NOVEMBER 4, 2020

EV Infrastructure Research

Looking Ahead

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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

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

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

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

2016
First eBus chargers in EU
Global partnerships with bus OEMs

2018
First eTruck chargers
Global partnerships with OEMs

CHAdeMO — **CCS alliance** — **Multi-standard** — **E-bus** — **Higher power** — **Near future**

Pilots — **First EV's** — **IEC 61851-23** — **Global EV spread** — **OppCharge** — **DC home**

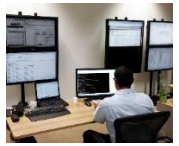
2010
First 50 kW charger in EU
Based on proprietary standard, no consumer EV's available

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

2012
First demo of CCS charging
ABB & CCS alliance at EVS26 Los Angeles, USA

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

2012, >
ABB leading Connectivity & uptime
ABB has industry leading uptime by remote mnmnt



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

2017
Launch of high power for cars
150-350kW fast charging for next generation EV's

2018
Gen2 charge post and Terra 54HV
Next steps in High Voltage charging

Public and commercial car charging

Range of EVSE offering

Public and commercial EV Charging

AC destination	DC destination	DC Fast	DC High Power
3-22 kW	20-25 kW	50 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 – Dealerships – Parking structures – 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’ – Gas station areas – City ring service stations – OEM R&D

Impact of Electric Vehicles for our Society

ABB Contributions

Public transit electrification

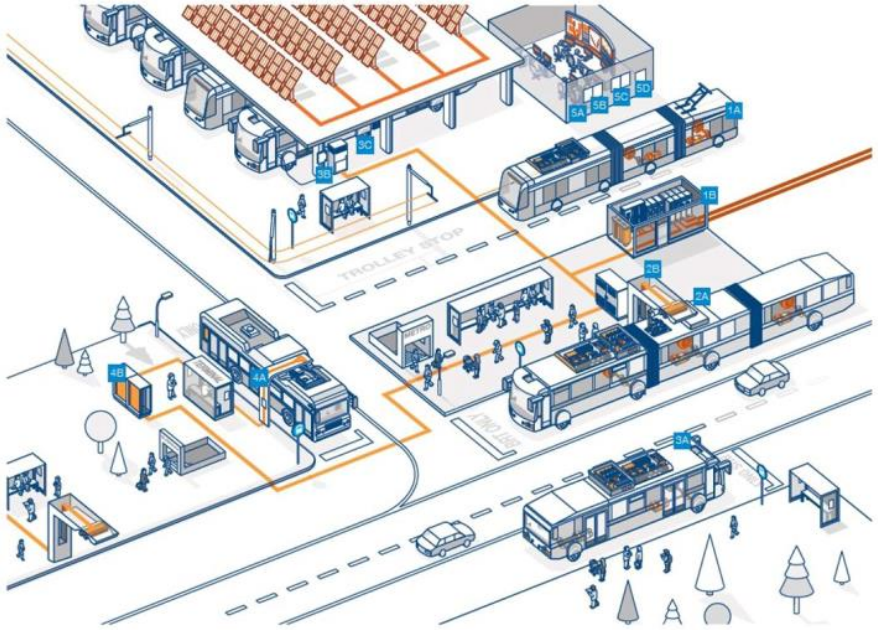
- Charging stations
  - Depots
  - “Pantograph” opportunity charging
- Projects primarily in Europe

Gothenborg, SE
Volvo Busar
– 1 x HVC 150P
– 1 x HVC 300P
– 1 x HVC 150C
– R&D

Harrogate, UK
Transdev
– 3 x HVC 300P

Luxembourg, Lux
Ville de Luxembourg
– 4 x HVC 150P
MDDI & Sales
Lentz
– 4 x HVC 150P

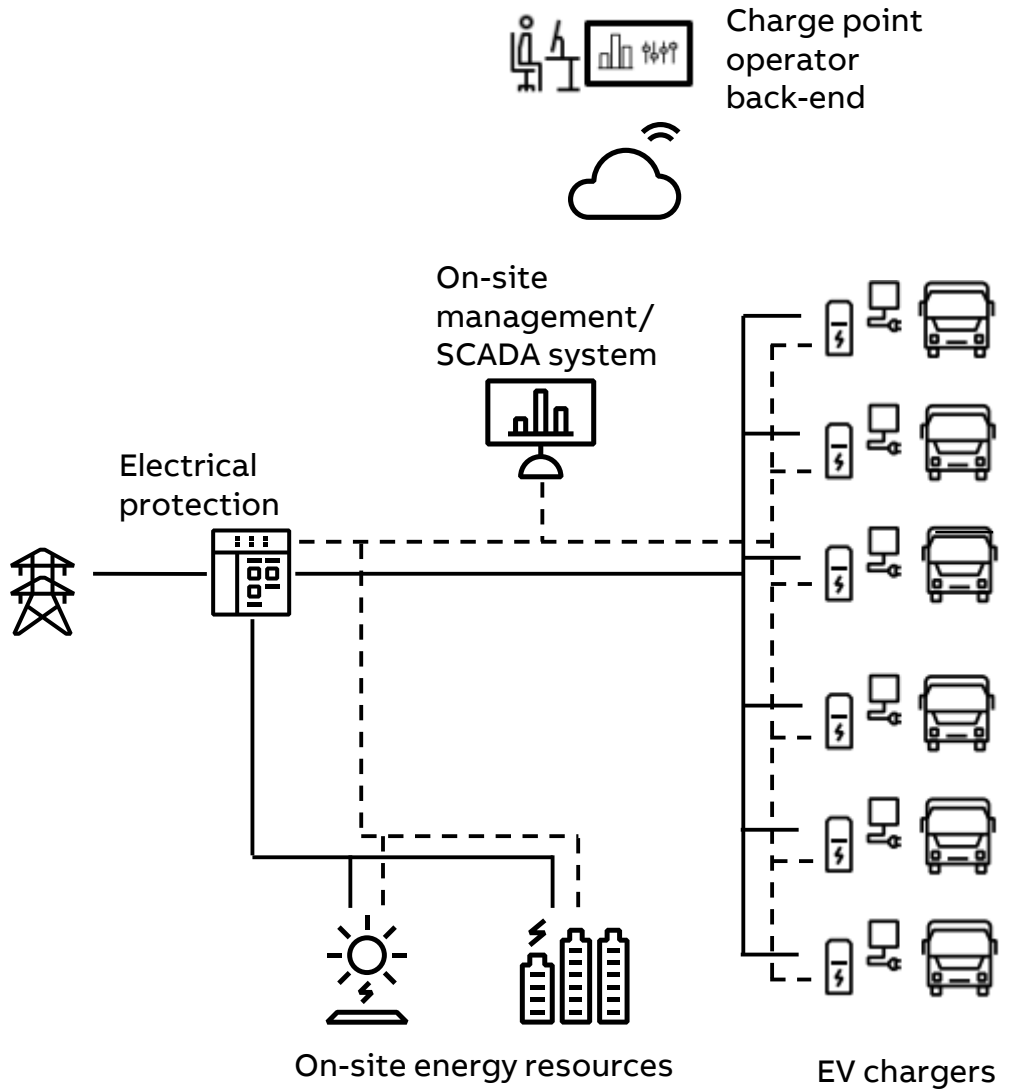
Plattsburgh, USA
Novabus
– 1 x HVC 300P



Complete Charging Site Solutions

Electrification and management

- Complete depot site may have:
  - EVSEs
  - DERs (PV, battery, etc)
  - Electrical protection panels
  - SCADA system
  - System management solutions (energy optimization, asset health monitoring, etc)
  - Cloud connection to charge point operator back office
- Solutions for:
  - Private EV fleets
  - Public fast charging depots
  - Destination charging sites – add building management system



Load Management

What are the motivations to manage load?

Interconnection Limits

- Existing or additional loads exceed ratings for interconnection equipment
  - Protection
  - Transformer
- Adding EV charging fleet to a site poses this risk

Going Green

- Altruistic desire to use more renewable energy
- Manage load to align with PV output
- Install storage
- More likely for residential customers

Reduce Energy Bill

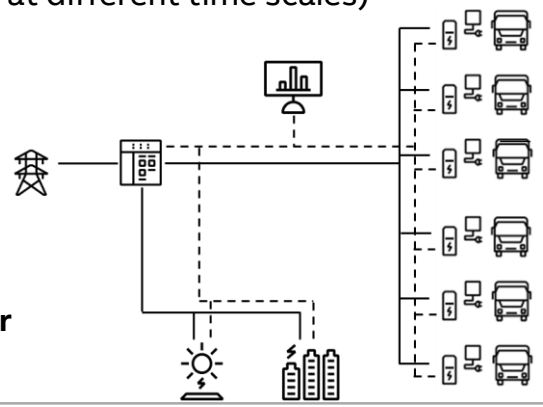
- Load dynamics affect utility operation
- Utility can apply incentives and disincentives to customer bill to influence load dynamics
- **Load management is an economics problem for the customer, connected with utility rate cases and programs**

EV Load Management

What is the industry direction? Two perspectives

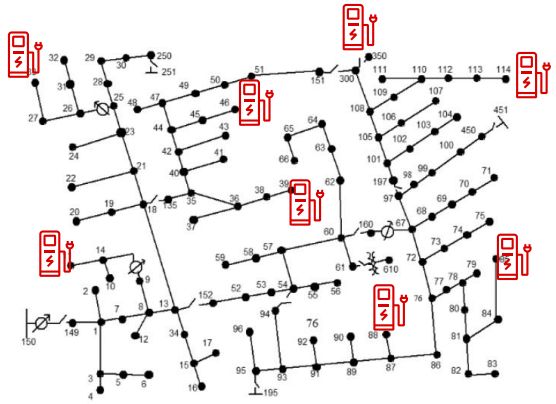
Depot/Site-Level Load Management

- Depot owner cost minimization:
  - DERs
  - Control costs against utility rate cases/programs
  - Direct control of EVs depends on ownership – private fleet depots vs. public charging
- Challenges for distribution utilities:
  - **Forecasting EV load**, especially at public fast charging depots
  - **Handling load dynamics** (behavior at different time scales)
  - Mitigation using price-based incentives and disincentives
    - Time-varying pricing
    - Demand charges
    - Demand response
  - **Mitigation by leveraging customer relationships** (e.g. fleet owners)



Network-Aggregated EV Load Management

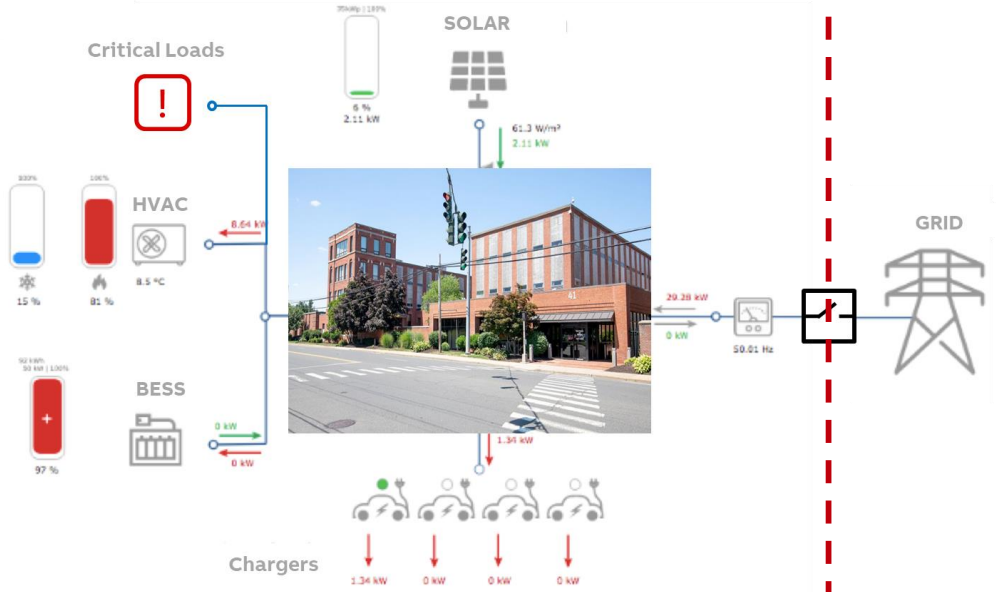
- Players and roles still being defined: will aggregated EV load control be offered as a service to utilities, and by whom?
  - Charge point operators
  - EV vendors
  - Utilities
- How can utilities distribute price signals to aggregators to help control impact **across the network**?
  - Congestion
  - Voltage profile
- **Rich area for advanced research**



EV Load Management

Common approach for sites

- Site makes best decisions for itself based on utility price structures
  - EV charging control
  - V2G
  - DER control
  - Building load control (HVAC, lighting, etc)
- Aggregator services simplify site owner decisions
  - Provide intelligent control platform
  - Handle utility signals
  - Possibly own assets (DERs, EVSEs)
  - **Aggregator business models an open question**
- **Coordinated intelligence** guarantees best outcomes for site owners
  - Avoid management silos (e.g. HVAC vs. DER vs. EVs)
  - Continue to develop communication and data model standards (e.g. IEEE 2030.5)

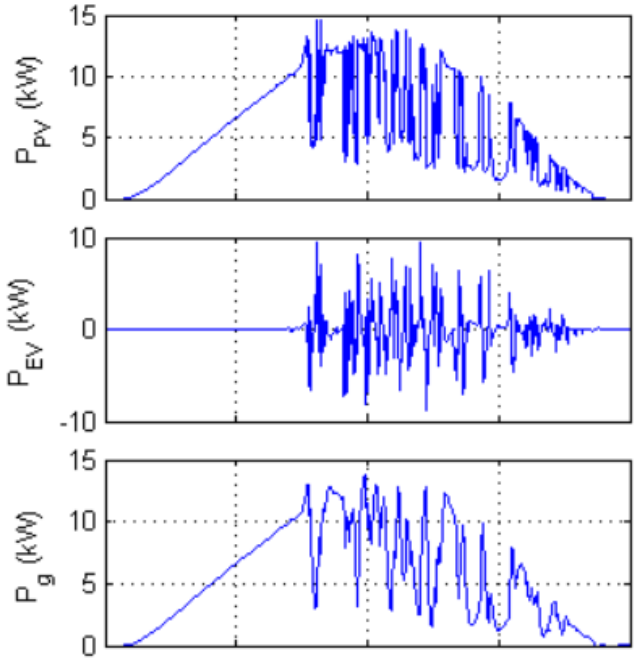


- How to determine the **real cost of energy delivery**, including e.g. GHG reduction by incentivizing EVs?
  - Time-varying rates (Time of use, critical peak pricing, etc)
  - Penalties for extreme behavior (e.g. demand charges)
  - Incentives for services (e.g. capacity, voltage/frequency support)
- Should only be interested in and bill for behavior of site at interconnection point

- Utility has no visibility beyond interconnection
- Continue to develop communication standards for utility pricing and programs (e.g. **OpenADR**)
- Mutually beneficial, novel methods of coordination is a valuable research area

EV Load Management

What is the future of V2G?



PV smoothing using EV

Possible applications:

- Bulk energy management, e.g. peak shaving/load shifting
  - Is there enough available stored energy to make a difference?
  - May be feasible for large fleets
- Resilience/backup power
  - For residential, EV capacity may cover a few hours' outage – acceptable to resident?
  - For buildings with fleets, critical loads could stay online
- Fast response energy management – with proper incentives, low energy/high power V2G works well for certain applications
  - Frequency response ancillary service
  - Renewable smoothing
- **Best outcomes come from stacking value propositions – pilot opportunities can help explore possibilities**

Other considerations:

- Impact on battery lifetime – how to compensate?
- For aggregators, is the extra responsibility worth the benefit?
- If EV vendor is an aggregator, easier to structure warranty/EULA to access stored capacity
- **Research opportunities for exploring novel partnerships**


ABB