JAMES KELLY

Electric Vehicle Charging – Infrastructure, Market and Connectivity

CPD

ENGINEERS IRELAND

REGISTERED TRAINING PROVIDER 2022

ABB

Presentation Overview

Why Electric Cars, Organization, Scope, References
Market (Cars & Standards)
DC versus AC Charging and EMC Class
Market Segments & Infrastructure
Connectivity – Operational and Economic

Why Electric Cars, Organization, Scope, References

We have only 12 years left to limit climate change catastrophe, warns UN

Why we want everybody to drive electric cars charged by clean, renewable energy

World is already 1 degC warmer today

There is now a growing recognition that the previous 2 degC negotiated Paris limit is dangerous and we need to limit to 1.5 degC instead of 2 degC

At the current level of commitments, the world is on course for a disastrous 3 degC of warming

To stay within 1.5 degC the global carbon pollution would have to be cut by 45% by 2030 – compared with a 20% cut under the 2 degC pathway – and come down to zero by 2050, compared with 2075 for 2 degC.

2/3 of global carbon pollution comes from transport and energy generation sector

Widest portfolio of EV charging solutions for customers across various use cases

Use case


Single home residential charging


Apartment, hotel & workplace destination charging


Commercial fleet


Public commercial parking


Fast-charging roadside stations


Bus charging

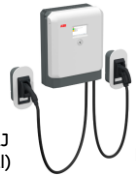

Industrial fleet


Heavy-duty truck charging

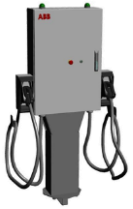
Charging products


Terra AC wallbox 3-22 kW


Terra Nova 11J (bi-directional) 11 kW


Terra DC wallbox 20-25 kW


Terra 124 60-120 kW


Terra HVC 50-180 kW


Terra 184 90-180 kW


Terra High Power (liquid cooled) 175-350 kW


Terra 360 (liquid cooled) 180-360 kW


Pantograph (panto up, panto down, connectors) 150-600 kW

To come in 2022


Megawatt charger up to 3 MW

Asset, energy & fleet management


Connectivity and remote software update


Remote support (configuration, troubleshooting)


24/7 network monitoring by ABB


User interface


Plug & charge


Payment module


EV site management


Bi-directional charging


Enable energy trading[1]


Predictive load profiles


e-fleet schedules & management

Source: Company information
Note:
1. ABB E-mobility does not engage in energy trading but enables customers to do so

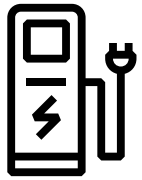
ABB’s EV Charging Infrastructure business

Key figures

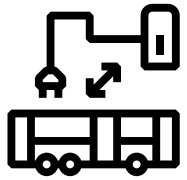
~ 800+
employees

High double digit growth rate

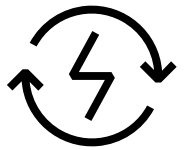
Chargers installed in **85+** countries



20,000+
DC chargers sold



~ 24 million charging sessions enabled



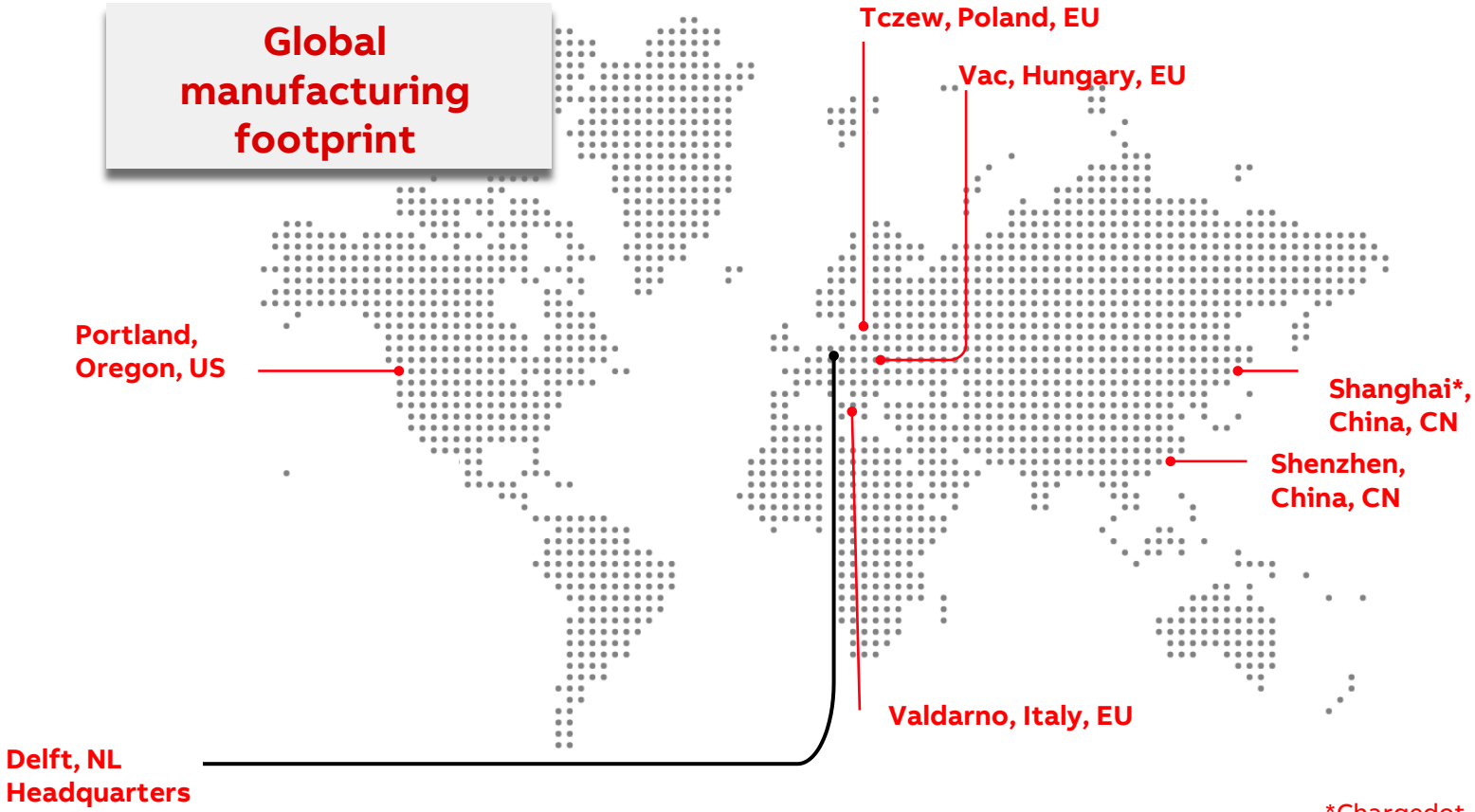
~ 332 GWh
delivered

ABB E-mobility solutions business

Positioned well for global growth

ABB has >10 years in EV charging

IP (Intellectual Property) and developments are ABB in-house.



*Chargedot

ABB in Ireland

At a glance

ENGINEERS IRELAND
REGISTERED TRAINING PROVIDER 2022

180

People work for ABB in Ireland

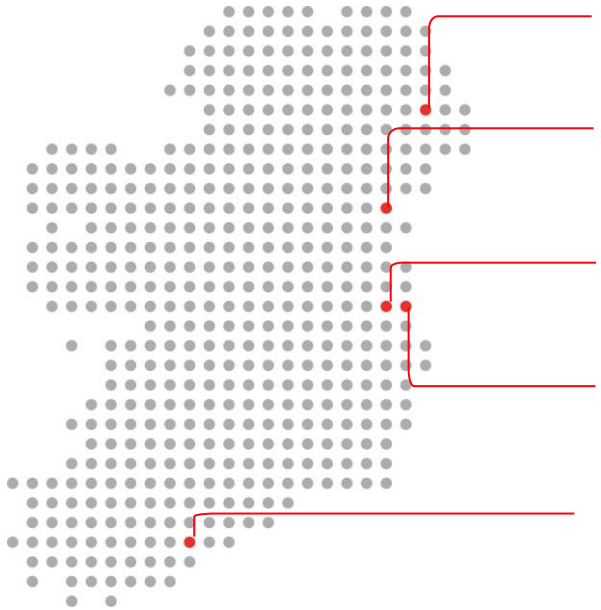
5

Sites where products are sold, serviced or engineered

Want to know more?

marketing@ie.abb.com

www.abb.ie



Lisburn, EL
Local regional office
EL Product supply & support

Dundalk, PAPI
IAPI QCS technology centre
R&D for QCS product line
Sales & marketing support

Dublin, HQ EL, PA, & MO
Automation, Power, Sales, Engineering, & Management

Dublin, Cylon Controls
Production & Service

Cork PAEN
Process Automation
Project delivery

Skilled and experienced Irish team, backed by global networks

ABB, eMobility and EV Charging

ABB’s focus and investments in eMobility are also recognized in the market place

ABB and Formula E

Together, Formula-E and ABB are defining the roadmap for electric mobility through motor sports.

Jaguar I-PACE eTROPHY Series

Jaguar I-PACE eTROPHY announces ABB as Official Charging Partner

ABB will provide custom-made, compact Terra fast chargers for the series

Fortune Magazine's August 20th 2018

Recognizing ABB’s groundbreaking leadership in e-mobility, Fortune Magazine today selected ABB as #8 on its 2018 “Change the World” list, a global ranking of companies whose innovative work is making a significant, positive social impact around the world.

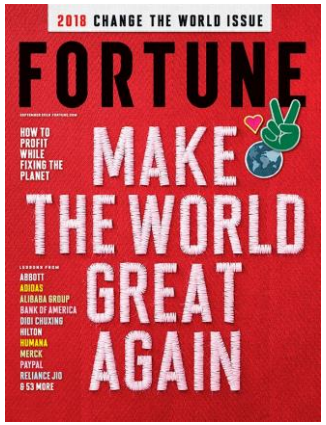


ABB is global charging partner for Car, Bus and Truck OEMs

Strong presence in China, USA and Europe

– R&D partners

– R&D partners
DC fast chargers at dealers

– R&D partners
DC fast chargers at dealers

– R&D partners
– DC Wallbox

– R&D partners

– R&D partners

– R&D partners

– DC fast chargers at dealers

– DC charging testing & R&D

– DC charging testing & R&D

– Global partnership
R&D partners

– Bus
– R&D partners

– Truck
– R&D & joint project

– R&D partners

– Cooperation
– R&D partners

– R&D partners

– Partnership
– R&D partners

– Cooperation
– R&D partners

– R&D partners

– Joint projects

– Cooperation
– R&D partners

– R&D partners

– R&D partners
– DC fast chargers at dealers
– Cooperation Dong-Feng

– R&D partners

– R&D partners

– R&D partners
DC wall box for Denza EV

Market (Cars & Standards)

Only few EVs can charge with 22 kW at an AC charge post

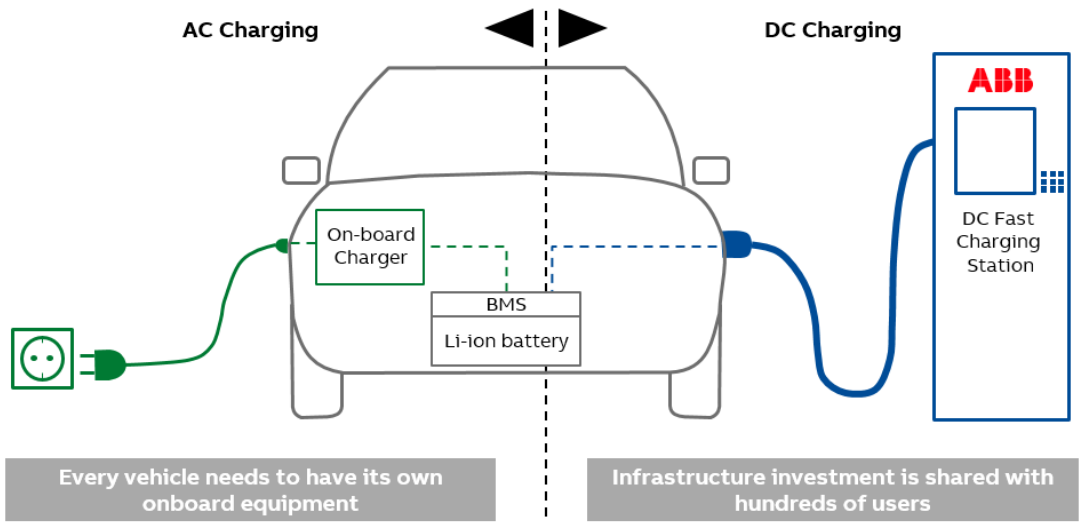
In most cases, the AC charging speed is limited by the EV on-board converter (OBC)

Only a very small amount of EVs can charge at 22 kW:

- Renault Zoe
- Tesla Model S with the optional 22 kW OBC. This was default at the begin but later changed to an 11 kW OBC (cheaper).
- Smart ED, only with the very expensive 22 kW OBC option. Default is a 3 kW to max. 6 kW OBC.
- Audi Quattro e-tron with 11 kW OBC (optional 22 kW OBC)
- Mercedes B-Class which is hardly sold, with 11 kW OBC.

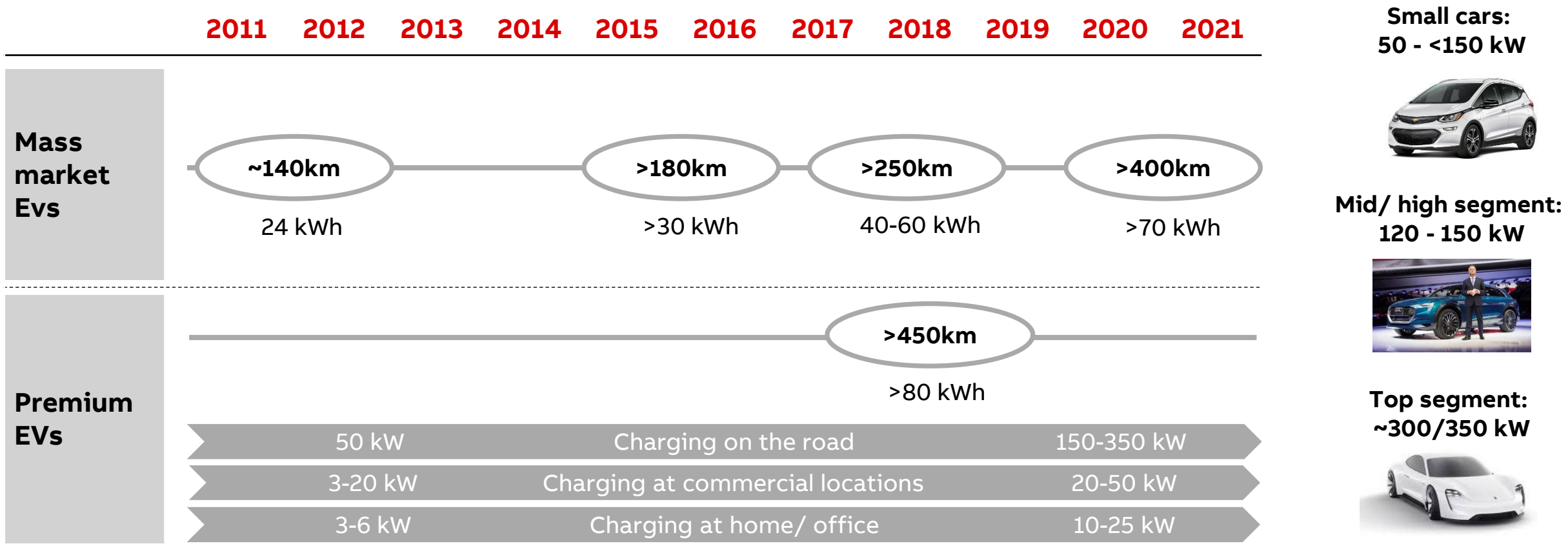
Other BEVs typically AC-charge with 3 kW to max. 6 kW.

The same holds for PHEVs: almost no car can AC-charge at 22 kW.



Driver: The EV range roadmap for EU, USA, APAC

Batteries get bigger, range gets longer



Next generation EV infrastructure market development

With new EVs coming (longer range, faster charging) different use cases will emerge

High Power Charging 150-350 kW

375 A/ 500 A

High speed– short stay

10-20 minute use cases

- Long distance corridors
- Highway rest stops
- Petrol station area's
- City ring service stations

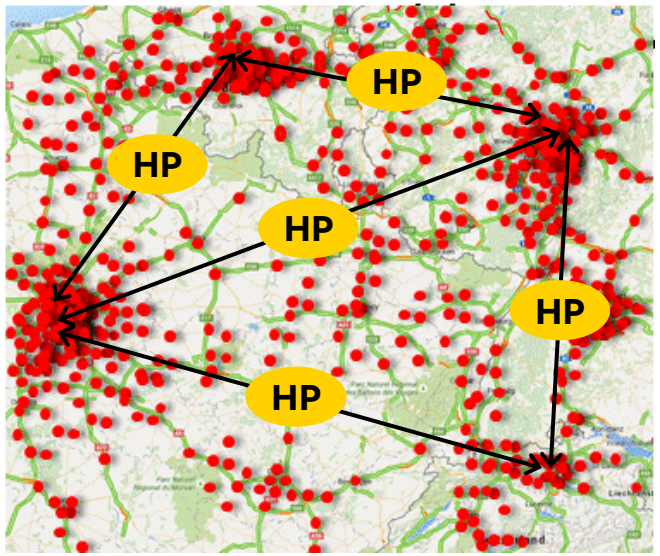
Regional fast charging 50 kW

125 A

More chargers per site – Longer stay

20-90 minute use cases

- Metropolitan locations
- Retail & food locations
- Shopping area's
- Supermarket locations
- Inner-city fast charging
- City ring service stations
- Fleet/ taxi solutions
- Solution for small EVs with <50 kW charging capability



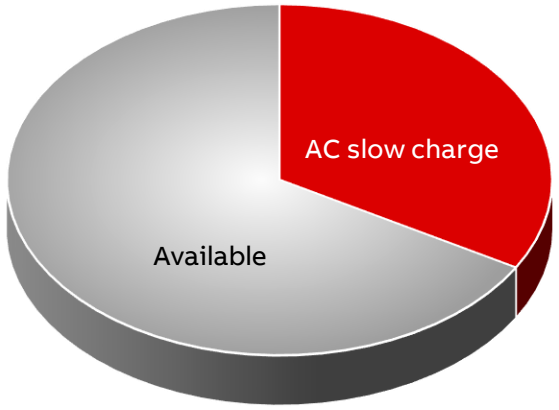
 Business rationale: Investment cost vs. charging performance should be optimized per location

DC versus AC Charging and EMC Class

Influence on range and availability by AC slow and DC fast charging

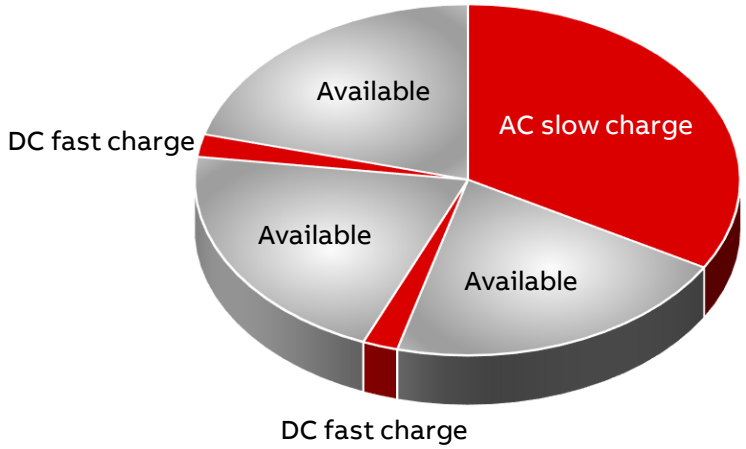
Possibility to strongly extend the range of a BEV by DC fast charging

Only AC slow charge (8 hrs)



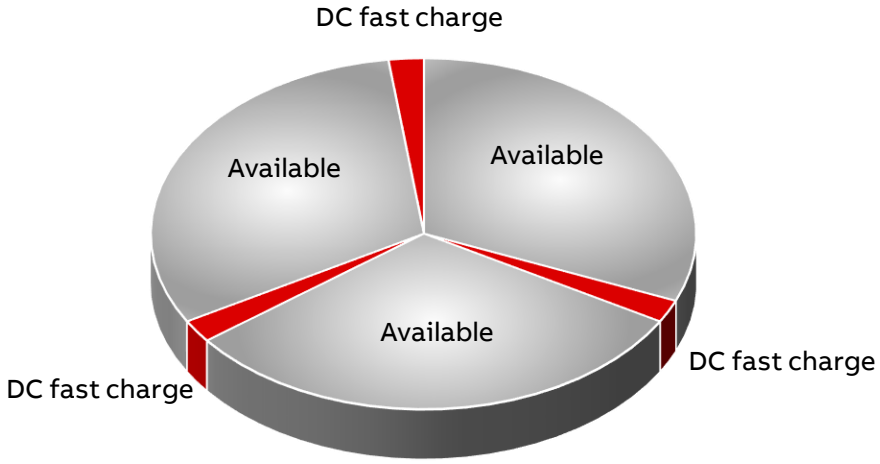
Availability 16 hours
Total range: 300 km

AC slow charge (8 hrs) +
2x DC fast charge (each 30 min)



Availability 15 hours
Total range: 900km

Extreme: for e.g. fleet owners:
3x DC fast charge (each 30 min)

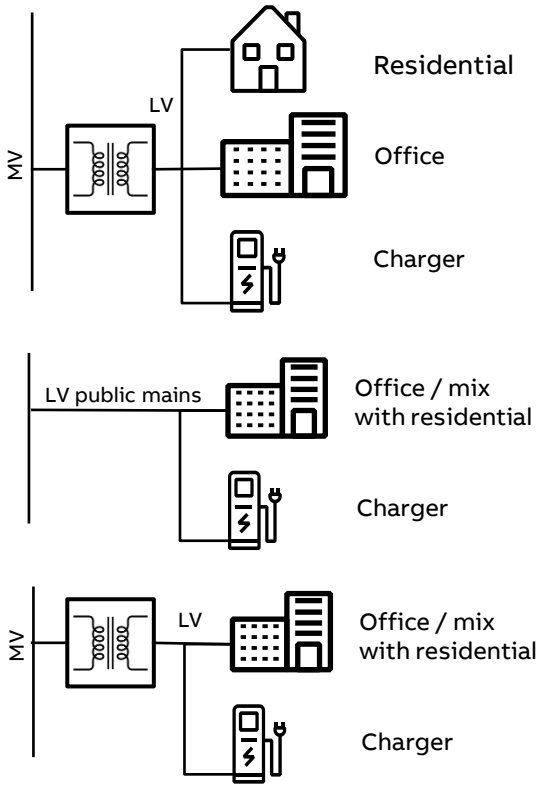


Availability 22,5 hours
Total range: 900 km

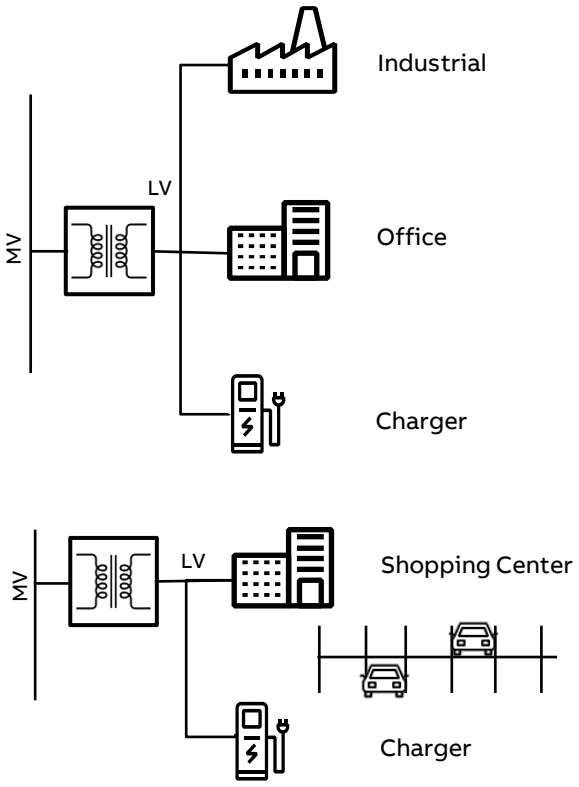
ABB EV Chargers

EMC Certification – Use Cases

EMC Class B needed



EMC Class A OK*



The main aspect to consider is if the charger is connected to the mains public LV network or to a LV network with residential purpose

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Requirement as described **IEC 61000-6-3 (currently applicable standard)**

Locations that are characterized by being supplied directly at low voltage from the public mains network are considered to be residential, commercial or light-industrial.

Requirement as described **IEC 61851-21-2 (future applicable standard)**

1) Class A off-board electric vehicle charging systems is equipment suitable for use in all locations other than residential ones and those directly connected to a low voltage power supply network which supplies buildings used for residential purposes.

Class A equipment shall meet class A limits.

2) Class B off-board electric vehicle charging systems is equipment suitable for use in residential establishments and in establishments directly connected to a low voltage power supply network which supplies buildings used for residential purposes.

*IMPORTANT: Specific definition of a residential purpose is depending on local regulation and interpretation of standards and above examples can only be considered as indicative guidance.

Market Segments & Infrastructure

Public and commercial car charging – Use cases

Charging service should match charging application and demand

Public and commercial EV Charging

AC destination	DC destination	DC Fast	DC High Power
3-22 kW	20-25 kW	50 to 150 kW	150 to 350 kW+
4-16 hours	1-3 hours	20-90 min	10-20 min
			
– Office, workplace – Home – Multi family housing – Hotel and hospitality – Overnight fleet – Supplement at DC charging sites for PHEVs	– Office, workplace – Hotel and hospitality – Parking structures – Dealerships – Urban fleets – Public or private campus – Sensitive grid applications	– Retail, grocery, mall, big box, restaurant – High turnover parking – Convenience fueling stations – Highway truck stops and travel plazas – OEM R&D	– Highway corridor travel – Metro ‘charge and go’ – Highway rest stops – Petrol station area’s – City ring service stations – OEM R&D

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	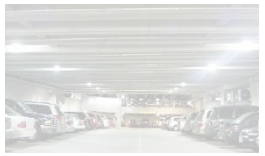		
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Terra AC Wallbox
Portfolio

EU portfolio

- Single phase
  - Up to 7.4 kW / 32 A
  - 110 … 240 V AC
- Three phase
  - Up to 22 kW / 32 A
  - 380 … 415 V AC, 50 / 60 Hz
- Type 2 socket with or without shutter
- Type 2 cable, 5 m
- Variants:
  - Display and MID certification
  - RFID
  - 4G

NAM portfolio

- Single phase
  - Up to 19 kW /80 A
  - 110 … 240 V AC
- Type 1 cable, 25 ft
- Variants:
  - RFID
  - 4G
  - Double ethernet

The Terra AC wallbox

The Terra AC wallbox provides tailored, intelligent and networked charging solutions for any business, home or location.

Ethernet, WiFi and Bluetooth are in every charger. 4G with 3G fallback is available in some variants.

Authentication can be done with a smartphone, via the BT connection, with an RFID card or tag.

The charger will switch off when it detects that the car is taking more current than is allowed.

Integrated protections, including DC ground fault and overvoltage, protects both user and car.

Public and commercial car charging – Use cases

Charging service should match charging application and demand

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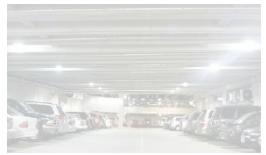			
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ABB Terra DC Wallbox 24 – 920V capable

Versions & Timing

This 920 V DC wallbox is available in the following configurations:

- Single outlet CCS1
- Single outlet CCS2
- Dual outlet CCS1 + CHAdeMO
- Dual outlet CCS2 + CHAdeMO

All variants with 3.5m and 7m cable

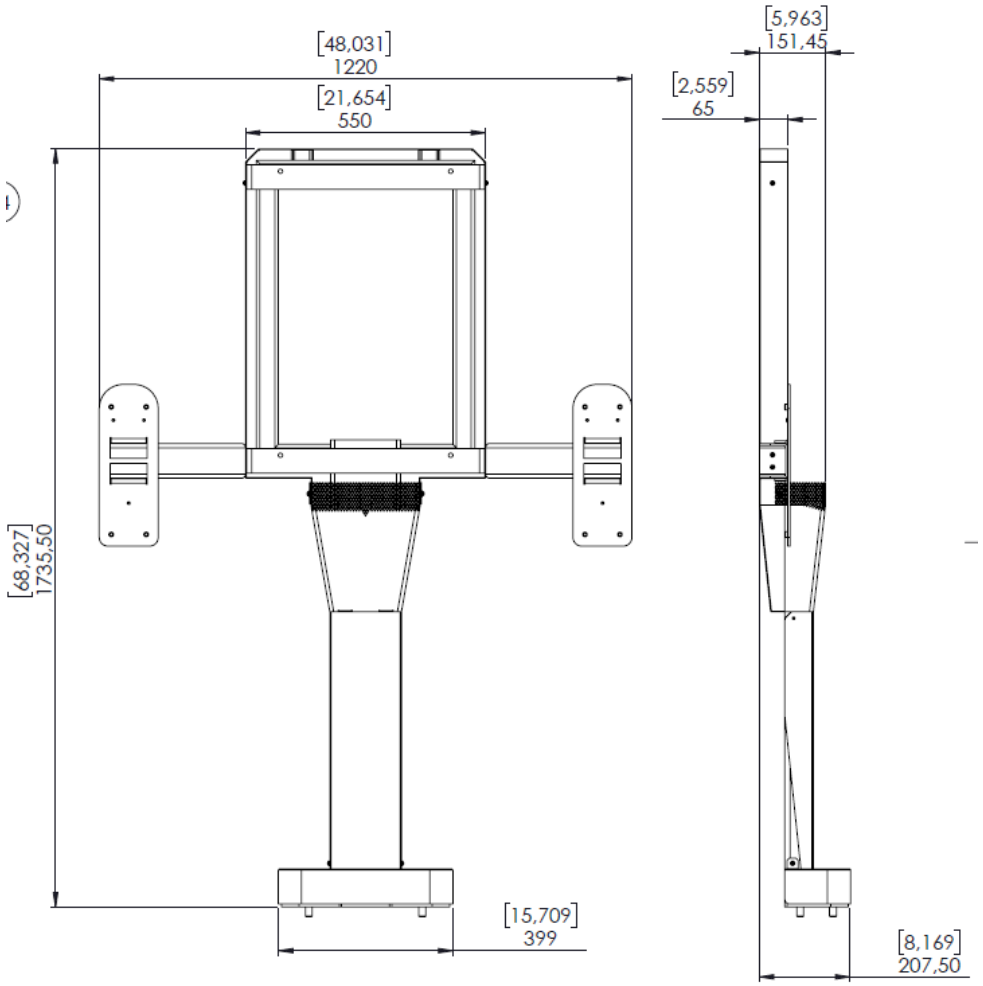
Availability can differ per country:

- EU versions (Class B EMC): available
- US versions (FCC): available

Accessories

Pedestal

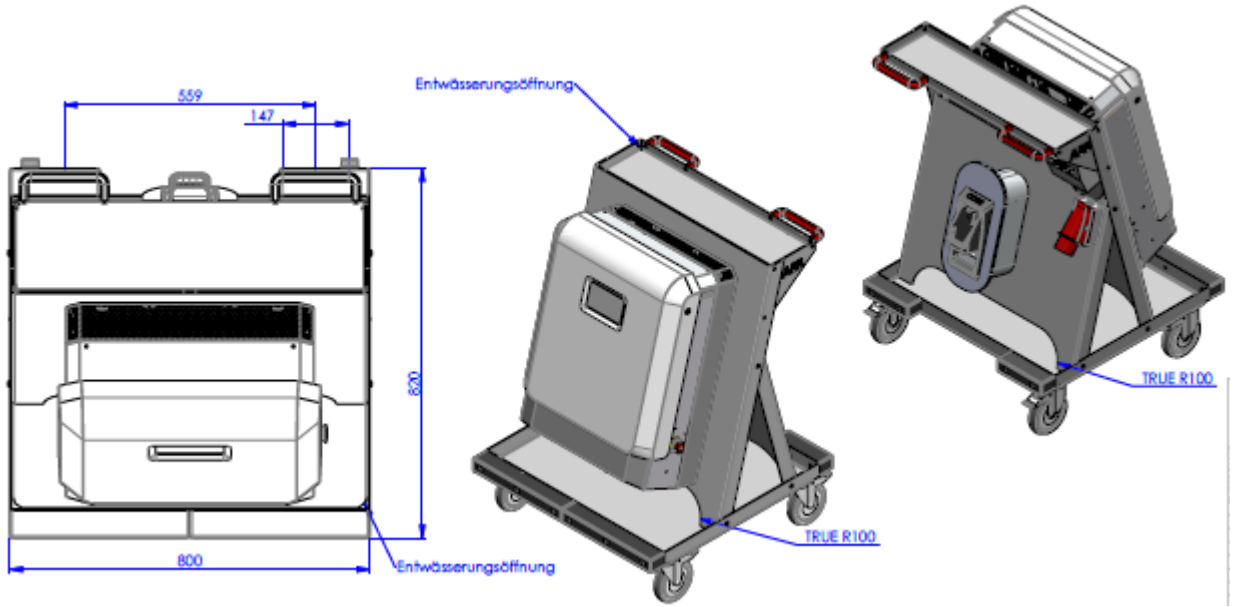
- **Product Code**
  ABB6AGC082120
- **31 Kg**
- **Metallic structure**
- **Internal conduits available for cabling**
- **Supports up to 2 Gun Holders on each side**



* Foundation not provided. Further details available

Mobile Cart Info

Under development – Available Q3 2020



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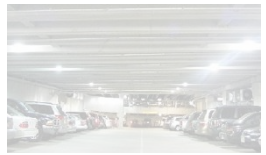	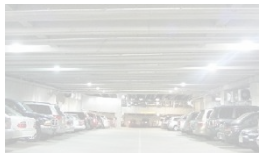		
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ABB DC Charging portfolio

The widest offering in the market

Destination	Fast Charging			High Power		
20-25 kW	50-150 kW			150+ kW		400 kW

Terra Wallbox
24 kW

Terra 24
20 kW

Terra 54
50 kW

Terra 94
90 kW

Terra 124
1 x 120 kW
2 x 60 kW

Terra 184
1 x 180 kW
2 x 90 kW

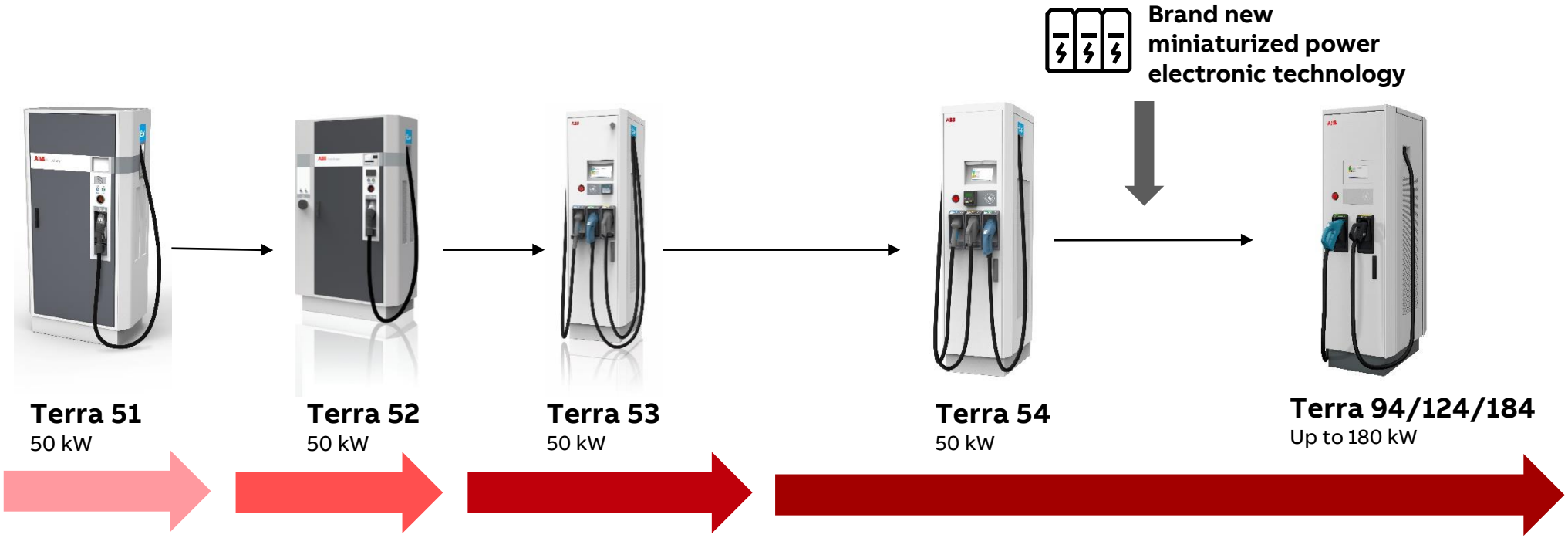
Terra 360
360 kW
Each outlet (90/180/270/360 kW)

Terra HP
350+ kW

DC charging more than one vehicle at the same time

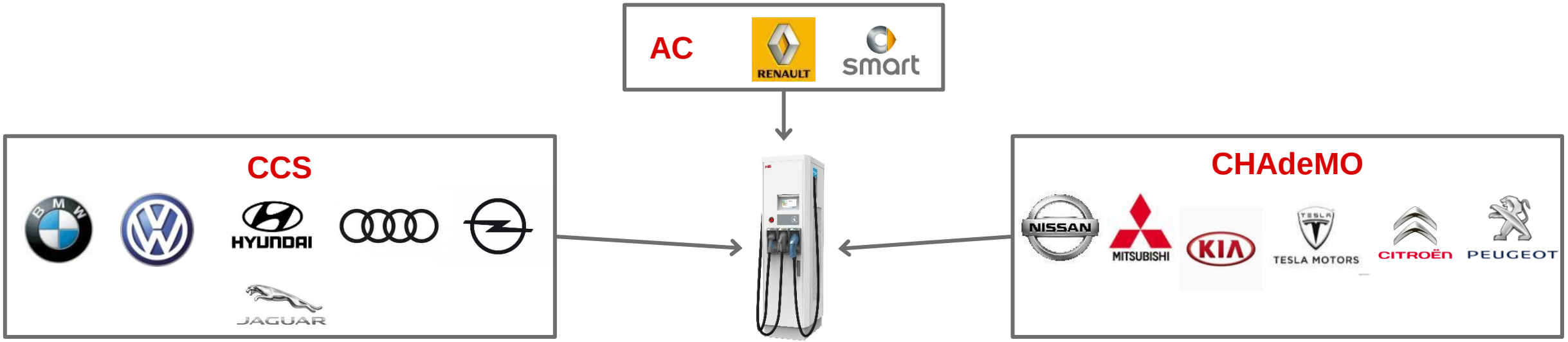
DC Fast Charging

Portfolio Evolution



Multi-standard charger solution Terra 184, 124, 94, 54(HV) & Terra 24

General explanation of naming convention



Terra **18**4 (180kW)	**C** - (Combo) = Combined Charging Systems (CCS)	- DC
Terra **12**4 (120kW)	**J** - (Japan) = CHAdeMO	- DC
Terra **9**4 (90kW)	**Z** - (China) = GB	- DC
Terra **5**4 (50kW)	**T** - (Socket) = Type 2 Socket	- AC
Terra **2**4 (20kW)	**G** - (Grid) = Cable + Type 2 Connector	- AC

HV = High Voltage
CCS: 200-920 V
CHAdeMO: 150-500 V
HC = High Current
CCS: 300A

Terra 54 DC Fast Charger

The pillar of growth for smart, sustainable mobility

Time-tested

- A decade of experience in EV charging and with more than > 8.000 units sold

Global

- Installations in 77 countries

Flexibility

- A single solution serving all electric vehicles
  - CCS connectors for American and EU cars
  - CHAdeMO connector for Japanese cars
  - AC Plug for early EV and hybrid cars

Future-proof

- Ready for the next generation of electric vehicle power trains, including trucks and vans, with up to 920V higher voltage charging

Connectivity

- 24/7/365 network monitoring by ABB for 99%+ uptime
- Remotely updated with latest features for the latest electric vehicles
- More than 75% of service cases are resolved remotely
- Serves all payment collection schemes

Easy-to-use

- Automatic customer authorization upon plug-in with Autocharge feature
- Touch-screen display with user-friendly flow and simplified visual of charge process

Safety

- Independently certified and 3rd party tested according to relevant electrical safety standards

Reliability

- Redundant power modules ensures continued operation in the event of single component failure

Source: ICG

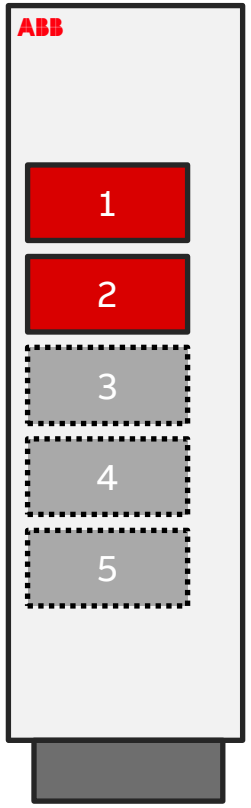
Terra EV Fast Charger

Power modules and upgradability

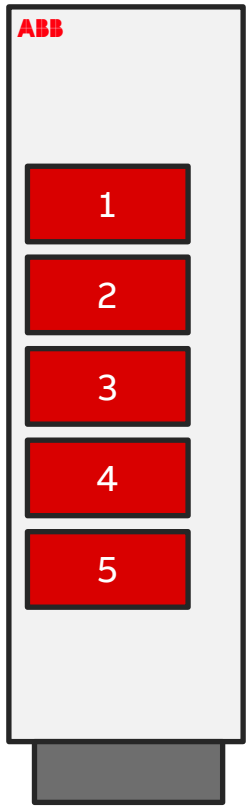
Installed power module

Slot available for upgrade

Terra 24

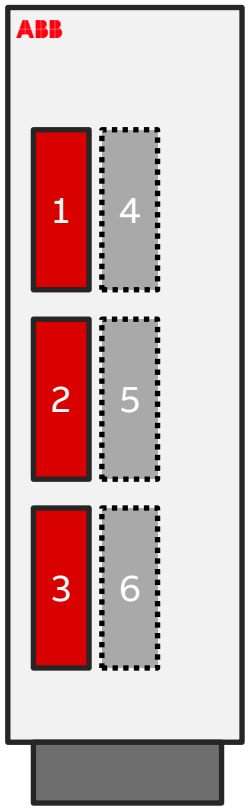


Terra 54

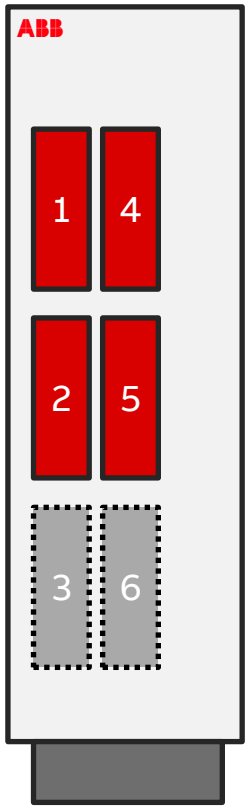


- Based on 2 (Terra 24) and 5 (Terra 54) 10 kw power modules
- Almost 10.000 chargers installed worldwide
- Terra 24 is upgradable to Terra 54
- Terra 54 is available also in High Voltage variant (150-920 Vdc)

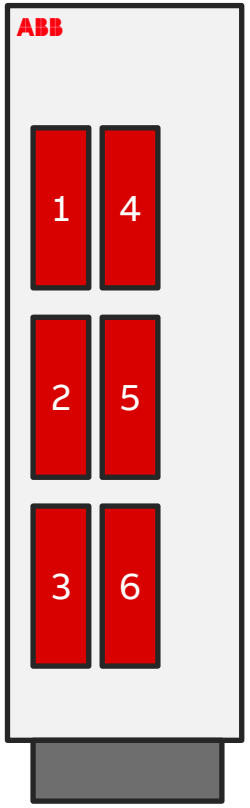
Terra 94



Terra 124



Terra 184



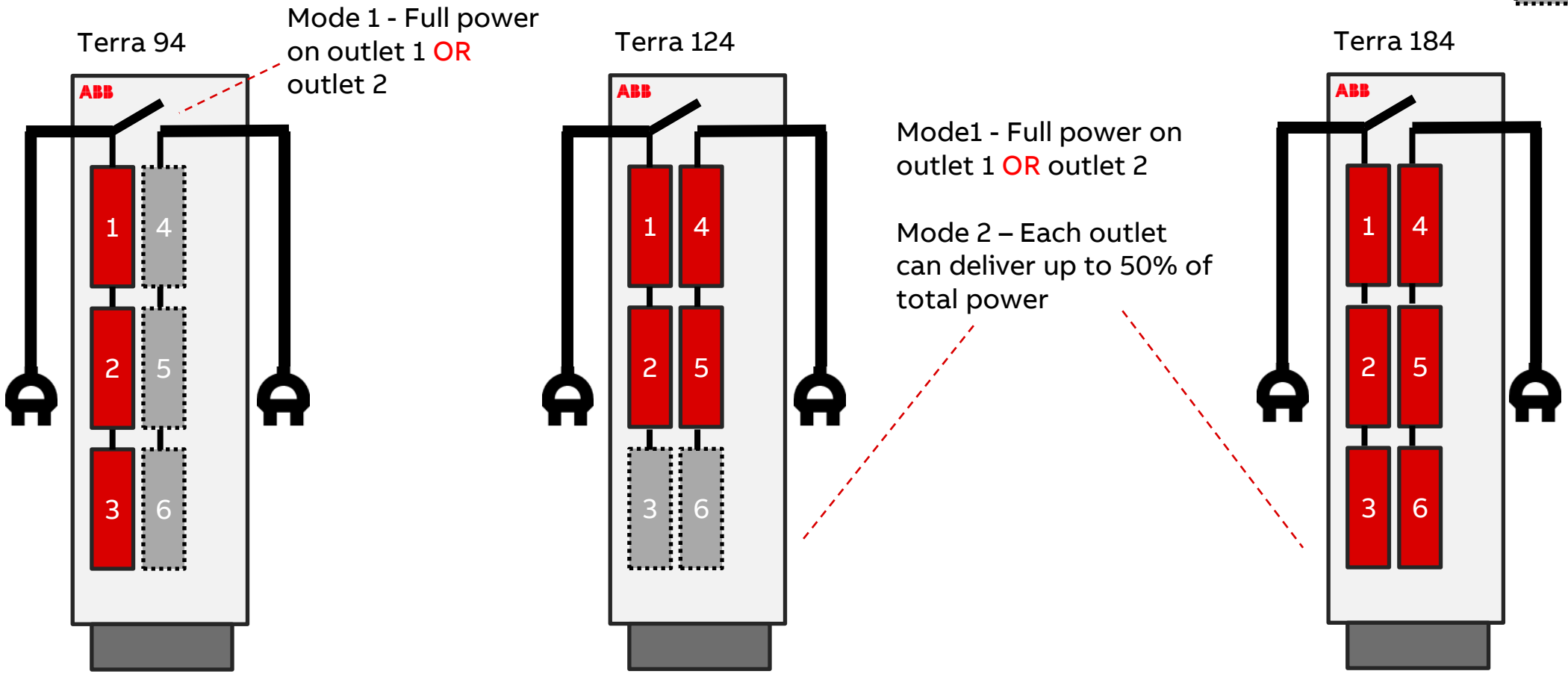
- Based on new 30 kw power modules
- Terra 94 and 124 upgradable to higher power rating, up to 180 kW
- Terra 54 cannot be upgraded to the new power modules due to different rating of the electrical components
- Terra 94-124-184 provide High Voltage capability (150-920 Vdc)

Terra EV Fast Charger

Power modules layout Terra 94, Terra 124 and Terra 184

Installed power module

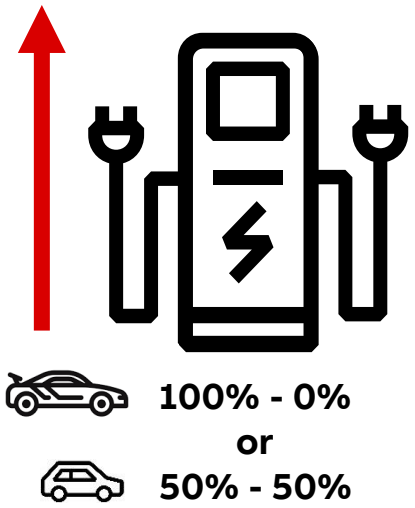
Slot available for upgrade



Terra EV Fast Chargers

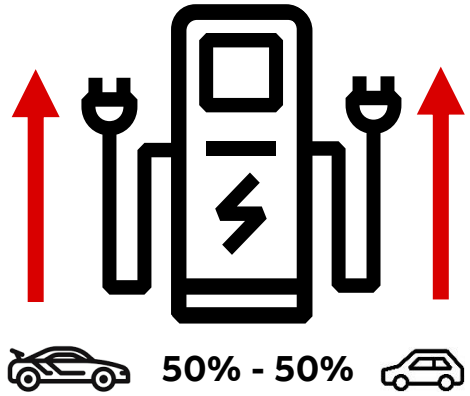
Power Sharing

Mode 1 – Dynamic power allocation (FIFO)



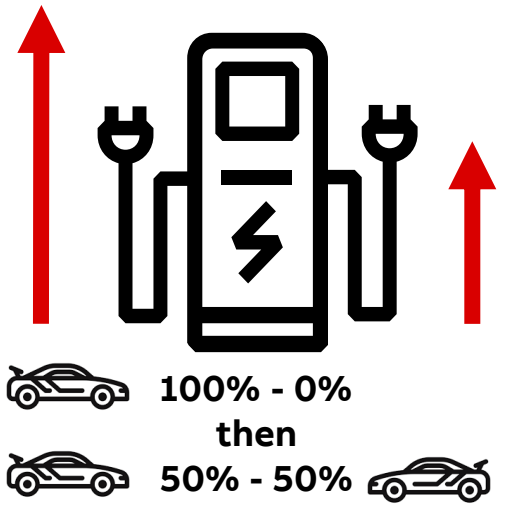
If EV-1 can charge at more than 60 kW (Terra 124) or 90 kW (Terra 184), the charger allocates all the power to that EV. Outlet 2 is not available during the charging session. Otherwise, both outlets are available delivering up to 60 kW (Terra 124) or 90 kW (Terra 184).

Mode 2 – Parallel charging (always 50%)



Outlet 1 and 2 can always charge at up to 60 kW (Terra 124) or 90 kW (Terra 184). Both outlets always available.

Mode3 – Dynamic power allocation (share power)



If EV-1 can charge at more than 60 kW (Terra 124) or 90 kW (Terra 184), the charger allocates all the power to that EV. Outlet 2 is available and if a second EV connects, the power is shared equally, up to 60 kW (Terra 124) or 90 kW (Terra 184),.

Terra 124/184

Public and commercial car charging – Use cases

Charging service should match charging application and demand

Public and commercial EV Charging

AC destination	DC destination	DC Fast	DC High Power
3-22 kW	20-25 kW	50 to 150 kW	150 to 350 kW+
4-16 hours	1-3 hours	20-90 min	10-20 min
			
– Office, workplace – Home – Multi family housing – Hotel and hospitality – Overnight fleet – Supplement at DC charging sites for PHEVs	– Office, workplace – Hotel and hospitality – Parking structures – Dealerships – Urban fleets – Public or private campus – Sensitive grid applications	– Retail, grocery, mall, big box, restaurant – High turnover parking – Convenience fueling stations – Highway truck stops and travel plazas – OEM R&D	– Highway corridor travel – Metro ‘charge and go’ – Highway rest stops – Petrol station area’s – City ring service stations – OEM R&D

Terra 360

Key components

500A CCS connectors ”air-cooled” (aka “uncooled” or “non-liquid cooled”)

Option for 500A CCS liquid cooled connectors from Q1-2022

Slot for the payment terminal

Four groups of power modules each one rated 90 kW

Each group contains three power modules rated 30kW

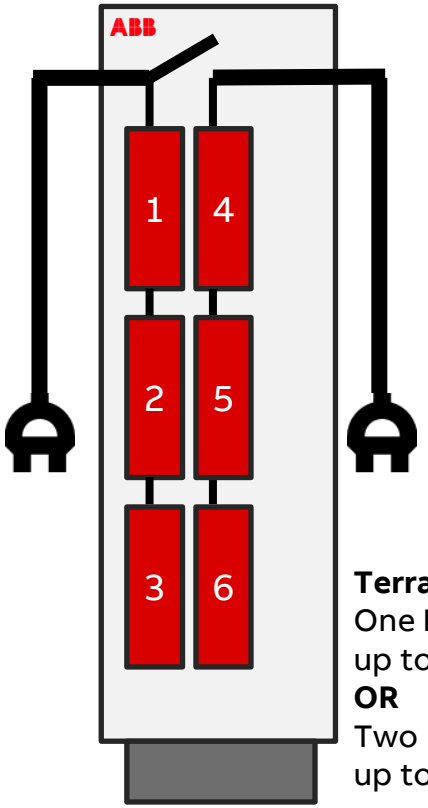
Redesigned gun holder, universal per connector type with courtesy light

Terra EV Fast Chargers

Power modules and switch matrix

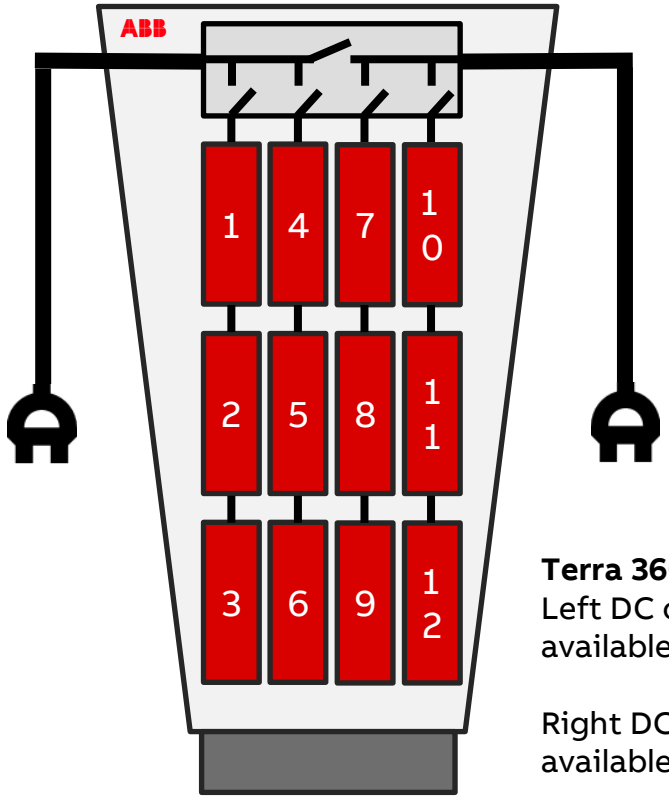
Power Module

Terra 184



Terra 184:
One DC charging session delivering up to 100% of available power
OR
Two DC charging sessions delivering up to 50% of available power

Terra 360



Terra 360 (two outlets):
Left DC outlet: 100-75-50-25-0% of available power (360-270-180-90-0 kW)

Right DC outlet: 0-25-50-75-100% of available power (0-90-180-270-360 kW)

ABB High Power Charging

Terra HP

Charge Post

- 500A CCS liquid cooled cables, up to 350 kW (920V)
- 200A CHAdeMO, typically 80kW (optional 125A) (500V)
- 7” and 15” touch screen options
- Programmable RGB LED strips + white LED top light
- Outdoor use: IP54, IK10, -35 °C to +55 °C
- Vandalism proof
- Resistant against heavy snow & rain

Payment solutions

- Credit card terminals for EU & USA & RoW
- RFID (Mifare, Calypso, etc.)
- PIN code access

Remote management & diagnostics

- OCPP
- ABB connected services

Power Cabinet

- Output: 175 kW - 375 A
- 150 – 920 V_{DC}
- Optional Dynamic DC power sharing
- Outdoor use: IP54, IK10, -35 °C to +55 °C
- Vandalism proof
- Resistant against heavy snow & rain
- Galvanic isolation included in cabinet
- Power module redundancy & automatic failover mechanism

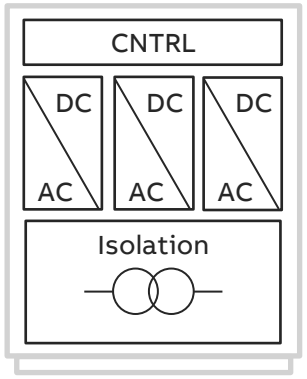


ABB High Power Charging

User experience

Colored LED strips

- LED strip colors can be set via the back-end to match customer branding.
- The following 8 options are available: White, Red, Green, Blue, Yellow, Light blue, Pink, OFF.
- Top up-light is always white.

Top light

White LED up-light illuminating the top styling element.

Programmable LED strips

- Vertical RGB LED strips on both sides of the front door.
- Colors can be set via the back-end to match customer branding.

ABB High power charging 2018-2025

Towards 15 minute charging – 400 km/ 250 Mi driving

Terra 54

Terra HP – 1 cabinet

Terra HP – 2 cabinets

3½x more power

50 kW → **175 kW_p**

7x more power

350 kW_p

3x higher current

125 A → **375 A**

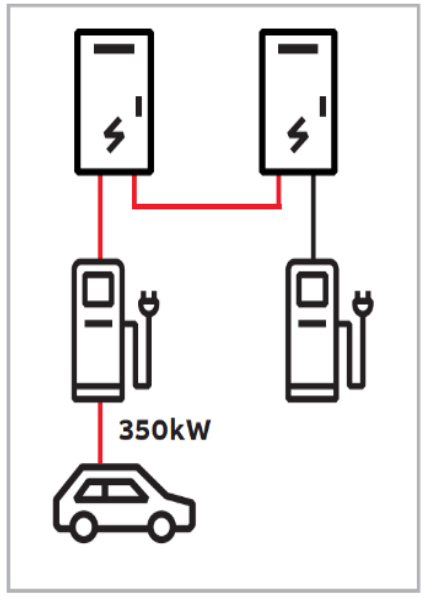
4x higher current

500 A

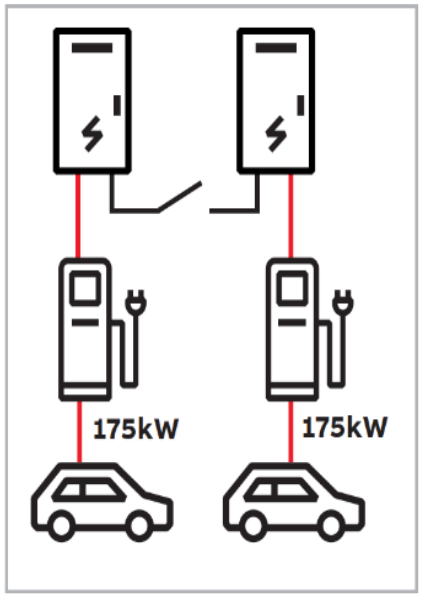
Dynamic DC Power Sharing

Optimize infrastructure use

Dynamic DC illustrated



High power charging at up to 350 kW and 500 A at either charge post.



Simultaneous charging at up to 175 kW and 375 A at both charge posts.

Dynamic DC software: operator settings

- **First In - First Out**
  If Car1 uses both power cabinets, it can use them for full session duration.
  In this case Car2 has to wait.
  If Car1 uses one power cabinet, Car2 can start immediately.
  Available: now

- **Equal Share**
  Car1 can use both power cabinets, but a power cabinet is made available when Car2 connects. Both cars will then charge at up to 175kW and 375A.
  Available per SW1.4: Q1 2021

Onsite test with 349 kW charging power

In August 2019, an onsite charging test in real life, was done with a vehicle on a customer's, public location, with a charging power of 349 kW, for a duration of more than ½ hour.

349 kW

Charge post versions (CE)

Standard charge post with 7” display and optional 15” display, standard cable length 3.2m (for CCS and CHAdeMO)

Standard versions with 7” touch screen display

- 500 A CCS liquid cooled (also 3.8m)

- 500 A CCS liquid cooled (also 3.8m)
- 200 A CHAdeMO

Versions with 15” touch screen display

- 500 A CCS liquid cooled (also 3.8m)

- 500 A CCS liquid cooled (also 3.8m)
- 200 A CHAdeMO

High Power (150-350 kW) versus Medium Level Power Charging (80-120 kW)

It is all about the Amps……

Most all-in-one chargers, without liquid cooled cables, can only do up to 200 A. With a 400 V drive train that is typically around **80 kW** (= 200 A x 400 V)

So this e.g. also holds for charging an Audi Quattro e-tron, which has a 400 V drive train.

At the same time, the ABB Terra HP can do with one power cabinet 375 A x 400 V = **150 kW** continuously, so almost double the power.

As the Audi charges flat from 0-80% SOC on 150 kW (see below graph on the Fastned website), the Terra HP charger charges almost double as fast as the all-in-one, 200 A chargers

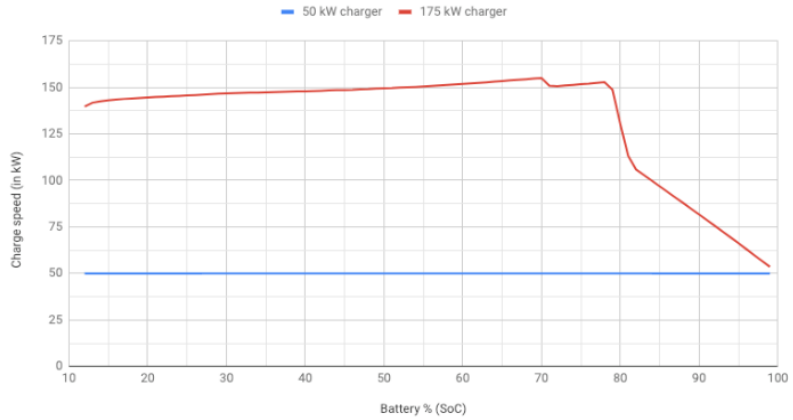
So when e.g. the Audi comes in with 10% SOC, and wants to drive away with 80%, he has to charge 70% of 95 kWh = 66 kWh (= approx. 330 real kms)

1. With a 80-120 kW charger that is: 66/ 80 x 60 = approx. 50 mins
2. With a ABB Terra HP charger that is: 66/150 x 60 = approx. 26 mins

…this is a huge difference in charging time…

What if you are a driver, and in a hurry, which charger would you then pick: charger 1. or charger 2. ?

(Of course, outside temperature etc. can influence the BMS of the car, and thus the charging speed).



Connectivity – Operational and Economic

ABB chargers support autocharge function

Plug-in-and-walk-away: payment processed automatically via vehicle identifier

What is autocharge ?
Automatic authorization solution based on open standards (OCPP/ CCS)

Working principle:
During start-up of charging a unique identifier is sent from CCS vehicles. This can be used in standard OCPP flow to identify a car and perform a transaction

Key benefits:

Maximum user-friendliness

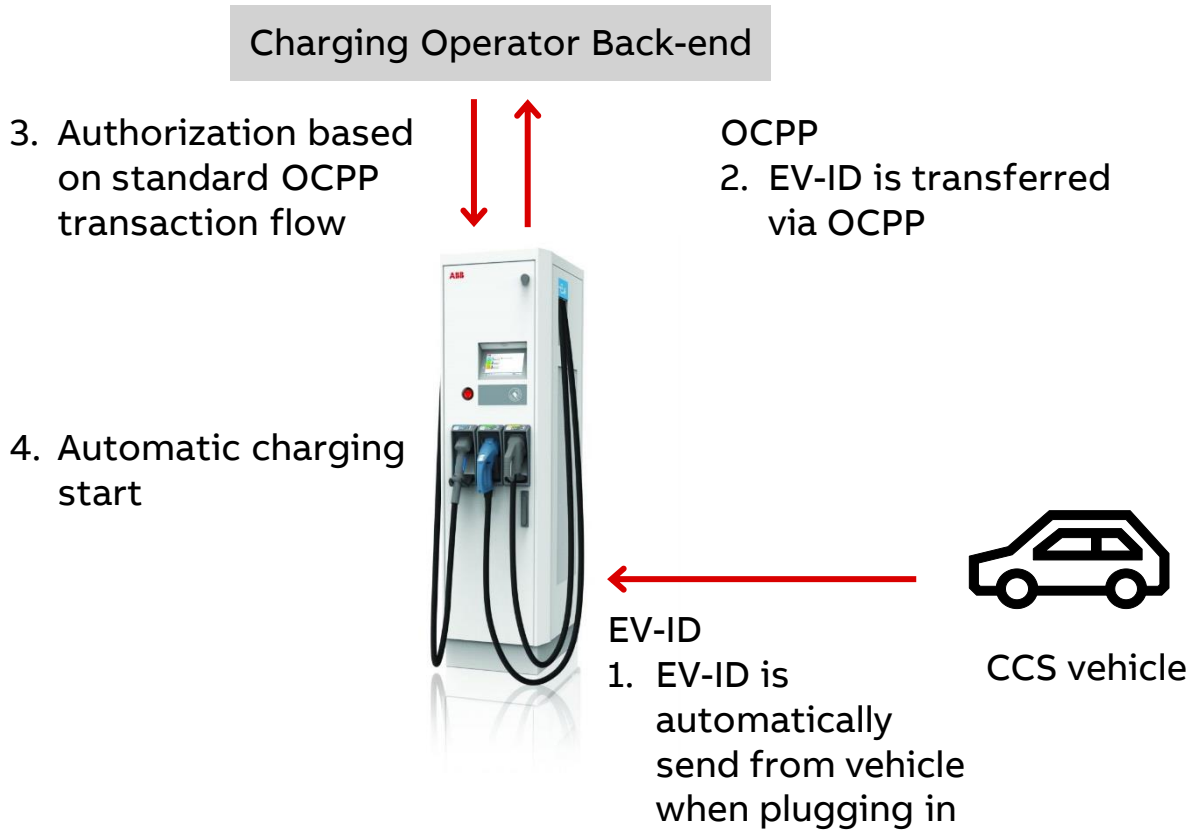
– After first-time enablement the user can just plug in and walk away

Works with “old” and new CCS cars

– Most CCS cars on the road today (since 2012) send the EV-ID

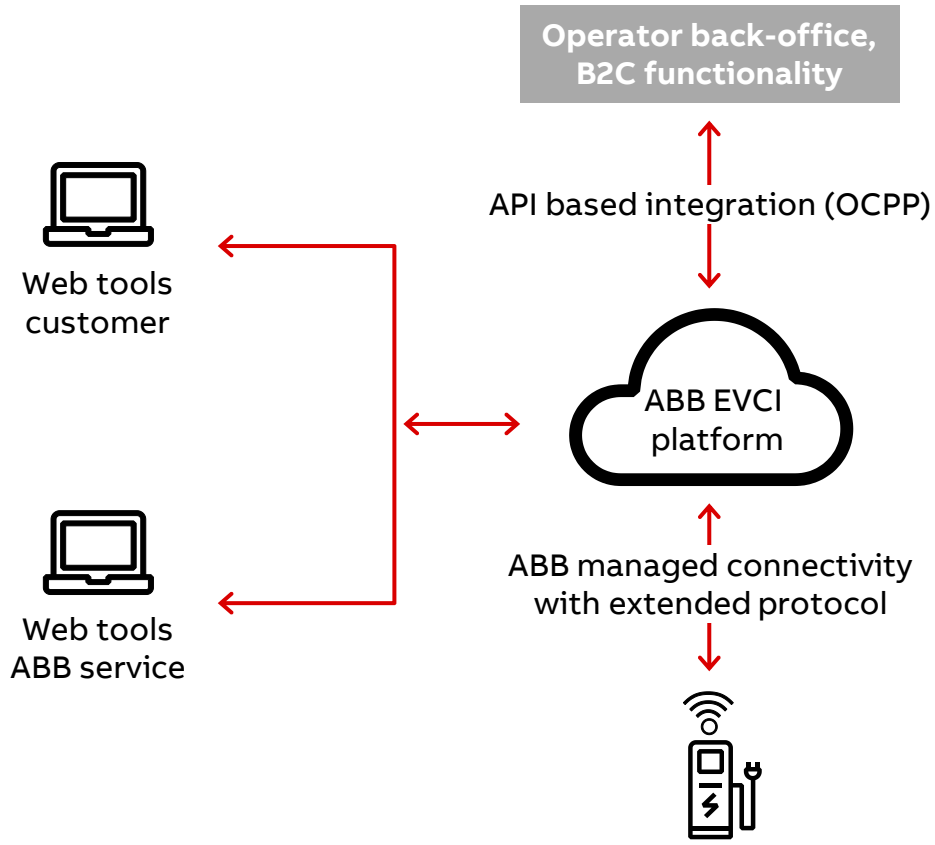
Works with standard OCPP back-ends

– Limited software changes required, simple implementation

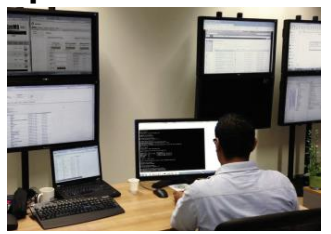


Digital integration of an ABB EV charger

OCPP 1.5 Single Uplink or OCPP 1.6 Dual Uplink



Network Operations Center (NOC)



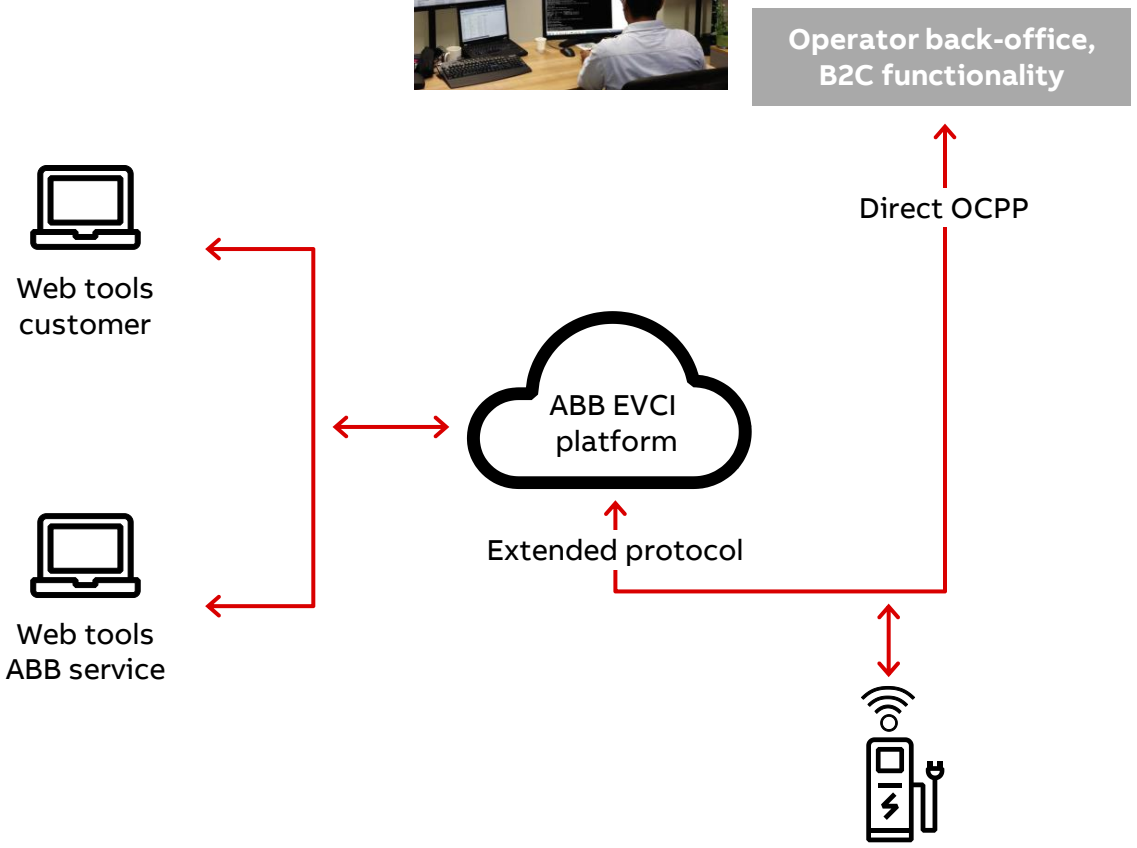
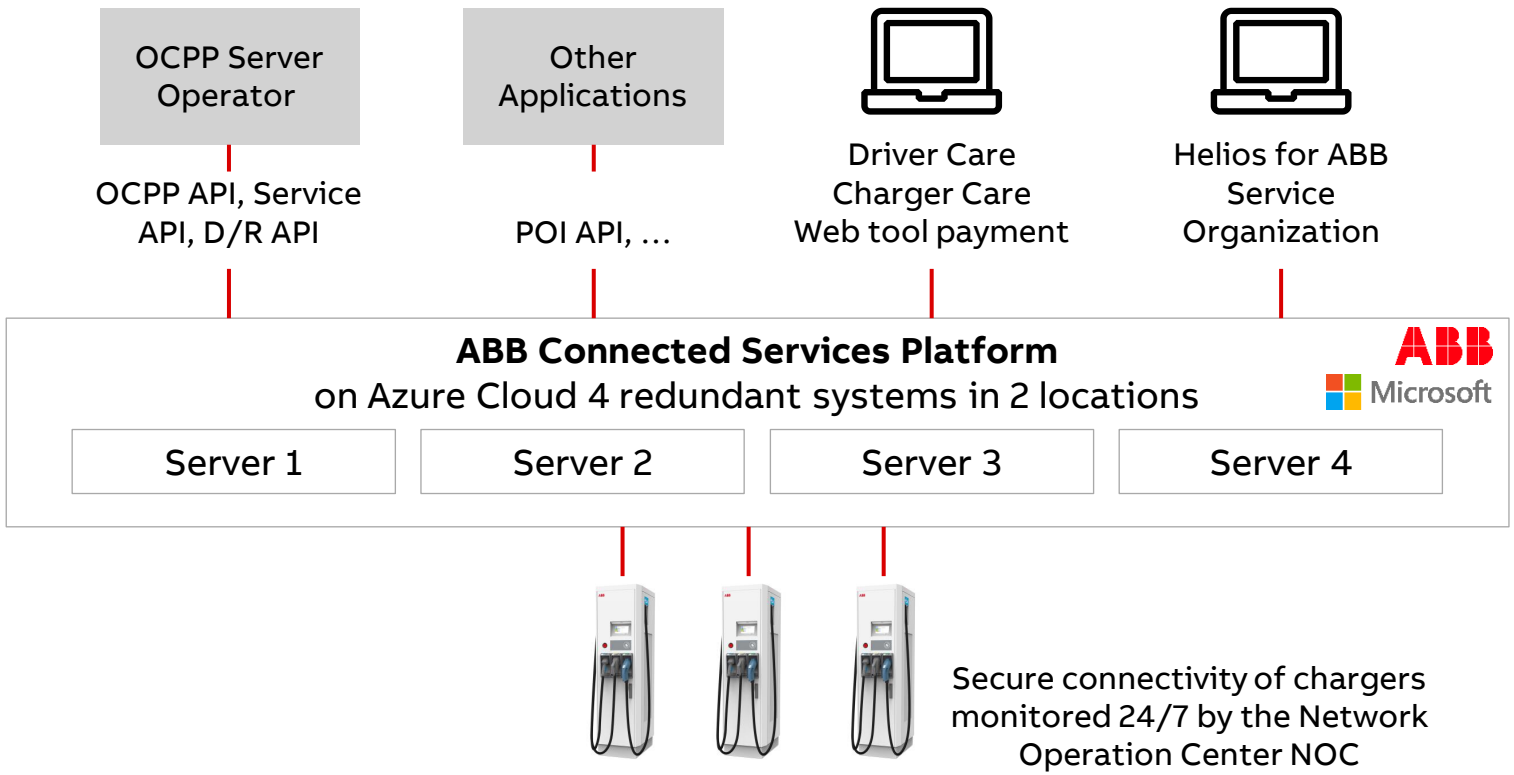


ABB Connected Services Platform

High level architecture



Platform **enables** customers and partners to integrate with the ABB chargers via web tools and APIs and to launch new/ innovate services

Worldwide availability of the Connected Services Platform ensuring stability, global scalability and advanced, innovative features for ABB customers & partners.

Best-in class Charging Stations for all charging protocols (CCS, Chademo, GB) and for all markets

ABB Ability™ – Electrification Smart Power

Re Imagining Smart Power from MV to Plug

Thanks for your time, I'd be delighted to answer any questions you may have

EV Charging Infrastructure and Digital LV Distribution Support

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