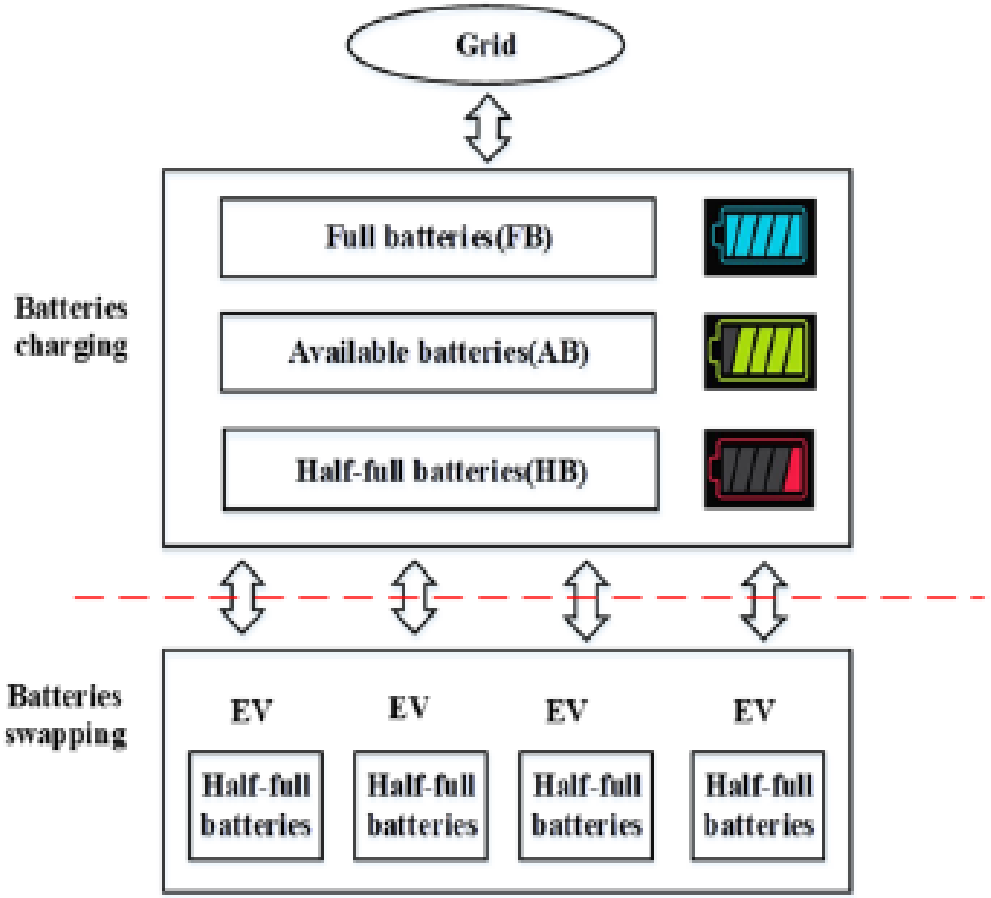
Battery Swapping, Kenyan Perspective and International Best Practices

Battery Swapping

- Battery swapping is a technology where a battery with a depleted state of charge is replaced with a battery that has a full state of charge.
- The basic structure of a battery swapping system has the following:

1. Power source, which could be from the grid or from a dedicated energy source for the battery swapping system.
2. A battery housing structure.
3. Power cables for to connect the batteries to the power source.
4. A human machine interface and a payment system.


Grid
Batteries charging
Full batteries(FB)
Available batteries(AB)
Half-full batteries(HB)
Batteries swapping
EV
EV
EV
EV
Half-full batteries
Half-full batteries
Half-full batteries
Half-full batteries

Battery swapping systems can be categorized into two types:

Manual battery swapping systems – This is a system where the batteries are placed and removed from the charging source manually - by hand. The Manual swapping stations are modular and occupy a less space compared to the other type of charging station. These systems are mainly used for two and three-wheelers vehicles as their batteries are smaller in size and weight.

Autonomous battery swapping systems – They uses a robotic arm that is semi or fully automated. These systems are mainly used for four-wheeler and heavy vehicle applications whose energy storage systems are larger and heavier. Autonomous battery-swapping systems require more space are capital intensive.

Advantages of Battery Swapping Stations

1. They eliminate battery recharge time as drained batteries can be quickly exchanged for fully charged ones. This gives EV users an almost similar experience as they would have at a fossil fuel recharging station.
2. They allow for separation of the cost of the battery from the vehicle cost lowering the cost of the EV with owners essentially paying a subscription for the battery.

Disadvantages of Battery Swapping Stations

1. They are capital intensive
2. They are vehicle – battery – connector specific meaning they lack interoperability making their usage difficult to optimize. Optimizing batteries for swapping means standardization and it is often difficult to get automakers to agree though this may soon change at least for 2 wheelers.
3. Reliability of the leased battery packs – there are questions on the reliability and quality of EV batteries from battery swapping stations.

- To address some of these issues, four major motorcycle manufacturers, Honda, KTM, Piaggio and Yamaha have agreed to form a swappable battery consortium.
- The consortium aims to:

1. develop common technical specifications of swappable battery systems
2. confirm common usage of the battery systems
3. make and promote the consortium's common specifications as a standard within European and International standardization bodies
4. expand the use of the consortium's common specification to global level

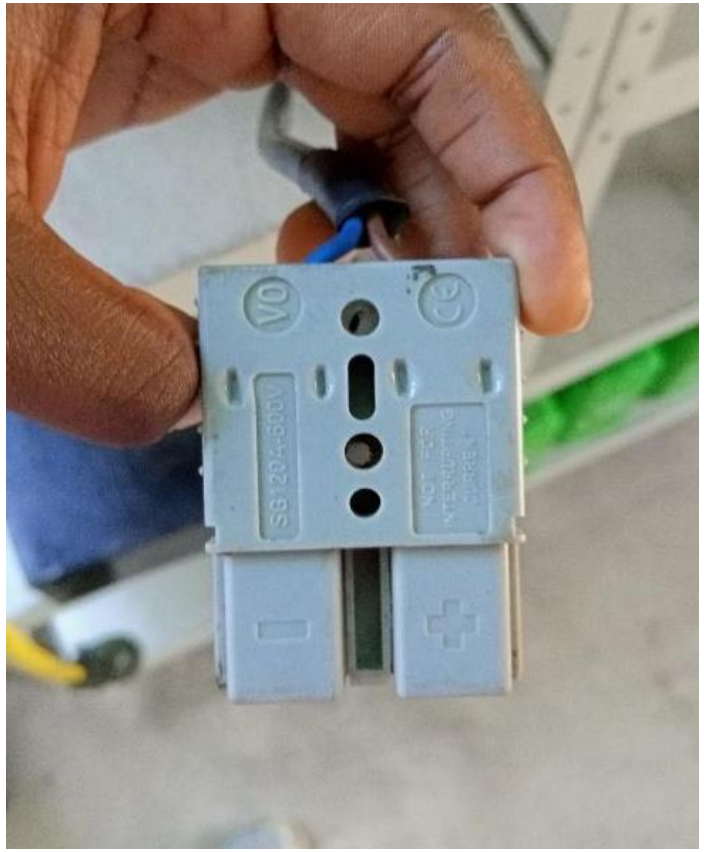
Status of Battery Swapping Station in Kenya

- As end of March 2022, there are only four operational battery swapping stations in the country.
- All the swap station specializes in swap systems for e-2Ws as they are affordable for the Kenyan market.
- The battery packs for these systems are also smaller and lighter, therefore easier to handle during swaps as the main battery swap technology that is implemented is the manual battery swap system.
- Two of the stations are located in Western Kenya whereas the other two are located within Nairobi County.

- The battery packs swapping stations are somehow light (about 16.5kg for Kiri EV) which makes it easier to manually handle them.

- The battery packs are not standardized – they have a different form factor, connectors/plugs, battery nominal voltages and also use different communication protocols.

- This makes interoperability of the batteries a challenge.



- At all swap stations, the battery charger is plugged direct to the standard AC mains outlet.
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- The battery chargers at the swapping stations are compatible with 50 Hz, 220-240VAC system.
- Kenya does not have policies, standards or a taxation regime for battery swapping technology.
- This might soon change - The State Department of Transport had advertised for consultancy services in developing an E-mobility policy that is targeted to be ready before the end of 2022.

Battery Swapping Station	Location	Description of Battery Swapping Station
i. WeTu Hub	Homabay Town, Homabay	• This battery swapping station has battery swapping systems for two companies – Opibus and Bodawerk. The battery swap station is a manual battery swap station. • The batteries are removed from an e-bike and connected to a charging port. The charging ports for these two companies were noted to be different. • The charging station is off-grid and is powered by a solar PV system.
ii. Kiri EV	Kiambu Road, Nairobi	• Kiri EV is at an advanced stage of implementing a battery swap station. • They have developed a manual battery swap station that can take up to 8 battery units for their e-2Ws.


WeTu
Homa Bay Hub


Kiri EV Ltd
Swap Instructions

Standardization

Standard	Title	Summary and Scope
IEC 62840-1;2016	Electric vehicle battery swap system Part 1: General and Guidance	IEC TS 62840-1:2016 gives the general overview for battery swap systems, for the purposes of swapping batteries of EVs when the vehicle powertrain is turned off and when the battery swap system is connected to the supply network at standard supply voltages according to IEC 60038 with a rated voltage up to 1 000 V AC and up to 1 500 V DC. It is applicable for battery swap systems for EVs equipped with one or more swappable battery system.
IEC 62840-2:2016	Electric vehicle battery swap system Part 2: Safety Requirements	IEC 62840-2:2016 provides the safety requirements for a battery swap system, for the purposes of swapping swappable battery system of EVs. The battery swap system is intended to be connected to the supply network. The power supply is up to 1 000 V AC or up to 1 500 V d.c, in accordance with IEC 60038. This standard also applies to battery swap systems supplied from on-site storage systems.
IEC PAS 62840-3:2021	Electric vehicle battery swap system Part 3: Particular safety and interoperability requirements for battery swap systems operating with removable RESS/battery systems	IEC PAS 62840-3:2021 applies to battery swap systems for removable RESS of electric road vehicle when connected to the supply network, with a rated supply voltage up to 480 V AC or up to 400 V DC, for battery systems with a rated voltage up to 120 V DC. This document applies to battery swap systems for removable RESS for an EV, where the removable RESS for the EV is stored for the purpose of transfer power between the battery swap station and removable RESS for the EV.
GB/T 40032-2021	Safety requirements of battery swap for electric vehicles	This is a Chinese standard that specifies the specific safety requirements, test methods and inspection rules for battery swappable EVs. This Standard applies to pure electric vehicles that can be battery swapped.

International Best Practices - Philipines

- Battery swap stations (BSS) are covered under EVCS policy guidelines issued by the Department of Energy in the Philippines.
- Under these guidelines a battery swap station is defined as an EVCS composed of systems which provide for battery mounting/unmounting, battery transfer, battery storage, battery charging, and other functions as defined by PNS IEC TS 62840-1.
- The BSS may include the following:

1. Lane system – used to transfer the EV to a designated location in readiness for battery handling.
2. Battery handling system – consist of swap equipment and transfer equipment
3. Storage system – used to store the swappable battery system (SBS) safely.
4. Charging system – used to charge the SBS safely.
5. Supervisory and Control system – applicable to automated BSS.

Philipines - Standards

- In the Philippines, the majority of EVs on the road are two-wheelers and three-wheelers (e-2Ws, e-3Ws).
- These are equipped with detachable batteries that can be charged through plug-in or battery swapping. This makes e-2Ws and e-3Ws prime candidates for battery swapping.
- In Philippines the following standards pertaining to battery swapping technology are in place:

1. PNS IEC/TS 62840-1:2016 - gives the general overview for battery swap systems, for the purposes of swapping batteries of electric road vehicles.
2. PNS IEC 62840-2:2016 - provides the safety requirements for a battery swap system.
3. PNS ISO 12405-4:2021 – specifies test procedures for the basic characteristics of performance, reliability and electrical functionality for lithium-ion battery packs and systems.

India – Policies and Regulations

- The key policy instrument in India with regard to battery swapping is the FAME II policy document which extends financial support for both EVs and charging infrastructure.
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- The Ministry of Power (MOP) Charging Infrastructure Guidelines and Standards give guidance on setting up battery swapping stations.
- In its capacity as a legislative authority, the MoP clarified that the operation of EV charging services (swapping stations included) did not require licensing under the Electricity Act 2003.

Selected Policy Initiatives for Battery-Swapping (BS) from State-level EV Policies

Haryana (2020)
- Land will be provided to set up BS stations
- Incentives for setting up BS stations in existing buildings (malls/ commercial buildings)
- 25% capital subsidy on fixed cost up to 10 lacs (excluding cost of battery inventory) for first 50 BS stations
- 100% SGST reimbursement on advanced batteries

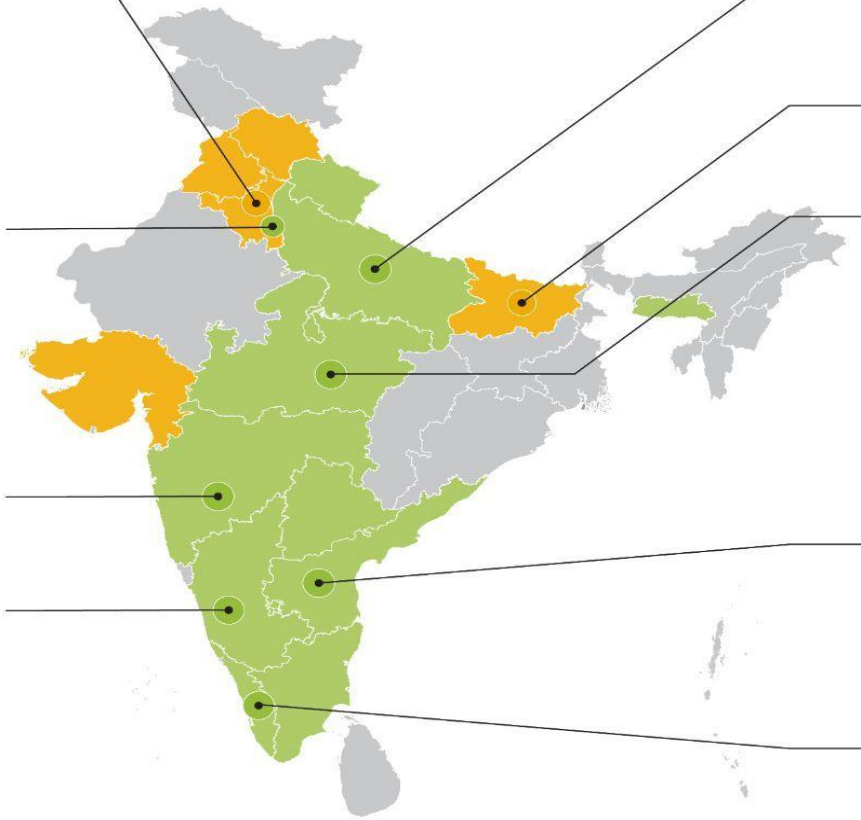
Delhi (2020)
- 50% of purchase incentives to vehicle OEM & 50% to Energy Operator
- EOs will be invited to set-up swapping stations
- Land at bare minimum rental lease
- Capital subsidy on chargers installation cost to selected EOs
- Open Access & Power Banking facility for BS stations with RE integration
- 100% SGST reimbursement on advanced batteries

Maharashtra (2018)

Robotic arms will be established at Public Bus Stations for BS

Karnataka (2017)

25% capital subsidy on equipment/ machinery for BS stations up to:
- Rs 3 lacs per station for e-2Ws & e-3Ws for first 100 BS stations -
- Rs 5 lacs per station for e-cars for first 50 BS stations -
- Rs 10 lacs per station for e-buses for first 50 BS stations -



Uttar Pradesh (2019)

25% capital subsidy on fixed cost for BS stations up to Rs 6 lacs (excluding land cost)

Bihar (2019)

Robotic arms will be established at Public Bus Stations for BS

Madhya Pradesh (2019)
- PCS must have standalone BS facility
- At identified locations, EOs will be invited through bidding to set up BS stations
- 25% capital subsidy on charging equipment/ machinery up to maximum subsidy amount
- Incentives for setting up BS stations in existing private buildings
- Rental holidays for EOs & V2G sale of power
- Open Access & Net Metering for BS stations with RE integration

Andhra Pradesh (2018)
- 25% capital subsidy on fixed cost up to 10 lacs (excluding cost of battery inventory) for first 50 BS stations
- 100% SGST reimbursement on advanced batteries
- V2G sale of power for BS stations

Kerala (2019)
- 25% capital subsidy on fixed cost up to 10 lacs for first 50 BS stations
- KSEB Ltd will establish first 150 BS stations for e-2Ws & e-3Ws

States with Approved EV Policies *States with Draft EV Policies*

Source: WRI India authors

DISCLAIMER: This map is for illustrative purpose and does not imply the expression of any opinion on the part of WRI, concerning the legal status of any country or territory or concerning the delimitation of frontiers or boundaries.

WRI INDIA — ROSS CENTER

India - Standards

- In India, there have been calls to develop battery swapping standards for light electric vehicles and buses.
- The standardization will address battery form factor, connector, battery nominal voltages and communication protocol.

Thailand – Policies and Regulations

To achieve the goals of the EV roadmap, the National Energy Policy Board has set three operational:

1. Phase 1 (2015–2017): Incentives, standards, electricity retail prices, and regulations of EVs were issued.
2. Phase 2 (2018–2020): The government would support investment in EV infrastructures.
3. Phase 3 (2021–2036): Expanding the EV usage and infrastructure across the country. A target of 80,000 charging stations by 2035 with individual charging stations being located no more than a 50-70 km radius from one another.

- The National New Generation Vehicle Committee (Under Thailand's Ministry of Industry) has approved incentives for EV charging and battery swapping businesses.
- Summary of the incentives include:

a) EV batteries – pack assembly (corporate income tax exemption for 5 years). Module production (corporate income tax exemption for 8 years). Cell production (corporate income tax exemption for 8 years). Ninety percent (90%) reduction of import duties on raw/essential materials for 2 years.

b) EV charging station - Corporate Income Tax (CIT) Exemption for 5 years. Exemption of import duties on machinery

- Regulation of EV charging rates - In March 2020, the approved the tariff of around US$ 0.079 /kWh, which made the operational costs of an EV cheaper compared to internal combustion engine vehicles.
- The National Science and Technology Development Agency (NSTDA) has formed a consortium with nine other institutions to develop a battery swapping platform for electric motorcycles**.** The consortium aims to (NSTDA, 2021):

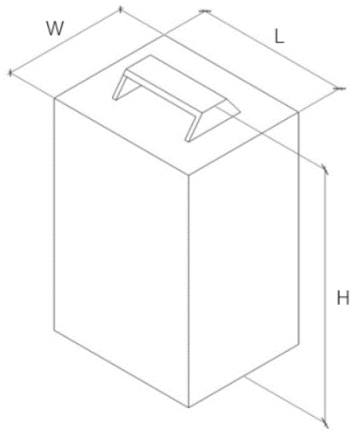
1. In collaboration with other stakeholders, define a standard battery swapping platform for motorcycles.
2. Design and develop a standardized battery pack that will fit universally across motorbike types and brands as well as a standard charging station.
3. Test the prototypes of the standardized battery pack
4. Formulate recommendations on industrial standards, regulations and business models for battery swapping stations.

Thailand - Standards

- Thailand has developed a national standard for battery packs and adopted the IEC 62840 standard which gives the general overview for battery swap system (BSS) of electric road vehicles (EVs).
- A consortium led by NSTDA defined a standard battery swapping platform for electric motorcycles and developed a standardized battery pack that will fit universally across motorbike types and brands.
- TITI 3316-2564 – This standard covers, Rechargeable Electrical Energy Storage System (RESS) for electric mopeds and motorcycle which can be taken out from vehicle for off-board charging.

Category [by voltage]

- 48V [in the range of 48 V - 52V]
- 60V [in the range of 60 V - 66V]
- 72V [in the range of 72 V - 72V]



dimension of battery

Voltage 48 V to 60 V

Side	L	H	W
mm	160	180	300

Voltage 72 V

Side	L	H	W
mm	180	220	300

Recommendations

Recommendations	Person Responsible
1. Interoperability of: •Payment Options – Use of different RFID cards. •Network - Open charge point protocol (OCPP) a standard used in Europe	Private Sector
2. Develop a national guideline on battery swapping for 2&3 wheelers	Ministry of Transport
3. Development of Kenyan standards on charging infrastructure and battery swapping	KEBS
4. Industry players to form a consortium	Private Sector
5. Government incentives – fiscal (land & concessional rates, taxes) and non – fiscal (streamline license process).	Government
6. EV Tariffs – To reduce the cost of electricity purchase by the CPOs which in turn results in lower charging costs for consumers.	Kenya Power
7. Repurpose EV batteries after the end of first life (< 80% state of health) to second life use in renewable energy applications such as solar PV battery energy storage.	EPRA/KEBS
8. Development of Battery Testing Laboratories	Government/Private Sector

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