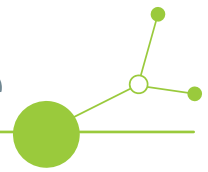


Deliverable D.3.2.2 Report on development of solutions to preserve value and reduce waste of public transport infrastructure

Definition of uptake criteria to re-use
trolleybus switches



Version 2

03 2026





DELIVERABLE D.3.2.2

Solution O3.6 - Definition of uptake criteria to re-use trolleybus switches

Project index number and acronym	CE0100250 CE4CE
Lead partner	LVB - Leipzig Transport Company
Deliverable number and title	D3.2.2 Report on development of solutions to preserve value & reduce waste of PT infrastructure
Responsible partner(s) (PP name and number)	PP4 SZKT
Contributors	Dr. Zoltán Ádám Németh, Gábor Jéga-Szabó
Project website	https://www.interreg-central.eu/projects/ce4ce/
Delivery date	31.03.2026
Status	Public
Dissemination level	Project



Authors and log change of the document

Partner No.	Partner Acronym	Name of the author	Action	Version
LP	Rupprecht Consult on behalf of LVB	Ana-Maria Baston	Template preparation	1
PP08	UM	Danijel Hojski	Template preparation	1.1
PP4	SZKT	Dr. Zoltán Ádám Németh	Provided input and data	1.2
PP4	SZKT	Gábor Jéga-Szabó	Provided input	1.3
PP4	SZKT	Dr. Zoltán Ádám Németh	Review and finalisation	2

Contents

1. Executive Summary	4
2. Project context	4
3. The objectives and scope of the solution.....	5
4. The solution concept	5
4.1 Summary description of the solution.....	6
4.2 Circular economy principles addressed.....	7
4.3 Identification of circularity gaps addressed	7
5. The solution development.....	7
5.1 Technical and functional requirements	7
5.2 Development and implementation.....	7
5.3. Operational use, performance and maintenance	9
5.4. Integration and transferability aspects	9
6. Challenges and lessons learned.....	10
7. Expected change	10
8. Sustainability, transferability and replicability.....	11
8.1 Sustainability	11



8.2 Transferability and replicability	11
9. Conclusions	11
10. Annexes.....	12
Annex 1: Procurement materials list (separate annex)	12
Annex 2: Media links	12



List of figures

Figure 1 Krummer & Matter switch	6
Figure 2 Elektroline high speed switch	6
Figure 3 Installation of new trolleybus switches	8
Figure 4 Installation of new trolleybus switches	9

1. Executive Summary

This report documents the pilot action carried out by Szeged Transport Company (SZKT) within the CE4CE project framework, focused on the renewal and circular reuse of trolleybus overhead electric switches. The pilot replaced four high-speed Elektroline switches in the revenue trolleybus network with new units, and relocated the replaced switches to the trolleybus depot, where they substituted four severely outdated K&M-like traction-current-operated switches. In total, eight switch locations were upgraded through this single investment, applying the circular economy principle of 'reuse'.

The core objective was to improve the operational safety and reliability of SZKT's trolleybus infrastructure at 8 locations simultaneously, while minimizing waste and investment costs by applying circular economy principles. The pilot also aimed to serve as a transferable model for urban public transport operators across Europe facing similar infrastructure renewal challenges.

- 4 new Elektroline high-speed radio-controlled switches installed in the revenue network (switch No. 502, 510, 904, 1004).
- 4 relocated Elektroline switches installed in the depot (switch No. T06, T07, T08, T11), replacing unreliable K&M-like units.
- Reduced risk of current collector derailment and service disruptions across all 8 locations.
- Circular economy approach demonstrated as replicable across all types of public transport infrastructure (tram rails, switches, masts, etc.)

2. Project context

The CE4CE project empowers circular economy system thinking for actors in public transport from Central European countries to reduce waste and create value along new life cycles of infrastructure and rolling stock. To achieve this, CE4CE jointly develops solutions that enhance knowledge and capacities for the sector, reduce barriers and costs, and initiate the development of new services and skilled jobs. Additionally, the project focuses on strategies and action plans that support policy development, learning, and exchange at both regional and transnational levels.

One of key aspects of CE4CE's initiatives is the implementation of pilot actions that demonstrate and validate circular economy principles in public transport. By applying these principles in real-world settings, CE4CE aims to create new value chains, optimize resource efficiency, reduce costs, and foster innovation within the sector. These pilot initiatives serve as practical examples of how circular economy strategies can



be integrated into public transport operations, ultimately contributing to a more sustainable and resource-efficient mobility system.

To achieve this, CE4CE pilots will test solutions that enhance knowledge and capacities for public transport stakeholders, address regulatory and financial barriers, and support the development of new services and job opportunities. The results of these pilots will contribute to shaping policies, guiding investments, and facilitating knowledge exchange at both regional and transnational levels.

Furthermore, CE4CE pilot actions will enable cooperation among key transport actors to co-develop and refine processes that integrate circular economy principles. This includes innovative procurement strategies, circular business models, extended life-cycle assessments, and cost-benefit methodologies.

3. The objectives and scope of the solution

SZKT operates 37 km trolleybus catenary with 45 electric overhead switches. These switches are critical safety elements: a faulty switch can cause current collector derailment, damaging vehicles and causing delays that affect the 35,000 daily users of the trolleybus system. Older switches in the depot used an outdated traction-current setting method (K&M-like type), which is highly unreliable and for which no spare parts are available.

The objective of this pilot was to exchange four ageing high-speed Elektroline switches in the revenue network with brand-new units, and to reuse the displaced switches in the depot to replace the K&M-like units – improving safety and reliability at 8 locations with a single procurement, in line with circular economy principles.

- SZKT operations and maintenance staff (direct beneficiaries of improved infrastructure reliability).
- Trolleybus passengers (35,000 daily users) benefit from improved service reliability and safety.
- Urban public transport operators across CE4CE partner regions and beyond, as potential adopters of this circular approach.

4. The solution concept

SZKT's trolleybus network had been operating Elektroline high-speed switches with automatic radio control since 2015. A number of these, installed between 2005 and 2014, were identified as needing replacement in the revenue network due to age and wear (used 200-300 times/day). Simultaneously, the trolleybus depot contained several K&M-like switches with traction-current operation – an obsolete technology with no spare parts supply and very high derailment risk.

The pilot action replaced four network switches (No. 502, 510, 904, 1004) with new Elektroline units and redeployed the replaced Elektroline switches at four depot locations (No. T06, T07, T08, T11), replacing the K&M-like switches. Since depot switches are used only 20-30 times/day, the relocated Elektroline units – though older – remain fully suitable for depot conditions.

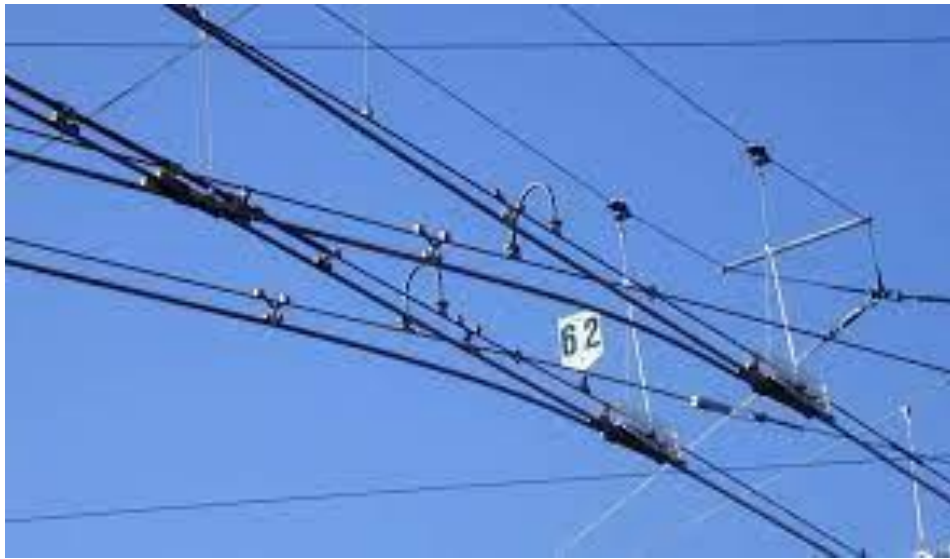


Figure 1 Krummer & Matter switch



Figure 2 Elektroline high speed switch

4.1 Summary description of the solution

The solution leverages a two-tier infrastructure model: a high-frequency revenue network requiring new, high-reliability equipment; and a low-frequency depot environment where older but still functional equipment can be acceptably reused. By matching the lifecycle state of equipment to the operational demands of each tier, SZKT achieved infrastructure improvement at double the locations compared to a conventional procurement approach.



4.2 Circular economy principles addressed

- Reuse: Elektroline switches removed from the revenue network were directly reused in the depot, extending their operational life.
- Waste reduction: The displaced Elektroline switches were not discarded; the K&M-like switches removed were the only waste generated.
- Resource efficiency: Investment in four new switches resulted in improvement at eight locations – doubling the impact per unit cost.

4.3 Identification of circularity gaps addressed

The conventional approach to infrastructure renewal in public transport does not systematically differentiate between the performance requirements of revenue network assets and depot/siding assets. This results in perfectly usable equipment being discarded prematurely, while high procurement costs prevent comprehensive upgrades. This pilot directly addresses this circularity gap by establishing a structured 'cascade reuse' framework for trolleybus and tram infrastructure.

5. The solution development

5.1 Technical and functional requirements

The pilot action did not require formal regulatory authorisation under Hungarian law, as the switch replacement falls within the operational authority of the public transport company. Quality requirements for the new switches were determined by SZKT's internal trolleybus catenary standards. The selection of switch locations was approved by the infrastructure department, traffic operations department, and the Chief of Railway Safety.

The main technical constraint was the varying age and condition of the surrounding infrastructure elements (catenary, masts, and mast foundations dating from 1979 to 2010), which required careful assessment during installation planning.

5.2 Development and implementation

The main milestones of the implementation are summarised in the table below:

Milestone	Description
Pilot design	The project definition was put together during the application for the CE4CE project.
Stakeholder engagement and joint development	Preparations were mainly internal within SZKT, since the pilot action mainly concerns different departments of SZKT.



Feasibility study and preparation	Internal preparation involving SZKT traffic operation and infrastructure maintenance departments.
Procurement process	Preparation of material list: 2024 Q1-Q2. Public procurement contract signed: 30 September 2024. Materials delivered: 24 November 2024.
Pilot implementation	Implementation carried out by SZKT overhead maintenance crew. Timeline was determined by crew availability alongside regular maintenance duties.
Operational launch	The last switches in the depot were installed in September 2025.
Monitoring and evaluation	Regular switch operation monitoring is continuous since installation, using regular maintenance operation processes.
Reporting and documentation	Data collection and analysis is performed through the reporting process.

Once materials were delivered (24 November 2024), the SZKT overhead maintenance crew planned the installations in coordination with:

- SZKT Traffic Department - organised trolleybus replacement bus service during installation works.
- Road Authority - involved for approximately 18 hours of road works.
- SZKT Technical Department - coordinated voltage shutdown required for depot installations.

After installation in the revenue network, a temporary period of manual radio control operation was necessary for the new switches, as the VETRA remote monitoring/control system integration was completed a few weeks after physical installation.



Figure 3 Installation of new trolleybus switches



Figure 4 Installation of new trolleybus switches

5.3. Operational use, performance and maintenance

All installed switches (both new units in the network and relocated units in the depot) are now under the standard maintenance regime of SZKT's trolleybus catenary system. This system is part of SZKT's railway infrastructure, regulated through Railway Safety Protocols – specifically BIE-07 (Maintenance and Supervision of SZKT Catenary). These protocols define inspection intervals, maintenance procedures, and documentation requirements ensuring long-term reliable operation.

The KPIs of the pilot are long-term in nature and require several years of operational data to assess definitively. Monitoring is ongoing using regular maintenance operation processes. The defined KPI framework is as follows:

Category	Indicator	Unit	Status
Operation	Current collector derailment (revenue operation)	pcs.	Monitoring ongoing
Operation	Current collector derailment (depot)	pcs.	Monitoring ongoing
Operation	False switch setting (revenue operation)	pcs.	Monitoring ongoing
Operation	False switch setting (depot)	pcs.	Monitoring ongoing
Infrastructure	Switch damage	pcs.	Monitoring ongoing

5.4. Integration and transferability aspects

The concept is directly transferable to any urban rail or trolleybus operator that maintains both a revenue network and a depot/siding infrastructure. The fundamental principle – matching the lifecycle state of



assets to the operational intensity of each network tier – applies broadly to tram rails, switches, masts, overhead wire, and other infrastructure elements. The pilot establishes a replicable model that requires only an internal assessment of asset condition and location-specific performance requirements.

6. Challenges and lessons learned

The project was relatively low risk given its internal focus within SZKT. The principal technical challenge was the heterogeneous state of the surrounding infrastructure at each switch location – masts and foundations spanning over 40 years of construction (1979-2010) required careful individual assessment before installation. No unexpected issues arose, and the SZKT overhead maintenance team's established troubleshooting protocols were available as contingency.

A key operational challenge was scheduling: the overhead maintenance crew also carries out regular maintenance duties, so installation windows had to be coordinated carefully to avoid conflicts with routine operations and service.

The temporary period of manual radio control following network switch installation (before VETRA system integration) was an anticipated minor inconvenience, managed through standard operational procedures.

The main lesson learned is the importance of systematically cataloguing infrastructure assets by operational intensity tier (revenue vs. depot/siding), as this creates a clear, evidence-based basis for circular reuse decisions. Public transport operators often lack this structured view, which prevents them from identifying circular opportunities that are, in practice, straightforward to implement.

7. Expected change

The pilot action is expected to generate the following results, lasting effects, and benefits:

- **Improved operational safety:** Elimination of unreliable K&M-like switches in the depot removes a significant source of current collector derailments, protecting both vehicles and infrastructure.
- **Higher service reliability:** New switches in the revenue network reduce false switch settings and associated delays, directly benefiting the 35,000 daily trolleybus passengers and the approximately 5,500 vehicle-km operated daily (approximately 30% of Szeged's total public transport volume).
- **Reduced environmental impact:** Reuse of Elektroline switches extend the operational life of existing equipment and reduces waste, contributing to a lower environmental footprint compared to a full replacement approach.
- **Cost efficiency:** Investment in 4 new switches achieved improvement at 8 locations, demonstrating a cost-effective infrastructure renewal model.
- **Organisational learning:** SZKT's internal departments have developed experience in circular infrastructure management that can be applied to future renewal cycles



8. Sustainability, transferability and replicability

8.1 Sustainability

The long-term operation of all installed switches is assured through SZKT's Railway Safety Protocol BIE-07, which governs the maintenance and supervision of SZKT's entire catenary system, including both trolleybus and tram overhead infrastructure. This regulatory framework ensures structured inspection, maintenance, and documentation of the newly installed switches as part of normal operational practice – with no additional organisational mechanisms required.

The trolleybus system itself serves as a cornerstone of Szeged's sustainable transport strategy: it is electric, low-emission, and carries approximately 30% of the city's public transport volume. Maintaining and improving the reliability of this system directly supports the long-term sustainability of urban mobility in Szeged.

8.2 Transferability and replicability

The circular reuse approach demonstrated in this pilot is directly transferable to any urban rail or trolleybus operator. The core concept – systematically differentiating between revenue network and depot/service area performance requirements and matching asset lifecycle stages accordingly – applies to:

- Trolleybus overhead switches (as demonstrated).
- Tram rails and track switches – depot usage is a fraction of network usage, making reuse of network-removed rails in depots a natural fit.
- Overhead masts and catenary wire segments.
- Any infrastructure element where a high-use and low-use environment coexist within the same organisation.

SZKT intends to introduce this pilot action to the public transport professional community, drawing attention to the potential of systematic circularity analysis in infrastructure asset management. The model can be adopted by operators of any scale with minimal adaptation, requiring only an internal audit of asset condition and usage intensity by location.

9. Conclusions

The SZKT trolleybus electric switch replacement pilot has successfully demonstrated that circular economy principles can be practically and effectively applied in urban public transport infrastructure management. Through a single procurement of four new Elektroline switches for the revenue network, and the cascade reuse of the displaced switches in the trolleybus depot, SZKT achieved safety and reliability improvements at eight locations – doubling the infrastructure impact per unit of investment.

All installations were completed by September 2025 and are now under standard operational monitoring. No significant implementation issues arose. The pilot was delivered within SZKT's organisational capacity, involving internal departments and standard public procurement processes.

This pilot directly advances the CE4CE project's objectives by:



- Demonstrating a concrete, replicable circular economy solution in public transport infrastructure, a sector with high potential for circularity that is often overlooked.
- Providing a transferable model for CE4CE partner regions and European public transport operators.
- Reducing waste and material consumption in infrastructure renewal – contributing to CE4CE's overarching environmental and circular economy targets.
- Strengthening the operational sustainability of Szeged's electric public transport system, which serves 35,000 passengers daily and represents approximately 30% of the city's total public transport volume.

10. Annexes

Annex 1: Procurement materials list (separate annex)

Annex 2: Media links

Press event and reports about the overhead trolleybus switches pilot action
<https://szkt.hu/sajtomegjelenesek-2025-04-29>