Electric Mobility in Kenya: Charging Infrastructure
Advancing Transport Climate Strategies (TraCS)
Overview

1. Types of Charging Infrastructure
2. Setting-up Charging Infrastructure
3. Step-by-Step Guide
4. Conclusion & Further Readings
Types of Charging Infrastructure

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

- 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 available

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
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)
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 8 hours

**Level 3: Direct current (DC)**
- Fast charger
- Charges battery up to 80% in 30 minutes
- Charging cable has to be fixed to the station

Sources: Roperld, ClipperCreek, Evcaro, ChargeHub
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
Diversity of Charging Plugs

Source: Enel X (2019)
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
## Consideration: Electricity system

<table>
<thead>
<tr>
<th>System Components</th>
<th>Consider</th>
</tr>
</thead>
</table>
| 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 consumption 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 network or to an overload of the installed building connection |

Source: Wirges (2016)
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 addressed 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
## Business Model: Cost for Setting Up Charging Stations

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

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
## Business Model: Profitability of Charging Stations – Example: EU

<table>
<thead>
<tr>
<th>Fast charger (DC)</th>
<th>Initial investment</th>
<th>Customer facing price in kWh</th>
<th>Costs of electricity</th>
<th>Utilization scenario</th>
<th>Daily utilisation in hours (lifetime average)</th>
<th>NPV (Net Present Value)</th>
<th>IRR (Internal Rate of Return)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low prices and utilisation</td>
<td>€25 000</td>
<td>€0,26</td>
<td>€0,18</td>
<td>50%</td>
<td>2,4</td>
<td>-€7 927</td>
<td>2%</td>
</tr>
<tr>
<td>medium prices and utilisation</td>
<td>€25 000</td>
<td>€0,34</td>
<td>€0,18</td>
<td>100%</td>
<td>4,8</td>
<td>€19 321</td>
<td>25%</td>
</tr>
<tr>
<td>high prices and utilisation</td>
<td>€25 000</td>
<td>€0,43</td>
<td>€0,18</td>
<td>150%</td>
<td>7,2</td>
<td>€47 551</td>
<td>44%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard charger (AC)</th>
<th>Initial investment</th>
<th>Customer facing price in kWh</th>
<th>Costs of electricity</th>
<th>Utilization scenario</th>
<th>Daily utilisation in hours (lifetime average)</th>
<th>NPV (Net Present Value)</th>
<th>IRR (Internal Rate of Return)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low prices and utilisation</td>
<td>€2 500</td>
<td>€0,20</td>
<td>€0,18</td>
<td>50%</td>
<td>3,8</td>
<td>-€1 962</td>
<td>-14%</td>
</tr>
<tr>
<td>medium prices and utilisation</td>
<td>€2 500</td>
<td>€0,25</td>
<td>€0,18</td>
<td>100%</td>
<td>7,6</td>
<td>€4 918</td>
<td>39%</td>
</tr>
<tr>
<td>high prices and utilisation</td>
<td>€2 500</td>
<td>€0,30</td>
<td>€0,18</td>
<td>150%</td>
<td>11,5</td>
<td>€17 532</td>
<td>87%</td>
</tr>
</tbody>
</table>

Source: Fishbone et al. 2017: 21
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

Step by Step Guide for Setting Up a Charging Station
Overview

1. Public participation
2. Choice of location
3. Application process
4. Decision-making process
5. Optional: Special requirements
6. Installation of charging station
7. Operation

Based on: checklist-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)
**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 energy 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
4 Decision-making & 5 Optional requirements

- Competent authority must examine the application and make its decision

- An inspection of the location might be useful 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
Installation & Operation

- The operator of the charging infrastructure is responsible 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

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

Who is involved?

- Local (municipal) administration
- Operator of charging infrastructure
- Construction Company
- Users
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 process
Recommended Readings & Additional Resources

Electric Vehicle Charging Infrastructure Guidelines for Cities

Optimal allocation of electric vehicle charging infrastructure in cities and regions

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