Exploring the Potential of Smart Charging for Electric Vehicles: Insights from USER-CHI project

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Need and context

The transportation sector, as Europe's largest energy consumer, significantly contributes to urban air and noise pollution. The decarbonization of this sector is crucial for meeting the EU's ambitious climate, pollution, and energy efficiency targets.

Electric vehicles (EVs) emerge as a key solution in this transition, aiding in the reduction of greenhouse gas emissions. Nonetheless, the shift towards electric mobility faces challenges, including the development of a cost-effective public charging infrastructure and the enhancement of grid capacity.

USER-CHI addresses these issues by leveraging smart charging strategies, optimizing charging sessions in alignment with energy availability and cost, thereby facilitating a smoother integration of EVs into urban environments.

Pilot, methodology, and objectives

The Àrea Metropolitana de Barcelona (AMB), in the framework of the USER-CHI project, tested a Smart Charging tool (SMAC) to apply smart charging strategies in their charging infrastructure network aiming to reduce the requested power but maintaining the quality of service. SMAC facilitated adoption of smart charging strategies to CPOs via Open Charge Point Interface (OCPI) protocol, making use of data provided by both CPO and EV drivers to ensure fulfilment of charging requirements at minimum cost.

Data from 55,873 charging sessions was collected from the AMB's network of 59 Electric Vehicle Supply Equipment (EVSE) units across 27 locations. Employing the OCPI protocol, this methodology categorizes and analyzes the charging infrastructure's performance. It assesses the impact of various charging behaviors on energy demand and grid capacity, offering insights into patterns and inefficiencies in current charging practices.

The objective is that the provided smart charging strategies help the operators to optimize their energy-related costs, enabling a better utilization of renewable energy sources and allowing their participation as active actors in the smart grid management. They also helped to speed up the charging infrastructure deployment by reducing the grid stress.

Proposed smart charging strategy

The SMAC tool, a Smart Charging-as-a-Service platform provided by the USER-CHI project, enables Charging Point Operators (CPOs) to optimize charging processes. This tool leverages real-time data and predictive analytics to minimize energy costs, maximize renewable energy use, and enhance grid stability through demand response and load balancing techniques. It is adaptable to specific site requirements, offering a scalable solution for diverse urban and rural settings.

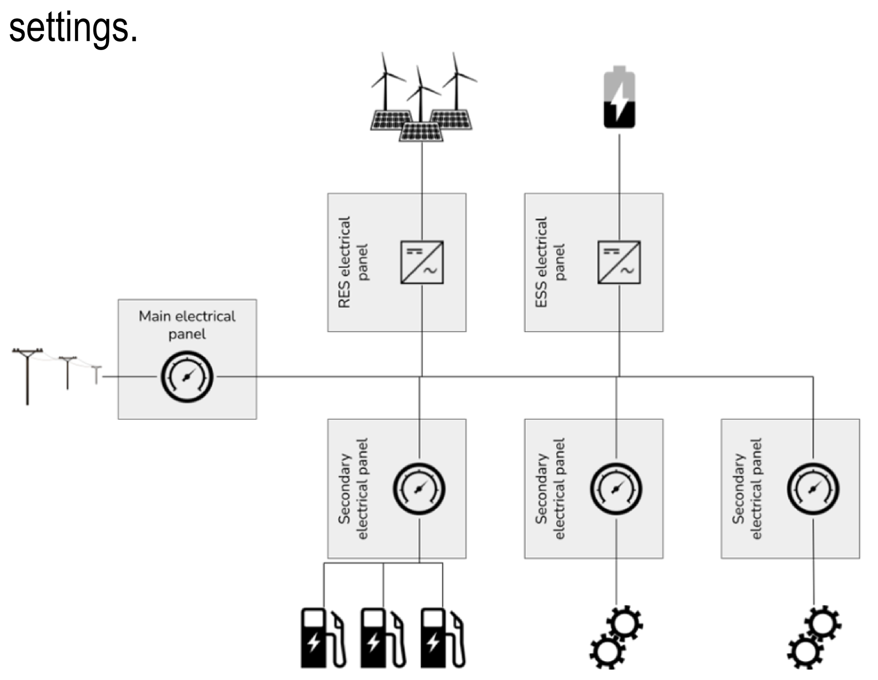

Fig. 1. Potential elements considered by infrastructure-level optimization.

Main findings on usage indicators of the charging infrastructure in AMB

The analysis quantifies several indicators that describe the usage of the charging infrastructure in the AMB. Analysis of the data shows that, due to the fact that the infrastructure is used to offer public services, duration of the charge sessions is generally low – with approx. 75% percent of all charging sessions taking less than 45 minutes.

On the other hand, values accounted for the average to nominal power ratio reveal that, in the 75% of the sessions, EVSEs would have potential to reduce power to about 60% without impacting the provided service.

Indicator	Q1 (25th percentile)	Median	Q3 (75th percentile)
Duration of charging sessions	25 minutes	32 minutes	46 minutes
Daily occupancy of EVSEs	1.72%	2.26%	3.23%
Daily charging sessions per EVSE	2	4	8
Energy delivered per charging session	3.7kWh	8.5kWh	17.4kWh
Average to nominal power ratio per charging session	16.39%	29.56%	58.22%

Table 1. Summary of usage indicators of the charging infrastructure in AMB.

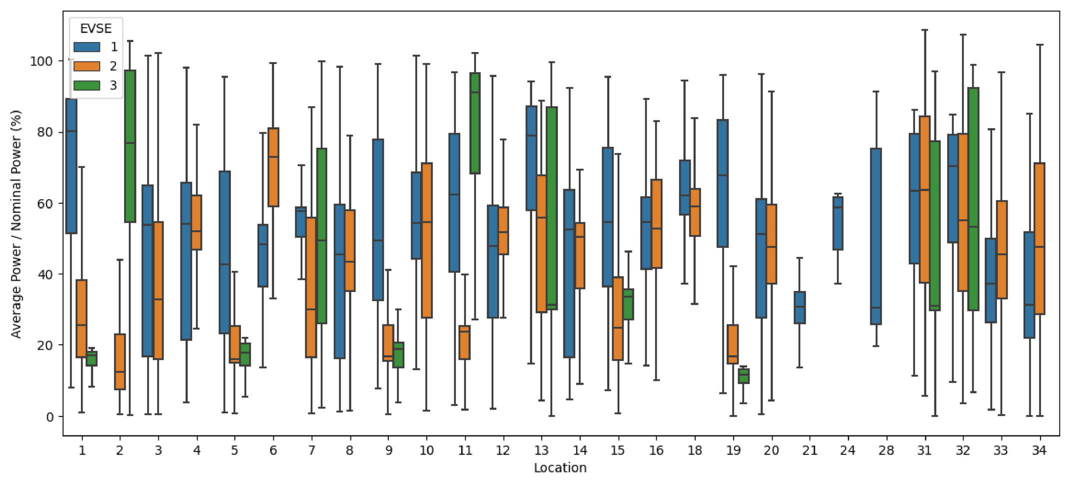

Fig. 2. Average to nominal power ratio per charging session.

Evaluation on potential for active power reduction using smart charging

From the previous indicators, two particular findings are relevant in order to evaluate the potential for active power reduction using smart charging strategies: the duration of the charging sessions, and the average to nominal power ratio per charging session.

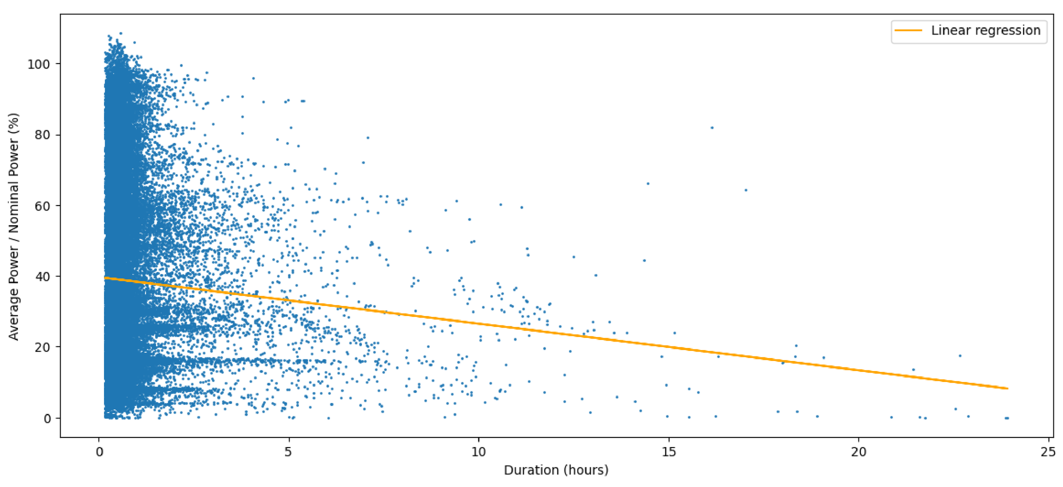

Fig. 3. Correlation between duration of the charging sessions, and the average to nominal power ratio per charging session.

The analysis of the correlation between those two indicators shows that longer charging sessions tend to show lower average to nominal power ratios. Linear regression over those indicators reveals that, in average, ratio is lower than 40% and shows a trend of reduction of 1.32% for every extra hour of duration. This fact means that the proposed strategies will be more effective in those locations with usage patterns that indicate longer stays of the EV drivers.

More in detail, data of December 2022 corresponding to 619 charging sessions taking place at locations 33 and 34 in Cornellà de Llobregat – accounting for 4 EVSEs which share a common supply point and selected by AMB to perform field tests of SMAC in the scope USER-CHI project – has been analyzed to obtain indicators of the potential to reduce the contracted power without affecting the service using smart charging strategies. The analysis consists in the evaluation of the hourly maximum power expected at the supply point feeding the 4 EVSEs. Contracted capacity of the supply point is accounted as the sum of the nominal power of all EVSEs under its connection, as this is the Business-as-Usual scenario.

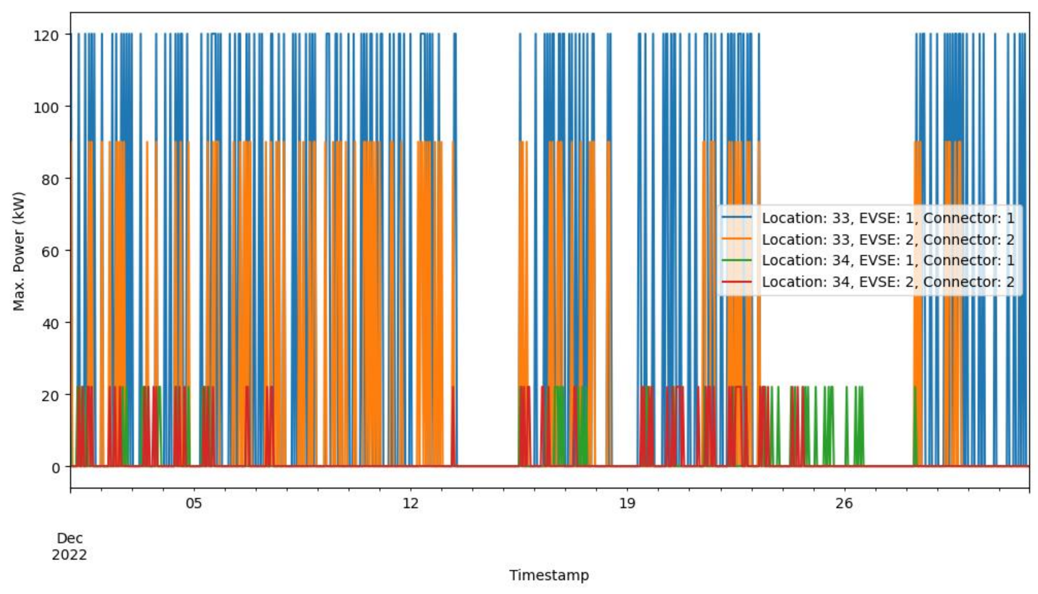

Fig. 4. Max. power per EVSE and hour.

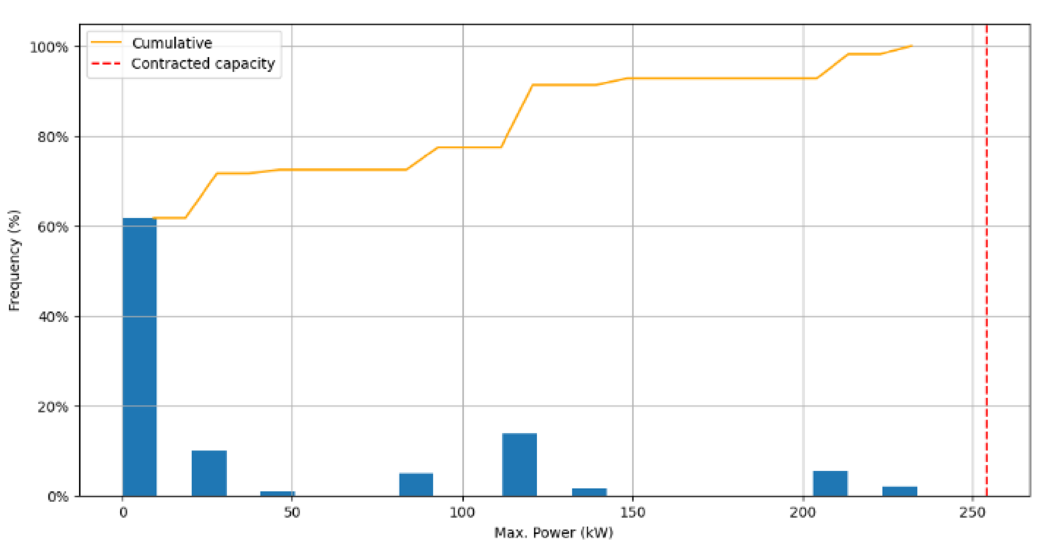

Fig. 5. Distribution of max. power at supply point, compared to contracted capacity

It can be observed that while contracted capacity is 254kW, the supply point remains under 150kW (59% of the contracted power) approximately 90% of the time.

In a second step of the analysis, data from actual charging sessions has been used as a basis to simulate the effects of applying SMAC strategies to the same locations and period of time. This second dataset has been used again to analyze the distribution of the power at supply point. The results show a clear reduction of the maximum power required at the supply point to provide the same level of service. Supply point would stay under 80kW (31.5% of the contracted power) approximately 90% of time.

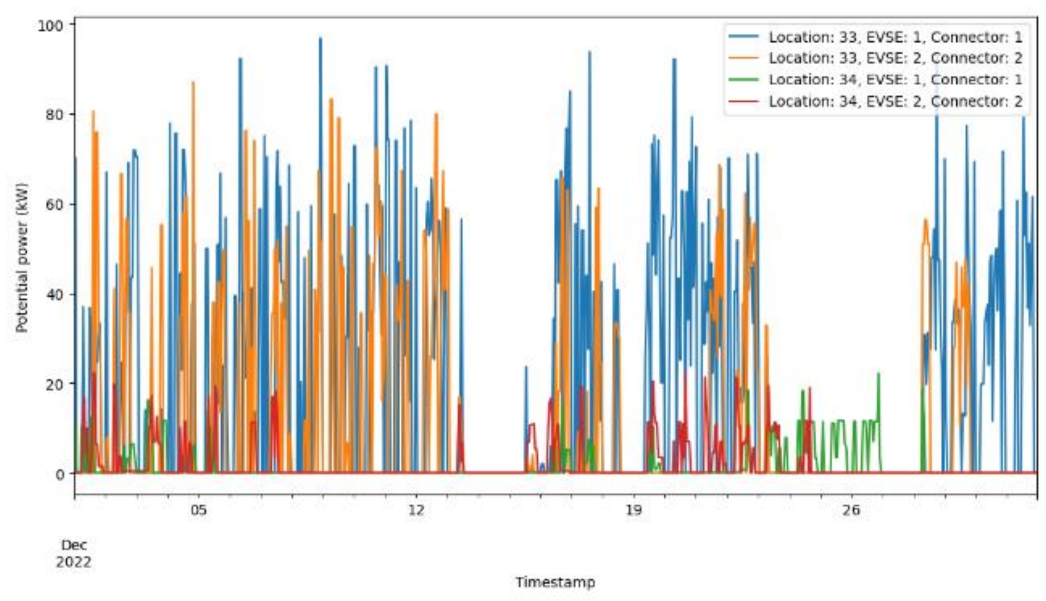

Fig. 6. Potential power per EVSE and hour with smart charging strategies in place.

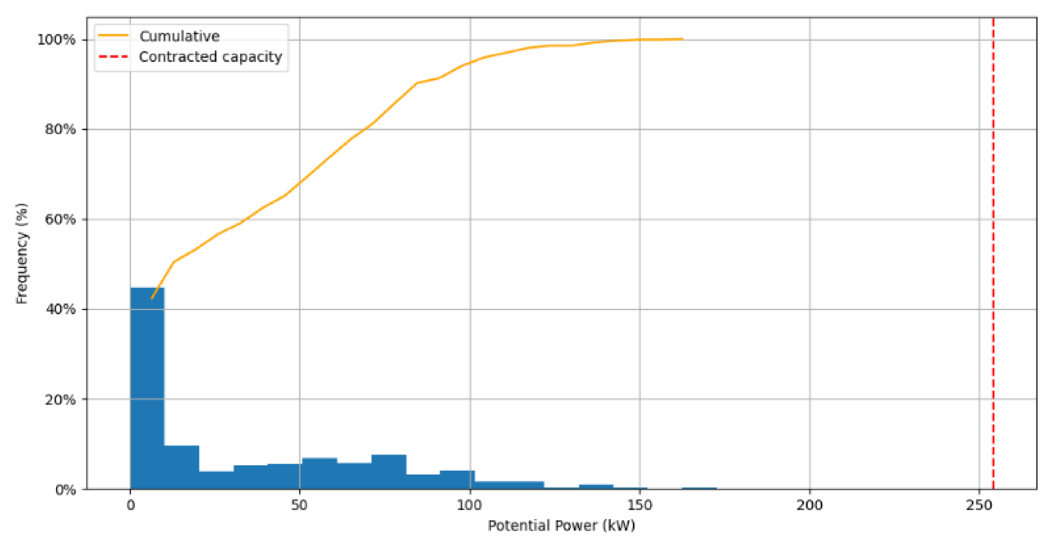

Fig. 7. Distribution of potential power at supply point with smart charging strategies in place, compared to contracted capacity.

Conclusions

The presented results confirms the potential of the proposed smart charging strategies to reduce the required capacity for the EV chargers, which brings benefits both for CPOs (direct reduction of faced capacity-related fix costs) as well as the grid planner (lower capacity requirements per charger, which would facilitate the deployment of new EV charging infrastructure in existing grids).

Future work

In the framework of the USER-CHI project, SMAC will be tested in real environments in 5 different pilot sites, which will account for infrastructures with different sizes constraints and optimization use-cases – economic optimization, self-consumption, V2G –. This will allow the collection of more data in order to validate the proposed strategies.

Furthermore, the results from these pilot sites will contribute to the development of best practices and guidelines for the implementation of smart charging infrastructure. This will include insights into technical requirements, operational workflows, and policy frameworks necessary to support the widespread adoption of smart charging solutions. The ultimate goal is to leverage the findings from these pilot tests to facilitate the deployment of new EV charging infrastructure, optimize existing operations, and accelerate the transition towards a more sustainable, efficient, and user-friendly electric mobility ecosystem.

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