EV Infrastructure
Electrification of Transport in Europe
Well-to-wheel efficiency of alternative fuels

Range per year per m² of land

Biofuel: 7km

Most efficient energy crops (palm oil, sugar cane) deliver 0.5L/m² including sowing, fertilizing, harvesting, refinement and distribution. A vehicle drives 15km/L, so 0.5L gives 7km range.

Hydrogen: 160km

A solar panel delivers 105 kWh/m². After electrolysis, compression and distribution 63kWh goes into the tank. The fuel cell generates 31.5kWh of electricity. The vehicle drives 5km/kWh, so 31.5kWh gives 160km range.

Electric: 380km

A solar panel delivers 105 kWh/m². After distribution, charging and storage in the battery, 77kWh is available to the motor. An EV drives 5km/kWh, so 77kWh gives 380km range.

Original source: Auke Hoekstra, Eindhoven University of Technology. Data was modified due to improved performance of biofuel and hydrogen.
Detroit Electric car charging at home in 1919
The traditional ICE can not improve on emissions and efficiency
The Car Industry is facing a massive transformation

3 major disruptions creating new business models

- High efficient long range full electric fast chargeable vehicles
- Always connected
- Full autonomous driving & automatic car sharing services
EV fast charging and global standardization

ABB leading in major developments this decade

2010
- Founding of CHAdeMO
- ABB was involved from the start

2010
- Launch ABB Terra 51
  50 kW CHAdeMO charger

2010
- First 50 kW charger in EU
  Based on proprietary standard, no consumer EV’s available

2010
- First EV’s with DC charging
  Nissan Leaf & Mitsubishi iMieV

2012
- Founding of CCS alliance
  ABB was involved from the start, basis for IEC standard

2012 - 2013
- First nationwide DC networks
  ABB in Estonia, Denmark, Netherlands

2013
- Launch CCS & multi-standard Terra 53
  CCS + CHAdeMO + AC

2013-2015
- Launch global variants Terra 53
  China, USA, APAC

2014, >
- DC networks spread globally
  Europe, USA, Asia

2016
- First eBus chargers in EU
  Global partnerships with bus OEMs

2016, >
- Leading Connectivity & uptime
  ABB has industry leading uptime by remote management
  and supports global payment solutions
Major installations of ABB

Some examples

EVgo: 450+ Fast chargers
Estonia: approx. 200 Fast chargers since Feb 2013 in operation
Fortum: 150+ Fast chargers

CLEVER: 150+ Fast Chargers
Fastned: 100+ Fast chargers
DC charging versus AC charging

On-board versus Off-board equipment

Every vehicle needs to have its own onboard equipment

Infrastructure investment is shared with hundreds of users
Follow the car through Europe, and open standard protocols
ABB is following the OEM Fast Charging standards

50kW CHAdeMO / 22-43 kW AC / 50-350kW CCS 2
Multi-standard charger solution Terra 53 & Terra 23

General explanation of naming convention

Terra 53 (50kW)  C - (Combo) = Combined Charging Systems (CCS)  - DC
Terra 23 (20kW)  J - (Japan) = CHAdeMO  - DC
                  Z - (China) = GB  - DC
                  T - (Socket) = Type 2 Socket  - AC
                  G - (Grid) = Cable + Type 2 Connector  - AC
Follow the car: key car developments

Step-by-step range improvement, long range in future

- **Nissan Leaf**: 30 kWh / ~50 kW charging
- **BMW i3**: 33 kWh / ~50 kW charging
- **Hyundai Ioniq**: 28 kWh / ~50 kW charging
- **VW e-golf update**: 35.8 kWh / ~50 kW charging
- **Chevrolet Bolt / Opel Ampera-E**: 60 kWh / ~50 kW charging
- **Tesla Model S/X + CHAdeMo adapter**: 60-100 kWh / ~50 kW charging
- **Audi Q6 e-tron**: 94 kWh / ~150 kW charging
- **Porsche Mission-E**: ? kWh / ~300 kW charging

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
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<tbody>
<tr>
<td>Vehicles</td>
<td>Tesla Model S/X + CHAdeMo adapter</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Charging Capacity</td>
<td>60-100 kWh</td>
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<tr>
<td>Charging Rate</td>
<td>~50 kW charging</td>
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<td>Production Volume</td>
<td>Medium volume production</td>
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©ABB September 7, 2017 | Slide 12
**Driver: The EV range roadmap for EU, USA, APAC**

Batteries get bigger, range gets longer / DC Charging power increases in the coming years

<table>
<thead>
<tr>
<th>Year</th>
<th>Mass market EVs</th>
<th>Premium EVs</th>
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<tr>
<td>2011</td>
<td>~140km 24 kWh</td>
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</tr>
<tr>
<td>2012</td>
<td>&gt;180km 30 kWh</td>
<td>&gt;450km &gt;80 kWh</td>
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<tr>
<td>2013</td>
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<td>&gt;400km &gt;70 kWh</td>
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</tr>
<tr>
<td>2021</td>
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**Small cars:**
- 50 - <150kW

**Mid/high segment:**
- 120 - 150 kW

**Top segment:**
- ~300/350 kW
**Driver: The EV range roadmap for EU, USA, APAC**

Batteries get bigger, range gets longer

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<td>2021</td>
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</tr>
</tbody>
</table>

**Charge rates**

- **50 kW**: Charging on the road
- **3-20 kW**: Charging at commercial locations
- **3-6 kW AC**: Charging at home / office

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**Charging locations**

- **50 kW - 150-350 kW**: On the road
- **20-50 kW**: At commercial locations
- **10-20 kW**: At home / office

**Power ratings**

- **Small cars**: 50 - <150 kW
- **Mid/ high segment**: 120 - 150 kW
- **Top segment**: ~300/350 kW
ABB in the lead for new high power standard (2018)

CCS standard changes required for power >150 kW

<table>
<thead>
<tr>
<th>Standard</th>
<th>Specification (today)</th>
<th>Max charging power for EV car</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAdeMO</td>
<td>50-500V, 125A</td>
<td>~50 kW</td>
</tr>
<tr>
<td>CCS</td>
<td>200-500V, 200A</td>
<td>~95 kW</td>
</tr>
</tbody>
</table>

**CCS today**
- CCS connector
- 200 – 500 V<sub>DC</sub>
- 200 A<sub>DC</sub>
- Up to ~95kW charging power

**New high power CCS**
- Special CCS connector, backward compatible with today’s cars
  - Up to 920 V<sub>DC</sub>
  - 350/500A<sub>DC</sub>
- 150kW – 350 kW/460kW charging power

Power electronics cabinet parameters changed
- Current
- Voltage
- Safety concept
- Isolation concept
- Electro Magnetic Compatibility (EMC)
- Power quality
- Accuracy

CE / UL charger certification based on today’s standard
ABB modular upgradeable high power charging solution
Charging 200km in 10 minutes

10 kV, 20 kV

1 x 1,2 MVA substation

400Vac

6 x 350kW charge post
Roll-out of first high power charge park with EVgo
eBus and heavy vehicle charging: 50 kW – 450 kW

Overnight and on-street opportunity charging

- Automated connection system
- High power DC transfer to bus
- Wireless communication to bus
- Based on
  - EN/IEC 61851-23
  - ISO/IEC 15118
  - OPPcharge compatible
- Industrial quality power cabinet
- 150kW, 300kW & 450 kW modular
- Redundancy per each 150kW module
- 200-920 VDC
- Galvanic isolation
- Remote management
New Opportunities: Energy & Digital convergence

Energy and Digital Threads connect Utilities, Industry and Transport & Infrastructure

Utilities

Industry

Transport & Infrastructure

Digital Grid – Energy Internet

Shift to Renewables

Industry 4.0
Collaborative, Flexible manufacturing
Real-time optimization

Smart Cities
E-mobility
Mobility-as-a-Service

Building Automation
Electricity production and spot prices in Germany

December 2016
Videos on YouTube and some websites

Site with ABB-EVCI movies:
https://www.youtube.com/user/ABBEVChargingInfra

General EVCI charging movie:
https://www.youtube.com/watch?v=aLh_P8TQzBg

E-bus:
https://www.youtube.com/watch?v=MS1foeINR5U

Official website Estonia project ELMO (English language):
http://elmo.ee/en/
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