D9.4: LCCA for the 7 use cases

June 2024 – 06/2024 (M48)

D9.4: LCCA for the 7 use cases. V2.0

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Technical References

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Document history			
V	**Date**	**Partner(s)**	**Action**
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V0.2	12/02/24	QiA	First Draft. Contribution from all partners
V1.0	30/06/24	QiA	First Consolidated version
V2.0	24/07/24	QiA	Second Consolidated version
V3.0	27/07/24	QiA	Final Consolidated Version

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This project has used a standard methodology already developed in INTERPRETER project (Grant Agreement number: 864360), following EU recommendations. Ad hoc modifications were added to comply with the Grant Agreement conditions for INCIT-EV (Grant Agreement number: 875683).'

EXECUTIVE SUMMARY

The methodology for analyzing the cost of charging infrastructure is the Life Cycle Cost Assessment (LCCA). This process estimates the total cost of owning and operating an asset over its entire life, considering both initial and end-of-life costs. It encompasses all expenses over a designated period, including design, purchase, installation, operation, maintenance, repair, replacement, and disposal costs. The LCCA helps determine if a higher initial cost is justified by lower future costs, optimizing the cost of acquiring, owning, and operating assets using present value techniques.

For charging infrastructures, the LCCA quantifies and characterize capital and operating expenses for innovative solutions demonstrated in Incit-EV, providing insights for decision-makers and identifying potential improvement areas.

Steps in LCCA:

1. **Identifying and Estimating Costs**: All cost categories, such as purchase, installation, operation, and maintenance, are determined and estimated based on experience, past data, and expert judgment. Templates are used to help identify and quantify these costs for wired and wireless charging units.
2. **Computing Life Cycle Costs**: All costs for each life stage of the asset are summed, considering inflation and the value of money to determine the net present cost.
3. **Analyzing Results**: Results are graphically represented to identify cost structure patterns, focusing on the cost profile.
4. **Sensitivity Analysis**: The impact of changes in key assumptions on lifecycle cost estimates is assessed, such as the cost of building a new charging point at different future dates. The section will be included in deliverable D9.5 (Business models)

Assumptions:

Stakeholder Viewpoint: The analysis is intended for designers, constructors, operators, promoters, investors, and owners of charging assets.

Cost Structure:

- **CAPEX** (Capital Expenses): Long-term investments providing enduring benefits with one-time payments and sole ownership, offering advantages beyond a single tax year.
- **OPEX** (Operating Expenses): Day-to-day costs deductible from taxable income, including fixed expenses (e.g., salaries, legal fees) and variable costs (e.g., production-related expenses).

Major refurbishments extending the asset's life are considered CAPEX, while maintenance actions preventing asset decline are OPEX. In this LCCA, electricity and power grid access fees are excluded and studied separately in D9.5. After the initial costs, additional capital expenditures may occur to extend the system's lifetime. Maintenance activities are included to ensure the expected lifetime of the asset during the analysis period.

The economic data for different use cases (UCs) using wireless and conductive technologies are provided, evaluating wireless technologies in 2030 and 2035 and conductive technologies in 2025, 2030, and 2035. Sensitivity analysis will be conducted in D9.5 for the years 2035 (wireless) and 2030 (conductive), with further details available in the attached spreadsheets. The business models to be presented in D9.5 use these years for the sensitivity analysis.

The deliverable main results distinguish between UC1 and the rest.

- UC1, (software as a service) titled "User-centric smart charging and bi-directional charging," demonstrates the technical and economic feasibility of managing charging sessions and adjusting power input/output by aggregating energy and load at local, neighbourhood, and regional levels. Unlike other use cases involving charging infrastructure, UC1 focuses on management software for smart charging (UC1a), vehicle-to-grid (V2G) charging (UC1b), and dynamic load balancing in a community garage (UC1c). This software investment benefits Distribution System Operators (DSOs) and Transmission System Operators (TSOs) by allowing them to manage power, reduce peak loads, and use vehicles as temporary energy storage, optimizing system operation and achieving significant cost savings. The economic results show an investment in software update, adaptation and maintained with the economic impact in the Transmission and Distribution Systems difficult to measure but very high, reaching €45 million in Utrecht/Haarlem in the best case, if all the charging stations were included in the GOPACS platform by a total investment of less than 2 million for the three potential use cases uses. UC1b compromises higher additional costs than UC1a. UC1c was approved at project end with very reduced investment costs (around 4,000 € for a single private community, 12 chargers with 11 kW each).

The remaining UCs are assets where the LCCA methodology was applied. The main content of each Use Case is described below.

- UC2 is titled “Dynamic wireless charging lane in urban area”. This demonstrator aimed to prove the technical and economic feasibility of Dynamic Wireless Power Transfer (DWPT) technology to recharge electrical vehicles in motion for urban trips. The complete solution could have different lane lengths depending on each specific case, and the business case could be analyzed for one or multiple lanes. For this analysis, 1 dynamic wireless charging lane is considered of 500 m.

- UC3 is titled “Dynamic Wireless Charging for long distance (prototype e-road)”. This use case aimed to demonstrate DWPT technology to recharge electrical vehicles in motion in an extra-urban scenario characterized by higher speeds and fewer city constraints such as pedestrians and bicycles. The system employs a primary coil longer than the secondary coil, eliminating the need for ferrite sheets and aluminium shielding, significantly reducing costs. The project demonstrator includes eight primary coils of 10 meters each, covering 80 meters. For LCCA, a single 25 km lane is considered to estimate savings achieved through scale factors.

- UC4 is titled “Charging hub in a park-and-ride facility”. This demonstrator aimed to prove the technical and economic feasibility of offering various technologies with different performances and prices in a single facility, allowing users to choose the most suitable option. It also aimed to demonstrate an interoperable payment system and synergies with the tramway through a direct connection of fast chargers to the tram’s DC network. The demonstrator, considered in the LCCA, includes two types of chargers: two units of a bidirectional low-power (3.6 kW) CCS2 DC/DC charging station, and one unit of a unidirectional ultrafast (150 kW) CCS2 DC/DC charging station.

- UC5 is titled “Superfast Charging Systems for European corridors”. This demonstrator aimed to prove the technical and economic feasibility of a Super-Fast Charging (SFC) system with two 200 kW DC super-fast chargers that provide ancillary services and EV charging at gas stations in the Tallinn peri-urban area. This technology aims to reduce range anxiety, a major concern for long-range trips, by enabling a full charge for a 40 kWh battery in just 10 minutes. The solution will provide charging services through the Enefit VOLT platform and offer grid services of interest to DSOs and TSOs. In the project the LCCA was made for one single Super-fast charger.

- UC6 is titled “Low power DC bidirectional charging infrastructure for EVs, including two-wheelers”. This demonstrator aimed to prove the technical and economic feasibility of a multi-modal charging station in an urban area, featuring two different chargers: a controllable low-power bidirectional CHAdeMO and CCS DC charger (V2X) with an output power between 7.4 kW and 25 kW per vehicle, integrated into a DC microgrid, and a theft-proof charging station rack for shared bicycles or other two-wheel vehicles with an output power ranging from 120 W up to 3.4 kW. The complete solution integrates AC/DC converters for renewable energy and energy storage management, but for LCCA, only the charging functions and related cost concepts are considered.

- UC7 is titled “Opportunity wireless charging”. This demonstrator aimed to prove the technical and economic feasibility of a static wireless charging system with V2X capability, intended for use at taxi stops such as airports or central stations for the opportunity charging of electric taxi vehicles. The system consists of a single 50 kW/85 kHz inductive charger, including an electromagnetic system for power transmission through electromagnetic induction, power electronics to control the system, and a cooling system to manage excess heat. For this analysis, a single unit is considered.

The project results are presented below through two combined diagrams. The first diagram shows the CAPEX investments over the study years, while the second diagram illustrates the OPEX.

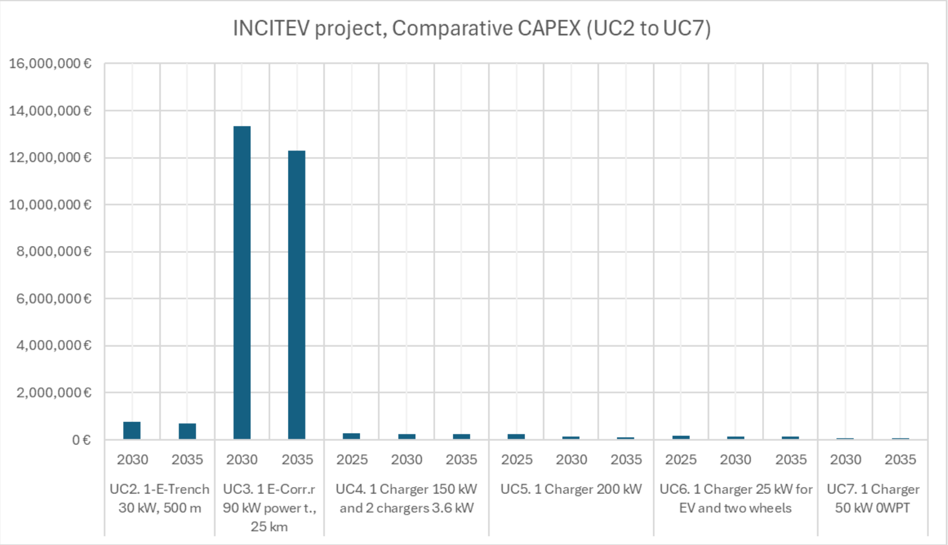

Figure 1. Comparative CAPEX (all use cases)

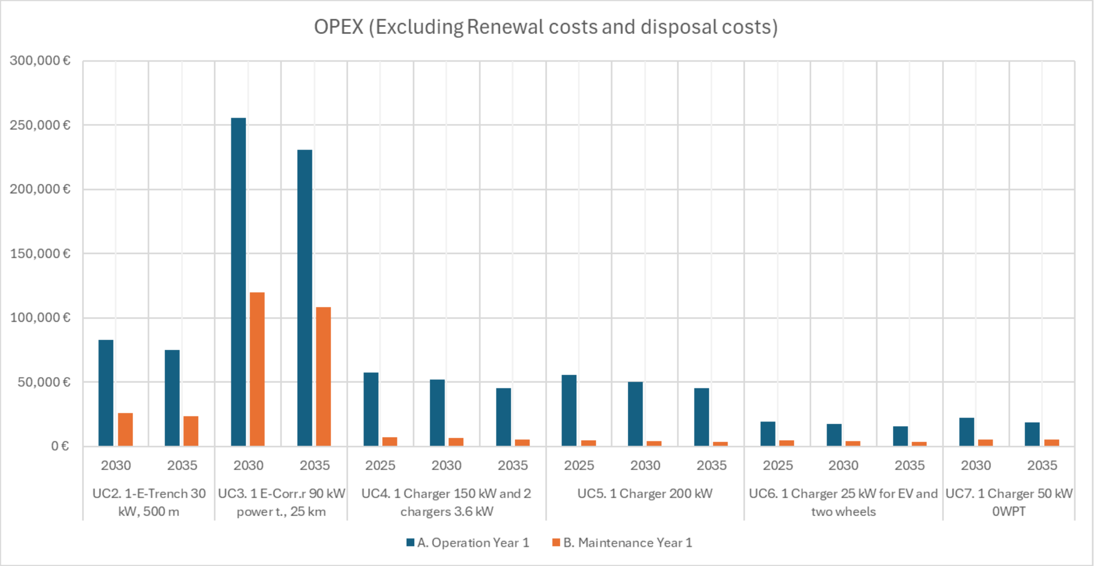

Figure 2. Comparative OPEX expenses (all use cases)

The study reveals several key insights into the cost and feasibility of charging infrastructure. New products or services often face overestimated costs due to factors like R&D expenses, lack of automation, and absence of economies of scale. The precision of future cost predictions is limited, but improvements can be made with identified cost factors incorporated into financial tools. Costs can fluctuate significantly due to unpredictable variables such as raw material prices and inflation. The lifespan of chargers is assumed to be 15 years with a WACC of 6.5%, though higher risk for lower TRL technologies may necessitate a higher WACC. Public chargers often suffer from low occupancy and high costs, making them less sustainable for private investors unless upfront investment and occupancy rates are favourable.

For conductive chargers, installing many units does not necessarily increase usage, as fewer vehicles per charger reduce profitability. Operating and maintenance costs rise with charger power and hub complexity. Concentrating similar chargers in hubs can lower costs, but mixed-type hubs complicate maintenance. In Zaragoza, organizing control services for scooters is crucial to prevent vandalism. The hub concept in Turin, at intermodal exchange nodes, could be viable if trends favour pedestrianization inside the city. Conversely, high-power superchargers in Tallinn face profitability challenges due to installation costs and limited usage, potentially leading to congestion during peak times.

For wireless systems, costs are high due to maintenance and potential service disruptions. In UC3, high speeds reduce charging efficiency, requiring longer vehicle stay times and high power, making it challenging to achieve profitability with rising copper prices. UC2 faces high installation costs and complex authorizations in urban areas, with lower power transfer rates. UC7's wireless charging for taxis at airports appears easier to implement and potentially more cost-effective, but profitability depends on sufficient occupancy and system-equipped vehicles.

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ACRONYM LIST

Acronym	Definition
AC	Alternative Current
ß	Market beta
CAPEX	Capital Expenses
C_{DIS}	Disposal Costs
C_{ENG}	Design and Engineering Costs
C_{INF}	Infrastructure Costs (electric and site)
C_{MAI}	Maintenance Costs
C_{OPE}	Operational Costs
CPO	Charge Point Operator
CPs	Charging Points
C_{REN}	Renewal Costs (Maintenance CAPEX)
C_{RTD}	Research and Technological Development Costs
DC	Direct Current
DSO	Distribution System Operator
DWPT	Dynamic Wireless Power Transfer
ERP	Equity Risk Premium
GOPACS	Grid Operator Platform for Congestion Solution
IP	Innovation Premium
LCCA	Life Cycle Cost analysis
MRA-E	Metropolitan Region Amsterdam Electric
MW	Megawatts
OPEX	Operational Expenses
OWPT	Opportunity Wireless Power Transfer
PV	Present Value
PWM	Pulse Width Modulation
Rd	Cost of Debt
Re	Cost of Equity
REs	Renewable Energies
Rf	Risk free Rate
Td	Marginal tax rate
TSO	Transmission System Operator
V2G	Vehicle to Grid
WACC	Weighted Average Cost of Capital

Table 1. Acronym List

0 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 – Utrecht 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 - Zaragoza
- UC7: Opportunity wireless charging – Zaragoza

0.1 Background

Incit-EV dedicates its work package 9 to the *"Wide replication of use cases and solutions: business models and exploitation strategies"*.

The background for the business models and exploitation strategies is, among other relevant knowledge provided by the partners and the experience acquired from the use cases demonstration.

0.2 Objectives

To contribute to improve the EV users experience through innovative charging infrastructures, and ensure the replication of these novel chargers, the task 9.3 "Business approach from stakeholders view point" include the elaboration of a comprehensive cost analysis of the charging infrastructure in each use case.

This report presents the result of the cost analysis for the 7 Use Cases with the objective of informing the decisions of key stakeholders in the electromobility domain, with special attention to public and private organizations investing and deploying charging infrastructures for EVs.

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1 METHODOLOGY

1.1 Life Cycle Cost Analysis

The proposed methodology for analysing the cost of each type of charging infrastructure is the lifecycle cost assessment (LCCA) methodology.

The LCCA is a process for estimating the total cost of owning and operating an asset over its entire life. It involves calculating and summing up all the costs associated with an asset from its initial cost to its end of life.

The basic premise of the LCCA is that all costs arising from the investment are potentially important to make the decision, including future and present costs.

Applied to charging infrastructures, the LCCA encompasses all relevant expenses over a designated period, including the costs of designing, purchasing, constructing/installing, operating, maintaining, repairing, replacing, and disposing the systems and subsystems that make up the charging station.

The LCCA method is generally used for determining whether the higher initial cost of a type of charger is economically justified by lower future costs when compared to a similar alternative with a lower initial cost but higher future costs. The method also seeks to optimize the cost of acquiring, owning, and operating physical assets over their useful lives by identifying and quantifying all the significant costs involved using the present value technique (Woodward, 1997).

In this case, the analysis will be used to quantify and characterise the capital and operating expenses required to build and exploit the innovative charging solutions demonstrated in Incit-EV. Therefore, more than a direct comparison, the analysis will be used as a tool to detect potential improvement areas and to inform decision-makers together with the revenue and pricing analysis that will be reported in D9.5.

The main steps in the LCCA methodology that will be applied for the charging infrastructures demonstrated in each Use Case are the following:

1. **Identify and estimate all the individual cost concepts.**
   This step aims to determine all the cost categories or concepts that will be incurred over the asset's life: purchase, installation, operation, maintenance, financing, disposal, etc. Once the cost structure is defined, each concept will be estimated based on the experience acquired in the demonstrator, as well as past data, manufacturer information, or expert judgment.
   Different templates were generated to help wired and wireless charging UCs identify which measurement units or indicators are adequate to quantify the costs. The templates were also used to gather the number of elements and quantify the cost of each unit in the case of the demonstrator and in the case of an optimized precommercial unit.

2. **Compute the life cycle costs.**
   This step consists of adding up all the costs for each stage of the asset's life to determine the total cost. It may not be as simple as a summatory, because the inflation and the price of money should be considered in order to get an idea of the net cost of the asset at the present time.

3. **Analyse the results.**
   Represent the results graphically and identify the main patterns of the cost structure. This analysis depends on the application, but in this case, it will focus on the description of the cost profile.

4. **Analyse the sensitivity to variations in some key factors**.

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Assess how changes in key assumptions would impact the lifecycle cost estimate. For example, the cost of building a new charging point in 2025 may vary in comparison to doing it in 2030 or in 2035, as the cost of materials, personnel, etc. are not constant over time.

1.2 Assumptions

1.2.1 Stakeholder viewpoint

The analysis is intended to provide information to the designers, constructors, and operators of the charging assets, but mainly to promoters, investors and owners.

1.2.2 Cost structure

The costs that aim to be analysed can be divided in two categories:

- **CAPEX** (or capital expenses) is the money spent to acquire the charging infrastructure, which is a fixed asset for long-term use. One key feature of capital expenditures is their enduring nature, signifying that these investments offer long-term advantages to the company, extending beyond just one tax year.

  Capital expenditures can be recognized by the following characteristics:

  - ✓ The purchases involve one-time upfront payments.
  - ✓ The business must have sole ownership of the asset after acquisition.
  - ✓ The asset acquired must deliver benefits to the business that last beyond a single tax year.

- **OPEX** (or operating expenses) are the day-to-day costs linked to the normal operation of the business. It is important to note that companies can deduct these OPEX from their taxable income, thereby lowering their tax liability for the fiscal year in which the expenses were incurred.

  Operational Expenditure can be further categorized as follows:

  - ✓ Fixed expenses: These remain constant and unavoidable, including essential costs such as employee salaries, legal fees, and other necessary expenditures.
  - ✓ Variable costs: These fluctuate with the level of business activity. As a corporation increases its production, related expenses rise; conversely, when production decreases, expenses fall. Changes in the economy or organizational structure can impact these variable costs.

In our LCCA, the electricity and the access fees to the power grid are not accounted. These variable concepts are studied together with the pricing in D9.5.

After the upfront costs assumed at the project start, before the asset enters in operation, there may be additional capital expenditures. Once the asset, or a relevant sub-system, reaches its final useful time, it can be refurbished to extend the lifetime of the whole system. As a rule of thumb, it can be considered as a capital improvement (CAPEX) if it is an enhancement that extends the life and/or improves the value of the asset, while it can be considered maintenance (OPEX) is it aims to prevent the decline or damage of the asset.

In our LCCA, major refurbishment is considered under the “Renewal costs” item (maintenance CAPEX). The billing equipment, IT and communication equipment is also considered Maintenance CAPEX but integrated under the “Operation /Equipment” item. The lifetime extension of the charging assets is considered 15 years although it can be extended or reduced in the spreadsheet. The chargers are assumed to work for its intended useful life, and, at the end of that period, the infrastructure is decommissioned considering those costs. This is reflected under the “Disposal costs” item.

However, the maintenance activities consider the need to take corrective actions, which mean the replacement of components or sub-systems due to prevent their degradation. These updates lead to reach the expected lifetime of the asset in the analysis period.

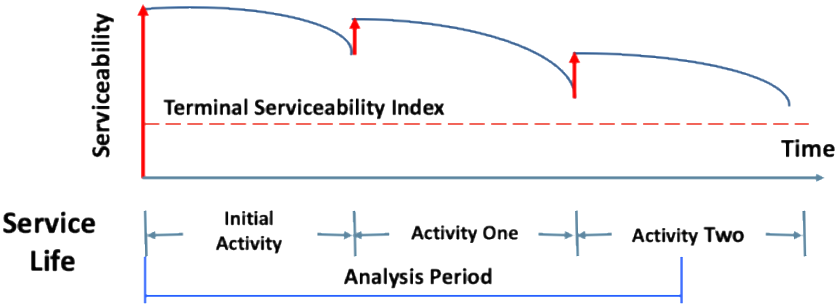

Figure 3. Useful life of an asset after two major corrective actions

In the next pages, the economic data (LCCA) for the different UCs is provided except in UC1 where another type of analysis is done as it is not strictly an asset (it is a software the avoid electric congestions). Those UCs using wireless technologies (UC2, UC3 and UC7) were evaluated in years 2030 and 2035, as the technology in a lower TRL, and needs some time for maturation. The remining UCs, using conductive technologies, were evaluated in years 2025, 2030 and 2035.

Although all the data are available in the attached spreadsheets, we provide hereinafter a summarised description for year 2035 for the wireless technologies and 2030 for the conductive technologies. The other LCCAs can be found in the mentioned spreadsheets.

The same years have been used to prepare the business models to be presented in D9.5, although the sensitivity analysis was done for year 2035 only, in the wireless cases, and 2030 in the conductive ones.

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2 UC1 - ECONOMIC RESULTS

2.1 UC1 Description and scope

2.1.1 Scope

UC1 is titled ***"User-centric smart charging and bi-directional charging"***. This demonstrator aimed to proof the technical and economic feasibility of managing the charging sessions and/or adjusting the power input/output by aggregating energy and load at different levels: local, neighbourhood and regional.

This use case, which is divided into three parts, cannot be strictly evaluated like the other use cases that involve the deployment of charging infrastructure (i.e., assets). Instead, it concerns management software that allows limiting or cutting the power of the chargers (UC1a Smart Charging), using them as energy storage buffers (UC1b V2G Charging), or a smart charging system with dynamic load balancing in a community garage (UC1c Dynamic Load Balancing).

In all three cases, there is an investment in software that requires maintenance, and the main beneficiaries are the DSO (Distribution System Operator) and the TSO (Transmission System Operator), who can globally manage the system's power, restrict it during peak times, or use vehicles as temporary energy storage to utilize their energy during peak periods. Therefore, these systems optimize the overall system operation and allow for significant cost savings.

2.2 Identification of UC1 concepts

Before delving into the economic details, it is important to recall the three use cases investigated in the IncitEV project. In the first case, the initial expectations for combined chargers in the same system were exceeded. However, the final case, which required the consensus of a community of residents, was implemented, after a long discussion with the building neighbour comunity. Herinafter, the three cases are summarised.

UC1a Smart Charging in Haarlem

The UC1a Smart Charging project in Haarlem involves the City of Haarlem and TotalEnergies (formerly PitPoint EV) as the Charge Point Operator for public AC charging infrastructure, with MRA-Electric as the Owner. Approximately 100 charging stations (200 charge points) have been selected for the Aggregated Smart Charging group. Each station has a 3x25A grid connection, supplying from 7 to 22 kW AC per socket. When both connectors are in use, the available 22 kW is divided between the two sockets through smart load balancing, with some stations having an increased grid connection (3x35A). Greenflux developed a Smart Charging Algorithm for congestion management using the Open Charge Point Protocol (OCPP), functioning as a Virtual Power Plant (VPP). Users can request high priority charging, which is always granted, with control focused on power.

A load forecast is created using historical data from the charge points for the following 24 hours. Input from the DSO (Congestion profile; required peak load reduction) is separately collected. The flexibility from the charging needs is calculated, and optimization is performed based on this flexibility and the required peak load reduction, resulting in an optimized aggregated load forecast. The GOPACS flexibility trading platform is utilized, reducing power by 10%-25% during peak hours (0.8 kW per charging station). The innovative aspect is the lack of contracts with EV drivers, who can opt-out via an application for priority charging.

Key points to be addressed include the cost (CAPEX) of a 7 kW to 22 kW charging station and the additional costs for converting it to Smart Charging, the cost of the GOPACS Platform and how these extra costs are charged to users, the maintenance and operation costs (OPEX) for one charging station and the GOPAC

Platform (for 100 charging stations), including personnel and other costs. Finally, the savings in grid adaptation and RES deployment due to the Smart Charging Ecosystem must be calculated.

UC1b. Bidirectional Charging project in Utrecht

The UC1b Bidirectional Charging project in Utrecht focuses on interoperability by integrating two new EV models into the V2G-EV system, initially with two public bidirectional e-car charging stations, expected to grow to five stations and five e-cars. The project demonstrates the use of shared EVs for local communities through a civil initiative in Odijk. Communication between the infrastructure, EV, and user interface is based on open protocols, enabling the car-sharing platform by Goodmoovs using ISO 15118 and OCPP 2.0. This platform shares the state of charge of specific vehicles with users and provides real-time monitoring of bidirectional charging. OCPI 3.0 is used for the charging station back-office to optimize the charging direction according to energy market prices.

The development of OCPP 2.0 is led by Wedrivesolar, which is the hub of a consortium including entrepreneurs, researchers, public bodies, and stakeholders. This consortium exploits bidirectional charging stations and shared EVs, with partners like ElaadNL for standardization, DSO Stedin for integrating bidirectional charging into the electricity grid, Utrecht Sustainability Institute for scientific validation, and the city and region of Utrecht for upscaling.

The charging stations, developed by WDS, are 22 kW smart/V2G charging points compatible with ISO 15118 and standard Type 2 charging. The smart-charged electric shared cars include models like Renault ZOE, Tesla Model 3, and Hyundai Kona, with plans to add V2G Hyundai IONIQ5 cars to reach a total of five vehicles. The back-office is developed by Last Mile Solutions.

Additionally, the project uses TOMP-API (a Dutch API for communication between transport operators and MAAS providers) to connect car-sharing data with aggregators, facilitating planning for when cars can be charged and testing load shift potential. A connection to the GOPACS network congestion trading platform between asset operators and TSO/DSO is also being developed.

UC1c Private charging in an apartment block in Purmerend

UC1c focuses on private charging in apartment blocks with owner associations in Purmerend. This use case involves the commissioning of intelligent charging infrastructure integrated into the grid connection of a privately owned apartment building. The project includes the installation of twelve 11 kW chargers, which will be managed by a single Charge Point Operator (CPO) for the entire building.

The system will employ Dynamic Load Balancing to continuously monitor the available capacity in the building and distribute it among the charge points. The preferences and priorities for the system can include AC/DC high/low power, cost-efficiency in operation and investment, reliability, flexibility, safety, CO2 emissions reduction, and optimizing the utilization of locally produced energy. The project is organized by MRA-E.

These use cases highlight different approaches to smart and bidirectional charging in various contexts, aiming to optimize energy use, manage grid load, and support the adoption of electric vehicles in both public and private settings.

In the three cases, a software provides the service and get advantages of the system management.

2.3 Economic impact

2.3.1 UC1a

As mentioned, TotalEnergies, MRA-E (Metropolitan Region Amsterdam Electric), and Greenflux have experimented with the IncitEV project with a network of 200 PCs (100 stations) in the city of Haarlem

(Netherlands), connecting to the GOPACS Platform (Grid Operators Platform for Congestion Solutions) network. This is an initiative in the Netherlands designed to manage and mitigate congestion in the electricity grid. It is a collaborative effort involving several key grid operators and other stakeholders.

The main aim of the GOPACS platform is to ensure the stability and reliability of the electricity grid by addressing congestion issues through innovative and market-based solutions.

As a result, it has been able to reduce about 100 kW in a network with a peak consumption of around 600 kW although the energy was returned later.

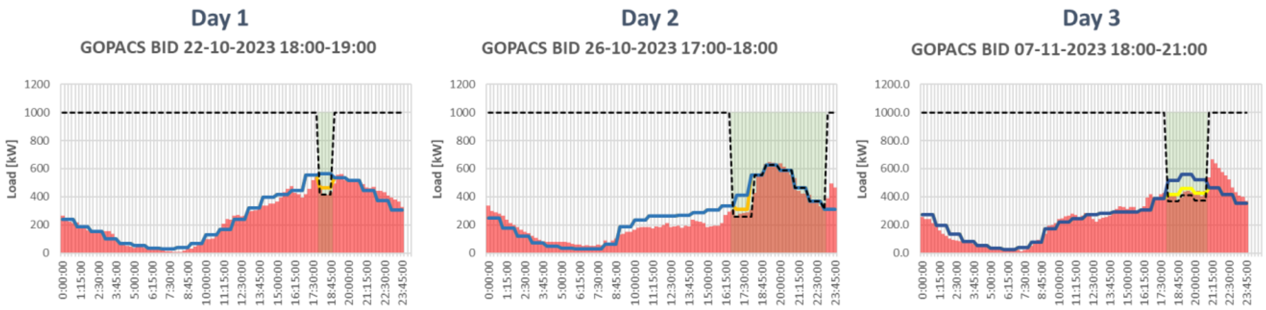

Figure 4. Example of power peak smart management in UC1a experiment

The Dutch electrical grid is heavily congested, so employing the algorithm developed by Greenflux has a very high impact on the following:

1. Unexpected power outages due to over-demand are avoided. These outages have an economic impact that is difficult to quantify, but very high.
2. Additionally, the costs for the Dutch public administration for installing new public chargers can be reduced by 10%. It is worth noting that in the Netherlands, the government has made a significant effort to install chargers, which was valued in Deliverable D9.2 at around €450 million between 2025 and 2035, considering the investment in charging points, associated renewables, and modifications to the electrical grid. If we consider these figures realistic, the implementation of a system like the one proposed by UC1 team could save the Dutch government around €45 million (10%) over the next 10 years.

UTRECHT NPV (M€)						
Year	**Stock EVs**	**CPs**	**REs**	**Grid**	**Total**	**Savings**
	Units	**M €**	**M €**	**M €**	**M €**	**M €**
2,025	**55,122**	**1.84**	**4.08**	**36.55**	**42.48**	**4.25**
2,026	67,358	1.78	4.12	37.63	43.53	4.35
2,027	79,870	1.66	4.06	37.80	43.53	4.35
2,028	90,172	1.51	3.92	37.30	42.73	4.27
2,029	100,479	1.32	3.75	36.37	41.44	4.14
2,030	**109,370**	**2.50**	**3.57**	**35.27**	**41.34**	**4.13**
2,031	116,442	2.70	3.39	34.24	40.34	4.03
2,032	120,719	2.23	3.25	33.48	38.97	3.90
2,033	123,573	1.38	3.16	33.13	37.66	3.77
2,034	125,474	1.13	3.10	33.24	37.47	3.75
2,035	**126,929**	**0.85**	**3.09**	**33.78**	**37.73**	**3.77**
	TOTAL (M €)	**18.9**	**39.5**	**388.8**	**447.2**	**44.7**

Table 2. Potential savings in Utrecht in 10 years by power reduction in a 10% by Smart charging and V2G

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However, the implementation costs are relatively low.

- Adapting electric vehicles to Smart Charging functionality is not necessary since it is a standard function of an EV using the Mode 3 control pilot PWM signal. Mode 3 control refers to a specific protocol defined by the international standard IEC 61851 for charging electric vehicles. The Control Pilot (CP) signal in Mode 3 is a critical communication signal between the EV and the charging station. It uses a Pulse Width Modulation (PWM) signal to exchange information about the charging process. Here's a breakdown of how it works:
    a. Detects the presence of the vehicle: When the EV is connected to the charging station, the CP signal ensures that the connection is secure, and that the vehicle is ready to receive power.
    b. Communicates charging current limits: The charging station sends a PWM signal to the EV to indicate the maximum current that can be drawn.
    c. Controls the charging process: The signal manages the start, continuation, and termination of the charging process.

Thus, the cost adaptation is considered 0.

- The same can be said from the Charging Station, which is also prepared for Smart Charging with no extra actions.
- There are some costs of the backoffice developed by Greenflux considered of **50,000 €/year** with apparently no extra marginal cost for additional CPs although it is expected some slight increase.
- There are some costs is in the connection to the GOPACS network congestion trading platform and to the TSO/DSO including the optimization and forecasting models. This cost is valued by Greenflux in **100,000 €/year.** In addition, to these costs, no OPEX is expected for the operation of the full ecosystem.

The results are summarised in the following table:

Parameter	2025	2030	2035	Source
Extra costs (CAPEX of vehicle adaptation to equip smart charging)	EUR 0,-	EUR 0,-	EUR 0,-	Smart Charging is a standard function of an EV using the Mode 3 control pilot PWM signal.
Cost of conventional 22 kW AC charging station (2 CP's)	2,500	2,500	2,500	Dutch Requirements demand every public charge point to be Smart (as per 2021 already). A standard AC charge station is therefore suitable for Smart Charging.
Extra cost of smart / charging point	EUR 0,-	EUR 0,-	EUR 0,-	See above
Extra costs of backoffice developed by Greenflux	50k€/y	50 k€/y	50k€/y	Backoffice is already operational, some maintenance estimated by Greenflux, as there are no marginal costs / CP
Extra costs for the connection to the GOPACS network congestion trading platform and to the TSO/DSO incl.	100k€/y	0	0	Baseline: smart charging point GOPACS connection is free, some software development estimated by Congestion Service Provider, as there are no marginal costs / CP

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Optimization and forecasting models				
Cost of OPEX to operate the full ecosystem. → CPO (smart charging)				Baseline: non-V2G smart charging points No additional costs expected apart from the above-mentioned
Which is the number of chargers and vehicles to consider the system to be useful and sustainable.	200 CP	200 CP	200 CP	Baseline: non-V2G smart charging points UC1a has proven that 200 CP's (100 stations) with a flexibility limitation of 8A minimum charging power, is sufficient to provide a congestion reduction request of 100 kW for at least 1 hour. Congestion zone could be the grid behind one substation, or a whole city, depending on the grid level of congestion. For balancing services, probably 100-200 V2G chargers would suffice to reliably provide 1 MW flex, these could be distributed over a wide area.

Figure 5. Economic impact of UC1a with 200 CPs

2.3.2 UC1b

Unlike UC1a, UC1b incurs significant additional costs, which are summarized as follows:

- Vehicle Adaptation to V2G: The cost for adapting vehicles to V2G technology is €200 per EV in 2025, decreasing to €100 per EV by 2030, and reaching zero by 2035.
- Smart/V2G Charging Points: Extra costs for smart/V2G charging points are €150 per charger in 2025, dropping to €50 per charger by 2030, and becoming free by 2035.
- Car-Sharing Platform Goodmoovs: The cost for the car-sharing platform is €100,000 per year initially, with no additional cost after 2030.
- OCPP 2.0 Costs: The extra cost for implementing OCPP 2.0, developed by Wedrivesolar, is €300,000 per year in 2025, reducing to €50,000 annually by 2030 and 2035.
- Backoffice System: The back-office system developed by Last Mile Solutions incurs an annual cost of €50,000, remaining constant throughout the period.
- TOMP-API Communication System: The TOMP-API communication system has an annual cost of €50,000, unchanged over the years.
- GOPACS Network Connection: Connecting to the GOPACS network congestion trading platform costs €100,000 per year in 2025, with no further costs expected after 2030.

The results are summarised in the following table:

Parameter	2025	2030	2035	Source
Extra costs (CAPEX of vehicle adaptation to equip V2G)	200€/EV	100€/EV	0	Baseline: standard EV. Current price V2L option in Hyundai IONIQ5 is 795€ for cheapest model[1], but standard option in other models. Expected to decrease fast with increasing numbers.
Cost of conventional 22 kW charging point	0	0	0	Baseline: 17 kW smart charging point. V2G can also be done with 17 kW chargers (with somewhat less potential though), so these additional costs are not necessary for the UC to function. Extra costs would be in the order of 100 €/charger and decrease over time.
extra cost of smart / V2G charging point	150 €/CP	50€/CP	0	Baseline: smart charging point (these are standard in NL), so costs for V2G Estimated by WDS, expected to decrease over time
Extra costs for the car-sharing Platform Goodmoovs/ Charging Point	100 k€/y	0	0	Baseline: non-smart-charging EV-sharing platform such as MyWheels Cost estimated by WDS as total per year, as there are no marginal costs / CP
Extra costs for the OCPP 2.0 made by Wedrivesolar/ Charging Point.	300 k€/y	50 k€/y	50 k€/y	Baseline: non-V2G smart charging point Cost estimated by WDS as total, as there are no marginal costs / CP
Extra costs of backoffice developed by Last Mile Solutions	50 k€/y	50 k€/y	50 k€/y	Baseline: non-V2G smart charging point Backoffice is already operational, some maintenance estimated by WDS as total, as there are no marginal costs / CP
Extra costs for the communication system TOMP-API	50 k€/y	50 k€/y	50 k€/y	Baseline: non-V2G smart charging point Backoffice is already operational, some maintenance estimated by WDS as total, as there are no marginal costs / CP
Extra costs for the connection to the GOPACS network congestion trading platform and to the TSO/DSO	100 k€/y	0	0	Baseline: non-V2G smart charging point GOPACS connection is free, some software development estimated by WDS as total, as there are no marginal costs / CP
Cost of OPEX to operate the full ecosystem → Shared V2G EV fleet	0	0	0	Baseline: non-V2G EV sharing fleet (several on the market already) No additional costs expected apart from the above-mentioned
Cost of OPEX to operate the full ecosystem. → CPO (V2G chargers)				Baseline: non-V2G smart charging points No additional costs expected apart from the above-mentioned
Which is the number of chargers and vehicles to consider the system to be useful and sustainable.	200	200	200	Baseline: non-V2G smart charging points What is the minimum # of V2G chargers needed to provide grid flexibility services? Current research suggests about 100-200 V1G smart chargers per congestion zone or about 25-50 V2G smart chargers per congestion zone, in order to make reliable flexibility bids of at least 100 kW. Congestion zone could be the grid behind one substation, or a whole city, depending on the grid level of congestion. For balancing services, probably 100-200 V2G chargers

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[1] https://www.hyundai.com/nl/nl/modellen/ioniq-5/configurator.html#/packages/overview

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				would suffice to reliably provide 1 MW flex, these could be distributed over a wide area.

Figure 6. Economic impact of UC1b

2.3.3 UC1c

For UC1c the additional implementation costs are relatively low. The cost of the charging infrastructure breaks down as follows. The additional costs are summarized as follows:

- Dynamic load balancing system: an additional coast of €1.190,- for installation and commissioning of the load balancing system.
- Replacement of the existing chargers: for integration of the charging system and dynamic load balancing. Total costs for replacement of the chargers is €2.634,-.

The results are summarised in the following table:

Parameter	**2024**	**Source**
Extra costs of dynamic load balancing	1,190€	Baseline: no local load balancing system installed
Replacement of existing chargers for integration in system	2,684€	Baseline: no replacement of existing chargers

Figure 7. Economic impact of UC1c

2.4 Analysis of results

In summary, UC1b involves notable additional costs than UC1a related to vehicle adaptation, smart/V2G charging points, and various system integrations, which decrease over time but represent a substantial financial commitment.

A question was made to the working team in the UC1a and UC1b in relation to “how can we evaluate the savings to the system in terms of less grid adaptation and more RES?”. The answer was for both cases:

Very hard to estimate from the viewpoint of a CPO. For Netherland, the potential savings are in the order of billions of € for DSOs and TSO, but these are regulated, which makes it hard to foresee how and how much of those savings would reach a CPO within current or possible adapted regulations.

The conclusion is that apart from the information given above, some additional research is needed to estimate the economic impact of these technologies in the long term.

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3 UC2 - LCCA RESULTS

3.1 UC2 Description and scope of the LCCA

3.1.1 LCCA scope. UC2 Paris Centre, DWPT, 30 kW, 23 km/h, 500 m

UC2 is titled ***"Dynamic wireless charging lane in urban area"***. This demonstrator aimed to proof the technical and economic feasibility of a Dynamic Wireless Power Transfer (DWPT) technology to recharge electrical vehicles in motion for urban trips.

The complete solution could have different lane lengths depending on each specific case, and the business case could be analysed for one or multiple lanes. For this analysis, 10 dynamic wireless charging lanes are considered.

3.1.2 Other assumptions

Reference year for initial data accounting	2024 input data
Reference year for LCCA	2034
Power rating of each module	30 kW
E-Corridor length	500 m
Average speed of the EVs circulating on the dynamic charging lane	23 km/h
Lifetime	15 years
WACC	6.5%
Percentage of engineering costs considered Research and Technology Development (RTD)	75%
Number of lanes used to amortize the investment in RTD costs.	10 lanes
Vehicle type	Standard EV + adaptation
Cost optimization from learning effects in 2030	In 2030, design and engineering costs are distributed; 75% to R&D and 25% are kept as engineering costs .
Cost optimization from learning effects in 2035	Costs are optimised a 2% from 2030 onward
Research and development	75% of design and Engineering goes to R&D in 2035 25% is kept in design and engineering with no reduction
Major repairs	30% of infrastructure costs in year 7

Table 3. UC2 main assumptions

3.2 Identification of relevant cost concepts 2035

The identification of costs for UC2 was done following a typical sequence of activities that should be applicable to all inductive Use Cases. Vehicle adaptation was included between infrastructure construction and operation, but it would run in parallel with the initial infrastructure tasks, always before the operation phase.

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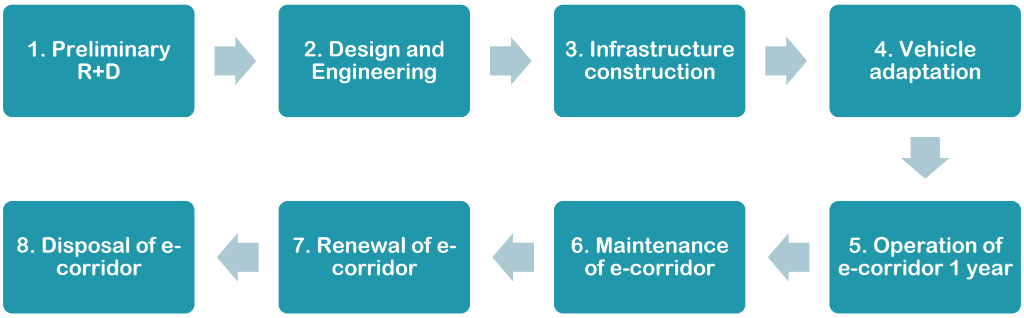

Figure 8. Sequence of activities considered to analyze the costs in UC2

1. **PRELIMINARY RTD** (C_{RTD}). The research and development activities were estimated to be 308,306 € in total. This preliminary investment will be depreciated in 10 city e-corridors, considering the amount to charge per corridor the following.

1	PRELIMINARY R+D (TO AMORTISIZE)		30,831 €
	1.1	R&D to amortise in 10 e-corridors	30,831 €

Table 4. UC2. R&D costs

2. **DESIGN AND ENGINEERING (C_{eng}).** This category includes two main activities:

- **2.1 Equipment design and engineering**: analyses, specification of technical features, dimensioning, elaboration of diagrams, calculations, electrical drawings, bill of materials, layout of the cabinets, and other tasks to define the details of the inductive power charging systems: 1) Charging Track (primary coils including sensors, thermal management, etc.); and 2 Electronic system (compensation network, PCBs, cabinet signals, etc.).

- **2.2 Project-site design and engineering**: has considered two concepts: 1) Simplified demonstration (system disposition at demosite, civil works definition, electric requirements analysis); 2) Paris demonstration (system disposition at demosite, civil works definition, electric requirements, coordination).

2	DESIGN AND ENGINEERING 2035			92,895 €
	2.1.	Equipment design and engineering		70,930 €
		211	Charging track	37,969 €
		212	Electronics system	36,609 €
	2.2.	Project-site design and engineering		21,965 €
		221 System emplacement design		13,728 €
		222 Civil works project design		8,237 €

Table 5. UC2. Design and Engineering Costs

3. **INFRASTRUCTURE EXPENDITURE (C_{inf}).** This category groups all the identified material costs in two blocks:

- **3.1 Construction costs**: civil works to prepare the ground, move the materials and prepare the pavement.

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- **3.2 Power supply, AC/DC and DC/AC converters**: power electronics, electric protections, cables, coils, filters, cabinets, etc.

3	INFRASTRUCTURE EXPENDITURE			584,483 €
	3.1.	Construction costs (pavement)		99,860 €
		311	Excavations and ground treatment	553 €
		312	Trench concreting	5,833 €
		313	Track concreting	31,890 €
		314	Extracted grounds transport	61,584 €
	3.2.	Electric and electronics Infrastructure		484,622 €
		321	Power Supply, AC/DC and DC/AC converters	339,971 €
		322	Coils	132,876 €
		323	Distribution lines	11,774 €

Table 6. UC2. Infrastructure costs (CAPEX)

A. VEHICLE ADAPTATION (C_{adap}). For the accounting of costs, it was considered that, for being compatible with the wireless charging lane, the electric vehicle (with conventional conductive interface) has to be adapted adding an inductive module.

A	VEHICLE ADAPTATION			36,203 €
	A.1.	Electric Vehicle cost		28,800 €
	A.2	Electric vehicle adaptation		7,403 €
		A21	Vehicle coil	3,083 €
		A22	Vehicle power adaptation	4,320 €

Table 7. UC2. Cost of Vehicle Adaptations for wireless power transfer

4. OPERATION OF E-CORRIDOR FOR 1 YEAR (C_{ope}). It is assumed that the operation includes:

- **4.1 Labor**. Activities that require human labor such as metering and billing, traffic management, or customer service
- **4.2 Consumables**. Mainly advertising and marketing and software and data bases
- **4.3 Equipment**. It is assumed that additional equipment is required for such purposes (e.g., billing, IT and communication equipment).
- **4.4 Other operating costs**.

4.	OPERATION E-CORRIDOR YEAR 2035 (Lifetime 15 years)			75,194€
	4.1.	Labor		6,618 €
		411	Traffic management labour	2,206 €
		412	Metering and billing administration	2,206 €
		413	Customer service	2,206€
	4.2.	Consumables		2,860 €
		421	Advertising and marketing	817 €
		422	Software and data bases	2,043 €
	4.3	Equipment (CAPEX Maintenance, depreciated)		55,393 €
	15	431	Billing Equipment	22,157 €

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	15	432	IT Equipment	11,079 €
	15	433	Communication Equipment	11,079 €
	15	434	Traffic management equipment	11,079 €
	4.4	Overtime and outsource		8,281 €
		441	Labour overtime (5% Labour costs)	110 €
		442	Outsource (external services)	8,171 €
	4.4	Other operating costs		2,043 €
		441	Other operating costs	2,043 €

Table 8. UC2. Operation costs

5. **MAINTENANCE OF THE E-CORRIDOR FOR 1 YEAR (C_{mai}).** These are the costs added to the maintenance of a conventional road for 1 year:

- 5.1 Preventive maintenance
- 5.2 Corrective maintenance

5.	MAINTENANCE OF E-CORRIDOR (year 2035, 15 years lifetime)			23,450 €
	5.1.	Preventive maintenance		4,902 €
		511	DWPT system inspection and testing	4,902 €
	5.2.	Corrective maintenance		18,548 €
		521	DWTP System unplanned repairs	2,206 €
		522	Small repairs	16,341 €

Table 9. UC2. Maintenance Costs

6. **RENEWAL COSTS OF E-CORRIDOR (C_{ren}).** Is the value when the asset is renewed (not necessarily the whole lane and equipment, but at least a part of it). Considered in year 2041 as maintenance CAPEX. This cost category differentiates two types of action:

- **6.1. major repairs**.
- **6.2. refurbishment in major repairs**.

6.	RENEWAL COSTS OF E-CORRIDOR (ADDED RENEWED ASSETS IN THE E-CORRIDOR)				242,969 €
	6.1.	Major repairs			218,598 €
		611	DWPT primary coil replacement	Equip& Labour	52,852 €
		612	DWPT power electronics replacement	Equip& Labour	65,591 €
		613	Energy Meter replacement	Equip& Labour	27,075 €
		614	Cable replacement	Equip& Labour	16,896 €
		615	Charging control equipment replacement	Equip& Labour	34,199 €
		616	Roadside & in road sensors replacement	Equip& Labour	21,985 €
	6.2	Refurbishment in major repairs			24,371 €
		621	Repainting road surface and signs	Cons & labour	24,371 €

Table 10. UC2 Renewal costs

7. **DISPOSAL COSTS (C_{dis}).** Considered for year 2049. The disposal costs have been split into two concepts:

- **7.1 Cost of assets disposal**. activities have a labour and equipment cost.

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- **7.2. Residual value**. The recovered materials could have a residual value that would lower the overall activity cost.

7.	DISPOSAL COSTS				24,871 €
	7.1.	Cost of assets disposal			33,989 €
		711	Labour for asset disposal	Labour	6,158 €
		712	Equipment for asset disposal	Outsource	27,831 €
	7.2.	Residual value			-9,117 €
		721	Recovered incomes for residual value	Others	-9,117 €

Table 11. UC2. Disposal costs

3.3 Life-cycle costs calculation

3.3.1 CAPEX

Given the type of charging system, the initial capital cost is calculated as follows:

$$CAPEX = C_{RTD} + C_{eng} + C_{inf}$$

The input data and the assumptions (section 3.1.2) were applied to calculate the CAPEX, which is an upfront cost accounted in 2034, right before the infrastructure enters in operation in 2035.

The design and engineering costs in 2024 are calculated as 25% of the initial engineering costs (2024), while the remaining 75% is considered as R&D.

Infrastructure expenditure by 2034 is estimated to be around 50% of the initial costs (2024) due to the improvement of this non-mature technology.

Vehicle adaptation is not considered as a cost in the lifecycle analysis, as it is not assumed by the asset owner.

		2034
1. R&D		30,831 €
Fix amount to amortize R&D investment (Nº units: 10)		30,831 €
2. DESIGN AND ENGINEERING		92,895 €
2.1.	Equipment design and engineering	70,930 €
2.2.	Project-site design and engineering	21,965 €
3. INFRASTRUCTURE EXPENDITURE		584,483 €
3.1.	Construction costs (pavement)	99,860 €
3.2.	Electric Infrastructure	484,622 €
TOTAL CAPEX (Excluding Vehicles' adaptation)		**708,208 €**

Table 12. UC2. Summary CAPEX

3.3.2 OPEX

Given the type of charging system, the OPEX is calculated as follows:

$$OPEX = C_{ope} + C_{mai} + C_{ren} + C_{dis}$$

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The input data and the assumptions (section 3.1.2) were applied to calculate the OPEX, which is computed annually taking in consideration some factors:

The operation and maintenance costs are continually optimized, decreasing 2% per year for the whole lifetime of the asset.

The infrastructure is partially renewed after 7 years of operation. At the end of the useful life of the asset, which is estimated in 15 years, it is disposed, and its residual value recovered.

UC2. OPEX	TOTAL	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
4. OPERATION	314,232 €	75,194 €	19,406 €	19,018 €	18,637 €	18,265 €	17,899 €	17,541 €	17,190 €	16,847 €	16,510 €	16,179 €	15,856 €	15,539 €	15,228 €	14,923 €
4.1. Labor	86,511 €	6,618 €	6,486 €	6,356 €	6,229 €	6,104 €	5,982 €	5,863 €	5,746 €	5,631 €	5,518 €	5,408 €	5,299 €	5,193 €	5,090 €	4,988 €
4.2. Consumables	37,381 €	2,860 €	2,803 €	2,747 €	2,692 €	2,638 €	2,585 €	2,533 €	2,483 €	2,433 €	2,384 €	2,337 €	2,290 €	2,244 €	2,199 €	2,155 €
4.3. Equipment	55,393 €	55,393 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
4.4. Overtime and outsource	108,246 €	8,281 €	8,115 €	7,953 €	7,794 €	7,638 €	7,485 €	7,336 €	7,189 €	7,045 €	6,904 €	6,766 €	6,631 €	6,498 €	6,368 €	6,241 €
4.5. Other operating costs	26,701 €	2,043 €	2,002 €	1,962 €	1,923 €	1,884 €	1,846 €	1,809 €	1,773 €	1,738 €	1,703 €	1,669 €	1,636 €	1,603 €	1,571 €	1,539 €
5. MAINTENANCE	306,528 €	23,450 €	22,981 €	22,521 €	22,071 €	21,630 €	21,197 €	20,773 €	20,358 €	19,950 €	19,551 €	19,160 €	18,777 €	18,402 €	18,034 €	17,673 €
5.1. Preventive maintenance	64,082 €	4,902 €	4,804 €	4,708 €	4,614 €	4,522 €	4,431 €	4,343 €	4,256 €	4,171 €	4,087 €	4,006 €	3,926 €	3,847 €	3,770 €	3,695 €
5.2. Corrective maintenance	242,445 €	18,548 €	18,177 €	17,813 €	17,457 €	17,108 €	16,766 €	16,430 €	16,102 €	15,780 €	15,464 €	15,155 €	14,852 €	14,555 €	14,263 €	13,978 €
6. RENEWAL COSTS	242,969 €	0 €	0 €	0 €	0 €	0 €	0 €	242,969 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.1. Major repairs	218,598 €	0 €	0 €	0 €	0 €	0 €	0 €	218,598 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.2. Refurbishment	24,371 €	0 €	0 €	0 €	0 €	0 €	0 €	24,371 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
7. DISPOSAL COSTS	24,871 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	24,871 €
7.1. Cost of assets disposal	33,989 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	33,989 €
7.2. Residual value	-9,117 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-9,117 €
TOTAL OPEX	**888,600 €**	98,644 €	42,387 €	41,539 €	40,708 €	39,894 €	39,096 €	281,283 €	37,548 €	36,797 €	36,061 €	35,340 €	34,633 €	33,940 €	33,262 €	57,468 €

Table 13. UC2 OPEX

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3.3.3 CAPEX + OPEX

SUMMARY	TOTAL	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042	2,043	2,044	2,045	2,046	2,047	2,048	2,049
Total Costs undiscounted	**1,596,808 €**	708,208 €	98,644	42,387	41,539	40,708	39,894	39,096	281,283	37,548	36,797	36,061	35,340	34,633	33,940	33,262	57,468
Present Value of Costs discounted	**1,288,959 €**	708,208 €	92,624	37,371	34,388	31,643	29,118	26,794	181,008	22,688	20,877	19,211	17,677	16,267	14,968	13,774	22,345
Discount Rate	**6,5%**	**1,000**	**0,939**	**0,882**	**0,828**	**0,777**	**0,730**	**0,685**	**0,644**	**0,604**	**0,567**	**0,533**	**0,500**	**0,470**	**0,441**	**0,414**	**0,389**

Table 14. UC2 Present Value Costs discounted (WACC, 6.5%)

Average Annualized Costs (undiscounted)	106,454 €/y
Average Annualized Costs(Discounted)	85,931 €/y

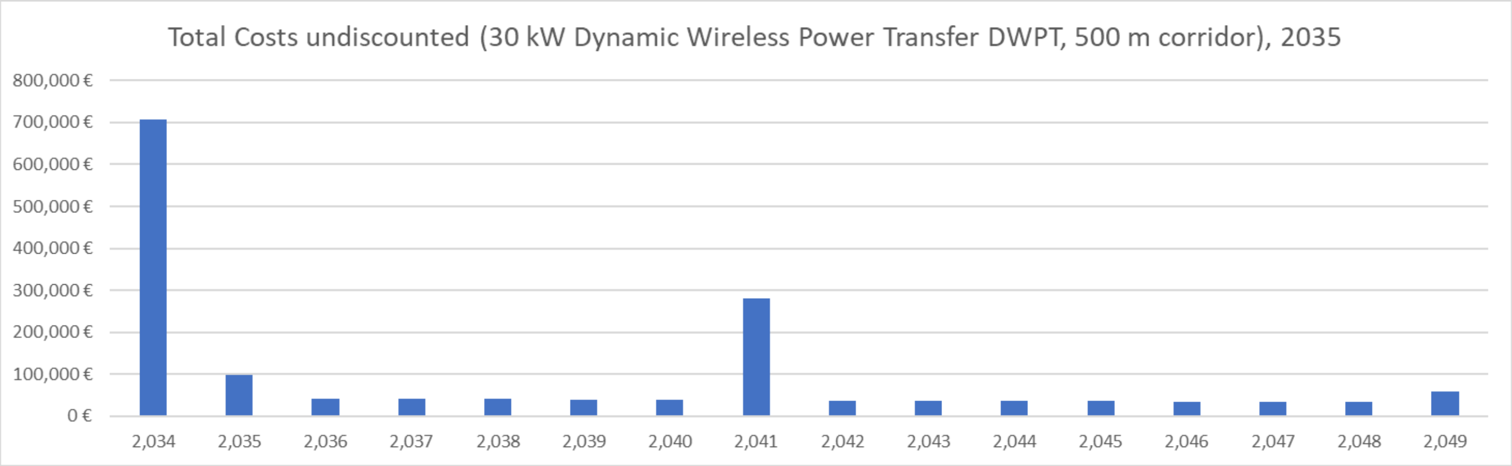

Figure 9. UC2. Total costs undiscounted diagram

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The "total costs undiscounted" adds up each year's CAPEX and OPEX considering a 0% inflation rate. The option to modify the inflation is added in the business model (Deliverable D9.5) but not here in the LCCA.

The "present value of the costs discounted" considers a discount rate (WACC) of 6,5% and gives a total value of 1,288,959 €.

3.4 Analysis of results

3.4.1 WACC

The WACC is the discount rate that defines the risk of the project. The components of its formulation are as follows:

$$
\begin{gathered}
WACC = E/V * Re + D/V * Rd * (1-Td) \\
Re = Rf + (\beta * ERP) + IP, \\
Rd = \text{base rate} + \text{credit spread}
\end{gathered}
$$

For its calculation, the following values have been estimated considering that there is no debt and that everything is considered Equity. These assumptions can be modified at convenience.

Equity	**Debt**	
100.00%	0.00%	**WACC**
6.50%	0.00%	**6.50%**

β	Market beta	1.53	Fix. For construction
IP	Innovation Premium	0.0%	Fix. By default.
ERP	Equity Risk Premium	2.54%	Fix. For construction
Td	Marginal tax rate	25%	Fix. For Spain
Rf	Risk free Rate	2.61%	Fix. For Spain
Rd	Cost of Debt	5.20%	Defined by bank conditions
Re	Cost of Equity	6.50%	Calculated

Fix data
Bank /decision
Calculated

Table 15. WACC calculation for all Use Cases

This WACC figure (6.5%) is indicative and was set the same in all UCs to facilitate comparison among them, although wireless technologies should have had a higher WACC due to the increased risk. However, for the sake of comparison, it was set equal in all cases.

3.4.2 Results

The total cost of an inductive charging lane for urban areas would have a life cycle cost of around 1.3 M€ from 2035 onwards, which is a substantial reduction of the current costs as the analysis includes the

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hypothesis of lower engineering costs, that would be amortized as R&D costs among all the installations, and an important optimization of operation and maintenance.

LCCA		**2.030**	**2.035**
CAPEX (Infrastructure)	€	780,208 €	708,208 €
OPEX (except electricity, undiscounted)	€	985,917 €	888,600 €
TOTAL COSTS (Undiscounted)	**€**	1,766,124 €	1,596,808 €
Annualized Costs (undiscounted)	€	117,742 €	106,454 €
WACC	%	6.5%	6.5%
Lifetime	years	15	15
PV COSTS (Discounted)	**€**	1,424,532 €	1,288,959 €
Annualized Costs (Discounted)	€	94,969 €	85,931 €
CAPEX (1 Vehicle)		40,225 €	36,203 €

Table 16. UC2 LCCA Results

TOTAL COST UNDISCOUNTED / KM	3,532,249 €	3,193,617 €
TOTAL COST DISCOUNTED /KM	2,849,064 €	2,577,919 €

Author's Note

These results are based on the extrapolation of economic data provided by the UC2 team, considering current technologies and without any process automation. While optimization has been attempted, it is evident that, given the immaturity of the technology, these results may vary significantly in the future. An important factor that could greatly affect future costs is the rising price of copper. Therefore, these figures should be regarded solely as indicative and approximate in terms of order of magnitude.

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4 UC3 - LCCA RESULTS

4.1 UC3 Description and scope of the LCCA

4.1.1 LCCA scope. UC3 Paris Periphery. DWPT, 90 kW, 90km/h, 25 km

UC3 is titled ***"Dynamic Wireless Charging for long distance (prototype e-road)"***. This use case aimed to demonstrate a Dynamic Wireless Power Transfer (DWPT) technology to recharge electrical vehicles in motion in an extra-urban scenario. This scenario is characterized by higher speeds compared with the urban use case and by a lack of city constraints like pedestrians, bicycles and other systems installed around.

The system implements the innovative concept of employing a primary coil longer than the secondary coil. This design approach eliminates the need for ferrite sheets and aluminium shielding on the ground side, leading to a significant reduction in costs compared to alternative dynamic charging systems.

In the project demonstrator, the charging track is formed by eight primary coils of 10 m length, covering 80 m. For the LCCA, a single 25 km lane is considered, estimating the saving achieved thanks to the scale factor.

4.1.2 Other assumptions

Reference year for initial data accounting	2024 input data
Reference year for LCCA	2034
Power rating	90 kW
Lane length	25 km
Average speed of the EVs circulating on the dynamic charging lane	90 km/h
Lifetime	15 years
WACC	6.5%
Research and development	75% of design and Engineering goes to R&D in 2030 25 % is kept as Engineering and design
Number of e-corridors used to amortize the investment in RTD costs.	20 e-corridors
Vehicle type	Standard EV + adaptation
Cost optimization from learning effects	2% optimization from 2025 onward

Table 17. UC3. Main assumptions

4.2 Identification of relevant cost concepts 2035

The identification of costs for UC3 was done following the sequence of activities that should be applicable to all inductive Use Cases. Vehicle adaptation was included between infrastructure construction and operation, but it would run in parallel with the initial infrastructure tasks, always before the operation phase (figure 2).

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4.3 Life-cycle costs calculation

4.3.1 CAPEX

Given the type of charging system, the initial capital cost is calculated as follows:

$$CAPEX = C_{RTD} + C_{eng} + C_{inf}$$

The input data and the assumptions (section 4.1.2) were applied to calculate the CAPEX, which is an upfront cost accounted in 2034, right before the infrastructure enters in operation in 2035.

The design and engineering costs in 2034 are calculated as 25% of the initial engineering costs (2024), while the remaining 75% is considered as R&D. The initial R&D investments costs were assumed to be 1,852,875 € that divided by 20 e-corridors represents 92,644 €.

Vehicle adaptation is not considered as a cost in the lifecycle analysis, as it is not assumed by the asset owner.

		2029
1. R&D		92.644 €
Fix amount to amortize R&D investment (Nº units: 10)		92.644 €
2. DESIGN AND ENGINEERING		569,678 €
2.1.	Equipment design and engineering	435,196 €
2.2.	Project-site design and engineering	134,481 €
3. INFRASTRUCTURE EXPENDITURE		11,649,095 €
3.1.	Construction costs (pavement)	3,586,859 €
3.2.	Electric Infrastructure	7,356,624 €
3.3.	Control and monitoring system	705,612 €
TOTAL CAPEX (Excluding Vehicles' adaptation)		**12,311,416 €**

Table 18. UC3 CAPEX Summary

Given the type of charging system, the OPEX is calculated as follows:

$$OPEX = C_{ope} + C_{mai} + C_{ren} + C_{dis}$$

The input data and the assumptions (section 4.1.2) were applied to calculate the OPEX, which is computed annually taking in consideration some factors:

The operation and maintenance costs are continually optimized, decreasing 2% per year for the whole lifetime of the asset.

The infrastructure is partially renewed after 7 years of operation. At the end of the useful life of the asset, which is estimated in 15 years, it is disposed, and its residual value recovered.

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UC3 OPEX		TOTAL	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
4. OPERATION		1.452.218 €	230,531 €	159,771 €	156,575 €	153,444 €	150,375 €	147,367 €	144,420 €	141,532 €	138,701 €	135,927 €	133,208 €	130,544 €	127,933 €	125,375 €	122,867 €
4.1.	Labor	564.691 €	39,049 €	38,268 €	37,503 €	36,753 €	36,018 €	35,298 €	34,592 €	33,900 €	33,222 €	32,557 €	31,906 €	31,268 €	30,643 €	30,030 €	29,429 €
4.2.	Consumables	392.146 €	94,912 €	93,013 €	91,153 €	89,330 €	87,544 €	85,793 €	84,077 €	82,395 €	80,747 €	79,132 €	77,550 €	75,999 €	74,479 €	72,989 €	71,529 €
4.3.	Equipment	75.000 €	67,500 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
4.4.	Overtime and outsource	341.952 €	23,647 €	23,174 €	22,710 €	22,256 €	21,811 €	21,375 €	20,947 €	20,528 €	20,118 €	19,715 €	19,321 €	18,935 €	18,556 €	18,185 €	17,821 €
4.5.	Other operating costs	78.429 €	5,424 €	5,315 €	5,209 €	5,105 €	5,002 €	4,902 €	4,804 €	4,708 €	4,614 €	4,522 €	4,431 €	4,343 €	4,256 €	4,171 €	4,087 €
5. MAINTENANCE		1,417,877 €	108,470 €	106,301 €	104,175 €	102,092 €	100,050 €	98,049 €	96,088 €	94,166 €	92,283 €	90,437 €	88,628 €	86,856 €	85,119 €	83,416 €	81,748 €
5.1.	Preventive maintenance	567,151 €	43,388 €	42,520 €	41,670 €	40,837 €	40,020 €	39,219 €	38,435 €	37,666 €	36,913 €	36,175 €	35,451 €	34,742 €	34,047 €	33,366 €	32,699 €
5.2.	Corrective maintenance	850,726 €	65,082 €	63,781 €	62,505 €	61,255 €	60,030 €	58,829 €	57,653 €	56,500 €	55,370 €	54,262 €	53,177 €	52,113 €	51,071 €	50,050 €	49,049 €
6. RENEWAL COSTS		3,849,468 €	0 €	0 €	0 €	0 €	0 €	0 €	3,849,468 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.1.	Major repairs	3,111,514 €	0 €	0 €	0 €	0 €	0 €	0 €	3,111,514 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.2.	Refurbishment	737,954 €	0 €	0 €	0 €	0 €	0 €	0 €	737,954 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
7. DISPOSAL COSTS		-325,132 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-325,132 €
7.1.	Cost of assets disposal	206,902 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	206,902 €
7.2.	Residual value	-532,034 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-532,034 €
TOTAL OPEX		7,140,782 €	339,002 €	266,072 €	260,750 €	255,535 €	250,424 €	245,416 €	4,089,976 €	235,698 €	230,984 €	226,364 €	221,837 €	217,400 €	213,052 €	208,791 €	-120,517 €

Table 19. UC3 OPEX

4.3.2 CAPEX + OPEX

SUMMARY	TOTAL	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Total Costs undiscounted	19,452,198 €	12,311,416 €	339,002	266,072	260,750	255,535	250,424	245,416	4,089,976	235,698	230,984	226,364	221,837	217,400	213,052	208,791	-120,517
Present Value of Costs discounted	17,002,393 €	12,311,416 €	318,311	234,585	215,862	198,633	182,780	168,192	2,631,925	142,416	131,049	120,590	110,965	102,109	93,959	86,460	-46,860
WACC	**6,5%**	**1,000**	**0,939**	**0,882**	**0,828**	**0,777**	**0,730**	**0,685**	**0,644**	**0,604**	**0,567**	**0,533**	**0,500**	**0,470**	**0,441**	**0,414**	**0,389**

Table 20. UC3. Present Value Costs discounted (WACC, 6.5%)

Average Annualized Costs (undiscounted)	**1,296,813 €**
Average Annualized Costs (Discounted)	**1,133,493 €**

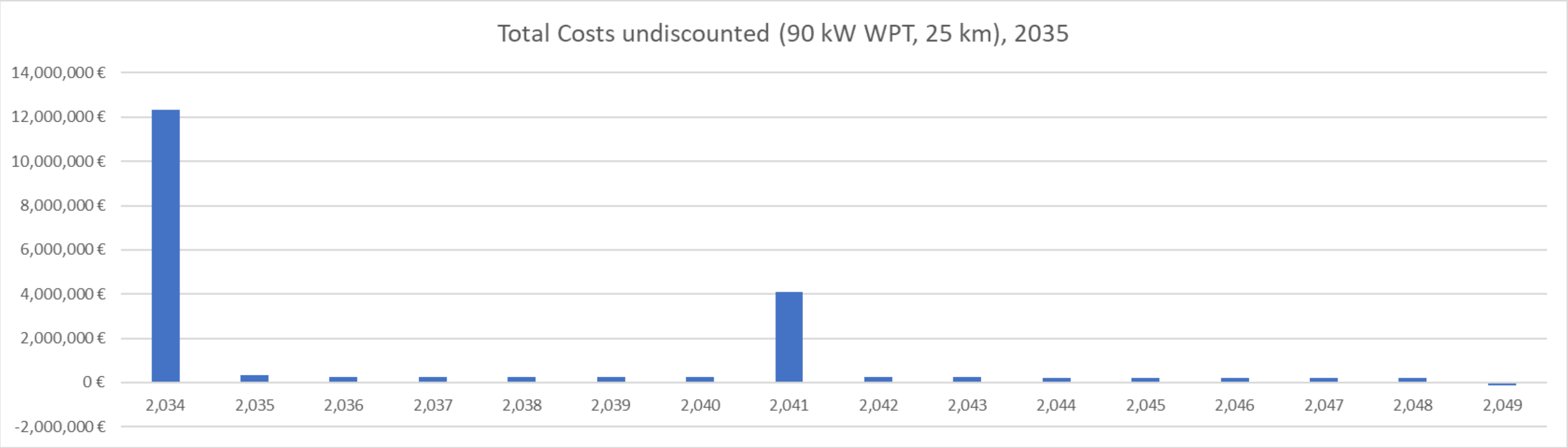

Figure 10. UC3. Total Costs undiscounted diagram

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The “present value of the costs discounted” considers a discount rate (WACC) of 6,5% and gives a total value of 17,002,393 €.

4.4 Analysis of results

The total cost of one 25 km inductive charging lane for a periurban area would have a life cycle cost of around 17,0 M€ from 2030 onwards, which is a substantial reduction of the current costs as the analysis includes the hypothesis of lower engineering costs, that would be amortized as R&D costs among all the installations, and an important optimization of operation and maintenance.

LCCA		**2.030**	**2.035**
CAPEX (Infrastructure)	€	13,339,819 €	12,311,416 €
OPEX (except electricity, undiscounted)	€	7,900,112 €	7,140,782 €
TOTAL COSTS (Undiscounted)	**€**	21,239,931 €	19,452,198 €
Annualized Costs (undiscounted)	€	1,415,995 €	1,296,813 €
WACC	%	6.5%	6.5%
Lifetime	years	15	15
PV COSTS (Discounted)	**€**	18,529,713 €	17,002,393 €
Annualized Costs (Discounted)	€	1,235,314 €	1,133,493 €
CAPEX (1 Vehicle)		37,150	36,203
TOTAL COST UNDISCOUNTED / KM		849,597 €	778,088 €
TOTAL COST DISCOUNTED /KM		741,189 €	680,096 €

Table 21. UC3. LCCA Results

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5 UC4 - LCCA RESULTS

5.1 UC4 Description and scope of the LCCA

5.1.1 LCCA scope. Turin, DC/AC 150 kW & two DC/AC 3.6 kW bidirectional

UC4 is titled ***"Charging hub in a park-and-ride facility"***. This demonstrator aimed to proof the technical and economic feasibility of providing users, in a single facility, several technologies with different performances and prices in order to make available a wide range of choices. Depending on their specific needs the user is able to choose the option that considers more suitable. Moreover, it aimed to demonstrate interoperable payment system and the synergies with the tramway through the direct connection of fast chargers to the tram's DC network.

The complete solution could combine many different technologies and charging solutions. In the demonstrator, which is the case considered in the LCCA, two different types of chargers were installed: 1) two units of a bidirectional low Power (3.6kW) CCS2 DC/DC charging station; and 2) one unit of a unidirectional ultrafast (150kW) CCS2 DC/DC charging station.

5.1.2 Other assumptions

Reference year for initial calculations	2024 input data
Reference year for the LCCA	2029
Power rating of each module	3.6 kW x 2 units 150 kW x 1 unit
Lifetime	15 years
WACC	6.5%
Vehicle type	Standard EV; CSS2
Engineering optimization from the pilot to commercial versions	25% for product 10% for site
Cost optimization from learning effects	All costs are optimized 2% annually
Major repairs	12% of infrastructure costs in year 7

Table 22. UC4. Main Assumptions

5.2 Identification of relevant cost concepts 2030

The identification of costs for UC4 was done following the same sequence of activities that should be applicable to all conductive Use Cases (figure 2).

1. **PRELIMINARY RTD** (C_{RTD}). The research and development activities were estimated in this case in 200.000€, which would be distributed among all the charging hubs implementing this intellectual property, that are estimated in 100. Therefore, each charging facility would assume a fraction of the total RTD investment.

1	PRELIMINARY R+D (TO AMORTISIZE)		2,000 €
	1.1	R&D to amortise in 100 charging hubs	2,000 €

Table 23. UC4. Preliminary R&D

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2. **DESIGN AND ENGINEERING (C_{eng}).** This category includes two main activities:

- **2.1 Product design and engineering**: analyses, specification of technical features, dimensioning, elaboration of diagrams, calculations, electrical drawings, bill of materials, layout of the cabinets, etc.
- **2.2 Project-site design and engineering**: layout of the chargers in the parking hub, definition of the civil works, electric requirements, coordination, etc.

2	DESIGN AND ENGINEERING 2030		**28,474 €**
	2.1.	Product design and engineering	16,271 €
	2.2.	Project-site design and engineering	12,203 €

Table 24. UC4 Design and Engineering Costs

3. **INFRASTRUCTURE (C_{inf}).** This category groups all the identified material costs in two blocks:

- **3.1 Site conditioning**: civil works to prepare the ground, move the materials and prepare the pavement.
- **3.2 Electric infrastructure**: power electronics, electric protections, cables, coils, filters, cabinets, etc.

3	INFRASTRUCTURE 2030			221,855 €
	3.1	Site conditioning		38,869 €
	3.2	Electric infrastructure		182,987 €
		321	Power Supply and cabinets - new DC feeding line from substation	65,296 €
		322	Power electronics - fast converters	53,693 €
		323	Power electronics - slow converters + EV charging system	31,637 €
		324	Communication and control	32,360 €

Table 25. UC4. Infrastructure Costs

4. **OPERATION (C_{ope}).** It is assumed that the operation includes:

- **4.1 Labor**. Activities that require human labor such as metering, billing, or customer service.
- **4.2 Consumables**. Marketing and data bases, etc
- **4.3 Equipment**. It is assumed that additional equipment is required for such purposes (e.g., billing, IT).
- **4.4 Overtime and outsource**.
- **4.5 Other operating costs**.

4.	OPERATION 2030			52,214 €
	4.1	Labor		5,478 €
		411	Management labour	2,585 €
		412	Metering and billing administration	904 €
		413	Customer service	1,989 €
	4.2	Consumables		2,851 €
		421	Advertising and marketing	1,043 €
		422	Software and data bases	1,808 €
	4.3	Equipment		42,936 €
		431	Billing Equipment	9,039 €
		432	IT Equipment	11,299 €

		433	Communication Equipment	11,299 €
		434	Traffic management equipment	11,299 €
	4.4	Overtime and outsource		407 €
		441	Labour overtime (10% Labour costs)	407 €
		442	Outsource (external services)	0
	4.4	Other operating costs		542 €
		441	Other operating costs	542 €

Table 26. UC4 Operation Costs 2030

5. **MAINTENANCE (C_{mai}).** These are the maintenance costs of the charging equipment in the hub:

- 5.1 Preventive maintenance
- 5.2 Corrective maintenance

5.	MAINTENANCE 2030			6,291 €
	5.1.	Preventive maintenance		3,580 €
		511	System inspection and testing	3,580 €
	5.2.	Corrective maintenance		2,712 €
		521	System unplanned repairs	904 €
		522	Small repairs	1,808 €

Table 27. UC4 Maintenance Costs 2030

6. **RENEWAL COSTS (C_{ren}).** Is the value when the asset is renewed (not necessarily the whole charging hub, but at least a part of it). Foreseen in year 2036. This cost category differentiates two types of action:

- **6.1. Major repairs**.
- **6.2. Refurbishment in major repairs**.

6.	RENEWAL COSTS				24,778 €
	6.1.	Major repairs			19,653 €
		611	DWPT primary coil replacement	Equip& Labour	10,059 €
		612	DWPT power electronics replacement	Equip& Labour	5,099 €
		613	Energy Meter replacement	Equip& Labour	1,739 €
		614	Cable replacement	Equip& Labour	1,070 €
		615	Charging control equipment replacement	Equip& Labour	281 €
		616	Roadside & in road sensors replacement	Equip& Labour	1,405 €
	6.2	Refurbishment in major repairs			5,125 €
		621	Repainting road surface and signs	Cons & labour	5,125 €

Table 28. UC4 Renewal Costs (year 7)

7. **DISPOSAL COSTS (C_{dis}).** Foreseen in year 2044. The disposal costs have been split into two concepts:

    - **7.1. Cost of assets disposal. activities have a labor and equipment cost.**
    - **7.2. Residual value**. The recovered materials could have a residual value that would lower the overall activity cost. In this case, it is even a negative cost, becoming an income.

7.	DISPOSAL COSTS				-12,052 €
	7.1.	Cost of assets disposal			7,834 €
		711	Labour for asset disposal	Labour	2,725 €
		712	Equipment for asset disposal	Outsource	5,109 €
	7.2.	Residual value			-19,886 €
		721	Recovered incomes for residual value	Others	-19,886 €

Table 29. UC4. Disposal Costs (year 15)

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5.3 Life-cycle costs calculation

5.3.1 CAPEX

Given the type of charging system, the initial capital cost is calculated as follows:

$$CAPEX = C_{RTD} + C_{eng} + C_{inf}$$

The input data and the assumptions (section 5.1.2) were applied to calculate the CAPEX, which is an upfront cost accounted in 2029, right before the infrastructure enters in operation in 2030.

The design and engineering costs in 2029 are calculated based on the pilot costs, applying a reduction of 25% of the initial product engineering costs (2024), and 10% reduction of the initial site engineering costs.

Infrastructure expenditure is estimated to decrease around 2% per year from the baseline year (2024).

Vehicle adaptation, if required, is not considered as a cost in the lifecycle analysis, as it is not assumed by the asset owner.

		2034
1. R&D		2,000 €
Fix amount to amortize R&D investment (Nº units: 100)		2,000 €
2. DESIGN AND ENGINEERING		28.474 €
2.1.	Equipment design and engineering	16.271 €
2.2.	Project-site design and engineering	12.203 €
3. INFRASTRUCTURE		221.855 €
3.1.	Construction costs	38.869 €
3.2.	Electric Infrastructure	182.987 €
TOTAL CAPEX (Excluding Vehicles' adaptation)		**252,329 €**

Table 30. UC4. CAPEX Summary

5.3.2 OPEX

Given the type of charging system, the OPEX is calculated as follows:

$$OPEX = C_{ope} + C_{mai} + C_{ren} + C_{dis}$$

The input data and the assumptions (section 5.1.2) were applied to calculate the OPEX, which is computed annually taking in consideration some factors:

The operation and maintenance costs are continually optimized, decreasing 2% per year for the whole lifetime of the asset.

The infrastructure is partially renewed after 6 years of operation. At the end of the useful life of the asset, which is estimated in 15 years, it is disposed, and its residual value is recovered.

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UC4. OPEX	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
4. OPERATION		52.214 €	8.219 €	8.054 €	7.893 €	7.735 €	7.581 €	7.429 €	7.280 €	7.135 €	6.992 €	6.852 €	6.715 €	6.581 €	6.449 €	6.320 €
4.1. Labor		5.478 €	4.852 €	4.755 €	4.660 €	4.567 €	4.476 €	4.386 €	4.298 €	4.213 €	4.128 €	4.046 €	3.965 €	3.885 €	3.808 €	3.732 €
4.2. Consumables		2.851 €	2.526 €	2.475 €	2.425 €	2.377 €	2.329 €	2.283 €	2.237 €	2.192 €	2.149 €	2.106 €	2.064 €	2.022 €	1.982 €	1.942 €
4.3. Equipment		42.936 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
4.4. Overtime and outsource		407 €	360 €	353 €	346 €	339 €	332 €	326 €	319 €	313 €	307 €	300 €	294 €	289 €	283 €	277 €
4.5. Other operating costs		542 €	480 €	471 €	461 €	452 €	443 €	434 €	426 €	417 €	409 €	401 €	393 €	385 €	377 €	369 €
5. MAINTENANCE		6.291 €	5.573 €	5.462 €	5.352 €	5.245 €	5.140 €	5.038 €	4.937 €	4.838 €	4.741 €	4.647 €	4.554 €	4.463 €	4.373 €	4.286 €
5.1. Preventive maintenance		3.580 €	3.171 €	3.107 €	3.045 €	2.984 €	2.925 €	2.866 €	2.809 €	2.753 €	2.698 €	2.644 €	2.591 €	2.539 €	2.488 €	2.438 €
5.2. Corrective maintenance		2.712 €	2.402 €	2.354 €	2.307 €	2.261 €	2.216 €	2.171 €	2.128 €	2.085 €	2.044 €	2.003 €	1.963 €	1.924 €	1.885 €	1.847 €
6. RENEWAL COSTS		0 €	0 €	0 €	0 €	0 €	0 €	28.708 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.1. Major repairs		0 €	0 €	0 €	0 €	0 €	0 €	23.583 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.2. Refurbishment		0 €	0 €	0 €	0 €	0 €	0 €	5.125 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
7. DISPOSAL COSTS		0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-12.052 €
7.1. Cost of assets disposal		0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	7.834 €
7.2. Residual value		0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-19.886 €
TOTAL OPEX		58.505 €	13.792 €	13.516 €	13.246 €	12.981 €	12.721 €	37.244 €	12.217 €	11.973 €	11.734 €	11.499 €	11.269 €	11.044 €	10.823 €	-1.446 €

Table 31. UC4. OPEX

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5.3.3 CAPEX + OPEX

SUMMARY	TOTAL	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Costs undiscounted	493,446 €	252,329 €	58,505 €	13,792 €	13,516 €	13,246 €	12,981 €	12,721 €	37,244 €	12,217 €	11,973 €	11,734 €	11,499 €	11,269 €	11,044 €	10,823 €	-1,446 €
Present Value of Costs discounted	423,328 €	252,329 €	54,935 €	12,160 €	11,189 €	10,296 €	9,474 €	8,718 €	23,967 €	7,382 €	6,793 €	6,251 €	5,752 €	5,293 €	4,870 €	4,482 €	-562 €
WACC	6,5%	1,000	0,939	0,882	0,828	0,777	0,730	0,685	0,644	0,604	0,567	0,533	0,500	0,470	0,441	0,414	0,389

Table 32. UC4. Present Value Costs discounted (WACC, 6.5%)

Average Annualized Costs (undiscounted)	32,896 €
Average Annualized Costs (Discounted)	28,222 €

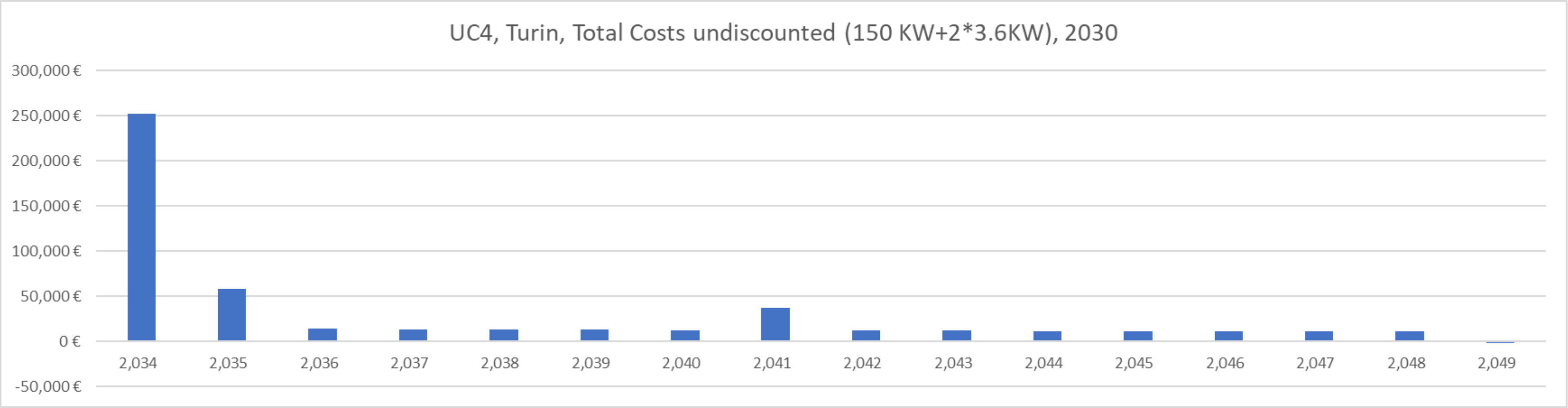

Figure 11. UC4. Total Costs undiscounted diagram

The “total costs undiscounted” adds up each year’s CAPEX and OPEX considering a 0% inflation rate.

The “present value of the costs discounted” considers a discount rate (WACC) of 6,5% and gives a total value of 423,328 €

5.4 Analysis of results

The results of the LCCA for the charging hub in Turin (with 1 fast charger and 2 slow chargers) , considering a lifetime of 15 years and a WACC of 6.5 %, reflects the following results

LCCA	**unit**	**2.025**	**2.030**	**2.035**
CAPEX (Infrastructure)	€	278,937 €	252,329 €	228,278 €
OPEX (except electricity, undiscounted)	€	286,722 €	241,117 €	187,731 €
TOTAL COSTS (Undiscounted)	**€**	565,659 €	493,446 €	416,009 €
Annualized Costs (undiscounted)	€	37,711 €	32,896 €	27,734 €
PV COSTS (Discounted)	**€**	480,436 €	423,328 €	363,519 €
Annualized Costs (Discounted)	€	32,029 €	28,222 €	24,235 €

Table 33. UC4. LCCA Results

WACC	%	6.5%	6.5%	6.5%
Lifetime	years	15	15	15

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6 UC5 - LCCA RESULTS

6.1 UC5 Description and scope of the LCCA

6.1.1 LCCA scope. 1 Superfast charger, 200 kW in the periphery of Tallinn

UC5 is titled ***"Superfast Charging Systems for European corridors"***. This demonstrator aimed to proof the technical and economic feasibility of an innovative Super-Fast Charging (SFC) system with two 200 kW DC super-fast chargers that provide ancillary services and EV charging service for EV users at Tallinn peri-urban area gas stations. This technology will contribute to reduce the range anxiety, that is one of the major concerns of users on long-range trips. In this sense, taking for example a 40 kWh battery, it will only take 10 minutes to fully charge the EV using this super-fast charger.

The complete solution will be able to: 1) provide charging services to EV-drivers through Enefit VOLT platform, and 2) provide grid services that are of interest to DSO and TSO.

6.1.2 Other assumptions

The study was done for a single ultrafast charger

Reference year for initial calculations	2024 input data
Reference year for LCCA	2029
Power rating of each module	200 kW x 1 unit
Lifetime	15 years
WACC	6.5%
Vehicle type	Standard EV
Number of chargers used to amortize the investment in RTD costs.	100
Research and development	75% of design and Engineering goes to R&D in 2030 25% is kept in design and engineering with no reduction
Engineering optimization from the pilot to commercial versions	0% for product in 2025 0% for site in 2025
Cost optimization from learning effects	All costs are optimized 2% annually from 2025 onward
Major repairs	Renewal costs are considered in year 7

Table 34. UC5 Main Assumptions

6.2 Identification of relevant cost concepts 2030

The identification of costs for UC5 was done following the same sequence of activities that should be applicable to all conductive Use Cases (figure 2).

1. **PRELIMINARY RTD** (C_{RTD}). The research and development activities are split in three different concepts: 1) hardware R&D performed by CIRCE, 2) software R&D performed by CIRCE, and 3) software R&D performed by EESTI. The R&D to depreciate is estimated in 2030 as off 247,350 € distributed in 100 Superfast chargers.

1	PRELIMINARY R+D (TO ACCOUNT PER SUPER FAST CHARGER)	2,471

Table 35. UC5. Preliminary R&D

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2. DESIGN AND ENGINEERING (C_{eng}). This category includes three main activities:

- **2.1 Project planning**. analyses, specification of technical features, dimensioning, elaboration of diagrams, calculations, electrical drawings, etc.
- **2.2 Product design and engineering**: includes the design and engineering of the electronics system (power converters, PCBs, cabinet, etc..) and their validation.
- **2.3 Project-site design and engineering**: layout of the charger, definition of the civil works, electric requirements, coordination, etc.

2	DESIGN AND ENGINEERING	32,350 €
	2.1. Project planning	3,750 €
	2.2. Product design and engineering	18,600 €
	2.3 Project-site design and engineering	10,000 €

Table 36. UC5. Design and Engineering Costs

3. INFRASTRUCTURE (C_{inf}). This category groups all the identified material costs in two blocks:

- **3.1 Site conditioning**: civil works to prepare the ground, move the materials and prepare the pavement.
- **3.2 Electric infrastructure**: power electronics, electric protections, cables, coils, filters, cabinets, etc.

3	INFRASTRUCTURE			107,012 €
	3.1	Site conditioning		2,893 €
	3.2	Electric infrastructure		101,517 €
		321	Power Supply - new feeding line	2,260 €
		322	Power electronics - converters	79,307 €
		323	Cabinet, screen, signalling, plugs and other components	18,033 €
		324	Auxiliary systems	1,916 €
	3.3	Site-level control and monitoring system		2.603 €

Table 37. UC5. Infrastructure Costs

4. OPERATION (C_{ope}). It is assumed that the operation includes:

- **4.1 Labor**. Activities that require human labor such as metering and billing, traffic management, or customer service
- **4.2 Consumables**.
- **4.3 Equipment**. It is assumed that additional equipment is required for such purposes (e.g., billing and IT equipment).
- **4.4 Overtime and outsource**.
- **4.5 Other operating costs**.

4.	OPERATION 2030			50,261 €
	4.1	Labor		4,050 €
		411	Management labour	1,880 €
		412	Metering and billing administration	723 €
		413	Customer service	1,446 €
	4.2	Consumables		2,350 €

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		421	Advertising and marketing	994 €
		422	Software and data bases	1,356 €
	4.3	Equipment		42,936 €
		431	Billing Equipment	9,039 €
		432	IT Equipment	11,299 €
		433	Communication Equipment	11,299 €
		434	Traffic management equipment	11,299 €
	4.4	Overtime and outsource		405 €
		441	Labour overtime (10% Labour costs)	405€
		442	Outsource (external services)	0
	4.4	Other operating costs		520 €
		441	Other operating costs	520 €

Table 38. UC5. Operation costs (2030)

5. **MAINTENANCE (C_{mai}).** These are the maintenance costs of the charging equipment in the site:

- 5.1 Preventive maintenance
- 5.2 Corrective maintenance

5.	MAINTENANCE 2030			4.050 €
	5.1.	Preventive maintenance		1,880 €
		511	System inspection and testing	1,880 €
	5.2.	Corrective maintenance		2,169 €
		521	System unplanned repairs	723 €
		522	Small repairs	1,446 €

Table 39. Maintenance Costs (2030)

6. **RENEWAL COSTS (C_{ren}).** Is the value when the asset is renewed (not necessarily the whole charging hub, but at least a part of it). This cost category differentiates two types of action:

- 6.1. Major repairs.
- 6.2. Refurbishment in major repairs.

6.	**RENEWAL COSTS 2036**				12,913 €
	6.1.	Major repairs			11,376 €
		611	Site repair	Equip& Labour	5,800 €
		612	Power supply refurbishment	Equip& Labour	935 €
		613	Power converter replacement	Equip& Labour	1,803 €
		614	Cables, screen, signaling or plugs replacement	Equip& Labour	1,104 €
		615	Auxiliary systems replacement	Equip& Labour	280 €
		616	Site-level control and monitoring sys replacement	Equip& Labour	1,454 €
	6.2	Refurbishment in major repairs			1,537 €
		621	Repainting road surface and signs	Cons & labour	1,537 €

Table 40. UC5. Renewal costs (year 7)

7. **DISPOSAL COSTS (C_{dis}).** The disposal costs have been split into two concepts:

- **7.1 Cost of assets disposal**. activities have a labor and equipment cost.
- **7.2. Residual value**. The recovered materials could have a residual value that would lower the overall activity cost. In this case, it is even a negative cost, becoming an income.

7.	DISPOSAL COSTS				-5,382 €
	7.1.	Cost of assets disposal			6,880 €
		711	Labour for asset disposal	Labour	1,771 €
		712	Equipment for asset disposal	Outsource	5,109 €
	7.2.	Residual value			-12,262 €
		721	Recovered incomes for residual value	Others	-12,262 €

Table 41. Disposal Costs (year 15)

6.3 Life-cycle costs calculation

6.3.1 CAPEX

Given the type of charging system, the initial capital cost is calculated as follows:

$$CAPEX = C_{RTD} + C_{eng} + C_{inf}$$

The input data and the assumptions (section 6.1.2) were applied to calculate the CAPEX, which is an upfront cost accounted in 2029, right before the asset enters in operation in 2030.

The design and engineering costs in 2029 are calculated based on the pilot costs, considering that only 25% of the initial costs (2024) are engineering, and 75% go directly as R&D costs. These R&D costs are amortized among all the chargers to be manufactured in the future (100 units).

Infrastructure expenditure is estimated to decrease around 2% per year from the baseline year (2030).

		2029
1. R&D		2,471 €
Fix amount to amortize R&D investment (Nº units: 100)		2,471 €
2. DESIGN AND ENGINEERING		32,350 €
2.1.	Equipment design and engineering	3.750 €
2.2.	Project-site design and engineering	18.600 €
3. INFRASTRUCTURE		107.012 €
3.1.	Construction costs	2.893 €
3.2.	Electric Infrastructure	101.517 €
3.3.	Site level control and monitoring system	2,603 €
TOTAL CAPEX (Excluding Vehicles' adaptation)		141.883 €

Table 42. UC5. Capex Summary

6.3.2 OPEX

Given the type of charging system, the OPEX is calculated as follows:

$$OPEX = C_{ope} + C_{mai} + C_{ren} + C_{dis}$$

The input data and the assumptions (section 6.1.2) were applied to calculate the OPEX, which is computed annually taking in consideration some factors:

The operation and maintenance costs are continually optimized, decreasing 2% per year for the whole lifetime of the asset. The infrastructure is partially renewed during its useful life. At the end of the period, which is estimated in 15 years, it is disposed, and its residual value recovered.

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UC5 OPEX	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
4. OPERATION	50,261 €	7,178 €	7,034 €	6,894 €	6,756 €	6,621 €	6,488 €	6,359 €	6,231 €	6,107 €	5,985 €	5,865 €	5,748 €	5,633 €	5,520 €
4.1. Labor	4,050 €	3,969 €	3,889 €	3,811 €	3,735 €	3,660 €	3,587 €	3,516 €	3,445 €	3,376 €	3,309 €	3,243 €	3,178 €	3,114 €	3,052 €
4.2. Consumables	2,350 €	2,303 €	2,257 €	2,212 €	2,168 €	2,124 €	2,082 €	2,040 €	1,999 €	1,959 €	1,920 €	1,882 €	1,844 €	1,807 €	1,771 €
4.3. Equipment	42.936 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
4.4. Overtime and outsource	405 €	397 €	389 €	381 €	374 €	366 €	359 €	352 €	345 €	338 €	331 €	324 €	318 €	311 €	305 €
4.5. Other operating costs	520 €	509 €	499 €	489 €	479 €	470 €	460 €	451 €	442 €	433 €	425 €	416 €	408 €	400 €	392 €
5. MAINTENANCE	4,050 €	3,969 €	3,889 €	3,811 €	3,735 €	3,660 €	3,587 €	3,516 €	3,445 €	3,376 €	3,309 €	3,243 €	3,178 €	3,114 €	3,052 €
5.1. Preventive maintenance	1,880 €	1,843 €	1,806 €	1,770 €	1,734 €	1,700 €	1,666 €	1,632 €	1,600 €	1,568 €	1,536 €	1,505 €	1,475 €	1,446 €	1,417 €
5.2. Corrective maintenance	2,169 €	2,126 €	2,084 €	2,042 €	2,001 €	1,961 €	1,922 €	1,883 €	1,846 €	1,809 €	1,773 €	1,737 €	1,702 €	1,668 €	1,635 €
6. RENEWAL COSTS	0 €	0 €	0 €	0 €	0 €	0 €	12,913 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.1. Major repairs	0 €	0 €	0 €	0 €	0 €	0 €	11,376 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.2. Refurbishment	0 €	0 €	0 €	0 €	0 €	0 €	1,537 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
7. DISPOSAL COSTS	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-5,382 €
7.1. Cost of assets disposal	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	6,880 €
7.2. Residual value	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-12,262 €
TOTAL OPEX	54,310 €	11,147 €	10,924 €	10,705 €	10,491 €	10,281 €	22,989 €	9,874 €	9,677 €	9,483 €	9,293 €	9,108 €	8,925 €	8,747 €	3,190 €

Table 43. UC5. OPEX costs

6.3.3 CAPEX + OPEX

SUMMARY	TOTAL	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Costs undiscounted	340,977 €	141,833 €	54,310 €	11,147 €	10,924 €	10,705 €	10,491 €	10,281 €	22,989 €	9,874 €	9,677 €	9,483 €	9,293 €	9,108 €	8,925 €	8,747 €	3,190 €
Present Value of Costs discounted	283,750 €	141,833 €	50,996 €	9,827 €	9,043 €	8,321 €	7,657 €	7,046 €	14,793 €	5,966 €	5,490 €	5,052 €	4,649 €	4,278 €	3,936 €	3,622 €	1,240 €
WACC	6,5%	1,000	0,939	0,882	0,828	0,777	0,730	0,685	0,644	0,604	0,567	0,533	0,500	0,470	0,441	0,414	0,389

Table 44. UC5. Present Value of Cost discounted (WACC, 6.5%)

Average Annualized Costs (undiscounted)	22,732 €
Average Annualized Costs (Discounted)	18,917 €

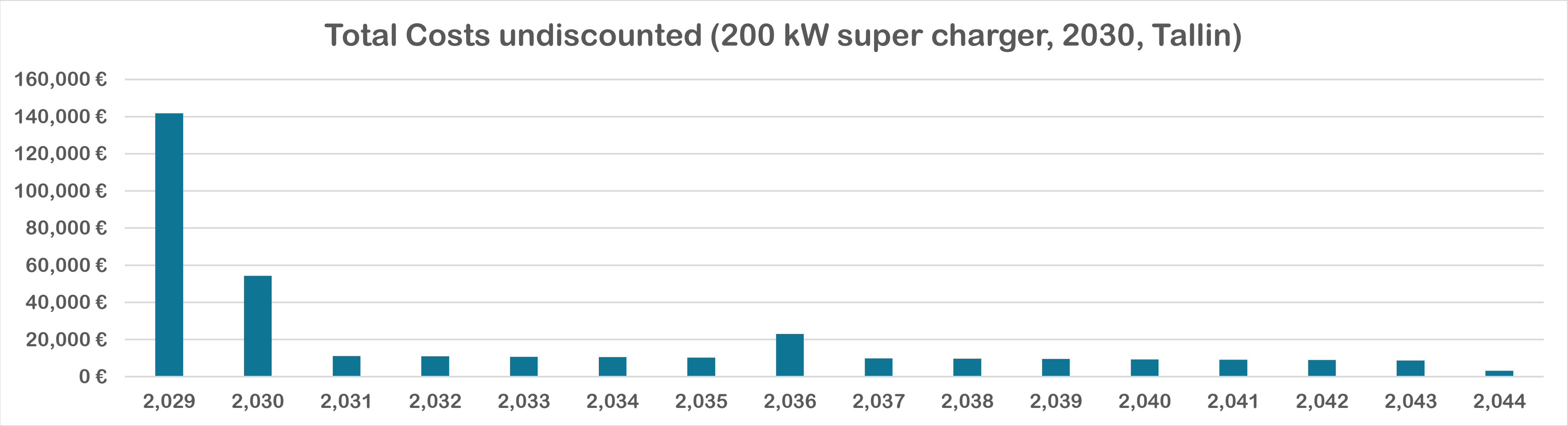

Figure 12. UC5. Total Costs undiscounted diagram

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The “total costs undiscounted” adds up each year’s CAPEX and OPEX considering a 0% inflation rate.

The “present value of the costs discounted” considers a discount rate (WACC) of 6,5% and gives a total value of 267.078 €.

6.4 Analysis of results

6.4.1 Summary of results

One unit of the fast charger would have a life cycle cost of around 283 750 € (including CAPEX and OPEX discounted at 6.5%) from 2030 onwards, which is a substantial reduction of the current costs as the analysis includes the hypothesis of lower engineering costs, that would be amortized as R&D costs among all the installations, and an important optimization of operation and maintenance.

LCCA	**unit**	**2.025**	**2.030**	**2.035**
CAPEX (Infrastructure)	€	249,287 €	141,833 €	119,452 €
OPEX (except electricity, undiscounted)	€	220,311 €	199,144 €	180,010 €
TOTAL COSTS (Undiscounted)	**€**	469,598 €	340,977 €	299,462 €
Annualized Costs (undiscounted)	€	31,307 €	22,732 €	19,964 €
PV COSTS (Discounted)	**€**	406,289 €	283,750 €	247,734 €
Annualized Costs (Discounted)	€	27,086 €	18,917 €	16,516 €

Table 45. UC5. LCCA Results

WACC	%	6.5%	6.5%	6.5%
Lifetime	years	15	15	15

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7 UC6 - LCCA RESULTS

7.1 UC6 Description and scope of the LCCA

7.1.1 LCCA scope. UC6. 25 kW (2 fast CPs + 4 slow CPs) for two wheelers (ZARAGOZA)

UC6 is titled ***"Low power DC bidirectional charging infrastructure for EV, including two-wheelers"***. This demonstrator aimed to proof the technical and economic feasibility of a multi-modal charging station in urban area made up of two different chargers: 1) a controllable low power bi-directional CHAdeMO and CCS DC charger (V2X) with an output power between 7,4 kW – 25 kW per vehicle, integrated in a DC micro grid; and 2) a theft proof charging station rack for shared bicycles or other two wheeled vehicles, with an output power ranging from 120 W up to 3,4 kW to charge multiple e-scooters at the same time, disposed in parallel to the rest of charging points.

The complete solution will be able to integrate AC/DC converters for the connection of REs (Renovables) and ESs (Energy Storage) 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. However, for the LCCA, only the charging function and related cost concepts are considered.

7.1.2 Other assumptions

Reference year for initial data	2024 input data
Reference year for LCCA	2029
Power rating of each module	25 kW x 1 unit; CHAdeMO and CSS 200 W x 2 units rack for s-cooters
Lifetime	15 years
WACC	6.5%
Vehicle type	Standard EV
Number of chargers used to amortize the investment in RTD costs.	200
Engineering optimization from the pilot to commercial versions	75% optimization for product engineering 50% optimization for site engineering
Cost optimization from learning effects	All costs are optimized 2% annually
Major repairs	Renewal costs are considered in year 7

Table 46. UC6 Main Assumptions

7.2 Identification of relevant cost concepts 2030

The identification of costs for UC6 was done following the same sequence of activities applicable to all Use Cases (figure 2).

1. **PRELIMINARY RTD (C_{RTD}).** The research and development activities were very diverse in this case. Therefore, several research and technology development categories have been defined for the cost analysis:

    - 1.1 RTD on hardware performed by CIRCE
    - 1.2 RTD on software performed by CIRCE

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- 1.3 RTD on system architecture performed by IDNEO
- 1.4 RTD on hardware and ECAD performed by IDNEO
- 1.5 RTD on software performed by IDNEO
- 1.6 RTD on mechanics performed by IDNEO

1	PRELIMINARY R+D (TO AMORTISIZE, 660,549 € in 200 units)	3,303 €

Table 47. UC6. Preliminary R&D

2. **DESIGN AND ENGINEERING (C_{eng}).** This category, for the UC6, includes four main activities:

- **2.1 Product design and engineering** for the EV low power bi-directional charger developed by CIRCE.
- **2.2 Project-site design and engineering** for the EV low power bi-directional charger developed by CIRCE.
- **2.3 Product design and engineering** for the two-wheeler theft proof charging station rack developed by IDNEO
- 2.4 **Project-site design and engineering** for the two-wheeler theft proof charging station rack developed by IDNEO

2	DESIGN AND ENGINEERING		**75,096 €**
	2.1.	Product design and engineering	67,096 €
	2.2	Project-site design and engineering	8,000 €

Table 48. UC6. Design and Engineering Costs

3. **INFRASTRUCTURE (C_{inf}).** This category groups all the identified material costs in three blocks:

- **3.1 Site conditioning**: civil works to prepare the ground, move the materials and prepare the pavement.
- **3.2 Electric infrastructure**: power electronics, electric protections, cables, cabinets, etc.
- **3.3 Site-level control and monitoring system**: control devices and their installation.

3	INFRASTRUCTURE			37,517 €
	3.1	Site conditioning		6,056 €
	3.2	Electric infrastructure		31,325 €
		321	Two wheels prototypes	7,970 €
		322	Power electronics – converters	3,589 €
		323	Cabinet, screen, signalling, plugs and other components	2,554 €
		324	Auxiliary systems	264 €
		325	Equipment	16,949 €
	3.3	Site-level control and monitoring system		136 €
		331	Site-level control and monitoring system	136 €

Table 49. UC6. Infrastructure Costs

4. **OPERATION (C_{ope}).** It is assumed that the operation requires human labor, consumables and other general expenses to ensure the seamless operation of the charging station. This could include metering, billing, or customer service.

- **4.1 Labor**.
- **4.2 Consumables**.
- **4.3 Overtime and outsource**.

- **4.4 General expenses**.

4.	OPERATION 2030			17,473 €
	4.1	Labor		2,712 €
		411	Management labour	904 €
		412	Metering and billing administration	904 €
		413	Customer service	904 €
	4.2	Consumables		1,582 €
		421	Advertising and marketing	452 €
		422	Software and data bases	1,130 €
	4.3	Equipment		10,305 €
		431	Billing Equipment	2,169 €
		432	IT Equipment	2,712 €
		433	Communication Equipment	2,712 €
		434	Traffic management equipment	2,712 €
	4.4	Overtime and outsource		1,971 €
		441	Labour overtime (10% Labour costs)	163 €
		442	Outsource (external services)	1,808 €
	4.4	General expenses		452 €
		441	General expenses	452 €

Table 50. UC6. Operation Costs 2030

5. **MAINTENANCE (C_{mai}).** These are the maintenance costs of the charging equipment in the site:

- 5.1 Preventive maintenance
- 5.2 Corrective maintenance

5.	MAINTENANCE 2030			4,181 €
	5.1.	Preventive maintenance		2,034 €
		511	System inspection and testing	2,034 €
	5.2.	Corrective maintenance		2,147 €
		521	System unplanned repairs	339 €
		522	Small repairs	1,808 €

Table 51. UC6. Maintenance costs 2030

6. **RENEWAL COSTS (C_{ren}).** Is the value when the asset is renewed (not necessarily the whole charging hub, but at least a part of it). This cost category differentiates two types of action:

- **6.1. Major repairs**.
- **6.2. Refurbishment in major repairs**.

6.	**RENEWAL COSTS 2036**				9,113 €
	6.1.	Major repairs			3,988 €
		611	Charger refurbishment	Equip& Labour	3,988 €
	6.2	Refurbishment in major repairs			5,125 €
		621	Site Refurbishment	Cons & labour	5,125 €

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Table 52. UC6. Renewal costs (year 7)

7. **DISPOSAL COSTS (C_{dis}).** The disposal costs have been split into two concepts:

- **7.1 Cost of assets disposal**. activities have a labor and equipment cost.
- **7.2. Residual value**. The recovered materials could have a residual value that would lower the overall activity cost. In this case, it is even a negative cost, becoming an income.

7.	DISPOSAL COSTS				917 €
	7.1.	Cost of assets disposal			2,725 €
		711	Labour for asset disposal	Labour	681 €
		712	Equipment for asset disposal	Outsource	2,044 €
	7.2.	Residual value			-1,808 €
		721	Recovered incomes for residual value	Others	-1,808 €

Table 53. UC6. Disposal Costs (year 15)

7.3 Life-cycle costs calculation

7.3.1 CAPEX

Given the type of charging system, the initial capital cost is calculated as follows:

$$CAPEX = C_{RTD} + C_{eng} + C_{inf}$$

The input data and the assumptions (section 7.1.2) were applied to calculate the CAPEX, which is an upfront cost accounted in 2024, 2029 and 2034, right before the infrastructure enters in operation. As mentioned before, the figures are shown in this report for 2029.

The research costs in 2029 are the sum up of the Research costs in 2024, plus the 75% of the Design and Engineering costs plus the 50% of the infrastructure costs in same year, but distributed among 200 chargers totalizing 536,224 € (or 2,681 € to add to any new installation)

Infrastructure expenditure is estimated to decrease 2% per year from the baseline year (2029).

		2029
1. R&D		3,303 €
Fix amount to amortize R&D investment (Nº units: 200)		3,303 €
2. DESIGN AND ENGINEERING		75,096 €
2.1.	Equipment design and engineering	67,096 €
2.2.	Project-site design and engineering	8,000 €
3. INFRASTRUCTURE		37,325 €
3.1.	Site conditioning	6,056 €
3.2.	Electric Infrastructure	31,325 €
3.3.	Site-level control and monitoring system	136 €
TOTAL CAPEX (Excluding Vehicles' adaptation)		115,916 €

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Table 54. UC6. CAPEX Summary

7.3.2 OPEX

Given the type of charging system, the OPEX is calculated as follows:

$$OPEX = C_{ope} + C_{mai} + C_{ren} + C_{dis}$$

The input data and the assumptions (section 7.1.2) were applied to calculate the OPEX, which is computed annually taking in consideration some factors:

The operation and maintenance costs are continually optimized, decreasing 2% per year for the whole lifetime of the asset. The infrastructure is partially renewed during its useful life. At the end of the period, which is estimated in 15 years, it is disposed with some residual value.

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UC6. OPEX		TOTAL	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
4. OPERATION		98,095 €	17,021 €	6,582 €	6,450 €	6,321 €	6,195 €	6,071 €	5,949 €	5,830 €	5,714 €	5,600 €	5,488 €	5,378 €	5,270 €	5,165 €	5,062 €
4.1.	Labor	35,447 €	2,712 €	2,658 €	2,604 €	2,552 €	2,501 €	2,451 €	2,402 €	2,354 €	2,307 €	2,261 €	2,216 €	2,171 €	2,128 €	2,085 €	2,044 €
4.2.	Consumables	20,677 €	1,582 €	1,550 €	1,519 €	1,489 €	1,459 €	1,430 €	1,401 €	1,373 €	1,346 €	1,319 €	1,292 €	1,267 €	1,241 €	1,216 €	1,192 €
4.3.	Equipment	10,305 €	10,305 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
4.3.	Overtime and outsource	25,758 €	1,971 €	1,931 €	1,893 €	1,855 €	1,818 €	1,781 €	1,746 €	1,711 €	1,676 €	1,643 €	1,610 €	1,578 €	1,546 €	1,515 €	1,485 €
4.4.	General expenses	5,908 €	452 €	443 €	434 €	425 €	417 €	409 €	400 €	392 €	385 €	377 €	369 €	362 €	355 €	348 €	341 €
5. MAINTENANCE		54,647 €	4,181 €	4,097 €	4,015 €	3,935 €	3,856 €	3,779 €	3,703 €	3,629 €	3,557 €	3,486 €	3,416 €	3,348 €	3,281 €	3,215 €	3,151 €
5.1.	Preventive maintenance	26,585 €	2,034 €	1,993 €	1,953 €	1,914 €	1,876 €	1,838 €	1,802 €	1,766 €	1,730 €	1,696 €	1,662 €	1,629 €	1,596 €	1,564 €	1,533 €
5.2.	Corrective maintenance	28,062 €	2,147 €	2,104 €	2,062 €	2,021 €	1,980 €	1,941 €	1,902 €	1,864 €	1,826 €	1,790 €	1,754 €	1,719 €	1,685 €	1,651 €	1,618 €
6. RENEWAL COSTS		9,113 €	0 €	0 €	0 €	0 €	0 €	0 €	9,113 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.1.	Charger refurbishment	3,988 €	0 €	0 €	0 €	0 €	0 €	0 €	3,988 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.2.	Site refurbishment	5,125 €	0 €	0 €	0 €	0 €	0 €	0 €	5,125 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
7. DISPOSAL COSTS		917 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	917 €
7.1.	Cost of assets disposal	2,725 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	2,725 €
7.2.	Residual value	-1,808 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-1,808 €
TOTAL OPEX		**162,772 €**	21,201 €	10,679 €	10,465 €	10,256 €	10,051 €	9,850 €	18,766 €	9,460 €	9,271 €	9,085 €	8,903 €	8,725 €	8,551 €	8,380 €	9,129 €

Table 55. UC6. OPEX

7.3.3 CAPEX + OPEX

SUMMARY	TOTAL	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Costs undiscounted	278,688 €	115,916 €	21,201 €	10,679 €	10,465 €	10,256 €	10,051 €	9,850 €	18,766 €	9,460 €	9,271 €	9,085 €	8,903 €	8,725 €	8,551 €	8,380 €	9,129 €
Present Value of Costs discounted	223,195 €	115,916 €	19,907 €	9,415 €	8,664 €	7,972 €	7,336 €	6,750 €	12,076 €	5,716 €	5,260 €	4,840 €	4,454 €	4,098 €	3,771 €	3,470 €	3,550 €
WACC	6.5%	1.000	0.939	0.882	0.828	0.777	0.730	0.685	0.644	0.604	0.567	0.533	0.500	0.470	0.441	0.414	0.389

Table 56. UC6. Present Value of Costs discounted (WACC, 6.5%)

Average Annualized Costs (undiscounted)	18,579 €
Average Annualized Costs (Discounted)	14,880 €

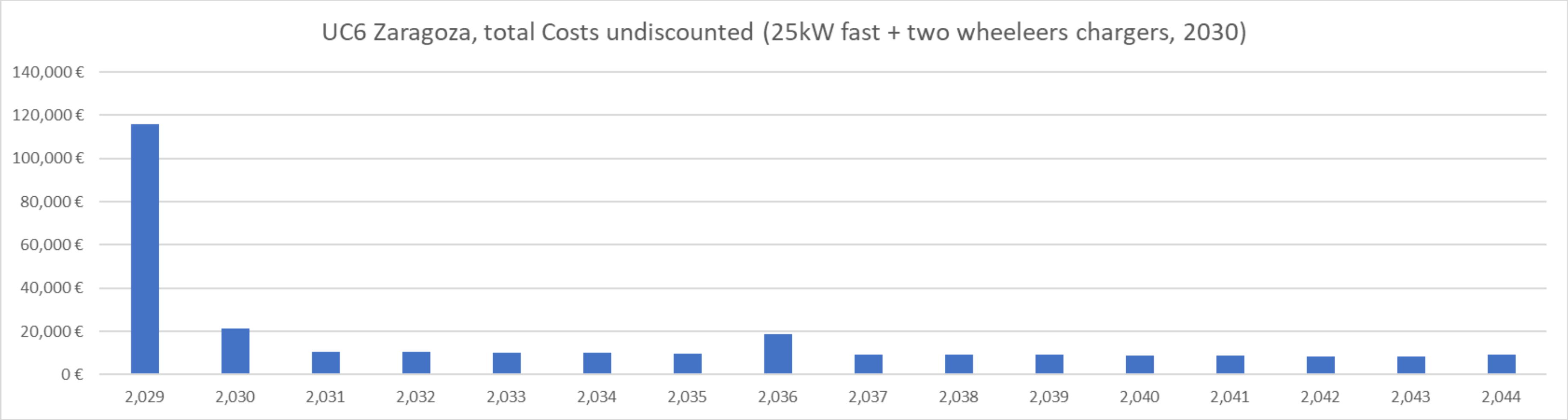

Figure 13. UC6. Total Costs undiscounted diagram

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The “total costs undiscounted” adds up each year’s CAPEX and OPEX considering a 0% inflation rate.

The “present value of the costs discounted” considers a discount rate (WACC) of 7% and gives a total value of 214,932 €.

7.4 Analysis of results

7.4.1 Summary of results

One unit of the project demonstrator (One 25 kW fast and 2 e-scooters charger) might have a life cycle cost of around 243,914 € from 2030 onwards (undiscounted), which is a substantial reduction of the current costs as the analysis includes the hypothesis of lower engineering costs, that would be amortized as the R&D costs and an important optimization of operation and maintenance.

LCCA	**unit**	**2.025**	**2.030**	**2.035**
CAPEX (Infrastructure)	€	127,886 €	115,916 €	105,096 €
OPEX (except electricity, undiscounted)	€	180,073 €	162,772 €	147,133 €
TOTAL COSTS (Undiscounted)	**€**	307,959 €	278,688 €	252,229 €
Annualized Costs (undiscounted)	€	20,531 €	18,579 €	16,815 €
PV COSTS (Discounted)	**€**	246,567 €	223,195 €	202,068 €
Annualized Costs (Discounted)	€	16,438 €	14,880 €	13,471 €

Nº EV Zaragoza	units	13.107	38.539	60.171
Nº Chargers level 3 (22 kW to 120 kW)	units	20	66	122

Table 57. UC6. LCCA Results

WACC	%	6.5%	6.5%	6.5%
Lifetime	years	15	15	15

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8 UC7 - LCCA RESULTS

8.1 UC7 Description and scope of the LCCA

8.1.1 LCCA scope. UC7. 50 kW Opportunity OSWC

UC7 is titled ***"Opportunity wireless charging"***. This demonstrator aimed to proof the technical and economic feasibility of a static wireless charging system with V2X capability. It is aimed to work incorporated in taxi stops such as the ones at airports or central stations for the opportunity charging of electric taxi vehicles.

The complete system consists of a single unit of 50 kW/85 kHz inductive charger, formed by the electromagnetic system, which function is to transmit power through the phenomenon of electromagnetic induction through a coil; power electronics, which feeds the inductive system through a control system; and the cooling system that evacuates the excess heat generated in the electromagnetic system. For this analysis, a single unit is considered.

8.1.2 Other assumptions

Reference year for input data	2024 input data
Reference year for LCCA analysis	2034
Power rating of each module	50 kW
Number of charging pads	1
Lifetime	15 years
WACC	6.5%
Design & Engineering optimization from the pilot to commercial versions	75% of costs in 2024 are moved to R&D in 2034 Infrastructure expenditure is kept the same
Vehicle type	Standard EV + adaptation
Cost optimization from learning effects in 2030 onward	2% yearly reduction
Major repairs	Renewal costs are set in year 7

Table 58. UC7 Main assumptions

8.2 Identification of relevant cost concepts 2035

The identification of costs for UC7 was done following the same sequence of activities that are applicable to all inductive Use Cases (figure 2). Vehicle adaptation was included between infrastructure construction and operation, but it is not included in the infrastructure LCCA.

1. **PRELIMINARY RTD** (C_{RTD}). The preliminary research and development activities were not explicitly considered in this case. Instead, they were included in the design and engineering phase. In 2029 the expense allocated in R&D were the 75% of the Design and Engineering costs and distributed among 100 units.

1	PRELIMINARY R+D (TO AMORTISIZE)		878 €
	1.1	R&D on hardware and software	878 €

Table 59. UC7. Preliminary R&D

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2. **PROJECT DESIGN AND ENGINEERING (C_{eng}).** This category includes two main activities**:**

- **2.1 Equipment design and engineering**: analyses, specification of technical features, dimensioning, elaboration of diagrams, calculations, electrical drawings, bill of materials, layout and other tasks to define the details of the inductive power charging systems: 1) Charging pad, 2) electronics, and 3) cooling system.
- **2.2 Project-site design and engineering**: has considered four concepts: system location selection and preparation, civil works project, inductive manhole design and electric requirements.

2	PROJECT DESIGN AND ENGINEERING 2034			23,899 €
	2.1.	Equipment design and engineering		18,384 €
		211	Charging pad	9,805 €
		212	Electronic system	6,128 €
		213	Cooling system	2,451 €
	2.2.	Project-site design and engineering		5,515 €
		221	System emplacement	1,226 €
		222	Civil Works project	2,451 €
		223	Inductive manhole design	1,226 €
		224	Electric installation requirements	613 €

Table 60. UC7. Project Design and Engineering

3. **INFRASTRUCTURE EXPENDITURE (C_{inf}).** This category groups all the identified material costs in two blocks:

- **3.1 Civil works**: civil works to prepare the ground, move the materials and prepare the pavement.
- **3.2 Electric infrastructure**: power electronics, electric protections, cables, coils, filters, cabinets, etc.

3	INFRASTRUCTURE EXPENDITURE 2034			41,115 €
	3.1.	Civil costs (pavement)		9,888 €
		311	Pavement demolition and cutting	2,206 €
		312	Ground removal and transport	245 €
		313	Trenches filling	564 €
		314	Marking lines painting	245 €
		315	Channelling	695 €
		316	Junction manholes	208 €
		317	Inductive manhole	3,083 €
		318	Cabinets pedestals and anchoring	456 €
		319	Material testing	113 €
		3110	Waste management study	236 €
		3111	Health and safety study	1,838 €
	3.2.	Electric and electronics Infrastructure		31,227 €
		321	Power Supply, AC/DC and DC/AC converters	9,269 €
		322	Charging pad (transmitter coil)	5,320 €
		323	Electronics cabinet	10,631 €
		324	Refrigeration cabinet	6,007 €

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Table 61. UC7. UC7. Infrastructure Costs

A. **VEHICLE ADAPTATION (C_{adap}).** For the accounting of costs, it was considered that, for being compatible with the wireless charging pad, the electric vehicle (with conventional conductive interface) has to be adapted adding an inductive module.

A	VEHICLE ADAPTATION			42,406 €
	A.1.	Electric Vehicle adaptation		42,406 €
		A11	Vehicle's cost	26,146 €
		A12	Vehicle Power Adaptation	16,260 €

Table 62. Vehicle Adaptation Costs

4. **OPERATION (C_{ope}).** It is assumed that the operation includes:

- **4.1 Labor**. Activities that require human labor such as metering and billing, traffic management, or customer service
- **4.2 Consumables**.
- **4.3 Equipment**. It is assumed that additional equipment is required for such purposes (e.g., billing and IT equipment).
- **4.4 Overtime and outsource**.
- **4.5 Other operating costs**.

4.	OPERATION 2035			18,719 €
	4.1.	Labor		2,712 €
		411	Traffic management labour	904 €
		412	Metering and billing administration	904 €
		413	Customer service	904 €
	4.2.	Consumables		3,164 €
		421	Advertising and marketing	904 €
		422	Software and data bases	2,260 €
	4.3	Equipment		12,256 €
	15	431	Billing Equipment	4,902 €
	15	432	IT Equipment	2,451 €
	15	433	Communication Equipment	2,451 €
	15	434	Traffic management equipment	2,451 €
	3.4	Overtime and outsource		136 €
		441	Labour overtime (5% Labour costs)	136 €
		442	Outsource (external services)	0 €
	3.4	Other operating costs		452 €
		441	Other operating costs	452 €

Table 63. UC7. OPEX 2035

5. **MAINTENANCE (C_{mai}).**

- 6.1 Preventive maintenance
- 6.2 Corrective maintenance

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5.	MAINTENANCE OF OWPT 2035			5,085 €
	5.1.	Preventive maintenance		2,034 €
		511	System inspection and testing	2,034 €
	5.2.	Corrective maintenance		3,051 €
		521	System unplanned repairs	339 €
		522	Small repairs	2,712 €

Table 64. UC7. Maintenance Costs 2035

6. RENEWAL COSTS OF E-CORRIDOR (C_{ren}). Is the value when the asset is renewed (at least a part of it). This cost category differentiates two types of action:

- **6.1. major repairs**.
- **6.2. refurbishment in major repairs**.

6.	**RENEWAL COSTS 2041**				14,005 €
	6.1.	Major repairs			13,716 €
		611	DWPT primary coil replacement	Equip& Labour	724 €
		612	DWPT power electronics replacement	Equip& Labour	832 €
		613	Energy Meter replacement	Equip& Labour	4,705 €
		614	Cable replacement	Equip& Labour	2,895 €
		615	Charging control equipment replacement	Equip& Labour	760 €
		616	Roadside & in road sensors replacement	Equip& Labour	3,800 €
	6.2	Refurbishment in major repairs			290 €
		621	Repainting road surface and signs	Cons & labour	290 €

Table 65. UC7. Renewal Costs (year 7)

7. DISPOSAL COSTS (C_{dis}). The disposal costs have been split into two concepts:

- **7.1 Cost of assets disposal**. activities have a labor and equipment cost.
- **7.2. Residual value**. The recovered materials could have a residual value that would lower the overall activity cost.

7.	**DISPOSAL COSTS, 2049**				1,232 €
	7.1.	Cost of assets disposal			4,310 €
		711	Labour for asset disposal	Labour	1,232 €
		712	Equipment for asset disposal	Outsource	3,079 €
	7.2.	Residual value			-3,079 €
		721	Recovered incomes for residual value	Others	-3,079 €

Table 66. UC7. Disposal Costs (year 15)

8.3 Life-cycle costs calculation

8.3.1 CAPEX

Given the type of charging system, the initial capital cost is calculated as follows:

$$CAPEX = C_{RTD} + C_{eng} + C_{inf}$$

The input data and the assumptions (section 9.1.2) were applied to calculate the CAPEX, which is an upfront cost accounted in 2034, right before the infrastructure enters in operation in 2035.

The design and engineering costs in 2024 are calculated as 25% of the initial engineering costs (2024), while the remaining 75% is considered as R&D.

Infrastructure expenditure by 2034 is estimated to be around 10% of the costs (2029) due to the improvement of this non-mature technology (2% reduction annually).

Vehicle adaptation is not considered as a cost in the lifecycle analysis, as it is not assumed by the asset owner.

		2034
1. R&D		878 €
Fix amount to amortize R&D investment (Nº units: 10)		878 €
2. DESIGN AND ENGINEERING		23,899 €
2.1.	Equipment design and engineering	18,384 €
2.2.	Project-site design and engineering	5,515 €
3. INFRASTRUCTURE EXPENDITURE		41,115 €
3.1.	Construction costs (pavement)	9,888 €
3.2.	Electric Infrastruture	31,227 €
TOTAL CAPEX (Excluding Vehicles' adaptation)		**65,891 €**

Table 67. UC7. CAPEX Summary

8.3.2 OPEX

Given the type of charging system, the OPEX is calculated as follows:

$$OPEX = C_{ope} + C_{mai} + C_{ren} + C_{dis}$$

The input data and the assumptions (section 8.1.2) were applied to calculate the OPEX, which is computed annually taking in consideration some factors:

The operation and maintenance costs are continually optimized, applying a discount factor of 2% per year for the whole lifetime of the asset. The infrastructure for billing and communication is partially renewed during its useful life in year 7. At the end of the period, which is estimated in 15 years, it is disposed with a certain residual value.

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UC7. OPEX	TOTAL	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
4. OPERATION	96,738 €	18,719 €	6,334 €	6,207 €	6,083 €	5,961 €	5,842 €	5,725 €	5,611 €	5,499 €	5,389 €	5,281 €	5,175 €	5,072 €	4,970 €	4,871 €
4.1. Labor	35,447 €	2,712 €	2,658 €	2,604 €	2,552 €	2,501 €	2,451 €	2,402 €	2,354 €	2,307 €	2,261 €	2,216 €	2,171 €	2,128 €	2,085 €	2,044 €
4.2. Consumables	41,355 €	3,164 €	3,100 €	3,038 €	2,978 €	2,918 €	2,860 €	2,803 €	2,747 €	2,692 €	2,638 €	2,585 €	2,533 €	2,483 €	2,433 €	2,384 €
4.3. Equipment	12,256 €	12,256 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
4.4. Overtime and outsource	1,772 €	136 €	133 €	130 €	128 €	125 €	123 €	120 €	118 €	115 €	113 €	111 €	109 €	106 €	104 €	102 €
4.5. Other operating costs	5,908 €	452 €	443 €	434 €	425 €	417 €	409 €	400 €	392 €	385 €	377 €	369 €	362 €	355 €	348 €	341 €
5. MAINTENANCE	66,463 €	5,085 €	4,983 €	4,883 €	4,786 €	4,690 €	4,596 €	4,504 €	4,414 €	4,326 €	4,239 €	4,154 €	4,071 €	3,990 €	3,910 €	3,832 €
5.1. Preventive maintenance	26,585 €	2,034 €	1,993 €	1,953 €	1,914 €	1,876 €	1,838 €	1,802 €	1,766 €	1,730 €	1,696 €	1,662 €	1,629 €	1,596 €	1,564 €	1,533 €
5.2. Corrective maintenance	39,878 €	3,051 €	2,990 €	2,930 €	2,871 €	2,814 €	2,758 €	2,702 €	2,648 €	2,595 €	2,544 €	2,493 €	2,443 €	2,394 €	2,346 €	2,299 €
6. RENEWAL COSTS	14,005 €	0 €	0 €	0 €	0 €	0 €	0 €	14,005 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.1. Major repairs	13,716 €	0 €	0 €	0 €	0 €	0 €	0 €	13,716 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
6.2. Refurbishment	290 €	0 €	0 €	0 €	0 €	0 €	0 €	290 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
7. DISPOSAL COSTS	1,232 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	1,232 €
7.1. Cost of assets disposal	4,310 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	4,310 €
7.2. Residual value	-3,079 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €	-3,079 €
TOTAL OPEX	**178,438 €**	23,804 €	11,317 €	11,090 €	10,868 €	10,651 €	10,438 €	24,235 €	10,025 €	9,824 €	9,628 €	9,435 €	9,247 €	9,062 €	8,880 €	9,934 €

Table 68. UC7. OPEX

8.3.3 CAPEX + OPEX

SUMMARY	TOTAL	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Total Costs undiscounted	244,329 €	65,891 €	23,804 €	11,317 €	11,090 €	10,868 €	10,651 €	10,438 €	24,235 €	10,025 €	9,824 €	9,628 €	9,435 €	9,247 €	9,062 €	8,880 €	9,934 €
Present Value of Costs discounted	183,731 €	65,891 €	22,351 €	9,977 €	9,181 €	8,448 €	7,774 €	7,154 €	15,595 €	6,057 €	5,574 €	5,129 €	4,720 €	4,343 €	3,996 €	3,677 €	3,863 €
WACC	**6,5%**	**1,000**	**0,939**	**0,882**	**0,828**	**0,777**	**0,730**	**0,685**	**0,644**	**0,604**	**0,567**	**0,533**	**0,500**	**0,470**	**0,441**	**0,414**	**0,389**

Table 69. UC7. Present Value of Costs discounted (WACC, 6.5%)

Average Annualized Costs (undiscounted)	16,289 €
Average Annualized Costs(Discounted)	12,249 €

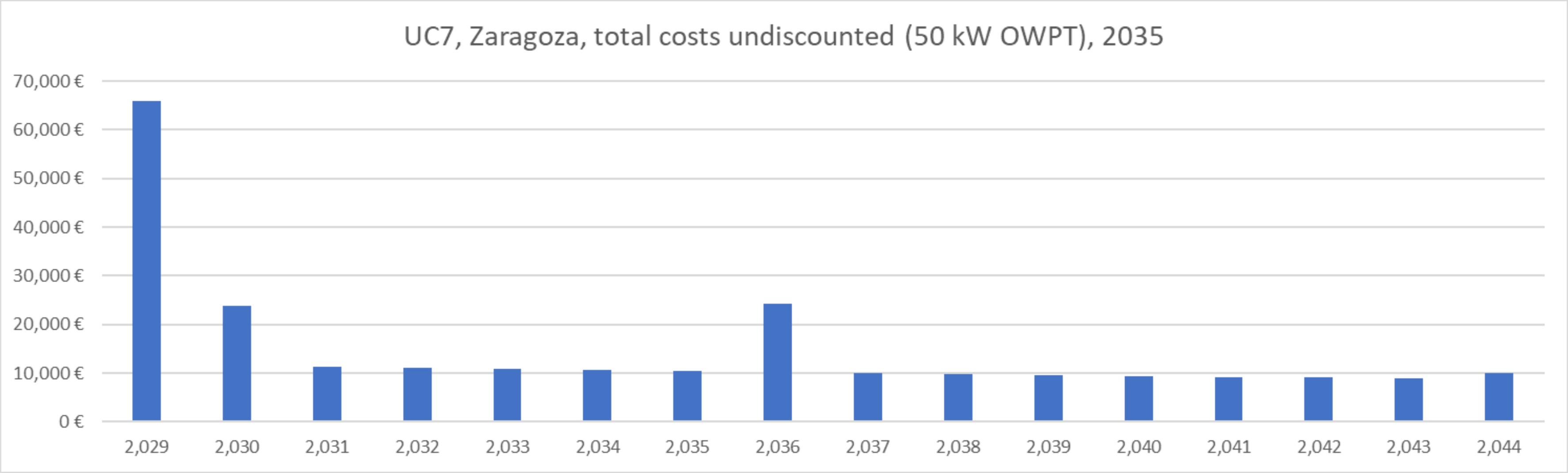

Figure 14. UC7. Total Costs undiscounted diagram

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The “total costs undiscounted” adds up each year’s CAPEX and OPEX considering a 0% inflation rate.

The “present value of the costs discounted” considers a discount rate (WACC) of 6.5% gives a total value of 146,811 €.

8.4 Analysis of results

8.4.1 Summary of results

One unit of the project demonstrator (1 fast and 2 e-scooters charger) would have a life cycle cost of around 185,361 € from 2035 onwards, reducing the current costs thanks to the progressive improvements in engineering and operation and maintenance.

LCCA		**2.030**	**2.035**
CAPEX (Infrastructure)	€	80,447 €	65,891 €
OPEX (except electricity, undiscounted)	€	198,846 €	178,438 €
TOTAL COSTS (Undiscounted)	**€**	279,292 €	244,329 €
Annualized Costs (undiscounted)	€	18,619 €	16,289 €
PV COSTS (Discounted)	€	212,165 €	183,731 €
Annualized Costs (Discounted)	€	14,144 €	12,249 €
CAPEX (1 Vehicle)		51,900	42,406

Table 70. UC7. LCCA Summary

WACC	%	6.5%	6.5%
Lifetime	years	15	15

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9 SUMMARY TABLE

LCCA INCITEV	UC2 500 m	Paris Cent. DWPT	UC3 25 km	Paris Pher. DWPT	UC 4	Turin	Hub 150 kW	UC5	Tallinn	SF 200 kW	UC6	Zaragoza	25 kW	Zaragoza	OWPT 50 kW
	UC2. 1-E-Trench 30 kW, 500 m		UC3. 1 E-Corr.r 90 kW power t., 25 km		UC4. 1 Charger 150 kW and 2 chargers 3.6 kW			UC5. 1 Charger 200 kW			UC6. 1 Charger 25 kW for EV and two wheels			UC7. 1 Charger 50 kW 0WPT	
Years described in the Deliverable in detail	**2030**	**2035**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2030**	**2035**
CAPEX Year 0	**780,208 €**	**708,208 €**	**13,339,819 €**	**12,311,416 €**	**278,937 €**	**252,329 €**	**228,278 €**	**249,287 €**	**141,833 €**	**119,452 €**	**127,886 €**	**115,916 €**	**105,096 €**	**80,447 €**	**65,891 €**
1. R&D	30,831 €	30,831 €	92,644 €	92,644 €	2,000 €	2,000 €	2,000 €	1,500 €	2,471 €	2,471 €	3,303 €	3,303 €	3,303 €	878 €	878 €
2. DESIGN AND ENGINEERING	102,769 €	92,895 €	617,625 €	569,678 €	31,500 €	28,474 €	25,738 €	129,400 €	32,350 €	20,250 €	83,078 €	75,096 €	67,881 €	29,250 €	23,899 €
3. INFRASTRUCTURE	646,608 €	584,483 €	12,629,550 €	11,649,095 €	245,437 €	221,855 €	200,540 €	118,387 €	107,012 €	96,731 €	41,505 €	37,517 €	33,913 €	50,319 €	41,115 €
OPEX (A+B) Year 1	**109,130 €**	**98,644 €**	**375,360 €**	**339,002 €**	**64,724 €**	**58,505 €**	**50,756 €**	**60,083 €**	**54,310 €**	**49,092 €**	**23,455 €**	**21,201 €**	**19,164 €**	**27,775 €**	**23,804 €**
A. Operation Year 1	**83,187 €**	**75,194 €**	**255,360 €**	**230,531 €**	**57,764 €**	**52,214 €**	**45,615 €**	**55,603 €**	**50,261 €**	**45,432 €**	**18,830 €**	**17,021 €**	**15,385 €**	**22,150 €**	**18,719 €**
1. Labour	7,322 €	6,618 €	43,200 €	39,049 €	6,060 €	5,478 €	4,476 €	4,480 €	4,050 €	3,660 €	3,000 €	2,712 €	2,451 €	3,000 €	2,712 €
2. Consumables	3,164 €	2,860 €	105,000 €	94,912 €	3,154 €	2,851 €	2,329 €	2,600 €	2,350 €	2,124 €	1,750 €	1,582 €	1,430 €	3,500 €	3,164 €
3. Equipment	61,280 €	55,393 €	75,000 €	67,500 €	47,500 €	42,936 €	38,035 €	47,500 €	42,936 €	38,811 €	11,400 €	10,305 €	9,315 €	15,000 €	12,256 €
4. Overtime	9,161 €	8,281 €	26,160 €	23,647 €	450 €	407 €	332 €	448 €	405 €	366 €	2,180 €	1,971 €	1,781 €	150 €	136 €
5. Other operating costs	2,260 €	2,043 €	6,000 €	5,424 €	600 €	542 €	443 €	575 €	520 €	470 €	500 €	452 €	409 €	500 €	452 €
B. Maintenance Year 1	**25,943 €**	**23,450 €**	**120,000 €**	**108,470 €**	**6,960 €**	**6,291 €**	**5,140 €**	**4,480 €**	**4,050 €**	**3,660 €**	**4,625 €**	**4,181 €**	**3,779 €**	**5,625 €**	**5,085 €**
Preventive	5,424 €	4,902 €	48,000 €	43,388 €	3,960 €	3,580 €	2,925 €	2,080 €	1,880 €	1,700 €	2,250 €	2,034 €	1,838 €	2,250 €	2,034 €
Corrective	20,519 €	18,548 €	72,000 €	65,082 €	3,000 €	2,712 €	2,216 €	2,400 €	2,169 €	1,961 €	2,375 €	2,147 €	1,941 €	3,375 €	3,051 €
C. Renewal costs Year 7	**271,661 €**	**242,969 €**	**4,258,634 €**	**3,849,468 €**	**27,411 €**	**24,778 €**	**22,397 €**	**14,285 €**	**12,913 €**	**11,672 €**	**10,081 €**	**9,113 €**	**8,237 €**	**15,494 €**	**14,005 €**
Major repairs	241,833 €	218,598 €	3,442,242 €	3,111,514 €	21,742 €	19,653 €	17,765 €	12,585 €	11,376 €	10,283 €	4,412 €	3,988 €	3,605 €	15,174 €	13,716 €
Refurbishment	29,827 €	24,371 €	816,392 €	737,954 €	5,669 €	5,125 €	4,632 €	1,701 €	1,537 €	1,390 €	5,669 €	5,125 €	4,632 €	320 €	290 €
D. Disposal costs Year 15	**27,515 €**	**24,871 €**	**-359,691 €**	**-325,132 €**	**-13,333 €**	**-12,052 €**	**-10,894 €**	**-5,954 €**	**-5,382 €**	**-4,865 €**	**1,015 €**	**917 €**	**829 €**	**1,362 €**	**1,232 €**
Cost of assets disposal	37,601 €	33,989 €	228,894 €	206,902 €	8,667 €	7,834 €	7,081 €	7,612 €	6,880 €	6,219 €	3,015 €	2,725 €	2,463 €	4,769 €	4,310 €
Residual value	-10,086 €	-9,117 €	-588,585 €	-532,034 €	-22,000 €	-19,886 €	-17,976 €	-13,566 €	-12,262 €	-11,084 €	-2,000 €	-1,808 €	-1,634 €	-3,406 €	-3,079 €
Total Costs undiscounted	1,766,124 €	1,596,808 €	21,239,931 €	19,452,198 €	565,659 €	493,446 €	416,009 €	469,598 €	340,977 €	299,462 €	307,959 €	278,688 €	252,229 €	279,292 €	244,329 €
Total Costs discounted	1,424,532 €	1,288,959 €	18,529,713 €	17,002,393 €	480,436 €	423,328 €	363,519 €	406,289 €	283,750 €	247,734 €	246,567 €	223,195 €	202,068 €	212,165 €	183,731 €
Average Annualized Costs (undiscounted)	117,742 €	106,454 €	1,415,995 €	1,296,813 €	37,711 €	32,896 €	27,734 €	31,307 €	22,732 €	19,964 €	20,531 €	18,579 €	16,815 €	18,619 €	16,289 €
Average Annualized Costs(Discounted)	94,969 €	85,931 €	1,235,314 €	1,133,493 €	32,029 €	28,222 €	24,235 €	27,086 €	18,917 €	16,516 €	16,438 €	14,880 €	13,471 €	14,144 €	12,249 €
Lifetime (years)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
WACC (%)	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%

Table 71. Summary Cost table for all IncitEV use cases (assets)

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10 CONCLUSIONS

From the conducted study, we can draw the following conclusions:

General Observations

- All costs associated with new products or services are overestimated because they include R&D costs, the lack of automation in manufacturing and installation processes, and the absence of savings from economies of scale. Therefore, it is difficult to assess what these costs will be once these factors are eliminated. The research has attempted to identify which costs can be eliminated in the future, but the precision level is evidently not very high. The advantage is that once identified, these can be input into the Excel tool, and all costs will be recalculated automatically.
- There are many variables in costs that are hard to predict and can cause significant fluctuations, such as the cost of copper, inflation, operating and maintenance costs of wireless systems, which are currently non-existent, etc.
- For simplicity, the lifespan of all chargers has been considered 15 years, and the WACC is set at 6.5%, although this shouldn't be the case for technologies at lower TRLs, such as wireless systems. In these cases, the WACC should be increased due to the higher project risk, complicating the business model.
- As will be discussed in deliverable D9.5, public chargers tend to have low occupancy. The reason is that they are more expensive than home and office chargers. Being deficit, their business model is hardly sustainable for private investors except in certain cases. Although this will be detailed in deliverable D9.5, it is noted that the two most important factors for making them profitable are the upfront investment and occupancy, although operation and maintenance also play a role.

Conductive Chargers

- UC6: Installing many chargers on public roads does not necessarily increase their usage because the number of vehicles per charger decreases. If only 1% of charging events occur at them, fewer vehicles per charger means less profitability. In general, public chargers should be installed in a proportion consistent with the number of vehicles in circulation, considering how many are driven by professionals with different habits and if there is a high vehicle turnover (e.g., in tourist cities).
- UC6 and UC4: Operating costs increase with the charger's power, but more so with managing various types of chargers in the same hub.
- Maintenance costs follow the same principle. If there is only one type of charger, processes are simplified, while a hub with multiple types complicates maintenance for the same staff due to handling different technologies.
- Even so, concentrating chargers in hubs reduces costs, especially if they are of the same type.
- UC6: In Zaragoza, where there is a scooter service charged at a single point, a collection and control service for these chargers should be organized to prevent vandalism. The business's success depends on their occupancy.
- UC4: The concept in Turin of a hub on the periphery at intermodal exchange nodes is very interesting and could be profitable if the trend of pedestrianizing cities and prioritizing citizens continues. This concept, combined with connection to DC networks, simplifies and reduces costs, potentially being a viable business model.

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- UC5: The concept in Tallinn of high-power superchargers at highway charging stations is doubtful in terms of profitability. Installation and access to medium-voltage lines in remote locations can be very costly. Additionally, the usage of these chargers is only guaranteed during peak periods (holidays and weekends), limiting their profitability. During peak times, however, chargers can become congested, causing frustration.

Wireless Chargers

- For wireless systems at lower TRLs, operating and especially maintenance costs will be very high, as any service interruption will greatly affect profitability. Additionally, being an underground installation, any issue will disrupt the normal road service. They should be independent lanes if they exist to prevent the road blockage.
- UC3: High speed in wireless systems opposes efficient charging because the vehicle spends less time over the coils. To achieve significant charging, the vehicle should stay on the corridor for many kilometres (we calculated 25 km) and receive high power (90 kW). Allowing many cars in the same electric corridor simultaneously poses a major challenge, and their speed should be regulated, possibly through autonomous driving. Without a significant number of cars using the corridor daily, the installation will hardly be profitable as copper prices are rising due to high demand for electrical systems and are expected to continue. It is unclear if users would prefer charging on electric asphalt in exchange for reducing battery size and consequently autonomy, as range anxiety remains a major factor in decision-making for transitioning to electric vehicles.
- UC2: In cities, installation costs will be much higher and more complex to implement for receiving authorizations, not to mention electromagnetic safety issues. As vehicles move slower, their charging capacity per meter increases. However, in UC2, the power transfer is lower. It remains an expensive system to operate and maintain.
- UC7: The OWPT system for taxis at airports seems easier to implement because it is technically not a corridor but a waiting area where the car charges more efficiently while stationary, and costs are lower as no corridor construction is needed. However, profitability is questionable if there is not enough occupancy and sufficient vehicles equipped with the system.

11. ANNEXES

Annex 1. Spreadsheet LCCA UC2

Annex 2. Spreadsheet LCCA UC3

Annex 3. Spreadsheet LCCA UC4

Annex 4. Spreadsheet LCCA UC5

Annex 5. Spreadsheet LCCA UC6

Annex 6. Spreadsheet LCCA UC7

Annex 7. Spreadsheet Combined Results