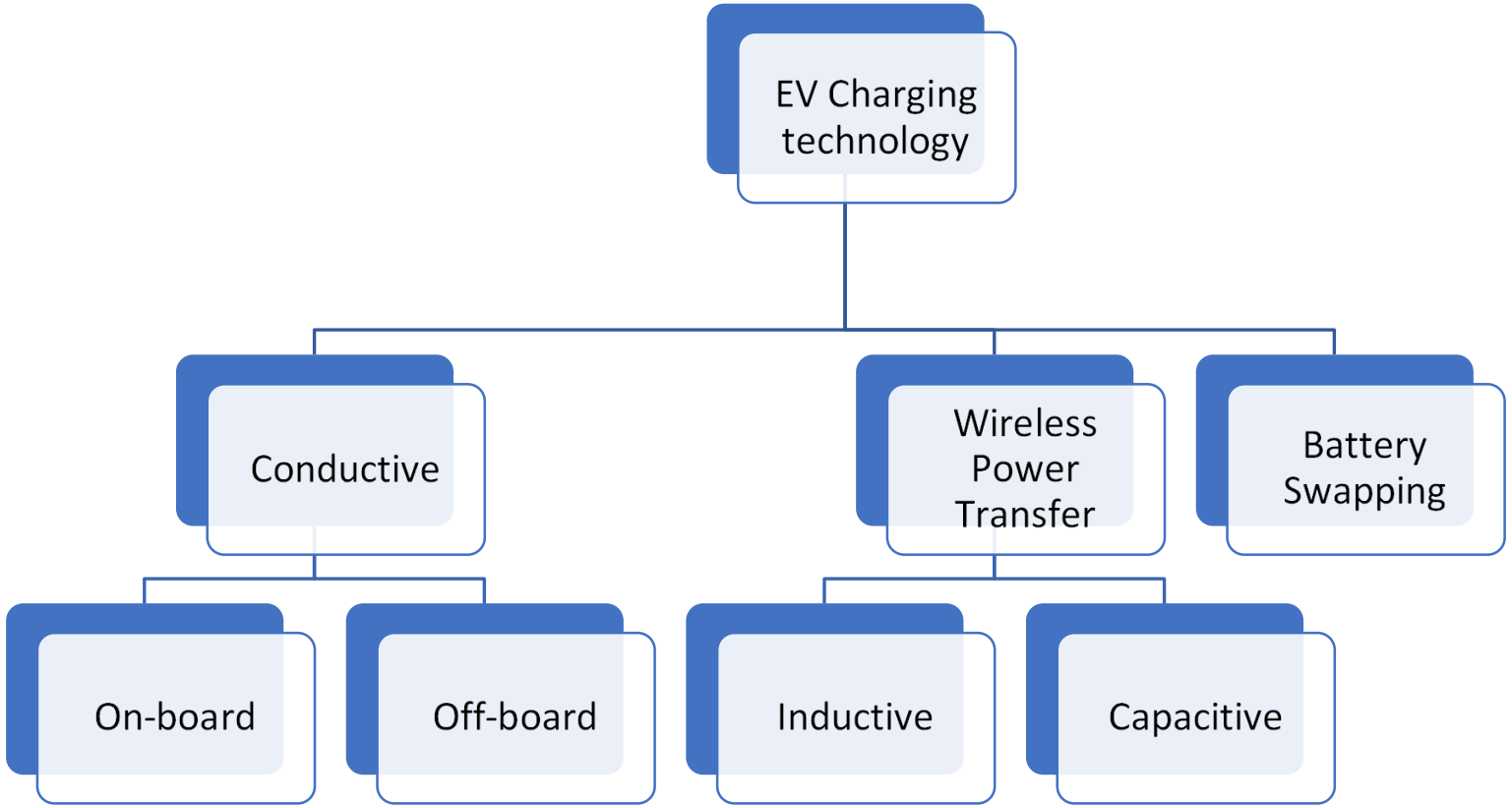
Charging Infrastructure, Kenyan Perspective and International Best Practices

Introduction

- Charging methods vary depending on the user requirement and location. The EVSE also vary depending on the country and the EV models in that specific region.
- Charging infrastructure networks ensure that the user needs are met. Thus, different types of infrastructure are available for different user needs.

1. Private Charging- This is “at home” charging that is not accessible to the general public the public.
2. Public charging- Charging available for the general public at designated public areas. May be public-public charging on the streets/highways, or public-private charging in private commercial areas accessible to the public such as shopping malls.
3. Long distance fast charging- This charging is based on fast charging needed during long distance travels along the highways.

Classification of Electric vehicle charging



Conductive Charging

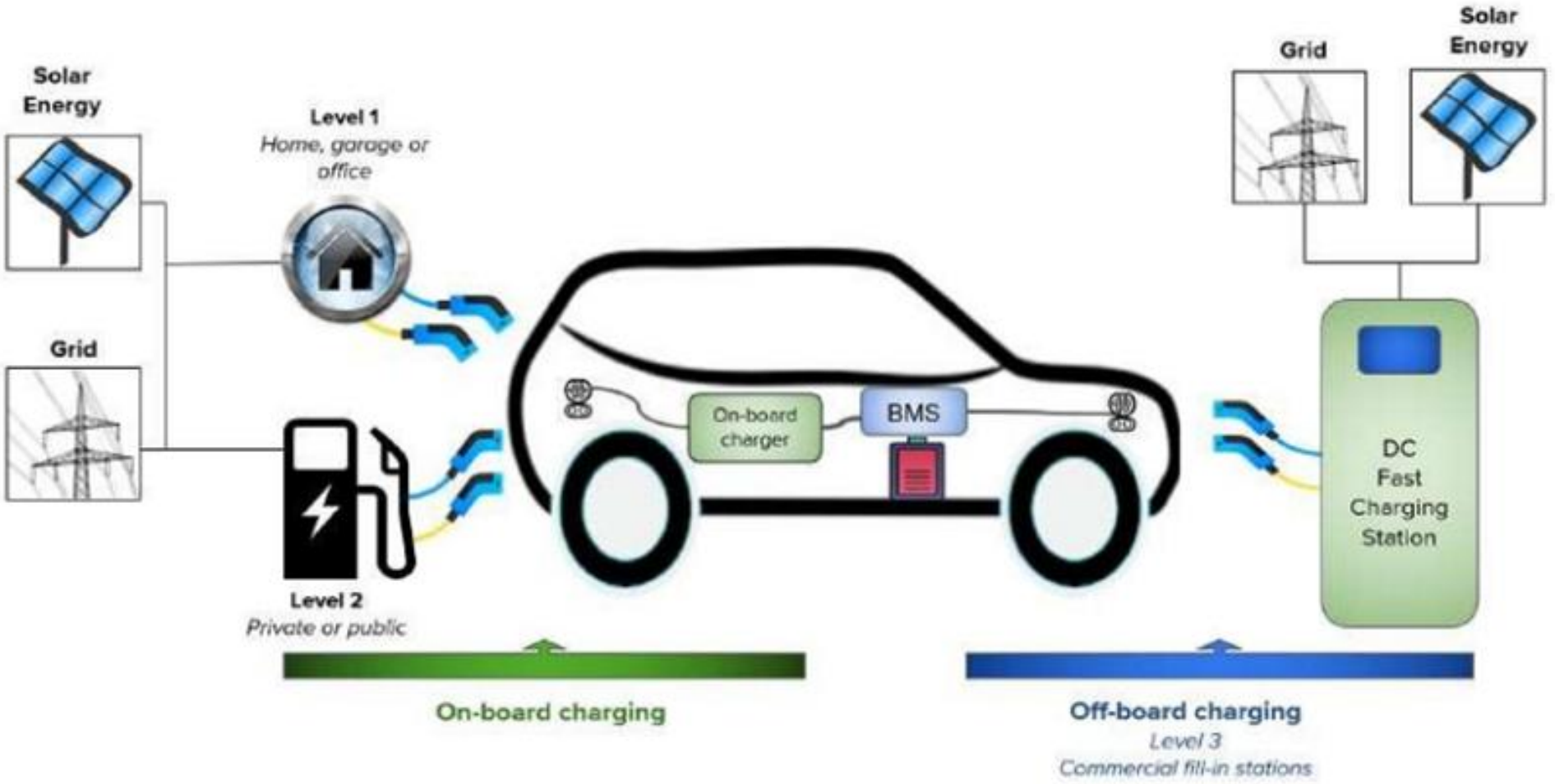
- Conductive charging can be further classified into:;

1. On board Charging

- This involves supply of AC power to an “on-board” converter which in turn converts to DC power for charging the battery. On-board charging charges the EV at moderate rates.

2. Off-board charging

- Involves directly supplying the DC power to the EV battery by by-passing the on board converter. The battery in this case is able to charge faster.

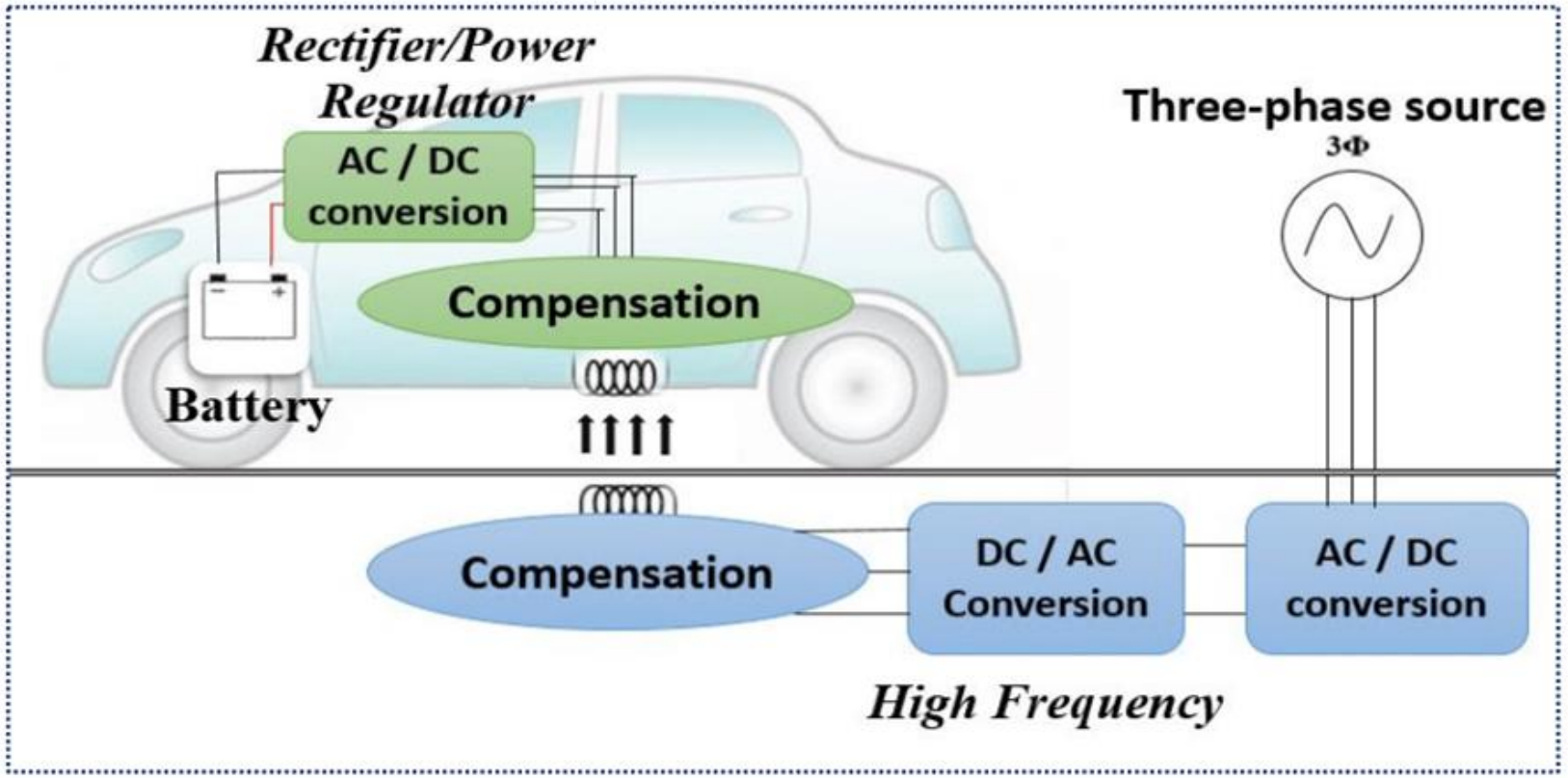

Solar Energy
Grid
Level 1
Home, garage or office
Level 2
Private or public
On-board charger
BMS
Grid
Solar Energy
DC Fast Charging Station
On-board charging
Off-board charging
Level 3
Commercial fill-in stations

Wireless Power Transfer (WPT)

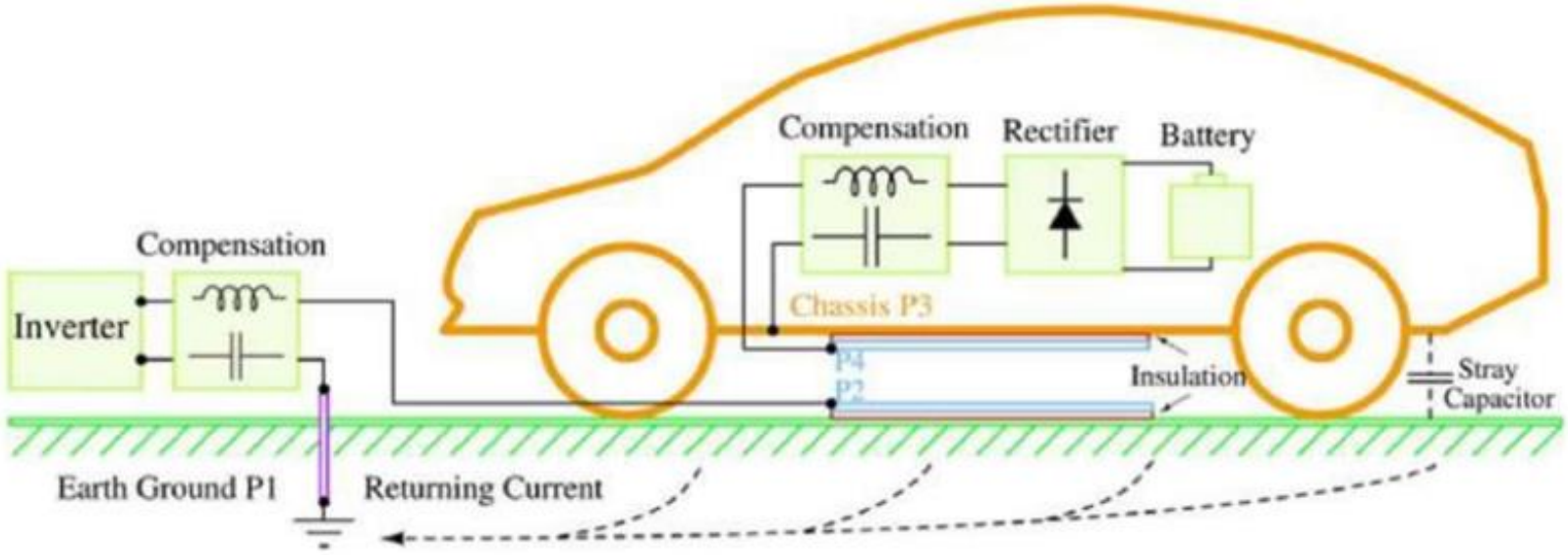
- This mode of EV charging does not include any physical connection between EV and EVSE. The following are two main types of WPT technologies.

1. Inductive WPT - The technology employs a transmitter and receiver side power electronic systems for power transfer. A high frequency inverter is contained in the transmitter side and is coupled to the receiver side by a magnetic coil.
2. Capacitive WPT - It eliminates the need for electromagnetic shielding. This is this advantageous over inductive WPT. It is less expensive due to the absence of ferrite, allowing use of high frequency resulting in smaller size of the charging system. However, this use of high frequency translates to design challenges. Electromagnetic safety also is an issue with capacitive WPT with high power transfer density at high efficiency

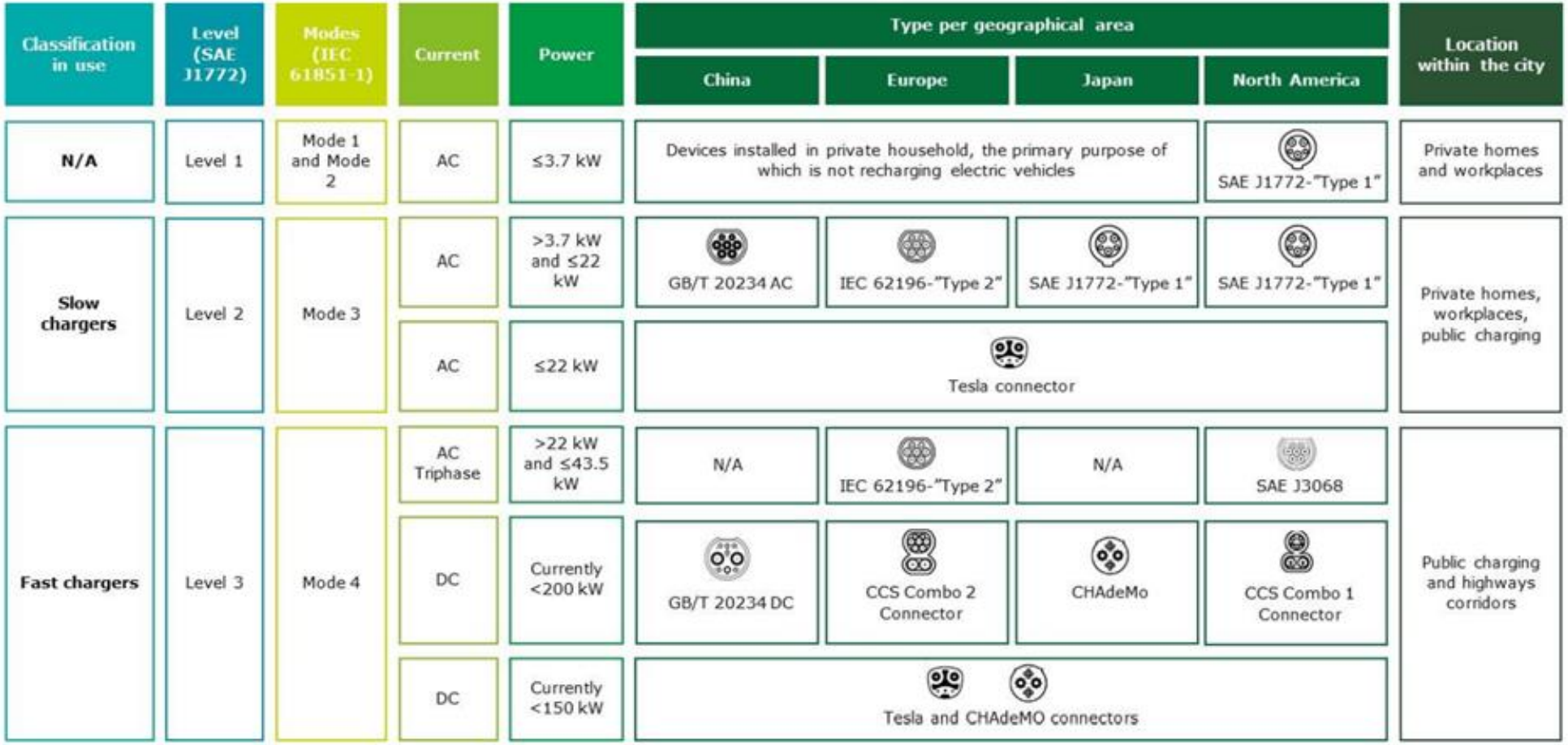
Inductive WPT



Capacitive WPT

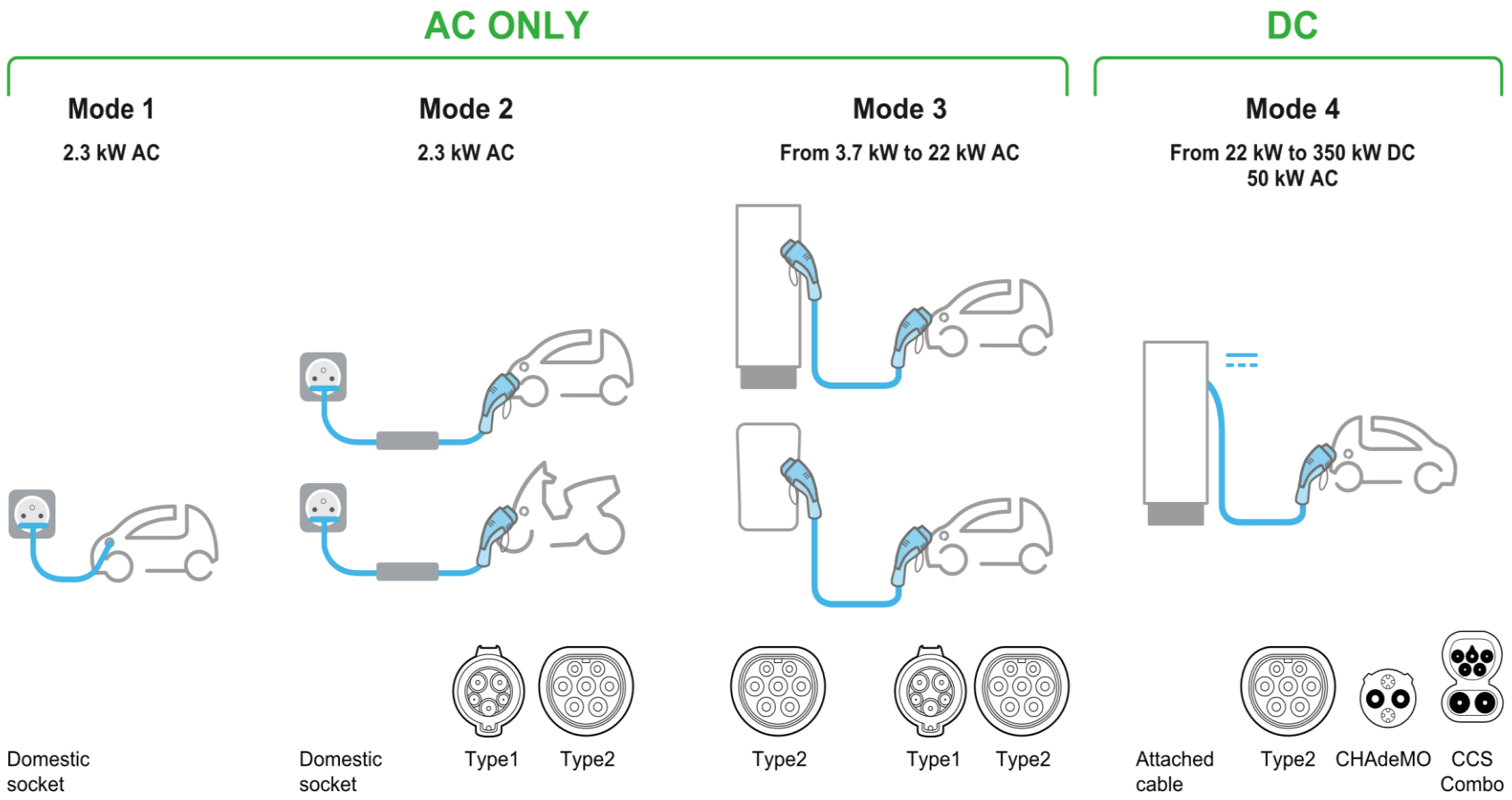


Descriptors of EVSE



Classification in use	Level (SAE J1772)	Modes (IEC 61851-1)	Current	Power	Type per geographical area				Location within the city
					China	Europe	Japan	North America	
N/A	Level 1	Mode 1 and Mode 2	AC	≤3.7 kW	Devices installed in private household, the primary purpose of which is not recharging electric vehicles			SAE J1772-"Type 1"	Private homes and workplaces
Slow chargers	Level 2	Mode 3	AC	>3.7 kW and ≤22 kW	GB/T 20234 AC	IEC 62196-"Type 2"	SAE J1772-"Type 1"	SAE J1772-"Type 1"	Private homes, workplaces, public charging
			AC	≤22 kW	Tesla connector				
Fast chargers	Level 3	Mode 4	AC Triphase	>22 kW and ≤43.5 kW	N/A	IEC 62196-"Type 2"	N/A	SAE J3068	Public charging and highways corridors
			DC	Currently <200 kW	GB/T 20234 DC	CCS Combo 2 Connector	CHAdeMo	CCS Combo 1 Connector	
			DC	Currently <150 kW	Tesla and CHAdeMO connectors				

Modes of EVCS



EVCS Levels

- Level 1 delivers basic charging which can be done from the standard AC supply socket. This level is limited to 120V and 1.8 kW.

- Level 2 delivers a maximum output of 19.2kW at a maximum current of 80A. The level is applicable to homes with three phase power of 11kW at 16A current, while single-phase power source needs to supply around 48A. The level has a voltage range of 208V to 240V.

- Level 3 provides up to 1000VDC with a power output of over 350kW. The level has a capability of reaching 500A in future. This level is applicable to TESLA supercharger for TESLA EVs.

EV Connectors

i. Type 1 connector (SAE J1772)

Type 1

This connector is used with AC charging stations and can deliver between 3 -7.4 kW for single phase at 32A maximum current. The connector has 3 large pins, for phase, neutral and ground with two smaller ones which act as communication points with the EV.

Countries Used: USA & Japan, but also EU accepted.

ii. Type 2 connector

Type 2

This connector is used with AC charging stations and can deliver between 3 -43 kW for single phase at 16A maximum current, and 63A for three phase. It is similar to type 1 with additional two more pins for 3-phase charging.

Countries Used: European countries

EV Connectors ctd

i. CHAdeMO (CHArge de Move)

This connector is used with DC charging stations and can deliver up-to 62.5 kW at 125A maximum current.

Countries Used: Japan, USA

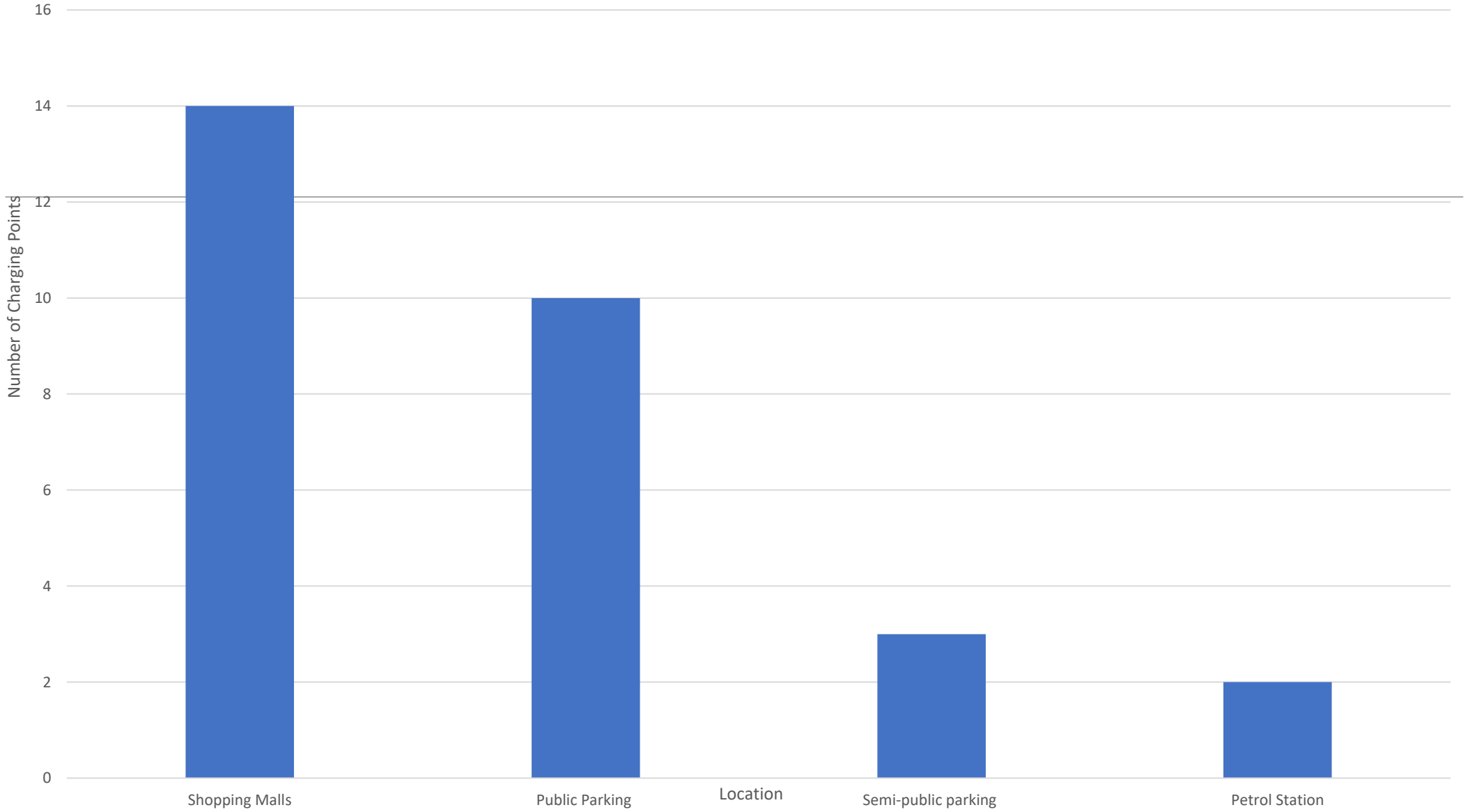
ii. Combined Charging system (CCS) Combo 2

This connector is designed for DC fast charging, with both AC and DC charging capability of up-to 350 kW.

Countries Used: European countries

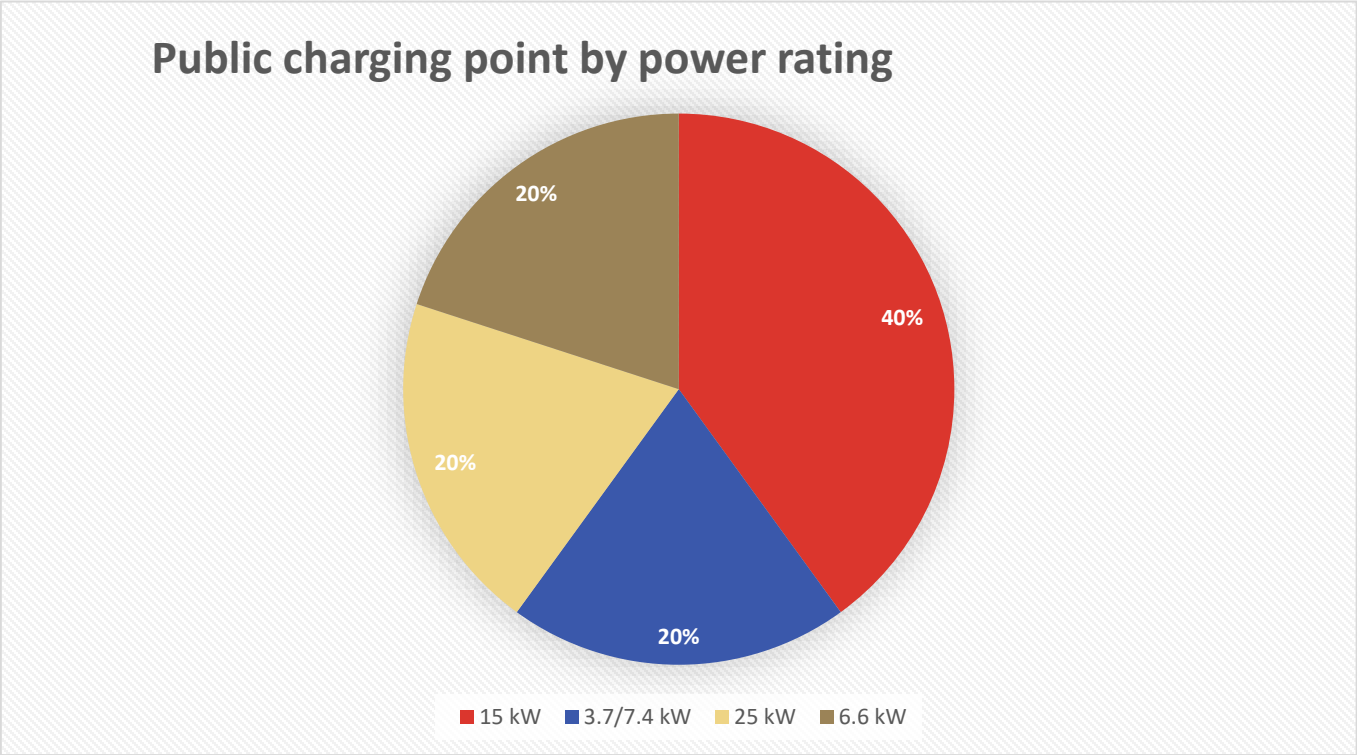
Status of charging infrastructure in Kenya

- In the bid to scale up adoption of e-mobility, some companies have set up charging infrastructure in Kenya.
- As at end of March 2022, there are about 29 public charging points in the country.
- All the charging stations are within Nairobi and are predominantly (more than 82%) are located in shopping malls and public parking spaces.
- The rest are located semi-public parking and petrol stations.
- Stakeholders such as Charge Net, Opibus and NaMaTa plan to introduce charging stations in fuel stations, public service vehicle terminals and on selected points along major highways respectively.


16
14
12
10
8
6
4
2
0
Number of Charging Points
Shopping Malls
Public Parking
Location
Semi-public parking
Petrol Station

All the charging points installed in the country are Level 2 (AC charging) though Opibus plans to install the first DC charger (Level 3) by end of 2022.

The Level 2 charging stations operate in mode 3. As shown in Figure 11, about 80% of the installed chargers are slow AC chargers (power rating less than 22 kW) while the remaining 20% are fast AC chargers (power rating greater than 22 kW).



- Charging cables for public use are provided at 66 % of the charging points whereas at the remaining 34% require users to have their own cables.
- Type 2 connector is the most prevalent connector used at Level 2 charging points whereas Opibus plans to use CCS 2 connector at its proposed Level 3 charging points.
- Type 1 to Type 2 adaptors are provided at some charging stations to accommodate EVs with Type 1 inlets.
- As at end of March 2022, there were no charging stations with CHAdeMO connectors in the country even though the Nissan Leaf brand of car is the most common EV car in Kenya.
- The Nissan Leaf uses two charging standards for its inlets – Type 2 and CHAdeMO.
- The Type 2 inlet is used when charging from AC electricity supply points whereas the CHAdeMO inlet is used to carry high power during rapid DC charging from a CHAdeMO connector.

- CCS 2 connector has a number of advantages including the following:

1. It combines both AC and DC charging capability in a single connector.
2. It has a higher power rating meaning it can charge the EV at a faster rate and;
3. It is promoted by a large number of manufacturers across the globe.

- There are no mandated standards for EV charging connectors in Kenya.
- There is a possibility that every company will promote its own charger, resulting in proliferation of different chargers that might be incompatible.
- This will result in reduced accessibility of charging infrastructure, ultimately turning off people from adopting EVs.

- The most common mode of payment at the charge points is the use of Radio Frequency Identification (RFID) cards.
- RFID cards are used at charging points owned by NopeaRide.
- At ChargeNet charging points, one can use mobile money (M-Pesa) payment option.
- The main challenge with the use of the cards is the lack in interoperability of the cards at stations operated by different charging point operators.
- With no standardized payment method, new entrants into the EV charging market will implement their own RFID cards - Users of charge stations will be required to have a different card for each different charging point operator in the market.

Currently, there is no special electricity tariff for EVs, and charge point operators are billed using the standard rates depending on the electricity tariff they are contracted to.

There is no guidance on charging fees that charging point operators should impose on their customers.

Different billing criterion is used at the charging stations as detailed below:

1. Variable/consumption-based billing where the EV users are billed per kWh consumed. This billing method is used at all the NopeaRide charging points.
2. Time based billing where the EV users are billed at cost per minute charge. This billing method is used at ChargeNet charging points.

- The permitting and licensing process for setting up an EV charging station is long and arduous making it difficult to set up public charging infrastructure.

1. The first hurdle is acquiring (by lease agreement or buying it outright) the parcel of land where the charging station will be developed.
2. The CPO then assesses the space and the power requirements and thereafter coordinates and seeks approvals from the following entities: Ministry of Planning, NCA, County government (business permits), NEMA, EPRA, KPLC and KRA.
3. Once all the approvals have been granted, the CPO procures and installs the EVSE.
4. Finally, the CPO manages and operates the charging stations.

- There is no guidance is available on the documentation (including exemptions) required by each entity - Unnecessary back and forth between the developer and the agencies.
- This results in delays and costs that could have been avoided.

Charging Station	Location	Description of charging station
Holy Family Basilica basement	Central Business District, Nairobi	• The points are to be used primarily used for public charging. There is a provision for an additional charger per floor. • Total Number of Charge Point: 8 • Level of Charging: Level 2
Nopea Charging stations	Sarit Centre, Thika Road Mall & The Hub mall, Two rivers mall	• The points are primarily used for private charging. • Billing: billed per kWh • Payment method: Radio Frequency Identification (RFID) cards
Charge Net charging station (Mayleen Corporation)	ABC Mall Westlands, Be Energy Racecourse, Hass Petrol Station Kasarani, The Arch Place Nyangumi Rd.	• The points are primarily used for public charging. • Billing: users are billed per minute. KES 4 per minute for type 1 charger and KES 7 per minute for type 2 charger. • Payment: through mobile money (M-Pesa) • Total Number of Charge Point: 4 • Level of Charging: Level 2.
Lites Infrastructure Company	Charging station in CBD (Haile Selassie Avenue)	• The point is primarily used for public charging. • Total Number of Charge Point: 2 • Level of Charging: Level 2.
Opibus	Charger locations: Thika Bus Station (Kiambu county), at Green Park Terminus, Marble Arch both in Nairobi Central Business District for buses	• The points will be primarily used for public charging. • Total Number of Charge Point: 6 • Level of Charging: Level 4
Knights and Apps (Drive Electric)	Great Jubilee Center, Karen	• The points are primarily used for private charging. • Total Number of Charge Point: 3 • Level of Charging: Level 2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International Standards – IEC Standards

- The IEC standards for EV conductive charging systems cover the following aspects:

1. System (IEC 61851-1, 23)
2. Plugs/connectors (IEC 62196- 1,2,3 & IEC 60309 -1)
3. Communication protocols (IEC 61851 - 24)
4. Electromagnetic compatibility (IEC 61851 – 21 – 1, 21 -2)
5. Supply Equipment Protection (IEC 61851 – 25, IEC 62955, IEC 62752)
6. EV Charging Cables (IEC 62893)
7. Switchgear and Control Gear Assemblies (IEC 61439-7)
8. EV Installation Requirements (IEC 60364 – 7 -722)

ISO EV Charging Standards

- At ISO, standards covering safety specifications, test procedures and electrical specifications have been developed for both light duty vehicles and 2 & 3 wheelers.
- These standards have been developed by ISO/TC 22/SC 37 Electrically propelled vehicles.
- ISO standards for EV charging systems cover the following aspects:

1. Communication protocols (ISO 15118)
2. Electromagnetic compatibility (ISO 11451 -2, ISO 11452 -2 & 4)
3. Safety and Interoperability Requirements (ISO 17409, ISO 19363, ISO 18246)

IEEE Standards

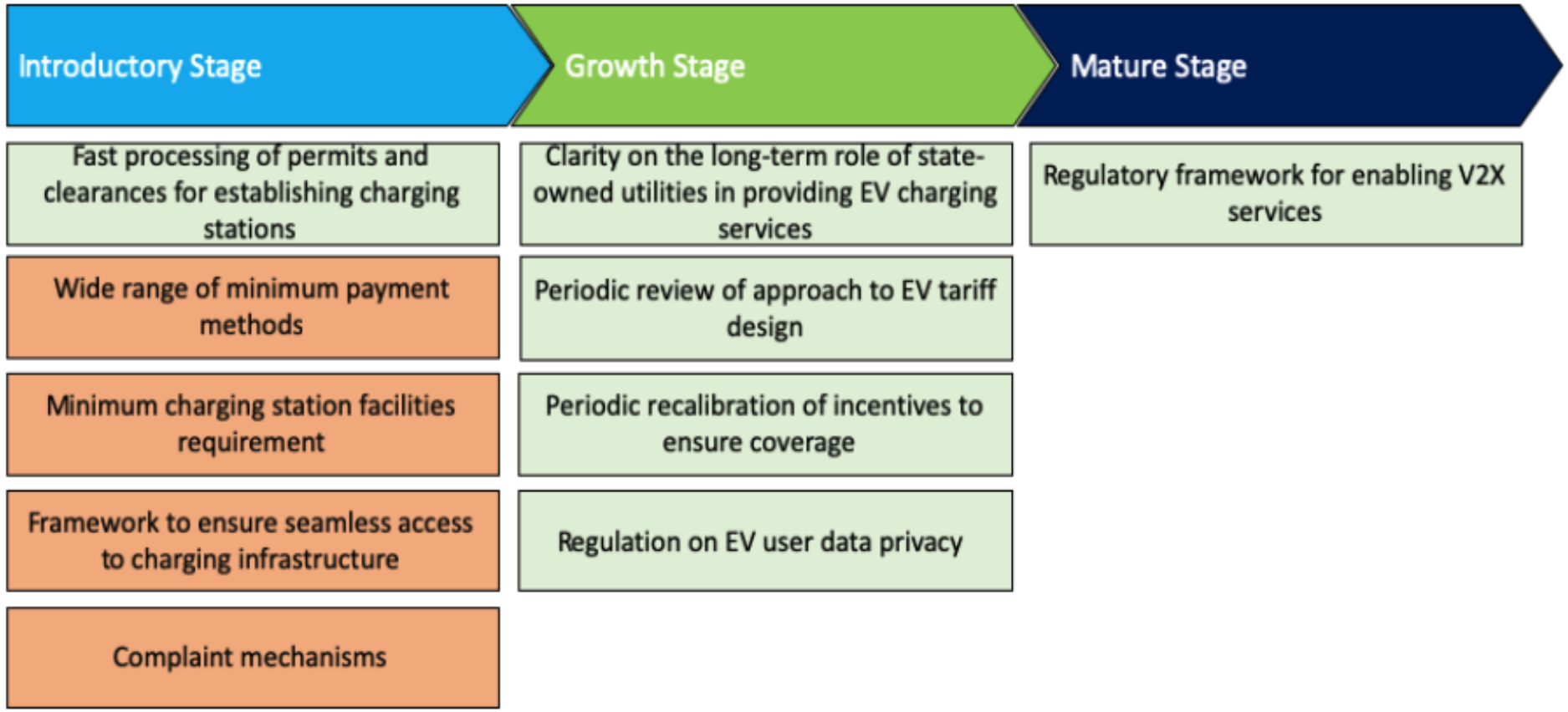
- Other international standardizations such as the Institute of Electrical and Electronics Engineers (IEEE) has developed the following standard on electric vehicle charging.

Standard	Title	Summary and Scope
IEEE 2030.1.1-2021	IEEE Approved Draft Standard Technical Specifications of a DC Quick and Bi-directional Charger for Use with Electric Vehicles	The standard covers conductive direct current charging for rapid charging of EVs from power source.

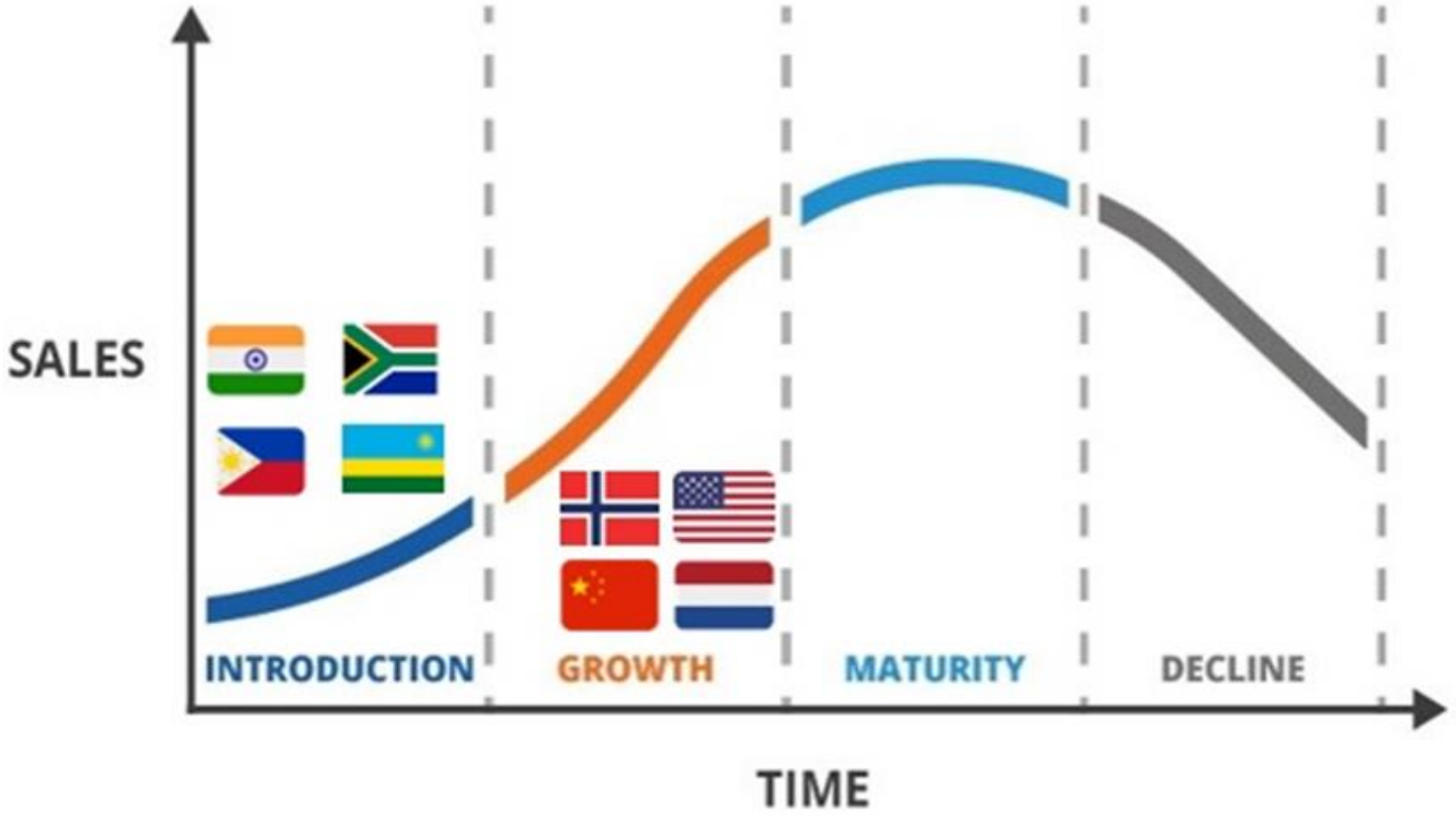
Kenyan EV Standards

STANDARD	Title
KS ISO 6469-1:2019	Electrically propelled road vehicles — Safety specifications — Part 1: Rechargeable energy storage system (RESS)
KS ISO 6469-2:2018	Electrically propelled road vehicles — Safety specifications — Part 2: Vehicle operational safety
KS ISO 6469-3:2020	Electrically propelled road vehicles — Safety specifications — Part 3: Electrical safety — Amendment 1: Withstand voltage test for electric power sources
KS ISO 6469-3:2021	Electrically propelled road vehicles — Safety specifications — Part 3: Electrical safety
KS ISO 6469-4:2015	Electrically propelled road vehicles — Safety specifications — Part 4: Post crash electrical safety
KS ISO/TR 8713:2019	Electrically propelled road vehicles — Vocabulary
KS ISO 8714:2002	Electric road vehicles — Reference energy consumption and range — Test procedures for passenger cars and light commercial vehicles
KS ISO 8715:2001	Electric road vehicles — Road operating characteristics
KS ISO 12405-4:2018	Electrically propelled road vehicles —Test specification for lithium-ion traction battery packs and systems — Part 4: Performance testing
KS ISO 18300:2016	Electrically propelled vehicles — Test specifications for lithium-ion battery systems combined with lead acid battery or capacitor
KS ISO 23274-1:2019	Hybrid-electric Road vehicles — Exhaust emissions and fuel consumption measurements — Part 1: Non-externally chargeable vehicles
KS ISO 23274-2:2021	Hybrid-electric Road vehicles — Exhaust emissions and fuel consumption measurements — Part 2: Externally chargeable vehicles

EV Market Development Stages



International best practices for charging infrastructure



India – Policy and Regulations

Policy Instrument	Measures
Ministry of Power (MOP) Charging Infrastructure Guidelines and Standards.	● De-licensed setting up of Public Charging Stations (PCS). Any entity can set up PCS provided the station meets the technical and performance standards prescribed by MOP. ● Details the minimum requirements for public charging infrastructure. These include the minimum number of charger connectors: CHadeMo, CCS, Type 2 AC, Bharat AC-001 and Bharat DC-001 ● Guidance on location of PCS i.e., the density and distance between two PCS. At least one PCS to be available in a 3km x 3 km grid. One PCS every 25 km on both sides of a highway. At least one fast charging station every 100 km on both sides of the highway. ● Tariff for supply of electricity for PCS. Separate metering for PCS. MOP mandated the state electricity regulatory commission to fix EV tariff that is not more than the average cost of supply plus 15%. ● All stations are required to have an exclusive transformer together with associated substation equipment.

Capital subsidies on EVSE	● Offered at state levels - Andhra Pradesh, Maharashtra, Bihar, Punjab and Madhya Pradesh provide 25% capital subsidies for a fixed number of PCS. The maximum amount is capped at different levels in different states. ● Delhi offers an unspecified capital subsidy for installing PCS. It also offers 100% grant up to It is the only state to offer financial incentives for private charging equipment, with a 100% grant up to USD 80 per charging point for the first 30,000 private charging points.

Concessional land provision	● Delhi, Uttar Pradesh and Punjab will provide land to charging service operators (CSOs) at concessional rental rates, while Madhya Pradesh offers a “rental holiday” for three years to CSOs selected to operate EV charging in a public-private.
Concessional tariffs for EV charging	● Concessional EV tariffs are meant to reduce the cost of electricity procurement for EV charging, resulting in lower charging costs for consumers. ● The EV tariffs in different states range between 5-11 US cents/kWh.

India - Standards

SL No.	Standard	Aspects covered and status
1	IS 17017-Part 1:2018 and Bharat Charger AC -001	Give general requirements for Electric Vehicle Conductive Charging System.
2	IS 17017: Part 21: Sec 1:2019 and AIS 138 (Part 1)	Defines electromagnetic compatibility (EMC) requirements for on-board charger or AC EVCS.
3	IS 17017: Part 21: Sec 2:2019 and AIS 138 (Part 2)	Defines electromagnetic compatibility (EMC) requirements for off- board charger or DC EVCS
4	IS 17017-Part 23* and Bharat Charger DC-001	IS 17017-Part 23 will be adapted from IEC 61851-23 and will give requirements for DC EVSE.
5	IS 17017-Part 24*	Defines requirements for control communication between DC EVSE and EV
6	IS 17017-Part 2: Sec 1*	Specifies general requirements for plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies as described in IEC 61851-1. The standard will be adapted from IEC 62196-1.
7	IS 17017-Part 2: Sec 2:2020	Specifies dimensional compatibility and interchangeability requirements for a.c. plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies as described in IEC 61851-1. The standard has been adapted from IEC 62196-2.
8	IS 17017-Part 2: Sec 3	Specifies dimensional compatibility and interchangeability requirements for d.c. plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies as described in IEC 61851-1. The standard has been adapted from IEC 62196-3.
9	IS/ISO 15118 series	Gives requirements for digital communication between the EV, EVCS and the utility grid. A total of 8 standards under this series have been directly adopted from the ISO 15118 series.
10	CEA Regulations, 2019 (Measures relating to Safety and Electric Supply) and (Technical Standards for Connectivity to the Grid)	Voltage change, frequency variations, power factor, harmonics measurements, flicker, DC injection, V2G process, the safety of EVCS. IS 17017 (Part 5) will be prepared by BIS in near future regarding grid connectivity and EVCS networks. Power quality standard requirements as per IEEE 519-2014.
11	IS 14700-6-2, IS 14700–6-3, and IS 14700-3-12	EMC testing for emission, immunity, and harmonic measurements

* Not published yet

South Africa – Policies and Regulations

- Long-term vision for the transport sector in South Africa is guided by the Green Transport Strategy for South Africa: 2018-2050.
- It calls for the replacement of fossil fuels by vehicle technologies with low or zero tailpipe emissions, such as electric and fuel cell vehicles.
- It gives provisions for;

1. Incentives (tax rebates, subsidies and non-financial incentives) for the EV sector.
2. Subsidies for both EV manufacturers and buyers. L
3. Lower- or zero-rated duty for identified unique EV components including EVSEs.
4. A commitment to expand the EV charging infrastructure to incentivize customers to switch to EVs. Charging network roll out will follow common standards stipulated by South Africa Bureau of Standards.
5. 2nd life of EV batteries – repurpose them to supply homes with electricity to mitigate against power outages and a better balance of energy demand and supply-cycles.

South Africa - Standards

SL No.	Standard	Aspects covered and status
1	SANS 61851-1:2018	Give general requirements for Electric Vehicle Conductive Charging System.
2	SANS 61851-22:2014	Gives requirements for AC electric vehicle charging stations
3	SANS 61851-21-2:2020	Defines electromagnetic compatibility (EMC) requirements for off- board charging system or DC EVCS
4	SANS 61851-21-1:2020	Defines electromagnetic compatibility (EMC) requirements for on- board charging system or AC EVCS
5	SANS 61851-23:2015	Gives requirements for DC charging station.
6	SANS 61851-24:2015	Defines requirements for control communication between DC charging station and EV
7	SANS 62196-1:2015	Specifies general requirements for plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies.
8	SATS 62196-3-1:2020	Specifies requirements for vehicle connectors, vehicle inlets and cable assemblies for DC charging intended to be used with a thermal management system.
9	SANS 62196-2:2018	Specifies dimensional compatibility and interchangeability requirements for a.c. plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies
10	SANS 62196-3:2015	Specifies dimensional compatibility and interchangeability requirements for d.c. plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies.

Philipines – Policies and Regulations

The Department of Energy (DOE) issued EVCS policy guidelines in July 2021 (Republic of Philippines, 2021). The EVCS policy guidelines address the following issues:

1. Set installation standards and permitting protocols for EVCS.
2. Set safety requirements for EVCS. EVCS are required to comply with the Building Code of the Philippines and the Philippine Electrical Code.
3. Classification of EVCS. Five categories are given – Mode 1, 2, 3 & 4; Battery Swapping Stations. Though no requirements are given for the type of connector to be used for each mode.
4. EVCS Energy Label and Marking Requirements
5. Endorsement to the Board of Investments (Under the Department of Trade and Industry) to be provided of fiscal incentives under the Omnibus Investment Code. Under this code EVCS businesses can receive an income tax holiday of between 3-6 years and capital equipment costs of up to USD 10,000.

Philipines - Standards

SL No.	Standard	Aspects covered and status
1	PNS IEC 61851-1:2019	Give general requirements for Electric Vehicle Conductive Charging System.
2	PNS IEC 61851-22:2012	Gives requirements for AC electric vehicle charging stations
3	PNS 61851-21-2:2018	Defines electromagnetic compatibility (EMC) requirements for off- board charging system or DC EVCS
4	PNS IEC 61851-21-1:2018	Defines electromagnetic compatibility (EMC) requirements for on- board charging system or AC EVCS
5	PNS IEC 61851-23:2018	Gives requirements for DC charging station.
6	PNS IEC 61851-24:2018	Defines requirements for control communication between DC charging station and EV
7	PNS IEC 62196-1:2019	Specifies general requirements for plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies.
8	PNS IEC 62196-3:2019	Specifies dimensional compatibility and interchangeability requirements for d.c. plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies
9	PNS IEC 62196-2:2018	Specifies dimensional compatibility and interchangeability requirements for a.c. plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies
10	PNS ISO 17409:2018	Specifies electric safety requirements for conductive connection of electrically propelled road vehicles to external electric circuits.
11	PNS ISO 11898-1:2019	Specifies the characteristics of setting up an interchange of digital information between modules implementing the controller area network (CAN) data link layer. Controller area network is a serial communication protocol, which supports distributed real-time control and multiplexing for use within road vehicles and other control applications.
12	PNS ISO 15118 series	Gives requirements for digital communication between the EV, EVCS and the utility grid. Parts 1,2, 3, 4, 5 & 8 have been adopted.
13	PNS IEC 62752:2016	Defines requirements for in -cable control and protection device to be used for mode -2 charging.

USA – Policies and Regulations

Policy Instrument	Measures
Tax credits to owners of EVCS (US DOE, 2019)	● 30% tax credit of the of the cost of purchasing and installing an EVCS (up to a maximum of USD 1000)
Federal loan guarantees	● up to USD 4.5 billion has been set aside for the development of EV charging infrastructure along identified EV corridors.
Designated EV corridors	● Federal Highway Administration (FHWA) has designated EV corridors approximately 95000 km of national highways in 48 states plus DC. ● Plan to install EVCS every 80 km on these EV corridors. Signage to help EV owners to easily identify the EVCS.
Charging space allocation	● Required charging space in new parking lots
California Calgreen Code	● Specifies minimum facilities to be provided at an EVCS. ● The Code specifies wiring practices, labelling, EV charging, space dimensions, and markings and accessibility.

USA - Standards

SL No.	Standard	Aspects covered and status
1	ANSI/UL 2594	Specifies safety requirements for on-board EV supply equipment or AC EVCS.
2	ANSI/UL 2202	Specifies safety requirements for off-board EV supply equipment or DC EVCS
3	ANSI/UL 62	Specifies safety requirements for EV cables.
4	ANSI/UL 2251	Defines safety requirements for EV connectors.
5	ANSI/UL 2231-1	Defines general requirements for personnel protection systems in EV supply equipment.
6	ANSI/UL 2231-2	Specifies particular requirements for protection devices for use in charging systems.
7	UL 2750	Specifies safety requirements for wireless power transfer equipment for EVs.
8	SAE J2954	Specifies requirements for the design of the wireless power transfer system for EVs. It covers interoperability and efficiency issues.

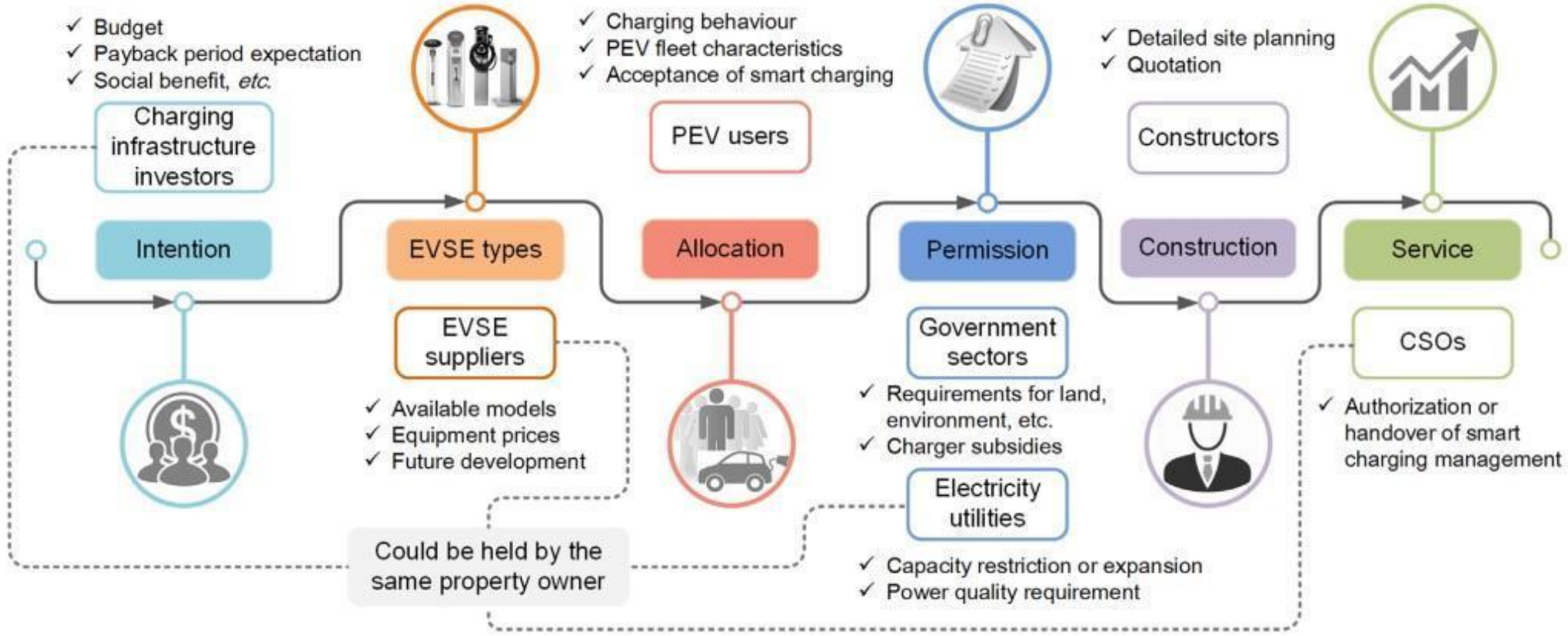
China – Policies and Regulations

Policy Instrument	Measures
Guidance on Accelerating the Construction of Electric Vehicle Charging Infrastructure	● Sets target to provide for charging infrastructure sufficient for 5 million EVs by 2020. ● All new residential buildings post-2015 are required to be EVSE equipped. ● 10% of parking spaces in large public buildings to be available for EV charging. ● at least one public charging station for every 2,000 EVs. ● The guidance also calls for public-private partnerships to develop charging infrastructure at shopping malls and major parking facilities.

Guidelines for Developing Electric Vehicle Charging Infrastructure (2015–2020)	● The guidelines call for at least 120,000 EV charging stations and 4.8 million EV charging posts by 2020. ● Divide China into three regions with varying degrees of EV infrastructure promotion and call for establishing a grid of EV-charging-enabled highways covering the most populous coastal provinces of East China. (See figure 21)
National standards for EV charging interfaces and communications protocols.	● In January 2016 the National Energy Administration released a notice summarizing five revised national standards for electric vehicle charging interfaces and communications protocols. ● The standards were issued in late 2015 by the National Standards Committee, the Ministry of Industry and Information Technology and others.

Five-Year Plan for New EV Infrastructure Incentive Policies	All provinces mandated to increase support for charging infrastructure development and to establish a reporting system for EV charging infrastructure construction with monthly reports on the number of charging facilities.
Notice on Accelerating Residential EV Charging Infrastructure Construction	Setting out standards and procedures for residential charging as well as designating the Jing-Jin-Ji, Yangtze River Delta and Pearl River Delta regions as demonstration zones for residential charging infrastructure development.

Notice on EV Charging Policy	• clarifies EV charging rates for three classes of customers. • residential customers pay the residential rate. • dedicated central EV charging and battery swap stations pay the large industrial customer rate, except they are exempt from the basic charge (demand charge). • government offices, public parking lots and other businesses pay the commercial and small/medium industrial (C&I) rate.
Regional policies	• The city of Shenzhen offers purchasers of EVs subsidies of up to RMB 20,000 for vehicle insurance and installation of charging equipment. • Over 30 other cities offer some form of subsidy for home or public EV charging. • Guangzhou has adopted a requirement that new buildings must have 18% of parking spots either equipped with EV charging or enabled for future installation. • In 2017 the Beijing municipal government began mandating that all parking spots in new residential developments set aside space for EV chargers, with new government or state-owned enterprise buildings required to install chargers at 25% of parking spots.


✓ Budget
✓ Payback period expectation
✓ Social benefit, *etc.*
Charging infrastructure investors
Intention
EVSE types
EVSE suppliers
✓ Available models
✓ Equipment prices
✓ Future development
✓ Charging behaviour
✓ PEV fleet characteristics
✓ Acceptance of smart charging
PEV users
Allocation
Permission
Government sectors
✓ Requirements for land, environment, etc.
✓ Charger subsidies
Electricity utilities
✓ Capacity restriction or expansion
✓ Power quality requirement
✓ Detailed site planning
✓ Quotation
Constructors
Construction
Service
CSOs
✓ Authorization or handover of smart charging management
Could be held by the same property owner

China - Standards

SL No.	Standard	Aspects covered and status
1	GB/T 18487-1-2015	Specifies general requirements for EV conductive charging system.
2	GB/T 18487-2-2017	Specifies requirements EMC requirements for off-board EV supply equipment.
3	GB/T 18487-3-2001	Specifies requirements (safety and performance) for AC/DC charging stations.
4	GB/T 27930-2015	Defines communication protocols between off-board conductive charger and battery management system of an EV.
5	GB/T 20234.1-2015	Specifies general requirements for connection set for conductive charging of electric vehicles.
6	GB/T 20234.2-2011	Specifies requirements for AC charging couplers for conductive charging of EVs.
7	GB/T 20234.3-2015	Specifies requirements for DC charging couplers for conductive charging of EVs.
8	GB/T 38775.1-2020	Specifies general requirements for wireless power transfer system for EVs.
9	GB/T 38775.2-2020	Specifies the communication protocols between on-board EV charger and wireless power transfer device
10	GB/T 38775.3-2020	Specifies specific requirements for wireless power transfer system for EVs.
11	GB/T 38775.4-2020	Specifies EMC limits for wireless power transfer for EVs.
12	GB/T 29317-2021	Defines the terms and definitions related to charging and battery swap facilities for electric vehicles
13	GB/T 28569-2012	Specifies the technical requirements of electric energy metering for electric vehicle AC charging spots, as well as electric energy metering device's configuration and installation requirements, test methods and inspection rules.
14	GB/T 29318-2012	Specifies the configuration installation requirements, technical requirements, test methods and inspection rules of the DC electric energy metering device for the electric vehicle off-board charger.
15	GB/T 29316-2012	Specifies power quality requirements for EVSE

NB: GB is a national standard and T represents recommended (to the contrary of mandatory).

Netherlands – Policies and Regulations

Policy Instrument	Measures
EV charging definitions and explanation	Developed by the Netherlands Enterprise Agency, it aims to give clear definitions and explanations on relevant aspects of EV charging. It is available to the public and receives regular content updates.
Publicly Accessible Electric Charging Infrastructure Green Deal	Dutch government commitment to eliminate uncertainty regarding organization of public charging infrastructure and promote roll out of publicly accessible charging infrastructure.
Environmental Investment Tax Scheme (MIA) for charging infrastructure	Provides tax incentives for businesses to make investments in environmentally friendly technologies including EV charging infrastructure.

Electricity tax breaks for public EV charging infrastructure	In the Netherlands, the first 10,000 kWh units of electricity consumed are taxed at a higher rate than subsequent consumption. However, EV charging station operators pay the rate normally paid after the first 10 000 kWh for all electricity consumption up to 50,000 kWh.
Open Charge Point Protocol (OCPP)	An open protocol used for connections between charging station operators and service providers. This protocol facilitates automated roaming for EV drivers across several EV charging networks, allowing them to charge on several networks using a single card.
Dutch Guidelines (B117)	These guidelines mandate EV charging station operators to accept any valid charging card from an e-Mobility Service Provider for access and payment.

Directive 2014/94/EU on the deployment of alternative fuels infrastructure	• Requires EU member states to establish a policy framework for EV charging infrastructure including targets and incentives for establishing public charging stations. • Defines technical specification for charging points. • It requires normal charging points for EVs to be equipped with at least socket outlets or connectors of type 2 as defined in EN 62196-2 (IEC 62196-2). • High power a.c charging points for EVs are required to have at least type 2 connectors. • DC high power charging points to be equipped with at least CCS Combo 2 as defined by EN 62196-3 (IEC 62196-3). • Labeling of EVs and EV charging stations has to be done as per the specification given in EN 177186:2019

Netherlands - Standards

SL No.	Standard	Aspects covered and status
1	NEN-EN-IEC 61851-1:2019	Give general requirements for Electric Vehicle Conductive Charging System.
2	NEN-EN-IEC 61851-22:2002	Gives requirements for AC electric vehicle charging stations
3	NEN-EN-IEC 61851-21-2:2021	Defines electromagnetic compatibility (EMC) requirements for off- board charging system or DC EVCS
4	NEN-EN-IEC 61851-21-1:2017	Defines electromagnetic compatibility (EMC) requirements for on- board charging system or AC EVCS
5	NEN-EN-IEC 61851-23:2014	Gives requirements for DC charging station.
6	NEN-EN-IEC 61851-24:2014	Defines requirements for control communication between DC charging station and EV
7	NEN-EN-IEC 61851-25:2021	Gives requirements for DC charging stations where protection relies on electrical separation.
8	NEN-EN-IEC 62196-1:2014	Specifies general requirements for plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies.
9	NEN-EN-IEC 62196-2:2017	Specifies dimensional compatibility and interchangeability requirements for a.c. plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies
10	NEN-EN-IEC 62196-3:2014	Specifies dimensional compatibility and interchangeability requirements for d.c. plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies.
11	NEN-EN 17186:2019	Defines requirements for labels for EVs and EV charging stations. For example, EV charging station label (identifier) gives compatibility information with either plug of the cable assembly or the vehicle inlet in case of attached cable configuration.

Norway – Policies and Regulations

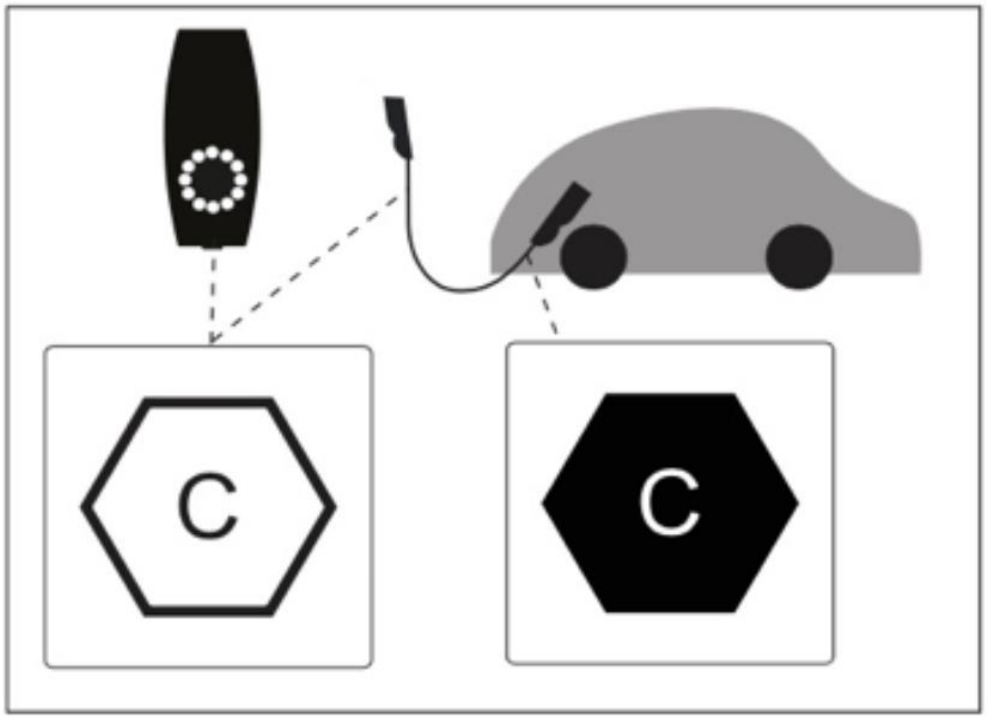
Policy Instrument	Measures
Financial stimulus package (2009-2010)	• Norway's first governmental support scheme for public charging infrastructure. Instituted after the 2008 financial crisis. It catered for slow chargers. • Funded 100 % of the installation cost for normal chargers, up to US$ 3380 per charging point. • The total support amounted to US$ 5.6 million, and the scheme resulted in around 1800 charging points installed across the country.

Enova financial support scheme for fast chargers (IEA, 2018)	• Aims to cover the Norwegian main roads with fast charging stations every 50 km (around 7500 km road network) • 100 % of installations costs for EV charging operators • The road network is split into several smaller segments, and operators compete for public funding. All the stations are owned and/or operated by charging operators. • To reduce the risk for charging stations being out of order and reduce charging queues all locations must have at least two multi standard fast chargers (CHAdeMO and CCS Combo 2) in addition to two 22 kW Type 2 points.

National database for charging stations (NOBIL)	• Joint effort between the governmental entity Enova and the Norwegian EV Association. • Open, publicly owned database that allows everyone to build services using standardized data free of charge. • Provide EV users with up-to date information about the charging infrastructure • Data is used by several in-car navigations systems in addition to charging maps and apps.
Regulation on the requirements for EVSE in new buildings and parking lots. (IEA, 2018)	• Came into force on 1st January 2018. • Requires parking lots and parking areas of new buildings to allocate a minimum of 6% to EVs

Building regulation EVSE Oslo (IEA, 2019)	• Oslo adopted a measure in 2017 to strengthen the availability of private charging infrastructure. • This regulation mandates that new buildings must have at least 50% of the parking facilities equipped for electric car charging. • The grid capacity must also be designed to charge at 3.6 kW all of the vehicles in the building without any need for smart charging to prevent local power shortages.

Supply type	Standard	Configuration	Type of accessory	Voltage range	Identifier
AC	FprEN 6185 1-1:2016 IEC 60884 EN 60309-1 and –2		Home plug Home socket Industrial plug and socket-outlet		**No graphical expression**
AC	EN 62196-2	TYPE 1	Vehicle connector and vehicle inlet	≤ 250 V RMS	B
AC	EN 62196-2	TYPE 2	Vehicle connector and vehicle inlet	≤ 480 V RMS	C
AC	EN 62196-2	TYPE 2	Plug Socket outlet	≤ 480 V RMS	C
AC	EN 62196-2	TYPE 3-A	Plug Socket outlet	≤ 480 V RMS	D
AC	EN 62196-2	TYPE 3-C	Plug Socket outlet	≤ 480 V RMS	E
AC	RESERVED				**Letters A, F, G and H**



Supply type	Standard	Configuration	Type of accessory	Voltage range	Identifier
DC	EN 62196-3	FF	Vehicle connector and vehicle inlet	50 V to 500 V	K
				200 V to 920 V	L
DC	EN 62196-3	AA	Vehicle connector and vehicle inlet	50 V to 500 V	M
				200 V to 920 V[b]	N
DC	Not defined in standard[a]	TYPE 2[a]	Vehicle connector and vehicle inlet	50 V to 500 V	O
DC	RESERVED				Letters P, R, S and T

[a] TYPE 2 is described in EN 62196-2 for AC. It is not described for DC and not forbidden.

[b] The current EN 62196-3 limits voltage at 600 V.

Rwanda – Policies and Regulations

- The strategy stipulates a raft of incentives for EVs and EV charging infrastructure aimed at getting users to opt for EVs as opposed to ICES. The incentives include the following:

1. Electricity tariff for EV charging stations – EV charging stations will be billed at the industrial tariff level (US$ 0.091/kWh) which is significantly cheaper than the residential tariff.
2. Import and Excise duty exemption for EVs, batteries and EV charging station equipment
3. Zero-rated Value Added Tax for batteries and EV charging station equipment.
4. Rent-free land for charging stations for land owned by the government
5. The building code and city planning rules will also include provisions for electric vehicle charging stations.

Rwanda - Standards

- Rwanda has not developed standards for publicly accessible charging stations.
- Discussions are underway to kick start the process of developing standards for EV charging infrastructure.

Recommendations

1. Interoperability of:

- Payment Options – Use of different RFID cards.
- Network - Open charge point protocol (OCPP) a standard used in Europe

2. Develop a national guideline on charging infrastructure.
3. Revision of the building code to incorporate charging stations in buildings.
4. Revision of the National Grid code & conducting a study.
5. Development of a common unified industry voice will be key in growing the industry locally and regionally as well as stimulating healthy competition.
6. Government incentives – fiscal (land & concessional rates, taxes) and non – fiscal (streamline license process).
7. EV Tariffs – To reduce the cost of electricity purchase by the CPOs which in turn results in lower charging costs for consumers
8. In the development of charging stations, use of renewable energy sources is recommended as the power generation source.