

## Innovative Electric Buses in Vienna

### Clean Fleets case study

- 12 electric microbuses purchased for the city centre
- New technology: batteries charged through tram's overhead power lines at end stations
- Pre-procurement test phase with four buses



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#### Contract tendered

- Supply contract for 12 electric microbuses launched by Wiener Linien, Vienna's city-owned transport company, in Sept 2011, for inner-city bus lines
- Awarded to Siemens/Rampini for the *ElectriCitybusse* in March 2012
- First buses operating in Sept 2012. Since July 2013, two inner-city bus lines rely entirely on *ElectriCitybusse*

#### Targets and planning considerations

Vienna is striving to be a leader in green transport. In its e-mobility strategy of 2012, it sets the aim to reduce personal motorised transport to less than 20% in 2025. As a model region for e-mobility it is testing new transportation systems and with SMILE (smile-einfachmobil.at) and MobilCard (mobilcard.info), the city is involved in two projects supporting multimodal transport.

The initiative for purchasing electric buses came from Wiener Linien themselves. They decided to create a zero-emission zone in the historic centre with low emissions in the wider centre. Viennese buses, which all used to be powered by liquefied petroleum gas (LPG), are therefore gradually being substituted by diesel, hybrid and electric buses. As the two bus lines the tender referred to run in the historic centre, zero-emission electric buses were specified.

As it would have been difficult to obtain a planning and building permit for new power lines or charging stations in the historic environment, Vienna decided to use the extensive existing network of overhead tram power lines to recharge the buses – Vienna has the fifth largest tram network in the world. This, however, required the development of new technology.



## Procurement approach

Given the novelty of the technology required, an extensive market dialogue and testing phase took place before tendering. Peter Wiesinger, head of bus procurement for Wiener Linien, contacted suppliers all across Europe and visited several fairs in order to choose a new drive system.

Four potential buses were identified on the market, however during initial testing two were rejected due to size or energy consumption. Therefore, following an open tender for *battery driven buses without diesel auxiliary power unit*, just two companies were able to meet the requirements.

## Clean Vehicle Directive (CVD) Methodology

The requirements of the CVD for considering CO<sub>2</sub> and toxic emissions were met through specifying the vehicle type (electric) – i.e. Option 1.

Further specifications were set relating to the technical performance of the vehicle:

- Maximum width, length, height and wheelbase due to the narrow and winding inner city streets.
- Two doors, low-floor buses (for the elderly) and a minimum of 30 passengers.
- Charging either via overhead lines or induction. Outlets must not be the exclusive charging technique, but have to be additionally provided.
- Charging time: max. 15 minutes
- Range: min. 150 km
- Reliability: Bus must not need to be removed from service for repair before 30,000 km is reached.

Compliant tenders were then evaluated against the following award criteria:

- 45% cost (including battery replacement cost, and operational overheads)
- 25% technology (e.g. vehicle dimensions, number of seats, door features such as low-floor and lowering ratio, range, charging time etc.)
- 20% reliability (e.g. downtime, maintenance time etc.)
- 10% charging process (e.g. charging time, charging cycle etc.)

## Contract Monitoring and Management

Two years of full warranty were requested, including both buses and batteries. Repairs are covered by the supplier, but maintenance is carried out by Wiener Linien. Extra training for maintenance personnel has been carried out.

The energy consumed by the e-buses will be measured with the support of the Technical University of Graz. As energy consumption is very low in summer – buses could complete five circuits before recharging – measurements are planned for winter 2013, when the heating draws additional electricity.

## Results

- Out of four companies which took part in the test phase, two bid. Only the consortium of Siemens/Rampini fulfilled all requirements, and was awarded the tender.
- Training on how to drive the new e-buses has been conducted for all bus drivers of Wiener Linien. Retraining directly at the charging station was necessary. Drivers have less space in the e-buses than in the previous buses.
- For external communication, Wiener Linien gave a press conference after the



introduction of the first bus. On the buses is written *ElectriCitybusse – emissionsfrei unterwegs* (travelling emission-free). Except for this, publicity on the buses is prohibited in order to maintain the design.

- Passengers do not notice the difference between the electric and previous buses when inside, but the charging process arouses their interest.

## Technology

The buses recharge at their end stations by hooking up to the overhead lines of the Viennese tram using an extendable pantograph, an arm on the roof. The overhead lines from the tram system supplies direct current, however alternating current is required to recharge the bus. As the bus needed to connect to the power lines without additional equipment, both the charger and inverter were requested to be included in the bus – a feature which had not been available on the market until then.

The direct current is converted to alternating current by an IGBT power inverter included on the bus. Not more than 30% of the batteries' power is used for each circuit, so each recharging process only lasts five to eight minutes, during which passengers can get off and on the bus. At night, the batteries are recharged at the depot.

With this recharging technique, it is possible to install a smaller battery system (nine lithium iron phosphate batteries with a total capacity of 96 kWh instead of the 180 kWh electric buses usually need). Like this, the buses still need a stronger rear axle, but have space for 46 passengers, as many as a comparable diesel driven bus. Batteries also last longer (at least four years), because they are always being fully recharged. In addition to the drive system, the batteries supply all of the onboard electronics, the heating and the air conditioning. Thanks to regenerative ESB braking systems, the buses can also recover energy.

“ElectriCitybusse” have a top speed of 62 km/h and a range of up to 150 km without recharging (the distance decreases to 120 km in winter when the heating system consumes ca. 7 kW more energy).

## Costs

Wiener Linien run 480 buses in total, so the twelve electric ones cover 2.5% of their fleet.

Each electric bus cost €400,000, double the cost of a comparable diesel bus. Prices are likely to drop as production rises, however. In addition, the additional charging infrastructure costs included a charging point at each end stations (each costing €90,000), and charging point at the bus depot (€320,000).

The operating costs of the electric buses offset some expenses. Prices for electricity are significantly lower than for diesel. In terms of maintenance, electric buses will save about one third compared with diesel buses (with maintenance costs estimated at €8.000 per year) which themselves have lower maintenance costs than LPG buses. According to regular reliability monitoring, buses only require maintenance every second week on average, less frequently than the previously used liquid gas driven buses. They can then be substituted by one of the three buses in reserve before customers even notice.

The operation of “ElectriCitybusse” is also less expensive than of other hybrid or electric buses, because the quick recharging allows them to use a smaller battery, which makes them lighter, and no new infrastructure had to be built.



## Environmental impacts

How environmentally friendly electricity actually is depends on its sources. Wiener Linien source 100% of their energy from the city-owned electricity company Wiener Stadtwerke of whom they are a subsidiary. One half of their supply derives from water, one third from wind and the rest from gas power, so mainly from renewable sources.

According to calculations of the Technical University of Graz, “ElectriCitybusse” will reduce emissions of CO<sub>2</sub> by 5.3t, of NO by 1.7t and of NO<sub>2</sub> by 0.06t per year compared to the liquid gas buses which had been used before. As NO<sub>2</sub> is far more dangerous to health than NO, it was considered very important to split NO<sub>x</sub> emissions. NMHC and particulates have not been measured, as the EURO VI standard already ensures that their values are below the European limits.

The environmental and as well social impacts caused by the batteries should also be taken into account. Their production takes place in China and requires rare earths. These are extracted with toxic acids which are, especially in the many small, rural and illegal mines, prone to be released into the general water supply.

## Lessons learned

- Unexpectedly, recharging only takes five to eight minutes and passengers can get off and on the buses during this time. For future tenders, Wiener Linien will therefore specify a significantly lower charging time of max. 5 min. for minibuses and max. 10 min. for buses of twelve meter length.
- Mostly in winter, the outer batteries got colder than the inner ones, which creates problems as electricity tends to be drawn from the warmer batteries. Special heaters for the outer batteries have therefore been installed. Costs had to be covered by the supplier.
- From spring 2014 on, Vienna will investigate how batteries could be reprocessed and reused, instead of being disposed of.
- Vienna plans to purchase other, larger electric buses, too. Around the turn of the year 2015/16, a 12m bus will be tendered for. The purchase of an articulated bus is also planned.
- Siemens is negotiating with other cities in Europe and in South America that have existing tram lines and might adopt the Vienna system.

## Contact information

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