ebalanceplus

Specification of electric vehicle charging stations based on PV and V2G

Deliverable 3.6

Date: 27/10/2022
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Technical References

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

Document history

V	Date	Beneficiary(ies)	Author(s)
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Summary

1.1 Summary of Deliverable

This deliverable presents a vehicle charging station solution, type vehicle to grid (V2G), developed for the ebalance-plus project, that is going to be implemented on the demo site of Malaga University (Spain).

Firstly, there is a brief introduction of the state of the art of the V2G chargers. Then, it describes the selected approach regarding the electric vehicle charger on the project.

Lastly, the product specification is described, technical drawings and photos of the developed solution and also included the PV canopies that will supply the energy to the charging station.

Disclaimer

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Acronyms

AC	Alternating Current
CAN	Controller Area Network
CCS	Combined Charged System
DC	Direct Current
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
IGBT	Insulated Gate Bipolar Transistor
kW	Kilowatt
LED	Light-Emitting Diode
PV	Photo-Voltaic
RIFD	Radio-Frequency Identification
SiC	Silicon Carbide
V2G	Vehicle to Grid
WB	Wallbox

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1 Introduction

Within the field of electric mobility there are several types of chargers and charging sockets. Chargers are classified into slow chargers, from 3.7 kW up to 22 kW, fast chargers, up to 350 kW, and bidirectional energy chargers, up to 10 kW. There are 2 types of charging processes, alternating current (AC) or direct Current (DC) charging.

This project will be focused on DC chargers and address bidirectional charging to carry out the DC charging, there are 3 types of outlets, the Combined Charged System (CCS), the CHAdeMO and GB/T.

This charger will be different from what currently exists on the market, because the conventional charging is AC/DC or AC/AC and the facility is in an AC network and does AC or DC charging. In addition to being bidirectional, these will provide a DC/DC bidirectional conversion, so it can be connected in a DC bus, which will also include an installation of photovoltaic panels and carry out DC charging. Furthermore, to make the ebalance-plus project chargers also different, the same equipment will have the ability to load and unload two vehicles simultaneously.

Within the above-mentioned charging protocols, only one at this moment allows the bidirectional operation, which is the CHAdeMO charging protocol, which will be the protocol selected for the development of this facility.

We present below all the specifications of the developed solution.

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2 Vehicle to Grid (V2G)

As previously mentioned, in this project bidirectional electric vehicle charging devices will be developed, as known as vehicle to grid (V2G). These devices will be developed based on silicon carbide (SiC) which is a much smaller, efficient and economical solution than the conventional insulated gate bipolar transistor (IGBT) based, the solutions developed using the old technology cannot achieve a efficiency higher than 90% and with the new topology using SiC higher efficiencies can be achieved (around 98%). The Figure 1 presents a V2G solution (AC/DC) based on IGBT.

Figure 1 – V2G from MAGNUM CAP on the market

These devices are assembled with CHAdeMO plugs to serve as a way of connection with the electric vehicle and to serve as a communication bridge/interface with the vehicle, when using the CHAdeMO communication protocol, the communication between the electric vehicle supply equipment (EVSE) and the electric vehicle (EV) will be based on communication CAN. Figure 2 shows a CHAdeMO plug.

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Figure 2 - CHAdeMO Plug

Each of these devices will allow loads up to 30 kW when only one vehicle is present. In case of two vehicles, it will allow two simultaneous charges of 15 kW, and the same happens in the vehicle during the discharge process. In Figure 3 is presented the V2G charging stations developed for the project.

Figure 3 - V2G for the ebalance-plus project

It was decided to develop the charging stations with 30 kW power electronics, divided in 15kW+15kW. That decision was based according to what is currently present on the market, in terms of power electronics and other manufacturers, to have a DC WB (Wallbox) of 30 kW to charge only one vehicle, but also able to charge two, so the power is divided 50/50%. Same logic is applied on the discharging phase.

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2.1 Specifications

This section will describe the technical specifications of the V2G charging station: electrical specifications, Table 1, mechanical specifications, Table 2, and the user interface, Table 3.

Table 1 - Electrical Specification of V2G

Input		Charging Output		Discharging Output		Electrical and Safety
Voltage Range (DC)	300-860V	Voltage Range (DC)	300-750V	Voltage Range (DC)	300-750V	Input/output over/under voltage protection
Max. Power (kW)	30	Max. Power (kW)	30	Max. Power (kW)	30	Overcurrent and short circuit protection
Current Range (A)	0-50	Current Range (A)	0-50	Current Range (A)	0-50	Over temperature protection
Efficiency (%)	98	Efficiency (%)	98	Efficiency (%)	98	Emergency Button

Table 2 - Mechanical Specifications

Cabinet Specifications		Environment Conditions	
Dimensions (WxDxH)	694x317x698mm (without pedestal)	Temperature	-25 to 50°C
Weight (kg)	50	Humidity	5% to 95%
Protection Degree	IP54/IK10	Altitude	Up to 2000m
Cooling System	Forced Air	Sound Noise	>65dB

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Table 3 - Communication specifications

User Interface	
Connectivity	Internet access via 4G/3G/Ethernet (RJ45)
Communication Protocol	ModBus, OCPP 1.6Json
User Authentication	RFID, Mobile App
RFID Card Reader	ISO 14443 Type A
User Interface	Color Display TFT 7'' 2 Push-Buttons
Language	Multilanguage

The user will interact with the equipment by using radio-frequency identification (RFID) cards and the present buttons on the equipment, will also be able to use a mobile application to perform actions. The charging stations has also 3 light-emitting diode (LED) bars that will indicate the status of the plugs and of the equipment, Figure 4.

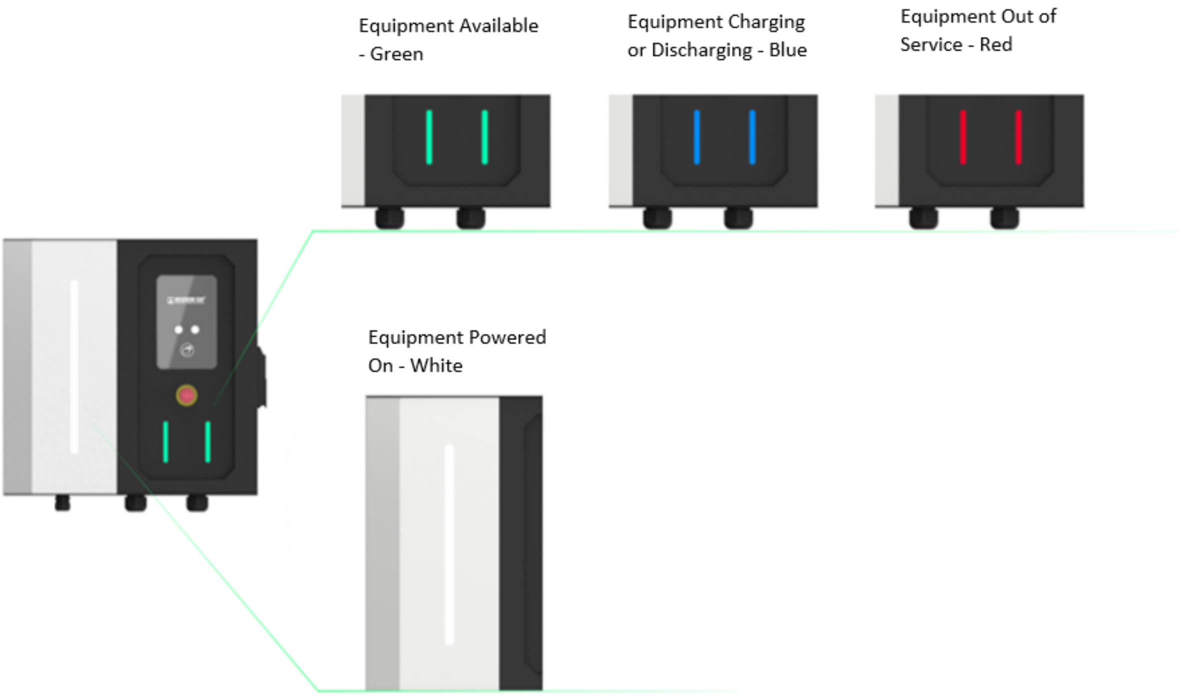

Figure 4 - LED colour code

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2.2 Drawings

In this section will be presented the prototype drawings resulted from the developing stage of the project, Figure 5 and Figure 6.

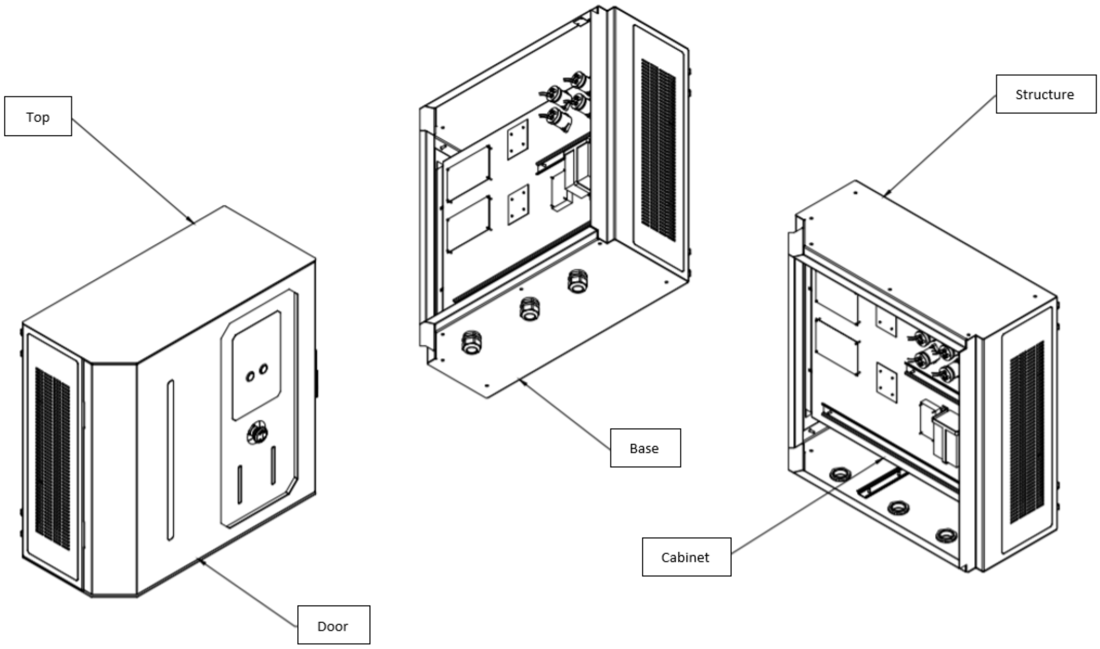

Figure 5 - General Drawing

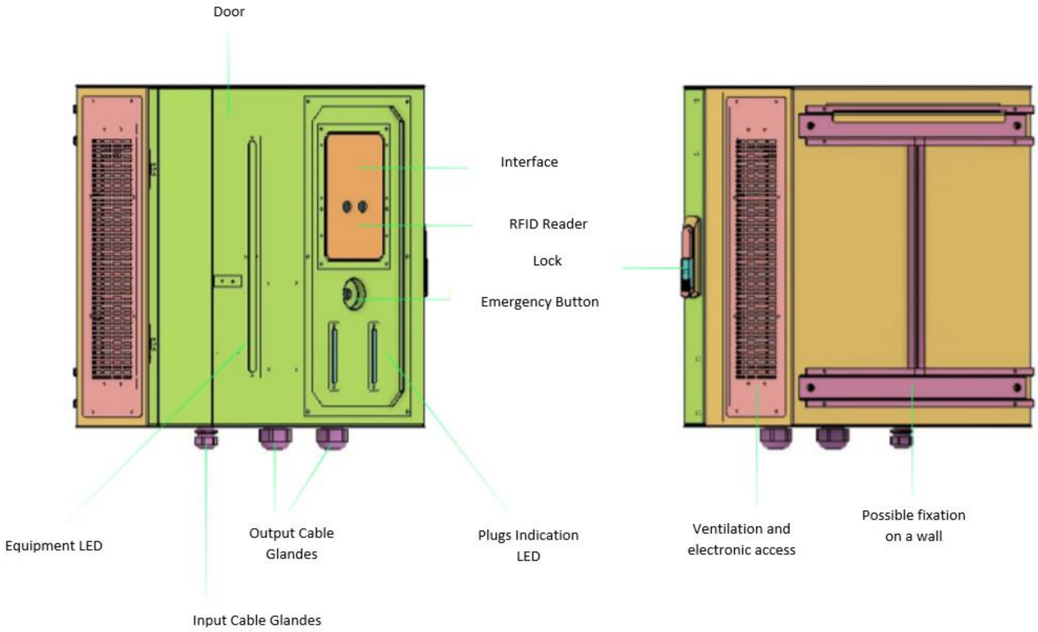

Figure 6 - 3D Drawing

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2.3 Charging Station Architecture

The architecture inside of the charger is showed in the Figure 7.

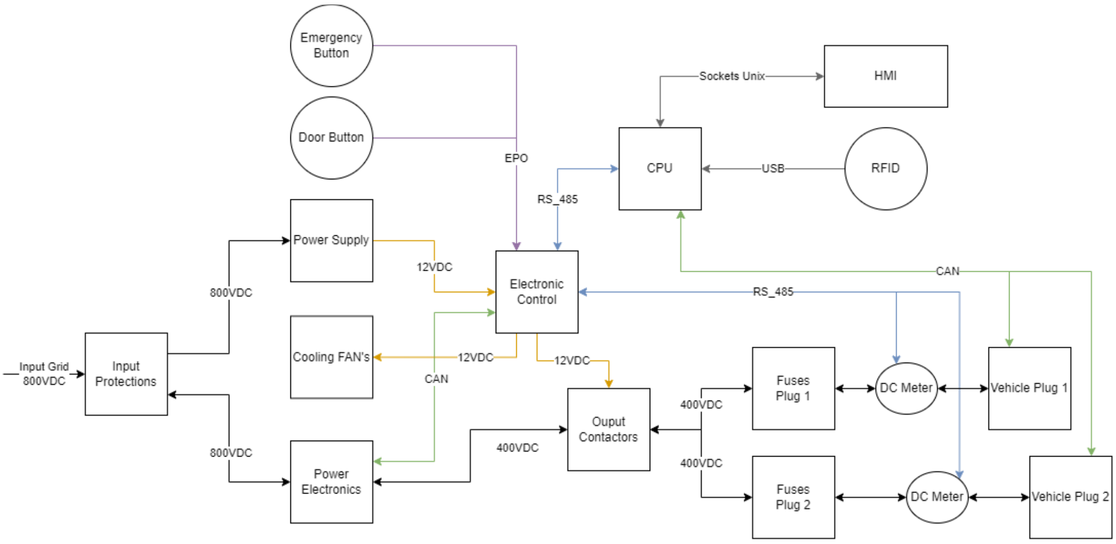

Figure 7 - Block Diagram of the V2G

In Figure 8, we can see the full block diagram of the power electronics.

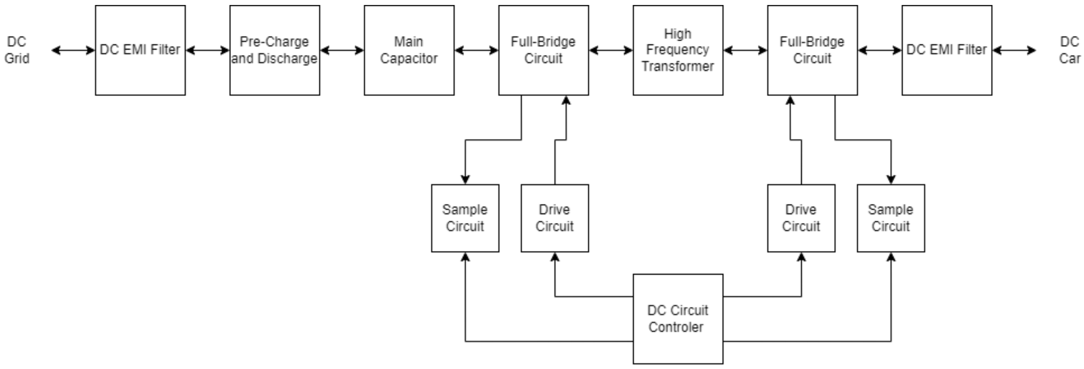

Figure 8 - Block Diagram of the Power Electronics

The charging station is equipment with 15kW power electronics that use a Dual Active Full-Bridge circuit, Figure 9.

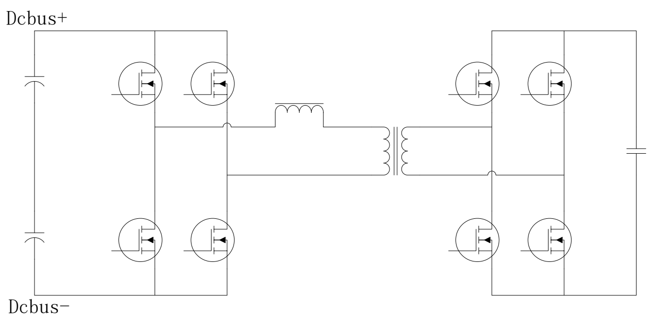

Figure 9 - Dual Active Full-Bridge Circuit

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2.4 SiC vs IGBT

Using SiC technology we can obtain devices with less components by comparing Figure 10 with Figure 11.

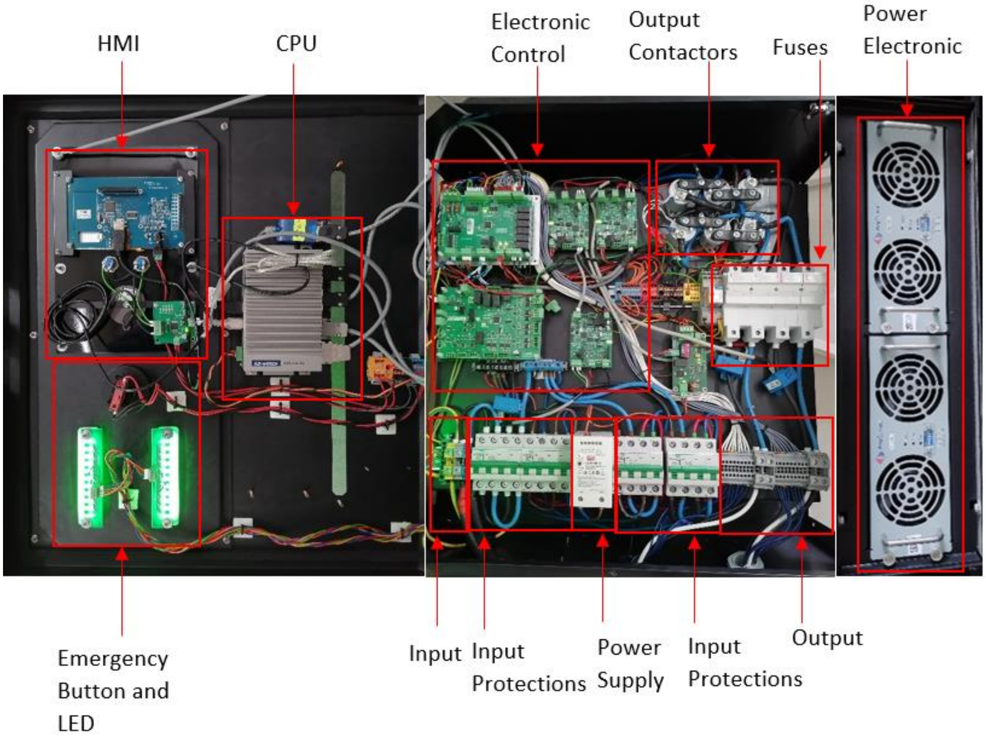

Figure 10 - V2G SiC ebalance-plus prototype

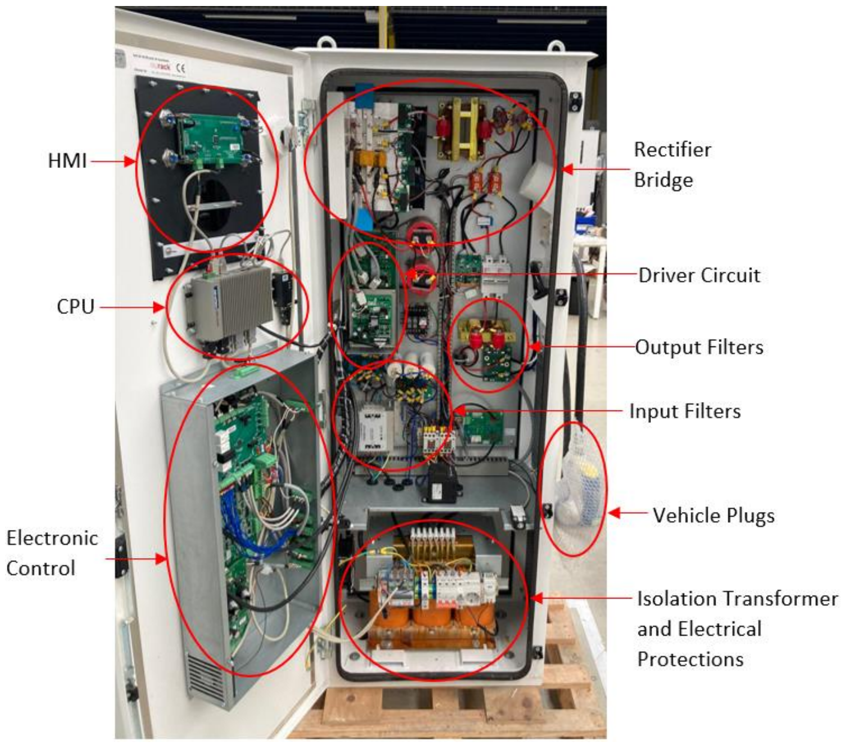

Figure 11 - V2G IGBT

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In Figure 11 and Figure 12, we can see side by side the solution with SiC technology compared with the solution with IGBT technology, realizing that the obtain a smaller charging station that we had previously.

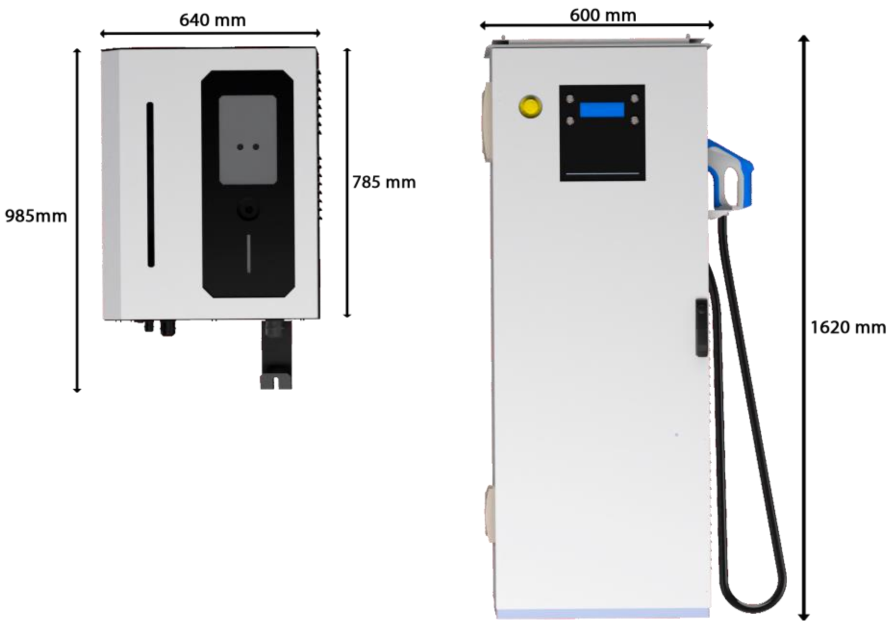

Figure 12 - V2G SiC vs V2G IGBT Front

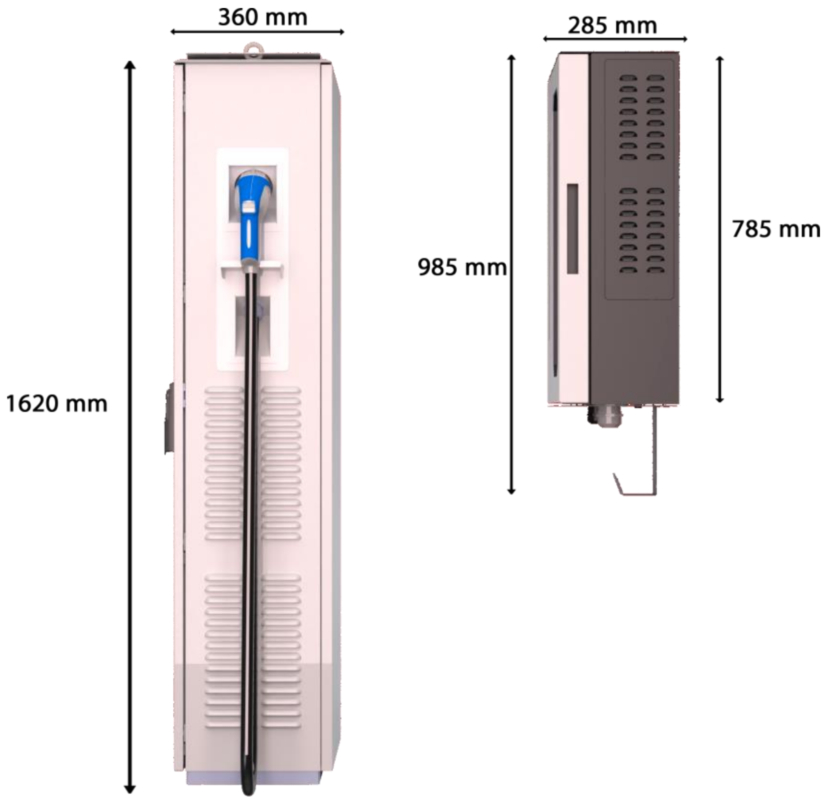

Figure 13 - V2G SiC vs V2G IGBT Side

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2.5 ModBus Communication

The charging stations can be remotely controlled by ModBus communication. The Annex 1 describes the available commands for the charger.

2.6 PV Canopies

On the ebalanceplus project the EVSE will be implemented on a DC Grid that also has PV (photo-voltaic) canopies integrated, Figure 13.

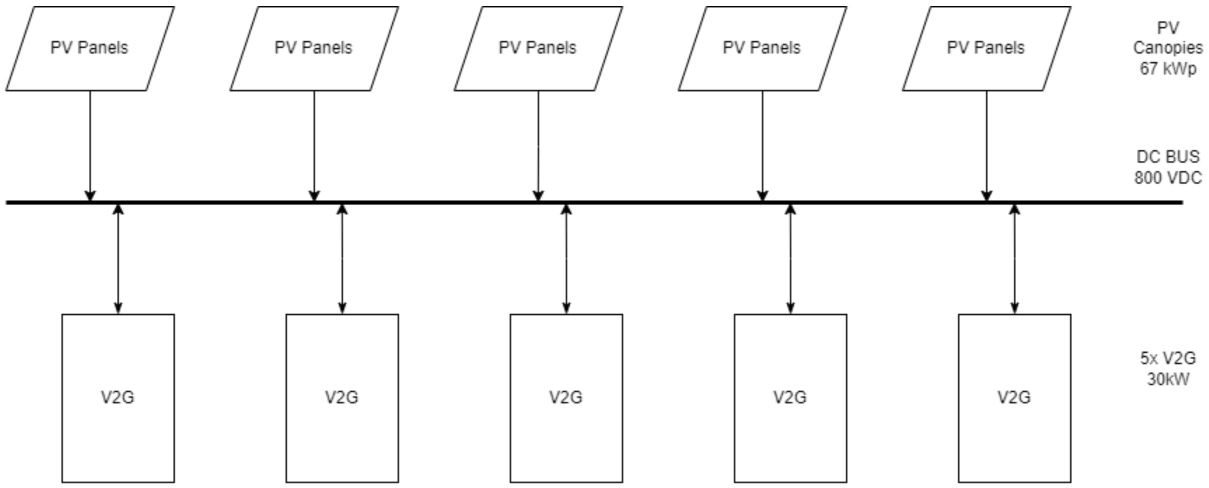

Figure 14 - Grid schematic with V2G and PV

In this facility, along 30 parking spaces, 162 PV panels will be installed, creating a 67 kWp all connect to a DC Bus, in this same DC Bus, the V2G charging stations will be connected using the energy provided by the PV panels to charge the electric vehicles.

In Annex 2, there is the manual for installation and user of the V2G equipment's.

3 Conclusion

The evolution and the appearance of new EV in the market, requires EVSE must continue improving as well. In this project has managed to develop and achieve a new prototype, a solution with SiC technology more efficient, smaller, cheaper and modular, better that the conventional technology based on IGBT. A brand-new type of solution developed for a DC grid, out the conventional scope of AC grid.

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Annex 1: ModBus

A.1 ModBus Register Map

MGC developed and delivered a document “ModBus Register Map” with all the information necessary for the communication ModBus with the equipment’s.

Address	Value	Data Type	Length (registers)	Read/Write	Notes
0000	Action	INT16	1	Write	Action to be executed by the charger 0 – Stop Transaction 1 – Charge Only 2 – V2G Pause 3 – V2G Charge 4 – V2G Discharge Other values will be treated as 0
0001	Action Confirmation	INT16	1	Read	Informs if action change was executed 0 means action NOT executed 1 means action executed
0002	DC current setpoint	INT16	1	Write	Max current allowed for present transaction
0003	Current setpoint change confirmation	INT16	1	Read	Informs if current setpoint changed 0 means setpoint did NOT change 1 means setpoint changed
0004	Max SOC setpoint	INT16	1	Write	Max SOC required for present transaction
0005	Max SOC change confirmation	INT16	1	Read	Informs if max SOC changed 0 means max SOC did NOT change 1 means max SOC changed
0006	Min SOC setpoint	INT16	1	Write	Min SOC required for present transaction
0007	Min SOC change confirmation	INT16	1	Read	Informs if min SOC changed 0 means min SOC did NOT change 1 means min SOC changed
0008	Status Code	INT16	1	Read	Gives information about charger’s operation mode
0009	Present DC Voltage	INT16	1	Read	Output DC voltage
000A	Present DC Current	INT16	1	Read	Output DC current
000B	DC charged energy	INT32	2	Read	Session DC charged energy
000D	DC discharged energy	INT32	2	Read	Session DC discharged energy
000F	Time to end	INT16	1	Read	Remaining transactions time
0010	Present soc	INT16	1	Read	Actual state of charge
0011	Start button	INT16	1	Read	Indicates if start button is active 0 means button is inactive 1 means button is active
0012	AC Energy Charged	INT32	2	Read	Total charged energy, AC side
0014	AC discharged energy	INT32	2	Read	Total discharged energy, AC side
0016	AC Power	INT32	2	Read	Present AC power
0018	AC Power timestamp	INT64	4	Read	Timestamp of the power reading
001C	Max charge current	INT16	1	Read	EVSE max charge current
001D	Max discharge current	INT16	1	Read	EVSE max discharge current
001E	Max charge voltage	INT16	1	Read	EVSE max voltage
001F	Max charge power	INT32	2	Read	EVSE max charge power

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Annex 2: Manual

A.2 User and Installation Manual

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