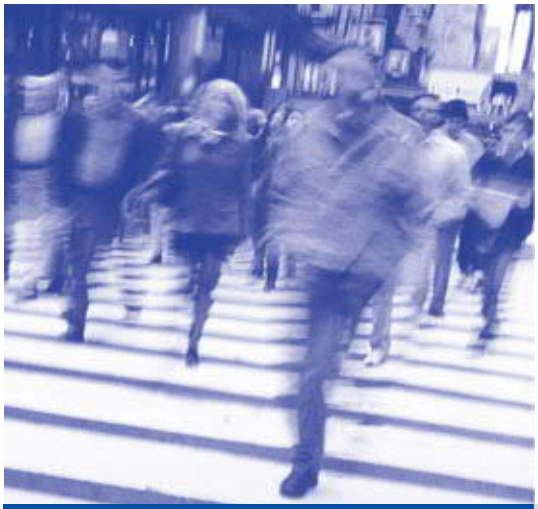

2020 CiVITAS
Cleaner and better transport in cities

ECCENTRIC

D5.2 Implementation Report WP5 Cluster 2:

Testing and operating clean and silent vehicles

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Abstract

Technical description of the demonstration measures dealing with *Testing and operating clean and silent vehicles* regarding the experiences of all the measures developed in cities. The document includes a description of the implementation process and the analysis of the main barriers and drivers encountered during the procurement and implementation phases.

CLUSTER 2, Testing and operating clean and silent vehicles

Measures 5.7, 5.8 and 5.9

Cluster Partners

Organisation	Country	Abbreviation
Consorcio Regional de Transportes de Madrid	Spain	CRTM
Empresa Municipal de Transportes de Madrid SA	Spain	EMT
Landeshauptstadt Muenchen	Germany	LHM
City of Turku	Finland	TUR
Turun Kaupunkiliikenne OY	Finland	TUKL
Turun Ammattikorekeakoulu OY	Finland	TUAS

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Disclaimer:

The views expressed in this publication are the sole responsibility of the ECCENTRIC consortium and do not necessarily reflect the views of the European Commission.

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List of Acronyms

ACM	Adaptive City Mobility
API	Application Programme interface
ca	*circa* (around)
CO_2	Carbon Dioxide
D	Deliverable
DoA	Description of the Action
DMP	Data Management Plan
EC	European Commission
ECOMM	European Conference on Mobility Management
EU	European Union
EV	Electric Vehicle
e.g.	*exempli gratia* (for example)
FCEV	Fuel Cell Electric Vehicle
GA	Grant Agreement
H2020	Horizon 2020
HOV	High Occupancy Vehicle
IA	Innovation Actions
i.e.	*id est* (that is to say)
ICT	Information and Communications Technology
IEE	Intelligent Energy Europe
IHFEM	Integrated Action Program for the Promotion of Electromobility in Munich
IT	Information Technology
KoM	Kick-off Meeting
KPI	Key Performance Indicator
LBG	Liquid Biogas
LDM	Local Dissemination Manager
LEM	Local Evaluation Manager
MaaR	Mobility as a Right
MaaS	Mobility as a Service
MER	Measure Evaluation Report
ML	Measure Leader
MR	Measure Report

MS	Milestone
NGO	Non-Governmental Organization
NOx	Nitrogen Oxides
OCG	Observers City Group
P&R	Park & Ride
P2P	Peer to peer
PAC	Political Advisory Committee
PAG	Political Advisory Group
PDM	Project Dissemination Manager
PER	Process Evaluation Report
PEM	Project Evaluation Manager
PMG	Project Management Group
PT	Public Transport
SM	Site Manager
SUMP	Sustainable Urban Mobility Plan
WP	Work Package
WPL	Work Package Leader
WS	Workshop
WT	Work plan Table

Executive Summary

The main objective of WP5, which integrates nine measures in the cities of Madrid, Munich, Stockholm, Ruse and Turku, is to demonstrate, in the outskirts of the different demo cities, efficient and clean public transport solutions in order to increase attractiveness and conditions for sustainable mobility in peripheral districts. To achieve this goal, these demos will implement different measures with the following specific objectives:

- Increase the use of public transport in the consolidated districts out of the city centre.
- Increase the efficiency and environmental performance of the public transport fleet, and consequently reduce energy consumption and associated emissions.
- Accelerate the introduction of e-mobility in cities.

This report gathers and summarises the experiences and lessons learned from Task 5.2 *"Procurement and implementation"* between February 2017 and August 2018 (M6-M24). The document includes a description of the implementation process and the analysis of the main barriers and drivers encountered during the procurement and implementation phases

Cluster 2 demonstration actions are focused on testing and operating clean and silent vehicles (fully electric and hybrid ones) in real operation conditions. This cluster also includes the implementation of (e-)mobility stations (initially 2, currently 4), by combining public transport, car-sharing and bike–sharing in a new housing area of one of the demo cities.

Information was provided by Measure Leaders (ML) by email through the measure reporting templates during October-November 2018. The MLs were asked about the same questions in order to have homogeneous information for this report.

Detailed background of the measures, as well as results from Task 5.1 "Research and measure planning" are detailed in D5.1 "Preparing for an efficient and clean public transport system".

The following chapters outline the procurement and implementation activities for efficient and clean public transport solutions in Madrid, Munich and Turku as well as the conclusions and recommendations of this phase regarding success factors and barriers at different levels.

1 Introduction

Transport is essential for economic growth and well-being, as well as for the quality of life in urban and metropolitan areas, in order to encourage social cohesion, addressing health problems and adapting to demographic changes.

Traffic jams, air pollution, safety and noise pollution are examples of problems commonly shared in European cities. In addition to the direct impact of traffic, urban transport also affects social development, social exclusion and accessibility for people with reduced mobility. The need for sustainable transport is increasingly recognised and receives more and more attention. Therefore in a context like the current one, an integral approach to mobility, as well as the main factors that condition it, is needed.

The promotion of sustainable forms of movement inevitably goes through to guarantee a system of efficient public transport, which represents a real alternative to private vehicles, as well as the promotion of non-motorised modes (on foot and by bicycle) and new mobility services (car, motorbike and scooter sharing, MaaS, etc.).

European cities face the challenge of improving mobility, guaranteeing accessibility and creating transport systems of high quality and efficiency, while reducing traffic jams, pollution and accidents.

In this regard, it is worth highlighting the European Parliament Resolution on a European Strategy in favour of low-emission mobility, adopted in December 2017 in which it is stressed the need for a greater contribution of the transport sector to climate objectives (UE transport policy: by 2030, goal of reducing greenhouse gas emissions by 20% with respect to the levels of 2008).

Currently, the main commons challenges of European cities are to relieve central areas through clean and efficient urban logistics, as well as to increase the attractiveness and sustainable mobility of suburban districts. To tackle these common challenges, the cities of Madrid, Munich, Stockholm, Ruse and Turku have formed the CIVITAS ECCENTRIC consortium.

According to the aforementioned challenges, the overall objective of the CIVITAS ECCENTRIC project is "*to demonstrate and test the potential and replicability of integrated and inclusive urban planning and sustainable mobility measures that increase the quality of life of all citizens in urban areas, with a particular focus on suburban districts and new developments and the clean organisation of urban freight logistics*".

WP5 will implement nine measures that could be grouped into two main clusters:

- *Cluster 1, Reorganising public transport network:* high level PT services corridors, speed up core bus routes, reorganisation of bus lines and provision of new lines and services (adaptive public transport priority and night services).

  This cluster also includes the provision of bike-sharing and car-sharing schemes as well as elements of the public transport chain.

- *Cluster 2, Testing and operating clean and silent vehicles* (fully electric, Hybrid and CNG buses) in normal operation conditions.

This cluster also includes the implementation of (e-)mobility stations, by combining public transport, car-sharing and bike–sharing in a new housing area of one of the demo cities.

Cluster	Measure	City	Partner(s)
1	MAD 5.1	Madrid	CRTM, EMT
	STO 5.2	Stockholm	STO
	RUS 5.3	Ruse	RUSEMUN, CSDCS
	RUS 5.4	Ruse	RUSEMUN, CSDCS
	TUR 5.5	Turku	TUR, VSL, TUAS
	MUC 5.6	Munich	LHM/MVG
2	TUR 5.7	Turku	TUR, TuKL, TUAS
	MAD 5.8	Madrid	EMT, CRTM
	MAD 5.9	Munich	LHM

Table 1: Overview of the measures included in WP5

2 Explanation of the work implemented in WP5 Cluster 2: Testing and operating clean and silent vehicles

Keeping in mind that this Deliverable *"Implementation report: Testing and operating clean and silent vehicles"* focuses on the findings of Task 5.2, regarding the procurement and implementation phases associated to the demonstration actions developed in cities, the following issues have therefore been addressed:

- The launch of the tendering and procurement process of the measures.
- The actual implementation of the pilot projects.
- The participatory processes accompanying the measure development.

WP5 cluster 2 is focused on testing and operating clean and silent vehicles and the implementation of (e-)mobility stations (initially 2 stations; currently 4). It includes three measures to be implemented in the cities of Madrid, Munich and Turku:

- TUR 5.7: Introduction of Electric Public Transport

  This measure will introduce new electric buses in the PT fleet of the city of Turku (the measure will be in line with other national and local measures). The main actions to be taken will be:

  - Piloting the first electric bus line.
  - Planning for extension of electric bus lines.
  - Development of charging solutions and analyses of use.
  - Marketing and communication including campaigns.

  Local partners: TUR, TUKL, TUAS.

- MAD 5.8: Electric and hybrid buses for public transport

  This task will increase the efficiency and environmental performance of the public transport fleet in Madrid. The main steps to carry out the measure will be:

  - Introducing at least 6 electric/hybrid buses into the EMT fleet.
  - To pilot these buses under real operation conditions in the laboratory area.
  - Monitoring the different technologies to guide for further renewal decision.

  The main output will be the guidelines for selecting major fleet renewal to be undertaken in the coming years.

  Local partners: EMT, CRTM.

- MUC 5.9: (e-)Mobility stations at the Development Area Domagkpark and centre periphery integration

  This task will implement (e-)mobility stations, by combining public transport, car-sharing and bike-sharing, in a new housing area in Munich called Domagkpark in

order to allow the residents to live a car-free life or at least to have significant lower mobility costs. The measure will consist of building mobility stations combining and providing different types of mobility services and ensuring that suitable means of transport are available for any purpose at any time. All these actions will be accompanied by marketing campaigns.

Local partner: LHM.

Research and planning activities in cluster 2 measures have already been described in Deliverable 5.1.

2.1 TUR 5.7 Introduction of Electric Public Transport

Figure 1: Electric bus at the airport

This measure will introduce new electric buses in the PT fleet of the city of Turku (the measure will be in line with other national and local measures). The main actions to be taken will be:

- Piloting the first electric bus line.
- Planning for extension of electric bus lines.
- Development of charging solutions and analyses of use.
- Marketing and communication including campaigns.

Key challenges

- Implementing relatively new and untested technology.
- Reaching a level of reliability comparable with conventional vehicles.
- High workload of driving staff and supervisors.

Figure 2: Electric bus charging

Expected impacts

- Noise level of bus traffic declines on the routes that is operated with e-buses.
- Customer satisfaction increases on line 1 because of more comfortable rides and better service quality.
- Driver satisfaction increases because of more comfortable driving environment (less vibration, lower noise level).
- Cost efficiency of bus traffic increases because of lower operation costs (energy + maintenance)
- Citizens are more satisfied to public transportation because of more environment friendly solutions (less emissions + noise).

2.1.1 Introduction

City of Turku has set the goal of becoming CO_2 neutral by the year 2029. Among the measures to reach that goal is the decision to switch to electricity as the primary source of energy in public transportation.

This measure introduces a pilot project that is the first step in that process. The pilot consists of one bus line operated with six electric buses supported by quick charge stations at each end of the line and an overnight charging station at the depot. Before piloting with fully electric vehicles the only experience of alternative fuels had been from hybrid buses. For this reason the project has been a major research, procurement and training effort.

The first trials started in October 2016 and since then the short term goals have been reached: Bus line 1 between airport and ferry terminal is fully electrified and customers are

satisfied with the electric buses. Now the focus is on the midterm goals: reaching 100% reliability, optimizing the system, planning for extension of electric bus operation and getting political approval for the extension.

2.1.2 Implementation

Implementation phase

Procurement and implementation phase begun in November 2016 and was completed in January 2018. The following activities were carried out:

- During this phase six electric buses were delivered and are currently in operation.
- Driver trainings on the use of electric buses: a total of 94 drivers were trained.
- Research for the pilot was compiled (compilation of studies on the system): the research consists of five graduates' thesis work on different technical and economic questions of electric buses.
- Some modifications were carried out on the buses: e.g. parts that were found to be prone to failure or otherwise unsuitable for the purpose were replaced. Also some standardization of the technical parts of the system was done.

Main changes were made from the original plans

The supplier requested adjustment to the original delivery schedule, and it was agreed on.

Stakeholders involved in the different implementation steps

Regional PTA (FÖLI) is the authority responsible for the service. The pilot route is operated by Turun Kaupunkiliikenne OY, a wholly owned subsidiary of City of Turku. Vehicle supplier is by Linkker Oy. Turku Energia Oy is the energy supplier. Turku University of Applied Sciences did research for the pilot.

Infrastructure required for the solution to function

Quick charge stations at each end of the line and an overnight charging station at the depot. Stopping at exactly the same spot on quick charging stops accelerates the wear of the road surface causing extra cost of repair and/or need for extra investment.

Other related sustainable mobility solutions

Currently electric vehicles are in use in different city departments e.g. nurses making house calls to elderly people. Also in measure 6.4 different types of light EVs (bikes, scooters etc.) are being tested.

Timeframe

This measure is ahead of schedule, as the planning and research process started already in 2015, being planned as an ECCENTRIC early measure. Therefore the phase 1 was only two months in the beginning of the project to plan the starting points of the measure. The phase 2 started from the M1 as well.

Procurement and implementation phase begun in November 2016 and was completed in January 2018.

2.1.3 Business model and contractual partnerships

The pilot route is operated by Turun Kaupunkiliikenne OY, a wholly owned subsidiary of City of Turku.

It was held a restricted procurement with a limited number of tenders. The supplier is responsible for regular servicing and warranty repairs for the duration of the contract.

The measure total investment is € 3.8 million. Ministry of Economic Affairs and Employment granted an investment subsidy of approx. € 1 million. A research subsidy of € 780,000 was received from Business Finland foundation.

2.1.4 Critical challenges and success factors

Key challenges

Adopting new technology combined with the reliability issues has been very demanding for the drivers and their supervisors. Training 94 drivers for the use of electric was a major effort and reliability issues require being constantly on alert in case a vehicle needs to be replaced.

The six buses delivered to Turku are the first production models of the series, in other words more or less prototypes and several modifications have been necessary to increase their reliability. The reliability of electric buses in daily service is not yet at the same level as diesel vehicles and they require more maintenance and service, which amounts to lower rate of usage. To some extent it should be accepted that adopting new technology is likely to cause problems that are difficult to anticipate. On the other hand this requires that the supplier of the vehicles is able to respond to these problems without delay.

Extra time was needed as the charging infrastructure was entirely new and it was envisaged that there would be some challenges in the beginning. The charging infrastructure that was planned for the city of Turku was based on the idea that the chargers itself would not be on the buses, but instead on the loading stations.

Key success factors and minimum requirements

Restricted procurement worked well, because there was a clear understanding of the requirements and technical details of the vehicles, charging stations and service. Limiting the number of tenders for the final round of competitive bidding was very helpful.

2.1.5 Lessons learned from implementation/replicability

From the point of view of expanding the electric bus network the pilot has been very instructive by raising a number of issues that require attention:

- Driver satisfaction was expected to increase because of more comfortable driving environment (less vibration, lower noise level). This is more or less the case, but on the whole the pilot has been very demanding for the staff.
- Another major goal was that customer satisfaction on the pilot line would increase because the ride is more comfortable and that citizens in general would be more satisfied with public transportation being more environment friendly. It is, however, difficult to evaluate how satisfied customers are with electric buses or if it actually makes any difference to them that the buses are electric. On one hand surveys

suggest that electric buses are an important feature to the citizens. On the other, the amount of actual customer feedback concerning electric buses is at best marginal.

- Noise level on the pilot route was expected to decline. As of yet there is no measurements to document this, but it would be consistent with experiences from elsewhere.
- Cost efficiency was expected to increase because of lower operation costs. There is indication that this goal can be achieved. However, a lot of experience is required to optimize the traffic and the technical solutions (e.g. the quick charge cycle).
- Extra care should be taken when evaluating the supplier's technical and financial abilities and their references when procuring vehicles. Depending on the type of contract it may be advisable to set sanctions for the amount of time the vehicles are out of order (due to e.g. break down), specific demands (e.g. deadlines) for dealing with technical problems and specifying the number of vehicles in reserve.
- The importance of preparing for problems and setbacks cannot be overemphasized. Even in case of a relatively small scale piloting it is recommended to allocate extra staff resources to avoid excessive workloads. Having spare vehicles readily at hand has proven more important than anticipated and could easily have become a bottleneck.

Other issues to be considered in procurement of electric buses or PT services using electric buses:

- The technology is relatively new and untested (compared to diesel). There are very few manufacturers and products to choose from and very few – if any – manufacturing standards.
- Charging while in traffic affects the schedule and may increase the number of vehicles needed for a given level of service. One estimate from an upcoming procurement is that 25 electric buses would be required to replace 23 diesel buses.
- Estimating the life cycle of batteries and consequently the cost of replacing them has proven difficult. This may be an issue for the planning for the extension of electric bus service and for bus operators tendering for PT services.
- Stopping at exactly the same spot on quick charging stops accelerates the wear of the road surface causing extra cost of repair and/or need for extra investment.
- The share of information technology related problems is bigger than before. (e.g. interfaces between the softwares of different subsystems in the vehicle).
- Evaluate need of on-board auxiliary power (e.g. a diesel engine for charging the battery, the so called range extender).

2.1.6 Recommendations

At this point conclusions and recommendations are preliminary and will be updated later.

Compared to diesel vehicles the manufacturers and products to choose from are currently fewer and there are very few – if any – manufacturing standards. This limits the available options and may in some cases make electric vehicles a less appealing alternative. The suitability of available electric vehicles for a given type of traffic should be taken into account when planning the long term transition to electricity.

It should be expected that adopting new technology will cause problems. In general this means emphasis on the importance of preparing for setbacks by allocating sufficient staff and other resources to avoid excessive workloads and related problems. In particular it needs be taken into account in procurement by emphasizing the suppliers' capability and responsibility to respond and solve problems without delay.

Large scale transition to electric vehicles in public transportation depends to a great extent on the development of battery technology. The life span of batteries and the cost of replacing them is a major component in the total cost of ownership. Also, at the moment the capacity and weight of batteries are perhaps the most important limitations to the use of electric buses.

2.2 MAD 5.8 Electric and hybrid buses for Public Transport

Figure 3: New Eccentric Diesel-hybrid buses operating in bus line number 140

This task will increase the efficiency and environmental performance of the public transport bus fleet in two peripheral districts of Madrid city:

- Introducing at least 6 hybrid buses into the EMT fleet.
- Piloting these buses under real operation conditions in the laboratory area.
- Monitoring the different technologies in order to guide for further renewal decision.

Key challenges

Regarding challenges, the main one is to assess the performance of buses to check its reliability compared to traditional diesel ones, including the total life cycle cost, maintenance needs and environmental performance.

Expected impacts

The expected impacts include:

- A reduction in energy consumption and emissions of 30% (compared to previously used diesel buses which were providing the service before the hybrid buses - based on data from 2017), as well as reductions in noise.
- Furthermore, it is expected that the new buses will be positively valued by users in terms of attractiveness and comfort, thus increasing their use of the service.
- Finally, energy savings are expected to result in operational cost savings, compensating the increased capital costs of the new buses.

2.2.1 Introduction

The main objective of the solution is to provide the best possible public transport service using a “clean” bus fleet in areas which lack high-quality public transport services. The environmental performance and attractiveness of the city of Madrid’s public transport service will thus, in general, improve as a result, and be better suited to compete with private car use, introducing at least six hybrid electric buses to Madrid’s existing bus fleet to test and use them in real-life conditions in the city’s living lab (two south-eastern peripheral districts of the city out of the first ring road: Puente de Vallecas and Villa de Vallecas.

The measure is consistent with the Air Quality Plan and the actions of Madrid’s Sustainable Urban Mobility Plan (SUMP). It is also aligned with EMT’s strategic plans regarding clean fleet uptake, and the experience will be used to better know the performance of these types of buses and therefore to help better define EMT Madrid’s own strategy on fleet renewal.

2.2.2 Implementation

Implementation phase

The key steps of this phase are:

- Planning and defining requirements.
- Launching a procurement process.
- Purchasing the buses.
- Adapting schedules and operational planning.
- Putting them into operation.

The procurement was done in autumn 2016 and 30 buses were delivered by December 2016/January 2017. EMT purchased two different models of hybrid-diesel buses: MAN (17 units) and IVECO (13 units). The ones used under the ECCENTRIC project are the model MAN A37 Lion's City Hybrid with 12 meters long. It combines two 75 kW-electric engines and one 250 CV diesel engine (186 kW), with a capacity to 28 seated and 67 standing passengers.

Testing of these units in real-life conditions is currently being carried out with the new buses being used in Bus Line Number 140, using 9 units to cover it completely (therefore, three more than described initially in the measure). This bus line crosses the demonstration/living lab area. The service began on October 1st, 2018. The performance of the buses is being monitored and assessed.

Main changes were made from the original plans

The research and planning phase saw the evaluation of different alternatives for the type of public transport service required, as well as the charging requirements, and due to the current conditions and limitations the conclusion was that the fully electric buses available on the market did not meet the necessary requirements regarding range and that the charging infrastructure investment required was too costly. Therefore, EMT opted to purchase hybrid electric-diesel buses.

Stakeholders involved in the different implementation steps

The main stakeholders involved have been EMT itself and Madrid City Council, as well as the bus manufacturer.

Infrastructure required for the solution to function

No particular infrastructure has been required for the solution to be functional, as the hybrid buses are non-plug in ones.

Other related sustainable mobility solutions

The measure is not directly linked to any other one, though initially it was suggested its potential synergy with the measure MAD 5.1 about the High Level PT corridor.

Timeframe

- The procurement was done in autumn 2016 and buses were delivered by December 2016-January 2017.
- The procurement process took nine months from the launch of the tender until the contract was signed with the bus manufacturer. At least two months were needed, prior to launching the procurement, for the internal preparatory work.
- Testing of these units in real-life conditions is currently being carried out. EMT is already in contact with UPM (the Madrid LEM) in order to provide data for the monitoring and evaluation.

2.2.3 Business model and contractual partnerships

- EMT fully owns its bus fleet. Therefore, these new buses have been purchased (not leased nor rented). The measure is owned by EMT.
- The procurement process took nine months from the launch of the tender until the contract was signed with the bus manufacturer.
- The funds for the procurement of the buses came from Madrid City Council, which in turn transferred the funds to the Madrid Public Transport Company (Empresa Municipal de Transportes de Madrid) - also known as EMT Madrid – which is the public mobility operator that manages the bus transport service in the municipality of Madrid, being the only bus operator of the City, and the largest company in Spain in its sector.
- The total budget of the contract (which included many other buses out of the scope of ECCENTRIC project) was 63.5 million euro. Each one of the ECCENTRIC hybrid buses had a value of 335,000 euro (model MAN Lion Hybrid).

2.2.4 Critical challenges and success factors

Key challenges

From the implementation point of view, the main challenge has been, firstly, to deal with the lengthy administrative procedure to purchase the buses, and secondly, to adapt the operational planning to include the new hybrid buses in the bus line number 140 and to relocate those old ones to be substituted.

Key success factors and minimum requirements

Due to the alignment of this measure to EMT strategical objectives, it has been relatively easy to overcome the aforementioned challenges.

2.2.5 Lessons learned from implementation/replicability

Among the lessons learned we would like to point out the following ones:

- Diesel-hybrid buses run and perform quite well compared to conventional diesel buses In terms of fuel consumption the savings of the hybrids running in bus line number 140 are around 30% compared to the previous diesel ones.
- The reliability (days/hours out of order due to breakdowns) is similar to diesel buses. However, there is only one unit out the 13 hybrid buses that were purchased in total in the same tender that has had a breakdown due to failures in the electronic system that manages the hybrid engine affecting 30% of its operational time.
- Diesel-hybrid buses do not show significant additional repairing costs vs diesel ones.
- Based on unofficial feedback, the riding comfort is better that the diesel buses and the acceptance and awareness from users and drivers is also higher. However, a survey will be conducted by the first quarter of 2019 in this regard.
- Compared to the same period in 2017, the number of passengers is increasing. As an example, in October 2018 since the buses started operations, the bus line 140

transported 248.755 passengers vs 237.810 in October 2017. However, it is too early to conclude that this is due to the new buses or due to other external factors.

- Diesel-hybrid buses do not show any significant difference with conventional diesel ones regarding seasonal weather conditions affecting their performance
- Based on our own experience, in order to scale up towards a fully electric bus we consider that the most significant characteristic should be having a bus line with a low and constant average speed.

2.2.6 Recommendations

- From the testing point of view, it is better to start with small pilots. However, big tenders make possible to get better prices from bus manufacturers.
- Aligning investments with city strategies is also crucial to get political support.
- Communication actions informing users (citizens) and bus drivers about the service improvements thanks to the new buses it is very useful to help the adoption of new clean fleet.

2.3 WP5: MUC 5.9 (E-) Mobility stations at development area Domagkpark and centre-periphery integration

Figure 4: (e-)mobility station construction works

In order to promote a more sustainable mode of mobility and to create a real an alternative to private car ownership, the City of Munich develops new multimodal mobility stations for all residents in the project area. A marketing campaign for sharing mobility is developed and rolled out to address all residents within the project area. Information and guidance will be offered and thereby fortify the usage of the new offers.

Key challenges

- A great challenge but essential backbone of the mobility station services is the provision of one common booking service where all sharing services are available. Consequently, the aim is to bundle all relevant stakeholders within the existing mobility app of MVG (Munich public mobility provider) in order to allow an easy mode of booking from anywhere online.
- The launch of the mobility stations will be accompanied by a marketing campaign to address all residents within the Domagkpark area (purely residential) but also companies and employees of neighbouring residential and business area Parkstadt Schwabing. The communication and marketing campaign will be combined with an

innovative direct and dialogue marketing campaign for every household and as many companies as possible within the development area (see ECCENTRIC measure 2.9). It offers information and guidance and will thereby fortify the usage of the new offers.

Figure 5: (e-) mobility station in Domagpark

Expected impacts

The expected impacts include:

- Car free housing / lower car ownership rate.
- Wide acceptance of the new (e-)mobility stations and its services.
- Foundation for legal and operational planning standards for Munich´s urban planning.
- Sustainable mobility behaviour in the Domagkpark and Parkstadt Schwabing area (8,000 Inhabitants at the development area). Mobility stations become part of a new urban mobility lifestyle.
- Different vehicles to use and share (i.e. (electric) are provided to the residents.
- Newly developed electric vehicles are tested within a public mobility service concept.
- Direct effects, observable and measurable:
  - Neighbours use the new mobility options.
  - Neighbours change their travel behaviour towards more multimodal.
  - Neighbours sell their cars, or abstain from buying one.

2.3.1 Introduction

Main objective of this measure is the development and implementation of (e-)mobility stations. These mobility hubs will combine and provide different types of mobility services and ensure that suitable means of transport are available for any purpose at any time in order to reduce private car ownership of residents and customers. The new and innovative aspect is a combination of several sharing mobility services (car-sharing (stationary, free floating, electric), (e-) scooters, cargo- and normal bikes) in connection and complementation with the use of public transport like trams and buses. The provision of multimodal mobility service enables residents to live a private-car-free-lifestyle or at least have significant lower mobility costs.

Main goals of this measure are:

- Mobility stations and sharing mobility become part of a new urban mobility lifestyle in Munich (Increased awareness of residents about the multimodal variety of mobility services within the living lab but also in the entire city)
- Mobility stations as proven concept for city wide up scaling – At least a standardized planning and implementation process for new development and housing areas within Munich´s urban planning
- To change mobility behaviour towards less car use: positive acceptance and active usage of the mobility station services by inhabitants and customers at the project area
- Test of newly developed electric vehicles within a public mobility service concept
- Introduction courses and events for using new vehicles and ways of mobility

2.3.2 Implementation

Implementation phase

- Set up of an interdisciplinary working group for mobility stations (stakeholders, city planners, living lab residents, district committee).
- Identification and approval of the locations for four mobility stations based on holistic spatial analysis.
- Development of an evaluation approach and methodology.
- Detailed planning process for the mobility stations.
- Identification and procurement of required material and equipment for the mobility stations.
- Construction process for two mobility stations (until summer 2018).
- Tender process for a marketing and communication campaign.
- Marking and signage works.
- Integration of first vehicles.
- Launch of the first charging infrastructure for e-vehicles.
- Official opening of the first two stations in July 2018.

- Launch of the communication campaign.
- Start of a strategy development for further mobility stations in Munich.
- Integration process for sharing mobility into the mobility planning of the city.

Main changes were made from the original plans

Phases 1 and 2 (Research & Planning and Procurement & Implementation) had to be extended due to dependence of overall construction works in the living lab and accessibility of the locations of the planned mobility stations.

Small changes in station configurations will bring small changes in equipment budget positions according to the services needed.

Within our implementation of the mobility stations we will have road and parking lot marking works on site. This will be done by the City of Munich. Consequently there are no costs for equipment as such but rather consumables/expendables costs of the category "other goods and services". Therefore we are planning a small shift of budget from "equipment costs" to "other goods and services".

Stakeholders involved in the different implementation steps

All relevant mobility providers have been integrated. Various departments of the city of Munich are involved in the planning and construction.

Infrastructure required for the solution to function

Electric charging infrastructure is required for e-vehicles. Special marking and signage is required for the parking spaces considered for shared vehicles. An information pillar is required for customer communication.

Other related sustainable mobility solutions

Cooperation started with M 2.9 mobility management for residents: The launch of the mobility stations was accompanied by a marketing campaign to address residents within the living lab area. The communication and marketing campaign will be combined with the measure M 2.9 and its innovative direct and dialogue marketing campaign for every household (June 2019). This will ensure a higher range of information.

The selection of services provided at the mobility stations follows the local spatial and socio-economic situation. For the first time two newly developed vehicles will be part of the shared vehicles fleet of the mobility station: Electric light vehicle (see ECCENTRIC measure 6.3) and E-Trikes (see ECCENTRIC measure 3.4).

Timeframe

The time of implementation depends on various factors, which can be different from location to location. If the location for the mobility station construction is available, the implementation can be done in 8-12 months.

Note, that tender processes might extend the process.

Note, that weather conditions and winter periods might extend the process.

2.3.3 Business model and contractual partnerships

The measure is owned by the City of Munich. The mobility providers offer the mobility services.

There is a contract in place between the City of Munich and the mobility providers in order to license the operation of sharing mobility services in Munich.

There was procurement of different material and equipment for the different mobility stations including leasing of vehicles, charging infrastructure, etc.

The measure is funded by the CIVITAS ECCENTRIC project budget provided by the European Commission. Urban household budget was provided by the City of Munich to support the measure implementation and financing.

2.3.4 Critical challenges and success factors

Key challenges

- How to raise awareness and acceptance in order to get more users to the system?
  - A marketing and communication campaign is designed aiming to raise awareness and acceptance.
- How to get broader political and residential support for the reduction of parking in public space?
  - Political hearings, evaluation results and expert posts are considered to facilitate the process.
- How to bring various (all) mobility providers together in one mobility app?
  - The City of Munich is trying to bring a resolution to the city council to develop an open data regulation for mobility providers.
- How can the business and operating areas of mobility providers be expanded to the periphery?
  - The City of Munich is considering a tender process for future sharing mobility providers in Munich. Within the tender, quality standards for services should be specified.
- How to scale up a sharing mobility concept into the entire city and contemporaneously give equal opportunities to all different car sharing operators?
  - A strategy for shared mobility based on the experiences with multimodal mobility stations is currently in preparation in order to upscale shared mobility concepts to a significant extent in Munich.

Key success factors and minimum requirements

- Involvement of political stakeholders and local city council.
- Parking management in the surrounding city district of mobility stations.
- Parking enforcement of exclusive parking spaces for sharing mobility.
- Combination of various (all) mobility providers at the mobility station.
- Good recognizable branding of the mobility station.
- Communication and branding based on the city level including all public and private mobility providers.

2.3.5 Lessons learned from implementation/replicability

Among the lessons learned we could point out the following ones:

- Start the stakeholder communication process and dialogue early enough considering different points of interest.
- Consider an umbrella communication and branding on city level and on (private) mobility provider level.
- Closely link the infrastructure work and the communication campaign.
- Choose the location of the mobility station wisely in order to be able to arrange all individual elements of the mobility station (Start early enough with the involvement of all relevant planning stakeholder).
- Consider that you might need tender processes and those are time consuming.
- Be aware of the need of parking enforcement at the mobility station.
- Make sure that all mobility providers have the chance to be integrated into a digital mobility service app. In Munich not all sharing mobility providers are included in the mobility app of the local PT provider. This needs to be addressed through a different political and administrative process and cannot be solved by the project CIVITAS ECCENTRIC.

Regarding things that could be done in a different way during the implementation phase:

- Parking enforcement is a key for the operation of exclusive parking spaces for shared vehicles. Since the German law for car sharing is not yet fully in place parking enforcement still cannot be carried out. This could have be done differently by knowing that the legislation of the German car sharing law takes that long.
- In order to recognize parking occupancy of the parking space on site a sensor or parking detection could be integrated.

2.3.6 Recommendations

- Parking management in the surrounding city district of mobility stations is needed to underline the benefits of using sharing mobility with exclusive parking space provided by the mobility stations.
- Parking enforcement of these exclusive parking spaces is crucial in order to provide a functioning concept of the mobility station to the clients and providers.
- Awareness and acceptance for the new services need to be developed carefully in order to get more users to the system. Hence closely link the infrastructure development and the communication campaign together and provide a good recognizable branding of the mobility station. The city should own the branding and communication in order to give a transparent and independent umbrella to all mobility providers.
- Combine various (all) sharing mobility providers since the car ownership rate only reduces with attractive alternatives to private vehicles.

3 Lessons learned from implementation

The European Commission is working to improve citizens' quality of life by promoting sustainable urban mobility and increased use of clean and energy efficient vehicles. Clean buses and shared mobility in urban areas have an important role to play in achieving EU policy objectives of reducing emissions of greenhouse gases, air pollutants and noise, and consequently have relevant health benefits to the citizens. Therefore there is a common interest in supporting zero-emissions transport system as the most efficient mobility in the European cities.

Regarding clean vehicles, the European Commission is supporting three main alternative types of fuels and propulsion technologies:

- Biofuels, liquid or gaseous
- Hydrogen and fuel cells
- Battery electric and hybrid electric vehicles with plug-in

Nevertheless, the potential of these innovative technologies is not widely used due to concerns about technological reliability and high costs, in particular electric battery and fuel cell buses.

The three measures of Cluster 2 outlined in Section 3 are being developed in three European cities (Turku, Madrid and Munich) and are practical examples of trends and challenges already identified in Europe.

Requirements to be considered in procurement and implementation of clean buses (electric and hybrid)

- The technology is relatively new and untested (compared to diesel). There are few manufacturers and products to choose from and very few manufacturing standards. This limits the available options and may in some cases make electric and hybrid vehicles a less appealing alternative.
- Charging infrastructure options are a key point to be considered mainly regarding with the high costs. It is also important to evaluate the need of on-board auxiliary power (e.g. a diesel engine for charging the battery, the so called range extender).
- Extra care should be taken when evaluating the supplier’s technical and financial capabilities and their references when procuring vehicles. Depending on the type of contract it may be advisable to set sanctions for the amount of time the vehicles are out of order (due to e.g. break down), specific demands for dealing with technical problems (e.g. deadlines) and specifying the number of vehicles in reserve.
- From the testing point of view, it is better to start with small pilots. Restricted procurements worked well; however, big tenders make possible to get better prices from bus manufacturers.

Adopting new technology and long term vision (fully electric buses)

- It should be expected that adopting new technology will cause problems. In general this means emphasis on reliability and the importance of preparing for setbacks by allocating sufficient staff and other resources to avoid excessive workloads and related problems. Having spare vehicles readily at hand has proven more important than anticipated and can easily become a bottleneck.
- Large scale transition to electric vehicles in public transportation depends to a great extent on the development of battery technology. The life span of batteries and the cost of replacing them is a major component in the total cost of ownership. Also, at the moment the capacity and weight of batteries are perhaps the most important limitations to the use of electric buses.
- Based on public transport operator experience, in order to scale up towards a fully electric bus the most significant characteristic should be having a bus line with a low and constant average speed.
- On the other hand, the suitability of available electric vehicles for a given type of traffic should be taken into account when planning the long term transition to electricity.

Adopting new (e)mobility stations

- The design of new mobility concepts must be focused on feasibility and financing and its implementation implies redefining urban planning and mobility schemes. In this context, it is necessary to develop tools to integrate shared mobility as a new mode in planning and modelling the cities.
- The (e)mobility stations combine and provide different types of shared mobility services in connection with and complementary to the use of public transport. The provision of attracting multimodal mobility service allows citizens to live a lifestyle without a private vehicle or at least have significantly lower mobility costs.
- The location of these mobility stations must be carefully selected in order to be able to arrange all individual elements of the mobility station. So it is a key point to start early enough with the involvement of all relevant planning stakeholders at the city.
- Special attention must be paid to electric charging infrastructures and parking enforcement at the mobility station. As shared / electrical mobility are relatively new concepts it is key that urban planners are awared of the need to jointly plan new urban developments (residential, industrial, services, etc.) with charging stations for electric vehicles.
- On the other hand, the integration of all mobility providers into a common mobility service app or platform is a relevant aspect regarding the success of the service.

Communication campaigns and actions

- Awareness and acceptance for the new mobility services and infrastructures need to be developed carefully in order to get more users to a sustainable and multimodal transport system.
- Communication actions informing users (citizens) and bus drivers about the service improvements thanks to the new clean buses (electric or hybrid) are very useful to help the adoption of new clean fleet.
- Regarding mobility stations, closely link the infrastructure development and the communication campaign is key as well as and providing a good recognizable branding of the mobility station.

4 Conclusions and Next Steps

4.1.1 Conclusions

By 2020, cities are expected to host around 80% of EU citizens and in many urban areas an increasing urban mobility has created an unsustainable situation with poor air quality, high levels of CO_2 emissions and noise as well as great traffic congestion. The European Commission's Urban Mobility Package and the European Parliament's initiative report on Urban Mobility both state the urgency of addressing the challenges regarding the aforementioned issues.

In this context, it is necessary a new approach which integrates transport policy with urban planning, air quality and vehicle emissions regulations to address a new urban mobility culture and a shift towards cleaner and efficient urban mobility systems.

In a multimodal and sustainable transport system approach the use of clean vehicles in public transport should be a priority. For urban areas, this implies a shift in public transport fleets from diesel buses to renewable or alternative fuels or electric buses.

On the other hand, the shared mobility systems (car, bicycle and motorbike), are growing exponentially in many European cities, offering a transport alternative tailored to the new citizens' needs. In addition, being electric vehicles or low emissions, are contributing greatly to improve the cities' air quality.

In this context of change, ECCENTRIC project and specifically the Cluster 2 measures regarding efficient and clean public transport solutions are an exceptional opportunity to share valuable experiences (and tested in the laboratory areas) with other cities allowing them to improve their sustainable mobility strategies.

The three measures presented in this report are examples of the introduction of cleaner public transport buses (electric or hybrid ones) as well as new and integrated sharing mobility services complementing public transport in new residential developments (e-stations) which highlight the role played by the City Councils regarding the provision of financing, regulation and policy instruments, public land, the necessary recharging infrastructure to support electric vehicles and communication campaign. Also the European Commission funding (through ECCENTRIC project) has been a key point.

Financing the high costs of electric and hybrid buses (up to twice the price of a diesel bus) and the fear of adopting a new and different technology (technological reliability, charging options), the existing regulatory framework (that in many cases does not take into account electric vehicles or shared mobility systems) and the reluctance of shared mobility operators to be integrated into a common digital mobility service app or mobility platform are the biggest barriers to the adoption of a more sustainable and clean transport system as it has been highlighted in this report.

This needs to be addressed through a different political and administrative process in which the municipalities have to adopt a leader role to overcome these barriers and upgrading the transport systems making them cleaner, more energy efficient and more sustainable.

4.1.2 Next steps on WP5 Cluster 2 measures

The implementation of different clean mobility measures regarding public transport is producing valuable inputs for relevant public transport stakeholders and urban policy makers. With the aim of maximize the benefits of these experiences, the following activities are proposed:

Measure	Next steps
TUR 5.7 Introduction of Electric Public Transport (Turku)	• Ongoing analysis of data (from OBD and charging systems) to improve reliability and optimize efficiency. • Planning for extension of electric bus network and getting political approval for the extension. See below. • Research for extension plans will be in the form of diploma and thesis work. Topics to be decided. Planning for further research has started and research is expected to be complete during 2019.
MAD 5.8 Electric and hybrid buses for Public Transport (Madrid)	• Keeping operating hybrid buses on a regular basis until the end of the monitoring phase (during 2019). • EMT is already in contact with UPM (the Madrid LEM) in order to provide data for the monitoring and evaluation. • Launch a survey amongst users and drivers to evaluate hybrid buses acceptance and use (March 2019). • Also working already in the stickers to put on the buses to identify them as an outcome of ECCENTRIC project.
MUC 5.9 (E-)Mobility stations at development area Domagkpark and centre-periphery integration (Munich)	• Detailed planning for remaining stations: September 2018–June 2019. • Construction works for Station # 3: November 2018-March 2019. • Opening of the remaining stations: 2019. • Development of a strategy how mobility stations can be scaled up in other areas in Munich. Integration of the mobility concept into a city wide resolution to be submitted to City Council in 03/2019: January 2018-June 2019.

Table 2: Next steps

5 Sources / References

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