Magically Stocking Up on Power

If there were only electric cars driving on Swiss roads, the country could reduce its total energy consumption by a quarter—this has been Josef Brusa's vision for over three decades. The electromobility pioneer from eastern Switzerland is currently building with his development firm Brusa Elektronik AG, an inductive charging station. With it, electric cars can be powered up as if by magic.

Pilot project of an inductive charging station for electric vehicles: Josef Brusa holds the small plate that is installed in the underbody of the car. Photo: B. Vogel

Dr. Benedikt Vogel, commissioned by the Swiss Federal Office of Energy (SFOE)

For several years now, e-bikes have been considered chic. However, the idea behind electric bikes is much older. One of the predecessors made by Flyers and Co. is the SOFA, a solar cycle. A group of young visionaries put these makeshift vehicles together in the early years of the green movement. A solar roof supplied the power for the sofa. The drive came from a young electronics engineer. His name was Josef Brusa who had at that time, in 1981, just graduated from the Interstate University of Applied Sciences in Buchs / SG. The young engineer was among the pioneers of solar power, whose electric vehicles strove to win the 'Tour de Sol' competitions. The first 'Tour de Sol' competition was launched in 1985. This was also the year in which Josef

A technical report about innovations realized by Brusa Elektronic AG. The innovations partially have been financially supported by the Swiss Federal Office of Energy.

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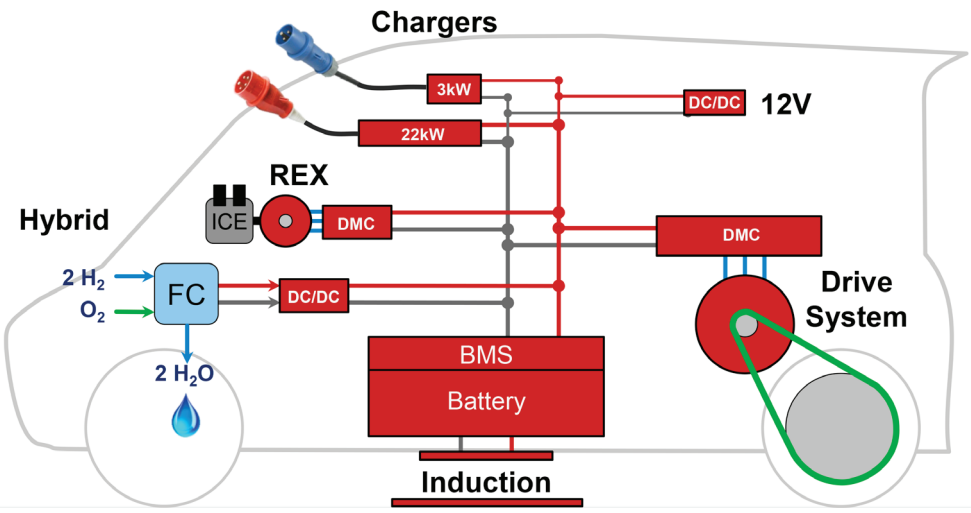
Brusa's fascination with alternative drive systems turned into his profession. He founded a company that produced components for solar and electric vehicles.

Think Tank for electromobility in Sennwald in the St. Gallen Rhine Valley: Brusa Elektronik AG. Photo: B. Vogel

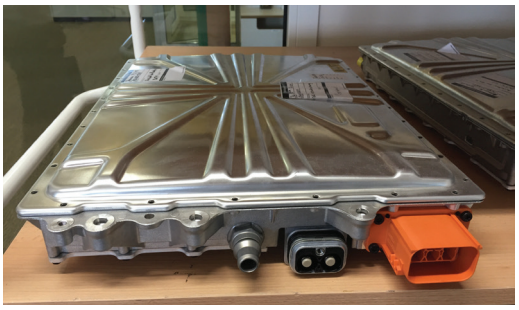
Think Tank for Electromobility

Thirty years later, Brusa Elektronik AG is renowned worldwide and has tight supplier relationships with automotive companies such as Daimler, BMW, Volvo, VW, Audi, Magna Steyr and American and Asian manufacturers. With the development and production of electric motors, batteries and power electronic components for electric vehicles, the 120 employees of the Brusa Elektronik AG turnover around 25 million Swiss francs a year (2015). On the company parking lot in Sennwald / SG, stand several alternative energy vehicles each outshining the next: a Renault ZOE, a Opel Ampera and a Volvo C30 Electric- a Tesla is in transit today. Josef Brusa, the company head, doesn't yet drive a fully electric vehicle. Instead, he has a Toyota Prius hybrid. "When I bought my car ten years ago, there were not yet pure electric vehicles on the market," says the 58 year old, as if he were apologizing for a mishap.



Representation of Brusa components (in red), which come in various electric, hybrid or fuel cell vehicle applications. In addition to Drive Systems and Batteries, Brusa provides a range of power electronics components: ***Chargers*** *with capacities of 3 and 22 kW.* ***DC / DC converters*** *that transform the battery current (400 V) to 12 V for use in lighting systems, radio, etc..* ***Converters (DMC)*** *in hybrid vehicles that transfer the alternating current (from an internal combustion engine (ICE)) from the* ***Range Extender's (REX)*** *generator into the direct current of a battery.* ***Converter (DMC)****, which transfers the battery's direct current into alternating current for operating drive systems.* ***DC / DC converters*** *that transform the direct current from a fuel cell (FC) to a 400 V battery.* ***Battery Management Systems (BMS)*** *to control the battery.* ***Inductive charging stations*** *for wireless charging. Graphics: Brusa*

From the parking lot to the production hall there are only a few steps to where Brusa chargers with varying storage capacities for electric vehicles are produced. The smaller chargers provide 3.5 or 7.2 kW of power, larger chargers can provide 22 kW, which are then incorporated into the electric Smart car in a factory in Hambach (Lorraine / F). In addition, the company manufactures a wide range of power electronic components for electric vehicles: Converters, which produce from the DC voltage of a battery alternating current to drive electric motors; Or DC / DC voltage converters that transform battery current (400 volts) into 12 volts for use in car radios, windscreen wipers and lighting systems; Or battery management systems, affecting the reliability and life of the batteries significantly.



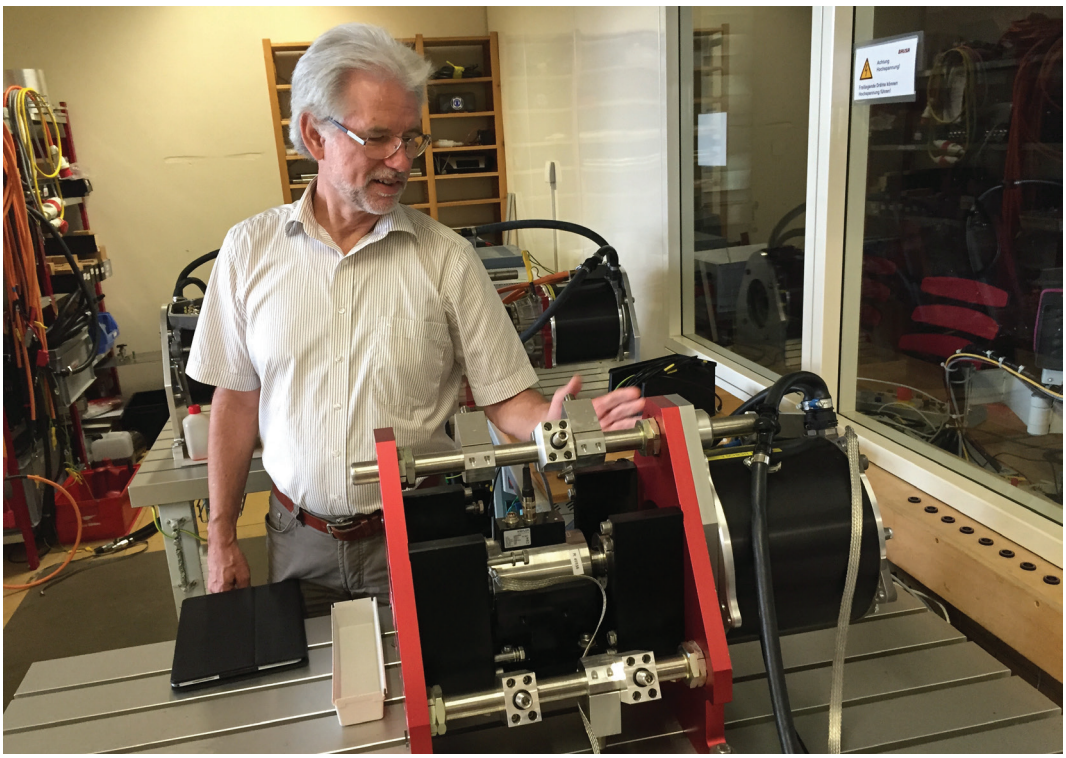
Chargers of this type with 22 kW are installed in the Electro-Smart car, for example. Photo: B. Vogel

An even greater site of production at Brusa Elektronik AG is the research and development department. "The company is a think tank, and the boss Josef Brusa is a Steve Jobs of electromobility," says Martin Pulfer from the Federal Office of Energy, that has continually supported Brusa'a innovative projects since 1991. Three-fifths of Brusa's workforce works in the research and development department. Every year some 100 000 francs flow into filing new patents. The St. Gallen firm accompanies the entire development chain from idea through product development, commercializaton and testing to series production. This makes it ideally positioned for equipping test fleets with large numbers of devices, enabling power of several hundred vehicles, for example, or small series up to several thousand pieces.

Comfortable Recharging Like Never Before

Josef Brusa leads visitors through the development department, past benches and measuring devices and workplaces with software tools for magnetic, thermal and mechanical calculations, to rich printed circuit boards, that cannot be photographed. Trade secret! Josef Brusa stops at a black monster that consists of a fixed and a loose plate. "The lower plate is installed at home in the floor of the garage, the loose plate is placed into the car. This inductive charging station will enable contactless charging of electric cars without connectors within 2 to 3 years," says Brusa. Owners can park their electric cars in the garage at night where the battery will be automatically recharged overnight. By morning the battery will be fully charged and the car will be ready to go. Indeed the loading capacity of the system at 3 kW is just about the same size as the smaller built-in chargers, but more convenient. A convenient solution for vehicles in the upper price segment, says Josef Brusa.

The inductive charging station is only one of Brusa's current development projects. Partners in the boat are two German carmakers, Daimler and BMW. The market potential of inductive charging stations is large. But also large are the demands of the developers. While an electric toothbrush with a capacity of less than 1 W can be inductively charged, the capacity should be 3.7 kW at the charging station for electric cars, about 3700 times more. The charging infrastructure in the car must be compact, work at high efficiency (> 90% at 13 cm ground clearance), and should cost as little as possible. In order for the charging station to work, a detection system must notify the driver whether the car is sitting correctly on the charging area- the



At this test stand, engines of up to 150 kW can be tested. Photo: B. Vogel

error zone is sideways at 15 cm and 7.5 cm in the direction of travel.

In addition, there are security issues that keep the Brusa engineers on their toes: The charging process must stop automatically, if the cat could be hurt, or if the electric field of the aluminum foil of a dropped box of cigarettes is liable to ignite a fire, for example. The regulations regarding electromagnetic radiation must be complied with, which should be relatively easy since the magnetic fields in the FRAME technology developed by Brusa are lower than, for example, those in an inductive stove hob. To check the reliability of its inductive charging system, there is in Sennwald a climate cabinet. Here the new charging technology is exposed to shock-like temperature changes ranging between 80 ° C and -40 ° C. Additional tests to evaluate the robustness of the equipment to salt spray and vibration are also done. At present, the Brusa experts test the smooth interaction of all components. If the inductive charging station functions as desired, the plan to is to commericialize the station, in cooperation with partners, and also to construct production lines for subsequent series production.

Electromobility Ushers in the Switch to Renewable Energy

Josef Brusa sits in a meeting room in front of a PowerPoint presentation, with which he repeatedly answers the central question that people around the globe always ask: Why must we drive electric cars in the future? The engineer clicks through the graphics. The comfort in which we live is 80% based on fossil fuels. Moreover, internal combustion engines waste much of this fossil fuel energy since they only have an energy efficiency of 15%. “With electric cars, the efficiency is 4 times higher, we can bring 60% of the energy to the wheel,” says Brusa and concludes: “If the Switzerland completely switched to electric vehicles, total energy consumption could be reduced by a quarter.”

Electromobility would not only enable the switch from fossil fuels to renewable energy sources on the road, but also on waterways. On the road, electric vehicles emit no gasses

or particulate matter. At lower speeds, they are less noisy, particularly in residential areas. Impressive advantages, says Josef Brusa, who then momentarily transforms from engineer into dedicated transport politician: He is calling for a well-developed charging infrastructure based on a unified standard. He is calling for incentives to promote electric mobility, similar to Norway's example. He is calling on replacing the current toll road pricing model in Switzerland with road pricing that favors electric cars. The driving range of electric vehicles, which is sometimes held against them, is not a real obstacle to Josef Brusa. Depending on the desired distance a person wishes to drive, in the future one could simply install the appropriate battery. Those who want to drive farther distances, will have to pay a bit more for greater electricity storage capacity.

From the Exotic to Everyday Product

Technically, there are no more obstacles to the electric car becoming widespread, says Josef Brusa. "We have been working on this for 30 years." The 30 years in which the electric car has gone from exotic to everyday vehicle is a long story with many small and large advances along the way. Around the turn of the millennium came the development of the hybrid synchronous motor, a powerful engine, which gave electric cars a development boost, as did lithium batteries, which arrived on the market around the same time. In the 30 years since Brusa Elektronik AG was founded, seven generations of chargers have been developed. The inductive charging station represents a continuation of this innovation.

The company has been repeatedly bestowed with innovation awards. In 2012, the award was for a quick charger with 22 kW of power, which recharges a battery 6 times faster and in considerably less than 1 hour. One year later, the all-electric truck E-FORCE ONE with a peak output of 300 kW (408 hp) and a range of up to 300 km caused a furor—Brusa had equipped the E-Truck with two electric motors, chargers and converters. The electrical engineer currently develops in Sennwald for a Japanese manufacturer, a converter for fuel cell operated cars that supplies the motor of the air turbine (200 000 rev / min) with electricity.

"If the political will is there," says Josef Brusa, "by 2050 we can replace Switzerland's traffic with half hybrid and half pure electric cars." Josef Brusa already started working towards this goal in 1980, 35 years have since passed. There is still 35 years to make this vision a reality.

- www.brusa.biz
- For information on the SFOE-projects with Brusa Elektronik AG, contact Martin Pulfer, head of the SFOE-research program Transport: martin.pulfer[at]bfe.admin.ch
- For more technical papers on research, pilot, demonstration and flagship projects in the transport sector, please use this link: www.bfe.admin.ch/CT/verkehr

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