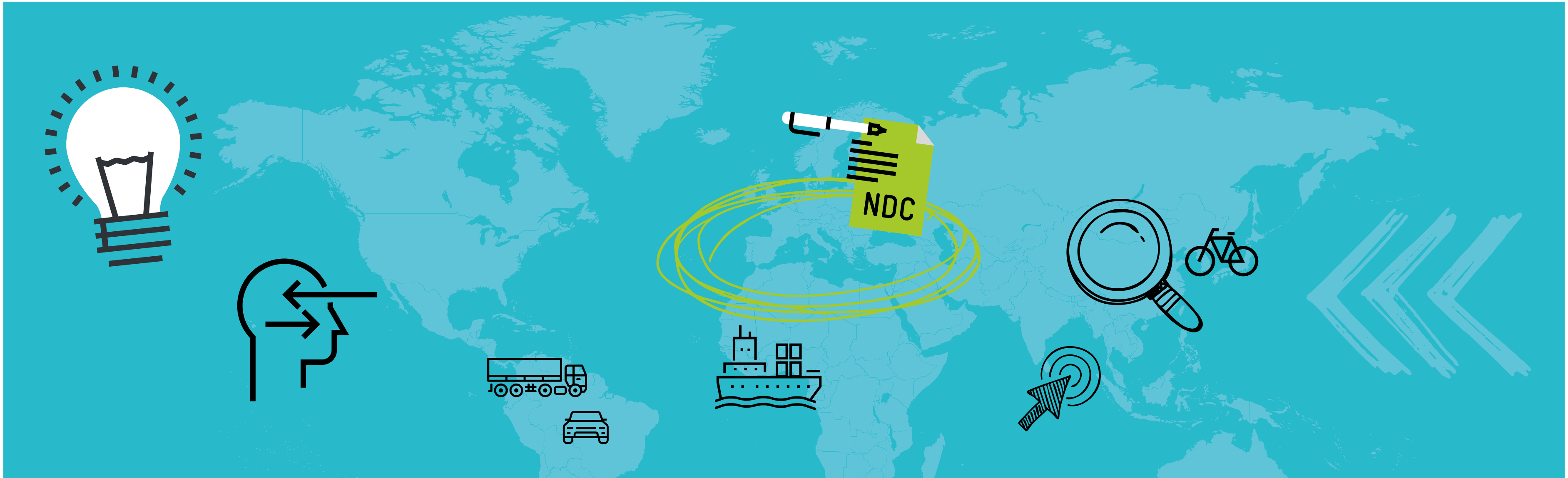

Electric Mobility in Kenya: Charging Infrastructure

Advancing Transport Climate Strategies (TraCS)

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

Overview

1. Types of Charging Infrastructure

2. Setting-up Charging Infrastructure

3. Step-by-Step Guide

4. Conclusion & Further Readings

Photo by Sr Roger Starnes on Unsplash

Types of Charging Infrastructure

- Rationale
- Charging Methods
- Charging Types
- Charging Levels
- Charging Times
- Diversity of Charging Plugs

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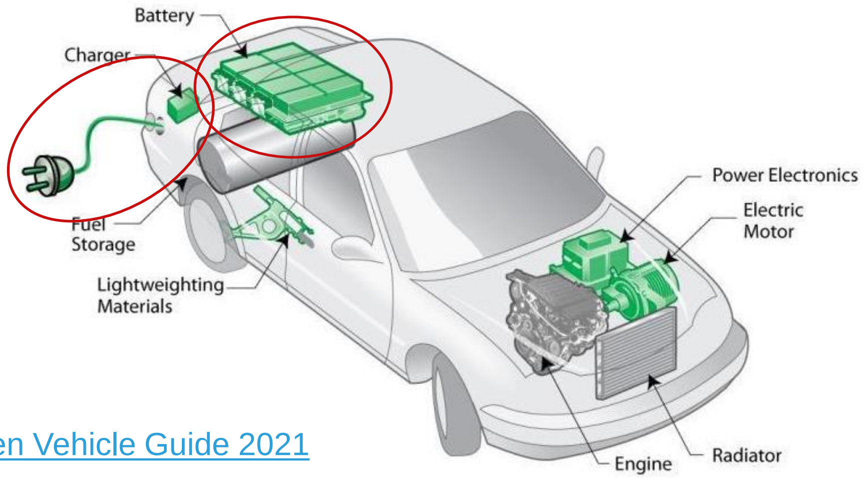
Rationale

- All type of battery electric vehicles (2/3-wheelers, cars, buses) use electricity stored in a **battery pack** to power an electric motor and turn the wheels

ICE vehicle → gas station

Electric vehicle → charging station

- A comprehensive national system for e-mobility requires thinking about charging infrastructure



Source: [Green Vehicle Guide 2021]

Charging Methods

Conductive

- Uses a connector to charge the vehicle
- Different types of connectors/stations avaialable

Inductive

- Uses magnetic fields to transfer power & delivers high energy transfer efficiency to the vehicle
- Currently not ready for market

Battery swapping

- Exchange of the whole battery
- Requires thinking about battery ownership
- Particularly interesting for micromobility & 2/3 wheelers

Pictures: Charged 2019, Wikipedia Creative Commons,Road Traffic Technology 2018

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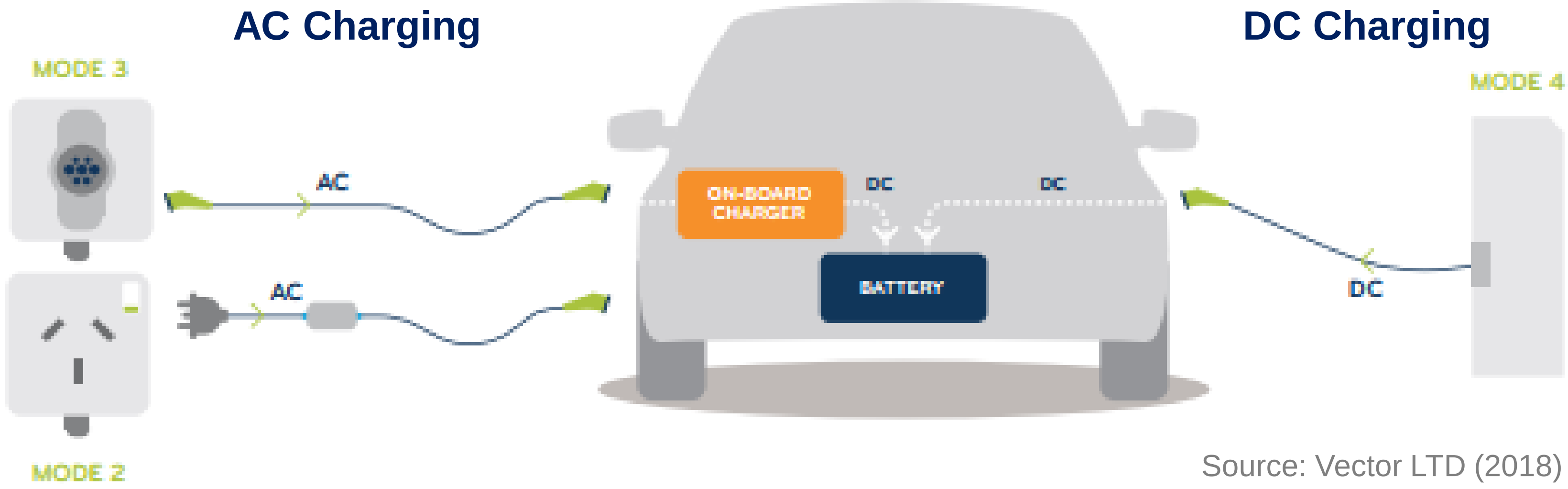
Charging Types: AC & DC Charging

- Grid electricity is essentially AC but the electric power of the battery is DC ➔ charging of EV requires conversion
  - Within the vehicle (Mode 3) or by a converter that is integrated into the charging device (Mode 2)
  - With a DC charging station (Mode 4) that directly provides DC (= fast charging)



Source: Vector LTD (2018)

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Three Major Levels of Chargers

Level 1: Standard 120V plug

- Charges slowly
- Fills a battery up to full capacity in several hours


Level 2: 240V plug

- Typical EV-plug
- AC option for public charging station (most widely used at the moment)
- Charging in up to 8h

Level 3: Direct current (DC)

- Fast charger
- Charges battery up to 80% in 30minutes
- Charging cable has to be fixed to the station

Sources: Roperld, ClipperCreek, Evcaro, ChargeHub

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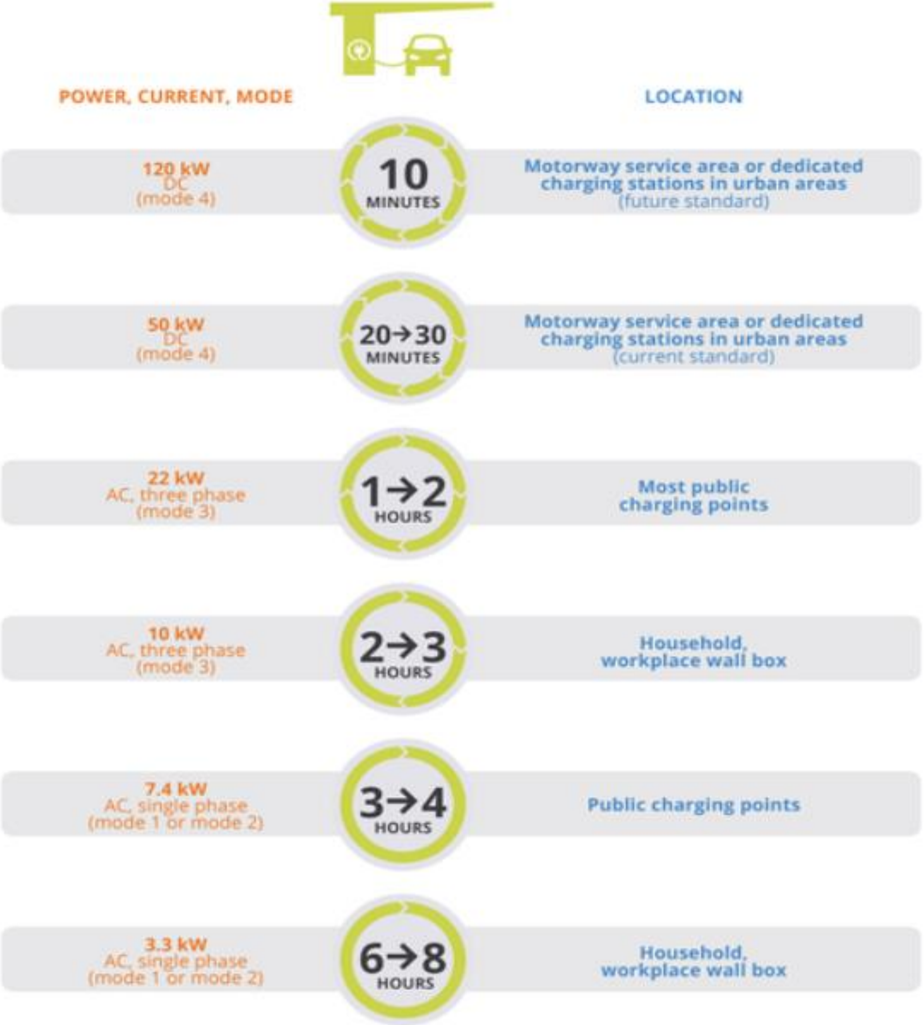
Charging Times

Charging time depends on:

- Type of charging (AC/DC)
- Level of charging (the higher the voltage, the quicker the charge)
- Battery capacity
- State of charge (batteries charge faster when they are at 20-80%)
- External factors (like outside temperature)



Source: E-mobility NSR, 2013, Hyundai 2021

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Diversity of Charging Plugs

Source: [Enel X (2019)]

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Picture by Michael Fousert on Unsplash

Setting Up Charging Infrastructure

- Considerations
  - Electricity system
  - Business model
  - Placement
  - Stakeholders

Considerations for Setting Up Charging Stations

The **suitability of different kinds of charging infrastructure** depends on:

- Vehicle
  - Type (2/3 wheelers, e-bus, e-car)
  - Origin (plug type)
  - Use (public/ private, returning times and parking time, urban/inter-urban)
- Local energy grid
- Costs
- Location

➔ Requires localised and case-dependent decision-making

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Consideration: Electricity system

System Components	Consider
Generation and storage	• Creation of new demand peaks due to uncontrolled charging • Peak shaving through *vehicle to grid (V2G)*
Transmission networks	• Can lead to network congestion, particularly if electricity production and comsumption are dispersed • Charging and feeding back of electricity from EV batteries provides the opportunity to offer services of negative and positive balancing power
Distribution networks	• Can lead to an overload of the installed transformers and power lines
Power lines	• EV charging can lead to degradation of power quality (introduction of current peaks and voltage harmonics) • EV charging can lead to voltage imbalances among the 3 phases in the electricity netwok or to an overload of the installed building connection

Source: Wirges (2016)

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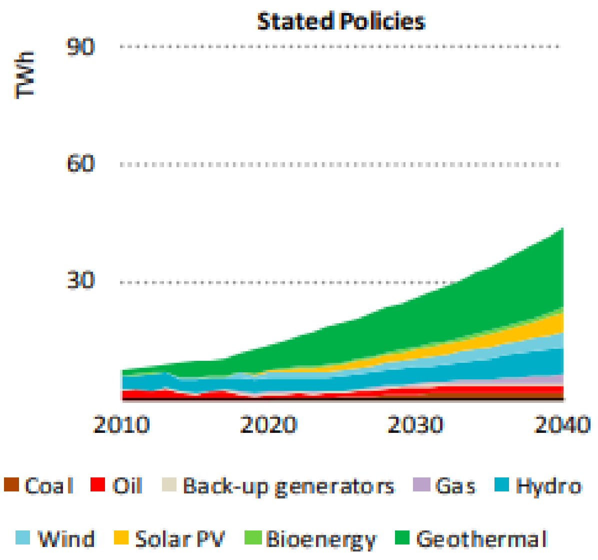
Consideration: Electricity system - Kenya

- High share of renewable energy
  - Favorable for e-mobility (low emissions)
  - Overall sufficient production of energy
  - Challenging: decentralized provision makes balancing of demand/supply difficult (wind/solar) → best adressed by smart grid solutions (already piloted in parts of Nairobi and Mombasa) (Mokveld & van Eije 2018: 5)

- National grid: 220kV and 132 kV transmission system & limited number of 66kV lines (Mokveld & van Eije 2018: 5)
  - Main challenge: frequent power outages & losses (10-30%)
  - EV charging could further increase instability

- Aim: reach full access with AC by 2022 (IEA 2019:16)
  - Will facilitate home charging

- One big energy provider: Kenya Power
  - Simplifies cooperation and coordination



Kenya: energy generation by technology (IEA 2019: 16)

Business Model: Cost for Setting Up Charging Stations

	Level 1 AC (1.4 kW)	Level 2 AC (3.3 - 6.6 kW)	DC Fast Charging (25 - 50 kW)
Equipment Price	$30 – 900 (Prices vary with system capability to monitor and charge for use)	$600 – 9,000	$15,000 – 60,000
Installation	$200 – 450	$2,000 – 12,000	$10,000 – 25,000
TOTAL	$230 – 1,350	$2,600 – 21,000	$25,000 – 85,000

Source: Adjusted from Chittenden County RPC. (2014) whereby installation cost estimates were obtained directly from experienced installers such as Green Power Technologies and Peck Electric

Business Model: Pricing for EV Charging

- Home charging prices are **consistent** rates per kilowatt-hour (kWh) set by utility regulators

- Schemes at public charging stations are often **inconsistent**:
  - Per-session fee
  - Per-minute fee
  - Tiered pricing based on a vehicle‘s maximum charging speed

➔ Lack of transparency about prices at charging stations

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Business Model: Profitability of Charging Stations – Example: EU

	Scenario					Profitability	
Fast charger (DC)	Initial investment	Customer facing price in kWh	Costs of electricty	Utilization scenario	Daily utilisation in hours (lifetime average)	NPV (Net Present Value)	IRR (Internal Rate of Return)
low prices and utilisation	€25 000	€0,26	€0,18	50%	2,4	-€7 927	2%
medium prices and utilisation	€25 000	€0,34	€0,18	100%	4,8	€19 321	25%
high prices and utilisation	€25 000	€0,43	€0,18	150%	7,2	€47 551	44%
Standard charger (AC)							
low prices and utilisation	€2 500	€0,20	€0,18	50%	3,8	-€1 962	-14%
medium prices and utilisation	€2 500	€0,25	€0,18	100%	7,6	€4 918	39%
high prices and utilisation	€2 500	€0,30	€0,18	150%	11,5	€17 532	87%

Source: Fishbone et al. 2017: 21

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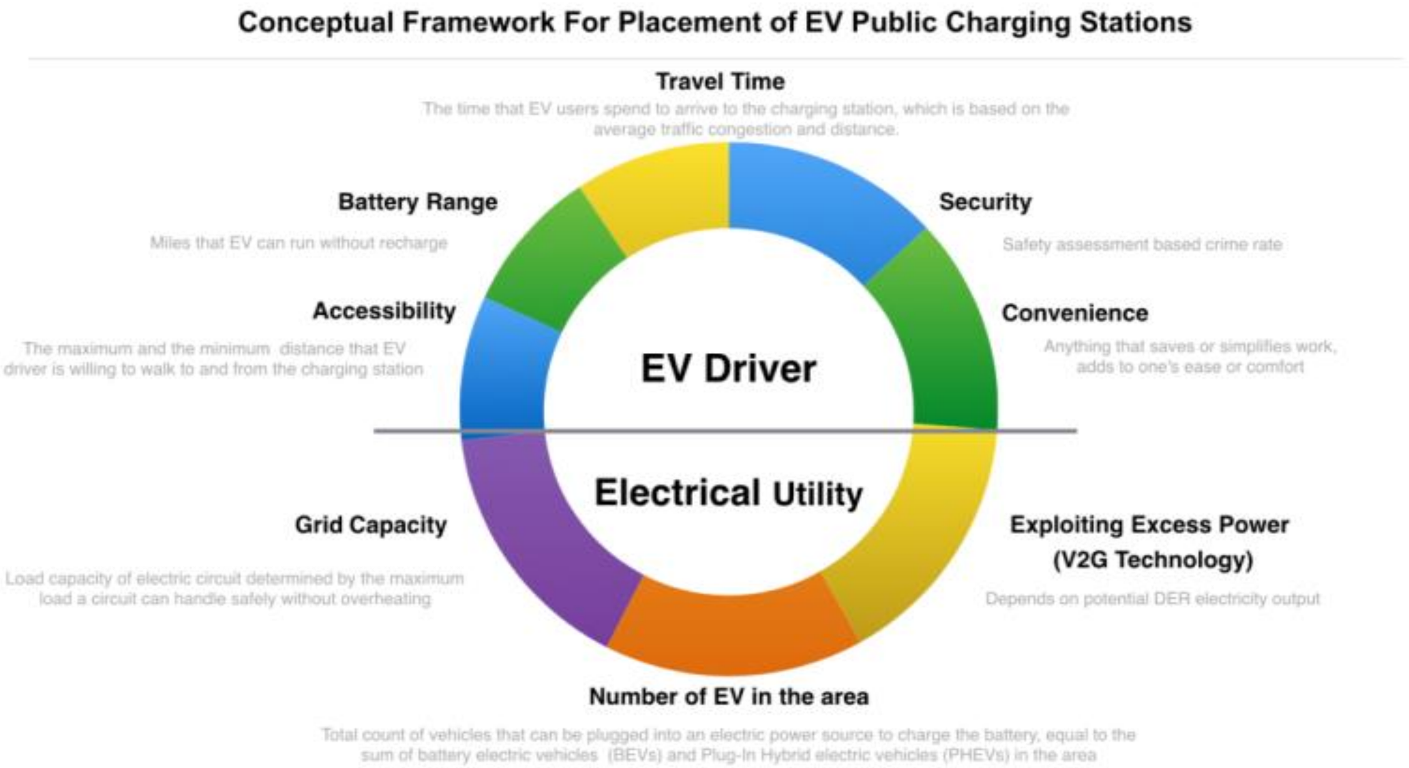
Consideration: Placement of Charging Stations

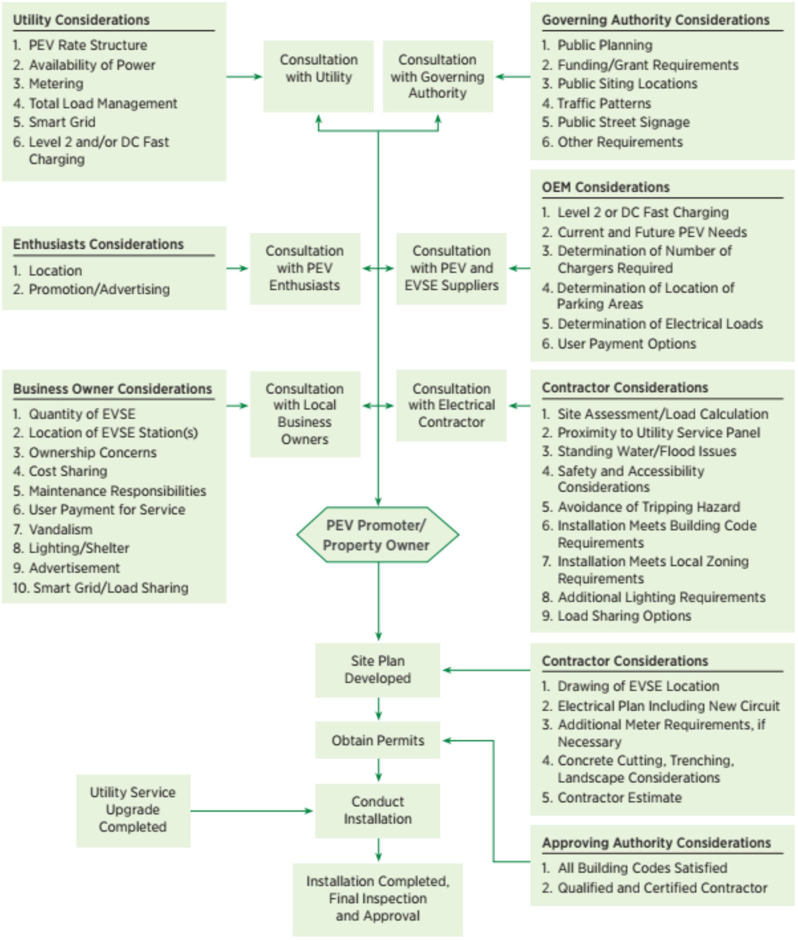


Source: Sultan et al. (2017)

Stakeholders and Processes

Potential stakeholders for putting up charging facilities

- Retail stores
- Parking garages
- Office parks
- Utilities
- Homeowners’ association
- Governments



Source: US Department of Energy. (2012). Plug-in Electric Vehicle Handbook for Public Charging Station Hosts

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Step by Step Guide for Setting Up a Charging Station

Photo by Kumpan Electronics on Unsplash

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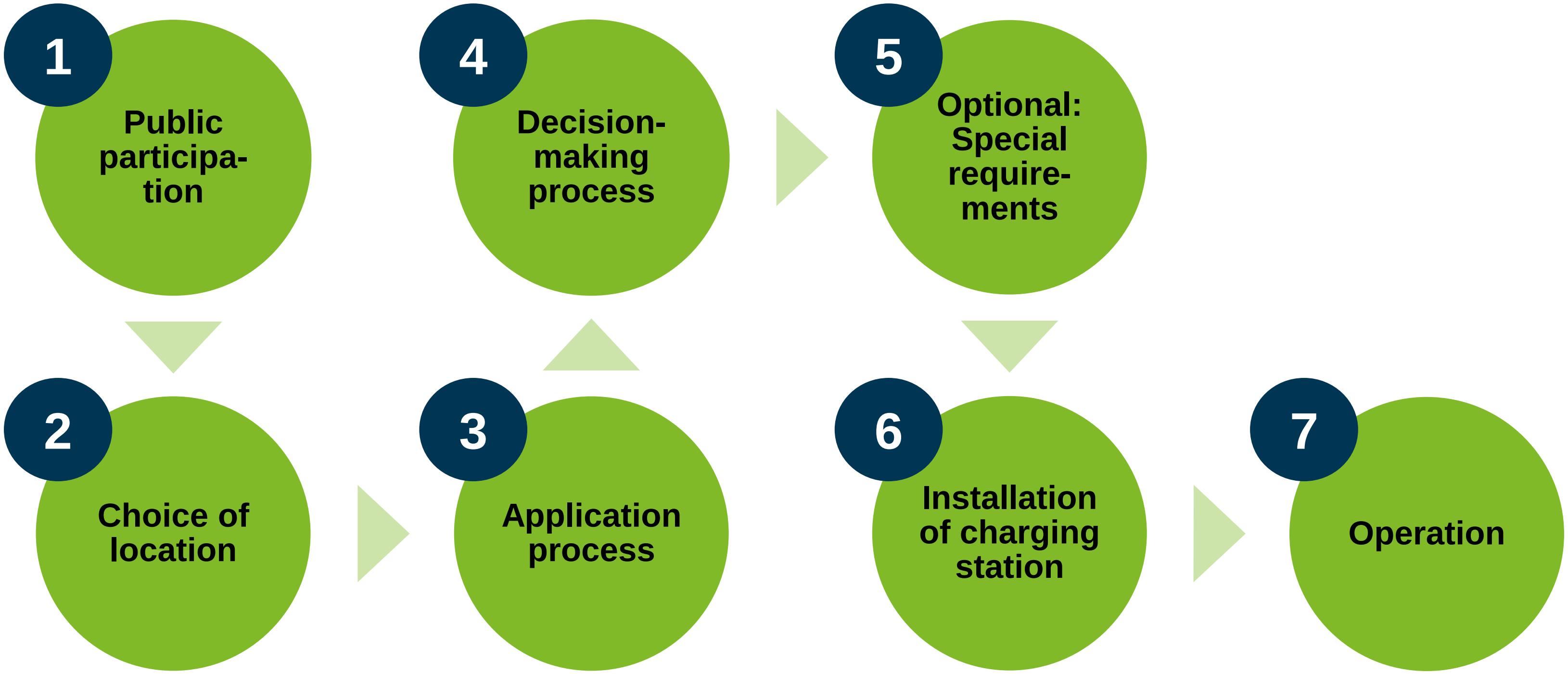
Overview



Based on: checkliste-ladeinfrastruktur.pdf (xn--starterset-elektromobilitt-4hc.de)

1 Public Participation

- Start public participation at an early stage ➔ increase acceptance and stewardship by local citizens
- Communicate/Inform local citizens about planned charging infrastructure
- Take concerns and new inputs of local citizens/users into account

Who is involved?

- Citizens (input provider)
- Local (municipal) administration (moderator)
- Local politicians (idea provider, decision-maker)
- Potential additional stakeholder (e.g. investor)

Based on: checkliste-ladeinfrastruktur.pdf (xn--starterset-elektromobilitt-4hc.de)

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2 Choice of Location

- Determine demand/need for charging infrastructure within the municipality (Concept of location)
- Consider relevant criteria for choice of location such as:
  - Availability of space
  - Local traffic condition
  - Accessibility of charging station
  - Local enegy grid (capacity, stability)
  - Visibility
  - Integration into urban space
- Insights from Germany on potential locations:
  - Shopping areas and commercial areas
  - Parking lots
  - Educational facilities (school, university, …)
  - Municipal buildings

Who is involved?

- Local (municipal) administration
- Operator of charging infrastructure
- Energy supplier
- Potentially: land owner

Based on: checkliste-ladeinfrastruktur.pdf (xn--starterset-elektromobilitt-4hc.de)

3 Application by the operator of the charging infrastructure

- Operator must submit an application
- Municipality should make known in advance which documents are required for the process (Increase speed & facilitate application)
- Potential requirements/documents might include:
  - Photos/aerial views of the desired location & site plans
  - Brief description of the location
  - Information about the charging station (equipment, type,…)
  - Information on current traffic regulations (signs, …)
  - Brief justification of the location decision
- Relevant Regulations & Laws in Kenya might include:
  - Physical And Land Use Planning Act 2019
  - County Government Act (2012)
  - Urban areas & Cities Act (2011)
  - Energy Act (2019)

Who is involved?

- Local (municipal) administration
- Operator of charging infrastructure

Based on: checkliste-ladeinfrastruktur.pdf (xn--starterset-elektromobilitt-4hc.de)

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4 Decision-making & 5 Optional requirements

- Competent authority must examine the application and make its decision

- An inspection of the location might be usefull to determine
  - Integration into surrounding area
  - Integration into local energy system
  - Traffic regulation & security
  - Special requirements

- Additional requirements might be set for the installation of the charging station

- If all criteria are met → issue of approval of charging station and building permission

Who is involved?

- Local (municipal) administration
- Operator of charging infrastructure

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6 Installation & 7 Operation

- The operator of the charging infrastructure is reponsible for the installation → specified requirements (step 4 & 5) have to be met
- Local administration might consider inspecting the charging station after installation
- During operation of the charging station the operator is responsible that security requirements are met
- Local administration might inquire about capacity utilisation to determine further demand

Who is involved?

- Local (municipal) administration
- Operator of charging infrastructure
- Constuction Company
- Users

Based on: checkliste-ladeinfrastruktur.pdf (xn--starterset-elektromobilitt-4hc.de)

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Conclusion & Further Readings

Conclusion

- Building a national e-mobility system requires setting-up charging infrastructure
- Diverse types of charging stations are available (differences in charging time & costs)

  → Choice of charging stations is a highly localised decision (depending on local aspects, fleet, use-case, electricity grid etc.)

- Setting-up charging infrastructure will thus greatly depend on local decision-makers (counties & municipalities)
- Local legislation and consideration about criteria for charging stations play a vital part in supporting the installation of charging stations and can speed up the proccess

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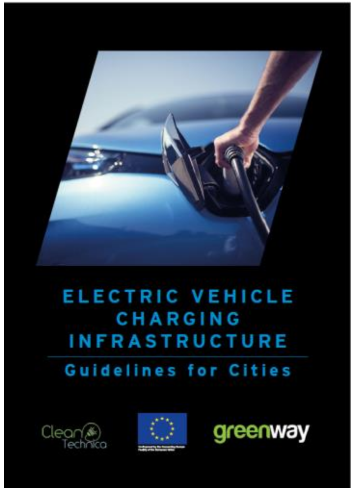
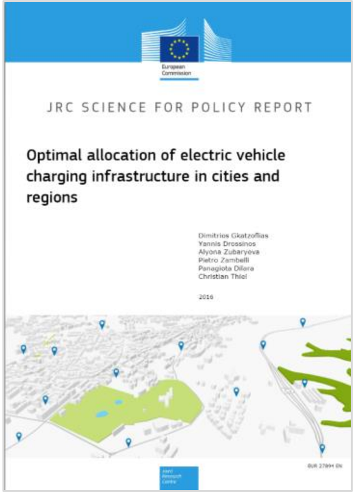
Recommended Readings & Additional Ressources



Electric Vehicle Charging Infrastructure Guidelines for Cities



Optimal allocation of electric vehicle charging infrastructure in cities and regions

Addressing the Different Needs for Charging Infrastructure: An Analysis of Some Criteria for Charging Infrastructure Set-up

Simon Árpád Funke, Till Gnann and Patrick Plötz

Abstract Electric mobility is an important means to decarbonise the transport sector. Especially in cities, the use of zero-emission vehicles like electric vehicles is favourable, as emissions of conventional cars cause severe air pollution. Besides CO_2, the most important emissions are nitric oxides, particular matter and noise. Given the trend of urbanisation, the problem of air pollution in large cities will rather grow than diminish. Although electric vehicles are an infrastructure-dependent technology, one important advantage of plug-in electric vehicles (EV) compared to hydrogen-powered vehicles is the possibility to use the existing electricity infrastructure in households for charging. While additional public charging infrastructure is also needed for interim charging or overnight charging for the so-called 'on-street parkers' without own garage, the majority of vehicles could be operated as EVs without additional public charging infrastructure. However, public charging infrastructure is an important component for the large-scale diffusion of electric vehicles and political action seems necessary since no business models are presently available. In the present paper the authors combine different data sets concerning German charging points and mobility patterns to describe the different needs for charging infrastructure, and provide an overview of the underlying different technical options. Based on the current charging infrastructure stock, the set-up methodology and the impact of user needs on charging infrastructure, the authors compare a coverage-oriented and a demand-oriented approach. The authors also estimate the number of public charging points for those two approaches. Finally, criteria for charging infrastructure are categorised and related to the different approaches. It results that the number of charging stations needed for the two

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