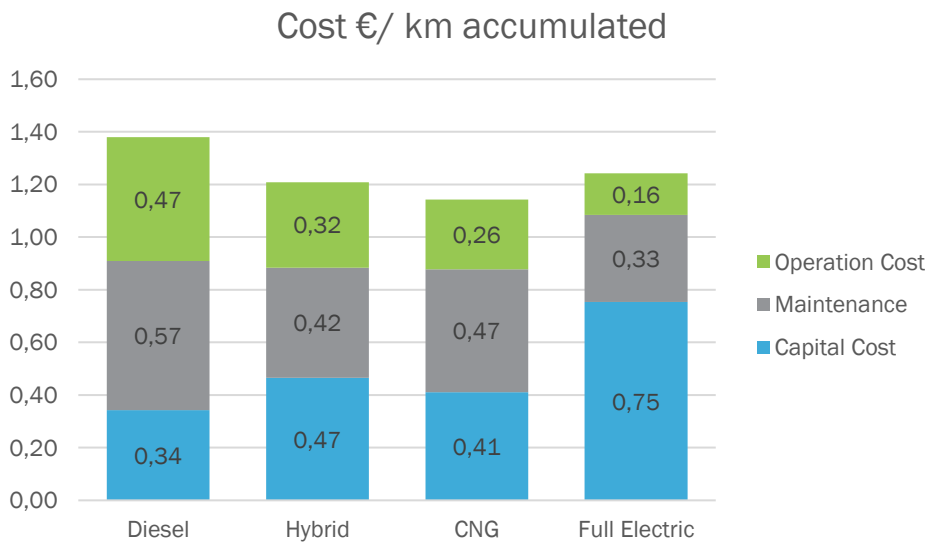
TCO by typology - 12m, year 2021, Italy. Source: GREEN elaboration

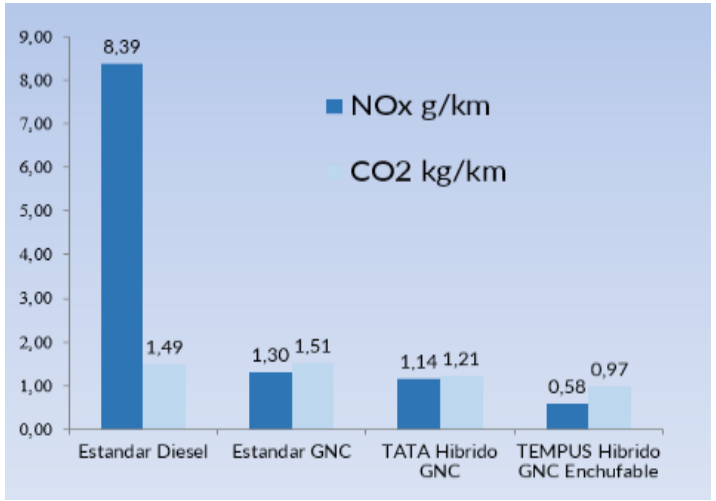


TCO by typology, percentage distribution 12m, year 2021, Italy. Source: GREEN elaboration

TCOP IN EMT MADRID







V. EMT CONCLUSIONS

Electrification is the best solution for Sustainable Public Transport

In the long term, EMT is committed to the use of Electric Bus

- ✓ **Choice Optimal charging model.** Overnight charging by inverted pantograph.
- ✓ **Design and Adaptation of the Depots to guarantee the availability of energy.**
- ✓ **Electrification according to the characteristics of the network.** Electrical infrastructures are 5-10% (approx.) of the investment in rolling stock (not counting the operating cost and energy cost)
- ✓ **The recharging of buses must be guaranteed efficiently and reliably**: The improvement of the efficiency in the management of the intelligent recharge allows an optimization in the investment of the infrastructure and in the consumption
- ✓ **Public-private collaboration:** Operator, Administration and electricity companies
- ✓ **Importance in terms of the training of maintenance staff.** Need for specific standards and certifications
- ✓ **Development of security plans** and importance of **fire protection** systems. Needs assessment and policy development

EMT CONCLUSIONS

- ✓ **The energy transition is not just buying a bus:** a change in the operation system is necessary (infrastructures, processes, contracts, etc.)
- ✓ Transitions are long:
  - ✓ **1994 to 2022 Transition Diesel to CNG at 100%!**
  - ✓ **2007 to 2035 Transition CNG to Electric. Today at 8%: 2027 at 34%**
- ✓ Electrical infrastructures are 5-10% (approx.) of the investment in rolling stock (not counting the operating cost and energy cost)

EMT CONCLUSIONS

Future of urban transport will be:

- Intelligent
- Autonomous
- Integrated
- Electric

✓ AND… IT WILL BE BY BUS!

Thank You!

Any questions?

UPCOMING WEBINAR:
Battery focus: safety, 2nd life, recycling

9th Feb 2023, 11.00-12.00 CET

You can register here

Prof. Maitane Berecibar

Full Professor at VUB & Head of the Battery Innovation Center, MOBI-VUB

CLEAN BUS EUROPE PLATFORM

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