Electric Vehicles

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Electric vehicle charging standards and protocols.

EV charger topology	Charging connector	Charging communication	Charging power quality	Charging safety
IEC 61851-1	IEC 62196–1	ISO 15118/IEC 61850	IEEE 1547	IEC 60529
IEC 61851- 21	IEC 62196–2	SAE J2847/SAE J2836	SAE J2894	IEC 60364- 7-722
IEC 61851- 22	IEC 62196–3	SAE J2293-2/OCPP	IEC 1000-3-2	ISO 6469-3
IEC 61851- 23	SAE J1772	OCPI/OSCP/	NEC 690	SAE J1766
IEC 61851- 24	IEEE 1901	OpenADR	SAE J2380	SAE J2464

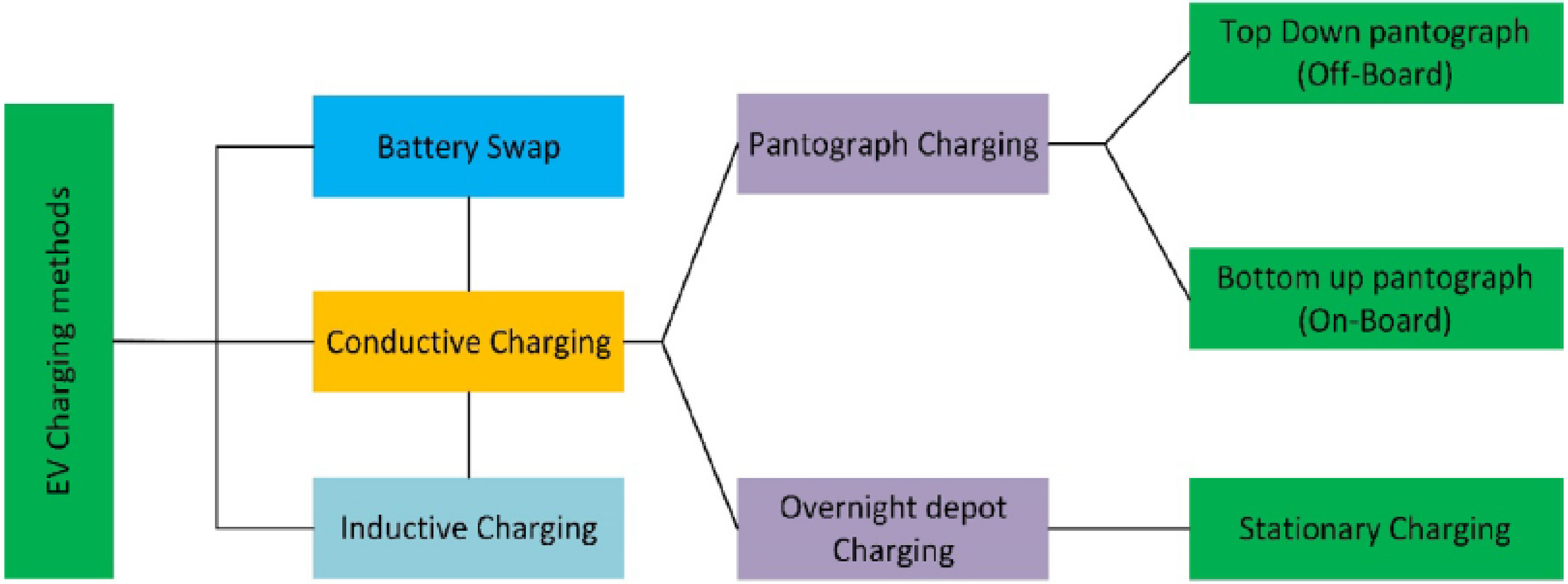


Fig. 5. Charging methods for electric vehicles.

Pantograph Charging

Conductive Charging Modes

- Level 1 charging –mainly used in homes. It uses 120 v AC with a current rating of 15A or 20 A. charging can take 8 to 16h for full charge of a battery. Can draw a power of 1.4-1.9 KW
- Level 2 charging – commercial charging stations. 240 V AC with a current rating up to 80A.
- Level 3 charging – Direct current fast charging. The stations convert AC power from the grid to DC power so that when a driver plugs in their EV, DC current flows directly to its battery. With DC fast charging at 500A and 400VDC, it would theoretically take the same battery about 30 minutes to reach full capacity.

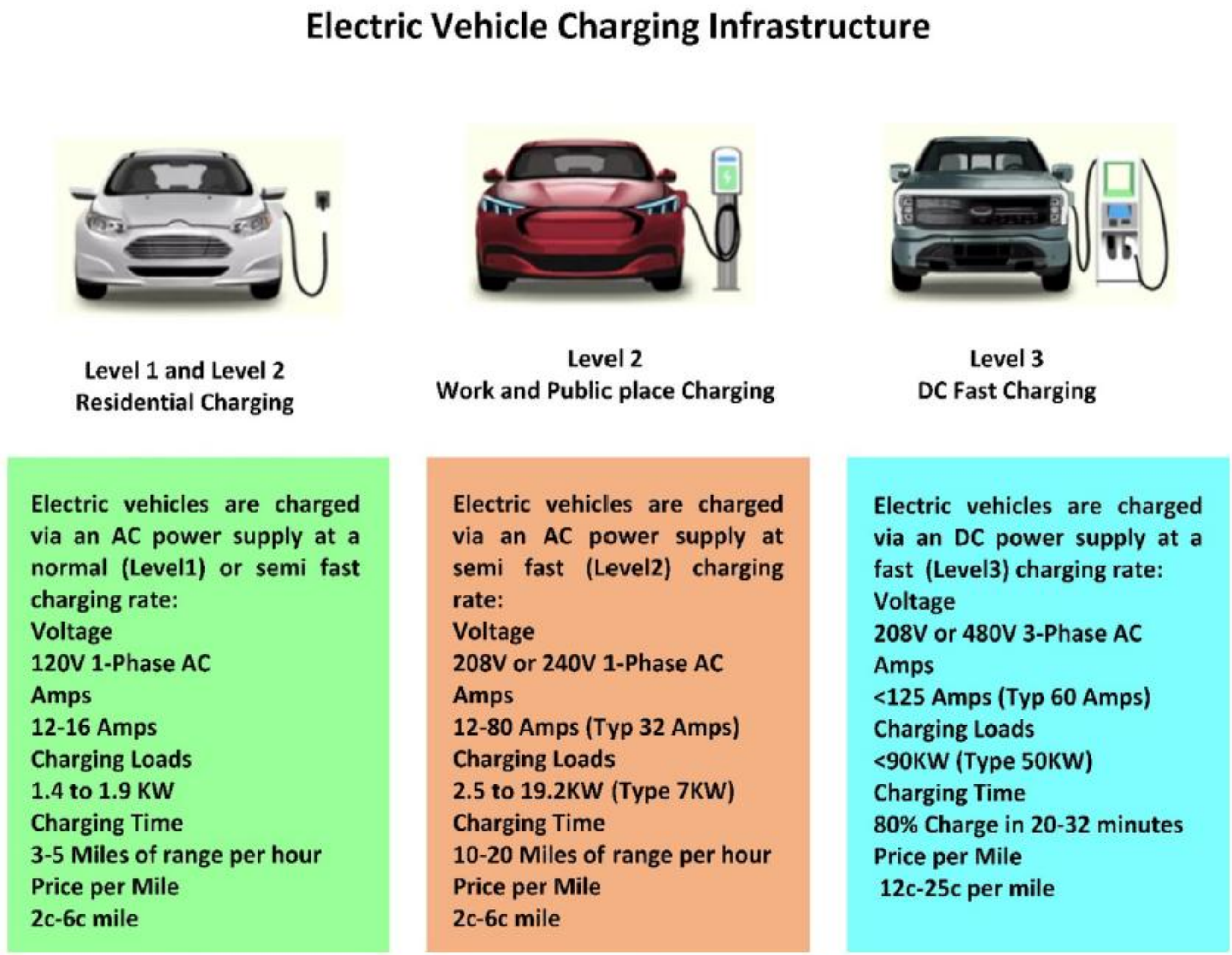
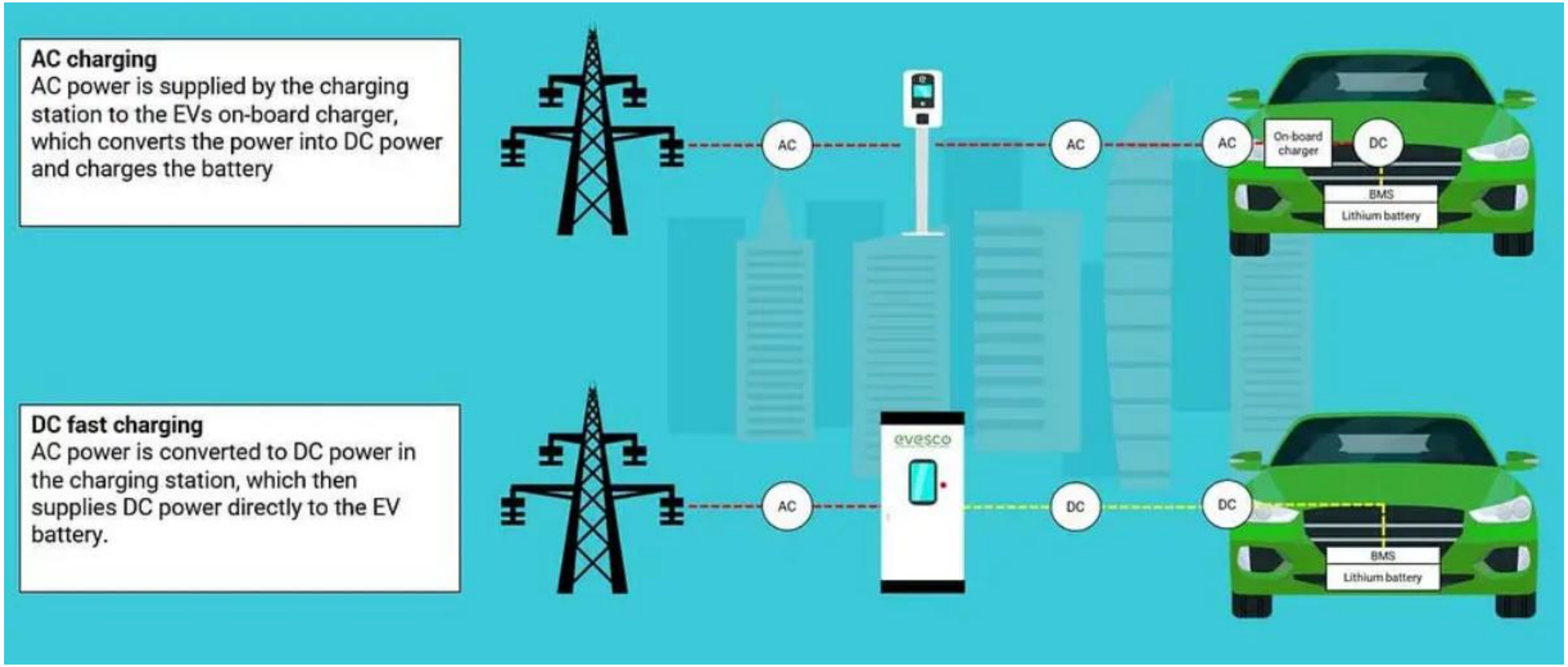
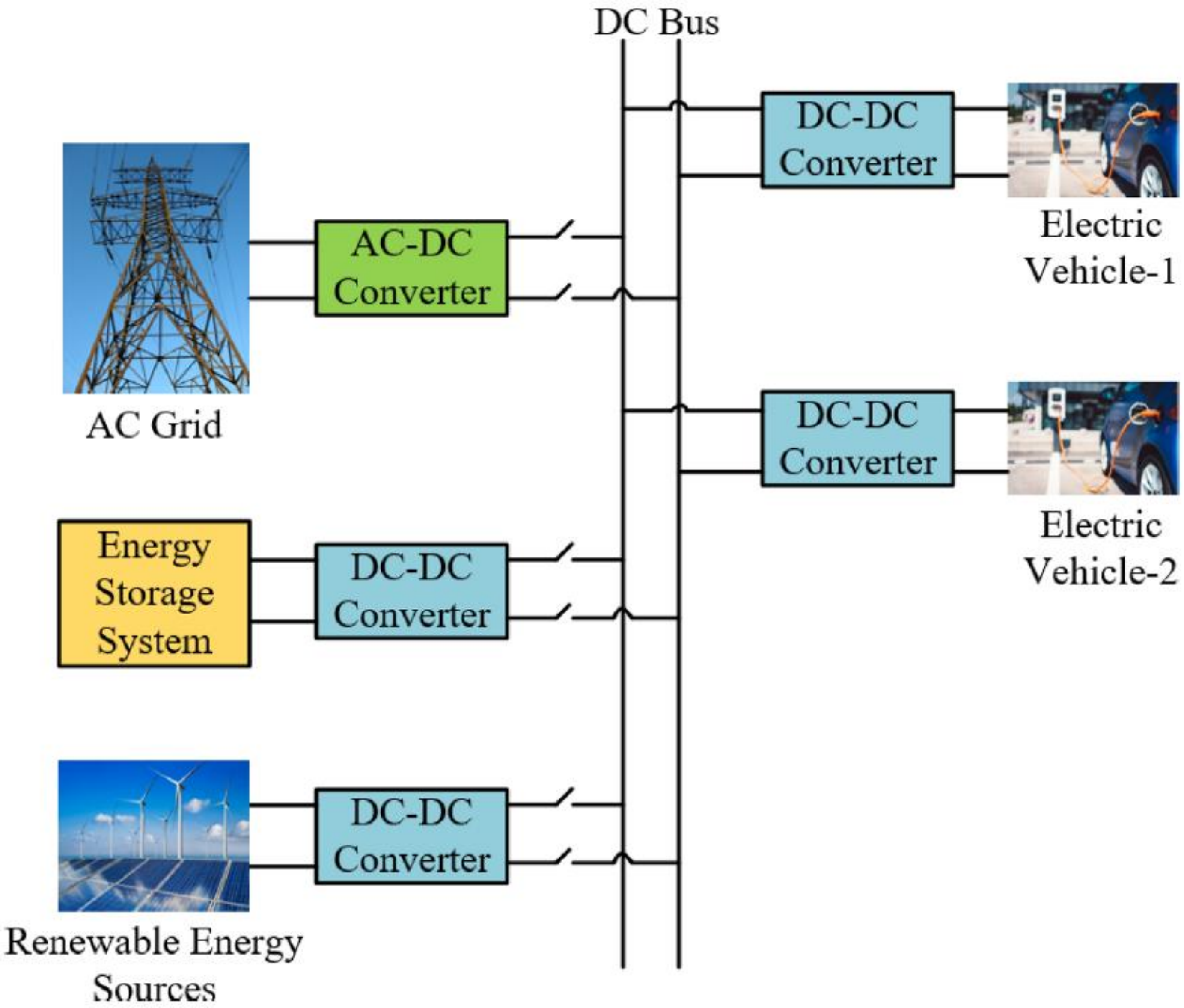


Fig. 1. Overview of charging infrastructure for electric vehicles (EVs).


AC charging
AC power is supplied by the charging station to the EVs on-board charger, which converts the power into DC power and charges the battery
AC
AC
AC
On-board charger
DC
BMS
Lithium battery
DC fast charging
AC power is converted to DC power in the charging station, which then supplies DC power directly to the EV battery.
AC
evesco
DC
DC
BMS
Lithium battery

Configuration of EV charging stations

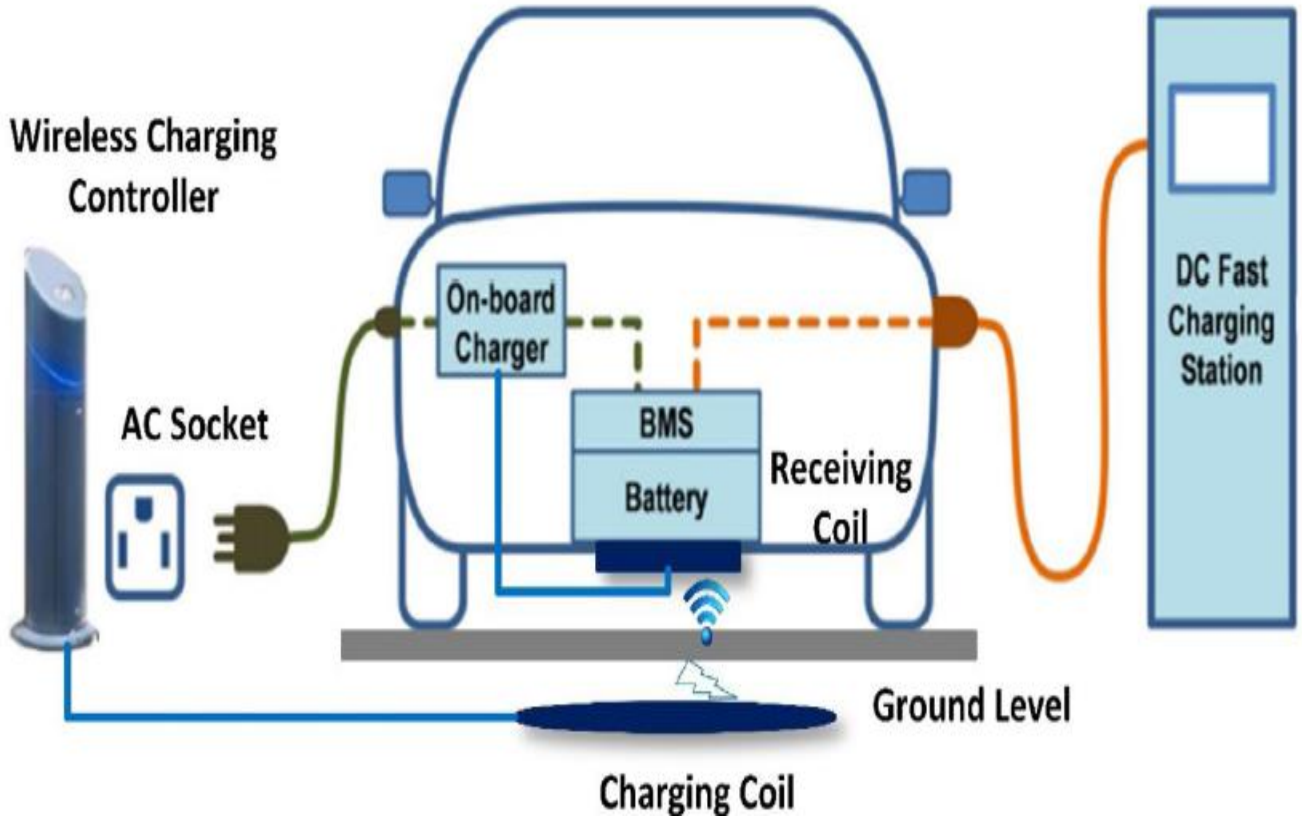
- Battery Swapping Technology
- Charging Station utilizing only grid power
- Charging Station utilizing grid power and Energy Storage System
- Charging station utilizing grid power and Renewable energy
- Charging Station utilizing grid power, Renewable energy and Energy Storage System
- Off-grid Charging Station



DC Bus
DC-DC Converter
Electric Vehicle-1
AC-DC Converter
AC Grid
DC-DC Converter
Electric Vehicle-2
Energy Storage System
DC-DC Converter
DC-DC Converter
Renewable Energy Sources

Inductive Charging

- Static
- Dynamic
- Transfer via magnetic coupling



Wireless Charging Controller
AC Socket
On-board Charger
BMS
Battery
Receiving Coil
DC Fast Charging Station
Ground Level
Charging Coil

Dynamic charging of Electric Vehicles

- Dynamic charging allows electric vehicles (EVs) to charge wirelessly while moving, eliminating the need for stops and extending range.
- This technology involves installing charging coils beneath roads that wirelessly transmit power to an EV's onboard receiver as it drives over them.
- Key benefits include reducing "range anxiety," extending operational range, and facilitating the use of smaller batteries.
- However, significant challenges include the high cost of infrastructure installation, particularly the need for extensive roadway coverage, and ensuring consistent and efficient power transfer.

How it works

- **Infrastructure:** Transmitting coils are embedded in the road surface.
- **Sensing:** IR sensors detect an approaching EV.
- **Activation:** Only the coils under the vehicle are energized by activating a relay, which transfers power wirelessly to the EV's receiver.
- **Power Transfer:** The system transfers power through the air gap to the vehicle's battery, which can be up to 91% efficient.

Key Benefits

- **Eliminates Range Anxiety:**
Drivers don't need to worry about running out of battery charge, as vehicles can continuously charge on the road.
- **Reduced Battery Size:**
With continuous charging, EVs can have smaller, lighter, and more efficient onboard batteries.
- **Increased Efficiency:**
Reduces downtime by eliminating the need to stop and charge.
- **Improved Grid Stability:**
Helps to distribute energy demand more evenly throughout the day, easing pressure on the power grid.

Drawbacks

•**High Infrastructure Cost:**
The primary hurdle is the high cost of installing charging coils across a large portion of highways and roads.
•**Energy Efficiency:**
Power transfer efficiency is affected by variations in vehicle speed, air gap distance, and alignment.
•**Scalability:**
Implementing a wide-scale dynamic charging infrastructure is a massive undertaking.

Impact of fast EV charging on the grid

- Voltage instability
- Harmonics
- Voltage Sag
- Power loss
- Overloading of transformer

Power Quality

- **Power quality refers to how well the electricity delivered to electrical equipment matches the desired characteristics. It is an essential aspect of electrical power distribution and consumption, and it encompasses a wide range of parameters that impact the performance, reliability, and safety of electrical equipment.**
- In today's digitally-driven world, power quality is more important than ever before. Most electrical and electronic equipment in industries, offices, and homes require high-quality power to function correctly. The efficiency and productivity of equipment depend heavily on power quality.
- Poor power quality leads to increased downtime, more fault conditions, and, in some cases, complete equipment failure. In addition, machines that rely on high-quality power run more efficiently, reduce energy waste, and decrease the risk of equipment damage, resulting in a significant reduction of operating costs.

Optimal Location of EVCSs

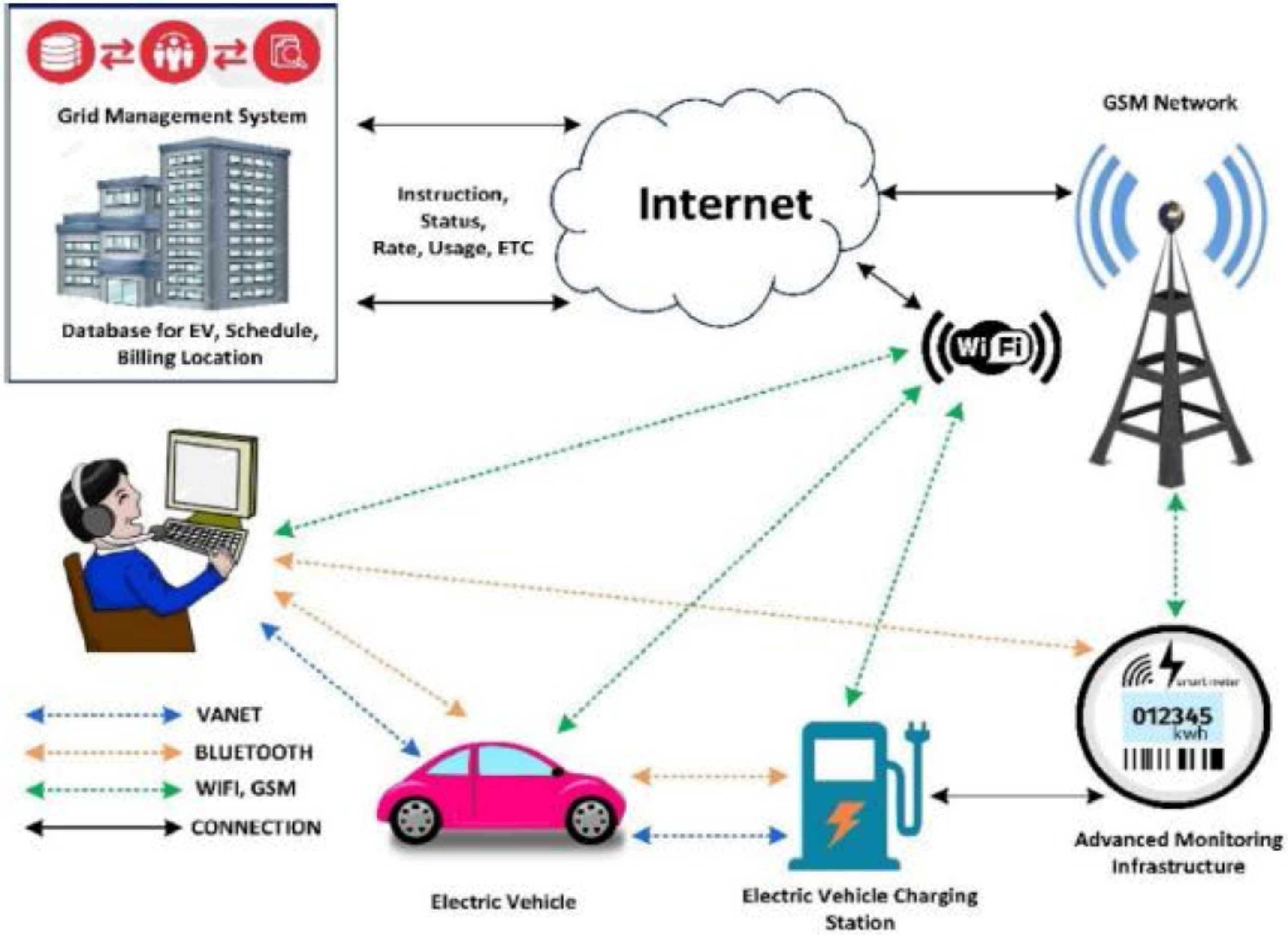
- Need to study -Transportation network and Electrical power distribution network together
- LMP-locational marginal price
- Multi-objective optimization

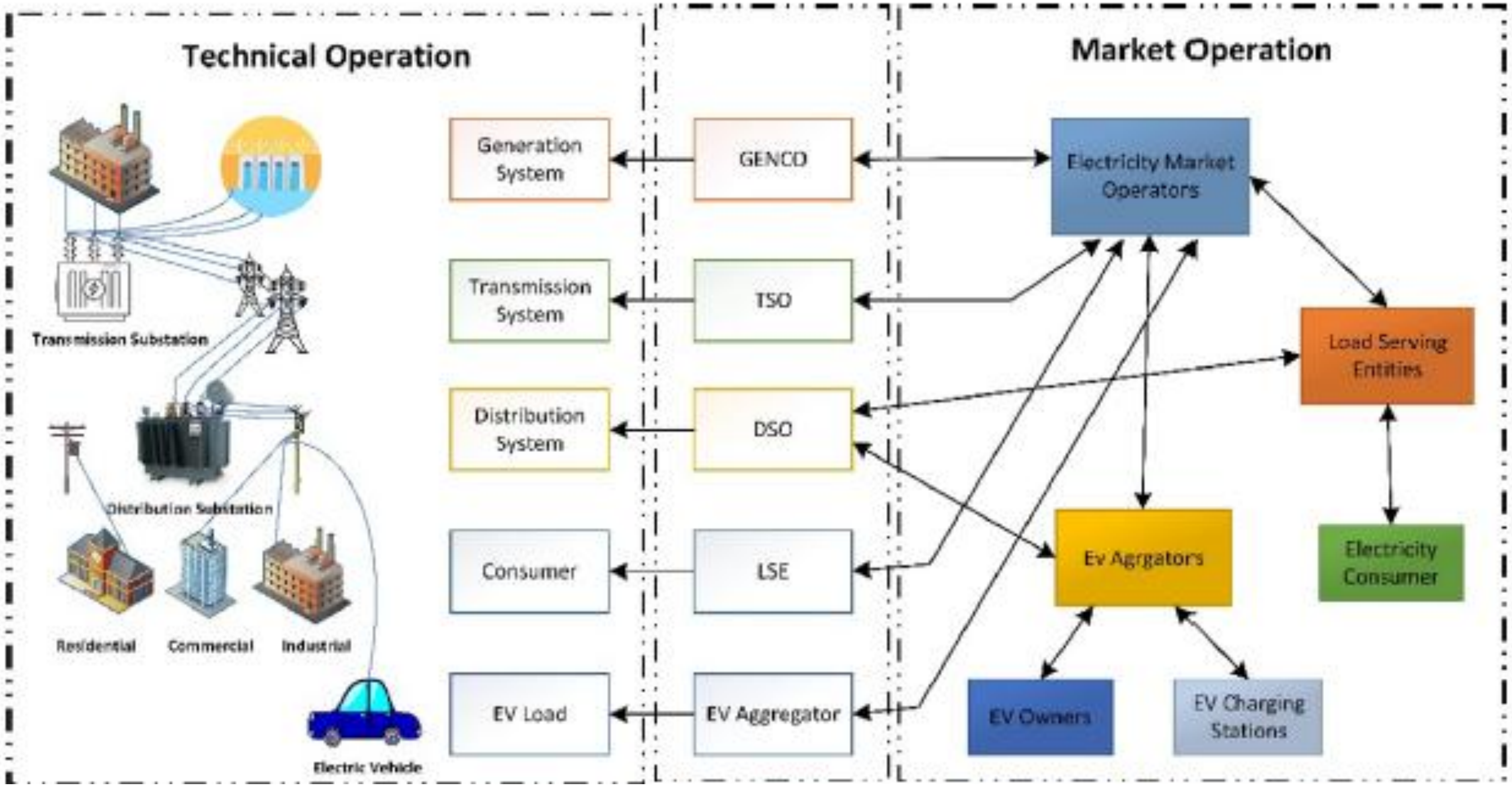
Power line Communication (PLC) for EV charging

- Power Line Communication (PLC) enables data transfer over existing power lines between an electric vehicle (EV) and a charging station, eliminating the need for separate communication wires.
- It facilitates essential communication for safe and efficient charging, including negotiating charging parameters, monitoring battery status, and supporting bidirectional charging and smart grid features.

EV aggregators

- Communicate with EVs and Grid for smart and effective charging
- Multiple EV aggregators can coordinate
- Hierarchical control


Grid Management System
Database for EV, Schedule, Billing Location
Instruction, Status, Rate, Usage, ETC
Internet
GSM Network
WiFi
012345
kwh
VANET
BLUETOOTH
WIFI, GSM
CONNECTION
Electric Vehicle
Electric Vehicle Charging Station
Advanced Monitoring Infrastructure


Technical Operation
Market Operation
Transmission Substation
Distribution Substation
Residential
Commercial
Industrial
Electric Vehicle
Generation System
Transmission System
Distribution System
Consumer
EV Load
GENCO
TSO
DSO
LSE
EV Aggregator
Electricity Market Operators
Load Serving Entities
Ev Agrgators
Electricity Consumer
EV Owners
EV Charging Stations

Reference

- TU Delft -   Electric Cars: Technology -DelftX eCARS2x
- An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends –Energy Reports