EVS37 Symposium
COEX, Seoul, Korea, April 23-26, 2024

Evaluation of Public Electric Vehicle Charging Stations

Ignac Završnik[1], Boštjan Okorn[2]

[1]*Ignac Završnik, Slovenian e-mobility Society, ignac.zavrsnik@dems.si*

[2]*Boštjan Okorn, Slovene Consumers' Association, bostjan.okorn@zps.si*

Poorly signed, uncovered, and not always functional

The electric vehicle (EV) landscape in Slovenia is evolving, with an increasing number of EVs on the road, making it essential to evaluate the usability of public EV charging stations. However, the results of this evaluation are far from promising. These charging stations frequently fall short of expectations in terms of user experience and lack the convenience that traditional gas stations offer. The study primarily focused on factors such as ease of finding, registration, initiation of charging, and payment methods. It also considered the availability of different services and whether the charging stations were suitable for individuals with disabilities and families with children.

The evaluation examined 48 EV charging stations across Slovenia, encompassing various providers, regions, and charging methods. The experiences ranged from good to outright failures, highlighting the need for improvement. Challenges included difficulties in finding charging stations, complex registration and payment processes, and the lack of standardisation in signage and markings. The absence of shelter or cover at most charging stations was noted as a significant inconvenience, especially during adverse weather conditions.

Furthermore, the study revealed several issues with technical aspects, such as problems with registration and payment, inconsistent charging speeds, and the limited availability of high-power charging options. The need for uniform charging standards, including connector types, was emphasised to provide a seamless experience for all EV users.

In conclusion, while some EV charging stations received good ratings in the evaluation, improvements are needed to make public charging more user-friendly, efficient, and easily accessible for all EV owners, including those who are not tech-savvy. Addressing issues related to station visibility, payment methods, and charging infrastructure standardisation will be crucial for promoting widespread adoption of electric vehicles.

Keywords: Electric Vehicle (EV), EV Charging Stations, User Experience

1.1 How did we evaluate?

In September and October 2023, we visited 48 electric vehicle charging stations throughout Slovenia, from Pince in the northeast to Piran in the southwest and from Brežice in the southeast to Planica in the northwest. The charging stations were randomly selected, representing various providers, technologies, charging speeds, and locations. The providers were not informed about this evaluation before the action.

At least three evaluators visited each charging station, and at least two different vehicles that support charging with various power levels and standards underwent testing. During our visit, we completed an evaluation sheet in which we recorded all observations and facts about the charging station. The most important data were recorded in an evaluation table, which consists of the following categories:

1.1.1 Charging Points (15% of the total score)

We counted the number of charging points for direct current or alternating current and noted the maximum rated charging power and types of charging connectors (Type 2, CCS, and ChaDeMo). Charging stations with more charging points and/or higher charging power received higher ratings.

Charging station: AC (alternating current)

- 37.5% number of charging AC stations (points): 16 and more (5.5), 8 (4.5), 4 (3.5), 2 (2.5), 1 (1.5).
- 12.5% power output AC measured in kW (points): 22 (5.5), 15 (4.5), 11 (3.5), 7 (2.5), 5 (1.5), 3.6 (0.5).

Charging station: DC (direct current)

- 37.5% number of charging DC stations (points): 16 and more (5.5), 8 (4.5), 4 (3.5), 2 (2.5), 1 (1.5).
- 12.5% power output DC measured in kW (points): 350 (5.5), 250 (4.5), 150 (3.5), 50 (2.5), 25 (1.5), 10 (0.5).

1.1.2 Signage (10% of the total score)

We checked if the charging station had any traffic signs at nearby roads, and at the charging station itself, we verified the accuracy of signs, both traffic signs and road markings, and their compliance with the legislation. The highest rating was given to charging stations that had signage at least at the last intersection, along with proper traffic signs and road markings (symbols and colours) under the Slovenian traffic signalling regulations.

- Traffic signs at nearby roads (points)
  - Marked before the junction (5.5), indicated on the property-garage (3), there are no traffic signs at nearby roads (0.5).
- Traffic signs (points)
  - Charging station or parking area with an additional sign (5.5), parking space (3.5), parking space with private marking (2.5), or no sign (0.5).
- Road markings (points)
  - Compliant colour and marking according to the law (5.5), an additional hue and/or pattern (2.5), absence of any form of marking (0.5).

1.1.3 Location (15% of the total score)

We examined the parking facility to see whether it was well-lit, covered, and if it had special parking spaces for disabled individuals or families with small children. We looked around for restroom facilities, options for food and beverages, a store or shopping centre, or accommodations. The lighting and coverage of the parking facility, the presence of restroom facilities, and access to food and drinks carried the most weight in the evaluation.

- 50% parking area (points)
  - Well-lit (5.5), covered (5.5), parking for disabled individuals (5.5), parking for families with small children (5.5).
- 25% restroom facilities (points)

    - Dedicated restroom (5.5), public restroom within a nearby establishment (4.5), restroom within a nearby establishment for customers only (3.5), no restroom (0.5).
- 15% Food and beverages (points)
    - 50% restaurant (5.5), buffet (3.5)
    - 50% vending machines with food and drinks (5.5).
- 5% retail complex (points)
    - At the charging station (5.5), close by (3.5), and not nearby (0.5).
- 5% accommodation (points)
    - At the charging station (5.5), close by (3.5), and not nearby (0.5).

1.1.4 Information (10% of the total score)

At the charging station, we checked for information on pricing and the charging process. Some points were also awarded to providers who displayed pricing in digital format (accessible via QR code).

- Details regarding charging fees (points)
    - At the charging station (5.5), in the application with the QR code (3.5), there is no information (0.5)..
- Instructions for activation (points)
    - At the charging station (5.5), in the application with the QR code (3.5), there is no information (0.5).

1.1.5 Charging Process (50% of the total score)

We assessed the method of initiating charging, with the "plug-and-charge" method receiving the highest rating. An equal weighting was dedicated to the operation of the charging station. Additional points could be awarded for the presence of a Type 2 charging cable at the station.

- 42.86% Functioning of the charging station (points)
    - Plug in and charge (5), payment card (4), application + call, application + provider's card + prepayment, application + provider's card (3), only application, only call or scan QR code (2), only provider's card (1)
- 14.29% Charging cable at the AC station (5.5)
- 42.86% The functionality of the charging station was confirmed by testing it with three distinct electric vehicles (points)
    - Operates without issues (5.5), operates with low power (3.5), operates intermittently with many attempts (1.5), does not work, and charging is impossible (0.5).

We took the limiting factor into account: if the score for the operation of the charging station is unsatisfactory (<1.5), the score for the charging process cannot be higher.

Charging stations for electric cars		Labeled max. power		Number of charging points										
	Type of charging station	AC	DC	AC	DC	CHARGING POINTS	SIGNAGE	LOCATION	INFORMATION	Station activation	AC charging cable at the station	Operation of the charging station	CHARGING	TOTAL SCORE
Location of the charging station		**kW**	**kW**			**15 %**	**10 %**	**15 %**	**10 %**				**50 %**	**100 %**
A2, rest area Grič	AC + DC	22	50	2	2	0	++	0	++	0	yes	++	+	+
A2, rest area Radovljica sever	AC + DC	22	350	1	5	0	++	0	++	0	yes	++	+	+
A1, rest area Tepanje	AC + DC	22	50	2	1	0	++	0	++	0	yes	++	+	+
Ljubljana, Supernova Šiška	AC + DC	22	150	6	3	+	+	0	++	0	yes	++	+	+
A1, rest area Dobrenje	AC + DC	22	350	1	5	0	0	0	++	0	yes	++	+	+
A1, rest area Maribor-vzhod	AC + DC	22	350	1	3	0	+	0	++	0	yes	++	+	+
Bled, BS Petrol	DC	/	100	0	2	–	++	0	++	0	/	++	+	+
Ljubljana, MOL Bratislavska ulica	AC + DC	22	50	1	1	–	+	0	++	0	yes	++	+	+
Žirovnica, N-GEN	AC	22	/	34	0	0	0	0	– –	++	yes	++	++	+
Celje, Citycenter	AC	11	/	10	0	0	++	+	++	0	no	++	+	+
Šmarješke toplice, hotels	AC	22	/	2	0	–	0	0	++	++	no	++	++	+
Koper, Lidl Šalara	AC + DC	11	20	1	1	–	–	–	++	++	yes	++	++	+
Brezovica, Špan	AC + DC	22	75	4	1	0	+	–	++	0	yes	++	+	+
Ljubljan, Lidl Dolgi most	AC + DC	10	18	1	1	–	–	– –	++	++	yes	++	++	+
Kozina, BS MOL	AC + DC	22	50	1	1	–	–	0	++	0	yes	++	+	+
A5, rest area Pince	AC + DC	43	150	1	3	0	– –	0	++	0	yes	++	+	+
Koper, Petrol Kolodvorska	AC + DC	22	50	2	2	0	0	0	++	0	yes	+	+	+
Kranj, BS MOL	AC + DC	22	50	1	1	–	– –	0	++	0	yes	++	+	+
H6, rest area Semedela	DC	/	350	0	4	0	–	0	++	0	/	++	+	+
Maribor, Slovenska cesta	AC	22	/	4	0	0	+	0	++	0	no	++	+	+
Portorož, center	AC	22	/	4	0	0	+	0	++	0	no	++	+	+
Brežice, Penzion Les	AC	22	/	2	0	–	+	0	– –	++	no	++	++	+
Strunjan, center	AC	22	/	2	0	–	+	0	++	0	no	++	+	+
Tržič, municipality	AC	22	/	2	0	–	+	0	++	0	no	++	+	+
Bohinjsko jezero	AC	22	/	2	0	–	+	0	++	0	no	++	+	0
Brezje	AC	22	/	2	0	–	+	0	++	0	no	++	+	0
Ljubljana, BTC Emporium	AC	22	/	2	0	–	–	+	++	0	no	++	+	0
Brežice, municipality	AC	7,2	/	2	0	–	+	0	– –	++	no	++	++	0
Kranjska Gora, sports hall	AC	11	/	2	0	–	+	–	++	0	no	++	+	0
Novo mesto, Supernova	AC + DC	22	350	6	2	+	+	0	++	0	no	0	0	0
Jesenice, Merkur	AC	22	/	2	0	–	–	–	++	0	no	++	+	0
Izola, AH Jereb	AC + DC	11	50	1	1	–	– –	– –	++	0	yes	++	+	0
Ivančna gorica	AC	11	/	1	0	– –	–	0	– –	++	no	++	++	0
Ljubljana, Aleja, basement	AC	11	32	8	1	0	+	+	0	0	yes	0	0	0
Planica, nordic center	AC	11	/	6	0	–	–	–	++	0	no	++	+	0
Ljubljana, BTC Kristalna Palača	AC + DC	22	75	2	2	0	0	0	++	0	yes	0	0	0
Trebnje, administrative unit	AC	11	/	2	0	–	+	–	0	0	no	++	+	0
Maribor, Europark	AC	22	/	10	0	0	0	0	++	0	no	0	0	0
Ljubljana, Porsche center	AC + DC	22	350	2	1	0	– –	–	– –	0	yes	++	+	0
Maribor, Studenci	AC + DC	11	85	1	1	–	– –	–	0	0	no	++	+	0
Ljubljana, P+R Barje	AC	22	/	4	0	0	–	–	++	0	no	0	0	0
Kranj, Iskratel	AC + DC	22	/	1	0	–	0	– –	0	0	no	+	0	0
Žužemberk	AC + DC	11	10	0	1	– –	+	–	0	0	no	0	–	–
Dobrovnik, Ocean Orchids	AC	11	/	8	0	0	– –	–	++	–	no	–	–	–
Ljubljana, P+R Dolgi Most	AC + DC	22	50	8	1	0	0	–	++	0	no	– –	– –	–
Seča, salt plants	AC	22	/	4	0	0	–	– –	0	– –	no	–	– –	–
Celje, A2S							Could not charge							– –
Piran, Fornače							Could not charge							– –

++ very good (80 - 100 %) + good (60 - 79 %) o average (40 - 59 %) - deficient (20 - 39 %) -- unsatisfactory (0 - 19 %)

AC - alternating current (Type 2 connector)
DC - direct current (CCS and/or ChaDeMo connectors)

Table 1: Evaluation of public electric vehicle charging stations

1.2 Recommendations for improvement

1.2.1 Standardised Signage and Markings

Introduce standard signage and road markings for EV charging stations to enhance visibility and facilitate easier navigation. Furthermore, the signage for the EV charging stations should follow the same pattern as for the traditional fuel stations, i.e. signs should be present at major roads around the charging station, leading the driver on the optimum route towards the station.

1.2.2 Streamlined Information Access

Ensure that pricing and charging processes and available charging power information are readily accessible and straightforward. Digital pricing displays with QR codes can enhance information access, but they should not be the only option. The user should be able to follow the flow of energy and be well informed if anything goes wrong with charging, even if only the charging speed is lowered because the other user started to charge at the same station.

1.2.3 Accessibility Features

Make charging stations more accessible to individuals with disabilities and families by offering designated parking spaces and easy access. There should be a wise, experience-based approach to designing a user-friendly charging station that does not leave any user groups behind. Special emphasis should be given to vulnerable and less capable users concerning access to the user interface, cables (knotting), and general space around the vehicle (including the curbs and surface quality).

1.2.4 Shelter and Amenities

Install shelters at charging stations to provide protection from adverse weather conditions. Consider the addition of amenities such as restrooms, food and beverage options, and shopping facilities. These are standard services at literally all traditional fuel pumps but are very rarely seen at the charging stations, although users and their passengers usually spend more time charging the EVs than filling up the gasoline. Avoid building the charging stations in remote areas (the far end of big parking spaces, the back of the fuel station or building, etc.). Make the charging station stop attractive, well-lit, and easy to see and observe.

1.2.5 User-Friendly Operation

Ensure that the operation of charging stations is intuitive and user-friendly, particularly emphasising the "plug and charge" method. This is especially important in public or commercial parking spaces and garages that are part of shopping centres. The energy used for charging the EVs during the short visit is not that expensive to justify all the complications with registering and paying. Of course, there should be clear rules to avoid unnecessary freebies, which would use the charging station excessively long.

1.2.6 Uniform Charging Standards

Work towards standardising connector types and power levels to ensure a consistent experience for EV users. To allow reliable user planning, avoid levelling the charging power when more users are connected. Better make it possible for users to choose the proper charging power and thus divide the available power for all charging points in the most optimal way.

1.2.7 Expand High-Power Charging Options

Increase the availability of high-power charging options (150 kW and above) to accommodate a broader range of EV models and reduce charging time. This is especially important with the charging stations at or close to the common transit roads. Build a network of high-power charging stations outside the traditional fuel stations and rest areas. Use industrial and commercial complexes close to the main roads to fill the gaps and increase the availability of charging points for EV drivers in transit.

1.2.8 Public Awareness Campaigns

Launch public awareness campaigns to educate EV owners and potential users about the locations, features, and benefits of public charging stations. Emphasise different user needs during their visit to cities, cultural, sporting, and other events, natural attractions, everyday driving, distance driving, etc. Don't focus only on one scenario.

1.2.9 Collaborative Efforts

Encourage collaboration between EV charging station providers, the government, and non-governmental organisations to drive improvements collectively. Their fruitful cooperation is crucial to finding the best possible solution for local EV owners, especially the ones who don't have the opportunity to install the wall charging point at their home. Work towards achieving plug-and-charge solutions for as many charging stations as possible, both locally and internationally.

1.2.10 Regular Maintenance

Establish a routine maintenance schedule to address technical issues promptly and maintain the functionality of charging stations. Solve the technical problems in the shortest possible time and promptly inform all the users of alternatives to not-functioning charging stations. All non-technical maintenance, such as renewal of road markings, construction works, and similar, should be carried out in a way that minimises disruption to the functioning of the charging stations.

Conclusion

Through the implementation of these recommendations, Slovenia could significantly enhance the usability and convenience of its public electric vehicle charging stations, thereby fostering the wider adoption of electric vehicles and contributing to a more sustainable future. We believe that this survey and evaluation might be useful as a guideline for NGOs, decision-makers, the government, and all others involved in segment charging stations for electric vehicles. We also believe that the experience gained could help to perform a similar survey and evaluation in other countries and thus assure the quality of chargiong infrastructure is regularly and structurally observed on international level.

Acknowledgments

I extend my heartfelt thanks to all members of the Slovenian e-mobility society, whose valuable contributions and active participation in testing significantly contributed to our outstanding success. Without your dedication, this achievement would not have been possible. I would also like to express my sincere gratitude to the Slovene Consumers' Association and Boštjan Okorn for their dedicated efforts, which have produced results critical to our assessment of the public charging infrastructure.

References

[1] White paper: *Supporting the bottom-up road transport decarbonization for local level decision makers,* https://www.rrc-kp.si/wp-content/uploads/2021/01/White_paper_AaCTA_DRAFT_version.pdf, accessed on 30.10.2023

[3] Electric Cars in Slovenia: *Calculating the Total Cost of Ownership for Consumers.*

https://www.zps.si/uploads/migration/tips/documents/20210430_BEUC-Slovenia-TCO-Report_final-report.pdf, accessed on 30.10.2023

Authors



Ignac Završnik has been involved in e-mobility since 2003, focusing on sustainable transportation and energy self-sufficiency. He's been testing electric vehicles in Slovenia since 2014 and collaborates with organisations like the Slovenia grid operator ELES d.o.o. and the Ministry of Environment, Climate, and Energy. As an author, he's written many articles on e-mobility and served as the Chairman of the Slovenian e-Mobility Society since 2017. Within the society, he's actively involved in organising e-mobility events, educational seminars, and awareness programs as an NGO. Ignac is also a co-author of a white paper on road transport decarbonization for local decision makers in Slovenia. He's actively engaged with the Global Electric Vehicle Association (GEVA) as well.



Boštjan Okorn became a computer technician in 1988 and graduated in marketing from Ljubljana Faculty of Economics in 1999. He worked as a part time journalist at Delo newspaper, covering cars and mobility, computers, and telecommunication. In 2006 he joined ZPS, Slovene Consumers' Association for the project on Capacity Building and became the head of testing in 2009, locally coordinating around 50 comparative tests every year. Parallelly, he works as the expert on telecommunications, mobility and sustainability, being the Chair of Sustainability Working Group at ANEC (European voice of consumers in standardisation) and, among others, the member of mobility and sustainability at BEUC, European Consumer Association. The results of his cooperation were the reports Low carbon cars in the 2020s: Consumer impacts and Slovenian policy implications (2017) and Electric Cars in Slovenia: Calculating the Total Cost of Ownership for Consumers (2020). He also published three reports on the gap between the officially labelled and real-life consumption of diesel and gasoline cars (2016, 2020 and 2022).