Original Research Article

Opportunities for local electric vehicle manufacturing in Africa

Akii A. O. Ibhadode

Affiliation
Department of Production Engineering, University of Benin, Benin City, Nigeria.

***For correspondence: email:** ibhadode@uniben.edu; **tel**: +234 802 343 8765

Abstract
In order to achieve the Sustainable Development Goals (SDG) of the United Nations on Clean Energy, Sustainable Industrialization and Climate Change, there is an urgent call on Africa to decarbonize transportation. Achieving these goals requires that Africa grows its current, largely, non-existent EV fleet to a reasonable level in the near future, to counter harmful emissions from fossil fuel vehicles. This paper discusses the opportunities available to African entrepreneurs on investing in electric vehicle (EV) manufacturing. It also discusses the factors militating against the establishment of a viable automotive sector. To exploit the opportunities offered despite the limitations, the paper advocates a paradigm shift from the conventional vehicle assembly of foreign vehicles to one in which African original designs are made in low-cost, low-volume vehicle manufacturing plants consisting of general-purpose workshop equipment and intensive labour such that the whole value chain for vehicle manufacturing is developed.

Keywords: *Sustainable development goals, automobiles, electric vehicles, vehicle manufacturing plants.*

1. Introduction
Africa is usually not considered a manufacturing continent due to a number of factors such as poor industrial infrastructure, and lack of appropriate skills among others, despite the large reserves of raw materials. Whereas the World manufacturing output in 2022 was 16,291 billion USD, that of Sub-Saharan Africa was only 229 billion USD representing 1.4% of World manufacturing [1]. To achieve the United Nations Sustainable Development Goals (SDGs) of 7 on Clean Energy, 9 on Sustainable Industrialization and 13 on Climate Change, for which the transport sector contributes 24% of CO_2 emission [2], Africa must decarbonize its transport sector. To achieve this, a great emphasis is placed on transition from fossil fuel transportation to renewables such as electric vehicles (EVs) [3, 4].

The President of African Development Bank Group at a 2022 Investment Forum in Morocco stated that the size of global EV market is estimated to increase from the current 7 trillion USD to 57 trillion USD by 2050, and that the future depends on Africa because, Africa accounts for the largest source of green materials for the development of EVs [5]. To fully exploit this advantage would require enormous investments by African countries especially in increasing its EV fleet. If the conventional response to this increase in demand on number of EVs is to be met by importation or mere vehicle assembly, this will further exacerbate the precarious economies of African countries. Thus, there is the need for Africa to develop the value chain for EV manufacturing.

Currently, EVs are gradually gaining ground in Africa through the major pathway of global automobile companies such as Nissan Motor Co. Ltd, Volkswagen AG, Tesla Inc., Geely Auto Group, BMW AG, Kia Corporation, Volvo Car Corporation, Mercedes –Benz Group, Groupe Renault, Hyundai, etc. through assembly plants in some countries such as South Africa, Morocco, Tunisia, Algeria, Egypt, Kenya, Nigeria, etc. An example is the Hyundai Kona EV launched in 2021 in Abuja, Nigeria [6].

Other pathways of EV introduction in Africa are through (i) new start-ups, (ii) conversion of internal combustion engine (ICE) vehicles to EVs and (iii) research and development (R&D) in universities and research institutes.

From internet search, old and new EV start-ups in Africa, include Kiira Motors in Uganda; JET Motors, Innoson Vehicle Manufacturing Company, and Siltech World in Nigeria; BasiGo, Mobius Motors and Nopea Ride (though recently folded up) in Kenya; Mellow Vans in South Africa; Greenfoot Africa in Tanzania; Ampersand in Rwanda; Solar Taxi in Ghana; and EV Station, Neo Kozmo, Hubbert, and EGIKE in Egypt. Algeria, Morocco, and Tunisia also have EV companies. Of these, special mention should be made of Kiira Motors in Uganda which was started in 2008 jointly owned by the Ugandan Government and Makerere University which stemmed from a research project at the university [7]. Kiira Motors has built original designs of EVs which are yet to be in the market.

The other pathway of EV introduction in Africa is through conversion of ICE vehicles to EVs. A good example is the Nigerian company based in Maiduguri which converts petrol minibuses to EVs [8].

At the R&D level, some African Universities are developing EVs, where the Kiira Motors, Uganda is a good example that has progressed to a national investment. Other examples at low levels of investment are the EVs produced at the University of Nigeria, Nsukka and the University of Lagos both in Nigeria [3].

With these activities on EV introduction in Africa, especially at the R&D level, where original EVs are being developed, it is important for these prototype vehicles to progress to the market. Thus, this paper discusses the opportunities that exist for local EV manufacturing in Africa, with the hope that investments can be made for these locally developed vehicles to enter the automobile market.

2. Opportunities for local electric vehicle manufacturing

The following are some opportunities that could be exploited for EV manufacturing in Africa.

2.1 Simpler design of EVs

EVs have simpler vehicle structure than ICE vehicles because they do not require complex mechanical transmission parts such as gearboxes, drive shafts and axles, and such other parts as exhaust system and fuel tank. This gives more space in an EV than the equivalent ICE vehicle. The absence of an ICE in EVs eliminates substantially vibrations and noise. The ICE is inherently eccentric in operation which promotes vibrations in the vehicle. The absence of drivetrain vibrations eliminates the need for complex mountings for the drivetrain in EVs. The explosions in ICE resulting from the combustion of fuel-air mixture, produce noise, which is non-existent in EVs, to the extent that some devices are incorporated in EVs to generate noise at low speeds for pedestrian safety.

Simpler structural design of EVs will readily allow the use of standard material sizes and shapes by welded construction eliminating the use of expensive production equipment and tools in low technology environments.

2.2 Availability of raw materials

Africa is blessed with a great number of raw materials suitable for EV manufacture. Table 1 lists the main parts of an EV, the main materials required for making them, the infrastructure required, and the African countries that have these materials and infrastructure.

Table 1: EV materials and availability of infrastructure for their manufacture

Main Part of EV	Group of Materials	Infrastructure Required	Availability in Africa
Frame/chassis	High strength steels	Steel plants and mills	Africa has a number of steel plants in the countries listed below [9]: • Algeria • Angola • Egypt • Ghana • Kenya • Libya • Morocco • Mozambique • Namibia • Nigeria • South Africa • Uganda • Zimbabwe
	High strength aluminium alloys/aluminium metal composites	Aluminium smelting plants	Major mines and smelters are found in the countries listed below [10]: • Cameroon - 3 • Ghana – 2 • Guinea – 7 • Mozambique – 1 • South Africa – 1

	Magnesium (not much in use though lighter than aluminium but quite expensive)	Magnesium smelting plants	No information
Body, internals, bumpers, etc.	Steel sheets	Same as for frame/chassis	
	Aluminium sheets		
	Plastics	Petroleum Refinery and Petrochemical plants	Major refineries in Africa with 100,000 barrels per day capacities are given below [11]: (i) Algeria • Skikda Refinery (356,500BPD) (ii) Egypt • Alexandria Midor Refinery (160BPD) • Cairo Mostorod Refinery (142,000BPS) • El Nasr Refinery (132,000BPD) • Alexandria El Mex Refinery (117,000BPD) (iii) Libya • Ziwayah Refinery (120BPD) (iv) Nigeria • Dangote Refinery (650,000BPD) • Port Harcourt Refinery (210,000BPD) • Warri Refinery (125,000BPD) In addition to these there are many other smaller refineries in different African countries
Electric Motor	Magnets (iron, cobalt, nickel)	Heat treatment shops/plants	No information
	Steel sheets	As above	
	Copper wire	Copper smelters	Major copper producers in Africa are [12] • Botswana • Democratic Republic of Congo • Namibia • South Africa • Uganda • Zambia
		Electric cable manufacturers	A great number of electric cable manufacturers exist in Africa

	Insulating materials (polymer resin, ceramic filler)	• As for petrochemical plants for polymers • Ceramic materials are also abundantly available	
Battery	Lead	Lead smelters	Lead mines exist in [13] • South Africa • Tunisia • Namibia • Morocco • Algeria • Kenya • Nigeria
	Acid	Chemical plants	There are a great number of acid manufacturers in Africa
	Nickel	Nickel smelters	Nickel mines exist in [14] • South Africa • Madagascar • Ivory Coast • Zimbabwe • Zambia • Morocco
	Lithium	Lithium smelters	Leading producers are [15] • Zimbabwe • Namibia • Democratic Republic of Congo • Mali • Nigeria
Transmission/ single-speed reducers	Steels	Machine shops	Machine shops exist all over Africa
Thermal system cooling/radiator	Steel	Radiator manufacturers	A number of manufacturers exist in a number of African countries
	Aluminium		
Electronic devices (Power inverter, power electronics controller, DC-DC converter, on-board charger, charge port)	Entails use of electronic components such as resistors, transistors, capacitors, inductors, diodes, etc. to design and fabricate integrated circuits and others used to	Specialized manufacturers exist in the world from which these basic components can be sourced cheaply to make desired devices	No information

	build the power inverter, power controller, DC-DC converter, charger, etc.		

2.3 Existing vehicle manufacturing infrastructure:
Africa's role in the global automotive industry is limited. An energy transition research and technologies company, Thunder Said Energy (https://thundersaidenergy.com/) reported that current global fleet of passenger and light commercial vehicles is 1.7 billion of which 60 million are in Africa [16]; that is, Africa has about 3.5% of global fleet compared to 20%, 18.8% and 17% of Europe, China, and the United States respectively. In a statement announcing the election of the new President of the African Automotive Association of Automotive Manufacturers (AAAM) in 2023, the President stated that it will grow Africa's automotive manufacturing industry from the current 1.1 million to 3.5 – 5 million vehicles annually in 2035 [17].

There is some existing vehicle manufacturing infrastructure in Africa. This infrastructure exists in the following countries: South Africa, Morocco, Algeria, Egypt, Tunisia, Nigeria, Ghana, Kenya and Uganda among others. The global automotive companies, listed earlier, have manufacturing plants in them. Most of these plants are essentially assembly plants for semi-knocked down (SKD) and completely – knocked down (CKD) parts. Some of these companies especially in South Africa, Morocco and Algeria have active auto parts manufacturing sub-sector.

Aside from the popular global brands listed above, Africa is increasingly developing its own home-grown vehicles as shown in Table 2.

Table 2: Some local vehicle brands manufactured in Africa (Extracted from the internet)

Vehicle Brand	Country	Year Founded	Ownership
Innoson Vehicle Manufacturing (IVM)	Nigeria	2007	Private
Wallys Car Company	Tunisia	2006	Private
Kiira Motors Company	Uganda	2008	Government
Katanka Automotive Ile Co. Ltd.	Ghana	1994	Private
Mobius Motors Company	Kenya	2011	Private
Laraki Manufacturing Company	Morocco	1999	Private
Birkin Cars Ltd	South Africa	1982	Private
Advanced Automotive Design	South Africa	1995	Private

Thus, with the availability of these manufacturing/assembly infrastructure, they could be points for starting EV manufacturing in Africa. However, more importantly, the body of skills in these plants could be harvesting grounds for African start-ups in EV manufacture of local designs.

2.4 Growing economies
Table 3 shows the real GDP growth rates for 63 countries having a growth rate of at least 4.0%. These represent the fastest growing economies in 2023. With 29 African countries in these 63 fastest growing economies in the world, there is a high prospect that a number of African economies will continue to experience high growth rates to support local vehicle manufacturing.

Table 3: Fastest Growing Economies in 2023 (Extracted from [18])

Country	Growth Rate (%)	Remark	Country	Growth Rate (%)	Remark
Antiga and Babuda	5.6		Laos	4.0	
Armenia	7.0		Liberia	4.6	Africa
Bahamas	4.3		Libya	12.5	Africa
Bangladesh	6.0		Macao	74.4	
Barbados	4.5		Madagascar	4.0	Africa
Belize	4.0		Malaysia	4.0	
Benin	5.5	Africa	Maldives	8.0	
Bhutan	5.3		Mali	4.5	Africa
Burkina Faso	4.4	Africa	Mauritius	5.1	Africa
Cape Verde	4.4	Africa	Mongolia	5.5	
Cambodia	5.6		Montenegro	4.5	
Cameroon	4.0	Africa	Mozambique	7.0	Africa
Chad	4.0	Africa	Niger	4.1	Africa
China	5.0		Panama	6.0	
Costa Rica	4.4		Paraguay	4.5	
Djibouti	5.0	Africa	Philippines	5.3	
Dominica	4.6		Republic of Congo	4.0	Africa
DR Congo	6.7	Africa	Rwanda	6.2	Africa
Egypt	4.2	Africa	St. Kitts and Nevis	4.9	
Ethiopia	6.1	Africa	St. Vincent	6.2	
Fiji	7.5		Samoa	8.0	
Guinea	5.9	Africa	Senegal	4.1	Africa
Gambia	4.6	Africa	Seychelles	4.2	Africa
Georgia	6.2		Tajikistan	6.5	
Guinea Bissau	4.5	Africa	Tanzania	5.2	Africa
Guyana	38.4		Togo	5.4	Africa
India	6.3		Uganda	4.6	Africa
Indonesia	5.0		Turkey	4.0	
Ivory Coast	6.2	Africa	Uzbekistan	5.5	
Kazakhstan	4.6		Venezuela	4.0	
Kenya	5.0	Africa	Vietnam	4.7	
			Zimbabwe	4.1	Africa

2.5 Large population

Africa's population was put at 1,477,304,021 as of Thursday, December 28, 2023, by the United Nations [19]. Such a large population could easily support local vehicle manufacturing especially in highly populated countries such as Nigeria, Ethiopia, Egypt, DR Congo, South Africa, Tanzania, and Kenya. More emphasis would be placed on local manufacture of mass transit vehicles such as buses.

2.6 National automotive policies

A number of African countries have national policies on the automotive industry. The policies tend to have incentives to promote local industry. Table 4 summarizes the government policies on vehicle manufacturing by some African countries. It is hoped that these policies will support the rapid growth of local EV manufacturing in Africa.

Table 4: Government policies on vehicle manufacturing in some African countries

COUNTRY	POLICY	
	NAME	MAIN THRUST
Nigeria	New National Automotive Industry Development Plan (NADIP) from 2023 to 2033 [20]	Target set to reach 40% local content and 30% locally produced electric vehicles by 2033
South Africa	South African Automotive Masterplan (SAAM) 2021-2035 [21]	To produce 1% of global vehicle production, or 1.4 million vehicles, per annum in South Africa by 2035
Morocco	Plan for Industrial Acceleration / Plan d'Accélération Industrielle (PAI)/ National Pact for Industrial Development / Pacte National pour l'Emergence Industrielle (PNEI) [22]	Develop Morocco into a major sourcing base for Europe
Egypt	Egyptian Automotive Industry Development Program (AIDP), 2022 [23]	To establish itself as a main gateway for emerging vehicle markets in Africa
Ghana	Ghana Automotive Development Policy (GADP) [24]	To make Ghana a fully integrated and competitive industrial hub for the Automotive Industry in the West Africa sub-region
Zimbabwe	Motor Industry Development Policy 2018 – 2030 [25]	Based on five strategies-assembly of semi-knocked down and completely knocked down kits, government support, control of second-hand imports, categorization and regulation of the industry and the development of the motor industry value chain and cluster

3. Discussion

3.1 *Major factors militating against local vehicle manufacturing*

3.1.1 ***Poor learning outcomes from educational institutions*****:** Most African countries are suffering from the consequences of colonial educational system which trained Africans for the exploitation of natural resources for export to the colonial masters which required only the lowest levels of learning in the cognitive domain. These levels are based on knowledge of factual information which are most amenable to testing in examinations. There is little or no emphasis on "understanding at higher levels which is indicated by more complex skills in evaluation, synthesis, or the creation of new information" [26]. This is why, though Africans may excel educationally,

such academic excellence is not translated to solving the myriads of problems confronting Africa. For example, providing low-cost vehicles for mass transportation is one of these problems. Most engineers who should be in the forefront of designing and developing these vehicles do not have the requisite skills needed. For example, some may find it difficult to derive differential equations for practical life situations involving variations but can provide solutions to already given differential equations. From the experience of this author in Nigerian universities, this shortcoming is shown glaringly in most final year mechanical engineering students not being able to derive from first principles the power requirement of a machine to be designed for a particular purpose.

To increase economic prosperity in Africa, African educational systems should be made functional to drive solutions to problems besetting the continent.

3.1.2 Lack of relevant technical capacity: Closely tied to poor educational system of most African countries is the lack of relevant technical capacity for development. The system places much emphasis on theoretical knowledge to the detriment of practical application of knowledge. For example, while Nigeria had 33,246 junior secondary schools and 27,042 senior secondary schools in 2018/2019 academic session, there were only 123 technical schools [27]. Virtually all secondary school students are headed to universities which only produce high level manpower. Without a lower-level technical manpower to carryout shop floor operations, the high-level manpower will be redundant. This explains why there is such a high level of unemployment of Nigerian university graduates while there is a gross shortage of craftsmen and artisans needed in industries.

African countries should study and possibly adapt the Chinese educational system that is able to produce technical skills covering virtually all aspects of industrial production.

3.1.3 Poor Industrial infrastructure: Loosely, industrial infrastructure may refer to the systems or assets that are used to produce goods and services in a country or region. The more developed this is, the more goods and services the country is able to produce such as China, the USA, Japan, Germany, etc. Many African countries have poor industrial infrastructure; and that is why, most are import dependent on industrial goods of which the automobile is one. To be a serious automobile manufacturing country, functioning steel and petrochemical plants, among others, are indispensable.

3.1.4 Poor capital availability: Henry Sheykin [28] reports that cost of establishing a vehicle production plant in the United States could range from as low as 12 million USD to 2 billion USD or even more depending on features desired. Startup cost could range from 12 million USD to 29.5 million USD, while that for an assembly plant could range from 7.5 million USD to about 27 million USD. These capital outlays are colossal, which may be beyond the reach of most African entrepreneurs.

3.2 Paradigm shift

The above factors militating against establishment of vehicle manufacturing plants for original local designs in Africa present very daunting odds despite the available opportunities identified earlier. To overcome these, a paradigm shift is required. Going through the conventional route to establish these vehicle manufacturing plants may be very difficult. Thus, we suggest a paradigm shift from the conventional assembly plant route to a vehicle manufacturing plant consisting

essentially of general-purpose workshop equipment, simple materials handling equipment, and jigs and fixtures, accompanied with intensive labor. Hopefully this may drastically reduce the cost of purchase of manufacturing equipment and machinery, and for construction and setup of manufacturing facility. This paradigm shift is based on the following reasons:

i. That if Henry Ford could produce 11 - 12 cars per month of Ford Model T with 1908 technology, we in Africa may be able to do at least the same with the low-cost technology of 2024 [29].
ii. Mass commuters in Africa do not necessarily require sophisticated state-of-the-art vehicles. For example, a number of Sub-Saharan African cities use tricycle rickshaws, popularly called 'keke' in Nigeria, for mass transportation. Thus, African vehicle designs could be made very simple and as functional as the keke.
iii. There is high unemployment in a number of African countries. For example, in Nigeria, about 53.40% of youths were unemployed in 2022 according to the National Bureau of Statistics [30]. Thus, it may be more prudent to use labor-intensive production methods in such a country than using expensive sophisticated automated production facilities requiring fewer labor.
iv. Poverty rates in Africa are high. For example, Sasu, D.D [31] reported that in 2022, an estimated population of 88.4 million people in Nigeria lived in extreme poverty. With such high level of poverty, it may be difficult to find interested entrepreneurs being able to mobilize 12 million USD – 2 billion USD required to establish a vehicle manufacturing plant.

3.3 Anticipated benefits of the paradigm shift

i. It will help to have a home-grown automobile industry in which the whole value chain of automobile production becomes internalized, leading largely to non-dependence on foreign technology.
ii. As a consequence of the above, there will be proliferation of automobile parts manufacturers such as for electric motors, batteries, inverters, controllers, etc. for EV; and even internal combustion engines and their parts.
iii. Having a functional home-grown automobile industry will have a great multiplier effect on the economy creating wealth and eradicating poverty.

3.4 Low-cost vehicle manufacturing plant

Putting side by side the opportunities for establishment of vehicle manufacturing plants for original African designs and the factors militating against this, the African automotive industry could receive a boost if entrepreneurs take advantage of the paradigm shift suggested above for local EV manufacturing in Africa. A 2020 study showed that a capital investment of N838,073,958, and a one year working capital of N2,033,620,298 are required to establish a low-cost, low-volume vehicle manufacturing plant to produce 14 units per day of a one-ton utility truck. The payback period was estimated to be 14 months, based on a production cost of N1,600,000/vehicle and a selling price of N2,500,000 [32]. This 2020 study [32] suggested a paradigm shift as above, in vehicle manufacturing in a low technology environment such as obtains in most African countries. The salient points of the study which could guide investors are summarized below:

i. A lightweight utility vehicle with a load carrying capacity of 1 ton was designed and constructed. It was powered with an 8.5kW internal combustion engine and had a driving speed of about 75km/hour [33, 34].

ii. The vehicle parts were made with jigs and fixtures designed in the project, to fit with lot production.
iii. A production plant was designed to produce 14 units of the vehicle per day. The production plant occupies a space of 1.68 hectares, consisting of six separate plants, namely: Wheel Assembly Plant, Chassis & Carriage Plant, Bumper and Dashboard Plant, Seat & Carpet Plant, Painting Shop, Vehicle Assembly Plant.
iv. The overall plant also consisted of a General Mechanical & Electrical Workshop, Warehouse, and an Administrative Building
v. The plant was estimated to have 205 workers including management staff.
vi. The lightweight utility vehicle developed had over 80% local content.
vii. The most significant step in the study was to design the vehicle manufacturing plant with general-purpose workshop equipment and tools along with appropriate jigs and fixtures for mass production. This made the cost of establishing this integrated vehicle manufacturing plant (2.1 million USD) negligible compared to 12 million – 2 billion USD in establishing such a plant [28]. The downside to the use of general-purpose workshop equipment is that it will be labour intensive and low volume production. However, with the high rate of unemployment in Nigeria and the total absence of a truly Nigerian-designed production vehicle with the attendant multiplier effect on the economy, these disadvantages are more than compensated for.

To break loose from the vicious cycle of poverty pervading African countries, this vehicle manufacturing model is recommended for African entrepreneurs interested in venturing into EV manufacturing. With time, capital will be accumulated for investment in state-of-the-art vehicle manufacturing equipment.

4. Conclusion

Opportunities exist for EV manufacturing in Africa. These include simpler vehicle design compared to fuel vehicles, abundance of relevant raw materials, existence of some amount of vehicle manufacturing infrastructure, growing African economies, large African population, and favorable government policies on automobile manufacturing. However, some militating factors against this include poor learning outcomes from educational institutions, lack of relevant technical capacity, and poor industrial infrastructure. To overcome these shortcomings and take advantage of the opportunities, a paradigm shift is required in the establishment of vehicle manufacturing plants from the conventional assembly of vehicles to one of low-cost, low-volume vehicle manufacturing plant consisting of general-purpose workshop equipment, simple materials handling equipment, jigs and fixtures and intensive labor. It is hoped that this could hasten the development of the whole value chain for vehicle manufacturing in order to meet the desired EV fleet for a decarbonized transport in Africa.

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