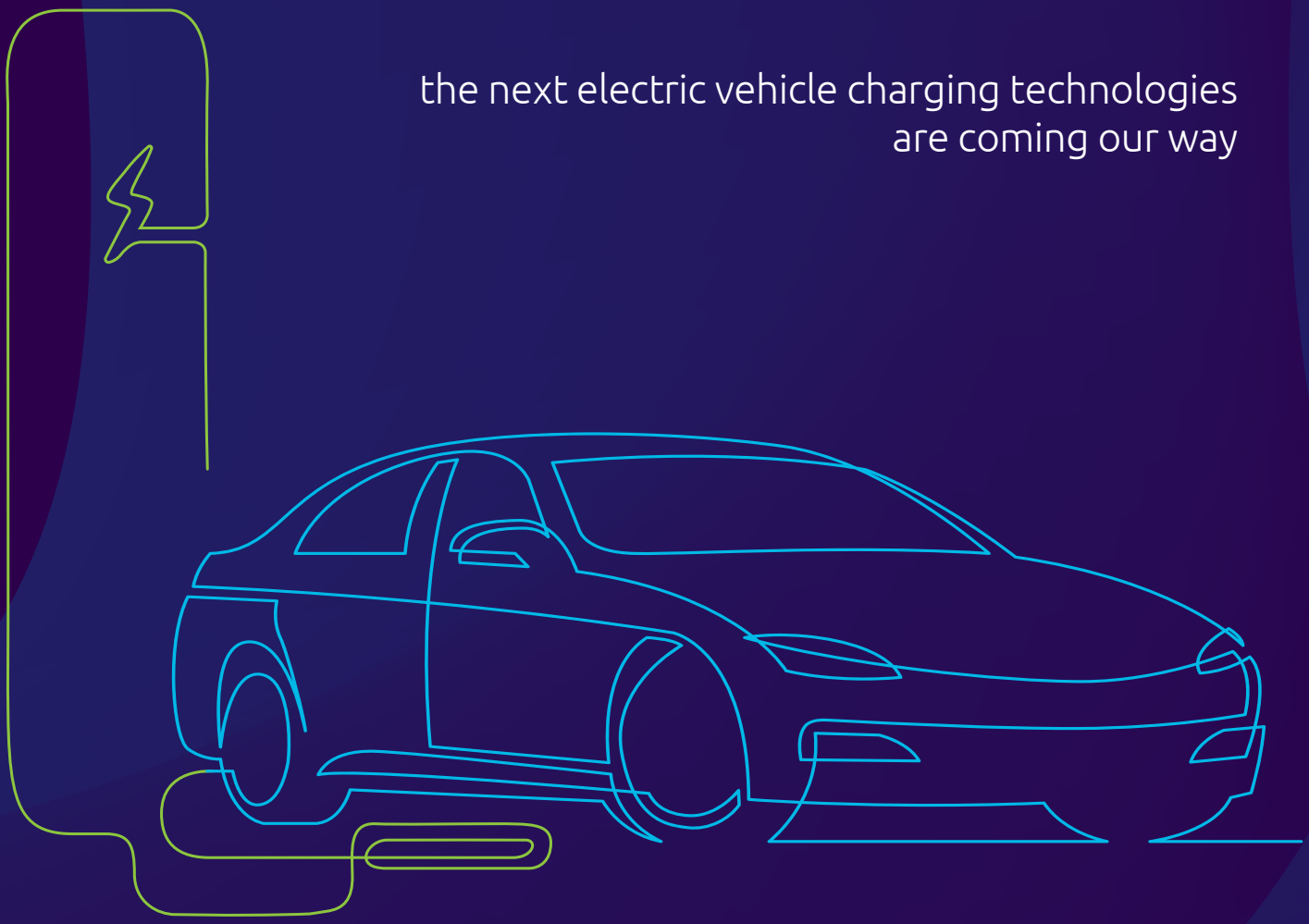
Capgemini invent

# HANDS ON THE WHEEL

the next electric vehicle charging technologies are coming our way



## Article description

There is no question that we are facing a worldwide explosion in the number of electric vehicles, but infrastructure is still problematic. Autonomous charging is a breakthrough technology that emerges in this context, aiming to provide a seamless way to charge and enabling for a more convenient driver experience. To win the race, it is crucial to understand the opportunity and challenges presented by it for actors along the entire value chain. By thinking ahead, new possibilities arise to capitalise on an industry that is set to grow and diversify in the coming years.

# THE ELECTRIC VEHICLE MARKET IS VAST BUT STILL FACES A BIG HURDLE: CHARGING INFRASTRUCTURE

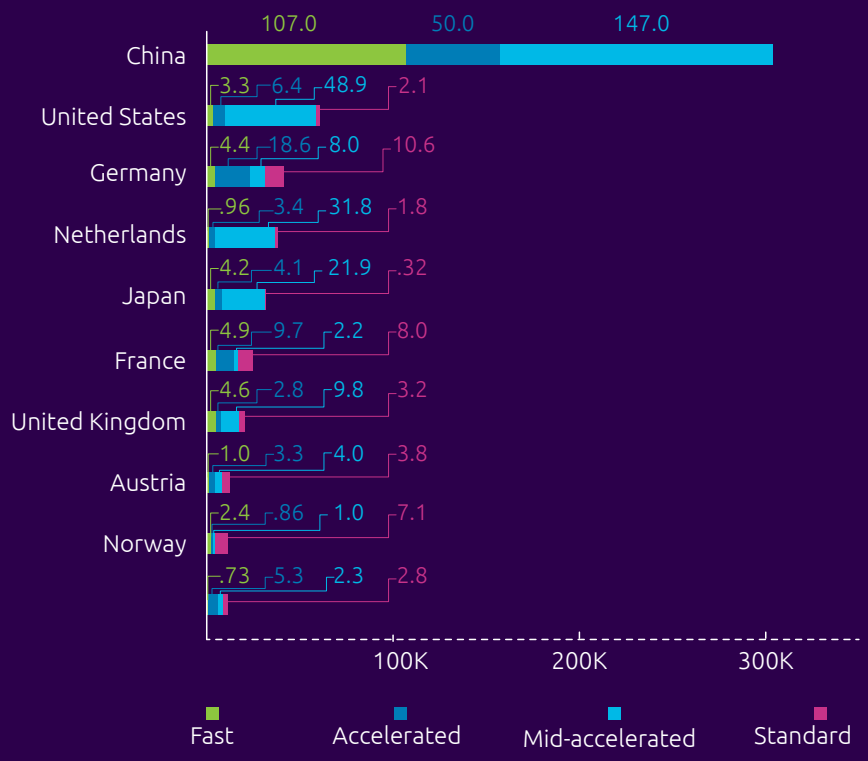
There is no question that we are facing a worldwide explosion in the number of electric vehicles (EVs). According to *BNEF*, the global fleet of EVs reached 5 million last year, supported by 632,000 public charging outlets around the world. Under a *scenario* where EVs will hit 30 percent market share by 2030, the International Energy Agency forecasts that as many as 30 million public chargers would be needed to serve regular passenger vehicles – a number 50 times in excess of today's.

With lack of infrastructure and range anxiety cited as some of the *main barriers to EV adoption*, charging solutions are urgently needed – presenting an opportunity for investments in deployment and operations.

There have been extensive investments in public charging infrastructure and much is being done to develop and implement the concept of fast charging (above 50kW) – e.g. *IONITY*, *Next-E* – backed-up mostly by giant Energy companies and OEMs trying to mirror ICE (internal combustion engine) refuelling network and ease-of-use. Fast charging is essential for drivers to complete journeys beyond the range of their vehicle; however, it lacks in convenience (with majority of stations located along highways) and only solves part of the puzzle, as most travel less than 30-50 kms daily in Europe.

Therefore, to cater for this demand, millions of new charging points would be needed at homes, workplaces and public areas. This new context brings up a series of questions for discussion: How to leverage the fact that EV refueling does not necessarily require the same set-up as ICE? Which solutions need to be developed and implemented to facilitate EV adoption and usage in the cities? What can future-proof charging look like?

**Where Are The Chargers?**
China has about half the world's 600,000 EV charging points, data show




**Source:** ***Bloomberg NEF***
***Data shows public infrastructure in top 10 nations as of end 2018***

# A SEAMLESS WAY TO CHARGE ENABLES A MORE CONVENIENT DRIVER EXPERIENCE

Just as we are becoming acquainted with seeing EV chargers and cables spread across the pavements of major cities, the industry is already looking at the next breakthrough. Driven mostly by start-ups (sometimes in cooperation with OEMs), autonomous charging is an interesting value-add technology, unlocking new possibilities by providing a more user-friendly environment.

Like commonly-known wireless mobile phone chargers – where the phone is placed over a charging pad rather than plugged in – **autonomous *inductive* vehicle charging** (or wireless charging) allows a vehicle to be charged without being physically connected to a station, filling in the battery when the car is parked over a charger on the ground beneath it. Electricity is transmitted through an air gap from one magnetic coil in the charger to another fitted underneath the car, connecting it to the vehicle's power electronics and battery systems via a wireless adaptor.

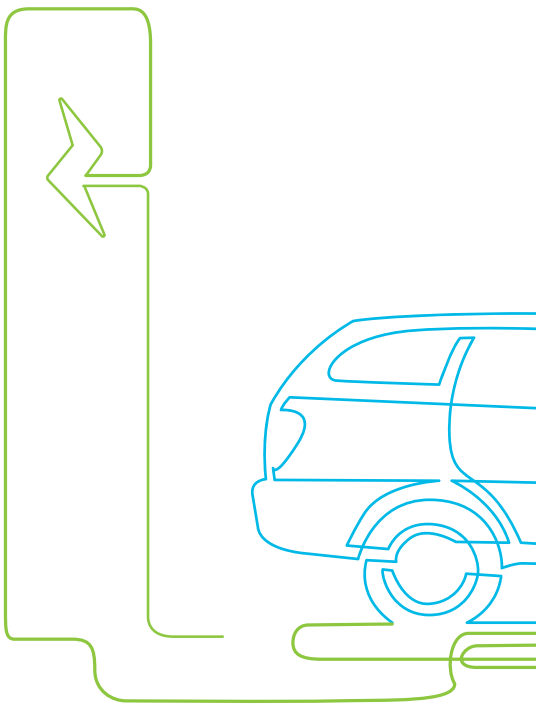
Similarly, **autonomous *conductive* vehicle charging** is usually composed of an off-board robotic device (the charger), placed on the ground or side-ways, and an onboard device (the inlet), installed in the vehicle. Power is transferred when the charger connects to the vehicle's inlet. With both inductive and conductive vehicle charging, the pad needs to be connected to a power supply.

The array of benefits for the driver includes ease-of-use and lack of cable management (avoiding trip hazards and electric shocks). Also, this technology ensures frequent vehicle charging at almost any parking space, as it maximises the overall connection time between the vehicle and the grid – thus mitigating range anxiety.

For public and private charging point operators – besides the abovementioned security aspects – it also allows for a more aesthetically pleasing infrastructure and nearly maintenance-free system.

However, there are potential safety concerns regarding autonomous charging. Since it is done without direct human control, it must be designed to respond safely to the presence of foreign and living objects under and near the connectors or electromagnetic field.

Retrofitting the car would also be required, which might pose some challenges for adoption. When it comes to wireless charging, various governments, OEMs and technology companies (including *WiTricity* and the *Society of Automotive Engineers*) are working towards a global standard for EVs, regardless of their brand. It could benefit OEMs by exempting them of the expense of building their own chargers, as a standard would allow them to simply purchase those from a supplier since any model would, presumably, work with any vehicle.



# THE POTENTIAL IS THERE BUT, AS IT STANDS, MOST IDENTIFIED CASES ARE SMALL SCALE PROJECTS OR PROOF-OF-CONCEPTS

The *European Commission* is calling for a climate-neutral Europe by 2050. Targets that have been set by governments of most member countries and other government-led initiatives are also starting to take shape. *In the UK*, government has awarded £37M to 12 wireless and Wi-Fi EV charging projects. This marks the one-year anniversary of the *Government's Road to Zero strategy*, which sets out targets to clean-up road transport.

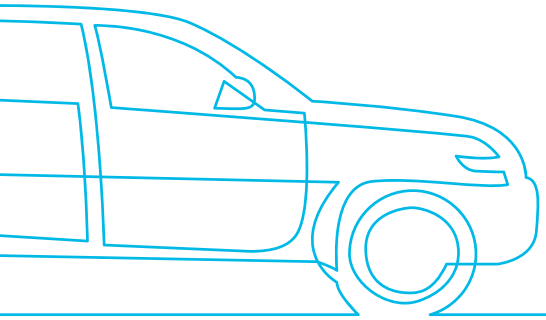
Norwegian capital Oslo is aiming to reach a *zero-emission taxi fleet by 2023*. It plans to install wireless, induction-based charging stations, allowing for opportunity charging (between rides) of up to 75kW. The goal is to minimise the time-consuming task of finding, plugging-in and recharging of vehicles. The project – first of its kind in the world – will be delivered by the municipal government of Oslo, Finnish utilities company *Fortum* and *Momentum Dynamics*, a US company specialised in wireless EV charging.

Automakers are also testing and investing in partnerships with wireless charging start-ups. Earlier this year, BMW announced its *wireless home charging pilot project* with selected drivers of their 530e plug-in hybrid model in California. *Renault* (in partnership with US-based *Qualcomm*) was testing wireless charging along roads already in 2017. The prototype allowed charging at up to 20kW at a speed up to 100 km/h.

An American team from the *Oak Ridge National Laboratory* managed to do even better by running an induction charging device with a power output of 120kW. To achieve this result, a new type of electromagnetic coil made of silicon carbide has been developed. Thanks to this innovation, now plans are to reach powers up to 400kW, which would allow vehicles to be recharged in record time of 15 minutes.

Austrian start-up *Easelink* has developed autonomous conductive systems that can charge at up to 22kW with an efficiency of 99%. *Showcased* during the Mission Innovation Austria Week 2019, is also includes seamless payment functionalities (developed by *lab10 collective* in association with *Future Grid*), allowing for verification and payment via blockchain.

*Electrify America* and *Stable Auto* have recently *announced* an agreement to create automated charging solutions ('robotic arms') for future self-driving vehicles. Designed for fleets and using a 150kW charger, the programme will run at a pilot site in downtown San Francisco, with opening predicted for early 2020.



# THE COMPETITIVE ANALYSIS OF AUTONOMOUS SOLUTIONS VERSUS CABLE-BASED ONES SHOULD GO BEYOND ITS INSTALLATION PRICE

It is a fact that the charging business is capex intensive, due to the infrastructure being quite expensive. Some governments offer incentives in the form of grants to people investing in home charging infrastructure meaning the end-user installation price goes down, which could foster adoption. This is the case of *Ireland* – where the government offers up to €600 – and the *UK* – up to £500.

The cost for installing autonomous charging varies both depending on technology and vehicle brand. For type 2 AC chargers, benchmark suggests that the installation of an inductive home charging system could range between €1,100-€2,700, whilst for a conductive one, around €1,500-€2,500 – making these solutions similar from a price-parity perspective. Compared to a regular cable-based home charging system, it is still not competitive pricewise as, on average, these are 30% cheaper (€800-€2,000, including installation).

Simply put, the value-add comes from convenience and lower maintenance – which should be considered when making an investment decision or accessing the competitiveness of the technology.

# IT'S NOT ONLY ALL ABOUT CHARGING ELECTRIC CARS AS WE KNOW TODAY

Looking not too far ahead, when thinking about connected smart cities, autonomous charging has the potential to become a breakthrough technology enabling for fully autonomous driving. This could benefit not only vehicle owners but other services such as taxis, busses, parcel delivery, city cleaning etc. And, because the cars are not plugged in, no precious seconds are wasted when vehicles are needed. While this might not be needed by most, timesaving could be crucial if emergency vehicles are electric.

Another crucial benefit we could leverage from the deployment of this technology is the impact on vehicle design. Lining-up wireless chargers along roads providing constant charge could result in shrinking the size of batteries, equalling to much lighter EVs. This would improve car performance, making it more energy efficient, and significantly decrease its price – as of now, batteries are its most expensive part.

# WINNING THE RACE

People that live in cities with no access to a private charging spot, those seeking convenience and fleet operators could be the leading groups pushing for autonomous charging – meaning a good place to start seems to be at homes, workplaces or parking spots. In this context, multiple technologies will coexist (cable-based, fast, autonomous etc.), as all present benefits for specific needs.

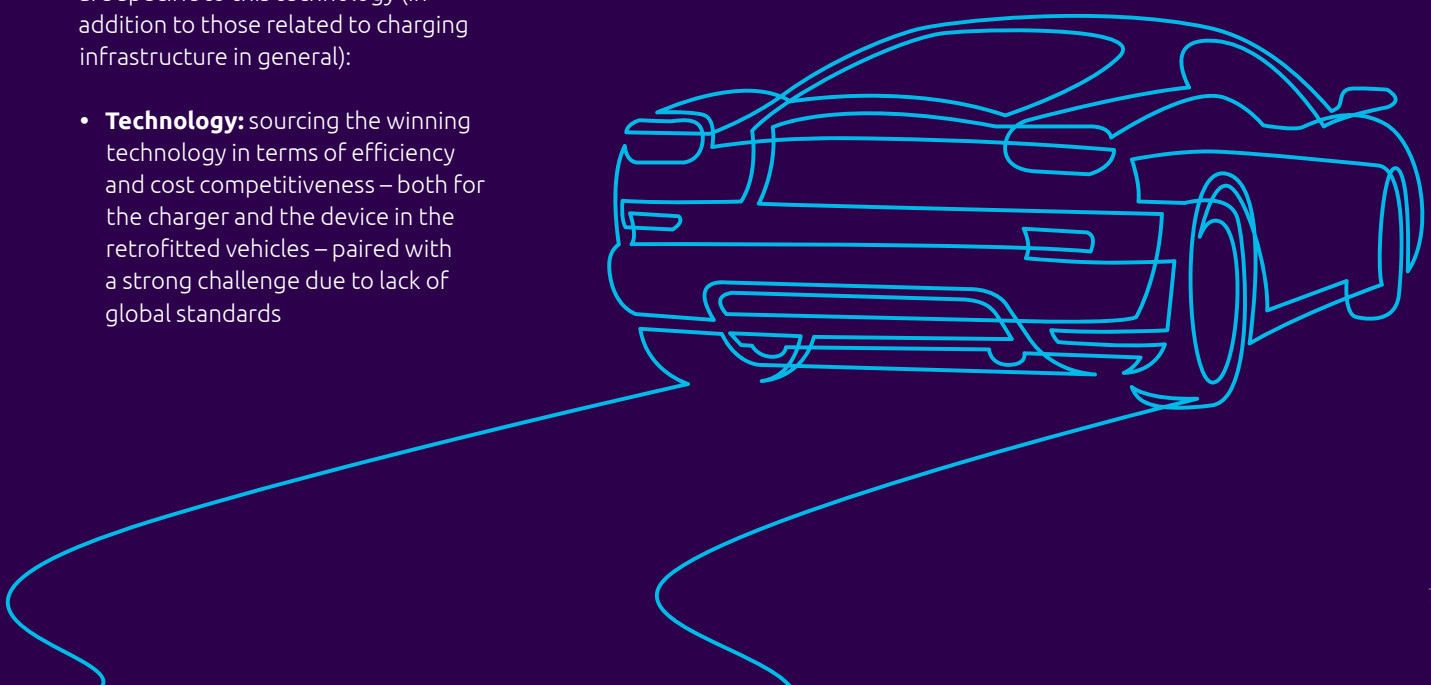
While it is widely known that the number of EVs will increase exponentially in the coming years – thus the number of charging points needed – the key success factor lays in grasping how the landscape will be set-up. Because charging infrastructure is a crucial asset that links mobility and power network, investing in these technologies is strategic for all players (OEMs, utilities, construction companies, mobility operators etc.). In our *Capgemini Invent's point of view*, we have illustrated new EV charging market perspectives.

Understanding the opportunity presented by autonomous charging will require tackling challenges that are specific to this technology (in addition to those related to charging infrastructure in general):

- **Technology:** sourcing the winning technology in terms of efficiency and cost competitiveness – both for the charger and the device in the retrofitted vehicles – paired with a strong challenge due to lack of global standards
- **Customer journey:** the entire user experience must be re-invented – notably to ensure the vehicle is charged when desired, that there is enough flexibility on parking slots, etc.
- **Operations:** installation and maintenance operations (although less needed) are more complex and shall be carefully foreseen. Besides, data management (e.g. car consumption) will be more difficult to measure, especially for inductive charging points along roads
- **Business model:** it is unlikely that charging operators will offer autonomous charging points only; rather, the technology will complement a portfolio of solutions to the final customer (e.g. electricity bundle). Therefore, it is crucial to design and communicate offers that are clear and simply understood
- **Acceptance:** educational pieces around the technology safety aspects (including concerns) are imperative to foster adoption and build trust

Assessing who can capture new value generated by this market is critical, thus the need to adopt viable business models that enable for differentiation from competition. By thinking ahead, opportunities arise to capitalise on an industry that is set to grow and diversify in the coming years.

Autonomous charging is the desired solution to charge EVs in a more convenient way than traditional ICE refueling. Although it is not now forecast as the main technology, how can we believe that charging will still be done manually with the advent of autonomous vehicles?



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