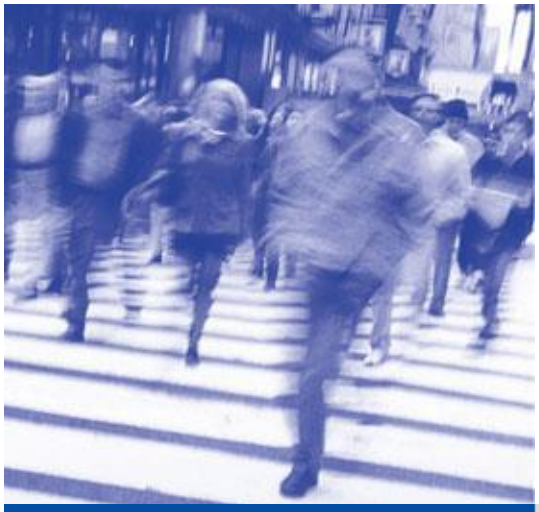

2020 CiViTAS
Cleaner and better transport in cities

DESTINATIONS

Measure Evaluation Results

LPA 7.2 – Hybrid buses in the urban bus fleet

Project Acronym:	DESTINATIONS
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Executive Summary

Before DESTINATIONS, the fleet of Guaguas Municipales, the public transport operator of Las Palmas de Gran Canaria, was composed of 242 buses with an average age of 10 years, each of which was fully diesel-fuelled, with different European emission standards (and only one was a hybrid bus).

Thanks to CIVITAS DESTINATIONS funding, Guaguas Municipales purchased three hybrid buses and one fully electric bus. The three hybrid buses substituted 3 diesel buses and have been in operation since August 2018, and the single electric articulated bus – the first in the Canary Islands – has been in operation since September 2019.

Before the arrival of the more energy-efficient vehicles, it was necessary to provide specific training to the maintenance staff and drivers (within the project lifetime almost all drivers completed their training).

Once the new vehicles were received, the hybrid buses were tested on different lines within the bus network. In addition, Guaguas Municipales reached an agreement with the university and a group of electrical engineers to collect data about the e-bus testing phase. This data was used to analyse performance, and took into account several different scenarios (passenger load, flat areas vs. hilly areas, air conditioner use, etc.). This enabled the best lines for the hybrid buses to be determined.

The insularity of the Canary Islands, however, posed a handicap from the point of view of maintenance issues, due to lack of trained staff in the islands, shortage of spare parts, etc.

Concerning the evaluation approach, this measure was evaluated from two perspectives: the environmental and the social side. Concerning the environmental perspective, the substitution of diesel-fuelled buses by hybrid ones contributed to reducing the consumption of diesel and therefore, CO_2 emissions. These savings were obtained thanks to the information that the operator collected about the operation and performance of the buses. As the electric bus was purchased later than the three hybrid ones, and therefore only put into operation in September 2019, it was not taken into account during the evaluation of the measure. The evaluation uses information about the operation of the buses during a whole year (2019), and only the hybrid ones had information for that whole year.

Moreover, on the social side, this measure contributed to an increase in the index of satisfaction about the public transport system of the city (+5.2%), calculated through surveys to bus users, as well as to the noise reduction that the city experienced during the CIVITAS DESTINATIONS project lifespan.

A Description

Thanks to CIVITAS DESTINATIONS project funding, Guaguas Municipales purchased three hybrid buses that began operation in August 2018, and a fully electric bus that started operation in September 2019. Guaguas Municipales, the public transport operator of Las Palmas de Gran Canaria, was the main actor involved in this measure. The company wanted to incorporate cleaner vehicles into their fleet and LPA 7.2 was the opportunity to do so.

The measure included the following actions:

- Definition of specifications and preparation of tender documentation. Market analysis for hybrid buses, choosing the appropriate vehicles for each case (orography, number of passengers, type of service, etc.)
- Identification of the oldest diesel units to be replaced
- Selection of routes. These routes had their origin/destination near attractive, safe, and accessible public space (LPA 3.1 measure)
- Purchase of 3 hybrid buses
- Purchase of 1 electric bus
- Testing and demonstration of the new vehicles in normal operation
- Promotion of clean vehicles

A1 Objectives and outputs

City policy level objectives

- Promotion of sustainable mobility among citizens and visitors

Measure specific objectives

- Renewal of the urban bus fleet with more ecologic vehicles
- Promotion of a vision of the city committed to sustainable mobility

Outputs

- 3 hybrid buses
- 1 electric bus

Supporting activities

- During the deployment of this measure, a promotion campaign about clean vehicles for public transportation was carried out in order to raise awareness amongst citizens

A2 Inter-relationship with other measures

This measure is related to LPA 3.1 – *Attractive, safe and accessible public space at major attractions* because routes that use the hybrid buses have their origin/destination near the Laboratory Area of LPA 3.1.

Outside the CIVITAS DESTINATIONS project, the Municipality of Las Palmas de Gran Canaria also improved the infrastructure dedicated to public transportation, including creating new bus lanes.

A3 Target groups and/or affected parts of the city or region

The whole city will benefit from the reduction of polluting emissions from the public bus fleet, as well as the reduction in terms of noise.

A4 Stakeholders: CIVITAS project partners and other important actors

Stakeholder name	Activities description
Hybrid buses suppliers & maintenance	These stakeholders will offer the technical resources needed in order to succeed in the purchasing and later maintenance of the vehicles
AUVE (Asociación de Usuarios de Vehículos Eléctricos)	Testing and demonstration of the new vehicles in normal operation
Plataforma para el Desarrollo del Vehículo Eléctrico en Canarias	This Foundation of the regional Government of the Canary Islands aims to minimise the existing barriers and enhance the benefits of electric vehicles, and to promote and disseminate the advantages of e-mobility. Testing and demonstration of the new vehicles in normal operation.

Table 1: Stakeholder involvement

B Measure implementation

B1 Situation before CIVITAS

Guaguas Municipales had only 1 hybrid bus within an overall fleet of 242 buses before the CIVITAS DESTINATIONS project took place. The aim of the company was to incorporate more clean vehicles into the fleet, and CIVITAS DESTINATIONS offered the opportunity for this.

B2 Innovative aspects

The hybrid buses are reducing both noise and air pollution, and thus contributing to a cleaner and more attractive destination. The promotion at the local level is raising interest for clean buses among other bus fleet operators in the Canary Islands region.

B3 Research and technology development

Guaguas Municipales carried out market analysis for hybrid buses before defining the specifications of the tender documentation. This analysis took into account what would likely be the most appropriate bus for each route. Moreover, once the buses were purchased, the company carried out a testing and demonstration process before putting them in operation for users.

B4 Actual implementation of the measure

The implementation of this measure occurred in different stages. The first stage concerned the hybrid buses market research and hybrid bus specifications definition, which took place between November 2016 and April 2017. The requirements for the hybrid buses were defined after analysing the current fleet, the routes, the number of passengers and the investment proposals. In parallel, Guaguas Municipales identified the oldest diesel units within the fleet to be replaced.

The next step was the Tender Process which occurred between May 2017 and July 2017. The tender process was launched on 26/05/2017 in the Official Journal of the European Union for the acquisition of three hybrid buses for the urban PT fleet.

Finally, the delivery of the three hybrid buses was in May 2018. After the purchase of the vehicles, Guaguas Municipales started a pilot test on selected lines within the bus network, in order to evaluate their performance in different situations (different orography, occupation of the bus, etc.). The hybrid buses were tested on lines 1, 2 and 17, all of them in the flat area of the city. On the other hand, the fully electric articulated bus was tested on the lines that are more similar to the upcoming BRT system (lines 12 and 17).

Following the conclusions of the pilot test, the company was able to decide on the most and least adequate lines for the new vehicles. Then, after several months of trials, the vehicles were assigned to the bus lines that go through the city center, where the terrain is flat and there is likely to be a high occupancy of the vehicles. These routes had their origin/destination near the Laboratory Area of measure LPA 3.1 (attractive, safe and accessible public space). They began operation in August 2018.

The electric bus was purchased some months later and initiated its operation in September 2019. Unfortunately, the electric bus could not be tested for long periods of time due to the lack of customer service which was capable of solving some key technical issues on the island of Gran Canaria. The problems were later solved and the bus resumed operation.

Figure 1: Hybrid bus (Vectia Veris.12)

Figure 2: Articulated e-bus (Irizar ie-Tram)

During the substitution of these diesel-fuelled buses by the hybrid and electric ones, promotional campaigns were carried out in order to promote these clean vehicles among the citizens of the city (e.g., through publication of news articles, information in the company's social media, advertising on buses, etc.) Nowadays, the three hybrid buses and the electric one are fully integrated into the Guaguas Municipales fleet.

C Impact evaluation

C1 Evaluation approach

Expected impacts and indicators

Impact category	Impact indicator	Unit of measure
Environment	1 - CO2 emissions	CO2 toe/year
Energy	2 - Vehicle fuel efficiency	Litres of diesel/year

Table 2: Expected impacts and indicators

Method of measurement

Impact indicator	Method *	Frequency (Months)			Target Group	Domain (demonstration area or city)
		Bef.	Dur.	After		
1 - CO2 emissions	E	28	-	40	citizens / tourists	city
2 - Vehicle fuel efficiency	E	28	-	40	citizens / tourists	city

* (Data collection (DC), Estimation (E), Survey (S)

Table 3: Method of measurement

Detailed description of the indicator methodologies:

1 - CO_2 emissions and 2 - vehicle fuel efficiency (toe consumed) – These indicators were estimated considering the tonnes of CO_2 emitted and the litres of diesel consumed by the 3 hybrid buses during 2019. For the baseline, the CO_2 emitted and the litres of diesel consumed per year by the 3 diesel-fuelled vehicles was considered. The impact evaluation was based on the comparison of the performance of the 3 hybrid buses and the 3 diesel-fuelled buses. Due to some key technical issues that took longer to be solved than anticipated (through the lack of capable customer service on the island of Gran Canaria), it was not possible to perform the impact evaluation for the electric bus due to the limited time for testing.

The estimation of the indicators was performed by means of a two-step calculation. First, the number of km (or veh-km) travelled by these 3 diesel buses in a year, was calculated. This number was then multiplied by the average fuel consumption rate for the diesel-fuelled buses (in order to obtain the baseline value) and by the average fuel consumption rate for the hybrid buses (for the Ex-Post value).

The Business-as-Usual scenario

If the three diesel-fuelled buses were not substituted by hybrid buses, the urban bus fleet of Las Palmas de Gran Canaria would continue to emit 29.8 additional tons of CO_2 per year, and continue to consume 10,368 additional litres of diesel every year.

C2 Measure results

Impact category	Impact indicator	Unit of measure	Baseline	Ex-Ante	Ex-Post
Environment	1 - CO2 emissions	CO2 toe/year	133.3	100	103.5
Energy	2 - Vehicle fuel efficiency	Litres of diesel/year	46,437	35,000	36,069

Table 4: Measure results

C2.1 Environment

1 - CO2 emissions

Thanks to the replacement of 3 diesel-fuelled buses by hybrid buses, Sagulpa's fleet saved 29.8 tons of CO2.

C2.2 Energy

2 - Vehicle fuel efficiency

With the replacement of the 3 diesel-fuelled buses by hybrid buses, Sagulpa's fleet saved 10,368 litres of diesel in 2019.

Whole fleet	veh-km (2019)	Average fuel consumption rate (l/100km)	Average fuel consumption rate (l/km)	litres of diesel consumed in 2019	kg CO2 / l diesel	kg of CO2 emitted per year by these buses
Diesel buses	11,246.592	55.36	0.55	**6,226,113**	2.87	**17,868,945**
Electric buses	1,400	0	0	**0**	2.87	**0**
Hybrid buses (3)	83,882	43.00	0.43	**36,069**	2.87	**103,519**
Hybrid buses before (when they were 3 diesel buses)	83,882	55.36	0.55	**46,437**	2.87	**133,274**
If all diesel-fueled buses were hybrid	11,246,592	43.00	0.43	**4,836,035**	2.87	**13,879,419**

Table 5: Kms, fuel consumption and CO2 emissions for hybrid and diesel buses

According to the data collected, it was possible to assess that the Diesel buses emitted an average of 1.59 kg of CO2 per km, while the Hybrid buses were shown to be more efficient, emitting only an average of 1.23 kg of CO2 per km.

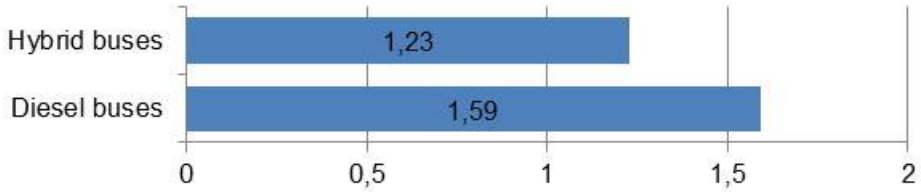

Figure 3: Kg of CO2 emissions between diesel and hybrid buses per km

In addition, the Hybrid buses were shown to be more efficient in terms of fuel consumption, consuming an average of 0.43 litres per km, while the diesel buses consumed an average of 0.55 litres per km.

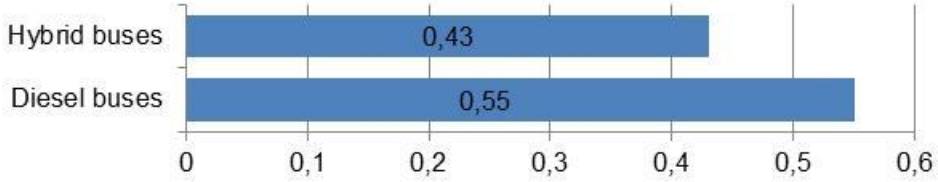

Figure 4: Litres of diesel consumed per km

Moreover, this measure also had an impact on two other common indicators which had been used to assess the overall performance of the project at a city level. These were the percentage of people troubled by noise, and citizens' satisfaction about the quality of the mobility system. Unfortunately, it has not been possible to assess the direct impact of this measure to these indicators as its evolution is linked to several measures, and therefore it can only be calculated at a city level. The indicator **percentage of people troubled by noise** registered the following evolution during the project lifetime:

Baseline (2016)	2019
95% > 55dB, 37% > 65dB, 1% > 75dB	69% > 55dB, 13% > 65dB, 0.05% > 75dB

Table 6: Traffic noise between baseline and 2019

As for the indicator **citizens' satisfaction about the quality of the mobility**, between 2016 and 2019, this index increased by 5.2% (from 7.57 to 7.96, on a scale 1 to 10).

The evaluation of the combined impacts of the CIVITAS DESTINATIONS measures concerning this indicator is provided in the MER Introduction: Global Executive Summary and Common Indicators document.

C3 Quantifiable targets

No	Target	Rating
1	Reduction in energy use and emissions	***
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

Table 7: Assessment of quantifiable targets

Target 1 was Exceeded. The diesel use and CO2 emissions were reduced by 22% thanks to the substitution of 3 diesel-fuelled buses by hybrid ones.

On the social side, this measure contributed to an increase in the index of satisfaction about the public transport system in the city (+5.2%), as well as to the noise reduction that the city experienced during the CIVITAS DESTINATIONS project lifespan. This was mainly due to the hybrid and electric buses being less noisy than the diesel-fuelled ones.

C4 Up-scaling of results

If all the diesel-fuelled buses from Guaguas Municipales' fleet were substituted by hybrid buses, the savings in terms of CO2 emissions and litres of diesel not consumed would be the following:

Measure	Indicator	Assumptions (variables) used for scaling up	Likely results
LPA 7.2 Hybrid buses in the urban bus fleet	1 - CO2 emissions (CO2 toe/year emitted)	100% of diesel-fuelled buses are substituted by hybrid buses	Savings of 1,390 CO2 toe / year
LPA 7.2 Hybrid buses in the urban bus fleet	2 - Vehicle fuel efficiency (Litres of diesel consumed /year)	100% of diesel-fuelled buses are substituted by hybrid buses	Savings of 3,989,526 litres of diesel / year

Table 8: Up-scaling of results

D Process Evaluation Findings

D1 Drivers/enablers

Guaguas Municipales gathered a lot of information about hybrid bus performance thanks to its close relationships with other public transport operators (for instance, through ATUC, the Spanish association of transit operators). Therefore, when the company finally put the 3 new hybrid buses into operation, its staff had the know-how for their operation and use.

D2 Barriers

Hybrid and electric technologies are not as common in the Canary Islands as they are on the continent. In fact, these 3 hybrids and 1 electric bus purchased in Las Palmas were the first in the Canary Islands. The insularity characteristic of the Region was a handicap from the point of view of maintenance issues, as this technology was not very mature there and, for example, there were no experts available to solve the technical problems arising from these vehicles. For this reason, the repair and maintenance service of hybrid and electric industrial vehicles was not enough on the island. In case of any technical problem, the cost for the operator would be very high as, on many occasions, it was necessary to wait for spare parts or maintenance staff from the continent, and meanwhile the vehicle was not in operation.

D3 Main Lessons Learned

Guaguas Municipales has learned a lot regarding hybrid and electric bus performance in different operational situations. On one hand, it was learned that the chosen recharging system configuration determines the quantity of batteries, charging infrastructure, electricity price (which is dependent on when the bus was charged and which power is used), and the operational management of the buses. On the other hand, that parameters such as route distance, performance in the summer with air conditioning use, battery reserve rates, and battery capacity that declines over time should also be taken into account.

E Evaluation conclusions

The electric bus suffered several technical issues and could not be tested in a fully operational environment for long periods of time. Therefore, the evaluation has been focused on the impact of the three hybrid buses. As seen in the previous sections, they allowed a reduction of fuel consumption that involved a reduction of CO_2 emissions, and they also contributed to noise reduction and an increase in the level of satisfaction of passengers.

F Additional information

F1 Appraisal of evaluation approach

The substitution of diesel-fuelled buses by hybrid ones in this measure was evaluated from two perspectives: environmental (CO_2 emissions and vehicle fuel efficiency), and social (noise and satisfaction). Concerning the former, the reduction of emissions and fuel consumption due to the introduction of hybrid buses was easy to determine because the company knew the consumption of both vehicles as well as the kilometres travelled. Therefore, we could estimate the specific effect this measure had in the environment.

F2 Future activities relating to the measure

Guaguas Municipales plans to continue the renewal of its fleet by introducing more energy efficient vehicles. The experience with the 3 hybrid buses purchased within CIVITAS DESTINATIONS has pushed the company into the use of hybrid buses. For now, no more electric buses will be purchased because, as outlined before, the difficulty in solving maintenance problems in the Canary Islands still poses a big barrier.

Figure 5: 10 new hybrid buses purchased by the end of 2019