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Cleaner and better transport in cities

2020 CIVITAS Cleaner and better transport in cities DYN@MO

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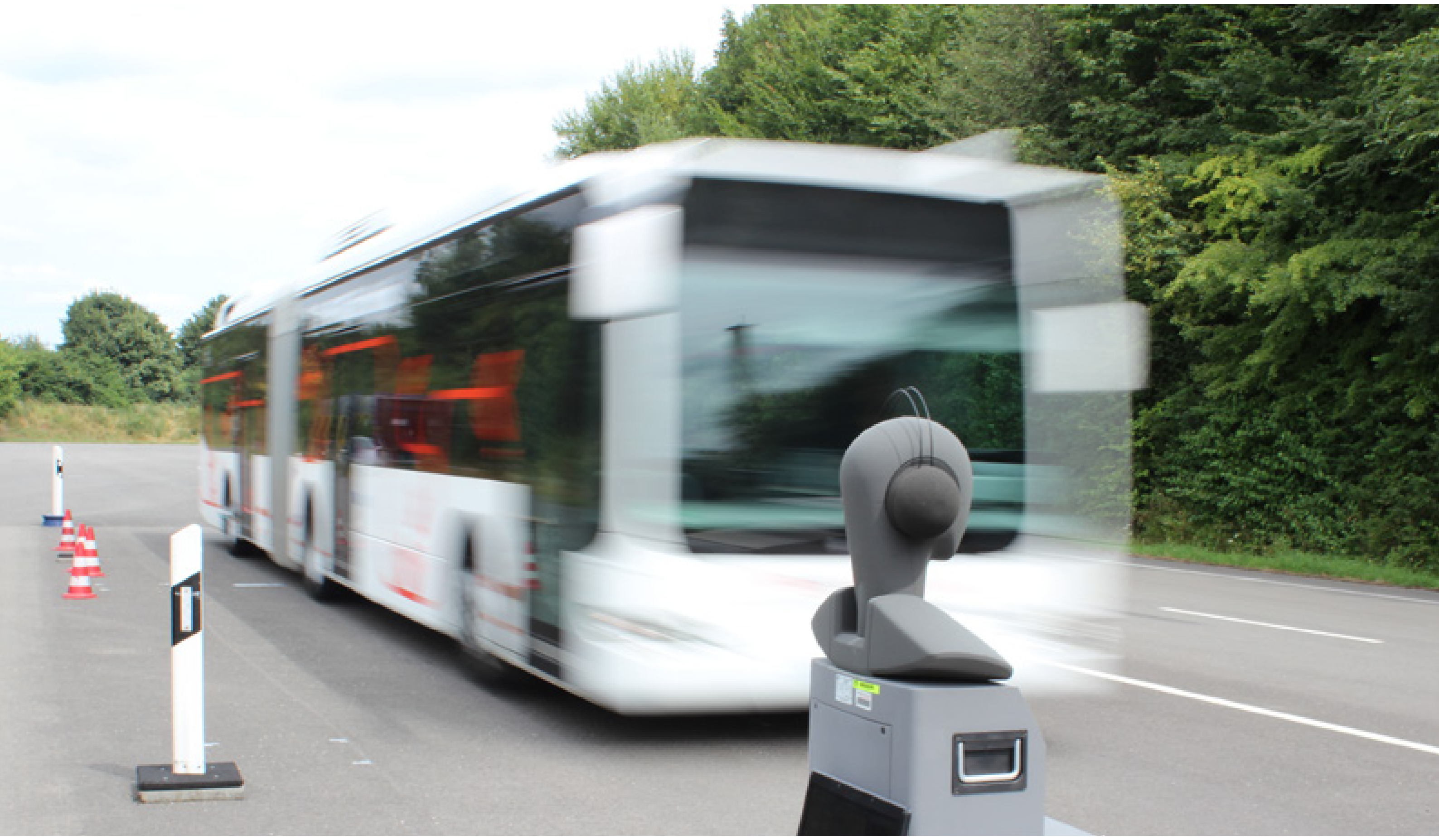


CONVERTING REGULAR BUSES TO CLEAN BUSES – EXPERIENCES FROM THE DYN@MO CITIES

CIVITAS

Towards cleaner vehicles in DYN@MO cities

Planning, testing and deploying innovative, clean and energy efficient vehicles for public and private transport is a central policy field for the CIVITAS initiative. The CIVITAS DYN@MO project contributes to this objective by:

- Implementing innovative mobility options with clean vehicles for individual, collective and freight transport;
- Implementing clean, energy efficient and silent public transport vehicles;
- Enabling an environment for clean vehicles through innovative technology to increase the energy efficiency of systems;
- Acquiring the relevant data and information for deploying clean vehicles.

The DYN@MO cities of Aachen, Gdynia, Koprivnica and Palma are strongly committed to making their public transport cleaner and to enhance the environmental performance and energy efficiency of their fleets. Within the framework of CIVITAS DYN@MO, the cities are testing and deploying different types of clean, innovative technologies to achieve these objectives. One of the measures is the conversion of existing vehicles, often running in a diesel engine, to cleaner vehicles exploiting more environmentally friendly energy sources.

This brochure will share cities' practical experiences and knowledge gained in the conversion processes – from a hybrid to an electric bus in Aachen, from a diesel bus to a trolleybus in Gdynia and from a diesel bus to an electric bus in Koprivnica.

This brochure complements the CIVITAS WIKI Policy Note - "Smart choices for cities - Clean buses for your city" available at www.civitas.eu.

About DYN@MO project in a nutshell

- DYN@MO (2012-2016) is part of the CIVITAS Initiative, supporting cities to introduce ambitious transport measures and policies towards sustainable urban mobility
- Four DYN@MO cities Aachen, Gdynia, Koprivnica and Palma have agreed on a common mission to strengthen sustainable mobility
- The project consists of 28 partners in the four cities supported by Union of the Baltic Cities, Rupprecht Consult and Lund University
- The strategic aims of the DYN@MO are to:
  - develop "Mobility 2.0" systems and services by applying new web-based technologies
  - implement innovative electric mobility solutions, using new electric and hybrid vehicles and
  - engage in dynamic citizen dialogue for mobility planning and service improvements

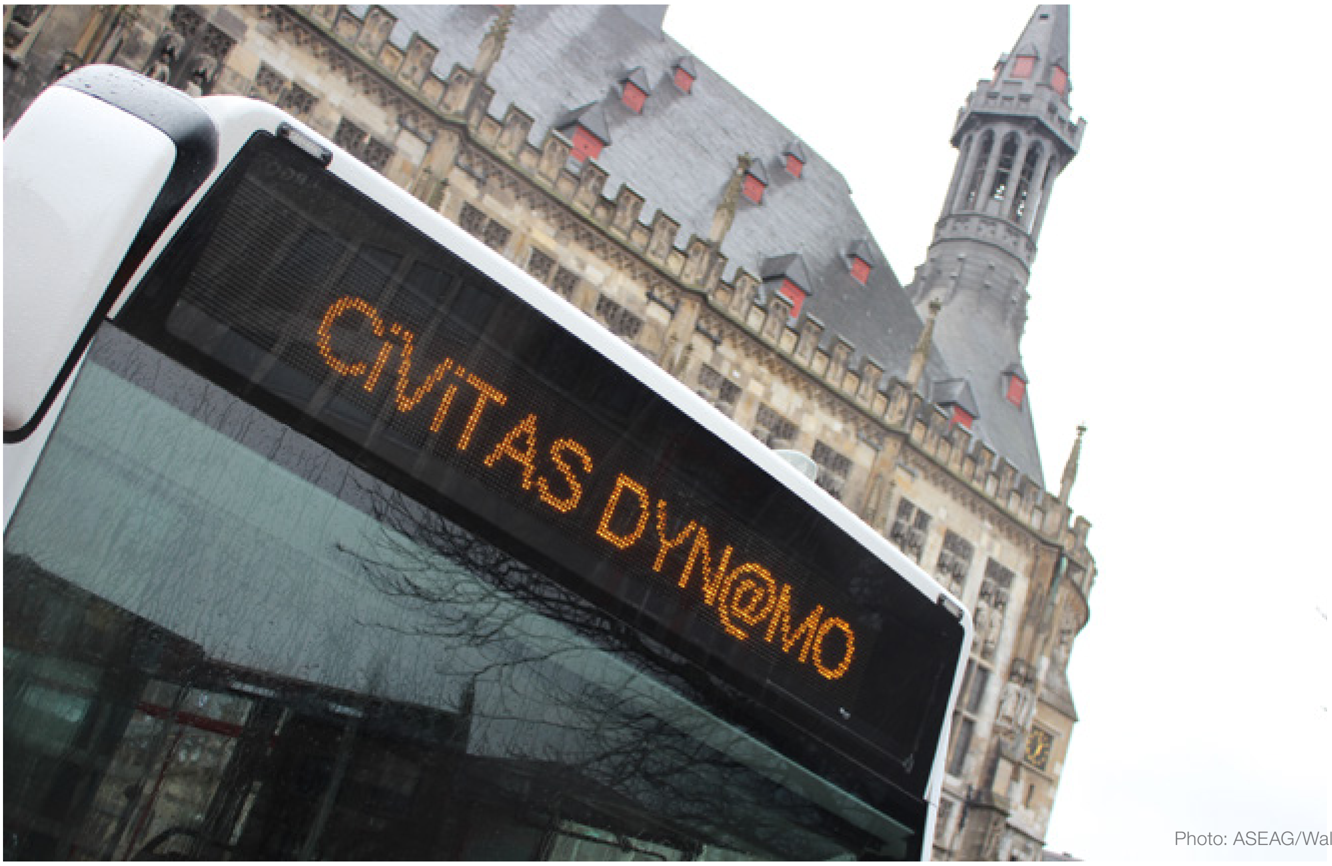


Photo: ASEAG/Walter Eßer

From hybrid to electric buses

The Aachen transportation company ASEAG is remodelling an articulated bus with regional partners

Text: Walter Eßer/ASEAG

Within the CIVITAS DYN@MO aiming at innovative strategies for cleaner city traffic as part of sustainable mobility concepts, ASEAG (Aachener Straßenbahn und Energieversorgungs-AG) as a participating transportation company is testing alternative drive concepts in the city traffic. In view of this, in April 2014, the company started working on the conversion of an articulated hybrid bus into an electric bus. The bus is expected to be deployed on a line in autumn 2014 and would then be the first articulated bus being an electric vehicle used on a bus line in Germany. Before the conversion was started the bus, produced by the manufacturer EvoBus (Mercedes Benz), was already tested in the Aachen region as a hybrid vehicle.

ASEAG is supported by regional partners in the realisation of the project. The Futavis GmbH of Aachen, which is specialized in the development and production of electronic systems for the support of renewable energies, delivers not only the battery pack but also brings technical know-how to the project. The company is convinced that the success of electromobility depends on the performance of the battery technology that is being used.

Steps to be taken to build a fully working electric bus

The converted bus will use a battery pack with a power of circa 180 kWh. In the end, there are about 1300 battery cells, which will supply the vehicle with propulsion power in a modular form, i.e. distributed to the front and rear wagon. The total weight is about 1800 kg. The manufacturer expects the battery to have a range of at least 50 kilometres. This range does not factor in the additional feedback of energy (recuperation) to the battery since there is insufficient experience to calculate a good estimate. However, ASEAG expects the bus to have a clearly higher range. Driver training on both economic and energy-efficient driving will most likely make further contributions. However, there are still many steps to be taken before the bus can be used on a line. The first step is to perform practical vehicle tests with a switched-off

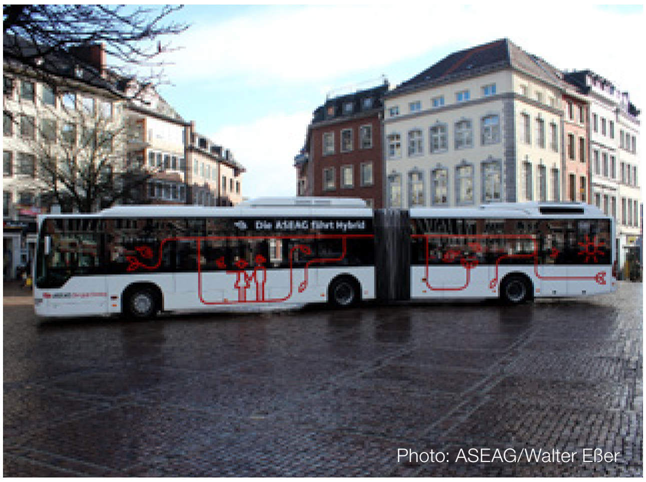


Photo: ASEAG/Walter Eßer

motor in order to record data. The engine and no longer needed additional drive systems must be removed from the vehicle, then weighed and measured. This is to determine the installation space so that the permissible axis loads are not exceeded later when the battery packs are installed. The electric drive train consisting of four-wheel hub motors and an associated transverter are to remain in the vehicle. The same applies to the electric ancillary components for power steering and compressed air supply.

For safety reasons, the battery pack is placed on the roof of the vehicle in two modules. The risk that the modules are damaged, for instance, in a traffic accident, is the lowest in that location. In order to compensate, as much as possible, for the dynamic performance drawbacks that come with large weights on the roof of the vehicle, the basic vehicle has already been equipped with an electronic pitch and a roll control system (Wank-Nick control system), which ensures that the vehicle remains balanced on bends.

Another important component for the conversion work is the heating concept for the vehicle. Since electric heating would be the worst choice in terms of efficiency – the energy loss would decrease the range – this vehicle uses a heating concept with a decentralised heater based on bio-ethanol. Four heaters in different positions will provide the necessary heating power. The old heat exchangers for driver's seat and the passenger cabin will be retained. For this purpose, separate water heating circuits are defined in order to avoid long, inefficient pipe distances.

Another important factor for the successful deployment on lines on the streets of Aachen is the charging infrastructure. The vehicle will be charged conductively, i.e. plugged in at the premises of ASEAG. Due to the charging cycles of the vehicle, the plan is to use the vehicle on a line which passes by the ASEAG facilities. The line is suitable for testing the bus due to its path along a large, topographically interesting stretch of the inner city, which provides good conditions for measuring energy consumption and noise emissions. The insights gained from the first phase will be used to develop and expand the charging infrastructure throughout the city. Later on, based on the results, it will be decided on which other lines the electric articulated bus could be used.

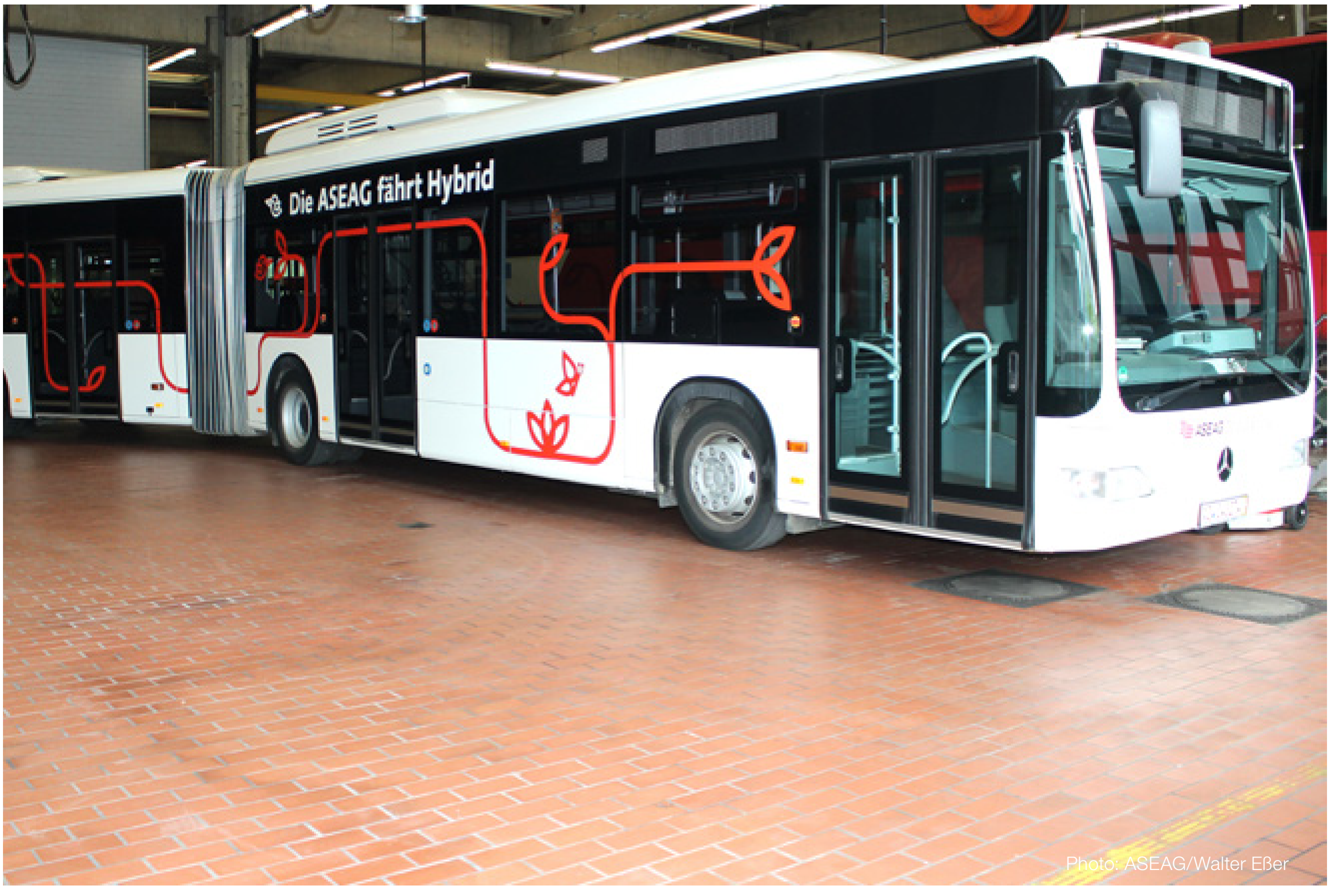


Photo: ASEAG/Walter Eßer

The process contributes to improving quality of life in Aachen

In particular, in view of the efforts to create a clean air plan for the city of Aachen, the activities aimed at increasing the use of alternative drive technologies is an important building block to achieve cleaner air in the city. In addition, the reduction of noise pollution plays an important role in enhancing the quality of life in the urban area. Comparative measurements of fossil and electric vehicles have shown that noise produced by local public transport can be significantly reduced with the introduction of electric vehicles. Therefore, it is important to follow closely the research and development in this field in order to decide which drive forms could supplement public transport in Aachen and surroundings in terms of environmental and economic considerations.

"As a communal company of great importance to Aachen and the region, we pool resources in order to drive innovative activities forward", explains ASEAG Chairman Michael Carmincke about the project. "We are closely

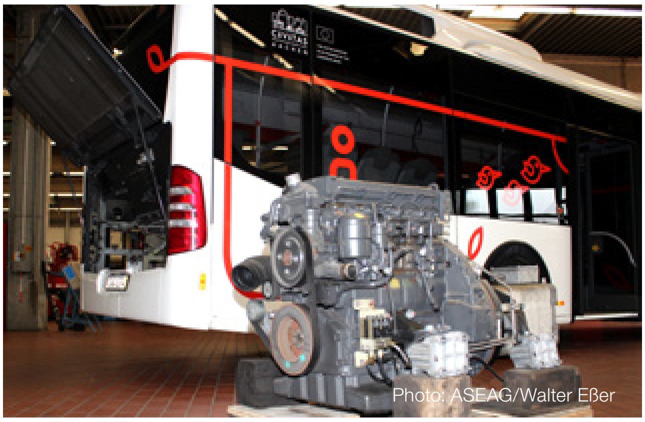


Photo: ASEAG/Walter Eßer

following trends which affect the public transport market. The future drive forms play an important role for us in this respect. In the end, we want to make an active contribution to climate protection and clean air in Aachen and the region as a whole. In this regard, the CIVITAS initiative is a valuable partner".

ASEAG Bus fleet

solo buses: 69

articulated buses: 137

double articulated buses: 8

Capacity: 7

hybrid buses: 2

ASEAG participates in CIVITAS DYN@MO by introducing hybrid buses to the city's fleet and has performed tests with:

- Volvo7900 Hybrid
- MAN LionsCity Hybrid
- EvoBus Citaro Hybrid

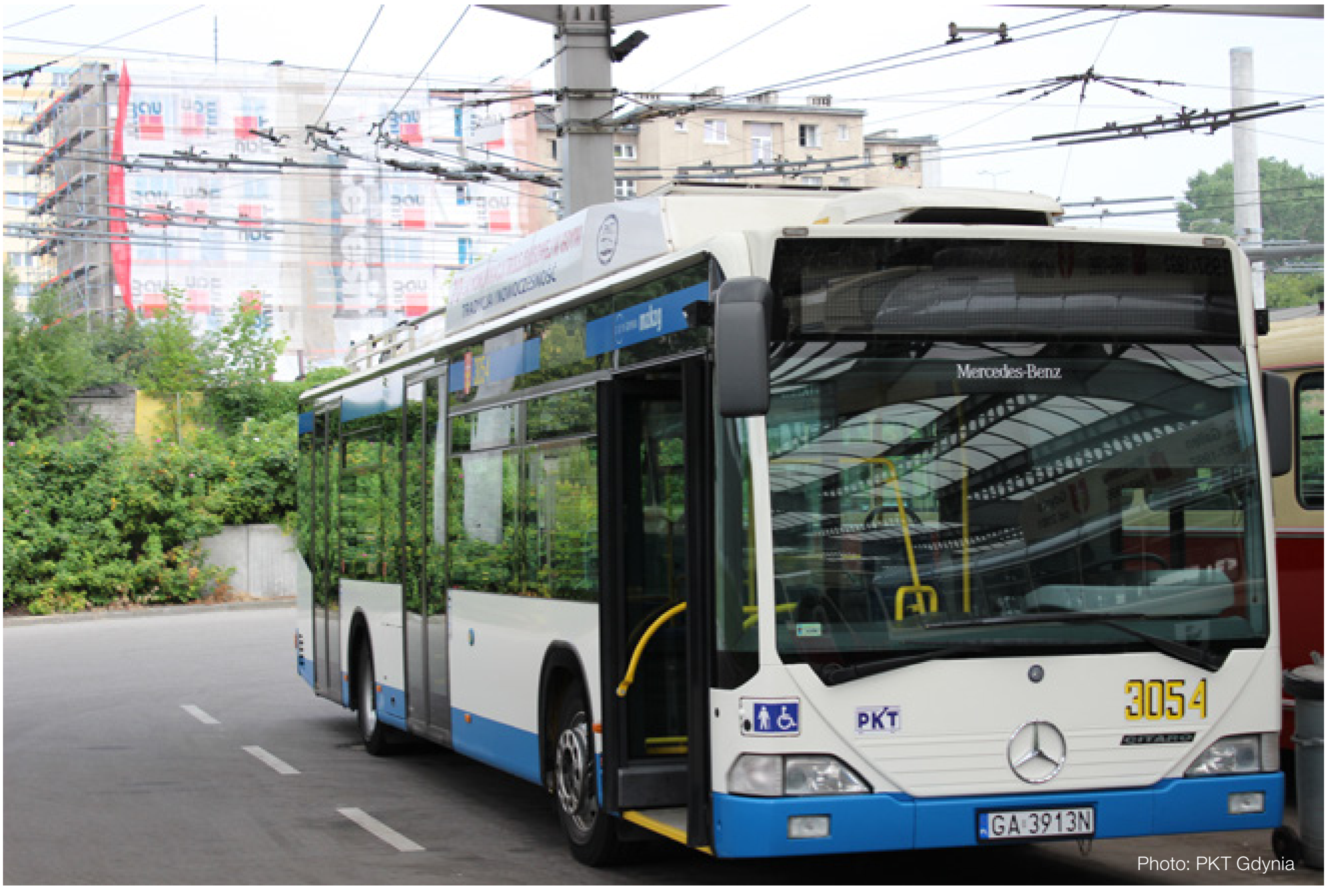


Photo: PKT Gdynia

From regular bus to trolleybus

Experiences from the city of Gdynia – famous for its beloved trolleybuses

Text: Marta Woronowicz/PKT

In 2014, PKT Gdynia, the trolleybus transport operator from Pomerania, north of Poland, is celebrating its 10th anniversary of converting diesel buses into trolleybuses. Within CIVITAS DYN@MO, PKT works to increase the attractiveness of trolleybus transport in the city. The concept of constructing a trolleybus on the basis of the coachwork of an old, low floor bus was developed in Gdynia in 2003. At that time, the trolleybus transport in the city was facing significant difficulties. There was a striking disproportion between the quality of bus and trolleybus services as the bus operator possessed mainly low floor fleet while PKT had mere 7 low floor vehicles out of 70 in operation. The image of trolleybuses was poor due to the shortage of modern vehicles tailored to the needs of disabled persons, providing also a sufficient level of comfort for all passengers. However, replacing the worn out high floor fleet with brand new trolleybus vehicles, costing twice as much as regular diesel busses, would have been too costly. Therefore, PKT decided to use their in-house knowledge to construct a low floor trolleybus by converting a traditional bus. This guaranteed the low cost and high speed of acquiring a low floor trolleybus at an estimated rate of 26-37% value of a brand new vehicle.

Thus, in 2004, the conversion work began on the coachwork of Mercedes Benz O405N, a 12-metre-long second hand bus. The converted vehicle was the first Mercedes trolley vehicle of this type ever produced. The introduction of such a vehicle, based on partially worn German coachwork, into the market raised concerns of a high rate of failure frequency. Yet, experiences showed that the failure frequency was a lot lower than in case of old high floor trolleybuses. The coachwork of the first in-house converted trolleybus, as well as subsequent ones, proved to be of high durability and, when properly protected, not prone to corrosion.

According to the first estimations, the converted vehicles were to be exploited for 6-7 years. The reality proved, however, that converted trolleybuses can be used on average for 10 years. Since 2004, PKT has converted on average 3 vehicles yearly. The conversion process takes 4-6 months. The value of converted vehicles ranges from 130,000 PLN (32,500 EUR) in the first years to 550,000 PLN (140,000 EUR) in the recent years. To compare, a new trolleybus currently costs ca. 1,600,000 PLN (400,000 EUR).

Phases of trolleybus conversion

Phase I – Documentation and preparation phase

Without preparing proper technical documentation one cannot professionally convert a bus into a trolleybus. Technical guidelines need to be followed:

- all significant decisions taken should be based on experts' opinions in the fields of: electro technology and electronics, mechanics, vehicles, marketing and communication and economics
- the type of a bus selected for conversion should be clearly specified
- the type (drive and auxiliary systems) and location (i.e. inside, on the roof) of equipment to be installed have to be defined

A schedule of the investment steps is recommended. Such a schedule is useful for companies performing the conversion in-house, as well as, in case of commissioning the conversion to an external operator.

Phase II – Mechanical work

The first stage of the mechanical work is dismantling the obsolete elements of the combustion power transmission system in a trolleybus including the engine, gearbox, cooling system and a fuel tank (if there is one). The second phase is the modification of the engine space by removing unnecessary construction elements and dividing it into 3 parts for the new elements of electrical installation.

Some basic requirements concerning converted trolleybuses in Gdynia are that they should have three doors, at least four hopper windows and a step less floor throughout the vehicle. A coachwork used for conversion into a trolleybus should not be older than 10 years for endurance reasons.

Phase III – Installing electrical units

After the dismantling phase, the coachwork must be prepared for incorporating the electric drive. Conversion requires building the roof with such elements of electrical machinery as: current collectors, starting and braking resistors, a lightning protector, a static converter (in case of trolleybuses with power electronic machinery), and a traction inverter (if necessary).

The next step is to assemble the main elements of 600 V installation. As trolleybuses can be fed from the contact system of a voltage rating of 600 or 750 V, it is necessary to make 600 V cable outlets. Also the new 24 V wiring control system is installed.

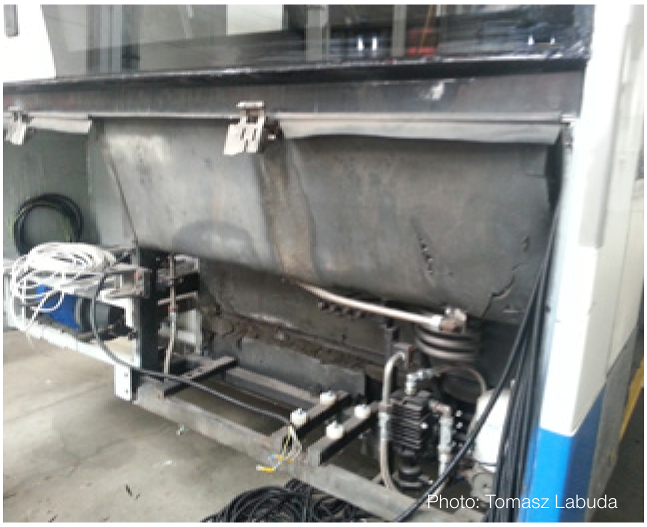
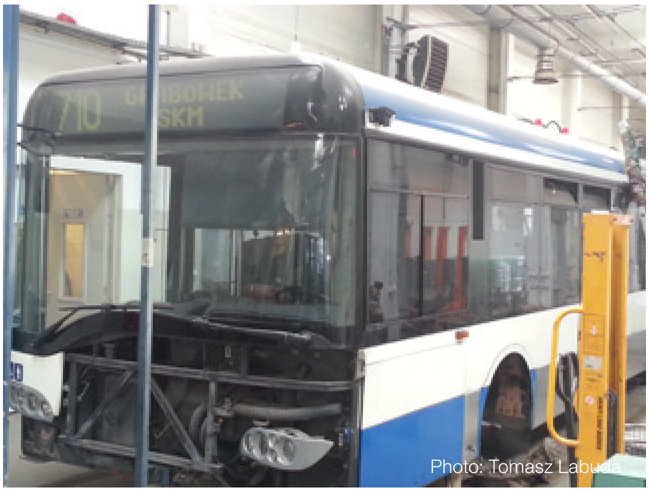


Photo: Tomasz Labuda



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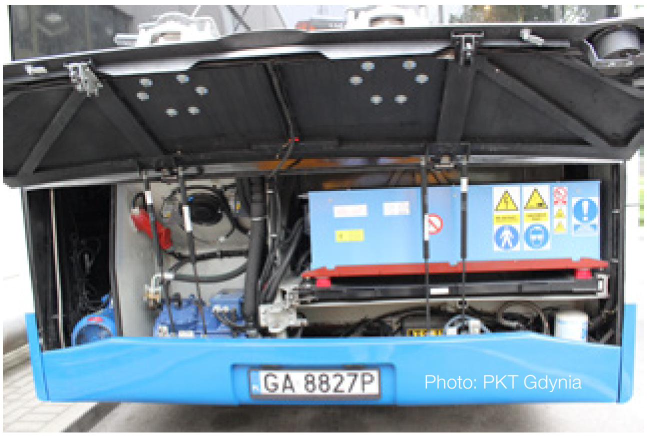

Photo: PKT Gdynia

The last part of electrical phase is the installation of control system elements, the majority of which in PKTs case, are produced in-house. All steering elements working with a traction drive control system have to be equipped with insulation for contact system full voltage (600 V).

Phase IV – Setting the trolleybus in motion

This is the stationary and movement test phase. Before the deployment of the vehicle, numerous tests need to be conducted, including the ones concerning 600 V installation.

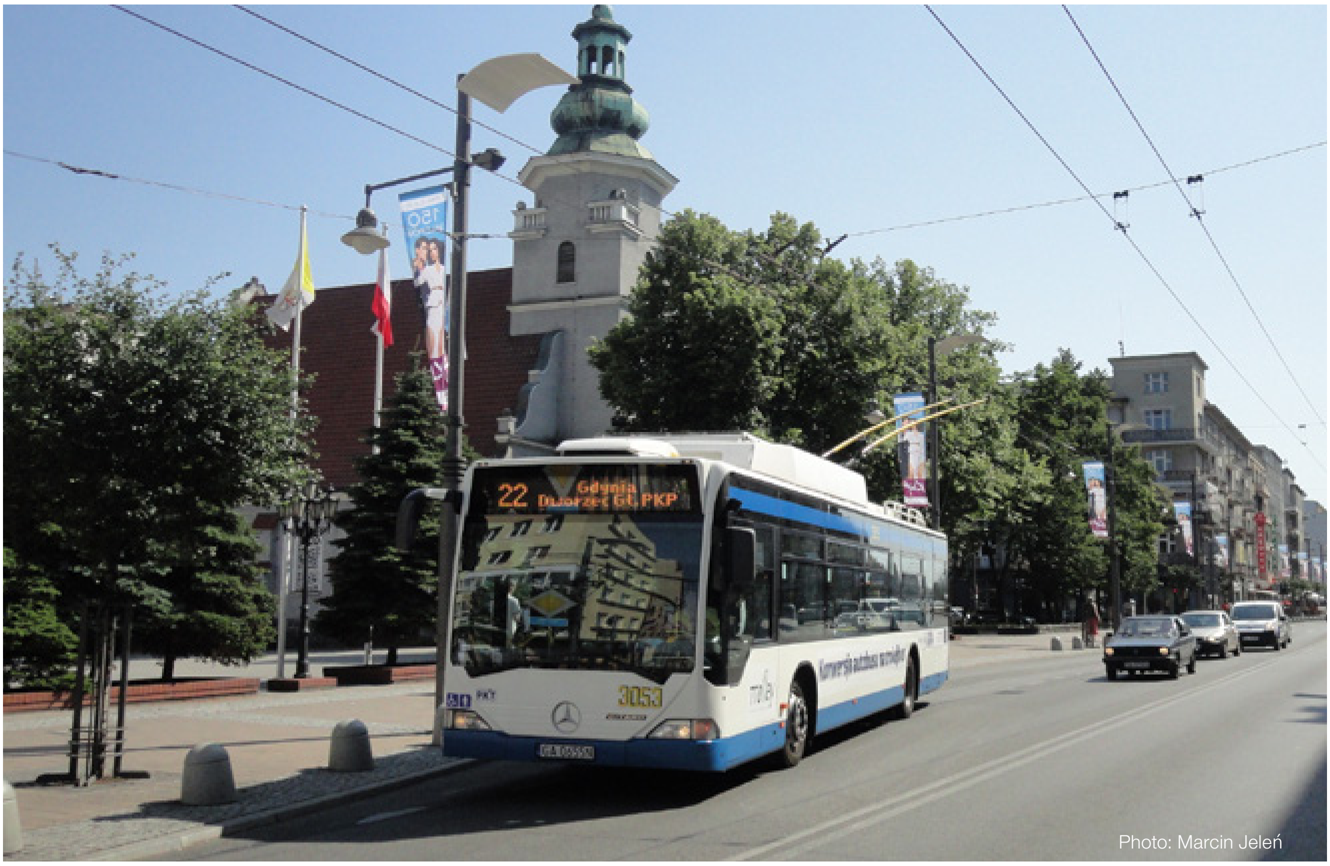

Photo: Marcin Jeleń

Phase V – process of trolleybus registration

The list of formal requirements in the process of converting a bus into a trolleybus

- Purchase a second hand bus
- Re-register the bus (still as a bus) under the new ownership
- Convert the bus into a trolley bus
- Obtain a positive expert opinion
- Obtain temporary admittance to service for the duration of the test period
- Obtain positive test results at a vehicle inspection station
- Register the converted vehicle as a trolleybus
- Obtain a positive result of extended tests

Advantages and disadvantages of conversion

The conversion has both advantages and disadvantages. PKT's main reason for performing it, since 2004, was the urgent necessity to modernise its fleet at a relatively low cost. In this way, the company could achieve two to five converted trolleybuses instead of one brand new. Fortunately, the conversion was possible in-house in depot conditions. Yet, in the process of exploitation, it has been discovered that the main disadvantages of the conversion are:

- the risk of unpredictable failure frequency
- the unknown history of a second hand bus used for conversion (e.g. lack of technical documentation)
- the uniqueness of each converted vehicle – the differences are usually significant. Therefore, it is impossible to prepare universal guidance for conversion
- a demand for a greater assortment of spare parts in case of a converted trolleybus, which entangles difficulties with supply and results in a lack of service uniformity

However, with regard to the failure frequency of conver-

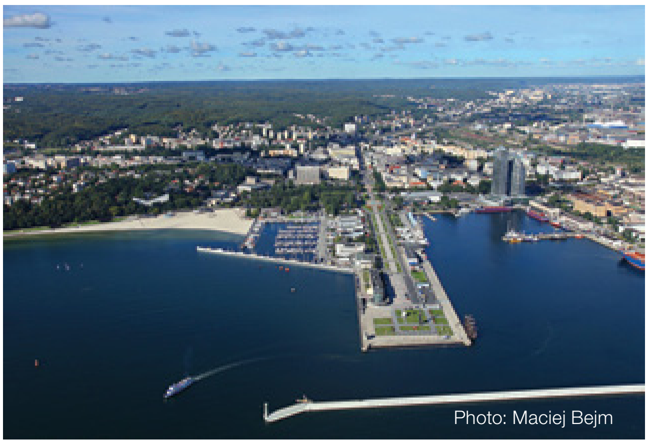

Photo: Maciej Bejm

ted trolleybuses, it turned out that it is much lower than expected. It is higher than for new vehicles but comparable to those exploited for 2 to 10 years.

To conclude, the process of conversion in PKT Gdynia, based on 10 years of experience, is perceived as economically efficient. At the moment 100% of PKT's fleet (87 vehicles) is low floor, as much as 39% of which were obtained thanks to conversion. Meanwhile, new vehicles were also purchased as a result of the company's participation in two European funded projects. In this way, the overall image of passenger transport services in the city of Gdynia has improved immensely. Conversion has proved to be such a sustainable practice that its continuation in Gdynia is guaranteed. For instance, if the new type of Li-Ion batteries to be tested within the CIVITAS DYN@MO proves to be successful, PKT will start installing them in the new trolleybuses, to be converted too.

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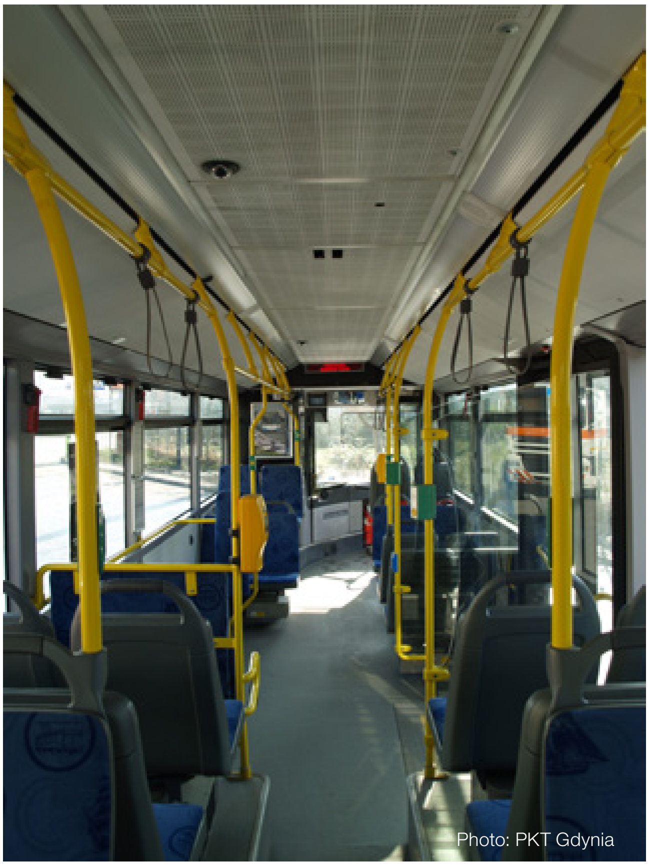
Photo: PKT Gdynia

Five key points to remember when implementing conversion

1. Buy up to 10 years old, good quality used buses, preferably gas (due to reinforced roof structure) with a known exploitation history
2. Ensure proper preparation of documentation
3. Create a feasible schedule of the conversion process investments
4. Consider potential disadvantages such as failure index or uniqueness of each converted vehicle
5. Consider in-house human and technical resources making conversion process viable

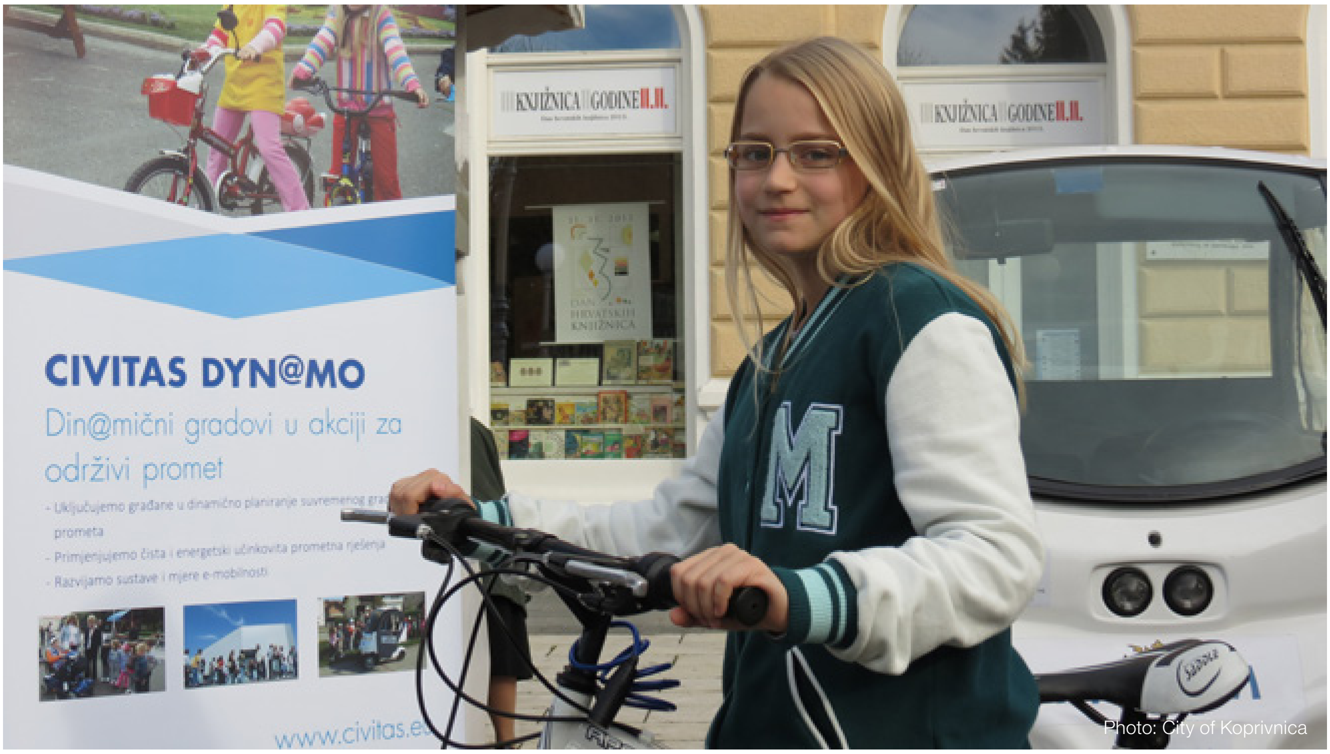

Photo: City of Koprivnica

Conversion of a diesel bus to a fully electric bus

Koprivnica – the frontrunner in promoting electric vehicles in Croatia

Text: Nebojša Kalanj/City of Koprivnica

During the last decade, the electric vehicle industry has taken large steps forward and the prospects for the future have seemed bright. However, due to the worldwide economic crisis that hit countries like Croatia, oil prices have not sky-rocketed as predicted. This has slowed down the development of electric vehicles and given way to conventional gasoline and diesel vehicles to stay on the throne.

The development has also had an impact on the introduction of electric vehicles in cities like Koprivnica. Koprivnica is a city with 31,000 inhabitants in north-west Croatia and is a frontrunner in promoting electric vehicles in the country. Due to the slow development of electric vehicle markets, Koprivnica has faced many challenges in order to meet the goals the city wants to achieve. To mention a few, the costs for acquiring electric vehicles are still relatively high and the supply is very limited. In addition, in many cases a suitable charging infrastructure does not exist.

Despite the challenges, Koprivnica sees many opportunities in the introduction of electric vehicles. The city aims to establish a public transport system that is based on electric vehicles in the city area. Currently, only regional public transport services are available.

Initially, Koprivnica planned to buy two fully electric vehicles that would serve as vehicles for the future public transport system of the City of Koprivnica being established within the CIVITAS DYN@MO project. The buses must comply with the minimum requirements that are set by Croatian law.

The first step in the process was to conduct a research study on the market availability of such vehicles. However, the results showed that the supply of electric vehicles on the Croatian market is non-existent. Koprivnica decided to turn to the European market hoping to find


Photo: City of Koprivnica

more available solutions. One big challenge concerning the procurement of electric vehicles from the European market was the lack of service network available in Croatia – essential in establishing a fully functioning public transport system with electric vehicles. Koprivnica needed to purchase a vehicle, not too highly-priced, suitable for public transport use and with a 24-hour mobility guarantee with a developed service network. None of the companies outside of Croatia offered such a solution.

In the end, a solution that was found was the conversion of a conventional vehicle to a fully electric vehicle. A major advantage was that there is a large number of companies in Croatia that already have experience of the conversion processes, which would also reduce the final price of the vehicle.

The other benefit was that a converted bus could be made to suit exactly the needs of Koprivnica. In Koprivnica's case this was crucial. Koprivnica is the first city in Croatia that has a network of five fast charging stations, which offer very fast charging for electric vehicles –from 20% to 80% charge level of a battery in 30 minutes. Thus, the requirements for the range of the vehicle do not need to be quite so high.

Additionally, a converted vehicle needs a smaller number of battery packs, decreasing the price of the vehicle since the battery pack is the most expensive component of the vehicle. Another advantage is that Koprivnica can purchase a second-hand vehicle, dismantle it and embed the necessary component of an electric vehicle – again, decreasing the final price of the vehicle. Nevertheless, the most important benefit, from the point of view of Koprivnica, was that, countries like Croatia that do not have a well-developed car industry, can still participate in such

Photo: City of Koprivnica

initiatives promoting electromobility by involving smaller component companies. This gives a boost to the local economy. On the other hand, purchasing a vehicle that is built in small numbers, also involves risks. The possibility of having reliability problems is higher than with vehicles produced in larger quantities.

To conclude, the conversion of conventional vehicles to electric vehicles is a good way to overcome current problems that exist in the electric vehicle market, especially in countries like Croatia. It can decrease the price of the vehicles and have a positive impact on the local economy. Koprivnica expects to have the first converted buses serving the public transport customers at the beginning of 2015.

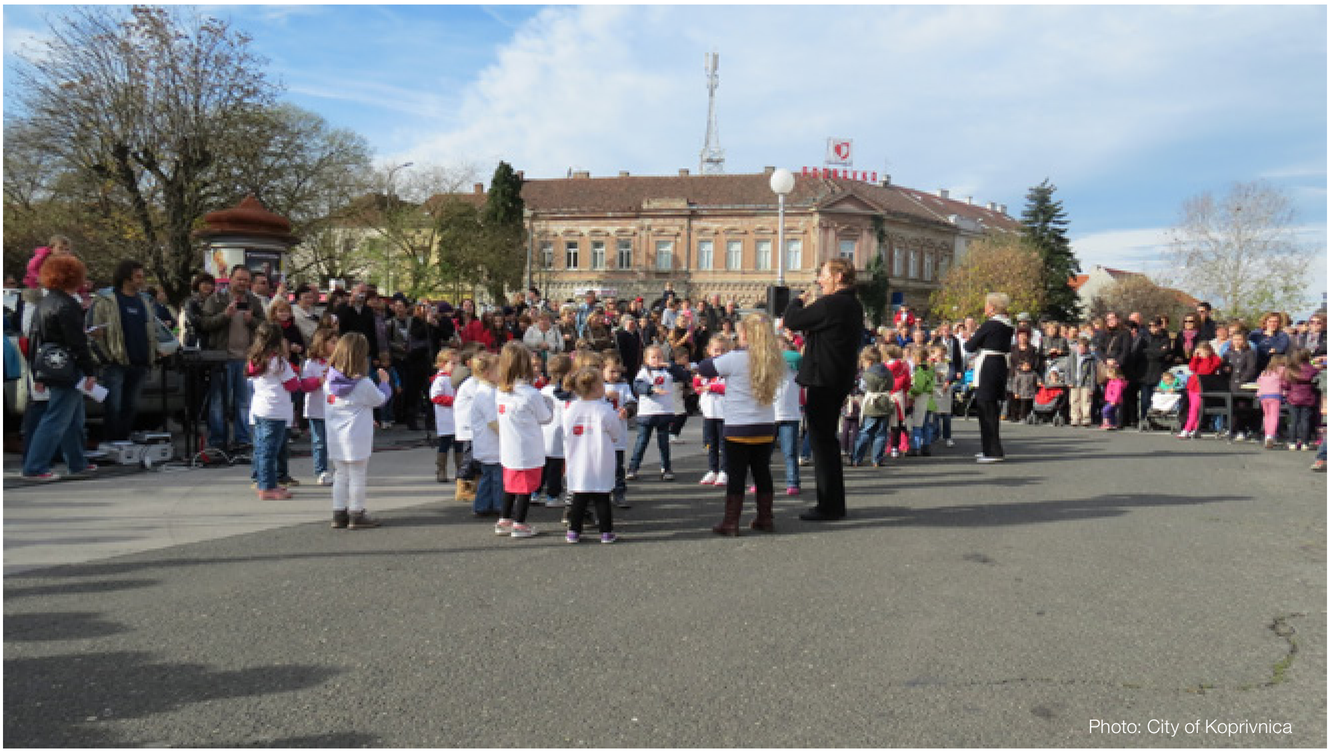
Photo: City of Koprivnica

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