



Updated User Stories and Policy Briefs

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D5.7 – Updated User Stories and Policy Briefs booklet

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Lead author	Maria Giuffrida (TRU)
Contributors	Claudio de Majo (TRU)
Peer reviewers	Golboo Pourabdollahian (IDC), Inessa Seifert (VDI)
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Glossary of terms

Item	Description
AI	Artificial Intelligence
AIOTI	Alliance for IoT and Edge Computing Innovation
AGVs	Automated Guided Vehicles
AMRs	Autonomous Mobile Robots
CEI	Cloud-Edge-IoT
EC	European Commission
EUCloudEdgeIoT or EUCEI	Short Name to refer to The European Cloud, Edge and IoT Continuum, an inter-project umbrella initiative of which UNLOCK-CEI is a member and coordinator with the sister CSA Open Continuum
IoT	Internet of Things
KPIs	Key Performance Indicator(s)
MEC	Multi-Access Edge Computing
TFs	Task Force(s)
VCAs	Value Chain Adopter(s)
WG	Working Group
WP	Work Package

Abstract

This deliverable presents the updated and final version of UNLOCK-CEI's collection of Cloud-Edge-IoT (CEI) user stories, white papers and a policy brief. The document outlines the updated approach and rationale for the preparation of the planned outputs, highlighting modifications occurred to the plan presented in D5.6. Eight additional user stories are described in this deliverable, together with a series of white papers summarising the project main results and a concluding policy brief, elaborating the policy-oriented insights stemming from the UNLOCK-CEI final stakeholder forum event held 23rd September 2024 in Brussels.

Keyword

Cloud-Edge-IoT; computing continuum; communication; dissemination; engagement, user stories, policy briefs, white paper

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Executive Summary

This deliverable provides an overview of the progress made in the adoption and integration of Cloud-Edge-IoT (CEI) technologies within various sectors through the UNLOCK-CEI project. It highlights key insights from a series of user success stories, white papers, and a policy brief, demonstrating the practical application of CEI technologies and the policy directions needed to support their further development in Europe.

The user stories section showcases 8 new case studies from sectors such as energy, mobility, manufacturing, and agriculture, illustrating the implementation of CEI solutions to address specific industry challenges. These stories, including those from the MetaOS cluster of projects, reveal how CEI technologies are being used to optimise energy systems, streamline logistics, and enable real-time decision-making. Each story is developed in the form of a short digital flyer and also includes a section for policy recommendations, focusing on interoperability, data sovereignty, and the need for open-source solutions to drive adoption.

The white papers offer in-depth analysis of the challenges and opportunities for CEI technologies across key industries. They identify gaps in infrastructure, connectivity, and skills that are hindering wider CEI adoption, while also proposing strategic pathways to address these challenges. For example, the white papers on energy and manufacturing highlight the importance of edge computing and open frameworks in improving operational efficiency and scalability. The agriculture white paper underscores the role of digitalisation in enhancing sustainability, while the mobility white paper discusses how CEI technologies are enabling smarter, more connected transport systems.

The policy brief, derived from the discussions held at the UNLOCK-CEI final event, addresses the broader challenges Europe faces in maintaining its competitiveness in the digital landscape. It outlines the need for greater investment in 5G infrastructure, edge computing, and the harmonisation of standards to overcome market fragmentation and support the development of a cohesive CEI ecosystem. The brief emphasises that joint efforts across cloud, edge, and IoT domains are essential to realising Europe's digital sovereignty goals.

Key themes across the deliverable include the need for enhanced interoperability, the importance of collaborative frameworks, and the value of data sovereignty to ensure secure and scalable CEI deployments. Additionally, the deliverable highlights the role of cross-sectoral partnerships, as demonstrated by the MetaOS projects, in addressing both technical challenges and business model development.

Overall, this deliverable offers a view of how CEI technologies are shaping various sectors in Europe and provides practical recommendations for policymakers, industry leaders, and stakeholders involved in fostering the CEI ecosystem. The findings underline the importance of aligning technological innovation with policy support to ensure successful CEI integration and to meet the EU's Digital Compass 2030 objectives.

Table of Contents

1.	Introduction.....	6
1.1	Purpose of this document.....	6
1.2	Link to other deliverables	6
1.3	Structure of the document	7
2.	Review of modifications in output selection and production from the initial plan.....	8
3.	Collection of outputs.....	9
3.1.	User stories	9
3.1.1.	User story #4: Enercoutim - Empowering Smart Education: Cloud-Edge-IoT solutions for Sustainable Energy Management.	9
3.1.2.	User story #5: Wackler and G+D - Optimising freight operations through IoT-enabled solutions 10	
3.1.3.	User story #6: aerOS - Data-Driven Cognitive Production: Revolutionising Industry 4.0 with Modular Manufacturing Systems.....	11
3.1.4.	User story #7: FLUIDOS - Enhancing Power Grid Resilience and Scalability through Edge-to-Cloud Orchestration	12
3.1.5.	User story #8: Smart Energy Management with IoT and Edge Computing: Revolutionising Domestic Energy Use (ICOS).....	13
3.1.6.	User story #9: Introduction of drones and implementation of Predictive Technology in windmill maintenance (NebulOuS)	14
3.1.7.	User story #10: Smart Media/City: Cloud-Edge-IoT solutions for modern-day Media (NEMO) 15	
3.1.8.	User story #11: Optimising Energy Management with Predictive IoT Devices: Interoperable Solutions for Real-time Room Occupancy (NEPHELE).....	16
3.2.	White paper collection	17
3.2.1.	Technology implementation model and architectural patterns for CEI use cases	17
3.2.2.	Market pathways for CEI in manufacturing	18
3.2.3.	Market pathways for CEI in energy	19
3.2.4.	Market pathways for CEI in agriculture.....	20
3.2.5.	Market pathways for CEI in mobility	20
3.2.6.	Gap analysis and strategic opportunities for the European CEI market.....	21
4.	Overcoming Barriers in the EU's Computing Continuum: Challenges and Future Directions	22
4.1.	Future CEI challenges in the EU context.....	22
4.2.	Current challenges and access barriers	23
4.3.	Solutions and recommendations	24
5.	Conclusions.....	26

List of Figures

Figure 1 - Flyer produced for ENERCOUTIM story in energy industry	10
Figure 2 - Flyer produced for Wackler and G+D user story in mobility	11
Figure 3 - Flyer produced for aerOS user story in manufacturing	12
Figure 4 - Flyer produced for FLUIDOS user story in energy	13
Figure 5 - Flyer produced for ICOS user story in energy	14
Figure 6 - Flyer produced for NebulOuS user story in energy	15
Figure 7 - Flyer produced for NEMO user story in media	16
Figure 8 - Flyer produced for NEPHELE user story in energy	17
Figure 9 - Selected views of the architectural patterns white paper	18
Figure 10 - Selected views of the CEI in manufacturing white paper	19
Figure 11 - Selected views of the gap analysis white paper	22

List of Tables

Table 1 - List of connected deliverables	7
Table 2 - Summary of Modifications	8

1. Introduction

This document forms a key part of the UNLOCK-CEI project's broader communication, dissemination, and engagement strategy, whose final results and impacts will be detailed in Deliverable D5.3, due at the project's conclusion. Specifically, this deliverable focuses on the essential role played by user stories, white papers, and policy briefs in fostering the adoption of Cloud-Edge-IoT (CEI) technologies. The user stories provide practical, real-world examples that clearly communicate the tangible benefits of these technologies. In parallel, the white papers and policy briefs delve deeper into the technical insights and offer informed recommendations, thereby shaping the project's influence on policy and industry practices.

Building upon the approach established in the preliminary version of this document (D5.6), WP5 has concentrated on developing white papers that summarise and capture the project's core learnings. These white papers cover the current state of CEI technologies, their potential impacts, and the challenges associated with their adoption, along with strategic recommendations for promoting market uptake. Contrary to the original plan, a single final policy brief has been prepared. This policy brief, which consolidates insights from the final event held on 23rd September 2024 in Brussels, will be shared with the European Commission and relevant European strategic initiatives. The originally planned three additional policy briefs have been replaced by eight white papers produced over the project's lifetime (2 prepared in the first reporting period and six reported in the present deliverable). They are all available on the project's website via [the final event dedicated webpage](#).

1.1 Purpose of this document

The purpose of this deliverable is to present the final collection of user stories, white papers, and the policy brief developed during the UNLOCK-CEI project. This document provides an overview of these outputs, which are designed to support the demand-side adoption of Cloud-Edge-IoT (CEI) technologies across various sectors and whose full versions are available on the EUCloudEdgeIoT website and Zenodo repository.

The deliverable serves multiple objectives. It consolidates practical examples, technical insights, and policy recommendations, ensuring that the project's outcomes are accessible and relevant to a diverse audience, namely:

- For **industry stakeholders**, the user stories provide real-world case studies that illustrate the successful application of CEI technologies, showcasing their potential to address specific industry challenges.
- For **policymakers**, the document includes white papers and a final policy brief, which provide analyses and recommendations on how CEI technologies can support Europe's digital transformation efforts, with a focus on innovation, and market uptake.
- For the **research community**, this deliverable offers a comprehensive view of the project's achievements, helping to inform future CEI-related research and innovation activities by outlining key challenges and opportunities identified throughout the project.

In addition to presenting these outputs, the deliverable reflects how the project's findings contribute to shaping the wider European CEI ecosystem, particularly in terms of aligning with strategic European digital initiatives.

1.2 Link to other deliverables

This deliverable interlinks with several other key documents, each adding depth and context to the overarching narrative of how UNLOCK-CEI engages with its audience and disseminates its findings. However, the following deliverables, in particular, have a direct and significant connection to this document:

WP	Deliverable No.	Deliverable Name	Connection with this deliverable
2	D2.3 (M30),	Final Position Paper on the future Open European CEI Ecosystem	D2.3 relates to the strategic outlook of UNLOCK-CEI. This deliverable provides significant input for the finalisation of D2.3
3	D3.3 (M24)	Report on CEI Service Requirements	D3.3 summarises key insights on CEI requirements that were fundamental to shape the vertical industry white papers collected in this document
4	D4.4 (M28)	Market developments learnings	D4.4 includes insights on market trends and developments, complementing the user stories, white papers and the policy brief in portraying a comprehensive picture of the project's impact.
5	D5.1 (M03), D5.2 (M18) D5.3 (M30)	Communication, Dissemination, and Engagement Plan (initial and updated versions)	D5.1 establishes the initial strategy for communication, of which user stories and policy briefs are a key component. D5.2 provides an updated framework for communication, aligning with the ongoing activities and outputs of user stories and policy briefs. D5.3 finalises the communication strategy, encapsulating the outcomes and learnings from user stories and policy briefs.
5	D5.6 (M18)	User stories and policy briefs booklet	This deliverable represents an updated version of D5.6 with the final and complete lists of all the user stories collected, white papers produced and the concluding policy brief
5	D5.8 (M18), D5.9 (M30)	Sustainability plan	The white papers and the policy brief presented in D5.7 are strictly connected to the strategic policy recommendations identified as one of the main KERs in D5.8 and its update D5.9

Table 1 - List of connected deliverables

1.3 Structure of the document

The document is structured as follows:

- **Chapter 2** provides an overview of the modifications made to the initial plan concerning the selection and production of outputs, highlighting adjustments to the expected deliverables.
- **Chapter 3** outlines the collected outputs, including detailed accounts of the new user stories and the white papers. Each subchapter within this section is dedicated to the presentation of the individual user stories and white papers.
- **Chapter 4** presents the concluding policy brief, reflecting the key policy-oriented insights from the project's final event and the project's findings.
- **Chapter 5** concludes the deliverable by summarising the overall achievements and future pathways for the UNLOCK-CEI project.

2. Review of modifications in output selection and production from the initial plan

Since the submission of Deliverable D5.6 in November 2023, some key modifications have been made to the selection and production of the project's outputs to be included in this deliverable. These changes were driven by recommendations from the M18 review, evolving project needs, and strategic discussions with the European Commission. This chapter outlines the modifications made, explaining the rationale behind each change and summarising the final outputs.

Key Modifications

- Introduction of white papers:** Since no specific white papers are included in the Grant Agreement (GA), this type of output was introduced in D5.6 but no further white papers were planned in that deliverable. However, based on feedback from the M18 project review, the project was advised to focus on producing shorter, more accessible dissemination materials. In response to this recommendation, the project intensified efforts to create white papers, which offer concise and digestible insights on key findings, much more than detailed deliverables. This shift aimed to make complex information more accessible and increase the impact of the project's outputs, especially for industry and policy stakeholders who require easy-to-read content.
- Increase in the number of user stories and expanded sources:** The original plan was to produce 10 user stories, primarily focusing on projects implemented by companies with more mature CEI solutions. However, following discussions with the European Commission, it was agreed that additional user stories could be drawn from research projects as well. This led to the inclusion of 11 user stories in total, with several coming from the **Meta Operating Systems (MetaOS)** research cluster, which UNLOCK-CEI has specifically supported. This shift broadened the scope of the stories, providing a richer view of CEI adoption by including both industry and research perspectives.
- Focus on a single policy brief for final recommendations:** While four policy briefs were initially planned in the GA, it became clear that the most relevant findings could be consolidated into a single policy brief. This policy brief summarises the key insights for policymakers based on the project's outcomes and the final stakeholder event held in September 2024. The decision to streamline the policy briefs ensured that the final recommendations were focused, avoiding redundancy.

The following table summarises the modifications occurred since D5.6 and implemented in the following chapters. This also reflects the project's adaptability in meeting emerging needs and ensuring the relevance of the final deliverables.

Output	Original plan	Final production	Rationale for change
Policy briefs	4 policy briefs planned	1 final policy brief	Streamlined recommendations into a single brief, making it more concise and focused.
White papers	None	8 white papers	Introduced based on M18 review feedback to provide shorter, more accessible insights.
User stories	10 stories from company projects	11 stories, including contributions from MetaOS research projects	Expanded to cover research projects as well as company projects, in agreement with the Commission.

Table 2 - Summary of Modifications

3. Collection of outputs

This chapter provides an overview of the specific subset of outputs produced within the UNLOCK-CEI project, as explained in the previous sections. While this chapter highlights these particular outputs, it is important to recognise that other deliverables, produced across various work packages, also contribute to the project's overall impact. The user stories and white papers presented here complement the broader range of deliverables, offering practical examples and sector-specific insights that support the adoption of CEI technologies. The chapter concludes with the final policy brief, which integrates the main policy insights gathered.

3.1. User stories

This section presents a collection of 8 success stories which add to the 3 already presented in D5.6. These use cases showcase the practical applications of Cloud-Edge-IoT (CEI) technologies across various sectors and highlight how organisations and projects have harnessed CEI solutions to address key industry challenges, foster innovation, and promote sustainability.

The success stories span the following sectors:

- **Energy and Smart Buildings:** 5 stories (Enercoutim, FLUIDOS, ICOS, NEPHELE, and NebulOuS), covering applications from energy grid management to smart building efficiency and windmill maintenance.
- **Logistics and Mobility:** 1 story (Wackler and G+D), focused on optimising freight operations through IoT-enabled tracking.
- **Manufacturing and Industry 4.0:** 1 story (aerOS), highlighting modular manufacturing systems driven by cognitive production.
- **Media and Live Events:** 1 story (NEMO), addressing enhanced media delivery and live sports event coverage using AI, IoT, and edge computing.

The stories from the MetaOS cluster were selected in collaboration with each project, and insights from the [CEI-LING tool](#) developed by UNLOCK-CEI were utilised to ensure that the selected stories reflect solutions with highest maturity and strategic relevance.

3.1.1. *User story #4: Enercoutim - Empowering Smart Education: Cloud-Edge-IoT solutions for Sustainable Energy Management.*

This story originates from the ended [Smarter School project](#) and highlights an innovative approach to energy management in educational environments through the integration of Cloud-Edge-IoT technologies. This success story was selected to demonstrate the potential of CEI technologies in revolutionising traditional energy management processes, particularly in educational settings, where both energy consumption and learning environments must be optimised for efficiency and sustainability.

Faced with the challenges of maintaining conducive learning environments while managing energy resources effectively, Smarter School was powered by [Enercoutim](#), an organisation recognised for its expertise in renewable energy and microgrid technologies to develop the Optimal Learning Environment Index™, a tool that leverages IoT, cloud, and edge computing to monitor and enhance indoor environmental quality in real-time. This tool combines data from various sources to optimise conditions within schools, addressing critical needs such as air quality—particularly highlighted during the COVID-19 pandemic—and ensuring energy efficiency.

The journey was not without obstacles, as the integration of IoT with existing infrastructures required addressing challenges like data privacy, user-friendliness, and scalability. The solution improved energy efficiency but also fostered better learning outcomes and well-being for students and staff alike.

Smarter School's implementation of this solution has societal and environmental implications. By reducing energy waste and enhancing sustainability, the project aligns with global efforts to decrease carbon emissions

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and promote greener practices. It also serves as a model for other educational institutions to follow, showcasing how Cloud-Edge-IoT technologies can be applied effectively in educational settings to drive innovation and environmental stewardship.

This project benefitted from research and funding support through the EU Horizon 2020 program, with the solution undergoing rigorous testing and refinement in real-world settings.

This story was presented as a success case in the UNLOCK-CEI project repository and has been promoted across various social media platforms, highlighting the role of Cloud-Edge-IoT in shaping smarter, more sustainable educational environments.

To date it counts **126 views** and **44 downloads** from the project's Zenodo channel where it is published. The link to the story flyer is available [here](#)



Figure 1 - Flyer produced for ENERCOUTIM story in energy industry

3.1.2. User story #5: Wackler and G+D - Optimising freight operations through IoT-enabled solutions

The story of Wackler, a member of the Cargoline logistics alliance, highlights how IoT-enabled solutions can transform freight operations. Facing challenges such as delayed shipments, uncoordinated dock management, and poor visibility into shipment conditions, Wackler sought a more efficient and reliable way to manage its logistics operations.

To address these issues, Wackler partnered with MECOMO, a [G+D company](#), to implement IoT tracking devices (mecSOLAR) and the mecFLEET platform. This integration allowed for real-time monitoring of <https://www.eucloudedgeiot.eu>

shipment locations, conditions, and expected arrival times. The solar-powered mecSOLAR devices provided continuous tracking without the need for frequent maintenance, enabling 24/7 visibility across Wackler's operations. The solution also included sensor-based monitoring of cargo conditions and temperature, ensuring that sensitive goods remained intact throughout transportation.

The impact of the solution was significant, with Wackler achieving real-time data access, eliminating manual inventory checks, and reducing phone calls to drivers. The company also saw improvements in yard management and sustainability, as optimised fleet deployment reduced its environmental footprint. Additionally, by avoiding penalties for late or damaged shipments, Wackler benefited from improved operational efficiency and customer satisfaction. The story has been presented in a webinar dedicated to mobility in July 2024, published on the project website and [Zenodo channel](#). To date, it counts **69 views** and **47 downloads**.



Figure 2 - Flyer produced for Wackler and G+D user story in mobility

3.1.3. User story #6: aerOS - Data-Driven Cognitive Production: Revolutionising Industry 4.0 with Modular Manufacturing Systems

The [aerOS](#) success story centres on implementing cognitive production processes to enhance flexibility, efficiency, and sustainability in manufacturing. As industries increasingly shift towards modular and digital production lines, this aerOS use case aims to enable autonomous, edge-powered orchestration, offering real-time data processing and smart decision-making capabilities.

This solution has been applied across four prominent Pilot Lines in Spain, Italy, Switzerland, and Germany, each featuring advanced Industry 4.0 systems. The aerOS solution integrates cloud, edge, and IoT technologies to support autonomous scheduling, zero-defect manufacturing, and energy monitoring. It aims

to establish the world's first Level 4 autonomous production line, leveraging intelligent edge orchestration to optimise manufacturing operations.

The project faces challenges in integrating diverse technologies across the Pilot Lines, ensuring seamless interaction between IoT devices, edge systems, and cloud environments. However, with contributions from Siemens and other consortium partners, aerOS has shown significant impact, including improved data distribution, enhanced human-machine collaboration, and energy-efficient production.

In the future, the project plans to further develop AI and machine learning models for continuous process optimisation. Future work will focus on green manufacturing, net-zero energy solutions, and more advanced production techniques for sectors such as automotive.

This use case flyer has been available on the project website and [Zenodo channel](#) since mid September 2024



Figure 3 - Flyer produced for aerOS user story in manufacturing

3.1.4. User story #7: FLUIDOS - Enhancing Power Grid Resilience and Scalability through Edge-to-Cloud Orchestration

The [FLUIDOS](#) success story focuses on improving the resilience and scalability of power grids by leveraging edge-to-cloud orchestration. The rise of renewable energy sources requires a highly monitored distribution grid, where data must be collected and processed in real time from thousands of Phasor Measurement Units (PMUs). These PMUs, positioned across the grid, provide crucial data for applications like grid monitoring, control, and protection.

FLUIDOS addresses the challenges of scalability and resilience by introducing a virtualised approach to managing PMUs and Phasor Data Concentrators (PDCs). Through cloud-edge orchestration, FLUIDOS aims to ensure that critical grid services can continue functioning even in the event of faults or disconnection from

control centres. This system automatically migrates workloads between edge nodes and optimises resource allocation to ensure real-time grid state estimation and fault response.

Beyond enhancing the grid's resilience, this use case also reduces latency issues and improves security by providing isolation for critical services and implementing anomaly detection measures.

In the future, the project will continue advancing its edge-to-cloud orchestration capabilities to support large-scale deployments and explore applications in other sectors like viticulture and robotics. This use case flyer has been available on the project website and [Zenodo channel](#) since mid September 2024.



Figure 4 - Flyer produced for FLUIDOS user story in energy

3.1.5. User story #8: Smart Energy Management with IoT and Edge Computing: Revolutionising Domestic Energy Use (ICOS)

The [ICOS](#) success story showcases a smart energy management system designed to optimise domestic energy use by integrating Electric Vehicles (EVs), heat pumps, photovoltaic (PV) systems, and energy storage. This system, developed by SSE Airtricity in collaboration with CeADAR, leverages advanced AI and edge computing to enhance energy efficiency, reduce carbon footprints, and enable net-zero emissions.

The solution uses an Energy Management and Decision Support System (EMDS) that operates through the ICOS meta-operating system. The system seamlessly connects various IoT sensors and edge devices,

optimising energy consumption, storage, and sale decisions in real time. By forecasting solar PV output, EV charging needs, and future retail energy prices, the system offers significant cost savings and boosts the use of renewable energy sources. Key benefits include reduced data transfers, enhanced data security, and optimised local computational resources at the edge.

Despite challenges such as ensuring robust data security and customising energy solutions, the ICOS system has automated complex energy decisions and improved customer satisfaction, waste reduction, and green energy use.

Future improvements will focus on expanding the system's edge-managed cluster and integrating additional renewable energy sources, particularly in regions with poor connectivity, to make the solution more robust and scalable. This use case flyer has been available on the project website and [Zenodo channel](#) since mid September 2024.

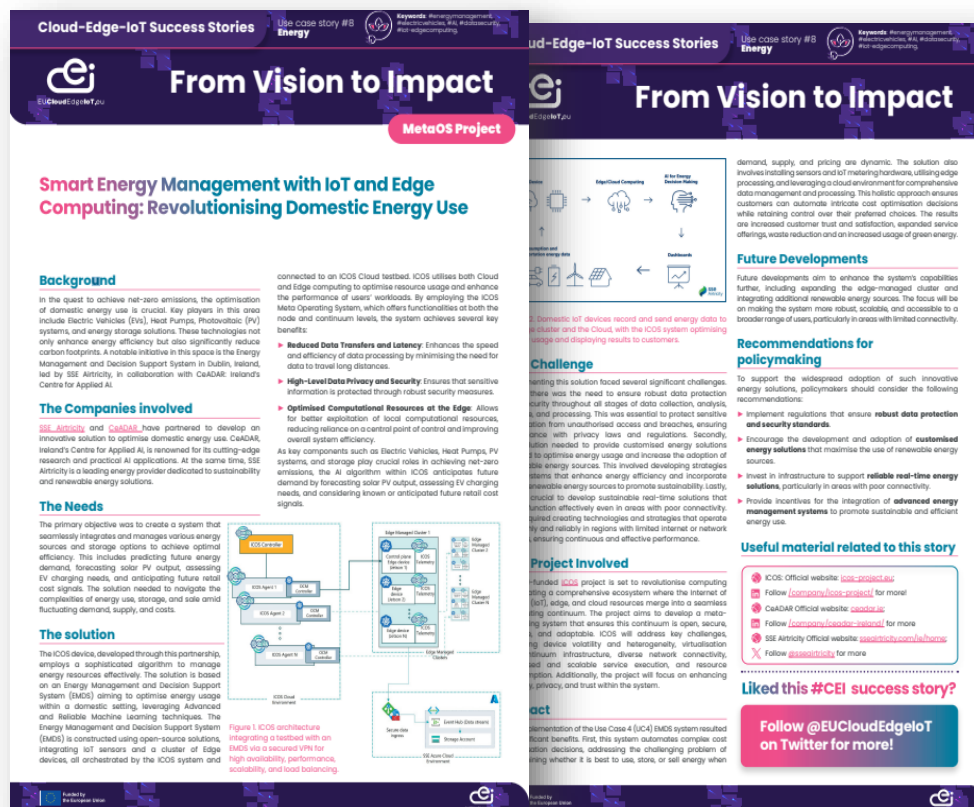


Figure 5 - Flyer produced for ICOS user story in energy

3.1.6. User story #9: Introduction of drones and implementation of Predictive Technology in windmill maintenance (NebulOuS)

The [NebulOuS](#) success story demonstrates the use of cutting-edge technology to revolutionise windmill maintenance through UAV (Unmanned Aerial Vehicles), AI, and edge-to-cloud computing. Traditionally, windmill inspections involved either ground-based cameras or manual climbs, both time-consuming and costly. NebulOuS addresses these inefficiencies by integrating drone-based inspections with advanced processing capabilities, allowing for real-time damage detection and maintenance planning.

In this use case, drones equipped with high-resolution cameras capture images of windmill blades. The data is processed on-board the drone and at the edge to detect damage, before being further analysed in the cloud. This setup reduces the need for extensive data transfer and enables faster, more accurate inspections. NebulOuS leverages 5G networks to ensure data is processed efficiently, utilising cloud resources when necessary to analyse potential damage in detail.

This approach eliminates the need for manual data uploads and repeated inspections, improving operational efficiency. The solution has also laid the groundwork for automated infrastructure scalability, ensuring that the system can handle varying workloads without human intervention.

For the future, NebulOuS aims to expand these inspection techniques to other sectors, including solar plants, electricity grids, and pipelines. Future developments will also incorporate advanced sensors like infrared cameras and ultrasound scanners to further enhance inspection capabilities. This use case flyer has been available on the project website and [Zenodo](#) channel since mid September 2024.



Figure 6 - Flyer produced for NebulOuS user story in energy

3.1.7. User story #10: Smart Media/City: Cloud-Edge-IoT solutions for modern-day Media (NEMO)

The [NEMO](#) success story highlights a smart media solution that enhances live sports event coverage using cloud-edge-IoT technology. The use case focuses on urban city marathons, aiming to improve the viewer experience by providing real-time, AI-enhanced, media content. Currently, spectators of such events have limited access to real-time information beyond traditional broadcasts or social media.

The NEMO solution uses the Next Generation Meta Operating System (NEMO Meta OS) framework to capture, process, and deliver personalised media content in real time. Media is captured through various sources, including drones, cameras, and smartphones, and processed at the edge for low-latency AI-driven analysis. Spectators can interact with the media using a dedicated app, allowing them to view, share, and comment on content in real time.

The solution addresses challenges such as high video latency and complex media processing by leveraging advanced network management and cloud-edge resource allocation. The system's energy-aware

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orchestration reduces the environmental impact, and the AI-enhanced spectating experience offers a tailored viewing experience, significantly improving user engagement.

In the future the project aims to expand the solution to other live events and media applications, using advanced AI for personalised content delivery and continuing to optimise resource usage for improved energy efficiency. This use case flyer has been available on the project website and [Zenodo](#) channel since mid September 2024.



Figure 7 - Flyer produced for NEMO user story in media

3.1.8. User story #11: Optimising Energy Management with Predictive IoT Devices: Interoperable Solutions for Real-time Room Occupancy (NEPHELE)

The [NEPHELE](#) success story focuses on enhancing energy management in buildings by using intelligent IoT devices that predict room occupancy in real time. Buildings account for a significant portion of global energy consumption, much of which is due to inefficient HVAC systems. The NEPHELE solution, developed by Siemens and Odin Solutions, addresses this by dynamically adjusting HVAC operations based on real-time occupancy data.

The solution uses AI-driven IoT devices to predict room usage, ensuring that HVAC systems operate only when necessary. This reduces energy waste, lowers operational costs, and improves indoor air quality. NEPHELE's interoperable IoT devices integrate seamlessly with existing building management systems, making the solution suitable for a wide range of building types. The system also incorporates robust cybersecurity measures to protect data and prevent unauthorised access.

Future advancements will include further integration of AI techniques, such as TinyML, and the use of Distributed Ledger Technology for secure access control, driving greater energy efficiency and sustainability in smart buildings. This use case flyer has been available on the project website and [Zenodo](#) channel since mid September 2024.

Cloud-Edge-IoT Success Stories Use case story #7 Energy

From Vision to Impact

MetaOS Project

Optimising Energy Management with Predictive IoT Devices: Interoperable Solutions for Real-time Room Occupancy

Background

The operations of buildings account for 30% of global energy consumption and 28% of global energy-related emissions. A significant contributor to this consumption is HVAC systems, which are critical for providing temperature control and indoor air quality but are known to be inefficient.

The Company

Siemens AG is a global powerhouse in electronics and electrical engineering. Operating in the fields of automation, digitalisation and electrification, Siemens holds leading market positions in all its business areas. The company has roughly 320,000 employees worldwide working to develop and manufacture products, design and install complex systems and projects, and tailor a wide range of solutions for individual requirements. For 176 years, Siemens stands for technological excellence, innovation, quality, reliability and sustainability. Siemens has a strong portfolio in Building Automation Systems, leveraging digital twins (virtual objects) and intelligent IoT devices to enhance building efficiency, particularly in terms of energy usage, and to foster innovation.

The Needs

The primary need identified was to reduce the energy consumption of HVAC systems, which typically account for up to 40% of a building's total energy usage. Current HVAC systems operate on predefined schedules, failing to adapt to actual room occupancy and usage patterns, leading to significant energy waste. There was a clear need for a solution to dynamically adjust HVAC operations based on real-time occupancy data to ensure energy is not wasted on unoccupied spaces. Furthermore, the existing HVAC systems could not integrate seamlessly with modern IoT devices and advanced energy management systems. The lack of interoperability made it difficult to implement smart, energy-efficient solutions across different types of buildings with varying systems.

The solution

NEPHELE proposed a comprehensive solution involving intelligent, customisable, and interoperable IoT devices to make HVAC systems more energy-efficient (see Figure 1). The solution starts with real-time occupancy prediction, utilising advanced IoT devices with built-in intelligence (see Figure 2). These devices use AI algorithms like TinyML to process sensor data and accurately predict room usage. With this real-time data, the system can dynamically adjust the operation of HVAC systems, ensuring energy is not wasted on unoccupied spaces. The IoT devices feature adaptive algorithms, allowing them to customise their operation based on the specific environment of each room or building section. This adaptability ensures optimised energy management tailored to the unique usage patterns of different spaces. Furthermore, the solution emphasises interoperability, ensuring these IoT devices can seamlessly integrate with existing building management systems. This integration allows for a cohesive and efficient energy management system across the entire building, from the solution to protect data and control access, leveraging modern, robust cybersecurity measures are embedded within, and Distributed Ledger Technologies to ensure secure and reliable operation.

The Service Provider

The distributed application that is developed in this use case is going to be deployed and managed by the developed synergistic meta-orchestration (SMO) solution in the NEPHELE project. The NEPHELE SMO supports the instant-on deployment and lifecycle management of distributed applications over programmable multi-cluster compute and network infrastructure that spans across the computing continuum.

Impact

The implementation of NEPHELE's solution led to significant energy savings in smart buildings. The solution reduced unnecessary energy consumption by enabling HVAC systems to adjust dynamically based on real-time occupancy data, directly contributing to lower operational costs for building owners and managers. The intelligent IoT devices facilitated more efficient use of renewable energy sources, aligning with global sustainability goals and reducing buildings' carbon footprint. Additionally, the improved energy management contributed to better indoor air quality and more consistent indoor temperatures, enhancing occupant comfort and well-being. The Smart Energy Balancer, a key component of the solution, and interoperability between IoT, cloud, and edge computing, leveraging 5G and distributed AI techniques for automation and decentralised intelligence. NEPHELE introduces an IoT and edge computing software stack that enables the virtualisation of IoT devices at the edge, supporting openness and interoperability in a device-independent manner. Additionally, it features a synergistic meta-orchestration framework that coordinates cloud and edge computing platforms through high-level scheduling and system supervision. These innovations will be demonstrated and validated across various industries, including disaster management, port logistics, energy management in smart buildings, and remote healthcare. The project will also conduct two open calls and aims to foster a broad open-source community to support its outcomes.

Useful material related to this story

NEPHELE Official website: nephel-project.eu
Follow [@EUCloudEdgeIoT](https://twitter.com/EUCloudEdgeIoT) for more
Follow github.com/nephel-project for more

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Figure 8 - Flyer produced for NEPHELE user story in energy

3.2. White paper collection

3.2.1. Technology implementation model and architectural patterns for CEI use cases

This white paper presents a comprehensive framework for implementing CEI use cases across various industry sectors. The UNLOCK-CEI team analysed 79 use cases spanning agriculture, energy, healthcare, manufacturing, and transport, identifying key architectural patterns and technical models needed for CEI implementation.

The paper breaks down all the use cases into six main architectural patterns: location tracking, visual inspection, condition monitoring, predictive maintenance, asset command and control, and process optimisation/autonomous operations. Each pattern is associated with specific technical components, data requirements, and service needs, such as sensors, gateways, and cloud or edge computing capabilities. The analysis also outlines how these components interact, from real-time data collection to advanced edge-cloud orchestration.

The white paper also explores challenges, such as ensuring scalability, managing the physical scope of use cases, and optimising communication between devices and gateways. The UNLOCK-CEI team emphasises that a common technical model can be applied across industries to address the diverse needs of CEI applications. The key takeaways of the paper include the following:

- **Adaptability and flexibility:** CEI implementations must be adaptable across industries. The six architectural patterns identified in the white paper can be applied flexibly to meet the demands of different sectors, offering a foundation for scalable solutions.
- **Edge-cloud integration is essential:** The success of CEI applications relies heavily on optimising the interplay between edge and cloud computing, ensuring real-time processing and low-latency data exchange.
- **Scalability challenges:** Scaling CEI applications requires overcoming key obstacles such as infrastructure costs and the complexity of managing large numbers of connected devices.

- **Cross-sector potential:** The findings highlight that, despite sector-specific nuances, a common set of technical models can drive the adoption of CEI technologies across various industries.

The white paper suggests further exploration into improving AI and machine learning models for edge computing and enhancing the scalability of CEI applications across Europe.

The document has been available in the [Zenodo repository](https://zenodo.org/record/10000000) of the project since June 2024. To date, it counts **223 views** and **138 downloads**.



Figure 9 - Selected views of the architectural patterns white paper

3.2.2. Market pathways for CEI in manufacturing

This white paper explores the strategic opportunities and challenges of CEI adoption in the manufacturing sector. It highlights the role of CEI technologies as critical enablers of Industry 4.0, facilitating vertical and horizontal integration across production lines and supply chains. The paper also provides an in-depth analysis of the infrastructure, solutions, and innovations available in the European market to support the digital transformation of manufacturing processes.

The white paper presents three key examples of innovative CEI solutions in the sector: Contact Software, Siemens' KICKS4EDGE project, and DRIMco. These solutions showcase how companies are leveraging CEI technologies to improve efficiency, enable data sovereignty, and address interoperability challenges. The solutions also demonstrate the critical role that digital twins, AI-based tools, and edge computing play in transforming manufacturing operations, from production planning to predictive maintenance.

Among the key messages of the paper we find:

- **Data sovereignty and openness:** CEI technologies can enhance data exchange and collaboration across manufacturing ecosystems, but only if openness and data sovereignty are maintained. The use of open standards is crucial for ensuring interoperability and preventing vendor lock-in.
- **Strategic advantage for SMEs:** CEI technologies offer great potential for small and medium-sized enterprises (SMEs), particularly by enabling more cost-effective, data-driven operations. However, SMEs face challenges related to the complexity and cost of these solutions.

- **Digital twins as enablers:** Digital twins and AI tools are pivotal for advancing smart manufacturing, enabling real-time monitoring, decision-making, and continuous improvement across the production lifecycle.
- **Collaboration is key:** To overcome dependency on US-based hyperscalers and achieve digital sovereignty, strategic collaboration among European companies, especially between large and smaller enterprises, is vital.

The white paper calls for more harmonisation of CEI standards across Europe, particularly focusing on interoperability and data sharing. It also recommends providing SMEs with more targeted support and resources to adopt CEI technologies, which are increasingly vital for staying competitive in a globalised manufacturing landscape. The paper is available on the website and [Zenodo](#) repository of the project since September 2024 with **56 views** and **52 downloads** to date.

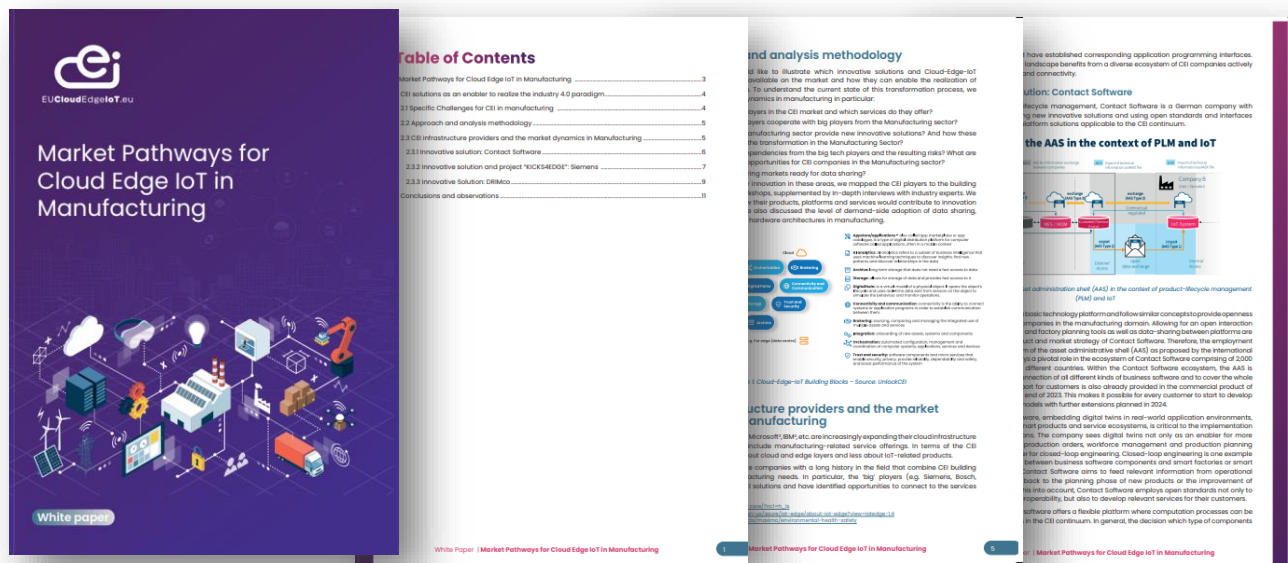


Figure 10 - Selected views of the CEI in manufacturing white paper

3.2.3. Market pathways for CEI in energy

This white paper explores how CEI technologies can drive the digital transformation of the energy sector, addressing critical challenges such as integrating flexible energy sources, enhancing network resilience, and improving efficiency. The paper reviews the dynamics of the CEI market and presents several innovative solutions from European companies that are playing a leading role in the sector.

The case studies discussed include Tibber, a digital electricity provider offering flexible tariffs and smart energy management, which contributes to grid stability. Technolution, a provider of edge hardware solutions, improves operational efficiency and resilience in energy grids by processing data locally. The open-source platform from PIONIX (Everest) enables electric vehicle (EV) charging stations to integrate multiple standards and protocols, avoiding vendor lock-in. Center Denmark provides digital infrastructure that supports energy demand-side flexibility, helping balance renewable energy use across sectors. Finally, Pratexo's AI-enabled edge-to-cloud management platform optimises energy system efficiency by reducing latency and processing data locally before sending it to the cloud.

The paper emphasises the need for increased digitalisation across the energy sector to enable flexibility, efficiency, and resilience. It highlights the importance of open-source solutions and edge computing as key enablers for improving system performance while reducing reliance on non-European vendors. Furthermore, collaboration and interoperability are essential to overcoming current market barriers and facilitating the seamless integration of CEI solutions.

Future directions in the paper include recommendations for greater investment in digital infrastructure and real-time data sharing to unlock the full potential of demand-side flexibility and support the energy sector's transition to a smarter, more efficient system.

ADD IMAGE

3.2.4. Market pathways for CEI in agriculture

This white paper delves into the potential for Cloud-Edge-IoT (CEI) technologies to transform the agricultural sector by enhancing efficiency, sustainability, and resilience in food production. It highlights how digital technologies, including edge computing, IoT, and data-driven platforms, are being leveraged to meet the challenges of modern agriculture, such as increasing food demand, climate change, and geopolitical tensions affecting global food systems.

The paper discusses several critical areas, including precision farming, automation, and operational efficiency, and presents innovative CEI-based solutions. Case studies include FarmNet 365, a farm management system that helps farmers automate documentation and regulatory compliance, and AgriDataSpace, a European initiative enabling data sharing between farmers, agri-tech companies, and public authorities. These platforms offer data-driven insights to improve decision-making and resource use, contributing to greater sustainability.

The paper also covers the COMECT EU project, which aims to bridge the digital divide in rural areas by providing connectivity solutions and smart infrastructure. The project supports agriculture through digital tools that enhance crop monitoring and decision-making in areas such as viticulture and livestock transport.

The paper emphasises the following key points, among others:

- **Digitalisation** is crucial for enabling operational efficiency, sustainability, and resilience in agriculture. CEI technologies offer solutions that address both the technological and socio-economic challenges faced by the sector.
- **Open-source and collaborative approaches** are essential for cost reduction and preventing vendor lock-in. CEI technologies can foster a collaborative infrastructure, bringing together farmers, agribusinesses, and other stakeholders.
- **Connectivity and rural infrastructure development** are vital to enable the adoption of CEI solutions, as many agricultural activities are located in remote areas with limited access to digital infrastructure.

Future directions include the need for increased investment in CEI infrastructure in rural areas and more support for data-sharing initiatives that can unlock the full potential of digital agriculture. A collaborative approach, involving stakeholders across the agricultural value chain, will be essential to ensure successful deployment and adoption of CEI technologies.

ADD IMAGE

3.2.5. Market pathways for CEI in mobility

This white paper explores the transformative potential of Cloud-Edge-IoT (CEI) technologies in the mobility sector, focusing on how digitalisation is reshaping transportation through automation, data analytics, and connectivity. The paper highlights various applications of CEI, from software-defined vehicles (SDVs) to intelligent transport systems, showcasing innovative solutions from leading industry players such as Continental, consider it, and Hanse Aerospace.

The mobility sector faces unique challenges, such as the need for real-time data processing, high-volume data flows, and integration of multiple sensors. CEI technologies are positioned to address these challenges by providing scalable and efficient solutions for managing data traffic, ensuring safety, and enhancing operational efficiency across vehicles, logistics, and traffic systems. For instance, Continental's Automotive Edge Framework integrates real-time data collection and operational control of electronic systems, enabling continuous software updates and predictive maintenance through digital twins.

Other examples include Co-operative Intelligent Transport Systems (C-ITS), which allow vehicles to communicate with each other and roadside infrastructure in real time, and Hanse Aerospace's cross-company supply chain management (SCM) platform, which automates logistics processes in the aerospace industry using edge computing for real-time monitoring.

Some of the key insights highlighted in the whitepaper are:

- **Scalability and efficiency:** CEI technologies enhance the scalability of mobility systems by enabling real-time data processing and communication at the edge, reducing latency and improving operational efficiency.
- **Safety and security:** CEI-based solutions improve safety in transport by enabling real-time decision-making and advanced driver assistance systems (ADAS), while also addressing cybersecurity concerns.
- **Collaboration and interoperability:** The success of CEI in mobility depends on close collaboration between stakeholders and the development of open standards to ensure interoperability across different systems.

Future directions outlined in the paper include the need for further investment in digital infrastructure to support automated driving and logistics, as well as the promotion of open-source solutions to encourage collaboration and avoid vendor lock-in in the European mobility sector..

ADD IMAGE

3.2.6. Gap analysis and strategic opportunities for the European CEI market

This white paper offers a thorough gap analysis of the current CEI market in Europe, identifying key challenges and opportunities that could influence the region's technological development. The analysis was based on survey data from 700 European enterprises and interviews with ecosystem participants, combined with desk research. The paper highlights gaps in technology adoption, infrastructure, and standards, while also providing recommendations to close these gaps and harness strategic opportunities.

The white paper explores several critical areas of the CEI ecosystem, including edge platforms, data management, analytics, AI, integration, security, and connectivity. The findings show that despite growing demand for CEI technologies, significant barriers remain, such as fragmented software solutions, data quality issues, and limited 5G coverage in rural areas. Furthermore, a shortage of skills in AI and cloud-edge management complicates CEI adoption. The key messages and recommendations of the paper include the following:

- **Need for harmonisation:** The CEI market suffers from fragmented standards, protocols, and proprietary solutions. Open standards and increased collaboration are crucial for promoting interoperability and reducing market confusion.
- **Focus on security and trust:** Security remains a major barrier to adoption, with vulnerabilities in edge devices and the need for better cybersecurity strategies at the forefront of concerns.
- **Infrastructure gaps:** There are significant gaps in connectivity, particularly in rural areas, which hinder the broader adoption of CEI solutions. The deployment of 5G networks and the use of private 5G solutions could play a critical role in overcoming these issues.
- **AI and analytics as a key enabler:** AI and analytics capabilities are vital for unlocking the full potential of CEI solutions, particularly at the edge. However, the need for improved data quality and a skilled workforce is a limiting factor.
- **Strategic opportunities:** Europe has the potential to lead in CEI by fostering innovation in areas such as AI, digital twins, and IoT. The adoption of open-source technologies and increased support for upskilling across industries will be crucial to achieving this.

The paper finally recommends further investment in AI development, harmonisation of edge computing standards, and increased support for the deployment of 5G networks to improve connectivity. Strategic focus

on security, workforce development, and cross-sectoral collaboration is essential for ensuring Europe's leadership in the global CEI market.

The document has been published on the website and [Zenodo](#) community of the project at the end of August and counts **39 views** and **34 downloads**.



Figure 11 - Selected views of the gap analysis white paper

4. Overcoming Barriers in the EU's Computing Continuum: Challenges and Future Directions

Policy brief based on the outcomes of UNLOCK-CEI final event

4.1. Future CEI challenges in the EU context

A recent report from Mario Draghi¹ addresses Europe's role in emerging digital technologies, including edge computing, which is critical to the continent's broader digital and industrial strategy. The report highlights that while Europe is increasingly lagging behind global leaders like the U.S. and China in key areas such as cloud computing and 5G deployment, it still has the opportunity to recover and lead in the field of edge computing. Europe's advanced industrial base provides a foundation for edge computing to play a vital role in sectors such as autonomous vehicles, smart cities, and Industry 4.0. However, Draghi stresses that infrastructure development and coordinated investments are urgently needed to achieve this potential.

One of the key challenges outlined in the Draghi report is the lag in infrastructure, including cloud and edge computing. Although Europe is behind in meeting its 2030 targets for the deployment of edge nodes, there remains an opportunity to recover ground, particularly in areas requiring technological sovereignty such as security, encryption, and AI. To address these issues, the report advocates for stronger coordination between

¹ EU competitiveness: Looking ahead: https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en
<https://www.eucloudedgeiot.eu>



policies and investments, emphasising the need to integrate edge computing with AI and 5G networks to boost Europe's competitiveness. It also calls for enhancing Europe's semiconductor industry, a fundamental component for the development of edge devices, and increasing R&D funding to advance edge computing solutions.

Today the computing continuum infrastructure spans a wide spectrum, ranging from micro edge to far edge and encompassing the cloud continuum. On the other hand, the growing array of intelligent devices demands the orchestration of all edge devices. The complexity of this continuum lies in the technical challenges of developing edge cloud infrastructure as a seamless, virtual infrastructure that orchestrates workloads effectively. For organisations seeking to operate their infrastructure efficiently, this orchestration is essential. The lack of tech infrastructures remains a critical bottleneck for the computing continuum, especially as the need for edge computing grows. More robust and widespread infrastructure is needed to support the expansion of edge and IoT technologies. On the other hand, Edge computing requires greater computing capacity at the edge to deliver on its promise, and efforts should be concentrated on enhancing this capability.

To overcome these challenges, in the European context, several research and innovation (R&I) projects are being launched, with initial implementations appearing in the market. The primary goal of such initiatives is to create an open framework, with particular interest in identifying the open-source communities in Europe that can contribute to delivering services for the computing continuum. Most of the research efforts in this field are brought together in the umbrella initiative [“The European Cloud, Edge, IoT Continuum - EUCloudEdgeIoT”](#). As part of this cluster, for instance, the Meta Operating Systems (MetaOS) projects, are collectively advancing cloud-edge-IoT solutions in various sectors, including energy, media, manufacturing, smart buildings and mobility. These projects are demonstrating the important role of edge computing in these sectors, where real-time data processing is key to improving efficiency and resilience. They also reflect the importance of collaboration and open frameworks for addressing technical challenges and enhancing CEI adoption across industries. The next wave of funded projects in this area will include large scale pilots aimed at further integrating CEI technologies into Europe's digital ecosystem.

4.2. Current challenges and access barriers

Europe faces the urgent need for a "radical change" to improve its competitiveness in the digital landscape, as outlined in the Draghi report, which emphasises the critical role of edge ecosystems in maintaining technological sovereignty. Such needs are reflected in the EU Digital Compass 2030, outlining Europe's vision for a digitally sovereign future, focusing on four key objectives: digital skills, digital infrastructures, digital transformation of businesses, and digitalisation of public services. By 2030, the EU aims to ensure that at least 80% of adults possess basic digital skills and that there are 20 million employed ICT specialists. For infrastructure, the target includes the deployment of 10,000 edge nodes, widespread gigabit connectivity, and 5G coverage, as well as advancements in quantum technologies. The EU also seeks to have 75% of companies using cloud, AI, and big data, with over 90% of SMEs reaching basic digital intensity levels. Public services are a priority, with the ambition of 100% of key services being available online, alongside comprehensive digital identity solutions for citizens. These initiatives aim to enhance Europe's digital leadership, competitiveness, and resilience within the global digital economy.

During the [final event of UNLOCK-CEI](#), held on 23rd September 2024, these crucial topics were discussed in a dedicated panel with representatives of [HiPEAC](#), [Chips Joint Undertaking \(JU\)](#), [AIOTI](#), [BDVA](#) and the [AI, Data and Robotics Association \(ADRA\)](#). The discussion highlighted the following key challenges and possible remedies.

Infrastructure and investment

One of the most pressing challenges discussed at the UNLOCK-CEI final event on 23rd September 2024, and as highlighted in the Draghi report, is the need for significant investment in digital infrastructure. Europe

must invest in 5G, fibre, and edge computing infrastructure to close the gap with global competitors. While Europe has made strides, the lag in infrastructure deployment, particularly for edge computing, remains a major barrier. Increased investments are required to strengthen infrastructure and ensure the computing capacity at the edge meets future demands. Insights from the "Gap Analysis and Strategic Opportunities" white paper by UNLOCK-CEI² highlights the key gaps and how Europe can bridge technological gaps by fostering open-source solutions and increasing collaboration across CEI ecosystems.

Market fragmentation and complexity

Market fragmentation is another challenge affecting the adoption of CEI solutions in Europe. Companies face significant barriers in navigating the various programmes and initiatives aimed at supporting digital transformation. While the proliferation of such programmes is designed to support policy agendas, the complexity and overlap of these initiatives can make it difficult for businesses to access funding and resources effectively. The Wackler and G+D success story collected by UNLOCK-CEI³ illustrates how businesses struggle with complex logistics and fragmented systems when integrating CEI technologies across supply chains. Greater clarity and coordination are needed to reduce confusion and facilitate smoother market access for companies looking to innovate with CEI technologies.

Standardisation

One of the key challenges discussed at the final event, but missing in many sectors, is the issue of standards and interoperability. The lack of common standards across cloud, edge, and IoT technologies creates significant roadblocks for companies looking to integrate solutions across different platforms. The absence of interoperability limits the potential for scalable solutions and creates fragmented ecosystems where solutions cannot work together efficiently. Ensuring that standards are developed and widely adopted is crucial for fostering a more connected and collaborative digital infrastructure. This issue has been highlighted by multiple CEI projects, including the MetaOS projects, which stress the importance of open frameworks to ensure seamless integration across industries and sectors.

Regulatory and financial barriers

Regulatory hurdles and financial constraints also play a role in slowing down the adoption of CEI solutions. Many businesses face uncertainty around return on investment (ROI) for digital transformation efforts, and venture capital in the CEI space remains limited. Poor R&D decisions and a lack of strategic direction further compound this issue, making it difficult for companies, especially SMEs, to scale up and commercialise new technologies. The need for clearer regulations, stronger venture capital investments, and more strategic R&D funding was a key takeaway from the discussions.

Alignment of technological innovation with business models

Another challenge lies in aligning technological advancements with actionable business models. Many companies struggle to find a clear market focus or concrete business cases for CEI technologies. The absence of scalable business models hinders the commercialisation of innovations, particularly in sectors where technological solutions have been developed but lack market traction. Greater attention must be paid to ensuring that CEI projects are not only technically innovative but also commercially viable.

4.3. Recommendations and remarks

Standards and interoperability

Ensuring compliance with EU values, particularly around data privacy and security, is fundamental to promoting a truly interoperable system. Only through harmonised regulations and standards can Europe

² The full paper is accessible at this link: <https://doi.org/10.5281/zenodo.13364675>

³ UNLOCK-CEI success stories are accessible at this link: <https://eucloudedgeiot.eu/success-stories/>
<https://www.eucloudedgeiot.eu>



build a functional digital single market, facilitating smoother cross-border operations and ensuring that digital products and services are widely adopted. The creation of interoperable frameworks will also help to foster trust in European solutions, further supporting the go-to-market process.

Interoperability remains a key factor in fostering the adoption of cloud, edge and IoT solutions. Technologies, especially in the domains of cloud, edge, and IoT, need to be interoperable to create seamless integration across systems. This would enhance their uptake by companies and consumers alike, stimulating further innovation and driving the growth of these markets. IoT nodes and edge computing, in particular, hold significant potential to bring value to the market, but they require better infrastructure and collaborative efforts to realise their full impact.

Open source and data sovereignty

Other key opportunities and benefits currently available in the European context revolve around open source, data sovereignty, and the automotive and energy sectors, which are seen as critical domains for CEI adoption. Infrastructure optimisation, semantic interoperability, and tech sovereignty reflect the needs for European companies to access improved systems that enable seamless integration, efficient resource management, and greater control over data.

An important emerging opportunity lies in the development of RISC-V⁴, an open-source hardware instruction set architecture that offers the potential to become a reference architecture in Europe. Projects under the Chips Joint Undertaking (JU) are already exploring the use of RISC-V as a foundation for common solution development, particularly in the context of CEI technologies. The adoption of RISC-V could facilitate more standardised, interoperable solutions across industries, while also promoting European independence in key technological areas, including chip design and manufacturing. This aligns with the EU's broader goals of achieving data and technological sovereignty.

Furthermore, the potential for new services, time to market, and the role of novel chips also reflect how CEI technologies can open doors to innovation and faster product development cycles.

Overall, while the current EU scenario suggests substantial opportunities for cloud, edge and IoT applications in sectors like energy and automotive through concepts like open source, compliance and interoperability, only overcoming structural barriers—particularly in terms of business focus, regulation, and financial clarity—will ultimately drive effective adoption.

Driving innovation, entrepreneurship and leadership

Europe's ambition to become a global leader in digital technologies requires a significant shift in mindset. A critical factor in achieving this goal is fostering an environment that nurtures entrepreneurship and innovation. Education systems should not only equip individuals with technical expertise but also inspire creativity and the drive to bring new ideas to market.

In addition, rather than focusing solely on challenges, projects' emphasis should be on identifying and implementing solutions. Shifting attention to future opportunities will foster momentum, driving innovation forward. Projects should not merely catalogue obstacles but should focus on showcasing success stories, creating roadmaps for sustainable growth, and promoting collaboration across ecosystems. Drawing insights from both within and outside individual project scopes will enhance the potential for broader impact and accelerate the development of cloud, edge, and IoT technologies.

Large-scale pilots recently funded across Europe are set to play a critical role in deploying CEI solutions, helping to validate technologies and showcase their real-world applications. These pilots will allocate a substantial portion of their funding to open calls, aimed at involving companies and elevating the innovations to the next level. Additionally, there is growing momentum in the telecommunications sector with the development of network software slices for 5G and 6G contributing to decentralised, connected and

⁴ More information available here: <https://riscv.org/>
<https://www.eucloudedgeiot.eu>

collaborative computing networks. The pilots will support the practical adoption of CEI technologies while fostering collaboration between public and private sectors, ultimately driving the integration of cloud, edge, and IoT systems across various industries.

Joint efforts and a holistic approach

To enhance the EU's competitiveness, joint efforts from strategic initiatives in cloud, edge, and IoT must be aligned with technologies such as AI. Europe needs a clear vision that fosters increased collaboration, not only within the EU but also with international partners through more international projects⁵.

For Europe to achieve digital autonomy, it is essential to develop the entire technological stack, from research and innovation to market delivery. A holistic approach is crucial—projects must address not only individual components but also work across the whole stack to ensure competitiveness in critical areas such as edge computing, which demands more infrastructure and computing capacity at the edge.

5. Conclusions

This deliverable has outlined the role of Cloud-Edge-IoT (CEI) technologies in various sectors, illustrating their practical applications through success stories and white papers. The examples provided demonstrate how CEI technologies are being implemented to address specific challenges in key sectors. The user stories, including those from the MetaOS projects, have highlighted the importance of collaboration across sectors and the use of open-source solutions to tackle issues such as market fragmentation and infrastructure limitations.

The policy brief from the project's final event has provided insights into Europe's current position within the CEI landscape, with a focus on the need for further investment in 5G infrastructure, edge computing capacity, and the harmonisation of standards. These elements are seen as essential for supporting the future development of CEI technologies.

Throughout the deliverable, the need for interoperability, data sovereignty, and enhanced collaboration has been emphasised. By building on these key factors, CEI technologies can be further integrated into European industries to meet the goals outlined in the EU's 2030 Digital Compass.

The findings presented in this deliverable offer a perspective on the next steps for supporting CEI adoption and addressing the infrastructure, regulatory, and market challenges that remain. These insights provide a reference point for future efforts aimed at fostering the development and deployment of CEI solutions across sectors.

⁵ One example is the [Discover-US project](https://www.eucloudedgeiot.eu), which represents a pivotal collaboration between EU and US research institutions, focusing on advancing distributed computing and swarm intelligence.

<https://www.eucloudedgeiot.eu>