INTEGRATION OF ELECTROMOBILITY AND INFRASTRUCTURE DATA FOR REGIONAL PLANNING AND ENERGY ASSESSMENT

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Electromobility is one of the key pillars of the European Green Deal and Slovakia's decarbonization pathway. While national EV statistics are available, regional differentiation remains limited. Slovakia's regions differ greatly in economic structure, settlement density, and infrastructure readiness — all shaping EV deployment. Understanding these disparities is crucial for effective energy and infrastructure planning. This study introduces a simplified integrative framework combining electromobility and infrastructure data at the regional level.

Study Scope and Core Metrics

This study analysed the evolution of electromobility across the regions of Slovakia (NUTS 3) from 2013 to 2024. The analysis used three core regional indicators: EVs per capita to measure market penetration, the Charging Infrastructure Index (chargers per 100 km^2)to assess geographical density, and the EVs per charger ratio to evaluate infrastructure load.

Modified GEMRIX Score

A modified Global Electric Mobility Readiness Index (GEMRIX) was computed to benchmark regional preparedness. Infrastructure dimensions were consolidated, and the global benchmark was replaced by the Slovak national average. This modification allows for direct comparison of each region to the national average, but the score cannot be compared globally or between regions.

Roland Berger-Inspired Infrastructure Index

A Composite Infrastructure Readiness Index, adapted from the Roland Berger methodology, was calculated to assess the charging network's maturity. Indicators were normalized and weighted using expert judgment, with the highest weight assigned to the chargers per 100 km^2 metric. The index is interpreted on a scale where a score above 75 is excellent and below 35 is very weak.

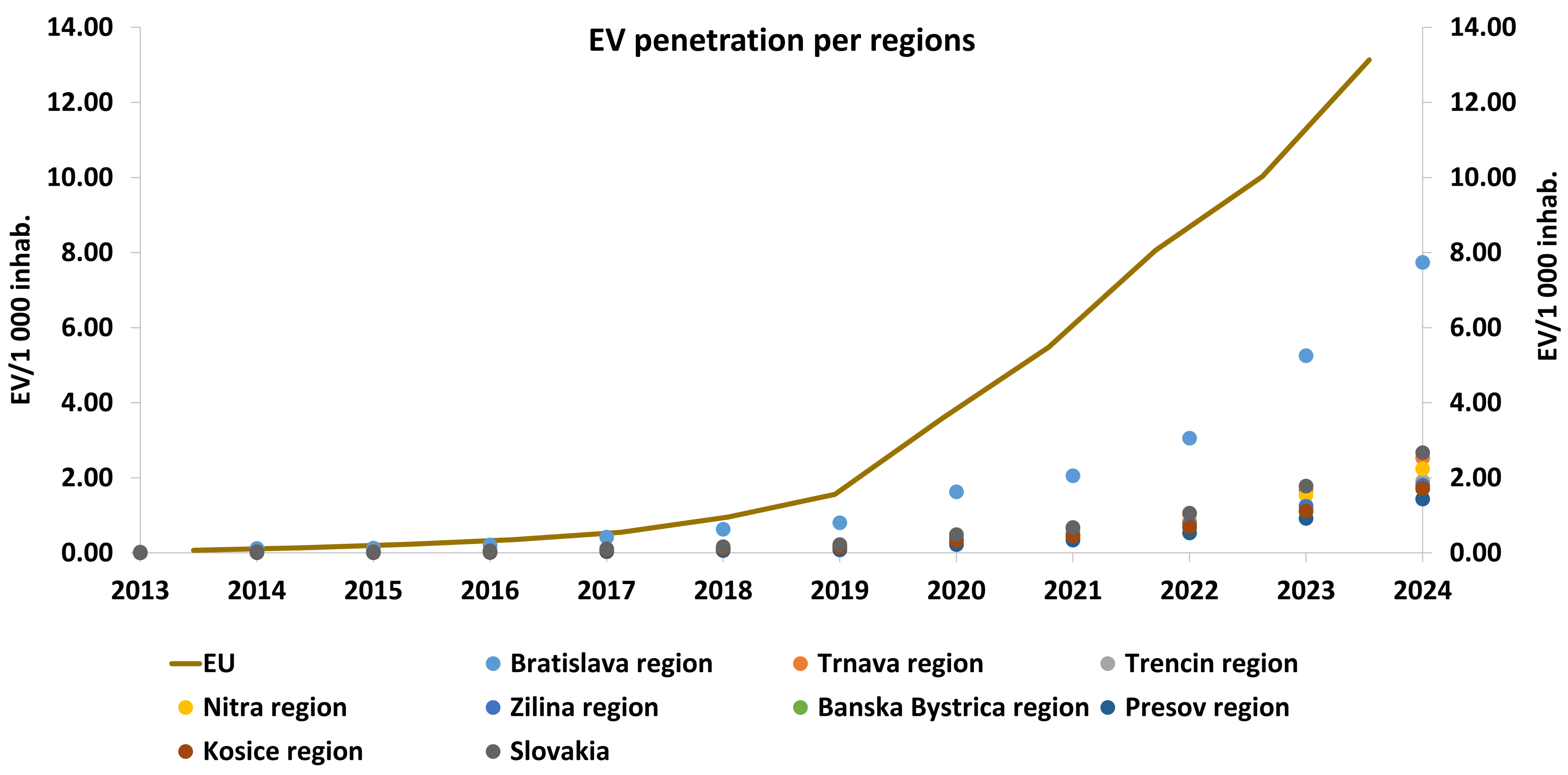

Figure 1: *EV penetration in different regions of Slovakia per 1 000 inhabitants compared to EU-27 wide average penetration (as of 2024).*

The analysis (***Fig. 1***) shows a **strong upward trend in electric vehicle adoption** across all Slovak regions since 2018, with a particularly sharp increase after 2020. The **national average** follows an exponential growth pattern, confirming the rapid acceleration of electromobility. Compared to the **EU average,** Slovakia still remains below the European level, yet the **growth dynamics** indicate gradual convergence with EU trends.

The **modified GEMRIX Score** confirms that Slovakia has a **solid starting position** for further electromobility development. The **Bratislava region** leads with the highest score (≈ 1.83), well above the national average, indicating the strongest readiness and infrastructure maturity. **Trnava, Nitra, and Trenčín regions** follow with moderate readiness levels, while **Prešov and Banská Bystrica regions** show lower scores, highlighting regional disparities and infrastructure gaps.

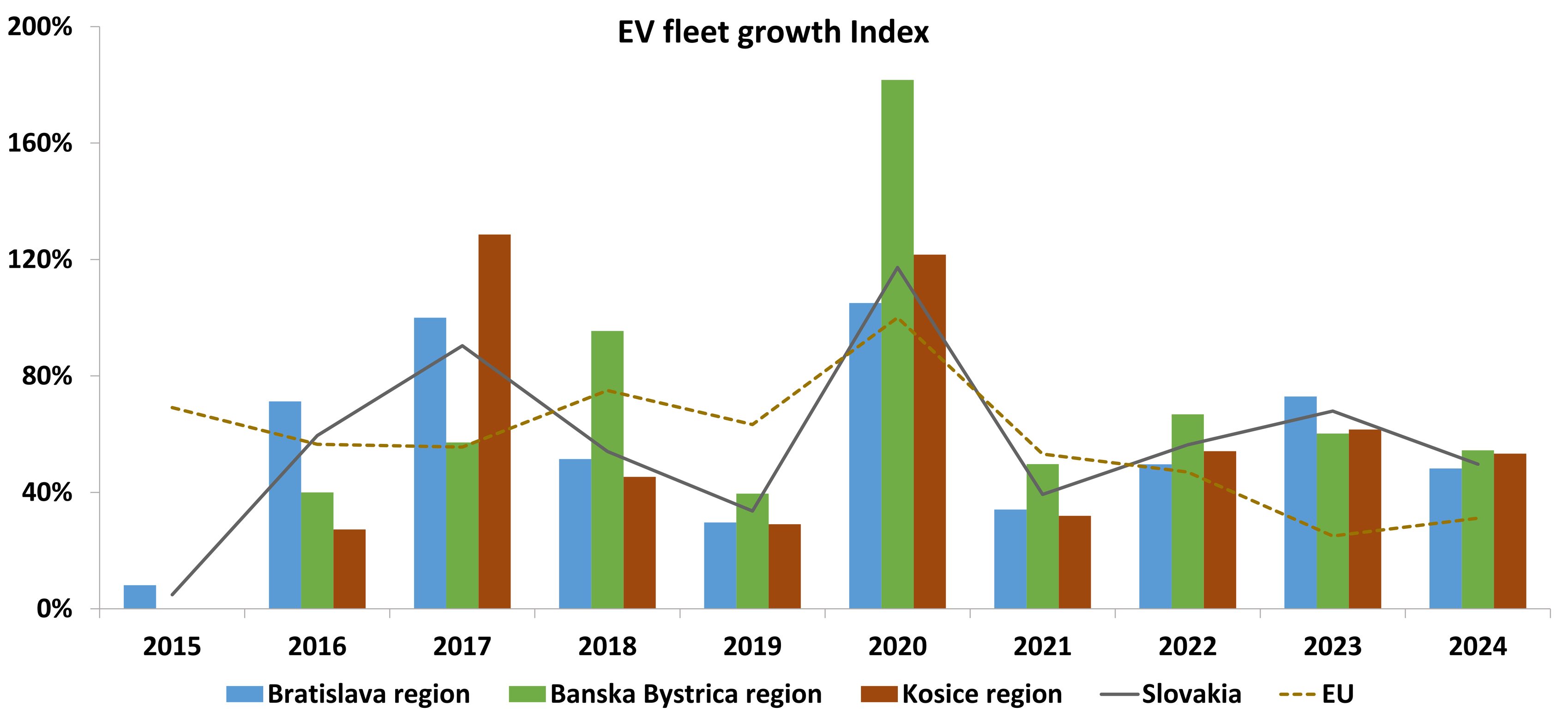

Figure 2: *Year-on-year EV fleet growth rate in Slovak regions compared to the EU-27 average growth rate (2024).*

The chart compares the development of electromobility in three representative Slovak regions — **Bratislava (west)**, **Banská Bystrica (central)** and **Košice (east)** — alongside **national** and **EU averages**. All regions show a noticeable growth in electric vehicle adoption after 2018, with a sharp increase around 2020 followed by stabilization in later years.

The **Bratislava region** clearly outperforms the others and remains above both the national and EU averages, indicating its leading position in infrastructure and market readiness. The **Roland Berger Infrastructure Readiness Index** supports this finding, showing that Bratislava reaches a significantly higher score (≈ 70) compared to the rest of the country. This confirms **strong regional disparities**, with central and eastern Slovakia lagging behind in charging infrastructure and overall preparedness for electromobility.

Conclusions

The analysis validates that **economic prosperity is the main catalyst for EV uptake**, positioning the **Bratislava region** as the national frontrunner across the Modified GEMRIX (readiness) and the Roland Berger Index (maturity). Although aggressive EV growth suggests **gradual alignment with the EU average**, this momentum has created infrastructure paradoxes. The **Charging Infrastructure Index** confirms high geographical density in the West, yet the **Charging Coverage Index** shows that fleet expansion has **overwhelmed local supply**, causing the network there to be the most overburdened. Conversely, Central and Eastern regions, despite sparse density, demonstrate superior **service adequacy**. The findings underline the need for a **multi-dimensional planning strategy**, utilizing the composite indices as a reliable tool for policy evaluation, demand forecasting, and achieving territorial balance.

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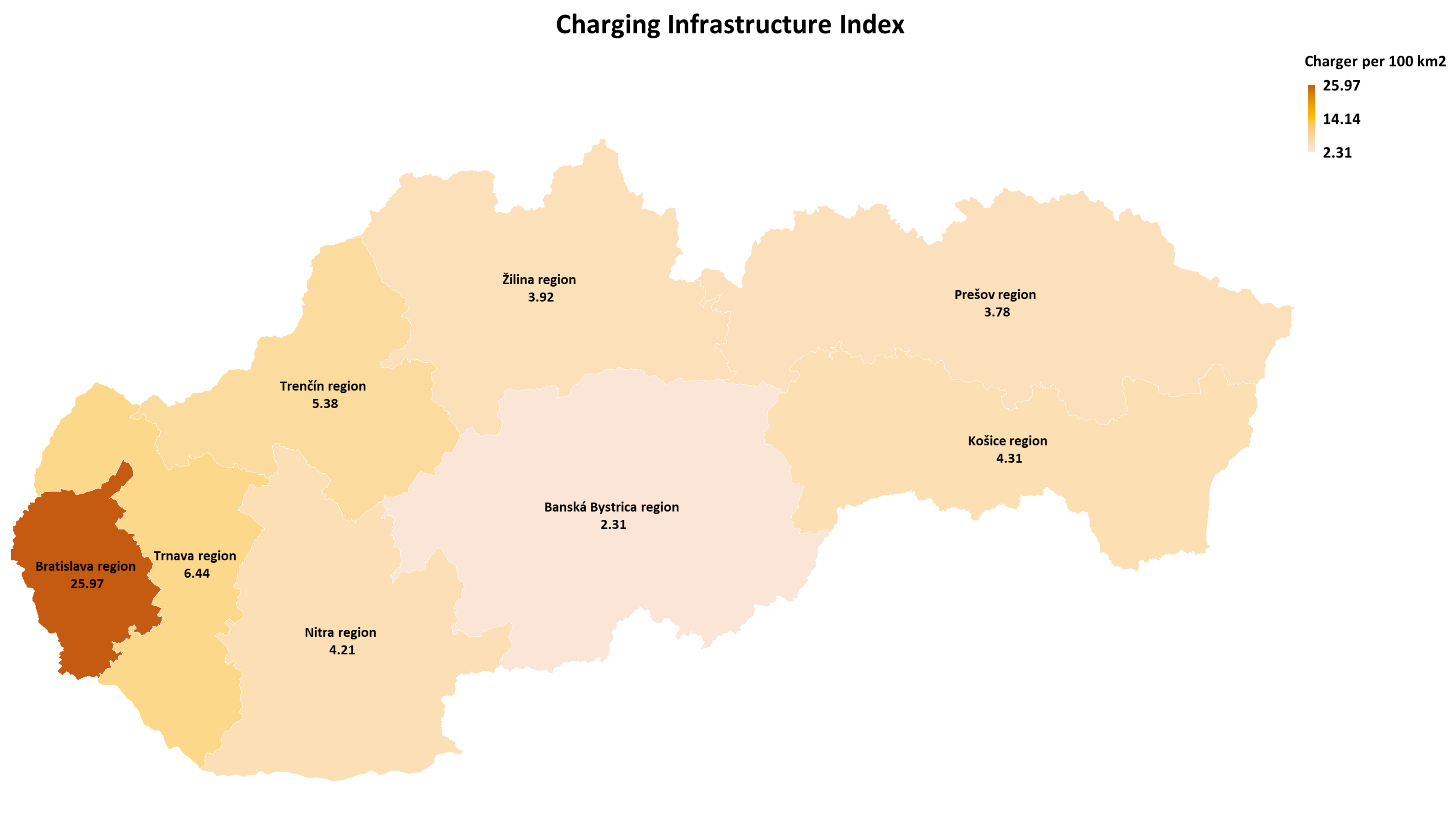

Figure 3: *Charging Infrastructure Index (chargers per 100 km²) across Slovak Regions in 2024. This visual represents the geographical availability of charging, where darker shades indicate higher density.*

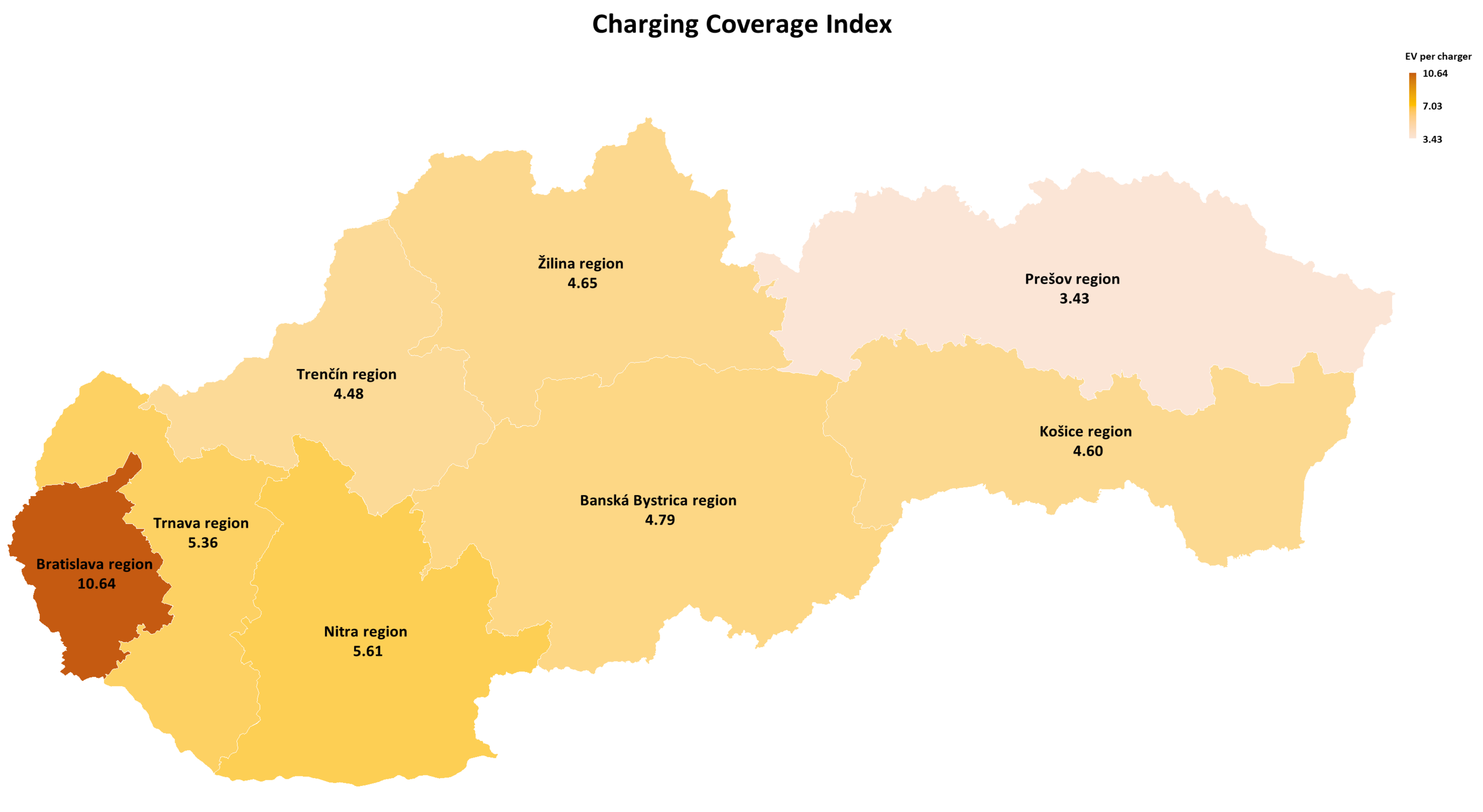

Figure 4: *Charging Coverage Index across Slovak Regions in 2024. The map displays the ratio of EVs per Charger, which indicates the utilization load on the public charging network in each region.*

Regional Disparities in EV Charging Infrastructure in Slovakia

The two presented choropleth maps analyse the regional distribution of Electric Vehicle (EV) charging capabilities in Slovakia using two distinct metrics.

Charging Infrastructure Index (charger per 100 km^2) shows a clear dominance of the **Bratislava region** (≈*25.97*), indicating the highest geographic density of charging points, while the Banská Bystrica region has the lowest (≈*2.31*).

Conversely, the **Charging Coverage Index** (EV/charger), which measures network adequacy (lower value is better), reveals an inverse pattern: the **Bratislava region** suffers from the **poorest coverage** (≈ *10.64 EV/charger*), suggesting that the rapid growth in EV adoption is outstripping infrastructure supply. The **Prešov region** exhibits the **best coverage** (≈*3.43 EV/charger*), meaning its current infrastructure is most efficiently meeting existing demand.

In conclusion, while **Western Slovakia is geographically saturated** with chargers, its network is the **most strained**, whereas **Eastern regions**, despite **lower density**, offer better service coverage relative to the local EV population.

Summary of Key Findings

1. **Economic Gradient:** EV adoption is primarily determined by the economic gradient (West»East), with Bratislava leading in overall readiness (GEMRIX & Roland Berger Index)
2. **Infrastructure Strain:** The Western network, despite high density, is the most strained (highest EV/charger ratio) due to rapid EV growth outstripping supply
3. **Balanced Coverage:** Eastern regions, while having lower absolute charger density, show better **network adequacy** relative to the local EV population
4. **Planning Tool:** The composite indices provide a robust, multi-dimensional tool for regional monitoring and targeted infrastructure planning to support national decarbonization