Barcelona Use case set up report

Pillar A+C

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SUMMARY SHEET

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Abstract	Pillar A: This A4 use case settle in Barcelona aims to compare two different recharging models in terms of bus services. The first models pretends to operate buses recharging off-street at depots during night time. The second models proses a fast recharge operation on-street at bus line extremes. This two models will be compare to see which has the best life cycle cost. Pillar C: The document exposes: background, objectives and definition of the study and subtasks assigned to each partner of the Use Case C3, located in Barcelona. In summary, it consists on carry out a feasibility study in order to determine whether the usage of the existing electric network from the Metro could be socially profitable. Besides, it could be used to recharge electric vehicles in off-street parking lots and on-street parking spaces.
Keywords	Pillar A: A4, Eliptic, Bus, Barcelona, feasibility study, overnight operation, recharging points, on-street operation, off-street operation

	Pillar C: Electric Vehicle, Metro, Recharging, Resilience, Sustainability, Pillar C
Critical risks	Pillar A: Political reasons can have a huge impact on the feasibility of the measure. Local planning can modify the intention to prove bus electric vehicles in those lines where opportunity recharge points are supposed to be installed. Financial issues are derived mostly from the political uncertainly. The last major risk is the legal requirements. Electro mobility is still new in legal terms and cap imply aspects such as selling energy from the metro operator to the bus operator in order to reuse the energy supplied. Pillar C: Operational, legal and demand forecasting

DOCUMENT CHANGE LOG

Pillar A:

Version	Date	Main area of changes	Organisation	Comments
0.1	24.11.2015	All	CENIT	1st draft.
1	21.12.2015	1.7, 1.9 I 1.10	TMB	Review

Pillar C:

Version	Date	Main area of changes	Organnisation	Comments
0.1	06/11/2015		BSM	1st draft. Some chapters yet to be completed
0.2	25/11/2015	Main review	CENIT	2nd draft.
0.3	18/12/2015	Main review	CENIT	Final revision
0.4	05/02/2016	Review Pillar C leader	VDV/Berends	Revised draft
0.5	08/02/2016	Update	CENIT	Final draft version
0.6	09/02/016	Fine tuning layout/ content	VDV/Berends	PreFinal version
1	24/02/016	Fine tuning layout/ content	VDV/Berends	Final version

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1. Executive Summary Pillar A

Use case A4 is embedded inside pillar A from the ELIPTIC project. The partners in charge of this measure are TMB, as the main bus operator, and CENIT, a transport research centre.

Electrical mobility is still being studied to check if it is feasible. In order to keep working on that, use case A4 propose to compare two different recharging models which implies different kind of buses.

ELIPTIC is mainly focused on a specific aspect of electro mobility: opportunity recharging points. To prove these elements, use case A4 will evaluate: a model based on recharging operations done at depot and a model where vehicles are recharged on street through fast recharging points. Each approach requires specific elements in terms of vehicles, operations and economic issues.

This approach matches with city council guidelines, so that represents an important element for the project's success. Anyway, there are always some risks that we need to control and surpass.

Normally, social welfare is one key motivation to join any ambitious project. Aligned with city council guidelines, ELIPTIC presents a perfect opportunity to test, validate, enhance and foster electric mobility in Barcelona. There are many aspects concerning electric mobility, the main pillars turn around vehicles and infrastructure. From use case A4, the efforts will be focused on evaluating the feasibility of recharging points.

2. Partner Contribution Pillar A

Company	Sections	Description of the partner contribution
CENIT	Entire Document	Leader of the document
TMB	Entire Document	General review of the document
UITP	Entire Document	Review of the document

3. Context conditions Pillar A

3.1. Economic, geographical and urban context of the Use Case

Use case A4 is set up at Barcelona. It is a Mediterranean port city and also the capital of the Autonomous Region of Catalonia. It is the second largest city in Spain after Madrid, with 1.6 million inhabitants in the municipality of Barcelona, and more than 4.7 million in the metropolitan region.

Barcelona is one of the most densely populated cities in Europe with an average population density of 15,926 inhabitants per square kilometre. It is the largest metropolis on the Mediterranean Sea, located on the coast between the mouths of the rivers Llobregat and Besòs, and bounded to the west by the Serra de Collserola mountain range, the tallest peak of which is 512 meters high.

Barcelona is one of the world's leading tourist, economic, trade fair and cultural centres, and its influence in commerce, education, innovation, entertainment, media, fashion, science, and arts, all contribute to its status as one of the world's major global cities. It is a major cultural and economic centre in southwestern Europe, 24th in the world (before Zürich, after Frankfurt) and a financial centre. In 2009 the city was ranked Europe's third and one of the world's most successful as a city brand. In the same year, the city was ranked Europe's fourth best city for business and fastest improving European city, with growth improved by 17% per year, but it has since been in a full recession with declines in both employment and GDP per capita, with some recent signs of the beginning of an economic recovery. Since 2011, Barcelona is a leading smart city in Europe.

From a transport point of view, Barcelona is a transport hub with the Port of Barcelona being one of Europe's principal seaports and busiest European passenger port; an international airport, Barcelona–El Prat Airport, which handles above 35 million passengers per year; an extensive motorway network and a high-speed rail line with a link to France and the rest of Europe.

In this manner, the tendency is to implement smart solutions to keep with the efficient and sustainable development of the city. As it has been shown in recent years, Barcelona is the European capital of innovation and Mobile World phone capital, pioneering new technological innovations and leading smart projects around Europe.

In the same way, smart mobility works to achieve a safe, sustainable, equitable and efficient mobility, reducing environmental impact, but also making the citizen to move more smoothly and easily. For that reason, the tendency of the urban solutions are increasingly intended for pedestrian and its needs, thereby encouraging public transport.

3.2. PT service context

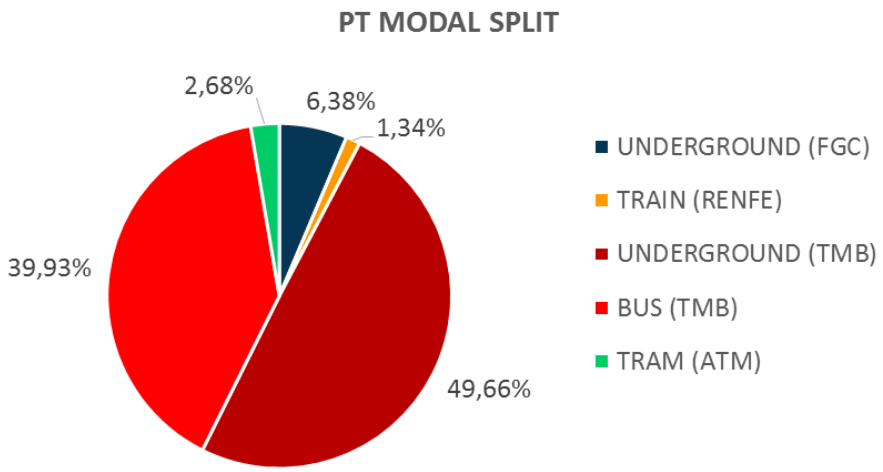
Barcelona has a well-developed public transport network. Its public network is formed by a multimodal infrastructure that includes railways, buses, cars, bikes and even cable railways. Although different companies run different transports modes, most services are included into an integrated fare system, managed by the Autoritat del Transport Metropolità (ATM).

Barcelona is the main city in its influence area that's why it represents the major attraction pole of journeys and travel, not just for residents but also for people who come every day for study/work. Each day 4,73 million journeys are split as follows:

Non-motorized	55,6 %
Public transport	29,3 %
Private vehicle	15,0 %

There are some points regarding this categorical split. One key aspect of Barcelona's mobility is the fact that more than a half of movements are done by bike or on foot. Besides, and mainly due to its weather, 42,6% of journeys done in private vehicle are carried out by motorbikes. Thus, under these conditions, public transport just has a

30% share and every day it moves 1,4 million people.



The public transport network is basically base on trains and buses. The most important actor is Transports Metropolitans de Barcelona. TMB runs the main network of buses and underground and that's why they move 9 out of 10 people in public transport.

Other operators are presented at Barcelona. RENFE and FGC are two different train operators, they both have a large network connecting Barcelona to its suburbs by public transport. They have an important impact in mobility not just inside the city but also letting people get in Barcelona by public transport. A part from these two railway companies, there is ATM who runs tram. This service just connects from its borders in the north and south but still it moves 67.000 people each day.

Looking at the main operator, TMB has two different services: underground and buses. On the one hand, Metro network operated becomes the leading actor in the internal mobility of the city. By the end of 2015, it operates 8 lines with a length of 102 km, owning 165 trains, 134 of them are operated simultaneously in the rush hour. The network, which includes 141 stations, offers 83.160,46 vehicles-km (thousands), 15.236,10 places-km in operation (millions), to satisfy city's demand of 375 million annual journeys approximately.

On the other hand, bus network is composed by NXB (Nova xarxa bus), regular lines and neighbourhood lines. NXB is the newest network that enhances time interval capacity, and finally, it improves the whole bus service at the city. To provide service to 110 lines different kind of buses are used: diesel, hybrid, gas and electric buses.

Electric buses are the last innovation approach made by TMB in order to fulfil the city councils objectives.

Barcelona is leading some initiatives in order to promote electromobility in the city, being Live platform, the most relevant among them. Live is a public-private platform open to all those entities involved in sustainable mobility, mainly electric and CNG vehicles, with the shared goal of developing projects, policies, strategies, new business models and creating a knowledge network.

Strongly linked to ZeEUs project and electric mobility, we expect ELIPTIC to contribute to improving the mobility of Barcelona in terms of sustainability and efficiency.

3.3. Information about the Use Case

Use case A4 is a feasibility study. As it belongs to Pillar A, its thematic is: “Safe integration of ebuses using existing electric public transport infrastructure”. Set in Barcelona, this study focus on opportunity charging operations, considering both approaches: fast on-street and slow depot recharges.

This study aims to analyse and evaluate suitable routes to be electrically performed. At the same time, it is required to check profitability trying to compare different operative models of recharge.

In charge of this use case, there is TMB, as the main bus operator of the city, and CENIT, a research centre in terms of transport and mobility linked to UPC.

4. Objectives Pillar A

4.1. Objectives of the Use Case

Normally, social welfare is one key motivation to join any ambitious project. Aligned with city council guidelines, ELIPTIC presents a perfect opportunity to test, validate, enhance and foster electric mobility in Barcelona. There are many aspects concerning electric mobility, the main pillars include vehicles and infrastructure. From use case A4, the efforts will be focused on evaluating the feasibility of recharging points.

Opportunity points are one key element to achieve electro mobility success. At this point, there are two different assessments: economic and operational issues. These are the key elements any operator or administration should analyse when deploying an electric infrastructure.

At the moment, there are mainly two different approaches concerning opportunity recharging points. Inheriting from conventional buses, recharging operations are commonly executed at depots; but, this scheme could change if we evaluate electric requirements.

ELIPTIC project will allow us to evaluate off-street recharge, also known as depot's recharge; and, also, the new approach where vehicles are charged on-street. These different methods imply different operative models.

The former must charge all the energy required to run during the whole service without any interruption in terms of recharging operations. That means a lot of batteries to provide high-energy capacity and a long period of time to recharge them, probably at night using opportunity points of 80kW.

While, the latter might require a lower number of batteries, meaning less capacity. This will imply shorter periods of recharge that could be done on-street while buses are waiting at headers. However, even recharge time will take some minutes, so the infrastructure will be able to provide high power, in this case 400kW of electrical power.

From these different models, the objective is to compare both underlying its benefits and drawbacks in terms of operations, efficiency and economy. Linked with economic aspects a feasibility study will be reported to analyse its electro mobility model. It will be used for further actions to determine if electric bus deployment is feasible or not.

Finally, the underlying objective of this use case is to improve air quality by deploying electro mobility in Barcelona.

4.2. Expected impacts

The expected impacts are directly depending on objectives presented above. Expected impacts of this use case are described below:

- The subject of the ELIPTIC project is electro mobility applied at main public actors. The final objective of these agents are to improve sustainability by deploying an electric environment. Therefore, at this use case there is a principal impact in air quality by switching from conventional buses to electric buses.
- Users may perceive a clear impact when riding an electric vehicle because the vehicle will produce lower noise increasing traveller comfort, compare to conventional buses.
- This use case will reinforce the visibility and it will present the city as a role model in terms of electro mobility and sustainable measures. Thus, people will be much more sensitive with the environment and they will have a better infrastructure and environment to switch to electro mobility.

All this impacts are clearly aligned with strategical policies of the city council in terms of mobility and sustainability. The conclusions of the feasibility study should determine the best way to achieve the objective and perform the best approach either with the on-street or the off-street recharging model.

4.3. Use Case KPIs

The list of Key Performance Indicators KPIs for the A4 use case is classified in 5 different groups concerning: Operations, Economy, Energy, Environment and People.

Operations is one of the two most important groups. These KPIs will represent the deployment and activities done at each model of recharging operations. This embraces aspects such as staff, supply, maintenance, service, safety, consistency and demand. In this group there are 29 KPIs.

Economy is the second most important group as it includes 29 KPIs. The principal components to evaluate concern costs, revenues and incentives. Through these parameters, we will assess the life cycle cost of each model.

Third group comprehends Energy parameters. There are 10 KPIs associated to supply and consumption.

Strongly related with a switch in the energy used by vehicles, we must talk about Environmental issues. At this topic, it is evaluated: noise, radiation, emissions savings (CO_2, NO_x, PM) and wastes.

Finally, last point to assess is People. Through questionnaires, we will evaluate aspects such as awareness of the project for both passengers and drivers.

From this groups, we have a total of 85 KPIs, but we must take into account the confidentiality of some of them.

5. Risks Pillar A

There are several points to consider in order to be aware of the possible risk for the success of the use case. These risk are classified in 4 different aspects:

- Political: Barcelona has recently changed its municipal government so many measures promoted in the past can be modified. Even if electro mobility is a key point for the current administration, there may be changes in the deployment of the use case. For example, in the past, the test line for the ELIPTIC project was supposed to be a new one located at Av. Diagonal called D30. Due to political reasons, this new route is still unknown and electric buses are going to be deployed on line H16
- Financial: Economic costs can exceed the initial budget and consequently, this can become a problem. In this use case, the TMB's budget directly depends on public administration, which means it depends on political decision. In this context, as part of the investment to deploy the use case is not included within ELIPTIC's budget, it can really become a risk.
- Legal: Opportunity recharging points at streets are something the public administration need to regulate in order to ensure civil risk. This is another new point that A4 use case is going to face and it could represent a problem.
- Technical: Electro mobility does really relay on communications. Anyone who wants to deploy an electrical system on the field of mobility requires to also ensure communications. The subject of this use case is electric buses and recharging points, so they need to be monitored in order to control mainly: battery status and its evolution. Other tests have proved that data provided by communications is a key point for the success of a measure and they can evoke many problems.
- Security: As electro mobility is not widely developed, there are some concerns about security that could become a problem. Electrocution, fires and radiation are some points that can represent a major problem if electro mobility cannot properly manage them.

6. Detailed description of the Use Case Pillar A

6.1. Description of expected use case features, establishing the link among use case conditions, objectives and background

Within ELIPTIC, TMB and CENIT want to verify two different models for electrical buses in A4 use case. Following the guidelines initiated in the ZeEUs project, in this case they want to go a step further and compare two approaches trying to identify its operative and economic implications.

ELIPTIC is mainly focused on a specific aspect of electro mobility: opportunity recharging points. To prove these elements, use case A4 will evaluate: a model based on recharging operations done at depot and a model where vehicles are recharged on street through fast recharging points. Each approach requires specific elements in terms of vehicles, operations and economic issues.

Depot recharging operations are already operative at TMB mainly thanks to ZeEUs project. This typology is based on a slow recharge during the night time. Electric buses from the IRIZAR manufacturer have a battery capacity of 352 kWh and a 12 m length. These buses use an 80 kW power supply. They will be tested during a time service of 16-17h on lines 20 and 34, with 9,4km and 10,9 km, respectively. In this case, the energy supplier is currently Endesa but depending on the evolution TMB-METRO could become the new supplier.

The second model is new at Barcelona. In this case, fast recharging operations will let the service run. Two SOLARIS electric buses are going to perform the service through this operative model. These vehicles have a battery capacity of 125 kWh and an 18 m length. Less capacity means less time and energy at each recharge but more recharging operations. The opportunity recharge points to ensure the service will be placed at each header of H16 line providing 400 kW electrical power. Besides, it will be also required a slow recharge at depot from a supply of 50 kW in order to let batteries recover themselves from fast recharging operations. H16 line has a length of 12,2 m between headers. Compare to the previous model, in this case recharging time will be within minutes instead of hours. The electric supply is going to be provided by Endesa.

Currently, depot opportunity points are place at Triangle's depot of TMB. The other 2 opportunity recharging points are supposed to be placed at Cisell Street close to Zona Franca and the other is still uncertain. These two elements are deployed by a

tender process. Cisell's recharging point is already awarded but the other is still on a planning stage.

To achieve the goal of the A4 use case, the partners should play its own role:
- TMB as the operator will be in charge of operative connectivity and tendering tasks.
- CENIT as the research centre will coordinate and control all the task apart from taking special care of the evaluation of KPIs.
- IRIZAR even if not formally part of the A4 use case, it is still the manufacturer of two buses that are going to be operated.

6.2. Use Case constraints

Directly linked with risks, use case constraints are strongly related with government decisions. As we have already explained above, the deployment of ELIPTIC project has been changed from the initial proposal. The major condition for the success of the objectives is to avoid possible risk presented before.
Nowadays, other constraints are focused on supply connectivity. As we are talking about new elements in an urban environment, it is highly required to ensure the civilian safety of the opportunity recharging points. This is mainly depending on city council laws.
There are other constraints in terms of technical requirements. A4 use case tries to evaluate the constraints of electric mobility from a buses approach. That means, it is also necessary to take into account energy autonomy of electrical buses as the main technical constraint.

6.3. Use Case monitoring criteria

In order to verify and control the measures deployed at this use case. TMB has different applications to monitor key elements of the infrastructure required for the models success.

- SCADA is a monitoring system that controls the operations of the running buses. It is not specific for electrical buses as its main goal is to track the service provided by each bus (place, time, speed, etc). It gathers data through the application called WONDERWARE from Schneider.
- POWER-studio is the application from CIRCUTOR for monitoring the electrical operations at opportunity points. This software is already running for the depot's opportunity recharging points used to charge IRIZAR buses.

- ENDESA is the supplier of the electric energy at opportunity recharging points set up on-street. In this case, as they are not partners of the project they have already signed a collaboration agreement to provide data required to evaluate the recharging operations from SOLARIS buses.

7. Use case work plan Pillar A

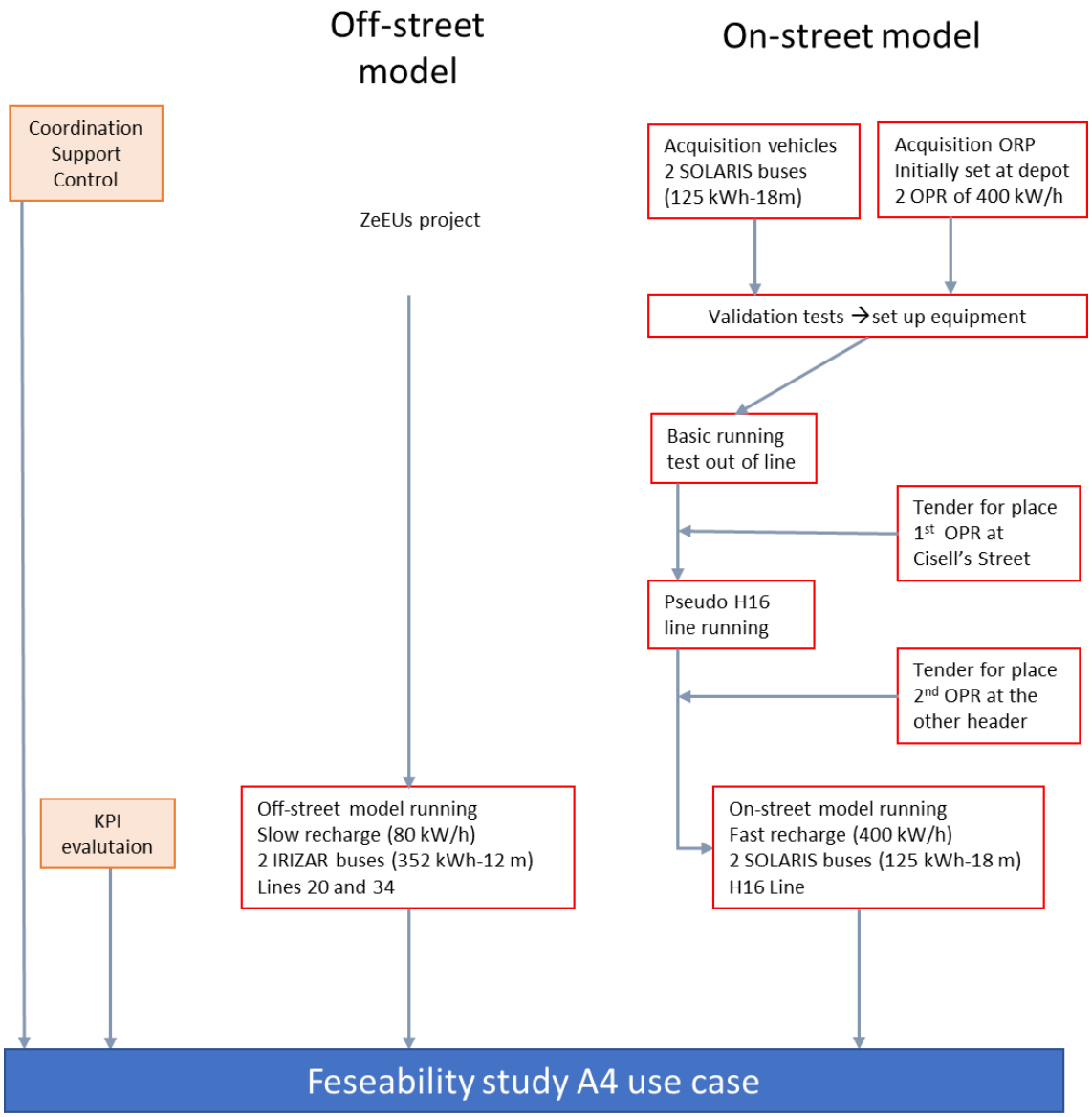
As the A4 use case is structured in two different measures, the work plan is strongly influenced by this division. Depot recharge, also known as off-street, is already running so the work plan will basically keep tracking the evolution of this model, which means monitoring its performance both in operative and economic aspects.

On the other hand, on-street recharging operations require a complete work plan to be deployed. For this model, the following tasks must be provided:

1. Acquisition of SOLARIS electric vehicles.
2. Basic test performance both for vehicles and opportunity recharging points.
3. Tender for the two recharging points placed at headers of H16 line.
4. Initial vehicle test for a pseudo H16 route
5. Performance of SOLARIS electric vehicles running on the current H16 line.

After having deployed the performance for each model, gathered data will provide the insight to evaluate the feasibility of each approach.

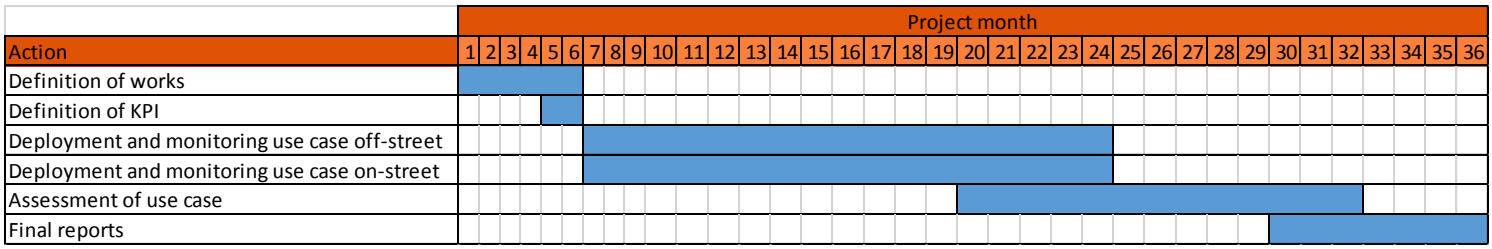
7.1. Use Case development logic



7.2. Work plan

Num.	Action	Responsible	Staff 1	Staff 2	Staff 3	Staff 4	Start-month	End-month
1.1	Monitoring off-street model	TMB	Josep M. Armengol	Josep Ariño			7	24
1.2	Implementing and monitoring on-street model	TMB	Josep M. Armengol	Josep Ariño			7	24
2	Evaluation and reports	CENIT+ TMB	Josep M. Armengol	Josep Ariño	Miquel Estrada	Victor Cuevas	20	36
3	Coordination, support and control	CENIT	Miquel Estrada	Victor Cuevas			0	32

7.3. Detailed timeline



8. Expected results Pillar A

Achieving the goals presented above, the results will try to represent the feasibility of the use case. In this particular use case, main results will define and quantify the life cycle cost of an electrical buses deployment and the operational requirements to do so.

A4 use case will present both approaches: one for an off-street electrical implementation and the other for an on-street electrical deployment of operations. Each model has its own advantages and drawbacks. Results regarding economic and operative KPI will try to demonstrate which model is more suitable for a specific situation.

The most important result in this use case will be to validate that each approach could be feasible in economic and operative terms.

9. Executive Summary Pillar C

The aim of this document is to define and expose the works to be done in the Use Case C3 of the ELIPTIC project.

Use Case C3 is located in the city of Barcelona. In summary, it consists on carry out a feasibility study in order to determine whether the usage of the existing electric network from the Metro could be socially profitable. Besides, it could be used to recharge electric vehicles in off-street parking lots and on-street parking spaces.

The document exposes: background, objectives and definition of the study and subtasks assigned to each partner of the Use Case. It is also included the KPIs of the entire project. In addition, it is provided an accurate planning of the tasks in order to do an appropriate following of the study.

10. Partner Contribution Pillar C

Company	Sections	Description of the partner contribution
B:SM	Entire Document	Leader of the document
CENIT	Entire Document	General review. Important contribution in the KPI and methodology sections

11. Context conditions Pillar C

11.1. Economic, geographical and urban context of the Use Case

Barcelona is the capital city of the autonomous community of Catalonia in Spain and Spain's second most populated city, with a population of 1.6 million within its administrative limits. Its urban area extends beyond the administrative city limits with a population of around 4.7 million people, being the sixth-most populous urban area in the European Union after Paris, London, Madrid, the Ruhr area, and Milan. Barcelona is one of the most densely populated cities in Europe with an average population density of 15,926 inhabitants per square kilometer. It is the largest metropolis on the Mediterranean Sea, located on the coast between the mouths of the rivers Llobregat and Besòs, and bounded to the west by the Serra de Collserola mountain range, the tallest peak of which is 512 meters high1.

Barcelona has become an important and sustainable tourism destination, demonstrating the city's commitment to economic, social, cultural and environmental values. It is a business center that is growing with a very high commitment in terms of environmental sustainability, economic competitiveness, quality of life and city services.

In this manner the tendency is to implement smart solutions to keep with the efficient and sustainable development of the city. As it has been shown in recent years Barcelona is the capital of European innovation and World mobile phone capital, pioneering new technological innovations and leading smart projects around Europe.

In an economical area, Barcelona City Council works to create jobs, promote investment and financing, attract talent and help businesses and entrepreneurs. Therefore, most projects try to cover all the smart areas, researching and keeping in touch with: associations, organizations, SMEs and entrepreneurs.

In the same way smart mobility works to achieve a safe, sustainable, equitable and efficient mobility, reducing environmental impact. Besides, it is making the citizen to move more smoothly and easily. For that reason the tendency of the urban solutions are increasingly intended for pedestrian and their needs, thereby encouraging public transport.

11.2. Mobility context

Barcelona is served by a comprehensive local public transport network that includes, as its mains actors, the followings: a metro, a bus network, two separate modern tram networks, and suburban and regional trains. Most of these networks are part of a coordinated pricing system, administered by the Autoritat del Transport Metropolità (ATM). However, they are operated by a number of different bodies2.

The largely underground Barcelona Metro network comprises eleven lines. Eight of which are operated on dedicated track by the Transports Metropolitans de Barcelona (TMB), whilst the

[1] http://www.barcelona.cat/ca/
[2] http://mobilitat.ajuntament.barcelona.cat/ca/documentacio?field_tipologia_documentacion_tid=12

three others are operated by the Ferrocarrils de la Generalitat de Catalunya (FGC) and share tracks with that company's commuter lines.

Metro network operated by TMB becomes the leading actor in the internal mobility of the city. By the end of 2015, it operates 8 lines with a length of 102 km, owning 165 trains, 134 of them are operated simultaneously in at the rush hour. The network, which includes 141 stations, offers 83.160,46 vehicles-km (thousands), 15.236,10 places-km in operation (millions), to satisfy city's demand of 375 million annual journeys approximately3.

Figure 1 – Metro network of Barcelona

Private transport management in the city is also an important issue in order to make the mobility of the city easier and sustainable. In this way, Barcelona de Serveis Municipals (B:SM) takes an important role into the day-by-day mobility of the city being the main parking operator of Barcelona.

In its business lines related to mobility, B:SM operates 40 public car parks and over 13,000 parking places throughout the city, being an affordable and effective solution for citizens and users looking for somewhere to park. In these locations, B:SM manages more than 200 slots for recharging electric vehicles (cars and motorbikes).

[3] http://www.tmb.cat/ca/home

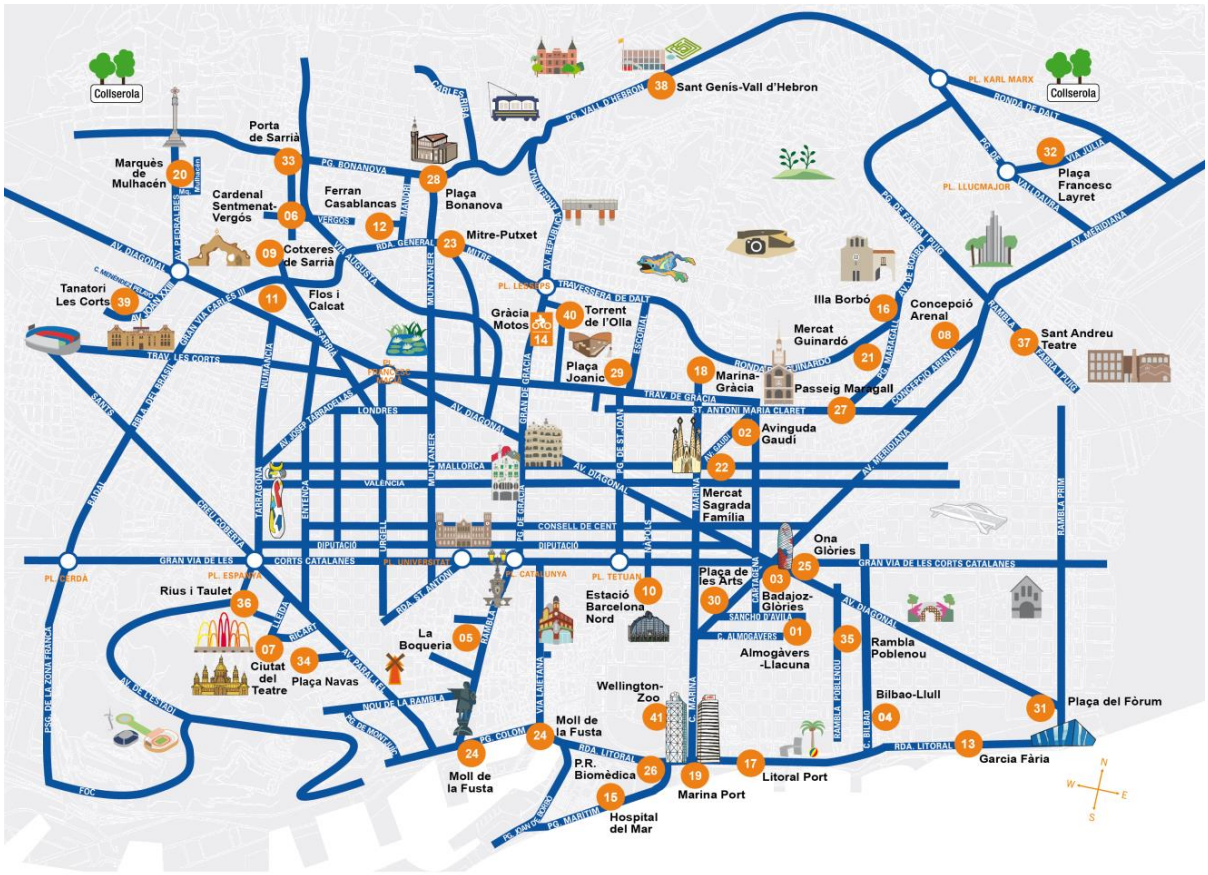


Figure 2 – Location of the off-street parking facilities managed by B:SM[4]

B:SM also participates in BAMSA society, which operates 15 additional parking equipment located mainly in the city center.

The AREA system is the comprehensive street-level parking plan, first introduced in 2005. It manages mobility for destinations inside the regulated zone and reduces traffic tensions. It also includes all the street-level parking space within the regulated zone, which is distributed on a priority basis and operates through a system of regulations and tariffs. There are several categories of spaces: blue, green, green only for resident use, loading/unloading, motorbikes, coaches and other special uses, totalizing up to 60.000 regulated spaces throughout the city.

Both Public Transport and Private Transport regulation are the key elements for achieving a mobility sustainable model in Barcelona. The trend observed in the last PMU (Urban Mobility Plan) shows that the urban mobility model should be no longer focused on private vehicle. The use of bicycles and public transport shapes the new behavior of the urban model and become the paradigm of sustainable mobility.

[4] http://www.aparcamentsbsm.cat/

Demand recovery responds, first, to a set of projects deployed to improve infrastructure. The aim of extending public transport network and bringing it to new towns, which can significantly increase its coverage area, as the following graphic shows, the growth trend of public transport in urban mobility is a reality and the forecast in a short term future is consistent with it.

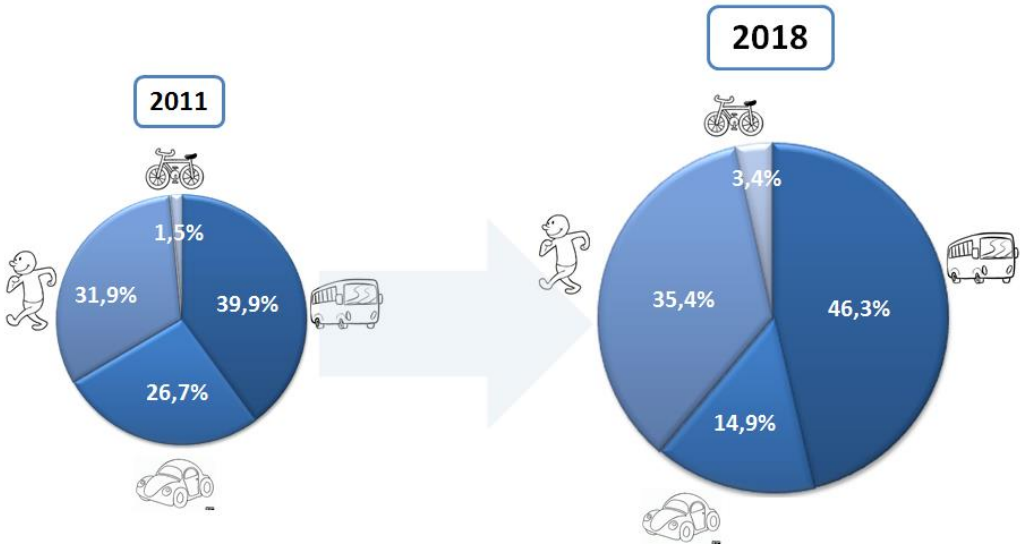


Figure 3 - Distribution of modal split mobility in Barcelona[5]

Therefore, the actual scheme for future plans follows the points below:

- To boost walking and cycling journeys.
- Increase public transport market share VS private.
- Private vehicles less polluting and a higher occupation rate.

As seen above, sustainable mobility is a key for mobility the evolution in the city. Since the usage of private cars is expected to decrease in the next years, electric mobility should take an important role in the mobility of the city.

Barcelona is leading some initiatives in order to promote electro mobility in the city, being Live6 platform, the most relevant among them. Live is a public-private platform open to all those entities involved in sustainable mobility. Mainly electric and CNG vehicles pursue a shared goal of developing projects, policies, strategies, new business models and creating a knowledge network in order to improve their use.

Within this framework, we expect that ELIPTIC contribute to improve the mobility of Barcelona in terms of sustainability and efficiency.

5 (walk, bicycle, PT and private car) at the time of the Urban Mobility Plan, and expected distribution at the end of its implementation

6 http://w41.bcn.cat/

11.3. Information about the Use Case

ELIPTIC's Pillar C from Barcelona Use Case (C3) intends to carry out a feasibility study to prove the convenience of deploying vehicle charging network connected both to the general electric network of the city, and to the electric network from metro system, benefitting of its synergies and opportunities.

The study will analyze the whole city, by exploring the possibilities of deploying and opportunity recharging point nearby metro substations. By doing so, it will be required to, analyze from an infrastructural, operational and strategic point of view the convenience of the intervention. If, as a result of the report, the measures results feasible we also have to provide the planning and proposes, Barcelona should follow in an eventual real deployment of the solution.

To do so, Use Case C3 is integrated by Barcelona de Serveis Municipals, the main public parking operator, TMB, the operator of the metro system, and CENIT, a research center in terms of transport and mobility associated to the Universitat Politècnica de Catalunya.

12. Objectives Pillar C

12.1. Objectives of the Use Case

As said before, the goal of the study is to analyze the potential of using energy from the metro's infrastructure to opportunistically charge vehicles in parking lots, to deploy a charging network of doubly connected (regular connection and metro)

The study will reach its conclusions by approaching to the solution by through a three stages scheme: infrastructure, operation and strategy.

The first stage will study the case from an infrastructural point of view. It will analyze connection opportunities that the current metro electric network brings, and, considering the potential vehicle demand of at different areas of the city, identify the parking lots and slots where recharging points could be deployed. The infrastructural analysis should provide the economical scheme cost of the project in order to better approach next two objectives.

The operational point of view will explore better solutions to carry out the system exploitation, once it would be deployed. The study will focus on how could match parking operator needs with customer needs in terms of charging its vehicles. It is also interesting to explore how the two networks will be used and combined.

As a combination of the infrastructural and the operational conclusions, the study will define the strategy for the following years about an eventual deployment of the electric vehicle charging system connected to metro's network. This last stage will define the objectives to achieve for an appropriate network deployment. As an initial approach, these objectives should be:

1. Increasing the use of electric vehicles in Barcelona, private ones as well as public fleets, which will be the main target demand.
2. Improving the air quality of the city by cutting down emissions of conventional cars, considering a switching from conventional cars to electric vehicles.
3. Social cost-benefit and urban resilience, improving the city networks to face eventual high demands or supply cuts.

12.2. Expected impacts

The expected impacts of this Use Case and its involved domains are described below. The list is extremely related with the objectives described, which will be the results of the study:

a. This project will permit to use electric power supply by public transport (Metro) for green mobility purposes. This may help to increase electric charging stations in the city; also, electric projects are aligned with the smart city criteria council strategy.

Therefore, there is a clear impact in an arise of the electric vehicle's demand in Barcelona

b. Local emissions reduction due to the increasing of electric charging stations. Related to higher demand, replacement of conventional vehicles for electric ones will clearly become into lower emissions in the city
c. The resilience of the city will be increased with these deployments. The city will be empowered in facing exceptional conditions in terms of electric demand

As a whole, ELIPTIC results are expected to impact directly into the strategical policies of the city in terms of mobility. The conclusions of the feasibility study should demonstrate the importance and benefits of switching to electro mobility by taking advantage of the already existing infrastructures of the city.

12.3. Use Case KPIs

A total amount of 35 Key Performance Indicators (KPIs), required to evaluate the success of this Use Case are defined for the Use Case C3. These KPIs have been classified in four main groups: Operations (5), Economy (10), Network effect (12) and Environment (8).

Related to the first group, Operation KPIs evaluate effects due to durability of charging infrastructures, batteries, and complementary components. Moreover, it takes into account staff accidents and external effects of the electric surcharge in the system.

Secondly, indicators involved in Economy assess effects and progress of: costs, mainly costs of investment, maintenance, and electric costs. Revenues, economic efficiency, revenues per demand and economic super plus are also calculated, as well as, incentives such as reduced price for electricity vs fuel.

Regarding Network effect, KPIs evaluate impacts on the network related to general demand, supply such as network coverage, and occupation of both on and off-street spots, service and resilience of the network operations.

Finally indicators concerning Environment issues, evaluate the consequences of using electric vehicles instead of fuel vehicles in terms of emission savings (CO2, NOx, PM), noise on and off-street, hazardous and non-hazardous waste, and other nuisance such as EM radiation.

The list of KPIs is described below:

- Operations
  - Staff
    - Management Workload
  - Maintenance
    - Durability of components
    - Durability of charging infrastructure

- Safety
  - Staff accidents
- Consistency
  - External effect

- Economy
  - Costs
    - Investment for the network
    - Maintenance of civil infrastructure
    - Maintenance of electric machinery
    - Cash flow
    - Recharging infrastructure
    - Grid connection
    - Electricity costs for vehicles
  - Revenues
    - Economic surplus
    - Economic efficiency
    - Revenues per demand
  - Incentives
    - Incentives for fuel/energy

- Network effect
  - Demand
    - General demand
    - Energy demand
    - Municipal fleets demand
    - Energy demand for municipal fleets
  - Supply
    - Network coverage
    - Proximity
    - Electric Spots
    - Spots Capacity
  - Occupation
    - Effective Occupation
    - Time of % Occupation
  - Service
    - Charging time
  - Resilience
    - Resilience

- Environment
  - Noise
    - Noise on-street
    - Noise off-street
  - Other Nuisance
    - EM Radiation
  - Emissions Savings
    - CO2 equivalent emission saved
    - PM emissions saved

NOx emissions saved

- Waste

  Hazardous waste
  Non- hazardous waste

13. Risks Pillar C

The feasibility study identifies the following list of risks to take into account in the development of the study.

Description of risk	Proposed risk-mitigation measures
Participation and commitment in the project of all the key stakeholders of the city in terms of electromobility	Including the main actors inside the project and disseminating properly the strategy, impacts and results of the project
Elevated cost of the electric connection from Metro substations to off/on-street charging stations	Strategical location of off/on-street parking lots: well-located not only for demand but also for a low cost cable connection
State government changes into electric fares, tax schemes and permissions to access to the electric network	Very likely to happen regarding last year's changes in Spain. The building of a strong model related to the infrastructure, operation and the general strategy should reduce the impact of these changes. In these terms, the project will analyze the social cost-benefit of the actuations in order to guarantee its success
Legal aspects in becoming providers of energy	With ELIPTIC scheme of action, TMB will be delivering energy to a third party, B:SM, who will be providing at the same time to private or public cars. ELIPTIC will find the proper fitting of all key players involved to not compromise the feasibility of the project. As the previous risk, it is very likely to change according to the current situation in Spain, so ELIPTIC will be paying attention to eventual legal modifications
City council political changes which lead into new strategies in the context of the Smart City initiatives	Empower the benefits of the double electrical connection, making a resilient network
Low electrical vehicle demand in Barcelona	The Use Case intends to have the participation of the City Council at all levels: by promoting the acquisition of private electrical vehicles as it regularly does, by forcing to join municipal fleets, etc. The project is fully aligned with Barcelona's city platform called Live, which aims for a higher penetration of electrical mobility in the city

Table 1 – Description of risks and proposed mitigation measures

14. Detailed description of the Use Case Pillar C

14.1. Description of expected Use Case features, establishing the link among Use Case conditions, objectives and background

Just as described in previous parts of this Use Case, using the existing PT infrastructure of metro for recharging electric vehicles at on-street and off-street parking slots applied in Barcelona, seems to be a great opportunity for the development of the city in terms of innovation and sustainability.

This approach, could meet the objectives of the city in terms of mobility, making it more sustainable. A feasibility study to analyze the potential of using electric energy from the metro infrastructure to charge at parking lots will have a highly positive impact on reducing local emissions.

Besides, by establishing a double electric connection for recharging electric vehicles, ELIPTIC is fully aligned with the strategy of resilience of the city, being included also in the smart city philosophy in which Barcelona is one of the European city leaders. And also it becomes an intervention with a high economic and social return, as it takes advantage of what the city already has.

Certainly, Metro electric network seems to be a great one to serve other city purposes, as charging electric vehicles can be one of those goals. Furthermore, both uses (metro and cars) complement each other, as their peak demand consumption do not coincide: Metro use is extremely high during the day (morning and afternoon rush hours) and vehicles needs are mainly at night when they are parked (which is the case of most of the public fleet vehicles: taxis, street cleaning, freight, etc).

The use of electricity coming from Metro's network would have a lower price than the regular cost of electricity from conventional suppliers. This could be seen as another reason to assure the feasibility of the solution here presented, rather than a social benefit coming from take advantage of the infrastructures that Barcelona already has.

But, for the same reasons, the electric connection to the conventional (and private) electric network should be implemented in the slots deployed by ELIPTIC in order to use it when Metro power would not be available due to operational reasons. This scenario will be required to charge some vehicles within daytime.

In order to do all the works exposed before, B:SM becomes the leader of the Use Case, it is the main parking operator with an extended experience in the deployment of slots for electric recharge and operational management of parking facilities since 1982, being part of the City Council. TMB as the metro operator will contribute to the Use Case by being the owner of the

electric network which feeds the metro system, and with a strong knowhow into recharging operations. Finally, there is also CENIT. It is the main research regional center in Catalonia in terms of innovation transport and mobility management, with a strong background in electric vehicle, mobility and emission studies.

The works of this Use Case could become, in a post-ELIPTIC scenario, a real demo test if the outputs of the feasibility study recommended so.

14.2. Use Case constraints

The study identifies as its main constraint, the participation of the key players in the work's development.

By explaining the description of the Use Case, and its goals, frameworks and risks, it has been remarkable the need of the key players participation to carry out successfully the study. In particular, the Barcelona's Metro participation (TMB-Metro) may be required to explore any actuation in its electric charging network. It is also necessary the participation of the different Administrations (city council, regional government), being aligned with its policies to make easier the developments, deployed plans, and demand's promotion (as said, in terms of public fleets).

14.3. Use Case monitoring criteria

The monitoring criteria will be aligned with the definition of the KPIs related to Barcelona Use Case.

As a feasibility study, most of the KPIs will be necessary to measure once the solution has been implemented successfully. This situation would occasionally occur in further projects that could be seen as a continuation of the ELIPTIC project.

However, some KPIs could be monitored since the feasibility study duration, and this will be collected mainly by the already existing official data, coming from the City Council. Some others, as the network effect ones, will come from forecasting determinations made by CENIT research. Finally, the environmental ones will be available by previous researches made as well by CENIT.

15. Use case work plan Pillar C

15.1. Use Case development logic

The logic development of the Use Case could be summarized in a scheme as it follows:

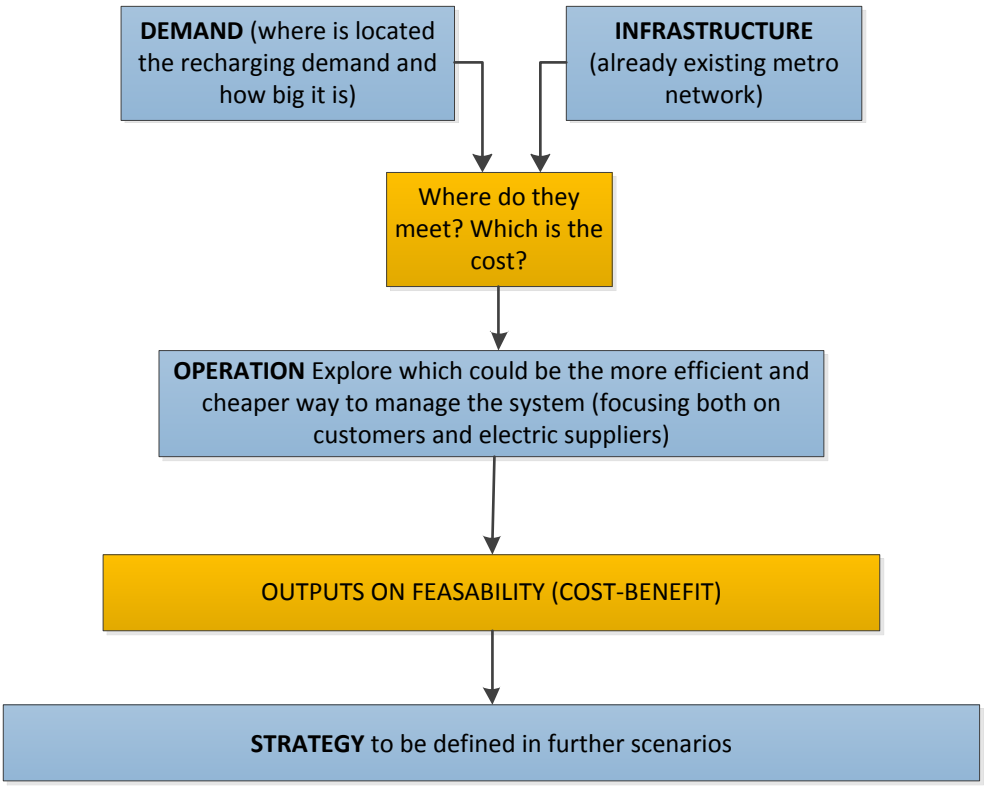


Figure 4 - Scheme of the Use Case logical development

15.2. Work plan

The work plan showed below represents the main tasks and subtasks of the works of the ELIPTIC Use Case C3.

Number	Action	Responsible	Start-month	End-month
1	Definition of works	ALL	1 (Jun15)	10 (Mar16)

2	Infrastructure design and installation	BSM	7 (Dec15)	24 (May17)
3	Demand analysis	CENIT	7 (Dec15)	24 (May17)
4	Operational model definition	BSM	7 (Dec15)	24 (May17)
5	Legal feasibility	BSM	7 (Dec15)	32 (Jan18)
6	Evaluation. KPI data collection	CENIT	7 (Dec15)	32 (Jan18)
7	Strategic analysis	ALL	20 (Jan17)	32 (Jan18)
8	Final summary and conclusions	ALL	28 (Sep17)	36 (May18)

Table 2 - Description of the tasks and partners involved in the work plan

Staff involved in every task will be:

- **B:SM** – Mr.Oscar Puigdollers, Mr. Víctor Jodar, Mrs. Maria Román
- **CENIT** – Mr. Miquel Estrada, Mr. Víctor Cuevas

15.3. Detailed timeline

A detailed timeline of the tasks shown before is presented in the next image

Id	Task/Subtask	Partners mainly involved	Start Month	End Month
1	Definition of works	ALL	1	10
2	Infrastructure design and	BSM	7	24
3	Demand analysis	CENIT	7	24
4	Operation model definition	BSM	7	24
5	Legal fasibility	BSM	7	32
6	Evaluation. KPI data collection	CENIT	7	32
7	Strategic analysis	ALL	20	32
8	Final summary and reports	ALL	28	36

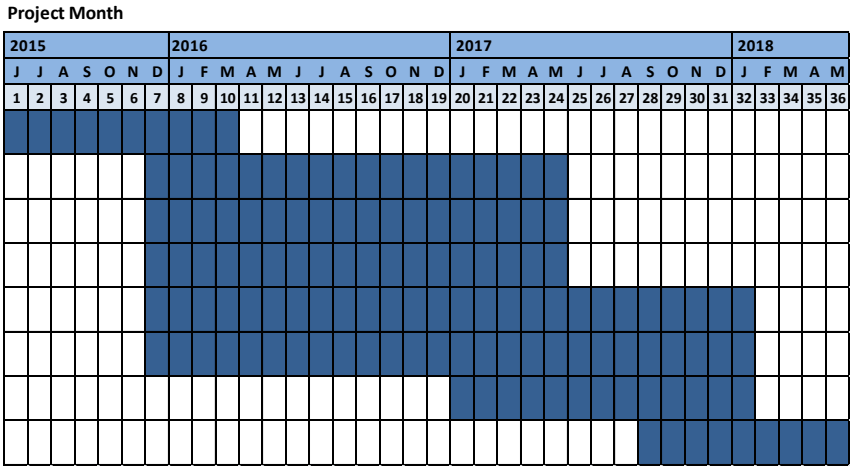


Table 3 - Work plan Schelude and GANTT diagram

16. Expected results Pillar C

The results of the feasibility study will be its conclusions about the convenience or not of the actuations that entails, in terms of social profitability.

Further works will be able to define numerical objectives to accomplish, as a strategy output of the project.