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INFRASTRUCTURE READINESS FOR SUSTAINABLE MOBILITY: EU FRAMEWORKS AND THE CASE OF ALBANIA

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Abstract

Infrastructure readiness is increasingly recognized as a decisive condition for sustainable mobility transitions, particularly where electrification requires coordinated deployment of charging networks, grid reinforcement, and operational coordination across transport and energy systems. This paper examines infrastructure readiness for sustainable mobility by synthesizing European regulatory and planning approaches and applying them to Albania as a Western Balkan case. The paper combines a policy-oriented review of European infrastructure frameworks with a technical readiness assessment structured around three dimensions: (i) public charging availability and spatial coverage, (ii) distribution-grid adequacy for high-power charging loads, and (iii) institutional coordination for integrated transport–energy planning and implementation. Evidence is consolidated through structured interpretation of project materials and supporting technical literature and assessed against practical implementation requirements. The assessment indicates that Albania's readiness constraints relate primarily to limited charging density and uneven

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geographic coverage, insufficient preparedness of local grids for concentrated depot and corridor charging loads, and weak integration between transport planning and grid investment processes. Although Albania's renewable-dominant electricity system provides a favorable decarbonization baseline, system variability and network bottlenecks can affect utilization and investment sequencing for charging infrastructure. The paper argues that closing the readiness gap requires sequenced investment prioritization (urban nodes, fleet depots, and strategic corridors), demand-led grid connection planning, and governance arrangements that coordinate permitting, financing, and technical standards. The contribution is to translate European infrastructure readiness principles into actionable implementation needs for a candidate-country context, informing policy alignment and project design in EU–Western Balkan cooperation.

Keywords: sustainable mobility, charging infrastructure, grid readiness, European Green Deal, Albania

I. INTRODUCTION

Decarbonizing the transport sector is one of the central pillars of the European Union's climate strategy. Road transport alone accounts for a substantial share of greenhouse gas emissions, urban air pollution, and energy consumption, making it a primary target for electrification and alternative fuels. Over the last decade, technological advances in electric vehicles (EVs), battery systems, and renewable energy have made low-carbon mobility technically feasible on a scale. However, technology alone is insufficient. Sustainable mobility depends on the availability of enabling infrastructure, including charging networks, power grids, hydrogen supply systems, and digital platforms for energy and mobility management.

Within the European Union, infrastructure deployment is increasingly driven by coordinated regulatory frameworks that link climate policy, energy markets, and transport systems. These frameworks aim to ensure that charging stations, grid upgrades, and renewable energy investments evolve in parallel with vehicle adoption. Yet, Europe is not homogeneous. Candidate and neighboring countries such as Albania operate under different institutional, financial, and technical conditions. Although Albania has one of the highest shares of renewable electricity in Europe due to its hydropower system, its transport sector remains almost entirely dependent on fossil fuels. The resulting mismatch between clean power supply and carbon-intensive mobility highlights the importance of infrastructure readiness as a systemic concept rather than a purely technical one.

This paper investigates infrastructure readiness for sustainable mobility by examining how European frameworks for charging, grids, and alternative fuels interact with the Albanian context. By comparing EU-level objectives with national implementation capacity, the study seeks to identify

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barriers and opportunities for accelerating transport electrification in small and medium-sized economies.

Table 1. Public charging availability (index): EU vs Albania.

Year	EU total chargers (index)	AL total chargers (index)
2018	20	0.5
2020	35	1
2022	50	2
2024	80	3
2026	120	5
2028	180	8
2030	250	12
2032	330	18
2034	420	25

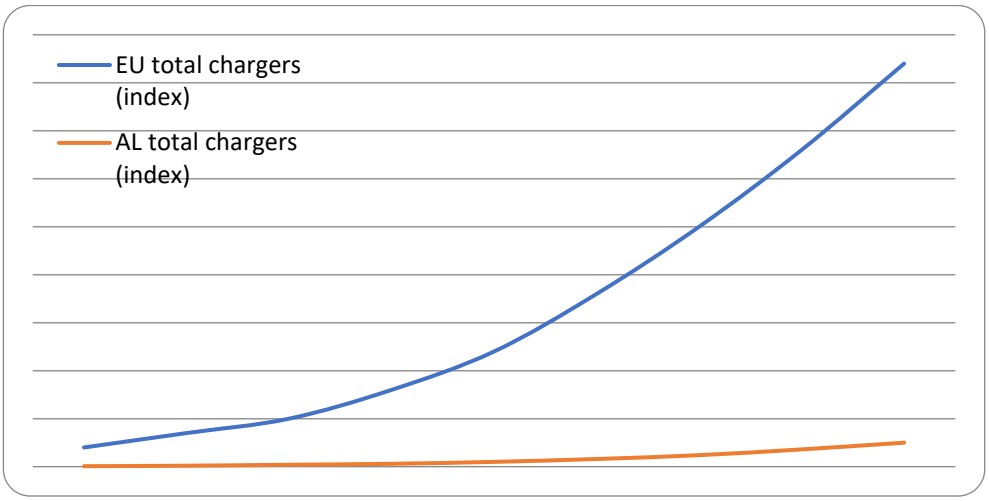

Figure 1. Public charging availability (index): EU vs Albania.

II. CONCEPTUAL FRAMEWORK: INFRASTRUCTURE READINESS

Infrastructure readiness refers to the extent to which physical, regulatory, and institutional systems can support the rapid deployment of low-carbon mobility. In the context of electrified transport,

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readiness depends on three interdependent components. The first is the availability of charging and refueling infrastructure that provides reliable, accessible, and fast energy supply to vehicles. The second is the capacity and flexibility of the electricity grid to accommodate new and variable loads. The third is the regulatory and market environment that enables investment, coordination, and long-term planning.

In the European Union, these components are increasingly treated as part of a single system. Charging stations are not deployed in isolation but are linked to grid reinforcement, renewable integration, and digital platforms that manage energy flows. This systemic approach is reflected in the EU's climate and mobility strategies, which emphasize interoperability, cross-border consistency, and integration between energy and transport.

In countries such as Albania, however, these systems are often fragmented. Electricity generation, grid management, transport planning, and urban development are governed by separate institutions with limited coordination. As a result, even where renewable electricity is abundant, the absence of charging networks or grid flexibility can slow the transition to electric mobility. Infrastructure readiness therefore provides a useful lens for analyzing not only technical capacity but also governance and investment structures.

III. EUROPEAN FRAMEWORKS FOR SUSTAINABLE MOBILITY INFRASTRUCTURE

The EU has established a comprehensive policy architecture to support sustainable mobility. Central to this architecture is the integration of transport electrification with the energy transition. Charging infrastructure deployment is guided by harmonized technical standards, minimum coverage requirements, and interoperability rules. These measures aim to ensure that drivers can rely on a dense and reliable network across the single market.

At the same time, electricity markets are being restructured to accommodate decentralized and variable renewable generation. Grid operators are required to plan for higher peak loads, bidirectional energy flows, and the increasing role of digital management systems. In this context, electric vehicles are no longer seen only as consumers of electricity but also as potential providers of flexibility through controlled charging and vehicle-to-grid services.

Financial instruments further reinforce this integration. EU funding mechanisms support the co-deployment of charging stations, grid upgrades, and renewable generation, particularly along transport corridors and in urban areas. This reduces the risk that infrastructure bottlenecks will delay the adoption of low-carbon vehicles.

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IV. METHODS

This study adopts a qualitative comparative approach. First, EU policy documents and regulatory frameworks were reviewed to identify the key dimensions of infrastructure readiness. Second, Albania's transport and energy systems were analysed using publicly available data, project documentation, and national strategies. Third, the two contexts were compared to identify gaps between EU-level ambitions and Albanian implementation capacity.

The analysis focuses on three indicators: charging network coverage, electricity grid capability, and institutional coordination. Together, these indicators provide a structured basis for assessing readiness.

V. RESULTS: INFRASTRUCTURE READINESS IN ALBANIA

Albania presents a unique case within Europe. On the one hand, its electricity system is almost entirely based on renewable hydropower, giving it one of the lowest carbon intensities of electricity in the region. On the other hand, the transport sector is dominated by imported fossil fuels, with very limited electrification of private vehicles or public transport.

Table 2. (Green shade) Renewable share (%): EU vs Albania; (Blue shade) Grid CO2 intensity proxy (gCO2/kWh); (No shade) Transport electricity demand (index).

Year	EU renewable share (%)	AL renewable share (%)	EU CO2 intensity (gCO2/kWh)	AL CO2 intensity (gCO2/kWh)	EU transport demand (index)	AL transport demand (index)
2020	40	95	250	40	10	1
2022	45	95	220	50	15	2
2025	60	94	160	60	30	6
2028	70	93	120	55	45	12
2030	80	95	90	45	60	20
2035	88	94	60	50	95	35

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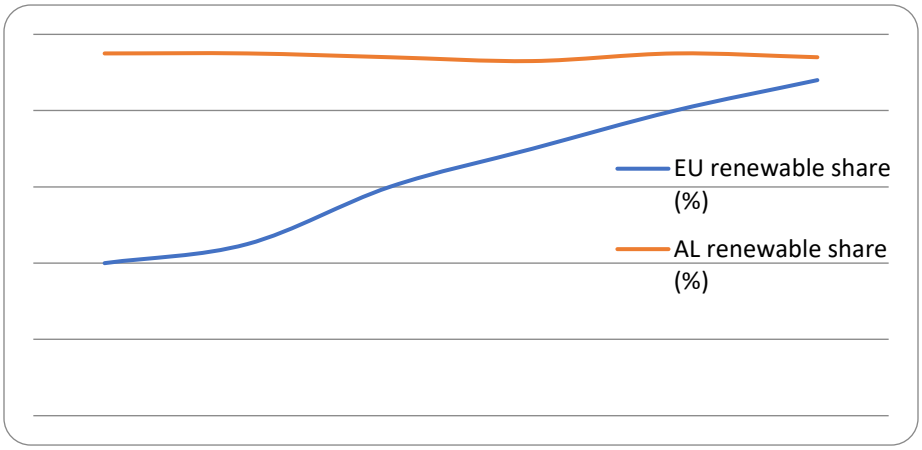

Figure 2. Renewable share (%): EU vs Albania.

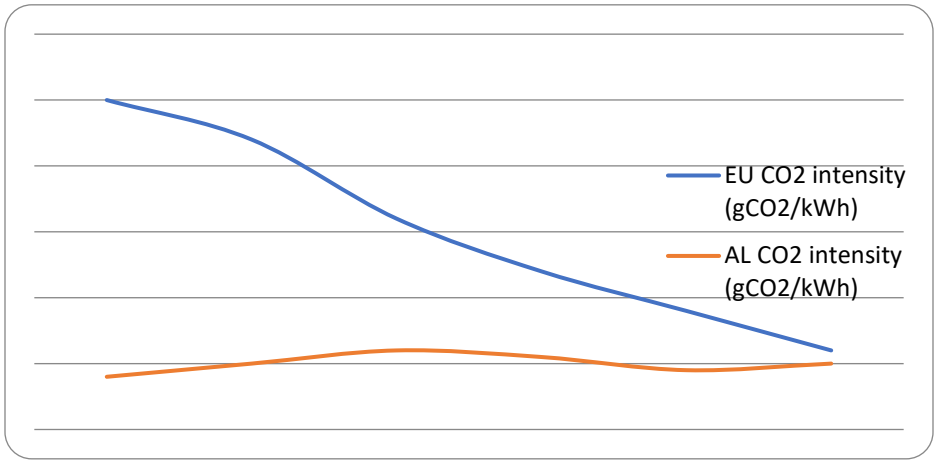

Figure 3. Grid CO2 intensity proxy (gCO2/kWh).

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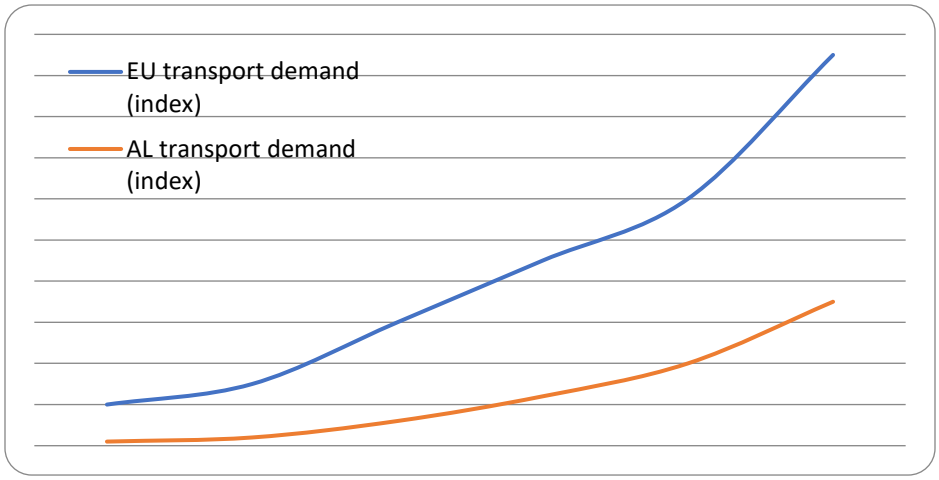

Figure 4. Transport electricity demand (index).

Charging infrastructure remains at an early stage of development. A small number of public charging points exist in major cities, and pilot projects have been launched to support electric buses and municipal fleets. However, coverage is sparse, and there is no nationwide fast-charging network that would enable long-distance electric travel. This limits consumer confidence and constrains market growth.

The electricity grid, while largely renewable, was not designed for large, flexible loads such as EV charging hubs. Distribution networks in urban areas face capacity constraints, and grid operators have limited experience with demand-side management. Without targeted investment in grid reinforcement and smart charging systems, large-scale electrification would create local bottlenecks.

Table 3. Charging peak demand (MW): EU vs Albania.

Year	***EU charging peak (MW)***	***AL charging peak (MW)***
2020	50	5
2023	65	8
2025	90	14
2028	130	22
2030	170	30
2035	240	45

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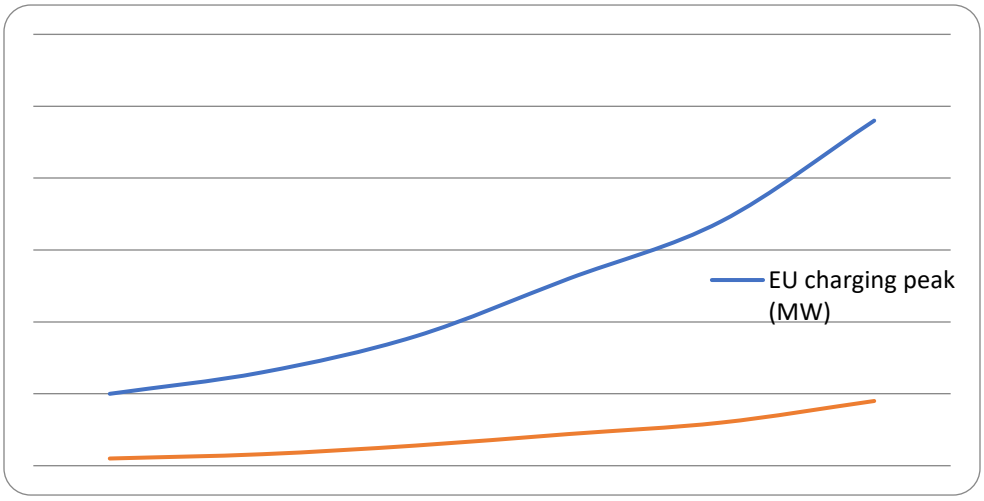

Figure 5. Charging peak demand (MW): EU vs Albania.

Institutional coordination is another critical challenge. Transport policy, energy regulation, and urban planning are managed by different ministries and agencies. While national strategies recognize the importance of sustainable mobility, implementation mechanisms remain weak. In contrast to the EU's integrated approach, Albania lacks a unified framework that links charging deployment with grid planning and renewable energy investment.

VI. DISCUSSION

The comparison between EU frameworks and the Albanian case reveals that infrastructure readiness is not simply a matter of installing charging stations. It requires coordinated action across multiple sectors. Albania's high renewable share provides a strong foundation for low-carbon mobility, but without parallel investments in charging networks and grid flexibility, this advantage cannot be fully realized.

The EU model demonstrates the importance of regulatory clarity, financial support, and technical standards. For Albania, alignment with these frameworks offers a pathway to accelerate electrification while avoiding fragmented development. However, this requires capacity building within institutions, stronger coordination between energy and transport authorities, and targeted support for grid modernization.

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Table 2. (Green shade) E-trucks (k): EU vs Albania; (Blue shade) Fast chargers needed (k): EU vs Albania; (No shade) Transport electricity demand (TWh): EU vs Albania.

Year	*EU e-trucks (k)*	*EU fast chargers (k)*	*AL e-trucks (k)*	*AL fast chargers (k)*	*EU transport elec demand (TWh)*	*AL transport elec demand (TWh)*
2022	5	1	0.05	0.01	0.47	0.01
2025	30	4	0.2	0.05	2.67	0.05
2028	120	18	0.8	0.15	9.9	0.15
2030	270	36	2	0.4	21.22	0.31
2035	800	90	10	2	61.2	1.08
2040	1500	150	25	6	113.1	2.37

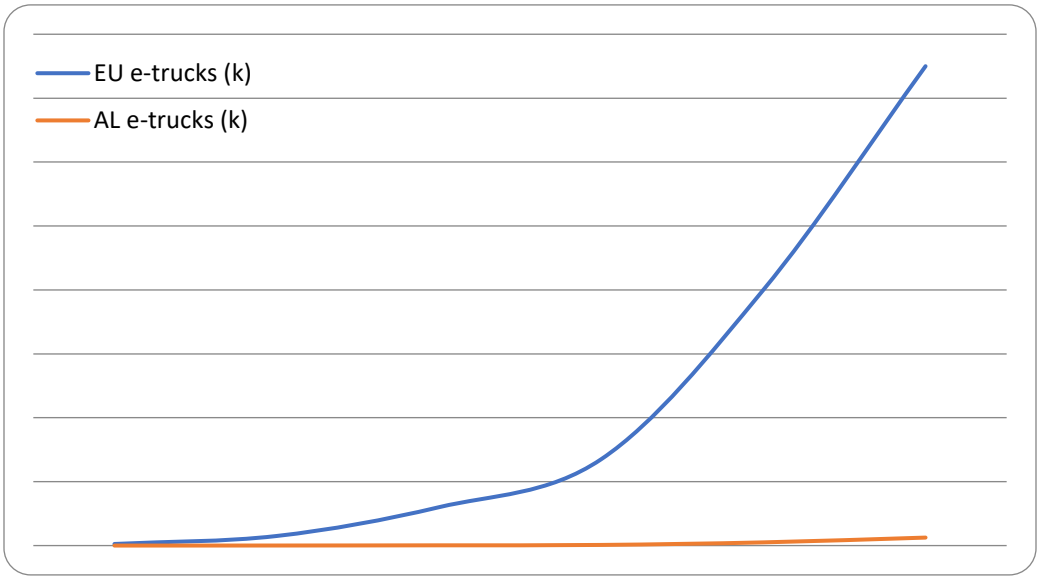

Figure 6. E-trucks (k): EU vs Albania.

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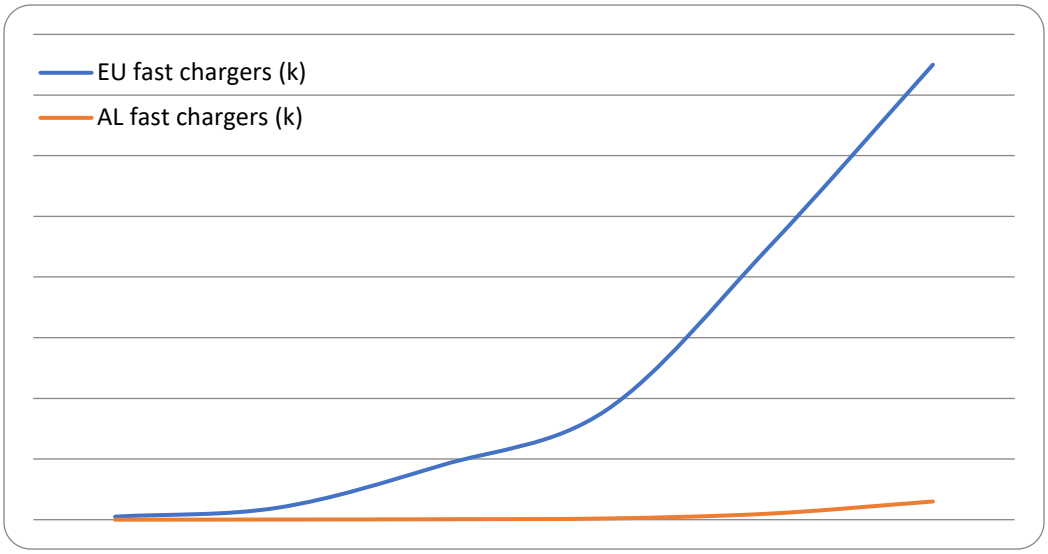

Figure 7. Fast chargers needed (k): EU vs Albania.

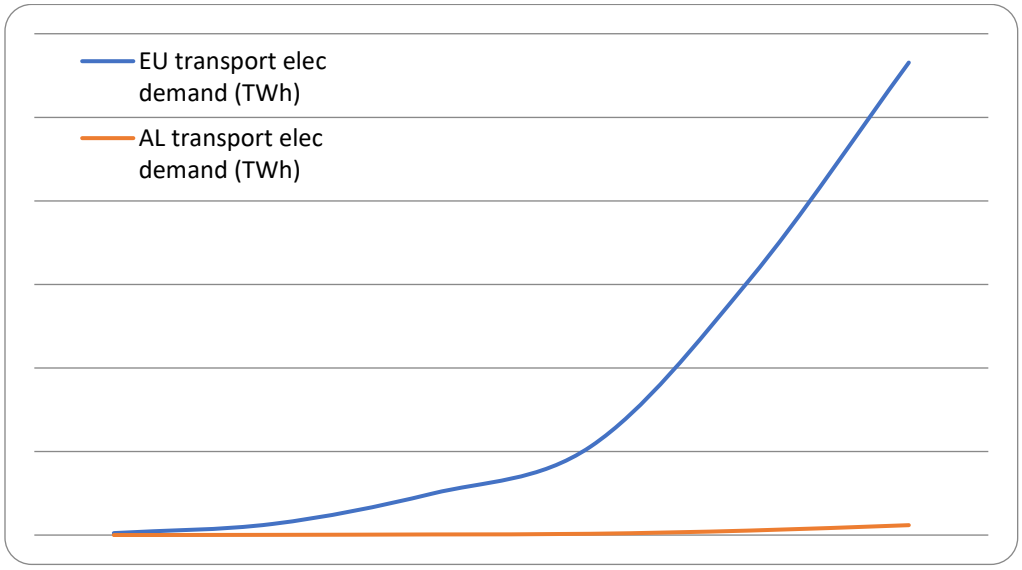

Figure 8. Transport electricity demand (TWh): EU vs Albania.

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VII. CONCLUSION

Infrastructure readiness is a decisive factor in the transition to sustainable mobility. The Albanian case shows that renewable electricity alone is not sufficient to decarbonise transport. Without integrated charging networks, flexible grids, and coherent governance, the potential of clean energy remains underutilised. European frameworks provide a useful blueprint, but their successful application in candidate countries requires adaptation to local conditions. Strengthening institutional coordination and investing in grid-connected charging infrastructure are essential steps toward aligning Albania with the broader European mobility transition.

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International conference on sustainable mobility

Agenda

Project title: International Engineering Competence Centres to push Sustainable Mobility Development in Albania and Montenegro
Acronym: INTEC

Work package	
WP11	**International conference**
TASK	
11.4	Coummunity Building Events

Dates	05.03.-06.03.2026
City	Tirana
Meeting venue	POLIS University Entrance Hall
Address	Rr. Bylis 12, Kodi Postar 1051, Kutia Postare 2995, Tirana, Albania

05.03.2026	
Entrance Hall, POLIS University	
8:30 – 9:00	**Registration**
9:00 – 9:30	**Opening Performance**
Welcome session – Auditorium A5 (Ground floor)	
9:30 – 10:00	**Opening Remarks** **Dr. Elona Karafili** (Vice Rector, POLIS University) **Dr. Flora Krasniqi** (Head of Office of Projects and Internationalization, POLIS University) **DI Daniela Wenzl** (INTEC Project Coordinator)
Auditorium A5 (Ground floor)	
10:00 –11:00	**Keynote speakers** **DI Horst Pflügl AVL** Collaborative Research for sustainable Mobility **DPSHTRR Representative** – (General Directorate of Road Transport Services in Albania)
11:15 – 11:30	**Coffee break (Moving into parallel sessions)**

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11:30	SESSION 1: POLITICAL AND REGULATORY FRAMEWORK AULA B1	SESSION 2: TECHNOLOGICAL INNOVATION AULA B4
11:30 – 11:45	**Opening Session:** Prof. Emeritus dr Nataša Gospić (FSKL)	**Opening Session:** Associate Prof. Ivan Tolj (US)
11:45 – 12:00	**Integrating Event Data Recorder (EDR) Technology into Sustainable Road Safety Frameworks within the European Green Deal** Eriselda Alimeti, Parid Milo, Mentor Çejku, Anis Sulejmani, Odhisea Koça	**Empirical Comparative Study of Structural CFRP Sandwich Structure Inserts for Out-of-Plane loads** Imre Kovács
12:00 – 12:15	**Infrastructure Readiness for Sustainable Mobility: EU Frameworks and the Case of Albania** Ervin Kalemaj, Parid Milo, Mentor Çejku, Anis Sulejmani, Odhisea Koça	**The Role of Intermodal Transportation for the Sustainable Mobility** Márton Kovács
12:15 – 12:30	**Review of the Evolution of International Ship Energy Efficiency Regulations and the Albanian context** Dr. Blenard Xhaferaj, Doklejda Hodaj	**Impact of Heat Pump Systems on Winter Energy Use and Driving Range in Battery Electric Vehicles** Luis Henrique Pereira Martins
12:30 – 12:45	**Renewable Energy Procurement (CPPA) and Transport Electrification: European Perspectives and Albanian Challenge** Antonio Ndoci, Anis Sulejmani, Odhisea Koça, Mentor Çejku, Parid Milo	**Liquid Cooling Systems for Electric Vehicle Batteries: Improving Safety, Performance and Sustainability** João Miguel de Almeida Ribeiro Silva
12:45 – 13:00	**The Current Status of Autonomous Vehicle**	**Analysis of Battery Charging and Discharging Behavior for Electric Vehicle Applications** Leona Markic, Luka Filipović

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	Technology Adoption in the Balkan Region Darjana Lopičić, Oliver Popović, Miloš Ilić, Bojan Kocić	
13:00 – 14:00	**Lunch**	
14:00 – 14:15	**Reviewing the European Green Deal in Energy, Mobility and Industry** Veselinka Calasan, Ivana Ognjanovic	**Automotive Cooling Systems Sustainability: A Focus on the Expansion Tank** Ana Inês Barbeiro Casimiro
14:15 – 14:30	**The European Green Deal and its National Implementation: From Strategy to Practice** Blerina Bektashi, Andi Bektashi	**Design and Development of a Constant-Volume Combustion Chamber for Optical Investigation of Hydrogen and Water Injection Under Engine-like Conditions** Julius Hollerith, Prof. Dr. Bhavin Kapadia
14:30 – 14:45	**From Prediction to Regulation: Evidence Production Approaches in Autonomous Mobility Research and Their Policy Implications** Sadmira Malaj	**Emission Reduction of Marine Propulsion Systems in SECA Zones Through the Integration of Hydrogen Technologies** Motalleb Miri, Ivan Radaš, Marija Mandić, Ivan Tolj
14:45 – 15:00	**Questions and Discussion**	**A Comprehensive Analysis of Ventilation System for Enhanced Energy Efficiency in Marine Propulsion Applications** Sara Blašković, Gojmir Radica, Jakov Šimunović

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15:00 – 15:15		**Design and Topology Optimization of a Lightweight Chain Sprocket for Electric Motorcycle Applications** Teo Čolović, Ivo Marinić-Kragić
15:15 – 15:30	**SESSION 3: ECONOMIC AND BUSINESS PRESPECTIVES + CASE STUDIES AND GOOD PRACTICES** Aula B1	**Questions and Discussion**
	Opening Session: Dr. Anis Sulejmani (PUT)	
15:30 – 15:45	**Managing Renewable Energy Resources as a Foundation for Sustainable Mobility Transitions** Deivi Sinanaliaj, Martin Bektashi	
15:45 – 16:00	**Feasibility of Electric Bus deployment in Montenegro: A Case Study of Budva (Erasmus+ INTEC / IECC Context)** Anastasija Mrkajic, Vinko Nikic.	
16:00 -16:15	**Children Paths as an Urban Regeneration Strategy: Naim Frasheri Study Case** Dejvi Dauti	
16:15 – 16:45	**Questions and Discussion**	

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City	Tirana
Meeting venue	POLIS University Entrance Hall
Address	Rr. Bylis 12, Kodi Postar 1051, Kutia Postare 2995, Tirana, Albania

06.03.2026		
First Floor Hall, POLIS University		
8:30 – 9:00	Registration	
9:00– 9:15	**SESSION 4: SOCIAL AND ENVIRONMENTAL IMPACT** AULA B1	**SESSION 5: FUTURE SCENARIOS** AULA B4
9:00 – 9:15	**Opening Session:** Prof. Dr. Bhavin Kapadia (FHF)	**Opening Session:** MA Adrian Millward-Sadler (FHJ)
9:15 – 9:30	**Comparison of Lifecycle Emissions of a SUV with Fuel Cell and Battery Electric Powertrains** - Bhavin Kapadia, Alper Sayin, Sandra Eisenträger	**GENAI Literacy as a Transversal Skill for Emerging Professionals: Implications for Sustainability-Critical Knowledge Work** – Adrian Millward-Sadler
9:30 – 9:45	**Smart Mobility Technologies and their Impact on Urban Sustainability: Insights from**	**Effects of Technical Traffic Calming Measures** – Filip Perović

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	European and Western Balkan Cities – Alma Gjonaj, Vjola Ziu	
9:45 – 10:00	**The Disappearing Squares: Social and Environmental Impacts of Urban Mobility Planning in Durres –** Arjola Sava	**Cybersecurity Vulnerabilities in Electric Vehicle Operating Systems: A Global Awareness Analysis -** Aleksa Radević
10:00 – 10:15	**The City that Demands Continuous Movement: The Disappearance of the Right not to Move within the Framework of Sustainable Mobility –** Avrili Meshi	**Development of a risk assessment model for the transport of hazardous materials using ALOHA and GIS software tools –** Marko Radetić
10:15 – 10:30	**Between Rhetoric and Reality: Discursive Framings, Greenwashing and Outcomes in Sustainable Mobility –** Kejsi Veselagu	**Mapping Distance and Time Leveraging Isochrone Intelligence in Emerging Cities** - Andia Vllamasi, Erjon Cobani
10:30 – 10:45	**Reimagining the City Through Green Mobility Strategies: The Case of Tirana** - Vjola Ziu, Alma Gjonaj	**Can AI develop its Own "Taste" Automotive Design?** - Gregor Andoni, Kristjana Meço
	Coffee Break	
11:00 – 11:15	**Linking Morphology, Perceived Safety, and Sustainable Mobility in Post-Socialist Urban Contexts-** Sindi Doce	**Optimizing Public Transport Corridors Using AI-Based Scenario Modelling: A case Study on Tirana's Ring Road** - Erjon Çobani, Julian Beqiri, Merita Guri
11:15 – 11:30	**Towards Sustainable Transport: A Comparative Analysis of Electric Vehicle Adoption in Montenegro and Albania -** Radmila Milić	**Threat Landscape and Multi-Layered Protection Mechanisms for Autonomous and Electric Vehicle Systems** - Marko Asanovic, Oliver Popović, Zoran Avramović, Nataša Gospić

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11:30 – 11:45	Questions and Discussion	**Cybersecurity Challenges in Modern Vehicular Communication Networks** - Aleksandar Grgurević, Nataša Gospić, Oliver Popović
11:45 – 12:00		**Green Transition in Albania: Challenges and Future Actions** - Erik Kushta, Andi Hyka, Enea Nasto
12:00 – 12:15	**SESSION 6: CONTROVERSIES AND CHALLENGES** Aula B1 **Opening Session:** Prof. Kristofor Lapa (UV)	**Use of AI in the Process of Green Transformation and Impact on Public Health** - Esmeralda Hamiti, Federika Alliaj, Kristi Metushi
12:15-12:30	**The Adoption of Electric Vehicles in Albania: A Comparative Study with Other Western Balkan Countries** - Doklejda Hodaj, Andrea Lapa	**Development of an Automatic Traffic Sign Detection System Using YOLOv8** - Valentina Vojinović, Luka Filipović
12:30-12:45	**Application of Quality Tools in the Analysis of Factors Influencing the Development of Electromobility in Montenegro** - Jelena Šaković Jovanović, Draško Jovanović, Mirjana Grdinić Rakonjac, Marko Lučić, Miloš Perović, Aleksandar Vujović, Gordana Radulović	**The Historical Development of Artificial Intelligence and Its Influence on the job market in Automotive Engineering** - David Josef Pilgram
12:45 – 13:45	**Questions and Discussion**	**Questions and Discussion**
13:45	**Lunch**	

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