Revolutionizing Electric Vehicle Infrastructure:

Smart Charging for Load Management to Propel Economic Advantages

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ABSTRACT

Electric vehicles (EVs) convert up to 77 % of electrical energy into mechanical energy [1]. To maximize this energy efficiency, it is vital to optimize the power and load distribution within a charging network to win financial advantage i.e., by avoiding expensive peak hours [2]. However, the orchestration of external dynamics such as surplus energy or time of the day on power availability is challenging and the infrastructure must be able to react quickly.

This paper educates on local and cloud-based smart charging options and static/dynamic load management solutions within an EV infrastructure to tackle this challenge. We present an innovative technical design, that utilizes a 50 m^2 solar panel to feed > 10 in-house manufactured chargers while facilitating a fast-response load management (LM) mechanism. Our LM includes an automatic fallback controller selection to ensure grid safety and group management options to distribute clients across circuit panels. Furthermore, the LM offers a dynamic yet equal power share within the cluster and the selection of VIP-EVSEs within the cluster, that always receive the minimum requested power, particularly important for fleet applications. Finally, we present mobile chargers as part of a modern load-balancing network to shrink the cost of ownership.

1. INTRODUCTION

Electric vehicles (EVs) master energy conversion at its finest as they convert up to 77 % of electrical energy into mechanical energy to propel a vehicle. In contrast, an internal combustion engine dissipates most energy into heat, utilizing only about 30% of available energy from gas or diesel for mechanical work [1]. To claim an impactful economic advantage of an EV's unique energy efficiency, it is vital to avoid expensive on-site circuit breaker upgrades whenever possible by optimizing the dynamic power and load distribution within a charging network [2]. However, the orchestration of the variables over time that affects power availability, such as surplus (i.e. renewable) energy or peak hours, is challenging, and the EV infrastructure needs to be able to react to multiple dynamic influences by being "smart" [3] (Fig. 1).

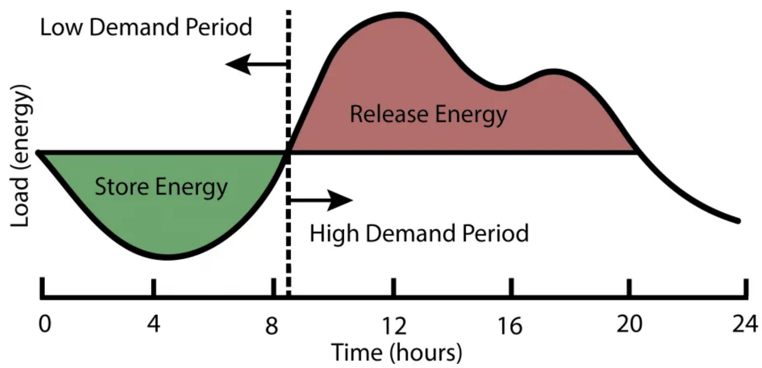

Fig. 1 Load (energy) variance over time [1]. Dependent on power availability a smart EV infrastructure can respond to current power restrictions by throttling Amperage or postponing the charging process to a later time or vice versa.

2. SMART CHARGING TECHNOLOGY FOR LOAD MANAGEMENT

This paper provides an in-depth overview of innovative smart charging technologies for load management to boost the economic advantage of vehicle electrification. We educate on local and cloud-based smart charging options, as well as static and dynamic load management solution approaches within an EV infrastructure and tie these back to their preferred applications.

We study the presented technical design concepts and present real-world energy distribution data from our own solar-driven EV charging site, which utilizes a 50 m^2 solar panel to feed > 10 in-house manufactured charging stations while facilitating fast-response load management between the chargers (Fig. 2).

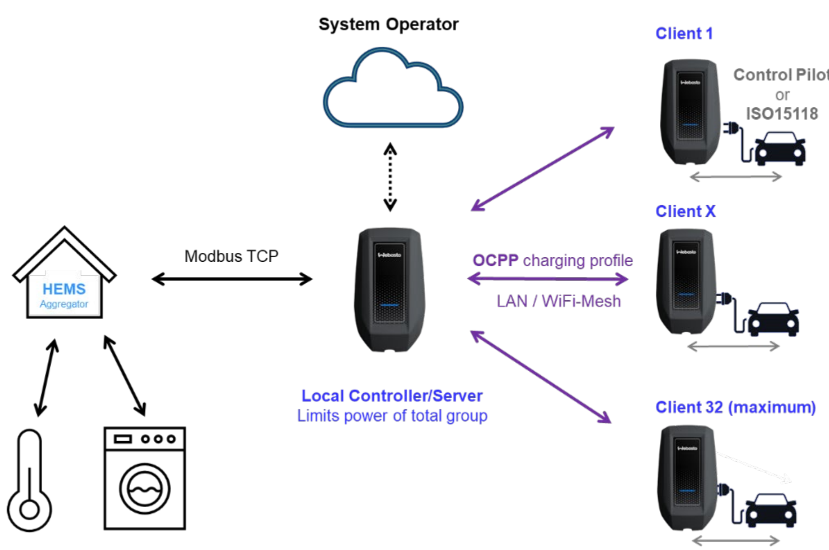

Fig. 2 High-level technical concept of our local load management approach installed at our solar carport.

The presented load management solution is pending two patents, as it includes an automatic fallback controller selection to always ensure grid safety and group management to distribute EVSE clients across circuit panels within a load cluster.

Our EVSE load management solution offers two modes, that are:

1. The dynamic yet equal power share between the cluster EVSEs (Fig. 3), and

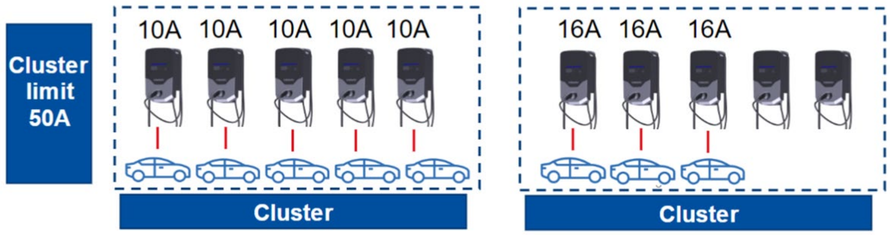

Fig. 3 High-level equal power share concept within the EVSE cluster.

2. The selection of one or more VIP-EVSEs within the cluster, that always receive(s) the minimum requested power. This is particularly important for fleet applications, that need to ensure the full charge of priority vehicles with respect to their dispatch schedule (Fig. 4).

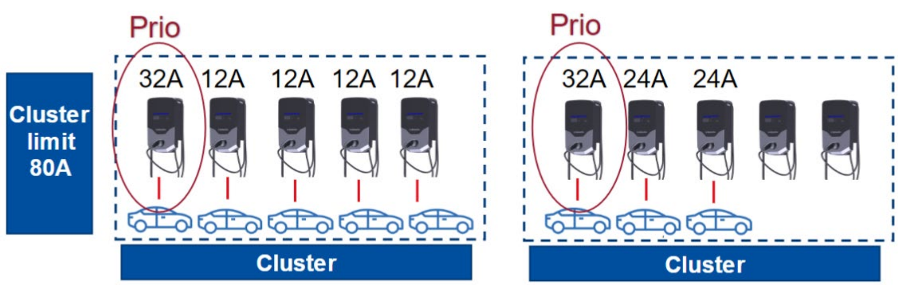

Fig. 4 High-level VIP power share within the EVSE cluster.

3. CONCLUSIONS AND FUTURE WORK

The cost to source electricity varies minute by minute [4]. The detailed paper on our innovative load management solution within an EVSE infrastructure together with our lessons learned educates the reader on how to maximize the economic impact of vehicle electrification while always ensuring grid safety. As a next step toward a future load-balancing network, we are working on the inclusion of mobile chargers as cluster clients.

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