ZeEUS

D53.8

Urban e-Bus Systems Deployment Plan and Recommendations

UITP

Chapter 1

Bus transition to clean propulsion

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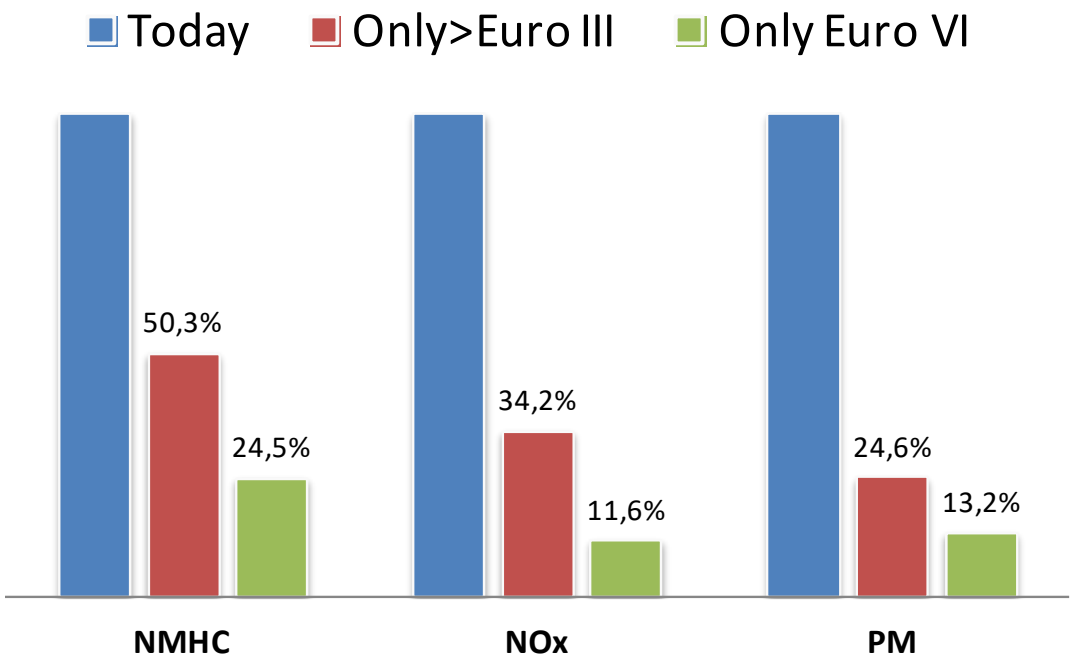
~ 450 Billion of bus journeys per year worldwide

Buses account for approximately 83% of the total PT journeys worldwide

Buses are the backbone of any public transport system and are the only PT mode in many cities

Fleet Renewal is a priority



Estimated emissions reduction by renewing the fleet

Source:
www.3ibs.eu

THE BUS IS CLEAN !
In Europe Urban Bus contribution to city transport pollution (25%) is **8%** calculated per passenger per km

In Europe, **45% - Euro III or older**

Renewal of old-bus fleets towards cleaner technologies is a priority for European Bus Stakeholders

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TRANSITION TO CLEAN BUS FLEETS

The changes leading to the transition to clean bus fleets shall improve and never put at risk the basic service of a bus:

Service excellence

Bringing passengers efficiently and comfortably from A to B

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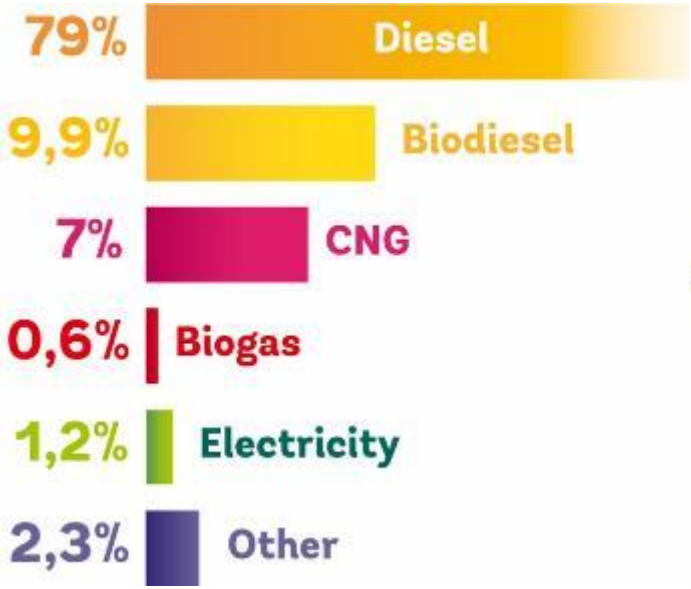
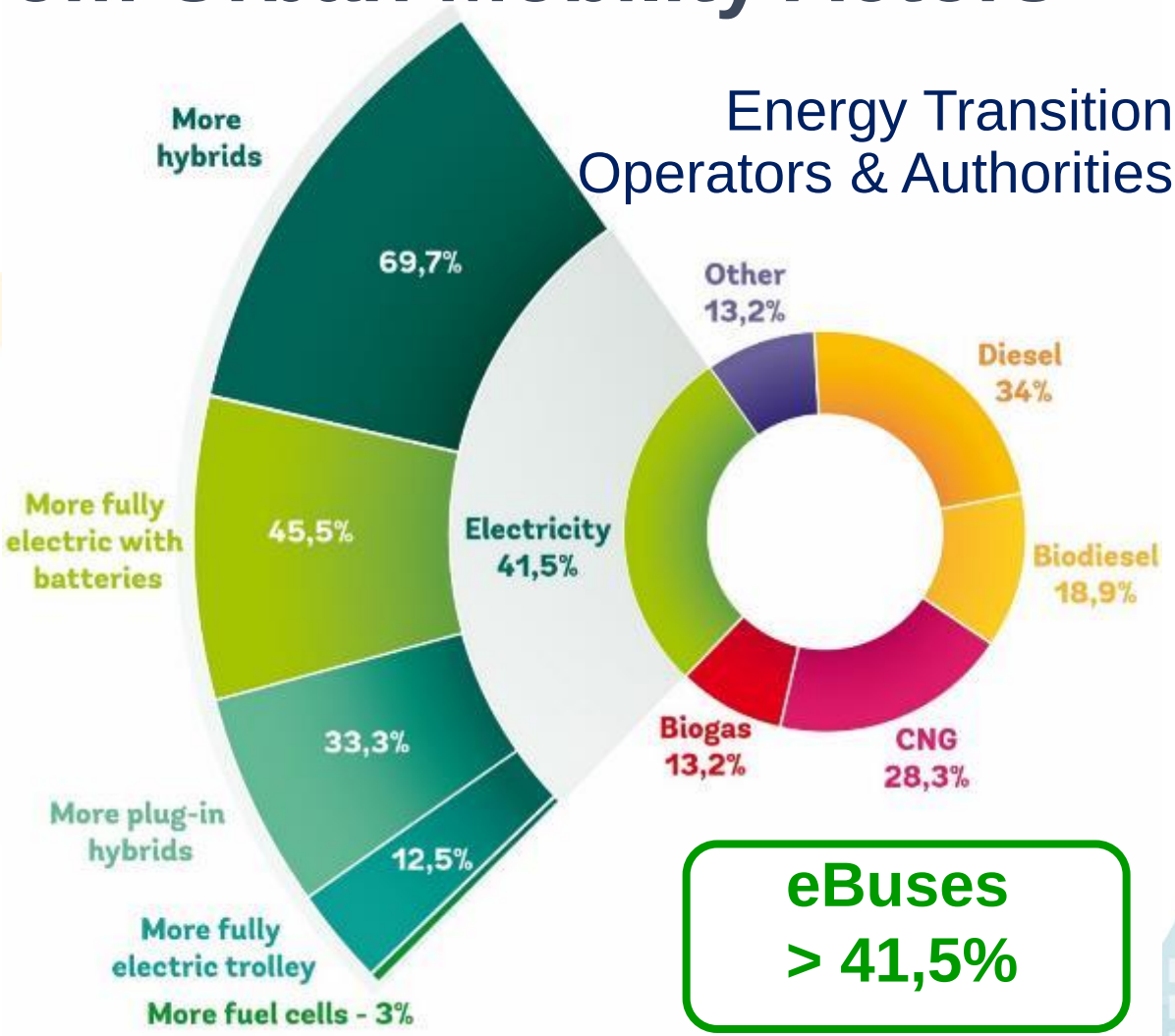
Clean Buses?
Great Interest from Urban Mobility Actors

European Current fleet composition



Bus fleet breakdown per fuel or energy used

Energy Transition Operators & Authorities



eBuses
> 41,5%

Respondents distribution according to future plans to change propulsion system ratio

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Chapter 2

Challenges to the deployment of electric bus fleets

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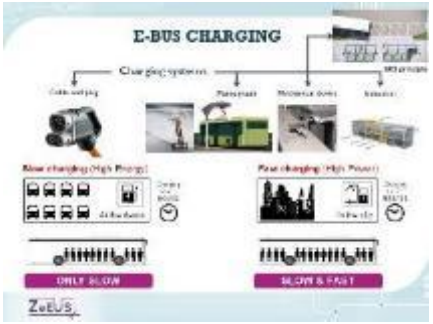
5 challenges to address for eBus deployment in Europe

High up-front costs

More challenging operation

New ways to procure:

- Vehicles & Equipments
- Operation services



Standardisation / Interoperability

Reinforcing cooperation energy/bus

TOP Challenge 1

High up-front cost

E-bus = 2 x the price of a conventional bus

- Battery=45% cost
- Lifetime is a key (battery, body)
- Disposal of batteries

Charging infrastructure cost and deployment

- Fast charging infrastructure
- Or…more buses (spare)

Local Depreciation rules

Very local TCO models

- Different maintenance cost

TOP Challenge 2

Challenging operation

Service Design according to today's reliability of the technology

- Trade-off = flexibility vs autonomy

E-bus performance = conventional bus performance?

- **A good analysis of the operational needs is key**
- Define the right type of eBus solution for the operational needs
- Influence of driving style
- Influence of on-board auxiliaries

A chosen technology performs well **if** put in its "***best operational conditions***"

Source: EBSF Project (DG-R&I)
Study by VDV and *Prof. Dr. Ralph Pütz (Landshut University)*

Procurement & Contracts

New technology risk: prevention and management

Functions sharing between stakeholders

- Project governance including ALL actors
  - PTA, PTO, Industry, Grid Owner, Electricity Supplier, etc.
- clear definition of roles & responsibilities:
  - Who pays? Who owns rolling stock/infra?

Tender of a system (not only a vehicle)

- Modelling the tender evaluation criteria
- UITP Tender Structure document can be a basis

Service/operation provider contract length & extensions

- Equipment ownership: what happens at the end of a contract?
- Think about decommissioning of harmful components

Positive externalities

- Emissions linked to air quality
- Noise

TOP Challenge 4

Interoperability

Standardisation of charging infrastructure is key

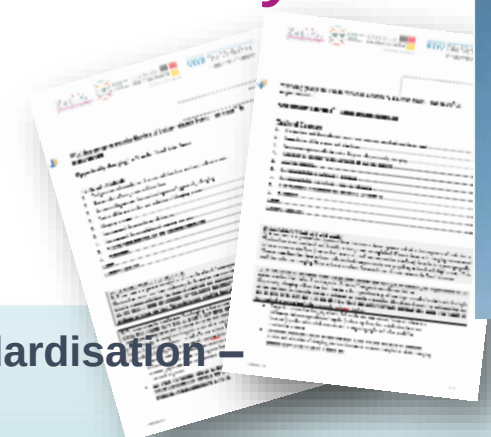
- Different implementations of the same charging philosophy

Slow charging / overnight

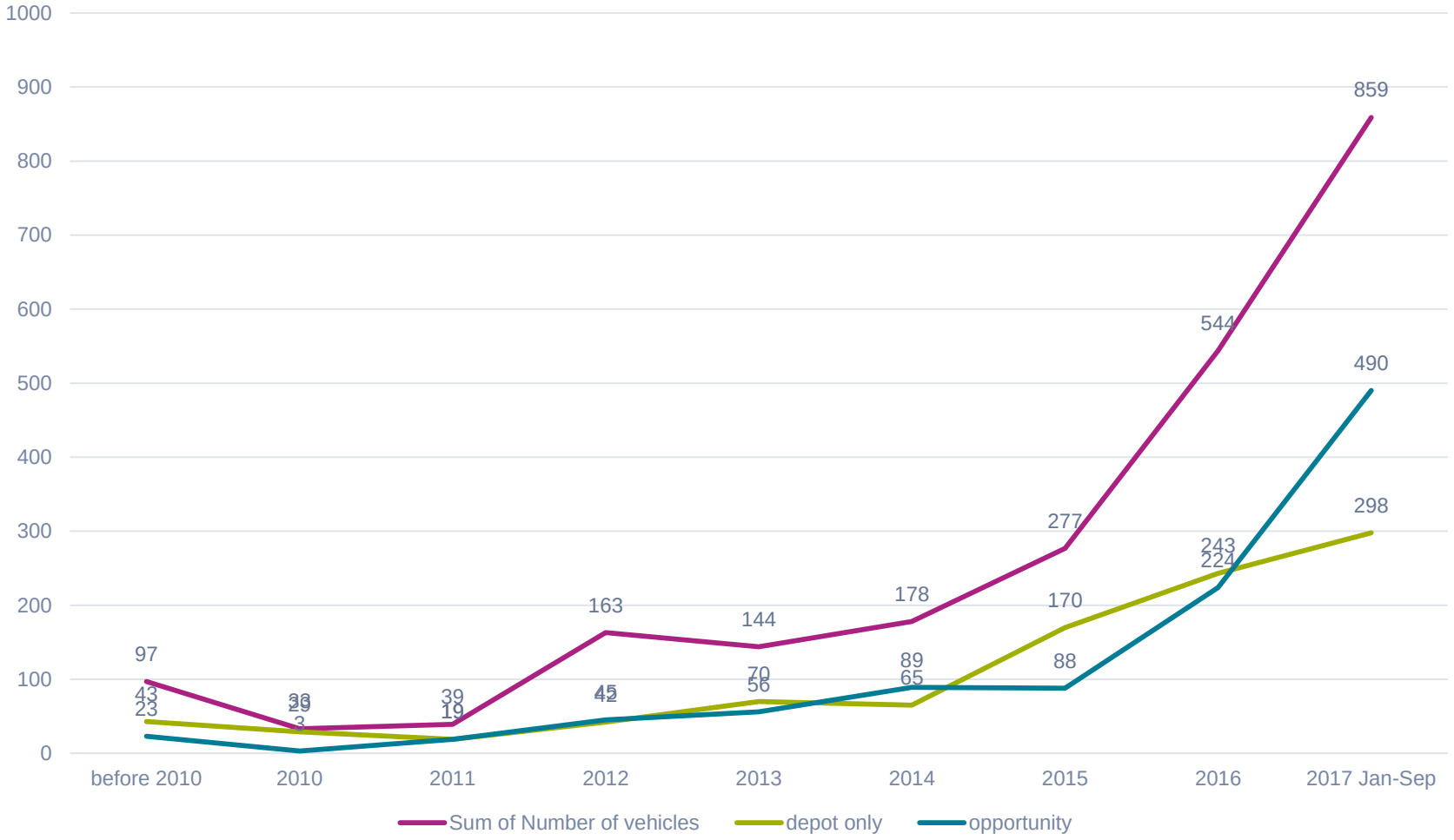
- CCS easy to be adopted
- Plug or same than opportunity

Fast charging / opportunity

- Many charging solutions
- Industry joint effort & interoperability agreements



Effect of effort towards interoperability



Energy sector: building trust & cooperation

Different market / service models in cities

Joint collaboration x optimal location of charging points

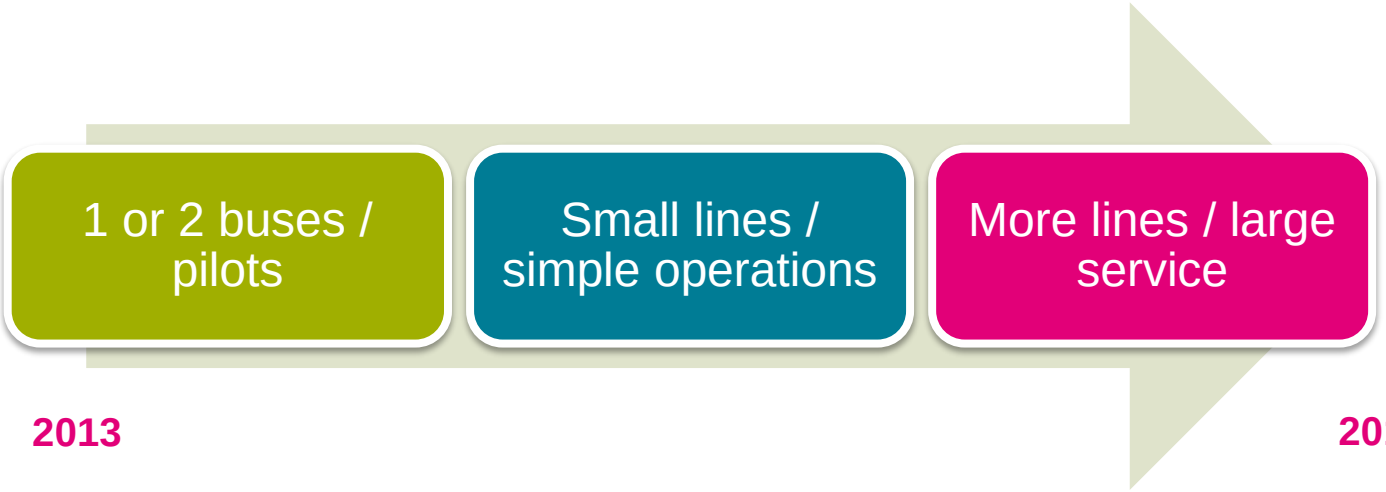
- Reduction of cabling
- Quality of the electricity distribution network

Electricity cost

- Urban vs industrial areas

Exploring opportunities

- Smart charging
- Use of PT power network (trams, metro)



e-Bus Deployment Plan: Steps

BONN
6 full electric
12m Bozankaya

BARCELONA
2 full electric
12m Irizar
2 full electric
18m Solaris

LONDON
3 Plug-in hybrid
(Induction)
Alexander Dennis

EINDHOVEN
43 full electric
(Opportunity)
18m VDL

CAGLIARI
12m Battery-Trolley
4 Voosloh/VanHool
2 Solaris

PARIS
23 full electric
12m Bolloré

WARSAW
10 full electric
12m Solaris

PILSEN
2 full electric
12m Skoda

MUNSTER
5 full electric
12m VDL

STOCKHOLM
8 Plug-in hybrid
12m Volvo

High capacity buses

- 12 meters,
- articulated,
- double-deckers

Different e-type

- Plug-in Hybrid,
- Full-electric,
- Battery Trolleys

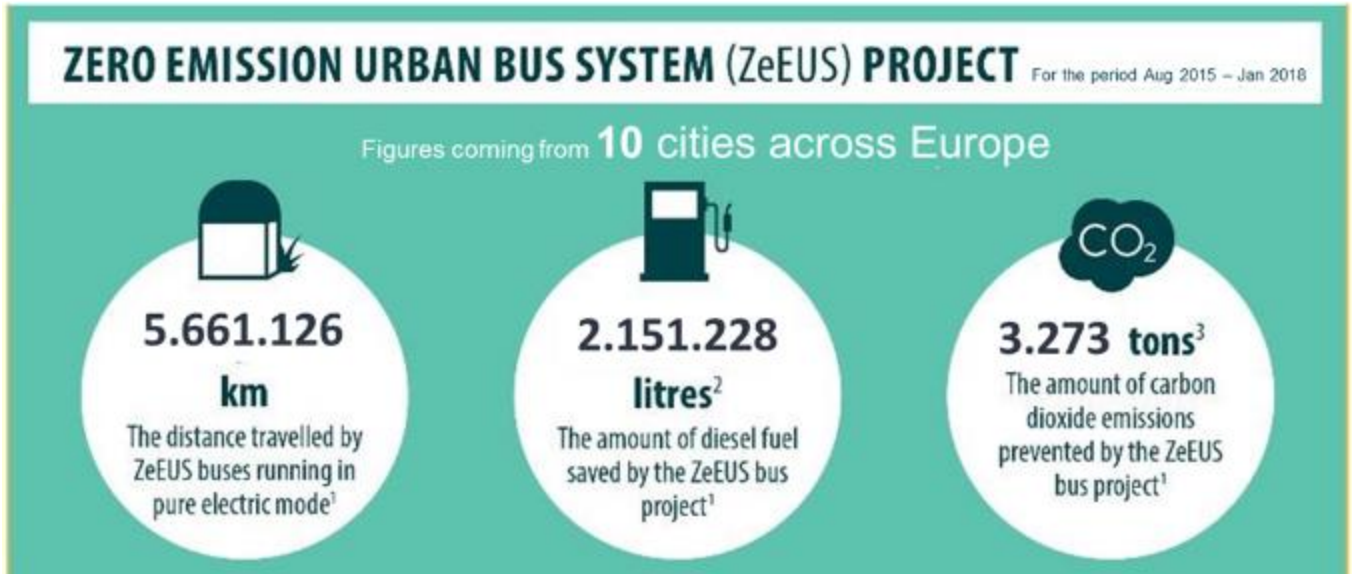
Energy supply

- Plug-in,
- Inductive
- Conductive (pantograph)
- Overhead (trolley)

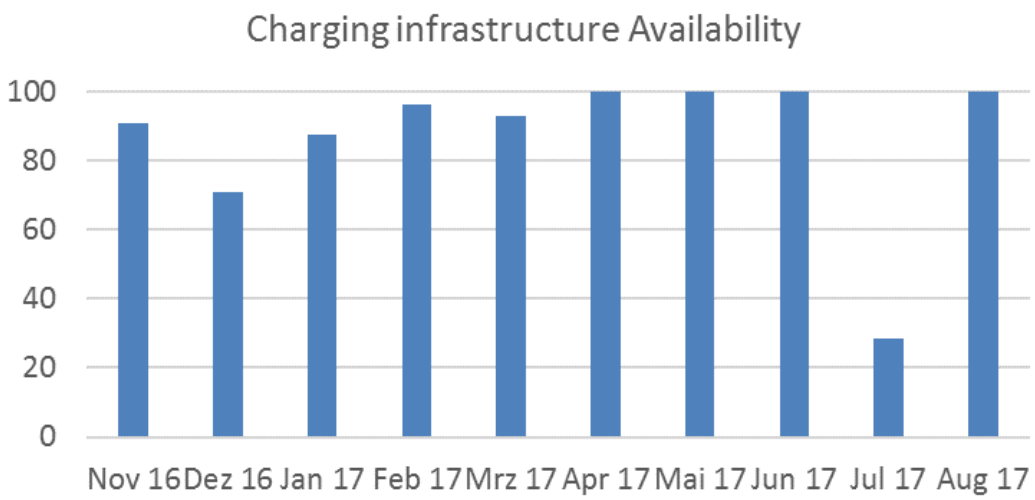
Fast and slow charging strategies

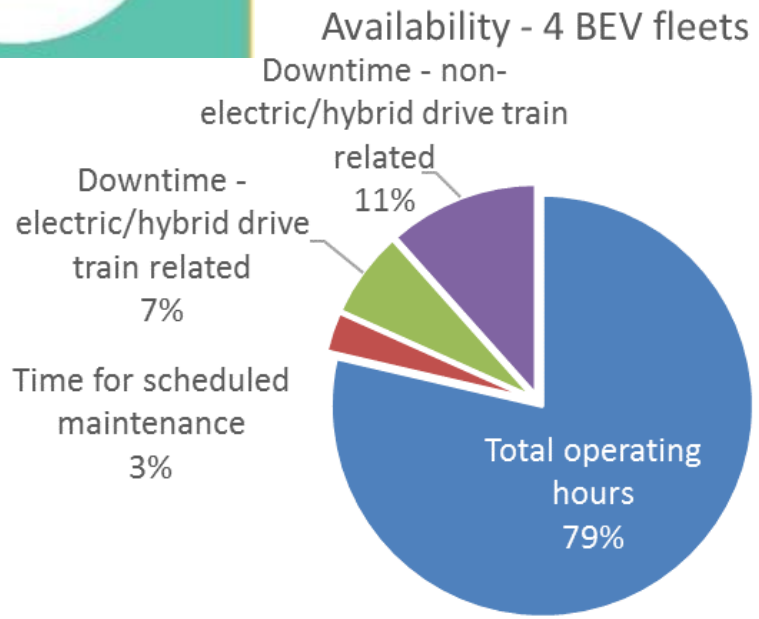
- Overnight (depot)
- Opportunity (terminals)
- On-route (trolley)

Growing Performances



ZeEUS
Zero Emission Urban Bus System





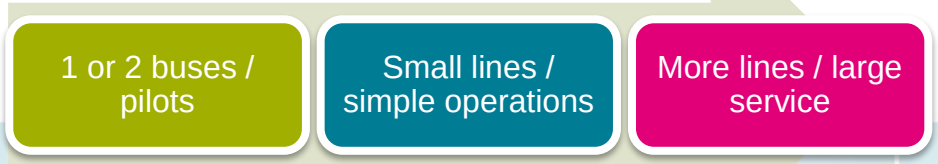
E-Bus Deployment Plan

Step 1: The “first steps”

Pilots: Basic Operations

- **Short route**: daily mileage load not too high.
- **Demands** on passenger's capacity low.
- **Energy consumption** not too high (no steep climbs, av. speed not too low).
- Enough **time to charge** the batteries in depot or at the terminal.
- There is the **back up** of conventional buses.

Not always necessary a system appoach, BUT more a *vehicle replacement* philosophy



E-Bus systems operating in Europe

ZeEUS eBus Report #2

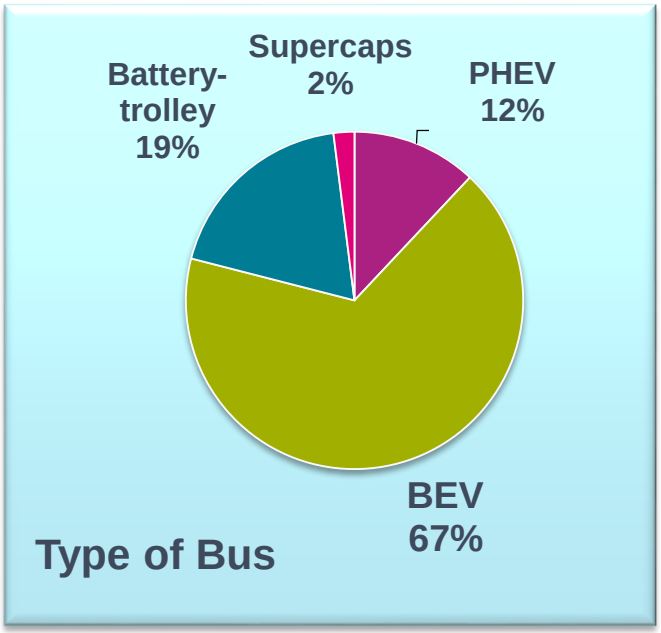
An updated overview of electric buses in Europe

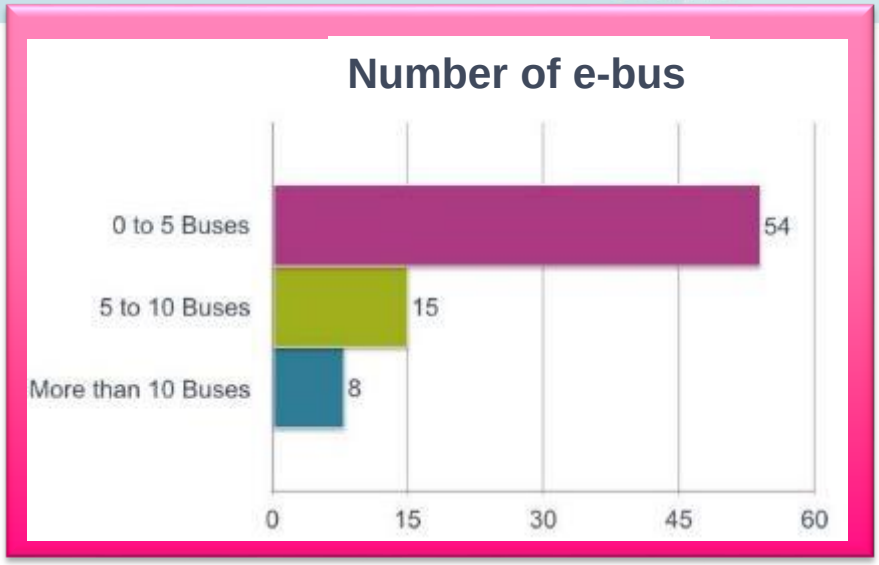
- 90 cities, over 800 vehicles and over 20 million km driven in pure electric mode
- 32 manufacturers
- 8 electric system suppliers

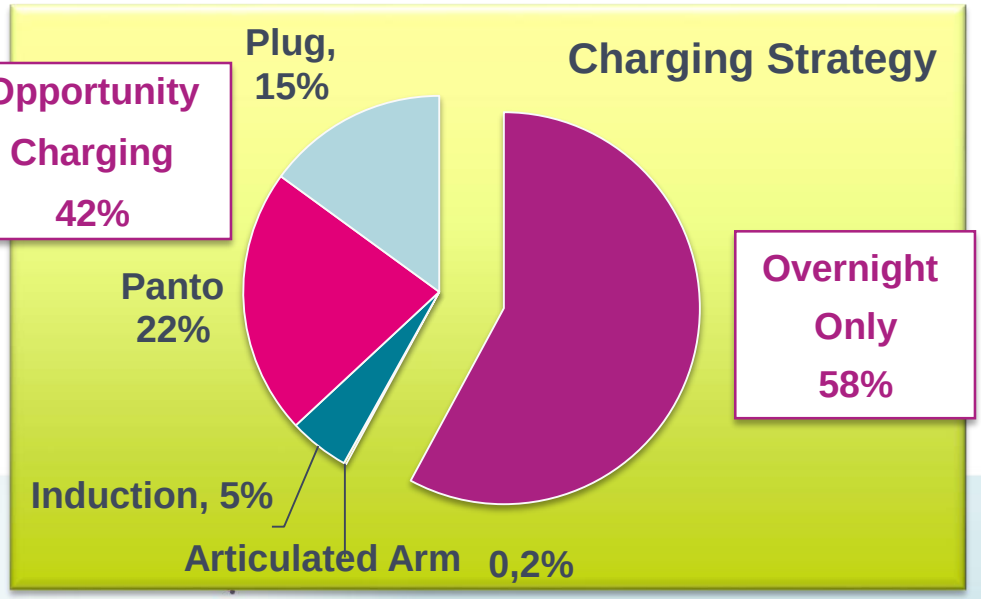
ZeEUS

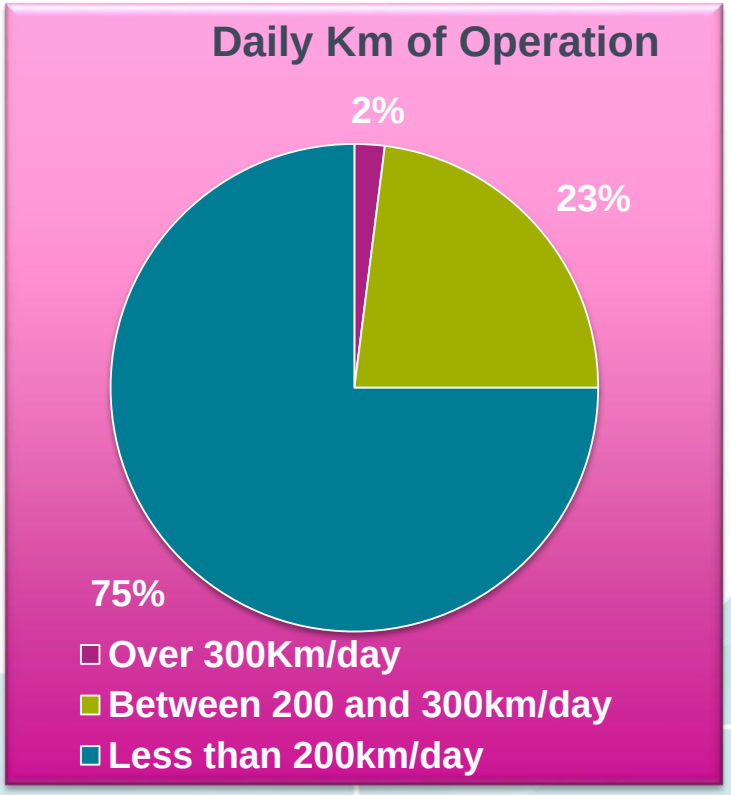
DOWNLOAD YOUR DIGITAL COPY AT:
www.zeeus.eu

ZeEUS Report









ZeEUS Follow-up: pilots

Bonn

- ZeEUS has provided valuable experience for shaping future approach.
- Persist in finding the optimum technical solution for balancing economic efficiency with environmental sustainability

Cagliari

- Results and lessons learnt will be used to improve several activities (vehicles' procurement, maintenance, etc.) and to design extensions of the trolleybus network in areas where the catenary is not available.
- In the following years (2018-2020), CTM will buy 10 full-electric buses.

Stockholm

- Focus on electrification in next inner city contract beginning 2022 or 2026
- Next step: study operational electrified solutions for suburban buses designed for highways.

E-Bus Deployment Plan

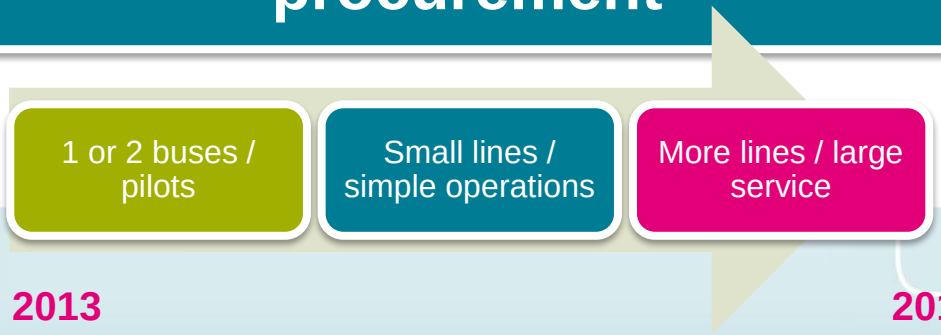
Step 2: Growing “line by line”

ZeEUS

Line(s): Simple operational conditions

- Selection of **more suitable line(s)** according to technical capabilities and operation requirements
- Early stage of new **urban strategy** for mobility and decarbonisation
- Early involvement of stakeholders from early planning stage: **joint feasibility studies**
- IT supporting fleet monitoring to optimise operation.

Paradigm shift: from vehicle procurement to system procurement



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ZeEUS Follow-up: Lines

Barcelona

- Electrify new lines with opportunity charging: “wait & see” overnight charging.
- In July 2018, TMB received 7 Irizar and Solaris 18m articulated e-buses with opportunity charging.
- In 2019, line H16 will be fully electric (with 22 buses) and TMB will begin electrifying another line.

Plzeň

- The strategy of public transport operator & authority in Pilsen is increasing the share of electric modes from 64% up to 85% till 2030, it means converting 3.2 mil. km annually from diesel to electric mode
- The clean transformation is based on using modern battery-hybrid trolleybus technology.
- The first stage is to purchase 33 standard and 14 articulated battery-hybrid trolleybuses

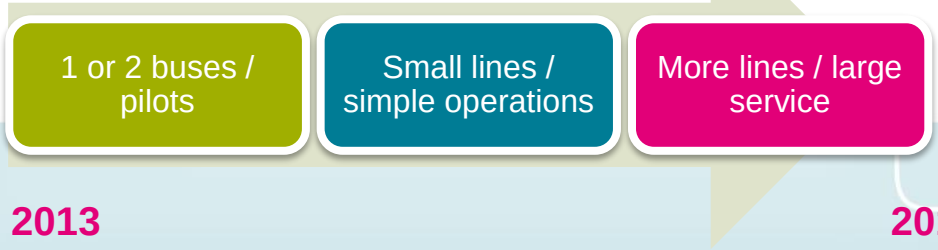
E-Bus Deployment Plan

Step 3: “BIG and Different”

Large scale operation

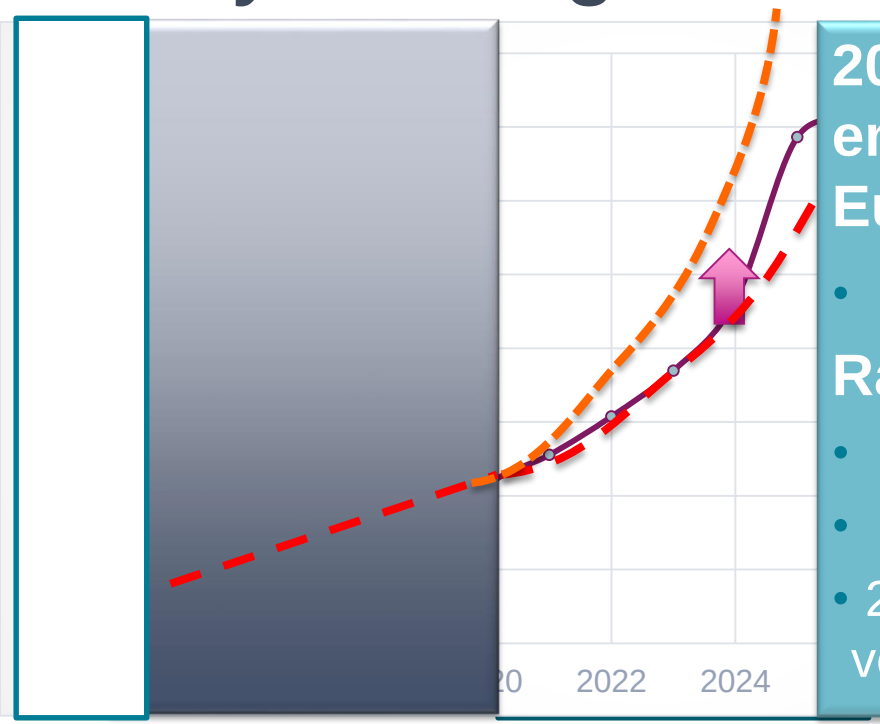
- **Replace a fleet** of conventional buses (no back up)
- Cover a **higher mileage** load on a daily basis
- The operation time is **20 h/day** or more (>300km)
- Need to transport a **high capacity** of passengers
- The time available for **charging** is limited.
- **Interoperability** is a must.

A new transport system to be deployed.



ZeEUS

Urban zero emission bus: European City Strategies



2015-2025 Strategies of zero emission bus deployment in European cities

- Data-set 43.000 buses

Rapid evolution in the last years

- 2014 – 2015 one / two test vehicles
- 2015 – 2016 first entirely electric bus-lines
- 2017 – subset of bus network (tens of vehicles)

Exercise done in 2015 –
Revision of forecast in 2017 shows higher grow-rate

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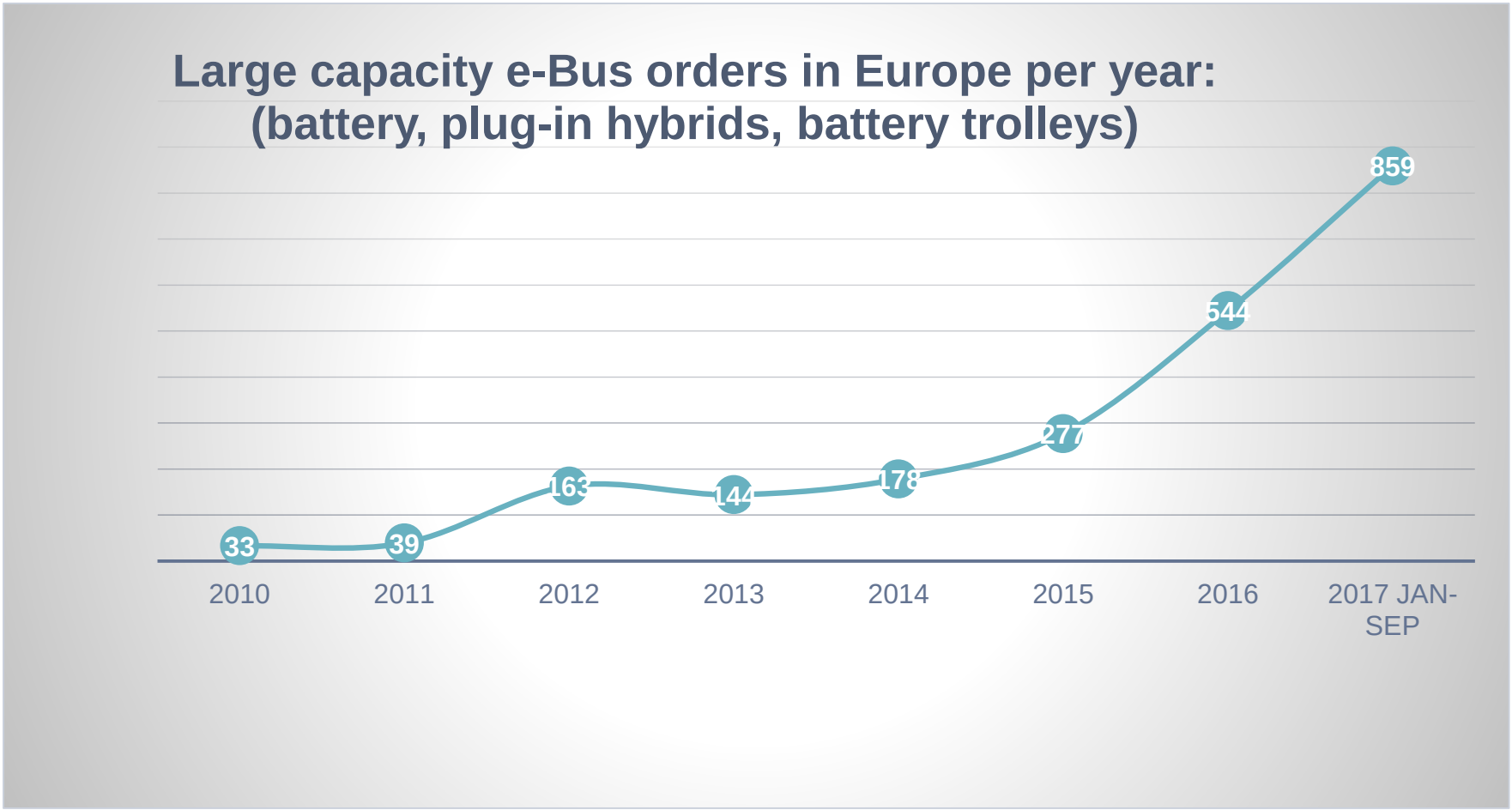
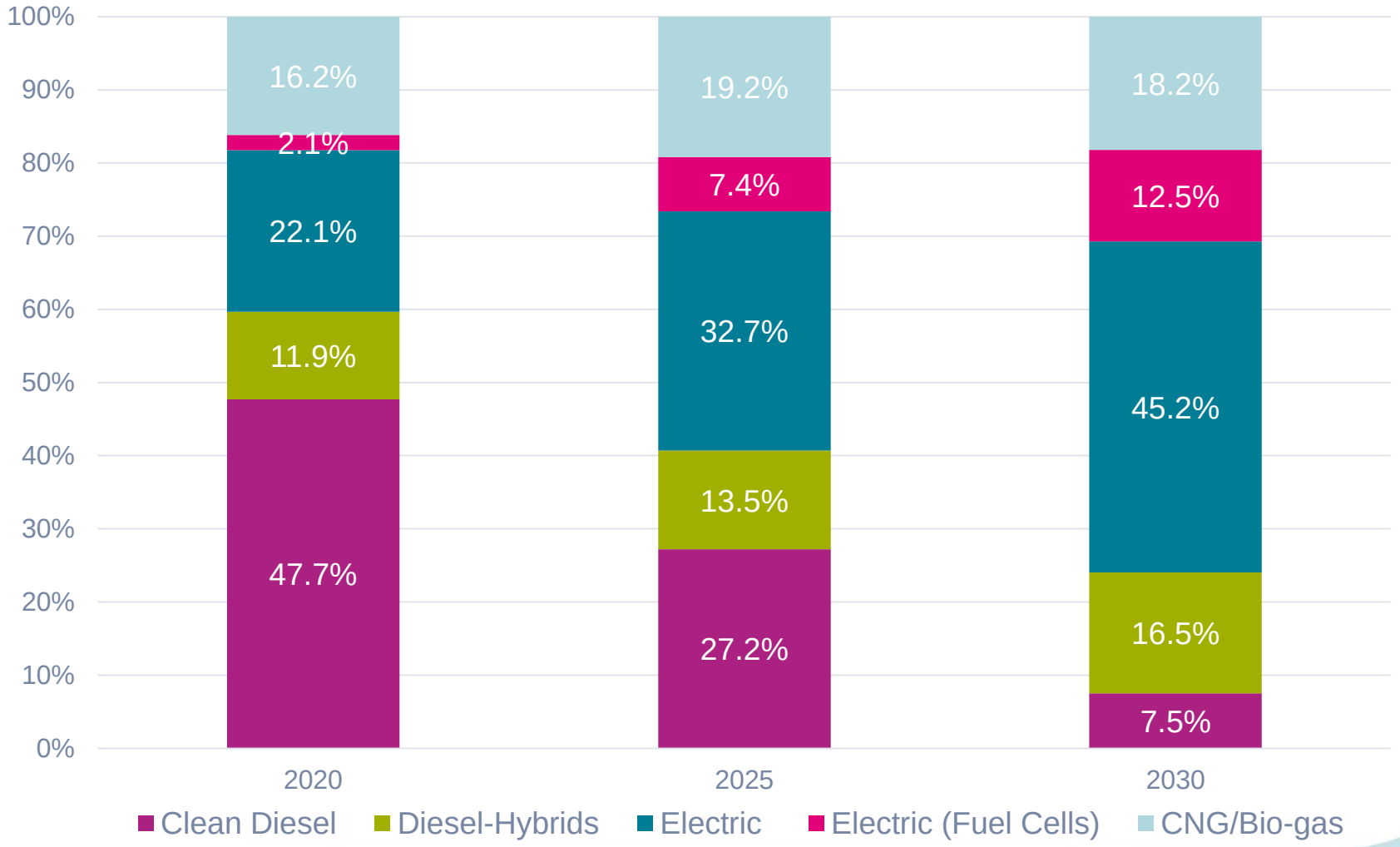
UITP ADVANCING PUBLIC TRANSPORT

Electric bus orders are growing fast!



Source: www.zeeus.eu - 2017

Industry view: market share projections



ZeEUS

Source: **www.zeeus.eu and UITP VEI Committee - 2017**

ZeEUS Follow-up: Large Fleets 1/3

Eindhoven

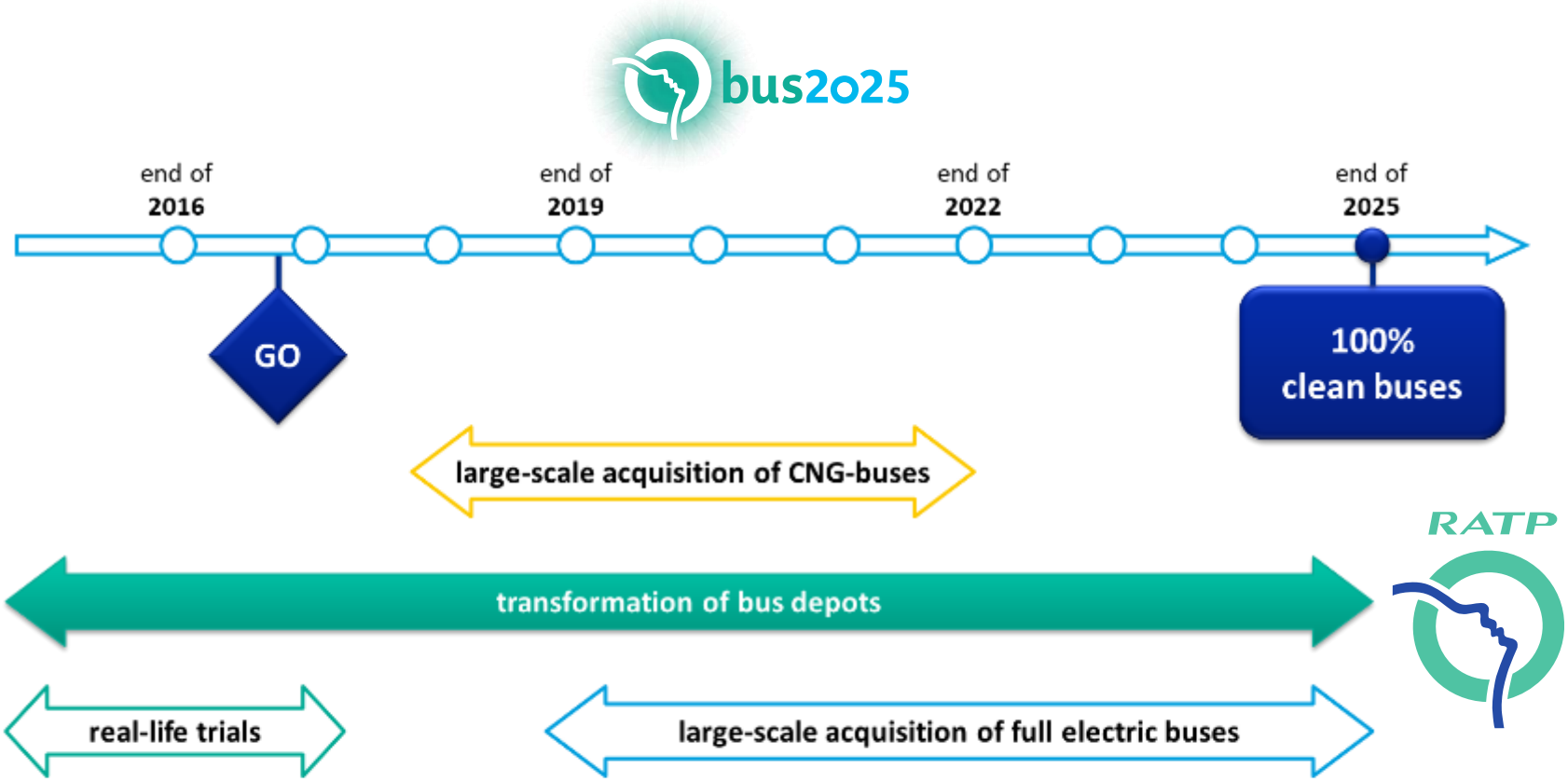
- Development of phase 2: adding the next 65 e-buses during the period 2019-2021
- Development of phase 3: adding of the next 65 e-buses during the period 2022-2024
- Upgrading the chargers and expanding charging facilities to further locations or other depots

London

- Moving from demo to widescale deployment; >120 e-buses by spring 2018, but – London's bus fleet is circa 9,500 vehicles
- Up to 300 ZE single deck buses by 2020; procure only ZE SD buses from 2020 & only ZE DD from 2025
- TfL is looking at how to supply electricity to all 79 bus garages in London and working to estimate the associated costs

ZeEUS Follow-up: Large fleets 2/3

Paris: From 75 to 3,000 e-buses



ZeEUS Follow-up: Large fleets 3/3

Münster

- Stadtwerke Münster will continue on the “zero emissions” path started with ZeEUS.
- 2 FCBs and 5 additional VDL BEBs will operate in Münster from 2018.
- Goal: 100 electric Buses (70% of the fleet) in operation for 2030

Warsaw

- In 2018 MZA will operate a total of 30 12-meter e-buses.
- Between 2019 and 2020, MZA intends to purchase further 130 articulated 18m e-buses
- In 2020 the Warsaw fleet will include 162 eBuses (12% of the entire fleet)

Large Operation and Orders in place

Recent Operations

- Schiphol (NL) 100 BEV
- London (UK) 73 BEV

Orders 2018

- Paris (F) 80 + 250 BEV
- London (UK) 68 DD BEV
- Manchester (UK) 105 BEV
- Milan (I) 34 BEV
- Trondheim (N) 35 BEV
- Rotterdam (NL) 55 BEV
- Messina (I) 13 BEV
- Umeå (S) 25 BEV
- Goteborg (S) 30 BEV
- Leiden (NL) 23 BEV
- Oslo (N) 57 BEV
- Berlin (D) 30 BEV

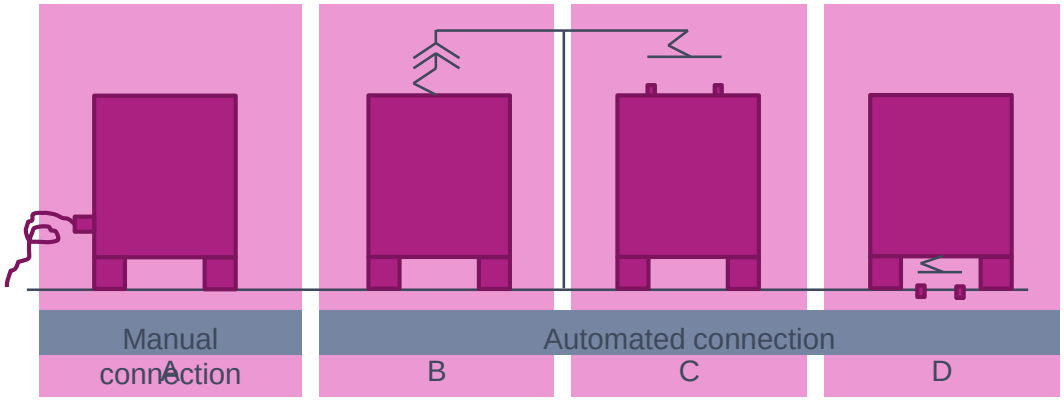
More and more cities in Europe are placing orders for Electric Buses

- Driven by National or Local Policies
- European legislative framework in definition for **Infrastructure** and **Procurement** (numbers)
- Financial support by Europe only for **large projects**
- Most of financement comes from **local Governments**

ZeEUS

Support to e-Bus Deployment

European Standards for harging



Charging options	Manual connection	Automatic connection		
	A (connector)	B (roof mounted pantograph)	C (infrastructure mounted pantograph)	D (under floor mounted ACD)
Communication	ISO 15118-2 Ed1	ISO 15118-2 Ed2		
	ISO 15118-3		ISO 15118-8	
Electrical	IEC 61851-1 IEC 61851-21-2 IEC 61851-23			
	ISO 17409 Ed1	IEC 61851-23-1 ISO 17409 Ed2		
Mechanical	IEC 62196-3 Configuration FF	prEN50696 Configuration xx	prEN50696 Configuration yy	prEN50696 Configuration zz

Guidelines for Tenders, E-SORT, Design

AVAILABLE
E-SORT for battery and plug-in hybrids

COMING SOON
Measures with Auxiliaries

3rd Edition including tendering for e-buses released (Oct '18)

Design Principles for eBus as a new urban object

ZeEUS

A phased approach

Recommendations for e-bus deployment

4 Phases

Action lines to Support PT stakeholders to deploy eBuses

Joint Effort of Institutions Stakeholders Cities

IF

Know
Decide

WHEN

Plan
Regulate
Finance

WHAT

Specify
Procure
Deploy

HOW

Operate
Maintain

Knowledge, guidelines, tools, to support stakeholders

IF: Know & Decide

- Define a **global & integrated mobility vision**
  - SUMP
  - UITP AP «Connection people and places, Integrated Mobility Plans for Sustainable Cities » - April 2014
- Exchanges **experiences** and **knowledge**
  - ZeEUS report, site visits…
- **Feasibility study** with all stakeholders
  - Wide scope: risk, cost analyses…
- Define **own operational needs** from Clean Buses
  - assess **IF** eBuses are the right Clean Bus solution for the identified needs and decide
- Solve **trade offs** in **own scenario**
  - Passenger capacity vs. Battery weight
  - Driver/bus utilization vs. Charging time
  - Fast charging stations costs vs. Battery/spare bus cost

Start from the needs, not the solution

Strategy for Decarbonisation

- Global & integrated **mobility vision**
- Better **Quality of Life** through **high Quality of Service:**
  - **Cleaner Vehicles**
  - Accessibility for all
  - High commercial speed
  - PT Dedicated Infrastructure
  - Traffic & operations management
  - Efficient combined & shared mobility
  - Smart energy use in the PT System

Policies and strategies promoting Modal Shift

The **Bonn** vision to 2030: the complete conversion from diesel to e-buses

- Market exploration
- Feasibility study
- Fields tests
- Technical specifications
- Charging concept
- Operational concept

SWB Bus und Bahn

Complete conversion of all conventional diesel buses to full electric propulsion until 2030 by decision of the Executive Board

WHEN: Plan, Regulate, Finance

- Ensuring **support** from competent Authorities
  - Ask for **Urban policies** to get maximum advantage by using Clean (electric) Buses in the city
  - Possible use of **PT power network** for charging eBuses
- Analyse the different **legislation** impacting eBuses
  - Ex. emissions regulations, emission zones…
- Most suitable **funding & financing schemes**
  - European or national level
  - Ex. EIB, Structural funds, German funding programme, Green Funds scheme
- Set up **project governance**
  - Optimise the relation between PT, Energy and ITS in cities, with mutual convenience
  - Possible contribution of eBuses to smart-grid
  - Define best contractual conditions for energy provision
- Embrace **system approach**

Don’t rush, it is all about planning

Umberto Guida
UITP Director – Research & Innovation

umberto.guida@uitp.org