

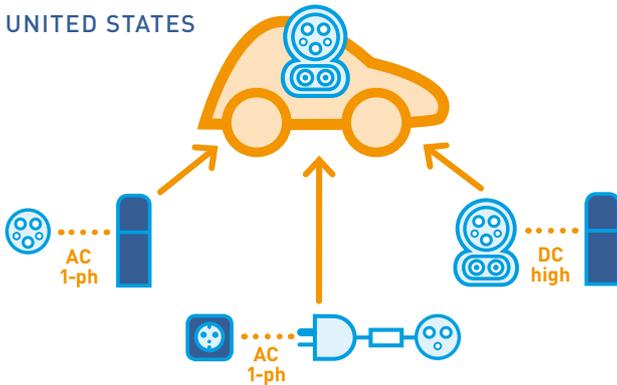
# Combined Charging – the universal charging system Design Achievements

The vast majority of global automotive manufacturers have jointly developed a universal charging system for electric vehicles designed for global deployment – the Combined Charging System. This new concept will result in a uniform standard for every market avoiding regionally diverse systems which, up to now, have impeded standardization and resulted in a costly coexistence. Vehicles featuring the new technology will lead the future of vehicle fast charging and maximize the integration into future smart grids.

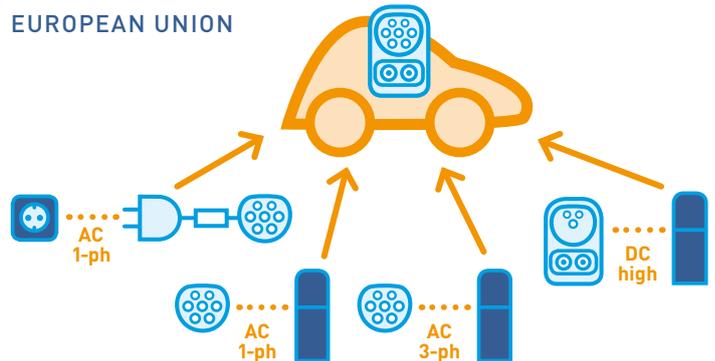
## One charging inlet for all charging options

The Combined Charging System was submitted for International Standardization in January 2011. The system requires just one single charging inlet in the vehicle that can be used for all available charging methods. Possible scenarios include 1-phase charging at an AC power source, high-speed AC charging with a 3-phase current connector at home or at public charging stations, DC charging at a conventional household installation and ultra-fast DC charging at power charging stations. This means that customers can charge their vehicles for several hours overnight using a standard household socket or plug them into public high-speed charging stations so that the vehicle can be back on the road in the shortest time possible. Only one charging inlet is required.

### UNITED STATES



### EUROPEAN UNION



## The Combined Charging System is safe

The Combined Charging System charge inlet complies with all requirements for a universal charging interface. Fitted with all the necessary pins for charging scenarios worldwide, the charge socket also features protective mechanisms for safe charging. For instance, a lock system prevents the connector from being accidentally pulled out of the inlet while charging. The charging process is controlled by special electrical signals from the moment the connector is connected to the inlet until the end of charging. The system also features fully automatic



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digital communication between vehicle and charging station. This allows for complex charging scenarios, including compensating for renewable energy-related power spikes.

#### Compact design features

The charging inlet in the Combined Charging System has an extremely compact design, allowing it to be easily fitted into conventional fuel filler doors of most cars. The existing charge socket (SAE J-1772™), designed to accommodate the 1-phase power supply commonly found in the U.S., has been extended by two pins for high-performance DC charging. The special feature of the SAE J-1772™ plug for AC charging and Combo 1 plug for high-performance DC charging is their compatibility with the new compact charging inlet.

In Europe, on the other hand, the infrastructure is predominantly 3-phase, and the Combined Charging System builds on the existing Type 2 charge socket (IEC 62196-2). Two pins have also been incorporated in the Type 2 plug to create the IEC 62196-3 Combo 2 plug for high-performance DC charging in Europe. The Combined Charging System was designed so that it can be deployed in all international vehicle markets. Its developers have succeeded in creating a uniform standard with identical electrical systems, charge controllers, package dimensions and safety mechanisms for every market. This means that the vehicle and the charging equipment can communicate the same way, enable global interoperability of the system and maximize the integration into future smart grids.

#### Charge communication integrates electric vehicles into the “smart grid”

In coming years it is expected that smart grids will become established in the energy market. These intelligent networks will control electrical devices to accommodate the fluctuating availability of renewable energy sources. Ideally, electric vehicles should be recharged when a surplus of wind and solar power is

available. The Combined Charging System is also capable of interfacing with these intelligent networks. The charge communication mechanism has been designed for integration in the smart grid so that it already meets many future requirements:

- Bilateral control of the charging operation by the vehicle and infrastructure
- Convenient charging options, such as remote charging even when the driver is not present
- Certified payment and billing systems
- Guaranteed electrical safety and data privacy
- Interoperability of certified value-adding services for electric vehicles (e.g., when vehicles are used in car pools).

The charge communication systems standard of the future is currently being developed by the International ISO/IEC 15118 Working Group as well as in SAE Standardization and includes contributions from nearly all global automotive companies.

An efficient and reliable means of communication between cars and the power grid is the prerequisite for the successful market launch of electric vehicles. The SAE Communication Task Force has adopted the most practical solution to use the existing connector for communication: Powerline communication, which runs through the charge cable, is a technology that is utilized for both AC and DC charging. No additional hardware, such as the ones used for RFID or radio-based communication, is needed. This reduces infrastructure complexity and charging technology costs.

#### The Combined Charging System is designed to be deployed worldwide

All in all, the Combined Charging System technology can be applied to overcome the variety of regional systems. It is technically mature and will be rolled out in 2013. Vehicles equipped with AC charging in compliance with the Combined Charging System are in the market. Vehicles with ultra-fast DC charging based on the Combined Charging System Standard have been announced by BMW, GM and Volkswagen for introduction in 2013.



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