

NO FUSS, JUST WIRELESS

**WIRELESS CHARGING FOR
ELECTRIC VEHICLES**





Electric Vehicles set for growth

The use and acceptance of Electric Vehicles (EVs) amongst businesses and consumers will become more prevalent, driven by investment from the automotive and infrastructure industries.

Behind this growth, total cost of ownership will be one of the key purchasing criteria, as will the simplicity of charging. Qualcomm believes that the improved user experience delivered by wireless charging will enhance EV growth. Plug-in charging is far from simple; it is cumbersome, brings potential health, safety and reliability issues, especially at street level, while public charging equipment is open to damage from the environment, vandalism, and is visually unappealing.

Qualcomm Halo believes that wireless charging, which is simple and convenient, will eventually become the preferred charging method for all EVs. That is why we are developing our universal wireless charging technology that can be deployed in all geographic areas. Simplicity and minimum driver intervention are key features that win out time-and-time again, and we believe when these features are coupled with high power transfer efficiency, wireless charging is a winning combination.

“It is relatively easy to muscle power across a gap without any consideration of the consequences. The real achievement is to understand the parameters at play and transfer that power effortlessly...”

Nigel P. Cook. Principle Investigator, Qualcomm Wireless Power



Wireless electric vehicle charging vision

Our lives are becoming less and less about wires and cables and more about wireless: from mobile phones, to the wireless Internet and recently low power wireless charging for mobile phones.

Wireless power though is about to take a huge leap in scale, as kilowatts can now be transferred over an air gap of hundreds of millimeters while still maintaining high-energy transfer efficiency.

Wireless Electric Vehicle Charging (WEVC), is a no fuss, simple solution for charging electric vehicles and hybrid electric vehicles. While WEVC technology is ideally suited to stationary wireless charging, it also opens up the possibility of dynamic wireless charging – charging the electric vehicle battery while the vehicle is being driven.

The adoption of WEVC technology will lead to a shift in charging behavior. Drivers will charge their electric vehicle little and often and potentially use dynamic charging to complement local stationary charging removing range anxiety. This means that batteries could be smaller with the resulting reduction in electric vehicle cost and vehicle weight.

WEVC stationary charging is the near term future with ease and simplicity of electric vehicle charging; while DEVC, Dynamic Electric Vehicle Charging, is the medium/long term vision of a totally no fuss wireless electric vehicle charging society.

Inventive Steps

Inductive power has been around for over 100 years, and many people today experience the unique physics of magnetic resonance when they charge their electric toothbrush. Qualcomm Halo has taken the fundamentals of inductive power transfer and by introducing several inventive steps and technology breakthroughs has developed a solution that meets the key criteria needed to grow the electric vehicle market.

One of those key criteria is that charging must be effortless.

Qualcomm Halo WEVC technology uses magnetic resonance to couple power from the BCU to the VCU that is part of the vehicle charging system. Power is transferred to the VCU pad via magnetic coupling and this energy is used to charge the vehicle's batteries.

A Qualcomm Halo WEVC system can also transfer energy from the electric vehicle battery to the electricity grid, in what is known as Vehicle to Grid (V2G) charging.

WEVC Technology Explained Acronyms

WEVC	Wireless Electric Vehicle Charging
DEVC	Dynamic Electric Vehicle Charging
BCU	Base Charging Unit – on or under the ground
VCU	Vehicle Charging Unit – on the vehicle
EV	Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
V2G	Vehicle to Grid

Why wireless electric vehicle charging will win

The early experience from electric vehicle drivers is that they generally charge overnight with very occasional charging at public charging points.

Early adopters likely have easy access to a home charging point, either in their garage or on their drive. The mass market though will bring with them different charging needs. Many EV drivers will have to use street parking due to a lack of dedicated private parking spaces, in city apartments for instance. Public charging demand will therefore increase as electric vehicle ownership expands.

Utilities and municipalities consequently have two options; to deploy plug-in charging with an increase in street furniture, that carries the risk of vandalism and the loosening and oxidization of electric connections; or to deploy ground based or below ground wireless charging with no street clutter. This also removes the health and safety risk to the general public of tripping and falling over high voltage cables.

Electric vehicle drivers themselves will also opt for the simplicity of wireless charging; no fuss and no hassle from unwieldy, dirty cables that are difficult to handle when it is cold and wet. In addition, we believe many drivers would be wary of using plug-in cables in heavy rain or when the car or charge point is covered in snow.

There is also a clear economical benefit to wireless charging; keeping the battery charge at between 40-80% will optimize the life of the electric vehicle battery. Small top-up charging will therefore become the norm: at home, at work, at the supermarket. Wireless charging lends itself perfectly to this kind of user behavior. We think drivers would not make the effort to plug-in and charge for 5-10 minutes, while a wireless charging driver would do so because of the simplicity of park and wireless top-up, especially if coupled with fast authentication.

Dynamic Charging

Charging an electric vehicle while driving is the ultimate deployment of WEVC technology. Dynamic Charging removes the need for constant charging stops, when travelling long distances: in fact, journeys of hundreds of miles/kilometers would be possible with Dynamic Charging.

Qualcomm Halo envisage a transport system where licensed operators build out the Dynamic Charging network in a similar way to which wireless communications networks have been deployed. Dynamic Electric Vehicle Charging (DEVIC) technology would be integrated into one or more lanes of main roads and highways and DEVIC drivers would drive and charge at the same time. It really would be that simple.

Qualcomm Halo expect new business models to develop around DEVIC networks and services, potentially mirroring the wireless communications business models that have helped drive global adoption of wireless mobile phones and devices.

Business model & Qualcomm pedigree

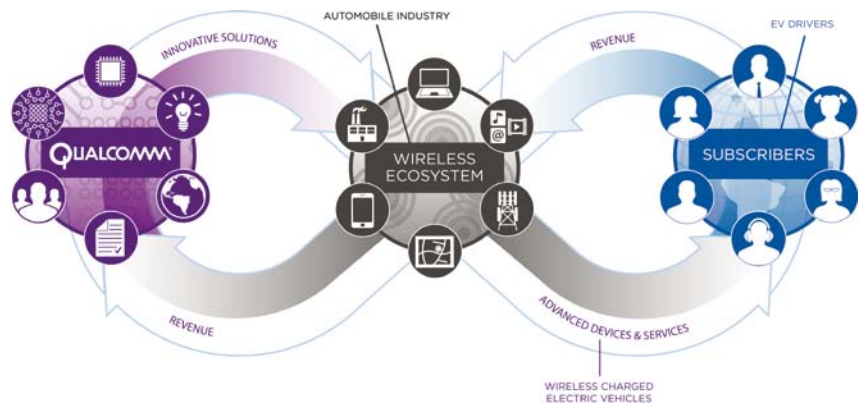
The world leader in next-generation mobile and wireless technologies, Qualcomm is no stranger to the wireless charging space.

Business Model

There are two approaches to an industry business model for wireless electric vehicle charging; a fragmented vertical model where multiple companies vie for market position based on a mostly proprietary technology offering; or alternatively, a horizontal model where a common standardized technology forms the basis for multiple company wireless charging solutions. Both business models offer technology innovation, which is essential to drive market adoption, but only a horizontal business model can deliver keen market competition and long-term economies of scale to drive down costs.

Qualcomm Halo's business model is horizontal; to aggregate Research and Development (R&D) and transfer technology from highly experienced engineering support functions so a broad range of licensees can be confident in the technology and products we provide.

This business model is collaborative and means that multiple companies can bring their own inventiveness to the table while enabling ecosystem partners to focus on their own core competencies to develop unique product features and build total system capabilities.



The validation of this model can be seen in the extensive competition in the markets that Qualcomm operates in and the growth these markets continue to experience. In addition, Qualcomm Halo participates in relevant standards bodies to help drive common standards that foster a faster transition to new technological advances.

It's a win-win-win situation; for the auto manufacturers who get competitive offers for a standards based interoperable technology; for component suppliers who can innovate at a feature level while benefiting from industry-wide R&D programs; and for customers who get cost efficient wireless charging and don't have to worry about the compatibility of wireless charging points.

Qualcomm Pedigree

The world leader in next-generation mobile and wireless technologies, Qualcomm is no stranger to the wireless charging space, having already developed technology and solutions for wirelessly charging mobile handsets and portable consumer electronics devices.

Qualcomm Halo technology is based on years of investment including technical and commercial development over the past two decades by The University of Auckland, an acknowledged pioneer in wireless power transfer. The result is a robust Qualcomm Halo solution and a substantial patent portfolio covering inductive charging for both low power and high power systems.



Standardization

Standards need to be at the heart of the WEVC technology and ecosystem to drive and accelerate industry growth.

Standardization leads the way to a No Fuss, Just Wireless, charging customer experience that is vital for customer adoption.

Charging has to be simple: all WEVC Base Charging Units (BCU) and Vehicle Charging Units (VCU) need to be compatible so that customers do not have to search for a charging station that works with their particular vehicle charging system.

Ubiquity is a must: coverage is what drives adoption. The more charging opportunity, at home, at the office, at all the places we park, the more confident customers will be about the electric vehicle driving experience.

Costs must be controlled: price is key to create a global market for WEVC and electric vehicle growth. Proprietary and closed technologies keep costs high and competition

low. Global open standards have proven time and time again that high growth rates can be achieved and sustained; and all players in the ecosystem can benefit financially from a standards-based approach to the electric vehicle charging industry.

The Qualcomm Halo business model is built around standards, technology licensing, and continued innovation to support ecosystem development.

Alignment and Tolerance

Qualcomm Halo WEVC technology uses patented innovative technology that enables highly efficient power transfer between the BCU and VCU even when the charging pads are not completely aligned. This makes parking simple and easy for drivers who do not need to park accurately in the WEVC charging bay.

This ability to magnetically align the two charging pads becomes essential should dynamic charging become one of the preferred charging solutions for electric vehicles in the future. A Qualcomm Halo dynamic charging network would still work at high power transfer efficiency even with the vehicle drifting across the dynamic charging lane, typical during normal driving.

Magnetic alignment is an inventive step; an innovative breakthrough; and it makes Qualcomm Halo WEVC technology effortless to use.

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