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Sector Report

Smart Charging: The Upcoming Revolution of Electric Vehicle Economics

IMPROVED CORPORATE FINANCE

P3

Dominique Houde
Partner
Houde@improvedcf.com

Bas Hendriks
Senior Associate
Hendriks@improvedcf.com

Nicolas Magnus
Senior Analyst
Magnus@improvedcf.com

Jan Traenckner
Senior Advisor E-Mobility
Jan.Traenckner@p3-group.com

Johanna Heckmann
Head of Charging Infrastructure
Johanna.Heckmann@p3-group.com

Falko Bartnik
Consultant E-Mobility
Falko.Bartnik@p3-group.com

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1. EXECUTIVE SUMMARY

Smart Charging: A simple concept, challenging to implement, but with massive potential payoff

Smart Charging presents a simple basic value driver for all electric vehicle (EV) users: charging an EV when it is cheapest and most convenient for the driving needs.

In addition, Smart Charging has many "hidden" value drivers for those who are in charge to monetise the charging infrastructure and deliver electricity for charging.

Those stakeholders have incentives to use EV charging as a "device" to optimise their business by balancing demand and (CO2 free) electricity production, simultaneously avoiding any shortage on the grid.

There are challenges that come with the implementation of Smart Charging. Technical components like connected chargers with complementary complex cloud software need to be further developed, installed and integrated into existing (legacy) technical environments;

- Comprehensive digital communication protocols need to be established and implemented cross-industry and among very diverse stakeholders
- Complex legacy regulation barriers / procedures need to be overcome or modified to succeed with commercial mass deployment of Smart Charging technologies

In summary, complex value drivers need to be translated into win-win business models by aligning several industries / stakeholders active in the market with partly conflicting interests.

Finally, all those Smart Charging business models need to "operate" in markets with already very tight and very distributed margins, which requires a standardised and efficient development and launch of underlying technology.

As a result, the authors believe it to be likely that mostly scaled and evolved systems with prominent platforms might work, delivering very substantial and attractive returns.

Other than the emerging winners in this heavily consolidated market, the biggest winner of Smart Charging will be the climate, as this is one important driver for a real sustainable and zero carbon mobility ecosystem, as well as the overall efficiency of developing the grid and energy systems as part of the energy transition.

IMRPOVED	P3
Dominique Houde	Jan Traenckner
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2. SCOPE OF REPORT

Key aspect of the whitepaper is to describe evolution phases of Smart Charging, give insights on technology drivers, potential business models, market dynamics and historic investment trends

Smart Charging is an unstoppable trend with new business models just emerging. To provide insights on investment trends and future market potentials, the whitepaper in the beginning is focusing on the definition of the evolution phases of Smart Charging. Chapter 3.1 describes in detail different Smart Charging phases. These phases range from Controlled Charging to Vehicle-Grid-Integration, their potential benefits, and the evolving business models as a baseline.

As Smart Charging requires interaction and cooperation between multiple players from both energy and mobility sectors. An overview of the stakeholder structures and their influences is given in Chapter 3.2, to highlight the need for elaborated incentive programs to develop winning business models in the area of Smart Charging.

With a high-level overview of technical requirements, main enablers and current market readiness, Chapter 4 provides basic insights into the underlying technology. The chapter illustrates that the availability of international standards in the market, which are partly under development, is among the crucial preconditions to enable Smart Charging services.

Chapter 5 focuses on the future market development and market potential up until 2030 in Europe from Smart Charging services for passenger cars, mainly reflecting the future economic relevance of the topic. Annual revenues of up to EUR 5bn from hardware and software sales, provision of services and trading of capacities shows the emerging growth potential linked to the market.

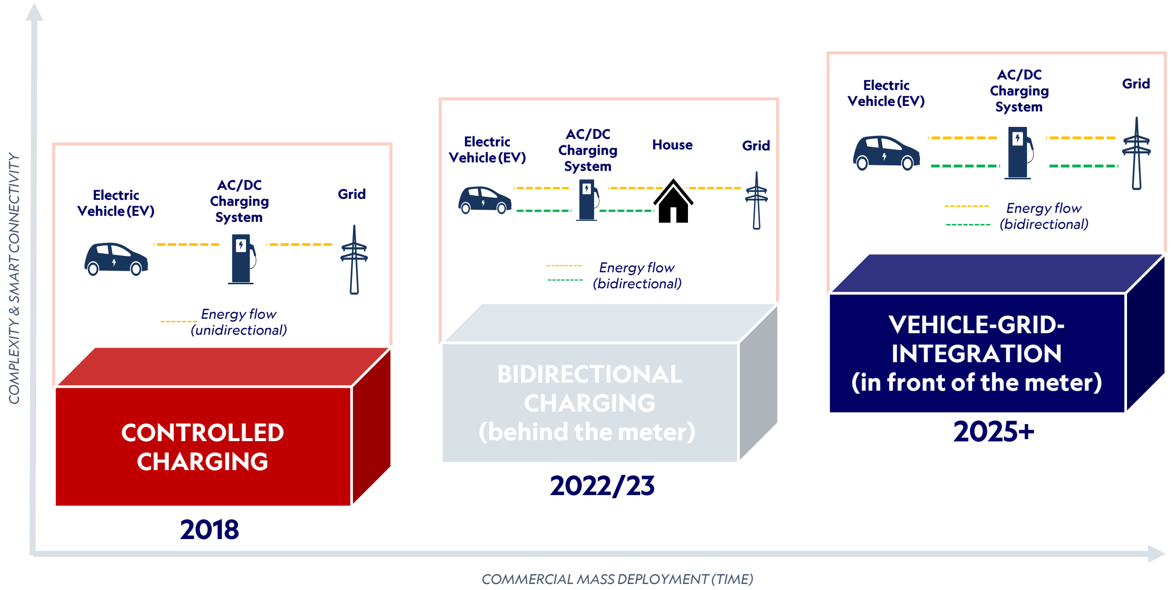
In that respect, capital formation trends will be discussed in Chapter 6 to show historic and current market dynamics based on global transactions involving Smart Charging hardware and software providers. The attractiveness of the market for Strategic Investors to enrich their existing EV charging portfolio, and for Growth and Institutional Investors to capitalise on the rapid growth and increasingly maturing market, is underlined and demonstrated.

As the whitepaper mostly focuses on the EU market and refers to the passenger car market, there are further significant potentials in the Smart Charging market from international markets and commercial vehicles, which were not considered in the paper, but present further growth boosters for the topic.

3. WHAT IS SMART CHARGING? DEFINITION AND THE OUTLOOK FOR SMART CHARGING

Smart Charging comprises different forms of managed and optimised EV charging, in order to save costs for grid expansion and demand charges, or to optimise the electricity bill.

Smart Charging as shown in this report can be clustered in three major evolution phases:



Expert view on the key drivers and bottlenecks for Smart Charging commercial mass deployment

"There are two main drivers to global scale integration of smart Charging; 1) From a grid perspective, there is a pressing need for a more stable grid. Smart Charging solutions is far more (cost)-effective than expanding the current grid, and 2) From an energy perspective, increasing CO2 tax will push consumers to adopt dynamic Smart Charging solutions to reduce their energy bill."

Marcus Fendt, Managing Director/CSO, The Mobility House

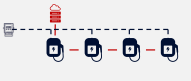
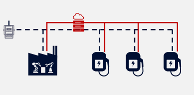
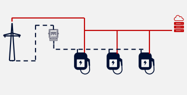
"The increasing volatility of energy demand and energy supply has made it clear that the energy system needs to be dynamic and, in being so, much more robust. Without smart charging, THE system will be less efficient with much higher energy prices and result in expensive system upgrades and backup generation.

Current systems are managed top-down. For the system to be managed bottom-up, and to avoid rationing, the system must be able to collect data at the driver level. The necessity for more dynamic and robust solutions will be the key driver to supplier-led and system operator-led smart charging solutions"

David Watson, CEO, Ohme

3.1 EVOLUTION PHASES AND BUSINESS MODELS

Controlled Charging

Controlled Charging	Introduction: All forms of "Controlled Charging" are offering potential to statically or dynamically manage and control energy flow to charge the EV to optimize loads and avoid both peak demands and high electricity costs. Technology and services to offer Controlled Charging services are available today and business models are evolving fast in line with growing EV stock in the markets, which requires cost-optimized deployment of charging infrastructure. As optimisation and energy management is limited to closed systems, the interaction between players is also lower than in other Smart Charging phases, which makes Controlled charging the "entry level" of this evolution. A strong demand uptake for these services is expected in the upcoming years, especially in applications where several charging stations need to be managed, e.g., in multi-unit dwellings, at workplace or for fleet charging.			
	Power Management	Intelligent Power Management	Local Load Management	Optimized Charging
Description	Static selection or limitation of power at each charging point to not exceed any connection limits. Fixed limitation to 3 or 11 kW is mostly set manually at the charging device, for example during commissioning – depending on available load	Dynamic distribution of available load among several charging points, controlled via hub-satellite set-up of charging devices or external controller. Different algorithms can be set, e.g., 1st-come-1st-serve or privileged charging for selected EVs	Power management between charging station(s) and other consumers in microgrid to balance loads, for example derating of charging stations during ramp-up of production with increased power needs	Via algorithm and data API to external providers, charging sessions can be optimized regarding different time, costs, CO_2 or self-consumption from PV and home storage. Settings ensure that charging takes place, when electricity is at a very low price, or a high share of renewables are available from the grid
HW-driven	x	(x)		
SW-based solution	(x)	(x)	x	x
Local controller		x	x	x
Commercial mass deployment				
Illustration (simplified)				

Short-term
Mid-term
Long-term

Electricity meter
IT backend/ energy management system

Data flow
Energy flow

"Smart Charging: The Upcoming Revolution of Electric Vehicle Economics" (IMPROVED & P3, January 2022)

Business models	
Business models	▪ Controlled Charging business models are built around existing infrastructure and are often bundled with the regular operation of charging stations as an add-on to standard services, e.g., billing, remote operation, or maintenance ▪ Most typical business modesl are monthly subscriptions per charging point or installation to benefit from advanced Smart Charging services in combination with one-off fees for the hardware product ▪ Providers of controlled charging are looking into Charging-as-a-Service / leasing solutions as the upfront capital investment (especially DC / HPC charging) increase. The customer, often the site owner, is paying a monthly recurring fee to the solution provider. In parallel, institutional and infrastructure capital providers become more interested in the EV charging asset class. The EV charging market and unit economics are maturing and becoming viable with shorter payback periods ▪ The main benefits from customer and user perspective in the area of controlled charging are cost saving potentials by decreasing the required grid connection capacity, peak shaving, self-consumption optimization or avoiding high electricity tariff time windows ▪ Future business models might intend to a) share potential cost savings between customers and Smart Charging providers or b) sell data on EV charging behaviour to distribution grid operators to increase transparency on usage patterns and requirements to reinforce existing grid infrastructures

Short-term
Mid-term
Long-term

Electricity meter
IT backend/ energy management system

Data flow
Energy flow

Bidirectional Charging

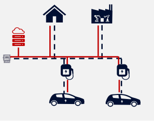
Bidirectional Charging

Introduction: With “Bidirectional Charging” (behind the meter), the EV can feed electricity back within the microgrid application to the house, the factory or other EVs to optimise overall consumption schemes within the local system (behind-the-meter). These Bidirectional Charging scenarios are designed to buffer high peak demands or at high energy price periods to optimise the overall electricity costs. The EV battery in these scenarios acts as an (additional) storage, which can also be used to optimize self-consumption from the PV and to storage local renewable energy production for later consumption.

Pilot Projects: Projects on Bidirectional Charging in Europe are mostly in a pilot status to identify potential benefits and determine additional efforts. A main gap to enter the mass-market with the technology is the widespread availability of EVs being able to charge bidirectionally, especially based on the European plug standard CCS – Combo 2 and charging devices with bidirectional charging capabilities. With a strong trend towards the standardisation of ISO 15118-20 and OCPP 2.0.1 the mass-market introduction of Bidirectional Charging services is expected to pick up significant speed from 2022/23 on.

Current implementations mostly rely on ModBus, but this communication layer enables a very individual design and therefore requires high integration efforts. The market penetration of ModBus therefore is rather slow and a real interoperability between the parties in the market is not yet given. The fast development of Bidirectional Charging in Europe is also necessary, as these services are the baseline prerequisite to enter a more advanced stage of smart charging and offer Vehicle-Grid-Integration (VGI) services.

One of the first practical applications from The Mobility House was ‘Vehicle2Coffee’, a project from 2015 where a Nissan Leaf was integrated into the power grid and supplied an office with electricity. The projects have become larger since then: From December 2019 onwards, electric vehicle drivers visiting events at the Johan Cruijff ArenA in Amsterdam can integrate their vehicles into the stadium’s power grid via bidirectional charging stations. The vehicles can supply energy so that the stadium can reduce electricity drawn from the grid, while it is ensured that the batteries are recharged when the event ends.

	Vehicle-to-Home (V2H)	Vehicle-to-Factory	Vehicle-to-Fleet
Description	Based on reverse energy flow from EV battery to local consumers, different scenarios rely on same baseline technology. Exemplary Vehicle-to-Home application is bridging operation during blackouts. For vehicle-to-fleet the charging schemes within the fleet can be cost-optimised – necessary charging processes can be bridged from fully charged EVs.		
HW-driven			
SW-based solution	(x)		
Local controller	x		
Commercial mass deployment			
Illustration (simplified)			

Short-term
Mid-term
Long-term

Electricity meter
IT backend/ energy management system

Data flow
Energy flow

"Smart Charging: The Upcoming Revolution of Electric Vehicle Economics" (IMPROVED & P3, January 2022)

Business models	▪ Applications of Bidirectional Charging can improve the unit economics and lower the total cost of ownership of an EV and the total electricity bill by benefitting from the EV's battery capacity and buffer energy demand during high-price energy periods ▪ One of the large value pools in bidirectional charging is linked to bidirectional charging hardware, which is required to feed back energy from the EV to other local consumers ▪ As smart algorithms for self-consumption optimisation or avoidance of high electricity tariff time window, also software-based revenues are addressable. As the EV is highly integrated in larger energy management schemes in this application, the functionality is typically covered by the local energy management system ▪ Comparable to controlled charging, Bidirectional Charging can optimise the overall energy costs by targeted and flexible usage of EV batteries comparable to a stationary battery storage system ▪ Typical revenue models therefore also could aim for share of these cost savings by offering technology for optimised algorithm

Expert view on the development and adoption of Bidirectional Charging

"For Bidirectional charging to be adopted, there are two critical factors;

1) There are currently very few bidirectional enabled EVs on the market. Bidirectional Charging standards need to be released to add CCS and AC-enabled V2G to the existing CHAdeMO capability, for more Automotive OEMs to start producing bidirectional EVs

2) Bidirectional chargers and installation costs are still significantly higher than for smart chargers. To convince customers to adopt Bidirectional Charging, we need to incentives and suitable regulation to reduce the cost difference/barrier, coupled with customer education."

Josey Wardle, Innovation Lead , V2G & EV Charging at Innovate UK

"Electric vehicles have the potential to store energy at all possible times – this potential should be leveraged. The storage potentials will initially be realised via larger fleets, bundlers and aggregators."

Claas Bracklo, Chairman, CharIn e.V.

Vehicle-Grid-Integration

Vehicle-Grid-Integration (VGI)	Introduction: The third evolution phase of Smart Charging "Vehicle Grid Integration" is enabling the exchange of power with the grid. Most of the services require specific smart meter devices. There are unidirectional service potentials such as grid-controlled load management, when local distribution grid operators can access and control charging devices to reduce stress on the grid, or participation in Reserve Control markets with EV battery capacities. More advanced services are centered around Vehicle-to-Grid (V2G) services, where power from EV batteries is fed back into the energy grid (in-front-of-the-meter) to balance the grid. To reach a significant effect and be able to trade the capacities on the energy market, several EV batteries need to be pooled (min. ~1 MW). To enable the interaction of the EVs with the energy grid on a large scale, there are some major barriers: The interface towards the grid shows high need for standardisation, due to the high number of existing standards and players in the market, the need for transparency on potential security issues and the smart meter roll-out policies across the European markets. Despite these issues, it is expected that OpenADR might play a more important role as a common standard in the market, but also established IEC standards (mostly IEC 61850) will stay relevant. It is highly recommended to develop a clear EU-wide legislation to provide the stakeholders in the market a security of investment and ensure the efficient and extensive implementation of Vehicle-Grid-Integration services. Based on the highly regulated market approach for grid operation in the EU markets, a strong commitment of public authorities is required to accelerate the availability of the smart services. Pilot Projects: Current projects in the market are mostly individual pilot schemes with a high individual planning and integration effort. The mass-market implementation of the services will ramp-up from 2025 on. Knowing that the life cycle in the area of grid infrastructure is up to 30 years, the market penetration is a long-term process and will show continuous growth even after the availability of the standards is ensured. An interesting upcoming project is the joint effort of Fiat-Chrysler, Engie and Terna with a V2G project at the FCA plant Mirafiori. With a regulation capacity of 25 MW, it will be the largest V2G project worldwide. One of the goals is the development of business models to trade EV battery capacities on the energy market.		
	Grid-Controlled Load Management	Reserve Control (V1G)	Vehicle-to-Grid (V2G)
Description	Macro-grid application to optimise consumption and loads in an open environment, to optimise overall grid utilization and avoid stress on grid. Distribution Grid Operators (DSOs) with ability to switch on/off individual loads such as charging stations	Ability of the Transmission System Operators (TSO) to pause active charging sessions (therefore unidirectional) in order to stabilise the power line frequency	Feedback of energy from EV batteries to the grid to trade capacities on the energy market (e.g., Arbitrage, FCR, Redispatch)
HW-driven			
SW-based solution	x	x	x
Local controller	x	x	x

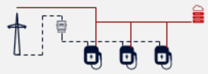
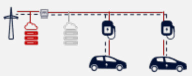
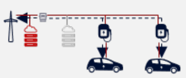
Short-term *Mid-term* *Long-term*

Electricity meter

IT backend/ energy management system

Data flow

Energy flow

Externally controlled	x	x	x
Commercial mass deployment			
Illustration (simplified)			
Business models	▪ Interaction of EVs with the grid offers many business model options and is a strongly evolving market. Core of the business models is the bundling of several EV batteries to stabilise and support the energy grid as buffer storage in a flexible way ▪ For this purpose, aggregators are required to bundle and trade the capacities on the energy market or to grid operators. To be able to participate in the market, large scale availability of EV battery capacities (>1 MW) needs to be ensured. Critical mass is an important determinator of success ▪ Typical trading options include intraday or day-ahead arbitrage, frequency containment reserves (FCR), redispatch or provision of reactive power, which offer long-term revenue potentials from VGI applications ▪ To succeed in VGI models, the development of an attractive incentive system to motivate users providing access to their EV battery capacities is required. To be eligible to participate in the energy market and trade flexibilities, local requirements apply and need to be considered ▪ Based on existing market framework and business models, revenue potentials of EUR 250 to 400 per EV/a are considered feasible. Further potentials might evolve from bundling several services or a high number of EVs to increase market relevance of the offer		

Expert view on the development and adoption of Vehicle-Grid-Integration

"From a grid perspective, Unidirectional Charging is sufficient for providing ancillary services, e.g. balancing or re-dispatch. Bidirectional Charging would certainly be better as you would have more flexibility, but it is significantly more effortful."

Kay Wiedemann , Team Manager Market Evolution, TransnetBW GmbH

"To optimise V2G and VGI, smart energy storage and microgrid solutions are required to manage peak shaving and balance the grid. Battery swapping stations (like ours) present excellent local storage solutions to do just that."

Hui Zhang, Group Vice President, Managing Director NIO GmbH
Managing Director NIO Performance Engineering

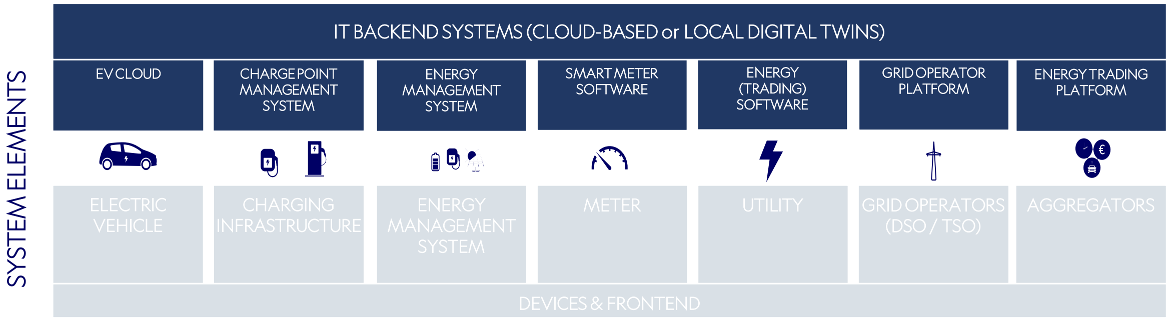
3.2 STAKEHOLDER ANALYSIS & ECOSYSTEM DEPENDENCY

Cooperation between multiple players along the value chain is required to make smart charging a success

The successful implementation of viable business models with Smart Charging requires the involvement and active empowerment of substantially different stakeholders from different "domains" across the whole value chain. For example, Smart Charging requires constant access to vehicle data ("State of charge") which is within the "domain" of the automotive manufacturers ("OEMs") and requires authorization and open technical "interfaces".

The challenge is, that most of those stakeholders along the smart charging value chain have their own strategy and (often clashing) economic interest in mastering the "value add" from those services. So, there is for example a "natural" conflict of interests between the OEMs and the charging point operators (CPOs), to keep control of the customer and keep the "ownership" of all involved data, as those will be a future potential additional value creator. And that is even more true if the grid / energy providers come into the game.

Another challenge for companies might be the pure total number of acting stakeholders. For example, in countries like Germany, the DSO landscape is extremely scattered and local (mostly "municipal utilities", >800). VGI players need to build individual cross stakeholder "win-win" business models, but probably some native stakeholders (e.g., DSOs) will build protectable "local-only" Smart Charging services. We also see a higher probability, that some cross regional players (e. g. utilities, OEMs) might consolidate the Smart Charging market with highly vertical integrated market approaches.



One of many possible solutions to the described complexity is the development and broad implementation of open standards. Standards like ISO 15118-20, OpenADR (IEC 62746-10-1) are under development and several players work on a bilateral implementation of the relevant interfaces and protocols. However, the current set of standards, highly individual implementation efforts and required cooperation prevent the fast large-scale roll-out of Smart Charging and grid-related services. In addition, regulators/governments need to take action by supporting the implementation of open standards / interfaces but also with specific de-regulating legislation, to "free-up" more flexible value creating business models (e.g., flexible cross-system electricity tariffs w/o tax burdens).

> "The customer needs to reasonably and properly involved with regard to the topic of grid integration – when merged with the technical requirements, the customer will be part of the mobility turnaround."
>
> **Markus Wunsch, Head of Grid Integration Electric Mobility, Netze BW GmbH**

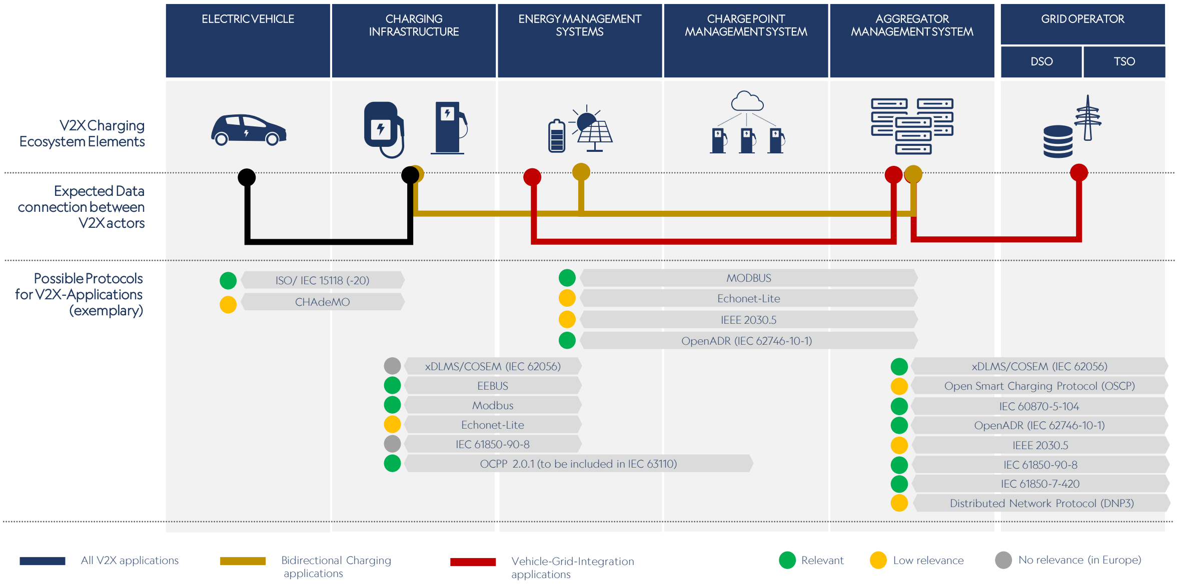
4. TECHNICAL ENABLERS

Key elements to enable future Smart Charging services and Vehicle-Grid-Integration are standardised communication protocols and Bidirectional Charging infrastructure

Two major building blocks enable the implementation of Smart Charging services up to Vehicle-Grid Integration. The first mandatory precondition is the provision of Connected Charging infrastructure and the availability of standardised data interfaces to exchange information and manage the charging sessions. Next to that, all involved hardware elements need to be enabled for bidirectional usage, especially the EV itself, the charging device, and the grid connection with the specific meter.

To tap into potential additional value pools, the application of smart and connected charging devices is mandatory – that is why a decreasing importance of non-connected charging devices is expected. This connectivity of the charging devices and all other elements along the chain enables the application of "digital twins" of these elements, which ensures the data exchange based on some standard interfaces and protocols.

Based on expert interviews with relevant stakeholders and market evaluations, P3 developed a data model to provide an overview of available and applied protocols and data interfaces as a baseline for services related to Controlled Charging, Bidirectional Charging and Vehicle-Grid-Integration. This model illustrates on the one hand that there is a great variety of different interfaces and protocols in the market. Based on the evaluation, several protocols show a high market relevance and are applied by different players, which prevents the market from a standardised mass-market launch of these future services.



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However, there is a clear trend towards a more standardised market approach. The key enablers for this are selected protocols, which will become more and more disseminated in the market:

Protocols	Purpose	Status
Type 2 & CCS – Combo 2	Plug types are being widely used and defined as the main standard in the EU market for AC (Type 2) and DC (CCS – Combo 2) charging. Other than the Japanese fast-charging standard, the European plug types were not designed for bidirectional charging from the very beginning, although, the standardisation is ongoing with ISO 15118-20. First proprietary implementations from selected players, oriented on the future standard or on current ISO 15118-2, which requires high implementation efforts, are available.	Bidirectional Charging currently only via ISO 15118-2 with high implementation efforts. New ISO 15118-20 under development, to be published 2022/23.
ISO 15118(-20)	Enable smart communication between EV and charging station to transmit status information and enable controlled charging. Basic versions of ISO 15118 are already available and high importance is already recognised by automotive and charging device manufacturers. However, ISO 15118-20, which enables bidirectional charging, is still under development and forms crucial enabler for Bidirectional Charging and Vehicle-Grid-Integration.	Under development, to be published 2022/23.
OCPP / IEC 63110	De-facto standard Open Charge Point Protocol is constantly further developed to include additional features and manage the data exchange between charging devices and the software systems. With version OCPP 2.0.1, which is expected to be available from 2022 on, bidirectional charging is supported. The increasing importance of OCPP based on additional features, which become available, including the connection with energy management systems may become a feasible alternative for Modbus, which requires highly individualised onboarding processes.	Under development, to be published 2022/23.

5. MARKET STATUS & OUTLOOK

For the assessment of the market size for Smart Charging, only revenue potential has been considered from a private setting (single homes and multi-unit dwellings) and from workplace charging. Those revenue streams are from one-off sales (incl. hardware for home energy management and bidirectional charging), recurring revenues (incl. subscription fees for energy management, bidirectional charging services or compensations), and trading (for vehicle-grid-integration). Additional value could also be generated from cost savings resulting from smart charging applications but are not considered in this market valuation.

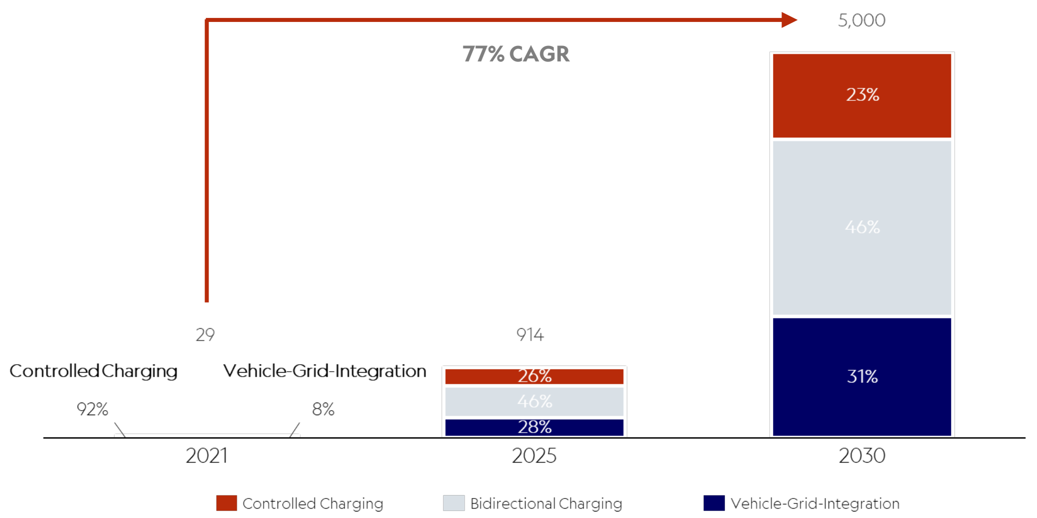
The key drivers of the market volume are:

- the increasing stock of both unidirectional and bidirectional charge points (derived as demand of the growing number of electric vehicles)
- the take rate of charging services

The market for Smart Charging will mostly be driven by Bidirectional Charging

The European market for Smart Charging as defined above has a value of EUR 29mn in 2021 which is almost solely based on revenues from Controlled Charging. The market will increase to up to more than EUR 914mn in 2025, with a significant increase of the revenues from Controlled Charging as well as with the emergence of Bidirectional Charging and Vehicle-Grid-Integration on the market. In 2025 already, Bidirectional Charging will be responsible for the largest share of revenue potential. The market will further almost triple until 2030 to a total value of EUR 5bn with growth across all segments, however Bidirectional Charging will remain the major driver with a share of more than 46%.

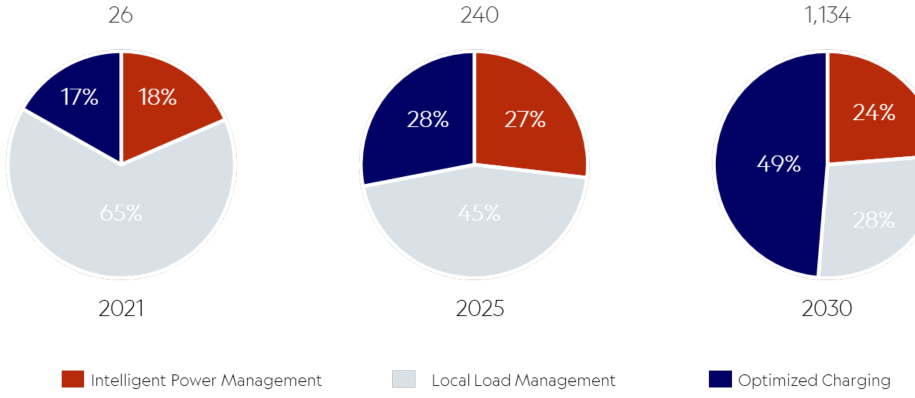
Overview of annual revenue potential for Smart Charging (in EUR mn)



Controlled Charging is today's use case which grows with the market ramp-up

Revenues for Controlled Charging will increase almost tenfold from EUR 26mn in 2021 to EUR 240mn in 2025, and even fortyfold until 2030 to a total value of more than EUR 1.13bn. In 2021, the most valuable use case is Local Load Management with a share of more than 65% of revenues related to Controlled Charging. While all use cases will show significant growth over time, Optimised Charging has the highest increase and will transform from the smallest (17% in 2021) to the largest use case (49% in 2030) in terms of revenue potential, making up for almost half of 2030's revenues.

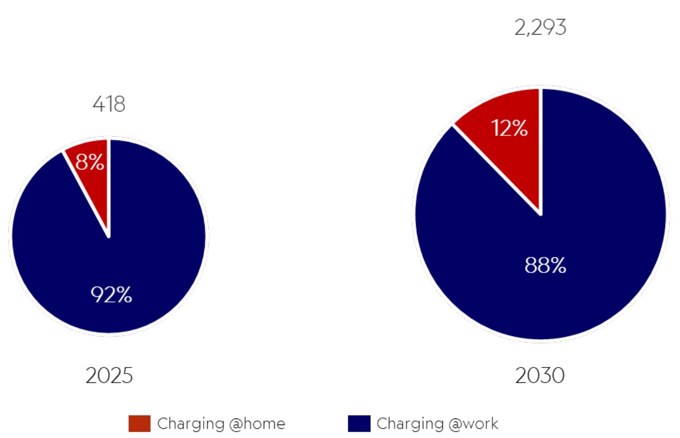
Overview of annual revenue potential for Controlled Charging (in EUR mn)



Bidirectional Charging is the future-shaping use case of the charging market

The largest market segment of Smart Charging services is Bidirectional Charging, though it is not suitable for the mass market yet. It will make up for 46% of the Smart Charging market both in 2025 and in 2030, though its revenue potential will increase from about EUR 418mn in 2025 to about EUR 2.3bn in 2030.

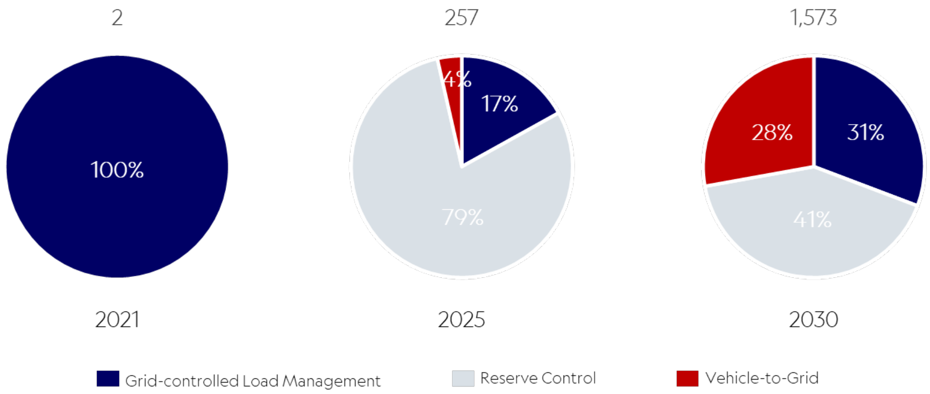
Overview of annual revenue potential for Bidirectional Charging (in EUR mn)



Vehicle-Grid-Integration will emerge from 2025 onwards

Applications for Vehicle-Grid-Integration are expected to be ready for mass-market by 2025 onwards and are by far the smallest segment in terms of revenue potential until 2030. The segment is valued at more than EUR 257mn in 2025, which is mostly based on revenues from Reserve Control (~79%). With a major increase to an annual revenue potential of EUR 1.58bn in 2030, the share of revenues related to Reserve Control drops to only 41% as the Vehicle-to-Grid application, as well as Grid-Controlled Load Management, become more and more important.

Overview of annual revenue potential for Vehicle-Grid-Integration (in EUR mn)



The energy trading value per charge point will decline over time

In 2025, the trading value for a charge point both at home or at work is estimated at EUR 270 with energy trading potentials from reserve control and Vehicle-to-Grid, with the majority of the value coming especially from Vehicle-to-Grid. Despite increasing revenue potentials in each segment, higher participation rates will lead to a moderate decline of the trading value per charge point over time as more and more charging points will be available to be used as operating reserve.

Revenue potential for smart charging will shift after 2030

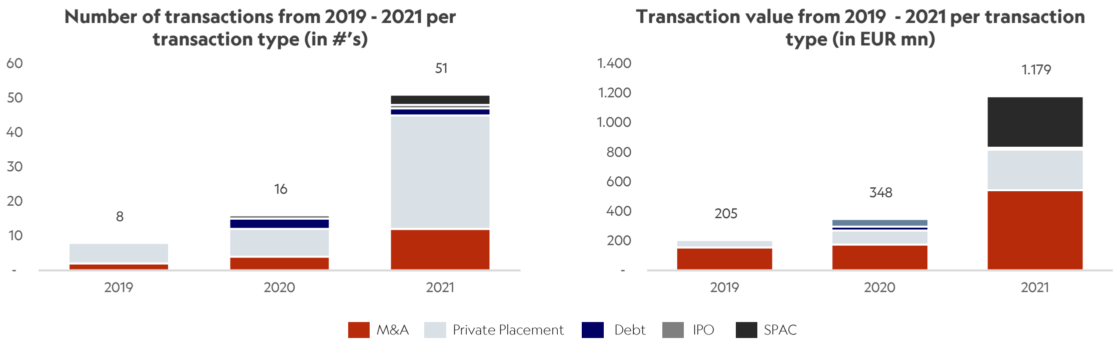
A high share of the revenue potential until 2030 is hardware-driven, such as the sale of bidirectional wallboxes which will enter the market, and which will be quite expensive in the upcoming years. However, several developments will cause the Smart Charging market to change after 2030. The price per unit of bidirectional hardware will become cheaper, while flexibilities in the energy market become bigger, and energy services will generally carry more weight in terms of revenue potential.

6. CAPITAL FORMATION TRENDS IN SMART CHARGING : CAPITAL RAISE, M&A, DEBT AND PUBLIC LISTINGS

Historic development of investment activity in the Smart Charging sector

In evaluating the historic capital formation development in the Smart Charging sector, all global transactions involving pure Smart Charging solution providers – hardware manufacturers and software solution providers – were included. Asset-light and asset-heavy Charge Point Operators (CPOs) have not been included in the evaluation of capital formation, given that the Smart Charging technology is not (wholly) owned and / or developed in-house.

During from 2019 to 2021, global smart charging investment activity has multiplied nearly six times and has really accelerated as of H1 2021. As such, the total transaction volume increased from 8 transactions in 2019 to 51 transactions in 2021. Similarly, the total transaction value increased nearly six times from EUR 205mn to EUR 1.8bn in 2021. The capital formation growth rate has been far superior to the growth of the E-mobility market of about 40% per year, underpinning a strong appetite to capture future potential, a "landgrab" of market share, and the increasing value-added of the products and services offered by these companies.



When looking at the number of transactions, activity doubled from 2019 vs. 2020, and more than tripled from 2020 vs. 2021. In 2021, over 65% of the transactions were Private Placements. The total transaction value increased by more than 50% from 2019 vs. 2020, and similar to the number of transactions, more than tripled from 2020 vs. 2021. The most notable transactions per deal type in 2020 vs. 2021 were as per below;

2020

- M&A: 1) The acquisition of PodPoint by EDF (deal value undisclosed), and 2) The acquisition of Chargedot Shanghai New Energy Technology by ABB (deal value undisclosed)
- Private Placement: 1) the EUR 45mn Private Placement from Mackinnon, Bennett & Company in AddEnnergie Technologies, 2) the EUR 12mn Private Placement from Soros Fund Management (lead), Siemens (lead), Congruent Ventures, Edison International in Amply Power
- IPO: The IPO of Compleo Charging Solutions (EUR 53mn)

2021

- M&A: 1) The acquisition of has-to-be by ChargePoint for EUR 250mn, and 2) The acquisition of ViriCiti by ChargePoint for EUR 75mn
- Private Placement: 1) the EUR 58mn Private Placement from Tiger Infrastructure Partners in Qwello, 2) the EUR 41mn Private Placement from Riverstone and BP Ventures (and numerous add-on investors) in FreeWire
- SPAC: 1) +/- EUR 300mn SPAC (incl. PIPE) of Wallbox, 2) EUR 52mn SPAC of Nuvve
- IPO: The IPO of Pod Point in November 2021

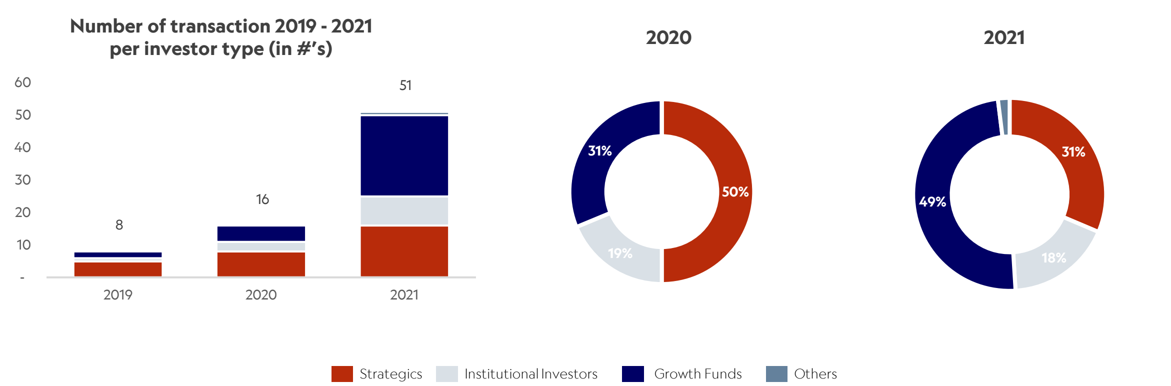
Conclusion 1: The investor universe is diversifying and maturing rapidly (from VC and strategics to institutional capital inflow)

Looking at the capital formation and types of investors active in the smart charging domain in 2019, it is noticeable that the majority of investors active in the space were Strategics. As of 2020, we can see that Growth and Institutional Investors started entering the smart charging market, investing approximately EUR 150mn in Smart Charging providers throughout the year. In 2021, the share of Growth and Institutional Investors has significantly increased and made up more than 65% of the transactions, investing over EUR 600mn into the sector.

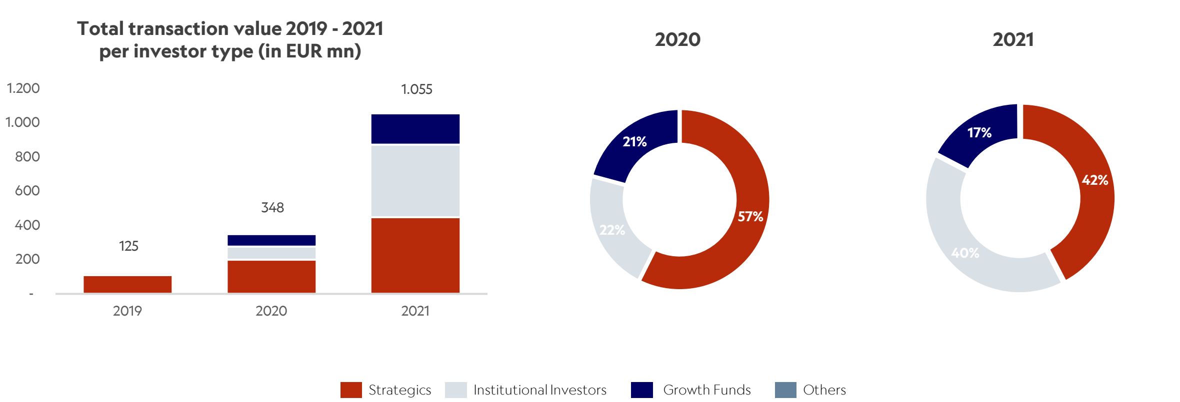
Driven by the increasing need for reliable Smart Charging solutions, changing risk profile and enormous financing need for mass-scale rollout, the growing presence of both Growth Funds and Institutional Capital can be explained. Their interest is further driven by the evolvement of business models (incl. energy management), improved unit economics and increasing commercial feasibility of Smart Charging applications, offering an increasingly interesting and long-term investment case.

When looking at the transaction value per year, most of the transaction value was allocated to Strategics, paying larger tickets and primarily focusing on M&A, rather than PP. Over the three years, CPOs and Utilities made up nearly 75% of all strategic investments and M&A. This partially explains the larger tickets paid by Strategics in predominantly M&A transactions, as CPOs and Utilities have made strategic decisions to 1) focus on acquisitions for internalising specialised Smart Charging technology instead of developing all elements in-house, and 2) secure their positions in the value chain.

Number of transactions per year



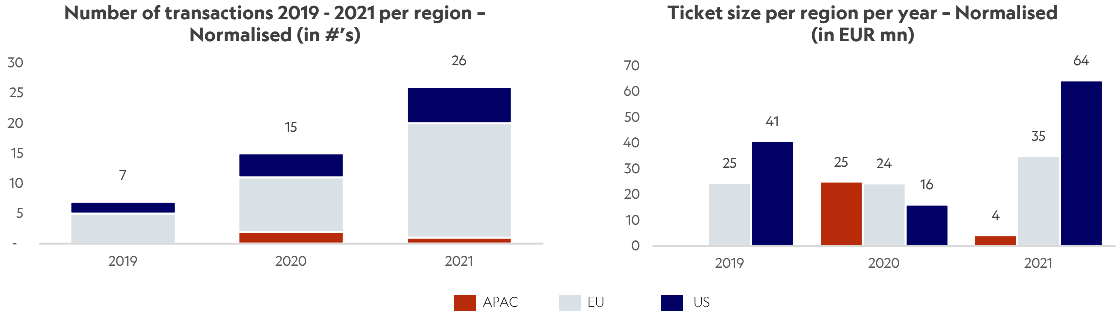
Transaction value per year



Conclusion 2: Investments in the US are accelerating quickly

Over the past three years, the number of EU transactions were significantly higher than in the US on both an annual and cumulative base. As such the number of EU transactions (33) from 2019 - 2021 were nearly three times as much as in the US (12). This can be partially explained by the US EV market not being as developed as the EV market in Europe, both in terms of technology and policy making. EU Governments have been supportive of E-Mobility innovations, while government support in the US has only accelerated with the entrance of the Biden Administration.

However, the average transaction size was significantly larger in the US than in the EU in 2021. This can be attributed to the increasing exposure to the US market from large strategics following feet on the ground, the large capital influx driven by an increasing amount of dedicated Cleantech SPACs (especially in 2021), and increasing favourable government programs such as the Biden Infrastructure Plan, further de-risking the market and stimulating the EV penetration.



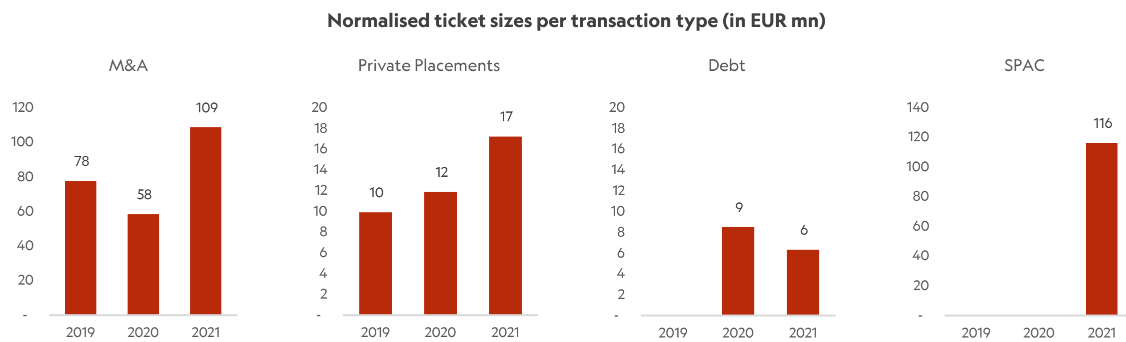
Over all three years, the majority of transactions took place in Europe (+/- 62%), then US (+/- 24%), and less in Asia Pacific (+/-14%).

When normalising* the number of transactions from 2019 - 2021 with an announced deal value & average ticket size per region, we noticed that the ticket size was significantly higher in the US vs. EU in both 2019 and 2021 (+/- 150% higher in 2019 and 180% higher in 2021), whereas the ticket size in 2020 was higher in Europe.

Conclusion 3: Fast increasing ticket size reflect concentration and market growth

The Smart Charging market is becoming more de-risked, as investors are convinced that EVs will soon become mainstream globally. This is evidences by the increasing amount of institutional capital flowing into the EV charging market, further driving up investment ticket sizes. Also, Smart Charging companies are maturing and raising larger rounds of Series B - C after their initial fundraising rounds.

When observing the average normalised* ticket sizes per type of transaction, it is noticeable that from 2020 to 2021 we notice a larger increase in ticket size in Private Placements (+/- 50%) and M&A (+/- 45%), and a slight decrease in Debt tickets sizes (+/- 10-20%). This again can be attributed to the sector becoming more mature and more interesting for Institutional Investors increasingly taking positions and generally committing larger tickets.



* Normalised by the number of transactions with announced deal value
Source: Pitchbook & IMPROVED market insights

7. CONCLUSION

Attractive & new business models ahead

Smart Charging offers various business opportunities for numerous established and new players within the EV charging ecosystem. The creation and investment in valid cross-industry "ecosystems" based on powerful standards and interfaces will unleash attractive business models and a EUR 5bn market in annual revenue of in hardware, software and value-added services up until 2030. The Smart Charging domain offers an attractive case for investors, as both the implementation and consolidation of Smart Charging solutions present significant new opportunities with high potential returns.

Ultimately, Smart Charging will be key in enabling the inevitable transformation of the mobility sector from fossil to renewable and emission-free sources.

Special thanks for sharing their valuable insights to:

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Marcus Fendt - Managing Director/CSO - The Mobility House

David Watson - CEO – Ohme

Hui Zhang - Group Vice President and Managing Director - NIO GmbH, Managing Director - NIO Performance Engineering

8. KEY CONTACTS

DOMINIQUE HOUDE
Partner

+44 7387 556 092
houde@improvedcf.com

DR. JAN TRAENCKNER
Senior Advisor E-Mobility

+49 (0) 171 22 00 335
jan.traenckner@p3-group.com

BAS HENDRIKS
Senior Associate

+31 (0) 6 124 53 435
hendriks@imrpovedcf.com

JOHANNA HECKMANN
Head of Charging Infrastructure

+49 (0) 163 77 17 204
johanna.heckmann@p3-group.com

NICOLAS MAGNUS
Senior Analyst

+31 (0) 6 812 47 844
magnus@imrpovedcf.com

FALKO BARTNIK
Consultant E-Mobility

+49 (0) 151 195 38 355
falko.bartnik@p3-group.com

ABOUT IMPROVED

IMPROVED Corporate Finance was founded in 2013 with the ambition of bringing more creativity, business intelligence and financial skills to corporate finance.

Today, IMPROVED is a premier corporate finance boutique with over 20 people across Europe, the US and APAC, with a combined experience of over 200 years. We have worked with the world's best entrepreneurs, investors and corporates across the Technology, Energy and Mobility (TEM) sectors.

IMPROVED has a deep conviction that there is no more room for local generalists in corporate finance, and that entrepreneurs, investors and corporates truly benefit from highly specialised boutique investment banks with relevant global sector expertise.

Since the early 2000s, our team has been synonymous with corporate finance for the Technology industry. This focus has enabled us to have a deep understanding of the business models and underlying value drivers of the most valuable tech companies dominating today's market. The global Energy and Mobility sectors are at the forefront of disruption, driven by iconic innovations that we aim to empower.

We excel at the intersection of Technology, Energy and Mobility – we focus on megatrends where innovation changes the way people and businesses interact, consume and travel. Entrepreneurs, investors and corporates are best served by a specialist corporate finance partner due to the pace of innovations. We are proud of what our clients have achieved, which is evidenced by our track record of success for our mid-market clients across the TEM sectors.

ABOUT P3

P3 as an international technology and management consultancy enables its clients to succeed in their business by delivering tangible value.

Founded in 1996 as a spin-off from a globally-recognised, leading technical university, P3 began with the goal of implementing an innovative new process and has remained focused on serving clients from innovation to implementation. P3 has around 1,000 employees across 20 locations globally.

P3 works within organisations and teams to develop and implement innovative solutions to complex technology challenges. Our clients are open-minded, secure leaders who seek solutions. They have the courage to bring in outside experts who can provide long-term value to their organisation.

Since 2005, P3 is active in e-mobility topics along the whole value chain. Its team of technical experts in this field has grown to >200 consultants with a focus on battery & cell technology, electric powertrain, charging infrastructure & grid integration and industrialization. P3 provides a holistic consultancy approach with expertise in technical & cost benchmarking, market & competitor studies, supplier selection and technical M&A topics, e.g., target screening, due diligence and integration strategies.

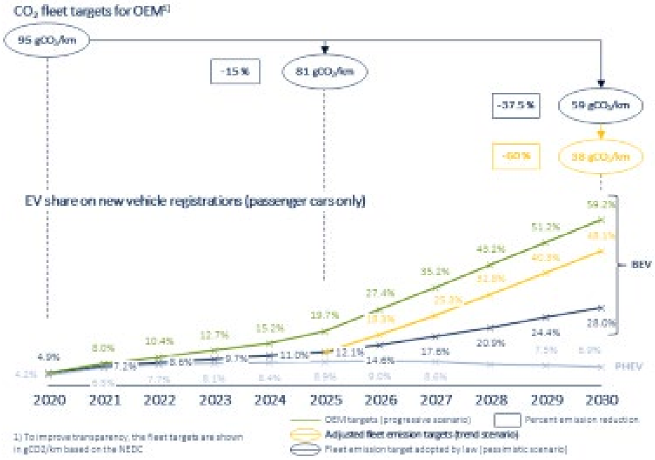
9. APPENDIX

9.1 NUMBER OF EVs in EUROPE UNTIL 2030

The ramp-up of electric vehicles was driven by fleet emission targets – now the industry sets the pace

A huge driver of electric mobility in Europe are the European Union's average fleet emission targets for passenger vehicles which car manufacturers need to achieve in order to avoid costly financial penalties. In 2020, most OEMs have managed to achieve the average of 95g CO2/km. As the EU intends for a further emissions reduction of 15% until 2025 and 37.5% until 2030 compared to the 2021 baseline, the need to get more zero emission vehicles on the road becomes stronger. Automotive manufacturers must achieve electrification rates of approximately 21% among new vehicle registrations by 2025 and about 35% by 2030 under the current legislation.

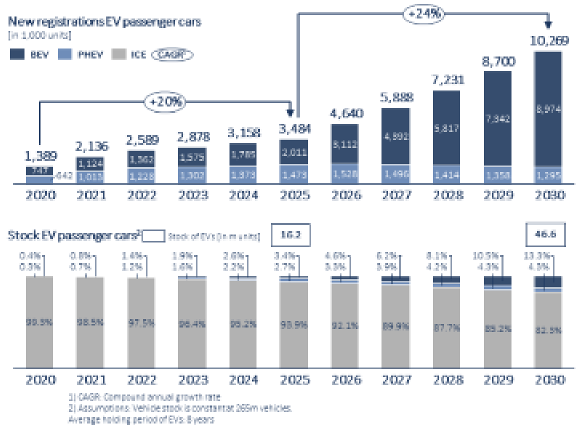
As part of the Green Deal initiative, it is currently being discussed politically to aggravate the target for 2030 by increasing the targeted emissions reduction to 60% - a proposition that is likely to succeed. In that case, OEMs are required to achieve electrification rates of about 55%. However, the car manufacturers seem to be prepared as some have already announced much more ambitious electrification targets to be achieved by 2030, which in case of success would mean that more than two out of three newly registered vehicle in 2030 is either a pure battery-electric vehicle (BEV) or a plug-in hybrid electric vehicle (PHEV).



The battery-electric vehicle will be of increasing significance in the upcoming years

In total numbers, the achievement of the fleet emissions target for 2025 results in approximately 3.5 million new electric (passenger) vehicle registrations, of which about 2 million are already pure battery-electric vehicles. Assuming the scenario of more ambitious EU targets of a 60% emissions reduction by 2030 becomes reality, the number of newly registered electric vehicles in Europe would already surpass the mark of 10 million in 2030. By then, the PHEV powertrain concept will have already lost importance as it will only account for about 12.5% of new electric vehicle registrations.

The stock of electric vehicles, which was less than 1% of the total stock of passenger cars in 2020, will increase to approximately 16 million by 2025 and nearly 50 million by 2030, representing a share of more than 6% (2025) respectively 17.5% (2030).



9.2 NUMBER OF EVSE in EUROPE UNTIL 2030

The electric vehicle is charged in a private setting – at residential locations or at the workplace

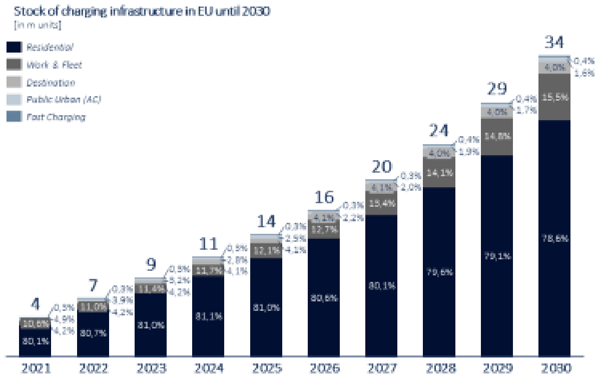
In contrast to fueling up cars with combustion engine, which always takes place at some kind of gas station, the charging of an electric vehicle's battery occurs rather decentrally at a variety of locations. It can be differed between five major use cases:

- Residential areas (e.g., homes, accommodations)
- Workplace (for employees, guests and fleets)
- Destination charging (e.g., at hotels, supermarkets, restaurants, etc.)
- Public urban area (AC charging)
- Public fast charging locations (HPC charging)

Based on a market forecast by P3, the total stock of charging infrastructure in Europe will rise from about 4 million today to approximately 14 million in 2025 and more than 34 million charging points by 2030. The drivers of electric vehicles will charge the car where they live, with the majority of charging points being in residential spaces. Residential charging points account for about 80% of today's total charging point stock and the share will hardly vary in the ramp-up of charging infrastructure over the next decade.

Charging at the workplace will contribute to the dominance of charging in a private setting, as this use case will increase its share from approximately 10% in 2021 to 15% in 2030, resulting in the fact that more than 9 out of 10 charging sessions will take place either at a residential or a workplace location.

With up to more than 1.3 million charging points by 2030, destination charging locations will show a significant growth representing a steady share of about 4% of the total stock until then. On the contrary, public urban charging will heavily lose importance. Despite being comprehensively available, its growth rates will decrease primarily due to a lack of investment interest as the business cases are unfavorable. Finally, the stock of high-power charging points will show high growth rates and increases to a total of 140K by 2030 – about 0.4% of the European charging infrastructure.



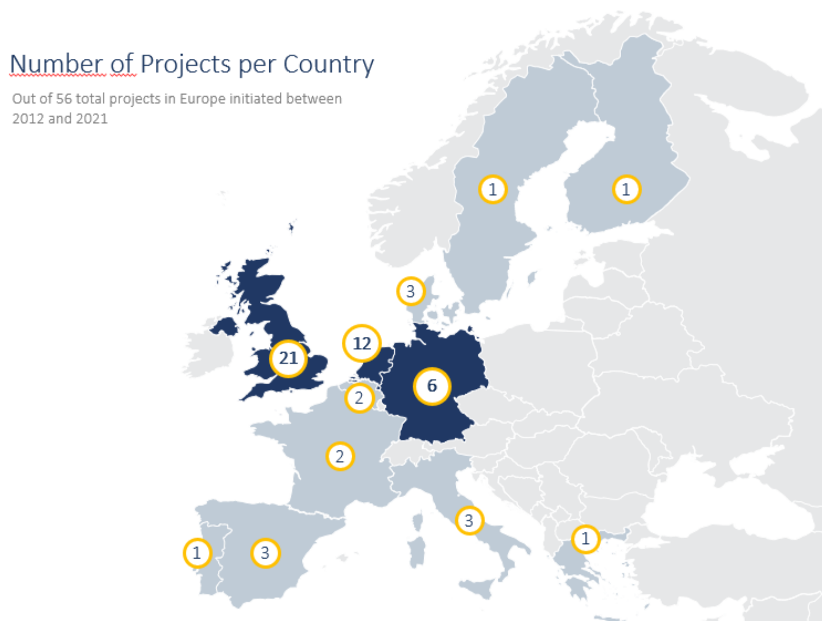
Smart Charging requires intelligent, connected infrastructure

With the ramp-up of electric vehicles and the charging infrastructure, Smart Charging becomes more and more important to be able to control the charging rate of electric vehicles. Therefore, charging infrastructure needs to be intelligent and connected so that loads can be balanced across charging points. Some funding programs already require charging infrastructure to be intelligently steerable in order to be eligible for subsidisation, such as the German subsidy for residential chargers.

9.3 PILOT PROJECTS IN EUROPE

Advanced Smart Charging projects for Vehicle-Grid-Integration are on a proof of concept or small-scale commercial trial level – industrialisation expected for upcoming years

Based on the public database V2G Hub, which serves as an exchange platform on future EV charging projects, in total 56 projects in the area of Vehicle-to-Grid have been realised between 2012 and 2021. The majority of them were realised in UK (21) and the Netherlands (12). The German is third with a total of 6 Vehicle-to-Grid projects realised.

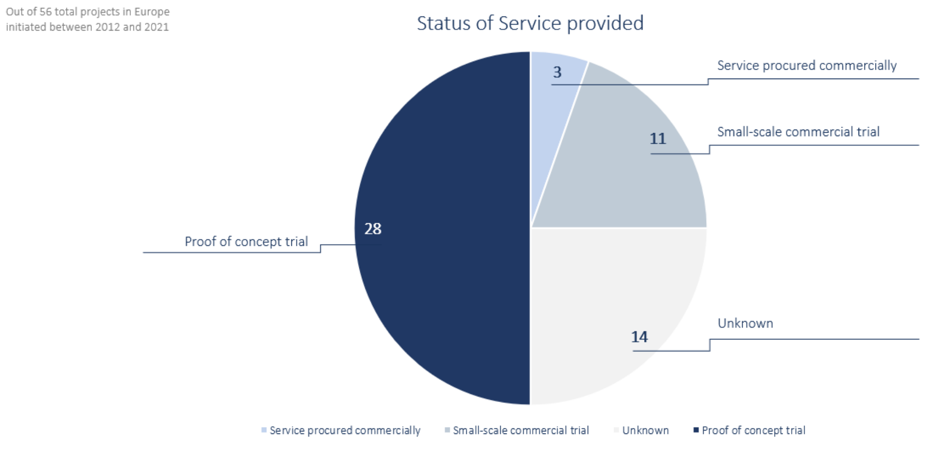


Projects per Country

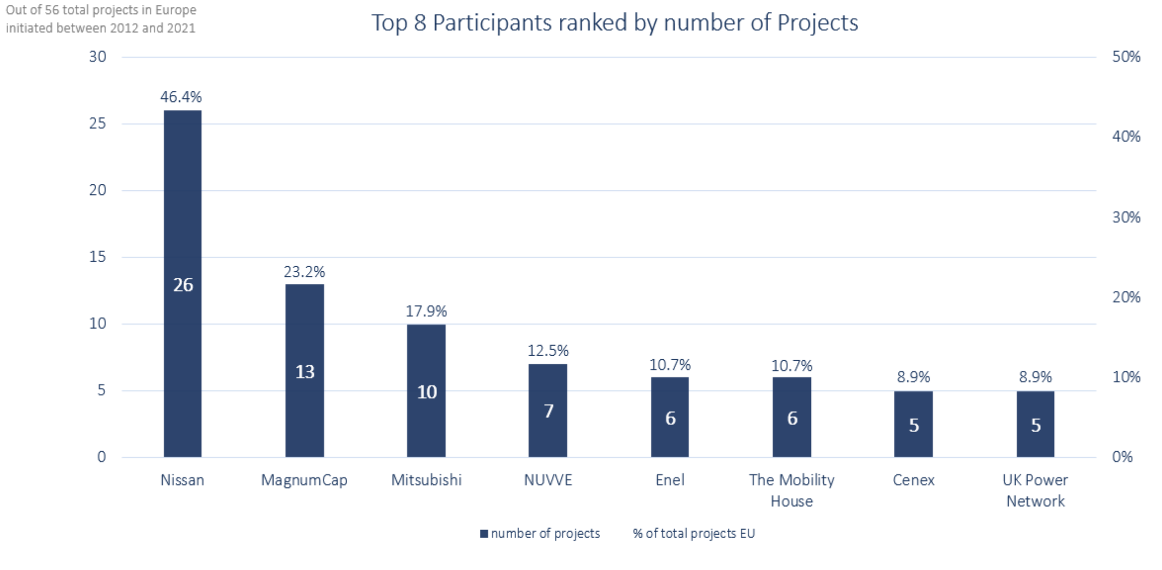
UK	21
NL	12
DE	6
DK	3
ES	3
IT	3
BE	2
FR	2
FI	1
GR	1
PT	1
SE	1

Source: P3 Analysis

The majority of the projects realised are Proof-of-Concept activities (50%) to further evaluate the technology and derive recommendations for the future standardisation of required interfaces and to assess the benefit potential for various stakeholders along the market. Next to that, there are some small-scale commercial trials projects, such as Parker Project, which in total make 20% of all the projects. Only a very small share of projects (5%) are projects, where the Vehicle-Grid-Integration was procured on a commercial level.



As already described earlier, the provision of future services such as Vehicle-to-Grid require a high degree of cooperation within a complex ecosystem and among several stakeholder. That's why the realised projects typically comprise of bigger consortiums including automotive manufacturer, utilities and grid operators, but also smart energy management specialists such as Nuvve (US), Enel (ITA) or The Mobility House (GER), which are also ranked among the top players participating in these projects. When it comes to automotive manufacturers taking part in these future projects, it is mostly Nissan and Mitsubishi, as the technology of these manufacturers is based on the CHAdeMO technology and plug, which has been enabled for bidirectional charging at an early stage already. The European charging standard Combined Charging System is now also enabled for these applications and some European manufacturers have announced major activities, especially Volkswagen during the VW Power Day.



Pilot projects tackle Vehicle-to-Grid services in residential and commercial environments

One of the proof-of-concept activities was the Parker Project in Denmark from 2016 – 2019. The project, aimed to explore V2G applications such as FCR services, as well as its scalability, was accompanied by several car manufacturers and energy companies. It concluded that V2G technology is technically ready and scalable, and that it is possible to participate on the energy market without negative effects on one's driving behavior. However, at the time the project results also stated a sensitive business case depending on several factors such as the energy costs, reimbursement fees, V2G charger costs and more, and that the supply chain is not available due to a limited number of suitable vehicles and hardware on the market.

Project Sciurus has been a large-scale domestic V2G project in the United Kingdom which has just been concluded in 2021. Originally planned with 1,000 charging points, the project was downsized to 320 bidirectional chargers which were provided by Ovo Energy to Nissan Leaf drivers who were willing to participate and installed in their homes. With receiving a fixed rate for the energy fed back to the grid, the participants were able to generate an annual revenue of £340 with tariff optimisation using V2G, compared to only £120 with a unidirectional charge point and tariff optimisation. The annual revenue with a V2G charger could have been further increased by including firm frequency response and dynamic containment services.

An interesting upcoming project is the joint effort of Fiat-Chrysler, Engie and Terna with their V2G project at the FCA plant Mirafiori. The 64 bidirectional charging points (up to 50 kW each) is meant to be increased to more than 700 in the course of the project. With a regulation capacity of 25 MW, it is the largest V2G project in the world. The goal, besides providing FCR services to Terna, is to develop business models to be able to participate on the energy market, and to test V2G charging effects on the electric vehicle's battery. The virtual power plant is complemented by a PV system and second-life batteries.

	Parker Project	Project Sciurus	Fiat-Chrysler & Engie
PROJECT DESCRIPTION	The Parker project was a Danish demonstration project focused on Vehicle-Grid-Integration and its applications (especially frequency regulation services), the development of a test protocol to support V2G and finally to explore the scalability of frequency containment reserve services. The project also partnered with the Frederiksberg Forsyning V2G hub, the first commercial pilot in the world for FCR applications.	With 320 bidirectional charging points, Project Sciurus has been one of the largest V2G projects which has just finished in 2021. Drivers of a Nissan Leaf were provided by Ovo Energy with bidirectional charging hardware by Indra at their homes. The participants had an app to decide on charging parameters and were paid a fixed rate (per kWh) for feeding back energy to the grid.	Italian car manufacturer FCA, energy supplier Terna and Engie plan the currently largest V2G project of the world at an FCA facility in Turin with up to 700 bidirectional charging points. The project works with a regulation capacity of 25 MW to provide ultra-fast FCR (frequency containment reserve) services to Terna. An additional 5 MW PV system on site and 2nd life batteries will be integrated as well.
PROJECT PARTICIPANTS	▪ DTU Electrical Engineering ▪ Enel X ▪ Frederiksberg Forsyning ▪ Insero ▪ Mitsubishi ▪ Nissan ▪ Nuvve ▪ PSA	▪ Cenex ▪ Indra ▪ Nissan ▪ Ovo Energy	▪ Engie EPS ▪ Fiat-Chrysler Automobiles Italy ▪ Terna
COUNTRY			
TIMELINE OF PROJECT	2016–2019	2018–2021	2023–2027

"Smart Charging: The Upcoming Revolution of Electric Vehicle Economics" (IMPROVED & P3, January 2022)

9.4 GLOBAL SMART CHARGING TRANSACTIONS 2019 – 2021

APPENDIX: SMART CHARGING M&A / PRIVATE PLACEMENTS/ IPO / SPAC BY DATE

Date	Target/ Investee	Country	Description	Acquirer/ Investor	Deal Type	Financing Round / M&A rationale
Dec-21	**Plugit Finland**	FI	Provider of EV charging infrastructure	DIF	M&A	Merger/Acquisition
Dec-21	**Charge+Zone**	IN	Operator of EV charging network	Venture Catalysts	PP	Later Stage VC
Dec-21	**Amply Power**	US	Developer of charging management software	BP	M&A	Merger/Acquisition
Nov-21	**EnBW Energie Baden-Württemberg**	DE	Charging station technology	Heidelberger Druckmaschinen	PP	Asset Financing
Nov-21	**Ykccn.com**	CN	Developer of an EV charging SaaS platform	Oppo	PP	Seed Round
Nov-21	**Jedlix**	NL	Smart charging back-end provider	Mobilize Invest, Osaka Gas, Skagerak Energi	PP	Later Stage VC
Nov-21	**Spark Charging Solutions**	CN	Provider of an on-demand EV charging network	Hypercharge (Automotive)	M&A	Merger/Acquisition
Nov-21	**Pod Point Group Holdings**	UK	Asset-light CPO focused on home and semi-public segments	*Undisclosed*	IPO	IPO
Nov-21	**Qwello**	DE	EV charging hardware developer and operator	Tiger Infrastructure Partners	PP	PE Growth/Expansion
Oct-21	**Xeal**	US	Developer of a smart electric vehicle charging system	Align Real Estate, ArcTern Ventures, Harrison Street Real Estate Capital, Hunt Companies, LPC Ventures, Moderne Ventures	PP	Early Stage VC
Oct-21	**Fermata Energy**	US	Developer of V2G bidirectional chargers	*Undisclosed*	PP	Later Stage VC
Oct-21	**Hypercharge**	CA	Operator of a smart charging network	*Undisclosed*	PP	Angel (individual)
Oct-21	**Exponent Energy**	IN	Manufacturer of electrical vehicles batteries	3one4 Capital, AdvantEdge Partners, YourNest Venture Capital	PP	Seed Round
Oct-21	**Wallbox**	ES	Designer and manufacturer of AC, DC and V2G chargers	Kensington Capital Acquisition II	SPAC	Reverse Merger
Oct-21	**Wallbox**	ES	Designer and manufacturer of AC, DC and V2G chargers	Cathay Innovation, Janus Henderson Investors, Kensington Capital Partners, Luxor Capital Group	SPAC	PIPE
Sep-21	**AmpUp**	US	P2P charging network (Charging back-end software)	Powerhouse Ventures	PP	Seed
Sep-21	**Ykccn.com**	CN	Developer of a third-party EV charging SaaS service platform	NIO Capital	PP	Early Stage VC
Aug-21	**AmpUp**	US	P2P charging network (Charging back-end software)	Goodyear	PP	Early Stage VC
Aug-21	**EO Charging**	UK	Designer and manufacturer of smart electric vehicle chargers	First Reserve Sustainable Growth	M&A	Reverse Merger
Aug-21	**Viricity**	NL	Developer of an online fleet management platform	Chargepoint	M&A	Merger/Acquisition
Aug-21	**Wirelane**	DE	Asset-ligt CPO focused on Home and Semi-public slow charging	Abacon Capital	PP	Later Stage VC
Aug-21	**Dcbel**	CA	Developer of an EV charger connecting solar systems to the grid	Silicon Valley Bank	PP	Debt
Aug-21	**Fermata Energy**	US	Developer of V2G bidirectional chargers	Waterland	PP	PE Growth/Expansion
Jul-21	**Hypervolt**	UK	Operator of smart charging networks	*Undisclosed*	PP	Early Stage VC
Jul-21	**has-to-be**	US	E-mobility software	ChargePoint	M&A	Merger/Acquisition
Jul-21	**EVOS Technology Australia**	AU	Manufacturer of EV charging products intended to uptake zero-emission fleet	Autostrada	M&A	Merger/Acquisition
Jun-21	**Char.gy**	UK	Provider of smart EV charge points utilising existing street infrastructure	Zouk Capital	PP	PE Growth/Expansion
Jun-21	**IoTecha**	US	Provider of integrated software and hardware solutions to the EV charging infrastructure	BP Ventures	PP	Later Stage VC
Jun-21	**Xcharge**	CN	Manufacturer and provider of AC and DC (ultrafast) chargers up to 480kW	Shell Ventures	PP	Early Stage VC
Jun-21	**GreenFlux**	NL	B2B focussed CPO	DKV	M&A	Merger/Acquisition
May-21	**Connected Kerb**	UK	Provider of smart EV charging solutions	*Undisclosed*	PP	Early Stage VC
May-21	**Hypervolt**	UK	Provider of smart EV charging solutions	*Undisclosed*	PP	Angel (individual)
Apr-21	**Wallbe**	DE	Provider of EV charging solutions to private, semi-public and public areas	Compleo Charging Solutions	M&A	Merger/Acquisition
Apr-21	**Etrel**	SI	Manufacturer of interactive charging stations	Landis+Gyr	M&A	Merger/Acquisition
Apr-21	**Virta**	FI	Back-end provider for EV Charging Management	Eneos Innovation Partners, Future Energy Ventures, Helen Ventures, Jolt Capital, JXTG Nippon Oil & Energy, Lahti Energia, Tesi, Vertex Growth	PP	Later Stage VC
Apr-21	**Enelion**	PL	Manufacturer of electric car chargers	PGNiG Ventures	PP	Later Stage VC
Apr-21	**Hypervolt**	UK	Provider of smart EV charging solutions	*Undisclosed*	PP	Early Stage VC
Mar-21	**Ykccn.com**	CN	Provider of customized services to electric vehicle charger companies	Contemporary Amperex Technology, Empower Investment	PP	Early Stage VC

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APPENDIX: SMART CHARGING M&A / PRIVATE PLACEMENTS/ IPO / SPAC BY DATE

Date	Target/ Investee	Country	Description	Acquirer/ Investor	Deal Type	Financing Round / M&A rationale
Mar-21	**Spirii**	DK	Provider of smart EV charging solutions	Nordic Alpha Partners	PP	Later Stage VC
Mar-21	**The Mobility House**	DE	Smart Charging and Energy Management Solutions provider	Mercuria	PP	Series C2
Mar-21	**Nuvve**	US	Developer of grid-integrated vehicle platform (VGI)	Newborn Acquisition Corp	SPAC	SPAC Acquisition
Mar-21	**Charge Amps**	SE	Developer of hardware and smart AC charging stations	Swedbank Robur	PP	PE Growth/Expansion
Mar-21	**Driivz**	IL	Cloud-based EV charging management platform	Volvo Group Venture Capital	PP	Later Stage VC
Feb-21	**Last Mile Solutions**	NL	Operator of EV charging & smart energy management platform	Eurowag	PP	Corporate
Feb-21	**Rolec Services**	UK	Manufacturer of smart AC and DC rapid chargers	Sdiptech	M&A	Merger/Acquisition
Feb-21	**MobilityPlus**	BE	Provider of smart, green charging stations	Concentra NV, Fritz Mertens, Luc Opdebeeck, Robert Decant	PP	Angel (individual)
Feb-21	**AmpUp**	US	P2P charging network (Charging back-end software)	2.12 Angels, TechNexus Venture Collaborative, Tsingyuan Ventures	PP	Seed Round
Feb-21	**Wallbox**	ES	Designer and manufacturer of AC, DC and V2G chargers	Cathay Innovation, Iberdrola - PERSEO, Seaya Ventures, Wind Ventures	PP	Later Stage VC
Jan-21	**FreeWire Technologies**	US	Manufacturer of mobile and battery-integrated EV chargers	Riverstone Holdings, BP Ventures, Alumni Ventures Group, Blue Bear Capital, Energy Innovation Capital, Trirec	PP	Later Stage VC
Jan-21	**ubitricity**	DE	Asset-light CPO offering smart charging solutions	Royal Dutch Shell, Shell Ventures	M&A	Merger/Acquisition
Jan-21	**Indra Renewable Technologies**	UK	Developer of smart charging and energy storage systems	Clean Growth Fund, Gulf Oil	PP	Early Stage VC
Nov-20	**Parking Energy**	FI	Provider of electric vehicle charging for property market	Atine Group	PP	Later Stage VC
Oct-20	**Compleo Charging Solutions**	DE	Provider of charging solutions	*Undisclosed*	IPO	IPO
Oct-20	**AddEnergie Technologies**	CA	Charging network operator for electric vehicles and a provider of smart charging solutions	Mackinnon, Bennett & Company	PP	Series C
Oct-20	**The Mobility House**	DE	Smart Charging and Energy Management Solutions provider	Singapore Power	PP	Series C1
Oct-20	**The Mobility House**	DE	Smart Charging and Energy Management Solutions provider	European Investment Bank	Debt	Series C1
May-20	**Wallbox**	SP	Designer and manufacturer of AC, DC and V2G chargers	Seaya Ventures (lead) Iberdrola, Endeavor Catalyst	PP	Series A
May-20	**Fermata Energy**	US	Developer of V2G bidirectional chargers	Tepco	PP	PE Growth/Expansion
Apr-20	**Amply Power**	US	Commercial fleet electrification operations (CaaS model)	Soros Fund Management (co-lead), Siemens (co-lead), Congruent Ventures, Edison International	PP	Series A
Apr-20	**AmpUp**	US	P2P charging network (Charging back-end software)	SAIC Motor & Hyundai Motor Company	PP	Series A
Apr-20	**GreenFlux**	NL	B2B focussed CPO	Joulz	M&A	Divestment
Apr-20	**Virta**	FI	Back-end provider for EV Charging Management	JXTG Nippon Oil & Energy	PP	Series C
Mar-20	**Chargedot**	CN	Smart charging AC/DC stations + EV software (mobile app)	ABB	M&A	Bolt-on
Mar-20	**POD Point**	UK	Asset-light CPO focused on home and semi-public segments	Triodos	Debt	Asset Financing
Feb-20	**Driivz**	IL	Cloud-based EV charging management platform	Gilbarco Veeder-Root (co-lead), Centrica Innovations (co-lead), Ombu, Inven Capital	PP	Series C
Feb-20	**POD Point**	UK	Asset-light CPO focused on home and semi-public segments	EDF, Legal & General	PP	Platform
Jan-20	**Jedlix**	NL	Smart charging back-end provider	Renault	M&A	Technology
Nov-19	**Pivot Power**	UK	Developer of transmission-connected battery storage and EV charging network	EDF	PP	Bolt-on
Sep-19	**Amply Power**	US	Commercial fleet electrification operations (CaaS model)	Obvious Ventures (lead), Congruent Ventures, Edison International, PeopleFund, KittyHawk Ventures	PP	Seed
Aug-19	**has-to-be**	AT	E-mobility software	Elli (Volkswagen Group)	PP	Later Stage VC
Jun-19	**The Mobility House**	DE	Smart Charging and Energy Management Solutions provider	Alliance Ventures (lead), Ventura Capital	PP	Series B
Jun-19	**Fastned**	NL	Operating fast charging network for EVs in Netherlands	IPO	IPO	IPO
Jun-19	**Wallbox**	SP	Designer and manufacturer of AC, DC and V2G chargers	Iberdrola	PP	Series A
Mar-19	**POD Point**	UK	Asset-light CPO focused on home and semi-public segments	Legal & General	PP	Series D
Jan-19	**Xcharge**	CN	Manufactuerer and provider of AC and DC (ultrafast) chargers up to 480kW	Innoven Capital	PP	Debt
Jan-19	**Greenlots**	US	Asset-light CPO offering end-to-end EV charging network management solution	Shell	M&A	Bolt-on

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