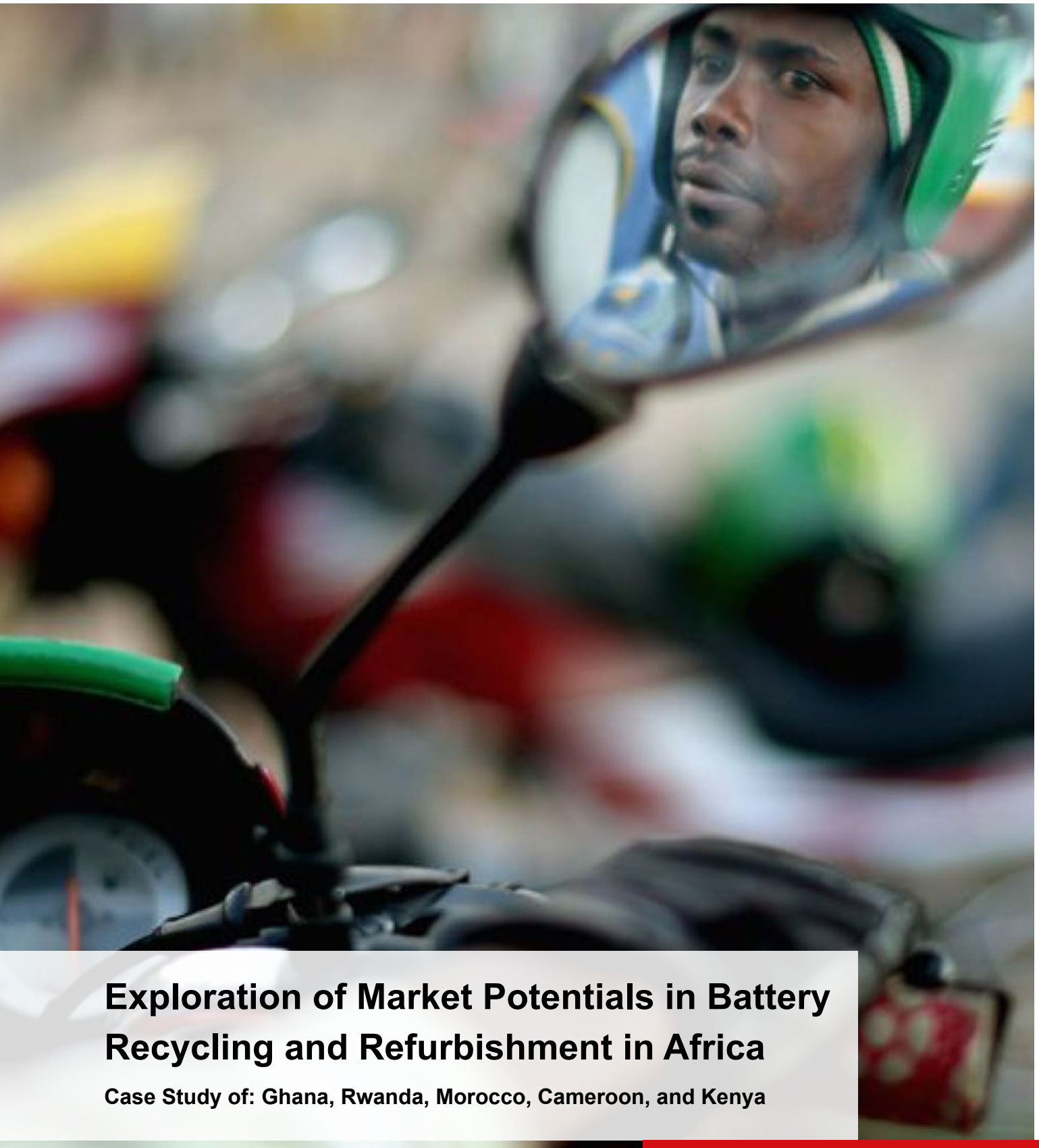

Exploration of Market Potentials in Battery Recycling and Refurbishment in Africa

Case Study of: Ghana, Rwanda, Morocco, Cameroon, and Kenya

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Chapter 1: Abstract

Due to the increasing relevance of lithium-ion batteries, the downstream elements of the battery life cycle are increasingly becoming more important. In addition to recycling, policy-makers, producers and consumers also need to consider the topics of reuse and refurbishment. **Reuse** refers to the usage of aged batteries from the mobility sector in other applications, such as stationary storage systems. **Refurbishment** refers to the extension of a battery's first life, for example by replacing individual, heavily aged modules. In recycling, a distinction is made between pyrometallurgy, hydrometallurgy and direct recycling. **Pyrometallurgy** refers to the heat-based and **hydrometallurgy** to the chemistry-based separation of battery materials to recover its basic elements. **Direct recycling**, on the other hand, only removes foreign materials while retaining the battery material composition. All these different scenarios for lithium-ion batteries can be developed as potential business cases and applications, with different important factors such as labor requirements, benefits and potential barriers noted for each.

This white paper provides an analysis of these potential business cases in five different countries: Ghana, Rwanda, Morocco, Cameroon, and Kenya, highlighting how each country presents unique opportunities and challenges for each of the business cases.

In general, the African continent offers specific advantages and disadvantages for battery recycling and refurbishment that are included in the analysis at hand. From this, a short-, medium- and long-term strategy for dealing with batteries is derived.

SOLAR PANELS IN AFRICA
Source: © GIZ/JAMES OCHWERI

Short-Term

The re-use of old battery systems or modules for stationary storage systems will be the business case that will be implemented the easiest. The actual need is alreadys exisiting since there are many off-grid communities in Africa.

With solar energy as the cheapest energy source that does not require significant investments, it seems to be one of the most promising paths for various African countries to electrify their infrastructure and provide electricity to their population.

To store such inconsistent energy, storage systems can be built from used electric vehicle (EV) batteries. Apparently, such systems are already produced in the European market.

Medium-Term

The refurbishment of used electric cars presents the business case with the highest potential. There is an existing infrastructure to import old combustion-engine cars as well as two-and-three wheelers from all over the world to African countries where they are utilized for many more years.

This could very well also be the case for electric cars and electric two-and-three wheelers.

Like combustion-engine cars, electric vehicles need refurbishment in order to deal with degradation of their battery system.

Many African countries rely heavily on imported motorcycles, tuk-tuks, and other smaller vehicles to provide affordable transportation for their citizens and have a very strong potential to keep growing.

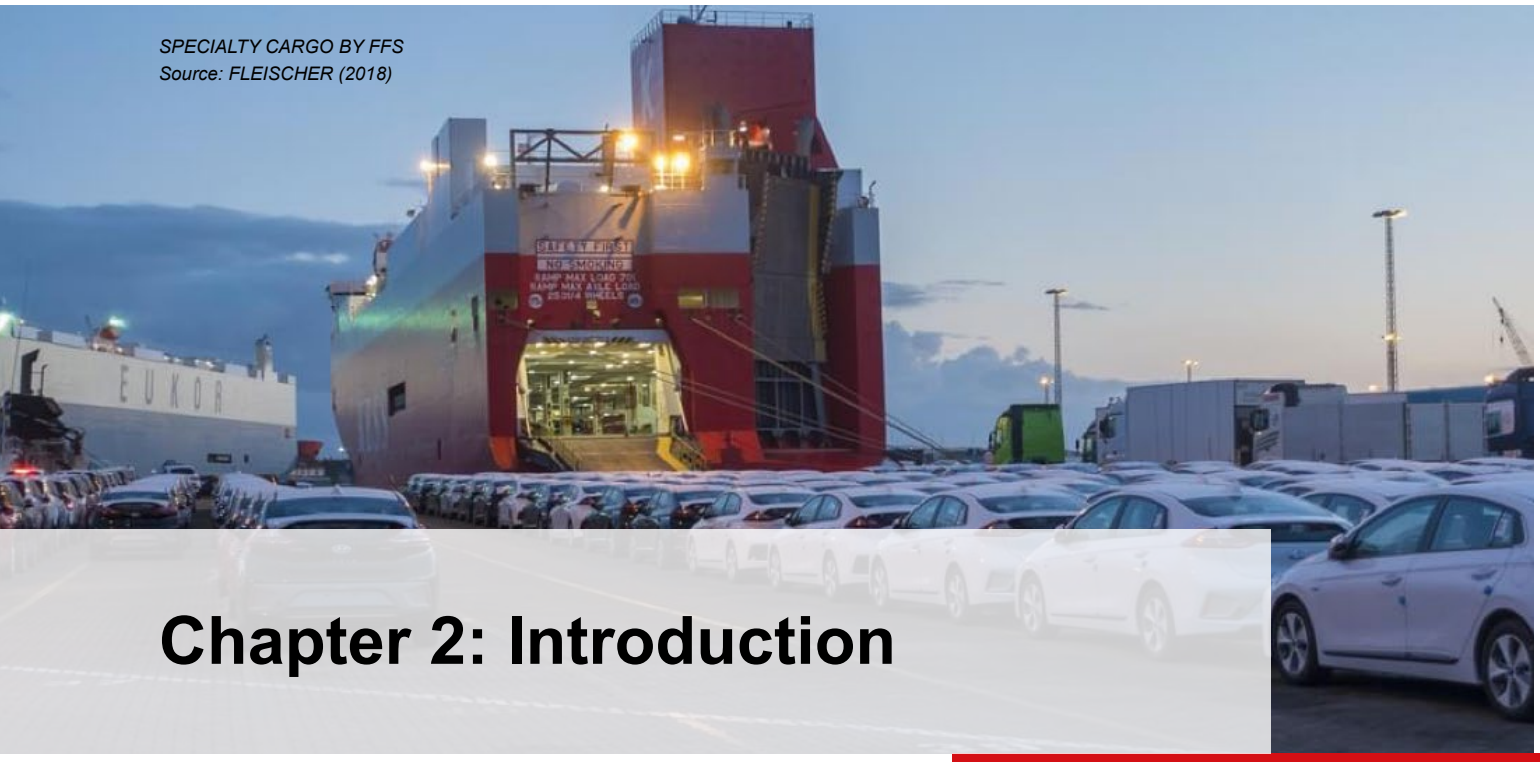
TUK-TUK IN KENYA
Source: © GIZ/JAMES OCHWERI

LITHIUM BATTERIES
Source: UNSPLASH (2017)

Long-Term

In the long run, the recycling of batteries holds the highest potential for Africa. Even though this has not gained related attention just yet, the African continent has the potential to become a major recycling hub. The main driver for this is the availability of resources, including almost every important battery material.

This will likely lead to a big part of the refining industry settling in African countries long-term when those nations try to minder their reliance on foreign countries. Therefore, most of the value chain for precursors and cathode material could be placed in Africa, which benefits the implementation of recycling facilities since the processes and know-how of these fields tend to overlap.



SPECIALTY CARGO BY FFS
Source: FLEISCHER (2018)

Chapter 2: Introduction

Lithium-ion batteries play an important role in building a CO2-neutral world by making it possible to store electrical energy. Batteries are required for electric mobility and allow for the storage of energy generated from volatile renewable sources. In recent years, the increasingly mature battery production technology has led to a significant decrease in the price of lithium-ion batteries. This has led to an exponential increase in the number of lithium-ion batteries produced since 2010, and this trend will likely continue (Dusseldorp: Kampker, 2022). However, like any other battery type, lithium-ion batteries cannot be used indefinitely, as they deteriorate over time, until, eventually, they reach the end of their life (Yi, Zhenxiao, 2022). Accordingly, it is foreseeable that in the near future, large quantities of batteries – which in many cases contain harmful materials – will have to be recycled to prevent environmental damage (Gaines, Linda, 2021). The existing materials in batteries are essential for the production of new batteries, as the increase in extraction capacity in the coming years is not expected to keep pace with the growing demand for such materials (Tankou, Alexander, 2023). In the long term, in a world with limited resources it is also imperative to build sustainable material cycles. Therefore, it makes sense to look at the life cycle of a battery beyond its production and use.

The public debate currently focuses on the upcoming challenges of battery recycling, overlooking the opportunities: With a growing and increasingly educated labor force, Africa can win the upcoming business field for itself. Particularly, African countries that are rich in resources have the opportunity to become significant players in green technologies and should position themselves to benefit from this value creation in their own countries in order to benefit from the restructuring of the global economy as a result of decarbonization.

This paper focuses on the business cases around three main areas of battery lifecycle including battery recycling, battery reuse, and battery remanufacturing. Chapter 3 describes the common use cases for lithium-ion batteries before discussing possible business cases in chapter 4. Chapter 5 presents five African countries under consideration while chapter 6 matches them with the previously defined business cases to showcase the potential in these countries.

AMPERSAND
Source: ESI-AFRICA.COM

Chapter 3: Fundamentals of Lithium-Ion Batteries

A lithium-ion battery is a type of rechargeable battery that uses lithium compounds in all of its three parts: the anode, the cathode and the electrolyte. It has a higher energy capacity than other types of batteries, which makes it ideal for applications where a lot of energy needs to be stored in a small space or weight, such as in smartphones, laptops, and electric vehicles. (Doppelbauer, Martin, 2020)

The lithium-ion battery describes a group of batteries whose common feature is the use of solid, structurally stable materials in both the positive and negative electrodes that can absorb and release lithium. When charging and discharging the battery, these charged lithium atoms, called “ions”, shuttle back and forth between the electrodes in a liquid medium called “electrolyte”. This concept is also called “rocking chair battery” due to the atoms’ movement. A variety of elements can be used in the materials for the electrodes. Particularly the choice of cathode material still varies greatly today and has a significant influence on the performance characteristics of the battery. While graphite has become the most widely accepted material on the anode side, various compositions of metal oxides are used as cathode materials. The most used metals for this purpose are cobalt, manganese, nickel, iron, and aluminum as mixtures.

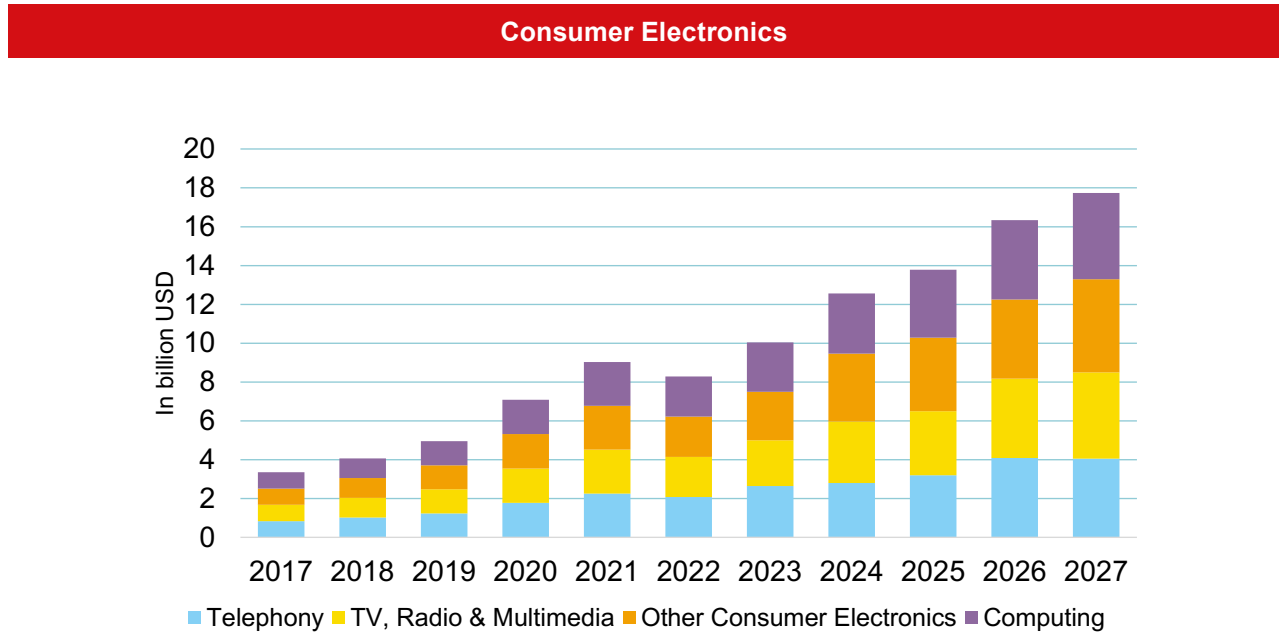
The concept of the lithium-ion battery was developed in the 1970s, but the first industrial implementation was only achieved in 1985 by the Japanese chemist Akira Yoshino who was employed at the chemical company Asahi Kasei. The battery became commercially available for the first time in 1991, when Sony used it in a video camera. Since then, it has found great success in consumer electronics such as laptops, mobile phones and cameras, and then enabled the implementation of electric vehicles from 2010 onwards.

The three most import areas of application for lithium-ion batteries are:

1. **Consumer electronics**
2. **Battery-electric vehicles**
3. **Stationary storage systems.**

Consumer Electronics

Most consumer electronics today are powered by a lithium-ion battery. This includes mobile phones, laptops, cameras, tablets, smart watches, and many more. The consumer electronics markets in Europe and in the US have seen a sharp rise in the early years of the 21st century first decade due to the availability of lithium-ion batteries but have saturated in the last years. The African market has risen significantly in the last years and is projected to grow even stronger in the next decade, as can be seen in the following chart. (Statista, 2023)



CONSUMER ELECTRONICS USAGE IN AFRICA FORECAST
Source: STATISTA (2023)

Battery-Electric Vehicles

Electric cars were invented over a hundred years ago, but only recently, with the development and availability of cheap lithium-ion batteries, reasonable ranges have been possible. The first commercially available electric vehicles (EVs) were introduced in 2004 by Tesla and in 2010 by Nissan, but due to their high prices and the low prices of petrol for conventional cars, they remained a niche product for quite some time. In the last years, EVs have become more financially competitive. With growing awareness of the importance of carbon neutral technologies, EV sales are growing exponentially (Energy Saving Trust, 2021).

Six countries make up around 70% of the annual vehicle sales in in Sub-Saharan Africa: South Africa, Kenya, Rwanda, Uganda, Ethiopia, and Nigeria. By 2040, their vehicle park is expected to more than double, with used vehicles from other continents dominating. Even though the African market has not seen significant amounts of electric cars yet, there are notable developments such as Rwanda's announced tax exemptions for electric vehicles or South Africa's ban on imported used petrol-powered cars. There is a growing number of EV start-ups in the region that are trying to bring electric vehicles – often two or three-wheelers – to the African market. (Lukuyu, 2022)

This is especially important since EVs have the advantage of producing no local emission. Africa boasts densely populated cities, leading to local communities benefitting from emission-free transportation alternatives. (Yinying, 2012; Dioha, Michael, 2022)

ELECTRIC THREE-WHEELER IN AFRICA
Source: EEP AFRICA (2022)

Stationary Storage Systems

In recent times, lithium-ion batteries have found applications in stationary storage systems. These systems can store energy generated from renewable solar and wind sources, which can later be utilized during periods of high energy demand or when the renewable source is insufficient. In Africa, this is especially important for smaller communities that are not yet connected to the electricity grid and must rely on off-grid solar systems. For these, energy storage systems are needed to enable round-the-clock energy supply.

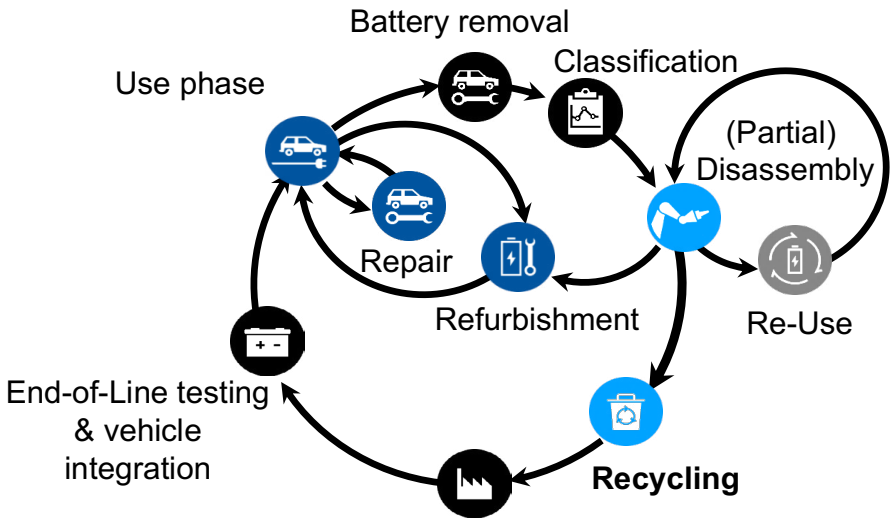
Examples of off-grid solar companies already working with stationary storage systems in Africa by being service providers are Angaza, Musoni, Sollaris Offrid, Frontier Markets, Enable Digital, and others. Manufacturers include Niwa, SolarWorx, BioLite, Barefoot Power, and more. (Off-Grid Solar Market Trends Report, 2022)

An increasingly important area of application for lithium-ion batteries is EVs. Over their operational lifespan, batteries experience continual aging due to various factors, leading to capacity loss. One metric used to quantify this is the State of Health (SoH). This expresses how much capacity the battery still has in relation to its original capacity, and it is expressed as a percentage. If the SoH of a battery falls below approximately 80%, it is generally no longer suitable for use in a vehicle, since the power output decreases as well as the range of the vehicle. However, those batteries can still be used before they need to be sent to recycling. Often some of the modules as sub-parts of the battery no longer have sufficient capacity, and by replacing them, the battery's life can be prolonged. This process is called "remanufacturing".

If most of the modules have a SoH of approximately 80% left, the battery can still be used for purposes in which its power and energy density play a less important role. This would be the case with stationary battery storage in combination with renewable energy sources. With a SoH of about 50%, batteries are generally no longer suitable for this use either and must be recycled to close the battery life cycle shown in the following graph.

In order to guarantee that the batteries are handled according to the described cycle, it must be ensured that there is an economically viable business case in each part of the life cycle. This paper will go into detail about the business cases of recycling, reuse and refurbishment.

Battery Life Cycle

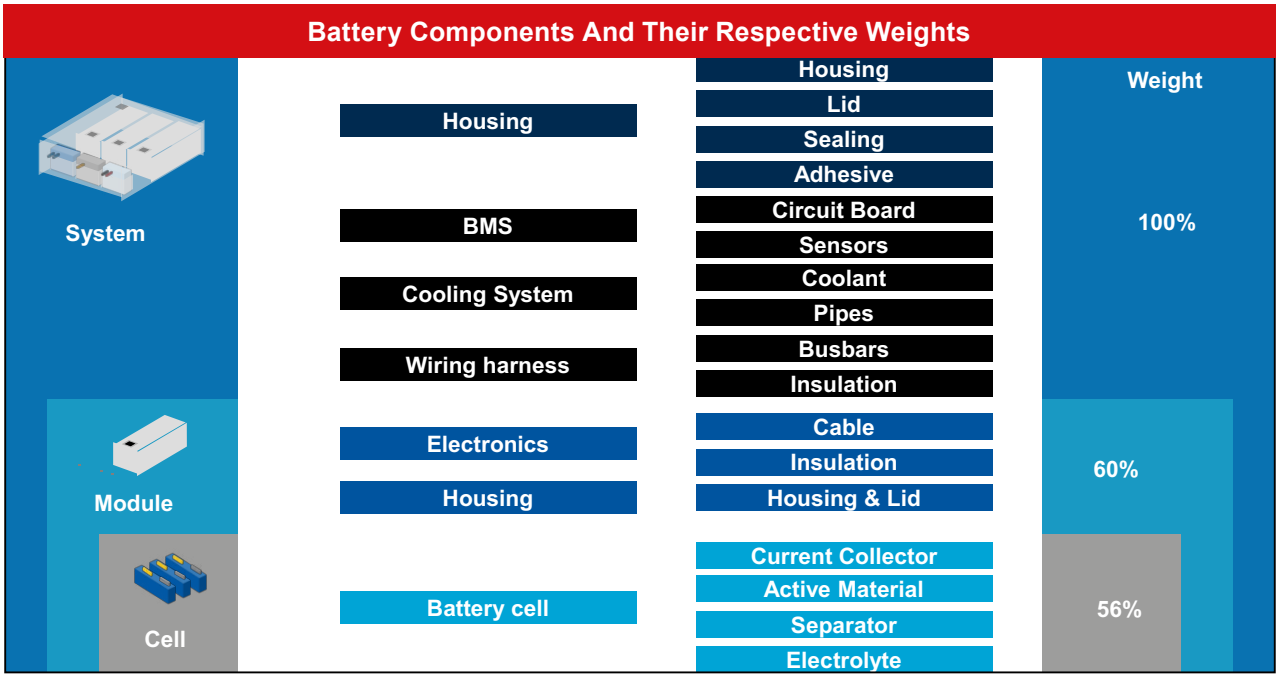


BATTERY LIFE CYCLE AND ITS INDIVIDUAL PROCESSES

Source: PEM OF RWTH AACHEN UNIVERSITY (N.D.)

Recycling generally refers to the reprocessing and reuse of materials. A battery consists of a variety of raw materials, and to comprehend what is important in recycling batteries, it must first be understood which materials are found in a battery and what the value of each of these materials is.

Generally, a battery consists of a protective housing in which the electronics and the battery modules are installed. These modules again consist of a housing in which the battery cells are placed. These cells in turn consist of an anode, a cathode and a separator, which are again protected by a housing. While the housings are usually made of steel or aluminum, the anode is usually made of graphite, and the cathode is made of a mixture of different metals. This mixture varies depending on the type of battery, but it usually contains nickel, cobalt, manganese, and lithium. The cells make up just over half the weight of the battery, as Figure 7 shows:

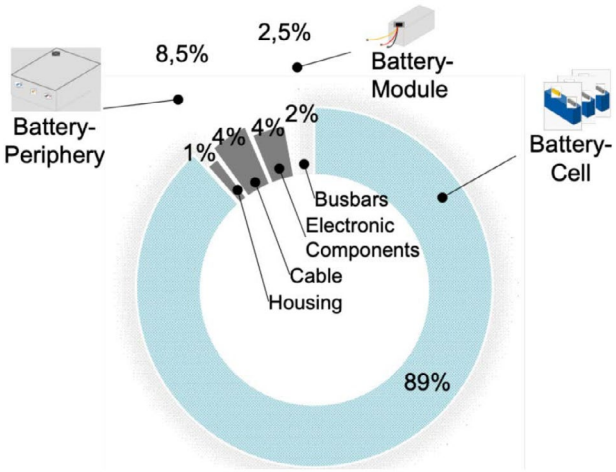


BATTERY COMPONENTS AND THEIR RESPECTIVE WEIGHTS

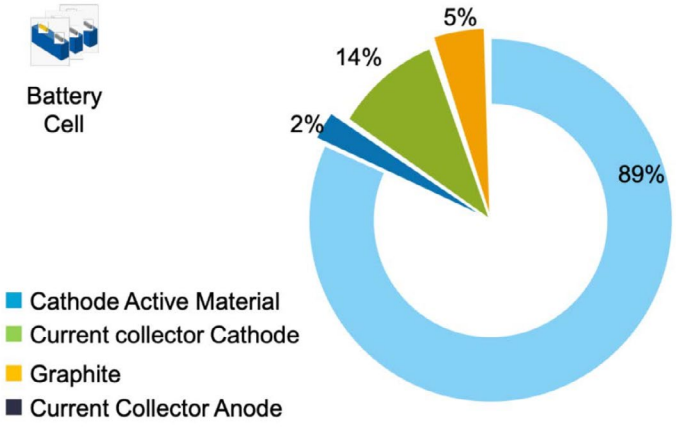
Source: PEM of RWTH AACHEN UNIVERSITY (N.D.)

However, if we look at the value of the materials they contain, the proportions are shifted. Almost 90% of the material value is contained in the battery cells, and of this almost 90% is accounted for by the cathode materials, as shown in the graphs below. Accordingly, established recycling paths focus primarily on the recovery of these materials. The European Union (EU) describes critical materials in their annual report – and all of the above-mentioned metals find themselves on this list. Consequently, the new “EU Battery Directive” specifies minimum recycling efficiencies for these raw materials. (German Federal Ministry for Economic Cooperation and Development, 2023)

Estimation of Material Values at Cell Level



Estimation of Material Values at Cell Level



MATERIAL VALUES PERCENTAGE AT CELL AND BATTERY LEVEL Source: PEM of RWTH AACHEN UNIVERSITY (N.D.)

BATTERY ASSEMBLY
Source: CLEAN TECHNICA (2020)

Chapter 4: Business Use Cases in Recycling

4.1 Types of Recycling

Although there is a wide variety of process routes with a lot of possible variations, three main approaches for battery recycling can be identified: hydrometallurgical recycling, pyrometallurgical recycling, and direct recycling.

In **pyrometallurgical recycling**, batteries are heated strongly so that a large part of the material melts. The different melting points of the components make it possible to recover copper, nickel, and cobalt in an alloy which must then be processed further before the metals are suitable for battery production again. Other materials contained in the battery, such as aluminum and lithium, form a so-called slack that usually cannot be processed further in an economical way. It can only be downcycled and used as a building material, for example in roads. (Kampker, 2021, Recycling of Lithium-Ion Batteries)

Hydrometallurgical recycling is based on chemical rather than physical processes. First, the battery is dismantled and shredded. Then, the cathode materials are separated from the remaining materials using various separation processes. The resulting product is called “Battery Active Material Mixture” (BAMM) or “Black Mass”. The individual metals are then dissolved out of this material using various strong acids and are afterwards crystallized. The materials obtained in this way can be used again directly to produce new batteries. (Kampker, 2021, Recycling of Lithium-Ion Batteries)

The cost of hydrometallurgical recycling of batteries can vary depending on the specific process and the type and quantity of batteries being recycled. According to a report by the European Commission, the cost of recycling a tonne of lithium-ion batteries using hydrometallurgical processes can range from €3,000 to €5,000. This amount includes all steps of the recycling process, such as collection, sorting, and treatment.

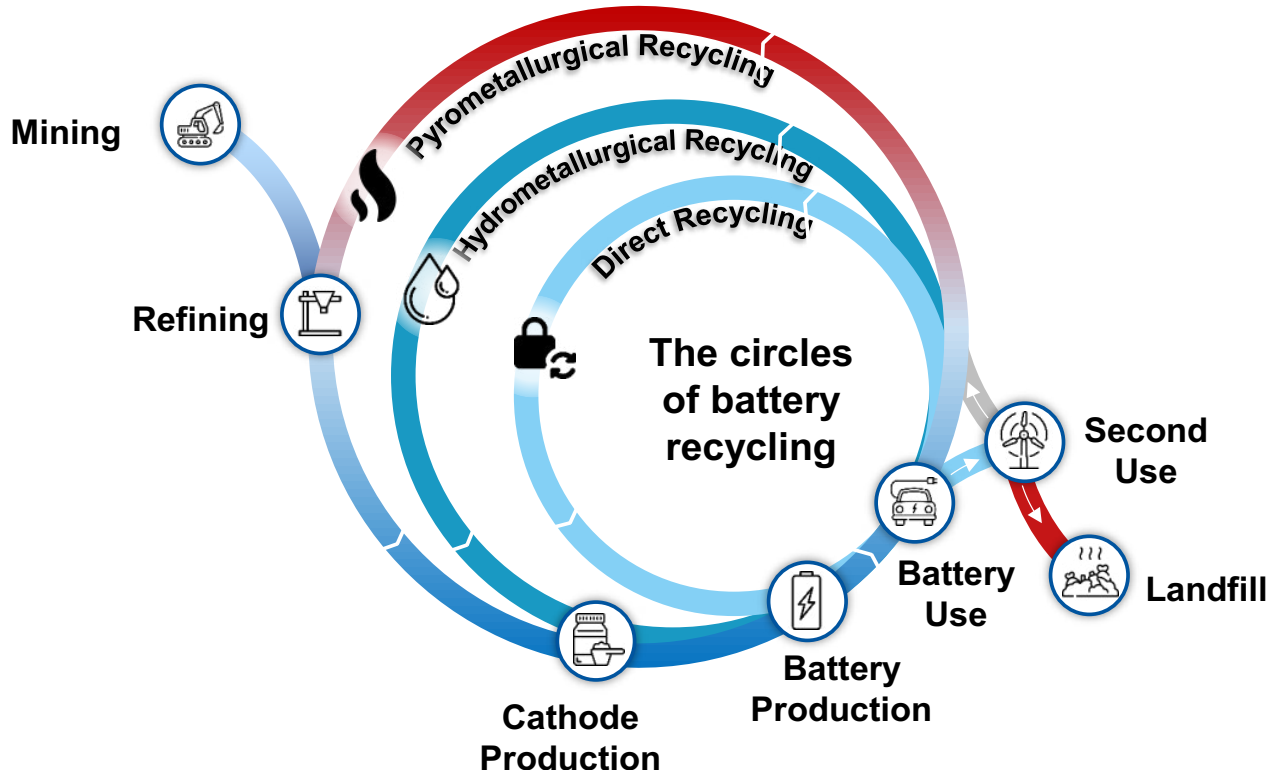
A newer method of recycling is the so-called **direct recycling**. The aim of this process is to retain the material composition of the cathode material and not to break it down into its individual chemical elements. After the physical shredding of the battery and the separation of the battery materials, the material is accordingly only reprocessed and thus to be used again directly in production.

GREEN & WHITE PLASTIC BOX
Source: UNSPLASH (2020)

The reprocessing mostly consists of a re-lithiation in which missing lithium ions in the lattice structure of the metal are replaced. The prerequisite for direct recycling is that only batteries of one battery type are fed into the process at the same time to ensure the correct composition of the cathode material. Direct recycling is a promising approach, but it is not yet applied on a large scale, as the processes have mostly only been tested on a laboratory scale.

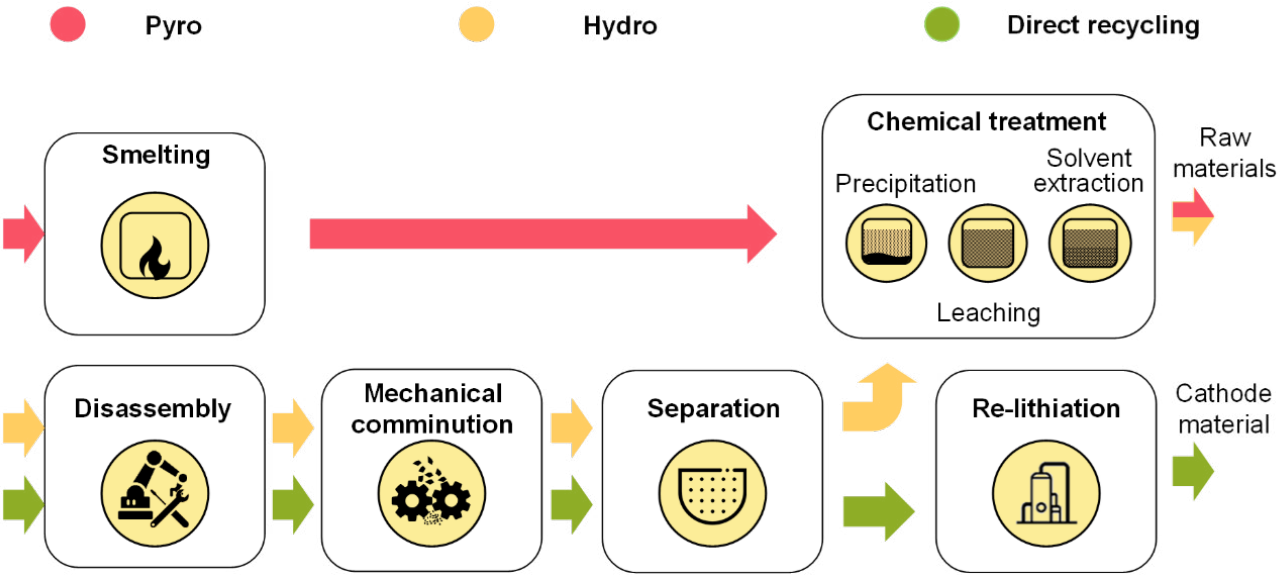
One possible field of application for direct recycling is the recycling of process waste from battery production, also known as “production scrap recycling”. The advantage here is that it can be ensured that only batteries of one battery type are used and that there is no need for re-lithiation, as these are batteries that have not yet been used. (Gaines, Linda, 2021, Direct Recycling R&D at the ReCell Center)

The Main Loops Of Battery Recycling



THE MAIN LOOPS OF BATTERY RECYCLING
Source: RWTH AACHEN UNIVERSITY (N.D.)

Each process route or chain consists of several sub-processes which subsequently can be performed through different technologies. Figure 10 shows the sub-processes for each recycling route and gives a rough estimation on how much energy and labor is required to perform the tasks.



PROCESS ROUTES FOR PYROMETALLURGICAL, HYDROMETALLURGICAL AND DIRECT RECYCLING

Source: RWTH AACHEN UNIVERSITY (N.D.)

Smelting

Smelting is a process that involves heating the batteries to high temperatures in a furnace to extract valuable metals like cobalt, nickel, and lithium. The batteries are fed into a furnace along with a reducing agent, which is usually a carbon-based material like coke or charcoal. The furnace is heated to temperatures of around 1,000°C, which causes the reducing agent to react with the metal oxides in the batteries, reducing them to their pure metal form.

As the metal oxides are reduced, they separate from the other materials in the batteries and form a molten liquid that collects at the bottom of the furnace. This liquid metal is then tapped off and poured into molds to form ingots or other shapes.

Disassembly

The disassembly of a battery for recycling involves the careful removal of all the components and materials that can be recycled or reused. Due to the wide variety of battery designs, this is often carried out manually.

Mechanical Comminution

Mechanical comminution typically involves the use of specialized machines called “shredders” which are designed to tear, crush, or cut the materials into smaller pieces. The shredders can be designed to handle different types of materials and can vary in size and complexity depending on the intended application.

Seperation

The crushed material then needs to be sorted, so that battery active materials are separated from non-active materials like plastic, aluminum, or copper. This can be done by severing, density separation, magnetic separation, or other techniques.

Re-Lithiation

Re-lithiation is a process of reintroducing lithium ions into a lithium-ion battery's cathode material which has lost its ability to store, and release.

Precipitation

Precipitation is a process that involves the formation of a solid from a solution, usually through a chemical reaction. It occurs when the solubility of a substance in a solution is exceeded, and the excess material comes out of the solution and forms a solid precipitate.

Solvent Extraction

In solvent extraction, a liquid solvent is added to a solution containing the desired compound or metal. The solvent is chosen based on its ability to selectively dissolve the compound of interest. When the solvent and solution are mixed, the compound of interest is selectively extracted into the solvent, leaving behind other unwanted compounds and impurities in the original solution.

Leaching

Leaching is a process used to extract a substance from a solid material by dissolving it in a liquid. In leaching, the solid material is placed in a container, or a heap and a liquid solvent is passed through it. The solvent dissolves the desired substance which then forms a solution with the solvent. The solution is then collected and processed to extract the substance of interest.

4.2 Business Cases

Across the battery life cycle, there are multiple possible business cases. Five of these are described in detail in this report.

4.2.1 Reuse of Old Electric Vehicle

As described above, batteries are usually used in vehicles until they still have about 80% of their original capacity. Then, they are no longer suitable for operation in the vehicle because, on the one hand, the range of the vehicle is limited and, on the other hand, because the battery ages more quickly than before due to the heavy use in the vehicle from approximately 80% SoH. However, the battery can still be used for other applications. Either they can be utilized as a complete unit, or the individual modules of the battery can be removed and used separately. The former has the advantage that the battery is immediately ready for use and the existing electronics, such as the battery management system (BMS), can continue to be used. However, the disadvantage is that the shape of the battery is often adapted to the vehicle and is correspondingly difficult to handle. If the modules are taken individually, they can be optimally packed for the new application, but the surrounding electronics must be reconfigured.

A common application for so-called second-life batteries is stationary battery storage. These can serve either to stabilize the grid or to store electricity from renewable sources.

Labor

As the batteries must be disassembled down to module level for hydrometallurgy, the labor-intensive process of disassembly is also involved, which was described previously. Apart from this, the process is automated and requires no further manual labor. Chemical, mechanical and process engineers are needed to develop and monitor the processes.

Opportunities

- Chemical processes are similar to those used in native material processing, which is common in African countries.

Challenges

- Only economically viable on large scales, which will be hard to achieve in the short and middle term.

4.2.2 Refurbishment of Old Electric Vehicle Batteries

In highly developed countries, cars are usually only used for about ten to 15 years before they are replaced with a new model. Many of these no longer needed vehicles are then shipped abroad, often to Africa, and used there for years to come. This trend has been observed with conventional vehicles for many years and could also become common with electric vehicles. However, the challenge is that old batteries cannot be used indefinitely, and measures are needed to counteract the aging of batteries. One of these measures can simultaneously represent an opportunity for a business model. In the case of batteries that only have a SoH of 80% on average, it is often only individual modules that are already at such a low level, while many other modules still have a SoH of 90% or higher. However, since the principle of the weakest link applies to a battery, the battery as a whole only has a low capacity. By replacing the weak modules with stronger modules from other batteries, the battery's life can be extended, and the vehicle can be used in the African market for years to come.

Labor

Compared to the first business case, refurbishment is even more labor-intensive. Employees with similar education backgrounds as for reuse are needed for dismantling in order to replace the broken modules. Trained electronics technicians are needed to ensure diagnosis and professional replacement without impairing the battery's operational capability. The vehicles must also be checked for general roadworthiness, for which vehicle mechatronic technicians are needed.

Opportunities

- Labor-intensive manual disassembly is more economically viable in countries with low labor costs.

Challenges

- Without political incentives, electric cars could still be more expensive than their conventional counterparts.

- Handling old batteries can be a safety issue and needs to be treated carefully in order to minimize risks.

- Without a charging infrastructure, the demand for electric vehicles will be low.

4.2.3 Recycling

4.2.3.1 End-of-Life Recycling (Hydrometallurgical)

"End-of-Life" (EoL) batteries refers to batteries that have reached the end of their usefulness and/or lifespan and no longer operate at sufficient capacity. (Guia, 2021) In EoL recycling, the battery is broken down into its individual components according to the processes mentioned above. These metal salts can then be sold.

Labor

As the batteries must be disassembled down to module level for hydrometallurgy, the labor-intensive process of disassembly is also involved, which was described previously. Apart from this, the process is automated and requires no further manual labor. Chemical, mechanical and process engineers are needed to develop and monitor the processes.

Opportunities

- Chemical processes are similar to those used in native material processing, which is common in African countries.

Challenges

- Only economically viable on large scales, which will be hard to achieve in the short and middle term.

4.2.3.2 End-of-Life Recycling (Pyrometallurgical)

The battery is broken down into its individual components according to the processes mentioned above. These metal alloys can then be sold.

Labor

In pyrometallurgy, disassembly is usually omitted, which means that even more parts of the process are automated. Here, too, chemical engineering and process technology are needed for the development and monitoring of the process, although the focus here is more on metallurgy.

Opportunities

- There are low investment costs needed in pyrometallurgy.

- Reliable processes are similar to those used in metal processing, which is common in African countries.

Challenges

- The process is very energy-intensive, which is commonly powered by natural gas.

- Lithium and Aluminum are lost in the slack and can only be downcycled.

4.2.3.3 Production Scrap Recycling (Direct)

Particularly in the ramp-up phase of battery production, many production rejects are produced that contain valuable battery materials. Recycling these is easier than recycling end-of-life batteries, as they do not have to be collected first, are sorted by type and contain fewer peripheral elements that have to be sorted out. These recycled metals can then be directly reused for production, so less new material needs to be purchased.

Labor

Like battery production, the direct recycling processes involved are highly automated and require no manual labor. Here, too, chemical engineering and process technology are needed for the development and monitoring of the process.

Opportunities

- Simpler processes that tend to have higher recycling efficiency and lower foreign material content.

Challenges

- There are currently only a few battery production facilities in Africa

Source: © GIZ/JAMES OCHWERI

Chapter 5: Country Profiles

Ghana

Capital:
Accra

Offical langauge:
English; more than 10 further recognized langauges

Population:
33,475,870 (2022)

Area:
238,535km²

GDP nominal*
75.9 billion USD

GDP per capita*
2,363.30 billion USD

Offical currency
Cedi: 1 USD equals 12.29 Cedi**

Location:

Ghana is a country in West Africa, bordered by Côte d'Ivoire, Burkina Faso, Togo, and to the south by the Gulf of Guinea as part of the Atlantic Ocean. Its area is almost as large as the United Kingdom, with whose history it is closely linked through colonialization.

Therefore, the official language of Ghana is English. Ghana has a flat landscape that only reaches heights of 900 meters in a few places. About half of the country lies below an altitude of 150 meters. The coast has a length of 543 kilometers. Ghana is geographically divided into coastal plains, rainforest, and savanna.

The country has about 33,475,870 million inhabitants and is divided into ten administrative units, comparable to the federal states in Germany. The capital of Ghana is the metropolis of Accra in the south. The second city with a population of over a million is Kumasi, located rather centrally. Ghana is a tropical country, so it has no seasons, but alternates between rainy and dry periods of time. Almost equally long days and nights determine life. Roughly, the climate can be divided into the humid south with its evergreen rainforest areas and the drier north with its tree savanna, shrub savanna, and the grass savanna in the northernmost part. (Planet Wissen; Learn Helfer, n.d.)

Globally, Ghana is economically important because of its wealth of raw materials. Gold, which also gave the former colony the name "Gold Coast," is Ghana's most important export commodity. About one third of export earnings and 93% of the mining sector's production are related to the extraction of gold. (Planet Wissen, n.d.)

With its multiparty system, independent judiciary and freedom of the press, the country serves as a model for the entire continent. Economic dynamics, on the other hand, suffer from high national debt and rising inflation. The investment climate has deteriorated in recent years due to currency decline, corruption, and a shortage of foreign currency.

“Ghana looks back on 30 years of political stability and is rightly regarded as the ‘democratic lighthouse of Africa.’ In addition, Ghana has been among the top group of the world’s fastest growing economies in recent years.”

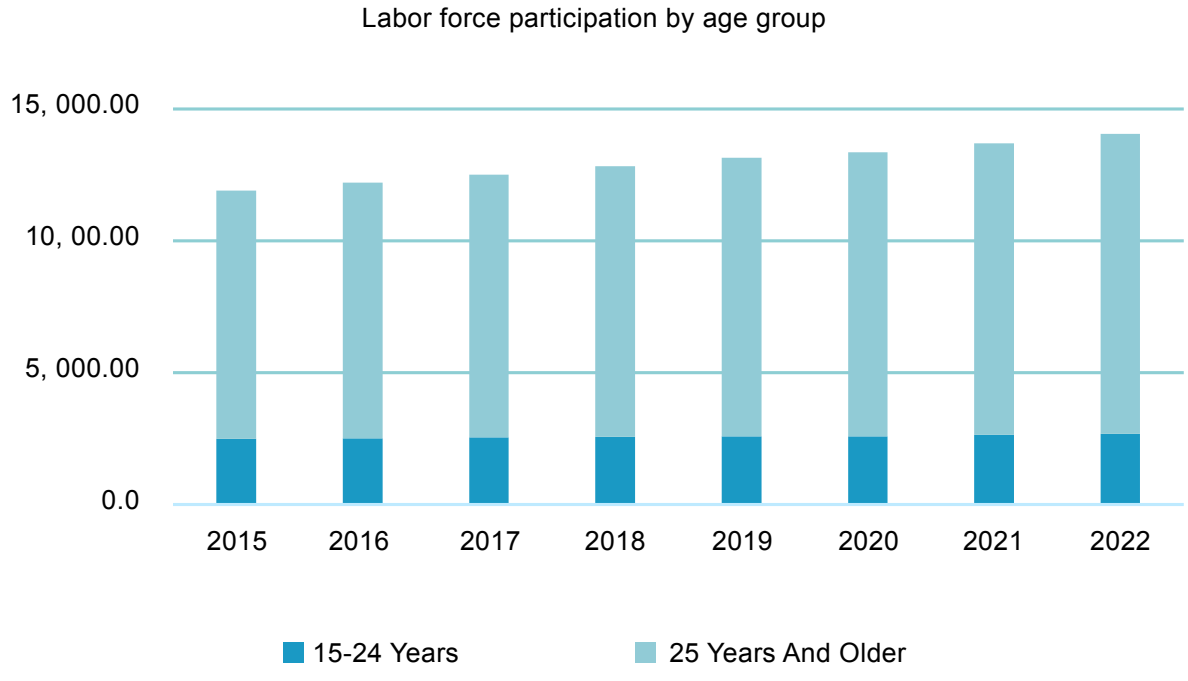
Burkhardt Hellemann, Delegate of the German Economy in Ghana
(Business Guide Africa, n.d.)

Mining, the service sector, and agriculture continue to develop positively. Ghana’s goal is to become less dependent on food imports and to expand food production. In the medium term, expansion in the transport, energy and health sectors offers opportunities. (Business Guide Africa, n.d.)

Workforce in Ghana is largely made up of 25-year-olds or older people and has grown significantly over the past few years. Ghana’s higher education landscape is undergoing a period of massive expansion. While only six public universities existed in Ghana in 1994, the tertiary education sector has a total of 205 universities, colleges, “polytechnics” and other institutes (public as well as private) recognized by the National Accreditation Board, according to figures from June 2019.

Universities are institutions of higher learning that offer the widest possible range of subjects and provide research opportunities in addition to education. Two- to three-year “polytechnics” offer post-secondary education in the technical field, and “colleges of education” offer subject-specific national diplomas in various subjects (languages, agriculture, nursing professions, etc.). These diplomas can be used either to start a career or – assuming a good degree – to continue studies at a university. A similar rising trend applies to Ghana’s student numbers, with an increase from over 240,000 to 443,693 between 2009 and 2018. These developments are accompanied by an increasingly strong focus on education in the political agenda. (Statista, 2023), (DAAD, n.d.)

Workforce Data

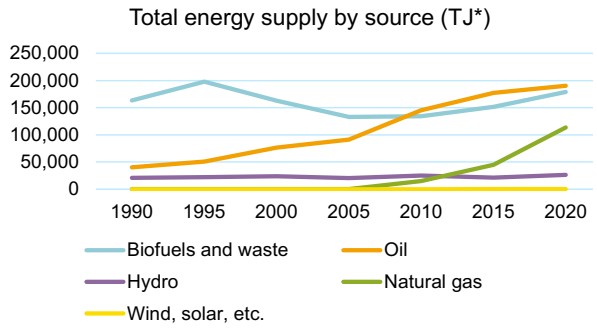


The Volta Reservoir with the Akosombo Dam, completed in 1966, is the largest inland lake in the country and still the largest surface artificial body of water in the world. With a size of 8,502 km², it is about 15 times larger than Lake Constance with its 536 km². With the construction of the dam, the Nkrumah government pursued the goal of securing the energy supply for Ghana's economic development and industrialization. (The European Space Agency, 2005) Also because of the Volta Reservoir, hydropower generation represents the largest part of the energy mix. In addition, thermal generation fueled by oil, natural gas, and diesel remain the main sources of electricity for Ghana. The country exports electricity to Togo, Benin, and Burkina Faso. (International Trade Administration, 2022)

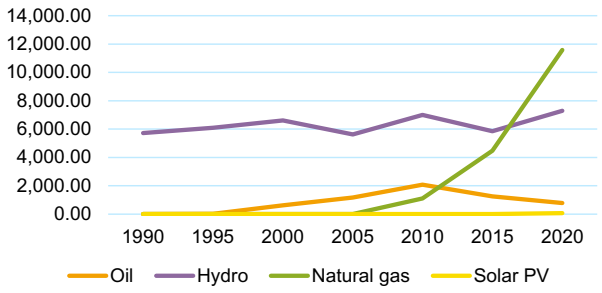
The need to reduce CO2 emissions and the recognition that conventional internal combustion engine (ICE) vehicles are a key contributor to air pollution is being increasingly recognized by officials and the public. Additionally, the high cost of gasoline and diesel during Ghana's particularly acute inflationary push in 2022 has led society to view electric vehicles as a fuel-efficient alternative. Because more than 80% of Ghanaian households have access to electricity, charging electric vehicles at home appears feasible. Ghana also has excess electricity generation capacity, although this has been decreasing over time. The high expenditure on electricity in Ghana, which is expected to increase by 30% in February 2023, poses a fundamental cost-benefit problem for consumers. (International Trade Administration, 2022)

Already, there are first battery recycling companies in Ghana, such as ERG (Electro Recycling Ghana) which however only operates a disposal plant for electronic waste in Accra. Recyclers Ghana Limited is a step-down subsidiary of the company Gravita India Limited, a leading global recycling company having its recycling presence around the globe and managing a broad range of hazardous and non-hazardous waste material for the protection of the environment. (Electro Recycling Ghana, 2023), (Gravita India Limited, 2019)

Energy Supply



Electricity Generation



Relevant Companies

ERG Electro Recycling Ghana

Recyclers Ghana Limited

KANTANKA AUTOMOBILE COMPANY LTD.

Regarding electric mobility, a Ghanaian automaker named Kantanka stated in 2020 that it is creating an all-electric city car that will be put together locally. Kantanka builds automobiles using Chinese (Complete Knock Down) kits. The German-Ghanaian firm Mana Mobility also declared plans to develop, construct, and manufacture electric vehicles in Ghana in 2023. (International Trade Administration, 2022)

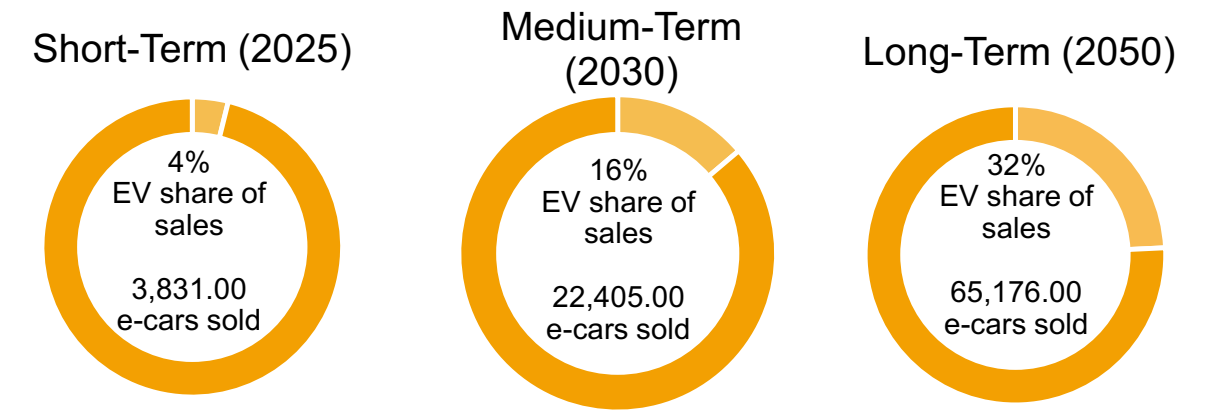
Kantanka Automobile is a Ghanaian car manufacturing company that designs, assembles and sells on- and off-road vehicles in Ghana, West Africa. Products range from high-quality 4x4 cars with built-in resistance to tough terrains, to latest clean energy technologies such as electric cars. Kantanka Automobile has the objective to manufacture and assemble cars with higher added value, expand as OEM (Original Equipment Manufacturer) and create a niche market with new types of vehicles that give value for money to medium and lower income earners in Ghana, Sub-Saharan Africa and the rest of Africa. (Kantanka Group, 2023)

The Kantanka Group which holds Kantanka Automobile is one of the leading technology conglomerates in Ghana, recognized for their meteoric scientific innovation and technology prowess exhibited annually. The group consists of ten brands geared at offering world-class services in tech, security, food sufficiency, construction engineering, contemporary herbal medicinal research, and safe transportation systems.

The increase in locally manufactured electric vehicles in the country and companies like Kantanka Automobile can not only promote electric mobility and boost the economy, but also take advantage of the existing infrastructure and particularly charging stations that are already being built in Ghana. This indicates a growing market for electric vehicles and makes the reuse and refurbishment of old vehicle batteries more feasible to implement in the long run.

Current Status & Targets

EVs	≈1,000
Charging stations	4 (located in Accra)



Rwanda

Capital:
Kigali

Offical langauge:
Kinyarwanda, French, English

Population:
13,246,394 (2022)

Area:
26,338km^2

GDP nominal*
11.07 billion USD

GDP per capita*
822.35 USD

Offical currency
Rwandan Franc; 1 USD equals 1,095.50 Rwandan Francs**

Location:

Rwanda, the most densely populated country in Africa, is located in the east-central interior and is bordered by Uganda to the north, Burundi to the south, Tanzania to the east and the Democratic Republic of Congo to the west. Kigali is the capital of the country, while Butare is the cultural capital.

The relief is characterized by a large plateau formed by several lakes. In the western part of the country lies Lake Kivu, the largest lake on the country. Kinyarwanda, French, and English are the official languages, but part of the population speaks Swahili. (Casa África, n.d.)

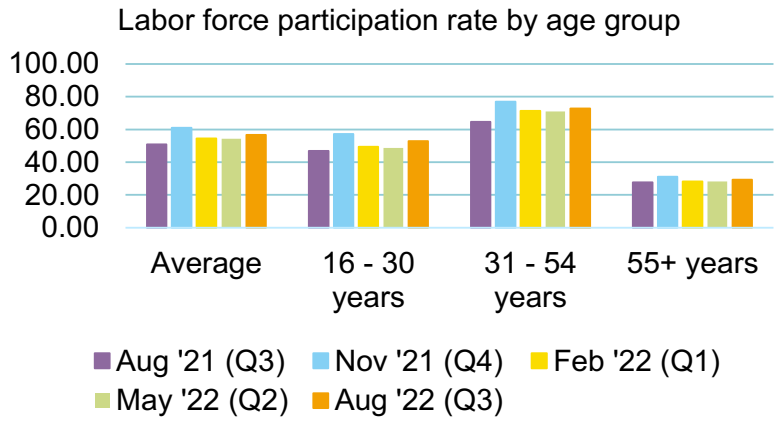
Rwanda was not recognized as independent until 1962 and held its first local elections in 1999; despite the aftermath of the 1994 genocide, it has established itself as one of the safest countries on the continent.

Economically, 90% of the population are engaged in subsistence agriculture, although most incomes derive from industry, tourism, and exports (mainly minerals, coffee, and tea). The country promotes regional trade and macroeconomic growth, especially through its accession to the EAC in 2007. (Casa África, n.d.) Despite Rwanda's fertile ecosystem, food production often fails to keep pace with demand, necessitating food imports. The energy shortages, instability in neighboring states, and the lack of adequate transport links to other countries continue to hamper the growth of the private sector. (Gilberto Bosques Center for International Studies, 2018).

Rwanda has enjoyed strong economic growth, averaging over 7% GDP growth annually over the last two decades, and the Rwandan economy grew by more than 9% in 2019. The government has adopted an expansionary fiscal policy to decrease poverty by improving education, infrastructure, and foreign as well as domestic investment. Rwanda ranks consistently well for ease of doing business and transparency. (Gilberto Bosques Center for International Studies, 2018)

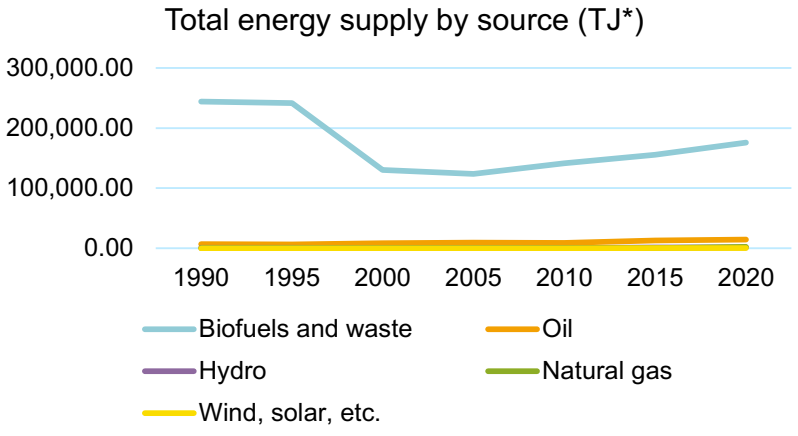
In August 2022, the working age population (16 years and above) was around eight million of whom 3,711,254 were employed; 819,936 were unemployed, and 3,469,591 were out of labor force. The sum of employed and unemployed population were 4,531,190 persons. Round-to-round comparison shows that the total employment increased by around 11.8% from 3.31 million in May 2022 to 3.71 million of employed population in August 2022. (National Institute of Statistics of Rwanda, 2022)

Workforce Data



Labor force participation rate by area of residence was revealed to be high in urban areas compared to rural areas. This may be attributed to the diversity of job opportunities in urban areas as opposed to rural areas where the number of employment opportunities is limited, and most people are involved in subsistence agriculture. (National Institute of Statistics of Rwanda, 2022)

Energy Supply

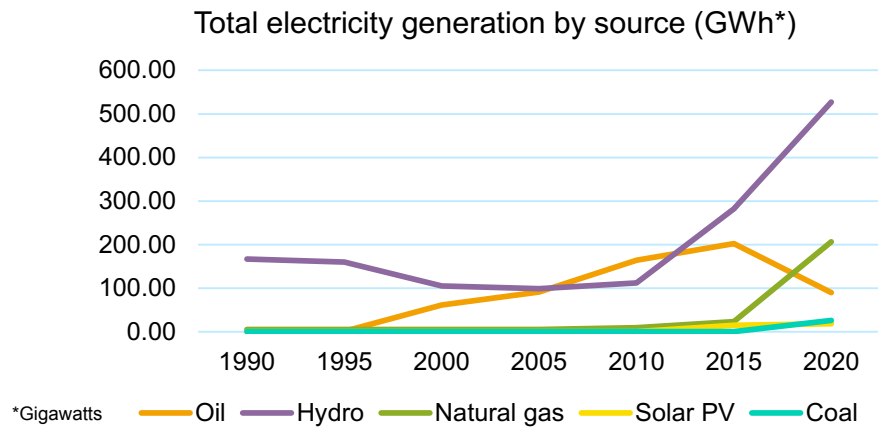


Currently, the total installed capacity to generate electricity in Rwanda is 276.068 MW from different power plants. By generation technology mix, 51% come from thermal sources, followed by hydro sources (43.9%), and solar sources with 4.2%. (Rwanda Energy Group, n.d.)

As part of the efforts to increase the current capacity, a number of projects to build new power plants is underway and will add more capacity to the existing national grid by the year of 2024. Some examples are Hakan peat to power plant which will add 80 MW, Rusumo Falls Hydropower plant (26 MW), Rusizi III (48.3 MW), Shema (56 MW), and Nyabarongo II (43.5 MW).

These projects are expected to considerably reduce the usage of expensive sources such as fuel, and the energy mix forecast for 2024 will be 50% of usage of hydro, 5% diesel, 20% methane, 17% peat and 8% solar energy. (Rwanda Energy Group, n.d.)

Electricity Generation

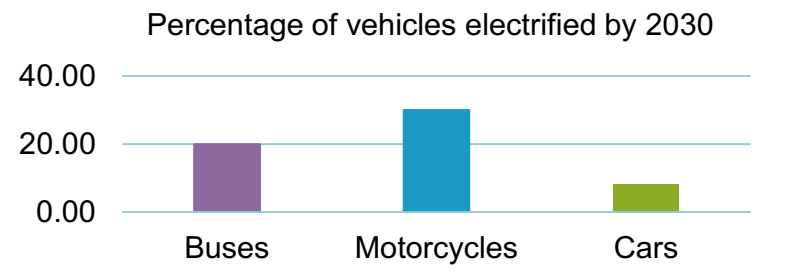


The 13-million-people country has recently implemented tax advantages for purchasers of electric vehicles, promoted local electric vehicle production, and advanced ambitious plans to electrify public transportation. The modifications are a part of the country's attempts to lower greenhouse gas emissions that contribute to climate change and minimize rising air pollution.

By working with government officials to speed the adoption of electric vehicles, the United Nations Environment Program (UNEP) has helped Rwanda make the switch to EVs.

Current Status & Targets

EVs	≈900
Charging stations	2 (located in Kigali)



"Rwanda is among the few countries that have an electronic waste policy and regulations and is the second in Africa to have a state-of-the-art e-waste dismantling and recycling facility."

Olivier Mbera, country general manager of EnviroServe Rwanda, which runs the recycling facility. (EIF, n.d.)

Right Honorable Prime Minister of Rwanda, Dr. Ngirente Edouard, stated that since operations started in June 2018, Volkswagen Rwanda's investment has contributed to job creation, particularly for young people. This assists Rwanda in achieving its objective of creating at least 1.5 million high-quality jobs by 2024. (United Nations Environment Programme, 2022)

The Rwandan government estimates that adopting electric cars and switching to electric mobility will cost USD$900 million. However, switching to electric motorcycles alone, a significant method of transportation, would spare Rwanda's economy the $22 million in fuel imports it currently spends annually. By 2030, Rwanda is aiming to have 20% of buses, 30% of motorcycles and 8% of cars electrified. (United Nations Environment Programme, 2022)

Due to a lack of awareness, a lack of environmental legislation, and a lack of adequate financial means, managing e-waste has become a significant challenge for many African countries. Due to the presence of heavy metals and other hazardous materials in electronics, the current methods of disposing of e-waste in Africa – open dumping, burning, and landfilling – may have detrimental effects on both human health and the ecosystem. As a result, Rwanda started debating its e-waste management policies in 2008. In 2016, the nation passed an e-waste policy after consulting those engaged in the industry, with assistance from the Enhanced Integrated Framework. (EIF, n.d.)

Currently, Rwandan streets are home to around 900 locally made electric vehicles, including motorbikes from the start-up Ampersand. Volkswagen produced the first electrified Golf in Africa, which has attracted the attention of major multinational producers. Furthermore, electric trucks have been used to deliver essentials in rural areas. Ampersand is Africa's first and leading integrated electric motorcycle and transport energy solution. Ampersand uses technology adapted for the local market and the right business model to achieve scale, its vehicles deliver superior driving performance, emit 75% less carbon than petrol motorcycles with zero tailpipe emissions and put over $500 a year back into drivers' pockets.

In May 2019, Ampersand started a new trend in African mobility with 20 e-motorcycles. Since then, they have put hundreds of e-motorcycles on the road, operating on a commercial basis, taking passengers and goods across Kigali and Nairobi, in Kenya. (Ampersand, 2023)

Enviroserve Rwanda is a company that specializes in e-waste management, work with customers and partners to champion the environment, by reducing greenhouse gas emissions and creating skilled green jobs in Rwanda. (Enviroserve Rwanda, 2020)

Relevant Companies

AMPERSAND

Enviroserve Rwanda Green Park
Rwanda E-waste recycling facility

Morocco

Capital:
Rabat

Offical langauge:
Arabic, Amazigh, French

Population:
37, 457, 971(2022)

Area:
446,300km^2

GDP nominal*
142.874 billion USD

GDP per capita*
3,896.00 billion USD

Offical currency
Moroccan dirham: 1 USD equals 10.18 Moroccan dirham**

Location:

Morocco is located in the northwestern part of the African continent. Encompassing a surface area of 446,300 square kilometers, it boasts a coastline that spans over 3,500 kilometers along the Atlantic Ocean and the Mediterranean Sea. This strategic coastal positioning grants it a significant role within the Strait of Gibraltar. Additionally, Morocco shares its physical borders with Mauritania, Algeria, and Spain, forming integral connections across these regions. (Africa Infomarket, 2022)

Morocco‘s topography exhibits remarkable diversity. The nation is characterized by two prominent mountain ranges: the Atlas and the Rif. These ranges effectively partition the country into arid regions in the south and west, contrasting with the zones where major cities and agricultural endeavors thrive – predominantly situated in the northwest. (Embassy of the Kingdom of Morocco in Madrid, n.d.)

Morocco‘s GDP advanced by 3.5% year-on-year in from January to March 2023, following an upwardly revised 0.7% rise in the previous three-month period. It was the strongest growth rate since Q4 2021, driven by external demand in a context of high inflation and an improvement in the financing capacity of the national economy (Trading Economics, 23)

The government has embarked on a series of economic reforms aimed at liberalizing the economy, catalyzing growth, and fostering job creation. The agricultural sector, employing nearly half of the workforce, plays a pivotal role and contributes 13% to the GDP. Morocco holds a prominent position as a substantial producer and exporter of fruits and vegetables. The nation‘s primary mineral resources encompass phosphates, further enhancing its economic profile.

Additionally, Morocco has large deposits of cobalt, fluorine, and phosphate, essential materials to produce any kind of electrical product and lithium-ion batteries, enhancing its economic profile. According to GlobalData, Morocco is the world’s ninth-largest producer of cobalt in 2022, with output up by 6% on 2021. (Mining Technology, 2023).

Industry accounts for a substantial one-third of the GDP, owing to the prominence of textiles, leather goods, agricultural processing, and assembly lines for automobiles and electronic products. Rabat aims to boost Morocco‘s production to 1 million vehicles annually by 2025, with a significant portion being EVs. (Tanchum, 2022) This shift towards e-mobility is expected to play a pivotal role in Morocco‘s socio-economic transformation.

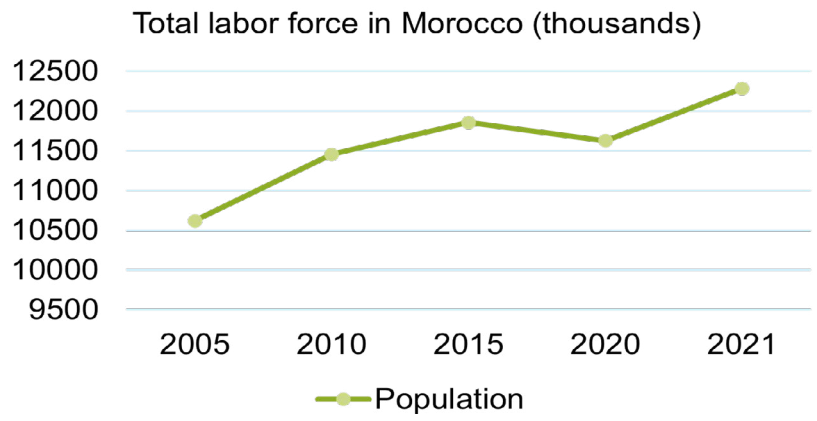
In contrast, the tertiary sector is evidently burgeoning, with a considerable dependence on tourism. Alongside the delegation of concessions for various public services in major urban centers, Morocco has embraced a liberalized approach to oil and gas exploration regulations.

Morocco‘s advantageous geographical position at the convergence of Europe, Africa, and the Middle East has significantly contributed to its achievements in exportation. Morocco’s export sector has experienced exponential growth in recent years, although the country has a trade balance deficit. The country’s main exports are phosphates, clothing, and canned fish, while imports are fuel and machinery. (Africa Infomarket,2022)

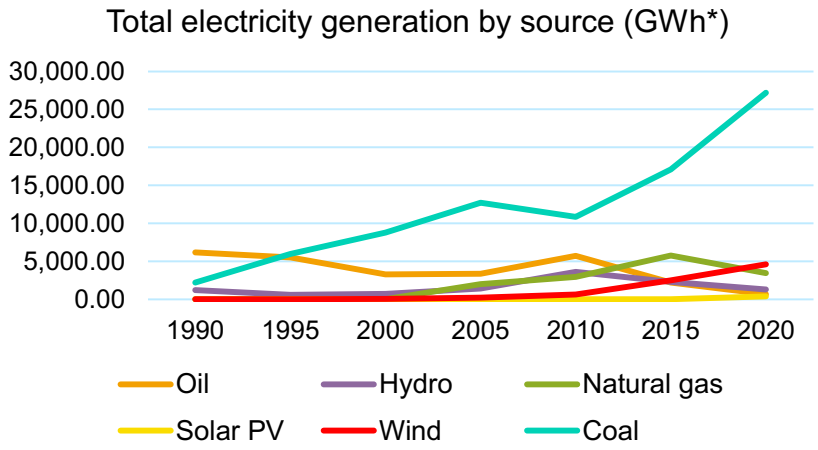
Particularly, the nation‘s automotive exports are predominantly directed towards the European market. A notable example from 2022 showcases Morocco exporting more than 280,000 vehicles to France, its primary export destination, and subsequently to Spain and Italy. Morocco‘s foreign exchange bureau has reported that the automotive industry in the country has set a record with exports of 44 billion dirhams (around $4.8 billion) in the half year of 2023. (Atalyar, 2023)

Some of the key characteristics of Morocco’s labor market include high employment in the service and agricultural sectors, low female labor participation, widespread youth unemployment, and a sizable informal sector. In 2021, about 12.3 million individuals made up the labor force in the nation, which included 34 those who were working or unemployed but actively seeking employment. For several reasons, women in Morocco are not especially economically active: The country’s female workforce participation rate is about 23%, which is significantly lower than the male rate of 66%. (Statista, 2023)

Workforce Data



Electricity Generation



Around 11.3 million people were working in Morocco throughout the year of 2022. According to the most recent sectoral distribution data, the service sector employed about 44% of the working population. The industrial sector attracted about 23% of the workforce, while the agriculture sector came in second with a share of 33%. In fact, services make up the biggest economic sector in the nation and represent more than half of the GDP, particularly considering the significant tourism industry. In addition, despite being the smallest economic sector, agriculture uses a higher proportion of the working population than the industrial sector, which requires less labor. (Statista, 2023)

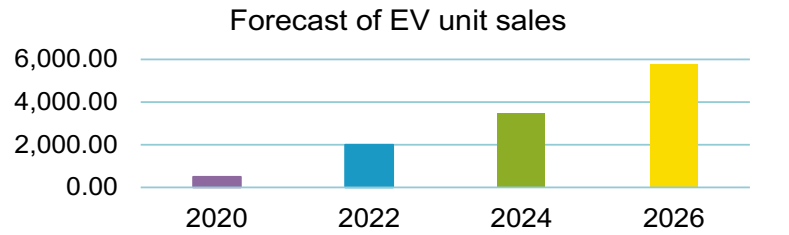
The Moroccan government has announced plans to study and subsequently put into action the country's first national electric mobility plan, which will advance the nexus of sustainability, transportation, and energy. Morocco's plan, which was adapted from the "Global Macro Roadmap for Transport Transformation" by the Paris Process on Mobility and Climate (PPMC), will assist the government in addressing and mobilizing all actors and stakeholders of the transportation ecosystem, ultimately assisting Morocco in developing innovative infrastructure to meet its sustainable development goals. (Morocco World News, 2022).

According to Ryad Mezzour, Morocco's Minister of Industry and Trade, the ability of his nation to produce 100,000 electric cars annually, or double current output, will be reached in two to three years. According to Asharq Business, Mezzour stated that "this objective can be achieved with current industrial capacities, without taking into consideration future foreign investments."

Mezzour emphasized that the country should be proud of its achievements in car manufacturing. The vehicles manufactured in Morocco will mark a new milestone as it will bear a Moroccan name. The Ministry is working together with Moroccan investors to increase the "integration rate so that parts are also mainly Moroccan." The head of government also highlighted the contribution of Moroccan managers to the progress of the electric car sector at the plant where they are built in the country. (Arredondas, 2022)

Current Status & Targets

EV's	≈2000
Charging Stations	120



In addition, the International Transport Forum (ITF), in partnership with the Ministry of Transport and Logistics of the country stated in a workshop that a path towards decarbonizing the transport sector, specifically the automotive supply chain has started, with plans to achieve it by 2050. Morocco has been very proactive in formulating effective legislation and concrete steps to reduce greenhouse gas emissions. (BNN, 2023)

By 2022, Morocco hopes to reach a 20% waste recycling rate with the help of the World Bank, while also improving the working circumstances for waste-pickers. To extract value from organic waste, Oum Azza, the biggest contemporary landfill facility in the Maghreb, uses biogas produced during decomposition. (The World Bank, 2016)

Rabat, the capital of Morocco stated that it would soon sign an agreement to build a gigafactory to manufacture EV batteries. That has put Morocco in an important position to become a leader in green mobility. Morocco's emergence as a major EV manufacturing hub on a global scale is a development of immense importance for the socio-economic and industrial transformation of the country and is also essential to the promotion of carbon-free mobility. (Tanchum, 2022)

Morocco has ratified the African Continental Free-Trade Area treaty (AfCFTA), being one of two largest car exporters in the continent accounting for over 80% of exports. (ODI, 2022).

Relevant Companies

GLENCORE MANAGEM STELLANTIS PILOT INDUSTRIES LIMITED

The Kenitra plant is a Moroccan car plant belonging to the Dutch automobile manufacturing group Stellantis. It is located in Ameur Seflia, Kénitra Province in Morocco. The plant started its operations in June 2019 with an annual output of approximately 200,000 cars. In November 2022, Stellantis announced that the company will invest 300 million euros in its Moroccan factory in order to build a range of new small cars as well as to increase production of electric quadricycles for Citroen and Opel. (Automotive News Europe, 2022) The capacity at the Kenitra plant, which opened in 2019, will be doubled to 400,000 cars per year, along with 50,000 quadricycles including the Citroen Ami and Opel Rocks-e, which is an electric car that is exported to the international market. (Afrik21, 2021)

In Morocco, the National Office of Electricity and Drinking Water (ONEE) is in the middle of preparing the “National Master Plan for Electric Mobility”. The initiative will enable the development of sustainable transport in the Kingdom of Morocco where factories of several car manufacturers are located.

At the same time, the Moroccan authorities announced in the second half of 2022 that they would build a factory for the local manufacture of electric batteries. This approach will make it possible to meet the demand in this area on the international market and to facilitate the introduction of one million electric vehicles by 2026 in the kingdom. To this end, the Moroccan Minister of Industry and Trade recently hinted that negotiations were underway with car manufacturers, notably the French company Renault, with a view to launching this factory making use of renewable energy, phosphate, and the 1,900 tons of cobalt produced annually in Morocco. (Africa Energy Portal, 2022)

Morocco‘s government and the China-based battery manufacturer Gotion High Tech have agreed to explore the possibility of establishing an electric vehicle battery facility in Morocco, with a potential investment of up to $6.3 billion, as stated by Morocco‘s investment agency. This collaborative effort marks a significant step towards enhancing the nation‘s electric vehicle infrastructure and promoting sustainable transportation. (Reuters, 2022)

As for relevant companies in battery recycling, Glencore and Managem announced that they have partnered to produce cobalt at Managem’s CTT Hydrometallurgical Refinery at Guemssa, a city near Marrakech, using recycled cobalt, nickel, and lithium, which are essential materials used in battery production. This collaboration demonstrates Glencore and Managem’s dedication to helping the electric vehicle sector meet its metals recycling goals.

Pilot Industries Limited is a company that specializes in recycling, including batteries from inverter, car, lead-based batteries, solar and industrial batteries. They also import drained batteries mostly from countries in the Middle East and provide a pickup service for bulk quality. (Glencore, 2022)

Cameroon

Capital:
Yaoundé

Offical langauge:
French, English

Population:
27,914,536 (2022)

Area:
475,442 km²

GDP nominal*
45.34 billion USD

GDP per capita*
1,666.93 USD

Offical currency
CFA Franc: 1 USD equals 618.58 XAF**

*Gross Domestic Product
**March 13th, 2023

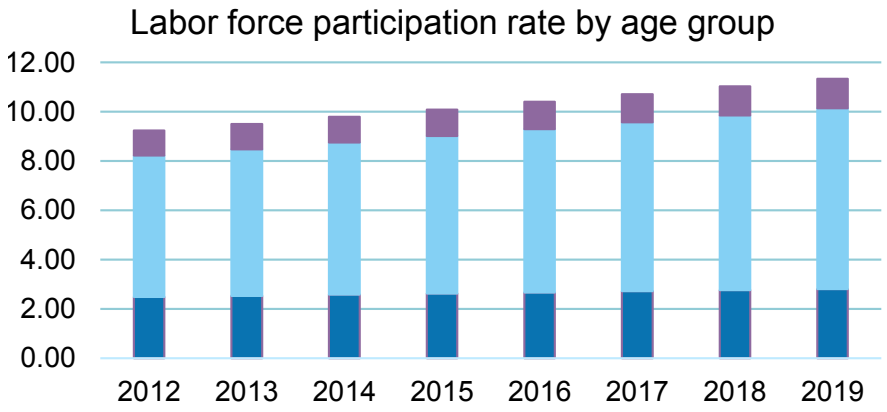
Location:

Cameroon is located in Central Africa, on the Atlantic coast of the Gulf of Guinea. It has a great variety of ecosystems, from the savanna of the north and the semi-desert of the extreme north to the equatorial jungle of the east. The official languages are English and French, although 24 other native languages are also spoken, mainly Fang, Bulú, Yaoundé, Douala and Mbum. Yaoundé is the political capital, while Douala is the economic capital.

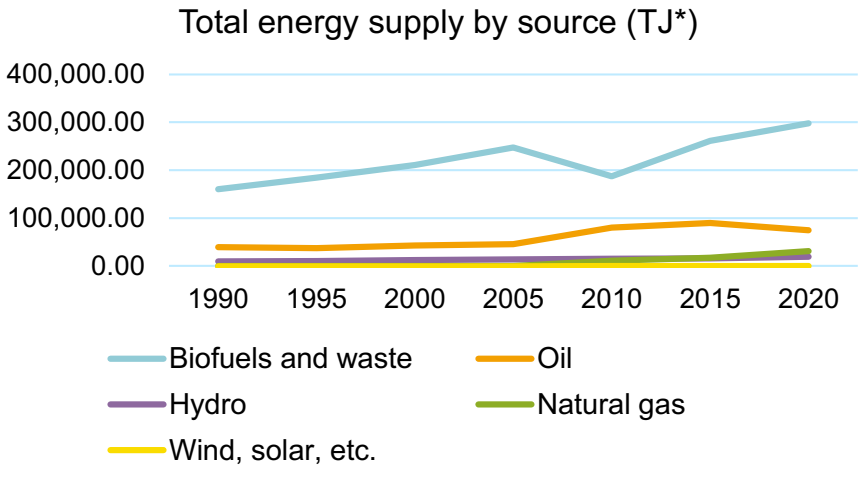
Relative to other countries in the sub-Saharan region, Cameroon has a diversified economy. Agriculture is the basis of the Cameroonian economy and the country's largest employer. However, the sector with the greatest relative weight is the tertiary sector, accounting for 37.5% of GDP, with telecommunications standing out. The services sector also includes the set of activities that have experienced the greatest dynamism in recent years. (Casa África, n.d.) In 2021, GDP growth picked up to 3.5% from 0.5% in 2020, driven by the revival of non-oil activity and continued investment. The budget deficit narrowed to 3.1% of GDP in 2021 from 3.3% in the two previous years, stemming from budgetary consolidation measures aimed at reducing expenditure and increasing non-oil budgetary revenue. (African Development Bank Group, 2023)

As of workforce data for the country, from 2012 to 2019, labor force in general increased from 8.5% to more than 10%. More specifically, in 2019 about 1.02 million male employees worked in the industry sector. In 2019, the share of the 25- to 54-year-olds labor force in Cameroon amounted to 7.33 million people. As a forecast, the unemployment rate is 0.00 in 2025. (Statista, 2023)

Workforce Data



Energy Supply



The primary modern energy supply in the nation is grid electricity. The main sources of energy are hydropower, natural gas, and oil fuels. Currently, the installed capability of the nation to produce electricity is around 1,402 MW, with hydropower accounting for 56.15%, fossil fuels for 43.84% (17.55% of which come from natural gas and 26.29% from oil), and photovoltaic (PV) solar power for the remaining percentage.

Electricity generation in the country is carried out by several utility firms, including ENEO, GLOBELEQ, ALTAAQA, Sinohydro China, and AGGREKO. The largest energy provider, ENEO, has a 1,010 MW installed capacity, with 73.49% coming from hydropower, 26.49% from fuel oil, and 0.02% from PV solar power. Oil is used to create electricity by independent producers GLOBELEQ (86.08 MW), ALTAAQA (216.00 MW), and AGGREKO (10 MW). (Renewable Energy and Environmental Sustainability, 2021)

The first electric mobility service in Cameroon is a pioneering solution with solar electricity. Two EVs carrying people and products have been introduced in Yaoundé, the capital of Cameroon, at the beginning of 2022 by the companies EasyRide and TotalEnergies in collaboration with the dealer 3S Motors. These vehicles, known as “Greenrides,” have a battery that can be recharged at a solar-powered terminal and, when completely charged, have a range of 250 kilometers. They are primarily used for shopping, and their cost is the same as that of regular vehicles.

According to the Yaoundé “Greenrides” promoters, the first electric cars to enter Cameroon’s public transport system have already made 400 trips in six months, covering a total distance of 11,000 kilometers. (Investir Au Cameroun, 2022)

Nowadays in Cameroon, there are already some recycling plants, focused on plastic and pollution reuse. One example is NAMé recycling, a company that specializes in plastic recycling, with the main purpose of reducing the amount of waste to reintroduce these materials into the value chain, contributing to a circular economy. Currently the company holds three plants in Cameroon. By including the unemployed in the recycling process, NAMé Recycling hopes to do its part to help with this challenge. Today, NAMé Recycling relies on lonely waste collectors who collect plastic from households and the street and receive a reward from NAMé for doing so. The company aims to integrate the most disadvantaged members of the Cameroonian society in this process and assist them in taking the first steps toward a better future. (NAMé Recycling, 2023)

Current Status & Targets

EVs	>100
Charging stations	4

Relevant Companies

EASYRIDE
EASY RIDE, EASY LIFE

TotalEnergies

NAMé recycling

Kenya

Capital:
Nairobi

Offical langauge:
English, Swahili

Population:
54,027,487 (2022)

Area:
580,442km²

GDP nominal*
110.374 billion USD

GDP per capita*
2,255.00 USD

Offical currency
Kenuan Shilling: 1 USD equals 130.588 Kenyan Shillings**

*Gross Domestic Product
**March 13th, 2023

Location:

"Kenya is the economic hub in the East African Community and for most German companies the entry point to the East African region. In recent years, we have seen a significant increase in interest from Germany in establishing a local presence. This is not surprising, as East Africa is the most important growth region on the continent."

Maren Diale-Schellschmidt, German Business Delegated for East Africa

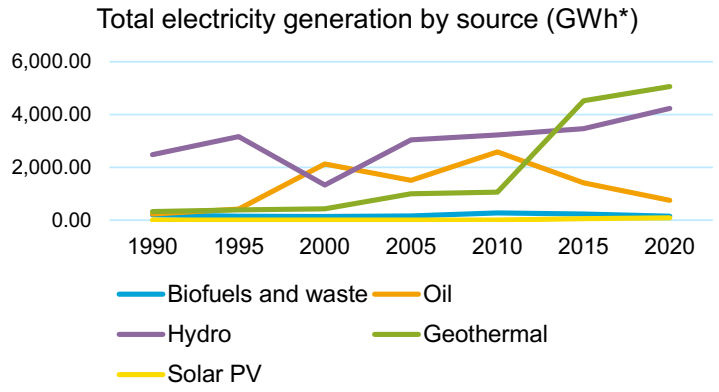
Kenya is located in East Africa. The country's capital and largest city is Nairobi, with Mombasa being the second town of a million citizens. Kenya gained independence from Great Britain in December of 1963. Following the adoption of a new constitution in August 2010, Kenya is divided into 47 semi-autonomous territorial authorities, known as "counties", each governed by an elected governor.

Thanks to a strong private industry, a growing middle class and a relatively stable political system, the country has a positive development. However, the high level of corruption and the enormous income inequalities are major challenges for the society. In addition, Kenya, like many African countries, is struggling with the consequences of climate change. (Gesundes Afrika, 2022)

The East African country is one of the largest economies in sub-Saharan Africa with a nominal GDP of around US$110 billion. The Kenyan economy is widely diversified. Agriculture is nevertheless the central pillar: cut flowers, coffee, tea, as well as fruits and vegetables are important export goods. (Germany Trade & Invest, 2022) In addition to a domestic consumer goods industry, a Kenyan service sector has also successfully established itself, mainly in tourism and finance. Kenya's start-up sector, often referred to as "Silicon Savanna," is one of the most dynamic on the continent. Many of the start-ups are active in FinTech, GreenTech, AgriTech, logistics, e-commerce, and energy.

The East African Community (EAC) customs union strengthens Kenya's function as East Africa's regional hub. With its port in Mombasa, the country fulfills an important role as a trade hub in the region. (Africa Business Guide, 2023)

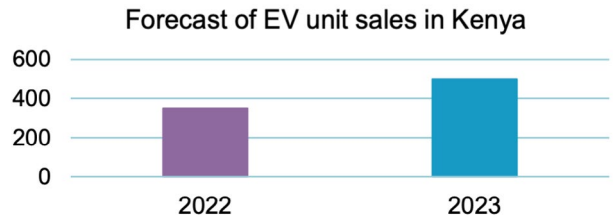
Electricity Generation



Kenya has a pro-renewable policy landscape in line with its long-term strategy, Kenya Vision 2030, to stimulate activity and investment in the renewable energy sector. This initiative encompasses a range of policies aimed at promoting growth and sustainability within the energy industry. Leveraging its natural abundance, particularly in wind, solar and geothermal resources, the East African nation has harnessed these elements to boost its energy capacity. This proactive use of natural resources sets the stage for sustainable energy practices.

Current Status & Targets

EVs	≈1350 (Feb. 2023)
Charging stations	29



In addition, Kenya showcases a diverse portfolio of energy solutions tailored to different needs, demonstrating its versatility in energy generation. From large-scale utility-scale wind and solar farms to decentralized rural micro-grids, the country has made significant strides in increasing energy production at multiple scales. This diversity encompasses a range of technologies and business models, ensuring that an energy solution can be tailored to meet each unique need and contribute to a more sustainable future. (Rapid Transition Alliance, 2022)

In Kenya, the transport sector, especially road traffic, is one of the main sources of climate-damaging CO2 emissions. The reason for this is the predominant use of fossil fuels to power vehicles. Increased electrification can therefore make an important contribution to Kenya's transport sector target of reducing emissions by 3.46 MtCO2e from the baseline by 2030. There are currently an estimated 350 registered electric vehicles (EVs) in Kenya. This figure is derived from the total number of 3.5 million registered vehicles, of which an estimated of 2.2 million are still on the roads. (E-mobility, n.d.)

“Kenya is actively promoting the adoption of electric mobility, aiming to reach a target by 2025 where 5% of all newly registered vehicles will be electric.”

National Transport and Safety Authority (NTSA)

As of February 2023, approximately 1,350 EVs are registered in the country. Kenya Power’s E-Mobility Conference Report said that currently, 844 of the 1,350 registered EVs are electric motorcycles, and electric three-wheelers are 153. (Kemp, 2023)

A manufacturer of electric vehicles with a focus on the African market has constructed a 10,000 m² facility in Nairobi, where it plans to produce 50,000 electric motorcycles per year. Roam, a Kenyan-Swedish start-up, will have its East African headquarters, production line, and battery labs in the building that was erected in Nairobi National Park. Roam’s vision is to make electric transport more accessible to a broader market by making the technology more cost-efficient and simplifying deployment. The company focuses on all-electric conversion kits for fleet vehicles such as light trucks, public transport, and buses as well as electric motorcycles and energy systems. (Roam, 2023)

BasiGo, another important company in Kenya, is emerging as a dynamic force in the countries quest for sustainable transport solutions. As an innovative electric vehicle (EV) startup, BasiGo,envisions a future where EVs play a pivotal role in addressing environmental challenges and reducing the nation‘s carbon footprint. They are committed to providing cleaner, greener, and smarter mobility options that include cars, motorcycles and public transport.

Their commitment is to provide cleaner, greener and smarter mobility options that include cars, motorcycles and public transport. The importance of BasiGo to Kenya is vital as it aims to reduce harmful emissions, promote energy independence through sustainable sources, stimulate economic growth, create employment opportunities and drive technological advancements within the automotive industry.

For e-waste, there are already companies located in Kenya, such as E-waste Initiative Kenya (E-WIK) and Waste Electrical and Electronic Equipment Centre (WEEE Centre) in partnership with Aceleron, based in Kiambu and Nairobi. (WorldLoop, 2022), (E-Wik, 2022) After winning the CLASP Global Leap award in February 2020, and overcoming a brief delay caused by the COVID-19 pandemic, Aceleron enthusiastically announced the launch of the 2nd Global Leap Solar E-waste Challenge.

Utilising the $300,000 award, Aceleron Kenya focused its efforts on improving product design and advancing usable battery technologies. Working with two dedicated implementing partners, the WEEE Centre in Kenya and Enviroserve in Rwanda, Aceleron‘s initiative aimed to provide access to high performance second- life energy across Kenya and Rwanda for an initial period of 18 months.

This transformative project had the objective to positively impact off-grid rural communities in both Kenya and Rwanda by increasing their access to clean energy technology. Envisaged outcomes include increased electrification and provision of efficient lighting sources, empowering rural smallholder women entrepreneurs with extended business hours and subsequent increased income generation opportunities. (Aceleron, 2020)

Relevant Companies

Source: © GIZ/Fabiana Anabel Woywod

Chapter 6: Matching Use Cases and Countries

Methodology

In order to match business cases with countries, the perspective of each country was considered to provide detailed reasoning about which business case is most suitable. There are big challenges for some of these business cases that are true regarding the location. One example is the high upfront cost and the necessity to scale big when building a hydrometallurgical recycling plant. Since this has nothing to do with the country itself, this report focuses on the differences between the countries and tries to highlight the specific opportunities that they present.

To assign the scores, a scale from 5 to 1 was used. Ranking the feasibility in each country, 5 stands for the most feasible use case, while 1 represents the least feasible.

Business Case/Country	Ghana	Rwanda	Morocco	Cameroon	Kenya
1. Re-use of old vehicle batteries	2	4	1	5	5
2. Refurbishment of old vehicle batteries for EVs	3	5	2	4	4
3. EOL-Recycling (Hydro)	5	3	4	2	3
4. EOL-Recycling (Pyro)	4	1	3	3	2
5. Production Scrap Recycling	1	2	5	1	1

BUSINESS CASE & COUNTRY MATCH

Source: OWN AUTHORSHIP

Ghana

Business Case 2: Refurbishment of Old Vehicle Batteries for EVs

Score: 3 (medium feasibility)

Since the EV market in Europe, America and China has grown almost exponentially in recent years, it is very plausible to assume that there will be a worldwide market for used electric vehicles in a few years. Unlike vehicles with combustion engines, it will be necessary to refurbish electric cars. This includes opening the battery and replacing modules that have reached their end of life. Ghana has three main factors that benefit this business case.

Firstly, the government of Ghana has recognized the importance of electric vehicles and is supporting their implementation. Therefore, there are already more than 1,000 EVs in operation right now. This shows that there is already a market for electric vehicles, and the infrastructure – mainly charging stations – is already being built. Secondly, the education system in Ghana is good, so there are well-educated people who are able to refurbish these battery systems safely. Thirdly, there are already some companies producing electric vehicles in Ghana, so they could be enabled to use their skill set to refurbish existing electric vehicles coming from other markets.

In Ghana, more than 38,000 off-grid solar photovoltaic systems and 25 grid-connected solar PV systems are currently installed. Together they reach a capacity of 8 MW, and this amount is growing. (Smart Solar Ghana, 2019) Since off-grid systems are already being used, companies can rely on this, decrease power outages and increase the development of rural areas by creating a new electricity supply.

For this use case it is necessary for the working labor force to be trained as electronic technicians and in handling high-voltage equipment. Examples of institutions that offer this training in Ghana are Kwame Nkrumah University of Science and Technology (KNUST), University of Ghana, Accra Technical University, Takoradi Technical University, Koforidua Technical University, Ghana Grid Company Limited (GRIDCo), Energy Commission of Ghana, Elective Africa Training Institute, and more.

Business Case 3: EoL Recycling (Hydrometallurgical)

Score: 5 (high feasibility)

As described in chapter 4, hydrometallurgical recycling only makes sense if it is implemented on a large scale. Furthermore, it requires high upfront cost and therefore needs to run for a long time to make profit. Ghana has some unique advantages that make this business case appealing. For a start, the country has a well-established democracy and is thus one of the highest-ranked African nations on the democracy index. This is necessary to make long-term investments attractive. Furthermore, the education system of Ghana is also ranked as one of the best in Africa. Since hydrometallurgical recycling requires engineers as well as trained electricians to safely disassemble the battery packs, this is beneficial for this business case. On top of that, Ghana's government is pushing the implementation of electric vehicles so that more than 1,000 of them are already in use there. With the accelerating global EV market, this trend will only continue, so that in one or two decades there will be the need for recycling facilities in Ghana.

Business Case 4: EoL Recycling (Pyrometallurgical)

Score: 4 (medium to high feasibility)

Ghana is also an attractive option for pyrometallurgical recycling facilities for a number of reasons. Firstly, Ghana is a resource-rich country with a well-established mining and refining industry. This requires a similar work force as pyrometallurgical recycling, since the processes itself are similar. Right now, these mining activities are mostly focused on gold, aluminum, and manganese, but there are plans to start mining and refining operations for lithium as well. Another important factor is the availability of energy, since the process is quite energy-intensive. As of 2023, the recycling process is mainly based on natural gas which needs to be available to implement plants in the near future. Since Ghana is producing a big part of their electricity with natural gas, its availability can safely be assumed.

EV STATION IN AFRICA
Source: © GIZ/PIE TER UYS; MIKI VAN R.

Rwanda

Business Case 1: Reuse of Old Vehicle Batteries

Score: 4 (medium to high feasibility)

With Rwanda having solar power as the biggest part of the country's energy mix, it tops the list of African nations in this regard. Only 60% of the population have access to grid electricity, so the rest of the population can benefit from this. Rwanda has a high percentage of renewable energy sources in general as well as a big labor force that can be participating in the disassembly process. Unemployment is bigger in rural areas than in urban areas, so the disassembly can take place there, and the batteries can also be used in the rural areas.

For this use case, it is necessary for the labor force to be trained in handling high-voltage equipment safely. Institutions in Rwanda that offer this kind of training programs for workers involved in the country's energy industry are Rwanda Energy Group (REG), Integrated Polytechnic Regional Centre (IPRC), Rwanda Standards Board (RSB), and the Kigali Institute of Science and Technology (KIST).

Business Case 2: Refurbishment of Old Vehicle Batteries for EVs

Score: 5 (high feasibility)

For this business case, Rwanda is the most feasible country for implementation, mainly because the country already has different start-ups and companies that are producing and managing EVs, including electric cars, electric motorcycles, and electric buses.

The government of Rwanda and different profit as well as non-profit organizations are supporting the transition to electric mobility, mainly by helping local companies to promote the implementation of tax breaks for EV buyers and by making plans to electrify public transport.

The country has received help from the United Nations Environment Programme (UNEP) to implement and shift existing forms of transportation to EVs, working closely with officials from the government to roll out the use of different EVs like electric motorbikes, three-wheelers, etc. The refurbishment of old vehicles' batteries as well as replacing the modules from other batteries into the country's existing EVs can extend the life cycle to a great extent.

SOLAR CELL
Source: © GIZ/JAMES OCHWERI

Morocco

Business Case 3: EoL Recycling (Hydrometallurgical)

Score: 4 (medium to high feasibility)

Hydrometallurgical recycling is currently the most common recycling path worldwide with high efficiencies for most materials. The biggest challenge is that it only becomes economically viable in large scales. Such a large-scale recycling plant needs a big amount of recyclable batteries. Since electric vehicles are not yet widespread in a worldwide context, there are hardly enough batteries for such a plant. With the sharp rise of EV sales in the last five years and the known degradation of batteries, a sharp rise of potential batteries can also be foreseen.

Since Morocco is ahead of other African countries in regards of EV sales and EV integration, this rise will come earlier for Morocco than for other African countries. Morocco has the chance to become Africa's recycling hub with then matured processes and big recycling plants. It also has the unique advantage of being located very close to Europe. Since Europe has seen an even sharper rise of EV sales, Morocco has the opportunity to become both a supplier for new batteries and the country that recycles old batteries coming from Europe. With these requirements met, it is no wonder companies have already started implementing recycling. The Swiss company Glencore has partnered with the Moroccon company Managem to set up a hydrometallurgical recycling plant in Guemssa, south of Marrakesh.

Business Case 4: EoL Recycling (Pyrometallurgical)

Score: 3 (medium feasibility)

Morocco has some unique characteristics that make it attractive for pyrometallurgical recycling, too. Firstly, it is an energy-rich country that already has an existing infrastructure for natural gas – which is important, since the involved processes are often still being operated by fossil fuels, namely gas. In the long run, these processes will need to be electrified to be carbon-neutral, and this will require big amounts of renewable energy. Morocco has excellent conditions for this. Their long coastline insures possible off-shore wind farms, their regions with sparse population makes on-shore wind farms plausible, and their proximity to the equator makes it very attractive for the usage of solar energy. The government of Morocco has recognized this for years and is investing heavily in the expansion of renewable energy. Secondly, there is already an existing infrastructure for the refining of cobalt, and there are plans for the refining of lithium. Both of these industries require process, chemical and mechanical engineers.

Universities in the country that offer process, chemical and mechanical engineering degrees are École Nationale Supérieure de Chimie de Rennes – Campus de Rabat (ENSCR), Université Mohammed V de Rabat, École Mohammadia d'Ingénieurs (EMI), École Nationale Supérieure des Mines de Rabat (ENSMR), and more.

Business Case 5: Production Scrap Recycling

Score: 5 (high feasibility)

The most important prerequisite for the implementation of production scrap recycling is the existence of battery production sites in the first place. While Morocco does not currently have such sites, it fulfils some important prerequisites for the establishment of battery production plants. For example, it already has an infrastructure in the automotive sector with several manufacturers producing cars in Morocco. Among them are Citroen and Stellantis. Furthermore, cobalt is currently both mined and processed in Morocco – with plans to set up lithium processing plants in the future. This secures the supply of battery raw materials.

MINING ACTIVITIES FOR COBALT RECYCLING SOURCE: THE TIMES (N.D)

In addition, the Moroccan government has set itself the goal of building a gigafactory for battery production in the next few years. Production scrap recycling combined with direct recycling routes have promising efficiencies and are potentially cheaper than common recycling paths and virgin material. Although these processes are not yet implemented on a large scale, many battery companies are researching this topic right now. With a few years to spare until the gigafactory will be set up, this poses a great opportunity for Morocco to then enter the direct recycling market when processes have matured.

Cameroon

Business Case 1: Reuse of Old Vehilce Batteries

Score: 5 (high feasibility)

Of Cameroon's total population, less than 70% have access to electricity which can be beneficial for this use case, since it is focused on off-grid electricity and renewable sources. This can help existing stationary storage systems to provide a constant energy supply. The main sources of Cameroon's energy are hydropower, natural gas, and oil fuels.

Same as with Rwanda, for this use case, it is necessary for the labor force to be trained in handling high-voltage equipment safely. Some institutions that offer this kind of training programs in Cameroon are National Advanced School of Engineering of the University of Yaoundé, Cameroon Electricity Transmission Company (SONATREL), Cameroon National Institute of Posts and Telecommunications (INPT). The latter covers the principles of high-voltage systems, safety procedures, and maintenance techniques.

Business Case 2: Refurbishment of Old Vehicle Batteries for EVs

Score: 4 (medium to high feasibility)

As described in the last chapter, the country doesn't have a significant amount of electric vehicles yet. Neither does it have the infrastructure or sufficient charging stations established, but they can be introduced with this use case and support the local companies that already exist.

With the refurbishment of old batteries, together with the already existing companies, such as Easy Ride and Total Energies, there is the opportunity to introduce more EVs to serve as transportation mode and taxis. Electric vehicles are being gradually integrated into the environmental protection system in Cameroon.

Labor costs in Cameroon are low compared to other African countries, with a minimum wage between 36,000 to 45,000 Central Rwandan Francs a month, the equivalent of US$75 a month. (Wage Indicator, 2023)

RENEWABLE ENERGY IN CAMEROON
SOURCE: CENTURION LAW GROUP (2021)

Finally, the labor force of 25- to 54-year-old people has increased in the past years, so it helps to the feasibility of the business case since it requires manual labor force.

For refurbishment, the labor force has to be trained as electronic technicians, and universities offering this kind of training programs in Cameroon are University of Buea, University of Bamenda, University od Douala, the National Advanced School of Engineering (École Nationale Supérieure Polytechnique), and more. Most of them offer undergraduate programs in electrical engineering and electronic engineering which also includes training for electronic technicians.

Business Case 4: EoL Recycling (Pyrometallurgical)

Score: 3 (medium feasibility)

Natural gas is not one of the priority energy supply sources in Cameroon, but it is used to a medium extent. Cameroon benefits tremendously from its oil and gas reserves. According to the U.S. Energy Information Administration, Cameroon has natural gas reserves estimated to be 4.8 billion cubic feet, and much of this gas remains undeveloped, so this business case can be useful in a large scale.

Kenya

Business Case 1: Reuse of Old Vehicle Batteries

Score: 5 (high feasibility)

In comparison to other countries assessed in this paper, Kenya shows the largest utilization of renewable energy with a strong dominance over any other energy source. Also, only 70% of the population have access to electricity, so the other 30% use off-grid electricity, which is helpful for the application of this business case and the country itself.

Use cases for the reuse of batteries in Kenya already exist, and there are already companies that supply themselves with the help of a decentralized solar photovoltaic system. In January 2023, for example, a study by the Oxford University explored the feasibility of using long-life batteries and solar photovoltaic power to provide affordable energy for elementary schools in Kenya. Researchers looked at how second-life batteries could be combined with rooftop solar photovoltaic in remote school buildings throughout East Africa. They found that such devices could provide lower energy costs than new storage systems. The academics spoke to twelve East African schools about their respective consumption profiles and projected energy needs as well as the technical and financial challenges. They aimed to compare the performance of the proposed system configuration to two reference systems featuring conventional batteries and grid electricity. (Bellini, 2023)

The electricity produced by the solar-plus-storage system would be used for classroom lighting, security lighting, information technology, and phone charging. Overall, the results of this study demonstrate that used batteries for school electricity in Kenya are feasible and cost-competitive with new batteries, offering the same advantages while minimizing waste. (Scientific Reports, 2023)

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PRIMARY SCHOOL IN KENYA
Source: UNICEF KENYA (N.D)

Business Case 2: Refurbishment of Old Vehicle Batteries for EVs

Score: 4 (medium to high feasibility)

To get electric vehicles on Kenyan roads, many electric mobility businesses have established offices there. This might turn Kenya into a hub for EVs on the continent. The companies are hoping to take advantage of Kenya's position as a global leader in renewable energy as well as its widespread acceptance of tech and the government's support for electric cars through friendly legislation in order to alter industries including public transportation, motorcycles, and taxis.

Applying this use case will be easier in Kenya because of the already existing initiatives in the country. Kenya's government is committed to actively advancing electric mobility. This is consistent with its pledge to switch to zero-emission vehicles and with its own objective of having 5% of all newly registered vehicles be EVs by 2025. Even though these goals are still far away, they indicate governmental goodwill and desire in increasing the adoption of electric mobility in Kenya.

To implement refurbishment, the labor force needs to be trained as electronic technicians. Universities in Kenya offering this kind of training are Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenyatta University, Technical University of Kenya, Masinde Muliro University of Science and Technology (MMUST), Dedan Kimathi University of Technology (DKUT), and more.

Business Case 3: EoL Recycling (Hydrometallurgical

Score: 3 (medium feasibility)

As previously mentioned, the implementation of this use case could be more feasible if the country already had battery recycling facilities in place, as this would provide long-term benefits. Even though there is no electric vehicle production, nor any plant specifically dedicated to battery recycling in Kenya, the country has been an active player in Africa's renewable energy space. As a result, the transition to cleaner and renewable transportation modes is developing quickly, and the government is providing considerable support. Thanks to this, Kenya has gradually become a country to invest in for various electric mobility start-ups from different parts of the world.

Private actors located in Nairobi, such as BasiGo, Kiri, and Opibus, are primarily responsible for this progress. Currently, the city is home to more than six electric vehicle manufacturers that concentrate on two-wheelers, several infrastructure suppliers for charging stations, and several interested financiers for mobility solutions.

Applying this use case can be beneficial for the country, since with the increase of foreign investors there is a very good chance that Kenya can start recycling batteries, as it already has plants for the recycling of other types of materials, such as plastic.

Source: © GIZ/UTE GRABOWSKY

Chapter 7: Conclusion and Outlook

Many African countries are developing rapidly and catching up with many developments that took much longer to establish in the Global North. Often, development stages of technologies are skipped, which is called “leapfrogging”. It is becoming apparent that this will be the case with battery recycling, refurbishment and electric mobility as well. Even if the current registration figures for electric vehicles in African countries are still low compared to nations of other continents, the development of the world markets has shown that the introduction of such technology often happens in leaps and bounds. This makes it even more important to take a holistic view of the market at an early stage to identify opportunities and address potential challenges for EV batteries. In the context of this paper, three main opportunities for the African market have been identified.

Reuse

The reuse of old vehicle batteries has the highest short-term potential, since this business case can combine second-life batteries from domestic markets as well as foreign, more established EV markets. Used batteries are disassembled to build so-called second-life storage units from the individual modules. This is labor-intensive and accordingly offers good opportunities for the domestic labor markets. Particularly in regions where not all population has access to grid electricity, these storage facilities can then be used for off-grid solar photovoltaic systems.

According to the Off-Grid Solar Market Trend Report 2022 (International Bank for Reconstruction and Development, 2022), the African market for these systems is growing strongly, with costs being the biggest entry barrier. Second-life storage could be a cheap alternative that creates jobs and at the same time electrifies different regions of the continent. One advantage of this business case is that there are many companies that can pursue it, partially with their existing facilities. These mainly include larger electronics companies that have experience with vehicle batteries or home storage systems or both. In order to increase the chances of implementing this business case, policymakers must firstly clarify the legal framework to ensure that the use of batteries in other applications is permitted and that liability issues are clarified. Secondly, the training of personnel should be initiated at an early stage. In addition to classical electrical engineering professions, this also includes training in the handling of high-voltage components.

ELECTRIC CAR USAGE
Source: GREEN MATTERS (2021)

Remanufacturing

In the medium term, remanufacturing offers great potential. As described, it is foreseeable that many African countries will push the implementation of electric vehicles in the near future. According to the International Energy Agency (IEA, 2022), the number of electric vehicles in Africa is expected to grow significantly over the next decade, and several countries have shown interest in promoting the adoption of electric vehicles, supported by incentives from each of their governments.

With combustion engine vehicles, new cars are often too expensive for the African middle class, and many used vehicles are imported from abroad to reduce costs. Unlike with internal combustion engine vehicles, the battery ages faster than the rest of the vehicle, which in most cases will make remanufacturing necessary. This involves examining the modules of the battery and replacing the most damaged ones with less damaged modules of the same model. In this way, the vehicle's lifetime can be extended considerably. Companies whose main business is the production of new vehicles can become active in this business field – as well as companies that have specialized in the repair of combustion engine vehicles up to now, if their employees are trained accordingly. It is interesting to note that there is an increasing tendency in Africa for companies to produce two- and three-wheeled electric vehicles. It may be possible to repurpose modules from large vehicles for this application.

To leverage the potential of this business case, policymakers must ensure that the import of used vehicles continues to be permitted while strengthening and protecting local manufacturing of vehicles and their components.

There are different regulations and policies regarding the import of used electric vehicles to different countries in Africa. Some African countries have put rules in place that limit the importation of used ICE vehicles, while others have no specific regulations. In general, regulations on the import of used vehicles to Africa aim at protecting the environment and ensuring road safety. Some countries require that imported used vehicles meet specific emission and safety standards as part of their efforts to reduce carbon emissions and to improve air quality.
For example, in Kenya, only vehicles that are below 8 years from the date of manufacture can be imported. This time frame varies across nations; some set the limit of approximately 5 years, while others permit the import of vehicles older than 10 years. Some stakeholders propose a different approach, instead of prohibiting used ICE vehicles import, they suggest reducing the age limit for this kind of vehicle to under 5 years whilst simultaneously encouraging the import of used EVs to lower emissions.

It is important to note that these regulations and policies can vary widely between countries, so it is always best to check with the relevant authorities in the specific country to find out specific requirements.

TWO-WHEELERS IN AFRICA
Source: TECHBAL (2023)

Recycling

In the long term, recycling also offers potential for the reviewed countries, but the challenges outweigh the benefits for the moment. For the economic operation of a recycling plant, high quantities of recycled material are usually necessary, which will not be available in Africa for the foreseeable future. In addition, many battery materials are mainly mined in Africa, and the local price is often somewhat below the world market price. This puts additional pressure on profitability. On the other hand, the local material production also offers opportunities, as many value chains in material processing are similar to those of recycling. Accordingly, specialized companies and personnel are often already available in the region. Policymakers must ensure at an early stage that the occupational health and safety of employees is legally anchored and also enforced, so that cheaper process costs do not come at the expense of the health of the population, as sometimes happens in the extraction of materials.

Next Steps

To accelerate the realization of these business cases into reality, the support and collaboration of international and local organizations from public, private, civil and academic sectors as well as respective local governments mentioned in this paper is required and encouraged. Such stakeholders, along with foreign companies from the private sector and different interest groups, can contribute to supporting local value creation and collaborate in many ways.

- **Support in doing research and development** as well as knowledge transfer of electric vehicle and recycling technology in initiatives suited to the African markets.
- **Form public and private partnerships** by working alongside each of the countries' governments to promote and advertise the adoption of the herein-mentioned business cases along with electric mobility.
- **Sharing knowledge and expertise** about electric mobility and experience from other markets to promote the development of related industries in the aforementioned African countries is key to create more opportunities in the business cases discussed.
- **Support partnerships** between African governments, private sector companies, and civil society organizations to promote the adoption of electric mobility. These partnerships could focus on developing new business models, sharing best practices, and identifying new opportunities for investment and collaboration.

For the local companies and stakeholders, following actions can be applicable:

- **Share their knowledge** of the local market and consumer preferences.
- **Create awareness** in their cities and communities on the importance of battery recycling and the benefits of a circular economy. This can include providing information on how to recycle batteries safely and on the environmental and economic benefits of recycling.

For international development agencies, the following actions can be applicable:

- **Provide technical assistance** to organizations in the aforementioned countries, providing expertise in developing policies, regulations, and standards for electric vehicles as well as helping to design and implement charging infrastructure.
- **Strengthen awareness and resulting actions through a just transition** in the transport sector of local African countries. By conducting means of capacity developments for a just transition in the transportation sector, many aspects for more equality and sustainability are addressed, such as gender and social equity as well as green, fair and dignified jobs, and public transport.
- **Provide funding** for the development of infrastructure needed for the introduction of electric vehicles and battery recycling facilities, as well as for additional production facilities and infrastructure needed to implement the aforementioned business models.
- **Support the development of skills and education** by offering training programs for engineers and technicians, impulse programs, or courses that teach the required knowledge to apply some of the business cases. For example, high-voltage equipment trainings for handling special equipment to apply in the reuse of old vehicle batteries, as well as support for research and development in electric vehicle technology.
- **Support public awareness** campaigns to promote the benefits of electric vehicles and increase consumer demand. This could include outreach to key stakeholders, such as government officials, transportation companies, and the public, as well as educational programs for schools and community organizations.

For governments and governmental development agencies, the following actions can be applicable:

- **Provide incentives** for the purchase and use of electric vehicles, including two- and three-wheelers, such as tax credits, rebates, and subsidies. Those incentives can make electric vehicles more affordable for consumers and help to spur demand.
- **Establish regulations** and policies that promote the adoption of electric mobility, such as fuel economy standards and emissions regulations in the public and private transportation sector, promote responsible handling and disposal of used batteries, setting standards for battery collection, transportation, and processing as well as developing regulations for the export and import of batteries.
- **Invest** in the development of battery recycling infrastructure, such as recycling plants and collection centers, and provide funding for the training of local workers.
- **Prioritize the introduction** of electric mobility in public transportation systems, such as buses and trains. This can help to reduce emissions from the transportation sector and improve air quality in urban areas.
- **Get involved in this exchange** as there usually are interest, network, and means in place to attract investment from applicable funding and financing institutions that support new businesses in various African countries.
- **Working together** with the aforementioned stakeholders to derive and further develop policies that incentivize the purchase of electric vehicles, including two- and three-wheelers.

This white paper aims to inspire and initiate discussions on the vast possibilities within the circular economy sector and its associated business cases in the observed African countries.

Collaborative efforts are essential to maximizing the benefits and opportunities of electric mobility, including its use and recycling for the region, fostering a more sustainable future for the continent.

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Source: UNSPLASH (2017)

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