D7.6: Zaragoza urban area energy model and UC-6 complete solution description

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Technical References

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Project Coordinator	CIRCE Miguel Zarzuela - mzarzuela@fcirce.es
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[1] PU = Public

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Document history			
V	**Date**	**Partner(s)**	**Action**
V0.1	06/04/22	CIRCE	Table of Content available for WP7 and WP8 deliverables
V0.2	13/07/22	CIRCE	First Draft. Contribution from CIRCE
V0.3	21/07/22	IDNEO	Revision from IDNEO
V1.0	22/07/22	CIRCE	First Consolidated version. Final quality review.

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0 EXECUTIVE SUMMARY

This document is the deliverable "D7.6: Zaragoza urban area energy model and UC-6 complete solution description" of the H2020 project INCIT-EV (project reference: 875683).

The main objective of this deliverable is to collects the main conclusions reached after finalizing the modelling, basic and detail engineering, and equipment development activities before the deployment of the UC-6.

This document includes the design and results of the demonstrators related to UC6. These demonstrators are:

- A conductive EV charger capable of transferring 25 kW. This charger is capable of operating with both CHAdeMO and CCS type chargers. In addition, its power electronics is completely designed in SiC. It has been designed with the V2G utility, with which it will provide auxiliary services to the electrical network.
- Two-wheeled EV charging station with thief-proof lockers. This demonstrator will contribute to the integration of electric mobility in urban environments, bringing wireless technology closer to the user through a low-cost device.

Throughout the document, both demonstrators will be presented, developing their objectives, and presenting the final solution that has been reached and verified in the development.

The delivery of this deliverable is done in accordance with the description in the Grant Agreement Annex 1 Part. UC7 related to the wireless charging will be included in a different deliverable.

A small deviation of 3 months delay in the civil engineering works is expected.

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ACRONYM LIST

Table 1 - Acronym List

Acronym	Definition
AC	Alternative Current
CCS	Combined Charging System
DC	Direct Current
ESS	Energy Storage System
EV	Electric Vehicle
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interferences
EVCS	Electric Vehicle Charging Station
LED	Light Emitting Diode
RES	Renewable Energy System
UC	Use Case
V2I	Vehicle To Infrastructure
V2C	Vehicle to Centre
V2G	Vehicle To Grid
V2R	Vehicle to Roadside
V2V	Vehicle to Vehicle

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1 INTRODUCTION

INCIT-EV aims to demonstrate an innovative set of charging infrastructures, technologies, and associated business models, ready to improve the EV users experience beyond early adopters, thus, fostering the EV market share in the EU. The project will seek the emergence of EV users' subjective expectations. 5 demo environments at urban, peri-urban, and extra-urban condition will be ready for the deployment of 7 use cases (UC) addressing:

- UC1: Smart and bi-directional charging optimized at different aggregation levels – Amsterdam – Utrech Area
- UC2: Dynamic wireless charging lane in urban areas - Paris
- UC3: Dynamic wireless charging for long distances -Versailles
- UC4: Charging Hub in a Park&Ride facility – Torino
- UC5: Superfast charging systems for EU corridors - Tallin
- UC6: Low power DC bidirectional charging infrastructure for EVs, including two-wheelers.
- UC7: Opportunity wireless charging

1.1 Contribution to INCIT-EV Objectives

WP7 and WP8 "Use Cases deployment and demonstration in urban and extra-urban areas" of the INCIT-EV project aims to model, design and develop the use cases to be demonstrated in all areas with aim of collecting real data from the field. The specific objectives are:

- To elaborate a plan for the successful deployment of the innovative use cases to be demonstrated (D7.1 and D8.1)
- To model, design and develop the different solutions addressing to be implemented in the project
- To commission all the developed equipment and prepare the field for the demonstration activities.
- To carry out the demonstration activities of the use cases, monitoring the defined KPIs for its ulterior contrast and analysis.
- To analyse the medium and long-term impacts of the use cases evaluating their techno-economic, environmental, regulatory and social aspects.

This deliverable collects the main conclusions reached after finalizing the modelling, basic and detail engineering, and equipment development activities before the deployment of the UC-6.

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1.2 Contribution from partner table

Table 2 - Contribution table

Partner	Contribution
1. CIRCE	The development of controllable Low power bi-directional CHAdeMO and CCS DC chargers (V2X) with an output power between 7,4kW – 22kW per vehicle, integrated in a DC micro grid.
12. IDNEO SAU	The development of a theft proof charging station rack for shared bicycles or other two wheeled vehicles, with an output power ranging from 120W up to 3,4kW to charge multiple bikes.
9. AYZ	Management and execution of the civil works of the demonstrators.

1.3 Relation to other project activities table

Table 3 - Relation to other project activities table

Task	Relation to other project activities
T3.1 - Cost-effective low and medium Power DC-DC bidirectional chargers	Theorical modelling of the solution
T7.5 - Evaluation and impacts assessment	Short term impacts

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2 UC6 OBJECTIVES

The main objective of this UC is in accordance with the objective of this project: To advance in the development of EV charging systems, test the viability of these advances and bring them closer to the end user.

There are several objectives of this UC. Among them we can highlight the bidirectional recharge. This UC is not only intended to demonstrate that the installation of V2G chargers is feasible, but the feasibility of supporting the network with these systems will also be studied.

In search of facilitating the consumption of electric transport for society, another of the fundamental objectives is to demonstrate that it is possible to develop chargers for both EVs and low-power two-wheeled vehicles, such as bicycles, at a low cost. In this way, the door is left open to the industrialization of these chargers.

On the other hand, as has been observed for some time, power electronics is trending towards the integration of SiC semiconductors, which allows higher power transfer with high efficiency. This is achieved because they are capable of operating at higher frequencies than other semiconductor technologies while maintaining, or even reducing, switching losses. The fact that this barrier in the operating frequency is overcome implies the development of magnetic devices, such as transformers, capable of operating at these frequencies. This is not an easy task, because the magnetic losses that occur in the core of magnetic devices increase considerably with increasing frequency. This UC intends to integrate these technologies in its demonstrators, developing innovative power electronics capable of linking up with the latest advances in semiconductor technology.

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3 UC6 COMPLETE SOLUTION

The UC that this section focuses on (UC6) is developing two low-power bidirectional charging infrastructures. On the one hand a controllable low power bi-directional CHAdeMO and CCS DC chargers (V2X) with an output power between 7,4kW – 22kW per vehicle, integrated in a DC micro grid is being developed. Additionally, a theft proof charging station rack for shared bicycles or other two wheeled vehicles, with an output power ranging from 120W up to 3,4kW to charge multiple bikes at the same time will be disposed in parallel to the rest of charging points. The system will be able to integrate AC/DC converters for the connection of RES and ESS in the same DC bus to reduce the energy needed from the grid and manage the peak load, as well as to enable its easy scale-up. Instead of using one low power AC/DC converter for each low power DC/DC converter, CIRCE will integrate one 50-70 kW AC/DC converter connected to various low-medium power DC/DC converters.

The demonstrator consists of a 25 kW AC/DC converter connected to the grid supply. The output of this converter branches into two branches: one will feed the two-wheeler charging station and the other feeds two DC/DC converters, which provide power to the 25 kW EV charging system. AC/DC converter is housed in the same enclosure as the EV charger.

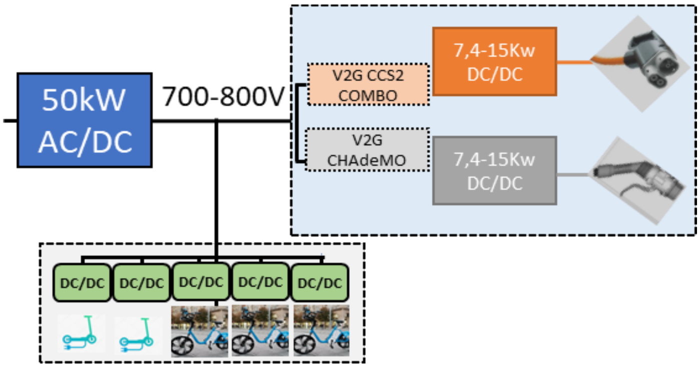

Figure 1 – Overall concept of UC6.

Next, the final developments of each of the parts that make up the demonstrator are detailed separately. On the one hand, the charger designed by Circe is presented and, on the other hand, the two-wheeled EV charging station designed by Idneo is presented.

- **<u>25 kW V2G EV charging system (CIRCE)</u>**

An innovative smart EV charger with advanced capabilities has been developed for this UC. The V2G charger was designed to make it able to provide ancillary and flexibility services to the electric grid, such as supporting grid stability by frequency and voltage regulation and able to interact with external platforms so as to deploy smart charging strategies. To this end, a grid-connected fully SiC 25-kW fast charger based on an AC to DC converter with high frequency isolation was implemented. The grid-side developed is a 4-leg converter based on SiC semiconductors, with phase independent control capability. This topology was selected in order to

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support the grid stability and provide advance ancillary services, including unbalanced grid facilities compensation, reactive and active phase current balancing, and multi harmonic cancelation, including homopolar components, which is an advance regarding other presented alternatives in the literature. Another feature that really differentiates this charger from the existing ones and gives it some innovative features is the ability to charge in both CHAdeMO and CCS modes, that is, it is a multi-protocol charger. The device implements hardware and software protections, such as grid under and over voltages, grid under and over frequencies, anti-islanding, grid over current, differential current protections, over temperature, isolation protection, microcontroller watchdog, hardware safety chain, and the necessary protections in CHAdeMO and CCS protocols.

Regarding the electrical design of the system, the charger takes the energy from the power supply, at 400 V. Subsequently, the current has to go through the hardware protection stage, which limits the current; and filtering, where there are filters that allow the system to comply with EMI regulations. The next stage of the system is the 25 kW AC/DC converter. To power the 25 kW EV charger, there will be 2 DC/DC converters of 12.5 kW each, which will be connected in series or in parallel through the linking box depending on the battery voltage of the vehicle to be connected, while adding the possibility of having several CHAdeMO or CCS vehicles with an unique converter. The last stage of the charger (before the connectors) is the communication protocol card with the EVs, which has been developed expressly for this project and allows communication to be established for EVs with CHAdeMO and CCS type charging, in addition to performing the tests of isolation.

In Figure 2 the general scheme of the charger is presented. The stages boxed with the dashed line are those that are located inside the charger enclosure. The proposed topology has many advantages, such as variable power factor, reactive power balancing, phase balancing and a flexible DC cur-rent source.

In this subsection, the characteristics of the converter are detailed first. Next, the 12.5 kW DC/DC converters are presented. And finally, the cabinet, or enclosure, is shown, where all the electronics of the charger are located and which, in addition, is the visual element of it.

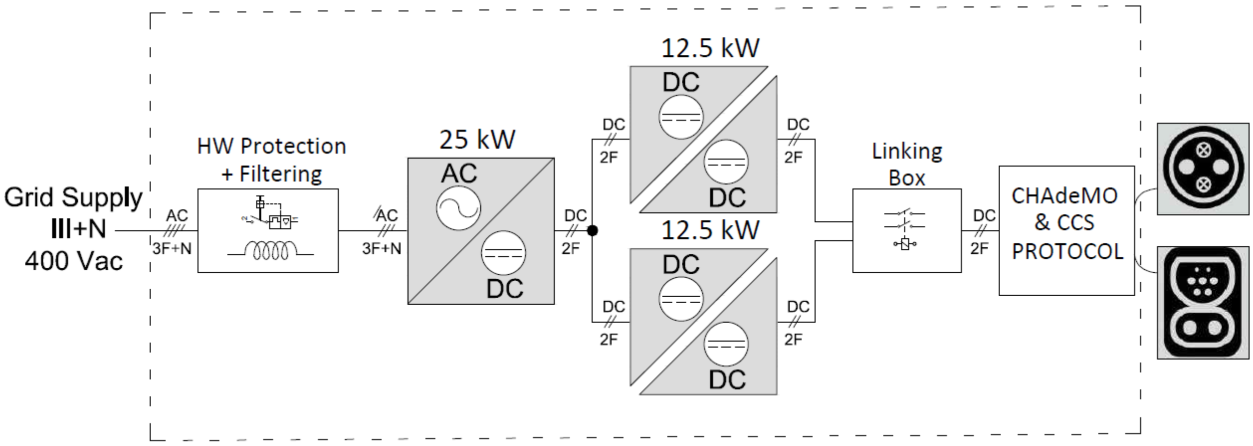

Figure 2 – Fully SiC 25 kW fast charger

Regarding the 25 kW AC/DC converter, this element is housed in the same enclosure as the rest of EV charger and it is responsible for converting the alternating current from the network to direct current, capable of

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feeding both the two-wheel vehicle charger and the two 12.5 kW DC/DC converters that form conductive EV charger.

In Table 4 the technical specifications of the converter are presented and in Table 5 its power specifications are presented.

Table 4 - Technical specifications of the 25 kW AC/DC converter

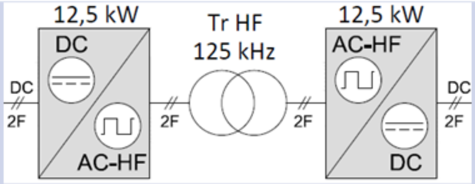
Specification	Description
Block diagram:	
DC/DC Converter Main characteristics:	DC/DC Converter: DC/AC-HF Converter + AC-HF/DC Converter Bidirectional Galvanic isolation High frequency switching (85 – 125 kHz) SiC semiconductors technology Noiseless, switching frequency >20 kHz
DC/DC Converter main functionalities:	Current source Voltage source for insulation test (without load) Vehicle-to-Grid V2G Battery charger
Refrigeration	By air, forced
Dimensions	400x300x100 mm
Protection	Without IP environmental protection, it must be provided/covered with an external envelope.

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Table 5 – Power specifications of the 25 kW AC/DC converter

Power specifications	
Maximum power:	12,5 kW
Connection type:	DC+/DC- (Input-Ouput) + Ground
Input voltage:	(500 ÷ 800) Vdc
Output voltage:	(150 ÷ 500) Vdc
Communication interfaces:	ModBUS RS485, busCAN
Efficiency:	More than 95% at rated power.
Auxiliary power supply:	230 Vac / 50 Hz / 16 Arms - Single-Phase (I+N) (+24/+15/-15/+5/COM) Vdc
Control Input/Outputs	Digital input and output signals Safety string state Optional: External light pilots and control buttons

In Figure 3 the 3D design of the converter is shown, and Figure 4 shows the electrical diagram of the system.

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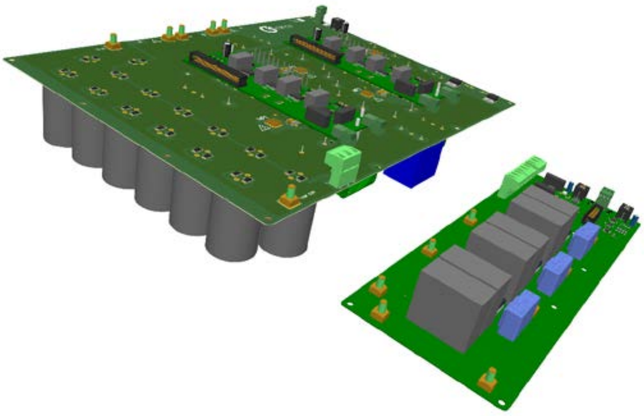

Figure 3 - 25 kW AC/DC converter 3D design.

Figure 4 - 25 kW AC/DC converter electrical diagram.

Analogous to the previous converter, the technical specifications of the 12.5 kW DC/DC converter are presented in Table 6 and its power specifications are presented in Table 7. The 12.5-kW DC/DC converter consists of two H-bridge converters: DC/HF converter and HF/DC converter, fully SiC, bidirectional, with galvanic isolation and high frequency switching between 83 and 125 kHz. It can operate as current source charging through CHAdeMO or CCS protocol, V2G or battery charger. The high switching frequency ensure the size and cost of the DC/DC converter can be significantly reduced.

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Table 6 - Technical specifications of the 12 kW DC/DC converter

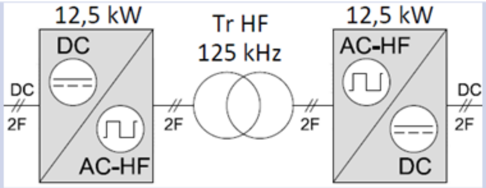
Specification	Description
Block diagram:	
DC/DC Converter Main characteristics:	DC/DC Converter: DC/AC-HF Converter + AC-HF/DC Converter Bidirectional Galvanic isolation High frequency switching (85 – 125 kHz) SiC semiconductors technology Noiseless, switching frequency >20 kHz
DC/DC Converter main functionalities:	Current source Voltage source for insulation test (without load) Vehicle-to-Grid V2G Battery charger
Refrigeration	By air, forced
Dimensions	400x300x100 mm
Protection	Without IP environmental protection, it must be provided/covered with an external envelope.

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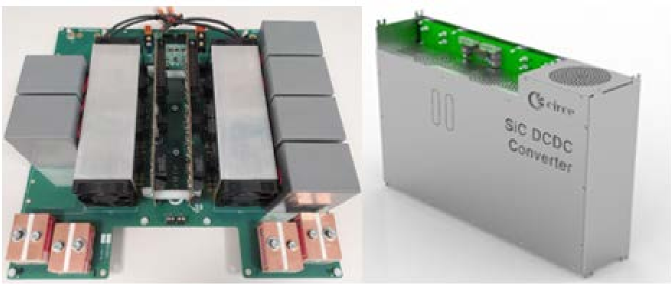
Table 7 - Power specifications of the 12 kW DC/DC converter

Power specifications	
Maximum power:	25 kW
Connection type:	DC+/DC- (Input-Ouput) + Ground
Input voltage:	400 Vac / 50Hz
Output voltage:	(650 ÷ 800) Vdc
Communication interfaces:	ModBUS RS485, busCAN
Efficiency:	More than 95% at rated power.
Auxiliary power supply:	230 Vac / 50 Hz / 16 Arms - Single-Phase (I+N) (+24/+15/-15/+5/COM) Vdc
Control Input/Outputs	Digital input and output signals Safety string state Optional: External light pilots and control buttons

The Figure 5 shows the final design of the converter, and Figure 6 shows the electrical diagram of the system formed by the set of converters (AC/DC 50 kW + 2 DC/DC 12,5 kW)



(a) (b)

Figure 5. 12 kW DC/DC converter design without (a) and with (b) metal casing.

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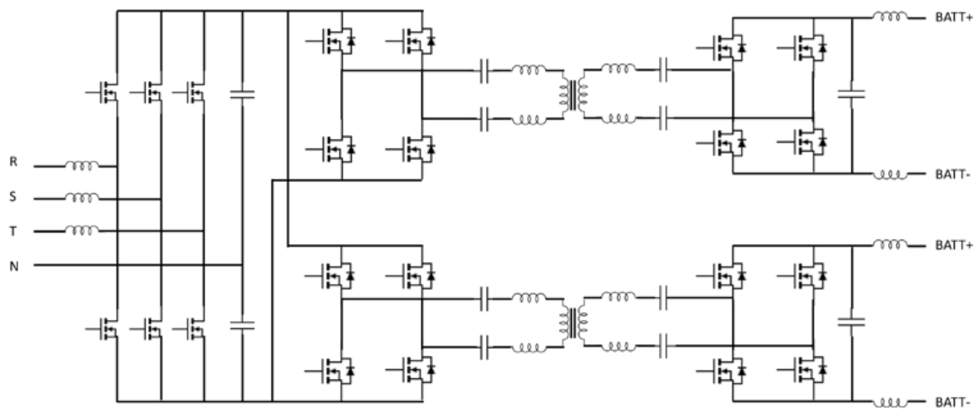

Figure 6 - Electrical diagram of the system formed by the set of converters: AC/DC 50 kW + 2 DC/DC 12,5 kW.

The last point to be covered for the 25kW EV charger is the system envelope. This element is a very important part for the charger; It is in charge of protecting the electronics from external climatic conditions, as well as being the final image of the charger for the user.

The envelope has been designed following several criteria. The first of these is compactness, in such a way that a compromise has been found between the size of the enclosure and the cooling capacity required by the electronics. Since the envelope is the visual element that will represent the charger, it has been designed trying to convey the image of a progressive and differentiating element from the chargers developed to date. As can be seen in Figure 7, this element has a LED screen, which indicates the status of the vehicle's charge at all times.

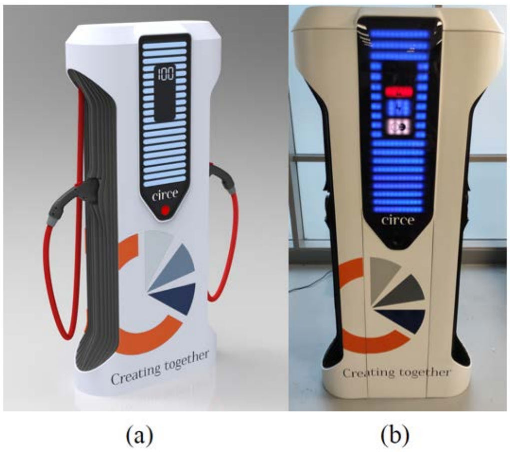

Figure 7 – (a) 3D model and (b) actual assembly of the 25 kW conductive charger enclosure.

Regarding the installation of the structure, the process is quite simple: a foundation of 0.45 m depth is required in which the fixing system of the envelope will be installed (Figure 8).

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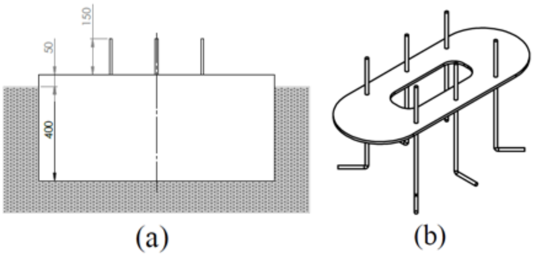

Figure 8 – (a) Foundation and (b) enclosure fixing system.

The enclosure design is protected by the European Union Intellectual Property Office Certificate Registration (Annex 1).

- **<u>Two-wheeler EV charging station with thief-proof lockers (IDNEO)</u>**

Idneo has developed a 2 wheeler dock station with wireless charger compatible with different types of electric bicycles and scooters. In Figure 9 the images of the dock station and wireless connector are shown.

(a) (b) (c)

Figure 9 – (a) 2 wheeler dock station, (b) wireless connector system for kick scooters, and (c) wireless connector system for electric bikes.

Regarding the anti-theft system, it is based on an individual charge station locker based in two main pillars:

- The lateral locking mechanism prevents manipulation of the 2 wheeler once it has been inserted into the station and the controller inside the locker prevents against any type of vandalism act (Figure 10).

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(a) (b)

Figure 10 – Lateral locking mechanism. (a) General view with a kick scooter, and (b) enlarged view.

- Possibility to modulate a bidirectional communication protocol between the 2 wheeler and the backend of the charging station, securing the information exchanged that includes the unique identification of the vehicle in order to prevent fraud and misuse of the charging stations. The electric scheme of the system can be seen in Figure 11 to illustrate this concept.

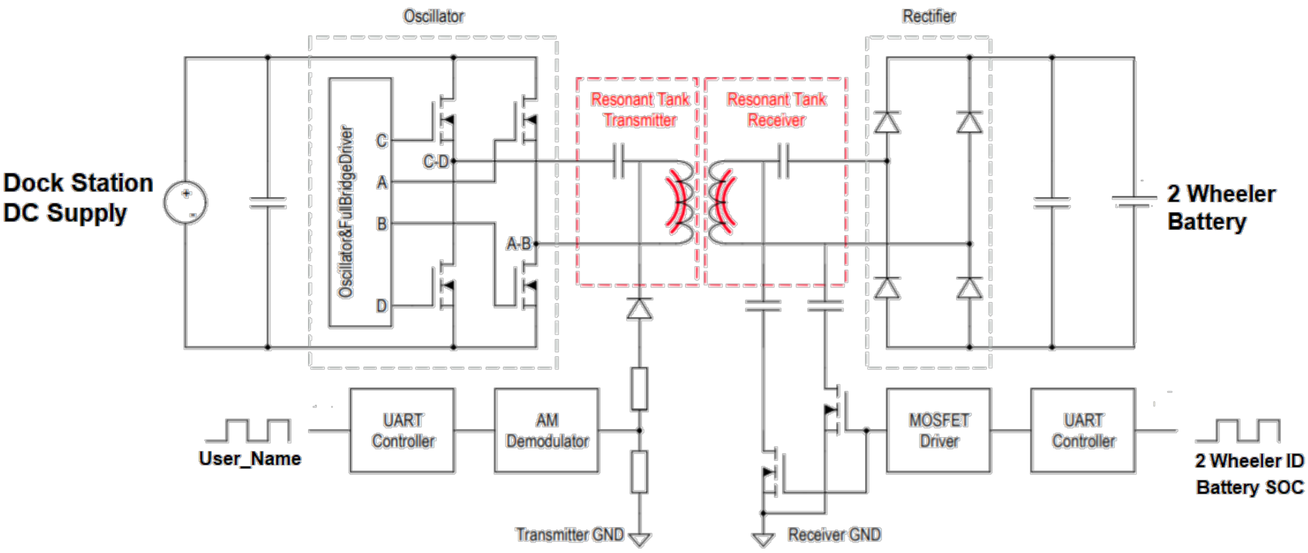

Figure 11 – Electric scheme of the two-wheeler charging system

Regarding the civil works necessary for its installation, the system will be mounted on a platform anchored to the ground as in Figure 11. Two charging stations will be installed, which are connected to each other. In turn, these charging stations will be connected to the ACDC converter of the EV conductive charger through an underground corrugated 40cm diameter tube

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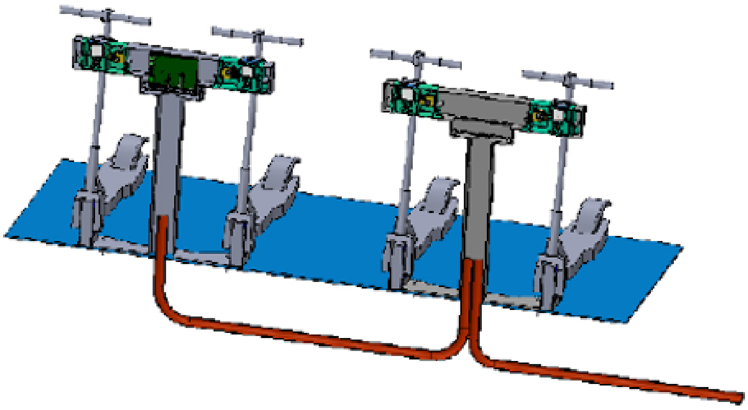

Figure 12 – Installation platform of two-wheeler charging station.

Once the systems that make up the UC6 have been described, the civil works installation plans will be shown. The installation will take place in Zaragoza, specifically in in the area of the expo Zaragoza, next to the river Ebro, that is an area reserved for implementing the mobility city. Figure 13 shows the plan of the civil works where the UC6 systems are located with dimensions together with the UC7 opportunity wireless charger.

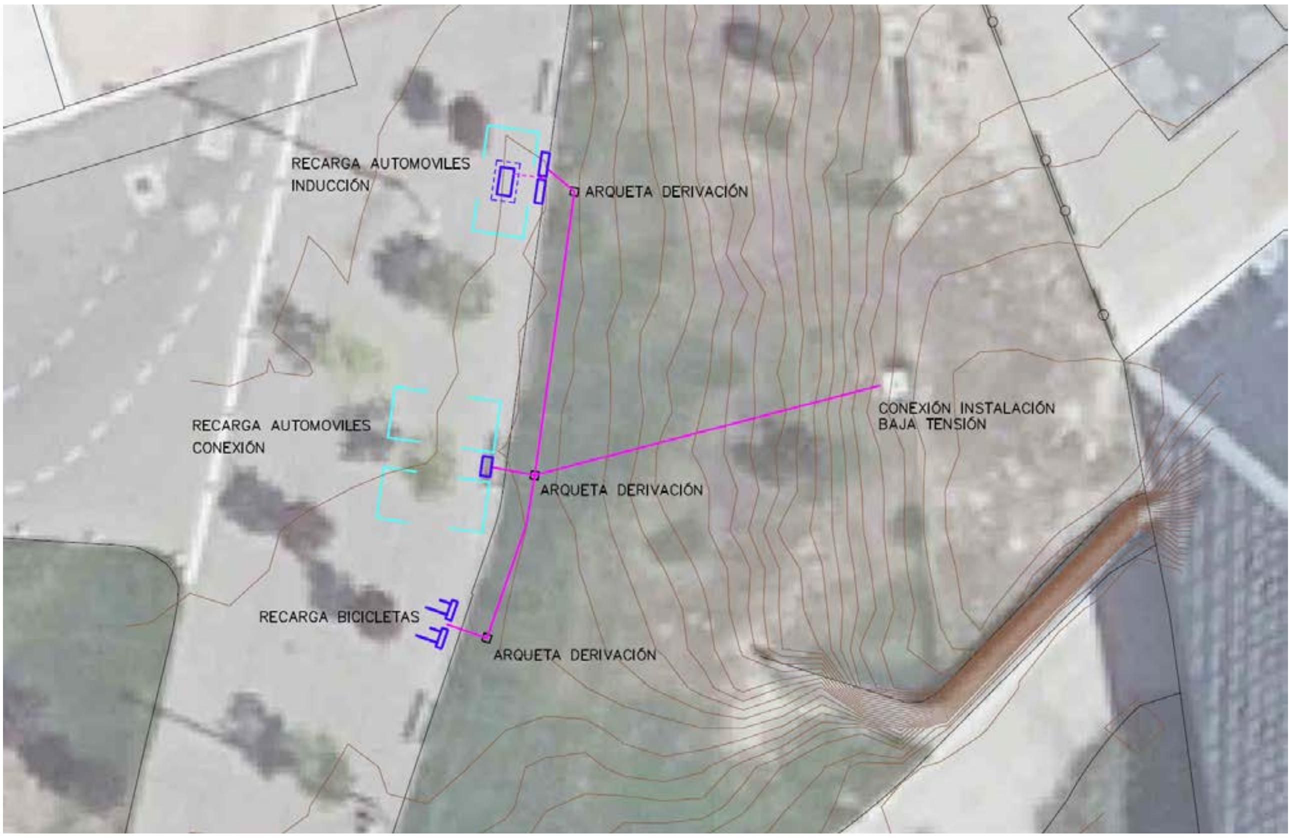

Figure 13 - Civil works plan for the UC6 and UC7 systems.

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Figure 14 shows the connection plan for the 50 kW inductive charger (UC 7) and the 25 kW conductive charger (UC 6).

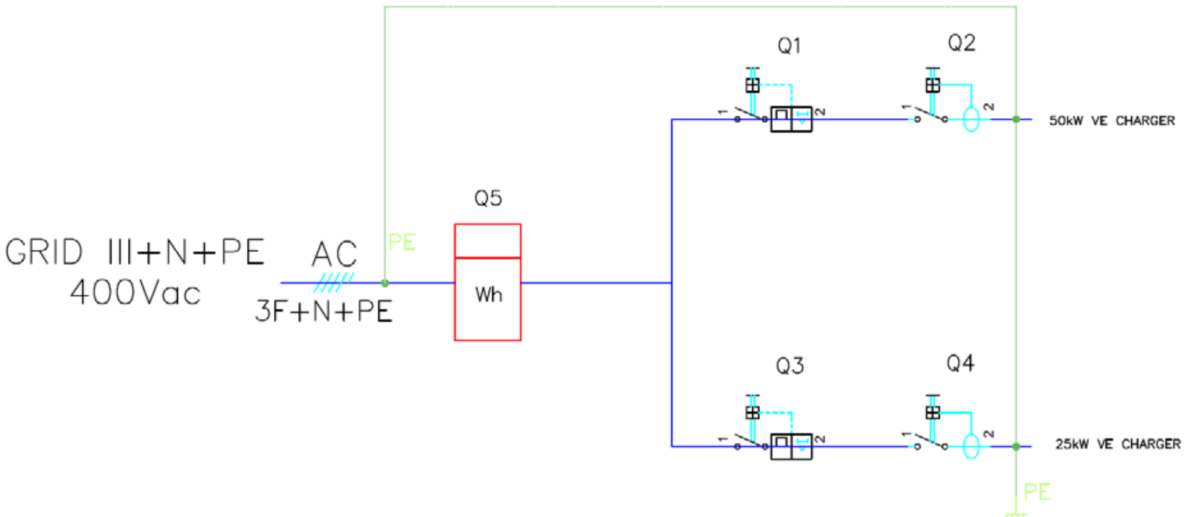

Figure 14 - Connection plan for the 50 kW inductive charger and the 25 kW conductive charger.

3.1 UC6 Final modelling and engineering results

The behavior of both demonstrators has been tested and verified. This section presents the tests carried out on the equipment to verify the operation of the utilities presented.

- **25 kW V2G EV charging system (CIRCE)**

Regarding the 25 kW AC/DC converter, tests have been carried out in which the demonstrator is able to charge the vehicle without increasing the consumption of the most heavily loaded phase, consuming energy only from the less loaded phases (Figure 15.a). Other tests have been done to dis-charge the vehicle on a single phase to mitigate occasional congestion (Figure 15.b); or even to balance the line currents when no vehicle is plugged in (Figure 15.c).

To carry out these tests, the Circe laboratory has equipment capable of simulating the voltage and current conditions of the line where the demonstrator is to be installed and capable of verifying the behavior of the demonstrator in a relevant environment. Specifically, this equipment is the Power hardware in the loop (PHIL). Shown in Figure 16.

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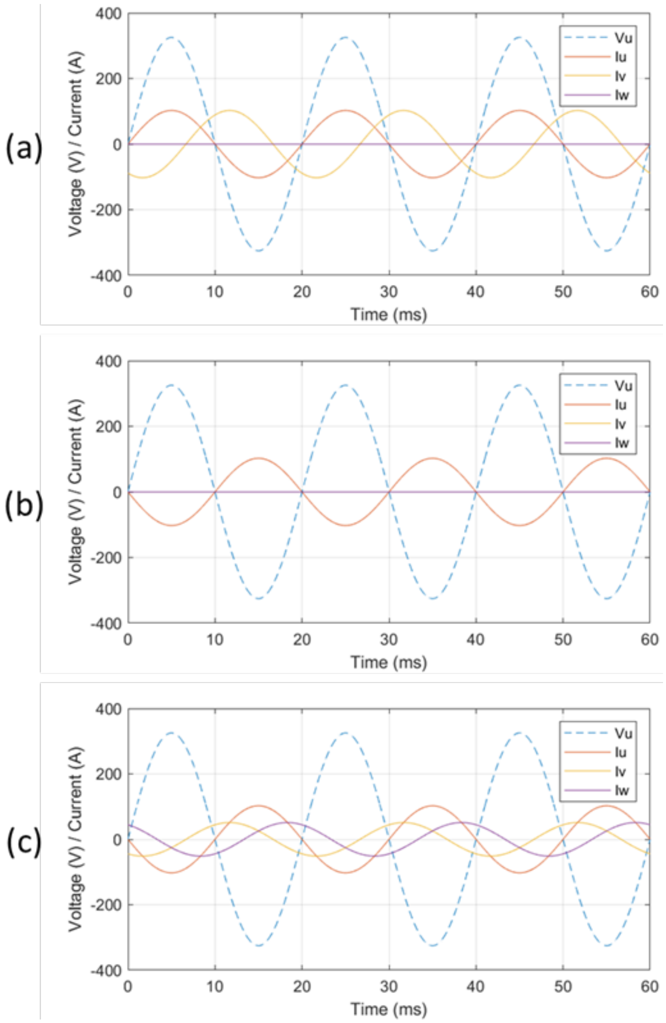

Figure 15 - EV charger providing different services: (a) charging the EV, consuming power only from the less loaded phases; (b) injecting power into one phase, taking the power from the EV batteries; (c) balancing the line currents when no vehicle is plugged in.

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Figure 16 – 50 kW AC/DC converter tested with PHIL in CIRCE Laboratory.

The feasibility of the V2G upload and all the utilities that have been presented have been verified through simulations and tests on real networks [1]. The most interesting results of the simulations of the different functionalities are presented below:

- Unbalanced charge. Can reduce energy losses reducing charging power and balancing voltages. Depending on the charger location, additional issues could be generated as the connection of new loads in remote areas of the network can produce new congestions and voltage problems.
- V2G. Discharging EV batteries always reduces energy provided by the transformer and grid distribution losses. The effect on congestions and undervoltage problems is greater in the case of the charger installation near the most distant loads.
- Reactive power management. The effect on the reduction of under voltages and congestions is much greater if the charger is located far from the transformer, near the most problematic points. It also has been seen that high power charges, although not at the nominal power, combined with a reactive power injection could congest the grid to undesirable levels.

The main conclusion of these simulations is that although EV chargers as the described in this document can provide a proper support to grid operators, its location must be carefully selected to avoid undesired effects.

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- **Two-wheeled EV charging station with thief-proof lockers (IDNEO)**

Over the wireless charger solution for two-wheeled EV vehicles, the main testing has been focusing on verifying that the wireless system can effectively provide enough charging power to the EV battery. Different aspects can alter the efficiency of a wireless charging system, like the misalignment of the coils, the properties and thickness of the material between both coils, possible metallic objects nearby the coils, etc.

With the following test, we make sure that the anti-theft mechanical solution provides a proper fixation between both coils in terms of inductive charging.

The testing set-up is described in Figure 17. In it, we can see two blocks, one for the charging system (simulating the electronics embedded in the charging structure presented in Figure 8a) and other for the two-wheeled EV system (simulating the composition in Figure 8b)

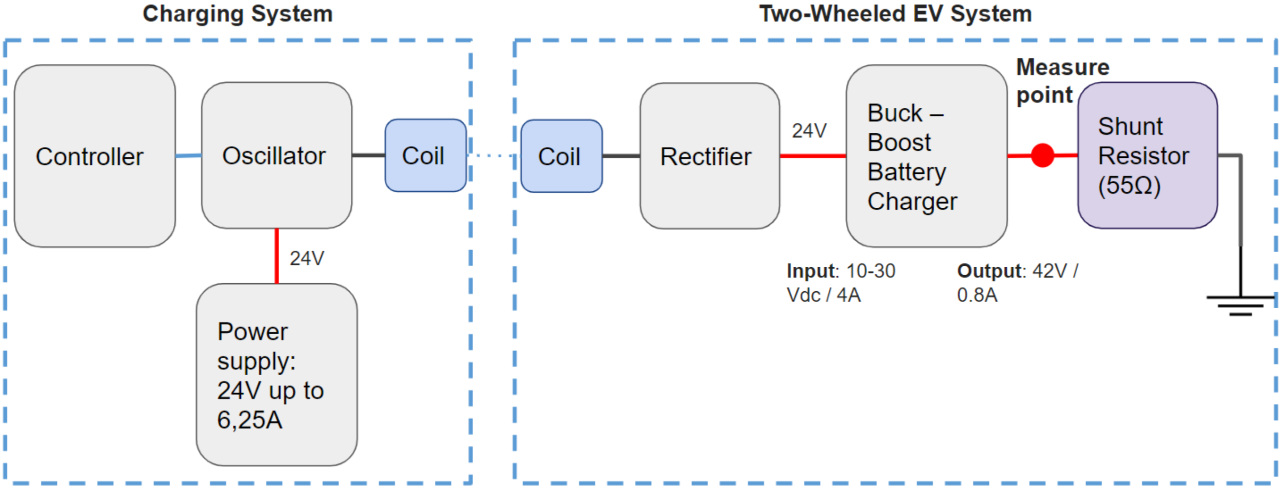

Figure 17 - Testing set-up scheme

The first test was to verify that the inductive coupling without our mechanical system is able to provide the expected output. For that, in Figure 18 we can see a laboratory set-up in which both coils are put together under a weight to ensure proper coupling.

As can be seen from the same image, the multimeter shows 41,1V at the measuring point defined in Figure 17, which considering the 55Ohm shunt resistor, is translated into approximately 0,75A charging current to the Two-Wheeled EV battery. This current is enough for charging the EV vehicle in reasonable time.

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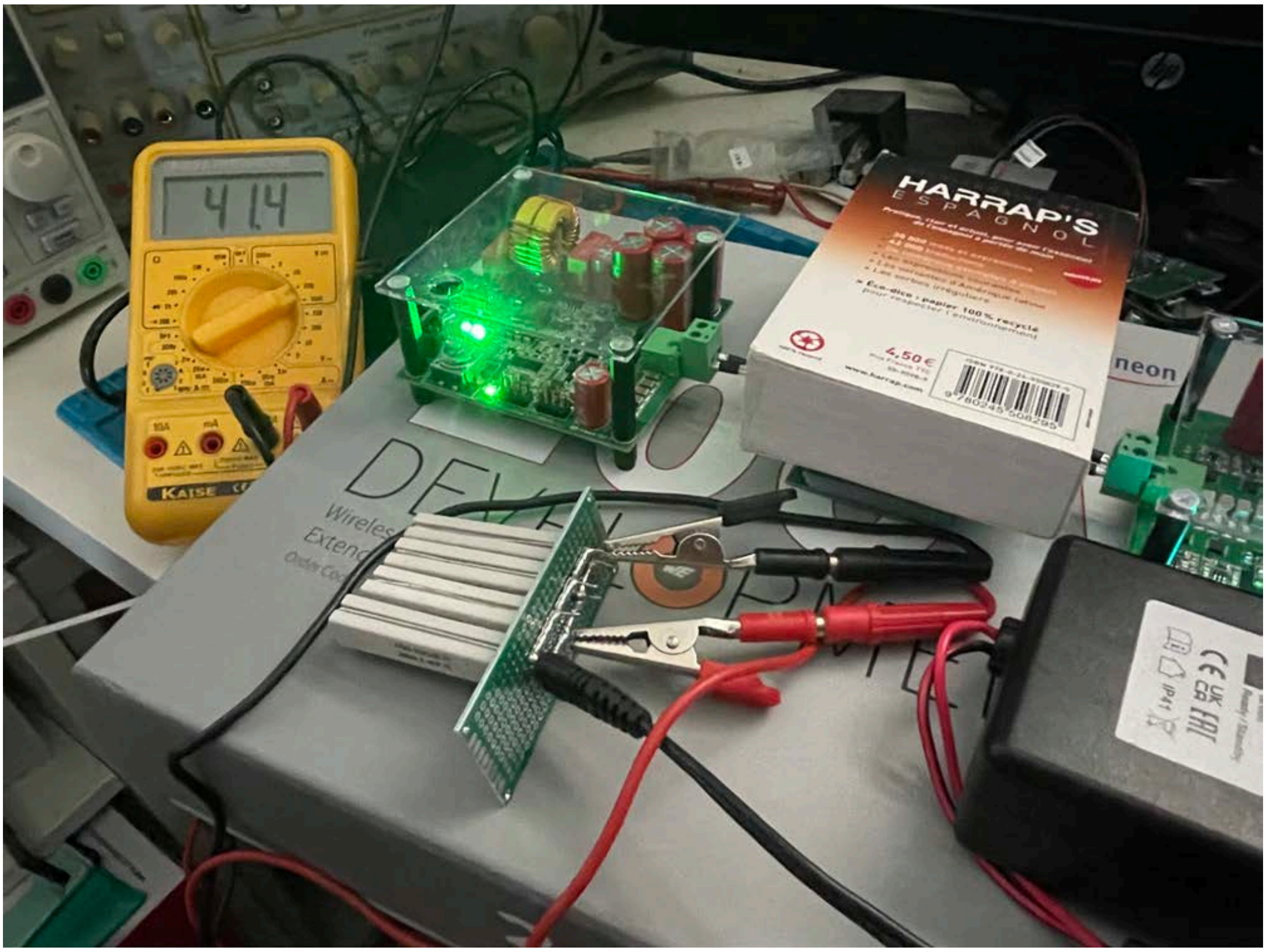

Figure 18 Laboratory set-up for charging measurement without anti-theft housing

The next test was to measure the possible difference in coupling conditions and provided power for the Two-Wheeled EV in a situation where anti-theft housing is used to cover both coils. As already mentioned, the mechanical structure may interfere in the coupling of the coils.

The connections are the same as in Figure 17 but adding the secured mechanical connection in between the coils. As result of this test and as seen on Figure 19, the measured voltage is the same as in the previous scenario, so we can verify that the mechanical protection has appreciable impact on the power delivery to the Two-Wheeled EV.

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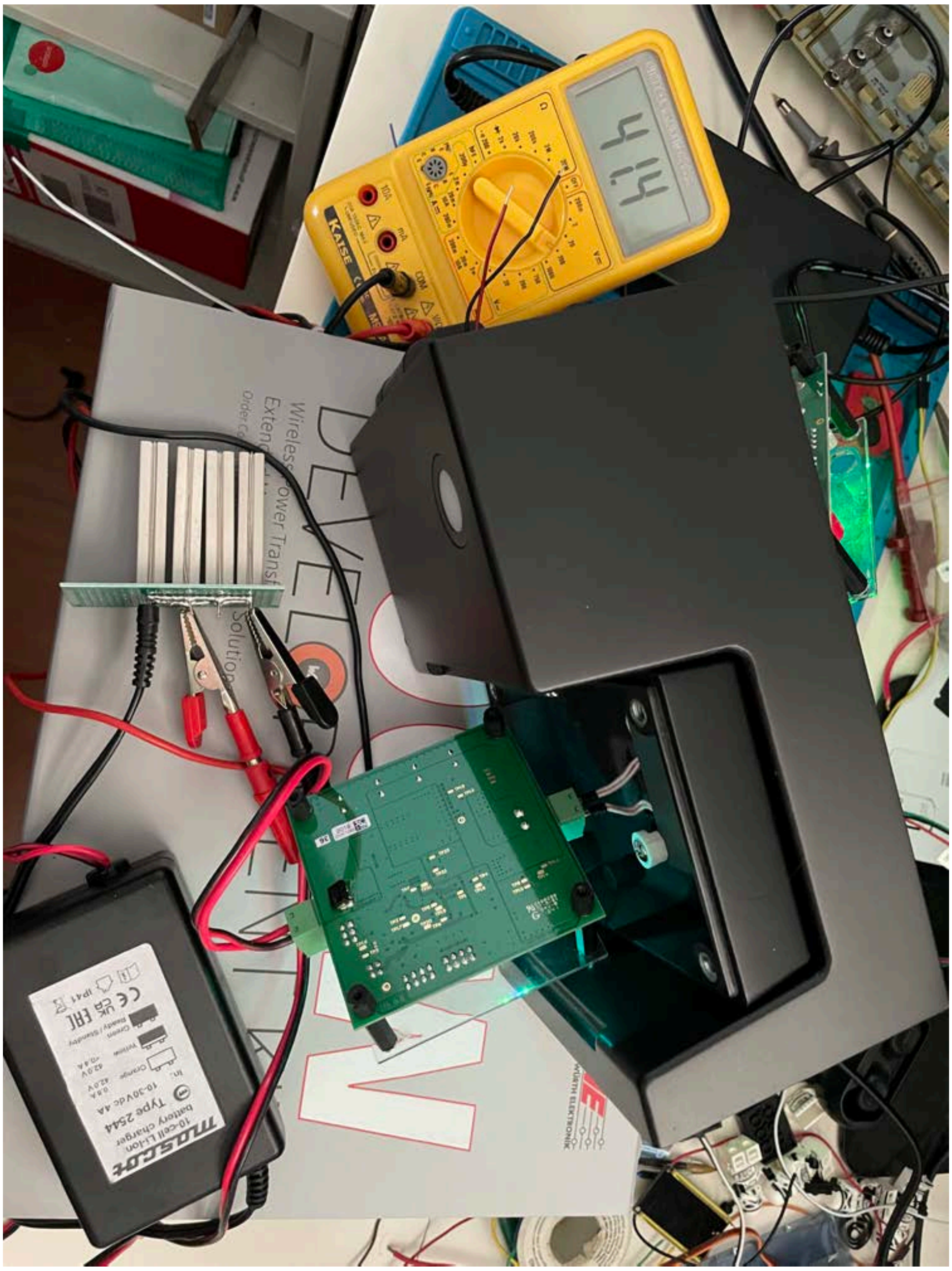

Figure 19 Laboratory set-up for charging measurement with anti-theft housing

It must be mentioned, that Idneo had to iterate over the proper material thickness between both coils. In a first prototype, the distance between coils was 10 mm (5 for each side) due to a thicker protection wall. Performing the same measures, we identified the coupling issue and we decided to reduce the thickness to 4 mm (2mm for each side), achieving virtually no effect, as seen on the previous results.

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The main conclusion is that a trade-off between mechanical resistance and coupling performance must be found at the time of protecting the coils. From the presented results, it is shown that using the right materials and measures an optimal solution can be found.

3.2 UC6 Expected data to be collected

There are several data to collect from the demonstrators. Once the vehicle is connected to the charger, the first data that is collected is the vehicle identification number. Once this step is done, the vehicle charging or discharging process will be monitored. To do this, it will be necessary to measure the active power and reactive power of the system, as well as the duration of the session.

On the other hand, in the case of the 25 kW conductive charger, a series of checks will be carried out in the Circe laboratories. Specifically, the efficiency and power density will be measured in both the ACDC and the DCDC. In addition, the energy losses in the magnetic components and the losses associated with the switching of the semiconductors will be determined.

Table 8 shows, in more detail, all the data expected to be collected that has just been commented on from the 25 kW conductive charger.

Table 8 – Expected data to be collected from the 25 kW conductive charger.

Component	Quantity	Comments	Unity
Electromagnetic Field	The magnetic induction inside the vehicle		[µT]
	The magnetic induction around the vehicle		[µT]
Weather conditions	Temperature	Ambient / Air temperature	[C°]
		Road temperature	[C°]
		Power Electronics' temperature	[C°]
Electrical	AC/DC	input voltage	[V]
		input current	[A]
		output voltage	[V]
		output current	[A]

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		efficiency	%
	DC/DC	input voltage	[V]
		input current	[A]
		output voltage	[V]
		output current	[A]
		efficiency	%
Other	Charging time	Vehicle over transmitting track	[s]
		Transferred energy	[kW/h]
		All system efficiency	%
	Vehicle data	Speed	[km/h]
		Vehicle identification number	
		Misalignment rate	

In the case of the Two-Wheeled EV charging station, we expect to measure similar parameters. The parameters are displayed in the following Tables.

Table 9 Expected data to be collected for the Two-Wheeled EV charging station

Component	Quantity	Comments	Unity
Weather conditions	Temperature	Ambient / Air temperature	[C°]
		Power Electronics' temperature	[C°]
Electrical	AC/DC	input voltage	[V]

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		input current	[A]
		output voltage	[V]
		output current	[A]
		efficiency	%
	DC/DC	input voltage	[V]
		input current	[A]
		output voltage	[V]
		output current	[A]
		efficiency	%
Other	Charging time	Time for the Two-Wheeled EV to be chargerd	[s]

3.3 UC6 Innovation

This demonstrator presents a series of innovations that make it a pioneer charger, especially in advances related to bidirectional recharging.

As already mentioned in this document, the V2G charger was designed to make it able to provide ancillary and flexibility services to the electric grid, such as supporting grid stability by frequency and voltage regulation and able to interact with external platforms so as to deploy smart charging strategies. This topology was selected in order to support the grid stability and provide advance ancillary ser-vices, including unbalanced grid facilities compensation, reactive and active phase current balancing, and multi harmonic cancelation, including homopolar components, which is an advance regarding other presented alternatives in the literature.

Another feature that gives this charger the title of innovative is that the 25-kW modular V2G charger station is a fully SiC converter to improve the converter efficiency and the power density. The choice of this technology allows a high frequency operation point, therefore, reducing the acoustic noise generation as another key factor for urban integration.

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Finally, the differentiating element of this charger compared to those developed to date is the possibility of charging both CHAdeMO and CCS in the same charger and with the same converter. For this, an exclusive design has been required that, in addition, complies with both communication protocols.

In the side of the Two-Wheeled EV charging station, the innovation can be found in the wireless charging application and anti-theft solution for a publicly available charging station. It is well known that the sharing services of small EVs is growing, and with it, the issues related with vandalism, occupying the citizen walking space area and other issues related with the recharging process of these devices (some of them must be manually recovered by devoted operators to be recharged) has grown.

For tackling all those issues, the Two-Wheeled EV charging station provides a robust antitheft solution, aided by the wireless charging, which at the end, improves the mechanical features of the system (the electrical connections are not visible). Not having the connectors open allows for a more weather-proof and overall safer solution. Also, the easy access to the user charging station secures that the small EV vehicles are stored in dedicated areas, avoiding interference with pedestrians.

3.4 UC6 Risks

There are several risks that are contemplated in the commissioning and operation of the demonstrators. Next, each of the risks that have been contemplated will be detailed, developing the consequences that they could generate and the corrective actions that are being carried out to minimize the probabilities of their occurrence.

3.4.1 Semiconductor delivery delays

Currently, the semiconductor market is facing a period of shortages, in which the delivery times of said devices have increased. For this reason, the delay in the delivery of the semiconductors, necessary for the construction of the demonstrator's electronics, is considered a possible risk.

This risk would mean a delay in the start-up. To try to prevent this from happening, the purchase of the necessary semiconductor devices was launched well in advance.

3.4.2 Civil works delays

Another risk that is contemplated is a delay in the civil works that have to be carried out for the installation of the demonstrators. As it is a civil work, the process is long and involves the launch of a tender, in which budgets are requested and evaluated, comparing them and accepting the one considered most appropriate. This process is likely to be lengthy and lead to a delay in the execution of the civil works and, therefore, in the commissioning.

In order to avoid this risk, periodic contact is being maintained with the Zaragoza City Council

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3.4.3 Power electronics and thermal debugging

The power electronics is designed in such a way that the system is capable of dissipating all the heat generated by the losses. Both the design and the experimental tests are carried out considering an ambient temperature of about 25 degrees, that is, laboratory temperature.

These demonstrators are going to be installed in Zaragoza, a city with a great thermal oscillation throughout the year, reaching temperatures close to 0 degrees in winter and exceeding 40 degrees in summer. This aspect must be taken into account, because it could cause problems in the operation of the demonstrator and delay the commissioning. To avoid these possible problems the power electronic and testing thermal behavior in harsh environment are being debugged.

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4 CONCLUSIONS

In this deliverable, the two demonstrators related to Use Case 6 have been presented. These are a conductive EV charger capable of transferring 25 kW with bidirectional capacities and two-wheeled EV charging station with thief-proof lockers.

The main milestones that have been achieved have been the construction of low-cost charging stations, the construction of a conductive EV charger capable of charging both in CCS and CHAdeMO modes, with both communication protocols. The functionalities of the 25 kW V2G charger with which it will provide auxiliary services to the electrical network have been verified. All power electronics have been designed and built with SiC technology, thus aligning with the latest advances in semiconductor technology.

Additionally, a theft proof charging station rack for shared bicycles or other two wheeled vehicles, with an output power ranging from 120W up to 3,4kW to charge multiple bikes at the same time has been designed to be disposed in parallel to the rest of charging points at DC level.

The installation processes of both demonstrators have also been presented, whose civil works are currently in the bidding process. The next steps are, for the 25 kW EV conductive charger, the system thermal analysis and efficiency tests and, for both demonstrators, to start the civil works and their commissioning.

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[1] Muñoz, A. M., Ballestín-Fuertes, J., Fernández, G., Marquina, D. and Igea, R. *Four-leg EV Chargers for Grid Supporting*. PCIM Europe 2022: International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management, Nuremberg, Germany.

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ANNEX 1 – 25 KW CONDUCTIVE CHARGER ENCLOSURE PROTECTION DOCUMENT

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El Director Ejecutivo / The Executive Director

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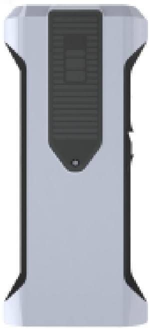

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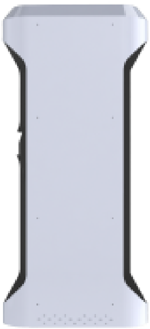

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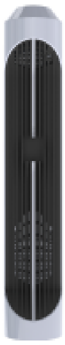

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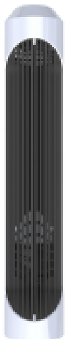

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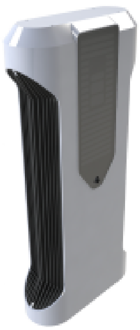

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