



MÁSTER UNIVERSITARIO EN INGENIERÍA INDUSTRIAL

TRABAJO FIN DE MÁSTER

Design and Business Model of an Electric Vehicle Charging Station Powered by a PV Plant

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Director: David Vallespín Fontcuberta

Madrid

Julio 2022

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Design and Business Model of an Electric Vehicle Charging Station Powered by a PV
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DISEÑO Y PLAN DE NEGOCIO DE UNA ESTACIÓN DE CARGA PARA VEHÍCULOS ELÉCTRICOS ALIMENTADA POR UNA ESTACIÓN FOTOVOLTAICA

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RESUMEN DEL PROYECTO

En el presente proyecto se demuestra la viabilidad económica y técnica de una electrolinera de carga rápida por una planta fotovoltaica de 169MWp y un sistema de baterías de 168kWh de capacidad. Se ha modelado el tránsito que tendrá la estación fotovoltaica para poder definir el plan de negocio y analizar la viabilidad económica del proyecto. Para ello también se ha realizado el diseño técnico de la estación.

Palabras clave: carga, vehículo eléctrico, fotovoltaica, estación, carga rápida.

1. Introducción

Los combustibles fósiles han constituido casi la única fuente de energía que permite el traslado de personas y mercancía, por mar, tierra y aire durante decenas de años. La invención de los vehículos de combustión supuso un avance inaudito en cuanto a movilidad y todo en su justa medida no es perjudicial, sin embargo, hoy en día el número de vehículos de combustión en todo el mundo está causando estragos, ha sido en el siglo XXI cuando han saltado las alarmas acerca del problema que supone, sobre todo en las grandes ciudades, tanto para el medioambiente como para las personas, que miles de vehículos circulen diariamente emitiendo gases tanto de efecto invernadero como nocivos para la salud al aire que se respira.

En este contexto donde, ante la necesidad de mejorar la calidad del aire de las ciudades y frenar el cambio climático, se presentan nuevas formas de propulsar y dar energía a los vehículos de forma viable, sostenible, limpia y que además presenta mejoras de eficiencia con respecto a las fuentes de energía convencionales.

Actualmente, la fuente de energía que mayor expectación y popularidad está teniendo en el mercado es la energía eléctrica almacenada en baterías de litio, ya que no emite ningún tipo de residuo al utilizarse. Es por ello por lo que organizaciones de países mundiales como la Unión Europea, están abogando por una transición definitiva hacia la movilidad eléctrica, hasta el punto de que se han marcado como objetivo terminar con la venta de vehículos de combustión en 2050.

Sin embargo, la sustitución del parque automovilístico por vehículos eléctricos presenta un reto en cuanto a que el abastecimiento de energía es distinto al de los vehículos convencionales, hasta el punto de que la principal causa que actualmente está frenando el

crecimiento del mercado de los vehículos eléctricos es la falta de infraestructura para la carga de dichos vehículos.

Entre los principales retos que presenta la carga de los vehículos eléctricos se encuentra:

- La estabilidad de la red, ya que se necesitan grandes cantidades de potencia de forma instantánea, pudiendo provocar picos muy irregulares en la curva de demanda.
- La falta de generación eléctrica, ya que el consumo de electricidad aumentará considerablemente, es necesario aumentar la generación con fuentes de energía renovables.
- El tiempo de carga de los vehículos. Aunque actualmente existe la tecnología que permite la carga en 15-30 minutos, falta infraestructura, se necesitan instalar puntos de carga rápida para que la carga de los vehículos no sea un impedimento para el comprador.

2. Definición del Proyecto

Este proyecto tiene como objeto definir un modelo de negocio entorno a la carga de los vehículos eléctricos (una electrolinería), por el nicho de mercado que presentan, ya que se estima que el parque de vehículos eléctricos crezca hasta alcanzar cerca de los 3 millones de vehículos eléctricos en circulación en España en 2030 e incluso los 5 millones según las últimas estimaciones del gobierno español. El tipo de electrolinería que este proyecto presenta se alimenta de un parque fotovoltaico ya construido de alta potencia (169MWp), de forma que la energía eléctrica suministrada a los clientes es completamente limpia, atajando el problema de la estabilidad de la red. Por otro lado, los cargadores serán de carga rápida, permitiendo la carga completa de vehículos eléctricos en menos de 20 minutos, atajando el problema del tiempo de carga de los vehículos eléctricos y acercándolo más a los tiempos de repostaje.

3. Descripción de la metodología

Para conseguir el objetivo, primero se ha realizado un estudio exhaustivo del estado del arte del vehículo eléctrico y de sus modos de carga para poder valorar correctamente las distintas alternativas que hay en el mercado, los problemas a los que se enfrenta y hacer estimaciones coherentes para el modelo de negocio.

Después, se ha modelado en Excel el plan de negocio de la electrolinería, realizando un estudio exhaustivo del mercado español de vehículos eléctricos y su potencial crecimiento, calculando la capacidad de las baterías de estos, sus tiempos de carga y la potencia de carga. Todos estos datos se han cruzado con los datos proporcionados por la DGT de la media de vehículos diarios que pasan cerca del emplazamiento de la electrolinería para hacer una estimación de la cantidad de VE que cargarán en la fotolinera y así calcular los ingresos por la venta de la energía. En el modelado de la rotación se ha tenido en cuenta la estacionalidad de la afluencia de la carretera, ya que une Madrid con Valencia, dos centros económicos importantes del país. El otro factor importante para el cálculo de estos ingresos es el precio: 0,35 € / kWh. Se ha puesto teniendo en cuenta la competencia de las estaciones de carga convencionales ya operativas en del país y en los alrededores del emplazamiento, así como el factor diferencial de la fotolinera, que contará

con energía 100% limpia. A partir de los datos de rotación ha sido posible realizar un estudio detallado de la cantidad de emisiones de CO₂ y de ahorro energético que la estación logrará (80,9 ton CO₂ y 2,5 tep/año de media).

La tercera parte del proyecto ha consistido en el diseño técnico de la electrolinera y del sistema BESS de baterías. Para ello se ha realizado un estudio de mercado de los distintos proveedores de cargadores, baterías, inversores y aparataje eléctrica de baja tensión contando con presupuestos reales y opiniones de expertos en la materia. Se han diseñado los planos pertinentes unifilares utilizando herramientas de CAD. Todos los aparatos y el diseño de las conexiones y secciones de los cables han sido calculadas teniendo en cuenta el reglamento de baja tensión. De este apartado se ha podido establecer cuál será la inversión total necesaria (CapEx) para llevar a cabo este proyecto: €449.823.

Una vez realizado el diseño completo, se realizó un estudio económico final calculando los indicadores económicos más comunes para valorar proyectos: VAN, TIR y período de retorno. Luego, se realizaron otros dos escenarios variando el porcentaje estimado de VE que habrá en el parque automovilístico español, analizando la importancia de este dato para la viabilidad económica del proyecto en cuestión.

4. Resultados

La electrolinera se ha situado en Olmedilla en la provincia de Cuenca, España. Se ha decidido implantar dos puntos de carga en la estación de 180kW para realizar la carga rápida, teniendo la posibilidad de cargar dos vehículos a la vez en cada uno a 90kW. La instalación fotovoltaica cuenta con 169MWp y su propio transformador. En el escenario base la cantidad de VEs que se estima que cargarán en el primer año es de 3.635, consumiendo 481.296 kWh. En el año cinco del proyecto cargarán 11.746 VEs (incremento del 223% respecto del primer año) y se venderán 5,05 MWh (incremento del 949%, mayor que el número de VEs debido a que se espera que aumente la capacidad de estos y por tanto la cantidad de energía que requerirá).

Del diseño técnico se han derivado las siguientes grandes partidas de CapEx:

DISTRIBUCIÓN DE LA INVERSIÓN

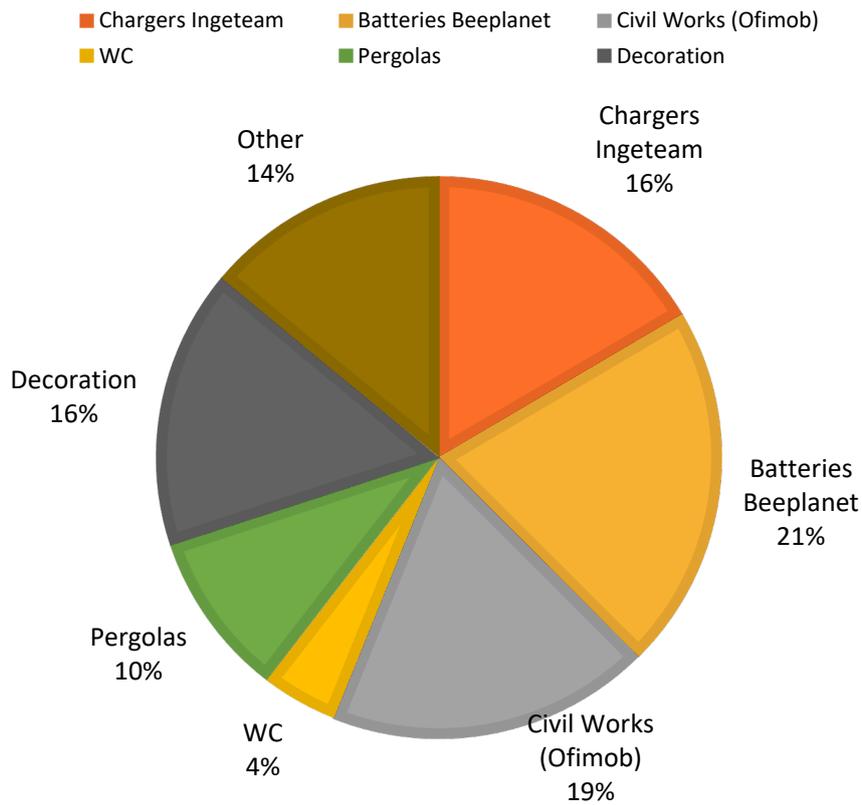


Figura 1: Inversión inicial de la estación

El montante de la inversión inicial asciende a 449.823 €, de los cuales la gran mayoría (19%) será destinado a los trabajos de acondicionamiento del terreno, cargadores (16%) y decoración (16%).

Del análisis económico del modelo de negocio se obtuvieron los siguientes resultados:

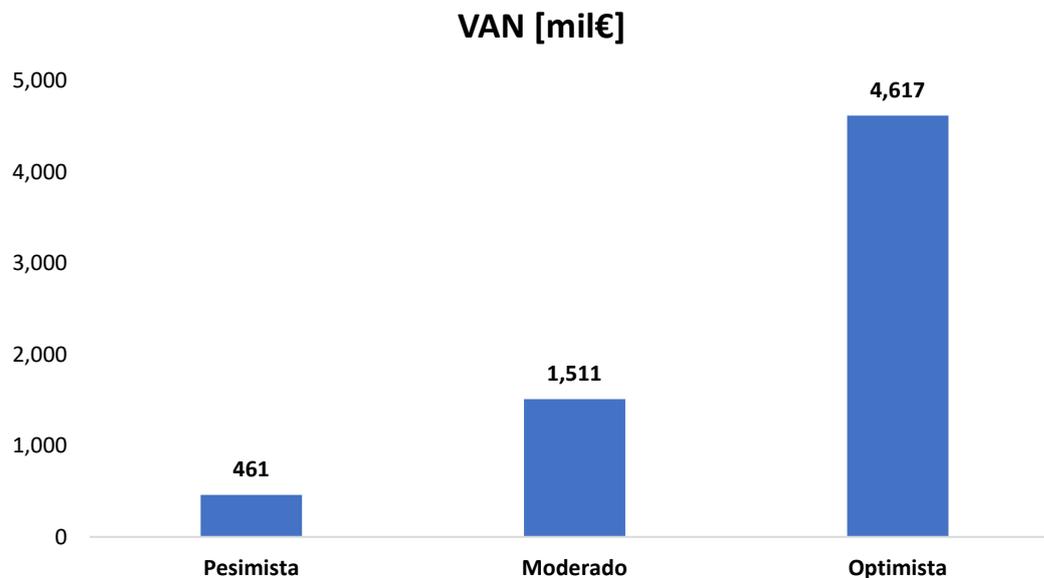
Tabla 1: Indicadores económicos del proyecto

VAN	1.510.878 €
TIR	53,5%
Período de Retorno	27 meses

Para el cálculo del TIR y el VAN se ha tenido en cuenta los cinco primeros años del proyecto y una tasa de descuento del 5%. Para el escenario base, desde el punto de vista económico, estos resultados son considerablemente buenos, teniendo en cuenta que generalmente el TIR esperado de una planta fotovoltaica de gran potencia que vende la energía a la red es de 23%.

Para el análisis de sensibilidad a la presencia de VEs en el parque automovilístico español, se ha simulado un escenario pesimista en el que el número de VEs se reduce en un 70% en el año 2030 y un escenario optimista, el que propone el Gobierno de España en el PNIEC, con cinco millones de VEs en circulación en el 2030. Los resultados del VAN han sido:

Tabla 2: VAN del análisis de sensibilidad



El plan de negocio es sensible a la variación del número de VE presente en el parque automovilístico, como era de esperar, pero se comprueba que, aunque la realidad en el año 2030 sea un 70% inferior a lo estimado, el VAN sigue siendo positivo, aunque inferior. Si, por el contrario, la realidad en el 2030 sea como la visualiza el Gobierno Español, el VAN sería el doble que en el escenario base.

5. Conclusiones

Las conclusiones obtenidas tras la elaboración del proyecto se resumen a continuación:

- Desde el punto de vista económico es viable el modelo de negocio de una electrolinera de carga rápida que se alimente exclusivamente de energía solar, siempre y cuando se pueda considerar que la energía es “infinita” durante el día.
- Con este modelo de negocio se contribuye a la adopción definitiva del vehículo eléctrico en España, atajando varios de las principales causas de ralentización del mercado como: la rapidez de carga, la falta de cargadores, el desequilibrio de la red por el requerimiento de grandes cantidades de energía y la producción de energía libre de emisiones contaminantes, además de contribuir a llevar el vehículo eléctrico a partes despobladas del país, que de otra forma no podrían disfrutar de cargadores de alta potencia debido a la baja rentabilidad que supondrían.

- Se ha comprobado que es completamente viable técnicamente realizar este tipo de proyectos de forma completamente segura y con elementos estandarizados.
- La rentabilidad del proyecto es considerable, con un VAN de €1,5 millones y un TIR de 53%, para una tasa de descuento del 5% a cinco años vista. Se establece un precio competitivo de venta de la energía de 0,35 €/kWh y un coste de 0,08 €/kWh, ya que la estación fotovoltaica es de la propiedad del gestor del punto de carga.
- Este modelo es escalable a otros parques fotovoltaicos de gran potencia que estén instalados en las proximidades de una carretera mínimamente concurrida y quieran sacar mayor rentabilidad a la energía producida.

DESIGN AND BUSINESS MODEL OF AN ELECTRIC VEHICLE CHARGING STATION POWERED BY A PV PLANT

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ABSTRACT

This project demonstrates the economic and technical feasibility of a fast-charging station powered by a high-power photovoltaic generator of 169MWp and a battery system of 168kWh capacity. The affluence that the photovoltaic station will have has been modelled to define the business plan and analyse the economic viability of the project. The technical design of the station has also been carried out.

Keywords: charging, electric vehicle, photovoltaic, station, fast charging.

1. Introduction

Fossil fuels have been almost the only source of energy that allows the movement of people and merchandise, by sea, land, and air, for dozens of years. The invention of combustion vehicles was an unprecedented advance in terms of mobility and everything in its fair measure is not harmful, however, today the number of combustion vehicles worldwide is wreaking havoc, it has been in the 21st century when alarms have gone off about the problem, especially in large cities, both for the environment and for people, since thousands of vehicles circulate daily releasing greenhouse gas emissions and harmful gases to health into the air.

In this context where, faced with the need to improve the air quality of cities and curb climate change, new ways of propelling and energizing vehicles are presented in a viable, sustainable, clean manner and which also presents efficiency improvements with compared to conventional energy sources.

Currently, the energy source that has the greatest popularity in the market is the electrical energy stored in lithium batteries, since it does not emit any type of waste when used. That is why organizations in world countries such as the European Union are advocating a definitive transition towards electric mobility, to the point that they have set themselves the goal of ending the sale of combustion vehicles in 2050.

However, the replacement of the car park by electric vehicles presents different challenges in that the energy supply is different from that of conventional vehicles, to the point where the main cause that is currently holding back the growth of the electric vehicle market is the lack of infrastructure for loading such vehicles.

Among the main challenges presented by electric vehicle charging:

- The stability of the network, since large amounts of power is needed instantaneously, which can cause very irregular peaks in the demand curve.
- The lack of electricity generation, since electricity consumption will increase considerably, it is necessary to increase generation with renewable energy sources.
- The charging time of the vehicles. Although there is currently technology that allows charging in 15-30 minutes, infrastructure is lacking, fast charging points need to be installed so that vehicle charging is not an impediment for the buyer.

2. Definition of the Project

The aim of this project is to define a business model of a charging station for electric vehicles (an electro-power station), due to the market niche they present, as it is estimated that the electric vehicle fleet will grow to around 3 million circulations in Spain by 2030 and even 5 million according to the latest estimates of the Spanish government. The type of electro-lighting station presented in this project is powered by an already built high-power photovoltaic park, so that the electricity supplied to customers is completely clean, tackling the problem of the grid stability and the generation of clean energy. On the other hand, the chargers will be “fast chargers”, allowing electric vehicles to be fully charged in less than 20 minutes, tackling the problem of charging time for electric vehicles, and bringing it closer to refueling waiting times.

3. Description of the methodology

To achieve the objective, first an exhaustive study of the state of the art of the electric vehicle and its charging modes was carried out in order to correctly assess the different alternatives on the market, the problems faced and to make coherent estimates for the business model.

Afterwards, the business plan of the electric station was modelled in Excel, carrying out an exhaustive study of the Spanish electric vehicle market and its potential growth, calculating the capacity of the batteries of these, their charging times and charging power. All this data has been cross-referenced with data provided by the DGT on the average number of vehicles per day passing near the site of the charging station to estimate the number of EVs that will charge and thus calculate the revenue from the sale of energy. The seasonality of the road's traffic flow has been taken into account in the rotation modelling, as it connects Madrid with Valencia, two important economic centres in the country. The other important factor for the calculation of these revenues is the price: 0.35 €/kWh. Which has been set taking into account the competition from conventional charging stations already operating in the country and in the vicinity of the site, as well as the differential factor of the petrol station, which will be powered by 100% clean energy. Based on the rotation data, it was possible to carry out a detailed study of the amount of CO₂ emissions and energy savings that the station will achieve (80.9 tonnes CO₂ and 2.5 toe/year on average).

The third part of the project consisted of the technical design of the electro station and the BESS battery system. To this end, a market study of the different suppliers of chargers, batteries, inverters and low-voltage electrical switchgear was carried out, using real budgets and the opinions of experts in the field. The relevant single-line drawings have been designed using CAD tools. All the devices and the design of the connections and cable cross-sections have been calculated taking into account the low voltage regulations. From this section it has been possible to establish the total investment (CapEx) required to carry out this project: €449,823.

Once the complete design was finalised, a final economic study was carried out, calculating the most common economic indicators for evaluating projects: NPV, IRR and payback period. Then, two other scenarios were modeled, varying the estimated percentage of EVs in the Spanish car fleet, analysing the importance of this data for the economic viability of the project in question.

4. Results

The petrol station is located in Olmedilla in the province of Cuenca, Spain. It has been decided to implement two 180kW charging points at the station for fast charging, with the possibility to charge two vehicles at the same time in each post at 90kW. The photovoltaic installation has 159MWp and its own transformer. In the baseline scenario, the estimated number of EVs to be charged in the first year is 3,635, consuming 481,296 kWh. In year five of the project, 11,746 EVs will be loaded (223% increase over the first year) and 5.05 MWh will be sold (949% increase, higher than the number of EVs due to the expected increase in EV capacity and therefore the amount of energy required).

The following major CapEx items have been derived from the technical design:

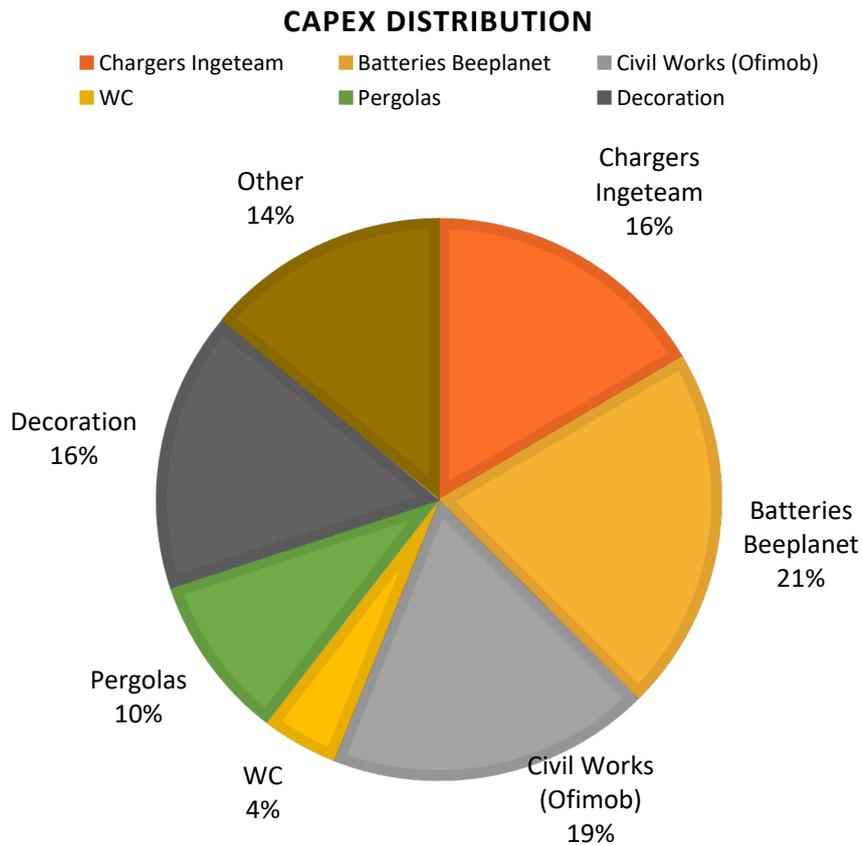


Fig. 1: CapEx distribution

The initial investment amounts to 449,823 €, of which the vast majority (19%) will be spent on site preparation, chargers (16%) and decoration (16%).

The following results were obtained from the economic analysis of the business model:

Table 1: Economic indicators

NPV	1.510.878 €
IRR	53,5%
Payback Period	27 meses

For the calculation of the IRR and NPV, the first five years of the project and a discount rate of 5% have been taken into account. For the base scenario, the results are considerably good, taking into account that generally the expected IRR of a large-scale PV plant that sells energy to the grid is 23%.

For the analysis of sensitivity of the project to the presence of EVs in the Spanish car fleet, a pessimistic scenario was simulated in which the number of EVs is reduced by 70% in 2030 and an optimistic scenario, as proposed by the Spanish Government in the PNIEC, with five million EVs in circulation in 2030. The NPV results are as follows:

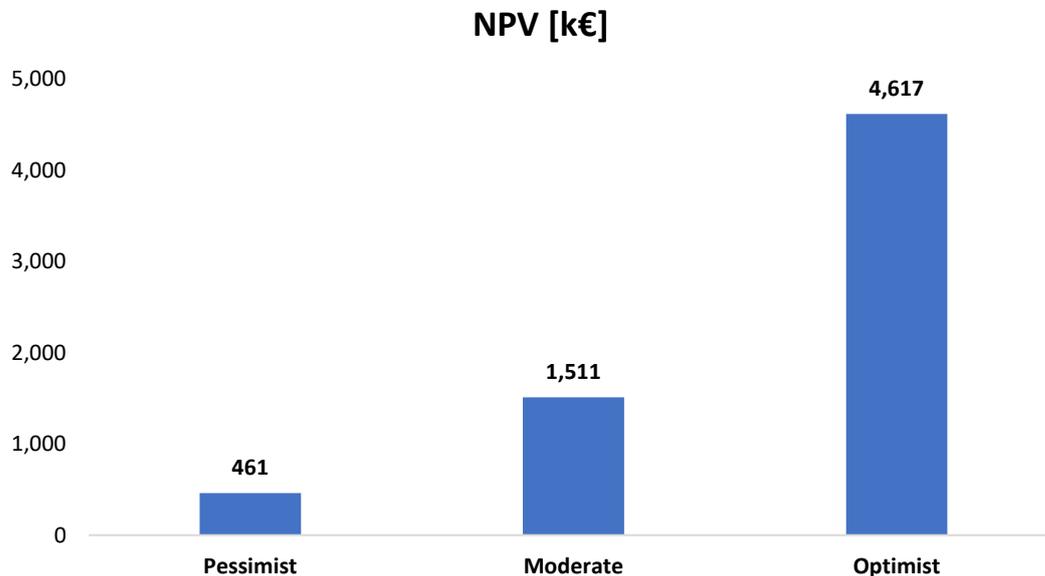


Fig. 2: NPV of the sensitivity analysis

The business plan is sensitive to the variation in the number of EVs present in the vehicle fleet, as expected, but it is found that, although the reality in 2030 could be 70% lower than estimated, the NPV is still positive, albeit lower. If, on the other hand, the reality in 2030 is as envisaged by the Spanish government, the NPV would be twice as high as in the baseline scenario.

5. Conclusions

The conclusions drawn from the project are summarised below:

- From an economic point of view, the business model of a fast-charging electric station powered exclusively by solar energy is viable, as long as the energy obtained from the PV plant can be considered "infinite" during day time.
- This business model contributes to the definitive adoption of the electric vehicle in Spain, tackling several of the main causes of slowing down the market such as: the speed of charging, the lack of chargers, the imbalance of the grid due to the requirement of large amounts of energy and the production of energy free of polluting emissions, as well as contributing to bringing the electric vehicle to unpopulated parts of the country, which otherwise would not enjoy high-power chargers due to the low profitability that they would entail.

- It has been proven that it is technically feasible to carry out this type of project in a completely safe manner and with standardised elements.
- The profitability of the project is considerable, with an NPV of €1.5 million and an IRR of 53%, for a five-year discount rate of 5%. A competitive energy sales price of €0.35/kWh and a cost of €0.08/kWh is established, as the photovoltaic station is owned by the operator of the charging point.
- This model is scalable to other large-scale photovoltaic parks that are installed in the vicinity of a minimally busy road and want to make more profit from the energy produced.



MASTER'S IN INDUSTRIAL ENGINEERING

FINAL MASTER'S THESIS

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Chapter 1 Introduction

Over the last years there has been a clear trend in the automotive sector towards the development and production of electric vehicles (EV), a trend which has been growing at a rapid pace (~3.000% growth from 2015 to 2021 [1]) and which is expected to continue in the short and long term. ANFAC (the Spanish car manufacturer's association) and KPMG, foresee that in 2035 there will be around two million EVs circulating in Spain and in 2040 around ten million. In Fig. 1 the exponential growth of EVs is clear.

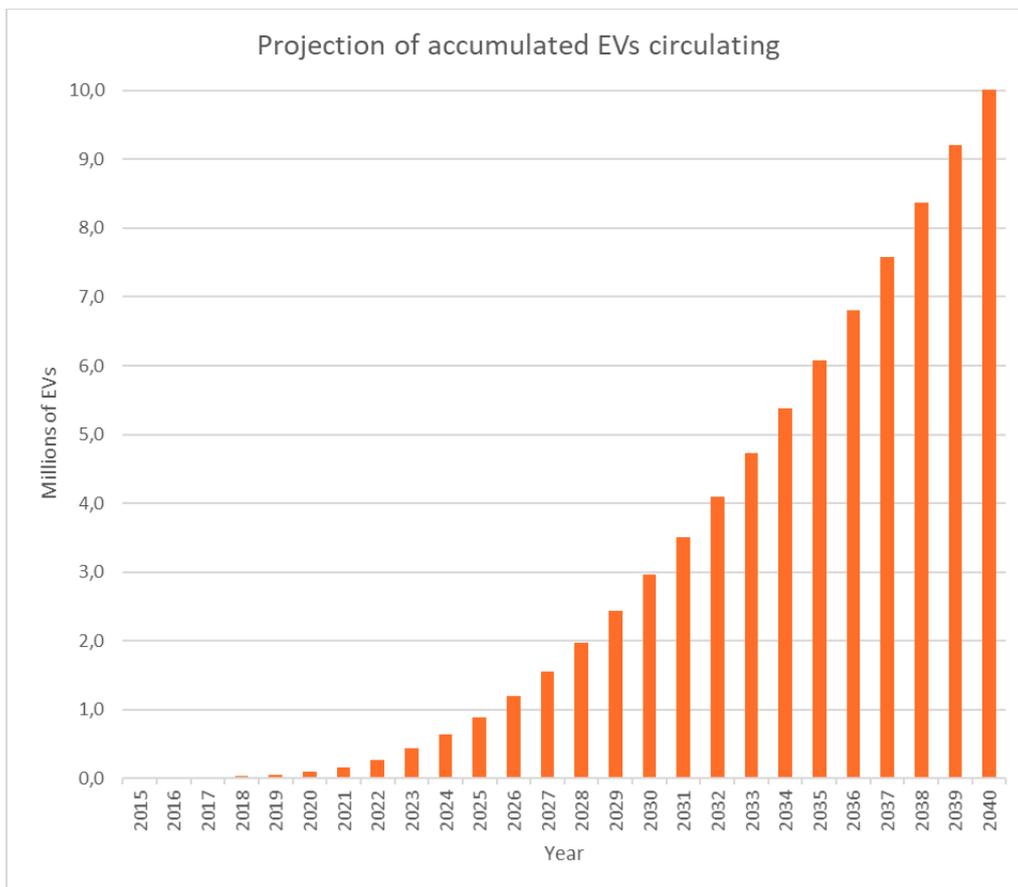


Fig. 1: EVs motoring park growth in Spain

Source: Informe Anual 2019 ANFAC & Informe Anual 2015 Anfac & Informe Ejecutivo Automóvil 2020-2040 Anfac and KPMG [14], Own elaboration

This exponential growth is being accelerated by the Spanish government and international associations (like the EU and the UN) which have set for themselves a very challenging objective, consisting of eliminating combustion vehicles from the market by 2050 (Paris Agreement). The motivation for this comes mainly from the threat that climate change poses and the overexposure of people to high concentrations of harmful gases like carbon monoxide, mainly on highly populated cities like Madrid or Barcelona in Spain.

Although the objectives are clear and have been set for a few years now, it is doubtful that with the actual growing pace of the EV market these objectives will be met. The predictions from KPMG [33], show that in 2030, there will be around two million EVs circulating, while the Spanish government's goal is to have at least five million, this number will be reached in 2034, according to ANFAC's and KPMG's predictions. The main restriction for EV growth is agreed to be the lack of charging infrastructure, in relation to the seemingly low autonomy of EVs. This last argument is mainly a marketing fault since the average distance a Spanish citizen does daily with their vehicle is around 42 km, and all current EVs in the market are able to travel such distance with ease. On the other hand, the lack of charging infrastructure is a true challenge, which appears in almost every ANFAC or IEA (International Energy Association) report. To accelerate EV's market growth it is imperative to increase charging infrastructure, mainly fast charging, to assimilate charging times to refuelling times.

Fast Direct Current (DC) charging can take down charging time to 3 minutes for a high end EV (Porsche Taycan for example) and to 20 minutes for an average EV, compared to the 3-8 hours needed with an Alternate Current (AC) charger. This poses another challenge to the grid, since these fast DC charger's power output go as high as 400kW, for the most advanced systems, causing peak demands in very concentrated time frames. This is a probable cause of imbalances in the demand curve. The solution for this is to endow electric charging stations with PV installations and BESS systems, making them more secure, stable, and sustainable.

This problem has been the subject of numerous research papers in recent years. Different authors have developed models to analyse the impact of charging stations on the network.

Some present different solutions to level the demand curve of the electricity grid, for example Xu et al. [2] shows in his work a coordinated strategy to improve the effects of the EV load on the demand curve, as well as to improve the profits of this type of stations. However, the first problem to tackle is to create a profitable and sustainable business model to promote business development around this technology. J.A. Domínguez-Navarro [3], presents an original optimization work in which he compares different charging modes that use different technologies (grid, solar, wind and mixed) to be able to discern which is the most efficient and profitable to create a possible business model. In this work, it is concluded that the most profitable technology is the mixed one, that is, having in the charging station energy from the grid, sun, and wind, creating a business model that, in addition to being profitable, is sustainable.

1.1. Motivation

Electrification of the motoring park is imperative to start reducing harmful gases emitted to the atmosphere and stop global warming. There are cities in which people are dying due to high levels of contamination caused mainly by gases emitted from vehicles [1]. This necessity is increased considering the effect of globalisation which is significantly increasing the necessity of transporting goods and people around the globe, thus the gases emitted by these means of transportation which to this day have relied mainly on energy obtained from the combustion of fossil fuels.

On one hand, electric vehicles offer a new way of obtaining energy without having to sacrifice the benefits of globalisation and fast transportation. On the other hand, even though electric motors do not cause emissions when used, the electricity stored in the vehicle's battery for its use when driving is most frequently obtained from energy sources which does produce contaminant gases. Thus, if the only action made is using EVs instead of CEs the main problem is not being entirely tackled. The electric energy must come from clean, renewable, and sustainable energy sources like solar or wind energy.

In this scenario, where electric mobility and renewable energies meet, Eranovum energy has a huge advantage. With a growing portfolio of high-power PV plants under

construction and its intention of creating a national charging network for EVs, it can analyse the viability of a business model in which the charging stations are fully fed by one of its PV plants, thus contributing to the EV transition and obtaining the energy from a fully renewable energy source. This would make Eranovum the first company in Europe, and probably the world, to implement a whole renewable mobility ecosystem, with a PV plant and a BESS system for EV charging, fully tackling the transportation problem of the gases emitted to obtain the energy required to fuel the vehicles.

Hence, Eranovum's motivation to analyse the economic and technical viability for this type of project has three perspectives: economical, since it is a potential new market niche, social, since it would contribute to the decarbonation of the economy, and disruptive, since it would be the first company to implement this business model.

1.2. Justification

The justification of this project is the necessity of analysing from the technical and economical point of view the viability of a project which could potential contribute to grow Eranovum's business and contribute to make mobility cleaner and more sustainable.

To decide whether to invest on a certain project, a company must be sure to a certain level that the project is physically and economically viable. If the project isn't technically viable with the current technology, then it is obviously impossible to implement it. Moreover, if the project is technically viable but the proposed business model isn't attractive to private investments with the current market and technology, then the project could only be undergone by a public non-profitable entity or for marketing purposes.

Furthermore, the market justification for this project is truly attractive. According to the Spanish Association of Manufacturers of Vehicles and Trucks (ANFAC) [15], during the second semester of 2020 there was a 16,8% of electric vehicles chargers deployed in Spain, versus a 20,5% in Portugal, and 150,7% in Norway, being Europe's average 27,3%. According to these indicators, in 2021 Spain sums a total of 11.517 charging points for public access of fast charging at national level. The estimations and

expectations indicate that for year 2030 in Spain there should be 339.998 charging points – this is a great business opportunity for the next years.

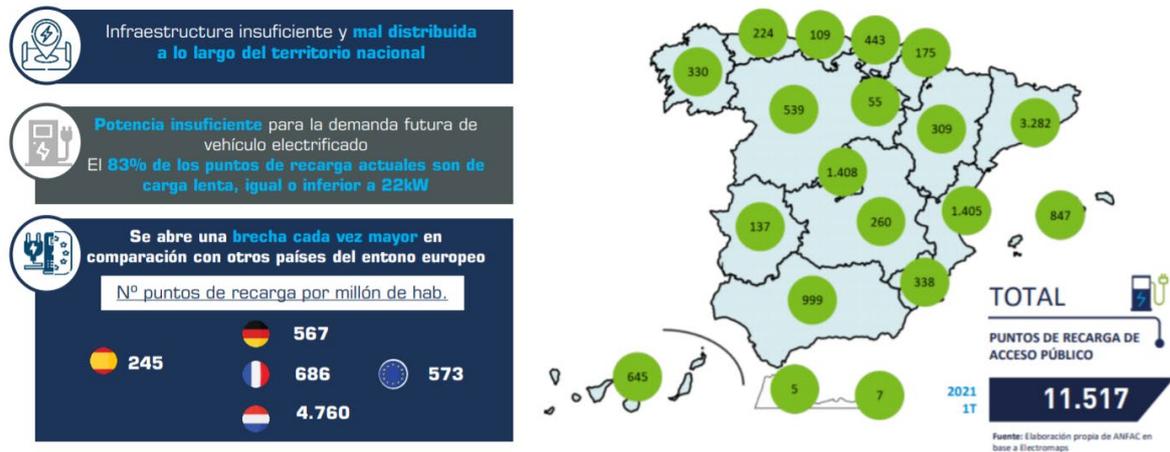


Fig. 2: Number of public access charging points in Spain during 2021

Thus, the market segment which this project is targeting is considered of high interest due to its great growth projection in the medium to long term, and it represents a great opportunity for Eranovum to position itself in the market.

1.3. Objectives

The general objective of this project is to define the business model for an electric charging point powered by a solar plant and design the engineering project for its implementation. The objectives of this project can be summarised in the following bullet points:

1. Define the business model:
 - Define a business model for the project, determining the key parameters like price, rotation, competition, and growth potential, with objective data and methodologies.
 - Conclude whether the business plan is economically viable, why is it or is it not viable, determining general economic indicators for valuation of projects like NPV, IRR and payback period.

- Conduct a sensitivity analysis of the Business Plan to determine whether the project is scalable and generalizable. What are the factors that determine whether a PV site is a potentially viable location for a PV fed charging station (minimum PV output power, minimum EV rotations).
 - Analyse the current EV market, both of actual EVs on the road and of the charging infrastructure market, to model the rotation of the vehicles at the station.
2. Design the charging point:
- Design the technical requirements for a high-power charging station which will be powered by a PV plant, already under construction, located in Olmedilla, Cuenca.
 - Conclude if, with the technology available today, it is physically possible to build the infrastructure and comply with the current EV market demands in the chosen location.
 - Create the corresponding documentation to build the actual charging station.

Chapter 2 State of the Art

EVs' main difference from conventional vehicles is their propulsion system. While the latter use an internal combustion engine (ICE), EVs rely solely on electrical energy for the same purpose. This electrical energy can come from three different sources: combustion generation, on-board generators, and on-board energy storage [11]. In this chapter the different technologies will be discussed as well as the different charging technologies that exist in the current market.

2.1. The Electric Vehicle

The concept of 'electric vehicle' or EV is a vehicle which uses electricity to power an induction motor to produce the rotation of the wheels. This electrical energy is previously stored in a battery, using the energy from the grid or an alternative source of energy.

In the last years, there has been an inclination from the motoring sector towards the development and production of EVs. This tendency is doomed to continue in the next years, with the support that this kind of transportation is receiving from the governments and international institutions, with local incentives like the '*MOVES* Plan' in Spain or the *Electric Vehicle Initiative (EVI)*, a multi-governmental policy forum established in 2010 to incentivize the adoption of measures in every country to grow the EV market. Another important fact that shows the establishment of the EV as a substitute for CVs, is that during COVID-19, despite the downturn in car sales which dropped globally by 16% [2], EVs registrations grew by 41% in 2020. During this period Europe overtook the People's Republic of China ('China') as the world's largest EV market for the first time [2].

The resilience of EV sales during the pandemic and its expected growth relies mainly on 3 pillars:

- Supportive regulatory frameworks: By the end of 2020, more than 20 countries had announced bans on the sales of conventional cars, Spain among them. Having

an EV poses an important advantage for a city like Madrid, where you can park for free and get into zones where a CV cannot (*Madrid Central*).

- The number of EV models is expanding and battery costs continue to fall improving the technology, charging times, and lowering general vehicle costs.
- Charging infrastructure is increasing: the main factor that has been draining the EV market growth is mainly the lack of charging infrastructure. Governments are incentivizing the deployment of these infrastructures, helping to make the initial investment (like the Moves Plan) making Business Plans more attractive to investors.

It is also important to remark that the EV market is already very established and consolidated. The first sign of this is the fact that, even though government incentives and economic aids have stabilized, consumer spending has continued to rise. We can see this in Fig. 3

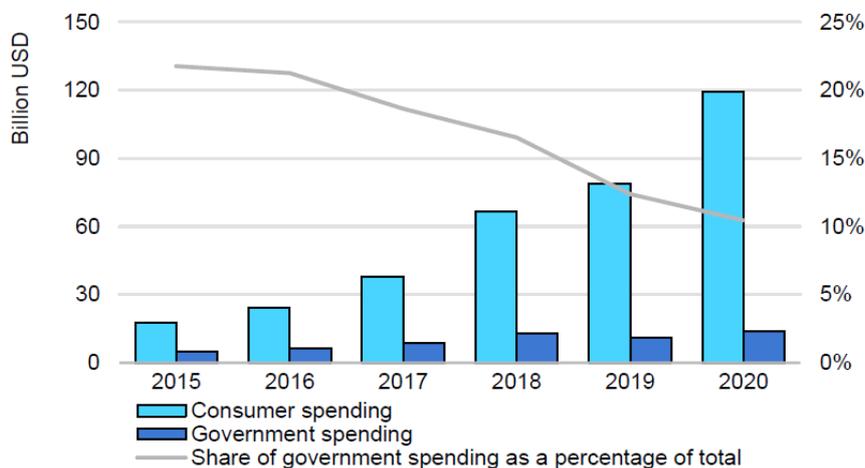


Fig. 3: Consumer and government spending on electric cars

Source: EV Outlook 2021, IEA

This growing consumer spending on EVs can also be explained by the technological advances that they bring compared to the traditional CV. Some of them being:

- Reduction of contamination levels in urban areas: direct emissions are avoided since the batteries don't emit any kind of residue when delivering energy. That is why it is so important to electrify motoring fleets in urban areas with heavy traffic.
- Better efficiency and performance: electric motors have an efficiency of up to 95%, compared to the maximum efficiency of a CV of 43%. Moreover, an EV can deliver par force instantly, improving driving experience even with low power models.
- Lower refuelling price: electricity is much more affordable than traditional fuel.

Besides these improvements, and the government incentives, there are currently various factors which are impeding the development of the EV market. One of the most important ones, highlighted in the EV Outlook 2021 and in almost every report of electric mobility, is the lack of fast charging infrastructure. To face this problem, the European Union (EU) is acting, with initiatives like the *EU Alternative Fuels Infrastructure Directive*, which is pushing the EU member countries to implement objectives for the installation of public charging infrastructure for 2025 and 2030. Moreover, this fast charging is being drained by the high demand of energy from the grid, which could destabilize it, hence the need of thinking a way of lowering this demand from the grid like incorporating renewable energy sources or batteries in the stations.

2.2. Types of Electric Vehicles

Currently, there are different types of vehicles which are commonly characterized as 'electric vehicles' and it is important to distinguish them since their range, charging needs, charging time and power needs, differ greatly. The market presence of each type of technology is crucial for sizing a charging point and determining its profitability, since a non-plug-in hybrid vehicle won't count a potential customer for the station, even though it is characterised as an EV. The different types of EVs currently in the market are:

Hybrid Electric Vehicle (HEV)

The Hybrid Electric Vehicle technology was patented in 1974. The vehicle is propelled by two different engines: a combustion and electric engine. It alternates from one engine

to the other, depending on the requirements of the driver. The battery is charged by the built-in internal combustion engine or through a generator which transforms the kinetic energy from brakes into chemical energy to be stored in a 12 - 48 V battery. Some car manufacturer brands promise their vehicles have enough power to drive solely on electric energy, reducing emissions significantly [10]. Although these types of cars don't usually have electrical autonomies higher than 20km, hence depending on the combustion engine for most displacements. These kinds of vehicles can't be externally charged. (Liansheng Liu 2015) (Toyota 2021) [30][24][27]

Plug-in Hybrid Vehicle (PHEV)

PHEVs are similar to HEVs but with the extra feature of being able to be charged from the grid, with a larger battery pack, which permits a longer electric autonomy. In Fig. 4 the most common architecture for this kind of vehicle, parallel hybrid, is depicted, other types of configurations include series hybrid and power-split hybrid [24][27].

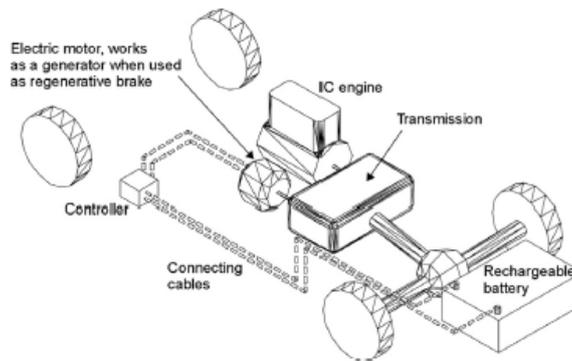


Fig. 4: The architecture of parallel hybrid EVs

Source: A review on electric vehicles interacting with renewable energy in smart grid

Full Electric Vehicle (BEV)

These vehicles are characterized for using electric energy stored in a battery as its solely propulsion source. The battery can be recharged by regenerative braking on drive and externally when the vehicle stops [27]. It is composed by three major parts depicted in Fig. 5 (electric motor, rechargeable battery, and controller). Another important part of a

BEV is the inverter, not shown in Fig. 5, which is responsible for converting direct current (DC) power (electricity stored in the battery) to alternate current (AC) power, since most electric motors equipped by EVs are AC motors, simpler and cheaper [24]. Another important component is the on-board charger (OBC), the component which determines the maximum AC power the vehicle can withstand; it is one of the most expensive components and most voluminous. Car manufacturers must select the correct equilibrium between being able to charge the vehicle at a higher AC power and hence shorter time, and costs. Currently in the market, the standard is having an OBC of 7.4kW, new models are including as an extra 11kW OBC, and luxury brands like Porsche 22kW OBC. The differentiation of the most sold model in the market, Renault Zoe, is its 43kW OBC, a patented technology.

Although, the alternative is to charge the battery directly with DC current. This enables much higher power charging, reducing charging times. A Tesla model S admits a charging power of 250kW DC, and the standard vehicle a mean of 90kW DC.

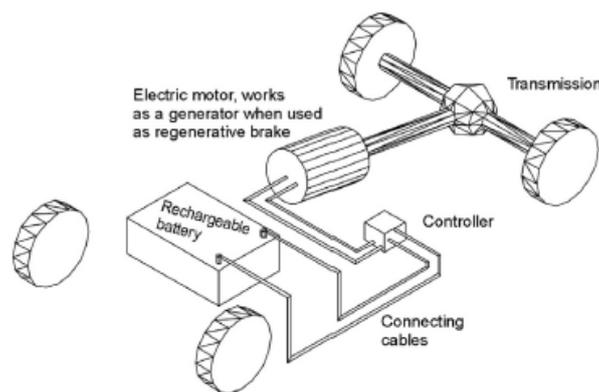


Fig. 5: Architecture of BEVs

Source: A review on electric vehicles interacting with renewable energies in smart grids

Electric Vehicle Extended Autonomy (E-REV)

These vehicles have a similar configuration and architecture as the BEVs but with the extra of including a small diesel engine, which can charge the battery if necessary [16].

2.3. *The Electric Vehicle History*

In the beginning of road mobility, combustion engines were not the first ones to come into market, in fact EVs reigned the market for the XIX century, with promising results and market acceptance. Combustion engines were very difficult to manage in the beginning, and fuel prices did not help. But as fuel prices lowered and the EV technology reached what seemed to be an end point, combustion engines finally won the battle.

Between 1832 and 1839, the first vehicle prototype propelled by an electrical engine was invented by Robert Anderson, although it was not suitable for practical use since it used a non-rechargeable battery [11]. Although, in the following years new discoveries were to come and the development of DC electrical motors and rechargeable batteries kept on. Even though there were great improvements on the DC motor side, batteries were already the nightmare of electric vehicles. Finally, 1842 Gaston Planté invented the first lead-acid battery, which made it possible to recharge batteries, later improved and commercialized in 1881 [19].

These improvements allowed in 1898 the company *London Electric Cab*, to commercialize the firsts EV taxis in London, with an autonomy of 20-30 km, 25km/h speed. Sadly, it didn't succeed and ceased activity two years later [19]. On the other side of the pond, in the US in 1897, a company called *Electric Charging and Wagon Company*, did succeed, reaching to own more than a one thousand electric taxis, like the one depicted in Fig. 6. In just three years, EVs took up 28% of the road vehicles [11]. Combustion still had many defects among others: very noisy, expensive, and hard to drive. These defects added to the fact that fuel was very pricy at the time and that large roads didn't exist made the choice for consumers quite easy [19].

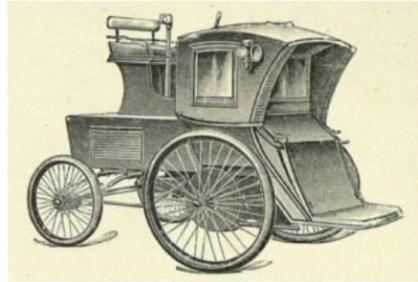


Fig. 6: Electric taxis in New York. Source: Yuzhakov Big Encyclopedia. Public Domain.

Although electric vehicles were making progresses and the market was demanding them, in the late 1890s, other two competitors were pushing hard to dominate the vehicle market, gasoline and steam cars. Between 1900 and 1910, the steam vehicle covered in the US 40% of the market, EVs 38% and ICE 22% [19].

The combination of fuel price decrease, with the petrol findings in the US, and the development of large asphalt roads interconnecting cities, made combustion vehicles win the battle in the 90s. EVs found a bottleneck in the range capacity, which was generally limited to 30km, and steam cars were never sufficiently efficient to compete. Moreover, Henry Ford developed and extraordinarily efficient assembly line, which lowered car prices. Finally, EVs ceased fabrication by 1930, in favour of the combustion engine [6].

A few decades later, in the 70s, the interest on EVs resurfaced due to the emissions related to gasoline-powered vehicles and high oil prices. Regulatory actions were taken into place by some governments (e.g., *California's Zero Emissions Vehicle Mandate*) which incentivized automakers to put efforts on hybrid vehicles. In 1996, General Motors produced and leased the EV1 model, and the next year Toyota introduced the world's first commercial hybrid electric vehicle. From year 2010 onward the automobile manufacturers have increased the number of electric vehicle models. This situation has been enhanced with people's increasing consciousness regarding social and environmental problems and the petrol's increasing price.

Chapter 3 The Business Model

This chapter will consist of defining the business model of the charging station and making an estimation of the revenues with essential market data, which will feed the economic viability analysis to estimate future cash flows.

The business model consists of giving a photovoltaic plant a double use by deriving some of the produced energy to charge electric vehicles (EVs). This energy is sold at a higher price than in the energy pool, given the added value of being available for EV users, being an extra revenue source for the PV plant.

To correctly design the business model, it is essential to:

- a) Define the characteristics of the PV plant: energy production, reliability of the energy and location
- b) Study the EV electric vehicle park in Spain – characteristics of the EVs circulating their current and future charging needs
- c) Growth perspectives, from different sources: government data, external sources, and international organisations
- d) Calculous and estimation of the rotation of the chargers i.e., the frequency at which vehicles will charge / consume electricity

3.1. *PV Plant Characteristics*

The main characteristics to know for the project are:

- Power output: 156 MWp
- Location: Olmedilla, Castilla-La-Mancha, Spain, close to N-111

The power output is more than enough to secure a highly reliable power source, even in low radiation periods like December or January. The expected needs of the power station will never be higher than 1kWp, taking into consideration the highest power input an EV can currently take is 800W and the station will have approximately six individual high-

power connectors. In the worst-case scenario in which all six are working at its peak power, which it is highly improbable, the power need would be of 3,6kW which is less than 0,005% of the plant's peak power. Thus, it can be assumed that the power supply is infinite.

The PV plant called "Sabinar" is in the Spanish community of Castilla-La-Mancha, in Olmedilla. One important aspect for the technical viability of the project is for the PV plant to be as close as possible to a road, to facilitate the access. Also, that this road is as frequented as possible so that the rotation at the station is higher – more charging means more revenues. Sabinar plant is located close to a national road called N-111, which is a parallel road to the A-3, one of the most frequented roads in the Spanish geography, with a mean affluence of 766 light vehicles per day in 2020 [36]. This road connects Community of Valencia to Madrid, two of the main centres of economic activity in Spain. Thus, the charging station will be in a privileged location due to the constant utilisation of the road by multiple vehicles, which will continue to be high in the long term.

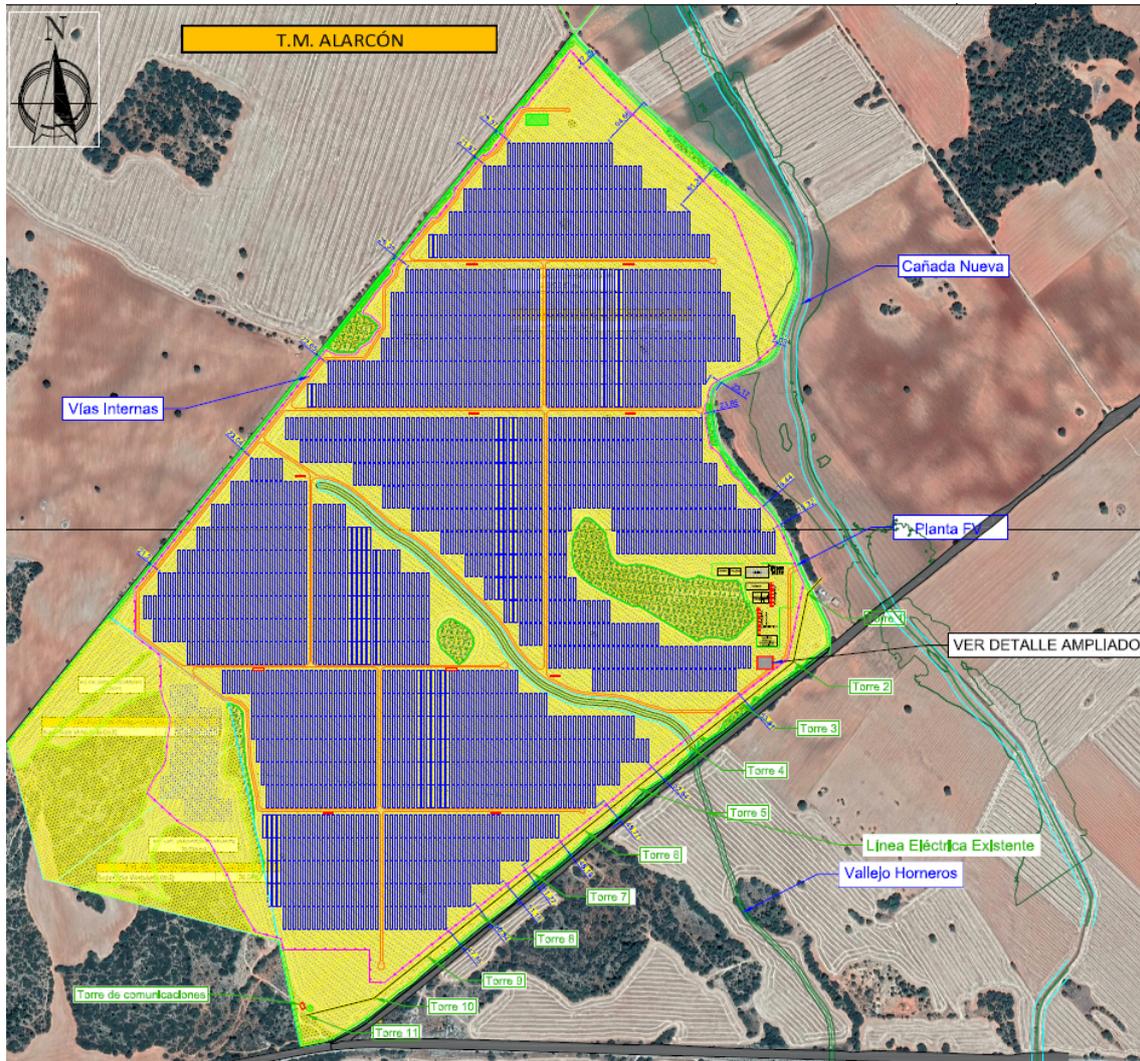


Fig. 7: Project location, including the PV plant next to which the charging station is located

In Fig. 7 the PV plant is currently in a construction phase; with the space distribution it will have. The charging station shown below, in Fig. 7, is the Amplified Detail of the location.



Fig. 8: Detailed location of charging station

3.2. Market Sizing

To correctly estimate the revenues and the power and energy needs of the station, it is important to estimate the number of vehicles that will pass through the road, how many of them are electric and how many of them will be needing charging and how much energy will they be buying. For this, the following calculations and estimations have been conducted:

- 1) The number of vehicles which are fully electric in the Spanish car park
- 2) The capacity of the batteries of these vehicles
- 3) The average time it will take to charge them

These calculations will be used to make an estimation of the rotation at the charging station, of the energy needs and to calculate the correct number of power posts needed at the station.

3.3. *EV Spanish park – Capacity*

To calculate the energy needs the EVs stopping to charge at the station will have, it is important to know the current EV Spanish market. The objective will on one hand, to have a good estimation of the average capacity an EV stopping at the station will have and the mean time it will take to charge each vehicle currently, and then project how is the EV Spanish market going to evolve.

Firstly, the mean capacity of the most numerous EVs currently circulating in Spain have and the mean time it takes to charge each one at 70% of the capacity. This 70% is since and EV should always be charged in the range of 20-80% to maximise the batteries life. The data has been extracted from the observatory for electric mobility of the Technological Investigation Institute for the Electric Mobility of the University of Comillas [32].

Table 1: Spanish EV car park in 2021

Model	# EVs Circulating	Capacity [kWh]	Min CC charging time [min]	time/kWh
Renault Zoe	7.406	55	45	0,82
Nissan Leaf	6.017	40	40	1,00
Smart Fortwo EV	3.171	18	55	3,13
Hyundai Kona BEV	3.003	68	44	0,65
Tesla Model 3	2.905	82	21	0,26
BMW i3	2.824	42	36	0,85
Smart Forfour ED	2.275	18	-	-
Volkswagen e-Golf	2.144	36	45	1,26
Peugeot e-208 EV	1.235	50	31	0,62
Kia Niro EV	1.081	42	43	1,02

The mean capacity of the represented models is 32,4 kWh, including the 70% mentioned above, the mean energy needs will be of 22,7 kWh per EV charged, that is, per client. The mean time this will require is 20,1 minutes per client.

Moreover, for the purpose of estimating future cash flows and determining the value of the project, a “growth factor” has been used. It is expected that the capacity of the EVs will grow, and the time needed to charge them will decrease. As an example, in more developed markets like the Chinese, an EV model of the brand NIO, which is already being commercialised, has a capacity of 1.500 kWh. The estimation is that the EV capacity will grow by an 80% factor each year to reach an average of 430 kWh. Regarding the time required to charge each vehicle, it has been estimated that it will decrease each year by a 20% factor, to reach a minimum of 8,2 minutes per vehicle.

Currently, each car will need an average of 22,7 kWh and will charge on average in 20,1 minutes. Now it is important to correctly estimate the number of vehicles which will be charging daily, weekly, and monthly to correctly calculate an estimation of the yearly revenues from the station.

3.4. *EV Spanish park – Charging power*

The objective is to design a high-power CC station, but to make a logical decision and not over size the station, a sample of 74 models of EVs has been analysed to know how the technology is advancing, and what are their characteristics, currently and expected.

In the introduction, all the types of vehicles have been analysed, and as it is mentioned, there is a limit on the amount of power an EV can take both AC and DC. Out of the 74 models on sale in Spain as of July 2021, the next graphs show the percentage of vehicles which accept each power:

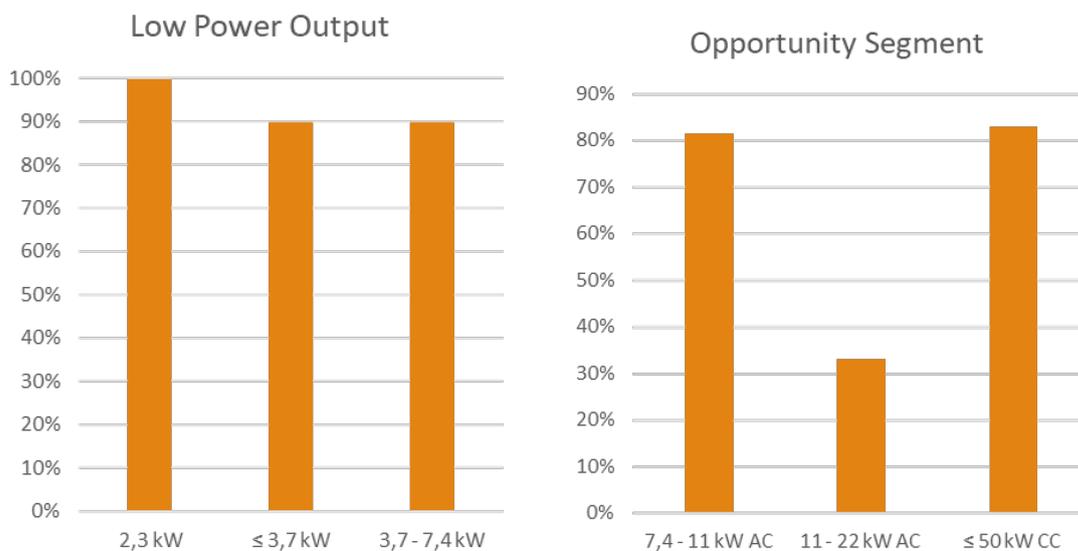


Fig. 9: : Number of vehicles which accept each power input [34] [35]

In addition, from this analysis, it has also been concluded that:

- Only Tesla supports 250 kW CC charging
- No EV supports more than 250 kW
- 56% of the sample analysed support 50-100 kW

On one hand, from this data it can be concluded that with the present EV park it is going to be a waste to install too high-power chargers. On the other hand, as this is an emerging

market, it is more important to look at how fast the market is growing and the objectives of the brands looking to improve the technology:

- Porsche has already built a car admitting 800 kW CC
- The EV charging brand “ionity” which is managed by top European car brands such as BMW and Audi, is only installing fast charge chargers
- The only way to substitute fuel cars with EVs is by reducing the charging time to something like fuel refilling

These arguments are the main pillars which defend the hypothesis that there are going to be clients wanting to charge in chargers with the highest power output, it is the only way to make the transition from fuel cars to EVs.

The power output chosen for the station will be 400 kWp per charger, considering two spots per charger, each charger will be able to charge simultaneously two cars at 200kW. In the technical analysis the model and brand of the chargers will be selected.

3.5. *Vehicle rotation at the station*

A key factor to determine future cash flows for the project is estimating the affluence of vehicles the station will have. The numbers considered to make this calculation have been the following:

- Forecast of the percentage of EVs in circulation in Spain from the data provided by recognised organisations such as ANFAC in its annual reports, more specifically in the report [32]. Although the Spanish government is estimating a more ambitious prediction, estimating 5 million EVs on the road by 2030, while ANFAC’s estimation used is more conservative, with 2,9 million EVs on the road by 2030. In **¡Error! No se encuentra el origen de la referencia.** a representation of the accumulated EV prediction is depicted.

Electric Vehicles in Spain - Long term estimation

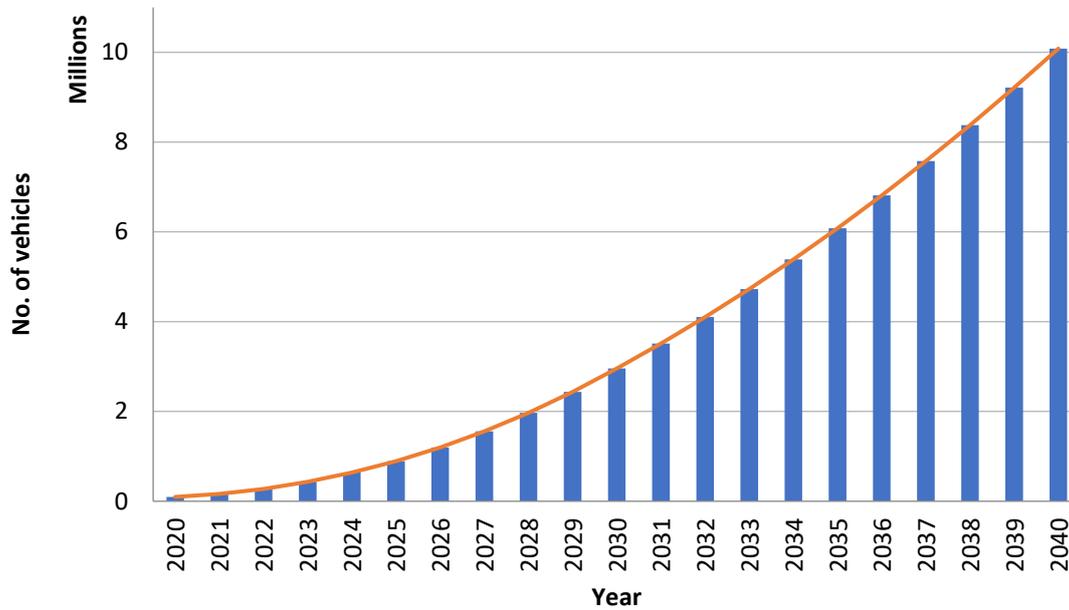


Fig. 10: Electric Vehicles in Spain - Long term prediction:

Source: Informe Anual 2019 ANFAC & Informe Anual 2015 Anfac & Informe Ejecutivo Automóvil 2020-2040 Anfac and KPMG [14], Own elaboration

- This percentage has been applied to the number of tourisms expected to go through the road in which the station is located (N-111). This estimation has been done with the data provided by the DGT (*Dirección General de Tráfico*), which indicate the mean number of daily vehicles circulating passing through a determined road section [36]. The estimation of vehicles passing through this road in the years of the project has been estimated applying a growth factor – the average growth of the last four years (2,4%).
- From those EVs which will be expected to pass through the N-111, an estimation of those in need of charge must be performed. For this purpose, it has been taken into consideration that this road is a privileged location at middle path between the Community of Valencia and Madrid, 170 km from Madrid. This range is the average in which a normal vehicle will need to charge. Thus, it has been estimated that 70% of the total calculated EV passing through the road will need charging.

- Another factor to take into consideration is the surrounding competition. As of November 2021, in this location the available chargers are the following:

Table 2: Surrounding competition / EV chargers

Chargers nearby	Owner	# of chargers	Power	Type	Price [€/kWh]
N-111					
Motilla del Palancar	Iberdrola	2	22	AC	0,3049
Alarcón, Cuenca					
A-3					
Autovía Madrid-Valencia	EV-Box	4	12,75	AC	0,3176
Área 175	Iberdrola	1	22	AC	0,3049
		2	50	DC	0,3049
Restaurante El Tebar	Wenea	2	50	DC	Not connected
		2	43	AC	Not connected
Repsol Ortiz Espis	Repsol	2	50	DC	Not connected
		3	22	AC	Not connected
		1	11	AC	Not connected
Castillejo de Iniesta	EasyCharger	2	22	AC	-

As shown in the table above, there is no charger close to the location offering the power that the present project aims to offer, making the analysed station more valuable. Also, all the charging points currently available are fed from the grid, the studied station will generate the energy completely clean. This factor is being increasingly valued by the customers, there are phone application which tell if the charging station is offering clean energy or not, e.g., Electromaps. For these reasons it is expected that the 70% of the EVs passing through the road in need of charge will decide to charge at Eranovum's station. Although, in the business plan it has also been estimated that the competition will increase – the estimation is 0,25% each year from 2023. Thus, the percentage of EVs passing through the N-111 and which will charge at Eranovum's station will decrease by 0,25% each year until reaching 48,5%.

These numbers were included in the model, arriving to a scenario like the one represented in Table 3.

Table 3: Extract from Excel model - premises on stations rotation

Charger's projected utilization	Y1	Y2	Y3	Y4	[...]	Y10
Parking spots	4	4	4	4		8
Number of chargers	2	2	2	2		4
Mean EVs charging daily at Eranovum [EV]	7	10	14	19		49
Peak day*: # of EVs	28	43	61	89		255
Number of rotations	2	2	3	4		6
Mean total functioning time of station [h/day]	1.50	1.72	1.93	2.61		6.74
Peak day: Mean total functioning time of station [h/day]	5.94	7.40	8.45	12.26		35.09
Total mean functioning time of each spot [h/day]	0.38	0.43	0.48	0.65		0.84
Peak day: Total mean functioning time of each charger [h/day]	1.49	1.85	2.11	3.06		4.39

To be able to size the station (e.g., estimating the number of electric posts that should be available), the “peak daily number of EVs has been calculated”. This is the maximum amount of EVs that is estimated that will be charging at the station.

3.6. Station Sizing and growth plan

As mentioned before, to size the station and develop a growth plan, it is mandatory to estimate a maximum and minimum of clients to calculate the demand. In the business model a model in Excel has been designed to recreate the peak times. A percentage of utilisation has been assigned for each month, day of the week and hour of the day. This % has been applied to the IMD number of the road. The model instructions and hypothesis have been the following:

Monthly

The demand will follow a stationary trend – as this road connects Madrid to the Community of Valencia, two major economical centres in Spain and a preference vacation location for Madrid’s citizens, the road will be most packed during summer months, reaching the peak in August.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
%	85%	85%	85%	85%	85%	110%	150%	170%	105%	85%	85%	85%



Weekly

The utilisation will be higher during weekends and lower during labour days. Also, it has been estimated that utilisation will be highest on Fridays and Sundays since it is when most people travel.

Table 4: Weekly affluence assumptions

	January				May - September			
Day of week	M-T	Friday	Sat	Sun	M-T	Friday	Sat	Sun
%	25%	25%	10%	40%	10%	25%	25%	40%

	June				July			
Day of week	M-T	Friday	Sat	Sun	M-T	Friday	Sat	Sun
%	7%	25.8%	25.8%	41.5%	5%	26.25%	26.25%	47.5%

	August			
Day of week	Monday - Tuesday	Friday	Saturday	Sunday
%	1%	24.5%	24.5%	50%

Daily

The distribution among day hours has been modelled depending on the day of the week and month of the year. The most affluent hours are in the mornings from 8:00h to 12:00 and in the afternoons from 15:00h to 21:00h, bearing in mind the most common time intervals for people to travel. In Annex I: Modelling of distribution of affluence to the station, the tables of the distribution are shown.

From the model it has been estimated that the maximum amount of affluence of EVs from Y1 to Y3 will be 61 EVs, this translates into a mean daily functioning demand of 1.9 h / day (Table 3). With this data it has been decided that the number of chargers at the station during the first three years is going to be of four.

Table 3 depicts that with this sizing the mean functioning time of each charger will be of 0.38 h / day per charger the first year and 0.48 h / day per charger the third year. During peak day, the utilisation will be of 1.49 h / day per charger and 2.11 h/day per charger.

From year three, it is expected that the affluence will grow. In order to maximise the capacity and not lose potential clients that may not be able to charge at our chargers because of high demand, a CAPEX influx has been introduced in year five to increase the capacity to eight spots. With this measure, the mean total functioning time of each spot will be of 0.84 [h / day] per spot and during peak day of 4.39 [h / day] per spot.

Chapter 4 The Charging Point

This chapter will consist of a classical engineering project with the necessary elements for the deployment of an electric charging point.

In order to achieve the objective of this innovation project, it will be necessary to fulfil a series of specific objectives:

- Installation of 2 recharging points (double) for electric vehicles, developing two chargers with a power of 400 kW.
- Develop an ultra-fast recharging system, so that the time needed to fill the batteries of the vehicles is as short as possible (less than 30 minutes).
- Feed the electric energy recharge through the adjacent photovoltaic plant (~156MWp), designing the necessary transformers and inverters for this purpose, and avoiding the need to transport energy from the grid and the associated GHG generation.
- Provide the system with an energy storage system with a capacity of 420kWh to be able to supply the demand in the hours when there is no sunlight. These batteries will be recycled from discarded electric vehicles.
- Build the necessary infrastructure to locate the photovoltaic station, with access for vehicles to arrive to recharge, and adapting it to be suitable for rest, with a roof to protect against weather incidents.
- Reduce emissions in the mobility and transport sector in the area by using solar energy and energy storage as a source of clean renewable energy.
- Bringing the necessary charging infrastructure to unpopulated areas to encourage the use of electric vehicles in these areas.

In addition, the implementation of this project will allow Eranovum to achieve different strategic objectives:

- Recharging electric vehicles through solar-powered infrastructures is a solution in the development and validation stage that has not yet been implemented in Spain, as there is currently no installation of this type in our country. It is therefore a pioneering project in our country that could open a new market for the company and position it as a reference in the sector.
- Create a brand image associated with the quality service provided at the photovoltaic station, and to associate Eranovum with renewable energy installations that improve the sustainability of the planet.
- Attracting investors interested in the type of technology used to create the photoline station, which, due to its easy replicability, can be very attractive.
- Diversification of its business, as it is a new activity that can bring the company great benefits.
- Highlighting the use of solar energy as one of the main sources of renewable energy and promoting its use in other areas or processes that require heavy investment to achieve decarbonisation.

4.1. *Chargers*

In order to select the chargers' providers different features were evaluated such as:

- Power output of models
- Reliability and trustworthiness
- Cost
- Deployment time
- Nationality

The conclusions for choosing the correct chargers are a result of meeting with the sales staff of different brands, in which some prices and characteristics were given orally and there are no written records of them. The summary of these meetings were:

Powerelectronics

This national brand was one of the first options to look into due to the close relationship with Eranovum. They have a wide variety of chargers which could fit into Eranovum's plan. Table 5 summarizes the characteristics of the chargers:

Table 5: Powerelectronics chargers main characteristics

Type of current	Model	Max power [kW]	Modularity	Simultaneity	Cost	No. of sockets	Dynamic Power Control	Dual Power Sharing
AC	NB Wall	2x22	No	Yes	2,904 €	2	Yes	Yes
	NB city	2x22	No	Yes	4,097 €	2	Yes	Yes
DC	NB Station 900kW				283,653 €	2	Yes	No
	NB 60	60	Upgradable	Yes	22,000 €	2	Yes	No
	NB 120	120	-	Yes	27,500 €		Yes	No
	NB240	360			32,199 €	2	Yes	No

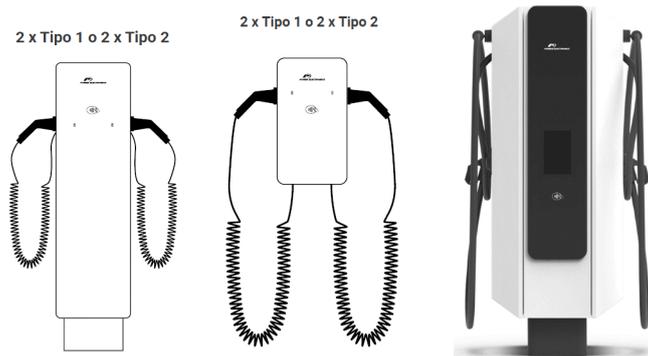


Fig. 11: Powerelectronics sample chargers

Ingeteam

Ingeteam is another national manufacturer with a consolidated reputation in the market. The models of chargers discussed with them are summarised in Table 6:

Table 6: Ingeteam chargers characteristics

Type of current	Model	Max power [kW]	Modularity	Simultaneity	Cost	No. of sockets	Dynamic Power Control	Dual Power Sharing
AC	FUSION Wall	2,3 - 22	-	-	-	2	Yes	Yes
	FUSION City	2,3 - 22	-	-	-	2	Yes	Yes
DC	RAPID 50	50	-	Yes	-	2	Yes	Yes
	RAPID 120	120	-	Yes	-	2	-	Yes
	RAPID 180	180	Yes	Yes	36,603 €	2	-	Yes
	RAPID ST 200	200	Yes	Yes	37,120 €	2	Yes	Yes
	RAPID ST 400	400	Yes	Yes	47,279 €	2	-	Yes
Optional	Contact-less card reader	-	-	-	917.00 €	-	-	-



Fig. 12: Ingeteam chargers sample

Ingeteam is also an inverter manufacturer – the adaptability would be excellent. The costs include transportation and two years of field assistance.

EFACEC

EFACEC is a Portuguese manufacturer exclusively of EV chargers. They have an extensive portfolio but lack the experience in CC chargers of high power.

Table 7: EFACEC chargers characteristics

Type of current	Model	Max power [kW]	Modularity	Simultaneity	Cost	No. of sockets	Dynamic Power Control	Dual Power Sharing
AC	PC G3	2x22	Yes	Yes	-	3	Yes	Yes
DC	QC 20	20	Yes	No	16.330 €	3	-	No
	QC 60	60	Yes	No	29.810 €	3	-	No
	HV350 G2	350	-	No	74.580 €	2	-	No



Fig. 13: EFACEC chargers sample

Schneider

Schneider is a German electric elements manufacturer which has recently introduced in the electric vehicle charger business. They have a quite limited offer. The characteristics of the chargers discussed with them are in Table 8:

Table 8: Schneider chargers characteristics

Type of current	Model	Max power [kW]	Modularity	Simultaneity	Cost	No. of sockets	Dynamic Power Control	Dual Power Sharing
AC	Evlink Wallbox	3.7-7.4-11-22	No	No	-	2	Yes	Yes
	Evlink Parking	7.4-22	No	No	-	1		
	Evlink Smart Wallbox	7.4-22	No	No	-	1	Yes	Yes
DC	EVlink DC	22ac-24dc	No	No	-	1		
		22.1ac-50dc	No	No	-	1		



Fig. 14: Schneider chargers sample

Although a good and recognised brand, Schneider does not offer yet sufficient power output for this project's purposes – its maximum power output charger is of 50 kW.

Spanish manufacturers have an advantage which is that the government incentivises acquiring the elements for them to give financial aid. EFACEC, although a very competent provider was discarded because of two reasons, first that they work with high orders and two because they were giving deployment times of 3-4 months after making the order and they would not confirm that the CC chargers would be available. Moreover, Schneider was soon discarded because they did not have available yet fast chargers. The decision was hence between Ingeteam, and Powerelectronics. The decision was made because of price, Ingeteam gave a lower budget that Powerelectronics.

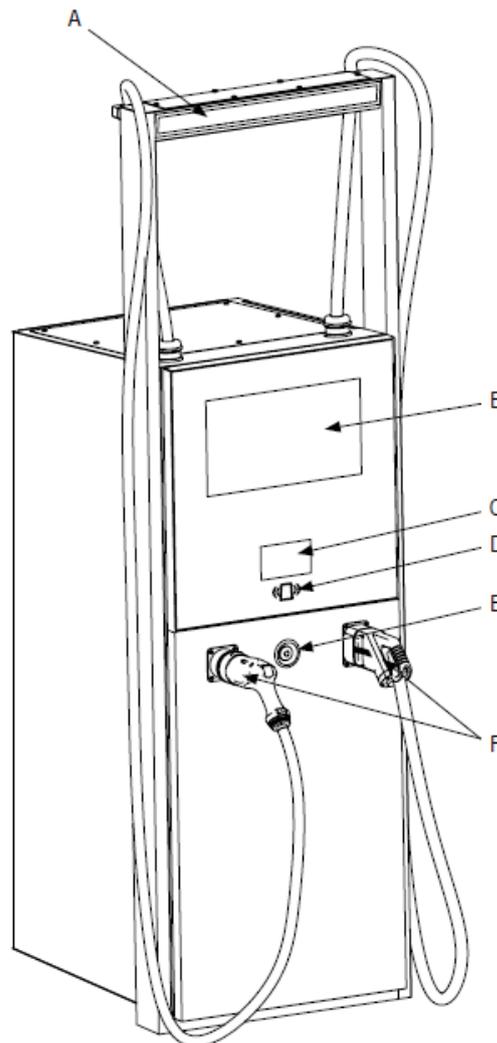
The characteristics of the chosen charger are as follows:

- Manufacturer: Ingeteam
- Model: INGEREV RAPID 180
- Description: ultra-fast multi-standard charging stations. The RAPID 180 chargers have a nominal power of 180kW with two CCS DC connectors so that it can simultaneously supply two vehicles with 90kW. In addition, a third 22kW AC connector can be added.

Technical reasons for choosing this system:

- Ultra-fast charger adapted to future demand.

- Design and production in Spain
- High efficiency
- High scalability with DC buses



- | | |
|---|----------------------------|
| A. Iluminación LED ambiental | D. Lector de tarjetas RFID |
| B. Pantalla de 21" con resolución Full HD para fines comerciales (opcional) | E. Seta de emergencia |
| C. Pantalla táctil de interacción (<i>Human-Machine Interface, HMI</i>) | F. Conectores de carga |

Fig. 15: Elements of the Ingeteam charging station

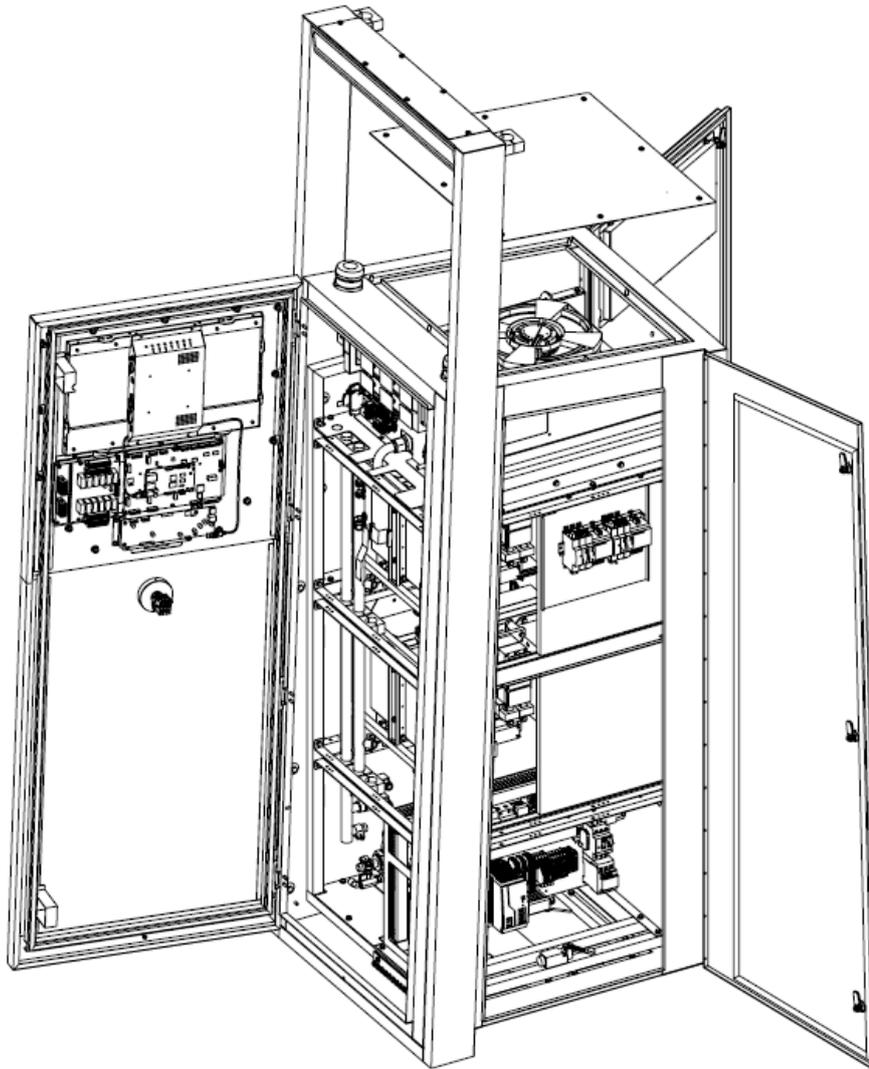


Fig. 16: Complete view of the Ingeteam service station

The 200ST and 400ST models were chosen as they provide the highest possible power from this manufacturer and offer the most cost-efficient solution. Ingeteam is also a supplier with extensive experience in the manufacture of chargers and complete charging stations. The table of characteristics of the 200ST and 400ST models is as follows:

	INGEREV® RAPID 120	INGEREV® RAPID 180
Entrada AC		
Tensión	AC 3ph.+ N + PE; 380/400/480 Vac ±15 %	
Frecuencia	50 / 60 Hz ±5 %	
Corriente nominal	190 A + 32 A	280 A + 32 A
Potencia nominal	120 kW + 22 kW	180 kW + 22 kW
Salida DC		
Rango de tensión	150 - 1.000 V	
Corriente máxima	400 A (200 + 200 A)	600 A (300 + 300 A)
Potencia máxima	120 kW (60 + 60 kW)	180 kW (90 + 90 kW)
Conectores de carga	CCS1 / CCS2 (300 A) / CHAdeMO (125, 200 A) / 22 kW AC Modo 3 Toma Tipo 2	
Salida AC (opcional)		
Corriente máxima	32 A	
Potencia máxima	22 kW	
Conectores de carga	AC Modo 3 Toma Tipo 2 con obturadores	
Cumplimiento de normativas y seguridad		
Estándares	IEC 61851-1 ed 3, IEC 61851-21-2 ed 1, IEC 61851-23 ed 1, IEC 61851-24 ed 1, IEC 62196-2, IEC 62196-3, IEC 61000	
Sobrecorriente	MCB	
Contactos indirectos	Control de fugas de DC IEC 62955 Dispositivo de fuga - RCD 30mA clase A (opcional)	
Sobretensiones	Protección contra sobretensiones permanentes y transitorias Tipo 2, tanto en entradas como en salidas DC	
Funcionalidades y accesorios		
Conexión	Ethernet, Modem 3G/4G (opcional)	
Protocolo de Comunicación	OCPP (estándares y versiones personalizadas)	
Pantalla publicitaria	Full HD de 21" (opcional)	
HMI	Pantalla táctil de 7", RFID (Mifare Classic 1K&4K, MifareDesFire EV1, NFC)	
Información general		
Consumo en stand-by	<60 W	<80 W
Sistema retráctil para mangueras	Incluido	
Longitud de mangueras	6,5 m (5 m útiles)	
Medición de energía	Medidas de salidas de AC (MID) y DC	
Temperatura de funcionamiento	-35 °C ~ 60 °C (opción kit de baja y alta temperatura)	
Humedad	<95 %	
Peso	380 kg	420 kg
Medidas (An x P x Al)	2.540 x 774 x 730 mm	
Envolvente	Acero inoxidable 430 y aluminio	
Altitud de funcionamiento	2.000 m (para altitudes superiores consultar con Ingeteam)	
Grado de protección	IP54 / IK10 (display IK08) / C5H	
Marcado	CE	
Directivas	Directivas de baja tensión : 2014/35/EU Directiva EMC : 2014/30/EU	

Fig. 17: Characteristics of the Ingeteam ST200 and ST400 models

4.2. BESS System

Since the station's power supply comes from the sunlight, it is important to provide the station with a complementary source of energy in order to be able to charge vehicles

during night hours. This way the number of clients that the station will be able to supply increases – hence the revenues – and the quality of service is also higher.

To size the capacity of this BESS system it has been estimated that from the total amount of EVs charging at the station, 5% will be during night hours without any sunlight to produce energy.

Table 9: Expected energy needed from BESS system

	23	24	25	26	27
Total charging sessions	7	10	14	19	25
# of night charging sessions	0	1	1	1	2
Mean energy needed [kWh/day]	8	20	51	126	298
Capacity [kWh]	168	168	168	168	168

From Table 9 in year 2027 the battery capacity starts to be deficient, and the station would be losing clients. Hence a CapEx input should be considered in the future to increase the batterie's capacity. The 168kWh capacity has been chosen since the needs for the first four years are covered and the cost is not dramatically high.

A similar process to choose the best battery provider was conducted. The decision was made taking into consideration the information gathered with the sales teams of the different brands. A summary of the findings is depicted in Table 10:

Table 10: Findings of Batteries' providers

Provider	Nationality	Cost [€/kWh]	Technology	Reliability	Deployment time
Chakratek	Portuguese	High	Kinetic Energy	Medium	High
Invinity	Spanish	High	Vanadium	High	Medium
Norvento	Spanish	High	Lithium	Medium	Medium
Tesvolt	German	High	Lithium	Medium	High
Beeplanet	Spanish	Medium	Recycled Lithium	High	Medium

Chakratek was an interesting option since they do not use Lithium to store the energy but rather store it as kinetic energy. After conducting several meetings with them this option was discarded due to the technology immaturity and the low ratio density-energy stored. Invinity offered vanadium batteries, which is a storing technology being developed which offers an infinite number of charging cycles and a higher energy density than Lithium batteries, the downside is that it does not allow for high power outputs, hence this option had to be discarded. Among the manufacturers offering Lithium batteries, BeePlanet was the most promising since they offer EVs recycled batteries. These batteries are highly efficient since they are designed to function in much harder conditions and have the upside that they are recycled, contributing to the objective of this project which is the decarbonisation of the motoring park.

Since the cost will be an important aspect for the final business plan, a budget was asked to every lithium battery manufacturer in order to correctly evaluate the options. These budgets were:

Table 11: BeePlanet budget

Type of product	Model [kWh]	Cost [€]	Cost [€/kWh]
Battery BeePlanet	420	135.558	323
Inversor Ingecon	Sun Storage 100TL 100kW	13.500	-
Container	20'	30.433	-
Container	10'	20.433	-
Switch	-	879	-
Assembly and commissioning	-	1.250	-
Transport and deployment	-	2.500	-
	TOTAL	204.555	487

Table 12: Norvento budget

Type of product	Model [kWh]	Cost [€]	Cost [€/kWh]
Norvento Grid Master	200kVA	31.513	
Batteries Cegasa	376	129.243	343
Toroidal network analyzer	-	340	-
Commissioning	-	1.800	-
	TOTAL	162.896	433

Table 13: Tesvolt budget

Type of product	Model [kWh]	Cost [€]	Cost [€/kWh]
TPS flex 20ft 300kW 360kWh	360	281.842	783

Tesvolt was discarded because of the high cost of the battery (783 €/kWh vs. 433 and 487 €/kWh), even though its characteristics were excellent they did not explain this high cost. Among Norvento and BeePlanet, since the costs are close, BeePlanet won because of the differentiation factor of using recycled batteries.

The summary of the characteristics of the chosen battery are:

- Manufacturer: BeePlanet [40]
- Model: Power ESS - 10" Container
- Description: container with 10 racks of batteries of the Power ESS model made from second life batteries from the automotive sector. It has a capacity of 168 kWh and a power of 100 kW.

The reuse of second-life batteries reduces CO₂ emissions by 70% compared to the use of new batteries, as no new limited raw materials such as lithium, cobalt or copper are used. In addition, the containers in which the batteries are housed are reused at sea.

- Elements inside the container: battery racks, inverters, air conditioning of the container itself, protections at the input and output of each electrical element, grounding, lighting, fire protection and EMS communication and monitoring system to control the system's consumption.

Technical reasons for choosing this system:

- Modularity
- Scalability
- Safety and security
- Mobility
- Robustness
- Integrated monitoring
- Design and production in Spain

Images of the BeePlanet container are shown below:

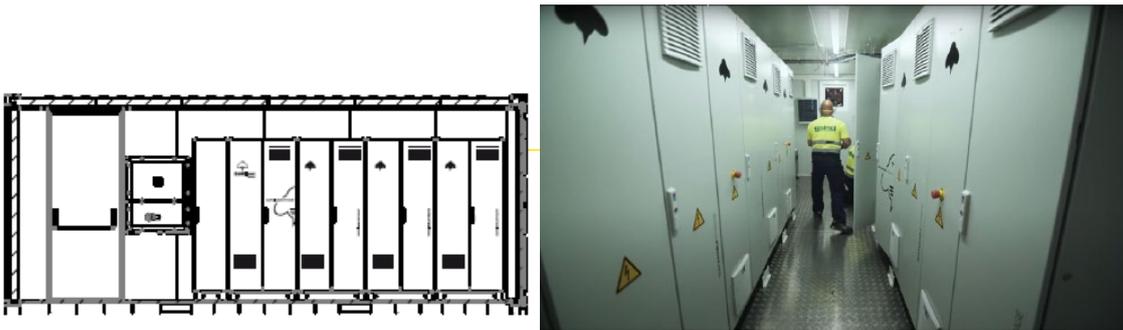


Fig. 18: Sample images of the BeePlanet container

Similarly, sample images of the battery racks offered by BeePlanet are also shown:

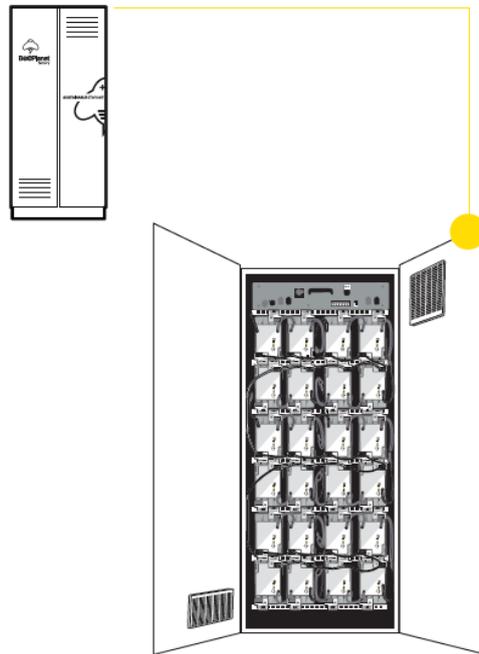


Fig. 19: Sample image of the BeePlanet battery rack

4.3. *Electrical elements and security*

The installation consists of two 4 MVA transformers at the output of the photovoltaic plant, an inverter associated with each 3,000 kVA transformer, 20 boxes per inverter (to house the strings) and 16 to 18 strings per box. Fig. 20 shows the single-line diagram showing the elements previously explained:

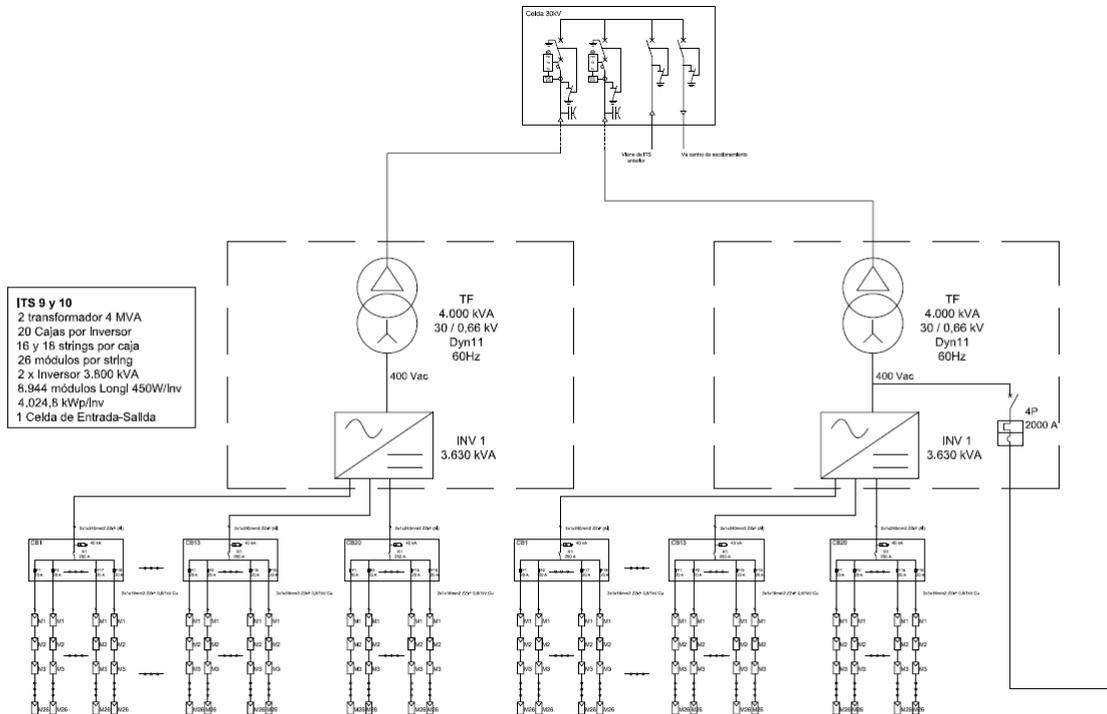


Fig. 20: Scheme of the electrical elements of the site

Inside the batteries' container, there will be the following scheme shown in Fig. 21:

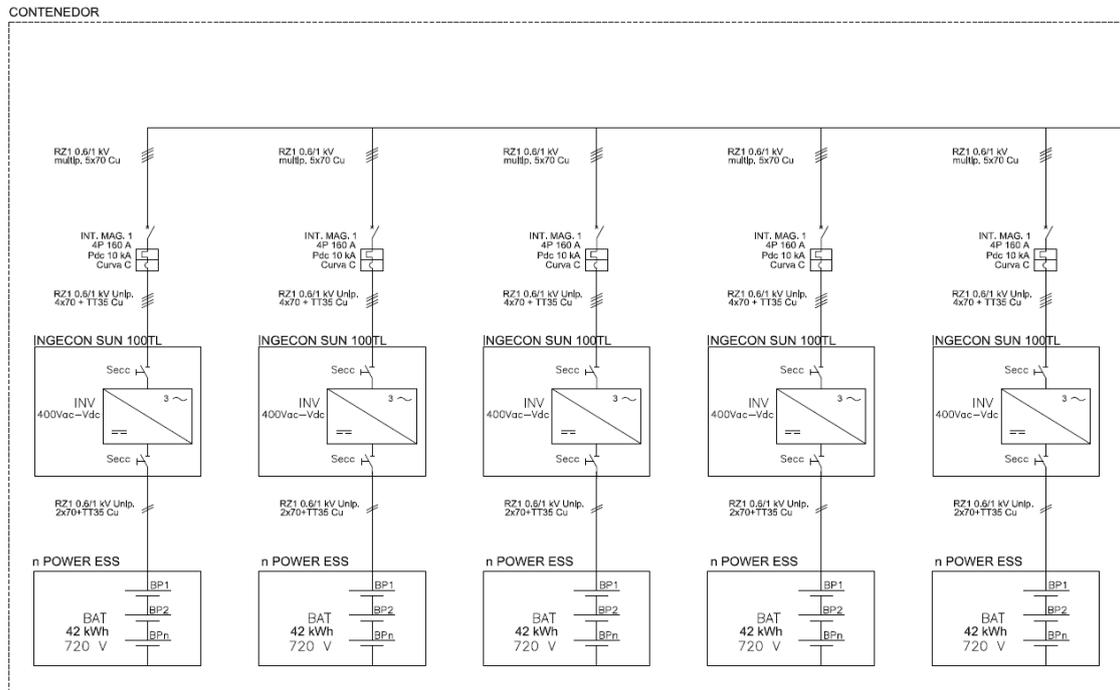


Fig. 21: Distribution of the container where the batteries are disposed

Finally, defines the recharging station layout proposed in this project. This figure shows the original configuration that will take place after the project is implemented, and in red shows the future extension that is intended to be developed to increase the number of chargers available at the electric charging station.

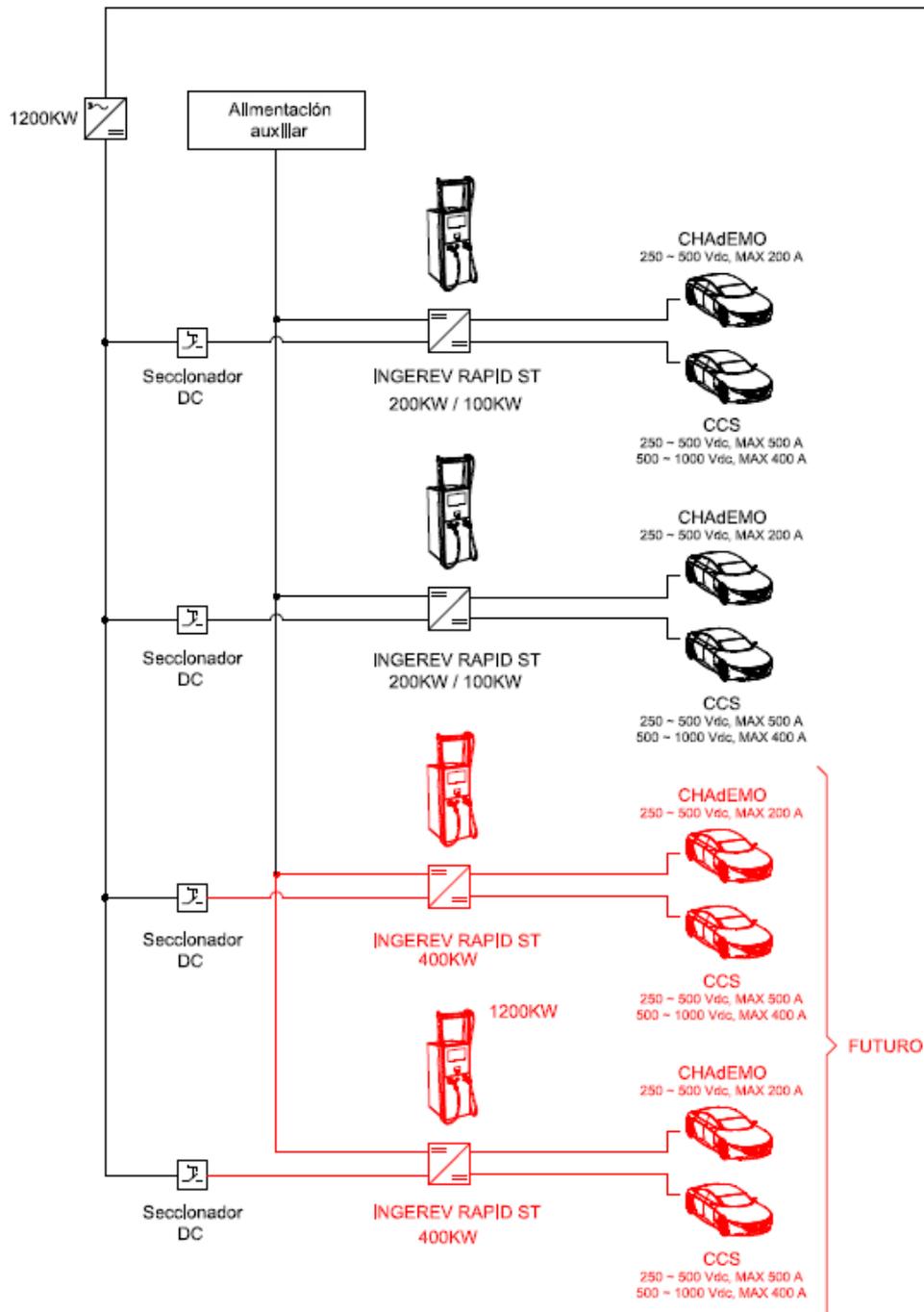


Fig. 22: Charging station scheme

With all this information on the distribution of the different elements of the charging station and their connections, the installation developed will have the following characteristics:

- Total output power: 1.200 kW
- Storage power output: 100 kW
- Stored energy: 168 kWh (in 6 racks of 42 kWh with second life batteries 1C)

Dimensioning for a station with 4 charging points (initially 2 chargers of 180 kW will be installed, but in the future 2 more of 400 kW will be installed), so that when there are two vehicles charging simultaneously in one of them, the charging power will be 90kW.

The power of the chargers is limited to 100 kW when there is no sun, during night hours

4.4. Planification

In line with the maximum duration established in the call for proposals, the actions to be carried out during this project have been designed to give rise to an execution plan for the 18 months provided.

The plan contemplates the execution of the entire project, from the application for the building permits to the preparation of the final project and legalisation of the installations.

The list of all the actions planned, with the estimated duration for each of them, is shown in Fig. 23.

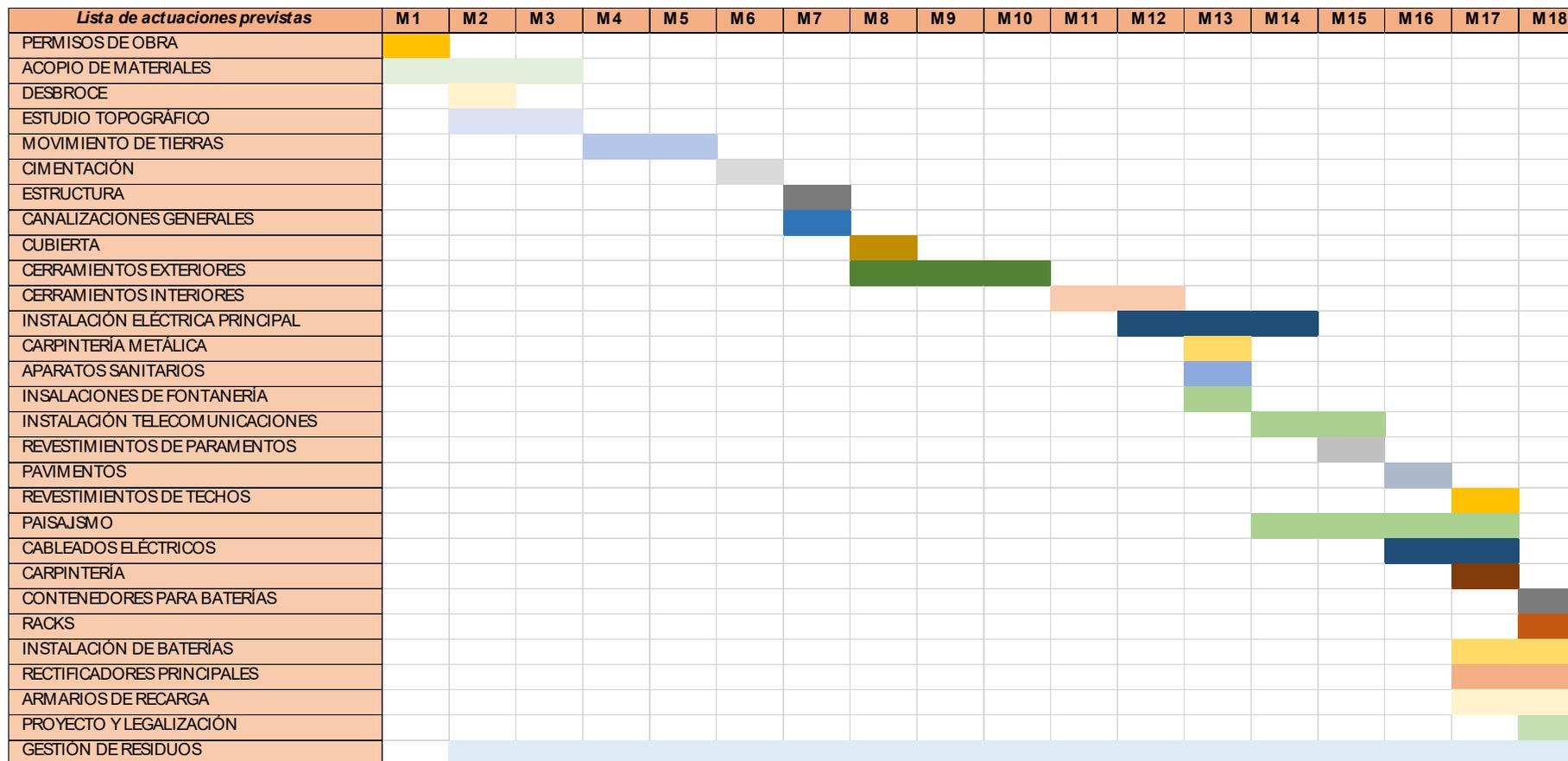


Fig. 23: Planification of the tasks included in the project

To ensure the correct execution of the proposed project, different milestones or events have been selected to be achieved during the development of the project, which will serve as a tool for monitoring the correct evolution of the project:

1. Execution of the civil works to adapt the land and be able to build the charging station with the necessary associated spaces.
Planned date for reaching the milestone: Month 12 from the start of the project.
2. Connection of the photovoltaic plant annexed to the charging station in order to provide electricity, including all the necessary transformers.
Planned date for achieving the milestone: Month 14 from the start of the project.
3. Supply of the necessary equipment to set up the two recharging points (chargers, batteries, BESS system...).
Planned date for reaching the milestone: Month 13 from the start of the project.
4. Execution of the necessary validation tests to ensure that the charging points work correctly with the desired power, and that they are capable of charging electric vehicles running on the power provided.
Planned date for reaching the milestone: Month 17 from the start of the project.
5. Connection of the adjacent road (N-III) to the photo station developed for easy vehicle access, and proper signage of the station so that drivers can be aware of its presence and the benefits of recharging there.
Planned date for reaching the milestone: Month 18 from the start of the project.

Once the implementation of the project is completed and the photo station is operational, the main monitoring measure will be to count the number of users of the facility, so that the number of refuelling stations per month is in line with the initial plan.

These estimated figures for the number of recharges have been calculated taking into account the projected growth of the electric vehicle market, so it will also be important to review the actual figures for the increase of electric vehicles per year so that the estimated sales can be in line.

Chapter 5 Financial Analysis of Business Plan

In this chapter an analysis of the business model will be conducted, taking into consideration all the hypothesis and the decisions made in the project in Chapters three and four. A sensitivity analysis will be conducting, taking into consideration that the most fragile and risk hypothesis made in the business model is the growth of the presence of EVs in the Spanish motoring park. Three scenarios will be tested: pessimist, moderate and optimist.

The business model consists of making a strong initial investment in the construction and adequation of the charging station. The revenues will come from the energy supply to EV users.

5.1. *Criteria for measuring profitability*

Currently, different criteria can be used to measure the profitability of an investment, some of the most used are defined below:

- a) Net Present Value (NPV): this consists of updating the cash flows estimated to be generated by the project to present value, discounting at a certain interest rate (the discount rate), and then comparing it with the initial investment.

If $NPV > 0$ -> the project is profitable

If $NPV < 0$ -> the project is not profitable

The higher the NPV, the more profitable the project will be. The equation used to calculate the NPV is shown below:

$$-I_0 + \sum_{t=1}^n \frac{V_t}{(1+i)^t} \quad (1)$$

Where:

I_0 -> initial investment

V_t -> cash flow during period t

i -> interest rate

n -> number of years the investment lasts

As for the interest rate, it is normally between 3% and 7%. For this project a realistic value of 5% has been used.

- b) Internal rate of return (IRR): this is a percentage that measures the viability of a business, determining the profitability of the updated receipts and payments generated by the investment. It is mainly used to objectively compare the profitability of different businesses. The way it is calculated is shown below:

$$\sum_{t=0}^n \frac{V_t}{(1+i)^t} = 0 \quad (2)$$

Where:

V_t -> cash flow during period t

i -> interest rate

n -> number of years the investment lasts

- c) Payback period (PP): the period required to recover the initial investment. The balance will be positive in the year in which the cash flow exceeds the initial investment. The project will be accepted if the RP is less than a time determined by the client, i.e., the maximum time the investor will be willing not to make a profit.

5.2. *Business Plan Premises*

The assumptions considered are the following, in the order of the financial projection table:

Revenues Assumptions

These assumptions have been explained and analysed in Chapter 3 The Business Model. The most important aspects to consider are:

- a) Price: 0,35 €/kWh – based on competitors and market analysis.
- b) Activity: this factor will change among scenarios – it has been calculated based on estimations of the growth of the EV motoring park as a percentage of the total Spanish car park, the average number of vehicles passing daily through the location, general charging requirements (capacity) of most EVs in Spain and its evolution, and competitive landscape around the location. A seasonality has also been considered, considering summer months as busier than other months.

Moderate Scenario

The moderate scenario has been defined using the estimations from ANFAC [14]. The growth perspective is depicted in Table 14: Revenues estimation in moderate scenario it is depicted the EVs affluence to the station in 2023, the first year of the project. The maximum will be in August with nearly 800 EVs in the whole month (25,8 EVs / day on average), and the minimum will be of close to 400 EVs a month (12,9 EVs / day on average).

Table 14: Revenues estimation in moderate scenario

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Number of vehicles passing daily through N-III	759	778	798	818	839	860	882	904	927	950
% of Electric Vehicles [EV] (moderate scenario)	2,48%	3,44%	4,58%	5,92%	7,45%	9,15%	11,04%	13,04%	15,14%	17,34%
Average of EV passing daily [EV]	20	29	39	51	66	83	103	124	148	174
Number of EVs annually [EV]	7.533	10.923	14.689	19.209	24.859	31.262	38.795	46.705	55.744	46.705
% of EV charging in Eranovum	48,25%	48,00%	47,75%	47,50%	47,25%	47,00%	46,75%	46,50%	46,25%	46,00%
Average of EVs charging daily in Eranovum [EV]	10	14	19	25	32	40	49	58	69	81
Average of EVs charging annually in Eranovum [EV]	3.635	5.243	7.014	9.124	11.746	14.693	18.137	21.718	25.782	21.484
Average charging time per client [min/EV]	10,31	8,25	8,25	8,25	8,25	8,25	8,25	8,25	8,25	8,25
Use of the station per day [h/day]	1,72	1,93	2,61	3,44	4,40	5,50	6,74	7,98	9,49	11,14
Average energy used per EV [kWh]	132,42	238,35	429,03	430,00	430,00	430,00	430,00	430,00	430,00	430,00
Energy sold per day [kWh/day]	1.324,18	3.336,94	8.151,66	10.750,00	13.760,00	17.200,00	21.070,00	24.940,00	29.670,00	34.830,00
Energy sold per year [kWh/year]	481.296	1.249.675	3.009.319	3.923.469	5.050.707	6.318.040	7.798.755	9.338.585	11.086.128	9.238.170
Selling Price [€/kWh]	0,36	0,36	0,37	0,38	0,39	0,39	0,40	0,41	0,42	0,43
Revenues [€]	171.823	455.057	1.117.730	1.486.411	1.951.736	2.490.299	3.135.411	3.829.574	4.637.132	3.941.447
Growth	-	165%	146%	33%	31%	28%	26%	22%	21%	-15%

Cost Premises

For the calculation of variable costs, the unit cost of energy sold per year has been considered. The unitary cost, since the PV plant from which the energy is being extracted is Eranovum's property, is considerably lower than the market price. For the fixed costs, the costs for the maintenance of the installation, land rent, software licence fees, local taxes and property damage protection insurance have been considered.

Table 15: Costs premises

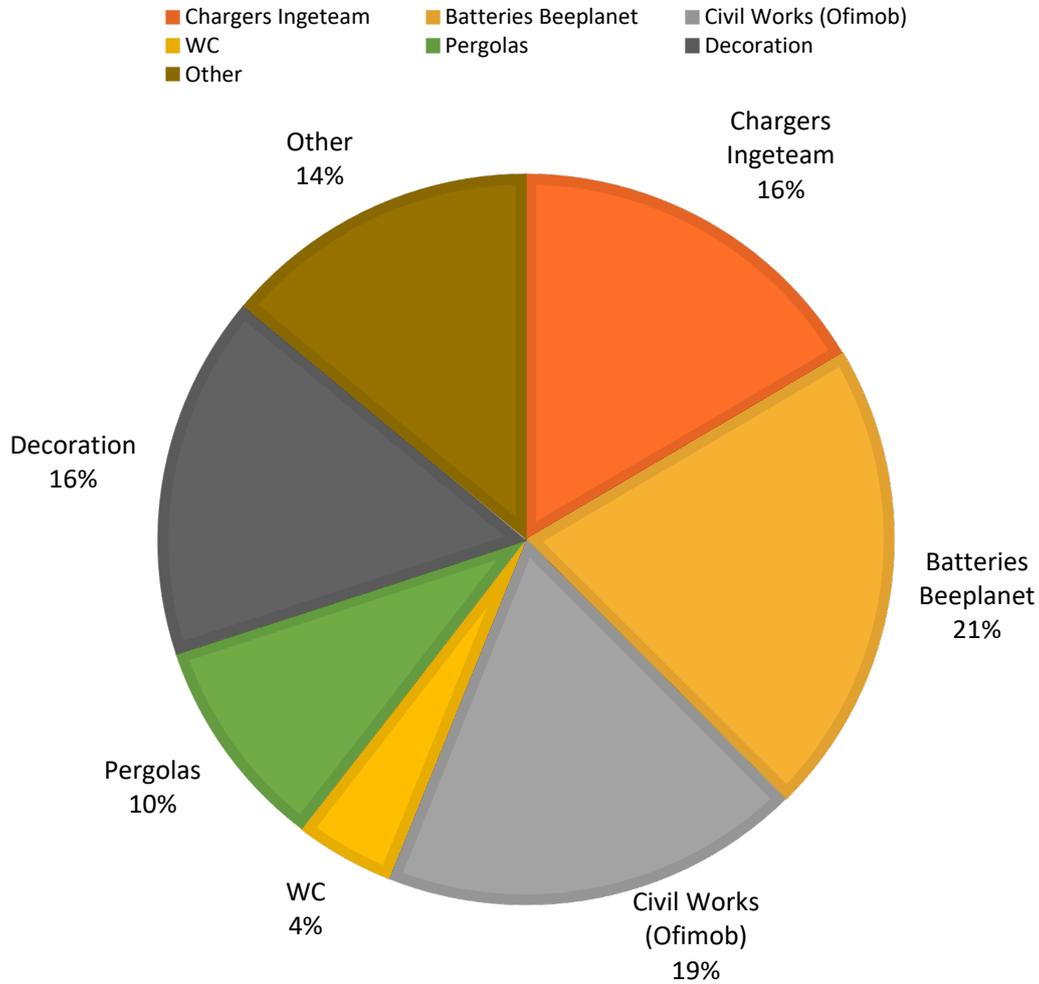
	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Variable Costs [€]	40.860	108.215	265.802	353.477,06	464.133,98	592.207,28	745.618,71	910.694,62	1.102.736,52	937.298,65
Unitary Cost of Energy [€/kWh]	0,08	0,09	0,09	0,09	0,09	0,09	0,10	0,10	0,10	0,10
Cost of energy sold [€/year]	40.860	108.215	265.802	353.477	464.133	592.207	745.618	910.694	1.102.736	937.298
Profit margin [€]	130.962	346.841	851.927	1.132.934	1.487.602	1.898.091	2.389.792	2.918.879	3.534.395	3.004.148
Fixed Costs [€]	6.531	6.533	6.534	7.286	7.288	7.290	7.291	7.293	7.295	7.297
EPC installation management [€/year]	750	750	750	1.500	1.500	1.500	1.500	1.500	1.500	1.500
Cost of terrain rent [€/year]	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
Software back-end [€/unit/year]	82	83	85	87	88	90	92	94	96	98
Local taxes [€]	500	500	500	500	500	500	500	500	500	500
Physical damage insurance [€]	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200
Total Costs [€]	750	750	750	1.500	1.500	1.500	1.500	1.500	1.500	1.500
EBITDA [€]	124.431	340.308	845.392	1.125.647	1.480.314	1.890.801	2.382.501	2.911.586	3.527.100	2.996.851
EBITDA / Revenues [%]	72,42%	74,78%	75,63%	75,73%	75,85%	75,93%	75,99%	76,03%	76,06%	76,03%

Finally, the costs related to amortisation and CapEx have been determined to calculate the net revenues of the project and the free cash flows for every year until 2033 (ten years). The CapEx can be found in the different budget tables in Chapter 4 The Charging Point. Other terms such as the conditioning of the area have been calculated based on budgets received from different providers, available in Annex II: CapEx detail.

In these costs several investments have been included in years 2027 and 2033, for the purpose of investing part of the benefits in growing the station's capacity incorporating a higher number of chargers. This way the station will be able to supply more clients. As a result of the analysis, the first year of the project there will be losses due to the lack of benefits and the big investment. But from year one the net result it is estimated that will be positive.

	Year 0	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Chargers amortisation	-	(8.321)	(8.321)	(8.321)	(16.641)	(16.641)	(16.641)	(16.641)	(16.641)	(16.641)	(16.641)
Batteries amortisation	-	(10.629)	(10.629)	(10.629)	(10.629)	(10.629)	(10.629)	(10.629)	(10.629)	(10.629)	(10.629)
Civil works amortisation	-	(6.237)	(6.237)	(6.237)	(6.237)	(23.760)	(12.473)	(24.947)	(24.947)	(24.947)	(24.947)
Total amortisation	-	(25.186)	(25.186)	(25.186)	(33.507)	(51.030)	(39.743)	(52.217)	(52.217)	(52.217)	(52.217)
EBIT	-	99.245	315.122	820.206	1.092.141	1.429.284	1.851.058	2.330.284	2.859.369	3.474.883	2.944.634
Result of exercise before taxes	-	99.245	315.122	820.206	1.092.141	1.429.284	1.851.058	2.330.284	2.859.369	3.474.883	2.944.634
Taxes over profit (25%)	-	(24.811)	(78.781)	(205.052)	(273.035)	(357.321)	(462.765)	(582.571)	(714.842)	(868.721)	(736.159)
Net profits	(449.823,14)	74.434	236.342	615.155	819.106	1.071.963	1.388.294	1.747.713	2.144.527	2.606.163	2.208.476
CapEx	(449.823,14)	-	-	-	(83.206)	-	-	-	-	-	(106.287)
Free Cash Flow	(449.823,14)	74.434	236.342	615.155	735.900	1.071.963	1.388.294	1.747.713	2.144.527	2.606.163	2.102.189

CAPEX DISTRIBUTION



The proper elements for the charging point (chargers + batteries) account for 37% of the investment needed, while conditioning takes about 45% of the investment, which is considerably high and should be looked into.

5.3. Economic results

To correctly evaluate the project, as explained before in 5.1 Criteria for measuring profitability the NPV has been calculated considering a discount rate of 5%. Taking into account that the full investment of 449.823,14 € is deployed in year 0, the result for the NPV of the first five years is of 1.510.878 €. Thus, the project is economically viable considering this indicator.

Regarding the second economic indicator considered, the IRR. Again, the full investment is made the first year of the project and the free cash flows considered pertain to the period from 2024 to 2028 in which the station will already be operating. The IRR calculated is therefor of 53,5%, considering that for leveraged renewable energy projects a considerably good IRR is around 23% [45], the project can be considered economically viable from this perspective.

Regarding the payback period, being the period in which the project is giving profits over the initial investment, it has been calculated to be of two years and three months, a good result considering the high profitability of the project and that it is projected to last over ten years.

A summary of the economic indicators obtained is shown in Table 16:

Table 16: Summary of economic indicators' result

NPV	1.510.878 €
IRR	53,5%
Payback Period	27 months

5.4. *Sensitivity and risk analysis*

Considering that the project is targeting a completely new and emerging market, the risk of making mistakes in the market growth estimations and the tendencies is considerably high. That is why a sensitivity analysis has been conducted to corroborate if the expected presence of EVs in the Spanish motoring park could in the worse scenario make the project inviable. It has been considered that the estimations used along the project are the moderate scenario, a pessimistic scenario with 30% less EVs present in the Spanish motoring park in years 2030 and 2040 has been used. Another optimistic scenario where the estimations from the Spanish government in the PNIEC [9] are met – this estimation

prognosticates five million EVs circulating in 2030 versus the 2,9 million used in the project from ANFAC estimations [14].

Optimistic Scenario

The optimistic scenario has been defined using the estimations from the Spanish government specified in the PNIEC [9], which expect that by 2030 there will be five million EVs on the road, for the rest of the years the growth is linear.

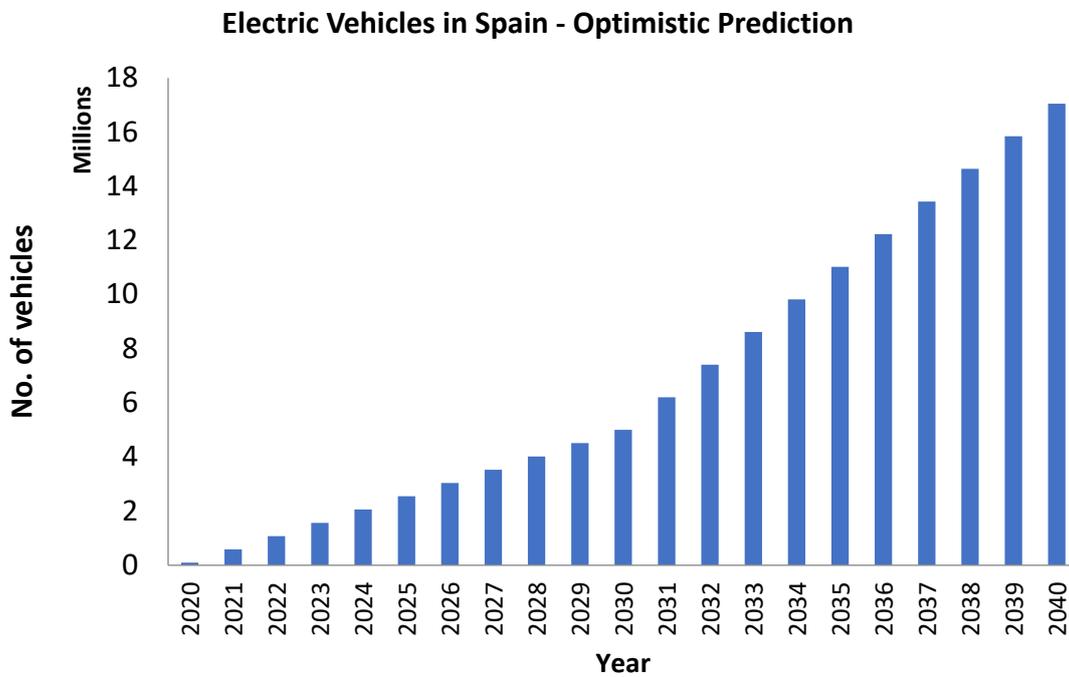


Fig. 24: Optimistic EV market growth estimation

Table 17: Revenues estimation in optimistic scenario

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Number of vehicles passing daily through N-III	759	778	798	818	839	860	882	904	927	950
% of Electric Vehicles [EV] (moderate scenario)	7,97%	9,81%	11,63%	13,42%	15,19%	16,94%	18,67%	23,03%	27,34%	31,60%
Average of EV passing daily [EV]	64	81	98	116	134	154	174	219	267	316
Number of EVs annually [EV]	24,106	30.509	36.912	43.691	50.471	58.004	65.537	82.486	100.566	119.021
% of EV charging in Eranovum	48,3%	48,0%	47,8%	47,5%	47,3%	47,0%	46,8%	46,5%	46,3%	46,0%
Average of EVs charging daily in Eranovum [EV]	31	39	47	56	64	73	82	102	124	146
Average of EVs charging annually in Eranovum [EV]	11.631	14.644	17.625	20.753	23.848	27.262	30.639	38.356	46.512	54.750
Average charging time per client [min/EV]	10,31	8,25	8,25	8,25	8,25	8,25	8,25	8,25	8,25	8,25
Use of the station per day [h/day]	5,33	5,36	6,46	7,70	8,80	10,04	11,28	14,03	17,05	20,08
Average energy used per EV [kWh]	132,42	238,35	429,03	430,00	430,00	430,00	430,00	430,00	430,00	430,00
Energy sold per day [kWh/day]	4.104.96	9.295.75	20.164,62	24.080,00	27.520,00	31.390,00	35.260,00	43.860,00	53.320,00	62.780,00
Energy sold per year [kWh/year]	1.540.148	3.490.471	7.561.879	8.923.968	10.254.466	11.722.629	13.174.596	16.493.146	19.999.974	23.542.433
Selling Price [€/kWh]	0,36	0,36	0,37	0,38	0,39	0,39	0,40	0,41	0,42	0,43
Revenues [€]	549.833	1.271.020	2.808.654	3.380.857	3.962.616	4.620.554	5.296.714	6.763.522	8.365.637	6.961.104
Growth	-	131%	121%	20%	17%	17%	15%	28%	24%	-17%

Pessimistic Scenario

The pessimistic scenario has been defined reducing the estimations for years 2030 and 2040 from the moderate scenario by 70% and calculating the rest of years linearly.

Electric Vehicles in Spain - Pessimistic prediction

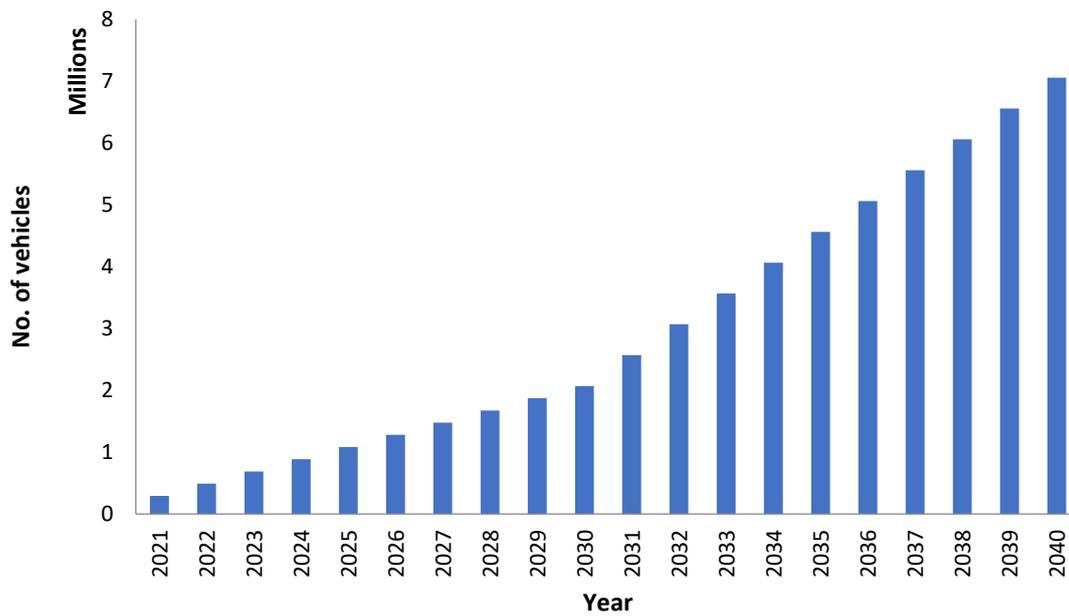


Fig. 25: Pessimistic EV market growth estimation

Table 18: Revenues estimation in pessimistic scenario

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Number of vehicles passing daily through N-III	759	778	798	818	839	860	882	904	927	950
% of Electric Vehicles [EV] (moderate scenario)	7,97%	9,81%	11,63%	13,42%	15,19%	16,94%	18,67%	23,03%	27,34%	31,60%
Average of EV passing daily [EV]	64	81	98	116	134	154	174	219	267	316
Number of EVs annually [EV]	24.106	30.509	36.912	43.691	50.471	58.004	65.537	82.486	100.566	119.021
% of EV charging in Eranovum	48,3%	48,0%	47,8%	47,5%	47,3%	47,0%	46,8%	46,5%	46,3%	46,0%
Average of EVs charging daily in Eranovum [EV]	31	39	47	56	64	73	82	102	124	146
Average of EVs charging annually in Eranovum [EV]	11.631	14.644	17.625	20.753	23.848	27.262	30.639	38.356	46.512	54.750
Average charging time per client [min/EV]	10,31	8,25	8,25	8,25	8,25	8,25	8,25	8,25	8,25	8,25
Use of the station per day [h/day]	5,33	5,36	6,46	7,70	8,80	10,04	11,28	14,03	17,05	20,08
Average energy used per EV [kWh]	132,42	238,35	429,03	430,00	430,00	430,00	430,00	430,00	430,00	430,00
Energy sold per day [kWh/day]	4.104	9.295	20.164	24.080	27.520	31.390	35.260	43.860	53.320	62.780
Energy sold per year [kWh/year]	1.540.148	3.490.471	7.561.879	8.923.968	10.254.466	11.722.629	13.174.596	16.493.146	19.999.974	23.542.433
Selling Price [€/kWh]	0,36	0,36	0,37	0,38	0,39	0,39	0,40	0,41	0,42	0,43
Revenues [€]	549.833	1.271.020	2.808.654	3.380.857	3.962.616	4.620.554	5.296.714	6.763.522	8.365.637	6.961.104
Growth	-	131%	121%	20%	17%	17%	15%	28%	24%	-17%

In order to conveniently compare each scenario, in Fig. 26 and Fig. 27 the economic indicators for each scenario are depicted:

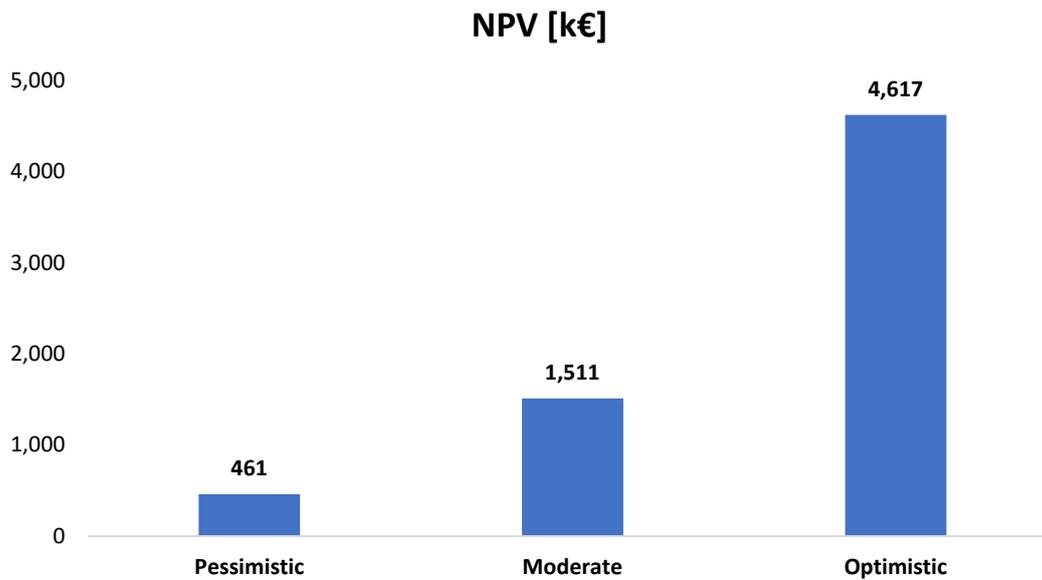


Fig. 26: NPV scenario comparison

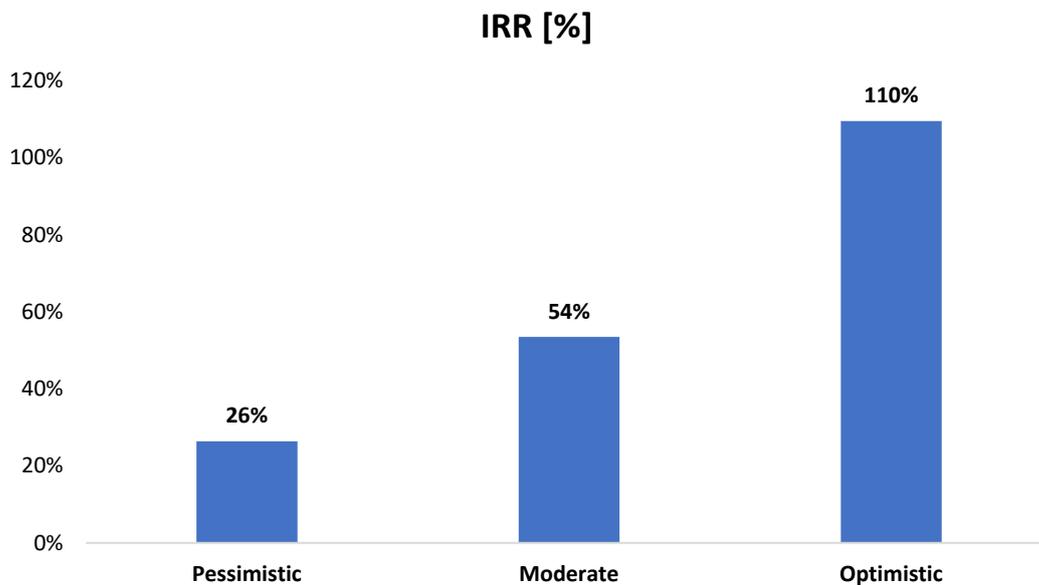


Fig. 27. IRR scenario comparison

Even though the pessimistic scenario has been set to have 70% less EVs on the road by 2030, the NPV value is still positive. Meanwhile, the NPV for the optimistic scenario is three times what has been calculated for the moderate scenario, it is important to bear in mind that this scenario is plausible since it is the Spanish government's objective.

Something similar happens with the IRR, it is important to highlight that event in the worst scenario the IRR expected for this project is higher than what is expected from the exploitation of a regular solar plant.

Hence the project, even though sensible to the amount of EVs on the road, is bound to be a success even if the expectations are 70% worse in 2030 and could be a huge success if the government's expectations become true.

Chapter 6 Sustainable Development Goals

This section will deal with a pressing issue in today's society, the objectives that the United Nations (UN) has defined to redirect the development of the human race towards a horizon with equal conditions for all, without poverty and without pollution, among others.

The UN has proposed 17 different points, objectives, to tackle different social urgencies, including climate change and the transition to a world with clean energy and without pollution. This project tackles several of these objectives. Mainly number 13. 'Climate action' and, secondarily, number 11. 'Sustainable cities and communities' or number 9. 'Industry, innovation and infrastructure'. An attempt will be made to explain the connection of this work with these objectives.

6.1. *Climate action (13)*

This objective seeks to raise awareness about climate change arising from global warming due to the huge amount of polluting gases being released into the atmosphere, causing global temperatures to rise.

In 2017, records were broken for greenhouse gas concentration levels (146% higher than pre-industrialisation), triggering natural disasters around the world, with an estimated 1.3 million deaths from natural disasters in the period 1998-2017. Climate change could end the way of life as we know it, so this goal is vitally important. In April 2019, 185 countries joined the Paris Pact, committing to legislate to reduce emissions of polluting gases into the atmosphere. One of the main fronts to be tackled, due to the fact that it is one of the main sources of polluting gases, is transport. As already mentioned in the introduction to this project, there are numerous initiatives by governments to make the transition to a form of non-polluting mobility. The one that is making the most headway is electric mobility. If the vehicle fleet is converted from combustion vehicles to electric vehicles, clean air will once again be breathable in cities. That is why it is of vital importance to

boost the EV market. One way to do this is by designing profitable business models for charging stations, thus motivating entrepreneurs to build charging points.

In this project, it has been possible to demonstrate from examples of business models that a charging station is perfectly profitable.

On the other hand, there is the need for the electricity that powers EVs to come from clean sources, in order to tackle the problem of climate change. This is why this project also presents a business model based on an electro-power station that demonstrates the technical and economic feasibility of using photovoltaic solar energy to power a fast-charging electro-power station.

6.1.1. Reduction of greenhouse gas emissions

This project will on one hand contribute to reduce greenhouse gas emissions in two ways: by obtaining all the energy from a completely clean energy source, photovoltaic energy, and not needing to transport the energy through the grid which saves energy and gas emissions. A detailed analysis has been conducted to back this up in Annex III: Detail and justification of energy savings and CO₂ emission reduction. The total savings have been estimated to be:

- Energy savings: 2,52 tep / year
- CO₂ emissions reduction: 80,9 ton / year

This is a significant contribution to improving the air quality and reducing the greenhouse gas emissions.

6.2. *Sustainable cities and communities (11)*

This objective aims to address the current situation of millions of people living in urban areas without access to public transport and having to breathe very poor quality air due to emissions from combustion vehicles.

This project, as mentioned above, addresses this objective in a secondary way, as its implementation does not directly increase the number of EVs in cities, but it does

encourage their purchase by making it easier for potential EV buyers to charge their EVs and reducing waiting time. More charging points are needed to encourage the purchase of EVs and consequently reduce the number of combustion vehicles in cities, thus improving urban air quality.

Furthermore, Olmedilla is a town suffering from depopulation, hence this project will aid in the adoption of electrical vehicles in cities where it is usually unprofitable to install electrical chargers. This business model will allow for electrical charging stations to be profitable in depopulated areas.

6.3. *Sustainable development (9)*

In order to achieve the objective of living in a world that respects raw materials and lives in harmony with nature, there is a clear need to respect the biosphere and achieve sustainable development over time to allow future generations to have access to these raw materials as well.

The aim of this objective, in a simplified form, is to link the Gross Domestic Product (GDP) of the countries and the emissions of polluting gases such as CO₂ in an inversely proportional way, i.e. that the GDP increases and the CO₂ emissions decrease. Until now, an increase in a country's GDP also led to an increase in CO₂ emissions, since, as a general rule, a higher GDP increases things such as exports, industry, transport, etc., which increase CO₂ emissions. Now, the aim is to decouple this historical relationship, to encourage economic development with clean energy and that this development can be maintained over time because, if we depend on the classic raw materials (oil, natural gas...) for this development, we will reach a limit and the inevitable collapse of the economy when they run out.

This project presents a profitable business model that partially uses a clean and sustainable source of energy, the sun's energy. From the outset, the main objective of this project was to seek a balance between economic profitability and sustainability and, although Model 1, which included conventional charging connected to the grid, augured higher profits, it was decided to develop the project that also included photovoltaic energy

(Model 3) since, as we have seen, this would save large amounts of polluting gas emissions (up to 500 tonnes of CO₂), making the project sustainable over time and respectful of the environment.

Chapter 7 Conclusions and Future Works

The two main conclusions from the project are that it is technically and economically viable to build an electric vehicle charging station annexed to a solar power plant with an energy supply of over 10 MWp, which can supply the demand for the current and future electric vehicle fleet.

The financial analysis of the business model demonstrates that using the energy produced from solar plants around the peninsula for charging stations is economically viable and profitable and could potentially open up a new market, contributing to increase the adoption of EVs by installing a higher number of profitable fast charging stations and allowing for the adoption of EVs in remote and depopulated areas where the charging stations would not be profitable if the energy didn't come from a solar plant.

This project's Net Present Value for the five first years with a 5% discount rate has been estimated to be of €1,5 million, making it highly profitable and viable from an economical point of view. Moreover, the elements and capacity of the project has been designed to last over ten years, thus the NPV would increase considerably. The sensitivity analysis has demonstrated that the project's main risk is the variation of the actual percentage of EVs that is estimated that will be on the Spanish road in the years to come, although the most pessimistic scenario analysed, which considered 70% less EVs on the roads by 2030 than in the original scenario, also yields a positive NPV for the first five years, hence the project will most probably be profitable even in the worst case scenario. Also, in the best-case scenario where the estimations from the Spanish Government for 2030 are accurate, the NPV for the project would triplicate.

It is important to mention that the NPV and IRR of the project have been calculated without leveraging the project, which it is the most likely scenario, this would make the Return on Investment much higher, another point regarding the economical interest of this project.

From the technical perspective, this project does not pose significant difficulties, considering that the solar plant has a transformer already built in and the station would not need connection to the grid. The electrical elements that are used are all standardised and from reputed providers such as Ingeteam. All elements and designs compile with the ITC-BT-52 and ITC-BT-30 regarding safety standards. The conditioning of the area for the charging station does not pose a real difficulty either since this conditioning would mainly consist of asphaltting the necessary space and building the road access. The only element that would have to be under watch is the BESS System, considering these types of systems are considerably new and do not count with significant ground testing over the years. The project is expected to last 18 months to be operative.

Future works regarding this project would include using a real data base for the rotation of vehicles in order to make more precise assumptions. The rotation is one of the most important aspects for the business model, it affects directly to the revenue stream and determines the viability of the project, even though the estimations made in this project have been moderate and with data provided by reputed corporations.

Moreover, the BESS System would also be an element to deep dive into, since it is a technology developing increasingly fast. With the assumptions made in this project, it is estimated that by the fourth year of the project a battery of 168kWh will not be enough to supply the expected demand.

Chapter 8 Bibliography

- [1] C. M. Duarte, S. Alonso, G. Benito, J. Dachs, C. Montes, M. Pardo Buendía, A. F. Ríos, R. Simó, and F. Valladares, *Cambio Global. Impacto de la actividad humana sobre el sistema Tierra*. CSIC. Consejo superior de investigaciones científicas, 2006.
- [2] “Global CO2 emissions in 2020,” *International Energy Agency*, 2021.
- [3] “Tracking transport,” *International Energy Agency*, 2019.
- [4] The Paris Agreement. [Online]. Available: <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>
- [5] ‘European Climate Law’. [Online]. Available: https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-law_es
- [6] G. Moreno. (2017) ¿qué países forman parte del acuerdo de parís? [Online]. Available: <https://es.weforum.org/agenda/2017/06/que-paises-forman-parte-del-acuerdo-de-paris/>
- [7] Jaume Duch Guillot, ‘CO2 emissions from cars: facts and figures’ European Parliament, 2019 [Article]. Available: https://www.europarl.europa.eu/pdfs/news/expert/2019/3/story/20190313STO31218/20190313STO31218_en.pdf.
- [8] Transport emissions. [Online]. Available: https://ec.europa.eu/clima/policies/transport_en
- [9] ‘Plan Nacional Integrado de Energía y Clima 2021-2030’, Gobierno de España, 2020, [Online]. Available: https://www.miteco.gob.es/images/es/pniecCompleto_tcm30-508410.pdf
- [10] Toyota. (2021) ¿Qué es un coche Híbrido? [Online]. Available: <https://www.toyota.es/hybrid-innovation/preguntas-hibridas/que-es-un-hibrido>
- [11] J. Y. Yong, V. K. Ramachandaramurthy, K. M. Tan, and N. Mithulananthan, “Are view on the state-of-the-art technologies of electric vehicle, its impacts and

- prospects,” *Renewable and Sustainable Energy Reviews*, vol.49, pp.365–385,2015
- [12] ‘Automoción 2020-40 Liderando la movilidad sostenible Informe ejecutivo’, Anfac, 2020
- [13] Global EV Outlook 2021
- [14] ANFAC & KPMG. “*Automoción 2020-40*”. Informe Ejecutivo, 2020.
- [15] ANFAC. “*Informe Anual de Movilidad 2020*”. Anual, 2021.
- [16] B. Xiao, J. Ruan, W. Yang, P.D. Walker, N. Zhang. «A review of pivotal energy management strategies for extended range electric vehicles. » ELSEVIER, 2021: 14.
- [17] Commission, European. «Transport Emissions. 22» s.f. https://ec.europa.eu/clima/eu-action/transport-emissions_en (last access: 30 de 11 de 2021).
- [18] Gobierno de España. «Plan Nacional Integrado de Energía y Clima 2021-2030.» 2020. https://www.miteco.gob.es/images/es/pnieccompleto_tcm30-508410.pdf (último acceso: 30 de 11 de 2021).
- [19] Guarnieri, Massimo. «When cars went electric, part 2[historical]. » IEEE Industrial Electronics Magazine, 2011: 42-51.
- [20] Guillot, Jaume Duch. «CO2 emissions from cars: facts and figures. » European Parliament, 2019.
- [21] HEV TCP. s.f. <http://www.ieahev.org/by-country/spain-charging-infrastructure/>.
- [22] International Energy Agency. «Tracking Transport. » 2019.
- [23] International Energy Agency. «Trends and developments in electric vehicle markets. » Global EV Outlook, 2021.
- [24] J. Y. Young, V.K. Ramachandaramurthy, K. M. Tan, and N. Mithulananthan. «A review on the state-of-the-art technologies of electric vehicles, its impacts and prospects. » Science Direct, 2015: 14.
- [25] Jia Ying Yong, Vigna K. Ramachandaramurthy, Kang Miao Tan, N. Mithulananthan. «A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects. » ELSEVIER, 2015: 1-10.
-

- [26] Kirsch, David A. *The Electric Vehicle and the burden of history*. Rutgers University Press, 2000.
- [27] Liansheng Liu, Fanxin Kong, Xue Liu, Yu Peng, Qinglong Wang. «A review on electric vehicles interacting with renewable energy in smart grid. » *ELSEVIER*, 2015: 14.
- [28] Moreno, Francisco Martín. «Vehículos Eléctricos. Historia, Estado Actual y Retos Futuros.» *European Scientific Journal*, 2016.
- [29] Organization, World Health. *The Global Health Observatory*. s.f. https://www.who.int/data/gho/data/themes/topics/sdg-target-3_9-mortality-from-environmental-pollution (last access: 3 de January de 2022).
- [30] Toyota. ¿Qué es un coche Híbrido? 2021. <https://www.toyota.es/hybrid-innovation/preguntas-hibridas/que-es-un-hibrido> (último acceso: 30 de 11 de 2021).
- [31] United Nations Climate Change. UNFCC Sites and platforms. s.f. <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement> (last access: 30 de November de 2021).
- [32] Instituto de Investigación Tecnológica de la Universidad Pontificia de Comillas IIT, 2021 [Web] <https://evobservatory.iit.comillas.edu/>
- [33] ANFAC, “*Automoción 2020-40 Liderando la movilidad sostenible Informe Ejecutivo*”, 2020
- [34] ANFAC, Informe Anual, 2019
- [35] Alex T., “Track Europe’s Transition to sustainable transportation”, EU-EV, 2021
- [36] DGT, Mapa de Tráfico de la DGC [Web] <https://mapas.fomento.gob.es/mapatrafico/2019/>
- [37] Chakratec [online] <https://chakratec.com/>
- [38] Tesvolt [online] <https://www.tesvolt.com/en/>
- [39] Norvento [online] <https://www.norvento.com/>
- [40] BeePlanet [online] <https://beeplanetfactory.com/>
- [41] EFACEC [online] <https://www.efacec.pt/>
- [42] Powerelectronics [online] <https://power-electronics.com/>
-

- [43] Ingeteam [online] <https://www.ingeteam.com/>
- [44] Schneider [online] <https://www.se.com/es/es/>
- [45] S. Joseph, *IRR Expectations from Solar Energy Rooftops Projects*, 2020, [Online] <https://de.energy/blog/irr-expectations-from-solar-rooftop-projects/>
- [46] Agencia Europea del Medio Ambiente, [Online] <https://www.eea.europa.eu/es>
- [47] *Guía de Vehículos Turismo de venta en España, con indicaciones de consumos y emisiones de CO₂*, Instituto para la Diversificación y Ahorro de Energía IDAE, 2020 [Online] <https://coches.idae.es/pdf/Guiasemestre12020.pdf>

Regulations/Legislation

- [48] Real Decreto 661/2007, de 25 de mayo. BOE núm. 126 de 26 de mayo de 2007
- [49] Real Decreto 1110/2007, de 18 de septiembre. BOE núm. 224 de 19 de septiembre de 2007
- [50] Real Decreto 1669/2011, de 18 de noviembre de 2011. BOE núm. 295 de 8 de diciembre de 2011
- [51] ITC-BT-30 del Reglamento electrotécnico de baja tensión aprobado por Real Decreto 842/2002, de 2 de agosto. BOE num. 224 de 18 de septiembre de 2002.
- [52] ITC-BT-52 del Reglamento electrotécnico de baja tensión aprobado por Real Decreto 842/2002, de 2 de agosto. BOE num. 224 de 18 de septiembre de 2002.
- [53] Guía-BT-40 del Reglamento electrotécnico de baja tensión aprobado por Real Decreto 842/2002, de 2 de agosto. BOE num. 224 de 18 de septiembre de 2002.
- [54] DB- SE- AE: Seguridad Estructural Acciones en la edificación, de abril 2009, del Código Técnico de la Edificación recogido en la Ley 38/1999, de 5 de noviembre, de Ordenación de la Edificación
- [55] DB- SE- C: Seguridad Estructural Cimientos, de 20 de diciembre 2019, del Código Técnico de la Edificación recogido en la Ley 38/1999, de 5 de noviembre, de Ordenación de la Edificación
- [56] UNE-HD 60364-5-52:2014 del Reglamento electrotécnico de baja tensión aprobado por Real Decreto 842/2002, de 2 de agosto. BOE num. 224 de 18 de septiembre de 2002

Annex I: Modelling of distribution of affluence to the station

Month	Percentage with respect to IMD
January	85%
February	85%
March	85%
April	85%
May	85%
June	110%
July	150%
August	170%
September	105%
October	85%
November	85%
December	85%

JAN-AP R OCT- DEC		May Sept	
Labour days	25%	Labour days	10%
06:00-07:00	1,32%	06:00-07:00	1,32%
07:00-08:00	1,32%	07:00-08:00	1,32%
08:00-09:00	1,32%	08:00-09:00	1,32%
09:00-10:00	1,32%	09:00-10:00	1,32%
10:00-11:00	1,32%	10:00-11:00	1,32%
11:00-12:00	1,32%	11:00-12:00	1,32%
12:00-13:00	1,32%	12:00-13:00	1,32%
13:00-14:00	1,32%	13:00-14:00	1,32%
14:00-15:00	1,32%	14:00-15:00	1,32%
15:00-16:00	1,32%	15:00-16:00	1,32%
16:00-17:00	1,32%	16:00-17:00	1,32%
17:00-18:00	1,32%	17:00-18:00	1,32%
18:00-19:00	1,32%	18:00-19:00	1,32%
19:00-20:00	1,32%	19:00-20:00	1,32%
20:00-21:00	1,32%	20:00-21:00	1,32%
21:00-22:00	1,32%	21:00-22:00	1,32%
22:00-23:00	1,32%	22:00-23:00	1,32%
23:00-24:00	1,32%	23:00-24:00	1,32%
24:00-01:00	1,32%	24:00-01:00	1,32%
Fridays	25%	Fridays	25,0%
06:00-07:00	3,33%	06:00-07:00	3,33%
07:00-08:00	6,67%	07:00-08:00	6,67%
08:00-09:00	6,67%	08:00-09:00	6,67%
09:00-10:00	6,67%	09:00-10:00	6,67%
10:00-11:00	3,33%	10:00-11:00	3,33%
11:00-12:00	3,33%	11:00-12:00	3,33%

12:00-13:00	3,33%	12:00-13:00	3,33%
13:00-14:00	3,33%	13:00-14:00	3,33%
14:00-15:00	3,33%	14:00-15:00	3,33%
15:00-16:00	3,33%	15:00-16:00	3,33%
16:00-17:00	10,00%	16:00-17:00	10,00%
17:00-18:00	10,00%	17:00-18:00	10,00%
18:00-19:00	10,00%	18:00-19:00	10,00%
19:00-20:00	10,00%	19:00-20:00	10,00%
20:00-21:00	3,33%	20:00-21:00	3,33%
21:00-22:00	3,33%	21:00-22:00	3,33%
22:00-23:00	3,33%	22:00-23:00	3,33%
23:00-24:00	3,33%	23:00-24:00	3,33%
24:00-01:00	3,33%	24:00-01:00	3,33%
Saturdays	10%	Saturdays	25%
06:00-07:00	3,3%	06:00-07:00	3,3%
07:00-08:00	3,3%	07:00-08:00	3,3%
08:00-09:00	12,5%	08:00-09:00	12,5%
09:00-10:00	12,5%	09:00-10:00	12,5%
10:00-11:00	12,5%	10:00-11:00	12,5%
11:00-12:00	12,5%	11:00-12:00	12,5%
12:00-13:00	3,3%	12:00-13:00	3,3%
13:00-14:00	3,3%	13:00-14:00	3,3%
14:00-15:00	3,3%	14:00-15:00	3,3%
15:00-16:00	3,3%	15:00-16:00	3,3%
16:00-17:00	3,3%	16:00-17:00	3,3%
17:00-18:00	3,3%	17:00-18:00	3,3%
18:00-19:00	3,3%	18:00-19:00	3,3%
19:00-20:00	3,3%	19:00-20:00	3,3%
20:00-21:00	3,3%	20:00-21:00	3,3%

21:00-22:00	3,3%	21:00-22:00	3,3%
22:00-23:00	3,3%	22:00-23:00	3,3%
23:00-24:00	3,3%	23:00-24:00	3,3%
24:00-01:00	3,3%	24:00-01:00	3,3%
Sundays	40%	Sundays	40,0%
06:00-07:00	2,3%	06:00-07:00	2,3%
07:00-08:00	2,3%	07:00-08:00	2,3%
08:00-09:00	2,3%	08:00-09:00	2,3%
09:00-10:00	2,3%	09:00-10:00	2,3%
10:00-11:00	2,3%	10:00-11:00	2,3%
11:00-12:00	2,3%	11:00-12:00	2,3%
12:00-13:00	2,3%	12:00-13:00	2,3%
13:00-14:00	2,3%	13:00-14:00	2,3%
14:00-15:00	2,3%	14:00-15:00	2,3%
15:00-16:00	11,7%	15:00-16:00	11,7%
16:00-17:00	11,7%	16:00-17:00	11,7%
17:00-18:00	11,7%	17:00-18:00	11,7%
18:00-19:00	11,7%	18:00-19:00	11,7%
19:00-20:00	11,7%	19:00-20:00	11,7%
20:00-21:00	11,7%	20:00-21:00	11,7%
21:00-22:00	2,3%	21:00-22:00	2,3%
22:00-23:00	2,3%	22:00-23:00	2,3%
23:00-24:00	2,3%	23:00-24:00	2,3%
24:00-01:00	2,3%	24:00-01:00	2,3%

June		July		August	
Labour days	7%	Labour days	5%	Labour days	1,0%
06:00-07:00	1,32%	06:00-07:00	1,32%	06:00-07:00	1,32%
07:00-08:00	1,32%	07:00-08:00	1,32%	07:00-08:00	1,32%
08:00-09:00	1,32%	08:00-09:00	1,32%	08:00-09:00	1,32%
09:00-10:00	1,32%	09:00-10:00	1,32%	09:00-10:00	1,32%
10:00-11:00	1,32%	10:00-11:00	1,32%	10:00-11:00	1,32%
11:00-12:00	1,32%	11:00-12:00	1,32%	11:00-12:00	1,32%
12:00-13:00	1,32%	12:00-13:00	1,32%	12:00-13:00	1,32%
13:00-14:00	1,32%	13:00-14:00	1,32%	13:00-14:00	1,32%
14:00-15:00	1,32%	14:00-15:00	1,32%	14:00-15:00	1,32%
15:00-16:00	1,32%	15:00-16:00	1,32%	15:00-16:00	1,32%
16:00-17:00	1,32%	16:00-17:00	1,32%	16:00-17:00	1,32%
17:00-18:00	1,32%	17:00-18:00	1,32%	17:00-18:00	1,32%
18:00-19:00	1,32%	18:00-19:00	1,32%	18:00-19:00	1,32%
19:00-20:00	1,32%	19:00-20:00	1,32%	19:00-20:00	1,32%
20:00-21:00	1,32%	20:00-21:00	1,32%	20:00-21:00	1,32%
21:00-22:00	1,32%	21:00-22:00	1,32%	21:00-22:00	1,32%
22:00-23:00	1,32%	22:00-23:00	1,32%	22:00-23:00	1,32%
23:00-24:00	1,32%	23:00-24:00	1,32%	23:00-24:00	1,32%
24:00-01:00	1,32%	24:00-01:00	1,32%	24:00-01:00	1,32%
Fridays	25,8%	Fridays	26,25%	Fridays	24,50%
06:00-07:00	3,33%	06:00-07:00	3,33%	06:00-07:00	3,33%
07:00-08:00	6,67%	07:00-08:00	6,67%	07:00-08:00	6,67%
08:00-09:00	6,67%	08:00-09:00	6,67%	08:00-09:00	6,67%
09:00-10:00	6,67%	09:00-10:00	6,67%	09:00-10:00	6,67%
10:00-11:00	3,33%	10:00-11:00	3,33%	10:00-11:00	3,33%
11:00-12:00	3,33%	11:00-12:00	3,33%	11:00-12:00	3,33%
12:00-13:00	3,33%	12:00-13:00	3,33%	12:00-13:00	3,33%

13:00-14:00	3,33%	13:00-14:00	3,33%	13:00-14:00	3,33%
14:00-15:00	3.33%	14:00-15:00	3.33%	14:00-15:00	3,33%
15:00-16:00	3.33%	15:00-16:00	3.33%	15:00-16:00	3,33%
16:00-17:00	10.00%	16:00-17:00	10.00%	16:00-17:00	10,00%
17:00-18:00	10.00%	17:00-18:00	10.00%	17:00-18:00	10,00%
18:00-19:00	10.00%	18:00-19:00	10.00%	18:00-19:00	10,00%
19:00-20:00	10.00%	19:00-20:00	10.00%	19:00-20:00	10.00%
20:00-21:00	3.33%	20:00-21:00	3.33%	20:00-21:00	3.33%
21:00-22:00	3.33%	21:00-22:00	3.33%	21:00-22:00	3.33%
22:00-23:00	3.33%	22:00-23:00	3.33%	22:00-23:00	3.33%
23:00-24:00	3.33%	23:00-24:00	3.33%	23:00-24:00	3.33%
24:00-01:00	3.33%	24:00-01:00	3.33%	24:00-01:00	3.33%
Saturdays	25.8%	Saturdays	26.25%	Saturdays	24.50%
06:00-07:00	3,3%	06:00-07:00	3,3%	06:00-07:00	3,3%
07:00-08:00	3,3%	07:00-08:00	3,3%	07:00-08:00	3,3%
08:00-09:00	12,5%	08:00-09:00	12,5%	08:00-09:00	12,5%
09:00-10:00	12,5%	09:00-10:00	12,5%	09:00-10:00	12,5%
10:00-11:00	12,5%	10:00-11:00	12,5%	10:00-11:00	12,5%
11:00-12:00	12,5%	11:00-12:00	12,5%	11:00-12:00	12,5%
12:00-13:00	3,3%	12:00-13:00	3,3%	12:00-13:00	3,3%
13:00-14:00	3,3%	13:00-14:00	3,3%	13:00-14:00	3,3%
14:00-15:00	3,3%	14:00-15:00	3,3%	14:00-15:00	3,3%
15:00-16:00	3,3%	15:00-16:00	3,3%	15:00-16:00	3,3%
16:00-17:00	3,3%	16:00-17:00	3,3%	16:00-17:00	3,3%
17:00-18:00	3,3%	17:00-18:00	3,3%	17:00-18:00	3,3%
18:00-19:00	3,3%	18:00-19:00	3,3%	18:00-19:00	3,3%
19:00-20:00	3,3%	19:00-20:00	3,3%	19:00-20:00	3,3%
20:00-21:00	3,3%	20:00-21:00	3,3%	20:00-21:00	3,3%
21:00-22:00	3.3%	21:00-22:00	3.3%	21:00-22:00	3.3%

22:00-23:00	3,3%	22:00-23:00	3,3%	22:00-23:00	3,3%
23:00-24:00	3,3%	23:00-24:00	3,3%	23:00-24:00	3,3%
24:00-01:00	3,3%	24:00-01:00	3,3%	24:00-01:00	3,3%
Sundays	41,5%	Sundays	47,5%	Sundays	50,0%
06:00-07:00	2,3%	06:00-07:00	2,3%	06:00-07:00	2,3%
07:00-08:00	2,3%	07:00-08:00	2,3%	07:00-08:00	2,3%
08:00-09:00	2,3%	08:00-09:00	2,3%	08:00-09:00	2,3%
09:00-10:00	2,3%	09:00-10:00	2,3%	09:00-10:00	2,3%
10:00-11:00	2,3%	10:00-11:00	2,3%	10:00-11:00	2,3%
11:00-12:00	2,3%	11:00-12:00	2,3%	11:00-12:00	2,3%
12:00-13:00	2,3%	12:00-13:00	2,3%	12:00-13:00	2,3%
13:00-14:00	2,3%	13:00-14:00	2,3%	13:00-14:00	2,3%
14:00-15:00	2,3%	14:00-15:00	2,3%	14:00-15:00	2,3%
15:00-16:00	11,7%	15:00-16:00	11,7%	15:00-16:00	11,7%
16:00-17:00	11,7%	16:00-17:00	11,7%	16:00-17:00	11,7%
17:00-18:00	11,7%	17:00-18:00	11,7%	17:00-18:00	11,7%
18:00-19:00	11,7%	18:00-19:00	11,7%	18:00-19:00	11,7%
19:00-20:00	11,7%	19:00-20:00	11,7%	19:00-20:00	11,7%
20:00-21:00	11,7%	20:00-21:00	11,7%	20:00-21:00	11,7%
21:00-22:00	2,3%	21:00-22:00	2,3%	21:00-22:00	2,3%
22:00-23:00	2,3%	22:00-23:00	2,3%	22:00-23:00	2,3%
23:00-24:00	2,3%	23:00-24:00	2,3%	23:00-24:00	2,3%
24:00-01:00	2,3%	24:00-01:00	2,3%	24:00-01:00	2,3%

Annex II: CapEx detail

	Unit cost €	Units	Total €
Rapid 180	€ 36,603	2 €	73,206.00
Installation	€ 10,000	1 €	10,000.00
Total cost of chargers		€	83,206.00
Battery BeePlanet Power 168kWh	€ 54,223	1 €	54,223.38
Inverter Ingecon Sun Storage 100TL 100kW	€ 13,500	2 €	27,000.00
Container 10' with climatization, fire detectors, isolation, battery integration and documentation	€ 20,434	1 €	20,433.76
Switch for battery communication + 2 inv. 100kW and system integration	€ 880	1 €	879.50
Assembly and commissioning	€ 1,250	1 €	1,250.00
Transport and delivery ADR DAP - Incoterms 2020	€ 2,500	1 €	2,500.00
Total cost of batteries		€	106,286.64
Clearing	€ 15	350 €	5,250.00
Paving and asphaltting	€ 90	350 €	31,500.00
Paving	€ 35	120 €	4,200.00
Illumination	€ 1,900	4 €	7,600.00
Sanitation	€ 12,000	1 €	12,000.00
Plumbing	€ 15,000	1 €	15,000.00
Electricity	€ 18,000	1 €	18,000.00
Total cost of installation		€	93,550.00
WC	€ 22,000	1 €	22,000.00
Pergolas	€ 24,000	2 €	48,000.00
Landscaping	€ 10,000	1 €	10,000.00
pavicesped	€ 35	40 €	1,400.00
Total Conditioning		€	81,400.00
Engineering	€ 15,000	1 €	15,000.00
Arquitects	€ 31,062	1 €	31,062.00
ICIO licenses	€ 1,553	1 €	1,553.00
Road permit license	€ 7,766	1 €	7,765.50
Electrical connections	€ 30,000	1 €	30,000.00
Total Workforce		€	70,380.50
TOTAL CAPEX		€	449,823.14

Annex III: Detail and justification of energy savings and CO₂ emission reduction

The following parameters have been taken into account for the calculation of the CO₂ emission reductions resulting from this project:

Table 19: Estimation of the reduction of emissions for the first year of activity

Emission reduction because the energy source is a PV system (First year)	
Number of chargers	2 (double)
Mean EVs charging daily at Eranovum	10
Mean functioning time of the station [h/day]	1,72
Mean functioning time of each charger [h/day]	0,43
Charge power [kW]	100
Total charging range [km]	159
Fuel [gCO ₂ /km]	144,84
Emission reduction [tonCO ₂ /day]	0,026
Emission reduction [tonCO₂/year]	9,64
Emission reduction because the energy is produced in the charging point (First year)	
Emission reductions from the absence of energy transport [gCO ₂ /kWh]	250
kWh/día Produced	172
Emission reduction [tonCO ₂ /day]	0,04
Emission reduction [tonCO₂/year]	15,70
Total emissions reduction first year (charge + absence of energy transport)	25,34 ton CO₂

The Eranovum facility will initially have 2 double chargers of 180kW of power each to provide electric charging service to 4 vehicles simultaneously, so that if there are 2 cars connected to the same charger each one will have 90kW, while the charger in which there is only one car can provide up to 180kW, so the estimates have been made considering

that the recharging of vehicles is at 100kW, being conservative. According to the data obtained from the General Directorate of Traffic on electric vehicles currently in Spain, and the traffic of vehicles that pass daily through the section of the N-III where the Eranovum station will be located, it has been estimated that by 2024 an average of 20 electric vehicles will pass through this point every day.

Given the power of the chargers installed and the travel range they allow, the savings in CO₂ emissions from daily recharging are calculated. It is assumed that a petrol car emits an average of 144,84 gCO₂ per km, which, multiplied by the 159 km that the recharges allow, means that this petrol car would emit 0,026 tonCO₂ on this journey. This is the amount of emissions that will be reduced per day thanks to recharging at the Eranovum petrol station, which means an annual reduction of 9,64 tonCO₂ of emissions per recharge.

Furthermore, it should be borne in mind that the energy is directly produced at the Eranovum installation and no transport of the energy is required to make it available at the recharging point. This means that the reduction in emissions is greater, as the transport of the energy required is 250 gCO₂/kWh (Conversion factors in the calculation of energy savings and CO₂ emission reductions, Spanish electricity grid mix published by the CNMC on 16 April 2021), which represents 0,04 tonCO₂/day for the daily charge at the installation, which will not be needed with the new installation.

The sum of the reduction in CO₂ emissions for the two points mentioned above results in a total reduction of 25,34 tonCO₂/year.

In the same way, the calculation of the reduction in emissions over a period of 10 years (2024-2033) has been carried out.

Table 20: Reduction of the emissions during the period 2024 - 2033

	2024	25	26	27	28	29	30	31	32	33
Number of chargers	2	2	2	4	4	6	6	6	6	6
Mean EVs charging daily at Eranovum	10	14	19	25	32	40	49	58	69	81
Mean functioning time of the station [h/day]	1,72	1,93	2,61	3,44	4,40	5,50	6,74	7,98	9,49	11,14
Mean functioning time of the charger [h/day]	0,43	0,48	0,65	0,43	0,55	0,69	0,84	1,00	1,19	1,39
Total reduction of emissions [tCO₂/year]	25,34	28,35	38,47	50,62	64,80	81,00	99,22	117,45	139,72	164,02

With these estimates, we have calculated the reduction in CO₂ emissions that would be obtained each year from 2024 when the Eranovum charging station starts operating. From these values, it is obtained that the average reduction of CO₂ emissions per year will be 80,90 tonnes.

EMISSIONS REDUCTION CO₂ (ton/year)	% Reduction compared to a previous situation or to a conventional refuelling station
80,90	100

In order to calculate the energy savings that will result from recharging at the Eranovum service station, the energy consumption factor (fce) and greenhouse gas emission factor for motorised modes (fco₂) data provided in the annex of the call regarding conversion factors in the calculation of energy savings and CO₂ emission reductions for electric cars and electric cars have been taken into account.

Thus, the following data for a car and an electric car have been used:

Table 21: Conversion factors used [46][47]

Mode	Occupancy factor [pax/veh]	fce [gep/pkm]	fCO ₂ [gCO ₂ /pkm]
Vehicle	1,2	48,3	120,7
Electric vehicle	1,2	4,9	17,1

With these data, and taking into account the autonomy that recharging allows according to the selected chargers, the following energy savings are obtained:

Table 22: Calculation of the energy savings from the implementation of the project

Energy savings				
Energy source	Charge [km/day]	fce [gep/pkm]	gep/día	Savings [gep/año]
Fuel	159	48,3	7.697,05	2.524.410,29
Electric	159	4,9	780,86	

ENERGY SAVINGS (tep/year)	% Reduction compared to a previous situation or to a conventional refuelling station
2,52	89,9

Annex IV: Battery Datasheet and plane

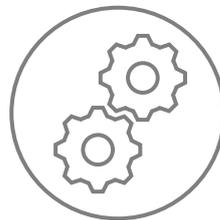


HOJA DE ESPECIFICACIONES POWER



SOSTENIBILIDAD Y ECONOMÍA CIRCULAR

Las baterías de segunda vida de NISSAN® permiten revalorizar un residuo y extender su vida útil.



FÁCIL MANTENIMIENTO

El diseño del equipo permite extender la vida útil del activo sustituyendo únicamente los módulos manteniendo intacto el resto del equipo.



BATERÍA MADE IN SPAIN

Centro productivo en Navarra, España.
Facilidad en la atención al cliente y acceso a ingeniería.



SEGURO, ROBUSTO Y MODULAR

Sistema protegido del exterior que permite ampliar la capacidad con instalaciones de hasta 1MWh.



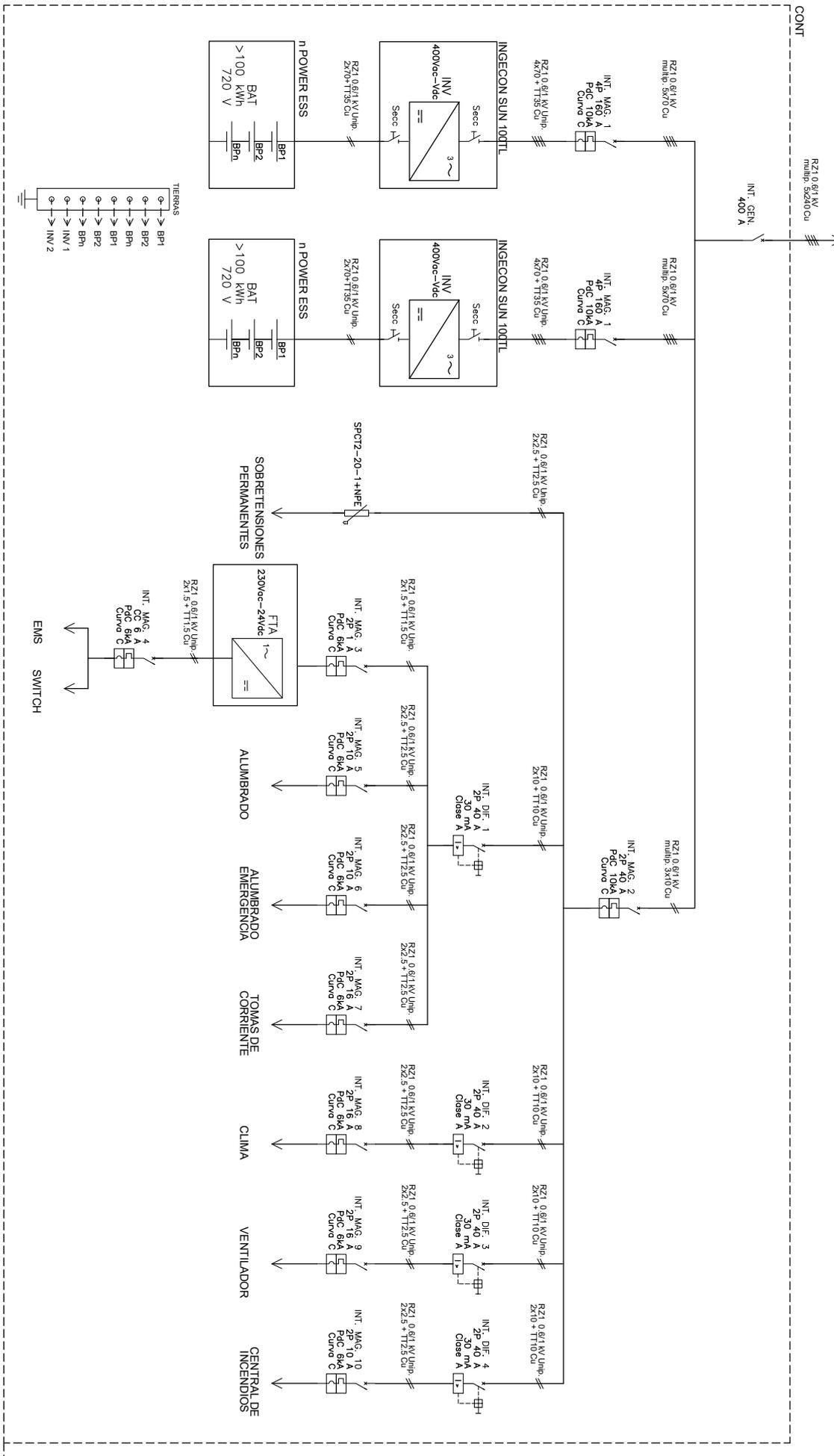
BATERÍA	Tipo de batería	EV Second Life
	Química	LMO
	Número de módulos	96 módulos
	Capacidad nominal (Wh)	42 kWh
	Capacidad nominal (Ah)	58 Ah
	Potencia nominal	36 kW
	Tensión nominal	720 V
	Tensión de trabajo	600 V – 800 V
	Corriente máxima	50 A
	Profundidad de descarga (DoD)	80 %
	Ciclos estimados @ 1C / 80% DoD / 25°C	> 5000 ciclos
	Ciclos estimados @ 0.8C / 80% DoD / 25°C	> 6500 ciclos
Ciclos estimados @ 0.5C / 60% DoD / 25°C	> 7500 ciclos	

ESPECIFICACIONES GENERALES	Temperatura de operación	15°C – 30°C
	Humedad relativa	5% - 90%
	Peso	580 kg
	Densidad energética	73 Wh/kg
	Dimensiones (Alto x Ancho x Fondo)	1800 x 800 x 500 mm
	Material de la envolvente	Chapa de acero
	Categoría OV	CAT II
	Grado protección IP IK	IP 54 IK 10
	Categoría de protección NEMA	NEMA 12
	Categoría tipo UL 508A	Tipo 1, 12
	Modularidad	Sí
	Ventilación natural	Sí
	Resistencia a ambientes químicos y corrosivos	Sí
	Comunicaciones	CAN Bus, Modbus-TCP
	Conectividad	Ethernet
	Protecciones	Sobrecarga, sobredescarga, sobrecorriente, sobrecalentamiento
	Garantía de batería*	4000 ciclos o 7 años
Garantía de componentes*	2 años	

NORMATIVA Y MARCADO CE	Envolvente	DIN-EN 62208:2012-6
	Batería	IEC 62619 UN38.3
	EMC Electromagnetic Compatibility (2014/30/UE)	UNE-EN 61000-2/4
	Seguridad eléctrica Low Voltage Directive (2014/35/UE)	UNE-EN 61439-1

*Garantía sujeta a condiciones de utilización especificadas en los manuales de usuario e instalación y en el documento de garantía del equipo BeeBattery Power®.

Salida trifásica
sist. almacenamiento



TITLE:	ESQUEMA UNIFILAR CONTENEDOR	DATE:	2021
PROJECT:		SHEET:	1 / 1
DRAWN BY:	LCP	SCALE:	-
REVISED BY:	AUS	REV:	1.0



Annex V: Inverter datasheet

INVERSOR TRIFÁSICO DE BATERÍAS SIN TRANSFORMADOR Y CON LA MÁXIMA DENSIDAD DE POTENCIA

100TL

Familia de inversores trifásicos para sistemas de almacenamiento comerciales, industriales y de gran escala. Estos inversores bidireccionales de baterías presentan la misma tecnología que los inversores fotovoltaicos.

Menores costes operacionales

Gracias a la red de comunicación inalámbrica que se puede establecer con el INGECON® SUN STORAGE 100TL, el sistema de almacenamiento puede ser puesto en marcha, monitorizado y controlado sin cables. Además, su filosofía de inversor de string permite una fácil y rápida sustitución que no precisa de técnicos cualificados.

Mayor flexibilidad y densidad de potencia

La mayor flexibilidad es posible gracias a sus elevados índices de tensión DC máxima (1.100 V) y a su amplio rango de tensión de entrada (570-850 V). Gran densidad de potencia, con 100 kW en un inversor de tan sólo 75 kg.

Diseño duradero y robusto

Envoltorio de aluminio, especialmente concebida para instalaciones de interior y exterior (IP65). El diseño de la familia INGECON® SUN STORAGE 3Play garantiza la máxima durabilidad en el tiempo y las mejores prestaciones, incluso ante temperaturas extremas.

Ethernet y Wi-Fi de serie

Este inversor de baterías presenta comunicaciones Ethernet y Wi-Fi de serie. Estas comunicaciones, junto con el webserver que integra el equipo, permiten una rápida y fiable puesta en marcha usando un teléfono móvil, una Tablet o un PC portátil. Además, es compatible con Cloud Connect externo.

Garantía estándar de 5 años, ampliable hasta 25 años



100TL

PRINCIPALES CARACTERÍSTICAS

- Capacidad para soportar huecos de tensión.
- Capacidad para inyectar potencia reactiva.
- Compatible con Cloud Connect externo.
- Eficiencia máxima del 98,8 %.
- Comunicaciones Ethernet y Wi-Fi de serie.
- Webserver integrado.
- Software de monitorización INGECON® SUN Monitor.
- Apto para instalaciones de interior y exterior (IP65).
- Alto rendimiento a altas temperaturas.
- Compatible fuentes de alimentación nocturna.
- 4 entradas digitales y 2 salidas digitales.
- Es necesario el circuito de pre-carga.

PROTECCIONES

- Cortocircuitos y sobrecargas en la salida.
- Anti- isla con desconexión automática.
- Fallo de aislamiento.
- Sobretensiones AC con descargadores tipo 2.
- Sobretensiones DC con descargadores tipo 2.

ACCESORIOS OPCIONALES

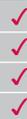
- Kit de autoconsumo.
- Comunicación RS-485.

BENEFICIOS

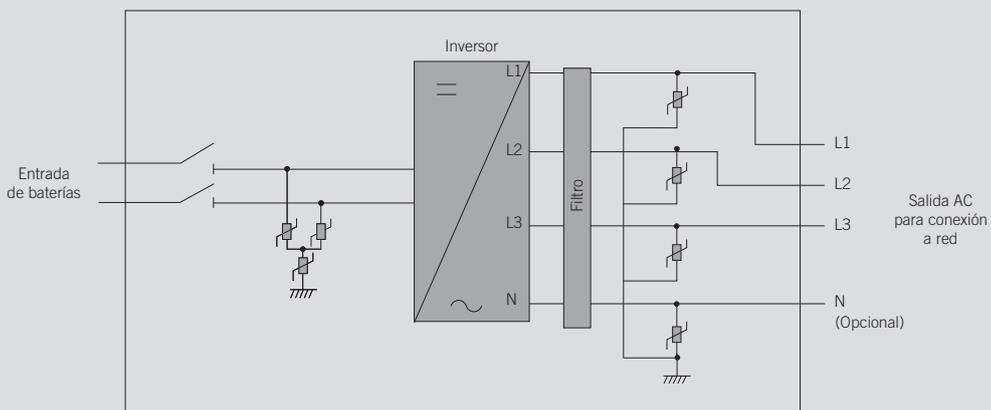
- Mayor densidad de potencia.
- Mayor competitividad gracias a la reducción del gasto en cableado.
- Alta disponibilidad comparada con inversores centrales.
- Elevados índices de eficiencia.
- Fácil mantenimiento.

Elementos integrados

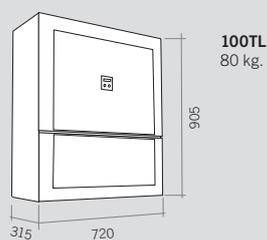
- Bornas DC
- Seccionador DC
- Descargadores DC, tipo 2
- Descargadores AC, tipo 2



3Play TL



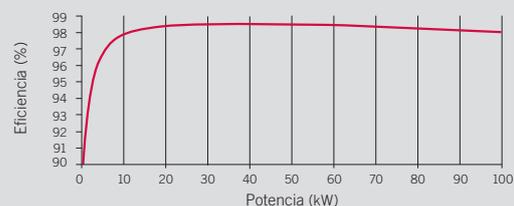
Dimensiones y peso (mm)



100TL	
Valores de Entrada de Batería (DC)	
Rango de tensión	570 - 850 V
Tensión máxima ⁽¹⁾	1.100 V
Potencia máxima de carga / descarga	60 kW / 100 kW
Corriente máxima de carga / descarga	111 A / 185 A
Tipo de batería	Ion-Litio, plomo, Ni-Cd y baterías de flujo
Corriente de cortocircuito	240 A
Comunicación con el BMS (Battery Management System)	CAN Bus 2.0 / Ethernet
Valores de Salida (AC)	
Potencia nominal	100 kW
Máx. temperatura a potencia nominal ⁽²⁾	50 °C
Corriente máxima	145 A
Tensión nominal	400 V
Frecuencia nominal	50 / 60 Hz
Factor de Potencia	1
Factor de Potencia ajustable	Sí. Smáx=100 kVA Qmáx=100 kVAR
THD	<3%
Rendimiento	
Eficiencia máxima	98,8 %
Euroeficiencia	98,1 %
Datos Generales	
Sistema de refrigeración	Ventilación forzada
Caudal de aire	570 m³/h
Consumo en stand-by	20 W
Consumo nocturno	1 W
Temperatura de funcionamiento	-25 °C a 60 °C
Humedad relativa (sin condensación)	0 - 100 %
Grado de protección	IP65 / NEMA 4
Interruptor diferencial	1.000 mA
Altitud máxima ⁽³⁾	3.000 m
Conexión	AC: Máxima sección: 240 mm² (un cable) Conexión DC (STD): Máxima sección: 300 mm² (un cable) Conexión DC (PRO): 6 mm² (24 pares de conectores PV-Stick) Permitido el cableado en cobre y aluminio, tanto en DC como en AC
Marcado	CE
Normativa EMC y de seguridad	EN 61000-6-1, EN 61000-6-2, EN 61000-6-3, EN 61000-6-4, EN 61000-3-2, EN 61000-3-3, EN 61000-3-11, EN 61000-3-12, EN 62109-1, EN 62109-2, IEC62103, EN 50178, FCC Part 15, IEC60068-2-1:2007, IEC60068-2-2:20007, IEC60068-2-14:2009, IEC60068-2-30:2005, IEC62116, IEC61683 y EN50530
Normativa de conexión a red	DIN V VDE V 0126-1-1, Arrêté du 23 avril 2008, EN 50438, EN 50439, EN 50549, CEI 0-21, CEI 0-16 VDE-AR-N 4105:2011-08, G59/3, P.O.12.3, AS4777.2, AS62040.1.1, BDEW, IEC 62116, IEC 61727, UNE 206007-1, ABNT NBR 16149, ABNT NBR 16150, Brazilian Grid Code, South African Grid Code, Chilean Grid Code, DEWA 2.0, Jordanian Grid Code, Thailand MEA & PEA requirements

Notas: ⁽¹⁾ El inversor no entra en funcionamiento hasta que Vdc < 1.000 V ⁽²⁾ Por cada °C de aumento, la potencia de salida se reducirá un 2,3 % ⁽³⁾ Por encima de 1.000 m, la temperatura máxima para entregar potencia nominal se reduce a razón de 5,5 °C por cada 1.000 m adicionales.

Rendimiento INGECON® SUN STORAGE 100TL Vdc = 570 V





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Annex VI: Charger datasheet

INGEREV

RAPID 120/180



Cambiar la **respuesta es**
EVOLUCIÓN

Cambiar la **pregunta es**
REVOLUCIÓN

Ser capaces de dar respuesta a las necesidades actuales del mercado es siempre un desafío, que requiere de una constante transformación. Para el desarrollo de la novedosa gama RAPID, en Ingeteam nos hicimos infinidad de nuevas preguntas, ya que estos nuevos equipos debían cubrir, no sólo las necesidades actuales, sino también las futuras, en un sector en constante evolución.

Ingeteam presenta la nueva gama de cargadores **INGEREV® RAPID, para carga ultra-rápida, de 120 kW y 180 kW**, para cumplir con el potencial de los vehículos más exigentes. Han sido diseñados para satisfacer los más altos estándares de calidad y prestaciones en cuanto a gestión de potencia, comunicaciones, fiabilidad y eficiencia.

Son compatibles con los estándares CCS y CHAdeMO, pudiendo llevar uno o dos cables de carga en DC. Los modelos Trio incorporan, además, toma Tipo 2 de 22 kW para carga en corriente alterna, permitiendo la carga simultánea de hasta tres vehículos. Así mismo, disponen de gestión de potencia entre las distintas salidas del equipo, o entre varios equipos INGEREV en una misma instalación.

NUEVA GAMA RAPID 120 kW y 180 kW

	RAPID 120/180 Duo	RAPID 120/180 Trio
Conectores	2	3
Carga simultánea	✓	✓
Tipo de conectores	CCS + CCS CCS + CHAdeMO	CCS + CCS + AC CCS + CHAdeMO + AC

FUNCIONALIDADES

- Electrónica modular. Los equipos de 120 kW son ampliables a 180 kW.
- Recarga en CCS, hasta 180 kW. Posibilidad de doble CCS.
- Recarga en CHAdeMO, hasta 80 kW. Solo en equipos Duo.
- Mangueras con sistema auto-retráctil.
- Recarga en AC Toma Tipo 2, hasta 22 kW, en equipos Trio.
- Indicación de estado mediante LEDs RGB.
- Lector RFID.
- Pantalla táctil a color de 7", multi-idioma.
- Vatímetros MID.
- Carga simultánea en todas las salidas de potencia disponibles.
- Envoltente de acero inoxidable de gran resistencia.

COMUNICACIONES

- RS485, Ethernet (modo switch).
- Modbus, MQTT, OCPP.
- Actualizaciones automáticas de software durante la vida del producto.



INGEREV

RAPID 120/180

Cambiar la **respuesta** es
EVOLUCIÓN

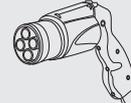
Cambiar la **pregunta** es
REVOLUCIÓN



TIPO DE CONECTORES



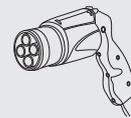
CCS 300
CCS 300 A



CHA125
ChadeMO 125 A



AC 22 kW
Toma Tipo 2



CHA200
CHAdEMO 200 A



SEGURIDAD

- Protecciones diferenciales y magnetotérmicas contra contactos indirectos, cortocircuitos y sobrecargas.
- Protecciones contra sobretensiones permanentes y transitorias Tipo II.
- Pulsador de emergencia de gran visibilidad para garantizar la seguridad de su uso.

OPCIONES

- Diferenciales autorrearmables.
- Sistema de bloqueo de conectores.
- Comunicación remota 3G/4G.
- Lector de tarjetas bancarias contactless.
- Pantalla comercial de 21".
- Smart DLM.



INGEREV**RAPID 120/180**Cambiar la **respuesta es**
EVOLUCIÓNCambiar la **pregunta es**
REVOLUCIÓN

	INGEREV® RAPID 120	INGEREV® RAPID 180
Entrada AC		
Tensión	AC 3ph.+ N + PE; 380/400/480 Vac ±15 %	
Frecuencia	50 / 60 Hz ±5 %	
Corriente nominal	190 A + 32 A	280 A + 32 A
Potencia nominal	120 kW + 22 kW	180 kW + 22 kW
Salida DC		
Rango de tensión	150 - 1.000 V	
Corriente máxima	400 A (200 + 200 A)	600 A (300 + 300 A)
Potencia máxima	120 kW (60 + 60 kW)	180 kW (90 + 90 kW)
Conectores de carga	CCS1 / CCS2 (300 A) / CHAdeMO (125, 200 A) / 22 kW AC Modo 3 Toma Tipo 2	
Salida AC (opcional)		
Corriente máxima	32 A	
Potencia máxima	22 kW	
Conectores de carga	AC Modo 3 Toma Tipo 2 con obturadores	
Cumplimiento de normativas y seguridad		
Estándares	IEC 61851-1 ed 3, IEC 61851-21-2 ed 1, IEC 61851-23 ed 1, IEC 61851-24 ed 1, IEC 62196-2, IEC 62196-3, IEC 61000	
Sobrecorriente	MCB	
Contactos indirectos	Control de fugas de DC IEC 62955 Dispositivo de fuga - RCD 30mA clase A (opcional)	
Sobretensiones	Protección contra sobretensiones permanentes y transitorias Tipo 2, tanto en entradas como en salidas DC	
Funcionalidades y accesorios		
Conexión	Ethernet, Modem 3G/4G (opcional)	
Protocolo de Comunicación	OCPP (estándares y versiones personalizadas)	
Pantalla publicitaria	Full HD de 21" (opcional)	
HMI	Pantalla táctil de 7", RFID (Mifare Classic 1K&4K, MifareDesFire EV1, NFC)	
Información general		
Consumo en stand-by	<60 W	<80 W
Sistema retráctil para mangueras	Incluido	
Longitud de mangueras	6,5 m (5 m útiles)	
Medición de energía	Medidas de salidas de AC (MID) y DC	
Temperatura de funcionamiento	-35 °C ~ 60 °C (opción kit de baja y alta temperatura)	
Humedad	<95 %	
Peso	380 kg	420 kg
Medidas (An x P x Al)	2.540 x 774 x 730 mm	
Envolvente	Acero inoxidable 430 y aluminio	
Altitud de funcionamiento	2.000 m (para altitudes superiores consultar con Ingeteam)	
Grado de protección	IP54 / IK10 (display IK08) / C5H	
Marcado	CE	
Directivas	Directivas de baja tensión : 2014/35/EU Directiva EMC : 2014/30/EU	