TRANSNATIONAL WORKSHOP

13 MAY 2020 // WEBINAR

Data-based planning of energy-efficient public transport services and infrastructure

EfficienCE

LOW-CARB

AGENDA

09:00	**WELCOME**
09:15	**INTRODUCTION** *Marlene Damerau, Rupprecht Consult* • Workshop Objectives • EfficienCE and LOW-CARB projects

Topic 1: DATA-BASED PLANNING OF ENERGY-EFFICIENT PUBLIC TRANSPORT SERVICES AND INFRASTRUCTURE

09:30	The value of data for the public transport sector *Hilia Boris Iglesia, UITP*
09:50	The "Leipzig Open Data Strategy" and the integrated urban data platform with application to a specific public transport development use case *Tilman Schenk and Sebastian Graetz, City of Leipzig (LOW-CARB & EfficienCE)*
10:10	Data-based mobility and PT planning in Szeged *Ádám Németh, SKZT (LOW-CARB) and Vilmos Bilicki, Uni of Szeged (UIA SASmob)*
10:30	Discussion, questions and wrap-up of topic 1
11:00	Coffee Break

Topic 2: HOW TO PLAN FOR ENERGY-EFFICIENT TROLLEYBUS INFRASTRUCTURE?

11:15	Project presentation: Trolley 2.0 *Wolfgang Backhaus, Rupprecht Consult*
11:30	Introduction to in-motion charging and the self-learning bus *Erik Lenz, Kiepe Electric*
11:50	Data-based trolleybus network planning *Ádám Németh, SZKT, Szeged (LOW-CARB)*
12:05	Digital "twinning"– a method for trolleybus data collection and analysis for better planning *Jan Röhl, Kruch*
12:20	Teaser: How to decide on vehicle technology infrastructure for local investments in Budapest (e-bus or trolley)? *Balázs Fejes, BKK, Budapest (EfficienCE)*
12:25	Teaser: Why Pilsen decided to widen the trolleybus network *Jiří Kohout, PMDP, Pilsen (EfficienCE)*
12:30	Discussion, questions and wrap-up of topic 2
13:00	Closing remarks and feedback options

This webinar is part of a series of events in the LOW-CARB Follower City Programme. To become a Follower City, please contact s.govender@rupprecht-consult.eu

THE CO-ORDINATION TEAM

Marlene Damerau

Wolfgang Backhaus

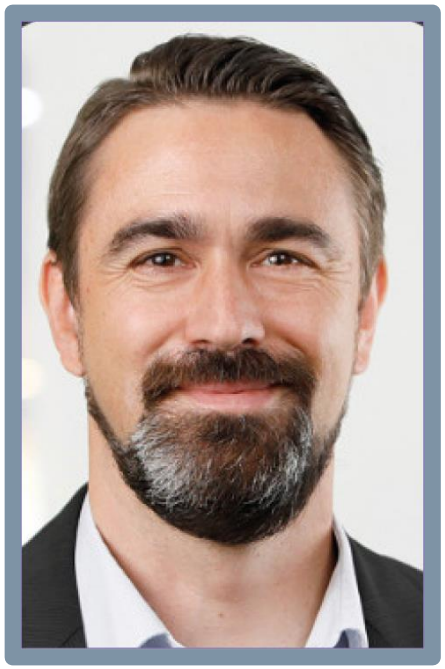
Video & Poll manager:
Saydrina Govender

Question manager:
Ana-Maria Baston

Technology manager:
Wolfram Buchta

Your Moderators

Your Techies



Wolfgang Backhaus

Rupprecht Consult

Trolley 2.0 Project Presentation

trolley:2.0 for smart cities

Electric Mobility Europe

European Commission

Webinar: Data-based planning of energy-efficient public transport services and infrastructure

Topic 2: How to plan for energy-efficient trolleybus infrastructure

Wolfgang Backhaus, Rupprecht Consult / trolley:motion

May 202

Interreg CENTRAL EUROPE European Union European Regional Development Fund

EfficienCE

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LOW-CARB

trolley:2.0 for smart cities

Electric Mobility Europe

European Commission

In a nutshell:

- **Partner:**
  - trolley:motion, Austria (Coordinator), AT
  - Barnim Bus Company mbH & Technical University of Dresden, DE
  - Evopro Group, Szegedi Közlekedési Kft. & University of Szeged, HU
  - Technical University of Delft & Power Research Electronics BV, NL
  - University of Gdansk, PL

- **Duration:** 04/18 – 09/20 (30 months)
- **Budget:** €2.887.580 - Funding: €1.958.590

Main goals

TROLLEY 2.0 aims

- to improve the efficiency of public transport based on **battery supported trolleybuses** (in-motion-charging concept; energy-efficient & economic)
- and to integrate **RES & new electro mobility services** based on a **smart trolley grid** as backbone for charging solutions in a smart city.

trolley:2.0 for smart cities

Electric Mobility Europe

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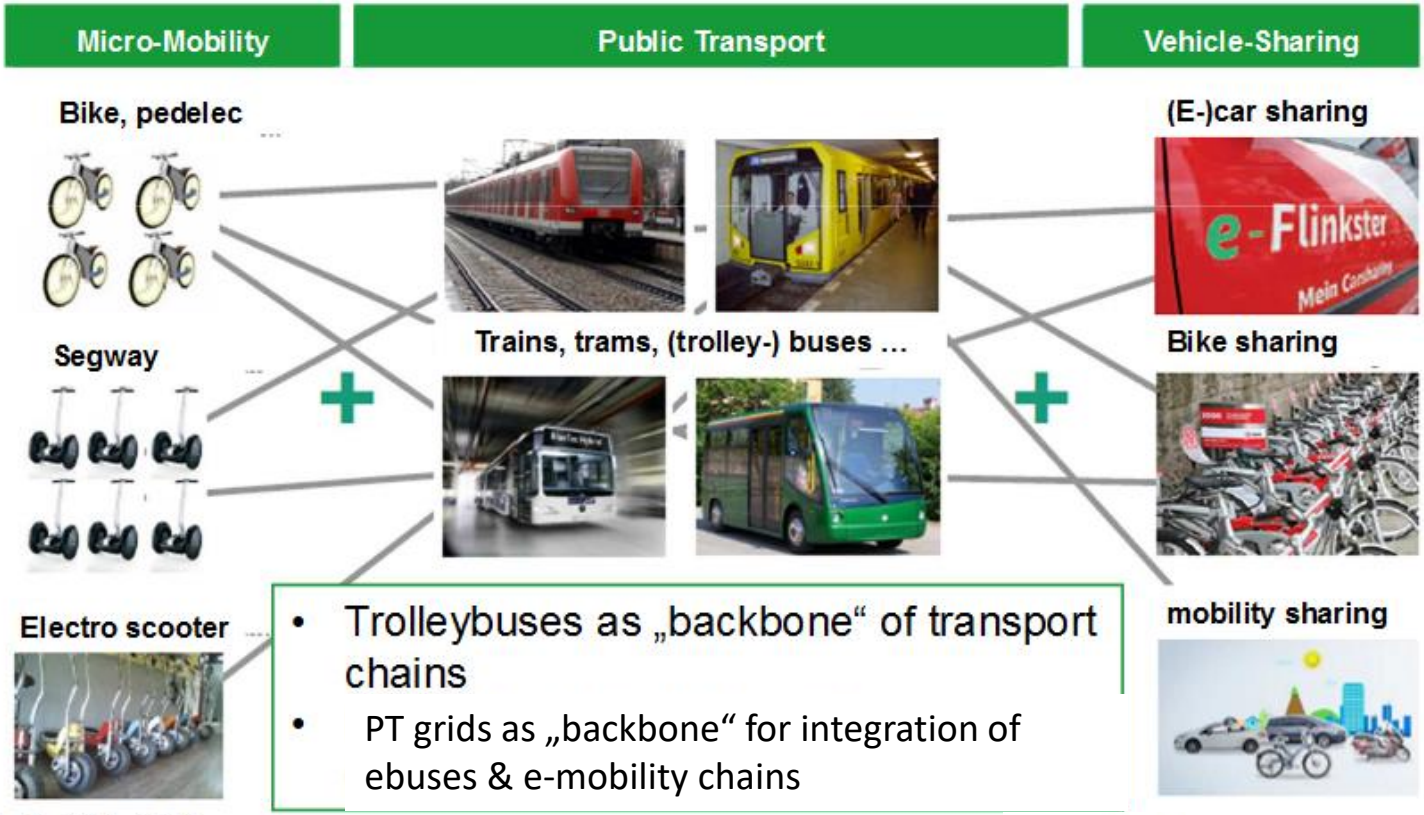
Electric public transport as a backbone of smart cities



Source: Spath, IAO, 2011

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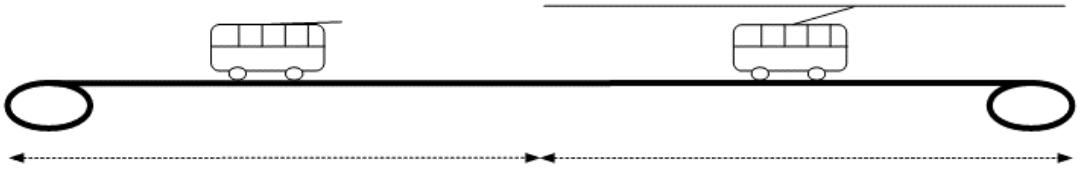
New in-motion charging concepts:
Eberswalde (regional), Szeged (feeder) & Gdynia (metropolitan)

2010 Conventional trolleybus → **2012- 2014** Battery mode feasability → **2016-2018** Demonstrations → **2018-2020** New battery trolley concepts → **2024.** Battery trolley regular operation

trolley · CiVITAS DYNAMO · ZeEUS (Zero Emission Urban Bus System) · eLIPTIC (electrification of public transport in cities) · trolley:2.0 for smart cities



Energy consumption	Length of off-wire distance	Discharging efficiency	Charging power	Time of ride in wire mode	Charging efficiency

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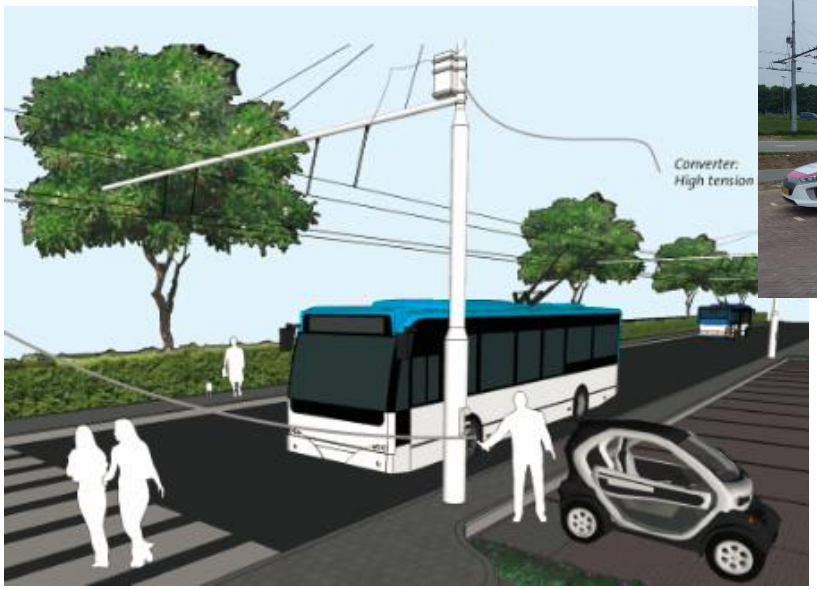
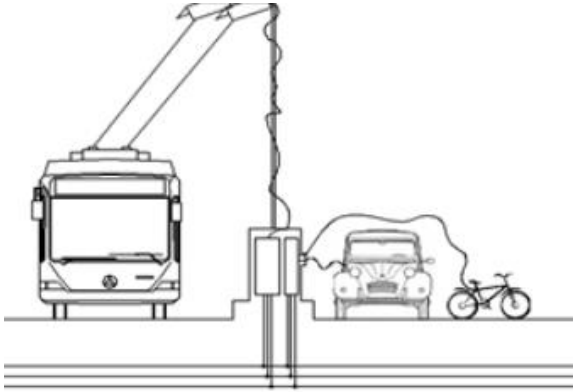
Multi-purpose trolley charging infrastructure in Arnhem, NL





http://www.omroepgelderland.nl/nieuws/2134955/Autorijden-op-energie-van-remmende-trolleybussen

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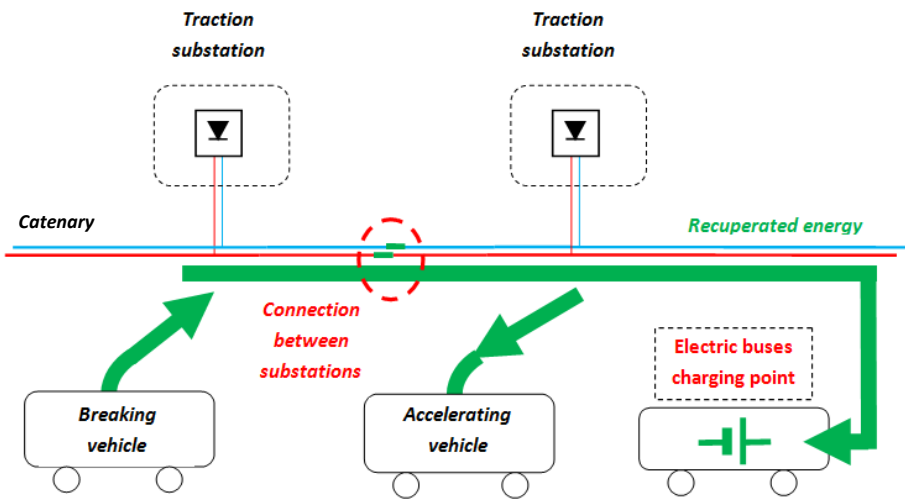
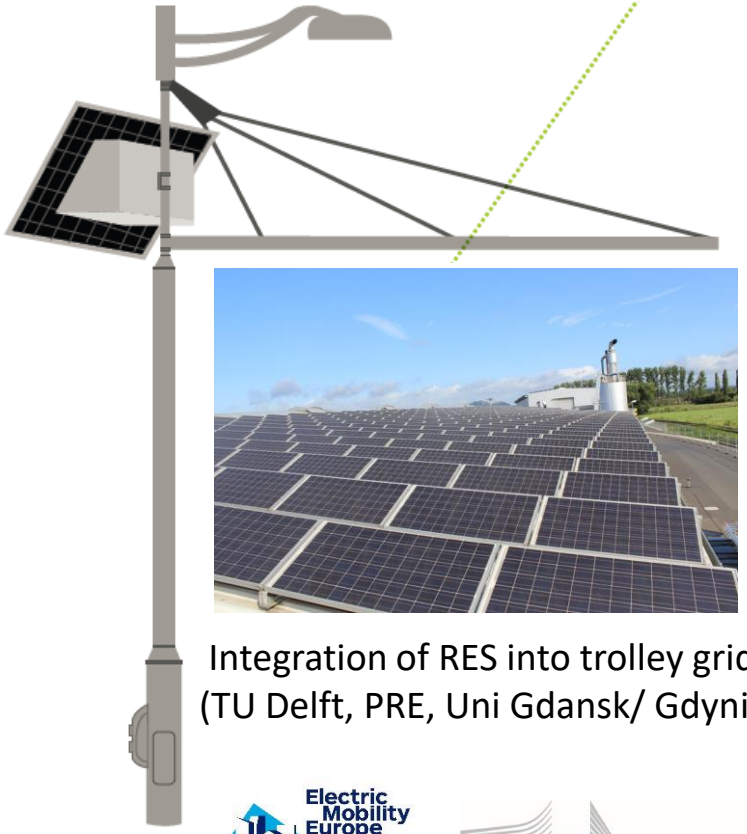
Smart trolley grids (physical and digital asset):



- Billateral energy supply & optimised usage of recuperation energy by balancing energy flow and levelling voltage drops & testing of energy storage concepts integrated into trolley grid / substations (incl. 2nd life batteries)



Integration of RES into trolley grids (TU Delft, PRE, Uni Gdansk/ Gdynia)

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Trolley 2.0 User Forum Members

- Salzburg AG, AT
- Stadtwerke Klagenfurt, AT
- Stadtwerke Solingen, DE
- Budapest BKV, HU
- BVG Berlin, DE
- Stadtwerke Marburg, DE
- PKT Gdynia, PL
- MPK Lublin, PL
- TLT Tychy, PL
- Municipality of Arnhem, NL
- Hordaland County Council, (Bergen) NO
- PMDP Pilsen, CZ
- Maribor City Council, SI
- TPER Bologna, IT
- OSY Athens, GR

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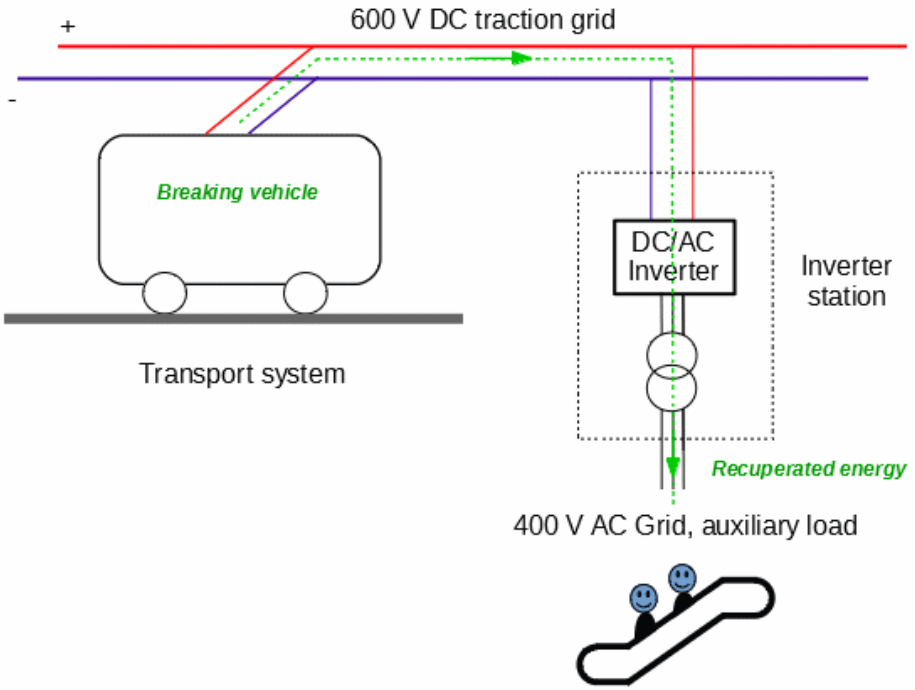
Innovations for smart trolley grids – Pilsen, CZ

On 1 April 2020, a buffer storage station was implemented to test

- regular operation (voltage level balancing)
- turn-off / power cut the supply from substation
- higher power consumption (charging battery trolley-buses, air-conditioning...)

Innovations for smart trolley grids – Gdynia, PL

Mini inverter station for Gdynia (PKT) for processing surplus energy from braking trolleybuses for the depot's own needs of 400V AC in the trolleybus depot.



Questions:

- What data is needed to plan for
  - electric bus systems?
  - zero-emission bus systems / integration/use of RES?
  - smart trolley grids?
  - in-motion charging systems?
- What are existing barriers for getting / analysing data?
- What tools / methodologies are available for processing of data (simulation/modeling)?
- …?

trolley:2.0 for smart cities

2020 CiViTAS

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Thank you for your attention!

Let's be smart together!

Wolfgang Backhaus

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2020 CiViTAS

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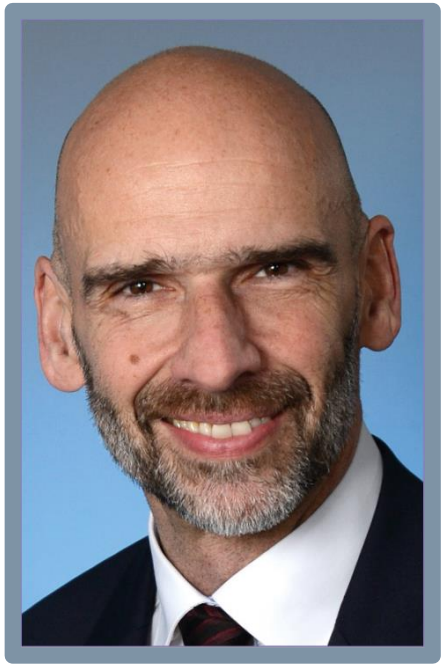


Erik Lenz
Kiepe Electric

Introduction to in-motion charging and the self-learning bus

KIEPE ELECTRIC

Webinar: “Introduction to in-motion charging and the self-learning bus”
Kiepe Electric: Reliable e-Mobility

Düsseldorf, 13.05.2020

Kiepe Electric – Focus on System Integration and Energy Management

KIEPEELECTRIC

Brief Description

- Worldwide recognized manufacturer of:
  - Electrical Systems for Rail Vehicles (Light Rail Vehicles, Underground Railways and Regional Trains)
  - Electrical Systems for Electric Buses (Trolley Buses, Diesel-Electric Buses. Fuel Cell Buses, Battery Buses)
  - Heating, Ventilation, Air Conditioning (HVAC) Systems for Rail Vehicles
- Service and Components for Industries
- Modular Systems – according to customers' and partners' particular requirements

Key Figures

- Employees: 749
- Production space: 8 766 m²
- Test facilities: 2 990 m²
  9 Test stations (DC & AC up to 1.4 MW)

Founding year

- 1906

Why Kiepe?

- High Quality - MADE IN GERMANY (Düsseldorf)
- System design optimized for lowest life time costs
- High reliability, focusing on generating income from passenger transportation
- Spare part availability over 20 years (in-house production)
- Focus on customer specific solutions
- Market leader in Western Europe and USA regarding IMC / Trolley Bus equipment
- Successful in electric bus business during over 66 consecutive years

Contact to end customer transport authorities:

- Own Kiepe marketing of high quality solutions
- Sales & services established in several locations
- Production facility in US
- Customer satisfaction shown by repeated orders
- Proven and in test field well tested equipment
- Capability of solving complex system problems

Growth through acquisitions – Electrification for Rail & Commercial Vehicle Systems supporting megatrend of Vehicle Efficiency and E-Mobility

KIEPEELECTRIC

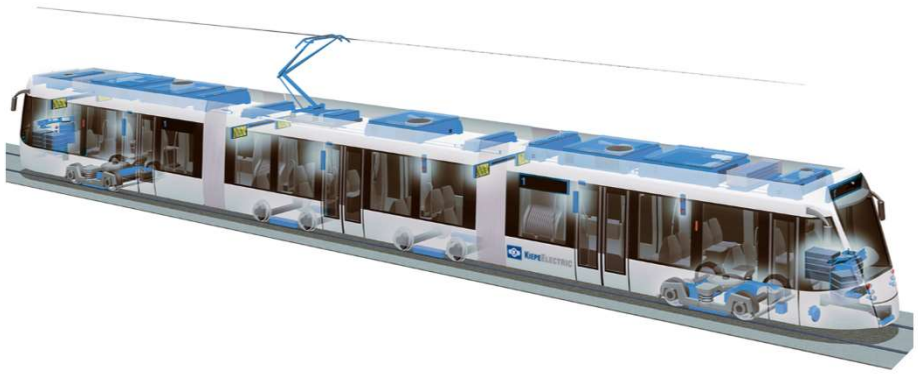
BRIEF DESCRIPTION

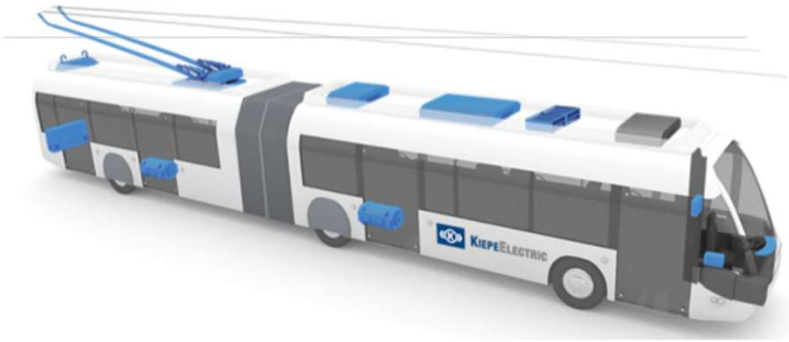
- Electrical Systems for Light Rail Vehicles, Underground Railways and Regional Trains
- Electrical Systems for Electric Buses
- Heating, Ventilation, Air Conditioning (HVAC) Systems

KEY FIGURES

Founding Year: 1906
Workforce: 749

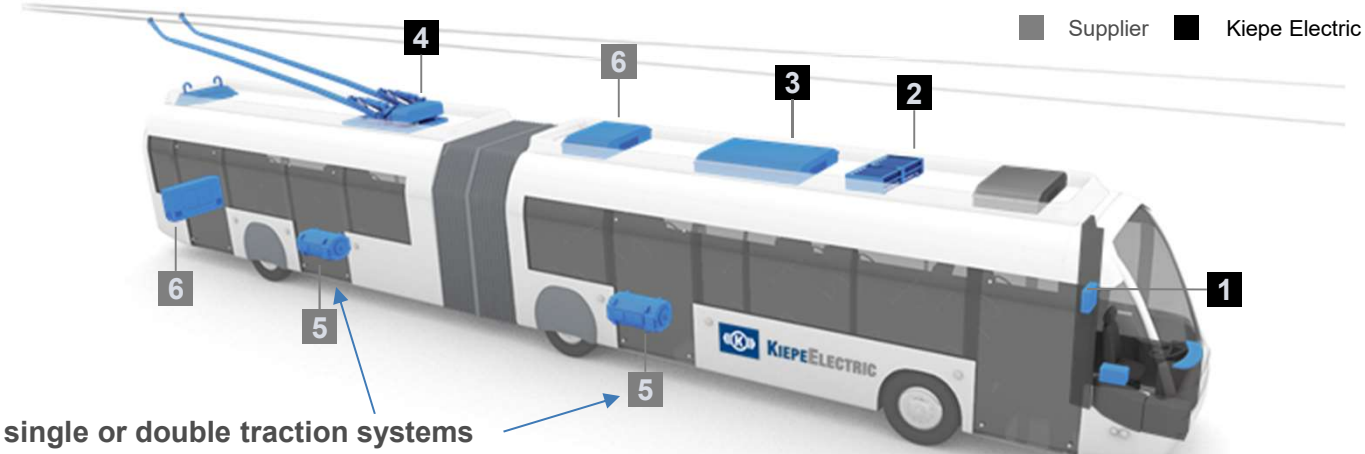
Rail Vehicle Scope





Commercail Vehicle Scope

Complete electrical systems for e.g. electric buses with In Motion Charging (IMC)



Supplier Kiepe Electric / Knorr Bremse Group

System Integrator

cabling
make it work reliable
optimize
homologation
long term availability

1 System Integration:
Energy Management,
Controlling Units, Diagnostics

2 Brake Resistor

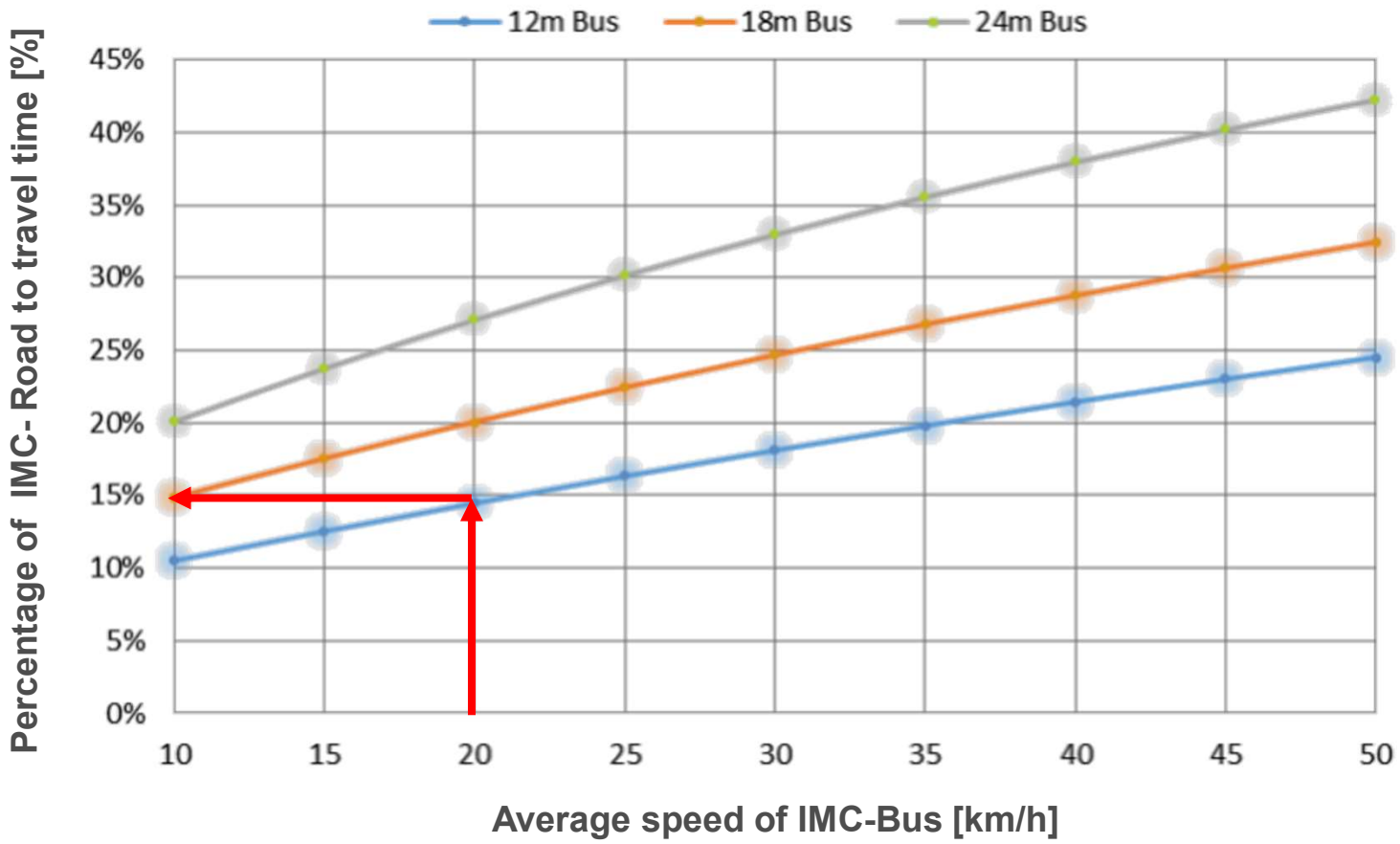
3 Power Electronics
(Traction and Auxiliary Inverter)

4 Current Collector
(or Pantograph, Connector)

5 Traction Motor

6 Traction Battery

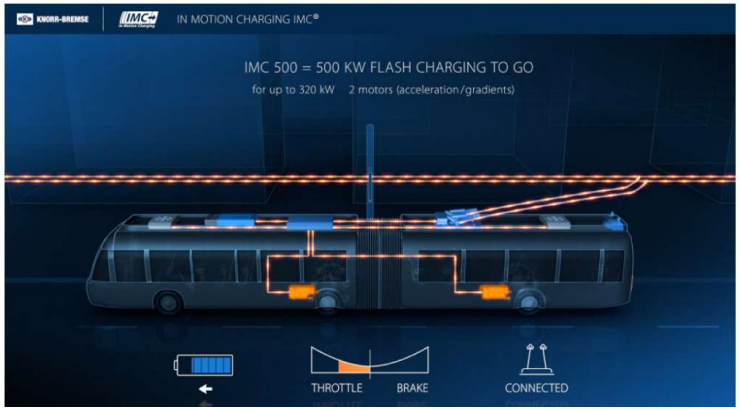
Time under overhead line: Bus size and speed



12m IMC Bus with 20km/h only needs 15% of the time in overhead line mode

What is In Motion Charging (IMC)?

Video on youtube „Kiepe IMC500“ see: https://www.youtube.com/watch?v=JEfC9Uz-XPc



IMC in combination with Opportunity Charing and Overnight

In Motion

Opportunity

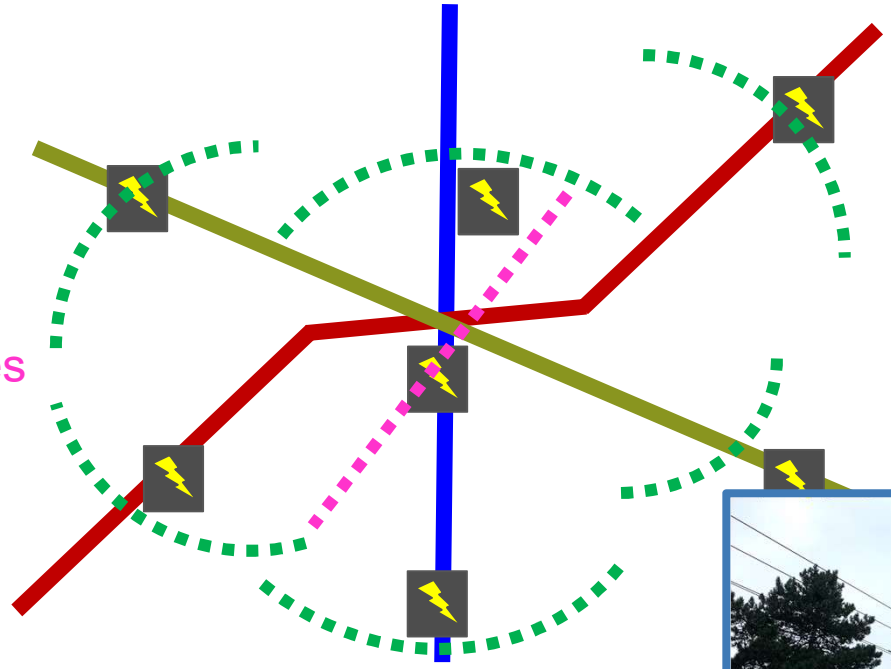
Overnight

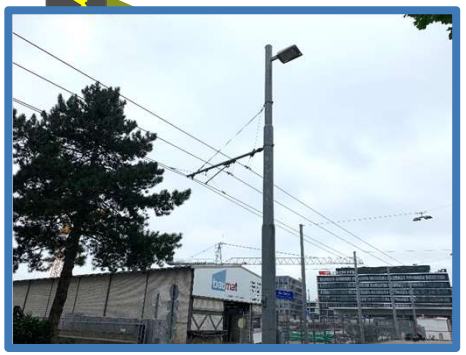
Extending e-mobility grid with existing resources
Combining In Motion Charging buses with trams

Existing LRV lines

With substations

Reusing LRV substations
With radial IMC lines
Or additional straight IMC lines





Re-use of existing
Substations
Masts / Poles?
Personal
- Electricians for infrastructure
- Electricians for rail vehicles

IMC lines as a complementation of existing rail grid

What is Smart Fleet-Charging Management (SFM)?

Video on youtube „Kiepe KFM“: https://www.youtube.com/watch?v=lwLeRqZzrIQ

and

Video on youtube „Kiepe SFM“: https://www.youtube.com/watch?v=ZHeO_dP17D4

SFM: Smart Fleet-Charging Management, improves reliability of line service

SFM Smart Fleet-Charging Management

Customer Benefits

Basic

- ☑ Collecting data (energy consumption, lines, charging times,..)

- ☑ Self learning energy consumption in dependence of daytime and season

- ☑ Signalization of charging status: Line service possible / with restriction possible / not possible

Advanced*

- ☑ AI: Situation dependent, predictive reduction of energy consumption

- ☑ AI: Smart Fleet Management (SFM) utilizing intelligent data cloud

- ☑ Charging time dependent energy consumption (e.g. different daytimes)

- ☑ Effective priorization of buses for robust line service

* Basic features included

Thank you

Erik Lenz
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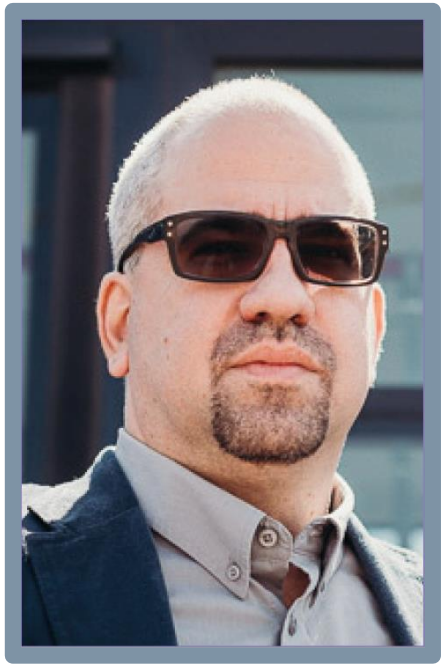


Ádám Németh

SZKT, Szeged (LOW-CARB)

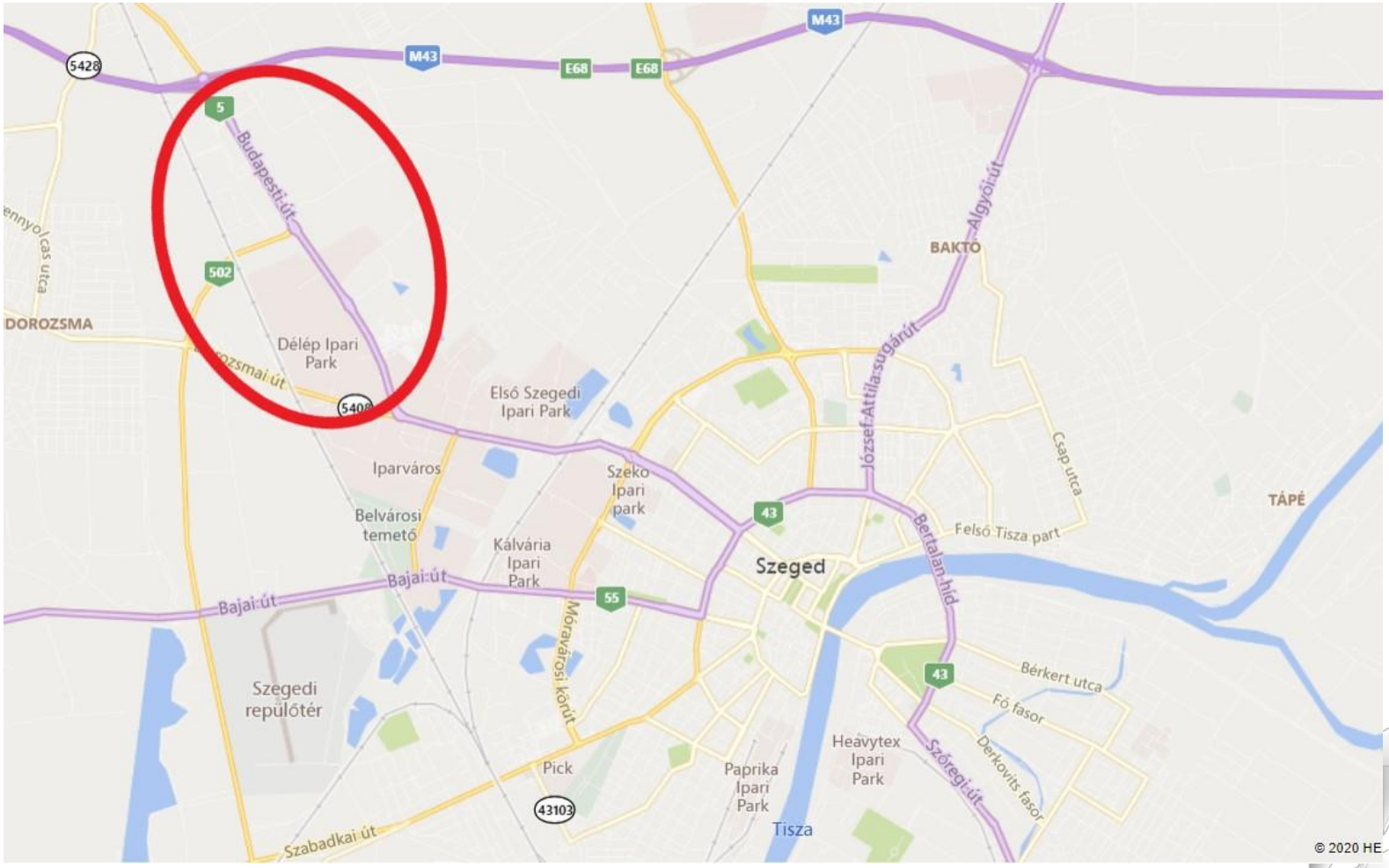
Data-based trolleybus network planning

Low-Carb and EfficienCE Transnational Workshop – 13 May 2020 Webinar

Data-based trolleybus network planning in Szeged

dr. Zoltán Ádám Németh – Szeged Transport Company – chief of public transport and railway safety

Szeged Functional Urban Area



Szeged Functional Urban Area

ACTION PLAN FOR COMPANY MOBILITY MANAGEMENT

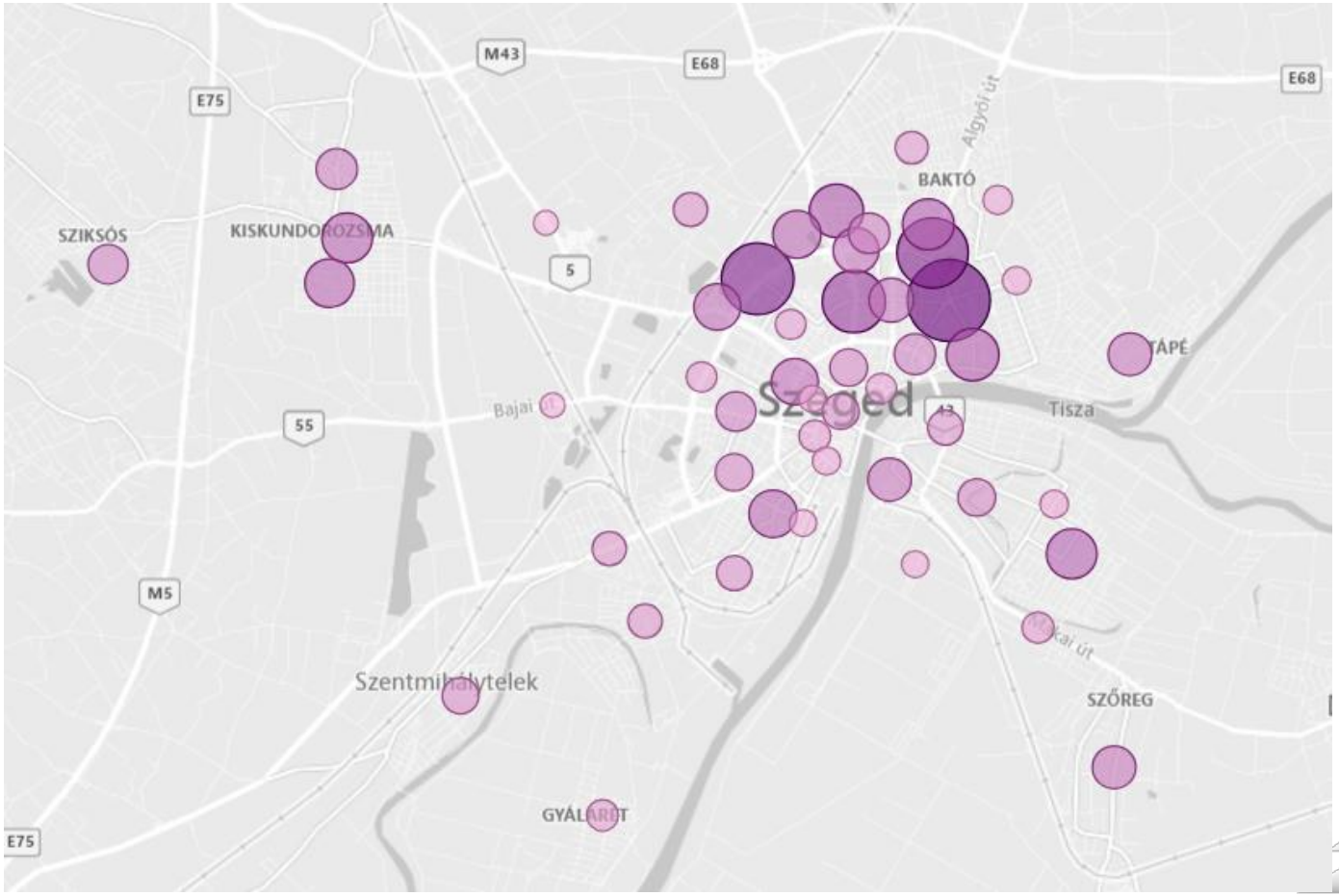
QUESTIONNAIRES:

- Paper based and online
- For employees and employers
- 23 companies
- 3007 employees in the FUA/area
- 1106 completed employee questionnaires

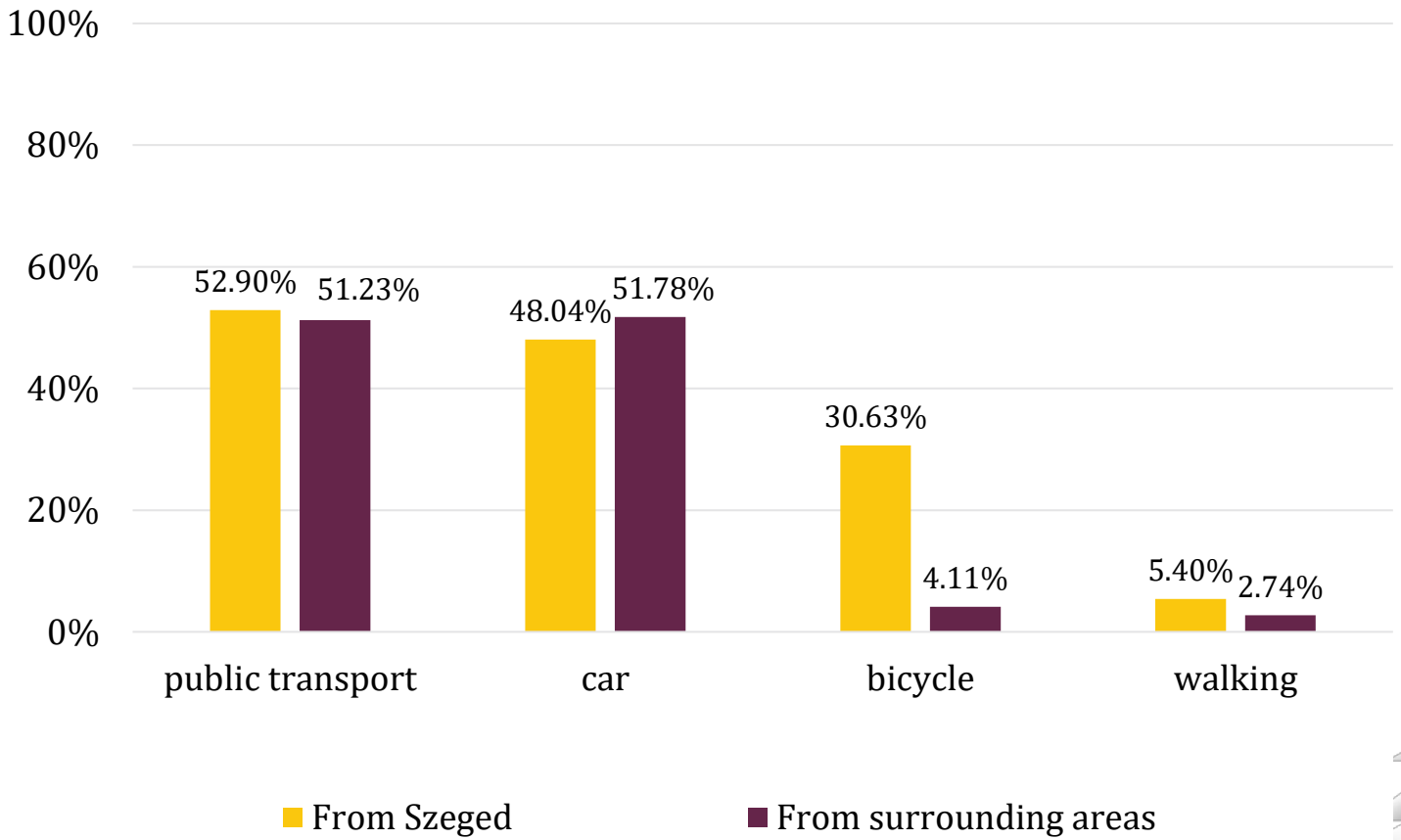
MAIN FINDINGS:

- 47% filling rate, 8 companies which have more than 60%
- Respondent 67% from Szeged, 33% from surrounding areas

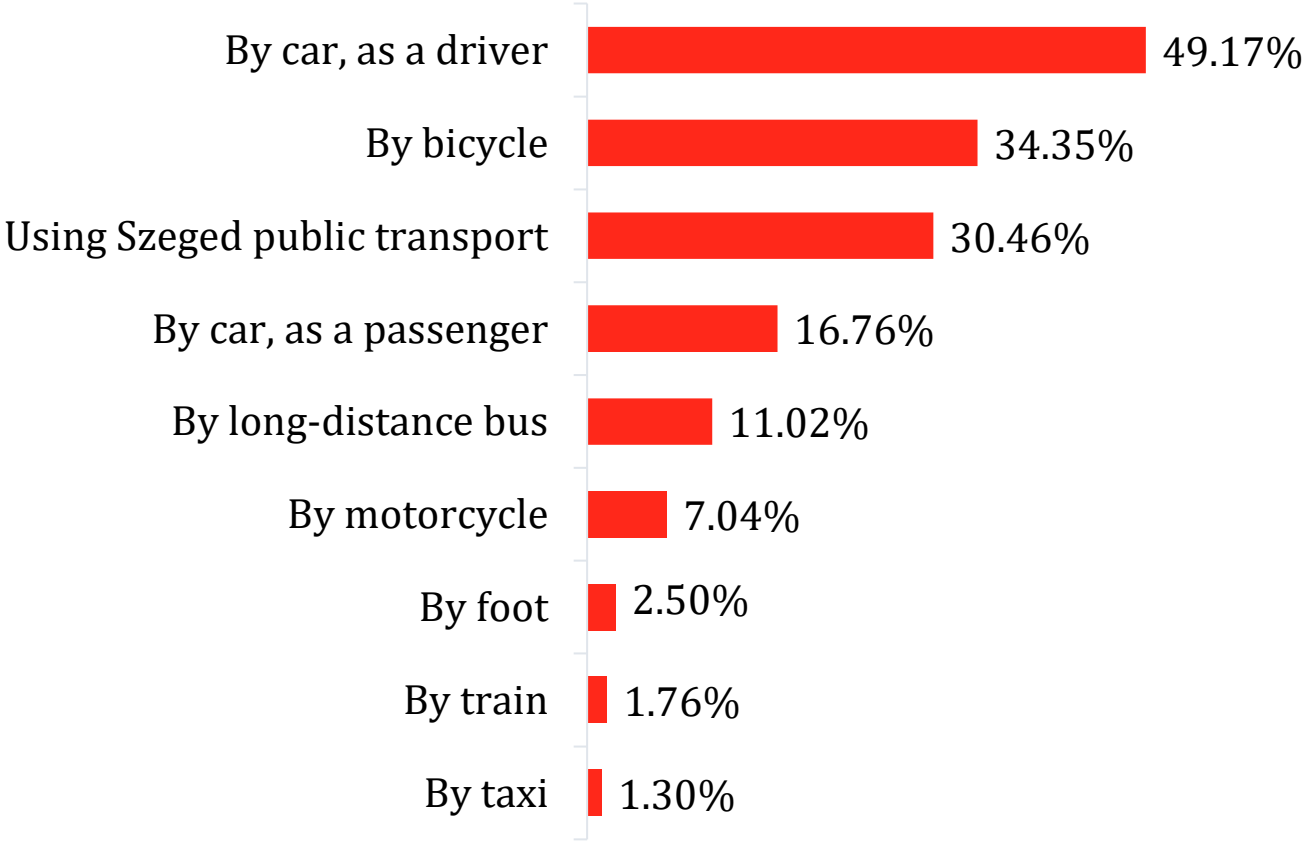
Place of departure of responders living in Szeged, by district



How Szeged and non-Szeged responders use means of transport to travel to work



Desired future means of transport



ACTION PLAN FOR COMPANY MOBILITY MANAGEMENT

- 1106 completed employee questionnaires: 67% from Szeged, 33% from surrounding areas
- respondents 53% physical worker, 47% intellectual worker
- 386 employee travel only with public transport: 61% from Szeged, 39% from surrounding areas

- 70% of physical worker using public transport
- 84% of physical worker from Szeged surrounding areas using public transport
- 61% of physical worker from Szeged using public transport

- 30% of intellectual worker using public transport
- 16% of intellectual worker from Szeged surrounding areas using public transport
- 38% of intellectual worker from Szeged using public transport

ACTION PLAN FOR COMPANY MOBILITY MANAGEMENT

MAIN FINDINGS OF THE SURVEY

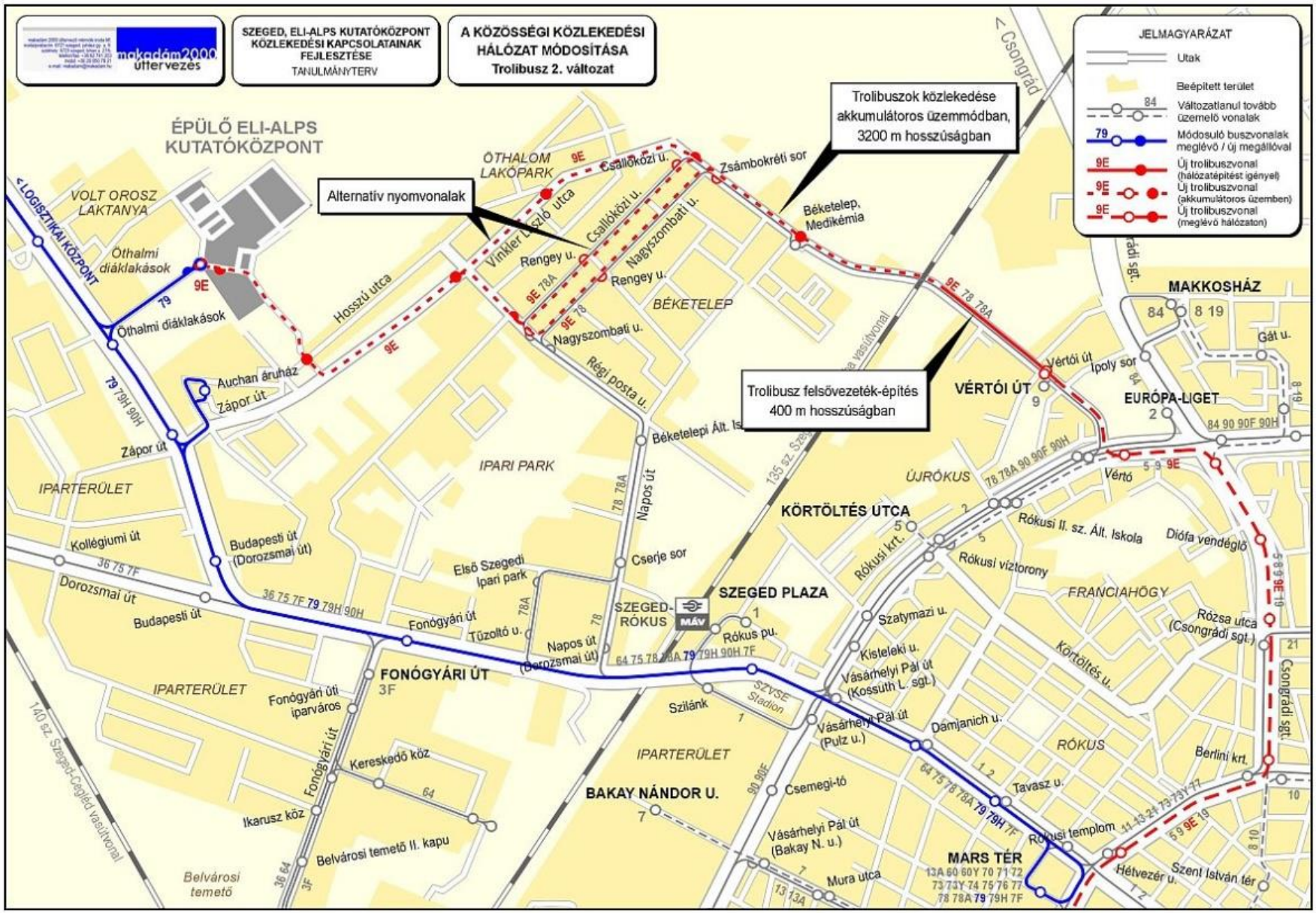
- Collaboration with all the companies (23 companies)
- 1100 employees gave their opinions
- Strong trust in the development of public transport and cycling
- Companies interested in the final results of the survey
- Different levels of cooperation → many of them do not trust in some projects
- We do not know the top manager's strategic view

MAIN GOALS AND MEASURES

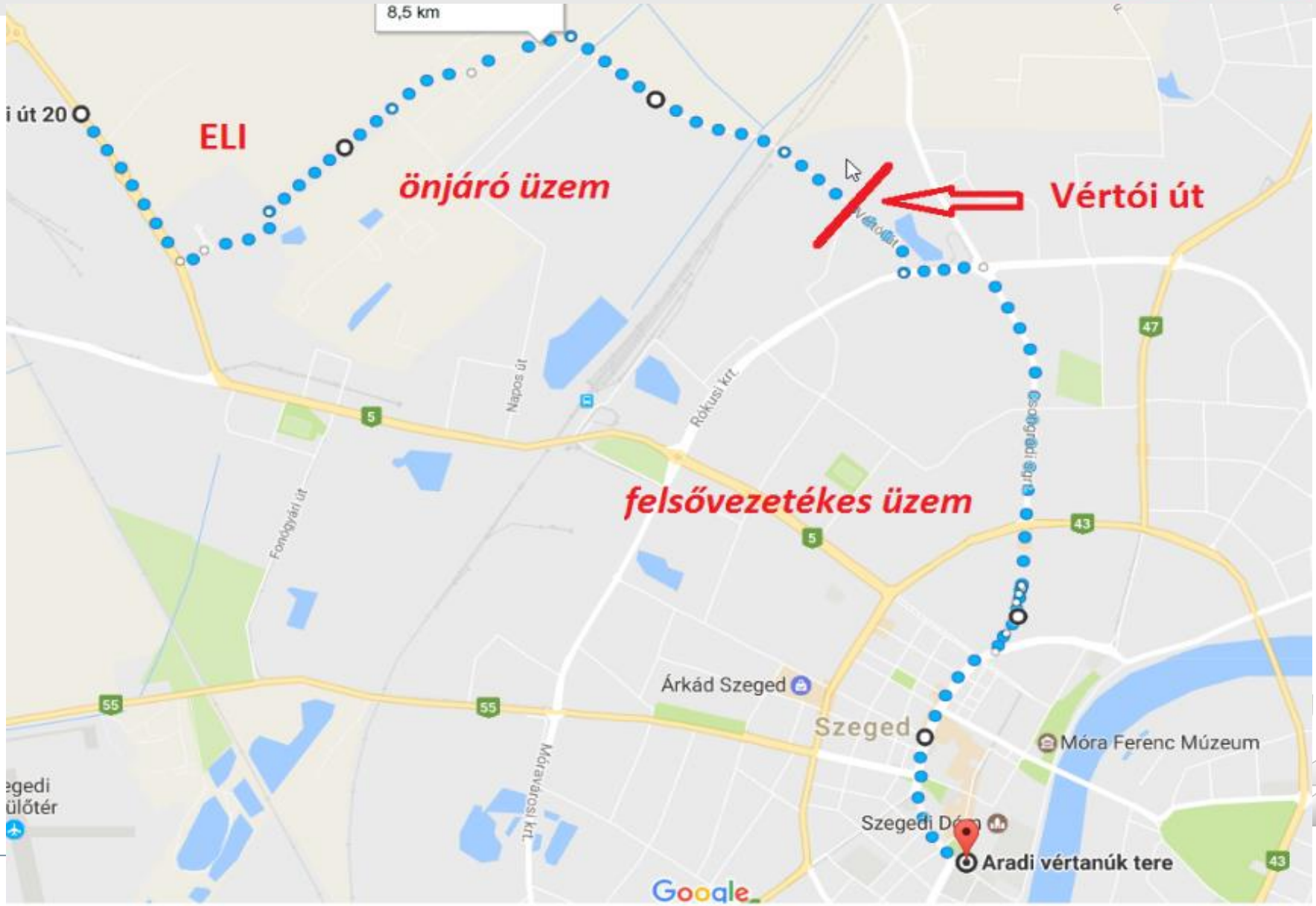
- **Develop public transport and cycle paths network based on the received data**
- Harmonize with Szeged SUMP - renewable and CO2 reduced energy source
- Sustainability and environmental awareness

POSSIBLE TROLLEYBUS NETWORK IN SZEGED FUA

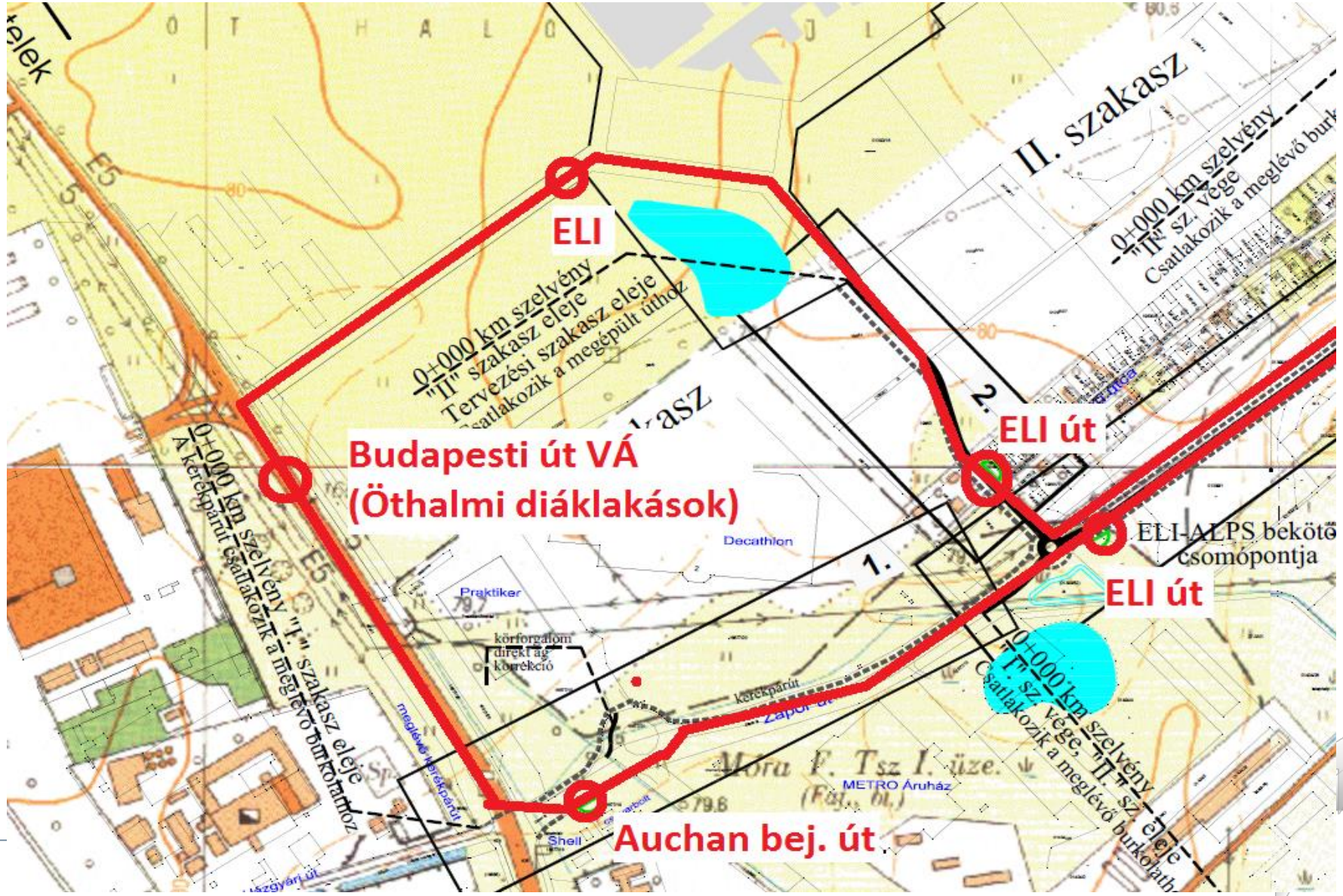
POSSIBLE TROLLEYBUS NETWORK IN SZEGED FUA



POSSIBLE TROLLEYBUS NETWORK IN SZEGED FUA



POSSIBLE TROLLEYBUS NETWORK IN SZEGED FUA

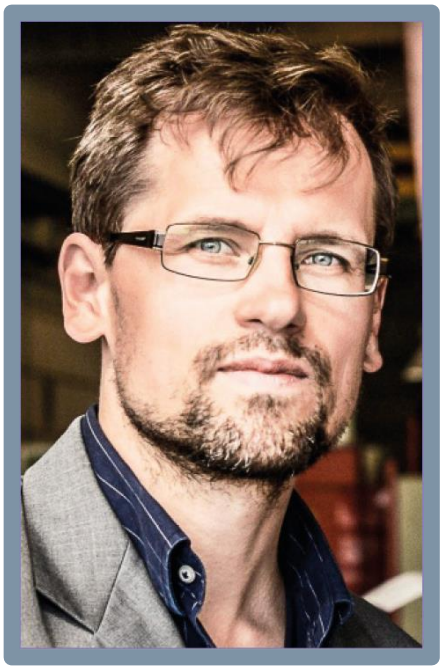


POSSIBLE TROLLEYBUS NETWORK IN SZEGED FUA

- battery hybrid trolleybuses
- in-motion charging
- new trolleybus line between the city centre and the industrial area
- direct connection with the most frequent areas (Rókus, Makkosház)
- half of the route without wire
- electric infrastructure development is necessary
- most environmentally friendly solution

Thank you for your attention!

Questions?



Jan Röhl
Kruch

Digital “twinning”- a method for trolleybus data collection and analysis for better planning

Jan Röhl

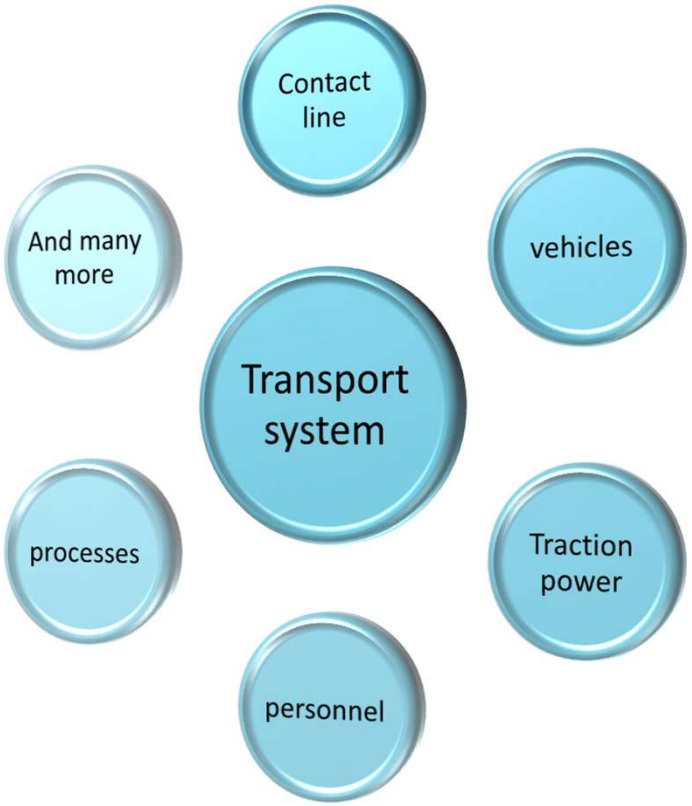
„Digital Twinning“ of transport networks

AUSTRIAN QUALITY since 1869

www.kruch.com

Status Quo
of transport data systems?

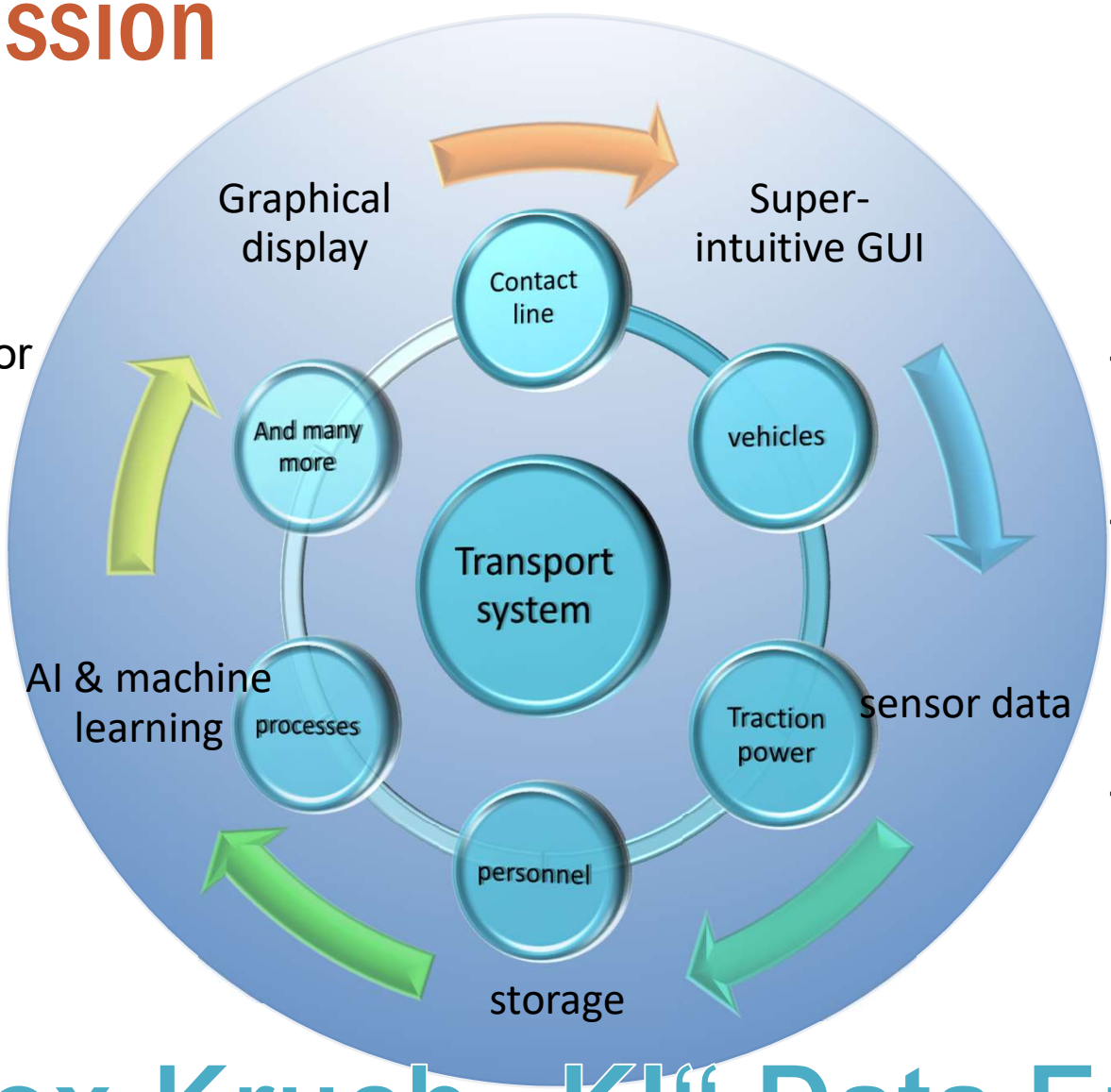
- Multiple solitair systems
- using their „own“ data
- Closed applications



- No synergistic effects
- Not using the full potential
- Not cost effective

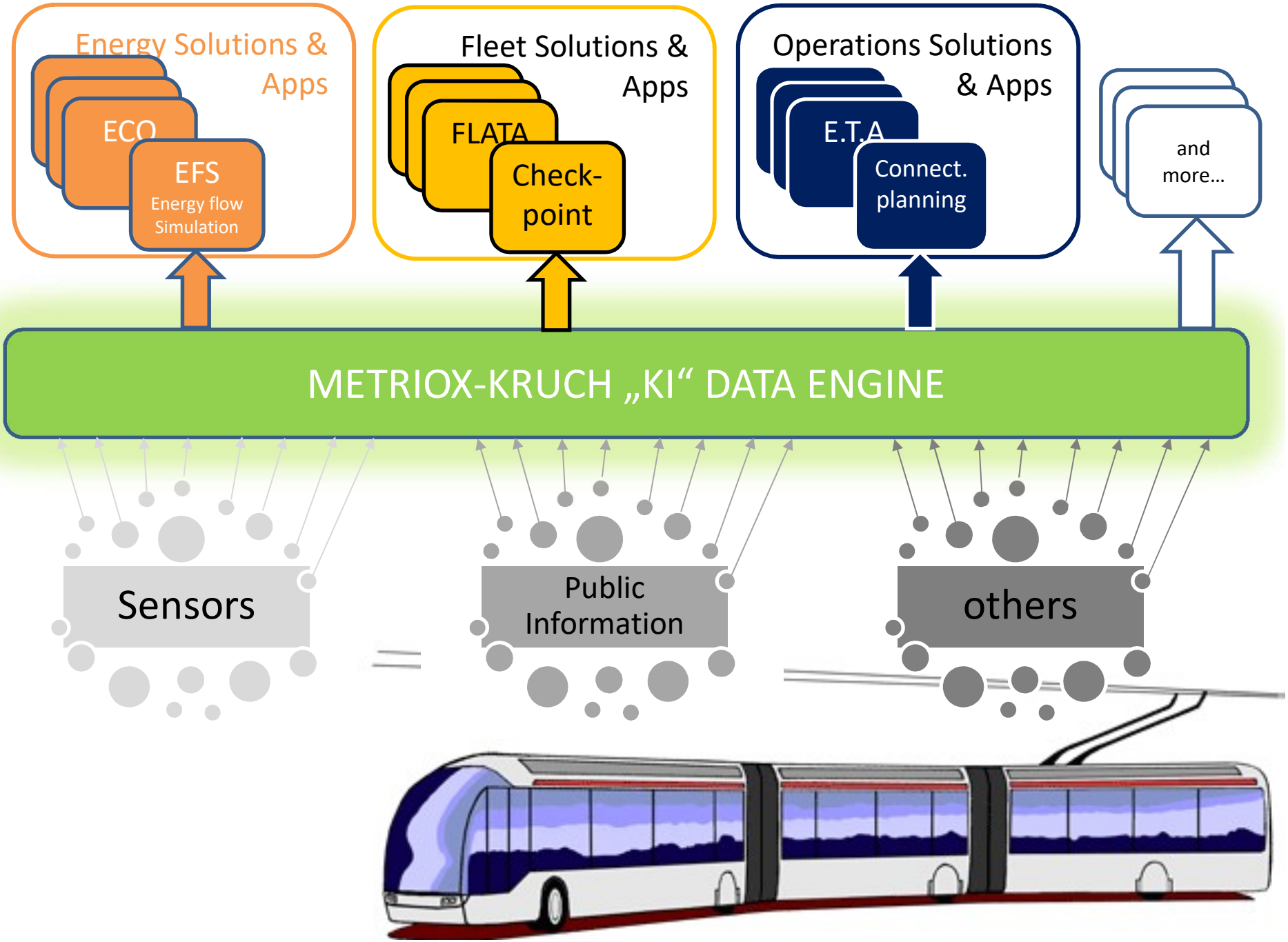
Our mission

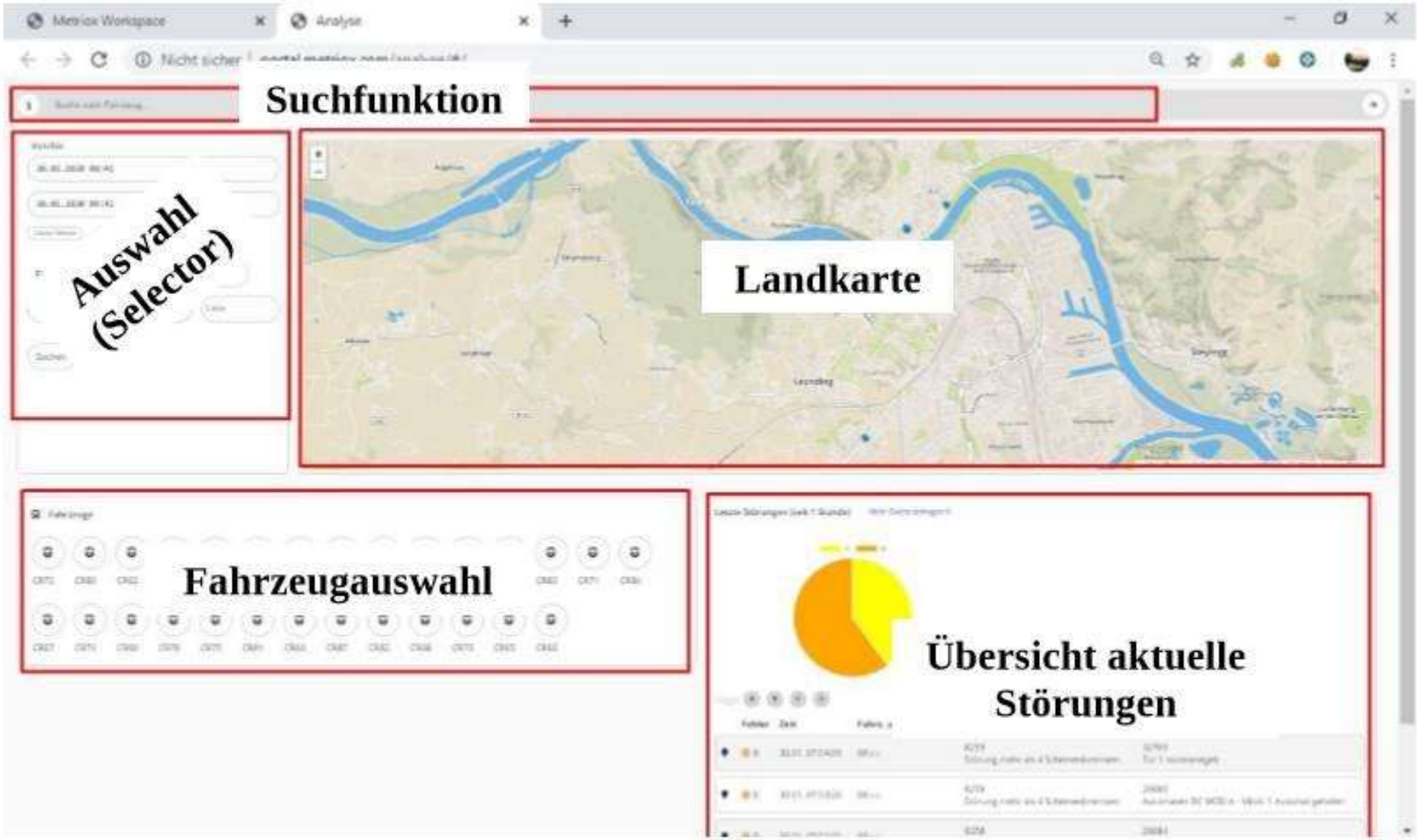
- One platform for everyone
- Combining all data and intelligence
- …available for all applications

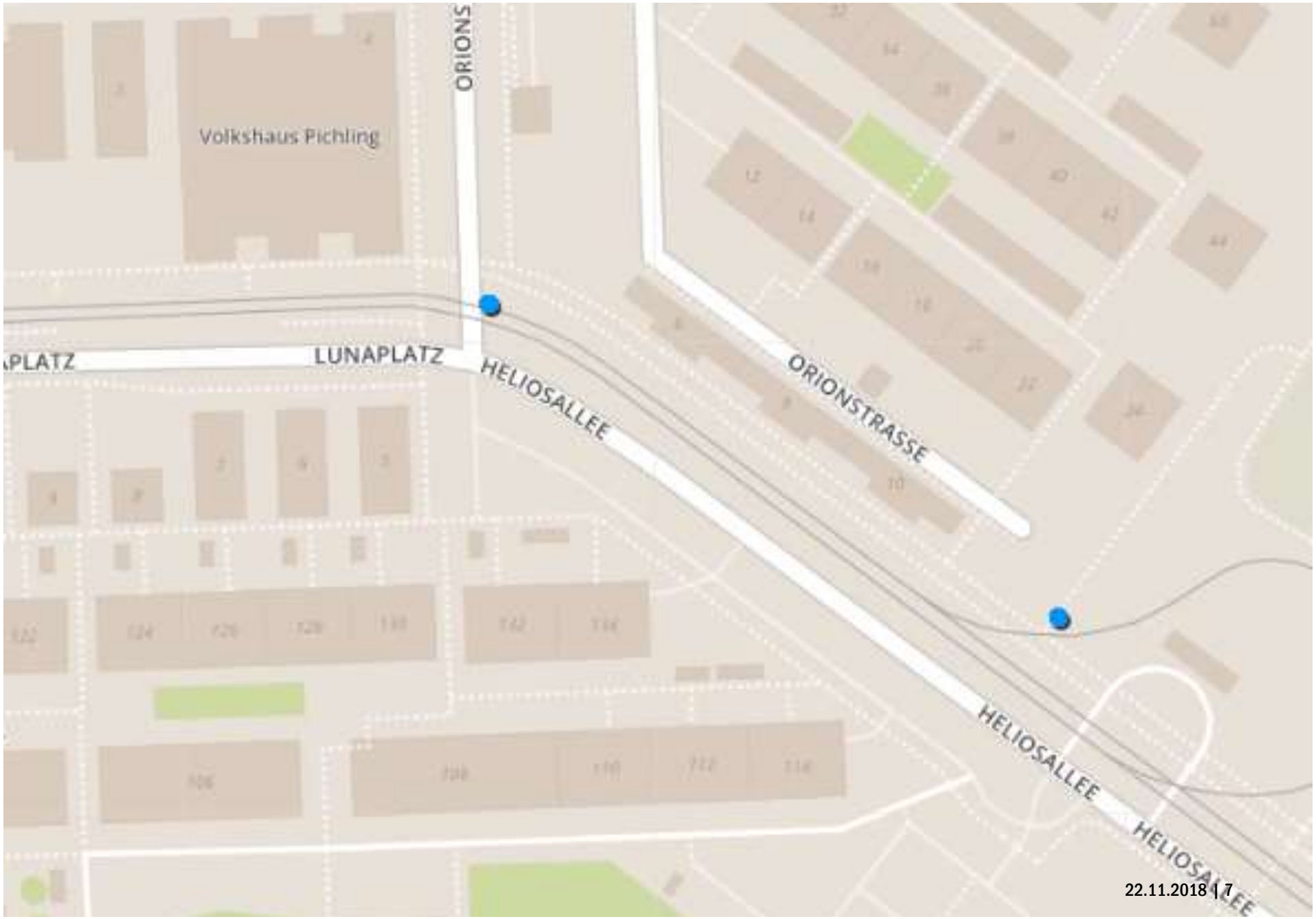


- full synergies
- using the full potential
- cost effective

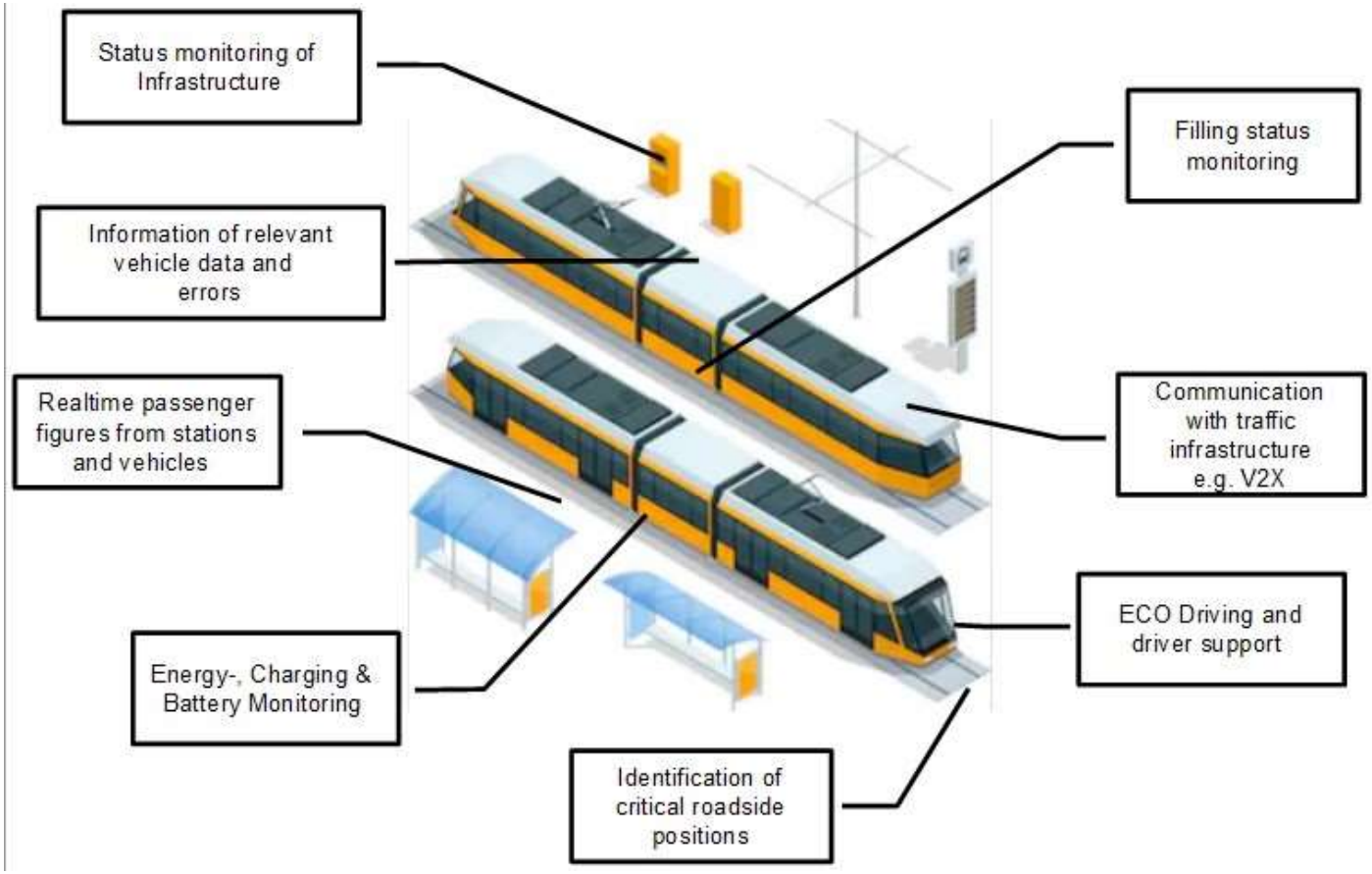
Metriox-Kruch „KI“ Data Engine


Energy Solutions & Apps
ECO
EFS
Energy flow Simulation
Fleet Solutions & Apps
FLATA
Check-point
Operations Solutions & Apps
E.T.A
Connect. planning
and more…
METRIOX-KRUCH „KI“ DATA ENGINE
Sensors
Public Information
others


Suchfunktion
Auswahl (Selector)
Landkarte
Fahrzeugauswahl
Übersicht aktuelle Störungen

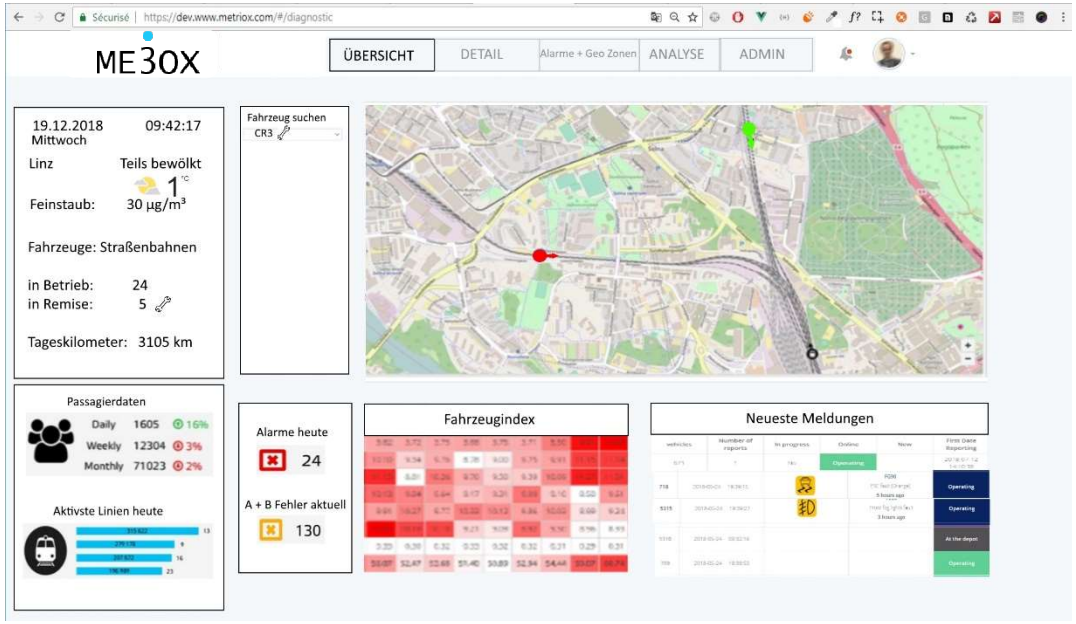

Volkshaus Pichling
ORIONS
LUNAPLATZ
HELIOSALLEE
ORIONSTRASSE
HELIOSALLEE
HELIOSALLEE

FLATA – Fleet Data



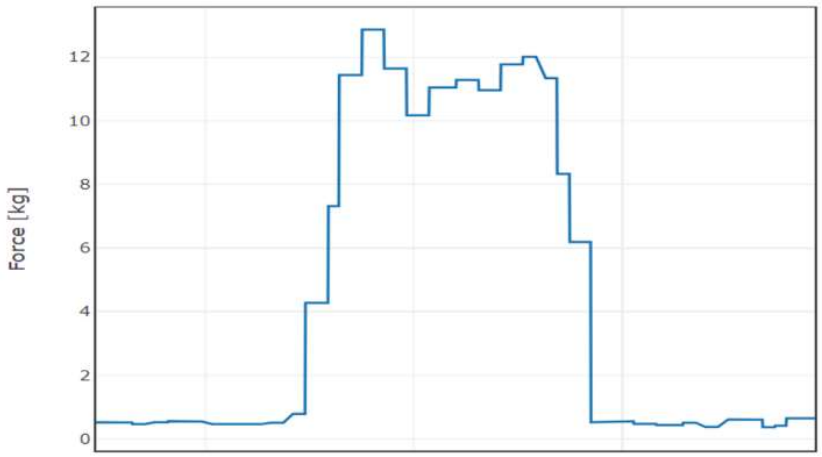
Real-Time Information from Trolleybus

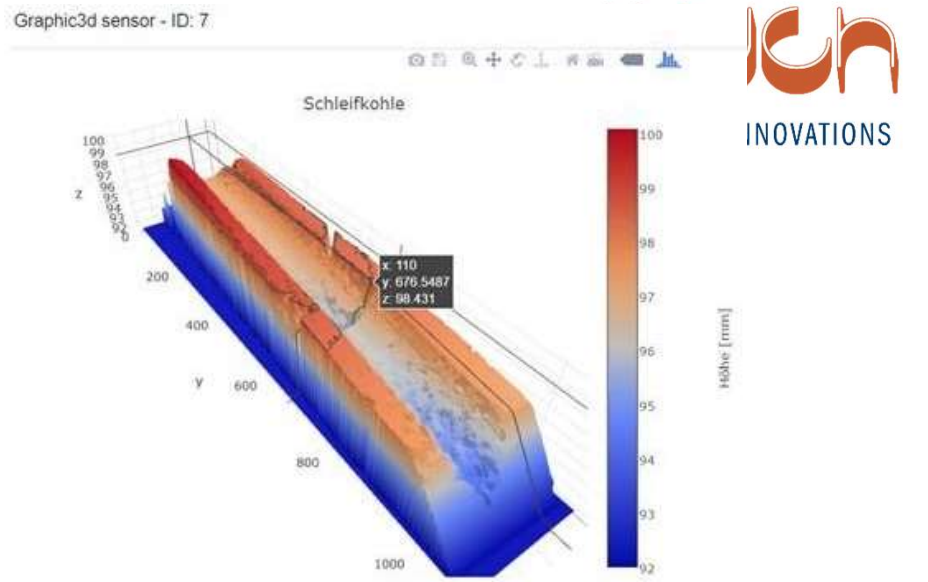
- **Vehicle defects**
- **Energy**
  - Traction (break, recuperated and pure traction energy)
  - AUX (heating and cooling energy consumption)
- **Traction Battery**
  - Energy: charging, discharging
  - SOH, SOC
  - Mileage powered by traction battery
  - Charging and discharging cycles
- **Operating resources (e.g. water for windshield…)**
- **HVAC / Temperature / air-quality**
- **Passengers**
- **Driving behaviour**
  - breaking, accelerations, torque, traction energy
- **Driveway & Surveillance camera monitoring**
- **General statistics**

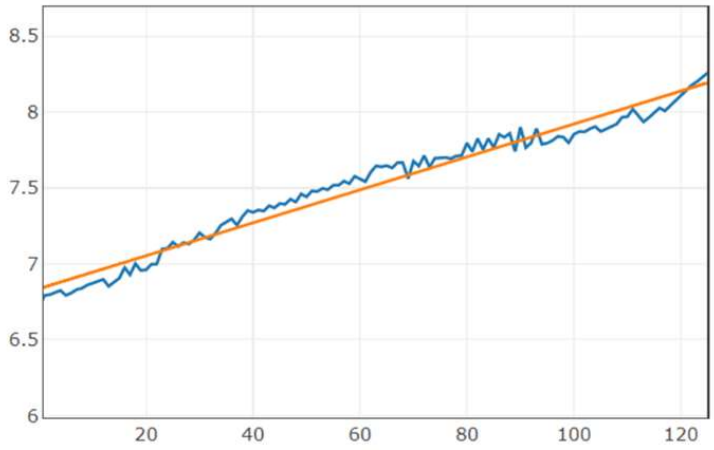


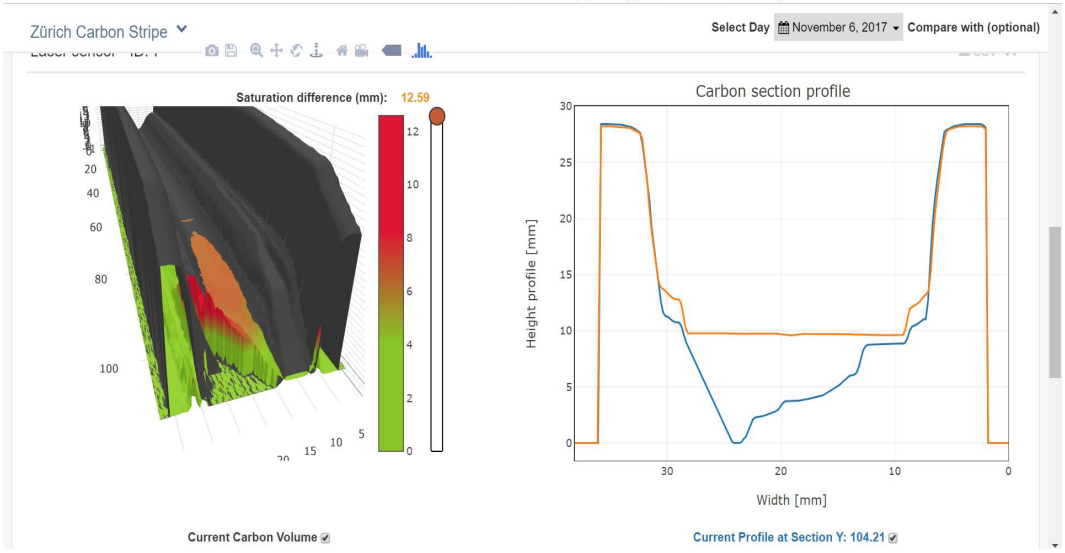
Trolleybus Checkpoint

Daily check of carbon inserts


Force [kg]
0
2
4
6
8
10
12


Graphic3d sensor - ID: 7
Schleifkohle
x: 110
y: 676.5487
z: 98.431
Höhe [mm]


6
6.5
7
7.5
8
8.5
20
40
60
80
100
120


Zürich Carbon Stripe
Select Day
November 6, 2017
Compare with (optional)
Saturation difference (mm):
12.59
Carbon section profile
Height profile [mm]
Width [mm]
Current Carbon Volume
Current Profile at Section Y: 104.21

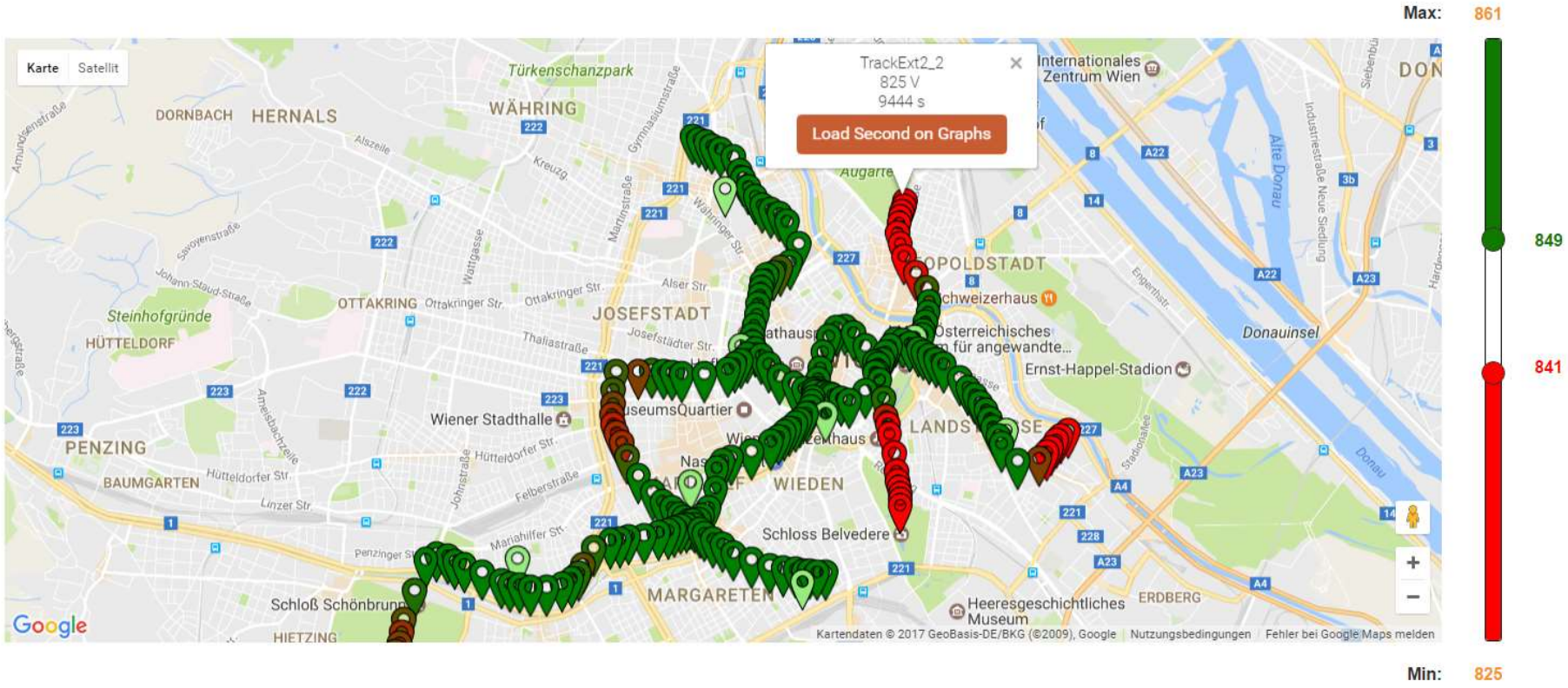
KRUCH EFS Energy Flow Simulation

RAILWAY INNOVATIONS

AUSTRIAN QUALITY since 1869

Results of EFS

Example: Displaying the voltage behaviour along the line



CONNECTION PLANNING

Digital twinning

THE POWERFUL DIGITAL REPLICA OF YOUR PHYSICAL ENTITIES

Jan.Roehl@kruch.com

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KRUCH Railway Innovations
GmbH & Co.KG
Pfarrgasse 87, 1230 Vienna - Austria

Questions?

Balázs Fejes
BKK, Budapest (EfficienCE)

TEASER: How to decide on vehicle technology infrastructure for local investments in Budapest (e-bus or trolley)?

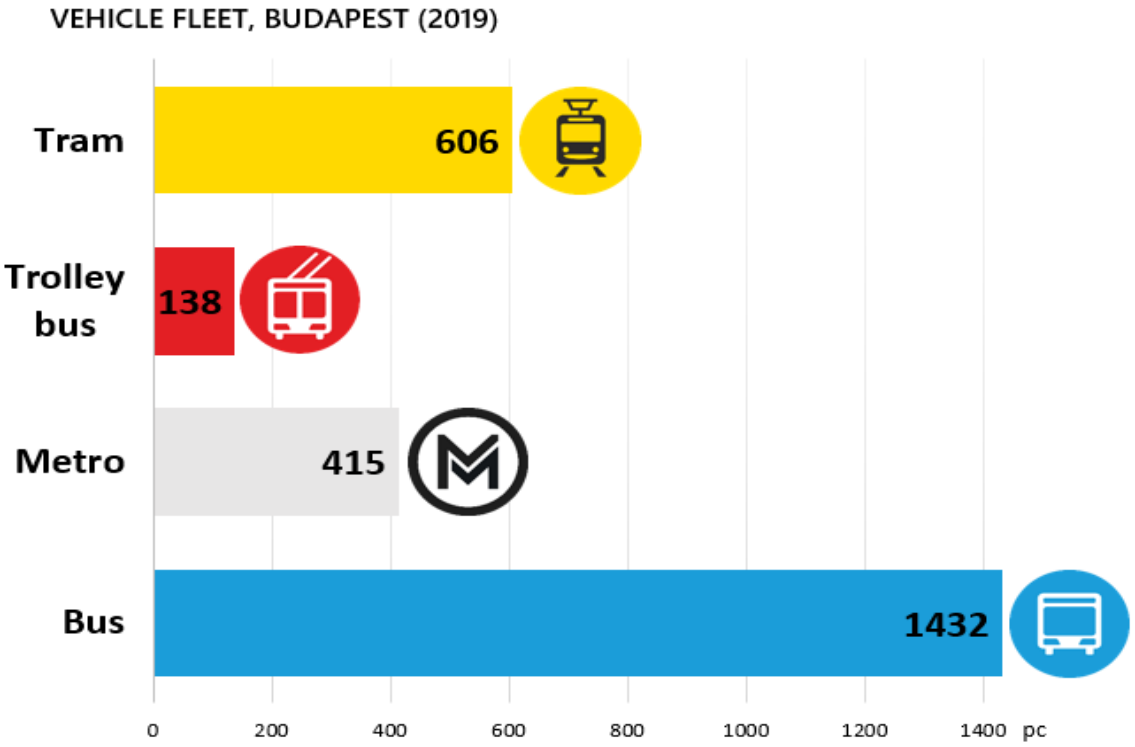
Transnational Workshop - Data-based planning of energy-efficient public transport services and infrastructure

13. May 2020. Virtual meeting

How to decide on vehicle technology infrastructure for local investments in Budapest (e-bus or trolley)?

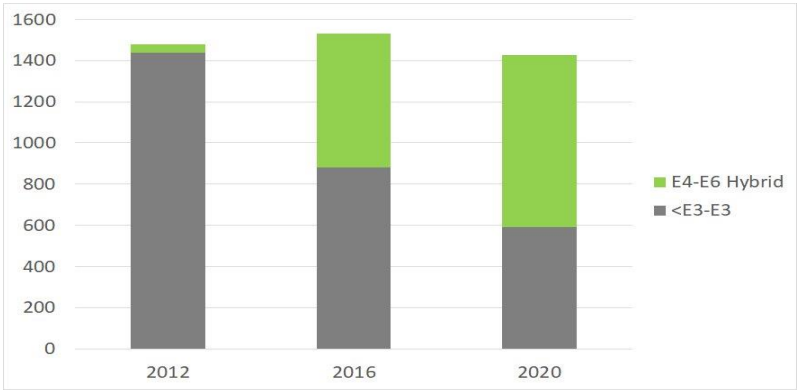
Balázs Fejes, innovation expert, BKK Centre for Budapest Transport

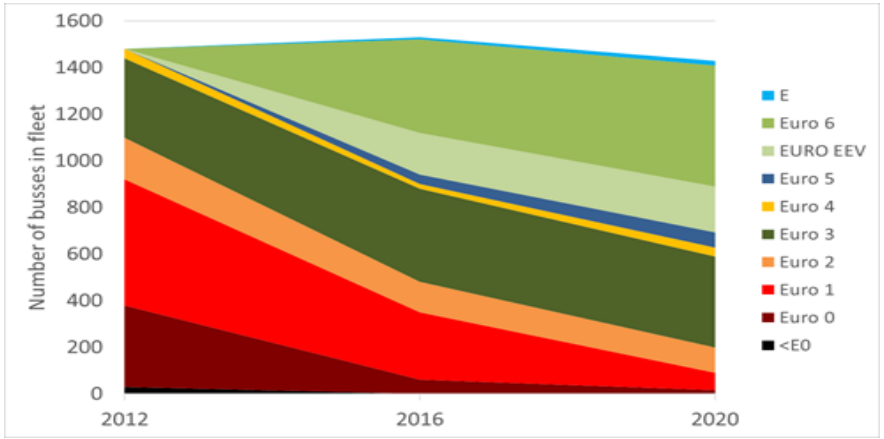
CURRENT PT FLEET IN BUDAPEST



BUS FLEET CHARACTERISTICS

Tendency in number of buses by engine category for the entire fleet





RECENT DEVELOPMENTS

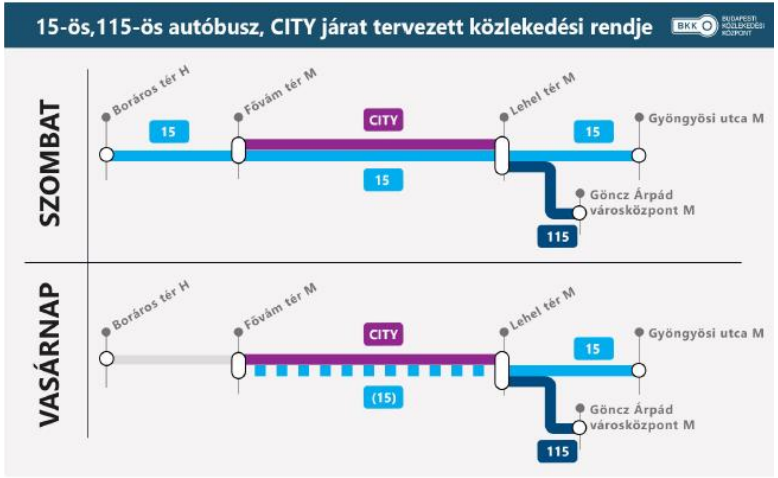
- City trolleybus line
- Weekend extension of line 72
- Metro station replacement

Features:

- Connecting existing trolley lines
- Without building catenary
- Battery mode ca. 4 km

Main drivers:

- Mitigate air pollution, liveable inner city
- „Green” image
- Piloting



LONG TERM STRATEGY – WHICH WAY TO GO?

?

?

What is the propulsion system for future buses?

- Battery electric
- Fuel cell (hydrogen)
- Battery hybrid trolleybus
- Diesel hybrid
- CNG
- Other

LONG TERM STRATEGY – BASIC CONSIDERATIONS

What are the considerations for the long term strategy?

- Is there a base DC electric network in the city (e.g. tram)?
  - If yes, trolley is easier
  - If not e-bus is easier
- Which is more efficient?
  - Trolley, where the battery is relatively small
  - E-Bus, where the infrastructure costs are lower
- Which is more preferred by the people:
  - E-Bus where there is no catenary
  - Trolley, where there is no battery pack in the interior

- By extending the trolley network, how far do we build catenary/which capacity should the battery have?
  - The least possible amount catenary/big battery with high range
  - Wherever it is possible catenary, the least possible battery pack
- If we run electric buses, should they charge:
  - Overnight in the depot
  - By opportunity on terminuses

OPEN QUESTIONS FOR THE AUDIENCE

- What is an optimum range of the battery hybrid trolleybuses?
  - If the range is high, the battery pack as a dead weight is large
- Cities using e-buses:
  - What are professional benefits of e-buses compared to diesel?
  - What is a passenger km cost compared to diesel?
  - Is it a real fact, that 1,5-2 e buses can replace 1 diesel?
- Shall we all phase out our diesel buses, or can they remain at certain places?
  - Low living density areas
  - Regional traffic

Thank you for your attention!

Balázs Fejes
Innovation Expert
BKK Centre for Budapest Transport, Mobility Strategy

balazs.fejes@bkk.hu
www.bkk.hu

BKK BUDAPESTI KÖZLEKEDÉSI KÖZPONT

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Plzeňské městské dopravní podniky PMDP

City of Leipzig

University of Maribor

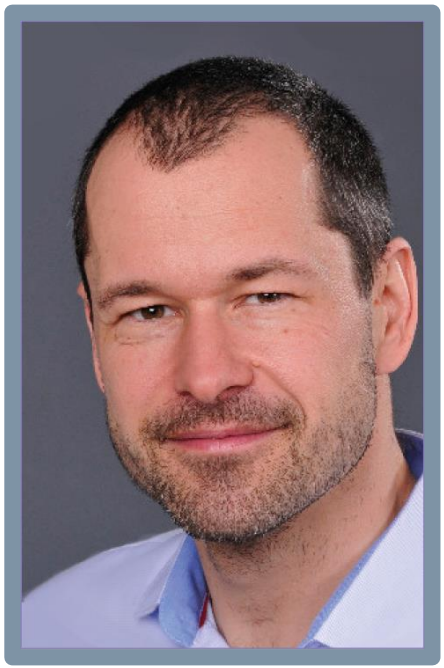
Faculty of Civil Engineering, Transportation Engineering and Architecture

BERGAMO CITTÀ DEI MILLE

COMUNE DI BERGAMO

PRZEDSIĘBIORSTWO KOMUNIKACJI TROLEJBUSOWEJ SP. Z O.O. GDYNIA PKT

QUESTIONS AND DISCUSSION



Jiří Kohout

PMDP, Pilsen (EfficienCE)

TEASER: Why Pilsen (Czech republic) decided to widen the trolleybus network.

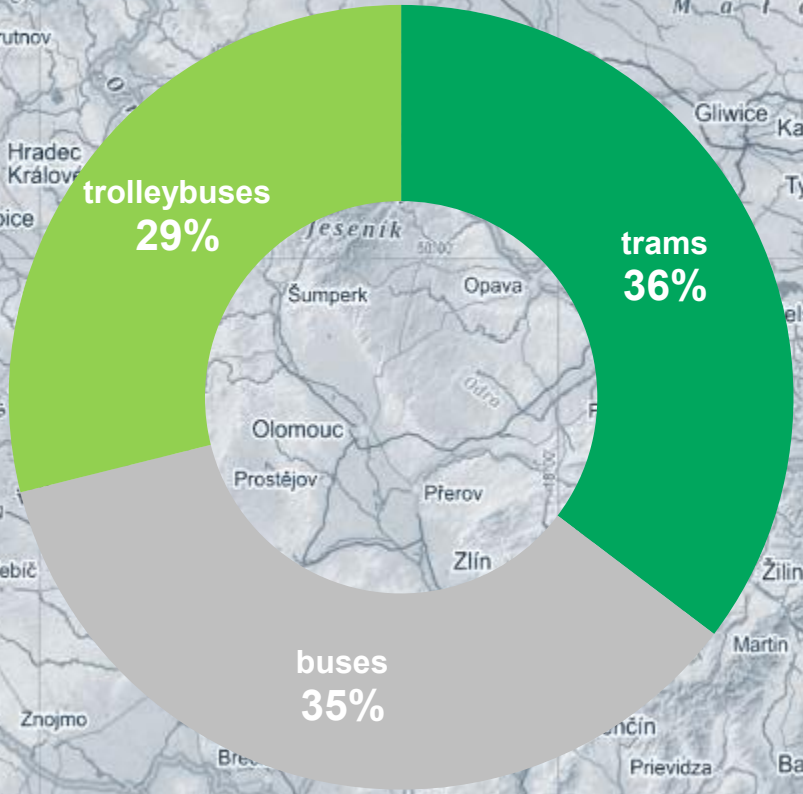
Transnational Webinar, 13 May 2020

EfficienCE – TEASER Pilsen to widen trolleybus network

Why Pilsen has decided to invest in battery trolleybuses?

Jiří Kohout, PMDP, Pilsen, Czech republic

65 % of Pilsner city public transport is already electric!



Annual performance	
Trams	5,5 mil. km
Trolleybuses	4,5 mil. km
Buses	5,3 mil. km

Město Plzeň

www.mapy.cz

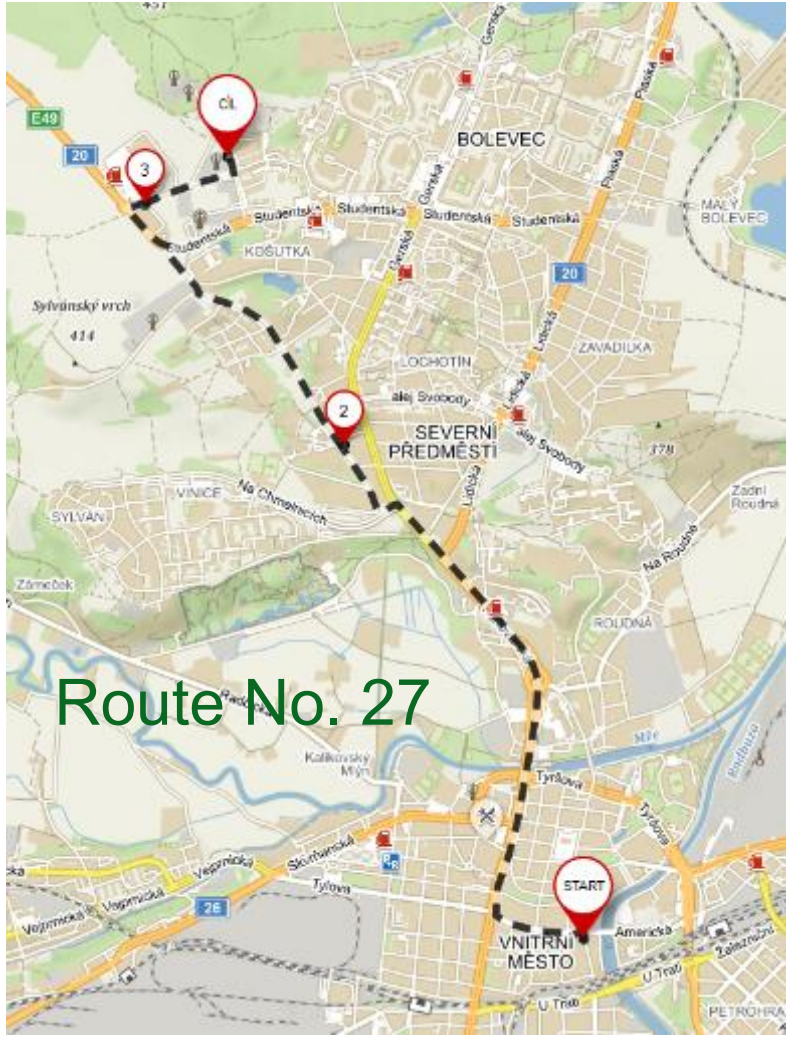
Pilsner Smart City Goal

"To increase share of electric traction in public transport - trams and trolleybuses - in Pilsen ***from 64 % in 2015 to 85 % in 2030"***

Plzeňské městské dopravní podniky PMDP

Lessons learned from fast charging e-bus project (ZeEUS)

Length of the bus line	6 km, in a hilly suburb
Total daily hours of operation (full electric)	7.5 - 18.5 h
Total km driven vehicle/day	80 – 200 km
Monthly avg. temperatures	Jun. 17.7°C / Jan. -2.2°C



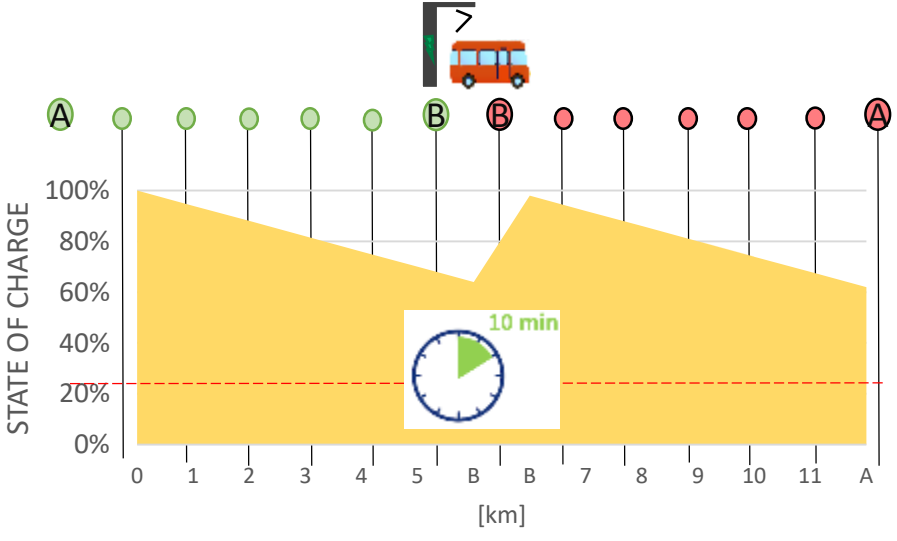
Results & Lessons learned (1)

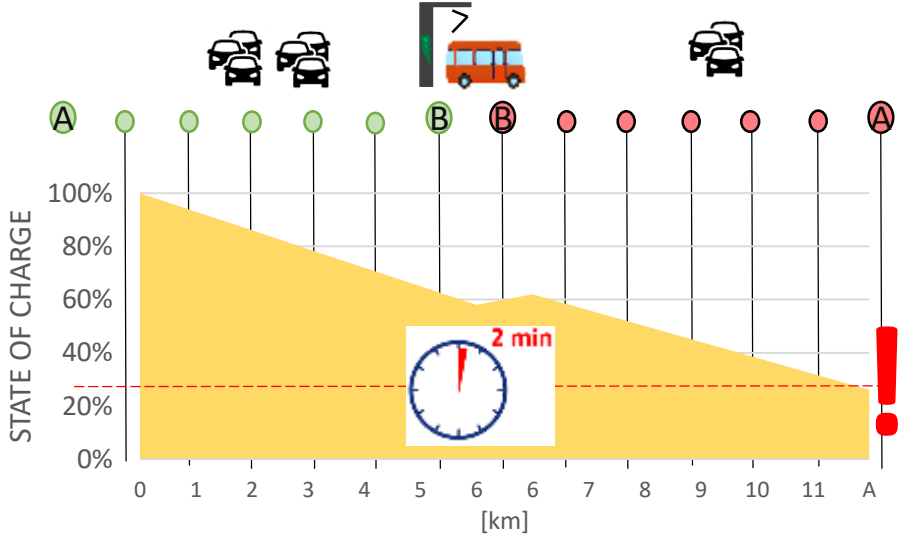
- **Limited operational range**

  due to heating in winters

  due to traffic jams (too short time for charging)

  only one vehicle can be charged at a time

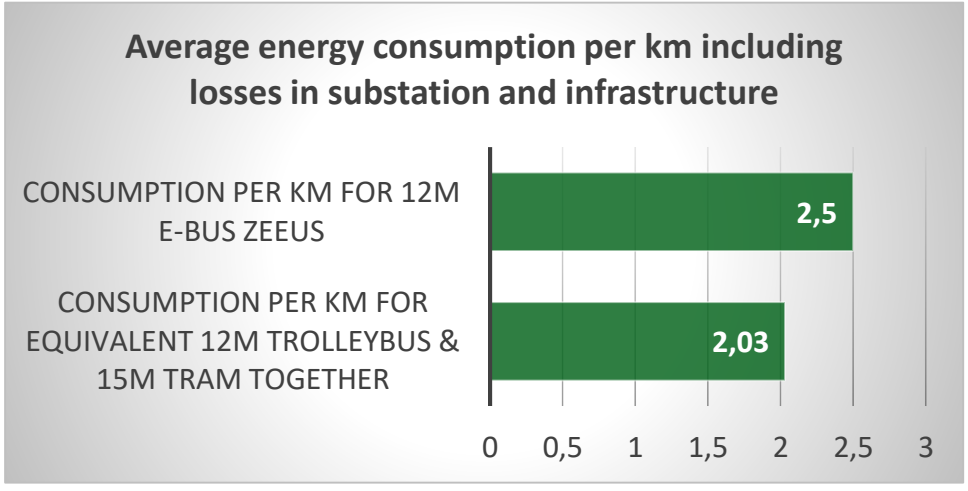


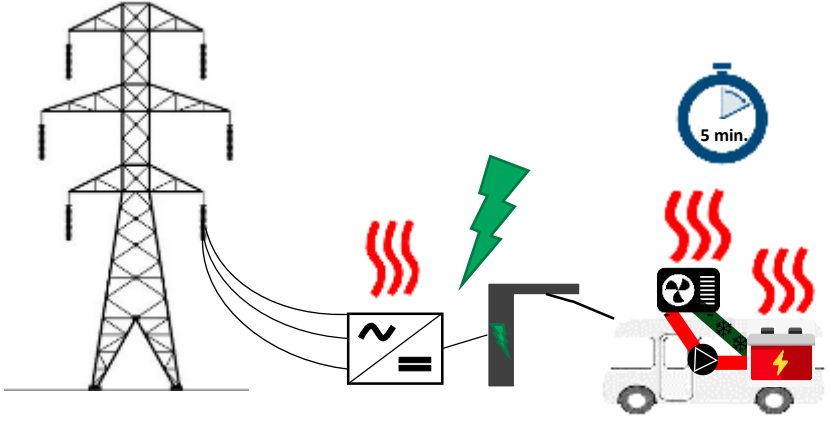


Results & Lessons learned (2)

Fast charging means

- **Robust energy supply**
- **High energy consumption**



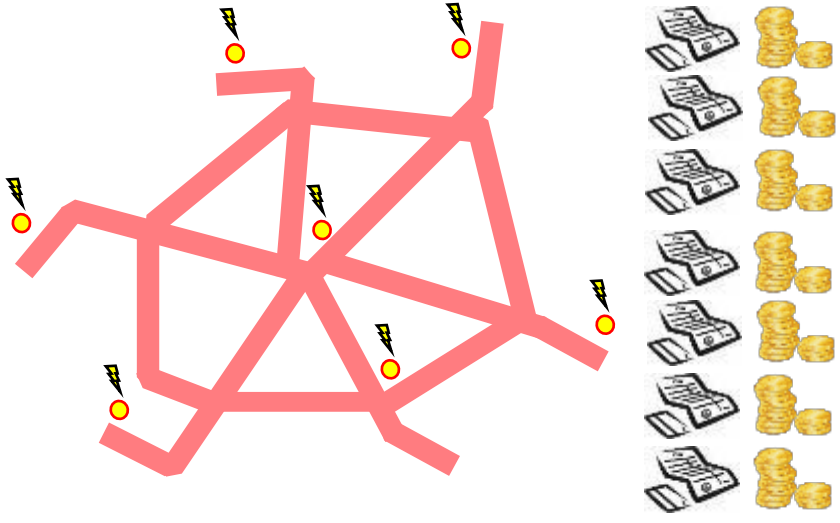


Plzeňské městské dopravní podniky PMDP

Power supply

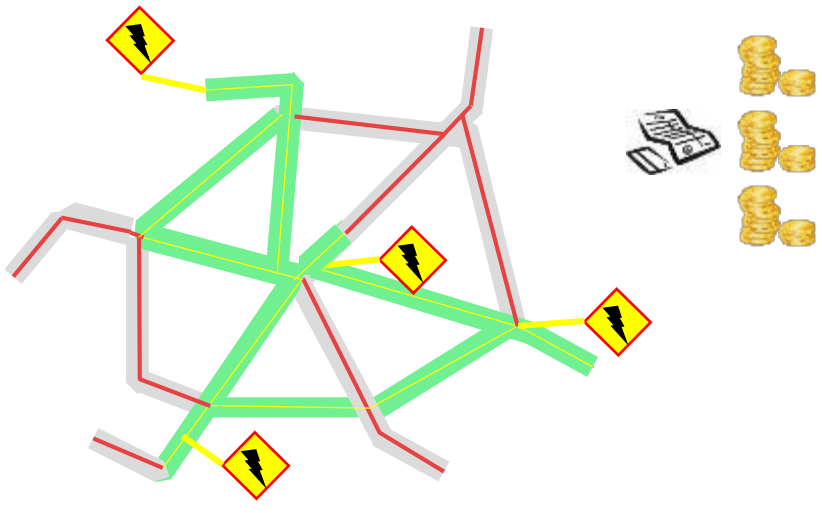
Fast/slow charging means

- **peak** energy demand in terminus/depot
- **higher price of electricity**



Network for dynamic charging (trolleybuses) means

- **smoother** consumption diagram
- **lower price of electricity**



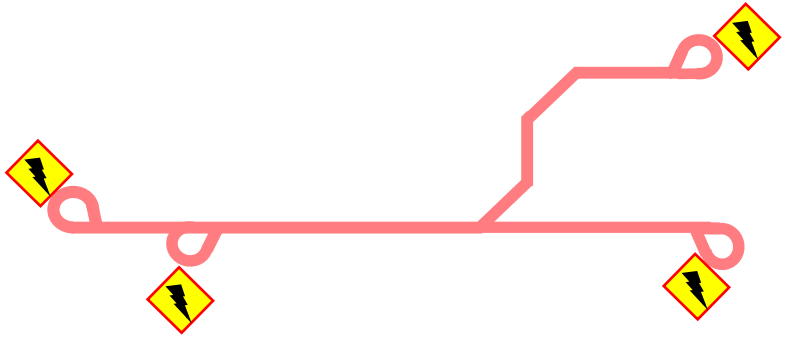
Plzeňské městské dopravní podniky PMDP

Having cramped space on terminus

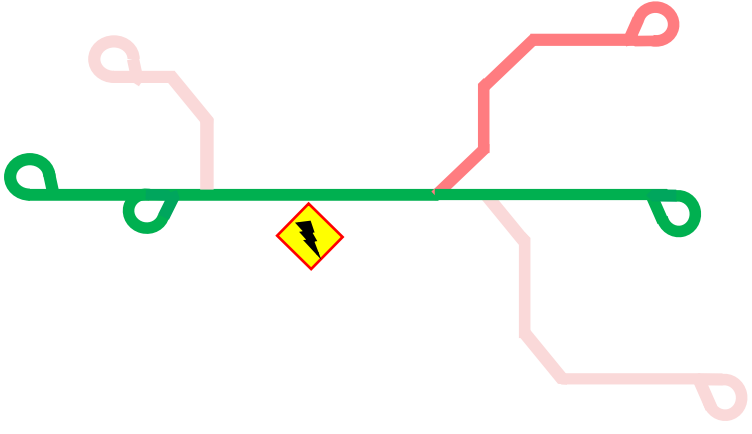
or having variable line route...

...Where to put charging stations?

Fast charging e-bus case



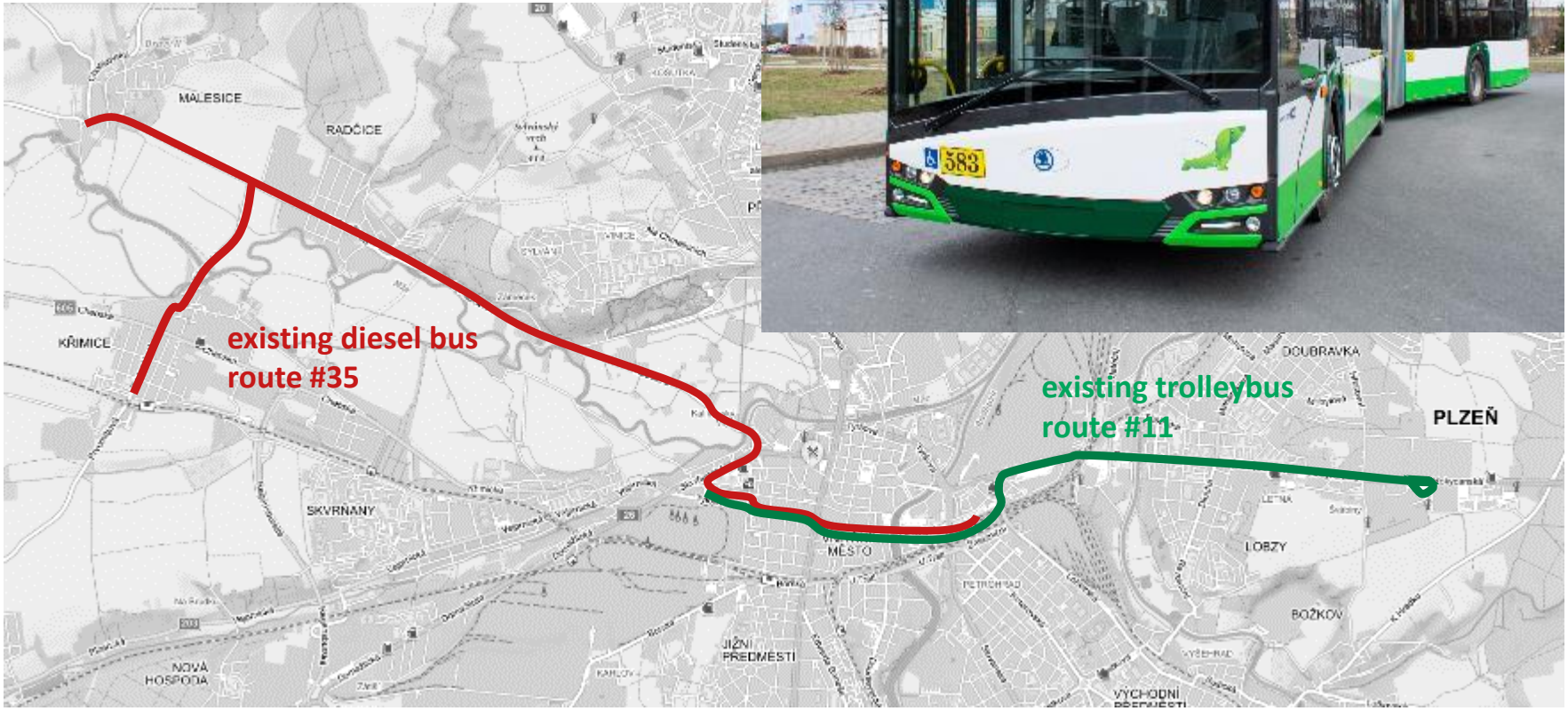
Dynamic charging (IMC) trolleybus case



It is about flexibility and efficiency!

- charging by standing as well as moving
- lighter battery & longer lifetime
- using and extending existing infrastructure
  - synergy with tram network

2021: Trolleybus route #11 extension without any investment to infrastructure!



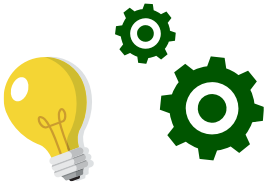
Thank you for your attention!

Pilsen city transport company (PMDP)

Jiří Kohout

kohout@pmdp.cz
www.pmdp.cz

QUESTIONS AND DISCUSSION



Closing remarks and feedback options

Interreg CENTRAL EUROPE European Union European Regional Development Fund

EfficienCE

WEBINAR

Interreg CENTRAL EUROPE European Union European Regional Development Fund

LOW-CARB

Thank you for your participation!