



The 10.7-meter Bozankaya-TCV Sileo has an empty weight of 12,200 kg, around 1,200 kg heavier than the corresponding diesel variant. The lithium-yttrium-ion batteries are housed on the roof, the hood will be modified. The batteries provide 200 kWh of usable energy. The entire drive system is duplicated: should one of the two battery sets, inverter, the drive control or DC-DC module for the on-board power supply system fail, you could continue with the same performance, says Stefan Rudolph, who has taken place on the driver's seat for the photo. In addition to ensuring the operation, this redundancy serves the protection of the components.

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 Photos: Kirsten Krämer, Bozankaya GmbH

SILENT REVOLUTION

BOZANKAYA-TCV SILEO

“A single electric vehicle can ferry hundreds, if not thousands, of passengers within local public transportation. Electric mobility delivers the greatest gains for quality of life, while receiving high levels of acceptance as well as being economical,” asserts Stephan Rudolph, project leader, Sileo Electric Bus.

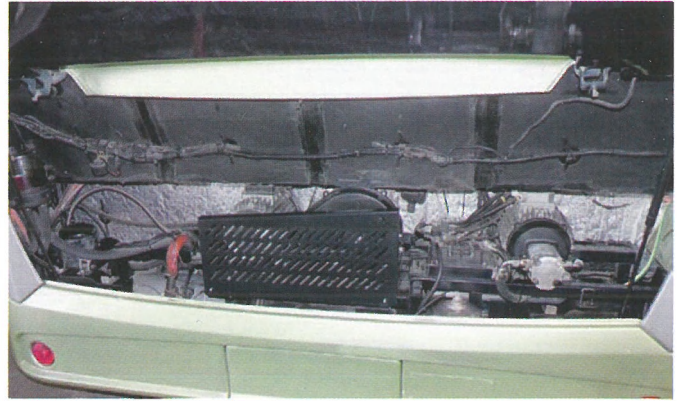
Owner, Murat Bozankaya is driven by similar ideals, “If we just wanted to build vehicles, we would develop motors with extremely low consumption levels; anyone can build a car body. We want to do something for the environment. Electric buses are the future, this is our firm belief.” With two such dedicated mentors, it is not surprising that the entire team

is highly motivated, realizing, among other things, this project in record time. With this new model they are about to leave most of the larger western European omnibus manufacturers behind them, an accomplishment financed out of pocket without subsidies. They also have found the perfect product name: Sileo, deriving from the Latin word *silentium*,

meaning quiet or silence. Sileo is a Turkish-German coproduction: the car body originates from TCV in Turkey. The entire drive propulsion system and battery technology is from Germany. Bozankaya Business Consultant & Commerce (BC&C) in Wolfenbüttel adapted or developed these products specifically for utilization in bus applications.



Sileo is available with two or three entrances. The prototype doors were supplied by the Turkish manufacturer Revar and operate pneumatically. The Sileo series will be outfitted with Bode electric CADS doors. The battery sets are still clearly visible from the rear. The two flaps on the rear right are used to connect the charging plug (top) and for the fuelling of diesel (below) for the heater operation. All TCV buses are manufactured with a raised roof and are therefore universally suitable for the various forms of traction.



Rarely do you find the engine room of a city bus so empty. Aside from the compressor unit with its non-synchronous electric motor, two inverters and the diesel tank for heating, only small parts were housed here. Additionally no danger can arise from this area.



Currently you can clearly see the battery packages arranged lengthwise left and right the roof of Bozankaya test bus. To protect them in the event of a frontal collision, in the series they are covered with a bulkhead and recessed 100 mm in the roof. This is made possible by eliminating the air conditioning ducts in the roof. Front and rear will each receive a streamlined cover.

TCV Centravel, known as Karat in Turkey, forms the basis. Complete car bodies are shipped to the Bozankaya plant in Salzgitter-Watenstedt, where they are finished into Sileo. This task sharing will also carry over into the serial production.

TCV, Turkish Commercial Vehicle, is still a young bus manufacturer, its first vehicle premiered April 2012.

The company belongs to the Bozankaya Group, known primarily as a system supplier for the bus and rail industry. They have since established themselves as manufacturers of omnibuses and light rail vehicles, as referenced in the article about the Trambüs in Omnibusspiegel 14-4.

Emphasis on Efficiency

With their first public appearance at Busworld Istanbul 2012, TCV was clear that electric buses are on their agenda (see OS12-4). Now the time has come, the first prototypes have successfully driven thousands of kilometres and Sileo's premiere is scheduled for September at the IAA in Hannover. We took an exclusive test drive and spoke to Murat Bozankaya and Stephan Rudolph about their strategic plan and technology.

Prior to utilization, every component was scrutinized and modified where needed in order to fulfil efficiency, life cycle and comfort standards. This begins with the rear axle, a ZF electric axle type AVE 130 with two asynchronous motors. The drive was designed by BC&C to ensure the best driving comfort, the highest

operating efficiency and the ideal system integration. Secondary equipment was critically examined, regarding energy consumption and weight. In some cases, this meant that new equipment was developed, because the units available on the marketplace did not satisfy the high demands. A good example of this is the air compressor developed with a partner: it compresses 240 l per minute to 10 bar and using on average no more than 180 W, one tenth of the commonplace compressor. Weighing in at 6 kg, it is extremely light, an additional advantage when comparing electric compressors.

The high voltage components are installed on the roof, whereas the low voltage axillary equipment such as the air compressor and power steering pump are arranged for easy access in the lower area. A three-phase asynchronous motor drives them, because it is considered the most reliable and secure.

The air conditioner, Spheros Citysphere, was chosen for its low power consumption. Its power supply is supplemented by elastic rooftop solar panels, supplied from within the Bozankaya Group/Alfasolar.



Our test bus has 32 seats available; the total capacity is just under 90 people. By eliminating the engine compartment, rear left, a second special use area can be incorporated.



Sileo has an ergonomic VDV workstation in its currently available form. In the series, it will receive its successor, developed by Continental, in which the consumption data is displayed in the dash panel.

In order to keep the power usage for cooling and heating at a minimum, Sileo will also be available with double paned glass. This insulation adds weight, but improves efficiency so that it is worth it bottom line.

The heating concept is an in-house development: an oil-fired Spheros auxiliary heater with an energy to heat conversion efficiency of nearly 100%, as well as an electric heater are used. Alternatively, a heat pump could be utilized. A purely electric heater is not considered sensible for energy efficiency reasons. Customer can also choose this alternative, if they wish, but it comes at the expense of range.

Rejuvenation

The self-developed SCL technology represents the core of the vehicle. SCL stands for single cell loading, a process that increases the efficiency of the battery and drive. This subject is dear to the heart of the research and development team, because this is what clearly sets Sileo apart from the competition.

"We have two integral foundations to our development strategy", explains the graduate physicist. "Firstly, we don't do anything that is not physically and technically feasible and secondly, we do not develop anything

that we cannot control." Stephan Rudolph remarks. The relationship between the power drive and the battery design parameters of most batteries are not compatible, causing damage. Against this backdrop, the company was not satisfied with the available battery systems, so they developed their own.

In order to understand the advantages, we will have to immerse ourselves into the fundamentals of physics: The less capacity a single battery cell has, the higher its internal resistance when energized. This leads to the generation of heat, which means not only a loss of energy, but also requires additional cooling, which is difficult and expensive. For this reason, the team chose suitably efficient cells. This is just half the battle, conventionally, the cells are then connected in series to obtain the desired voltage curve; at Bozankaya there are 150 in each case. High-performance cells are also subject to fluctuations in relation to production and its efficiency in energy conversion (electrical into chemical or vice versa). When individual cells are full, but others not, current must continuously be supplied in order to achieve the desired energy content for the entire battery. This inevitable phenomenon is called disbalance. The fully loaded cells cannot absorb more

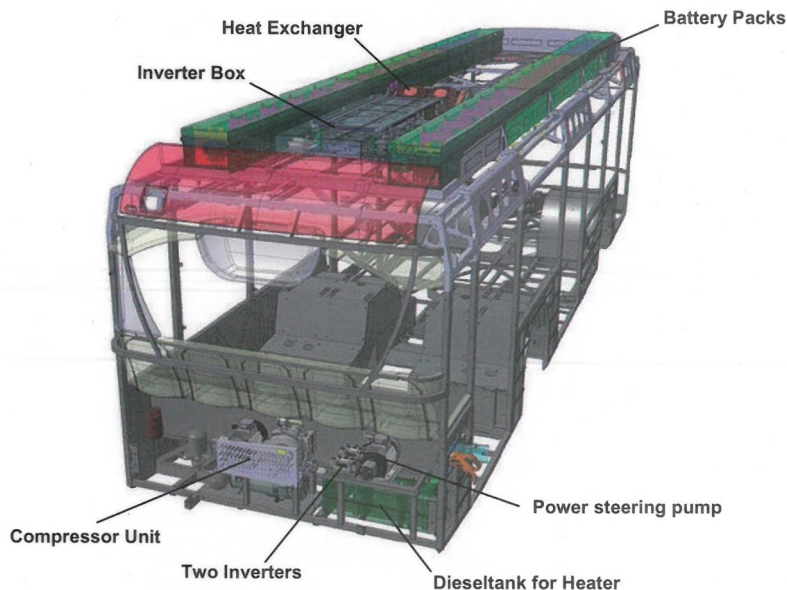
energy, causing the battery management system (BMS) to engage, resulting in heat production.

The approach to disbalance is the highlight of the Bozankaya batteries: each cell has its own, active BMS, which can transport energy with an efficiency of up to 96% from a full cell to one with a higher power demand. You charge using 200 kW with losses of less than 5% with the SCL technology," Stephan Rudolph says confidently. "SCL ensures that each cell is always running in the optimum operating range. Because minimal internal resistance is manifested, there are hardly any losses."

Due to their design, the SLC batteries are also able to absorb brake energy; up to 500 kW can be regenerated and stored. It should be emphasized that approximately 40% of the energy from the battery used for traction can be fed back to the battery via recuperation.

Personal Experience

So much for theory, we asked ourselves how Sileo performs in practice. We therefore visited the Bozankaya headquarters in Salzgitte-Watenstedt to test drive the electric bus. The excellent acceleration capability of the test bus, although not completely loaded, is impressive.



“The starting torque would still be sufficient if we would switch one of the two wheel motors in the ZF electro-axis”, Stephan Rudolph notes. We did not want to go that far during our test drive, but we tried a hill starts - with convincing result: even on a slope, Sileo accelerates quickly. This is true, according to the engineers, even when fully loaded.

The energy consumption we achieved without major driving instruction was very impressive: for a distance of 67.2 km, we used 0,620 kWh per kilometer. “Even the loaded bus, using all common application profiles, always remains under 0.8 kWh”, says Stephan Rudolph. Under these circumstances, the 200 km range that Bozankaya guarantees its customers is very conservative. We could have driven a good 280 km on our test drive, had we fully exploited the available amount of energy in the batteries.

During our test run, the recuperation rate was 39.6%. In order to achieve such high values, the batteries must be designed to quickly absorb high amounts of energy; this is the case with Sileo. A feature of all electric buses is that you suddenly become aware of the auxiliary consumers because they are not drowned out

not by the diesel engine. However, the ZF axle is relatively loud in this case, but the Friedrichshafen Company plans to reduce the noise level by year-end. The electric brake can be used with a foot pedal in addition to a hand lever, similar to a retard lever. However, this lever has more functions: You can adjust whether and how much the bus brakes and recuperates when you take your foot off the gas. For interurban routes level one is recommended, whereas for inner city runs level two is preferred. The setting of the brake level has a direct influence on the pedal path for acceleration. The higher the brake level is set, the longer the pedal path to achieve a certain speed. As a result, the bus accelerates slower in the city.

There is much to do

In addition to the 10.7 m version, a version with 12 m total length is feasible due to the modular design. Next year an articulated version will be introduced. A designed variation comparable to the Trambüs is also conceivable. Soon the first Sileo with the final design, including a modified roof cover, will come to Germany; it can be admired both statically as well as dynamically at the IAA

Commercial Vehicles in Hanover. In addition, a zero series of ten buses, primarily for demonstration purposes in various countries, will be built. Early 2015 the first order of 20 vehicles for a Western European customer will be processed.

Murat Bozankaya pursues quite ambitious goals for Sileo, both in terms of the development as well as in sales: by the end of 2017, he wants to sell 1000 vehicles in Europe and North America, and beginning in 2018 it will be 1000 buses a year. “The number is not high if the buses prove themselves and the municipalities recognize that this is what they need”, he comments.

The owner ensured us that Sileo’s price is competitive, although he chose not to put a price tag on it just yet.

Technically, high on the agenda is a further significant weight reduction. Murat Bozankaya does not want to discuss how he plans to achieve this. Considering the target of 1 – 2 tons, drastic measures will be required; a simple reduction of wall thickness or switching to other cladding materials, cannot achieve these numbers. We saw an old Neoplan MIC (Metroliner in Carbon Design, an all-plastic car body) on the premises, was this a coincidence? In any case, the highly dedicated team surrounding Murat Bozankaya and Stephan Rudolph will continue to be full of surprises, wanting to keep one-step ahead of the competition.

>>Dieter Hanke / Kirsten Krämer
>>Translation, Christine Bozankaya



At the start of our test drive, the settings were set to zero, so that we

could immediately see all the parameters at the finish.