Deploying e-fleets: Building solid fundamentals for e-operations

31st of January 2024
Iztok Štrukelj,
Business development director
Arriva Slovenia

arriva

a DB company

Arriva Group

- 9 european nations and UK
- 35.500 employees
- 1.5bn passenger journeys
- 564 trains and trams
- €4.1bn revenues
- 13.000 buses

arriva

Where we operate

We hold leading market positions in many of the countries we operate in thanks to significant competitive advantages from our scale and local leadership

We are amongst the leading operators of **electric vehicles** in Europe

We operate **350 bike sharing bikes in Slovakia and Netherlands**

We operate waterbuses in Italy and Netherlands, mainly in joint venture with other partners.

arriva

a DB company

Our Strategy

This is how we'll achieve our goals.

Our people

Be a proud, performance-driven, diverse and inclusive team, inspired and passionate about delivering the safest and best services.

Sustainability

Inspire and promote greener, more connected transport for all, and become a climate neutral business we can be proud of.

Operational excellence

Continuously improve how we operate and drive efficiencies, and make the most of both our scale and local knowledge to win together in our markets.

Our clients

Build trust with our clients so that we can better understand, shape and meet their needs and those of our passengers in an ever-changing world.

Innovation

Apply data-driven insights to deliver high quality innovative solutions today and in the future.

Value creation

Apply commercial discipline and deliver a competitive cost base to achieve strong, profitable growth.

arriva

Our values

Whether it's creating the best environment for our people to thrive, delivering a great customer experience, or working with our partners to think beyond today for a more sustainable tomorrow, our values are ingrained in everything we do.

We care passionately

- About creating the best environment for our colleagues to thrive
- About delivering a great customer experience
- About being part of a high-performing team, and winning together
- About our planet, and transforming towns and cities through greener, more sustainable transport.

We do the right thing

- By putting safety first
- By striving for improvement in everything we do
- By embracing diversity and treating people with respect
- By working to the highest standards and holding each other to account
- By investing in the wellbeing and development of our people to create a more sustainable workplace.

We make the difference

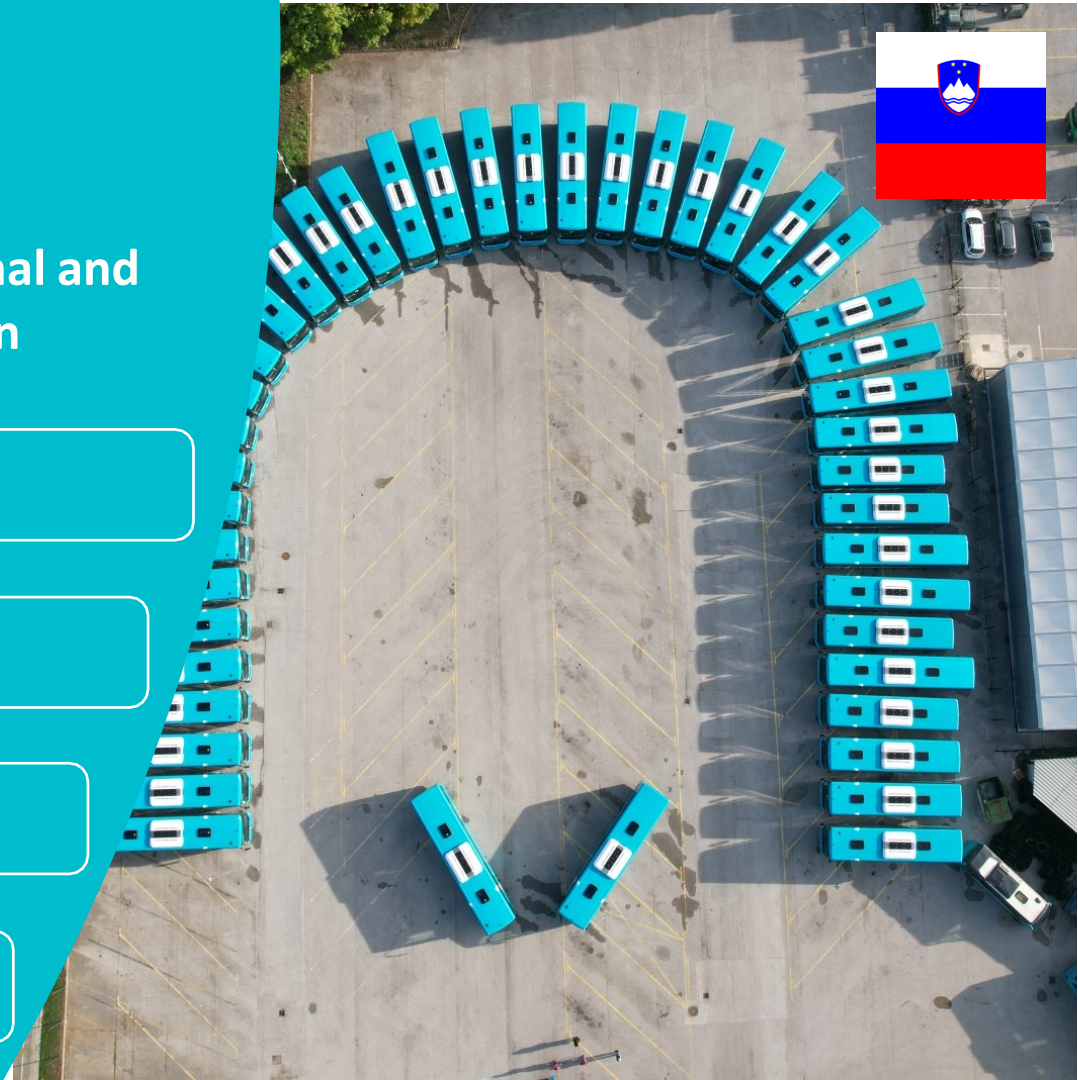
- By delivering what matters most to our clients, customers, colleagues and stakeholders
- By recognising a job well done
- By finding solutions and not letting challenges get in our way
- By actively listening and embracing the learning when we get it wrong
- By innovating and thinking beyond today for a better, more sustainable Arriva tomorrow.

arriva

Arriva Slovenia
A national operator

Arriva Slovenia is the leading regional and tendered urban transport operator in Slovenia

- 590 vehicles
- Total revenues of €70m
- 34m km/year
- 950 employees



Where we operate

We operate public transport services in different places:

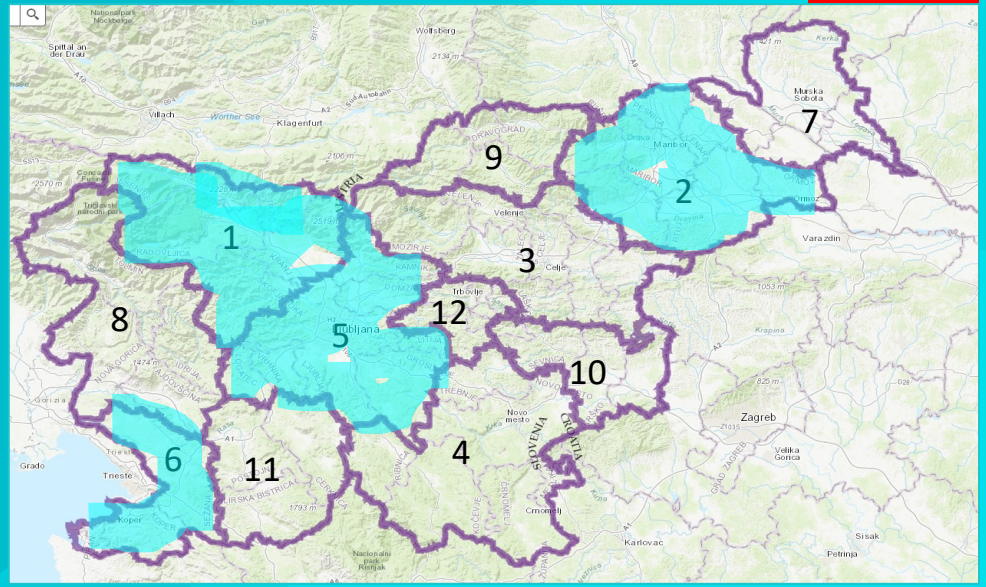
Regional operations:

- As of July 1st Arriva will operate tha marked areas – 47 % market share

Urban transport operation:

- Koper – coastal and port city;
- Piran – tourist city;
- Kranj – ZE and digitalization leader;

- 65 % market share in tendered market.



Arriva Italia
A national operator

Arriva Italia is one of the leading transport operators in Italy

- More than 2400 vehicles
- Total revenues of €360m
- 90m km/year
- 3500 employees

Where we operate

We operate public transport services in different places:

Local operations:
Valle d'Aosta, Torino, Bergamo, Lecco, Brescia, Cremona

Subsidiaries:
- Arriva Veneto
- Arriva Udine
- Trieste Trasporti
- ASF Autolinee

arriva

Roma Capitale - Transport service for students with reduced mobility needs

Arriva Italia, in partnership with Meditral, provides a reserved school transportation service for disabled students in the municipality of Roma Capitale from January 10, 2022.

The service is provided thanks to a fleet of more than 240 new vehicles, 25 of which are electric, to ensure high standards of mobility while putting environmental sustainability at the center

arriva

Sustainability and green mobility

Arriva Italia is implementing high-level sustainable mobility solutions to offer an increasingly **green travel** experience to its passengers and reduce its environmental impact.

Investments in **electric mobility** are growing: 11 new electric buses were introduced in Cremona in 2023, with the goal of making the city's entire urban fleet entirely electric-powered by 2026, for a total of 32 vehicles.

Arriva also operates electric vehicles in **Udine**, where service to the historic center is provided by 3 e-buses, and in **Rome**, where it operates 20 electric vehicles used to transport disabled students.

arriva

a DB company

Our approach to Zero Emission

- It is our responsibility **to drive the change** – our job after all is being **in the driver‘s seat**!
- We believe in the must of our own learning and empowerment to be able to be „the partner of choice“ for our clients and passengers!

- Key challenges for implementing change with new technologies:

    1. Stakeholders‘ onboarding;

    2. Reluctancy to change.

- **Data, good use of it and enough communication** make the difference to a succesful change

– Gradual learning +

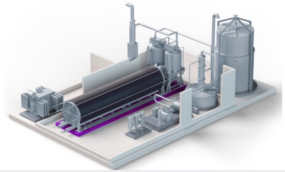
arriva

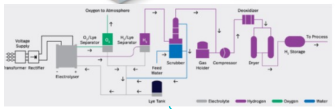
a DB company

Where are we today?

- Fleet of 12 m buses in Urban transport Kranj

- Pushing a „Water2Water“



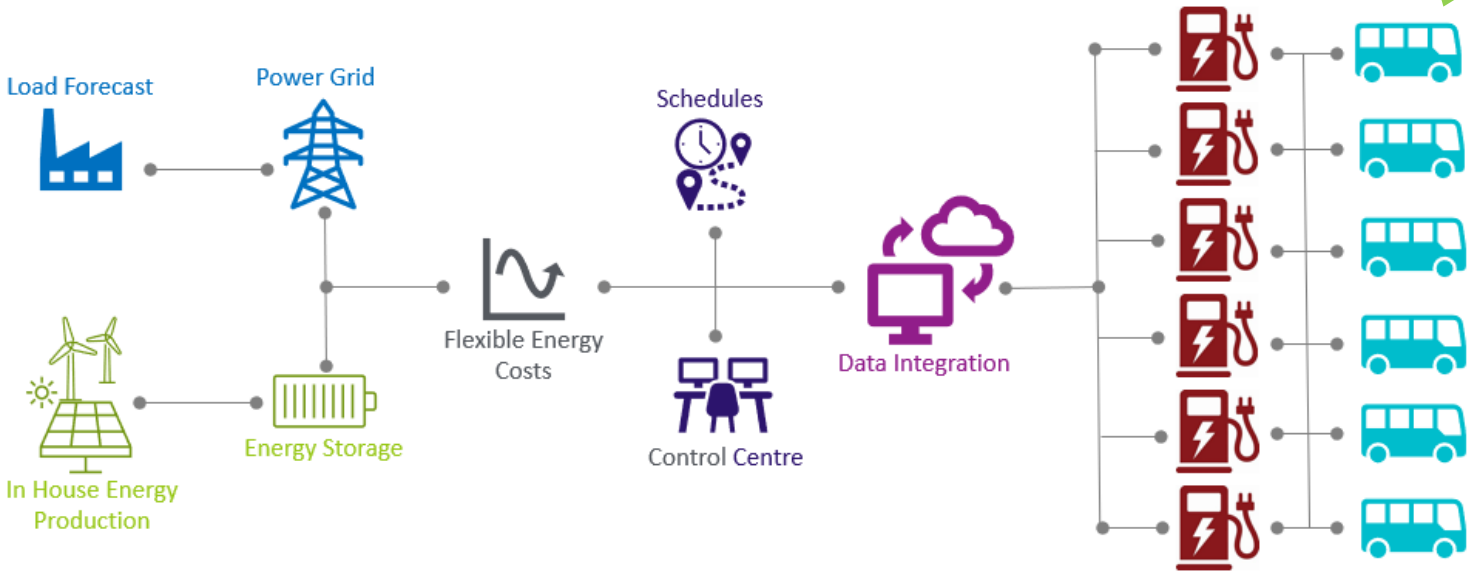


Green Hydrogen circle

Data management as key to a solid business case

Higher Bus and Infrastructure CAPEX

ZE complexity vs. ICE simplicity

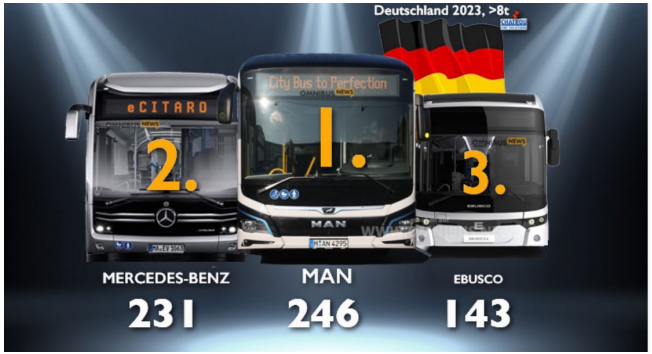


The BUSiness case - The e-BUS with its CAPEX

1. Prices of EU based OEMs (MAN, IVECO, EVOBUS, SOLARIS, VAN HOOL, EBUSCO, VDL) - Urban e-buses are almost twice as expensive as ICE Diesel vehicles – 600.000 EUR/bus;
2. Non-EU based OEMs (BYD – Hungary based, YUTONG) offer better prices with comparable warranty conditions – 500.000 m EUR/bus;

Price is not the only criteria:

- Battery warranty (5-10 years, State of Health %) & general warranty
- Battery Size & Battery Depth of Discharge
- Availability (% of uptime)
- Aftersales
- Weigth and passenger capacity
- Heating – diesel or electric
- Driver and Engineers training
- **Vehicle procurement lays the foundation!!!**



a DB company

The BUSiness case - The e-BUS with its OPEX

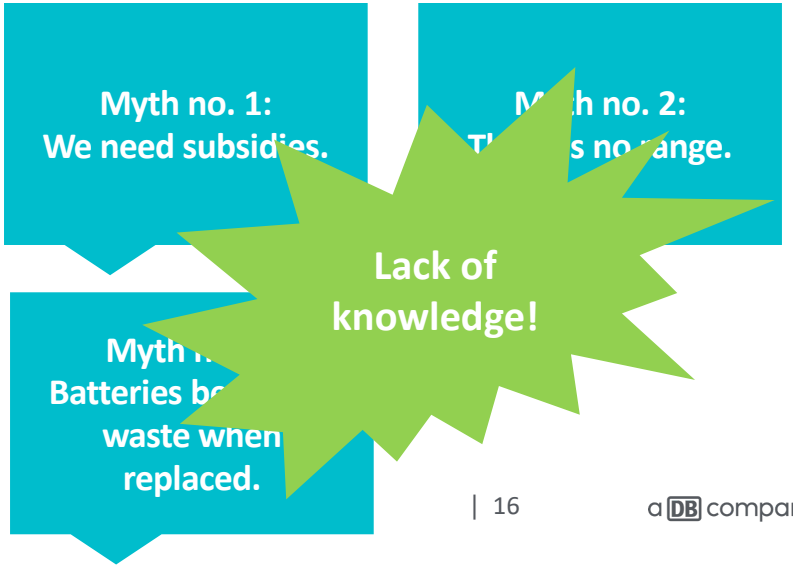
WHERE CAN I MAKE MONEY OR SAVE COSTS??

1. e-BUS Operating Expenditure (OPEX) is lower/km, so the more mileage the buses cover, the more financial savings are created when compared to a diesel ICE bus;
2. Lower Operating expenditure comes from the following causes:

- **Costs for energy consumed** - kWh consumed and price/kWh;
- **Recuperation levels** - driver‘s driving style may contribute 20 – 35 % of the consumption of the e-Bus;
- **No AD-Blue** necessary;
- **Lower Engineering costs** – less spare parts, less piping, no lubricants (except for brake oil), more demanding workforce qualifications necessary – bigger IT costs.

KEY TAKE-AWAYS:

1. Vehicle procurement (consumption and recuperation capabilities);
2. Costs of energy (procurement of energy) – can I produce my own energy, can I store it?
3. Actual recuperation levels – driver training and follow-up performance.



The e-BUSiness case – Gen 1

CONCESSION INFORMATION	
Batch amount	10
Concessionperiod (year)	10 Yr
Km per year	80000 km

	1ST GENERATION 363 kWh		DIESEL BUS EURO VI	
	Input	Cost per year	Input	Cost per year
BUS				
Price Bus	€ 600.000,00	€ -	€ 300.000,00	€ -
Residual value bus after concession period	€ 30.000,00	€ -	€ 5.000,00	€ -
Depreciation bus per year		€ 57.000,00		€ 29.500,00
Interest	1,50%	€ 4.275,00	1,50%	€ 2.212,50
MAINTENANCE				
Maintenance average excluding tyres	€ 0,173	€ 13.800,00	€ 0,23	€ 18.400,00
Tyres average	€ 0,03	€ 2.400,00	€ 0,03	€ 2.400,00
Replacement battery pack after 10 years		€ -	N/A	€ -
ENERGY/FUEL CONSUMPTION				
Energy consumption per km (in kWh , Liters Diesel, L LNG)	01,20 kWh	€ -	0,43 lt	€ -
Energy cost per kW/hr, Lt diesel, Lt LNG, per year	€ 0,15	€ 14.400,00	€ 1,30	€ 44.720,00
Adblue consumption per km in Liter (6% of fuel consumption)	N/A	€ -	0,03 lt	€ -
Adblue price per liter €0,70	N/A	€ -	€ 0,70	€ -
Adblue cost per km , total	N/A	€ -	€ 0,02	€ 1.444,80
CHARGER				
Charger per electric bus, depreciation 90% in 10 years	€ 40.000,00	€ 3.600,00	N/A	€ -
Installation charger	€ 25.000,00	€ 2.500,00	N/A	€ -
TAXES				
Road tax per year	€ 7.000,00	€ 7.000,00	€ 2.400,00	€ 2.400,00

The e-BUSiness case – Gen 1 – TCO – Total Cost of ownership

TCO PER BUSES					
Bus + charger	per km	€ 0,84	per km	€ 0,40	
Maintenance + replacement batterypack	per km	€ 0,20	per km	€ 0,26	
Consumption	per km	€ 0,18	per km	€ 0,58	
Taxes	per km	€ 0,09	per km	€ 0,03	
TOTAL cost per kilometer	per km	€ 1,31	per km	€ 1,26	

TCO PER BUSES					
Bus + charger	concession	€ 6.737.500,00	per km	€ 3.171.250,00	
Maintenance + replacement batterypack	concession	€ 1.620.000,00	per km	€ 2.080.000,00	
Consumption	concession	€ 1.440.000,00	per km	€ 4.616.480,00	
Taxes	concession	€ 700.000,00	per km	€ 240.000,00	
TOTAL cost over concession	concession	€ 10.497.500,00	per km	€ 10.107.730,00	

Saving on fleet
€ -389.770,00

No ETS allowance costs assumed!
3,4 m l of diesel

arriva

a DB company

The e-BUSiness case – Gen 1 – non EU

CONCESSION INFORMATION	
Batch amount	10
Concessionperiod (year)	10 Yr
Km per year	80000 km

	1ST GENERATION 420 kWh		DIESEL BUS EURO VI	
	Input	Cost per year	Input	Cost per year
BUS				
Price Bus	€ 500.000,00	€ -	€ 300.000,00	€ -
Residual value bus after concession period	€ 30.000,00	€ -	€ 5.000,00	€ -
Depreciation bus per year		€ 47.000,00		€ 29.500,00
Interest	1,50%	€ 3.525,00	1,50%	€ 2.212,50
MAINTENANCE				
Maintenance average excluding tyres	€ 0,173	€ 13.800,00	€ 0,23	€ 18.400,00
Tyres average	€ 0,03	€ 2.400,00	€ 0,03	€ 2.400,00
Replacement battery pack after 10 years		€ -	N/A	€ -
ENERGY/FUEL CONSUMPTION				
Energy consumption per km (in kWh , Liters Diesel, L LNG)	01,20 kWh	€ -	0,43 lt	€ -
Energy cost per kW/hr, Lt diesel, Lt LNG, per year	€ 0,15	€ 14.400,00	€ 1,30	€ 44.720,00
Adblue consumption per km in Liter (6% of fuel consumption)	N/A	€ -	0,03 lt	€ -
Adblue price per liter €0,70	N/A	€ -	€ 0,70	€ -
Adblue cost per km , total	N/A	€ -	€ 0,02	€ 1.444,80
CHARGER				
Charger per electric bus, depreciation 90% in 10 years	€ 40.000,00	€ 3.600,00	N/A	€ -
Installation charger	€ 25.000,00	€ 2.500,00	N/A	€ -
TAXES				
Road tax per year	€ 7.000,00	€ 7.000,00	€ 2.400,00	€ 2.400,00

The e-BUSiness case – Gen 1 – non EU – Total Cost of ownership

TCO PER BUSES					
Bus + charger	per km	€ 0,71	per km	€ 0,40	
Maintenance + replacement batterypack	per km	€ 0,20	per km	€ 0,26	
Consumption	per km	€ 0,18	per km	€ 0,58	
Taxes	per km	€ 0,09	per km	€ 0,03	
TOTAL cost per kilometer	per km	€ 1,18	per km	€ 1,26	

TCO PER BUSES					
Bus + charger	concession	€ 5.662.500,00	per km	€ 3.171.250,00	
Maintenance + replacement batterypack	concession	€ 1.620.000,00	per km	€ 2.080.000,00	
Consumption	concession	€ 1.440.000,00	per km	€ 4.616.480,00	
Taxes	concession	€ 700.000,00	per km	€ 240.000,00	
TOTAL cost over concession	concession	€ 9.422.500,00	per km	€ 10.107.730,00	

Saving on fleet
€ 685.230,00

No ETS allowance costs assumed!
3,4 m l of diesel

arriva

a DB company

The e-BUSiness case – Gen 2

CONCESSION INFORMATION	
Batch amount	10
Concessionperiod (year)	20 Yr
Km per year	80000 km

	2nd GENERATION 363 kWh		DIESEL BUS EURO VI	
	Input	Cost per year	Input	Cost per year
BUS				
Price Bus	€ 600.000,00	€ -	€ 600.000,00	€ -
Residual value bus after concession period	€ 30.000,00	€ -	€ 10.000,00	€ -
Depreciation bus per year		€ 28.500,00		€ 29.500,00
Interest	1,50%	€ 4.275,00	1,50%	€ 4.425,00
MAINTENANCE				
Maintenance average excluding tyres	€ 0,196	€ 15.640,00	€ 0,23	€ 18.400,00
Tyres average	€ 0,03	€ 2.000,00	€ 0,03	€ 2.000,00
Replacement battery pack after 10 years + revision	€ 200.000,00	€ 10.000,00		€ -
ENERGY/FUEL CONSUMPTION				
Energy consumption per km (in kWh , Liters Diesel, L LNG)	0,90 kWh	€ -	0,43 lt	€ -
Energy cost per kW/hr, Lt diesel, Lt LNG, per year	€ 0,15	€ 10.800,00	€ 1,30	€ 44.720,00
Adblue consumption per km in Liter (6% of fuel consumption)	N/A	€ -	0,03 lt	€ -
Adblue price per liter €0,70	N/A	€ -	€ 0,70	€ -
Adblue cost per km , total	N/A	€ -	€ 0,02	€ 1.444,80
CHARGER				
Charger per electric bus, depreciation 90% in 10 years	€ 40.000,00	€ 1.800,00	N/A	€ -
Installation charger	€ 25.000,00	€ 1.250,00	N/A	€ -
TAXES				
Road tax per year	€ 7.000,00	€ 7.000,00	€ 2.500,00	€ 2.500,00

The e-BUSiness case – Gen 2 – TCO – Total Cost of ownership – 20 yrs business case

TCO PER BUSES					
Bus + charger	per km	€ 0,45	per km	€ 0,42	
Maintenance + replacement batterypack	per km	€ 0,35	per km	€ 0,26	
Consumption	per km	€ 0,14	per km	€ 0,58	
Taxes	per km	€ 0,09	per km	€ 0,03	
TOTAL cost per kilometer	per km	€ 1,02	per km	€ 1,29	

TCO PER BUSES					
Bus + charger	concession	€ 7.165.000,00	per km	€ 6.785.000,00	
Maintenance + replacement batterypack	concession	€ 5.528.000,00	per km	€ 4.080.000,00	
Consumption	concession	€ 2.160.000,00	per km	€ 9.232.960,00	
Taxes	concession	€ 1.400.000,00	per km	€ 500.000,00	
TOTAL cost over concession	concession	€ 16.253.000,00	per km	€ 20.597.960,00	Saving on fleet € 4.344.960,00

No ETS allowance costs assumed! 6,8 m l of diesel

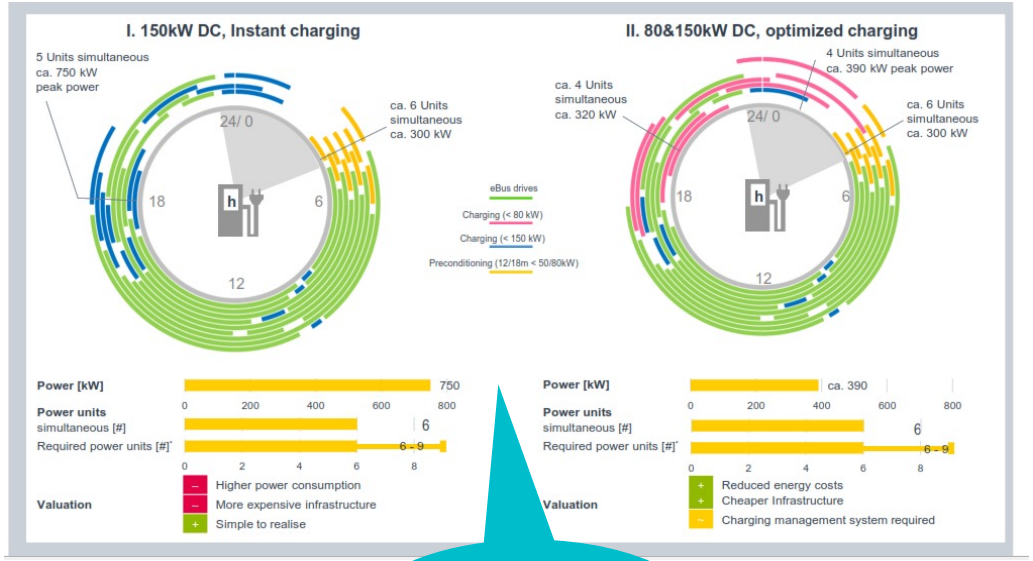
Over 10 years numbers even-out!

arriva

a DB company

Charging infrastructure - Planning of transport and charging - to optimize costs and investments

1. Length of overnight charging (8-9 hours), need for power and vehicles number define our **connection power** – infrastructural availability and our power reserve define whether we need additional infrastructure **(own sub-station).**
2. Use of infrastructure which allows for **power redistribution** as is needed.
3. Use of infrastructure which allows charging at higher power in period of **lower energy prices**.
4. Consider transfer **losses.**
5. Will we market the charging points and create additional **revenues?**



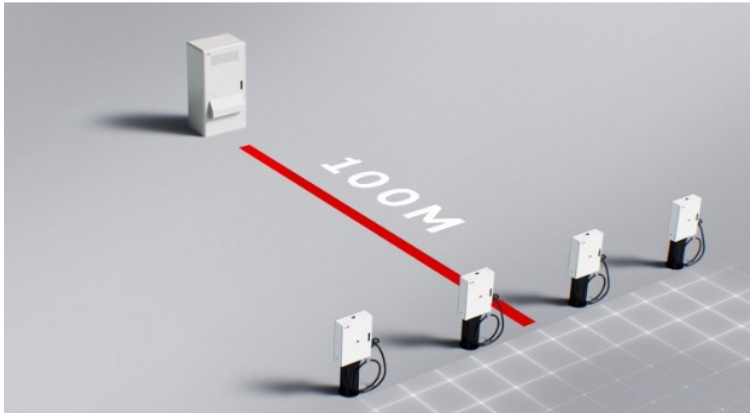
750 kW c/a
390 kW power needed

Source: MAN simulation for Arriva and City of Kranj

a DB company

New charging infrastructure - more brains and flexibility

1. To optimize costs, we need to control our charging;
2. Holistic power management for optimal connection power;
3. Power boxes where space is available and dispensers where space is limited.



Sources: ABB, Heliox, Kempower

arriva

a DB company

Standing buses – an opportunity to earn revenues and decrease costs

A – Load management

1. Dynamic Load Balancing
2. Smart Scheduling

B – Price-based optimization

1. Tariff/ Day-ahead
2. Imbalance Optimization
3. Intraday Optimization

C – Site Energy Control

1. Peak Shaving
2. BESS Command
3. Increase PV Self-consumption (HBE+)

D – Grid Services

1. Ancillary services (BSP)
2. Congestion Services (CSP)

Smart imbalance optimization

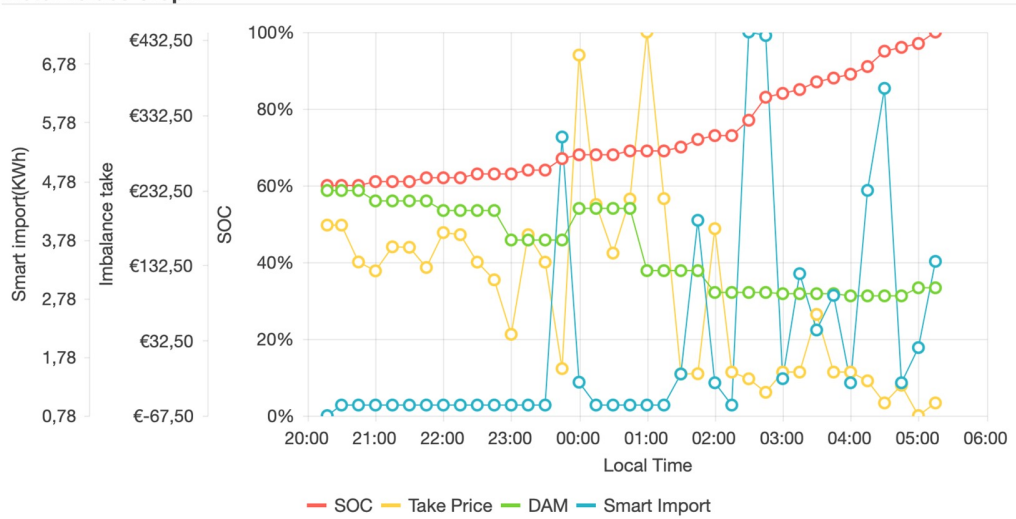
- A random charging session conducted on May 20th and 21st, 2022 at Arriva bus depot in Venlo, NL.
- The imbalance prices are shown in yellow, with charging power shown in blue.
- Based on the software‘s imbalance price predictions, the vehicle is charged while taking into account its time of leave.

Smart charging cost : 2.70 €
Greedy charging cost : 16.30 €
Smart charging cost : 35.47 €/MWh

Savings : 13.60 €
Savings : 83.43 %
Savings : 178.63 €/MWh

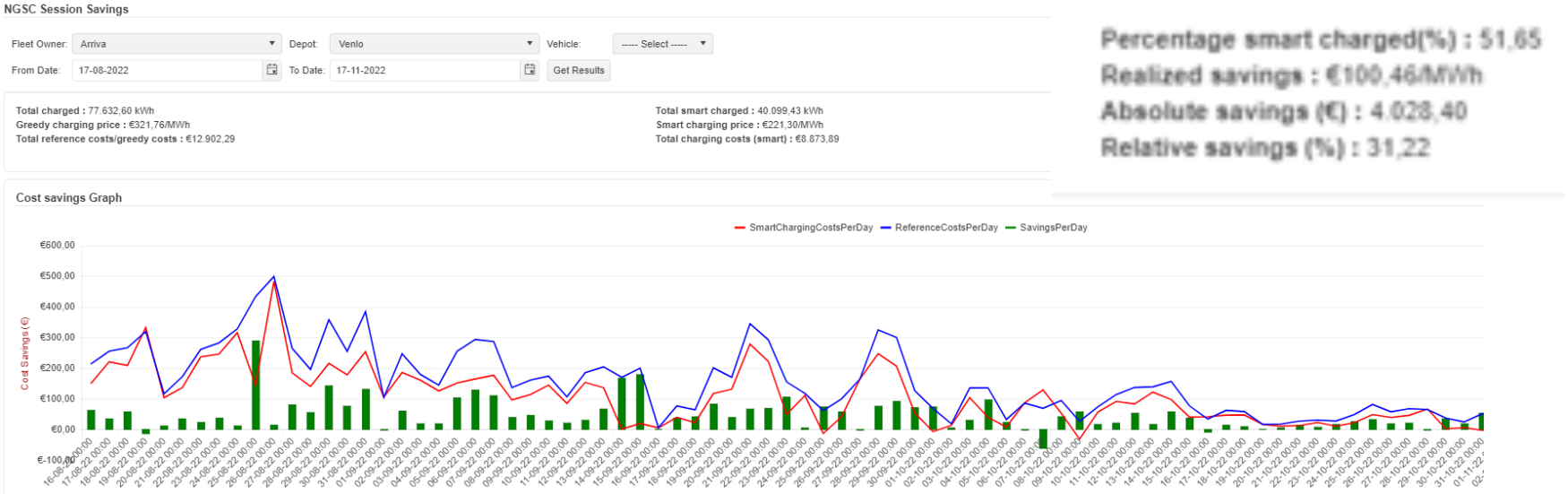
Start SoC : 59 %
End SoC : 100 %

Meter Values Graph



a DB company

Smart imbalance optimization – pilot results



a DB company

Our plans for the future

1. Electrify our 1st million km of our regional transport within 3 years (CEF Funding, GBER changes);
2. Electrify 100 %Urban transports by 2030;
3. Establish a Megawatt charging capacity in City of Kranj in agreement with the national transmission operator – ELES;
4. Combine¸private and public Charging in Koper Bus station to make more revenues and increase available charging infrastructure.

Sharing is caring – Any questions?

Iztok Štrukelj

Iztok.strukelj@arriva.si

+386 41 751 332