



Transports Metropolitans
de Barcelona



URBAN QUALITY AIR

PUBLIC TRANSPORT in BARCELONA CITY:

TMB USE CASE

Valencia, February 2016

URBAN QUALITY AIR PUBLIC TRANSPORT in BARCELONA CITY: TMB USE CASE VALENCIA

Francisco González Balmas

Technical Director

fagonzalez@tmb.cat

Josep Ma Armengol

Engineering and new development Director

jmarmengol@tmb.cat

1.- Some data about the mobility in Barcelona

2.- Fleet Characteristics.

3.- How one bus operator become efficient and sustainable??

- New Network.
- Installation of Filters.
- Transformation of Diesel and GNC buses in hybrid.

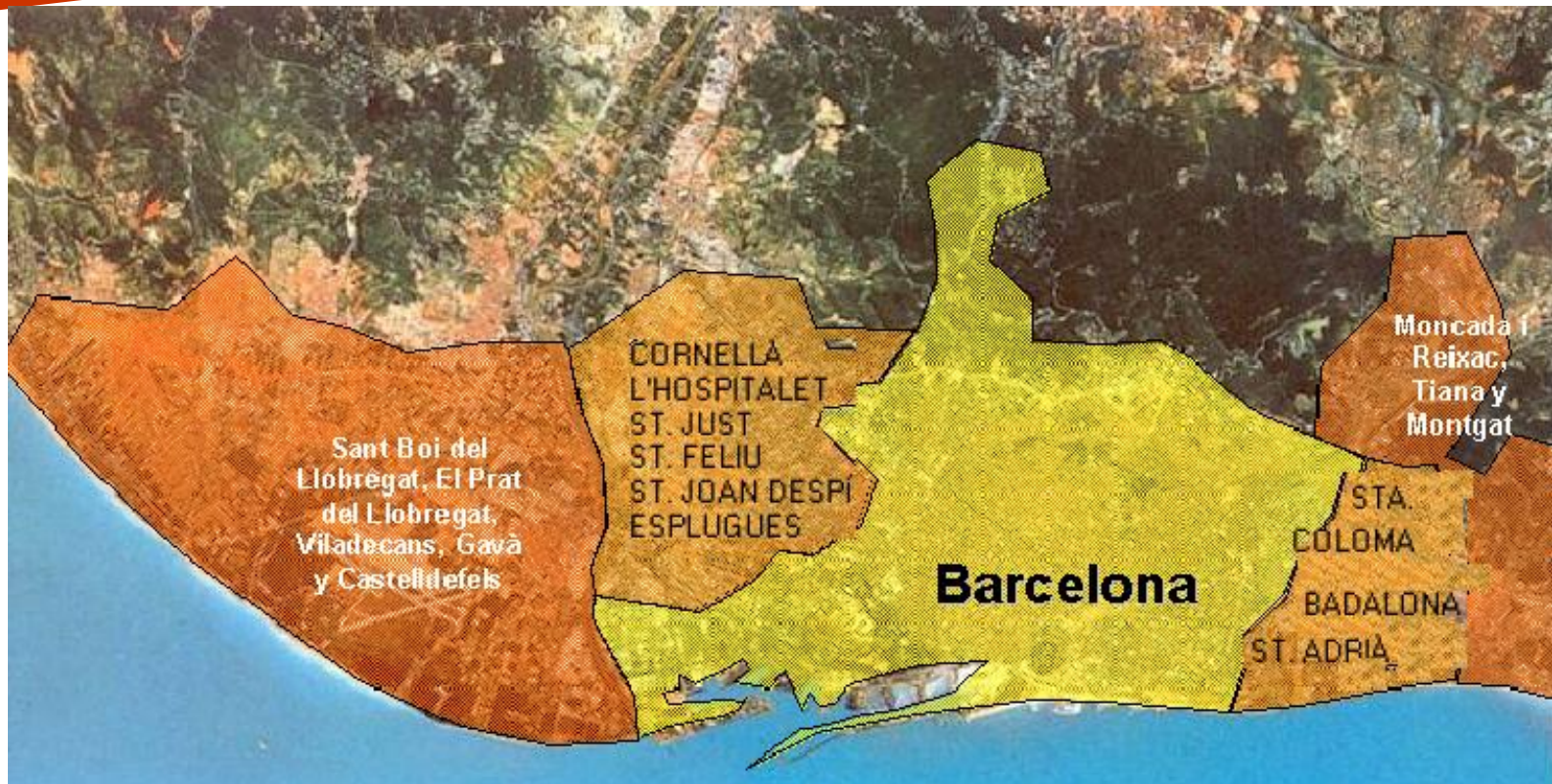
4.- Electrics buses?

Barcelona CITY



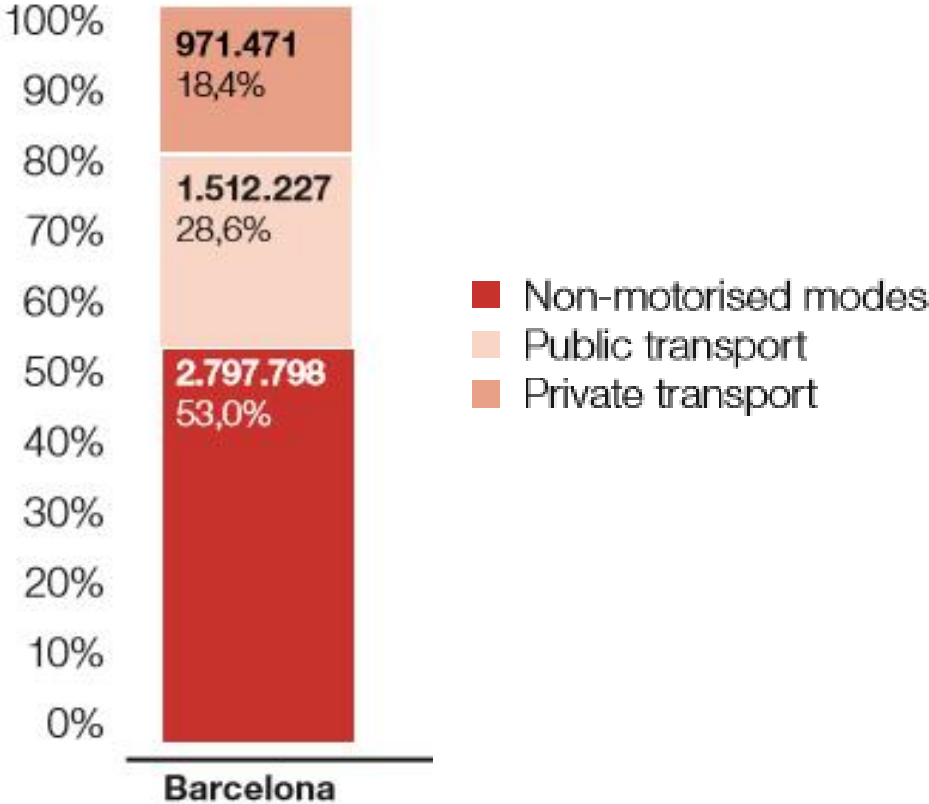
- **Surface:** 100,4 km²
- **Inhabitants:** 1.615.908

BARCELONA METROPOLITAN AREA (AMB)



- **Number of boroughs:** 18
- **Surface area:** 333,4 km²
- **Population:** 2.819.867 (Data 2008, Font: Idescat)

MOBILITY IN TMB AREA OF INFLUENCE

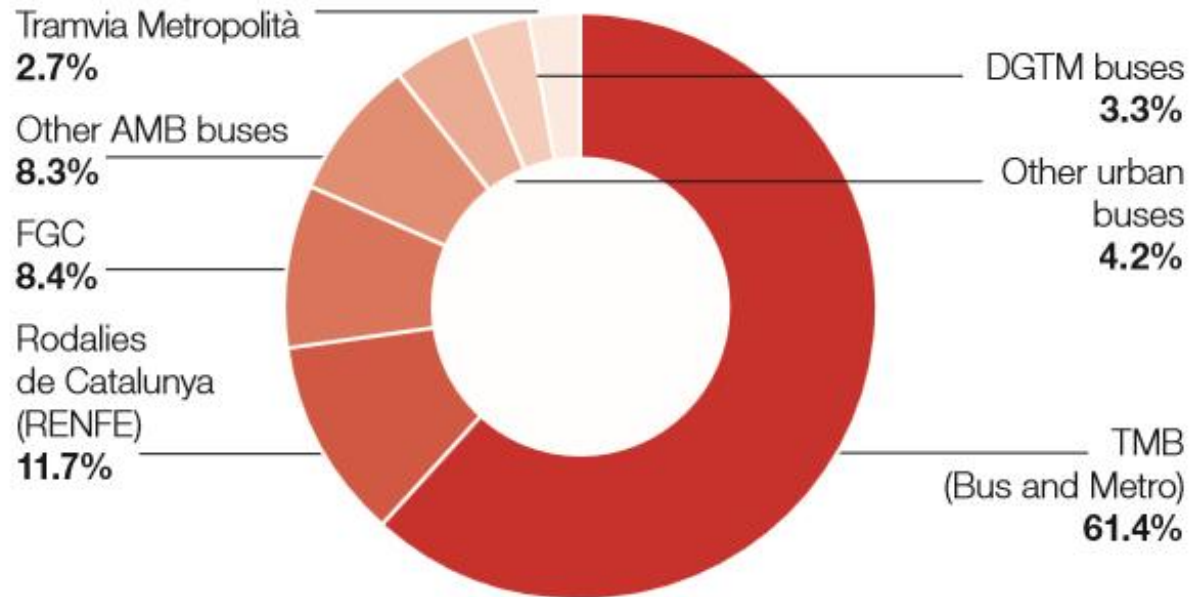


Source: EMEF (2013).

DISTRIBUTION OF PUBLIC TRANSPORT BY OPERATOR



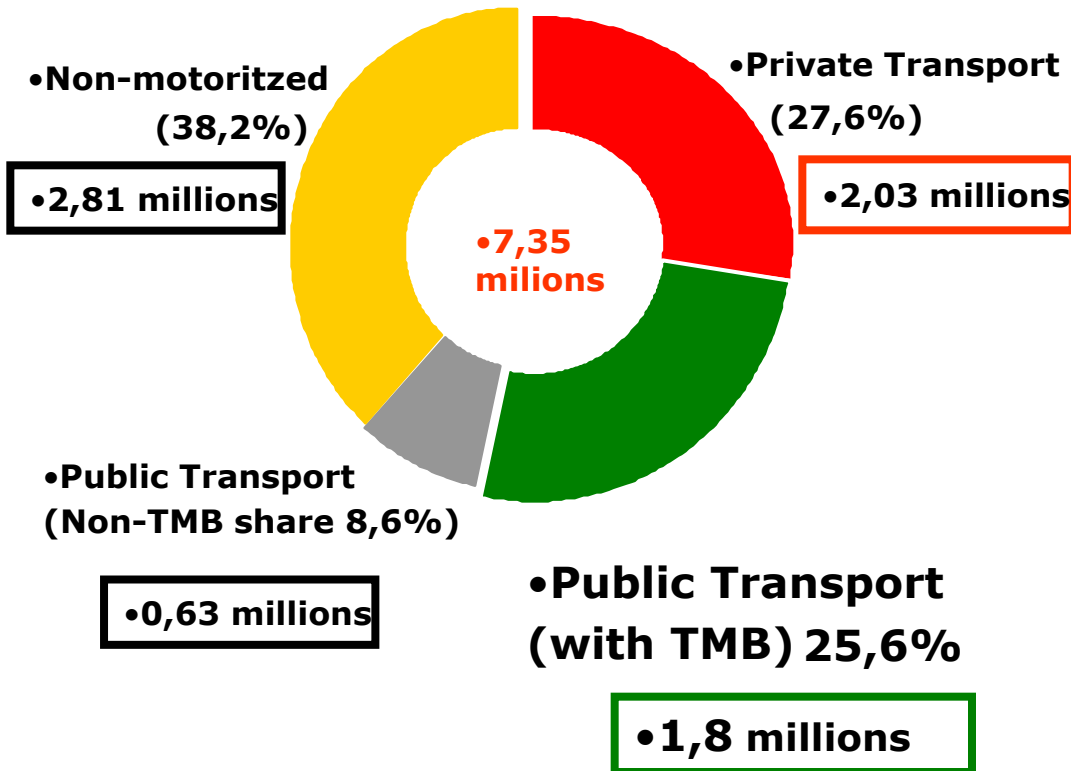
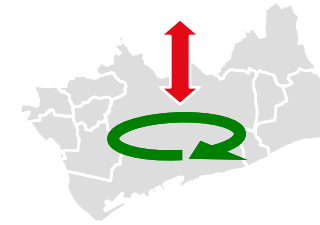
Distribution of public transport passengers by operator



Source: ATM (2013).

TMB and mobility in Barcelona

Daily trips in the area of influence of TMB



Àrea de influencia de TMB

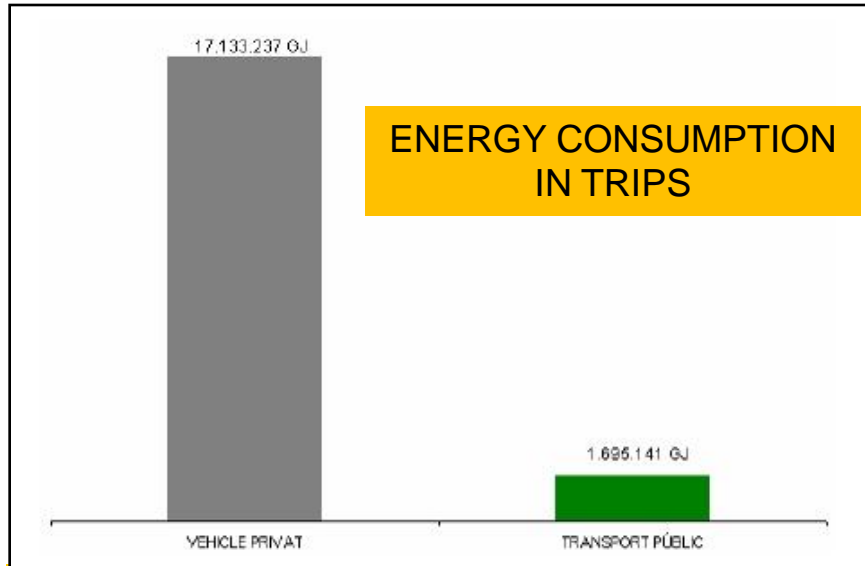
TMB makes 41,4% motorizes daily trips.

Public transport share: 74,8%

Metro: 1,25 million trips

Bus: 0,72 millions daily trips

ENERGY and EMISSIONS IN Barcelona (AMB)



Energy used in transport:
Only 9% is for public transport.

Source: Barcelona Energy Agency.

TRANSPORT PUBLIC IS NOT PART OF THE PROBLEM, BUT PART OF THE SOLUTION,

- Public transport (Bus and rail) represent 3% of global greenhouse-gas emissions.

- Passenger car traffic represents 36% of global greenhouse-gas emissions

Source: Estern review.



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CHARACTERISTIC OF TMB BUS FLEET

NETWORK CHARACTERISTICS

Bus lines	112
Km of lines	972 km
km dedicated bus lines	110 km
Bus fleet	1,070 buses
Number of garages	4
TB staff	4,084
Passatgers/year	180 m
→ Bus stops	2580
→ Comercial speed	12,5 Km/h
→ Bus stopped in whole trip (bus stops, traffic lights, etc..)	50%

NETWORK CHARACTERISTICS



Els centres operatius de negoci (CON)

Vehicles per CON

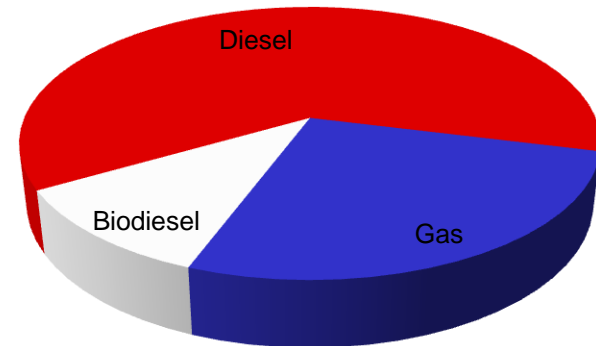
Horta	325
Zona Franca	355
Triangle	253
Ponent	137
Total	1.070

Font: TMB (2014).

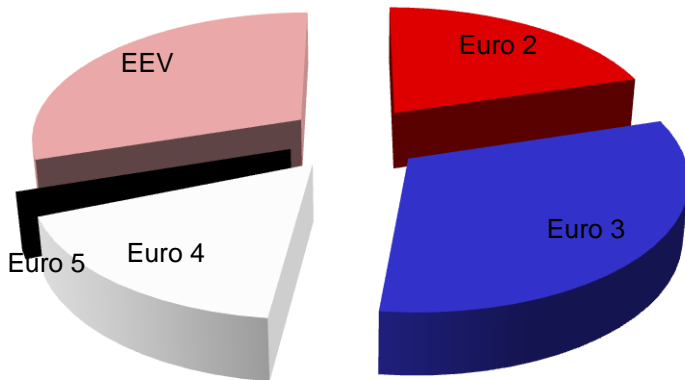
NETWORK CHARACTERISTICS

BUS Fleet in 2010:
1065 vehicles

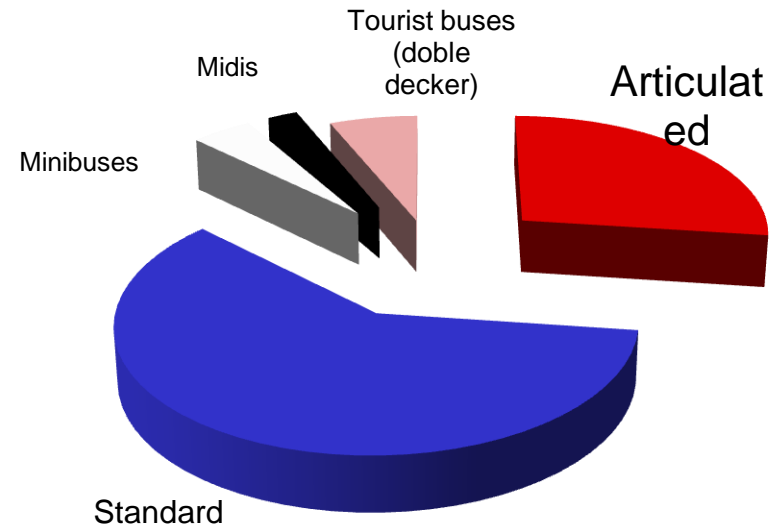
FUEL



EMISSIONS TECHNOLOGY



SIZE OF THE VEHICLE





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TMB: Environmental Efficiency

TMB and EFFICIENCY: CHALLENGE

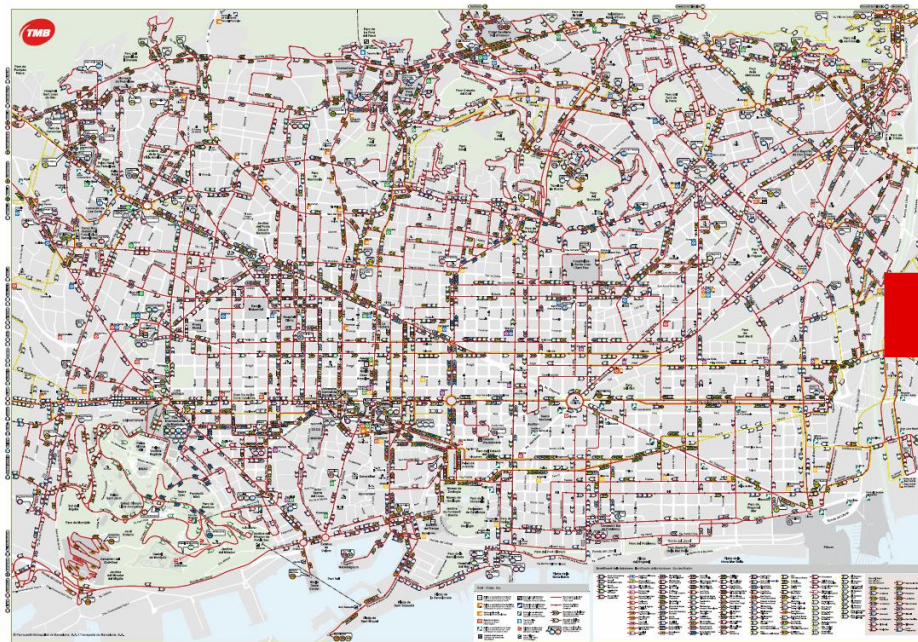
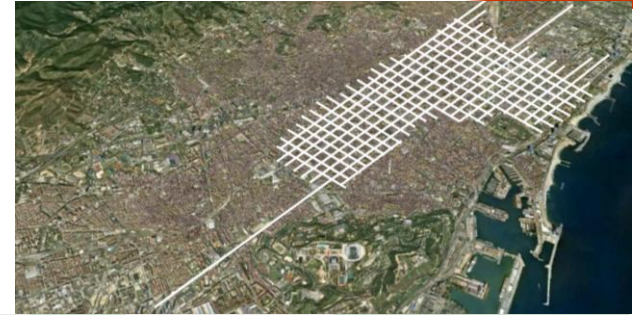
Challenges facing TMB in achieving a Surface network that is **sustainable and more efficient**.

- ❑ Design of an ***operating system*** that will reduce a large part of the trips made in private vehicles.

TECHNOLOGY

- ➔ ❑ Actions taken with respect to the ***existing fleet***
- ➔ ❑ Purchase/renewal of ***new vehicles*** with the latest clean technologies.
- ❑ Actions taken in the infrastructures (Garages, facilities, etc..)

NEW NETWORK



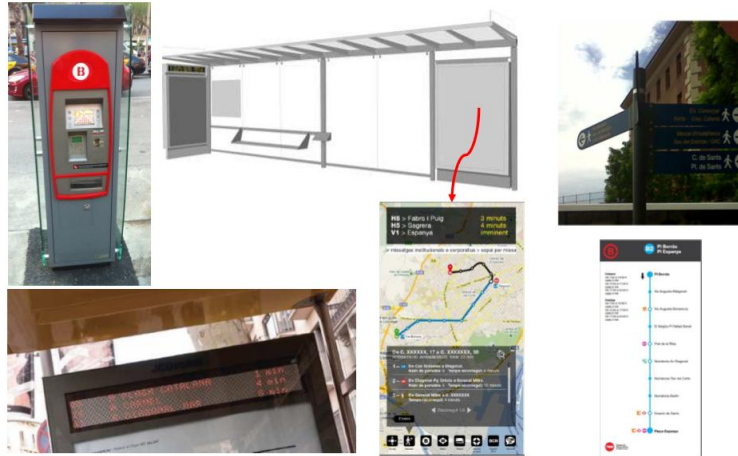
1975-2011 network



2012 NEW network:
Easy to understand
Effectiveness and efficiency

TMB and EFFICIENCY: CHALLENGE

The new urban furniture with RTI & TM



Information to the customer



Friendly environmentally fleet:
CNG
Hybrid
Diesel Euro V



CNG Standard bus



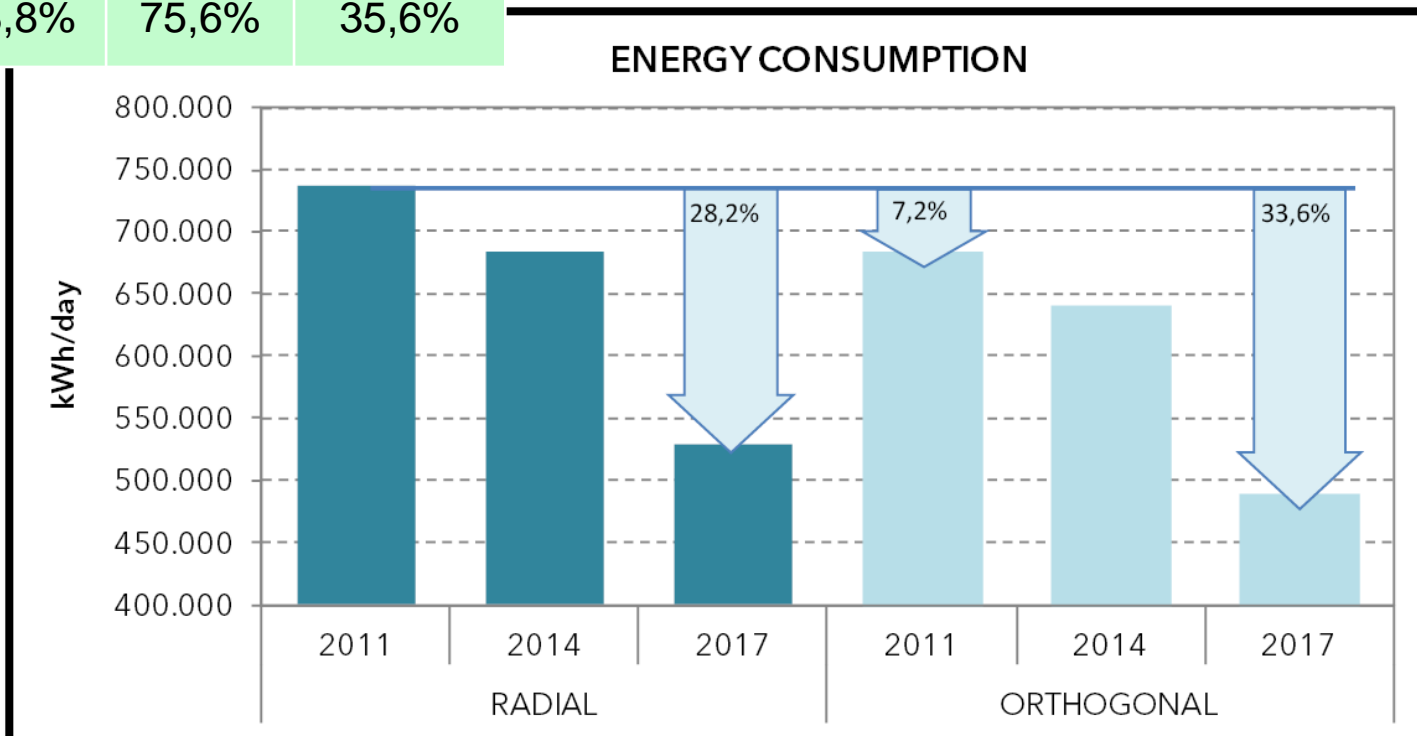
CNG Articulated bus



Hybrid Biarticulated bus (2013)

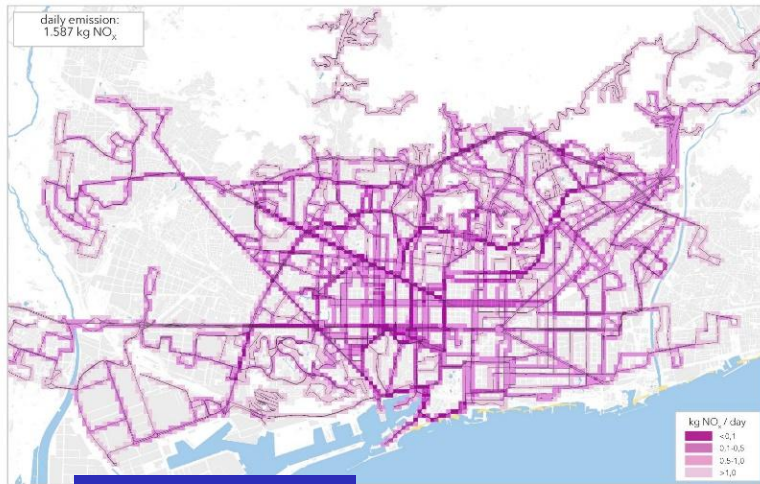
Theoretical RESULTS: Impact in CONSUMPTION and EMISSIONS in fleet and in network

REDUCTIONS	NOx	PM	CONSUMPTION
FLEET (2011-2017)	65,3%	73,7%	28,2%
NETWORK (2011-2011)	10,1%	8,8%	7,2%
FLEET + NETWORK (2011-2017)	68,8%	75,6%	35,6%



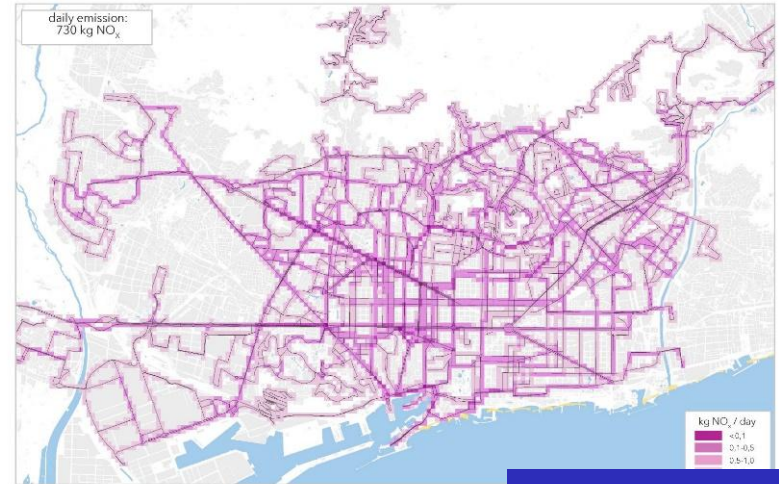
- 28, 2 % of reductions: only due to fleet improvements.
- 7,2 % of reduction: only due to network improvements
- 33, 6 % both affects together (fleet and network)

RESULTS: Map of NO_x EMISSIONS



NO_x 2011

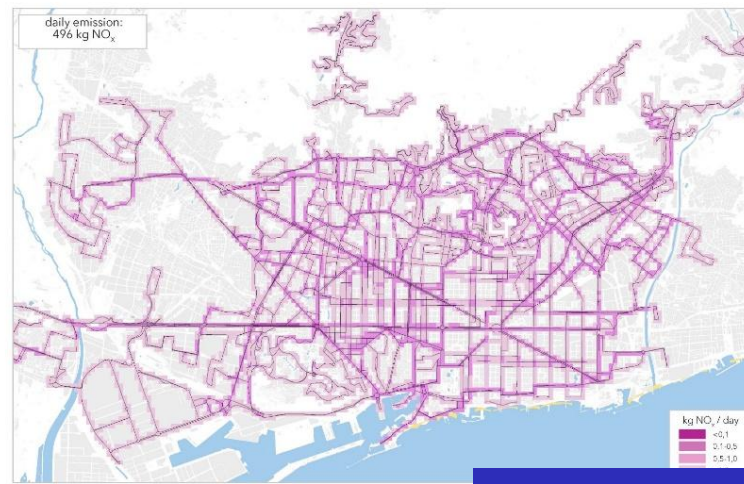
RAD 2011 working day analysis 1:65.000



NO_x Emissions

PAR 20

NO_x 2014



NO_x Emissions

TOT

NO_x 2017





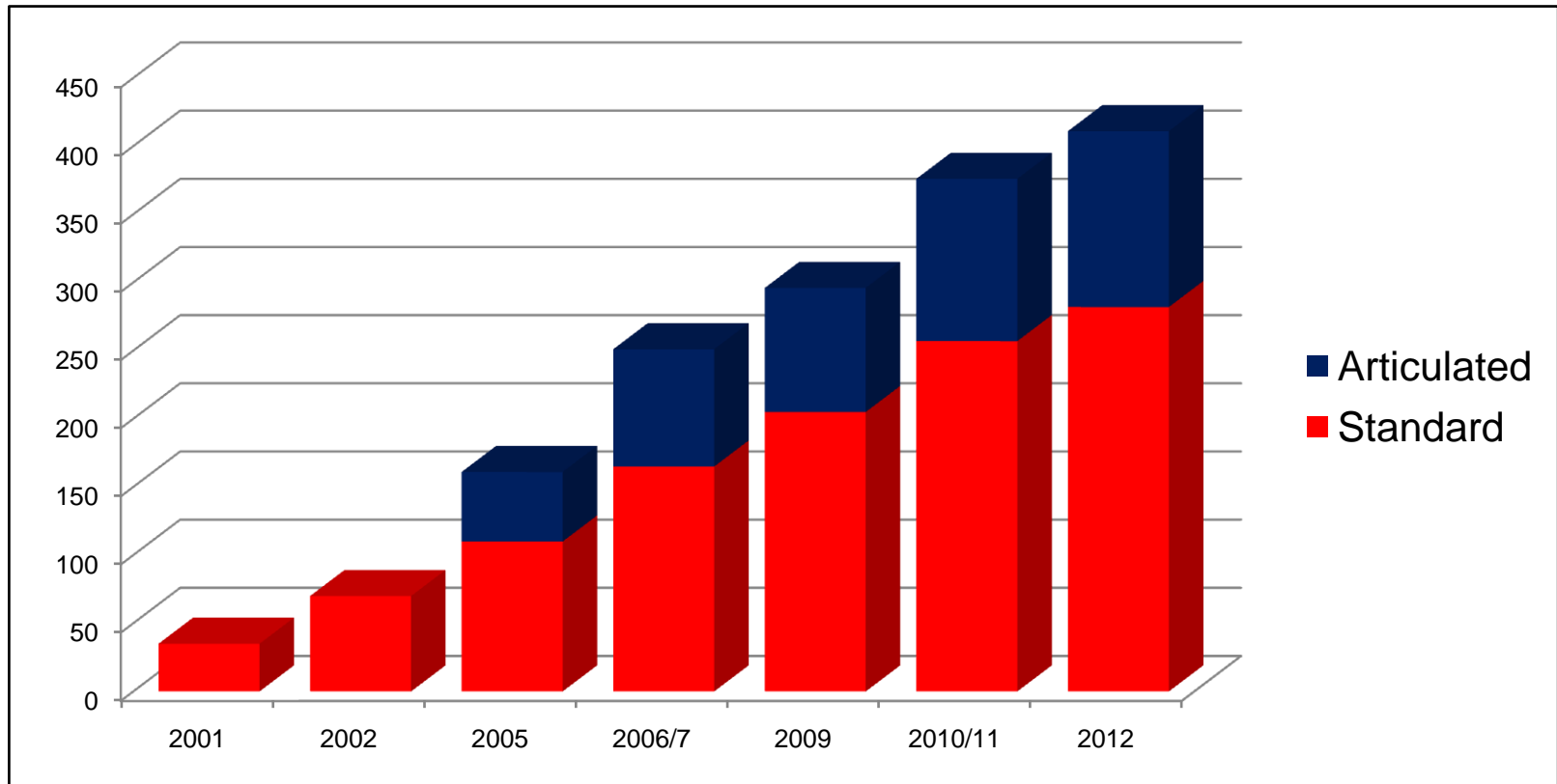
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STRATEGY TO REDUCE EMISSIONS: new technology

STRATEGY: To solve local EMISSIONS (PM + NOx)

CNG Strategy: 411 buses (38%)



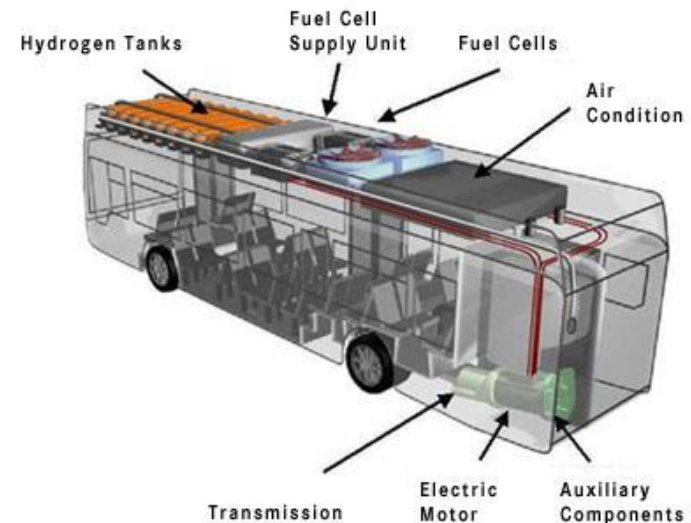
500 CNG Buses expected by 2017



ONLY A TEST FOR 3 YEARS. CUTE Project

- Average bus autonomy: 145 km/h.
- Extremely high purchase and life cycle cost
- Unreliable infrastructure.
- Total count of emissions (well to wheel) questioned due to the fabrication of hydrogen.

Average consumption by vehicle			Average consumption
1084	1085	1086	
[kg/100 km]	[kg/100 km]	[kg/100 km]	[kg/100 km]
28.29	28.26	27.94	28.18



FILTERS: More than the LAW commitments (2012)

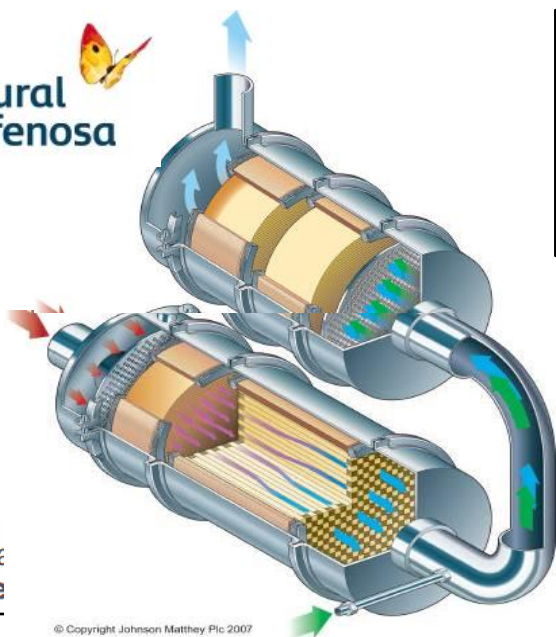
❑ Decret 152/2007 de la Generalitat de Catalunya: “**Pla d’Actuació per a la Millora de la Qualitat de l’Aire als municipis declarats zona de protecció especial**” .

- Force to install PARTICULATE FILTERS in buses with technology lower than Euro IV:

❑ TMB, decided to install (2012/2013):

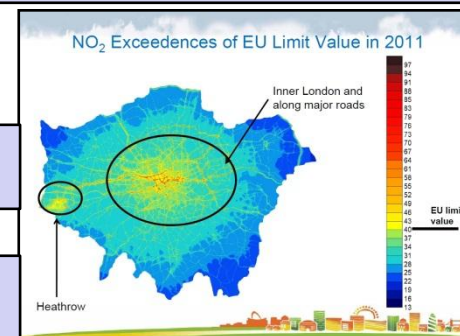
425 PARTICULATE filters + NOx FILTERS (SCR)

- ❑ **Objective:**
- ✓ Particulate: reduction 90%
 - ✓ NOX: reduction 50%

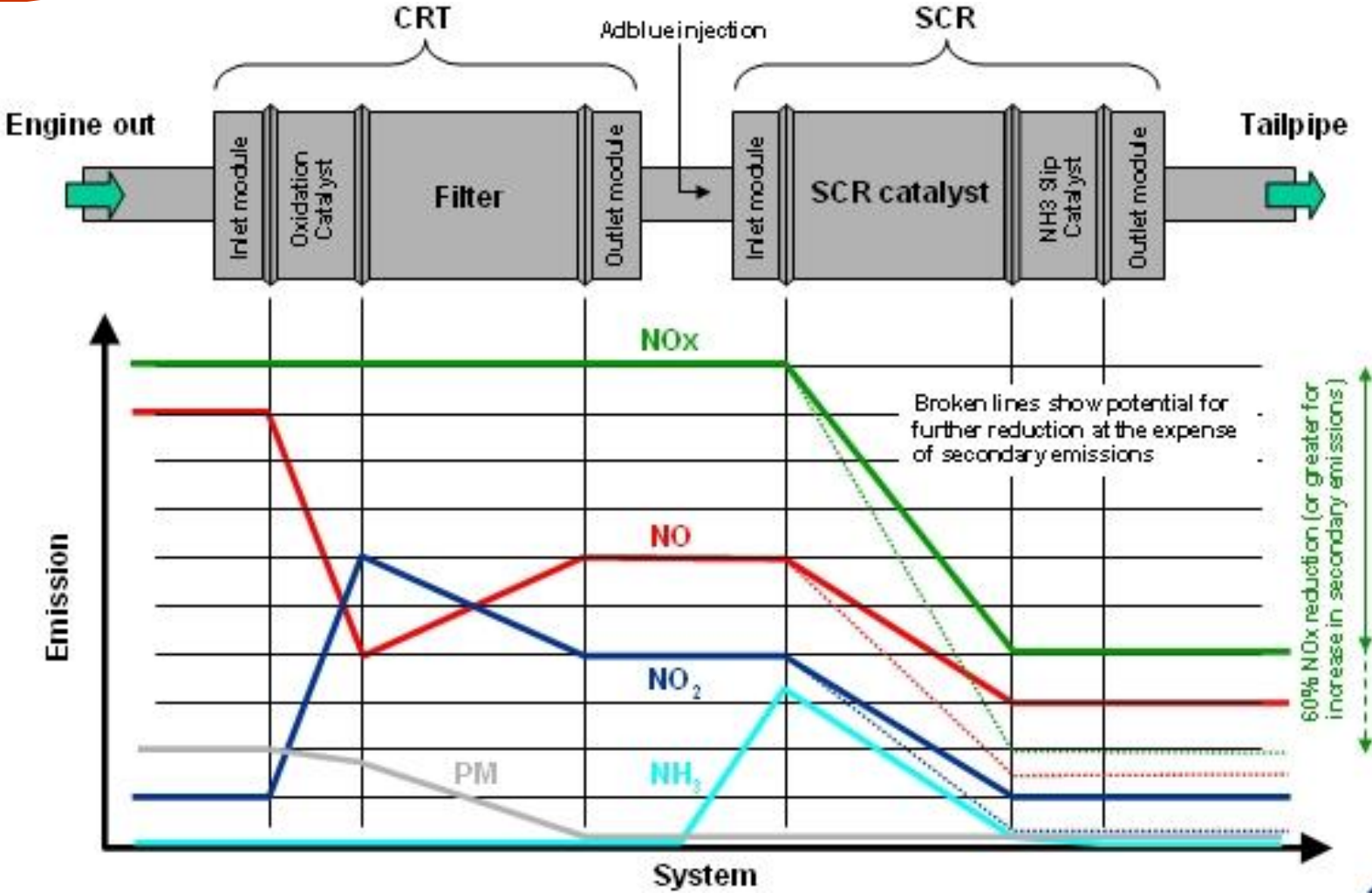


Low emissions zone

LONDON



OBJECTIVE

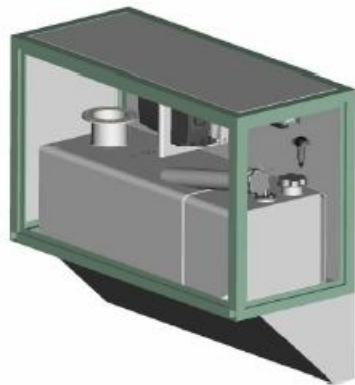


FILTERS: PARTICULAS AND NOx

MAN



Mercedes





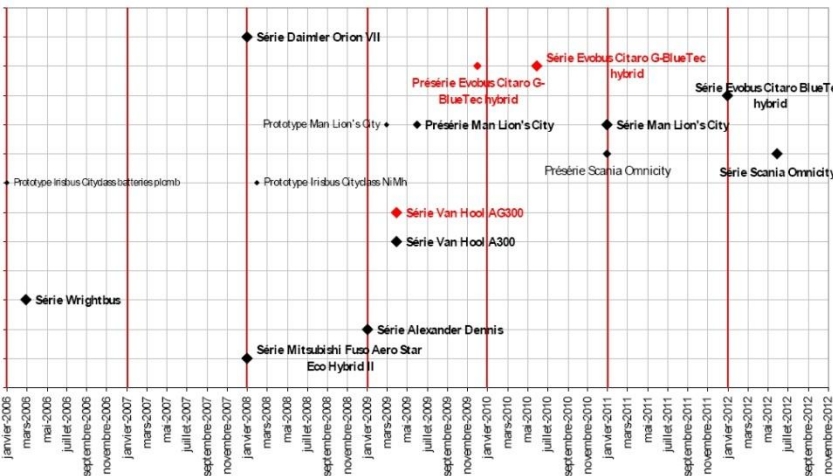
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EXPERIENCE IN NEW TECHNOLOGY (2008)

HYBRID BUSES IN EUROPE (2010)???

THE BEGINING OF HYBRID WORLD.....



	TYPE	ENERGY STRATEGY	SIZE
EVOBUS	Serial	Batteries	18
SCANIA	Serial	Batteries	15
VOLVO	Parallel	Batteries	12
MAN	Serial	Ultracaps	12
IRISBUS	Serial	Batteries	12
SOLARIS	Parallel	Batteries	12-18
VAN-HOOL	Serial	Ultracaps	9-10-18
VDL	Parallel	Batteries	18-24
TATA-HISPANO	Serial	Batteries	12
DENNIS	Serial	Batteries	9-10,7-DD
CASTROSUA	Serial	Batteries	9,6-11,5
HESS	Serial	Ultracaps	18-25





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ACCIO
CIDEM | COPCA



Unió Europea
Fons Europeu de Desenvolupament Regional
"Una manera de fer Europa"

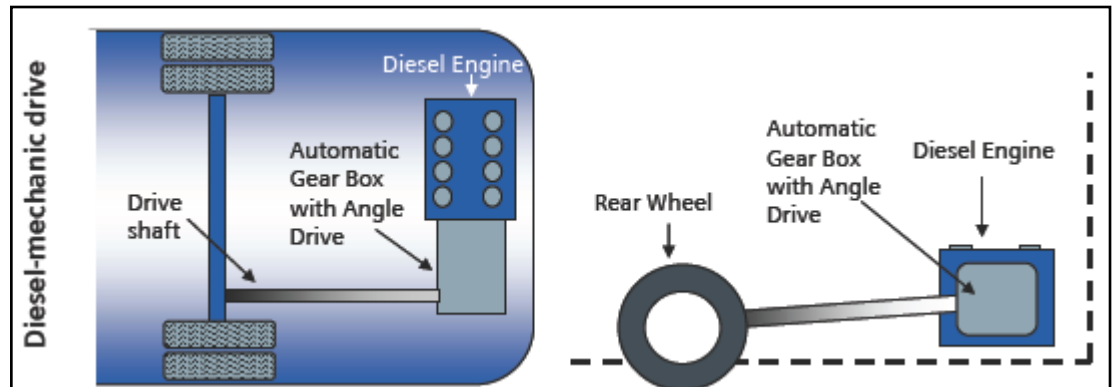
**EXISTING FLEET: RETROFIT PROJECT
BUSES TRANSFORM TO HYBRID**

DEFINITION OF THE PROJECT HYBRID TRANSFORMATION

PROTOTYPE

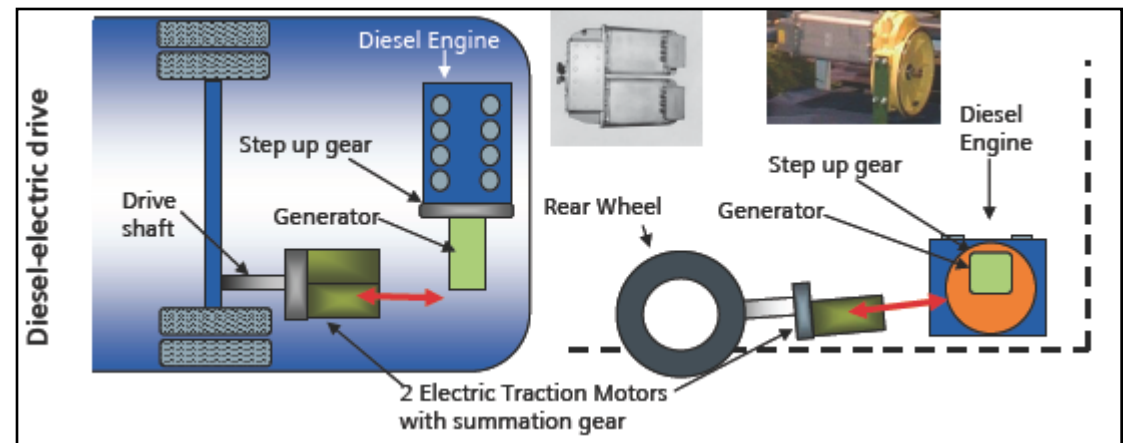
MEMBERS

Operator:	TMB
Hybrid technology:	SIEMENS
Body builder:	NOGE
Engineering:	EDAG

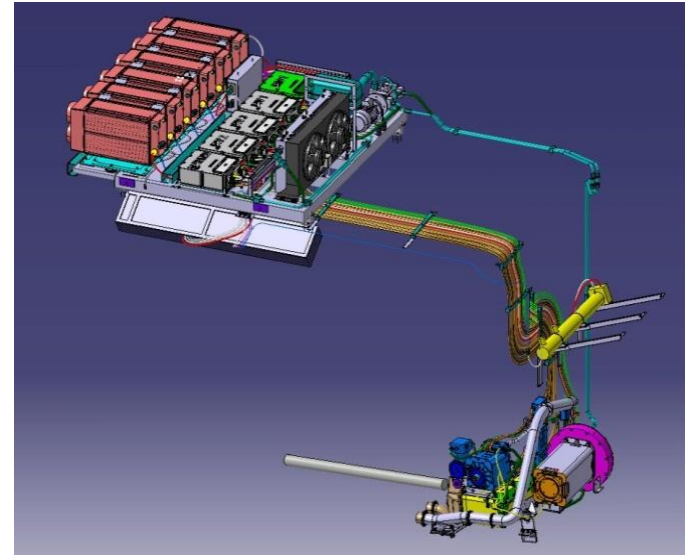
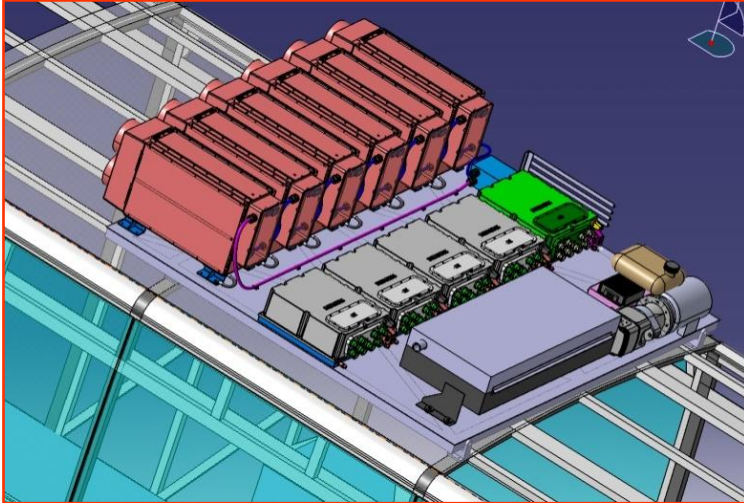


CHARACTERISTICS

- SERIAL System
- Storage system: U-caps
- Stop and go
- 2 electric engines



FEASIBILITY PROJECT: HYBRID TRANSFORMATION



PROTOTYPE FEASIBILITY ANALYSIS (LAB + BUS lines).

Recovery time: We worked with this information:

- Fuel Savings: More than 20% (depending of the bus routes).
- Moderate increasing of the fuel.

In less than 10 years we'll recuperate the investment cost (without measuring the emissions reductions).

HYBRID TRANSFORMATION: PROTOTYPE

**70 DIESEL RETROFIT
buses are running for
TMB bus routes.**





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Model: IVECO CITY-CLASS GNC 491.12.27

Carroceria: CASTROSUA

Tipus de Motor: IVECO Cursor 8 GNC

Potencia: 270 CV

Norma Mediambiental: EEV.

Caixa de canvis: Voith 854.3 E

**PROJECTE prototipus TRANSFORMACIÓ VEHICLE GNC A HÍBRID.
Projecte conjunt entre TMB i Gas Natural Fenosa**

GNC-HYBRID TRANSFORMATION PROJECT

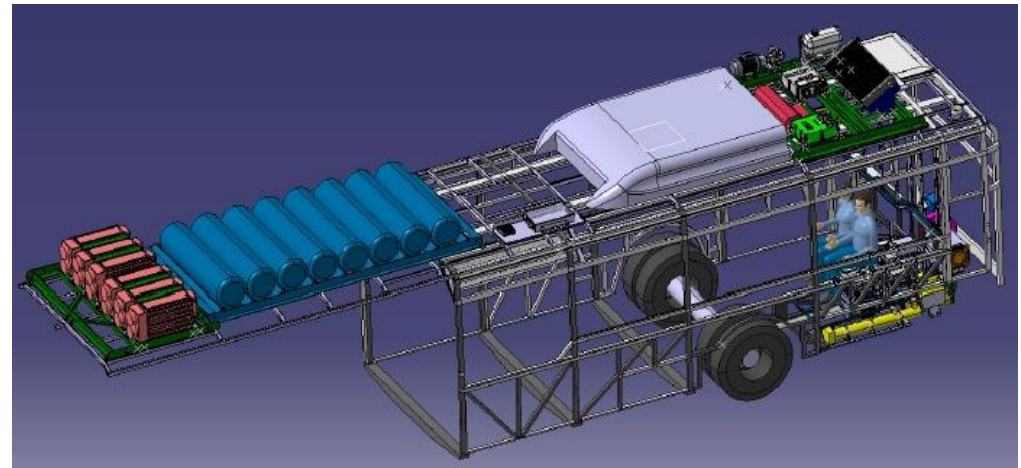
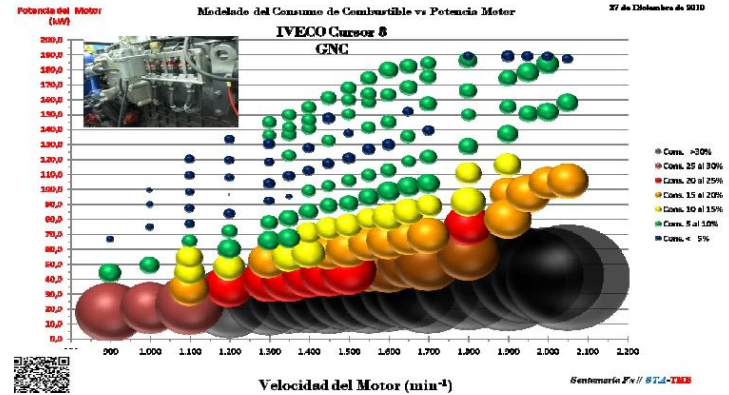
The consumption test in
IDIADA (saving around
30%)



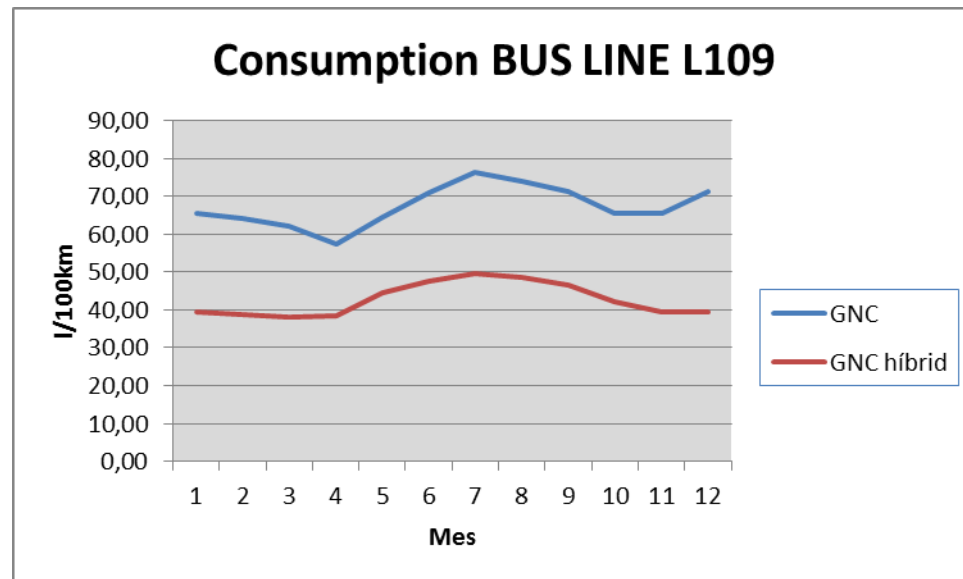
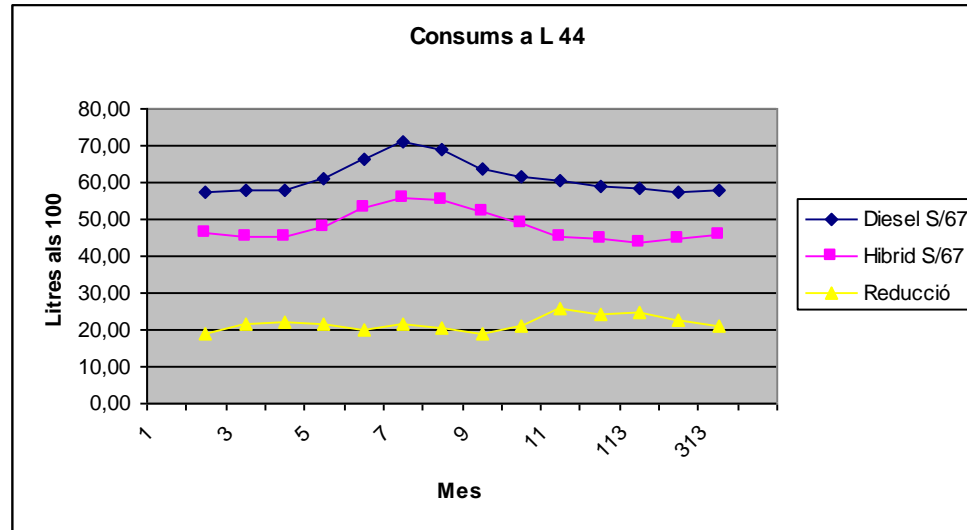
the technical feasibility



Serial Production:
10 UNITS



CONSUMPTION: DIESEL AND GNC HIBRID VEHICLES



LEADERSHIP..... IN TRANSPORT TOO

The Role of a leader: “set a stage, not perform on it”.

Leader: “Create the space where everybody’s parts of genius can unleashed and harnessed”

One Genius?????.....“Collective Genius”



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NEW HYBRID VEHICLES

Hybrid vehicles : characteristics / NEEDS for TMB.

What to buy???

- Configuration: Serial or Parallel system, **stop and start/pure electric**, Batteries/Ultracaps, specific SW designed for bus routes (flat/hilly), engine technology (Diesel, CNG, H2, etc..)
- Reduction in fuel consumption = **20% - 35%**
- Reduction in emissions (CO₂, HC, CO, NO_x, PM) = **20% - 35%** (in proportion to consumption or higher in some cases).
- Reduction in noise = **4 dB** (50% acoustic power).
- Very smooth driving for passengers and comfortable for drivers.

HYBRID BUSES TODAY: DECEMBER 2015

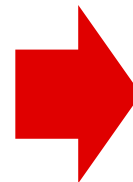
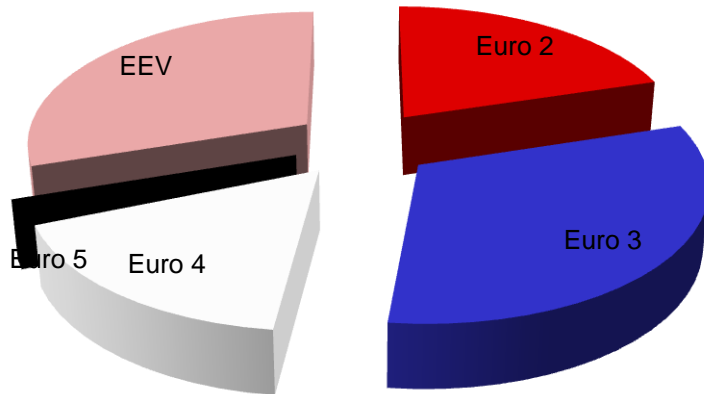
	SIZE	BRAND	UNITS
HÍBRIDS	24	Van Hool	3
	18	Volvo	12
	18	Solaris	15
	12	Tata-Dennis	12
	12	MAN	21
	12	RETROFIT DIESEL	70
	12	RETROFIT gas	13
	12	Iveco	5
	12	Volvo	5
	11,5/9,75	Castrosua	3
	TOTAL		159



FLEET CHARACTERISTICS 2010/2013

BUS FLEET in
2010

BUS FLEET in
2013



Tecnologies:
Diesel filtres PM+NOx)
GNC
Hybrids
Elèctric



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VEHICULOS ELECTRICOS

Antecedentes 2010 en el mundo



FOTO

King
Long

Gruau

PVI



ANKAI
Automovil



Tecnobu



Hino



Bredamenari

小型(ワンボックス)の概要		環境性能	
全長	6,990 mm	項目	1km 当たりの消費
全幅	2,480 mm	消費電力	約 0.2 kWh
全高	3,100 mm	燃料消費量	約 60% 低減
乗車定員	31 名	発生NOx 量	約 90% 低減
最大積載量	7,500 kg	※ 運転モードにより変動	
最高速度	60 km/h		
水素タンク容量	150 kWh		
リチウムイオン電池	30 kWh		

充電方式
プラグイン方式 / 非プラグイン方式

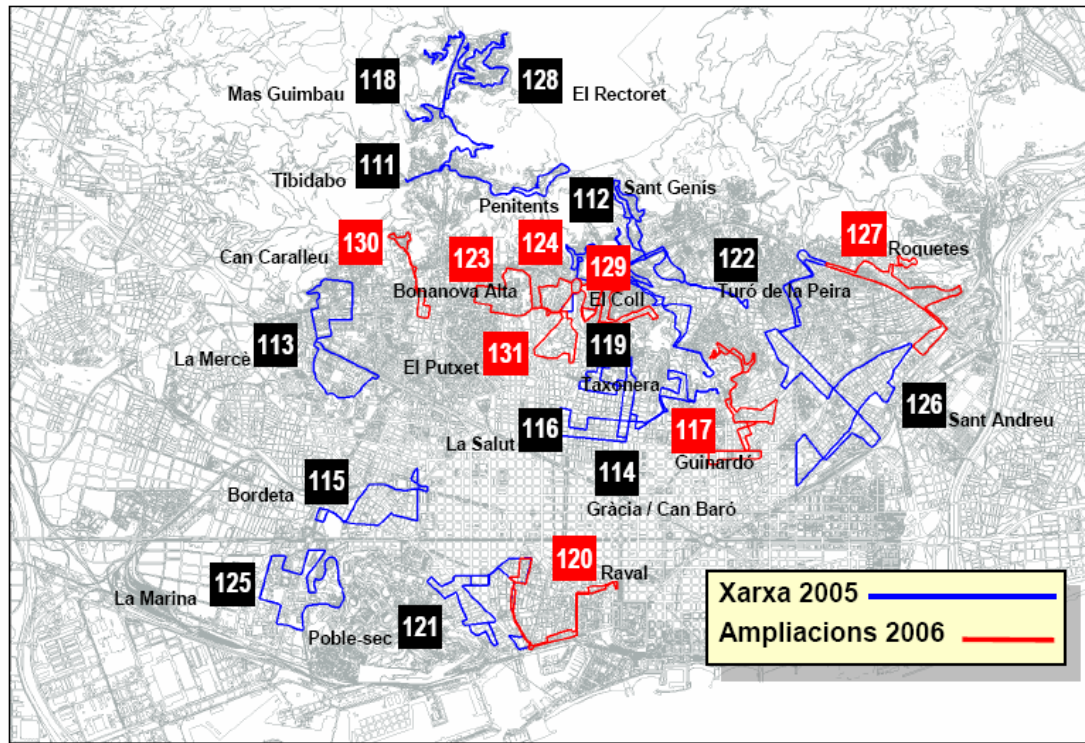


PRIMERA PROPUESTA DE VEHÍCULOS ELÉCTRICOS

BUS DE BARRI Operation: Proximity bus service in the neigh borough

Bus routes: 21

Total minibuses: 42



FIRTS TEST IN ELECTRIC BUSES

THE CHALLENGE OF ELECTRIC BUSES: ENOUGH AUTONOMY FOR THE DAILY OPERATION: MORE THAN 16 HORAS (closed to 18h)



BUS ELÈCTRIC 12 m. - BYD
BATERÍA ion-Li 324 kWh



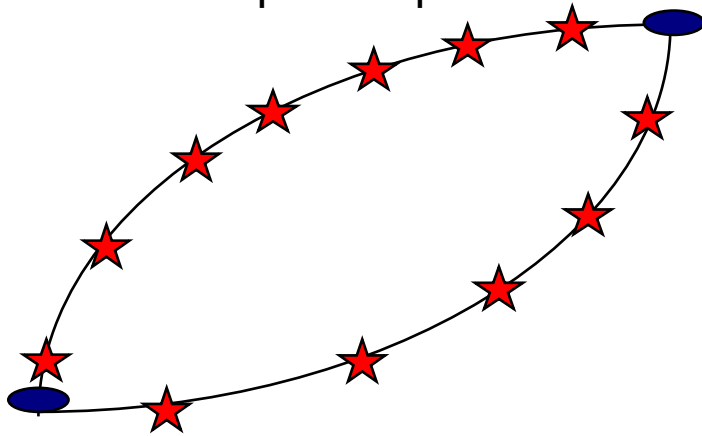
PROJECTE ZeEUS
2 BUSOS ELÈCTRICS 12 m. IRIZAR
BATERIES ZEBRA 352 kWh

EN BUSOS ALTA CAPACITAT, IMPOSSIBLE AUTONOMÍA SENSE RECÀRREGA LÍNEA

Project TOSA

Transport with Optimized Powering System

Line 5: Palexpo - Hôpital 8.8 km



Stops: 22 in each direction
Feeding stops: 7+5 400 kW 15 s.
Feeding Terminals: 2 200 kW 5 m

GINEBRA



CÀRREGA CONDUCTIVA

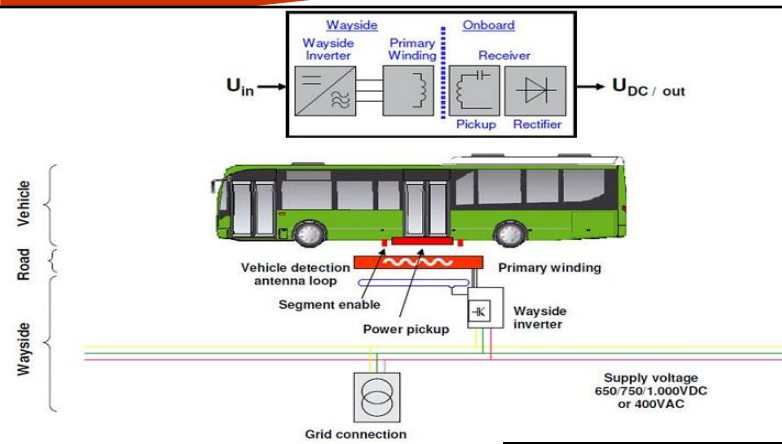
PROJECTE AUTOBÚS ELÈCTRIC - 18 m.

PURE ELECTRIC VEHICLE: STRATEGIES: INDUCTION

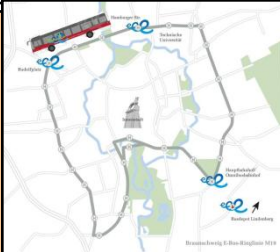
INDUCTION
(Hess and Van
Hool-
Bombardier:
Bruge and
Berlin) 2014 in
operation.



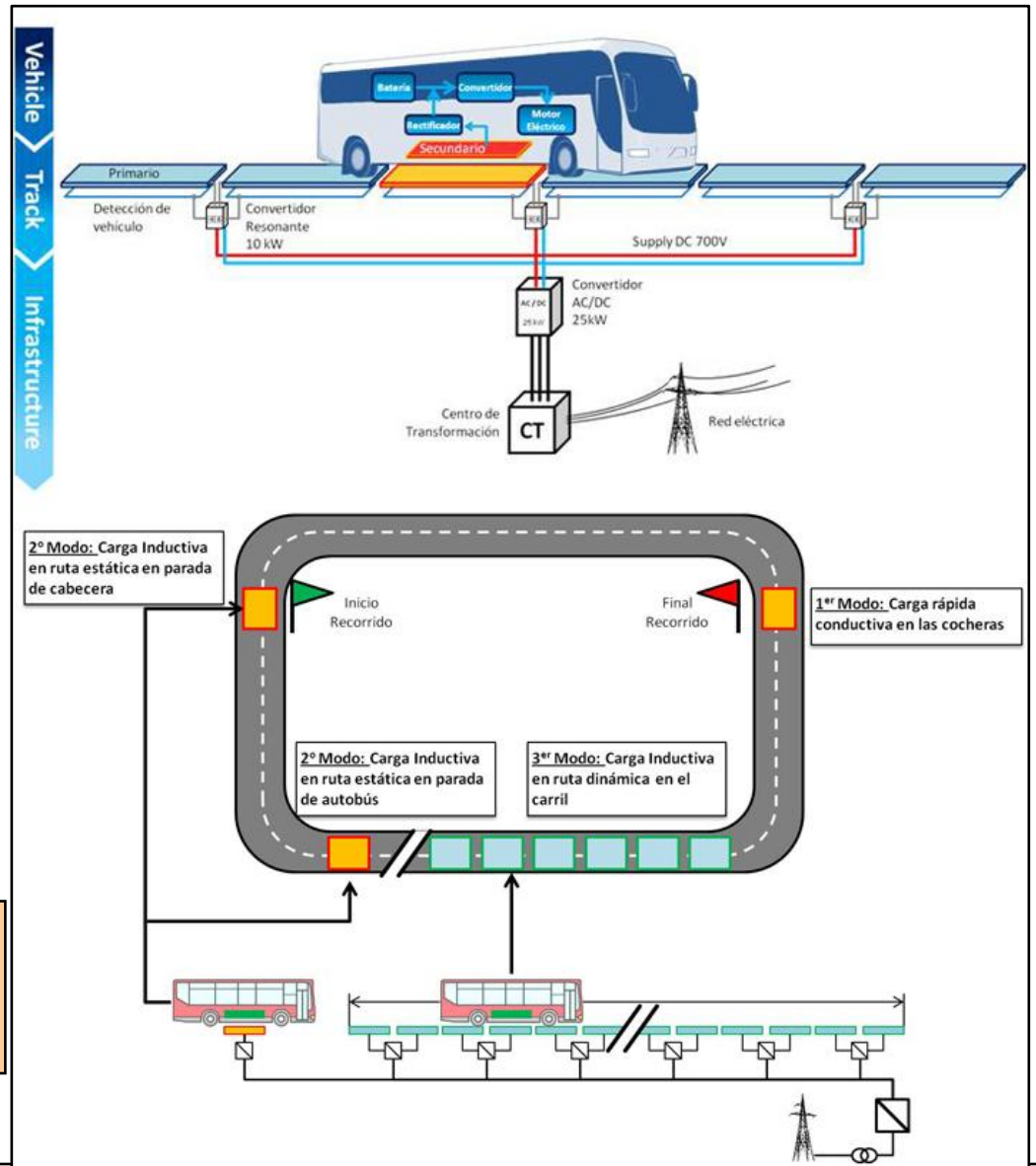
PURE ELECTRIC VEHICLE: STRATEGIES: Braunschweig and Malaga



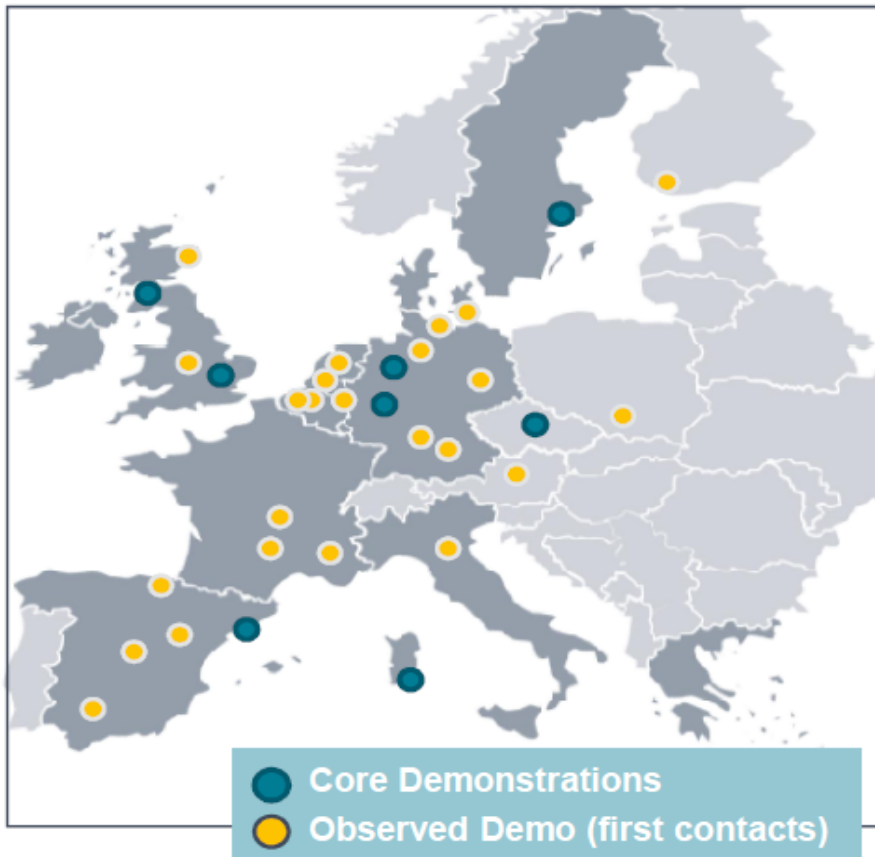
**INDUCTION:
Solaris.
Braunschweig**



**INDUCTION:
Malaga**



ZeEUS Demonstrations



8 Core Demonstration

- Barcelona, Bonn, Cagliari, Glasgow, London, Münster, Plzen, Stockholm

~35 electric buses

- 12 meters, articulated, double-deckers
- Plug-in Hybrid, Full-electric, Battery Trolleys

Energy supply modes:

- plug-in, conductive, inductive, overhead

Fast and slow charging strategies

- Overnight (depot)
- Opportunity (terminals, bus-stops)

Observed / Monitored Demos

- 50 contacts already!
- Annual publication & workshops

OTHER CITIES AND COUNTRIES

North America: 7.500 hybrid buses

Nueva York (6000 buses): 1.670 híbrids. Last bought 700.

London (8500): 900 hybrid buses, The aim is 2.000.

Electric buses: 10 + 50 (Fuel Cell: 10)

Last declaration: < 2020 40% of fleet will be
0 emissions

Paris (4500) Last declaration < 2025 without diesel.

GNC: 900 + 3600 Elèctrics

Madrid (2000) City Council (2010) → NO more diesel

Germany Electric vehicles in some cities. Hamburg (10),
Berlin (18), Colònia (8), Dresden (10) Hamburg 10 FC.

Xina > 10.000 Electric and hybrid buses.



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NEW PROJECTS
PURE ELECTRIC buses **TODAY????**

How to decide whether to buy a diesel or electric vehicle?

LIFE CICLE COST (LCC)

DIESEL

ELECTRIC

PRICE

TOTAL MAINTENANCE (INCLUDING Batteries)

ENERGY CONSUMPTION

ENVIROMENT COST (Directive 2009/33)

INFRASTRUCTURE

DEMONSTRATIONS PROJECTS

ZeEUS: PURE ELECTRIC BUSES

IRIZAR PROJECT: 2 buses

Recharging station on the depot: 100kW

Energy Capacity: batteries (352 kWh) + 5 Ucaps

Operation: 2 buses running in bus line 20.



SOLARIS PROJECT: 2 buses

Opportunity charging on both terminals with pantograph.

Charging station on the depot: 50kW

Charging station on the street: 400kW

Capacity batteries: 125kWh

Operation: October 2015



New way of operating

OPERATIONAL SYSTEM: new way of operating

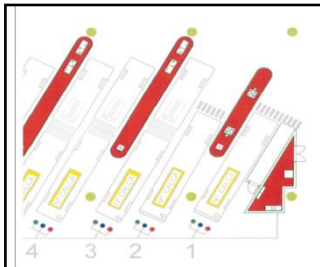
1.- PLUG IN: on the depot



2.- FAST CHARGING: on the terminals or bus stops



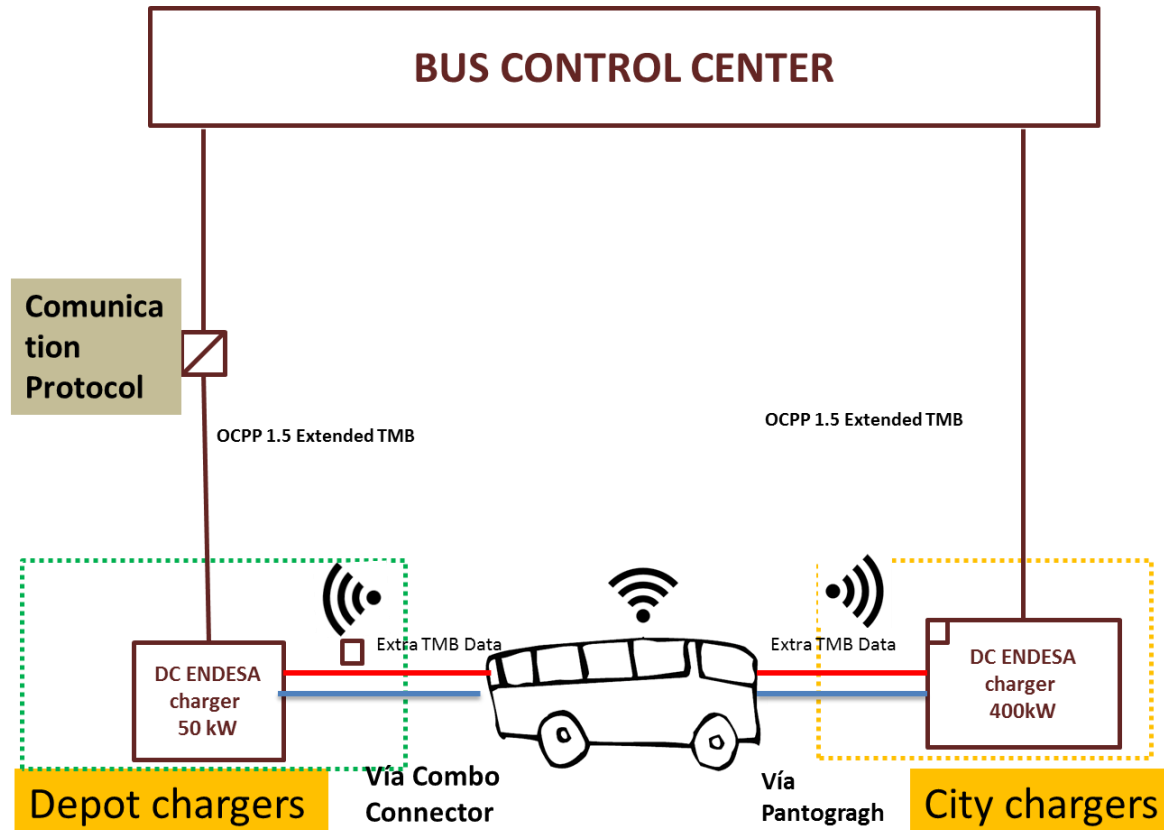
3.- LOGISTICS (INFRASTRUCTURE)



OPERATIONAL SYSTEM: new way of operating

4.- COMUNICATION SYSTEM: the bus should be connected to the control center on line.

NEW CHALLENGE in ELECTRIC SYSTEM (similar to Metro system)



OPERATIONAL SYSTEM: new way of operating

5.- TRAINING AND AFTER SALE SERVICE

6.- HOW ACT IN CASE OF FAILURE (infrastructure):
alternative service with diesel buses.

7.- Designing schedule for buses: summer and
winter time in the worse conditions.

8.- SIZE OF THE VEHICLES:
autonomy (range)



Complementing ZeEUS: ELIPTIC



Objective:

- Technical development and demonstration of cost and energy savings by electrifying public transport.

ELIPTIC thematic pillars:

- integration of ebuses in cities
- Upgrading and/or regenerating electric public transport systems
- Multi-purpose use of electric public transport infrastructure



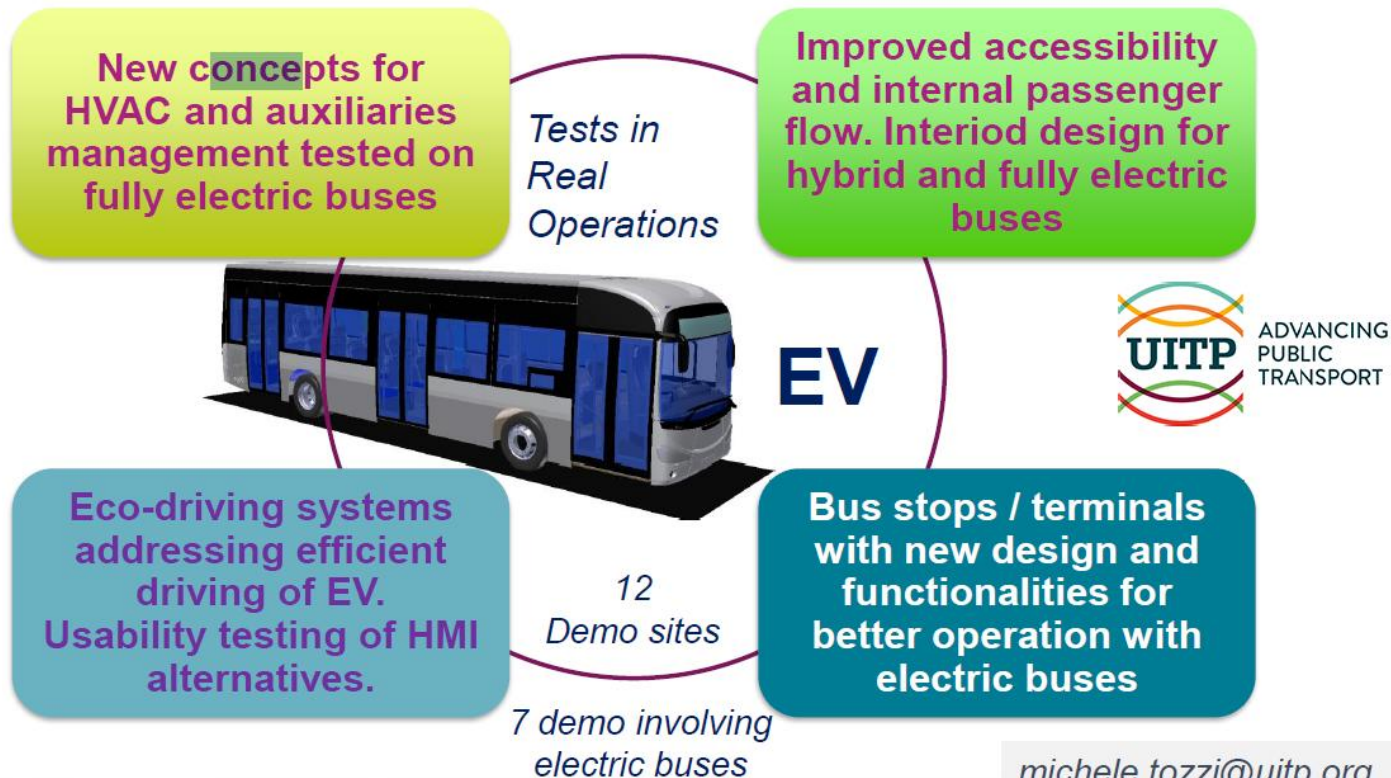
ELIPTIC is 'practitioner driven'

Coordinator: City of Bremen
hendrik.koch@umwelt.bremen.de

www.eliptic-project.eu



Complementing ZeEUS: EBSF_2



Thank you very much for your attention.



Josep Ma Armengol
Engineering and new developments Director
jmarmengol@tmb.cat

Francisco González Balmas
Technical Director
fagonzalez@tmb.cat