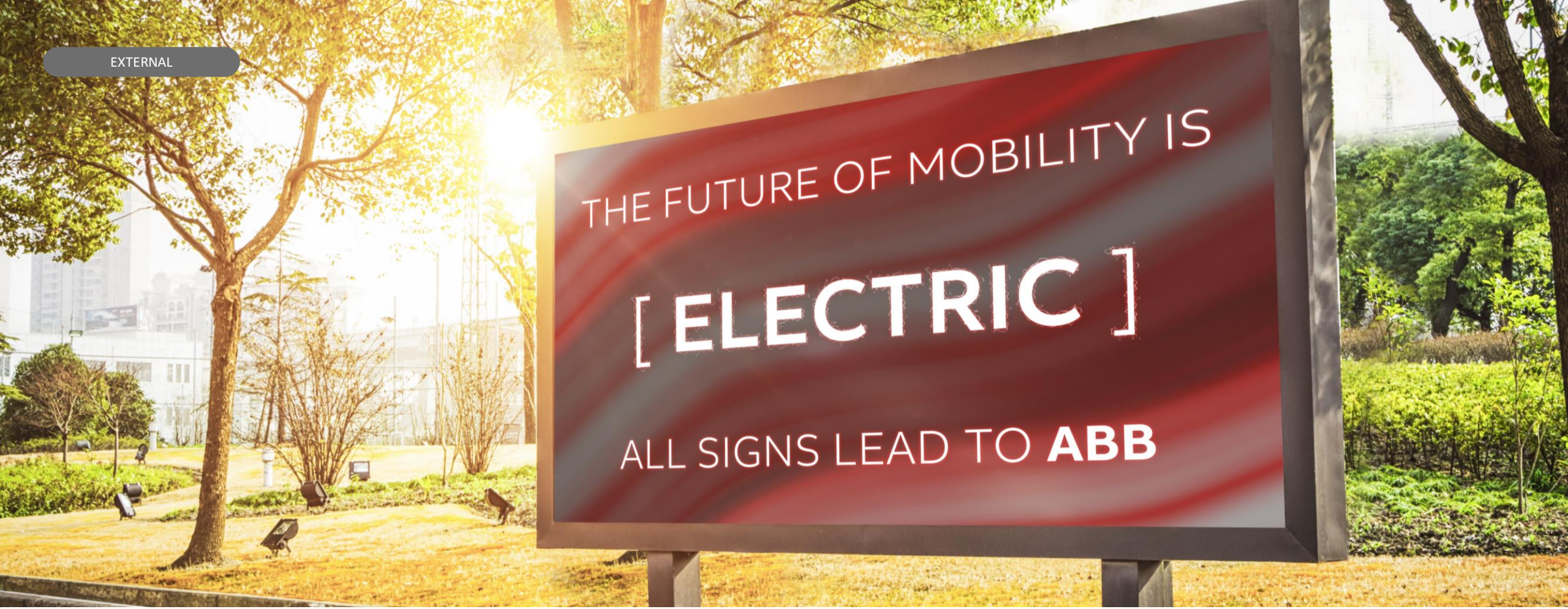
EXTERNAL



EXTERNAL PRESENTATION

E-mobility Roadside Electrification Solutions

Electrification - Packaging and Solutions

Agenda

- Market size and growth
- Charging infrastructure basics
- ABB e-mobility infrastructure solutions by application
  - Roadside stations
- Other considerations
- Digital options
- Value of ABB offering
- Detailed solutions by application

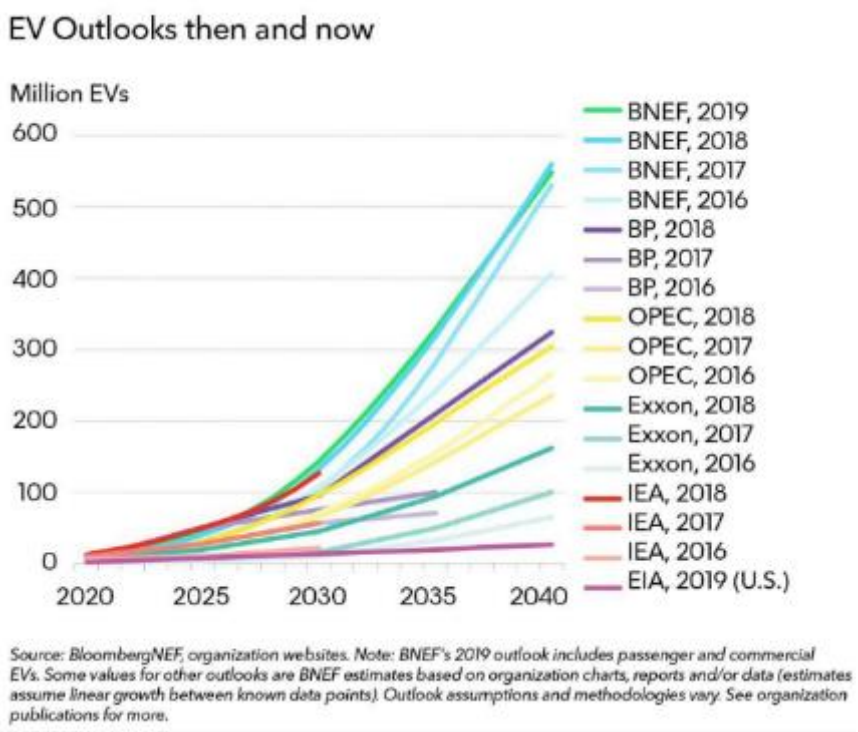
Market size and growth

Trends in the industry

Growth of e-mobility market

The e-mobility market is growing at a record pace

Global EV outlook



Source: BloombergNEF, organization websites. Note: BNEF's 2019 outlook includes passenger and commercial EVs. Some values for other outlooks are BNEF estimates based on organization charts, reports and/or data (estimates assume linear growth between known data points). Outlook assumptions and methodologies vary. See organization publications for more.

Drivers for consumers to buy electric vehicles

- Environmental - consumers desire to change to electric cars charged by clean, renewable energy
- Electric vehicles are approximately 3X-5X cheaper to charge/fuel
- Electric vehicles have 25% lower maintenance costs than internal combustion engine vehicles
- Electric vehicles can last 2.5X longer than internal combustion engine vehicles
- Initial cost of electric vehicles has decreased as battery costs have decreased

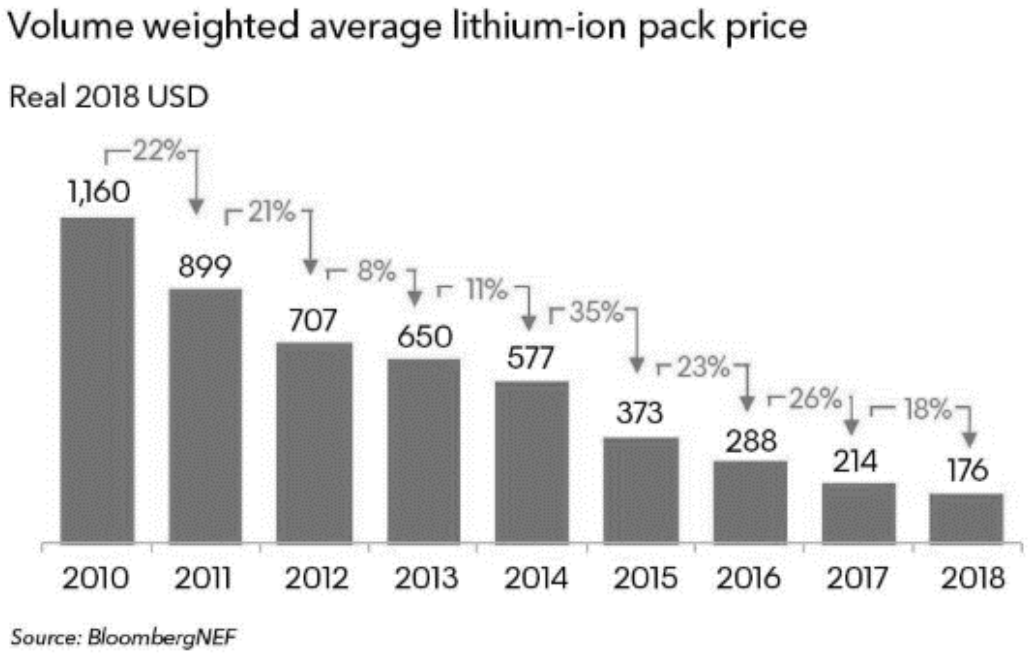
Drivers for retail, industrial, municipals and private companies

- Attract people to their stores, companies and cities
- To serve their customers, employees, and consumers
- Increase store sales as consumers spend time in their stores while their cars are charging
- Environmental stewardship
- New business models for petrochemical industry and store fronts
- To decrease traffic and parking within cities (buses, light rail)

Industry trends driving growth

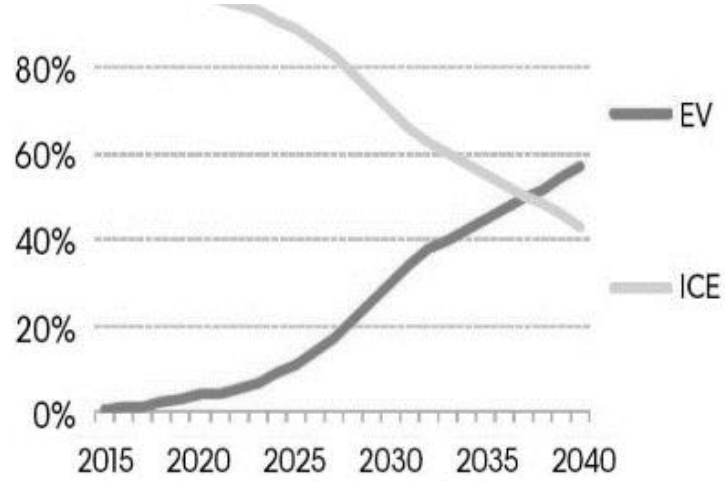
Lower battery pricing and tighter emission regulations continue to drive the trend towards EVs

Battery prices keep falling



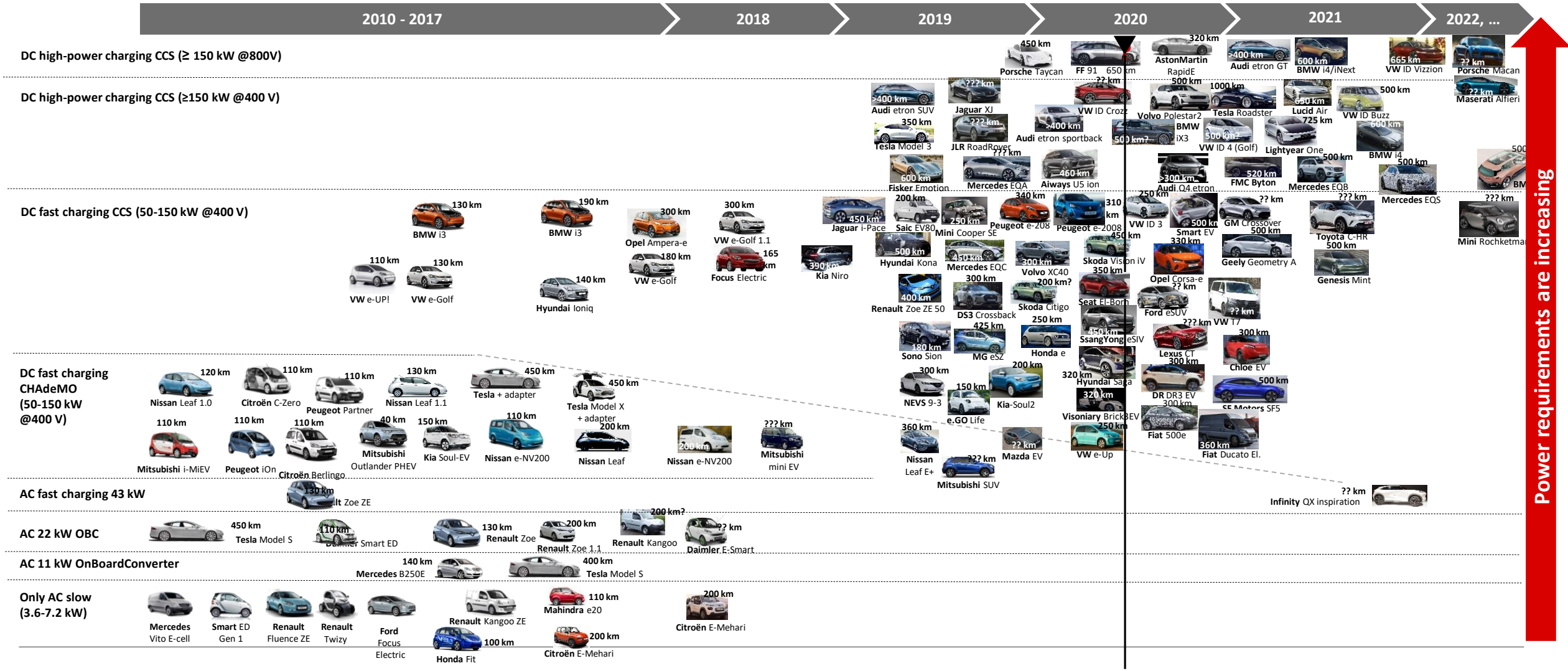
Emission regulations getting tighter and tighter

Global Electric Vehicle (EV) and Internal Combustion Engine (ICE) share of long-term passenger vehicle sales

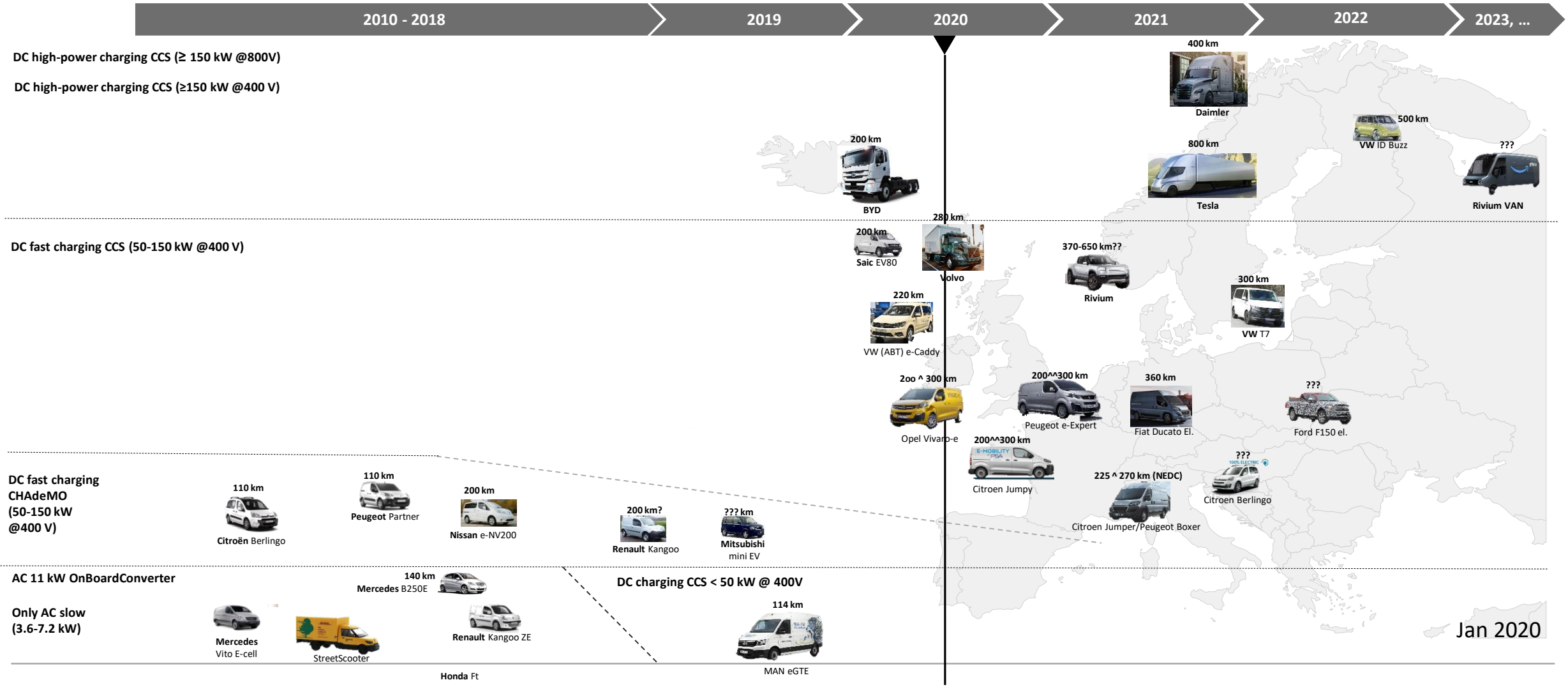


Source: BloombergNEF

Trend towards bigger cars with higher power requirements



Increasingly more electric commercial vehicles and truck models coming



Trends toward faster charging times and higher power

As electric vehicles increase in use, quicker and higher power charging infrastructure is needed

Bus Depot

Medium Voltage
Typically 3- 8 hrs overnight

eBus En-route Charging

Medium Voltage
Typically 3-6 mins

Industrial Fleet

Medium Voltage
Varies significantly by application

Commercial Fleet

Medium Voltage
Typically 3-8 hrs overnight

Road-Side Fast-charging Station

Medium Voltage
Typically 10-20 min

Public Commercial Parking

Medium Voltage
Typically 20-90 min

Office / Apartment Charging

Low Voltage
Typically 8 hours

Residential Charging

Low Voltage
Typically 8 hours overnight

Trends in electrical infrastructure

Movement towards higher power chargers and faster charging times = MV grid connection

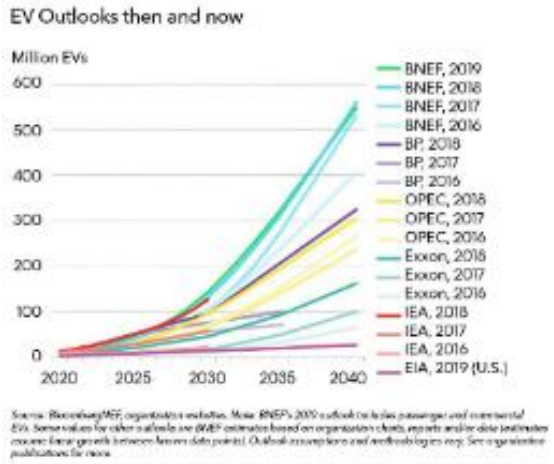
Ever-increasing # of electric vehicles

+

Bigger cars, higher power needs, longer ranges

+

Faster charging times



2007

Only AC slow (3.6-7.2 kW)

Honda Fit
100 km

2019

DC high power charging CCS (≥150 kW @400 V)

Audi etron SUV
>400 km

Overnight charging
8+ hours

High power charging
10-20 mins

Different electrical infrastructure is needed to support the load:

- **Leading to more MV grid connection installations**
- **Energy storage to allow fast charging in LV grid connection**
- **High safety requirements for equipment in public installations**
- **Relocatable energy storage allows site locations to be evaluated without premature permanent infrastructure costs**

The future of mobility is electric

Now is the time to future-proof your electrical infrastructure

The key to future-proofing is investing in the right combination of traditional and smart solutions, ensuring the infrastructure can be scaled in close alignment with growing demand

- E-mobility is coming, and its **tipping point will arrive much sooner** than most people expect
- Experts predict that just a couple of decades from now, **there will be more than 540 million electric vehicles crowding our roads** – and their energy needs will be much more intense than today's first generation of electric vehicles.
- To make your investment count and to earn the full ROI on the electrification of transport, the technology you install has to be both **scalable and futureproof**
- New long-range EVs demand fast-charging at higher power levels. Make sure that your e-mobility solution is **ready to grow both in size and sophistication.**
- Smart, connected technologies, such as energy management or battery energy storage, provide a means of **utilizing current electrical infrastructure** and avoiding or delaying costly grid expansions in markets where e-mobility is still in early stages.
- Fleet operators and transportation authorities are facing challenges, such as technological uncertainty, large up-front investment, and need for new capabilities. ABB's holistic approach provides a **complete e-mobility solution** helping fleet operators effectively outsource many of these uncertainties.

Charging infrastructure basics

Types of charging infrastructure and application

E-mobility solutions landscape for cars and fleets

Applications, charging times and power options

Public and commercial EV Charging				
AC destination	**DC destination**	**DC Fast**	**Depot Charging**	**DC High Power**
3-22 kW	20-25 kW	50-180 kW	50-150 kW+	150-350 kW+
4-16 hours	1-3 hours	20-90 min	4-8 hours	10-20 mins
				
– 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	– Fleet depots for bus, truck and light commercial vehicle (LCV), and industrial vehicles charging – Private campus – Central bus depots and bus-line turning point – Bus, truck and LCV, and industrial vehicles	– Highway corridor travel – Metro “charge and go” – Highway rest stops – Truck stops – Petrol station areas – City ring service stations – OEM R&D

ABB’s portfolio of EV chargers span across multiple charging applications

EV charging experts can help identify the right solution for your charging operation

Public and commercial EV Charging				
AC destination	**DC destination**	**DC Fast**	**Depot Charging**	**DC High Power**
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For car
(*350kW)

For bus

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For car
(*350kW)

For bus

Alternate use-cases for depots

E-mobility solutions landscape for cars and fleets

Applications, charging times and power options

Our focus for this presentation

Public and commercial EV Charging				
AC destination	**DC destination**	**DC Fast**	**Depot Charging**	**DC High Power**
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ABB e-mobility electrification infrastructure solutions

Overview

ABB Electrification has the complete line of charging infrastructure solutions

Your one-stop shop for e-mobility infrastructure

AC chargers

DC fast chargers

– Terra systems

E-bus chargers

– HVC

Service

– Asset management
– Upgrades & retrofits
– Installation & commissioning

Energy storage

– ESM

Integrated solutions

– Energy storage
– eHouse with chargers

Electrical power

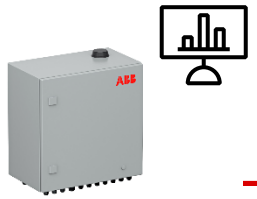
– Electrical only

Distribution Solution Components

– MV & LV Switchgear
– Relay

Residential

– Distribution boards/panels
– Home automation



Energy Management

– EV Site Solutions

Charging network software services

– ABB Ability

Electrical systems supporting chargers get more complex

As power levels rise charging locations may need to bolster their electrical infrastructure as well

Public and commercial EV Charging

AC destination	DC destination	DC Fast	Depot Charging	DC High Power
3-22 kW	20-25 kW	50-180 kW	50-150 kW+	150-350 kW+
ABB Charger – AC charger **Electrical Infrastructure** – Circuit protection – Residual current protections – Smart meters - optional for facility energy management	**ABB Charger** – DC charger **Electrical Infrastructure** – Cable pillars – Circuit protection – Residual current protections – Energy management solutions	**ABB Charger** – AC or DC charger **Electrical Infrastructure** – Switchboards – Cable pillars – Energy management solutions	**ABB Charger** – AC and DC charger(s) **Electrical Infrastructure** – LV Switchgear – MV Switchgear – Switchboards – Distribution transformers – Enclosures or skids – Battery Energy Storage System – Energy management solutions	**ABB Charger** – DC charger(s) **Electrical Infrastructure** – LV Switchgear – MV Switchgear – Switchboards – Distribution transformers – Enclosures or skids – Battery Energy Storage System – Energy management solutions

Electrification offering

Customized Solutions

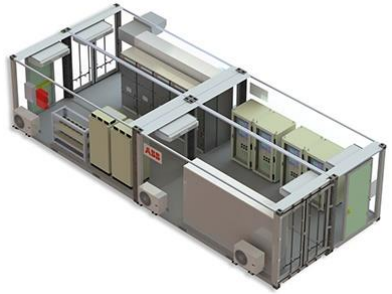
Description

Customized solution for a specific project. Offering for complex, non-standard, jobs requiring multiple ABB products and services.

Offerings

– Custom designed product packages

– Customized eHouses, skids and mobile substations



Solution Architectures

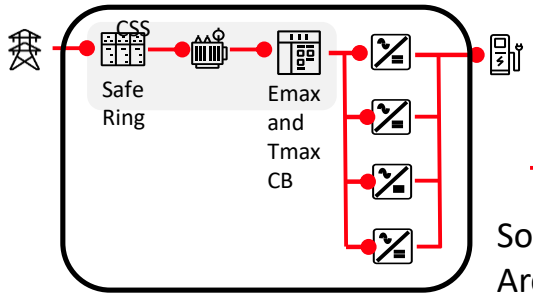
Description

A pre-engineered solution development with digital applications. Packages ABB products into a turnkey digital solution for specific applications.

Offerings

– Offerings by segment and specific application

– Digital offering with key benefits for user application



Solution Architecture

Productized solutions

Description

Productized solution that is pre-engineered, pre-fabricated, and type tested for rapid deployment.

Offerings

– Standardized eHouses and skids; ex. EcoFlex

– Compact Secondary Substations (CSS)

– Energy Storage Modules (ESM)

Productized Solution

Electrification offering – Productized solutions

Building blocks for e-mobility

Electrical infrastructure

- Built as modular or expandable solutions for future-proofing
- Aesthetically pleasing enclosures to help hide necessary infrastructure in plain sight

Integrated charger solution

- Ideal for turnkey charging solutions that can be commissioned quickly on-site
- Bridges the gap of connecting charging and electrical infrastructure
- Provides flexible solutions from reliable vendor with common products

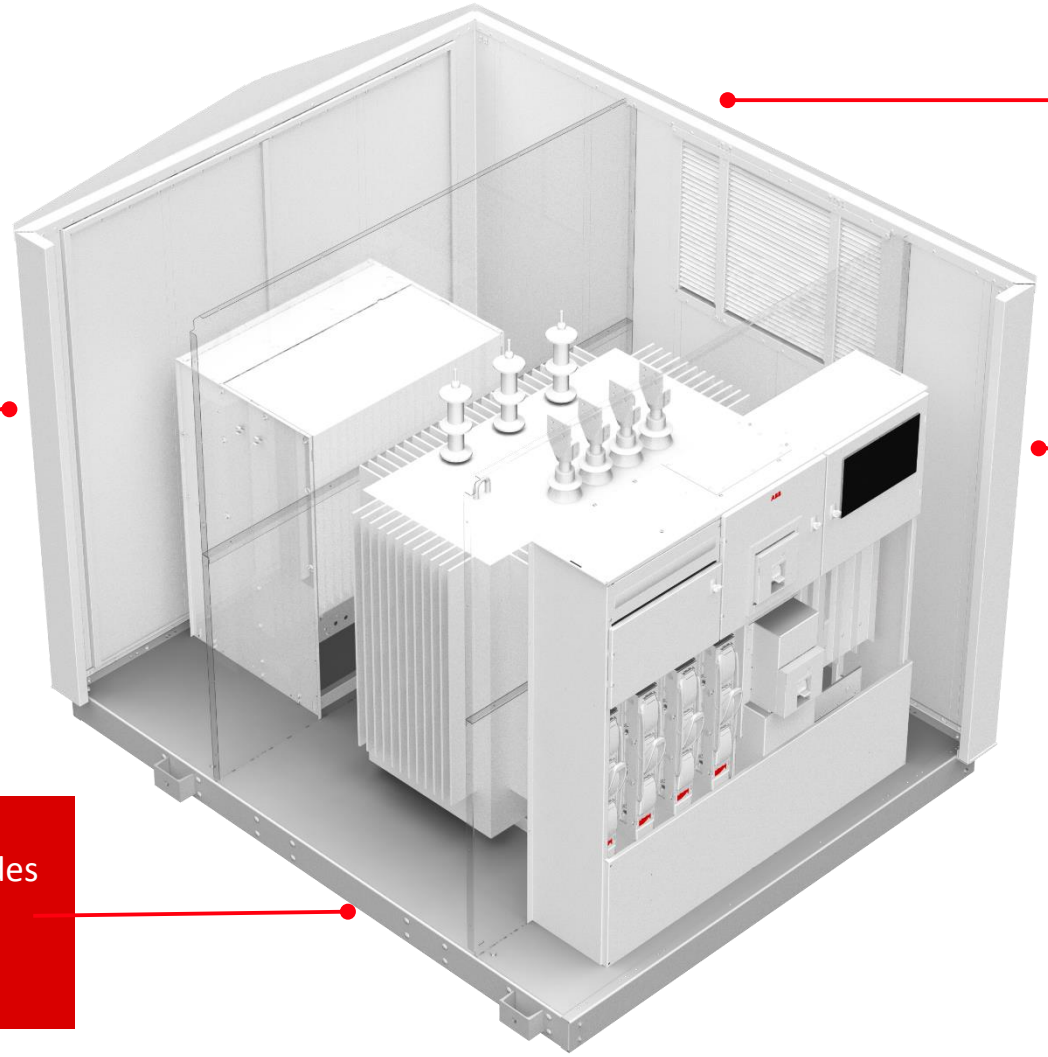
Battery energy storage

- Available with synchronized charging and is especially important where grid constraints limit charging power
- Ideal for peak shaving especially for fleets where multiple cars charge
- Ideal way to connect solar to local chargers reliably

Integrated load management across all building blocks provides fast deployment and reliable operation

Productized solution

Electrical infrastructure



Modular solution reduces complexity – 60% faster to deploy

Factory assembled, pre-wired and pre-tested - reduces risk by over 90%

Arc tested solution – safe for installation in public areas

Transportable provides flexibility to move between sites

Productized solution

Integrated charger solution

Factory assembled, pre-wired and pre-tested - reduces risk by over 90%

Integrated chargers simplify space constraints, connections and prevent start-up delays

Transportable - provides flexibility to move between sites

Arc tested solution – safe for installation in public areas

Optimized charging through intelligent energy management

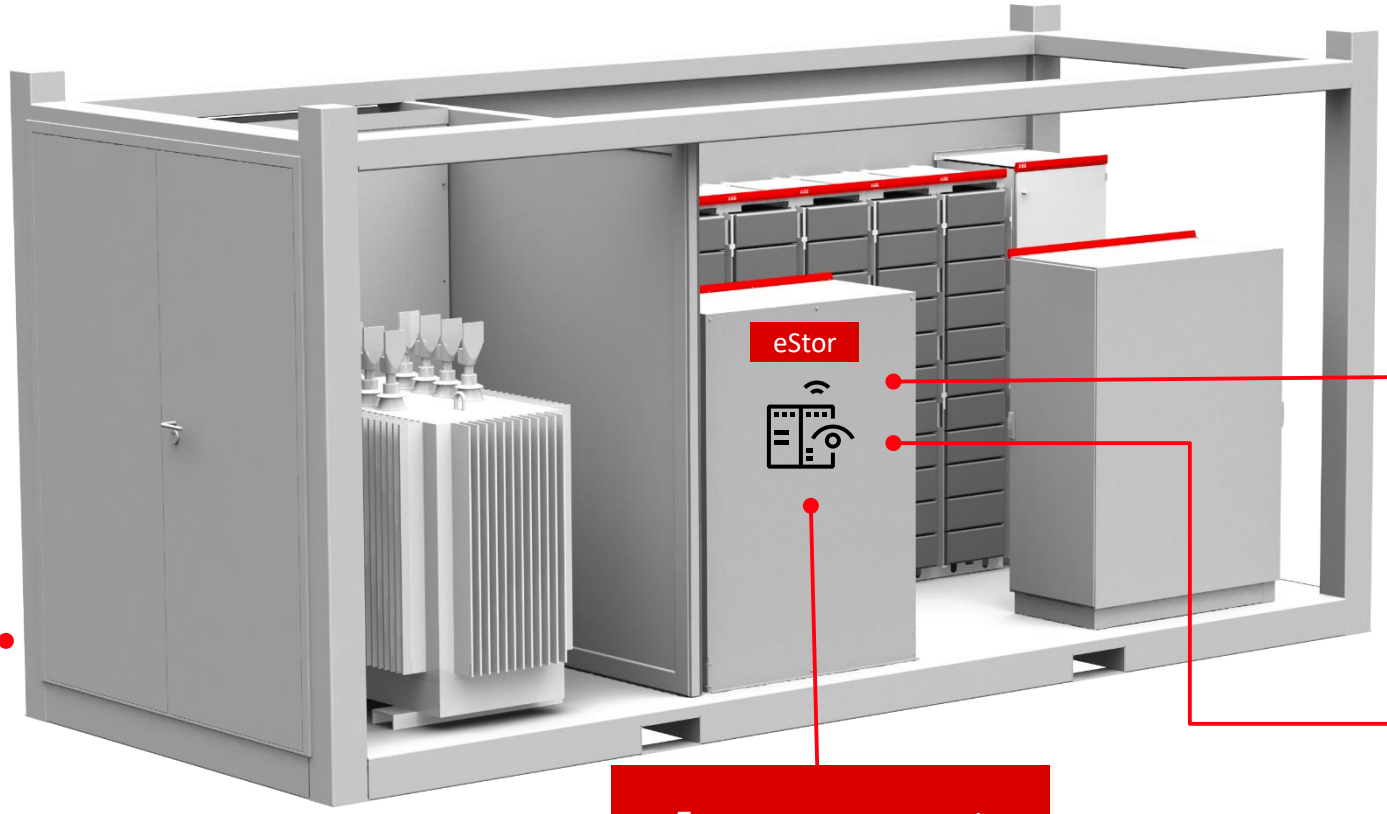
Modular solution reduces complexity – 60% faster to deploy

Productized solution

Energy storage

Factory assembled, pre-wired and pre-tested - reduces risk by over 90%

Transportable - provides flexibility to move between sites



Modular solution reduces complexity – 60% faster to deploy

Critical power operations digitally controlled for fastest response time

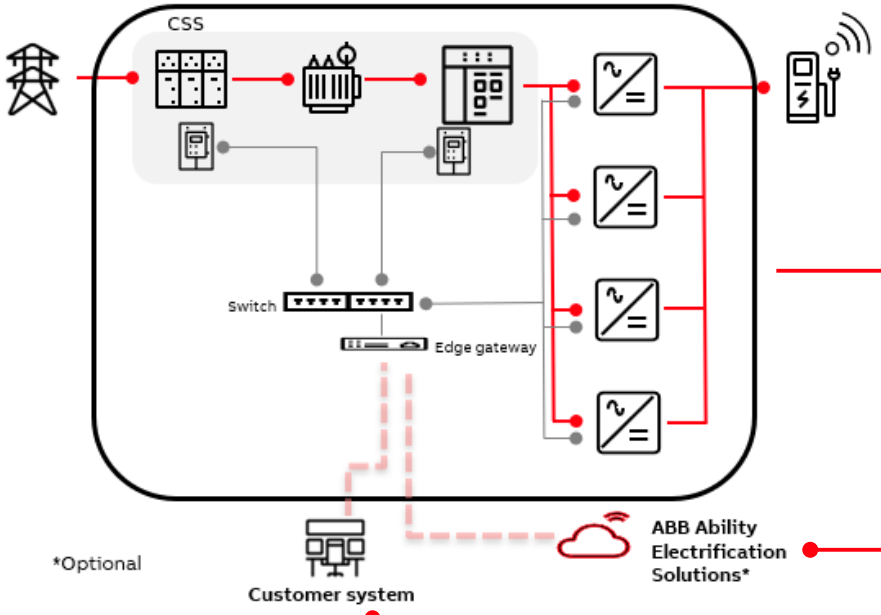
Asset health and management for product longevity

Energy management software for optimization and energy storage control

Solution architecture

Electrification and digital offering

Combines **products, pre-engineering** and **digital applications** to create scalable solutions to fit specific application requirements



Application based ABB products for seamless integration

Digital connectivity provides greater flexibility and information

Strong digital solutions for improved asset and energy management

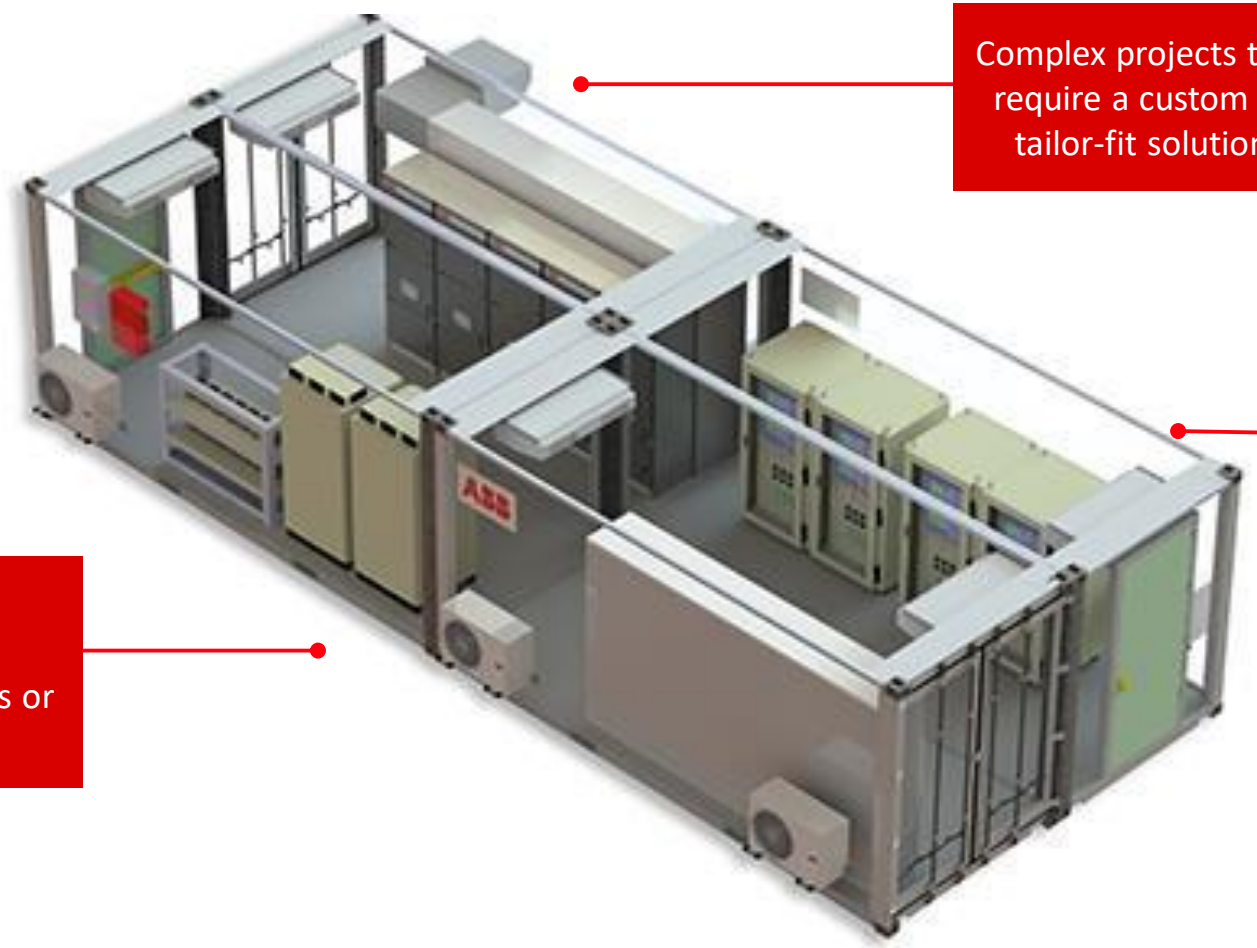
Pre-engineering reduces project complexity

Customized Solutions

Packaging & eHouses

Complex projects that require a custom or tailor-fit solution

Custom engineering – unique product engineering requirements to specific specifications



Project that requires design, engineering, integrated components, manufacturing and project management

Enclosures can vary depending on job demands; eHouse, skids or mobile substations

ABB’s e-mobility integrated solutions

Benefits of integrated electrical and charging infrastructure

- Modular and scalable, plug-and-play solutions **reduce complexity and are 60% faster to deploy**, helping customers turn ideas about sustainability into quick action.
- Factory assembled, pre-wired and pre-tested solutions assure a smooth startup
  reducing risk by over 90% that modifications will be required on site
- Internally arc tested unit offers the **highest safety for people and equipment**, with solutions tested according to IEC requirements for public installations
- The ability to place this solution in public spaces can **save 30% on installation costs** — no fencing or security required.
- Relocatable solution provides means **proposed site locations are evaluated temporarily without disruptive and costly grid connection expansions.** The permits required for temporary solutions are also often easier and faster to obtain.
- Transportable solution provides **flexibility** to move between sites with **simplified logistics.**
- Energy storage can easily be added in the future to cover higher peak demand and/or
  resolve grid limitation issues.
- Easy to transport and handle or relocate; many designs are stackable, **reducing land space requirements;** some designs fit into standard parking space.
- Digital connectivity, intelligent energy management, predictive maintenance, and deep insights and statistics at the charger, the site, and the network level **optimize e-mobility charging operations.**

Roadside stations

Roadside stations

The fastest car charging application

- Addresses consumer concern about range anxiety requires the introduction of fast charging stations
- Consumers want to charge as fast as possible in the shortest amount of time in these locations
- Typical charging power is between 50kW to 350kW.
- In 10 minutes time:
  - A 50 kW charger can add typically 40-60km
  - A 350 kW charger can add typically 290-350km
- These applications typically require a MV connection to the grid
- Relocatable battery energy storage solutions typically reduce the amount of time needed for permits, offering the fastest deployment for establishing a loyal customer base

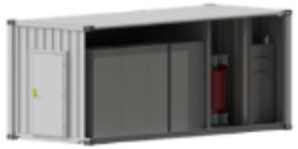
Roadside stations

Integrated solution

		Voltage rating	Power rating	Applicable standards	Standard components	Key solution features
	**EcoFlex with HP chargers**	Up to 1kV		IEC, ANSI	LV protection equipment, energy management system, high power charging posts	Expandable uses with ES and HP chargers, quick start from LV connection, movable
	**CSS with HP chargers**	2.4 – 40.5kV Typical rating (kVA): up to 1250 kVA		IEC, ANSI	MV switchgear, transformer, LV switchboard, HP chargers	Quick setup solution for plug-and-play charging requirements
	**Unisub with HP chargers**	Low voltage connection		IEC, ANSI	LV switchboard, HP chargers	For plug-and-play charging requirements with only LV connection, visually appealing
	**CSS with fast chargers**	2.4 – 40.5kV Typical rating (kVA): up to 1250 kVA		IEC, ANSI	MV switchgear, transformer, LV, fast chargers	Skid mounted, fast installation, ideal for small public or private charging
	**CSS with HP chargers**	2.4 – 40.5kV Typical rating (kVA): up to 2000 kVA		IEC, ANSI	MV switchgear, HP charger LV switch board, transformers	Skid-mounted, ideal for highway rest areas, immediate charger installs
	**EcoFlex w/ LV distribution & HP chargers**			IEC, ANSI	LV distribution, 8 power modules or 4 power modules and 2 charging posts	Quick setup; plug-and-play solution, reduced site works, standard connection interfaces

Roadside stations

Battery energy storage building blocks

		Voltage rating	Power rating	Applicable standards	Standard components	Key solution features
	**EcoFlex with energy storage**	2.4 – 40.5kV Typical rating (kVA): up to 2000 kVA	Up to 1800kW/1800kWh	IEC, ANSI	MV switchgear, transformers, LV switchboard, energy storage	Easy to ship and install, BESS for reliable power and peak power demand control
	**EcoFlex with energy storage & fast chargers**	Up to 1kV	200kWh/200kW - 900kWh/900kW	IEC, ANSI	LV switchboard transformers, energy storage, solar, fast chargers	Solar roof, energy storage for fast charging with LV grid connection, relocatable
	**EcoFlex w/ energy storage & HP chargers**	2.4 – 40.5kV	Up to 400kW/400kWh	IEC, ANSI	MV switchgear, transformer, LV switchboard, energy storage	Easy to ship and install, BESS for reliable power and peak power demand control
	**EcoFlex Energy Storage Module**	Up to 1kV	Up to 500kW/500kWh	IEC, ANSI	LV switchboard, energy storage	Plug-and-play low voltage energy storage solution, easy to ship and set up

Roadside stations

Electrical infrastructure building blocks

		Voltage rating	Applicable standards	Standard components	Key solution features
	**Compact Secondary Substation (CSS)**	2.4 – 40.5kV Typical rating (kVA): up to 3150 kVA	IEC, ANSI	MV switchgear, transformer, LV switchboard	Versatile configurations and functions with quick setup and pre-engineering

Other considerations

Things to consider when selecting the proper electrical infrastructure

Enclosures are specific to power requirements and site considerations.
Below you will find detailed information on selecting the right enclosure.

Solutions

CSS family: Internally arc tested to meet IEC62271-202 standard making it ideal for public spaces


EcoFlex eHouse: Internally arc tested and easy to transport and relocate

Open-air skid: Ideal pre-assembled, pre-tested solution for quick installation and simple maintenance

Site considerations	CSS	EcoFlex	Open-air skid
Public space	+++	++	
Environmental (moisture, salt, fog, etc.)	+++ (GRP) ++ (Steel)	++	+
Seismic	++	++	++
Wind	++	+++	
High Altitude	++	+++	+
Arc containment	+++	+++	
Transportability	++	+++	++
Relocatable	+	+++	+
Compactness	++	+	+++

+ Good
++ Better
+++ Best

Advantages of integrated skid-mounted, complete solutions

Eliminate time and cost

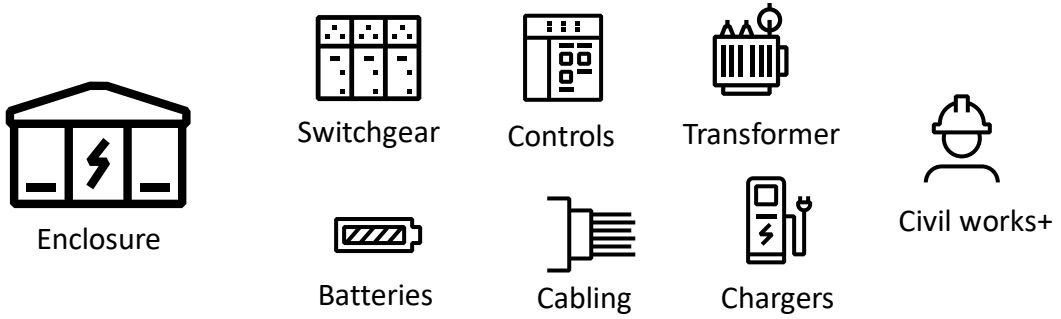
For simple, quick installation consider placing high power chargers on the same skid with the enclosure to eliminate:

- Placing the enclosure behind a fence
- Cabling and cable trays costs
- Installation costs

Integrated solution provides simple, quick installation

versus

Individual product delivery

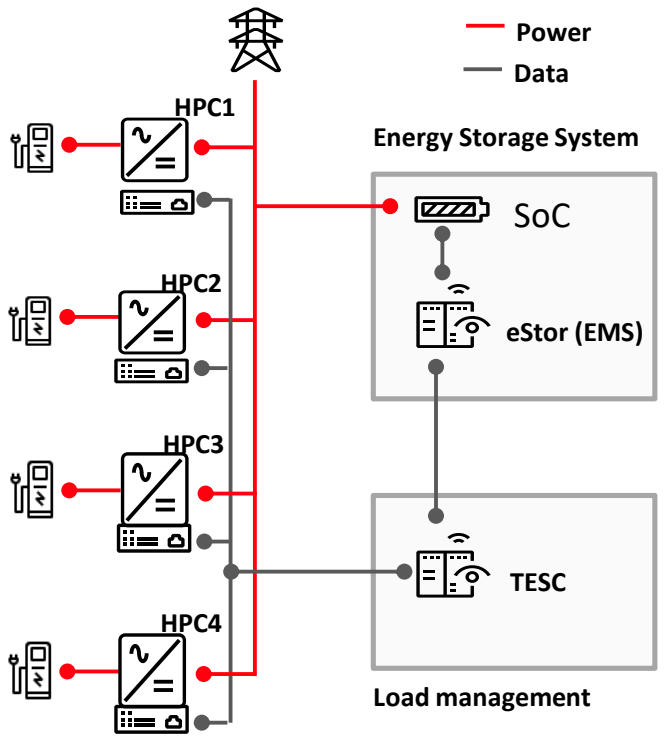


Digital options

Digital controls to solve grid constraint issues

Synchronized charging digital solutions

Synchronized charging for e-mobility



Grid constraints can often limit placement of eV charging locations or require long permitting times and infrastructure improvements.

However, with the addition of a Battery Energy Storage Systems (BESS) performing peaking capacity and the eV site controller performing load management, customers are able to synchronize charging for optimized energy flows in order to:

- Keep the grid under the capacity limit
- Provide maximum power to the eV customers
- Deploy eV charging infrastructure more quickly and to test possible locations before investing in costly grid capacity and electrical distribution expansions

Energy storage and synchronized charging digital solutions

Advantages

The energy storage and controlled synchronization allows customer to charge more than their existing power limit on the grid, this is specifically important when facing grid limitation issues.

It can take up to 1 year to obtain permits needed to deploy permanent charging infrastructure. The permits needed for a temporary installation are easier and faster to obtain. This allows a charge station to be deployed quickly and buys more time for the necessary permits to be collected for the permanent charging station. The temporary solution can then be relocated to the next planned site.

The solution allows a possible location to be tested before investing in costly grid capacity and electrical distribution expansions.

This solution prevents undervoltage issues and nuisance trips

The synchronization and voltage control helps prevent frequency excursions

The system can automatically detect load and synchronize

Why choose ABB for your e-mobility needs?

ABB Electrification is your total solution for e-mobility

A one-stop-shop

EV chargers for cars, buses and fleets

E-mobility infrastructure solutions

Financing for e-mobility solutions

ABB can help make your investments scale with needed capacity

ABB can help install your electrical vehicle infrastructure in over 80 countries

ABB will service and maintain the infrastructure for optimal use and availability

We will help you design, install and service your investment

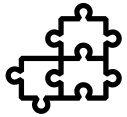
ABB Packaging and Solutions for your e-mobility infrastructure needs

The perfect partner

Trustworthy partner
ABB is a global partner with a focus on advanced technologies

Ensure operability
Pre-engineered, pre-assembled and pre-tested solutions reduces risk

High reliability
Our solutions have undergone extensive risk and failure mode analysis



Flexible modular concept
Modular concept allows for ease of scalability in power and capacity

Safe, easy to install and operate
Pre-assembled and tested at ABB premises to ensure personnel safety and reduce time on-site

Maximize your ROI with highly reliable, scalable and safe solutions

Consider ABB Packaging & Solutions for your e-mobility solution needs

The perfect partner

Trustworthy partner

- World leader in digital industries to serve customers
- Pioneering technology leader focused on digital industries
- Strong global team

Ensure operability

- Pre-engineered and industrialized products with reduced project engineering
- Reduced installation and transportation costs
- Maximize uptimes with factory assembled and pre-tested solutions
- Ensures immediate operability
- Can be dropped in parking space – ready to work

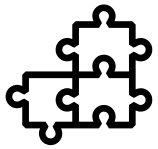
High reliability

- Protect equipment from environmental influences
- Factory tested solution
- Designed to withstand severe environmental conditions
- Undergone extensive risk and failure mode analysis
- Advanced and efficient temperature control provided for the inverter and battery system.
- IEC compliant

Consider ABB Packaging and Solutions for your e-mobility solution needs

The perfect partner

Flexible



- Modular concept to allow ease of scalability in power and capacity
- From low-voltage to a wide range of AC medium-voltage levels
- Engineered footprint to optimize customer's requests
- Different options of MV switchgear from ABB's SF_6 gas-insulated secondary switchgear portfolio (also available with air-insulated switchgear)

Safe and easy to install and operate

- Internally arc tested for public and service personnel
- No live parts accessible
- Locking system for all enclosure doors prevents unauthorized entry of personnel
- Local and remote monitoring and control, easy integration to customer SCADA and ABB Ability™
- Ease of transportation due to standardize solutions
- Pre-assembled and tested at ABB premises to reduce on-site times
- 24/7 service support available to ensure uptime

Partnering with an expert is critical to success

ABB is a leader in delivering EV charging and electrical infrastructure

The standards for EV charging infrastructure are evolving

– ABB is a founding member to CHAdeMO and CCS standards and are co-developing the next advancements, such as ultra-fast charging solutions.

Interoperability between EV charger and the electric vehicle is not universal

– ABB offers an interoperability consultancy, working directly with all of the major car and bus OEMs to ensure successful interaction between your chosen vehicle and ABB EV chargers.

ISO 15118 can be utilized for advanced services, such as preconditioning

– Allows the vehicle cabin to be brought to the perfect temperature prior to departure from depot, saving valuable battery capacity.

– On-site connectivity solutions can be used to integrate chargers in local control systems, such as for fleet scheduling and energy management.

Cloud-based connectivity is critical:

– To ensure chargers are always working with the latest electric vehicles, software updates are delivered remotely

– To extend charging to public use-case, such as setting up pricing for charge sessions, to accept credit card payments, to authorize new vehicles to use the chargers

– To analyze charging statistics for business insights, such as trends in charging schedule, energy usage, and for testing new business models

– For evaluating the health of the EV chargers, such as any alerts or warnings, and using predictive maintenance to prevent disruption to charging operations


ABB