

# CURRENTS IN ELECTRIC CARS ARE WELL SHIELDED

One might think that when people are driving an electric car, they are likely exposed to stronger electric, magnetic, and electromagnetic fields (EMF). However, a study has now reached a different conclusion. Extensive measurements during the use of electric vehicles suggest that people are not more highly exposed while driving electric cars. The reason is likely that the batteries and electric motors are effectively shielded.

Vehicles with internal combustion engines are equipped with a variety of electrical components, including ignition, lighting, assistance and automation systems, as well as communication and entertainment electronics. Electric vehicles (EVs) add more electrical components, especially for propulsion and the batteries. All of these components generate electromagnetic fields (EMF). Depending on their oscillation and propagation behavior, these are divided into high-frequency and low-frequency fields (the latter group in the present context also includes static fields from direct currents). In low-frequency fields, the electric and magnetic fields are considered separately. In high-frequency fields, the two fields are closely coupled, so they are measured together as an electromagnetic field.

Over the past two years, a research project sought to answer the question of whether people driving electric cars are exposed to particularly strong or additional EMFs, and whether



Measurement of magnetic fields during charging. Photo: Fields at Work

there might be previously unrecognized radiation exposures. The project was conducted by the Forschungsstiftung Strom und Mobilkommunikation (FSM) and by Fields at Work GmbH, which specializes in EMF measurements (see box p. 4). The SFOE financially supported the research project.

### Test Drives around Lake Zurich

In our modern, technologically supported daily life, people are constantly exposed to electric, magnetic, and electromagnetic fields at home, on trams, at the train station, or at work. The situation in a car is special in that passengers are sometimes exposed to a variety of fields from various sources for extended periods, all within a confined space. Against this backdrop, the research team set out to determine the EMFs in electric vehicles through a series of measurements, providing clues to possible exposures.

The scientists conducted EMF measurements in five electric vehicles and, for comparison, in a diesel-engine car. During 10 measurement trips on two routes around Lake Zurich, high-frequency fields (90 to 6000 MHz) were measured, which are typically used for radio broadcasting, mobile phones, navigation systems, or Bluetooth interfaces. Additionally, they determined the low-frequency magnetic fields (up to 100 kHz) typically generated by direct currents in batteries and electric motors. The test cars were equipped with measuring devices at seven locations inside the cabin (see figure on the right). These devices determined the fields to which drivers and passengers were exposed in various situations (driving, accelerating and braking, regenerating, charging, and standing still). Low-frequency electric fields were not measured because they can be easily shielded and are therefore considered harmless.

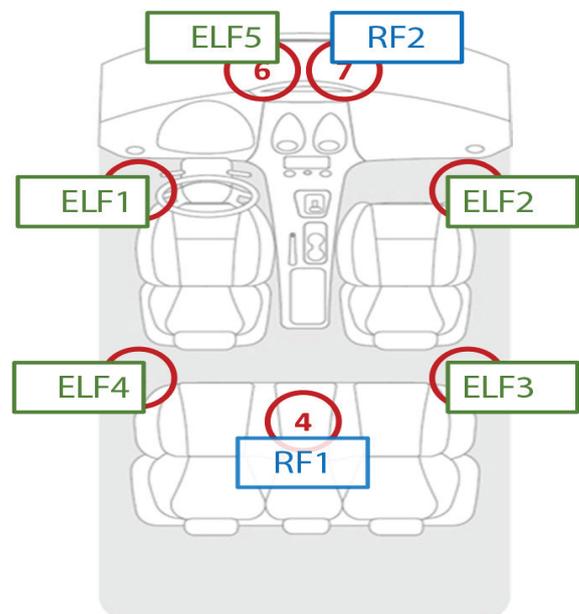
### EMF Emissions «Unproblematic»

«The measurements have confirmed that EMF exposure in electric vehicles is significantly below the limits,» says Jürg Fröhlich, CEO of Fields at Work. High-frequency electromagnetic fields averaged up to a maximum of 10% of the limit, while low-frequency magnetic fields averaged less than 5% of the limit. Sporadic and typically localized peak values reached 50% of the limit for low-frequency magnetic fields. The internationally established guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) were used to establish the limits. In the final report of the research project, the scientists assess the EMF exposure in electric cars as comparable to conventional cars: «To the



Measuring device for low-frequency magnetic fields on the back seat. Since the strength of EMF fields varies by location, three positions were measured: directly on the backrest, about 5 cm from the backrest, about 10 cm from the backrest (shown). Photo: Fields at Work

extent that the results of this study can be generalized, the electric propulsion with energy from a battery appears unpro-



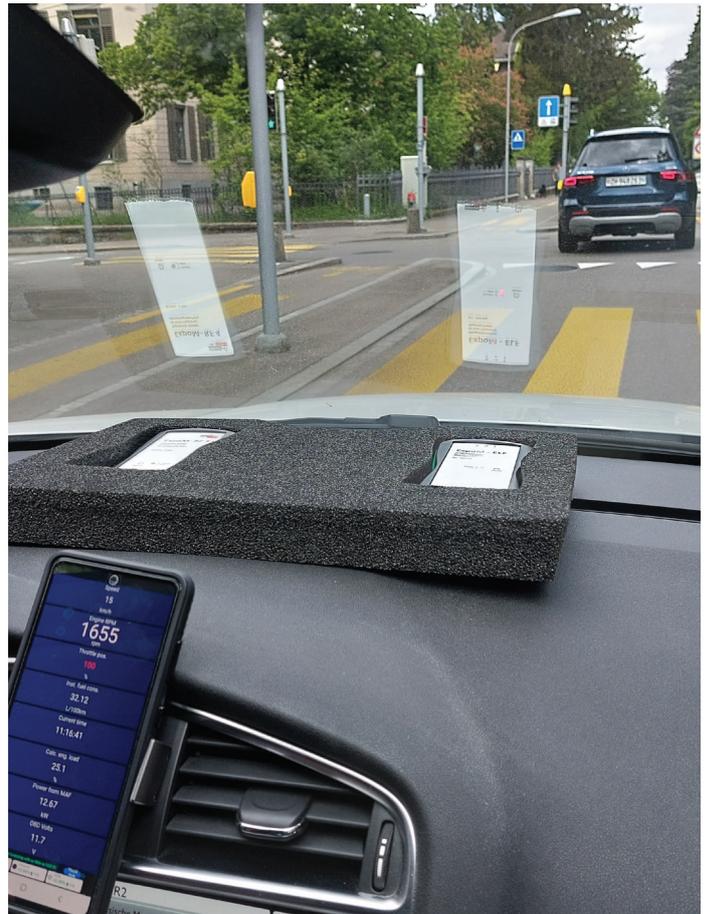
The test cars were equipped with five measuring devices for low-frequency magnetic fields (ELF) and with two measuring devices for high-frequency electromagnetic fields (RF). A sixth ELF measuring device was used for measurements during charging stops. Illustration: SFOE final report

blematic regarding additional EMF emissions,» they wrote.

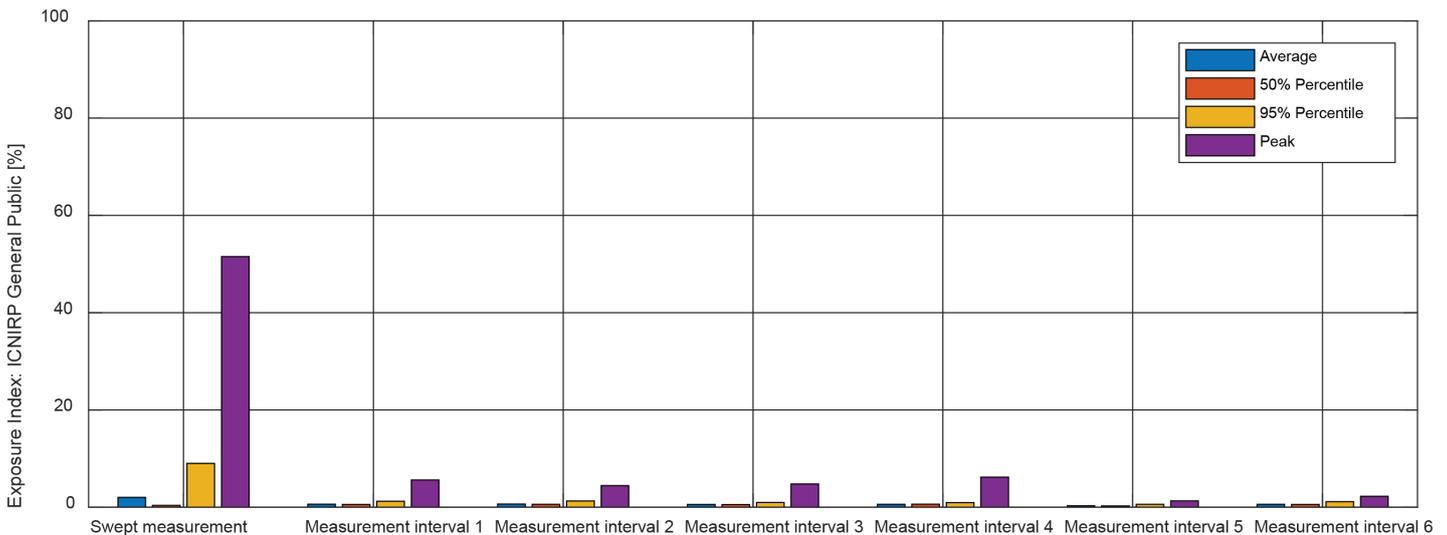
The results confirm the findings of earlier studies on the subject. Nevertheless, for Marco Zahner, who led the project at Fields at Work, it is somewhat surprising: «We expected that we would measure stronger EMFs in electric cars because of they are equipped with batteries and electric drive. In the end, we were surprised at how little the additional electrical drive components of these vehicles were reflected in the measurements.» According to the researchers, the additional contributions from the electric drive and its components do not significantly alter the exposure situation and do not pose an additional health risk. This finding confirms that manufacturers of electric vehicles have made the necessary efforts to shield drivers and passengers from the fields. Interestingly, the largest fields were measured, for example, at the seat heater, a vehicle component not specific to electric vehicles.

**Regulatory Clarification Needed**

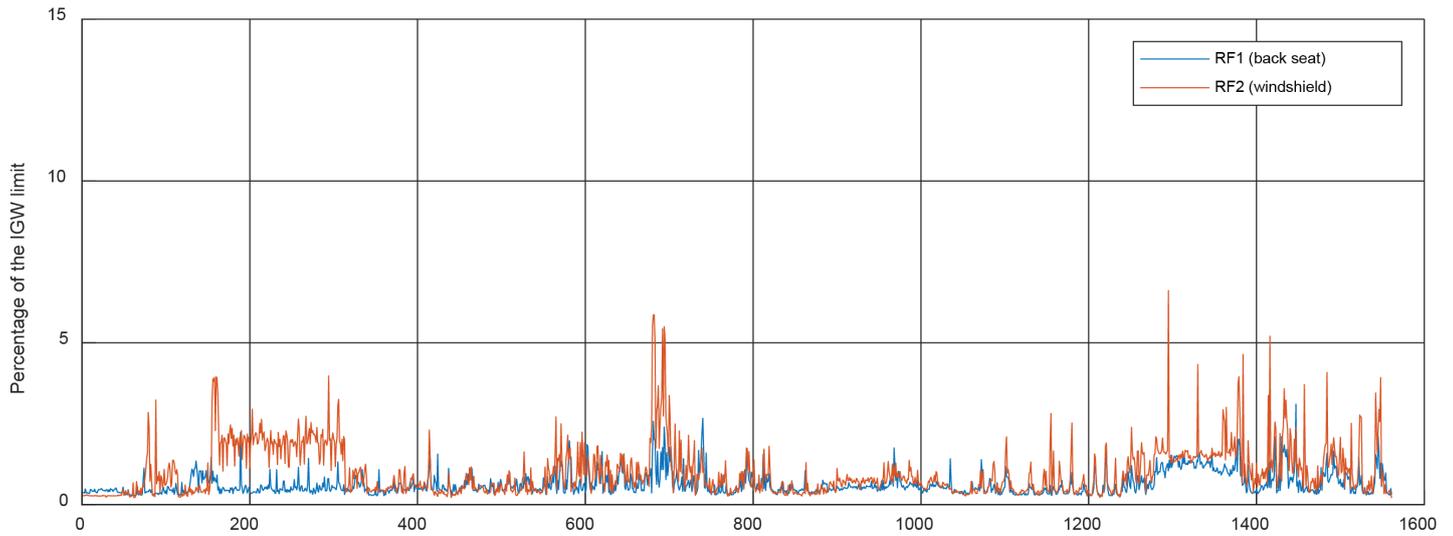
«Our study was designed as an initial study to determine whether previously unrecognized or underestimated exposures to EMF exist in electric cars. We did not come across any such risks,» summarizes FSM CEO Jürg Eberhard. Eberhard, however, finds it unsatisfactory that no clear limits have been set for exposures in car interiors. Should they correspond to the limits for public spaces (as used in the study)? Or should they be set at the more stricter limits applicable in private



The device on the left under the windshield measures high-frequency electromagnetic fields, while the device on the right measures low-frequency magnetic fields. Photo: Fields at Work



Result of the measurement of low-frequency magnetic fields during the six measurement intervals of a test drive (and a swept measurement, which records magnetic fields of a stationary vehicle with the motor running). The column height represents the percentage at which the ICNIRP limits have been reached. Hundreds of readings were recorded in each measurement interval. They are shown here with different statistical weights in column form (blue, red, orange). The purple columns represent sporadically measured peak values. These peak values also remain well below the ICNIRP limits. Graphic: SFOE final report



Result of the measurement of high-frequency electromagnetic fields during the first 26 minutes of a test drive in the back seat (blue) and under the windshield (red). The measured values are well below the ICNIRP limits. Graphic: SFOE final report

homes or schools? Here, clarification of regulatory requirements would be desirable, according to Eberhard.

Electromobility is evolving dynamically. A final assessment of EMF in electric vehicles is therefore not possible. Regardless

of the type of propulsion, attention must be paid to further technological development, particularly regarding the trend towards increased networking and digitization, emphasize the authors of the final report. Wireless power transfer deserves special attention if this charging technology becomes

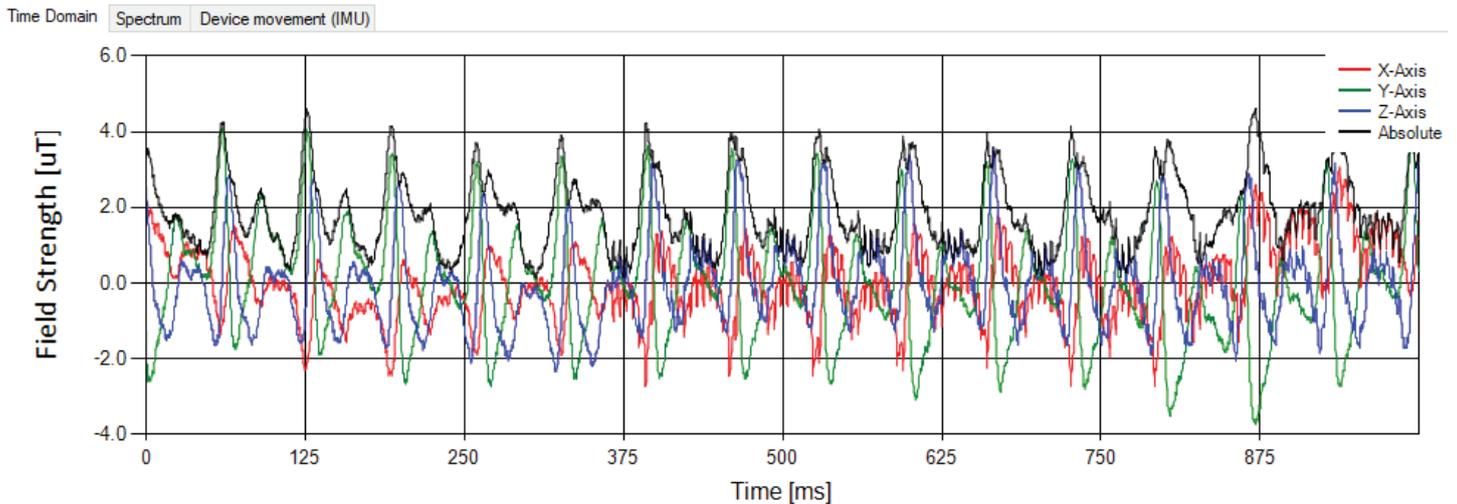


Chassis of an electric car with drive train and power lines. Photo: Shutterstock

## THE RESEARCH TEAM

The Research Foundation for Electricity and Mobile Communication (FSM) is based at the ETH Zurich. It promotes scientific research on the opportunities and risks of technologies that generate and use electromagnetic fields (EMF). The FSM currently receives funding from Swisscom and Sunrise, from the Swiss transmission grid company Swissgrid, and from the companies Cellnex and Ericsson. Sponsors include the Federal Departments of Energy, Health, Communications and Environment, as well as various associations (such as Electro-suisse and VSE) and non-governmental organizations.

Fields at Work GmbH emerged in 2014 from a research group at ETH Zurich. The company's seven employees use specially developed measuring instruments to determine the low-frequency magnetic and high-frequency electromagnetic fields to which people are exposed in everyday life. The measuring devices are mobile and can be carried on the body by people being measured, if necessary.



The determination of EMF requires some detective's intuition. Often it is not clear by which components the measured fields are caused. Sometimes, unusual phenomena are discovered with the measurements. The magnetic field shown here (strength in microtesla) is likely due to tire magnetization. This is the phenomenon where the steel mesh contained in car tires magnetizes under the influence of external magnetic fields (the earth's magnetic field, for example, or during production) and develops into (weak) permanent magnets. If the tires are not demagnetized, a (speed-dependent) magnetic field can be measured while driving. Graphic: SFOE final report

established in electric cars in the future. During the charging process, strong fields are generated, requiring special protective measures.

- The **final report** on the project «Electromagnetic fields (EMF) in electric vehicles» is available at: [www.aramis.admin.ch/Texte/?ProjectID=50465](http://www.aramis.admin.ch/Texte/?ProjectID=50465)
- For **information**, please contact Roland Brüniger ([roland.brueeniger@brueniger.swiss](mailto:roland.brueeniger@brueniger.swiss)), external head of the SFOE Research Program Electricity Technologies.
- Further **technical papers** on research, pilot, demonstration and flagship projects in the field of electricity technologies can be found at [www.bfe.admin.ch/ec-strom](http://www.bfe.admin.ch/ec-strom).