TOWARDS SMART ZERO CO_2 CITIES ACROSS EUROPE

VITORIA-GASTEIZ ✣ TARTU ✣ SONDERBORG

Deliverable 3.5: Electric bus line in operation

WP3, Task 3.6

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Abbreviations and Acronyms

Abbreviation/Acronym	Description
SmartEnCity	Towards Smart Zero CO_2 Cities across Europe
BEI	*Bus Eléctrico Inteligente* (“Smart Electric Bus” in Spanish)
SUMP	Sustainable Urban Mobility Plan
TUVISA	Transportes Urbanos de Vitoria-Gasteiz Sociedad Anónima (Vitoria-Gasteiz Public Bus Company)
H2020	Horizon 2020
EV	Electric Vehicle
ETS	Euskal Trenbide Sarea (Basque Railway Network in Basque language)

Table 1: Abbreviations and Acronyms

0 Publishable Summary

As a significant milestone towards the desired fully electric public transport network of Vitoria-Gasteiz but also to increase the visibility and acceptance of electric vehicles and to raise awareness about sustainable mobility in the city of Vitoria-Gasteiz, the BEI project arose from the inter-institutional agreement between the Vitoria-Gasteiz city council, the provincial government and the Basque Government.

By this agreement it was decided to finance the evolution of the circular bus-line with the highest number of passengers in the city (Line 2 or "peripheral") into a modern and clean electric bus rapid transit line with 48 bus-stops (24 for each direction), 4 ultra-fast CPs (inverted pantographs), 7 articulated e-buses and 6 conventional-size e-buses. This has represented a significant technical challenge given the length of the bus line (>10 km) and market´s charging/battery constraints.

The tender for the purchase of the buses and the associated infrastructure was awarded in March 2019. The first e-bus unit along with the pantographs were deployed by July 2020. More buses and their associated infrastructure have been deployed since that date along with the completion of the public works. Thirteen smart electric buses (BEI) that will replace twelve diesel buses that currently give service to Line 2 are expected to enter in full operation by May 2022.

As the time of the writing of this document, construction works have already been completed (January 2022). The EIB started operating on Tuesday 1 March 2022 to provide service to passengers. Six electric buses are running in Vitoria-Gasteiz. A seventh vehicle will arrive late winter 2022, which will undergo the same testing process as those that are ready to run and will then be incorporated into the service. The remaining electric vehicles will gradually be added to the EIB's fleet, which will comprise thirteen buses once the system will be fully implemented in May 2022.

This deliverable describes the process since the first agreements regarding the electrification of public transport were signed at regional level in 2016, through the implementation of the different elements of the BEI (including a state-of-the-art e-buses charging infrastructure and a new bus depot to accommodate the new convoys) until its entrance in operation.

1 Introduction

The deployment of high capacity and 100% electric public transport is paramount for sustainable mobility and to achieve carbon neutral cities in the near future. Moreover, public administrations play an important exemplary role in the promotion of electric vehicles, by raising awareness and shifting their fleets, including public transport ones, to electric alternatives. However, as cited in the updated version of the Vitoria-Gasteiz´s SUMP, if the vehicle fleets of the main Spanish public administrations are added up, the share of electric and hybrid vehicles was less than 3% in 2019; in the case of the Basque Government the share was estimated at 1%.

In the specific case of Vitoria-Gasteiz, the introduction of the tram in 2008 was an important milestone in the electrification of the city's public transport giving service to the central and northern part of the city. Since then, the tram has progressively continued its extension to cover now also the south and east (neighbourhood of Salburua) and it is expected to arrive to the new developments in the western part of the city (the neighbourhood of Zabalgana) in the next years.

Apart from the tram and the progressive substitution of city council´s staff fleets, the public bus transport company, TUVISA, incorporated five hybrid buses for the first time in 2018, and five more in 2019, making a total of ten vehicles of these characteristics with an investment of 3.3 million euro.

However, the next most significant milestone regarding electric mobility in Vitoria-Gasteiz, is the incorporation of the smart electric bus (BEI) in the Line 2, the highest capacity line of the city bus network, with a BRT format (dedicated lane for most of the route) and with a total of thirteen electric buses planned to enter in full operation by May 2022.

Furthermore, given the length of the bus line (>10 km) and current charging/battery constraints, the operation of the new fully electric Line 2 represents a significant technical challenge that fits well within an Innovation Action in the H2020 Smart Cities and Communities context.

The deployment of the BEI represents one of the main activities within SmartEnCity and the introduction of its first elements is reported at the present deliverable.

1.1 Contributions of partners

The following Table 2 depicts the main contributions from participant partners in the development of this deliverable.

Participant short name	Contributions
CEA	Overall content of sections 1, 2, 3 and 4
TEC	Comments to the document, contributions to Section 5, overall review and QC.

AVG	Contents in Sections 1, 2, and 3
VIS	Review and comments to the document,

Table 2: Contribution of partners

2 Objectives and expected Impact

2.1 Objective

Objective(s):

- To fully electrify the highest capacity bus line in the city of Vitoria-Gasteiz
- To implement a state-of-the-art e-buses charging infrastructure in the municipality
- To increase the visibility and acceptance of EVs
- To raise awareness about sustainable mobility and, specifically, fully electric public transport

2.2 Expected Impact

Estimated saving of CO_2: 1.304 tn/yr.

The medium-term goal of the operator is to supply the system with 100% RES electricity, which would significantly improve the figures.

12 conventional diesel buses (around 1753 gr CO_2 per km) replaced by electric ones (around 200 kWh/100 km and 1 kWh= 0 gr CO_2 renewable energy) and around 62.000 km/yr per vehicle[1].

[1] These impacts are calculated taking into account the full deployment of the fleet.

3 Deployment of the BEI

Preliminary works

On June 1st, 2016, the Vitoria-Gasteiz city council along with the provincial and Basque governments' representatives signed the "Collaboration Agreement for the drafting of projects to adapt the public transport offer in the city of Vitoria-Gasteiz by generating an integrated and fully electrified multimodal public transport system".

On September 20th, 2016, the Basque Government adopted the "Proposal of Agreement by which the Basque Railway Network - Euskal Trenbide Sarea (ETS) is entrusted with the drafting of the studies and projects necessary to adapt the supply of public transport in the city of Vitoria-Gasteiz through the generation of an integrated and fully electrified multimodal public transport system".

In the city of Vitoria-Gasteiz, as a result of preliminary studies, the first step towards the desired electrification of the public transport, it was decided to implement a smart electric bus (BEI) in the current Line 2 (also known as peripheral Line), the one with the highest number of passengers in the city.

On May 10th, 2018, the Cooperation Agreement between the Basque Government and Vitoria-Gasteiz City Council to complement the implementation of the BEI in the city of Gasteiz was signed. The purpose of this agreement was to promote the implementation of several complementary actions to foster the introduction of electrification in urban public transport in Vitoria Gasteiz.

Once completed and in operation "*it will be a revolutionary breakthrough for public transport in the city*", has declared the Vitoria-Gasteiz´s mayor, Mr. Gorka Urtaran.

This line has been transformed following a fully electric bus rapid transit model with a dedicated lane for most of the route. The deployment of the BEI represents the acquisition of 13 high-capacity 100% electric buses and their charging infrastructure by the municipality (AVG) that also tendered and awarded the public works on the affected streets. While the buses include 7 articulated and 6 conventional-size e-buses, the charging infrastructure is composed by four ultra-fast charging pantographs on the street and slow charging infrastructure in the new public transport company garage (for night charging). The total investment of the project amounts up to 42,850,000€ with a SmartEnCity contribution of 395.000 € for the purchase of e-buses/charging infrastructure.

Figure 1 shows the new Line 2 design including the location of the charging infrastructure. More into detail, light and dark blue lines represent the two directions of Line 2 (Lines 2A and 2B to be more precise) to be fully electrified (dots for the planned bus-stops; the yellow circles highlighting those with pantographs for opportunity charge on-street; Boulevard and Mendizorrotza stations, at the top/north and the bottom/south of the map, respectively). Night charge will be performed in the new TUVISA facilities (red circle), which first phase is expected to be completed in July 2022.

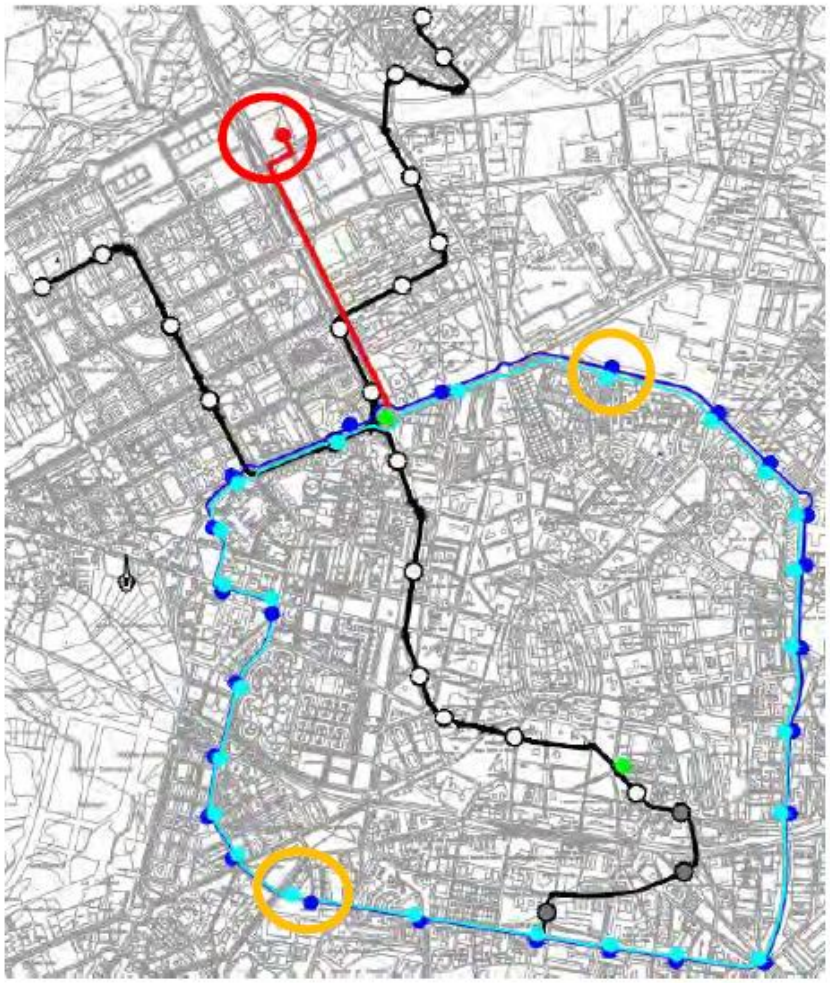

Figure 1: BEI project

Tenders awarded

The Smart Electric Bus (BEI) was tendered on June 2018 with a budget of 44,691,341.71 €, VAT included and, finally awarded on May 2019 to a consortium leaded by the bus producer company Irizar e-mobility by a total amount of 42.3 M€. For this project, Irizar e-mobility has counted on the collaboration of the construction company Yarritu and LKS, which have carried out the engineering, civil work, signage, communications, etc.

The term of implementation of the entire project to provide service on the current line 2 of the urban bus network of Vitoria-Gasteiz (which transported more than 3 million passengers in 2017 and connecting 14 neighbourhoods of the city) was established at 65 weeks from the award of the contract. This included the drafting of the projects; the construction of the necessary infrastructure; the interventions in the public space for the urbanization of the exclusive lanes of the BEI; the placement of the stops and their equipment; or the manufacture and start-up of the vehicles, as well as their maintenance. The BEI is being operated by the municipal company TUVISA.

In the tender it was also specified that the BEI would cover a route of just over 10 kilometres and 24 new stops per direction with a service frequency of 8 minutes and circulating through

exclusive lanes for a large part of the route. Moreover, BEI enjoys priority traffic lights at junctions and serves key points in the city such as the Txagorritxu Hospital, the Basque Government or the Mendizorrotza sport and leisure facilities.

By May 2022 Vitoria-Gasteiz will receive a total of thirteen new buses [seven articulated buses of 18 meters long and six of 12 meters long, with a capacity of 139 people (39 of them sitting) and 90 people (25 sitting), respectively] that are being deployed progressively. They are 100% electric and equipped with innovative technology in areas such as user experience, information, safety systems and driving assistance. Regarding the charging infrastructure, vehicles are loaded through a five-minute fast loading system using pantograph technology, with one loading point per line (2A and 2B), on Boulevard commercial centre, and another reserve charging point in Mendizorrotza. Apart from this, balance load will be made at night-time when the service is not in operation at the new TUVISA facilities (the new public bus garage) which construction is expected to be completed in July 2022. Until the new garages are completed, night slow loading of buses is being carried out in the existing depots, along with fast loading of pantographs.

More into detail, the new e-buses also incorporate three spaces for wheelchairs. In order to facilitate accessibility, the articulated buses have four doors, with two accesses between the front part and the articulated joint and the other two at the rear. These access doors are sliding and have an outer and inner opening button, like the tram. All doors serve to enter and exit, since the validation of the tickets are made at the bus stop (at the marquees). The buses also have three LED screens so that users can obtain information regarding the route, correspondence, waiting times, the next stop and so on. There also are USB chargers for users, as well as, in the case of articulated ones, a suitcase cage. As for the driver's console it provides real-time information about the route, technical bus sections or possible incidents. Moreover, the buses have a system of automatic guidance and assistance to the driver from approach to stop, minimizing the distance between curb and vehicle to 3-5 cm; cameras replace the rear-view mirrors. The marquees are similar to the tram ones, with modern aesthetics, multimedia information updated in real time, ticket holders and ticket dispensers. The Irizar ie tram incorporates technology from the Irizar Group, both in electronics and communications and in the main vehicle systems: power train, battery modules and charging systems. The Irizar ie tram is a 100% zero emission electric bus, completely silent, with aesthetic attributes of tram that combines the great capacity, ease of access and inner circulation of a tram with the flexibility of an urban bus.

The 7th of June 2019, the works´ direction was awarded to IDOM Consulting Engineering and Architecture by nearly 724,000 €.

During the 20th and 21st of June 2019, one e-bus unit, similar to the one expected to be implemented, was presented in a public event and displayed in the streets of Vitoria-Gasteiz (Figure 2 and 3) as to allow citizens to know better how the new buses will look like and also to experience the service *in situ*.

Figure 2: Smart Electric Bus (BEI) public presentation with SmartEnCity representatives (left picture) and the mayor (right picture). Source: VISESA & AVG

Figure 3: Smart Electric Bus (BEI) circulating through the city of Vitoria-Gasteiz as part of the public presentation on June 2019. Source: AVG

Construction works began the 2nd of September 2019, have been carried out since then and have been fully completed in January 2022. Nearly 1000 parking spaces have disappeared as to generate a dedicated (BEI-only) lane. The city council set up a specific website to inform in detail on the development of the works (in Spanish and Basque only); this website was replaced (July 2020) by the official one[2] (Figure 4) that contains all the information on this new sustainable transport mode and also provides information on specific problems that may arise during the deployment period.

[2] https://bei.eus/

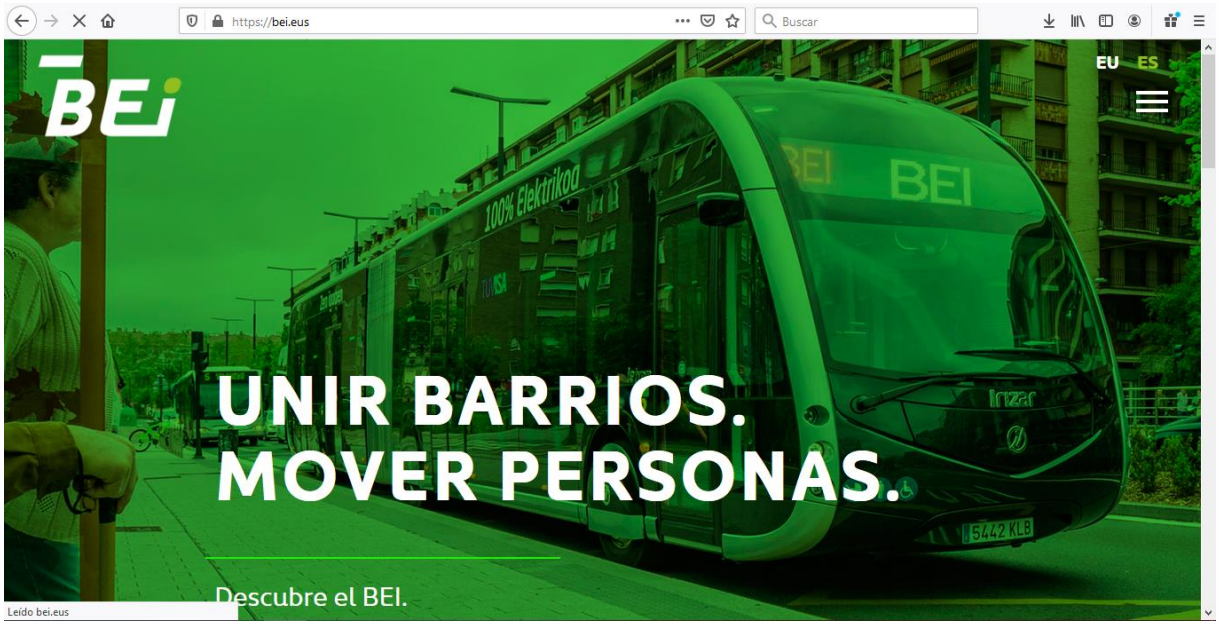

Figure 4: Official website of the Smart Electric Bus (BEI) showing one of the mottos in the landing page ("Join neighbourhoods/Move people" in Spanish)

More into detail, buses circulate in a reserved lane 3.5 meters wide and, in some cases, they cross roundabouts through new central spaces. Some greater interventions have been carried out such as the "*Esmaltaciones*" area, where two roundabouts have been remodelled to join them and create a large gazebo. Apart from them, the overnight chargers will be installed in a new facility that is being built outside the herein describe contract.

In this regard, one of the commitments of the aforementioned Cooperation Agreement between the Basque Government and Vitoria-Gasteiz City Council to complement the implementation of the BEI in the city of Gasteiz (signed 10th of May, 2018) was to draft the construction project for the bus garage where the slow-charging system (Functional Charging Unit) would be located.

As a consequence, the new facilities to host the BEI (and also, at a later stage, the rest of the public bus fleet) are planned to be built by July 2022 after a several months delay to the need, as requested by the Basque Government, to study their environmental impact in advance because of its location in the surroundings of a protected Natura 2000 Network area. Added to this, supply and weather problems have also led to delays. More into detail, this infrastructure was tendered (with an approximate value of 5.6 M€ for this stage) in December 2020 and awarded in April 2021.

The construction of the new garage and mechanic workshops for both BEI and regular bus fleet is being undertaken in phases. The first phase includes the construction of the Functional Charging Unit (Figure 5) which is scheduled to be completed in July 2022 and the second phase of construction of the depot will be tendered in April 2022.

Figure 5: Infographic of the future public bus Functional Charging Unit. Source: AVG

Of the 52.000 m² to be occupied by the new garage, 16.000 m² will be for the BEI's Functional Charging Unit, which includes the infrastructure needed to ensure the operation of the Smart Electric Bus. The facilities will include parking spaces and canopies for the 13 electric buses, mechanical workshop, vehicle washing site and staff's changing rooms.

In a later stage, the construction of the remaining facilities (that will be tendered in April 2022), including the new administrative building of TUVISA (Municipal Urban Transport Company), will be undertaken on the same plot. The area, sized for a total of 110 buses and considering the future electrification of the entire fleet, will have a 10.029 m² canopy with photovoltaic panels installed on top to maximise energy efficiency of the site (Figure 6).

Figure 6: Infographic of future public bus garage and facilities. Source: AVG

First pilot units for testing

The final prototype of the vehicle was presented on July 14th, 2020, at an official ceremony with the city´s mayor and representatives from the provincial and regional governments. This prototype has been tested without passengers on the route of Line 2 where it will enter into full service in May 2022. Apart from the first convoy, the four interoperable ultra-fast charging stations (pantographs) that allow to re-charge batteries at the two Line extremes were also installed that month (although only the two at Boulevard station were giving supply for the first tests).

The model presented was the Irizar ie tram (Figure 7; the 12m long version with 3 doors and 22 passenger seats). It is powered by a motor of up to 180 kW with lithium-ion batteries, which are also developed and manufactured by Irizar e-mobility at its facilities in the Basque Country. During the tests the vehicle (and the new ones to follow) charged during the trip in 5 minutes at the two route extremes´ pantographs (Figure 8) as to check performance; testing has included also passengers at a later stage.

Figure 7: Final prototype of the e-buses implemented in Vitoria-Gasteiz (12m long version; front, side and inside views, respectively). Source: AVG

Figure 8: The new e-bus prototype connected to a pantograph at Boulevard stop. Source: AVG/TUVISA

The citizens were able to visit the convoy, which was showcased in different points of Vitoria-Gasteiz from the 14th to the 20th of July, to get to know its characteristics from a personal experience.

Further steps:

From summer 2020 to May 2022 when the BEI is expected to enter into full operation, a total of 13 buses will be deployed. The EIB started operating on 1st March to provide service to passengers on the current TUVISA Peripheral line (L-2). For the time being, six electric buses are running in Vitoria-Gasteiz. A seventh vehicle will arrive late winter 2022, which will udergo the same testing process as those that are ready to run and will then be incorporated into the service. The remaining electric vehicles will gradually be added to the EIB's fleet, which will comprise thirteen buses once the system has been fully implemented in May 2022.

The public works finished in January 2022 including the whole charging infrastructure (4 pantographs). The new TUVISA garages where the BEI will be based, have been delayed for the reasons previously mentioned: supply and weather problems and the necessary environmental impact study. They will be completed in July 2022. Until the new garages are completed, night slow loading of buses will be carried out in the existing depots, along with fast loading of pantographs.

Once the road works are completed, the dedicated bus lanes have increased from the current 5.76 km of bus lane to 13.95 km, thanks to the implementation of BEI L2 line.

This first convoy (since July 2020) and the next ones to be incorporated, are being monitored in terms of both performance and energy consumption through monitoring devices embarked in each e-bus until the end of the project. Moreover, charging is also being monitored by devices installed at the charging units (immediately upon each deployment as with the e-buses); fast-charging performance at pantographs is being thus tested since August 2020 until the end of the project. These data will be integrated within the SmartEnCity ICT platform as to monitor charging performance until the end of the project.

Once the BEI is fully deployed, Vitoria-Gasteiz will have 23 electrically driven vehicles (10 hybrids and 13 fully electric), representing 26% of TUVISA's total public transport fleet of 90 units.

Finally, it is worth mentioning that although the Vitoria-Gasteiz public transport network (bus + tram) has grown significantly in the last years (Figure 9), due to the ongoing Covid 19 pandemic we have serious concerns about the representativeness of the data to be collected in SmartEnCity regarding the volume of passenger.

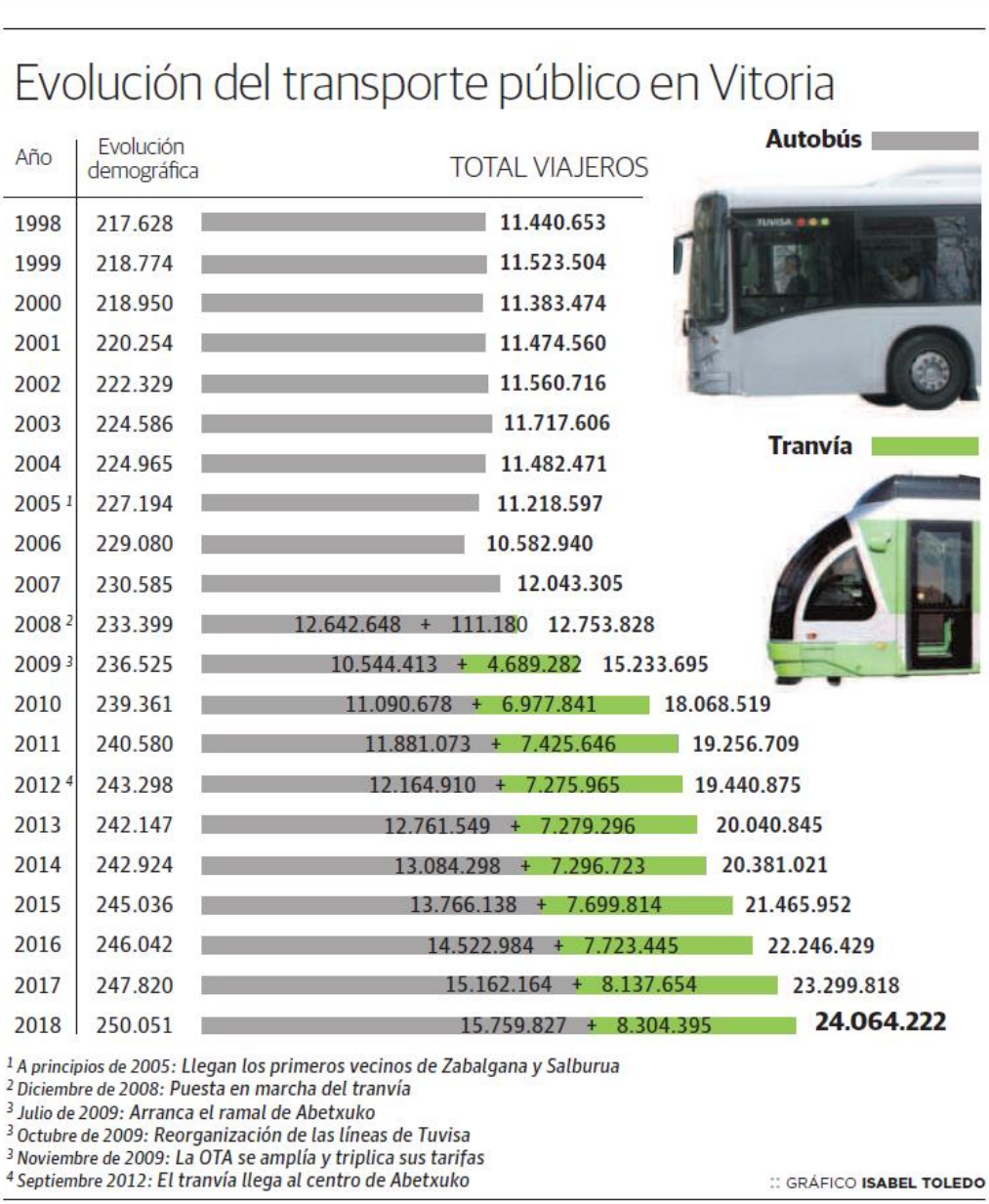

Figure 9: Evolution of the number of passengers in the Vitoria-Gasteiz public transport network Source: El Correo (data from TUVISA and ETS)

In this regard a 60% loss of passengers in the Vitoria-Gasteiz´s public transport was measured as of July 2020 (link to local press news –in Spanish only-; source `El Correo´, 22th July 2020[3]

However, we hope that this crisis will be soon overcome, allowing public transport to recover acceptance and prestige among the citizens.

While a high capacity 100% electric public transport is worldwide recognized as critical to achieve the desired carbon neutrality in the near future, the deployment of the BEI in Vitoria-Gasteiz (European Green Capital 2012), described in the present deliverable, reinforces the commitment of the city for a sustainable future.

[3] (https://www.elcorreo.com/alava/araba/transporte-publico-pierde-20200723214414-nt.html)

4 Deviations to the plan

There have been some significant deviations to the plan, mainly related to the construction of the new garages, as requested by the Basque Government, to study their environmental impact in advance because of its location in the surroundings of a protected Natura 2000 Network area. Added to this, supply and weather problems have also led to delays into the supply of the e-buses.

Apart from this, all the planned steps to the initial deployment of the bus line have been completed.

After a few months in which several buses have been operating on a test mode, the EIB has started operating on March 2022 to provide service to passengers on the current TUVISA peripheral line. So far, six electric buses are currently in service in Vitoria-Gasteiz. A seventh vehicle will arrive late winter 2022, which will undergo the same testing process as those that are ready to run and will then be incorporated into the service.

The remaining electric vehicles will gradually be added to the EIB's fleet, which will comprise thirteen buses once the system has been fully implemented.

Further steps to the full operation of the line are progressing according to the plan, and the expectation is to have the complete fleet in operation by May 2022.

5 Outputs for other WPs

The following Table 3 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the SmartEnCity project and that should be considered along with this document for further understanding of its contents.

Table 3: Relation to other activities in the project

Deliverable number	Contributions
D3.1	This deliverable provides the overall description of the current state of the lighthouse city area and provides a comparison in future after demo actions have been implemented
D3.8	This deliverable connects all demo actions into ICT platform. Data will be easily used for evaluation and replication purposes
D3.10	This deliverable summarizes all demo actions in the Vitoria-Gasteiz Lighthouse project.
D7.8	This deliverable provides the overall description of the KPI's and therefore the measurements to be implemented