

150kW Public Multi-Charger DC System: a viable public charging infrastructure

Alexander Jochum¹, Markus Kramis², Roland Bucher²

¹ *Chargelounge GmbH (Germany), Tegernseer Platz 7, 81541 München*

² *EVTEC AG (Switzerland), Rengglochstrasse 19, CH-6012 Kriens-Obernau, m.kramis@evtec.ch*

Summary

There is common understanding that beyond car models and pricing, the infrastructure for refuelling the electrically powered cars, the charging infrastructure, is the crucial part of introducing this new means of mobility to wider circles. [1]

The viability of the charging infrastructure must be considered more detailed. As soon as public funds are spent on it, its viability must be raised to a publically acceptable level just by selecting components which proofed applicability in the relevant sectors of the public.

The technological acceptance of the electrically driven vehicles will be dependent not only on how much money is spent and what charging infrastructure is installed. It will be raised by recognizing the fact, that electric cars and its systematic technical components can close gaps between formerly independent sectors of sustainable energy supply. Examples are the higher efficiency of battery electric vehicles and the advantage, that its batteries are able to store the volatile sustainable energy from solar panels, the improvement of grid stability by consuming oversupply from sustainable energy sources and all other impacts on power distribution within the grid by energy management for a smarter grid utilization [2]

Optimizing the public spending means to enable the majority of the public and the energy related sectors as potential beneficiaries of such a more systematically considered public charging system to satisfy more foreseeable requirements than the mere mobility during the projected use time of a subsidized public charging system [3]

Keyword: BEV, charging, subsidy, smart grid, second-life battery, ZEV

1 Introduction

Fast charging is a relatively young term, but it is ageing fast. The experience with the first publicly offered charging systems proofed, that the development of car battery systems of BEVs is faster than the expected amortisation time of publicly funded infrastructure. The first fast chargers were designed at a time, when batteries varied between 16 and 24kW and even pioneers of bigger battery systems publicly stated, charging would take place at home rather than at charging stations [4].

At those times public opinion assumed charging of electric vehicles a question of providing sufficient energy to the prevailing onboard chargers of cars while the car was parked at any destination, at work or at home. The first electric cars (BEVs) were equipped with onboard chargers for alternating current (AC) only.

This changed beginning with Japanese patents, when the suppliers of vehicles started to offer fast charging as a direct current (DC) system. By detecting that the range anxiety was a major threat for the acceptance of the new electric vehicles, the charge time could not be allocated to home or work periods any longer. The recharge had to be accommodated in a breaktime as well. “Charge while we have a cup of tea” is the intended meaning of the name “CHAdeMO”. Some years later it is even expected, that there should be no difference to the refueling experience at a classic gasoline station [5].

In 2009 for 16-24kWh BEVs a charge power of 20kW up to 50kW was considered as “fast” enough. But up to now, the car batteries turned out to become rather 60, 80 or 100kWh instead of only being doubled in size, a rather exponential than linear growth especially due to the fact, that nowadays at least 200-400km are considered to be a sufficient travelling distance for an electric car [6].

The conditions of the grid changed as well as the power requirements for the predicted transition to BEVs. The prevailing installations did not account for the future needs of high-power charging so far.

Nowadays the increased yields of sustainable energy sources like solar- and wind-energy are considered of the same importance to the stability of the grid as it is the sufficiency of the supply. Both effects can be improved by means of one of the immanent qualities of electrically powered vehicles – its batteries, either in its pre-, first- or secondary life cycle – with the side effect an overall reduction of carbon emissions. [2][6]

Against those publicly discussed requirements the current investment looks more like the early beginnings of gasoline stations in the 1920s, when restaurants and shops offered gasoline along the road side occasionally, in order to be one of the pioneers to attract the new customer group [7]

2 Requirements to maximize public utilization of a Multi-Fast-Charger

A publicly funded Multi-Fast Charger must pay off for a longer period than chargers which serve private refuelling needs or proprietary chargers services for one car model exclusively. While public opinion mainly focuses on the connectors for fast charging, it is the effective charging speed and the compatibility with the grid which has to be maintained over a wide variety of communication- and battery systems of the various car manufacturers and over an acceptably long amortisation period.

In order to allow a user experience as close as possible to what drivers know from petrol stations, a public fast charger must utilize the technical limits of the recharge capacity of as many as possible different proprietary battery systems over a period as long as foreseeable. It must be adjustable in the same rate, the battery systems of the cars tend to grow.

Since the development times of car models are more than 5 five years and the marketing requirements force them to preinform about standards, the future developments can be analyzed in order to improve the amortisation period.

Publicly used chargers need not necessarily to serve all market segments of cars but should operate the expected fleet at least according to the expected market share of the different models in order to increase the user and potential financial income base of the investment.

In order to maximize the benefit of a public fast-charge station

- a) it must generate a charging experience for users which is close to what they know from their conventional cars [5]
- b) therefore it must serve as many as possible electrical rechargeable cars of the utilization period according to their expected market share,
- c) in order to improve the amortization period and to raise the life-time efficiency of the public investment, the technical setup has to anticipate the foreseeable developments, [10]
- d) the power output has to be adapted to varying power allowances of existing grid connections
- e) minimization of civil and service cost during the life time

Picture 2: upgradeability of a futureproof Multi-Charger (EVTEC Switzerland, 2015)

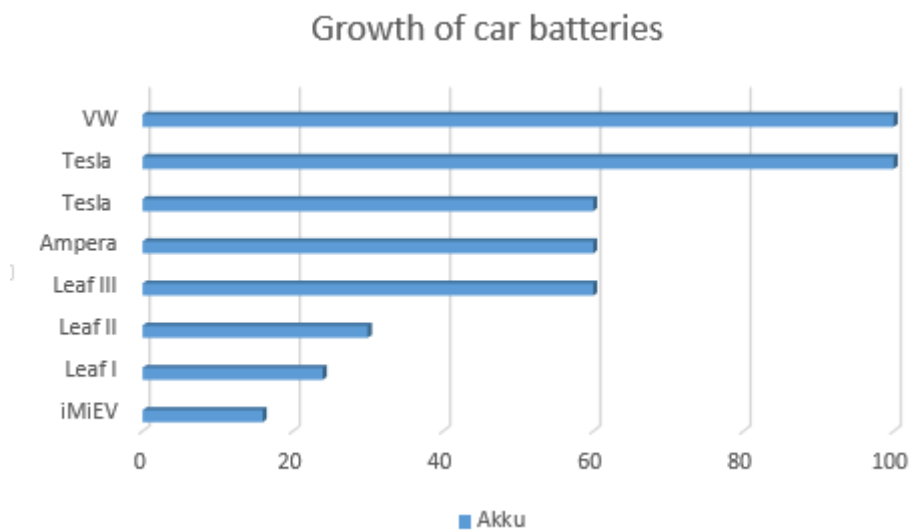


Illustration 1: growth of car batteries in public announcements during the last five years, 2016



Picture 1: upgradeability of a Multi-Charger for remaining futureproof (EVTEC Switzerland, 2015)

3 Technical description of the charging system

A public Multi-Charger can be connected to 3phase grids of 400V, 50-60Hz. While the grid voltage is a given factor by standardization, the available power is an unpredictable variable. [3]

Publicly funded Multi-Fast Charger should offer at least

- AC charging socket 22kW for cars with onboard AC/DC modules
- AC charge plug European standard for cars with onboard AC/DC modules, 43kW
- DC standard european combo AC/DC sockets for combined charging standard for future communication and power requirements
- DC standard Japanese, pioneer standard of vehicles with a already impressive customer base
- DC compatible with the luxury brand “Tesla” as one of the main drivers of electrification of vehicles

Upgradeability

Incremental power units, which can be connected to variable setups of multiple power output according to the growing battery capacity of cars in order to serve current or future needs flexibly.

Two voltage ranges 250-500V or 170-940V allow to charge all currently projected battery systems.

Dynamic DC Switch

A switch system in order to share the AC and DC power between 1 + n users in order to serve more than one plugs for simultaneous use.

Dynamic Charge Management System

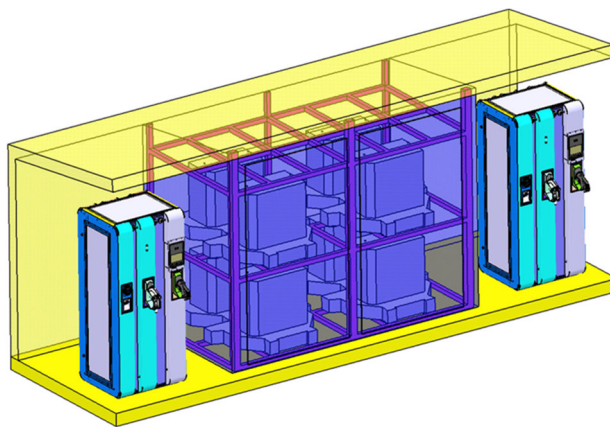
An optional Power Management System to control the power consumption of the charger according to the available grid power at the connection point in order to avoid a cost increase due to additional power allowances from the energy supplier.

Buffer Battery

An optional battery system can be used additionally to buffer the peak power of the charger down to approximately 50% of the required power. To raise the overall efficiency of the system, the car batteries can be used for that before or after their technical lifetime as traction battery within the car.

Housing

A systematic housing incorporates all components of a visually comprehensive refuelling station in order to simplify the recognition as close as possible to the common refuelling experience and shelters the user and the equipment from the weather.



Picture 2: three methodical components of a public Multi-Charger: Charger unit, buffer battery, housing for plug and play installation, Protoscar, Switzerland for Chargelounge GmbH, Germany, 201

4 Technical feasibility

The DC fast charging with external AC/DC power converters was firstly introduced as a version of 2 power modules in a cabinet similar to AC charging poles. The average battery size of the prevailing car models could be recharged with those 20kW within 20-30 minutes.

While the first public DC charging networks set a new standard: instead of only one connection system, the user should make his purchasing decision not according to any prevailing standard, but the charging manufacturer should offer the available connectors on one unit.

The market diversified and certain cabinetmakers offered upgradeable cabinets with additional allowance for doubling the output power of the unit up to 50kW by accommodating 5 power modules for cars with battery-sizes of 24kW up to 30kW. During the 5 years the new car models were acknowledged with quickly increasing battery capacities from 16kWh to 20kWh, 27kWh, 33kWh, 60kWh, 80kWh and 100kWh. In order to increased battery required a cabinet size for taking up to 7 times more power modules than the first car batteries according to growth of car batteries, can be charged with the maximum speed due to the modular setup and dynamic power distribution. [11]

The battery and controller are operated in independent test projects or commercial installations of pioneer customers. [12]

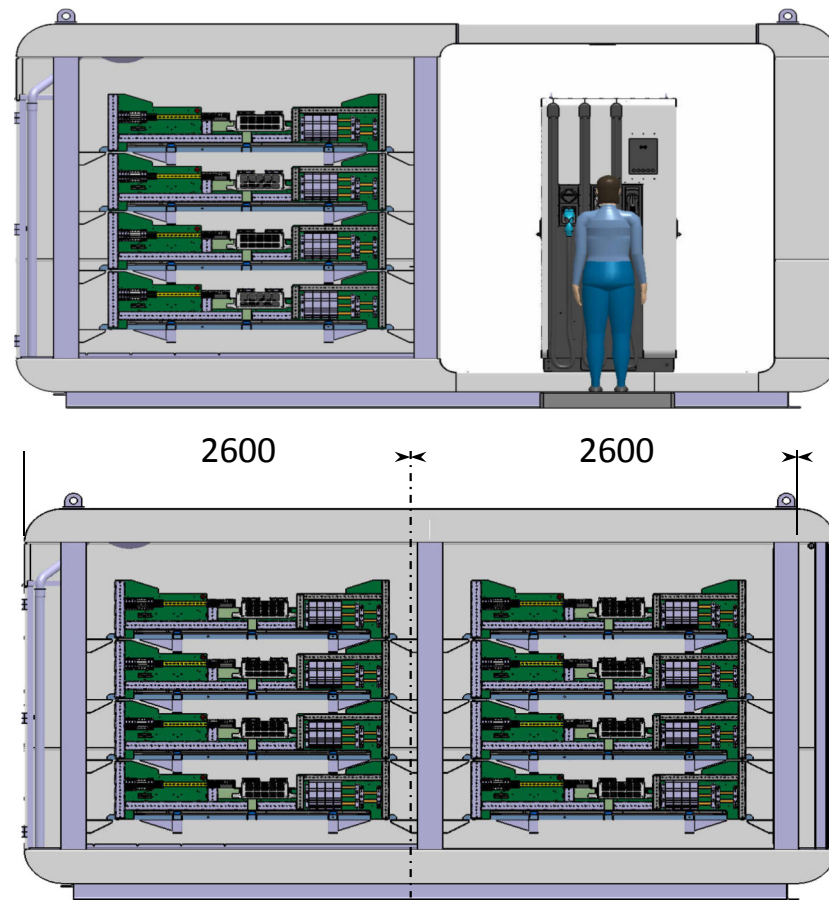
All components of the system are already commercially available and proofed under everyday conditions. At four independent projects a combination of the systems is already implemented, at three of these projects it is operated under everyday conditions. The projects are, if not publicly used but accessible on short notice.



Picture 3: Installation of one of the first Multi-Chargers with 150kW at the Fraunhofer IAO, Nobelstr., Stuttgart, 2016



Picture 4: a temporary / small plug&play gasoline station, Bourgoin Jallieu, France, 2017



Picture 5a, 5b: adaption of plug&play gasoline station for electric vehicle charging and increased storage with secondary-use traction batteries, Protoscar, Switzerland, 2017

5 Economical feasibility

The business model is comparable to the operation of parking meters and public phone services (in the pre-smartphone-era). By making use of the service, the customer enjoys time savings: The customer accepts the system cost of the service, but it is expected that the service is available not only in urban environments, where it can be economically serviced and operated, but also in remote areas where access-costs might raise. Those rare locations attract higher traffic and might perform economically better than those in areas with alternative offers. [15].

The systematic factors for economic feasibility are accommodated in the components:

- a) Up time: a proofed and widely used technical system avoids proprietary complication factors which leads to a more continuous utilization and payback of the investment similar to parking meters.
- b) Serviceability: focussing on simple connection to one power supply in the centre of a 4 accessible charging lots, the system approach reduces civil work cost factors around the installation which contribute a unpredictably large share to the overall installation and life-time service costs, like ground works and accessibility of parts to be serviced
- c) Utilizing the full amortisation time: By considering the foreseeable technical development of cars, the potential user base doesn't shrink before the end of the expected life time of the investment

- d) Avoiding civil work for upgrading the grid-connection by utilizing storage capacity which has its own market value by offering primary grid regulation capacity on the emerging market [14].
- e) Remaining independent from market prices of storage capacity by utilizing traction batteries of selected car manufacturers, increasing the life-time and reducing handling cost of waste batteries and raising the efficiency of the system
- f) Improving the overall system life time by wheater shelter and controlling the climatic impact on the equipment
- g) Raising the frequency of potential customers at the site by selecting environments for the charging infrastructure in order to generate future demand around the recharging of cars, bike rental, fleet service, suburban train or flight connections, tourist services, lodging and food service agencies or services
- h) Improving the customer loyalty and raising the potential customer base by payment partners which achieved the critical mass of their payment services outside the ev-charging business



Picture 6: Rendering of multipurpose site, Chargelounge GmbH, Germany, 2017

One psychological factor assumedly operates in favour of the investor/operator of public fast charge investment: It can be presumed average price per kilowatt hour, although traded officially on marketlike platforms, has different market values. The average car user is likely to pay more for the enjoyed benefit of each kilowatt hour for refuel his car and improve his psychological comfortability and physical “real” autonomy, than industrial power suppliers would be willing to pay, when they buy the same unit of power at a market to fullfill the requirement of an abstract grid stability.

6 Public awareness and attractiveness for users

Pioneer users of electric vehicles are driven by a set of various motivations. [15]. They enjoy the experience of a charge speed as fast as their car technically allows [16], especially if the available infrastructure have deprived them of this experience. The first installations in Germany were elected by independent user community No. 1 and No. 3 of the most accepted public charging sites. [17],



Charging Hyundai Ioniq on 100 kW CCS

Picture 4: Hyundai Ioniq User at a 120kW public multi charger station as described; User published a video about it in the internet enjoying the charging speed with 69kW

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Authors

Alexander Jochum graduated from the Universities of Applied Sciences in Augsburg and Rosenheim at the Level of Master of Business Administration (1996) and was in charge of public and investor relations of the Promotion Fund of Timber Industries at federal level of Germany and the market development of family owned UV light business before he entered the emobility business for deployment of the state-of-the-art technology.

Markus Kramis and Roland Bucher received their bachelor degrees in Electrical Engineering on 2007 from the Lucerne School of Engineering and Architecture. He is the founder of EVTEC AG in 2010. Current activities contains charging infrastructure development, secondary used battery integration for peak shifting and reduction, dynamic charge management system implementation on stationary batteries and charging stations, bidirectional charging station and control system developments.