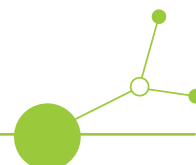# Report on joint implementation, testing and evaluation of the CE4CE public transport circularity platform

Deliverable D1.2.2 (Output 1.2)

Version 1
June 2024

Contents

Table of figures

List of abbreviations

Public transport	PT
Circular economy	CE
The CE4CE project - Public Transport Infrastructure in Central Europe – facilitate transitioning to circular economy	CE4CE, the project
The CE4CE circularity in public transport knowledge platform	The CE4CE knowledge platform
Renewable energy sources	RES
Public transport operator	PTO
Public transport authority	PTA
The Public Transport Circular Economy Self-Assessment Survey	The self-assessment survey
Project partner	PP

1. Project context and background information

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 do so, CE4CE jointly develops solutions that increase knowledge and capacities for the sector, help reduce barriers and costs, and initiate the development of new services and skilled jobs, as well as strategies and action plans that improve policy development, learning and exchange on the regional and transnational level. CE4CE aims at bringing circular economy principles into the public transport sector and,

thus, reduce waste, increase efficiency in the sector and improve the ecological footprint of public transport.

Furthermore, stakeholders from the public transport community will cooperate in CE4CE to jointly develop and adapt processes and solutions as key enablers for the integration of circular economy principles, like data sharing concepts, new (innovation) procurement guidance, product and business model designs, extended life-cycle assessment, and cost-benefit analysis methodologies.

CE4CE will jointly develop outputs based on co-creation and peer reviews for take up by the public transport sector, e.g. pilot actions and solutions such as the CE4CE Circularity Compass for public transport, the CE4CE Circularity Knowledge platform, a web-based second-hand marketplace, strategies and pilot actions to increase resource-efficiency and pilots demonstrating use more, reuse and recycle approaches for the public transport sector.

CE4CE's partnership reflects the whole value chain and transport sector system perspective including 11 project partners from 6 Central European countries, ranging from public transport authorities/operators, industry and research to interest groups. The complete list of project partners can be checked below and on the project website:

1. Leipzig Public Transport Company, Germany (lead partner)
2. Przedsiębiorstwo Komunikacji Autobusowej w Gdyni sp. z o.o., Gdynia, Poland
3. University of Gdansk, Poland
4. Szeged Transport Company, Hungary
6. Kruch Railway Innovations GmbH & Co.KG., Vienna, Austria
7. Municipality of Maribor, Slovenia
8. University of Maribor, Slovenia
9. ATB Mobility S.p.A., Bergamo, Italy
10. Redmint social enterprise, Milan, Italy
11. Mobilissimus Ltd., Budapest, Hungary
12. trolley:motion, Austria.

To enlarge this cooperation, associated partners like the international active networks ICLEI European Secretariat[1], UITP Trolleybus Committee[2] and EIT Urban Mobility Innovation Hub East[3] are strategically involved to maximise communication outreach and knowledge transfer of project results.

This document is the project deliverable D1.2.2, corresponding to the project output O.1.2 - The CE4CE public transport circularity knowledge platform. It aims at presenting the concept, usability and scope of our solution.

This document is organized as follows:

- Chapter 2 presents a short introduction
- Chapter 3 addresses the user needs analysis
- Chapter 4 addresses the concept development and design

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[1] https://iclei-europe.org/topics/circular-economy/

[2] https://www.uitp.org/topics/trolleybus/

[3] https://www.eiturbanmobility.eu/our-hubs/innovation-hub-east/

- Chapter 5 is explains the platform outlook and functionalities.
- Chapter 6 focuses on further development, exploitation and sustainability of the platform.
- Chapter 7 presents annexes to the document.

The document has been prepared by the team of experts from Rupprecht Consult Forschung & Beratung GmbH, under the supervision of the Lead Partner Leipzig Public Transport Company, Germany.

2. Introduction

The CE4CE circularity in public transport knowledge platform – in short, the CE4CE knowledge platform or the platform - is an online repository of tools, resources, best practices and learning materials that enable the introduction of the circular economy principles and methods in public transport. The CE4CE knowledge platform aims to identify and represent the skills and knowledge required for the successful introduction and implementation of circular economy principles in public transport. The platform is one of the project's solutions that responds to the need of the public transport sector of understanding how to increase efficiency, improve the management of resources, and reduce costs through learning and exchange.

Nowadays, organizations are increasingly reliant on comprehensive, accessible, and well-structured digital platforms to facilitate the exchange and dissemination of information. An online knowledge platform is thus a strategic solution designed to meet these needs by providing a centralized repository for information, resources, tools and methodologies tested and validated within the project. This report explains the concept and structure of the online knowledge platform, outlining its core components, functionalities, and benefits. By offering a detailed overview of how such a platform operates and the principles underpinning its design, we aim to highlight its significance in up taking of circularity principles, fostering innovation, enhancing productivity, and supporting continuous learning within the public transport sector.

3. The user needs analysis

Understanding who the key stakeholders of the knowledge platform are is crucial for an effective user needs analysis and management. The user needs analysis focus on the stakeholder identification, analysis of the current situation in the sector to identify areas where circular economy principles can be integrated, identifying and understanding the user needs and expectations, and responding to these needs by offering a comprehensive collection of useful resources.

3.1. Results from the needs assessment

At the start of the development process, a needs assessment was conducted to identify the potential knowledge gaps, skills needed and specific target groups that the knowledge platform will respond to.

The public transport sector plays a crucial role in urban mobility, contributing to economic development and environmental sustainability. However, it also faces significant challenges such as resource consumption, waste generation, and carbon emissions. By integrating circular economy principles, the sector can enhance its sustainability, efficiency, and resilience. The analysis that the CE4CE team made was conducted both in the framework of testing the pilot O1.1 The Circularity Compass and on defining the solution O1.2. the CE4CE knowledge platform. The analysis aimed at identifying current practices, opportunities and challenges in the four key areas within the public transport sector where circular economy principles can be effectively integrated. Starting from this point, the user needs analysis concentrated on the main four topics that the CE4CE project addresses:

1. **Infrastructure:** the public transport infrastructure refers to the underlying system of built and fixed structures, installations and facilities that support public transport operational activities. Circular infrastructures maximise resource efficiency, prioritize using, reusing, and recovering low-carbon and high-quality materials, and are designed for durability and disassembly.

2. **Vehicles/ rolling stock:** Circular economy principles can be applied to public transport vehicles, including buses, trolleybuses, trams, and trains, as well as their batteries, to enhance sustainability and resource efficiency. The circular economy principles applied to different types of public transport vehicles look closely at aspects like design durability and modularity, remanufacturing and refurbishment, battery recycling and second life applications, circular procurement and supply chains, data-driven maintenance and optimization, but also at collaboration and partnerships within the industry.

3. **Energy:** Circular economy principles can significantly influence the energy aspect of public transport, promoting sustainability, efficiency, and resource conservation. Aspects such as renewable energy integration, energy recovery and storage, or smart energy management systems are important to embrace circular principles in the public transport energy management, enhance operational efficiency, and contribute to the transition towards more sustainable and resilient systems.

4. **Governance:** Circular economy principles can be integrated into the governance and policy making of public transport systems to promote sustainability, resource efficiency, and resilience. Through policy alignment, regulatory frameworks, funding and incentives, monitoring, knowledge sharing and participation, the public transport sector can transition towards a more sustainable, resilient, and resource-efficient one.

In conclusion, integrating circular economy principles into the public transport sector presents a substantial opportunity to enhance sustainability, operational efficiency, and economic viability. By focusing on sustainable procurement, efficient resource utilization, waste reduction, renewable energy adoption, and adaptable infrastructure, public transport systems can transition towards more circular models. This shift not only supports environmental goals but also improves service delivery and reduces costs, ultimately benefiting both the operators and the communities they serve.

Identifying and understanding the user needs and expectations

This analysis aimed to identify and elaborate on key needs and expectations, ensuring that circularity and resource efficiency initiatives align with user priorities. The analysis was conducted in the framework of working interviews with the project partners conducted at the start of the project in the framework of piloting the circularity compass. These interviews helped shed light on the needs of PTOs and PTAs involved in the project and managed to draw conclusions on the current market needs in Central Europe:

Public transport operators – needs and expectations

- Operational efficiency → maximizing vehicle uptime and minimizing maintenance costs.

- Cost efficiency → lowering expenses through efficient resource use and waste management.

- Compliance → adhering to environmental regulations and standards.

- Durability and sustainability → vehicles and infrastructure designed for longer life cycles.

- Training and support → training for staff on circular economy practices and resource-efficient operations.

- Best practices → case studies and guidelines on implementing public transport policies.

- Innovation → Incorporating cutting-edge technologies to improve service and sustainability.

Public Transport Authorities

- Sustainability goals → meeting local, national, and international sustainability targets.

- Public satisfaction → ensuring high levels of user satisfaction and community support.

- Economic viability → balancing budget constraints with the need for infrastructure investments.

- Policy Implementation → effectively rolling out policies that promote circularity and resource efficiency.

- Sustainable infrastructure → development of infrastructure that supports circular economy principles.

- Monitoring and evaluation → effective systems to track progress towards sustainability goals.

- Public engagement → encouraging public participation in sustainability initiatives.

Government bodies and other public institutions

- Regulatory information → up-to-date information on national and international transport regulations and policies.

- Funding mechanisms and sources → identification of funding mechanisms, financial incentives, grants and subsidies to support circular economy projects in public transport.

- Technical assistance → access to technical assistance and consultancy services to design and implement circular economy projects.

- Data and statistics → access to data and analytics to inform policy decisions.

- Innovations and trends → information on the latest innovations and trends in public transport.

Public transport passengers and community members

- Reliability and efficiency → passengers expect reliable and timely services with minimal disruptions.

- Affordability → cost-effective transport options are a priority.

- Comfort and convenience → clean, safe, and comfortable travel experiences.

- Environmental impact → increasingly, passengers value sustainable practices and lower carbon footprints in their transport choices.

- Eco-friendly options → availability of transport options that are less harmful to the environment.

- Awareness and information → clear information about the environmental benefits of the transport options available.

- Incentives → rewards or discounts for choosing sustainable transport options.

Technology and service providers, manufacturers and innovators

- Market insights → information on the current state and future trends of public transport technology.

- Partnership opportunities → opportunities for collaboration with transport operators and authorities.

- Innovation showcases → platforms for showcasing new technologies and solutions.

- Standards and regulations → information on standards and regulatory requirements for transport technology.

Environmental groups and international networks

- Sustainable practices → adoption of practices that protect and preserve the environment.

- Reduced environmental impact → minimizing air and noise pollution from public transport.

- Transparency → clear reporting on environmental impacts, resource use and sustainability initiatives.

- Advocacy and awareness → promoting the adoption of best practices in circular economy and resource efficiency.

- Partnerships → collaboration on projects that enhance sustainability in public transport.

Experts and researchers

- Research materials → access to research papers, articles, and case studies on public transport.

- Data and analytics → comprehensive datasets for conducting research and analysis.

- Collaboration opportunities → platforms for collaborating with other researchers and institutions.

- Trends and innovations → information on the latest research trends and technological advancements in public transport.

Potential strategies for meeting user needs and expectations have been identified within the partnership: circular solutions related to infrastructure, vehicles/ rolling stock and energy, sustainable policies, circular procurement and business planning tools, training and support, collaborative initiatives, second hand market for PT products.

Based on this analysis, the CE4CE knowledge platform was developed to bring together resources on different topic areas and for different target groups, but with the overall goal of providing a one-stop-shop access point to support planning for circular public transport systems.

The assessment results have been integrated in a dedicated section on the platform, namely its competence map. The competence map aims to identify and represent the skills, expertise, capabilities, and knowledge required across various functions and roles for the successful introduction and implementation of circular economy principles in public transport. The competence map is built on the 10 principles of the circular economy and follows the different threads detailed in the CE4CE circularity compass. A visual representation of the competence map and the relationship between the competence areas has been prepared and it is published in the respective section. The graphic explains in an easy and understandable way the main topics the platform will build competences upon, having at the core the results of all activities that the project partners will be conducting throughout the project.

3.2. Key aspects related to the skills market

The transition to a circular economy is not merely a shift in economic models but also a transformation that impacts employment and necessitates the development of new skills. As policy initiatives like *the European Green Deal* [4] drive this transition forward, understanding the skill needs and challenges becomes imperative. The CE4CE Knowledge Platform explores the evolving landscape of skills required for the circular economy, and matches them with tools, resources, best practices, webinar recordings and training materials to help experts acquire the necessary knowledge for up- and reskilling of the public transport sector in Central Europe.

Evidence suggests that most green jobs require upskilling rather than reskilling, indicating a need to build upon existing skill sets. This emphasizes the importance of continuous learning and adaptation to meet the evolving demands of the circular economy in different sectors such as public transport.

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[4] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Effective policymaking in skill development requires robust data on skill needs and trends. Harmonized statistics on skills for circularity, regularly disseminated through platforms like *Eurostat*[5], are essential for informed decision-making and monitoring progress towards circularity goals. As the circular economy transition gains momentum, addressing skill needs becomes paramount for ensuring a smooth and inclusive transition. By understanding the evolving landscape of skills and implementing targeted strategies for upskilling, policymakers and stakeholders can navigate the challenges and unlock the full potential of the circular economy.

In 2021, forecasts indicated that the adoption of the European Green Deal would not only spur employment growth, but also generate approximately 2.5 million new jobs. Bachus, author of a chapter in *The Circular Economy and Green Jobs in the EU and Beyond*[6] highlights the positive employment outcomes and emphasizes the need for upskilling workers to meet the demands of circularity.

Despite the projected growth in employment, challenges persist in defining and comprehensively assessing the skills required for circularity. The European Economic and Social Committee's study *Europe's Circular Economy and its Pact for Skills: working together for an inclusive and job-rich transition?*[7] - published in 2023 - identifies constraints such as the lack of clear definitions and comprehensive data on skill needs, hindering effective skill development strategies.

In conclusion, improved skills in the public transport sector on the topic of circular economy can be acquired through trainings, knowledge and exchange offered within the CE4CE Knowledge Platform.

3.3. Usability and target groups

The target groups of the knowledge platform are characterized by a relatively high diversity in technological knowledge in circular economy, maintenance, energy engineering, infrastructure, and transport planning. They either work for Public Transport companies or authorities, transport planning departments in municipalities or regional institutions, or are political decision-takers, or industry suppliers. To achieve better integration of circular principles in public transport systems, it is important to give access to knowledge resources that are easily accessible and comprehensive, but also advanced, depending on the education and work-context of the target groups.

The main target group is formed of stakeholders from the public transport sector, that include but are not limited to:

- Public transport authorities: overseeing the implementation of policies and operational standards.

- Public transport operators: companies that operate buses, trains, trams, and other public transport services.

- Government bodies and other public institutions: policy makers and regulators.

- Suppliers and manufacturers: providers of vehicles, infrastructure, and materials.

- Maintenance and service providers: entities responsible for the upkeep of public transport infrastructure and vehicles.

- Experts and researchers in the field of public transport, circular economy, sustainability, electrification.

- Urban planners and infrastructure developers who are planning and designing new public transport routes and infrastructure and are implementing sustainable and circular urban mobility solutions.

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[5] https://ec.europa.eu/eurostat
[6] https://feps-europe.eu/publication/852-the-circular-economy-and-green-jobs-in-the-eu-and-beyond/
[7] Europe's Circular Economy and its Pact for Skills: working together for an inclusive and job-rich transition? | EESC (europa.eu)

- Environmental groups: organizations advocating for sustainable and circular practices.

A CE4CE knowledge platform dedicated to circularity in public transport must thus cater to a wide array of target groups, each with specific needs and expectations. By providing tailored resources and functionalities for public transport authorities, operators, urban planners, academics, environmental advocates, passengers, and technology providers, the CE4CE platform aims at facilitating knowledge sharing, innovation, and collaboration across the sector. This comprehensive approach ensures that all stakeholders can access the information and tools they need to contribute to a more efficient, sustainable, and user-friendly public transport system.

4. The knowledge platform concept design

The determination of the scope and usability of the knowledge platform was carried out together with all project partners. It was clear that the structure should be based on the one of the Circularity Compass. During the interviews and discussions, a joint definition of the structure of the competence map was reached. In addition, research and collection of existing qualification and training offers on relevant topics of the circular economy for public transport was carried out.

The main goals of the knowledge platform can be summarized as follows:

- ✓ To identify and represent the skills and knowledge required for the successful introduction and implementation of circular economy principles in public transport (PT)
- ✓ To increase knowledge and capacities of stakeholders in public transport to identify circularity gaps
- ✓ To provide tools to close these gaps in own organisations through co-creation (circularity compass) and training.

4.1. Examples of existing platforms and potential synergies

In the preliminary phase of the conceptualisation, a market analysis was conducted to understand the position the product on the market and to ensure in this way its originality and potential for exploitation and sustainability.

The lead partner and other partners have been previously involved in the Interreg Europe project EfficienCE, within which a tool repository has been developed: https://tools4efficience.eu/ The experience and lessons learnt from the EfficienCE tool repository has been assessed and contributed greatly in the CE4CE knowledge platform conceptualisation stage. The EfficienCE Tool Inventory filled a gap around energy efficiency capacities in public transport. It represented the only collection of knowledge resources and tools in the field of energy efficiency in public transport and continued to be managed and maintained by the EfficienCE project manager Rupprecht Consult (subcontracted by EfficienCE Lead Partner City of Leipzig) after the end of the project in 2023. The EfficienCE Tool Inventory will be promoted through the new CE4CE platform to complement the knowledge on circularity with the specific topic of energy efficiency in public transport, thus ensuring its sustainability further on.
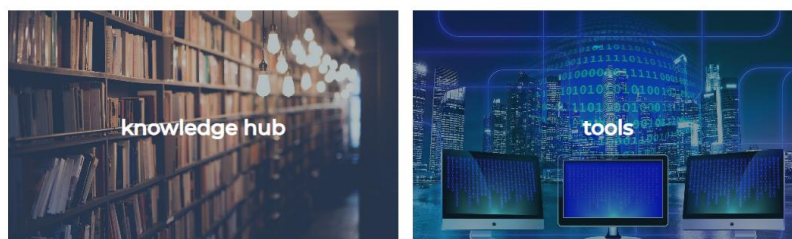
Figure 1 Screenshot of the Interreg Central Europe EfficienCE tool repository

Another source of inspiration analysed during the conceptualization phase was represented by the European Circular Economy Stakeholder Platform of the European Commission[8]. The platform is a joint initiative d the Commission and the European Economic and Social Committee. It features a rich collection of resources tools, and it provides regular updates related to events, news and possibility of networking within the partnership. During the assessment, the CE4CE partnership identified a potential knowledge gap represented by circularity in the public transport sector which is not sufficiently covered on the European platform. This insight led to the conclusion that the CE4CE project can bring an added value from the public transport perspective through the knowledge that the partnership will be catering within their activities.
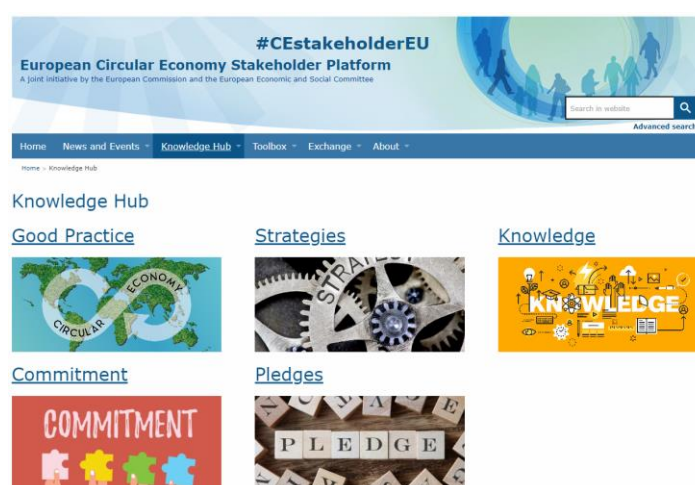
Figure 2 Screenshot of the European Circular Economy Stakeholder Platform

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[8] https://circulareconomy.europa.eu/platform/en

Moreover, a map of the circular economy-related initiatives of the past years initiated, either funded or supported by the EIT Knowledge and Innovation Communities[9] namely EIT Raw Materials, EIT Climate-KIC, EIT Digital, EIT Food, EIT Manufacturing and EIT Urban Mobility, shows that there are less projects funded by the initiative on the topic of public transport:
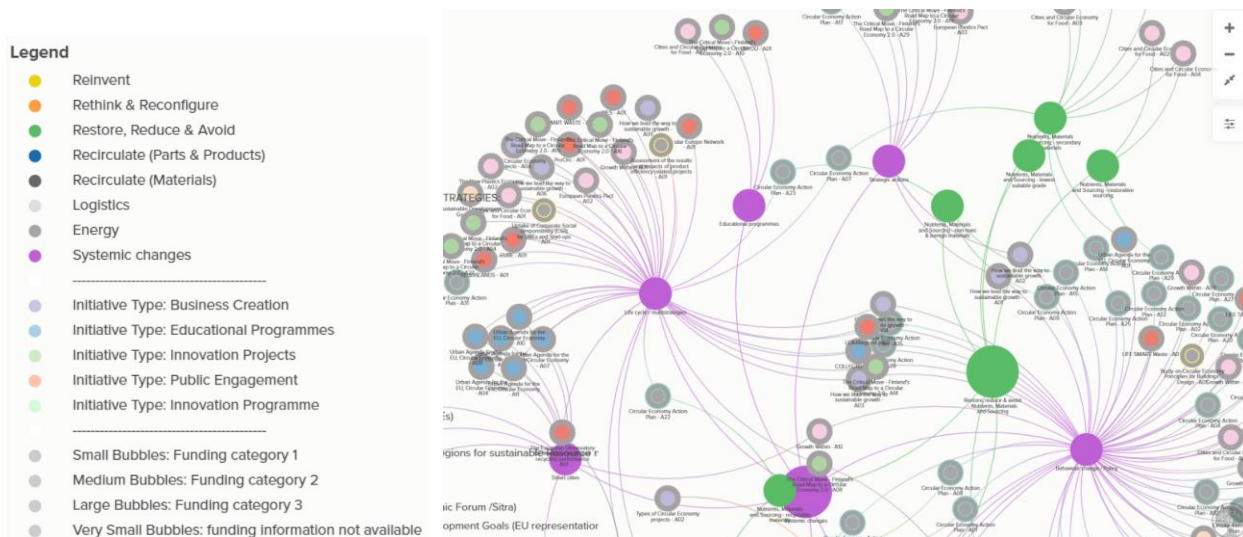
Figure 3 Map of the circular economy-related initiatives and projects funded by EIT

In the use analysis process, important feedback has been provided by the project partners who are leading the development of strategies to integrate circular principles into the infrastructure, vehicles/ rolling stock and energy aspects of the PT sector (part of work package 2) and who conducted a desk research to identify the status quo in the field of circularity processes and actions taken by public transport actors in the field of infrastructure, rolling stock and energy. After analysing the above-mentioned platforms and with the feedback of the partners, the conclusion drawn was that valuable knowledge is scattered across multiple sources, such as academic journals, industry reports, online forums, and online databases. This fragmentation makes it challenging to locate and synthesize relevant information. The knowledge platform will centralize these disparate sources on the topic, creating a comprehensive repository that is easily navigable and searchable.

In conclusion, the platform has the potential to critical knowledge gaps that exists in the public transport sector. These gaps stem from a lack of centralized, accessible, and up-to-date information, which can hinder innovation, efficiency, and informed decision-making. By addressing these gaps, the CE4CE knowledge platform will empower PT organisations and experts to leverage expertise effectively.

4.2. The concept of the CE4CE knowledge platform

The concept of the knowledge platform has been developed together with the concept of the circularity compass (output O1.1) and it is based on the 10 Rs of circular economy adapted to the public transport context. Adapting the 10 Rs of circular economy to the public transport context involved rethinking how resources are utilized, managed, and preserved within the system. The graphic below shows the result of

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[9] https://www.eit-circulareconomy.eu/system-maps/eu-stakeholders-circular-economy-initiatives/

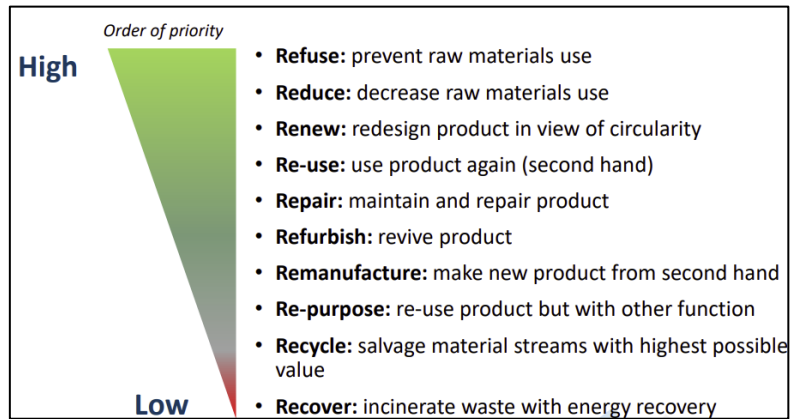the adaptation in the framework of the conceptualisation phase of the circularity compass and of knowledge platform:

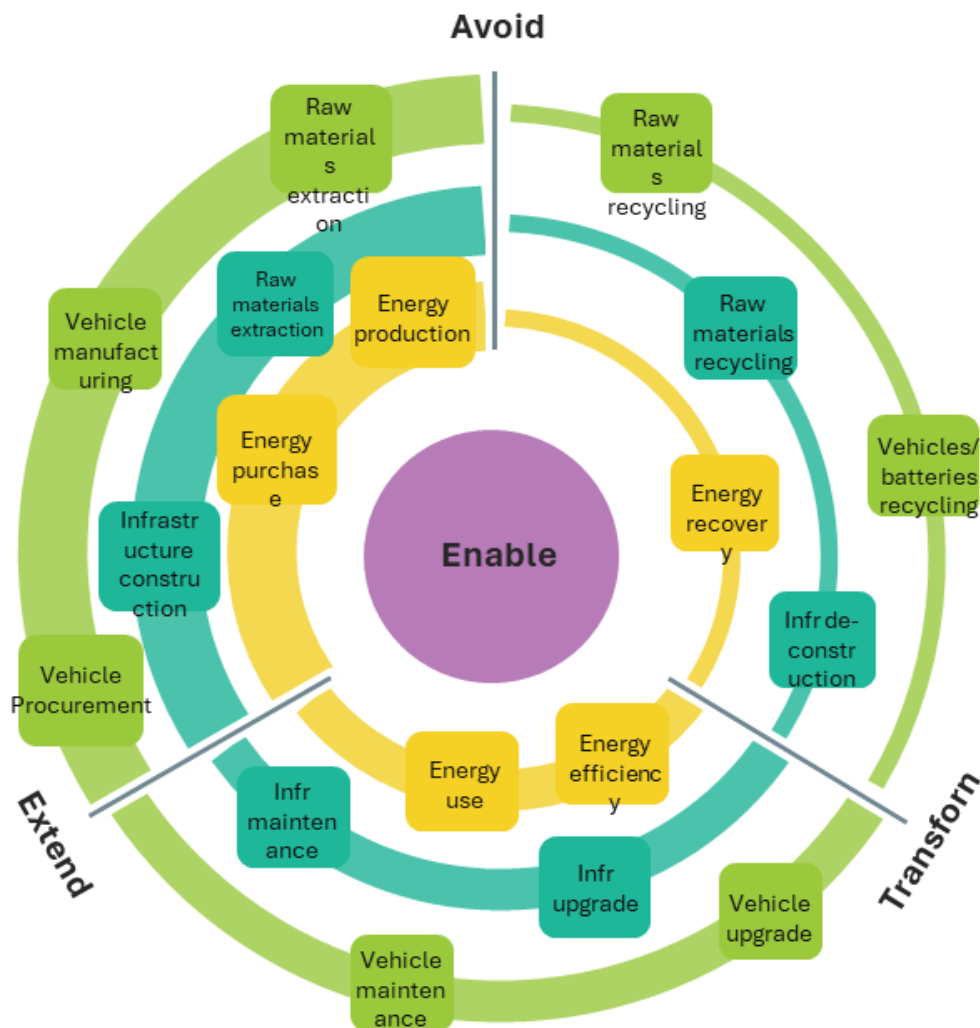Figure 4 The 10 Rs of the circular economy

Figure 5 The CE4CE circularity compass visual representation (credits: Rupprecht Consult and trolley.motion)

The circularity compass is the starting point of the knowledge platform as it offers a tool for public transport actors to assess their circularity processes and to understand the potential for improvement. It impacts employment and up/reskilling of workers in PT companies. Based on these insights, gathered with the support of a survey, the platform offers in response resources, tools, best practices and knowledge that support in the circularity up taking process. In a nutshell, the platform matches new skills with knowledge, and it is a response (resources) to a knowledge gap (survey outcomes).

All resources are built upon the main four main competence areas touched upon the in the survey: infrastructure, vehicles, energy and governance.
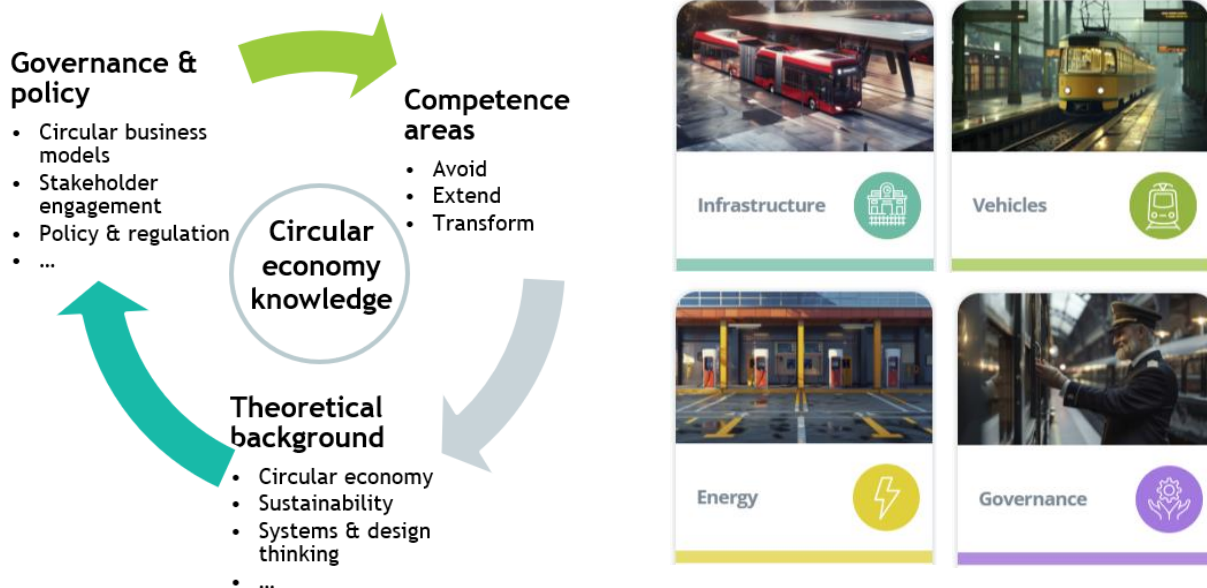
Figure 6 The main CE4CE competence areas

A task analysis along the developed outputs strategies and pilots and transfer to task profiles, key roles or positions as the basis for the competence map will be carried out in a second step of the knowledge platform development. An initial analysis of the requirements through interviews with involved project partners or personnel development experts from the partner organisations as well as with external experts in order to obtain comprehensive information about new requirements in terms of skills and competences has been carried out.

Discussion and validation of the competence areas, map and the circularity compass key areas has been conducted with all partners in the form of working sessions during the last two partner meetings.

5. The platform outlook and functionalities
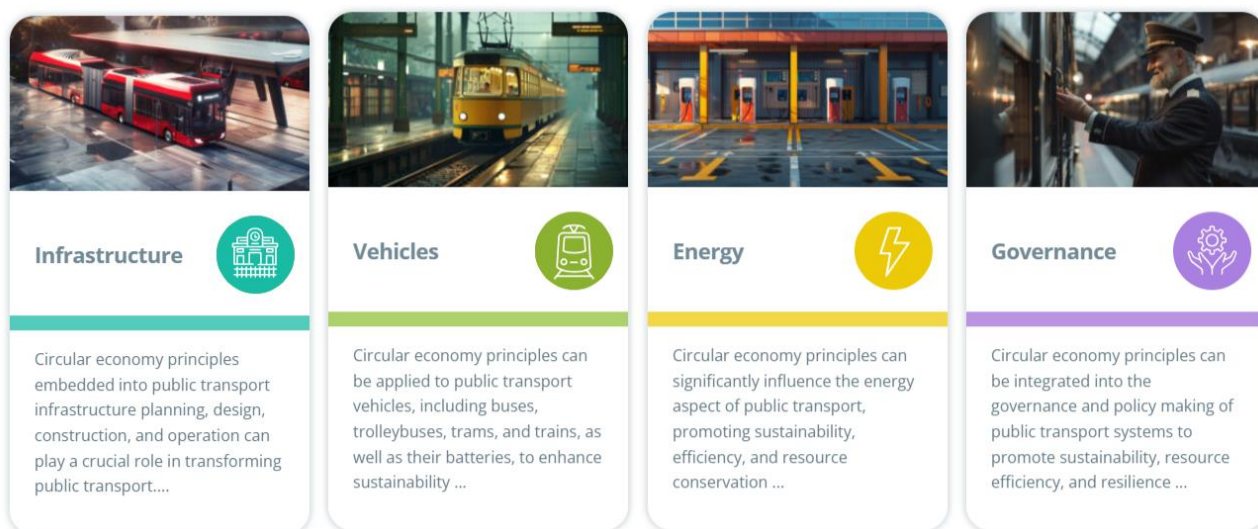
5.1. The structure of the platform

The platform has been developed together with a web developer and a web designer. It is publicly available either as a direct link at https://circularity4publictransport.eu/ or through the CE4CE project website: https://www.interreg-central.eu/projects/ce4ce/?tab=outputs.
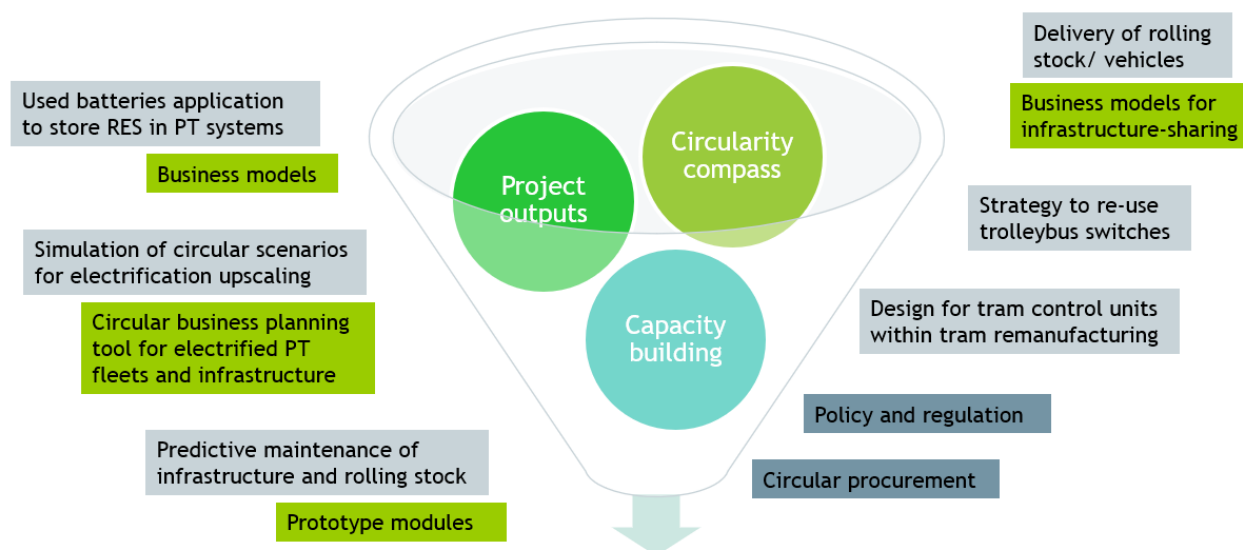
CE4CE knowledge platform matches new skills with knowledge

Figure 7 The detailed representation of the competence areas and types of resources covered by the knowledge platform

The knowledge platform is focusing on offering learning materials linked to the following main project competence areas:

Infrastructure

Circular economy principles embedded into public transport infrastructure planning, design, construction, and operation can play a crucial role in transforming public transport....

Vehicles

Circular economy principles can be applied to public transport vehicles, including buses, trolleybuses, trams, and trains, as well as their batteries, to enhance sustainability ...

Energy

Circular economy principles can significantly influence the energy aspect of public transport, promoting sustainability, efficiency, and resource conservation ...

Governance

Circular economy principles can be integrated into the governance and policy making of public transport systems to promote sustainability, resource efficiency, and resilience ...

The knowledge platform is structured into 5 main sections:

1. **Competence map**
2. **Circularity Compass**
3. **Best Practices**
4. **CE4CE Knowledge Hub**
5. **Matchmaking Forum**

The following chapters describe these main sections, their scope and content.

5.2. The competence map

The development of the competence map, taking into account different skill categories, e.g. technical, methodological skills, specialist knowledge or industry knowledge, which are crucial for the successful performance of the respective tasks and roles, is an ongoing joint process that runs in parallel with the development of the Circularity Compass and with the development of the project strategies and evaluation of project pilots.

The CE4CE Competence Map aims to identify and represent the skills, expertise, capabilities, and knowledge required across various functions and roles for the successful introduction and implementation of circular economy principles in public transport. The competence map is based on the 10 principles of the circular economy and follows the different threads detailed in the CE4CE circularity compass.

The Competence Map is a visual representation of the key competence areas that the CE4CE knowledge platform aims to enhance for the successful introduction and implementation of circular economy principles in public transport. Users will be able to search the platform using specific keywords to find the exact resources they need. Additionally, the project will offer various resources such as webinars, workshops, and training sessions to promote the integration of circular principles and thinking into the public transport sector.
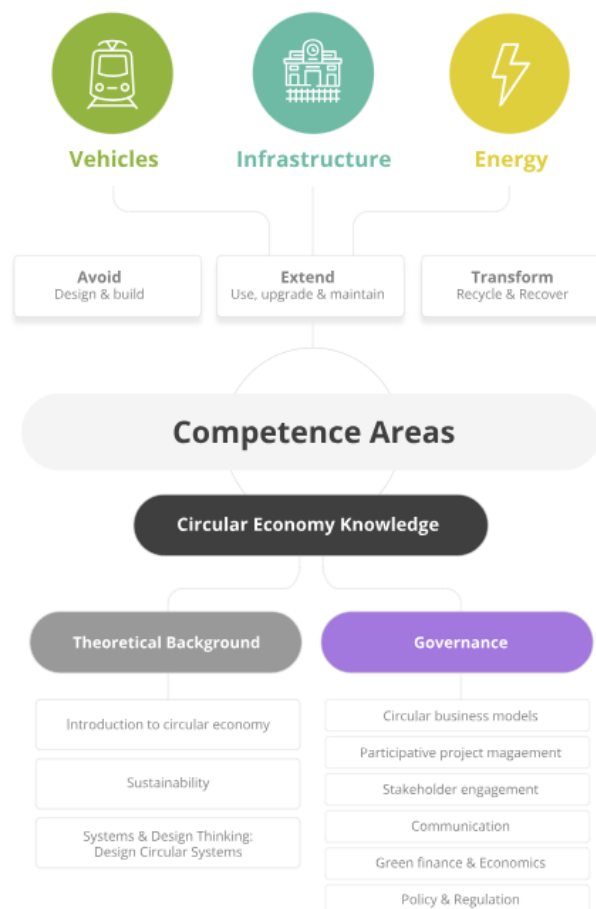
*Figure 8 The CE4CE competence map*

Key topics covered include circular procurement in public transport, predictive maintenance for infrastructure and rolling stock, business models for infrastructure-sharing, and addressing regulatory challenges associated with using recuperated waste energy from trains. Insights from pilot projects conducted by the CE4CE partners will focus on big data analytics and AI as enablers of circularity in public transport, cooperation along lifecycle value chains to preserve the value of infrastructure and vehicles, assessing the value of circular solutions, and facilitating circular economy practices through information sharing.

5.3. The circularity compass

The Circularity Compass is a whole life-cycle evaluation framework designed to easily assess the circular economy status of public transport systems through their planning, procurement, operations, maintenance, and end-of-life stages. Targeting public transport operators and authorities, it takes shape of a Public Transport Circular Economy self-assessment survey that consists of seven independent surveys that address the interconnected critical components of public transport system, i.e. vehicles, infrastructure, energy, and governance - and caters to different transport modes (i.e. rail and road). The Public Transport Circular Economy self-assessment survey (in short the self-assessment survey) enables organizations to review and reflect on their current processes, evaluate their readiness for circular practices, and uncover innovative solutions to kickstart or accelerate the transition towards circular public transport systems, where resources are used mindfully, recirculated efficiently, and the emissions footprint is reduced to net-zero.

The self-assessment survey comprises seven building blocks, each containing 10 to 20 questions. A person with a good level of information in a thematic area should take around 20 minutes to complete one section thoroughly. Upon section completion, respondents are directed to the results page, which summarises the answers, an overall score, and an explanation of the rating based on low, moderate, and high ranks. It is recommended that an organisation complete all pertinent sections to ensure a thorough and holistic assessment of a company's circularity status. To do so, the survey should be completed by two, three, or more respondents according to their specific expertise and responsibilities. For instance, one person may answer on behalf of the vehicle operations team, whereas another could respond on behalf of the building management team.

The Public Transport Circular Economy self-assessment survey can be accessed here: https://circularity4publictransport.eu/self-assessment-selection/
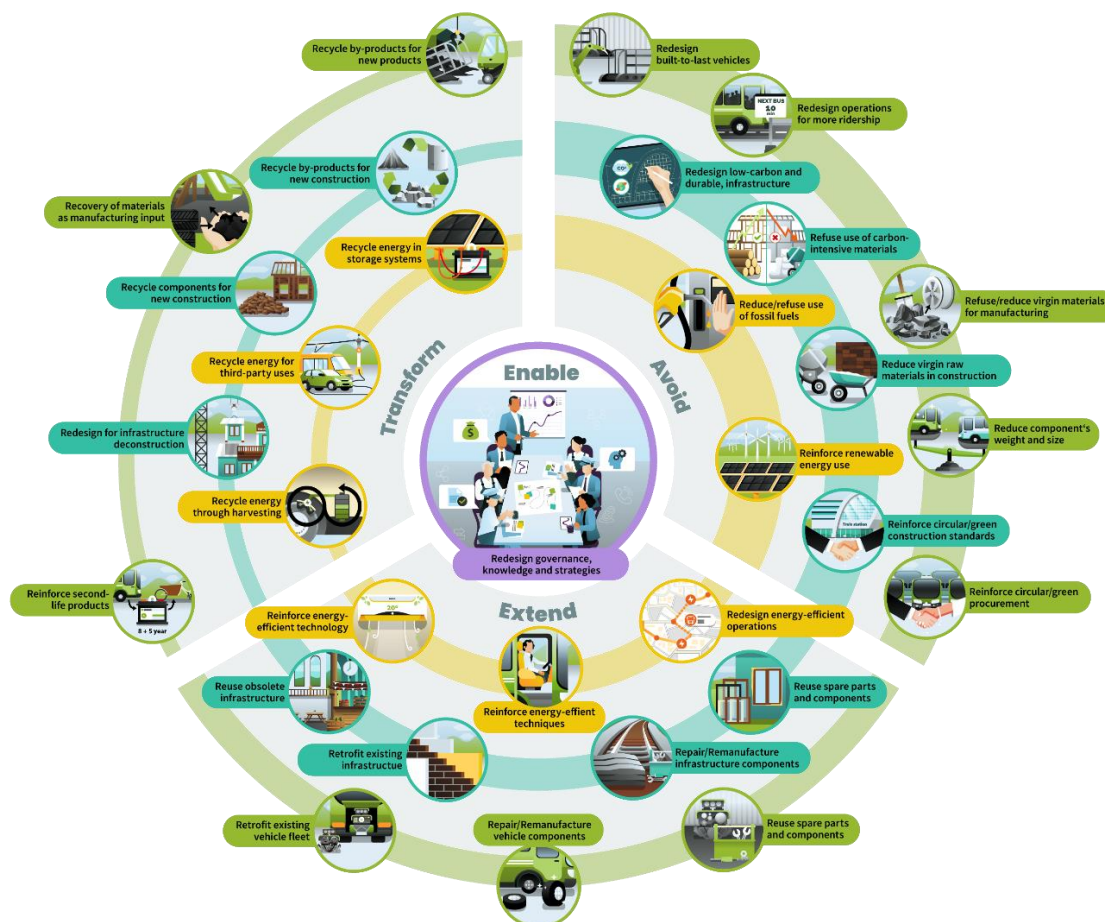
Figure 9 The 7 R-principles for circular PT systems

The circular compass categories are presented in the table below:

	Vehicles (including batteries) Circular economy principles can be applied to public transport vehicles, including buses, trolleybuses, trams, and trains, as well as their batteries, to enhance sustainability and resource efficiency. The circular economy principles applied to different types of public transport vehicles look closely at aspects like design durability and modularity, remanufacturing and refurbishment, battery recycling and second life applications, circular procurement and supply chains, data-driven maintenance and optimization, but also at collaboration and partnerships within the industry.
	Infrastructure (including railway infrastructure, buildings, electric infrastructure) Circular economy principles are embedded into public transport infrastructure, which refers to the underlying system of built and fixed structures, installations and facilities that support public transport operational activities. Circular infrastructures maximise resource efficiency, prioritize using, reusing, and recovering low-carbon and high-quality materials, and are designed for durability and disassembly.

	Energy
	Circular economy principles can significantly influence the energy aspect of public transport, promoting sustainability, efficiency, and resource conservation. Aspects such as renewable energy integration, energy recovery and storage, or smart energy management systems are important to embrace circular principles in the public transport energy management, enhance operational efficiency, and contribute to the transition towards more sustainable and resilient systems.
	Governance
	Circular economy principles can be integrated into the governance and policy making of public transport systems to promote sustainability, resource efficiency, and resilience. Through policy alignment, regulatory frameworks, funding and incentives, monitoring, knowledge sharing and participation, the public transport sector can transition towards a more sustainable, resilient, and resource-efficient one.
	General knowledge
	The basic knowledge on circular economy and sustainability key principles and application in public transport is crucial for the actors from the public transport sector. For a public transport company, acquiring basic knowledge in circular economy, sustainability, and design thinking is crucial for creating efficient, user-friendly, and environmentally sustainable transport systems. By integrating these principles, the company can improve operational efficiency, enhance passenger experiences, and contribute to broader environmental and social goals.

5.4. Best practices

The Best Practice section on the CE4CE knowledge platform serves as a comprehensive resource for public transport stakeholders of examples of concrete solutions, methodologies and solutions emerging from the CE4CE partnership and their network. This section showcases successful case studies and innovative solutions linked to the four main competence areas, providing practical examples and insights into effective circular economy practices. This collection of best practices is designed to inspire and guide public transport operators, policymakers, and other stakeholders in adopting and scaling circular economy solutions within their own contexts.

This section offers best practices and use cases that are easily accessible to a wide audience, facilitating the spread of knowledge across geographical boundaries. It will be continuously updated with practices and case studies, ensuring users have access to relevant information that will inspire them in acquiring new competences and knowledge necessary for advancing in adopting the circular way of thinking.
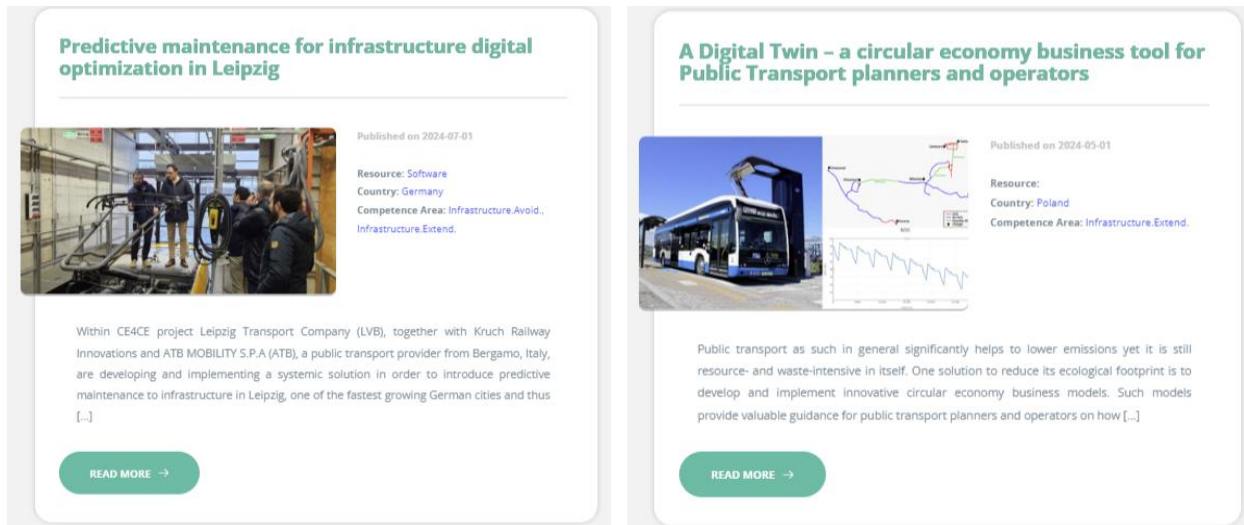
Figure 10 Examples of best practices published on the knowledge platform

This section will firstly cover the best practices arising from the partnership, however with the support of our partner trolley:motion[10] additional examples will be prepared. The partnership will build on their wide networks of actors from the PT sector, including having access to the networks of the Advisory Board members, to collect relevant and useful examples. The examples could go beyond public transport to reflect different perspectives of circularity in the public sector, such as buildings, waste or energy.

5.5. CE4CE knowledge hub

The Knowledge Hub is the centrepiece of the CE4CE knowledge platform and contains a abroad variety of resources that inform, educate, and help make decision on circular thinking in public transport. Its goal is to build solid knowledge bases founded on the experiences of previous projects dealing with circularity and energy efficiency in public transport.

The users can find here a collection of tools and resources such as guidelines, Tool, Methods, Software, Reports, Studies, that are useful for the different stages of the enhancing circularity concepts in the public transport planning, operation and maintenance.

To refine searching for specific tools relevant to the user's needs, the user can use the filters from different categories, then only tools matching those filters are displayed. The filters are: competence area, country, resource type and year published.

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[10] https://trolleymotion.eu/

Figure 11 The overview of filters used for a quick search of resources on the platform
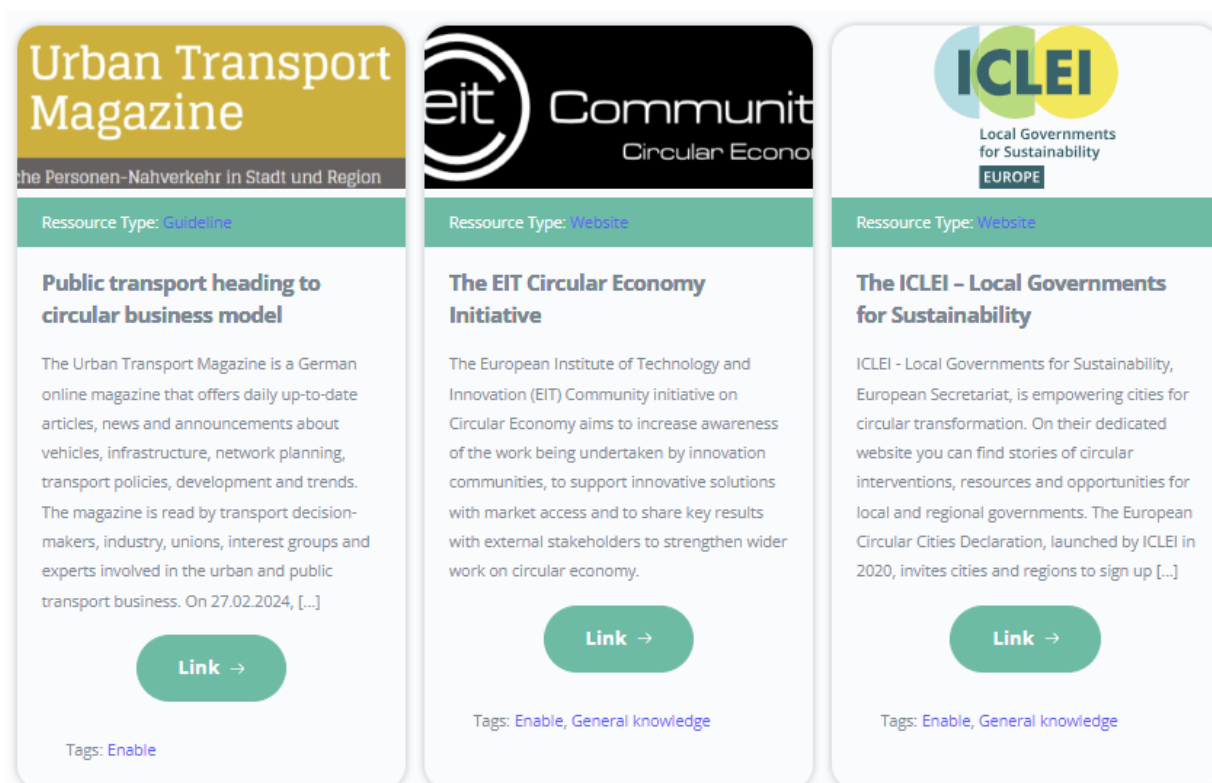
Figure 12 Snapshot of tools and resources displayed in the CE4CE knowledge hub section of the platform

5.6. The matchmaking forum

Furthermore, one of the project's solutions (output O3.10) is the development of a matchmaking forum for spare parts. The idea discussed jointly within the consortium was to enable matchmaking between commercial hardware providers, that are partly very specialised and not easy to find, and public transport companies. Therefore, the project's consortium will incorporate an open marketplace that fosters the exchange of new technologies and pieces of equipment. This would make these providers an additional, separated, target group of the platform.

The matchmaking forum will facilitate the exchange of information about used parts, fostering a circular economy approach within the public transport sector. It will allow public transport operators, maintenance providers, and suppliers to buy, sell, and trade parts efficiently, reducing waste and promoting sustainability.

The structure of the matchmaking forum will encompass several key components designed to ensure smooth operation and user engagement. These components include user registration and profiles, listings and search functionalities, communication tools, stakeholder database and support features.

Currently this section is under construction and will be finalised in the second part of the project.

5.7. The main functionalities and features of the platform

In the following section, several aspects that needed to be considered when creating the architecture of the CE4CE knowledge platform are presented. Some of the following aspects may change during the further development of the platform.

Below is a detailed description of the technical features and functionalities that such a platform should include:

Content management

The content creation, editing and organization involves the development of pre-designed templates for developing different types of content such as best practices and resources, as well as the creation of a taxonomy system based on competence areas (tags).

Search and navigation

A search functionality allows users to navigate directly to the resources they are particularly interested in. Using filters such as competence areas, type of content, country and year of publication allows for a quick and simple filtering of searched resources.

Collaboration and communication

Within the matchmaking forum section a discussion forum will be developed that will allow for organised discussions with threading and nesting for clarity, moderation tools for moderating and managing discussions, as well as the possibility of providing feedback and registering to the project newsletter which will feature a regular section on knowledge platform updates.

Learning and training

The competence map section of the platform will be enriched with training and learning materials that will complement the collection of best practices, tools and resources. Regular webinars and online sessions, presentations and insights from events will be published in this section throughout the project.

Security and compliance

The CE4CE partnership will ensure that the platform complies with GDPR data protection regulation. The protection of user data especially in the matchmaking forum will be transposed into practice through the consent of Data Protection Notice by users, already integrated into the Circularity Compass section.

6. Proposed actions for further development and sustainability of the platform

6.1. Next steps in the development process

The platform has been made public in April 2024 and will be officially launched on 23 October 2024, together with the results of the circularity compass, in the framework of the 7. International E-Bus Conference[11]. Until then, further fine tuning of the content and structure will be integrated. The automatic translation integrated in the internet browsers will enable a wider outreach of the platform within the public transport sector in Central Europe for non-English users. Methods and tools for the circular economy in public transport developed within the CE4CE project will be made available to the public in a particularly structured and accessible way, together with guidelines, software, apps and planning approaches.

Moreover, PP12 trolley:motion will coordinate the integration of the second-hand market and match-making tool for information-sharing on the platform in the dedicated "Matchmaking Forum" section.

Further feedback from external associated partners and Advisory Board members to ensure that the competence map reflects the requirements and goals set will be conducted in the framework of further life-cycle actor workshops and during the next partner meeting planned for October 2024. The necessary updates

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[11] https://trolleymotion.eu/prag-2024/

will be made to the competence map or online environment based on the feedback received. The Advisory Board members will be involved in the process of linking the knowledge platform with existing training and (further) online education offers. The project learning outcomes such as the e-course and trainings will be stored on the platform.

A mature version of the competence map will be made available on the platform, matching the new required skills with diverse resources. Analysis of these requirements through interviews with project partners and associated partners, as well as with external experts (e.g. UITP, TH Cologne) to obtain comprehensive information about new requirements in terms of skills and competences. Different skill categories, e.g. technical, methodological skills, specialist or industry knowledge, which are crucial for the successful performance of the respective tasks and roles will be taken into account in the map.

Moreover, PP12 TM will lead the collection, assessment and publication of further best practices, resources and tools from inside and outside CE4CE. The most relevant CE4CE materials from transnational workshops (such as recordings) and the project e-course will also be added to the platform's wealth of resources.

Transfer of the competence map with competence levels to the learning outcomes principle i.e. stronger orientation towards learning outcomes in order to create the ability for the target groups to act and focus on the results of competence expansion and not so much on the way in which competence is acquired. The learning outcomes principle has been systematically promoted in the EU's policy agenda for education, training and employment since 2004. This is intended to ensure compatibility with the European Qualifications Framework (EQF). This principle emphasizes the importance of defining and assessing what learners know, understand, and can do after completing a learning process. The orientation towards or description of learning outcomes is intended to form a basis for a qualification framework for circular economy in public transport and can be used to create qualifications and further training.

During the project the partnership will continue to provide feedback to the platforming terms of usability and relevance. A more mature version of the platform will be available at the end of the project.

6.2. Dissemination and exploitation strategy

Rupprecht Consult supported the project lead partner Leipzig Public Transport Company in developing the CE4CE knowledge platform and will continuously promote it throughout Europe via the company's broad networks of contacts. The CE4CE platform will be included in the CIVITAS Urban Mobility Tool Inventory[12] too with the support of Rupprecht Consult.

Online posting and promotion of the knowledge platform in cooperation with the Communication Manager of the CE4CE project will be conducted until the end of the project. To promote the knowledge platform, both the communication channels of the project (website, newsletter, social media) and those of the individual partners – including the associated partners UITP, EIT-UM or ICLEI – will be used. Organization of a webinar to promote the platform and how it can be used for the European public transport community will be coordinated by the project manager in the second half of 2024.

Several key measures and strategies are proposed to ensure the long-term sustainability of the knowledge platform. Firstly, the platform should prioritise the continuous collection and publication of useful resources as well as other learning materials produced during the project. This activity will be carried out throughout the project lifetime. Regular updates and features reflecting the latest developments, solutions and innovations will increase the attractiveness of the platform for users and stakeholders. Prioritizing continuous innovation and staying on top market trends will be key to maintaining the platform's relevance and attractiveness. Secondly, fostering strong partnerships with the networks of the projects' Advisory Board can contribute significantly to the credibility and relevance of the platform. Collaboration with the

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[12] https://civitas.eu/tool-inventory

Advisory Board members and other industry experts, with strong support from the trolley:motion association, will not only enhance the quality of information and services provided, but also open opportunities for potential funding and support.

A sustainability strategy for the platform will be developed together with the Advisory Board members in September 2024 (deliverable D1.2.3). To ensure that the competence map can also be used after the end of the CE4CE project and that necessary updates can be ensured, a strategy will be developed – together with project partners and especially the associated partners UITP, ICLEI and EIT-UM – on how the use the competence map and to keep the platform up to date. In particular, the integration of the competence map into existing formats such as the UITP Academy, ICLEI Circular Cities Declaration or Innovation Hubs of the EIT will be analysed. The basis for the development of the sustainability strategy are tools such as a business canvas, network business plan templates, etc.

The platform is publicly available either as a direct link at https://circularity4publictransport.eu/ or through the CE4CE project website: https://www.interreg-central.eu/projects/ce4ce/?tab=outputs.

7. Annexes

Example of best practice published on the CE4CE knowledge platform

Predictive maintenance for infrastructure digital optimization in Leipzig, Germany

*Within CE4CE project Leipzig Transport Company (LVB), together with Kruch Railway Innovations and ATB MOBILITY S.P.A (ATB), a public transport provider from Bergamo, Italy, are developing and implementing **a systemic solution in order to introduce predictive maintenance to infrastructure** in Leipzig, one of the fastest growing German cities and thus in need of state-of-the-art transport services. It is all with an aim **to turn from generally costly reactive and manual maintenance to much more economical and minimally invasive predictive and automated maintenance**.*

The LVB Group has extensive experience in the construction and maintenance of public transport infrastructures and it is intensively working on introducing digitalization processes intro daily operation in order to adopt greener and more sustainable working structures in their organization.

*As for the currently implemented pilot, it has already been determined which types of assets and their sections (rails & catenary) will be used for this measure. First, **prototype modules for predictive maintenance** will be developed and they will be applied to some selected parts of infrastructure in order **to roll out the methodology for predictive maintenance which in a further step could be deployed in the entire Leipzig transport network**.*

*After conducting the procurement process, the infrastructure will be equipped with sensors. The evaluation of the data and testing of the algorithms will go parallel. Continuous exchange will be carried out between Kruch data specialists and the ATB and LVB specialist so as to allocate and interpret the recorded information on the assets condition. For this purpose **measurement technology algorithms for data-based and automated condition recording** will be used. **An asset assessment and fault reporting system will allow for***

checking the condition of assets automatically and constantly including dates, rhythms and forecasts. *A collaborative damage catalogue will also enable the evaluation of defects*.

With predictive maintenance system faults will be detected quickly and automatically, and **the necessity of costly routine manual fleet and infrastructure checks will be minimized**. Early detection of a fault on the infrastructure will also be economical from the point of view of repair costs as it is considerably cheaper to remove a smaller defect. **Predictive maintenance will also be of paramount importance as for passengers' and workers' safety**.

At the later stage the partners will further improve this pilot based on peer-review and user-feedback. **Transferability to other organizations** will be enabled via creating specification of standardized interfaces, data formats, parameters, demonstration of operational dependencies and a universal methodology to create damage catalogue and impact analysis. In such a way this effective and sustainable maintenance solution could be taken up by other PT stakeholders **to optimize delivery of infrastructure and thus save costs and assets** helping to turn to more circular economy model and achieve zero emission targets for cities and regions in Europe by 2050.

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