TECHNICAL & FEASIBILITY STUDY FOR THE MANUFACTURE OF LEAD-ACID BATTERIES IN GHANA

JET/319203

ABSTRACT

This study explores the opportunities for battery manufacturing in Ghana and the potential for incredible ECOWAS volumes.

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INTRODUCTION TO LEAD ACID BATTERIES

What is a Battery

A battery is chemical energy storage device. The function of a battery is to store energy, retain it for a prolonged period, and to release the energy on demand. Various chemistries are applied in automotive-use batteries, such as lead acid, nickel-metal-hydride, lithium ion and lithium polymer.

Lead Acid Battery (LABs) is one of the most common chemistries, with the lowest cost, ease of manufacture, good performance in both high and low temperatures, multi role capability, safest to operate, and easiest to recycle with highest recovery rate.

Lead acid battery (also known as LABs) is the core of this study, with focus on the technical requirements and feasibility assessment to manufacture LABs in Ghana.

Below table compares the Advantages and Disadvantages of LABs :

Advantages	Disadvantages
Mature technology (more than 150 years), stable and safe	Heavy end product due to the high atomic mass of Lead at 207.2 versus 6.9 for Lithium
Continuous developments and improvements have resulted in Enhanced Flooded LABs for Start Stop use	Generally shorter service life compared to other technologies such as Lithium Ion or Nickel-Metal-Hydride
Easy to recycle, with high recovery rate	Poor weight to energy ratio
High power output, capable of high discharge currents, very tolerant to abuse and overcharging	Even Maintenance Free (MF) LABs will have some form of water loss, although these will not require topping up during the service life.
Does not require battery management system (BMS)	Lower cycle life compared to Lithium Ion
Very economical compared to other technologies	Slow to accept charge
May be connected in serial or parallel easily	Capacity is limited by dimensions and weight
Stable even in extreme climates (hot, cold)	Possibility of acid leaks during transport

Applications of LABs

LABs are a very flexible and mature technology. LABs may be used for all of the following applications, making them the "jack-of-all-trades" of the energy industry :

1. Starting, Lighting, Ignition (SLI) : Automotive use (cars, bus, trucks, bikes, marine, construction / mining equipment, ATV), starting of electrical generators. To a certain extent, some mild hybrid vehicles such as Nissan Serena use 2 units of LABs in 1 vehicle.
2. Motive / Traction : Electric Forklift, Scissor Lift, Pallet Truck, Golf Buggy,
3. Standby : Telecommunication towers, Power plants, Emergency Lightings.

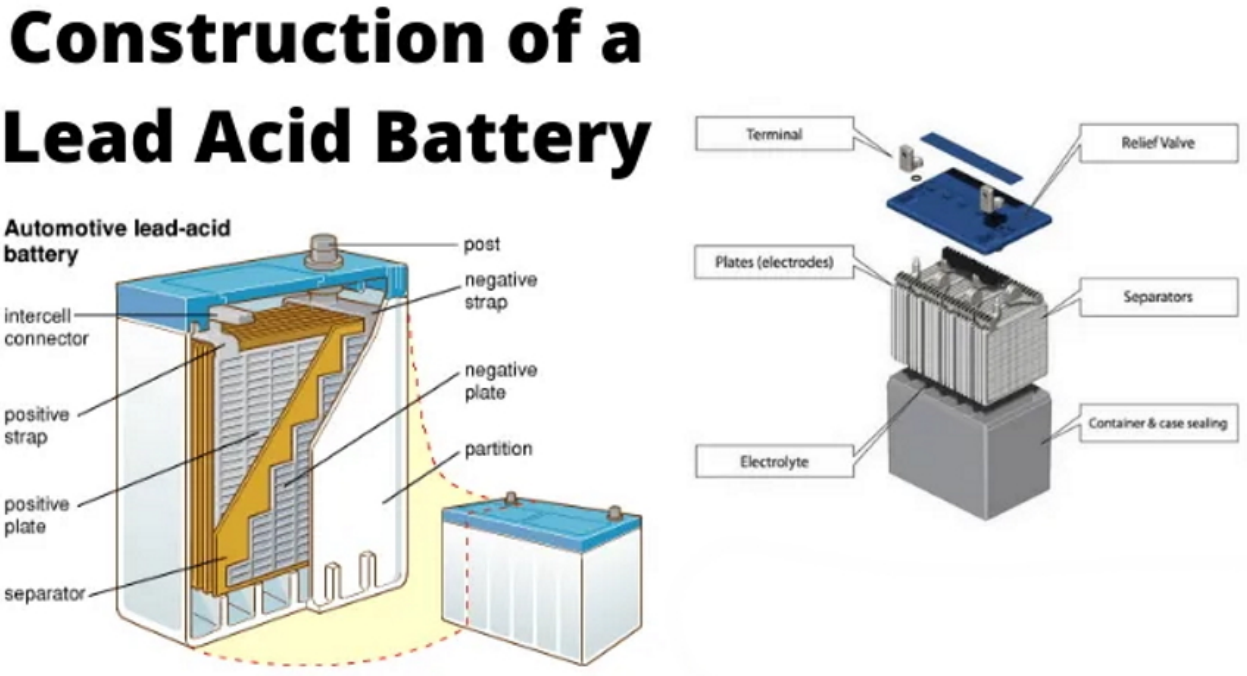
Standards for LABs

In general, the original standards for automotive batteries are :

1. **JIS D5301** : Japanese Industrial Standard
2. **EN 50342** : European Standard
3. Battery Council International (**BCI**) : Mainly for USA sizes

Subsequently, **IEC 60095** merges the above standards and adopts most of the testing methods.

Some vehicle assemblers may have their own internal standards for batteries, and in most cases, these will call for additional tests that may be more stringent or designed to be destructive to test the limits of the battery. It is important to identify the "Need" versus the "Want" when performing tests according to the vehicle assembler's standards.



Above diagram shows the construction of a lead acid battery.

Types of Lead Acid Batteries (LABs) :

Maintenance Free (MF) LABs

Made from a combination of Lead Calcium alloy technology, this is a more advanced version of LABs, compared to conventional or basic LABs that are made from Lead Antimony technology. The reason for the term Maintenance Free is clear, the battery does not need any topping up of electrolyte. This is due to 2 key factors, the chemical composition of the plates, and the design of the battery's venting system.

The absence of antimony content in the plates ensures that the water loss is kept to a minimum. The chemical composition also results in significantly lower gassing. The battery lid is usually a double layer with a labyrinth venting system. These combinations allow the MF to perform without needing to top up with water until the end of the battery's service life.

In most cases, Maintenance Free (MF) batteries are pre-filled and fully charged by the battery manufacturer. The batteries leave the factory in a "ready to use" condition.

The key challenge of MF batteries are logistics and shelf life. Batteries filled with acid are considered Dangerous Goods (DG) cargo, **therefore shipping costs are significantly higher than conventional dry charged batteries**. Due to the chemistry involved in MF batteries, the batteries generally have a limited shelf life of six months from the date of charging. It is strictly recommended that the MF batteries be sold on a First In First Out (FIFO) basis, and battery recharging should ideally be done on the fourth to fifth month from the date of initial charging.

In recent years, some manufacturers will offer "Dry Charged MF batteries". This technology is in limited use due to the overall higher cost and the preference by battery manufacturers to limit access to the cells of the MF batteries.

However, this term does not apply to countries such as India or Pakistan. Due to demands from the consumers, MF batteries sold in these countries have vent plugs intentionally visible to the end user to allow them to top up the electrolyte. As such, the treatment of MF and conventional batteries are identical in these 2 markets.

Sealed Maintenance Free (SMF) LABs

SMF batteries are similar to MF batteries above, with the exception that SMF are completely sealed batteries. The SMF batteries are filled and charged by the battery manufacturer, and the secondary lid is heat sealed to prevent access by the battery dealer or end user.

They were made popular by high volume exports from South Korea, which were incredibly competitive between 2005 to 2015 due to support from the Korean government via low interest export credit reinsurance for all destination countries. This effectively allowed the battery manufacturers to offer payment terms of up to 90 days from Bill of Lading date, which is highly uncommon given the high value of goods and risk of default.

The challenges of SMF are same as MF batteries.

In certain countries, MF and SMF LABs are erroneously referred to Electronic Battery or Dry Battery. This is due to the inability to see the electrolyte (thus assuming there is no electrolyte inside), and the presence of a battery charge indicator on the battery's lid. The indicator is assumed to be an electrical device that changes colour from Green (good battery) to Red (low charge). In reality, the Red and Green colour are 2 balls (one Red and one Green), either one of which will float depending on the electrolyte's specific gravity to provide a general idea on the state of charge for the battery.

Conventional LABs

Made from Lead Antimony technology, this is the most common type of LABs, usually characterized by the white body (box) of the battery. The white body is slightly translucent (also called natural white colour), which allows the user to visually inspect and determine the electrolyte level inside the battery.

These batteries are usually Dry Charged, meaning the plates are "pre-charged" by the factory in a process called plate formation prior to the battery being assembled. The battery dealer or end user can then "activate" the battery by filling it with diluted sulfuric acid. The acid will react with the pre-charged plates and bubbling will be observed within minutes of filling in the acid. It is generally good practice to "boost charge" the battery for 10 to 20 minutes prior to installation into the vehicle / equipment. Although boost charging is not compulsory, it can provide the benefit of improving the acid penetration into the middle part of the plates and will prolong the service life of the battery.

Conventional LABs are usually more resilient for long term storage and able to be recharged to near full capacity even when it is in a state of deep discharge.

Conventional LABs need to "vent freely", meaning the care must be taken to ensure that the batteries are not installed in a completely sealed or pressurised operating environment.

Due to the chemical composition involving antimony, Conventional LABs have a significant weakness in terms of water loss. As such, Conventional LABs require regular inspection and topping up of the electrolyte. While the first filling is done with diluted sulfuric acid, all subsequent topping up must be done using distilled water only.

Other types of LABS

Enhanced Flooded Battery (EFB)

EFB LABs are improved versions of Conventional and MF batteries. The construction is usually thicker plates (often double sided pasting) and higher quality separators. Commonly used for vehicles with Start-Stop technology.

Absorbent Glass Mat (AGM)

AGM LABs are made from both thicker plates (similar to EFB) and the separators are Absorbent Glass Mat (hence the battery's name). The electrolyte is completely absorbed into the AGM separator, sometimes called immobilized acid. As such, AGM batteries will not leak when tilted to the sides at 90 degrees or overturned 180 degrees. Used for vehicles that have both Start-Stop and Regenerative braking systems where the battery is under constant and rapid short charge-discharge cycles.

GHANA VEHICLE MARKET STATISTICS AND PROJECTED BATTERY VOLUMES

In determining the market volume for batteries, we use the following methodologies :

A. Vehicle registration data from DVLA
B. Roadworthiness data from DVLA
C. Vehicle sales data from public domain

Assumptions for Method A and C :

Bike batteries are 1 piece per vehicle. Average warranty / lifespan is 6 months. The optimistic annual quantity is 2 pieces per vehicle.

Passenger vehicle batteries are 1 piece per vehicle. Average warranty is 12 months, and lifespan is generally 12-18 months. Therefore the optimistic annual quantity is 1 piece per vehicle.

Commercial vehicles are 2 pieces per vehicle. Average warranty / lifespan is 6 months. The optimistic annual quantity is 4 pieces per vehicle.

A) Vehicle Registration Data from DVLA :

The following table presents the vehicle registration data from DVLA for period of 2020 and 2021, summarized into 3 key categories :

1. Bikes : Includes two wheelers and three wheelers.
2. Passenger Vehicles : Includes private motor vehicles up to 2000 cubic capacity, commercial motor vehicles up to 2000 cubic capacity, private motor vehicles above 2000 cubic capacity, motor vehicles above 2000 cubic capacity
3. Commercial Vehicles : Includes all buses, coaches, rigid cargo trucks, articulated trucks, agricultural equipment, combine harvesters and construction equipment.

Year	Bikes	Passenger Vehicles	Commercial Vehicles	TOTAL
2021	148,126	104,949	19,106	272,181
2020	105,059	84,275	15,086	204,420
TOTAL	**253,185**	**189,224**	**34,192**	**476,601**

Estimate Battery market volume for 2023 : From the above table of DVLA vehicle registration data, we will use the combined totals of 2 years because vehicles are rarely disposed after just 2 years. Therefore taking the total volumes of 2 years will represent an accurate volume of potential batteries in 2023.

Vehicle Type	Number of Battery Per Vehicle (pcs)	Average battery life (months)	Total Number of Vehicles 2020-2021	Estimate Total Battery Volume for 2023 (pcs)
Bikes	1	6	253,185	506,370
Passenger Vehicles	1	12	189,224	189,224
Commercial Vehicles	2	6	34,192	136,768
Grand Total			**476,601**	**832,362**

As illustrated in the above tables with 2 year vehicle volumes for **Method A**, the **expected volume of batteries for Ghana domestic market in 2023 is 832,362 pcs.**

B) Roadworthiness Data from DVLA :

VEHICLES ROADWORTHINESS - 2015 - 2021								
Year	2015	2016	2017	2018	2019	2020	2021	TOTAL
TOTAL	**861,039**	**760,020**	**870,781**	**1,062,157**	**1,190,548**	**1,287,102**	**1,422,454**	**7,454,101**

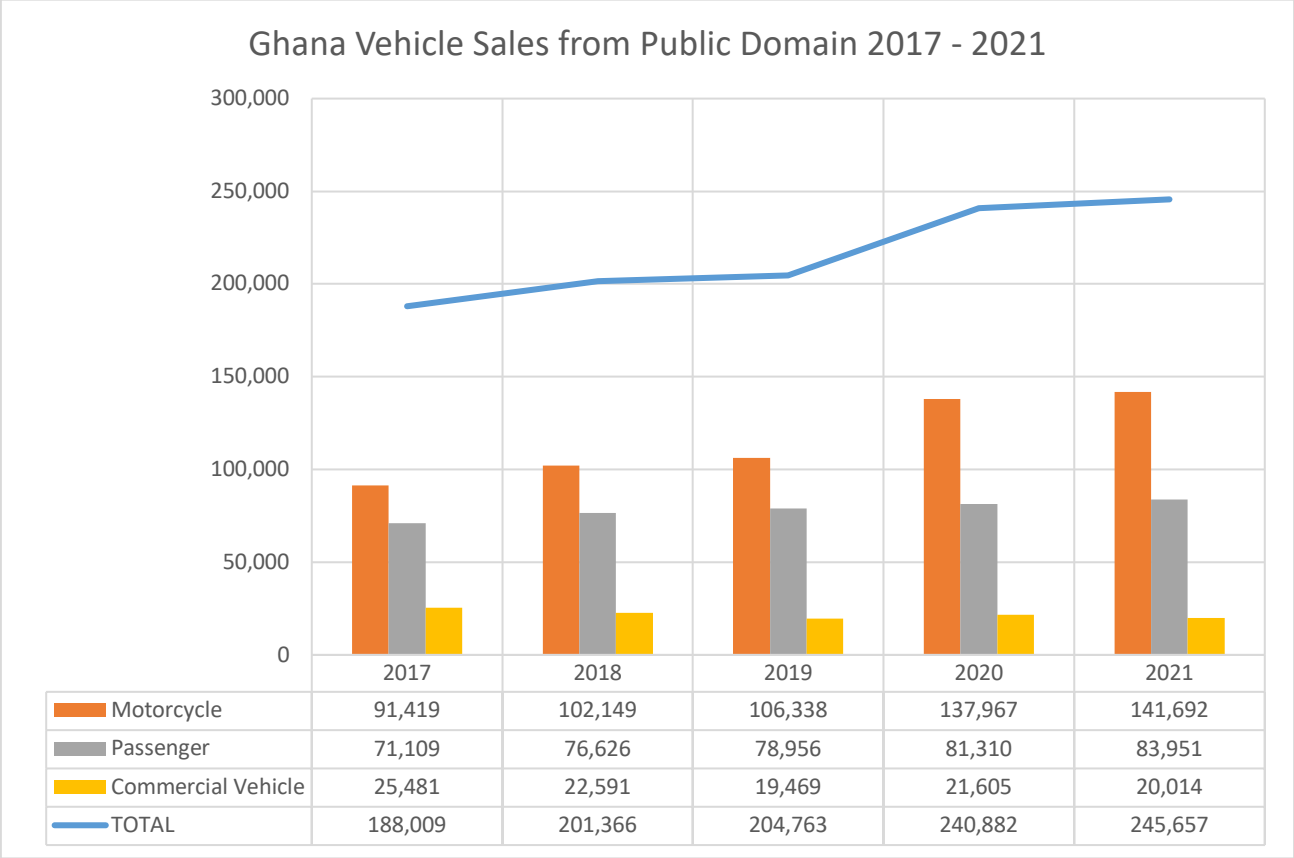
Estimate Battery market volume for 2023 : As the Roadworthiness data does not separate between bikes, passenger and commercial vehicles, we shall take a simple assumption of only 1 battery per vehicle. This is a bottleneck / accuracy challenge with this data, and we shall use it as it is for comparative purposes. Therefore using 2021 as the basis of assumption for **Method B**, **the conservative number of batteries in 2023 shall be 1,400,000 pcs**.

We do not consider year 2020 or any other prior year because this would cause data duplication.

Taking into account that there are vehicles that do not undergo the mandatory roadworthiness test, it is safe to assume that the actual number of vehicles are higher than shown in this chart.

C) Vehicle Sales Data from Public Domain (drawn from sales data of vehicle companies, Customs data, government statistics) :

The following table presents the vehicle sales data that includes **New, Reconditioned Imports, and Used Vehicle sales**. This data is based on insights garnered through paid databases and public sources (OEM annual reports and information published on their website, documents and information published by local governing bodies, documents published by industry associations (OICA and other country level and region level associations), news articles, and information provided in documents published by international trade associations). Based on these data sources (paid and public sources), the overall vehicles sales in several countries across Africa, including Ghana witnessed an increase for the year 2020, despite of the COVID-19 pandemic and associated bottlenecks. This was primarily attributed to consumers' inclination towards personal transportation rather than public transportation due to safety concerns. This further led to increase in demand for affordable used vehicles over their counterpart (new vehicles). Moreover, decrease in new vehicle manufacturing across the world and increased cost of new vehicles further supported the sales of used vehicles.



	2017	2018	2019	2020	2021
Motorcycle	91,419	102,149	106,338	137,967	141,692
Passenger	71,109	76,626	78,956	81,310	83,951
Commercial Vehicle	25,481	22,591	19,469	21,605	20,014
TOTAL	188,009	201,366	204,763	240,882	245,657

Estimate Battery market volume for 2023 : From the above chart, we will use the combined totals of 3 years (instead of 2 years based on vehicle registration data from DVLA). The following table calculates the estimate batteries for 2023 :

Vehicle Type	Number of Battery Per Vehicle (pcs)	Average battery life (months)	Total Number of Vehicles 2019-2021	Estimate Total Battery Volume for 2023 (pcs)
Bikes	1	6	385,997	771,994
Passenger Vehicles	1	12	244,217	244,217
Commercial Vehicles	2	6	61,088	244,352
Grand Total			**691,302**	**1,260,563**

Based on the above table for **Method C**, **we expect the 2023 battery market to be 1,200,000 pcs.**

Summary of Ghana battery market :

All 3 methodologies yield annual volumes between **800,000 to 1,400,000** pcs of batteries. Therefore it is fair to assume that the average annual volume is a minimum of 1,000,000 pcs of batteries. This also corresponds with the general feedback from the battery importers and distributors that the annual market is between 800,000 to 1,000,000 pcs of batteries. These numbers do not include Electric Vehicles (EVs, both BEVs and PHEVs). BEVs generally require proprietary batteries from the vehicle manufacturer, while PHEVs will mostly use AGM batteries.

Broken down into 12 months, this is an average of 80,000 pcs per month. This represents the comfortable volumes of a medium-large full scale battery manufacturing plant. If we use a conservative approach and reduce it by 30%, the resulting figure of 700,000 pcs for 2023 still represents an average monthly volume of 58,000 pcs.

Therefore, there is a solid business case for the setting up of at least one "Full Scale Battery Manufacturing plant" , or up to three "Battery Assembly and Battery Charging Plants" to cater for domestic Ghana market alone.

ECOWAS VEHICLE MARKET STATISTICS AND PROJECTED BATTERY VOLUMES

We will use a combination of vehicle sales data from government statistics and importer associations to determine the total vehicle population for ECOWAS countries. All data is gathered, and where possible, verified on best effort basis.

Passenger Vehicle Sales by Country

No	By Country	2017	2018	2019	2020	2021
1	Nigeria	57,355	59,109	63,446	62,526	66,954
2	Ivory Coast	67,993	70,636	15,385	13,707	12,947
3	Togo	31,970	31,058	32,252	40,127	36,372
4	Senegal	23,005	25,676	23,476	21,180	25,456
5	Benin	59,211	19,145	21,444	15,859	14,438
6	Burkina Faso	21,377	20,812	21,148	23,417	22,807
7	Cabo Verde	4,900	5,654	5,907	5,336	4,883
8	Gambia	34,476	37,405	37,795	35,246	33,688
9	Guinea	21,570	20,774	24,326	26,116	25,571
10	Niger	12,173	11,725	14,395	13,814	13,788
11	Sierra Leone	8,066	7,928	6,089	8,544	8,370
	TOTAL	**342,096**	**309,922**	**265,663**	**265,872**	**265,274**

Commercial Vehicle Sales by Country

No	By Country	2017	2018	2019	2020	2021
1	Nigeria	18,030	31,334	38,710	36,767	40,303
2	Ivory Coast	16,475	15,402	12,990	12,841	13,552
3	Liberia	2,726	2,214	1,534	1,790	1,700
4	Senegal	10,677	10,318	9,415	6,885	7,030
5	Burkina Faso	11,128	10,699	11,534	12,434	13,404
	TOTAL	**59,036**	**69,967**	**74,183**	**70,717**	**75,989**

Two Wheeler (Motorbike) Sales by Country

No	By Country	2017	2018	2019	2020	2021
1	Nigeria	781,856	730,708	742,964	650,866	640,668
2	Ivory Coast	58,471	53,339	54,050	55,509	60,282
3	Togo	185,335	178,776	168,360	241,987	316,369
4	Senegal	31,402	35,407	34,427	30,378	32,610
5	Benin	132,120	214,612	288,318	247,518	404,919
6	Burkina Faso	245,679	261,978	279,358	297,891	317,654
7	Gambia	2,428	2,928	3,691	5,879	6,352
8	Guinea	50,953	52,550	50,505	58,969	57,072
9	Niger	40,077	44,082	45,935	40,494	38,804
10	Sierra Leone	13,454	13,766	12,493	13,089	11,594
	TOTAL	**1,541,775**	**1,588,146**	**1,680,101**	**1,642,580**	**1,886,324**

Total Vehicle Population

Total Vehicle Population	2017	2018	2019	2020	2021
Passenger + Commercial + Two Wheeler	1,942,907	1,968,035	2,019,947	1,979,169	2,227,587

However, below points should be noted that will affect the accuracy of the data in the vehicle population tables :

1. Lack of transparency in import declarations, such as wrong declaration of HS code.
2. Smuggling from neighbouring countries via land borders. Therefore the vehicle is marked as imported into country A, but is actually delivered into country B.
3. Import of used vehicles declared as scrap to minimize duties.

Assumptions :

Bike batteries are 1 piece per vehicle. Average warranty / lifespan is 6 months. Therefore the annual quantity is 2 pieces per vehicle.

Passenger vehicle batteries are 1 piece per vehicle. Average warranty is 12 months, and lifespan is generally 12-18 months. Therefore the annual quantity is 1 piece per vehicle.

Commercial vehicles are 2 pieces per vehicle. Average warranty / lifespan is 6 months. Therefore the annual quantity is 4 pieces per vehicle.

Estimate Battery market volume for 2023 : From the above table, we will use the combined totals of 3 years because vehicles are rarely disposed after just 2 years. Therefore taking the total volumes of 3 years will represent an accurate volume of potential batteries in 2023.

Vehicle Type	Number of Battery Per Vehicle (pcs)	Average battery life (months)	Total Number of Vehicles 2019-2021	Estimate Total Battery Volume for 2023 (pcs)
Bikes	1	6	5,209,005	10,418,010
Passenger Vehicles	1	12	796,809	796,809
Commercial Vehicles	2	6	220,889	883,556
Grand Total			**6,226,703**	**12,098,375**

Based on the above table, **we expect the 2023 battery market to be 12 million pcs for the entire ECOWAS market. If we take a conservative approach and reduce it by 30%, it is still a massive 8.4 million pcs for 2023.**

VEHICLE ASSEMBLY IN GHANA – THE ROAD TO ORIGINAL EQUIPMENT MANUFACTURER (OEM) MARKET

The Government of Ghana has outlined the Ghana Automotive Development Policy (GEDP) with attractive Corporate Tax holidays and Waivers on Import Duties on machineries and equipment.

Key Challenges for the Vehicle Assemblers

Prices of Imported Used vehicles are nearly **HALF** of New vehicles assembled in Ghana. Due to massive price difference in New and Imported Used vehicles, most buyers will choose the latter.

Despite coming with warranty and after sales service package to offer peace of mind, the high financing cost for vehicle loans at nearly 30% interest further discourages buyers from choosing new vehicles. Nearly 70% of vehicle buyers will purchase their vehicle in cash.

As such, Imported Used vehicles represent 90% of the sales volume, while New Vehicles are only 10%. These challenges are causing the assembly plants in the country to achieve only 10% to 20% of their annual capacity. With better new vehicle financing policies the local assemblers are optimistic of achieving far higher sales (one assembler is confident of the new vehicle Total Industry Volume growing by three times).

Expectations of Vehicle Assemblers

All assemblers interviewed have echoed the same sentiments :

- The smooth and disciplined implementation of the GEDP with solid political willpower is critical to the survival of the assemblers.
- The prohibition on import of vehicles more than 10 years old is a welcome development. This should gradually be further restricted to vehicles not more than 7 years old.
- Franchise dealers should be allowed to offer more locally assembled models as pre-owned or pre-registered vehicles on special promotion pricing to attract buyers. This will help increase the sales of SKD / CKD vehicles.
- Improved credit reporting system coupled with a lower interest financing scheme, for example targeting first time car buyers of compact cars, may help the passenger vehicle market grow by threehold. The TIV may increase as much as 35%.
- The increase in volume of vehicle assembly is critical to the growth of automotive parts makers.

Labour Cost

Generally, the assembly plants are paying wages of USD 200 and above for production operators. For engineers, the wages are usually USD 400 and up. There are no complaints from the assemblers on the labour cost.

Original CKD Battery Supply

At present, the batteries come as part of the CKD / SKD pack. The batteries come fully-charged with acid inside. There are concerns of the batteries being in a state of discharge upon receipt, as the time taken for CKD / SKD pack consolidation, packing, shipment, clearance will usually be 3 months or more.

Quality of Original CKD Battery

In general, there is no major failure of the original battery. If there is any failure, the assembler will purchase a similar size battery from the local market and install it into the vehicle.

Warranty for Original CKD Battery

In most cases, there is no warranty provided by the CKD supplier. If there is any warranty to the assembler, it is pro-rated. There is no spare battery shipped with the CKD / SKD pack. The vehicle buyer is still entitled to a battery warranty, usually for a period of one year and sometimes two years.

Assembly Plant Volumes for the OEM supplier

With due respect, the combined present and foreseeable 2023 volumes for the assembly plants do not provide a stable or significant volume of business for a Battery Assembly plant. It is important to note that this situation is same in many countries. Even so, it is still important for the Battery Assembler or Battery Manufacturer to become a OEM supplier. There is much to gain in learning from the management systems, planning and control methods that are utilized by the vehicle assemblers.

GHANA BATTERY MARKET – AFTERMARKET / REPLACEMENT MARKET

Survey of Ghana Battery Market

Using an on-site survey of various battery sales channels, we have identified the following distribution methods :

1. Importer
2. Distributors / Wholesalers
3. Retailers / Workshops
4. Used battery dealers

Surveys on the battery market was focused primarily in the **Abossey Okai** spare parts hub. Both importers, distributors and retailer / workshops are aplenty in this automotive parts hub.

Example of a battery retailer in Abossey Okai market

The most popular type of LABs is Maintenance Free (MF). There is little concern as to whether the MF battery is **Fully Sealed (completely inaccessible)** or **Accessible (may be opened to top up water)**. It is almost impossible to find Conventional LABs in Abossey Okai, partly due to the focus of the exporters themselves in producing MF batteries. During our survey, we found that more than 98% of batteries in the market are MF batteries, of which 80% of these are Fully Sealed MF, and the remaining are Accessible MF.

Photo : Various brands of batteries displayed on a battery distributor's shelves, manufactured in South Korea, China, India, Turkey and Kenya. These are all Maintenance Free (MF) batteries.

LABs originating from South Korea have the largest market share, followed closely by India, China and Turkey. European brands are present in the market, catering to clients that trust in European goods to be of superior quality.

One major importer was willing to share their monthly import volumes :

No	Country of Origin	Number of 20 foot Containers per month	Distribution Share
1	Korea	5	50%
2	India	3	30%
3	Turkey	2	20%
	TOTAL	**10**	**100%**

Another 2 importers revealed that they each import between 1 to 3 containers per month from South Korea and from China respectively. Another 2 importers surveyed declined to reveal their import volumes, however they shared that their sales are roughly 3,000 pcs per month. This would translate into roughly 2 containers per month.

The quantity of batteries in one 20 foot container varies depending on the sizes and packing method by the exporters. In general, it will vary between 800 pcs to 2,000 pcs. As such, it is fair to estimate an average of 1,500 pcs batteries in 1x20 foot container.

Car and Truck LAB's are not exported in 40 foot containers due to the maximum weight limitations. However, motorbike batteries may be exported in 40 foot containers as the batteries weigh far lighter.

There are smaller importers that consolidate their imports with several types of goods in the same 40 foot container. For example, tyres are hollow in the middle. Batteries, lubricants or other spare parts will be stuffed into the hollow tyres. This offers good protection and maximizes the space utilization, and may escape visual identification of the stuffed items should Customs open the container for visual inspections.

An example of a shop that sells both batteries and tyres. This shop was closed on both survey days.

Types of Batteries in Ghana Market

Maintenance Free (MF) batteries dominate the Ghana market, representing 98% of the surveyed types. Two types of MF batteries are found in Ghana, namely Fully Sealed MF and Accessible MF.

For ease of reference without recommending any brand in particular, Korean and Chinese batteries are Fully Sealed MF, while Indian batteries are generally Accessible MF.

In general, the experienced dealers prefer to sell Accessible batteries and even Conventional batteries, because these LABs are easy to maintain and they carry a useful value for sale in the used battery market. However, Conventional LABs are almost non-existent in Ghana.

Automotive batteries represent the highest volume application, estimated by both importers and dealers at 90%. Solar batteries are available, however demand is low due to the overall cost of solar systems. This may change in the near future depending on certain incentives for solar applications or significant rise in electricity tariffs.

Example of Accessible MF (left) and Full Sealed MF (right) batteries fitted on a truck. These are 120Ah batteries, commonly called N120.

Fast Moving Battery Models and the Selling Prices to the Wholesale Market

1. **DIN 72** : Commonly known as DIN 72 or 57220, this type belongs to the European group called L3. Other variants of this model are DIN66, DIN 68, DIN 70, and DIN74. The dimensions are Length 278 * Width 175 * Total Height 190 mm. DIN batteries have recessed terminals, thus the Height and Total Height are the same. While DIN types were exclusively used for European vehicles before 2017, Japanese car makers have started to phase in these types. Examples include Toyota Hilux and Fortuner, moving from the traditional D31 to DIN 74. The wholesale price of this model ranges from GH₵ 380 to 860. The generally accepted price are for the brands that are priced from GH₵ 700 onwards.

2. **DIN 55** : Also known as DIN 52, DIN 45, these are commonly used for compact car models from Kia and Toyota. This type is also known as European group L2, with dimensions Length 242 * 175 * 190 mm. Owners of older Japanese cars will replace their original B24 (NS60) battery with DIN 55, which is far more common in Ghana. Wholesale prices range from GH₵ 320 to 640. Although this a “bread and butter model”, a survey of 12 Uber drivers revealed that they are mostly paying GH₵ 450 upwards for better quality, and that the ones priced below GH₵ 400 do not last more than 10 months.

3. **D31 series** : Regularly called 105D, 95D, 75D, the correct size definition is D31 with dimensions of Length 306 * Width 173 * Height 204 * Total Height 225 mm. This is a Japanese Industrial Standard (JIS) model, the terminals are raised. This model is commonly used for SUV and pickup trucks. This is generally premium market, with prices ranging from GH₵ 470 upwards to 1100.

4. **N120** : Used primarily for trucks and sometimes for bus, this type has dimensions of Length 505 * Width 182 * Height 213 * Total Height 236 mm. This can be used for both Japanese and European trucks. The general wholesale price is between GH₵ 720 to 1450.

The large price gap between brands are highly unusual. The author is of the opinion that there is significant under-value declaration for Customs (under-invoicing) by certain importers.

Battery retailers in general will enjoy a margin of between 20% - 35% (depending on model), when buying directly from the importer.

Payment Terms

Most importers will sell at cash or 30 days payment terms to distributors / wholesalers. Cash will net the highest discount amount, at the expense of capital tie down. Retailers and workshops generally buy in cash due to the low quantities. Dealers of used batteries always buy and sell on cash terms only.

Warranty

One importer claimed that the all battery manufacturers offer a 1 year warranty for all batteries. We feel this is doubtful, as export batteries mostly carry no warranty or 6 months warranty at best. Another 2 importers disclosed their same suppliers provide a No Warranty Discount or No Claim Discount of between 1.5% to maximum 3%.

The common issues faced by Distributors are mainly Undercharged LABs. This is not prevalent across all brands, however it is observed to occur more in Korea and Chinese batteries. The average shipment of batteries from Asia takes 8 to 10 weeks of sailing to reach Tema, while from India is it generally 3 to 5 weeks. Assuming Customs clearance and transport to warehouse taking up to 3 weeks, this is a maximum of 13 weeks. The average shelf life of a MF battery is 24 weeks (6 months) maximum before needing recharge. Therefore, importers may at times need to recharge the batteries before sale, thus incurring extra costs. However, this is not a monthly occurrence, but still considered as an inconvenience.

Below table illustrates the warranty period for the respective sales channels :

No	Sales Channel	Warranty Period
1	Importer to Distributor / Wholesaler	Between 6 months to 1 year
2	Distributor / Wholesaler to Retailer / Workshop	Between 6 months to 1 year
3	Distributor / Retailer / Workshop to Vehicle Owner	Between 1 month to 6 months
4	Used Batteries Dealers	Between 3 days to 1 week

Curious Practices

Importers also revealed that they import Sulfuric Acid in concentrated form (between 96% to 98%). These are shipped in 57 liter Jerry Cans on a quarterly basis, usually with other goods. They will then dilute the acid, and sell to their clients. According to the importers, there is no quality supply of battery grade sulfuric acid in Ghana, and they do not have confidence to explore local sources. It is uncommon for a battery importer to purchase battery acid in large volumes. A battery importer or distributor may want to store some acid for incidental use, such as topping up of batteries that were spilled in transit, however this is incredibly rare. A theoretical assumption would be that there is some activity in the form of refurbishing used batteries, as these will require large volumes of diluted acid of varying density (concentration).

What if there are MADE IN GHANA Batteries?

The general consensus of the battery distributors are positive towards the prospect of a Made in Ghana battery. They are supportive for the following key reasons:

1. Regular supply : Presently imported batteries from South Korea will require a lead time of average 16 weeks from order to shipment departure. Sailing time is sea is generally 8 weeks. This is a total of 24 weeks of preplanning orders. Any disruption may cause disastrous effects on the battery market.
2. Reduced inventory : Distributors and dealers are weary of theft and undercharged batteries needing recharge. With a local manufacturer, they are able to reduce their stockholding and batteries are always fresh.
3. Payment terms of between 30 to 45 days : Most manufacturers export on prepayment basis, while some will offer payment terms of 30 days. It is uncommon to find exporters offering 90 days, although some Exporters may offer this if they are able to secure facilities such as Export Credit Refinancing.
4. Removing Sulfuric Acid from the open market : Nearly all distributors and dealers surveyed have expressed a common concern on the dangers of having sulfuric acid sold separately. Apart from threat to the environment, they are worried that the sulfuric acid may be used for criminal intents.

A domestic Ghana battery manufacturer or assembler with proper stock planning and good quality batteries will enjoy consistently good sales all year round, especially with most distributors and retailers preferring to maintain a lower inventory. We do recommend that proper risk management analysis and background checks before providing payment terms to any client, especially if there is no solid collateral in place.

Used Battery Market

There is a significant market for Used batteries. These may be batteries that were collected by the battery dealers during the sale of a New battery, and found to be usable after recharging.

The general price of a Used battery is Half of a New battery. For example, the most popular model 105D31 model will sell at GH₵ 300 to 400, compared to the average GH₵ 900 for a brand new one of perceived good quality.

Used batteries are sold mostly in the back streets of Abossey Okai spare parts market. They will deliver to the main road shops upon request by workshops. This is, however, done with relatively low profile, and the used batteries are almost always without carton box packaging.

Photo : Used batteries for sale. This shop sells an average of 20 pcs per week.

The dealers of used batteries revealed that on average, they sell between 10 – 20 pcs per week.

The Battery terminals (Positive and Negative) always appear brand new, which is highly unusual. The logical explanation for this is that there was welding work done to remove and make new terminals. This is further reinforced by the fact that plastic material at the base of the terminals are damaged or melted, but the terminals themselves look brand new.

The “Guarantee” of a used battery generally for a period of 3 days to maximum 7 days. Some aggressive dealers will offer up to 15 days “guarantee” for used batteries, but this is very rare and occurs only when sales are challenging.

During the survey of 8 used battery shops, it was observed that women represent the majority owners of used battery shops. They outnumber the men-owned shops by more than 2 to 1.

The majority number of used batteries sold are of ROCKET brand, which comes from South Korea. They represent about 70% of used batteries sold openly. When asked about the origin of these used batteries, most dealers responded they may be from the local market. However, there were no new ROCKET batteries being sold in Abossey Okai market, and new battery dealers commented that they have not seen new ROCKET batteries since early 2021.

One used battery shop in particular, while displaying over 50 pcs of used South Korean and Chinese batteries outside, also had used batteries from Australia and USA inside their shop. The owner, a lady who spoke reasonably good English, was alarmed when asked about the origin of the Australian and USA batteries. Instantly stopped conversing in English, she became agitated and did not wish to continue the discussion. She invited me to take photos of the batteries outside, but she strictly prohibited me from taking photos of the Australian and USA batteries inside her shop.

Photo : Used batteries for sale. Interestingly, batteries from Australia and USA are for sale at this shop in Abossey Okai’s back streets.

Considering the absence of ROCKET from Ghana market for over 1 year, the large number of ROCKET used batteries in the market, plus batteries from other regions found in the same Abossey Okai shop, there is a possibility that these used batteries originated from another country. The good condition of the battery terminals (positive and negative) further confirms that there are activities of refurbishing used batteries. There are rumours in the battery market that there is a foreign-owned company based in Tema that engages in the refurbishing of used batteries.

Photo : Used batteries for sale. Some are with relatively new battery terminals which indicates that there was they were refurbished.

KEY CONSIDERATIONS TO SETUP A LABS MANUFACTURING PLANT

Types of Battery Manufacturing Setup

The process to manufacture LABs from start to finish, is a long one that ranges from 14 – 21 days in total. Upstream processes require large batch runs to achieve economy of scale, and carries concerns of product wastage due to oxidation.

As a general idea, the manufacturing of LABs can be grouped into the following categories :

No	Category	Capital	Manpower	Working Space	Process Time	Value Added Content
1	Full Scale Battery Manufacturing	Very High	High	Large	Long	Full. A minimum 55% is achievable, upwards to 85% if lead is sourced in Ghana
2	Battery Assembly and Battery Charging	Medium	Medium	Small to Medium	Short	Medium, 35% is achievable.
3	Battery Charging	Low	Low	Small	Short	Low to near zero. Not more than 10% local content.

Below table details the list of main processes involved in the manufacture of LABs from start to finish (Full Scale Battery Manufacturing) and the estimate labour size :

No	Process	Production Batch Size	Labour outlay (estimate)
1	Grid Casting	Large	6 – 8
2	Oxide Milling	Large	4
3	Mixing	Large	1
4	Pasting	Large	3
5	Curing	Medium, may be mixed	1
6	Plate Formation	Medium, may be mixed	4
7	Plate Drying	Medium, may be mixed	1
8	Plate Cutting	Medium	3
9	Plate Enveloping	Medium	4
10	Small Parts Casting	Medium	3 – 4
11	Assembly	Medium	9 – 11 per line, recommended minimum 2 lines
12	Filling and Charging	Low to Medium	4
13	Engineering, Maintenance, Technical, Quality, Logistics, and Support	Not applicable	15 - 18
	TOTAL		**77**

Market Volume Guide to Different Manufacturing Setups

Full Scale manufacturing, apart from having the longest process, lead time and capital outlay, also requires the highest volume to achieve economy of scale. There should be a stable minimum annual volume of 400,000 pcs batteries for this operation to be sustainable.

Assembly and Battery Charging, with the batteries imported as a semi finished product, only requires a minimum annual volume of 150,000 pcs to operate profitably.

Battery Charging, as the simplest form of operation with no significant value added content, has no requirement for minimum annual volume. It can be done easily by any battery importer and is easily scalable.

Key Considerations on different manufacturing setups

1. Market Volume – Domestic and Export – please refer to sections "**GHANA BATTERY MARKET – AFTERMARKET / REPLACEMENT MARKET**" and "**ECOWAS VEHICLE MARKET STATISTICS AND PROJECTED BATTERY VOLUMES**"
2. Raw Materials availability
3. Labour Rates

Raw Materials Summary

The basic key raw materials for LABs production are :

No	Material	General Content Ratio in a battery	Domestic Sourcing
1	Pure Lead min purity 99.98%	65%	Possible
2	Lead alloys	10%	Possible
3	Separator	5%	Not possible
4	Plastic box and lid	6%	Possible
5	Sulfuric acid	4%	Possible
6	Chemicals	10%	Not recommended

Pure lead and Lead alloys

Nearly all LABs are produced using secondary lead, as there is no significant quality or cost advantage in using virgin lead. Although easily available from secondary lead smelters, the key concern would be purity (quality).

Pure lead is used to make the Oxide (powder) of the battery.

Lead alloy is used to produce the Grids, Passbars, Intercell Connectors, Pillars and Battery Terminals.

Separator

The separator, as per its name, functions to keep the positive and negative plates apart to prevent short circuits. There are generally 4 types of separators :

No	Type	Usage	Pros	Cons
1	PE (Polyethylene)	The most common type for automotive use.	Low cost. High production speed.	Easy to puncture thus causing short circuit.
2	PE + GM (Polyethylene + Glass Mat)	Heavy duty applications such as construction / mining, or long drain use such as solar.	Helps prolong battery life. More robust than PE alone.	Higher cost than PE.
3	AGM (Absorbent Glass Mat)	Used in the manufacture of higher end LABs with gel electrolyte (also known as immobilized acid).	Resistant to vibration and may help prolong battery life.	High cost. Slower stacking speed affects production efficiency.
4	PVC (Polyvinyl Chloride) Note : This type is widely considered as Obsolete	Formerly widely used for automotive and solar applications	Easy to use, resistant to mishandling, low cost.	Inconsistent quality, prone to premature degradation.

Separator manufacturing is a long setup, high reject, complicated QC process type of industry. The long setup process is due to extensive calibration of the long production line, and this must be done for every tooling change. This subsequently leads to large amounts of rejected output during calibration, as the line must be in full production mode during calibration. The quality control process is a mix of extensive laser measurement, laser scanning and laboratory acid tests.

Separator selection is a crucial element in battery manufacturing because the separator needs to be able to resist shocks, impact, vibration, and heat without melting, while allowing continuous acid penetration.

We do not recommend the use of PVC separators except for very low cost and zero warranty solar applications.

For the Ghana and ECOWAS market, we recommend the use of PE as the primary separator for passenger vehicle use, and PE+GM for commercial vehicle use. This is a cost-benefit balancing factor as even though commercial vehicle batteries have lower volumes, these will always generally fetch a higher margin than passenger vehicle types.

Plastic box and lid

Each battery consists of one box and one lid, with handles and vent plugs. The material is Polypropylene Copolymer.

With more than 10 unique battery models, each having different dimensions, plastic injection moulding is easily the single most expensive investment. Due to the high capital cost, it is recommended to invest in the injection mould when a particular model has a stable monthly volume of minimum 3,000 pcs or more.

Below table is an indicative cost for the plastic injection moulds (conventional LABs), based on 2022 June mould prices.

No	Model	Capacity (Ah)	Individual Mould Price (USD)			Total Box + Primary Lid + Secondary Lid (USD)	Handle Mould Price (USD) (may be shared across multiple models)
			Box	Primary Lid	Secondary Lid		
1	B20	35	41,000	21,000	19,000	**81,000**	13,000 *
2	B24	45	43,000	22,000	20,000	**85,000**	*
3	D26	50, 60, 65	50,000	25,000	22,000	**97,000**	*
4	D31	70, 75, 80	55,000	28,000	24,000	**107,000**	*
5	D23	55, 60	50,000	25,000	22,000	**97,000**	*
6	N100	90, 100	60,000	29,000	26,000	**115,000**	13,000 ^
7	N120	110, 120, 130	63,000	33,000	27,000	**123,000**	^
8	N150	135, 150, 170	66,000	34,000	28,000	**128,000**	^
9	DIN55	50 , 55	55,000	26,000	22,000	**103,000**	*
10	DIN66	60 , 66 , 72	57,000	30,000	24,000	**111,000**	*
11	DIN80	75 , 80	60,000	32,000	26,000	**118,000**	*
12	DIN88	82 , 88	63,000	34,000	29,000	**126,000**	*

Marks * and ^ denote that the handle mould may be shared across the respective marked models, thus eliminating the need for multiple handle mould investments.

Sulfuric Acid

LABs, no matter what high quality materials that were used to make them, will finally depend on good quality sulfuric acid to ensure its quality. Iron (Fe) is the number one killer of a battery, and it exists in water that is used to dilute concentrated sulfuric acid. For LABs use, the Iron content should to be lower than 15ppm (parts per million) or 0.0015%.

Chemicals

Different applications of LABs require different mix ratios of chemicals. For example, Automotive applications have subtypes premixes for MF and Conventional, and Solar applications require a significantly different premix.

Due to the purity involved, it is highly recommended to procure these chemicals in premix form, ready for use. This is a common practice among the battery industry, whether the factories are producing full scale at 20,000 pcs per month or up to 500,000 pcs per month.

Labour Rates

Ghana has a minimum wage policy of about USD 80 per month. The average factory is paying USD 130 to 150 for a general machine operator. Vehicle assembly plants are paying on average USD 200 and upwards for an assembly line operator.

In general, monthly wages of between USD 90 to 150 is considered as highly conducive for the growth of a battery manufacturing or assembly plant. As wages touch the level of USD 250 per month, the management of the battery manufacturing or assembly plant should begin considering more automation to reduce the numbers of unskilled and semi skilled labour. Experienced employees should receiving training to ensure they become skilled workers and be assigned to specialized tasks.

BUDGET FOR BATTERY MANUFACTURING EQUIPMENT AND THE MANUFACTURING PROCESSES

We have broken down the budget into 2 types of Manufacturing Setups, namely :

a) Battery Assembly and Battery Charging
b) Full Scale Battery Manufacturing

A) Battery Assembly and Battery Charging. Achievable Local Content up to 35%.

Capacity : Up to 300,000 pcs per year (monthly 20,000 pcs).

Machine & Equipment : Budget USD 1.8 million.

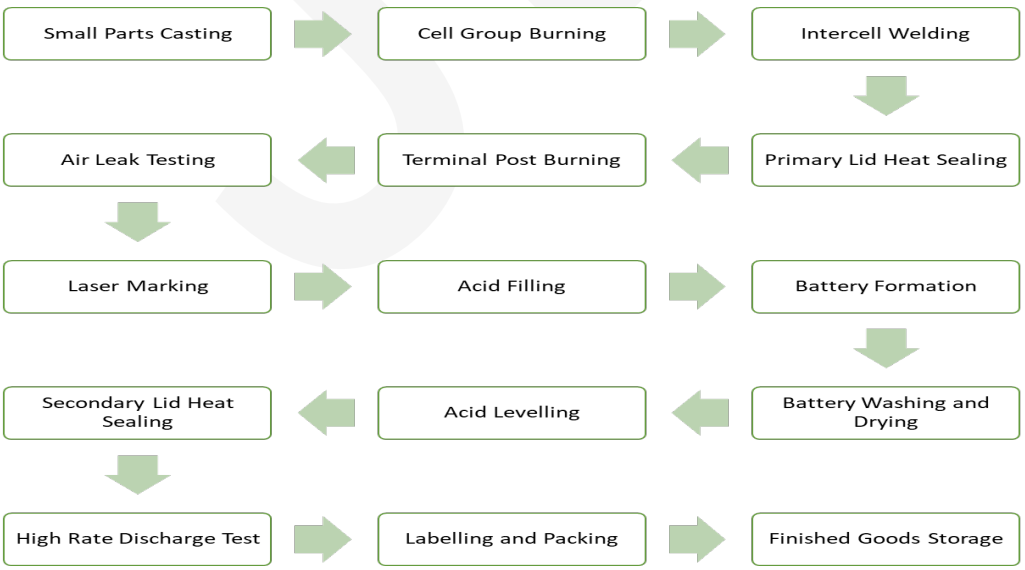
Working Capital for Materials : USD 10 million per year

Recommended Plant size : Minimum 20,000 sq ft

Expected Labour size : 20 – 25 persons

Processes :

1. Small Parts Casting (optional, may be done at Advanced stage of Battery Assembly and Battery Charging)
2. Cell Group Burning
3. Intercell Welding
4. Heat Sealing – Primary Lid to Box
5. Terminal Post Burning
6. Air Leak Testing
7. Laser Marking
8. Acid Filling
9. Battery Formation
10. Battery Washing and Drying
11. Acid Levelling
12. Heat Sealing – Secondary Lid to Primary Lid
13. High Rate Discharge test
14. Labelling & Packing
15. Finished Goods Storage



Above chart illustrates the process flow for Battery Assembly and Battery Charging

B) Full Scale Battery Manufacturing. Achievable Local Content min 55%, upwards to 85%.

Capacity : Up to 480,000 pcs per year (monthly 40,000 pcs).

Machine & Equipment : Budget USD 4.8 million.

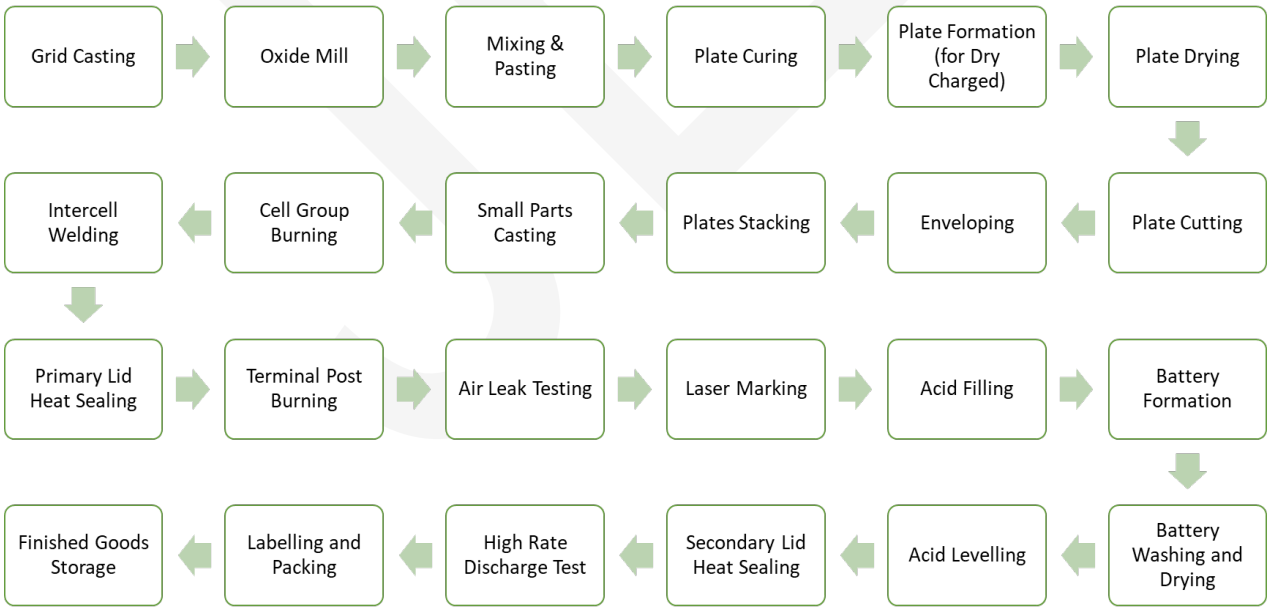
Working Capital for Materials : USD 18 million per year

Recommended Plant size : Minimum 50,000 sq ft.

Expected Labour size : 70 – 80 persons

Manufacturing Processes :

1. Grid Casting
2. Oxide Milling
3. Mixing & Pasting
4. Plate Curing
5. Plate Formation (if dry charged batteries are required for export)
6. Plate Drying
7. Plate Cutting
8. Enveloping
9. Plates Stacking
10. Small Parts Casting
11. Cell Group Burning
12. Intercell Welding
13. Heat Sealing – Primary Lid to Box
14. Terminal Post Burning
15. Air Leak Testing
16. Laser Marking
17. Acid Filling
18. Battery Formation
19. Battery Washing and Drying
20. Acid Levelling
21. Heat Sealing – Secondary Lid to Primary Lid
22. High Rate Discharge test
23. Labelling & Packing
24. Finished Goods Storage



Above chart illustrates the process flow for full scale battery manufacturing

COLLECTION AND RECYCLING OF SCRAP BATTERIES

Presently, there is no formal program or regulation that mandates the collection of scrap batteries by genuine licensed scrap collectors. The market is well aware that there was a Bosch-sponsored program that promoted the collection of scrap batteries to be exported out of Ghana for recycling in 2021.

The scrap collectors will buy the scrap batteries from the workshops, battery dealers, and battery distributors. The battery importers are not keen to collect the scrap batteries due to the low margins, hassle of transportation and storage space.

In Abossey Okai, prices for scrap batteries are in the range of GH₵ 30 to 100 per unit, depending on sizes. In other areas, they are sometimes sold by weight, at a price of up to GH₵ 10 to 13 per kg. The most popular and fast moving battery D31 (referred to as 105D, 95D and 75D on the market) carries a scrap value of of GH₵ 40 to 100 per piece depending on location. At GH₵ 40 , it is considered as a very low price. An average value of of GH₵ 80 is more reasonable for this size.

From the various interviews done, most of the battery dealers share the same feeling that there should be a better-organized long term scrap battery collection program. This may be achieved through the creation of a specific scrap battery collection licensing program that comes under the purview of a government authority or agency.

In general, most countries will place scrap batteries in the same category as scrap metals. We would caution against this practice. Scrap metals usually do not contain corrosive liquids; they usually have grease or oil. The grease, oil and other lubricants may be oxidized during the melting of the scrap metal, or they may be diluted and washed using detergents prior to melting.

Scrap batteries, on the other hand, contain sulfuric acid, a highly corrosive colourless liquid that releases more fumes as the temperature rises. While air pollution due to sulfuric acid fumes is not an alarming situation, it is the concentration of sulfuric acid in the recycling area's grounds that makes it a key hazard. There is a high likelihood of the sulfuric acid mixing into the underground water and is carried into the streams or rivers. This will alter the pH value of the water, and will be absorbed by crops and plants, and consumed by grazing animals. It has been observed in certain countries such as Bangladesh and India, where the local villages depend on a limited number of ponds or lakes for their water, that the discharge of waste water containing sulfuric acid has caused a massive increase in the cases of skin inflammations, burning sensations in the throat when drinking, and other irritations when showering.

We would recommend that scrap batteries be placed in a category together or equivalent with toxic waste. The management of scrap batteries should ideally be designated as follows :

1. Collection, Transport and Temporary Storage of Scrap Battery
2. Storage, Breaking, Recycling and Smelting of Scrap Battery

The Secretariat of the Basel Convention has issued **Technical Guidelines for the Environmentally Sound Management of Waste Lead Acid Batteries**, a detailed document that outlines various recommendations and best practices for the industry.

Collection, Transport and Temporary Storage of Scrap Batteries - Recommendations

The Collection, Transport and Temporary Storage of Scrap Batteries should be a controlled activity that is licensed by a central authority, hereafter referred to as the Controlling Agency. We recommend the Environmental Protection Agency (EPA) or other agencies under Ministry of Environment, Science, Technology and Innovation (MESTI) to be the Controlling Agency.

The following should be considered in the scrap battery collection licensing program :

- Ownership of the scrap battery collection company. There should ideally be a minimum 40% shareholding by Ghana citizens. We would further recommend shareholding by Ghana female citizen of at least 10%. This is important for both shareholder traceability, accountability, and economic participation for Ghana citizens as a whole.
- Environmental track record by EPA or local councils. Should the company be fined twice or more for any offence related to environmental laws in the same year, their license may not be renewed for the following year. This will increase pressure on their operational responsibilities to protect the environment and the communities that they operate in.
- Mandatory presentation of original DVLA inspection certificates during registration and renewal of license. This will prevent unfit vehicles from being used to transport scrap batteries.
- Mandatory annual training for all scrap collection drivers for handling of scrap batteries and disaster management (acid spills, fires).
- Online weekly reporting of scrap batteries collected and disposed (sold) to smelters or recycling plants. Details to be recorded should include the seller's name (battery shop name, workshop name or vehicle owner's name), battery brand, model, gross weight and buyer (smelting or recycling plant). This will ensure the traceability of the scrap batteries from point of collection until point of disposal (smelter). This report may be done in a preset Excel template provided by the Controlling Agency (for example EPA), and submitted by email or uploaded into a designated website.

- Any new site for Temporary Storage of Scrap Battery must first receive written approval by the Controlling Agency before it may be operational. Any such site must be situated at least 150 meters away from any residential area, forest or water source (such as but not limited to river, lake, pond, drinking water processing plant), may not exceed 6,000 square meters (smaller than a football field). There shall be adequate measures in place for control of acid spills, fire fighting and all personnel must wear appropriate personal protective equipment (PPE) when inside the storage site. For any existing such site, this requirement may be enforced with due consideration on the economic impact on the site owner or operator. However, we strongly recommend that the existing site to be situated not less than 50 meters from any forest or water source (river, lake, pond) or residential areas. If the site owner does not wish to relocate, they must build a suitable bund or buffer zone to completely encircle their storage area for prevention against fire incidents spreading beyond their compound. The bund will also serve as a safe zone for neutralizing any major acid spills that may occur after a fire.
- Corporate Social Responsibility (CSR) programs done by the scrap collector companies in the past 2 years may be used as additional criteria for license renewal. Examples of these CSR activities include but are not limited to : environmental protection or conservation (such as tree planting, river cleaning, contributions towards rescue and rehabilitation or rehoming of endangered animals) and community empowerment (such as building of community centres, disaster relief, or contributions to charity programs or charity homes).

Storage, Breaking, Recycling and Smelting of Scrap Batteries - Recommendations

- The Storage, Breaking, Recycling and Smelting of Scrap Batteries should be a controlled activity that is licensed by a central authority, hereafter referred to as the Controlling Agency. Similarly, we recommend the Environmental Protection Agency (EPA) or other agencies under Ministry of Environment, Science, Technology and Innovation (MESTI) to be the Controlling Agency. This will create a single controlling agency to oversee these related activities. It should be made compulsory for any proposer for such site to conduct a thorough Environmental Impact Assessment (EIA) study that includes participation from all stakeholders (such as investors, all residential and commercial and industrial premises within a 400 meter radius, government, scrap collectors and other relevant parties).
- The following should be considered in the scrap battery recycling and smelting licensing :
- Ownership of the Recycling or Smelting company. There should ideally be a minimum 20% shareholding by Ghana citizens. We would further recommend shareholding by Ghana female citizen of at least 5%. This is important for both shareholder traceability, accountability, and economic participation for Ghana citizens as a whole. We also take into consideration of the large investments that have been made by existing players, therefore we do not recommend to cause undue alarm to foreign investors by enforcing higher Ghana citizen shareholding.

- Environmental track record by EPA or local councils. Should the company be fined twice or more for any offence related to environmental laws in the same year, their license may not be renewed for the following year. This will increase pressure on their operational responsibilities to protect the environment and the communities that they operate in.
- Mandatory presentation of original DVLA inspection certificates during registration and renewal of license. This will prevent unfit vehicles from being used to transport scrap batteries.
- Mandatory annual training for all personnel for handling of scrap batteries and disaster management (acid spills, fires).
- Online weekly reporting of scrap batteries collected and purchased from licensed scrap battery collectors. Details to be recorded should include the seller's name (scrap battery collector) and gross weight. This will ensure the matching traceability of the scrap batteries from point of collection until point of disposal (smelter). This report may be done in a preset Excel template provided by the Controlling Agency (for example EPA), and submitted by email or uploaded into a designated website.
- Any proposed site for Recycling or Smelting plant must be situated at least 400 meters away from any residential area, forest or water source (such as but not limited to river, lake, pond, drinking water processing plant). The site must meet the requirements of Schedule 2 under the Environmental Protection Agency Act 1994, Act 490 and Ghana Environmental Assessment Regulations 1999, LI 1652. There shall be adequate measures in place for control of acid spills, fire fighting and all personnel must wear appropriate personal protective equipment (PPE) when inside the storage site. For any existing such site, this requirement may be enforced with due consideration on the economic impact on the site owner or operator.
- Any existing or proposed site for Recycling or Smelting plant must have include in their site plan, the installation of Air Pollution control system such as Dust Collector for dry dust, Wet Scrubber for fumes and Waste Water Treatment for the water run-off within the plant. Where necessary, bunds or internal drainage shall be installed to prevent any untreated liquids from escaping outside the plant's premises. There shall not be any untreated liquids flowing into the outside drainage system, whether intentional or unintentional.
- When Dust Collector is used, there must be weekly monitoring records to ensure that the filtration efficiency is maintained by using magnehelic differential pressure gauges at inlet and outlet. Filter bags or filter cartridges shall be replaced at suitable intervals, and the old filters must be disposed according to scheduled waste guidelines.
- When Wet Scrubber is used, the packings should be washed at suitable intervals, and the system's efficiency may be monitored using magnehelic differential pressure gauges at inlet, packing, outlet.
- Emission standards for the Recycling or Smelting plant should meet the requirements of 100mg/m3 of lead or lower (measurements done at chimney, also known as Stack Sampling). This should be done at regular intervals, for example every 3 months during full operations inside the plant.
- For the workers inside the Recycling or Smelting plant, we recommend following the standard of OSHA PEL (8-hour TWA) at 0.050 mg/m3; read in reference to 29 CFR 1910.1025.

- The Scrap Battery Storage areas, Battery Breaking plant, Waste Water Treatment plant, and Waste Water Tanks / Ponds must have a suitable bund or buffer zone to prevent acid leaks. The bund will serve as a safe zone for neutralizing any acid spills or acid run-offs resulting from of the plant's processes. As a general guide, the total bund capacity should be 1.5 times the maximum capacity of the Waste Water Tank.
- Not located inside any Free Zone or Export Processing Zone. If there are any existing plants located inside such zones, we recommend that they be subject to monthly inspections by the Controlling Agency or Ghana Revenue Authority (GRA) to ensure compliance to all environmental laws and verify their export volumes. The purpose is to discourage the use of Ghana resources to process the scrap while exporting precious raw materials out of the country.
- Corporate Social Responsibility (CSR) programs done by the recycler or smelter in the past 2 years may be used as additional criteria for license renewal. Examples of these CSR activities include but are not limited to : environmental protection or conservation (such as tree planting, river cleaning, contributions towards rescue and rehabilitation or rehoming of endangered animals) and community empowerment (such as building of community centres, disaster relief, or contributions to charity programs or charity homes).

There is inadequate data from Customs repository in Ghana to identify the amount of recycled or refined lead exported out of the country. Due to the absence of a battery manufacturer in Ghana and the import of lead by Ghanaian cable manufacturers, it is safe to assume that nearly 100% of the recycled or refine lead are exported out from Ghana.

BUDGET FOR SCRAP BATTERY RECYCLING EQUIPMENT AND THE MANUFACTURING PROCESSES

The scrap battery recycling equipment consists of the following machines / processes :

1. Battery breaking / cutting
2. Lead and plastic separation unit
3. Plastic material crusher
4. Rotary furnace
5. Refining / Alloying pots
6. Lead Ingot casting

The battery breaking / cutting process will involve large volumes of waste sulfuric acid. An effective Waste Water Treatment System must be installed to treat the wastewater before release into the public drainage system. A Wet Scrubber system should be installed to treat acid fumes from the battery breaking process.

The rotary furnace and refining / alloying processes generate large amounts of lead dust at high temperatures. An effective Dust Collector system with suitable filter bag system must be installed to ensure the effective capture of the lead dust.

Our recommendations are detailed in section **"Storage, Breaking, Recycling and Smelting of Scrap Batteries".**

For a 30,000 ton per year capacity, the estimate equipment cost is USD 3.5 million.

Battery recycling and smelting operations will generally require a land size of 25,000 square foot and above. The cast lead ingots will usually weight between 25 – 35 kg, depending on the mould. Strong security measures such as High Walls with Razor Wire, CCTV cameras, motion-activated alarms and strict security checks are important to prevent theft of the lead ingots.

POLICY MAKING :

The growth of any industry depends on various factors such as market demand, investor commitment and government support. In terms of LABs in Ghana, the market is a constant one with no seasonal limitations. Therefore market demand is relatively stable one.

The three (3) types of battery manufacturing setups may be defined in comparison to automotive manufacturing, as follows :

No	Battery Manufacturing Setup	Equivalent to Automotive Manufacturing setup
1	Full Scale Battery Manufacturing	Completely Knocked Down (CKD)
2	Battery Assembly and Battery Charging	Semi Knocked Down (SKD) or Enhanced Semi Knocked Down (e-SKD)
3	Battery Charging	Completely Build Up (CBU)

With the above definitions in place, we recommend the Government of Ghana to consider the following incentives for the LABs industry :

A) Investment Based incentives :

1. Full Corporate Tax holiday of minimum 3 years for companies that invest in "Battery Assembly and Battery Charging."
2. Full Corporate Tax holiday of minimum 10 years for companies that invest in "Full Scale Battery Manufacturing". For companies that invested in "Battery Assembly and Battery Charging" that enjoyed the earlier 3 years Tax Holiday, this next 10 years Full Corporate Tax holiday shall be calculated from the date of commissioning of the new investments in "Full Scale Battery Manufacturing" equipment.
3. Double tax deductions for paid industrial trainings conducted by training centres that are approved by the Ghana government.

B) Growth Based incentives :

1. Reduced corporate / income tax when reaching certain threshold of export sales. For example, corporate tax rate reduction of 1% when achieving export of 10% from total turnover, and 2% when achieving export sales of 10% from total turnover. This is easily traceable using Customs export declarations as supporting document. This also serves to discourage any under-invoicing because the manufacturer / assembler will want to maximize their tax benefits.
2. Reduced corporate / income tax when achieving certain threshold of Ghanaian employment. For example, corporate tax rate reduction of 0.5% with a minimum of 90% Ghanaian full time employees in the company for more than 8 months in a calendar year. This will maximize employment opportunities for Ghana citizens.
3. Reduced corporate / income tax when achieving certain threshold of Ghanaian women employment . For example, corporate tax rate reduction of 0.5% with a minimum of 10 Ghanaian women full time employees in the company for more than 8 months in a calendar year.

Activity that does not qualify for any incentive :

Tax holidays or incentives shall not be granted for investments in Battery Charging works.

Phased-In Approach for Industry Protection

We further recommend that the Government of Ghana consider the following **3 stage Phase-In** approaches to support the growth of the local battery assembly or battery manufacturing plant.

Phase 1 : Full Import Duty for Complete Batteries as a Finished Goods product

The initial 3 years of a battery plant is a crucial period where the business demonstrates the ability to become a going concern. Government support is critical to ensure that the local plant is able to grow their production volumes and achieve certain economy of scale to compete with imported goods. We recommend that the government adopt the ECOWAS Common External Tariff for import of batteries under Category 4, with 35% import duty. We also recommend to consider implementing an environmental tax or recycling duty of between 3% to 5% for batteries at the point of import, calculated on top of the landed price before VAT. This will ensure that the importers are paying their part in environmental conservation and rehabilitation.

Phase 1 : Minimum Import Duty for Battery Materials

To ensure the growth of the battery plant while contributing directly to the nation's income, import duty should still be charged for the import of the related materials, however at a minimum rate of 5%. Further, we recommend that the importation of battery materials be limited by means of a permit system to ensure that only the genuine battery manufacturer may import materials at minimum import duty. This permit system shall prevent non-manufacturers from using the HS code to import Complete Batteries disguised as Battery Materials.

Phase 1 : Licensing of Scrap LABs Collection

The collection, transportation, and storage of scrap LABs is a hazardous process, and should be handled in a safe, traceable and accountable way. We recommend that the government introduce a centralized licensing program to register scrap battery collectors. This registration and database maintenance may ideally be handled and managed by the Environment Protection Agency (EPA). The registration may be valid for one year, and is renewable annually. Please refer to section "**COLLECTION AND RECYCLING OF SCRAP BATTERIES"** in this report for more details.

Phase 1 : Implementation of Last Highest Verified Goods Value on import of finished batteries

The computerized Customs systems may ease and facilitate the recording and retrieval of unit prices of batteries that are / were imported. In any dispute on value of imported goods that exceeds 20%, we recommend that Customs use the last assessed value or the present value, whichever is higher. This will prevent instances of under-valuing and ensure that the right amount of duty is collected.

Phase 2 : Tax on Export of Lead (Scrap, Refined, Pure and Alloyed)

The process of recycling a lead acid battery is a highly polluting, high carbon emitting and high energy consumption industry. We recommend that the government introduce taxes or cess on the export of lead, whether in scrap or refined form (pure and alloyed). This will generate income for the government for purposes of environmental rehabilitation and conservation.

Phase 2 : Physical Verification of imports at Port of Destination, such as Tema seaport

Several nations in the African region require Third Party Inspection at point of export (country of origin). Based on numerous real life experiences, these Third Party Inspection services are primarily simple photographic verification of the nature of goods being exported. We are of the opinion that inspection at point of import (destination port) is more useful and effective. Physical verification will enable the Customs department to detect any attempts to under-declare quantities or undeclared goods (for example, batteries or lubricants loaded inside the hollow section of a tyre).

Phase 3 : Mandatory Battery Testing at Port of Destination, such as Tema seaport

In the course of growth of the battery factory along with the automotive sector, the research, development and testing capabilities of Ghanaian laboratories will be expanded. The laboratories will then be able to perform electrical tests on imported batteries to ensure that they meet certain minimum standards. While a National Standard for Batteries may be ideal, it is not compulsory and we recommend the use of existing International Standards such as IEC to simplify the process and to avoid disputes. We recommend that the testing to be compulsory, on per Bill of Lading basis, one piece for every model.

Key Pitfalls to avoid in Policy-Making

In some African and Asian countries, we have observed foreign battery manufacturers setting up "manufacturing plants" locally. However, in reality these are merely Battery Charging Plants that are used for a single process : to Fill Acid and Charge the fully imported batteries. This is a common strategy used to circumvent the import duty on complete batteries, by declaring the imported batteries as "Parts for battery manufacturing". Furthermore, in most cases, these plants do not have the proper waste water treatment systems to control the quality of discharged water.

The setting of a Charging Plant is a low cost venture, requiring minimum manpower. The Charging Plant operators generally declare a local value added content of up to 25%, but in reality, it rarely exceeds 6% because the only material costs are sulfuric acid, water, and electricity.

Charging Plants do not provide significant employment numbers, and their electricity power draw is high. Risk of untreated waste water discharge, whether accidental or otherwise, is known to be high. In general terms, the carbon footprint per employee or per local content value is considered to be high.

It is important for the authorities to visit the factory or manufacturing plant on a regular basis, for example once every 6 months. This will assist in verifying that the actual processes are as per declared in the license or permit, and to ensure that the environmental laws are adhered to.

Bi-Lateral and Multi-Lateral Trade Facilitations among ECOWAS Members

Battery demand in ECOWAS is expected continue to grow with more industrial growth providing additional employment opportunities, populations becoming more affluent, more new vehicles being assembled leading to better affordability, and traded-in vehicles finding excited new owners. We recommend the Government of Ghana to initiate talks with immediate land border countries to promote the Made in Ghana batteries, taking advantage of the **ECOWAS Trade Liberalization Scheme (ETLS)** to obtain duty free or minimum duty trade benefits. This will enable the domestic battery manufacturer to expand their export sales and bring in more foreign currency income for the nation.

GENDER, EQUALITY AND SOCIAL INCLUSION (GESI)

We believe that Women have an equally important role to play in both Family, in the Workforce and in Business. It it most encouraging that companies such a Scania have put a focus on women in the workforce by training more than 100 women to become bus drivers in Accra.

We recommend the business to employ more women in the battery assembly department. The efficiency of women in the welding process is highly recognized in battery manufacturing plants in China and Vietnam, where their speed and accuracy far outshine the men. The author observed on numerous visits to battery manufacturing plants in these countries and all the manufacturers share the same sentiment.

In the supply chain, the Company should consider providing priority to Women-owned companies and Unemployed women as potential suppliers. For example, in support of home based businesses, the Company can consider to outsource the cutting of “Battery Protective Foam” to women who are unable to take on full time employment due to family commitments. As the initial market volume may be low, it may not be feasible for the Company’s foam supplier to invest in a mould for the foam. Thus, we may provide a source of part time employment to the women who can then acquire skills for the future.

Throughout the distribution chain, the Company can encourage women entrepreneurship by offering a lower start-up capital program for the dealership of batteries, or set up small distribution outlets that are operated by women, particularly in rural areas. For improved security, we recommend that the distribution outlets to be located close to police stations or junctions where there have constant police presence.

We further recommend the business to provide equal employment and career growth prospects to the physically disabled. Administrative, planning and financial positions are key areas for the business to take the lead and empower the physically disabled.

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