Federal University Of Technology, Minna.

EMISSIONS CONTROL TECHNOLOGY BY AUTOMOTIVE INDUSTRY: TRENDS AND CHALLENGES

by

Kazeem Adebayo Salami

[Ph.D, FNATT, MIAE, TECH (CEI)]

Professor of Industrial And Technology Education.

Inaugural Lecture Series 10

16TH AUGUST, 2007

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

EMISSIONS CONTROL TECHNOLOGY BY AUTOMOTIVE INDUSTRY: TRENDS AND CHALLENGES

KAZEEM ADEBAYO SALAMI [Ph.D, FNATT, MIAE, TECH (CEN)]
Professor of Industrial And Technology Education.

Inaugural Lecture Series 10

16th August, 2007

PREAMBLE

Bismillahi Rahaman Raheem. In the name of Allah the Beneficent, the merciful, the Lord of the World. The chairman of the occasion, The Vice Chancellor, Deputy Vice-Chancellors, Principal officers of the University, Deans and Directors, Members of Academic Community, Invited Guests, Friends of the University, Gentlemen of the press, Dear students, Distinguished ladies and gentlemen, you are mostly welcome to this unique occasion. I feel highly delighted to stand before you today to deliver the 10th Inaugural Lecture of the Federal University of Technology Minna and the first in the series from the Department of Industrial and Technology Education.

The lecture is titled **"Emissions Control Technology by Automotive Industry: Trends and Challenges".**

As awareness of the need to protect the global environment grew world wide and more importantly in Nigeria there was an increasing demand to re evaluate the automotive industry. This is necessary because internal combustion engines burn fuels which produce emissions in the combustion process. The purpose of emission control is to reduce the amount of harmful combustion gases released into the atmosphere.

Vehicle emissions are the by products of burning automotive fuels. To this end, emission has become one of the most complicated environmental challenges. Hence, there is need to use quality fuel and improved automobile technology. The automobile industry is an engine of growth whose establishment serves as an important stimulus to other types of manufacturing industries.

Development of new technologies and mechanisms that have been taking place in automobile industry to reduce emission are discussed. The design and production and principles of operation of emission control systems as related to automobile fuel were also discussed.

KEEPING UP WITH TECHNOLOGY

Today's automobile technologists are constantly being challenged with new technology. As a result good technologists are always striving to improve their

knowledge and skills to keep up with new car designs. The auto-mechanic must keep up with the advanced technology being used in new cars. Recent innovations include: computers, electronic ignitions, gasoline/petrol injections and front-wheel drive. Therefore, a good mechanic must constantly study service manuals, service bulletins and other literature to learn how new components work and how to repair them. Avoid the pitfall of ever thinking you know every thing about your job. This only leads to trouble. You will soon be left behind by the new technology (Salami, 2004).

VOCATIONAL AND TECHNOLOGY EDUCATION AS:

A comprehensive term referring to the educational processes it involves, in additional to general education, the study of technologies and related sciences and the acquisition of practical skills and knowledge relating to occupations in various sectors of economic and social life (UNESCO, 1986, p.23)

TABLE OF CONTENTS

EMISSIONS CONTROL TECHNOLOGY BY AUTOMOTIVE INDUSTRY: TRENDS AND CHALLENGES

INTRODUCTION

The automobile is a commonly used product but it is an extremely complex and technologically sophisticated one. Automobile plays a major role in people's lives whether it is used for daily transportation or used for pleasure. In this regard, the development of the vehicle industry is instrumental to personal life as well as to the development of the nation's industry.

When automobile first appeared, the world's population was relatively small, and few. Automobiles on the road then were not recognised as a cause for environmental concern or climate change. Photo-chemical smog first became a nuisance in the 1950's causing people to view the effects of air pollution as a problem. Although air pollution was mostly attributed to industrial emissions rather than exhaust emissions from automobiles (Duffy and Smith, 1992, Salami, 2000)

A more serious problem emerged in the second half of the 1980's. The concentration of carbon dioxide in the atmosphere had increased leading to global warming. During this time automobiles are thought to be responsible for under 20 percent of total carbon dioxide emissions.

As awareness of the need to protect the global environment grew world wide and more importantly in Nigeria there was an increasing demand to re-evaluate the automobile industry. This is necessary because internal combustion engines burn fuels which produce emissions in the combustion process, including water vapour and carbon dioxide as well as carbon monoxide, hydrocarbons and nitrogen oxides.

Experts on safety and emission management of vehicles/automobiles stated that vehicular emission has become one of the most complicated environmental challenges. Hence, there is need to use quality fuel and improved automobile technology.

Following the robust development of automobile industry and production of a wide range of vehicles, emissions that caused air and other kinds of pollution became a serious burning issue. Regulating vehicular emission became a top

priority in the western world in the early eighties. Developments of new technologies and mechanisms have been taking place along with development in automobile industry, which has made it very useful to reduce emission. For instance, in recent past, the problems of carbon dioxide and hydrocarbons have been largely overcome by various techniques used to clean engine emissions.

Efforts need to be geared towards resolving the problem of carbon monoxide emission in the world and Nigeria in particular since it is noted that the protection of the global climate change is clearly a major concern that the automobile industries cannot ignore in this millennium. It has now become a complex issue that combines multiple factors, including environment resources, traffic congestion and safety. The automobile industry is regarded as an engine of growth whose establishment serves as an important stimulus to other types of manufacturing activities. This is so because the industry has capabilities to create many job opportunities and generate acquisition of technology.
The main sources of technological improvement on vehicles are design and production. The process and product technologies develop increasingly and Nigeria must be prepared to join the race now or remain underdeveloped.

There is also the need for law regulators to work with automobile manufacturers to ensure a "green" environment. However, automotive companies cannot bear the burden of building technologies that adhere to environmental regulations all by themselves. It has also been realised that making internal combustion engines that run cleaner will require efforts beyond the automobile industry; the oil industry could help by supplying lower-sulphur fuels.

It is to be noted that apart from ecological issues, sustainable development is also a long-term strategy in the automobile industry. The three dimensions of sustainability include: economic, developmental protection and social process. The automotive industry in North America and the Asia pacific has been showing sustainable development with a vengeance. Germany, the United Kingdom and Luxembourg have set strict standards in adherence to environmental policies and are always a step ahead of legislation. Through their globalization activities, manufacturers and suppliers also export excellent environment protection, safety and technological and managerial expertise. This actually helps promote sustainable development in other countries. **What is the position of Nigeria? This is a million naira question to answer.**

The main thrust of this paper, therefore, is to re evaluate the present and re-construct the future role of the automobile industries in this century in the context of the needs of Nigeria in particular and the entire world due to climate change and future transport systems.

Early history of automobile industry

The history of the automobile, its development with an analysis of the problems and prospects cannot be over emphasized. Its contribution to health and prosperity, its influence on engines, its effect on personal efficiency, and its service and mission to humanity as the latest and greatest phase of transportation is a pointer to that fact. Therefore, advances in automobile technologies are out to pursue these to logical conclusion. In the nineteen-seventies much effort was devoted to the development of various stratified charge engine e.g. the Gas turbine

By the nineteen-eighties, however, high-compression lean-burn systems had been the main practical outcome. With increasing pressures for fuel economy as a means of reducing CO_2 output, interest in stratified charge began to surface again in the early 1990s.

(May, 1989; Flink, 1988; Cusumano, 1985)

EVOLUTION OF AUTOMOBILE INDUSTRY IN NIGERIA.

The automotive industry is the central agent of creating and managing patterns of technology change or innovation. In Nigeria, the 1970's was a turning point in the development of automobile industry. By this time, government had become aware of the importance of the industry as an engine of growth in economy. Given this strategic importance, government become involved in the sub-sector essentially to aid its early integrated development that will stimulate the growth of the indigenous automobile know-how. This led to establishment of Peugeot automobile of Nigeria (PAN) and the Volkswagen of Nigeria (VON). The third National development plan (1975 1980) provided for the establishment of commercial truck plants. They are Leyland Nigeria Ltd., Anambra Motor Manufacturing Co. Ltd., National Trucks Manufacturing Ltd. and Steyr Nigeria Ltd. The assembly plants performed fairly well in the 1970's as the country's economy was relatively good. The decade was the boom period when the products of the assembly plants were affordable by government and the citizens alike. The #3, 000 could buy a Volkswagen beetle car and # 5,000 was enough to buy a brand new Peugeot 504 car on the road. All these meant increased demand and boom for the assembly plants. But unwillingly, the attendant effect of these good times was the neglect of essential requisites of the partnership agreements by the Federal

Government.All the automobile plants set up in the 1970's have closed down except Peugeot Automobile of Nigeria (PAN) due to unfavourable policies. This was an immense advantage for technical partners. They saved the money that should have been put into research and development (R & D) of Local Content Programme.

As it were, nothing significant was achieved in the local content development and transportation. However, the good old days of the 1970's should have achieved for Nigeria the type of gains in Brazil but for lack of proper policy guidelines in the country. It would be recalled that the Auto industry in Nigeria was set-up about the same time as those of Brazil and Argentina. Today to our greatest dismay, CKD's and Fully Built Units (FBU) are imported from Brazil and Argentina. Needless to say that the reverse fortunes in the nation's economy affect the assembly plants.

Incidentally, the 1980's was also the period when private investment in automobile component parts manufacture was gaining momentum. And this was by virtue of the private sector spirit of adventure in the country. Despite lack of reasonable government support in the aspect of automobile sub-sector, significant progress has been made in local content incorporation. For instance, PAN is known to be making use of a number of auto products, such as seat from paddings, engine mountings, engine flywheel, glasses, radiators and others.

With the formulation and adoption of the National Policy in 1993, and subsequent establishment of the National Automotive Council (NAC) represented a landmark in the development of automobile industry.

However, the basic technological knowledge has been elusive due to unfavourable socio-economic and political atmosphere in the country. This unfavourable climate has brought out automotive production capacity, under-utilization, high production cost, absence of a clear-cut policy guideline for a long time, uncontrolled importation of new fully-built units and used vehicles. As a consequence of this scenario, the 1988 market share level of the domestic plant, which stood at 66%, tumbled to 38% in 1991. In 1982-1989 vehicle registration dropped but scrapped vehicles (used vehicles) rapidly caught up and exceeded new ones.

THE NATIONAL AUTOMOTIVE POLICY

The automotive industry is regarded as an engine of growth whose establishment serves as an important stimulus to other types of manufacturing activities. This is so because the industry has capabilities to create many job opportunities and generate acquisition of technology.

In realization of the need, the established National Automotive Council (NAC) has the following policy objectives:

1. To aid the early integrated development of the industry by exercising some measure of control over both the passenger car and commercial vehicle arms of the industry.
2. To accelerate the stagnant pace of local parts incorporation by halting the trend towards a proliferation of makes and models, thereby ensuring that parts for the few makes available can be locally manufactured in commercial quantities.
3. To stimulate the growth of indigenous automotive components manufacturing and auxiliary industries.
4. To ensure greater standardization of technology and a more efficient utilization of costly equipment in the industry

(FRN, 1993).

Had these objectives been vigorously pursed, 100% local content incorporation would have been achieved by now.

In order to accelerate the desired skill in the manufacturing of auto-component parts, the government should make Ajaokuta and other steel rolling mills a functional reality. With a little encouragement by the government for the private sector to invest more in the automotive industry the popular "Igbo made" or "Ijebu made" and "Taiwan-made" spare parts will have been perfected to compete favourably with any standard in the auto world. Such standardization may involve re-specification arising from a functional review of the original design to adjust to climate (condition) change. Effort to establish an auto Components Test Centre to ensure that components manufacture locally meet acceptable standards is direly necessary. Standardization to ensure interchangeability of parts among the rationalised brands/model should also be given required attention. The much desired integrated automotive industry which is one of the objectives of National Automotive Council (NAC) must have been achieved.

The main sources of technological improvement are design and production. The process and product technologies develop increasingly, and Nigeria must be prepared to join the race now or remain underdeveloped.

The purpose of this paper is to re-evaluate and re-construct the future role of the automobile industries in the context of the needs of Nigeria in particular and the entire world due to climate change by automobile emissions.

VEHICLE EMISSIONS

Vehicle emissions are the by products of burning automotive fuels. There are **four** basic types of vehicle emissions:

- ☐ Hydrocarbons;
- ☐ Carbon monoxide;
- ☐ Oxides of nitrogen; and
- ☐ Particulates.

Hydrocarbon emission can be **caused by incomplete combustion or by fuel evaporation**. Another cause is the escape of fuel vapours from a car's fuel system.

Hydrocarbon emissions are a health hazard. **They contribute to eye, throat, and lung irritation, other illness, and possibly cancer.**

Carbon monoxide is an extremely toxic gaseous emission **that is found in partially burned fuel**. Carbon monoxide is colourless, odourless and deadly. It causes headaches, nausea and respiratory problem. Oxides of nitrogen (NOx) are emissions **produced by extremely high temperature combustion**. An engine with a high compression ratio, lean fuel mixture, high temperature thermostat, and resulting high combustion heat, emits high levels of NOx. **Emission control systems must interact to lower each of these forms of pollution.**

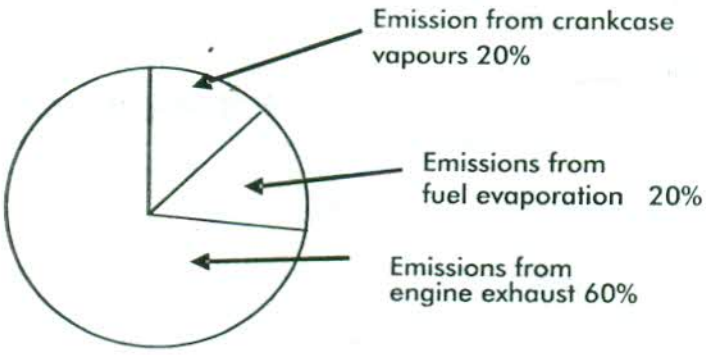
Particulates are solid particles of carbon soot and fuel additives from a car's exhaust. Carbon particles make up the largest percentage of these emissions. Particulate emissions are a serious problem with diesel engines. Diesel particulate is normally caused by an extremely rich, high-powered fuel mixture or a mechanical problem in the injection system.

About 30 percent of all particulate emissions are heavy enough to settle out of the air. The other 70 percent can float in the air for extended periods contributing to health hazard.

SOURCES OF VEHICLE EMISSIONS

Vehicle emissions have **three** basic sources:

1. Engine crankcase blow by fumes (20%)
2. Fuel vapour (20%)
3. Engine exhaust gases (60%)



Source: (Duffy &Smith, 1992)

Fig. 1 Auto air pollution comes from three sources.

Motor vehicles are the largest source of global air pollution, and ironically growth in developing countries such as Nigeria. Fortunately, technologies are now available that can slash engine emissions including ultra-low sulphur fuels, advanced tail-pipe controls, and hybrid driven for automobiles and buses. Accelerating the adoption of these technologies in Nigeria and other developing countries around the world is one of the greatest environmental opportunities of our time.

It is worth noting that internal combustion engines are significant contributors to air pollution, which has a damaging impact on our health and the environment. Increasing tighter environmental regulations worldwide call for advanced emissions controls and near-zero diesel emission levels in few years to come. Environmental benefits of diesel, such as low greenhouse gas emissions are balanced by growing concerns with emission of nitrogen oxides and diesel particulates.

Having a cursory look at trends in global automotive manufacturing, Japanese automakers have been leaders in streamlined manufacturing process systems.

These efforts were pursued in order to increase productivity and product quality. There is need therefore to assess the extent of their manufacturing development.

Recently most modern automobiles are equipped with catalytic converters that treat engine exhaust before it leaves the car. Currently technology requires the exhaust to reach a high temperature before the catalytic converter begins to work (Farley, 2004). With regard to this development, most cars are equipped with three-way catalytic converters. Three-way refers to three regulated emissions-carbon monoxide, an odourless and colourless poisonous gas; hydrocarbons or volatile organic compounds (NASA, 2003)

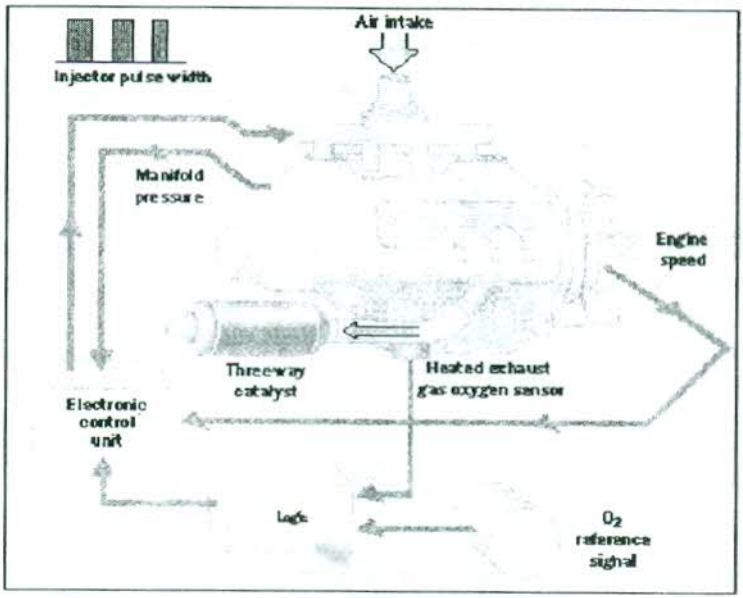


Figure 2: Basic components of the engine control system related to exhaust emissions abatement

ENGINE MODIFICATIONS FOR EMISSION CONTROL

Several engine modifications have been introduced **to improve combustion efficiency.**

The following are modifications to lower emissions:

- ☐ Lower compression ratios.
- ☐ Leaner air-fuel mixtures.
- ☐ Heated intake manifolds.
- ☐ Smaller combustion chamber surface.
- ☐ Increased valve overlap.
- ☐ Hardened valves and seats.
- ☐ Wider spark plug gaps.
- ☐ Reduced quench areas.
- ☐ Higher operation temperatures.

The purpose of emission control systems is to reduce the amount of harmful combustion gases released into the atmosphere. In automobile, different systems are used to reduce the amount of air pollution.

The major ones include:

- ☐ Positive crankcase ventilation system (PCV)
- ☐ Heated air inlet system (thermostatic controlled air cleaner maintains incoming air at a constant temperature for improved combustion).
- ☐ Exhaust gas recirculation (EGR) system.
- ☐ Air injection system.
- ☐ Catalytic converter **(this is a thermal reactor for burning and chemically changing exhaust by products into harmless substances).**

The converter is inserted into the exhaust system between the exhaust manifold and muffler.

- ☐ Fuel evaporation control system.

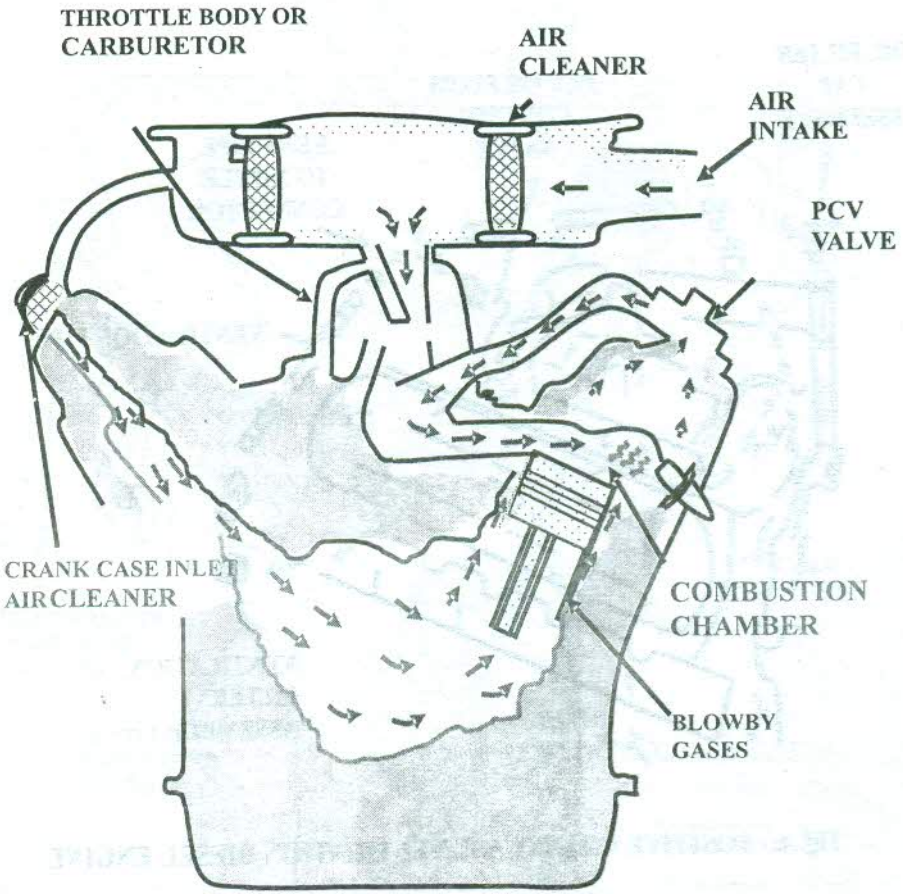


Fig. 3 A POSITIVE CRANKCASE VENTILATION (PCV)

Source (Duffy & Smith, 1992)

Figure 3 shows a Positive Crankcase Ventilation (PCV) system where toxic vapors from the crankcase are drawn and returned them to the intake manifold, allowing them to be burnt by the engine.

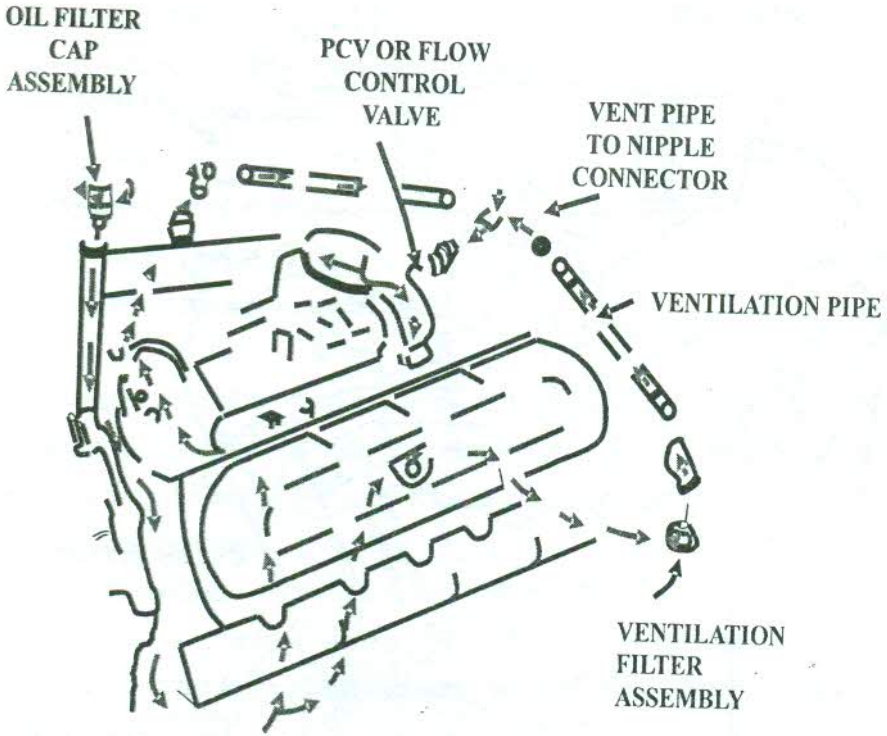


Fig. 4: POSITIVE CRANKCASE VENTILATION DIESEL ENGINE

Source: (Duffy & Smith, 1992)

Figure 4 indicates a diesel engine PCV system variation. It shows how outside sir is drawn in through the oil filter cap. The breather cap contains a check valve that prevents crankcase fumes from leaking out of the engine.

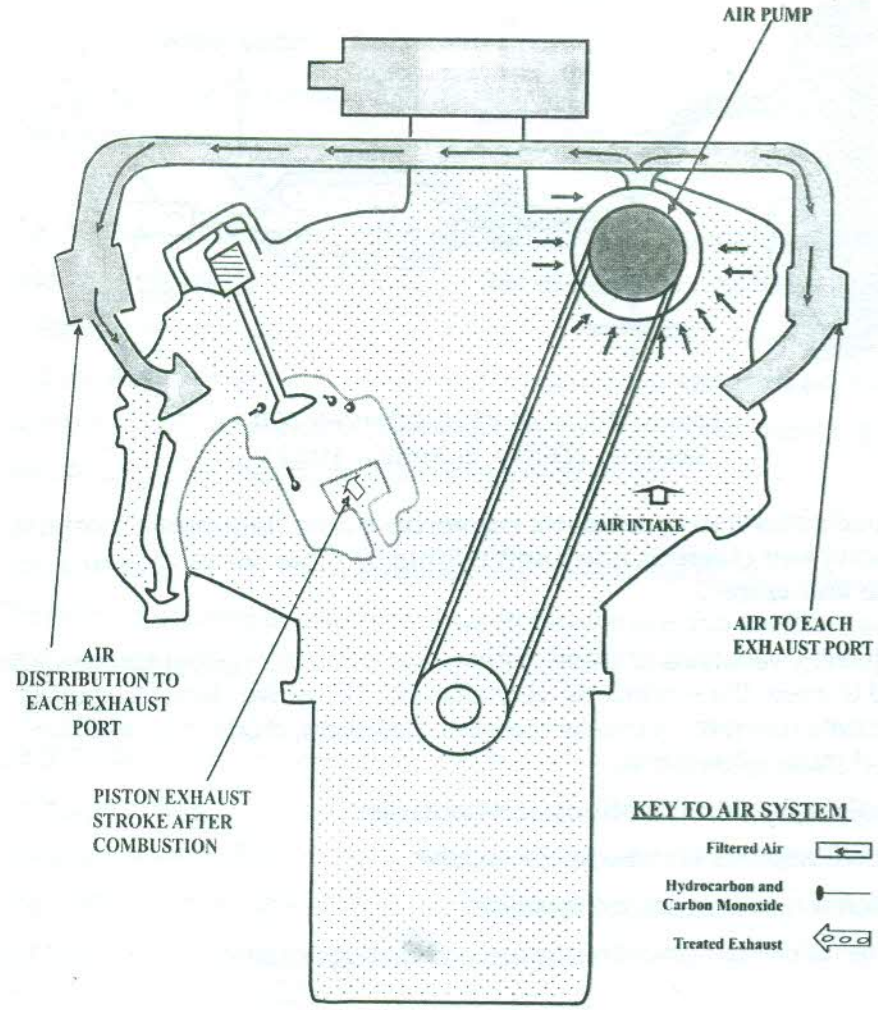


Fig. 5 AIR INJECTION SYSTEM

Source (Duffy & Smith, 1992)

Figure 5 shows the operation of an air injection system. (EGR). It has small jets in the bottom of the intake manifold. They meter a small amount of exhaust gases into the air-fuel mixture.

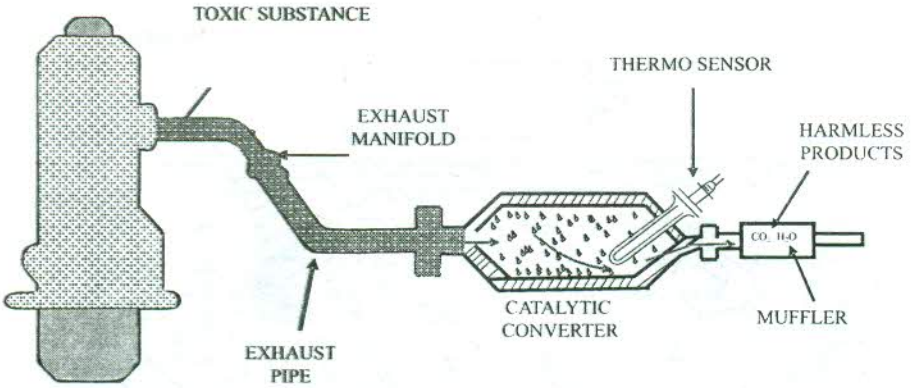


Fig. 6: A CATALYTIC CONVERTER
Source (Duffy & Smith, 1992)

Fig 6 **Indicates how a catalytic converter burns flammable exhaust emissions and changes non combustible into harmless carbon dioxide and water.**

Consequently, variations of these systems and computer control systems are all used to make the modern car very efficient. The active chemical catalyst in a catalytic converter is usually platinum, palladium, rhodium or a mixture of two of these substances.

Internal Engine Modifications and Controls

This classification contains two major subdivisions;

- ☐ Internal modifications to the engine.
- ☐ External controls placed on the fuel and ignition systems.

It is noted that in modern vehicles, engine internal parts are designed to balance the needs of performance, emissions and driveability.

The engine internal parts include:

- ☐ Combustion chamber designs.
- ☐ Camshaft designs.
- ☐ Hotter thermostats.

- ☐ Lower compression.

The external fuel system controls include:

- ☐ Carburettors.

The carburettors on most new vehicles try to maintain a stoichiometric air-fuel ratio which is as close to 14.7 to 1. This is the ideal ratio for mileage and emissions, but not necessarily for power and driveability. It should be noted that **newer carburettors** have **smaller main jets, reduced accelerator pump output, and power valve springs** which do not allow the power valve to open until the engine is under very heavy loads.

Other ways in which the carburettor has been modified to produce lower emissions are **faster opening chokes and more precise control opening of the idle speeds.**

CAUTION: Never disconnect or render the EGR valve inoperative on a permanent basis. To do so is a violation of federal and state law and will cause emissions level to rise. In addition many engines will run hotter and in some cases, detonate to the point of serious engine damage (burn valves and pistons).

External Engine Controls

Common external engine controls are the air **injection system** and **catalytic converter.**

The air injection system provides extra oxygen which causes further burning of the exhaust gases. This additional burning reduces the amount of hydrocarbons and changes a sizeable portion of the carbon monoxide into carbon dioxide.

Automobile emissions control by Automotive Industry

Automobile emissions control covers all the technologies that are employed to reduce the air pollution-causing emissions produced by automobiles. Exhaust emissions control systems were first required on 1966 model year vehicles produced for sale in the state of California, followed by the United States as a whole in model year 1968. Their use became widespread in the following decades and now they are **ubiquitous** in industrialised nations and common in most others.Emissions controls have been highly successful in reducing the emissions produced by motor vehicles in terms of quantity per distance travelled. However, substantial increases in the distance traveled by each vehicle, and equally substantial increases in the number of vehicles in use, have meant that the overall reduction in pollution has been much slower. (Wikipeadia, 2005)

The emissions produced by a vehicle fall into two basic categories:

1. **Tailpipe emissions:** This is what most people think of when they think of vehicle air pollution; the products of burning fuel in the vehicle's engine, emitted from the vehicle's exhaust system. The major pollutants emitted include:
    1. Hydrocarbons: This class is made up of unburned or partially burned fuel, and is a major contributor to urban smog, as well as being toxic.
    2. Nitrogen oxides (NOx): These are generated when nitrogen in the air reacts with oxygen under the high temperature and pressure conditions inside the engine. NOx emissions contribute to both smog and acid rain.
    3. Carbon monoxide (CO): a product of incomplete combustion, carbon monoxide reduces the blood's ability to carry oxygen and are dangerous to people with heart disease.
    4. Carbon dioxide (CO_2): although this is a product of the complete combustion of hydrocarbons, it is plentiful in the atmosphere, has no immediate harmful effects to humans and is essential to plant life. Emissions of carbon dioxide are considered a pollutant because it is a significant greenhouse gas and increasing its levels in the atmosphere is thought by many to be a contributor to global warming.

2. **Evaporative emissions:** These are produced from the evaporation of fuel, and are a large contributor to urban smog, since these heavier molecules stay closer to ground level. Fuel tends to evaporate in these ways:

   1. Gas tank venting: the heating of the vehicle as the temperature rises from the night-time temperature to the hottest temperatures of the day means that gasoline in the tank evaporates, increasing the pressure inside the tank above atmospheric pressure. This pressure must be relieved, and before emissions control it was simply vented into the atmosphere.
   2. Running losses: the escape of gasoline vapors from the hot engine.
   3. Refuelling losses: these can cause a lot of hydrocarbon vapor emission. The empty space inside a vehicle's tank is filled with hydrocarbon gases, and as the tank is filled, these gases are forced out into the atmosphere. In addition, there is loss from further evaporation and fuel spillage.

Tailpipe emissions control

Tailpipe emissions control can be categorised into four parts:

1. Increasing engine efficiency
2. Increasing vehicle efficiency
3. Increasing driving efficiency
4. Cleaning up the emissions

Increasing engine efficiency

Engine efficiency has been gradually improved with progress in the following technologies:

- ☐ Electronic ignition
- ☐ Fuel injection systems
- ☐ Electronic control unit

Increasing vehicle efficiency

Contributions to the goal of reducing fuel consumption and related emissions come from

- ☐ lightweight vehicle design
- ☐ minimized air resistance
- ☐ reduced rolling resistance

- ☐ improved powertrain efficiency
- ☐ increasing spark to the spark plug

Each of these items breaks down into a number of factors.

Increasing driving efficiency

Significant reduction of emissions come from

- ☐ driving technique (some 10-30% reduction)
- ☐ unobstructed traffic conditions
- ☐ cruising at an optimum speed for the vehicle
- ☐ reducing the number of cold starts

Cleaning up the emissions

Advances in engine and vehicle technology continually reduce the amount of pollutants generated, but this is generally considered insufficient to meet emissions goals. Therefore, technologies to react with and clean up the remaining emissions have long been an essential part of emissions control strategy.

Air injection

A very early emissions control system, evolves the Air Injection Reactor (AIR) which reduces the products of incomplete combustion (hydrocarbons and carbon monoxide) by injecting fresh air into the exhaust manifolds of the engine. In the presence of this oxygen-laden air, further combustion occurs in the manifold and exhaust pipe. Generally the air is delivered through an engine-driven 'smog pump' and air tubing to the manifolds. This technology was introduced in 1966 in California, and was in use for the next several decades. It is not generally in use any longer, having been supplanted by cleaner burning engines and better catalytic converters.

Exhaust Gas Recirculation

Engines produced after the 1973 model year have an exhaust gas recirculation valve on the intake manifold; its sole purpose is to reduce NOx emissions by introducing exhaust gases into the fuel mixture, lowering peak combustion temperatures. Around 1990, the Jeep division's powerplants (2.5 and 4.0) were the only engines that eliminated the exhaust gas recirculation (EGR) system.

Catalytic converters

The catalytic converter is a device, placed in the exhaust pipe, which converts various emissions into less harmful ones using, generally, a combination of platinum, palladium and rhodium as catalysts. Catalytic converters have been steadily improved over the years. They make for a significant, and easily applied, method for reducing tailpipe emissions. Their other significant effect on pollution was that they were incompatible with the use of tetraethyl lead as an octane booster in gasoline, prompting the phasing-out of that additive as converter-fitted cars became more prevalent. The lead emissions were highly damaging to human health, and its virtual elimination has been one of the most successful reductions in air pollution.

Evaporative emissions control

Efforts at the reduction of evaporative emissions include the capturing of vented vapors from within the vehicle, and the reduction of refuelling emissions.

Capturing vented vapors

Within the vehicle, vapors from the fuel tank are channelled through canisters containing activated carbon instead of being vented to the atmosphere. The vapors are absorbed within the canister, which feeds into the inlet manifold of the engine. When the vehicle is running, the vapors absorb from the carbon, are drawn into the engine and burned.

Evaporative emissions from the vehicle are limited by law and tested as part of the new vehicle type approval by a so-called SHED-test. The current limit is 2 grams of HC per hour, which may amount to an evaporation of one liter (1/4 gallon) in a month.

Reducing refuelling losses

All modern vehicles have tank filler necks that instead of just being a tube into the tank, as in earlier vehicles, now have a small-diameter hinged and spring-loaded door only large enough for the tip of the filler nozzle. This prevents vapor leakage when the filler cap is removed, and also prevents a catalytic converter-fitted vehicle being refuelled with leaded fuel (since the leaded fuel nozzle is too large to fit).

This is accompanied by modifications to the filling station pumps. They are now equipped to suck the vapors back into the pump as they are displaced by

fuel. Some have intakes around the head of the filler nozzle, while others have a rubber 'boot' that presses securely around the end of the filler neck to prevent vapors escaping.

Emission Testing

In 1966, the first emission test cycle was enacted in the State of California measuring tailpipe emissions in PPM (parts per million). The most common test used until the 1980s was the idle test (usually a two-speed idle test), later to be succeeded with a dynamometer (the latest variant is known as the **accelerated simulated mode** (ASM).

ASM testing tests for three gases instead of two; if one gas emission is higher, the vehicle fails the test. Usually, vehicles less than 8500 GVW and gasoline powered are subjected to ASM testing with the exemption of all-wheel drive vehicles (including full-time four wheel drive). The Environmental Working Group used California ASM emissions data to create an Auto Asthma Index that rates vehicle models based on emissions of hydrocarbons and nitrogen oxides, the chemicals that create smog.

Some cities are also using a technology developed by Donald H. Stedman, (a chemistry professor at the University of Denver) which uses lasers to detect emissions while vehicles pass by on public roads, thus eliminating the need for owners to go to a test center. Stedman's laser detection of exhaust gases is the progenitor of remote sensing devices - commonly used in metropolitan areas.

By the early 1990s after the passage of the Clean Air Act of 1990, stricter testing criteria were phased in; the Environmental Protection Agency (EPA) introduced the IM240 testing. Around 35 states (as of this writing) have phased in I/M (inspection/maintenance) criteria modeled after the California Air Resources Board's emission testing standard.

California emission testing laws were amended in 1998 when SB 42 was passed - a new criteria phased in was the rolling chassis exemption to which vehicle manufactured between 1973 - 1998 were subjected to emission testing. This law was reversed last year by California governor Arnold Schwarzenegger where the rolling chassis exemption was repealed; as of 2005, and newer vehicles are subjected to testing.

Automobile Technology and Innovation

The product life-cycle for automobiles continues to shorten due to competitive market pressures. This is so because competitive market forces have caused automakers to dramatically redesign car models every four to five years.

New technologies developments have led to unique and innovative designs for future automobiles. Alternative fuel technologies, such as electric hybrids and fuel cell cars, have received considerable attention. International Trade Commission (ITC, 2002).

It is to be noted that the movement towards electric powered vehicles began as a result of the 1972 oil embargo in America, in which efforts were made to utilize electric battery technology to power engine propulsion. However, problems and limitations regarding driving range, speed and a very small market, all led to automakers (GM, Ford, Honda and Toyota) discontinuing their electric vehicle programmes during the late 1990's.

Also, hybrid vehicles combine two or more sources of power, which are able to operate using a rechargeable battery and gasoline. These are highly fuel efficient. It has to be noted that Japanese automaker Toyota, is one of the auto industries leaders in hybrid vehicle research and production with its Prius model. General Motors also involved in producing hybrid vehicles. Most major automakers plan to introduce hybrid vehicles to the market within the next decade.

Another automobile technology that is presently viewed as the latest catalyst in future automobile technology is fuel cell powered vehicles. In this system, fuel cell systems operate by compressing hydrogen made from natural gas and gasoline, which is then converted to hydrogen by on-board systems. Consequently, automakers and suppliers worldwide are investing substantially in the development of fuel cell systems. General Motors (GM), Ford and Daimler-Chryster have invested billions of dollars in a collaborative project to develop hydrogen fuel cell technology. Having considered the trend of events, many industry specialists indicate that fuel cell technology will not be available on the commercial market until the next one or two decades.

There are however, problems associated with hydrogen fuel systems which consist of:

☐ Developing a system for producing and distributing hydrogen Fuel.

☐Fuel cell vehicles will be more expensive.

☐Fuel cell will require a new infrastructure for vehicle manufacturing and maintenance.

There are many uncertainties regarding the development and use of hydrogen fuel cell technology as well as addressing the major question on how to create a viable infrastructure that supports the use of fuel cell vehicles.

For instance, **Ford Motor Company** offers more alternative fuel vehicles that are:

- ☐ Developing a hybrid which will switch between gasoline and Electric power and will achieve fuel economy.
- ☐ Pursuing fuel cell vehicle that will run on hydrogen and produce only water as a by-product.
- ☐ Developing more fuel-efficient and cleaner diesel powered engines.
- ☐ Offers many advanced safety technologies in their products (for example, personal safety system to protect front seat occupants during frontal clashes).

Advanced product design and vehicle operating systems

Recently many automobiles are increasingly relying on more **advanced electronics, computer,** and **wireless communication systems to assist drivers and enhance safety**. These technologies replace mechanical systems that power, steer and brake the vehicle. For instance, General Motors (GM) has introduced the **Autonomy Concept Model** which uses hydrogen fuel cell technology that powers electric motors in each wheel. The vehicle uses a chassis and replaceable body, allowing greater flexibility and freedom in designing the interior. The vehicle operates using sophisticated computer and electronic systems. Voice activation is another technology being developed for use in future vehicles. Voice activation systems are expected to operate internal climate controls, open doors and respond to navigational request by the driver.

Further development in automobile electronic and communications technology is vehicle sensor technology. A sensor technology uses radar or laser

technology to control systems that detect vehicle in front which then automatically slow down the vehicle.

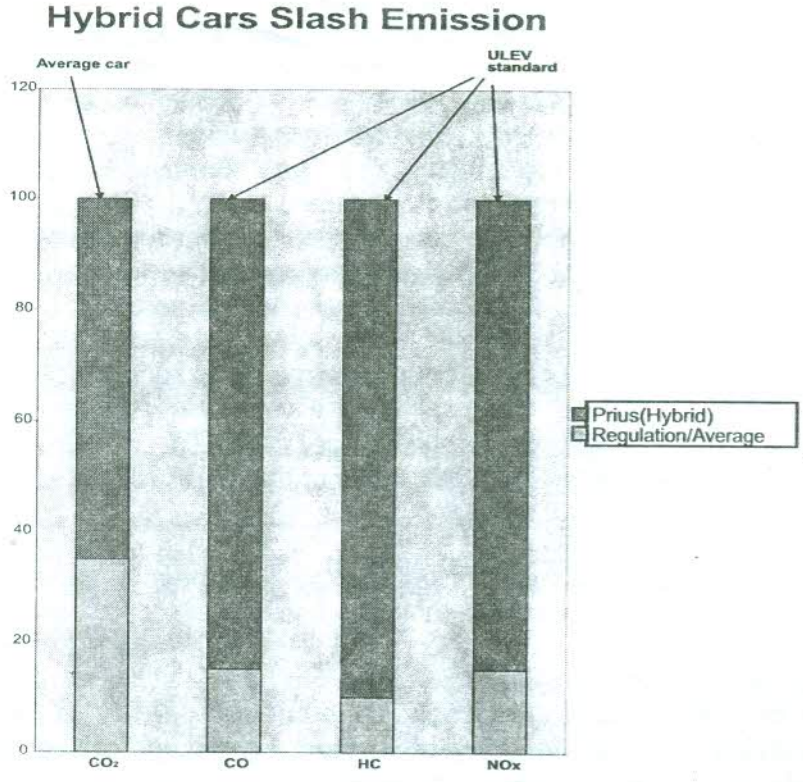


Fig 7: Hybrid Cars Slash Emissions

Fig. 7 shows the average car emission with respect to CO_2, CO, HC, and NOx indicating 35, 15, 10 and 15 percent emission reduction respectively.

How Individual Emissions Are Influenced By Different Fuel Proportion

They are as follows:

- ☐ Nox
  - Increases slightly with cetane number
  - Decreases as aromatic content is lowered.
- ☐ CO
  - No significant effects.
- ☐ HC
  - Decreases slightly as cetane number increases.
  - Decreases with density.

- Relationship with volatility inconsistent.

☐ Black smoke
- Increases with fuel density and decreases with aromatic content.
- Is not significantly affected by volatility.
- Increases with injection retard (e.g. for reducing NOx).

☐ Particulates
- Reduces as volatility is lowered.
- Reduces as cetane number is lowered, though inconsistently.
- Unaffected as sulphur content is lowered.
- Reduced as sulphur content is lowered.

☐ White smoke
- white smoke is a mixture of partially vaporised droplets of water and fuel. If there is no white smoke, no light is reflected back to a sensor alongside the light source; the degree of reflection therefore is a function of the density of the white smoke.

It is to be noted that a good quality fuel is generally regarded as one having a cetane number of 50 and sulphur content not greater than 0.05%.

The reason why the cetane number does not have a significant effect on the output of black smoke is that smoke density is largely determined during the burning of the last few drops of fuel to be injected into the combustion chamber.

In summary, the overall quantity of particulates can be reduced by increasing the injection pressure and reducing the size of the injector's holes to atomise the fuel better.

The Parameters Determining Emission from Automobiles

Since pollution is caused by various sources, it requires an integrated, multidisplinary approach. The different sources of pollution have to be addressed simultaneously in order to stall widespread damage.

There are four (4) parameters determining emission from automobiles. These include:

- ☐ Vehicular Technology
- ☐ Fuel Quality
- ☐ Inspection and maintenance of in-use vehicles
- ☐ Road and Traffic Management

Each one of the four factors mentioned has direct environmental implications. The vehicle and fuel systems have to be addressed as a whole and jointly optimized in order to achieve significant reduction in emission.
In Nigeria we are yet to address the vehicle and fuel system standards. There is need for holistic approach so that up gradation in engine technology can be optimized for maximum environmental benefits.
In Nigeria currently, only transport vehicle that is vehicles used for hire are required to undergo periodic fitness certification. The large population of private vehicles are not yet covered by any such mandatory requirement. In most countries that have been able to control automobile pollution to a substantial extent, **Inspection** and **Maintenance** of all categories of vehicles have been one of the chief tools used. Developing countries in the South East Asian region, which had severe air pollution problem few years back, have introduced an **Inspection** and **Maintenance** system and also effective traffic management.
Therefore, there is need for Nigeria to join the race now or remain undeveloped.
Thus, it should be noted that inadequate and poor quality of road surface leads to increase automobile operation costs and also increase pollution.

Standards for Fuels and Vehicles
Standards generally regulate the emissions of NO_x, particulate matter (PM) or soot, carbon monoxide (CO), or volatile hydrocarbons.
Emission standards are requirements that set specific limits to the amount of pollutants that can be released into the environment. Many emission standards focus on regulating pollutants released by automobiles and other transport vehicles, but they can also regulate emissions from industry, power plants, small equipment such as lawn mowers and diesel generators.

Fuel standards
The introduction of Fuel Standard (Petrol) Determination 2001 and Fuel Standard (Diesel) Determination 2001 from 1st January 2002 reduced sulphur levels in Australia diesel fuel from 1300 parts per million (ppm) to 500 ppm (since January 2003).

The sulphur content in fuel contributes to emissions of the particles. Studies have linked particulate matter with serious health problems. Therefore,

reducing the sulphur content in petrol and diesel is one way of limiting fine particle pollution.

It is to be noted that in Europe and the United States, particulate emissions from vehicles are expected to decline considerably over the next decade. For example, the European Union have introduced more stringent standards for particulate emissions from light duty vehicles of 0.025 grams per kilometre. Even under these standards, diesel-powered cars may still warm the climate more than many gasoline-powered cars. (Jacobson, 2002).
Consequently, the European Union will soon introduce stringent legislation as car manufacturers fail on emission targets.
(http//:www.stanford.ed/dept/news/pr/02/Jacobson VGR1023.htm/Particulate Emissions)

TOWARD A RADICAL TRANSFORMATION OF THE AUTOMOBILE

The twentieth century witnessed profound transformations in the way we live. Extraordinary scientific and technological advances have given society greater health, mobility and knowledge. They have greatly improved the quality of life for most people. One of the great challenges of public policy today is to extract the good from new technology while limiting the harm it does.

The automobile is a special case. The car is surely the greatest force multiplier of our time: it expands the individual domain a thousand fold, but brings with it in burnt fossil fuels the whiff of environmental catastrophe. The automobile makes a compelling case study because its pollution can be tamed. Over the past two decades, new technologies have reduced emissions of several automobile pollutants by three-quarters while doubling fuel efficiency.

European cities surveyed exceeded World Health Organization (WHO) air quality standards for at least one pollutant. In developing nations, air pollution often exceeds WHO standards by a factor of 3 to 6. As many as 1.4 billion urban residents globally breathe air exceeding the WHO air guidelines.

To exacerbate the problem, the world's auto fleet is growing at an extraordinary rate. In 1950, there were 53 million cars in the world. By 1990, the global fleet had increase more than eight fold to 430 million vehicles. If the trend continues, the world's population of cars will be 650million by 2010.

The health and environmental consequences of urban air pollution simply cannot be solved without taming the automobile. Fortunately, just as conventional auto technologies are responsible for much of the problem, so advanced technologies can offer much of the solution.

Hybrid Cars

Hybrids can increase fuel efficiency by 50 to 100 percent compared with conventional technologies, depending on configuration. Hybrids do not require any fundamental engineering advances, although they do require automakers to master new systems and develop sophisticated methods of optimizing the gasoline and electric components.

Several hybrid cars are entering the market place. They are expected to have wider market appeal than battery vehicles, which offer a limited range on each charge of electricity. Toyota has sold, in Japan, some 30,000 Prius hybrid gasoline-electric cars that get double the gas mileage of a conventional auto, with a commensurate drop in greenhouse-gas and toxic emissions.

Consequently, Honda introduced a hybrid two-seater in the United States in 1999. The car, called the insight, gets 60 to 70 miles per gallon. It is light, safe, aerodynamically efficient and clean.

Fuel cells

The fuel cell is a truly transformational technology. Some fuel cells combine hydrogen and oxygen to generate electricity, producing pure water as a by-product. Fuel cell vehicle configurations are nearly 50 percent efficient, a threefold increase over today's cars. Electric-drive automobiles powered by fuel cells can slash pollution while increasing energy efficiency.

Hydrogen Fuel Cells

- ☐ Emit only water
- ☐ Twice as efficient as other power trains
- ☐ Enable energy feedstock diversity
- ☐ Can substantially reduce greenhouse gases
- ☐ Potential source of electrical power

Automakers recognize the market potential of fuel cell vehicles and have begun to make serious investments in their development. Progress has been

strong over the last nine years, with costs and weight dropping tenfold or more over the last decade.

But a billion dollars spent on R&D, globally, is a pittance for the automobile and oil industries, and the population of companies working on these technologies is dangerously small. Fuel cell vehicles need more than cheap, small, reliable fuel cells. Fuel cells operate on hydrogen, which must be produced from a conventional fuel, such as methanol or natural gas.
One of the most significant benefits of advanced hybrid, fuel cell, and battery electric cars is that they can be designed to be inherently clean.
To understand this goal, it is useful to consider the antithesis: today's car. Our automobile run on engines that do not attain even their limited potential to be clean or efficient unless they are operated at the right temperature, with the right load, under proper maintenance. A deviation from any of these conditions results in vastly greater pollution and energy waste.

Automakers and oil companies are clearly capable of significant long-term technological innovation. The growth in vehicle kilometres travelled is fast overcoming reductions in tailpipe emissions. Further improvements are needed to protect public health and ecosystems. Only inherently clean vehicles will enable the world's large cities to reach the clean-air standards required to protect human health. And the energy efficiency of the transportation sector must improve dramatically to meet any reasonable goal of reducing greenhouse gases.
An important benefit of holding auto manufacturers accountable for real-world results is that over time they will move away from technologies that tend to behave suboptimal toward those that perform well regardless of vehicle's age, driver behaviour, or maintenance. This will speed the introduction of such technologies as hybrid gasoline-electric, battery electric, and fuel cell cars. Real-world improvements in air quality demand real-world performance by automakers.

The California Air Resources Board used the Zero-Emission (ZEV) regulation to ask automakers to design cars a new. Despite initial protests, auto companies and other private sector firms have responded with extraordinary innovation. Battery and fuel cell costs, size and weight have dropped as performance has

improved, with more gains in the past decade than in the previous four. All the major manufacturers launched electric or fuel cell programs, and investments in these technologies grew to over $ 2 billion.

Automakers need to be recognized and rewarded for bringing "risky" technologies into the market place. Similarly, to induce early market introductions, public agencies should offer incentive funds to help lower the cost of new technologies.

Developing International Antipollution Policies

Because the auto and fuels industries are dominated by global companies, policy-makers must build a coordinated international response. The auto and oil companies have to meet the standards of dozens of countries and therefore often pursue different goals with different technologies in different countries.

It is time for air regulators from major cities and countries to work together. National environmental officials have a difficult challenge, and they need to reach across political boundaries to build a coordinated strategy. Officials in the world's large and small cities have to provide for the health of their residents. They cannot do basic job without advanced auto technologies. The air regulators of Japan, Europe, China and the United States could send a powerful signal to auto companies about the technologies they need to develop (e.g. clean their air). If policy-makers link their plans together, manufacturers will have a strong incentive to deliver cleaner technologies.
Unless air regulators reach across political boundaries, they will fall victim of industry trends, largely powerless to clean their air or reduce greenhouse-gas emissions.

In sum, effective regulation will:

- ☐ Insist on real-world performance
- ☐ Set aggressive requirements, but give manufacturers flexibility
- ☐ Build programs that transform technology
- ☐ Reward innovation and early adoption
- ☐ Regulate carbon dioxide
- ☐ Form a coordinated, international antipollution front

Health Hazards of Air Pollution

According to the American Lung Association:

Air pollution contributes to lung disease, including respiratory tract infections, asthma, and lung cancer. Lung disease claims close to 335,000 lives in America every year and is the third-leading cause of death in the United States. Over the last decade, the death rate lung disease has risen faster than that of any of the top five causes of death.

The diesel engine runs at hotter temperatures and with higher compression ratios than its gasoline counterpart and, as a consequence, has higher fuel efficiency. That has made diesel fuel a favourite for truck, ships, locomotives, and other vehicles that run for long periods. This efficiency also makes converting gas cars to diesel a tempting component of a strategy for reducing greenhouse gases, since emissions of CO_2 are between 10 and 30 percent less in diesel engines. Some very large government and industry programs have been built on this idea, including the Partnership for a New Generation of Vehicles.

Unfortunately, diesel soot is increasingly implicated as toxic and carcinogenic. According to California Air Resources Board (ARB).

- ☐ Emissions from diesel-fuelled engines are mainly composed of particulate matter and gases, which contain potential cancer-causing substances such as arsenic, benzene, formaldehyde, nickel, and polycyclic aromatic hydrocarbons.
- ☐ Emissions from diesel-fuelled engines currently include over 40 substances that are listed by the U.S Environmental Protection Agency (U.S EPA) as hazardous air pollutants (HAPs) and by the ARB as toxic air contaminants.
- ☐ Research studies show that emissions from diesel-fuelled engines may cause cancer in animals and humans.
- ☐ Studies show that workers exposed to higher levels of emissions from diesel-fuelled engines are more likely to develop cancer.
- ☐ In 1990, the State of California identified diesel exhaust as a chemical known to cause cancer.
- ☐ The International Agency for Research on Cancer has concluded that diesel engine exhaust probably cause cancer in humans.
- ☐ The U.S EPA has proposed classifying diesel exhaust as a probable human carcinogen.

Diesel exhaust clearly poses a serious health risk. Therefore, without significant Improvements, diesel fuel will be increasingly unacceptable to the

public health. The ARB recognised this in insisting that future diesel engines for light duty vehicles meet the same standards as gasoline engines. Officials in Tokyo, Hong Kong, and Beijing are considering banning or severely restricting the use of diesel.

If diesel manufacturers expect to maintain their market shareor avoid becoming a moribund industry altogetherthey will have to reinvent their engines and make them meet the most stringent air pollution standards. The current European trend toward a greater use of diesel will shortly run into harsh reality.

GLOBALIZATION: THE AUTOMOBILE INDUSTRY'S QUEST FOR A "WORLD CAR"

Globalization is based on the belief that the world is becoming more homogenous; distinctions between national markets are fading and for some products may actually disappear. As a consequence of globalization, Automobile Industry firms are able to capitalize on the blending of national markets through attacking these markets with universal strategies and products.

The global automotive industry has for decades been attempting to develop and produce "world cars" for the mass market that can be sold around the world with only minimal modifications. It has been observed that the "world car" strategy has traditionally only been successful in the upper end of the consumer market with cars of international appeal such as Rolls-Royce, Mercedes, BMW to mention a few. The feasibility of a true world car strategy in the near future is doubtful as the world has not become globalized enough to support this strategy. In the automotive industry, globalization can have tremendous cost benefits.

Complications in Developing "World Cars"

During the 1990's, three noticeable attempts were made at producing a world car. Ford made an attempt with its Mondeo/Contour models, General Motors (GM) with its Cadilac Catera/Opel Omega models and Honda with its Accord model. All three of these models fell far short of their goals of achieving global success in the European, North American, and Asian markets for many reasons.

The major theme in the failures of these world cars is the trade-offs in their

development that were needed to satisfy the disparate preferences of the consumers in these different geographic markets.

Three (3) important factors were identified as major challenges in developing a world car. These among others include **Tastes, Infrastructure/Economics and Rules and Regulations**. It is to be noted that in our increasingly globalized world, significant differences in tastes in automobile exist between the people in the different geographic markets. Among these changes in tastes include preference in automobile size, design and aesthetics. The most noticeable reason for failure of the world cars of the 1990's was the interior size of the cockpits of the automobiles. For example, the Ford Mondeo/Contour was well accepted in the European market, while the North American market found the interior of this automobile too cramped leading to its failure in this market. Another taste disparity between the North American and European markets exists in material preference for automobile construction of steel panels to be of superior construction to automobiles constructed of plastic panels. This taste discrepancy created issues for the GM subsidiary Saturn in its attempt to launch a world car during the late 1990's. For a world car to be successful, the cultural differences between the different regions of the world will need to diminish over a time (decade?).

Infrastructural/Economics

The disparities in the infrastructures present in the different regions of the world create another challenge for the success of a world car. For example, a major hurdle in developing a world car that will satisfy the preferences of consumers in North America and Asia is created by the differences in the road infrastructures between these two regions. North Americans prefer large roomy cars as opposed to Asians who prefer a car small enough to squeeze through their crowded city streets. Honda designed its Accord model to meet the large car preference of the North American market, which led to its demise in Asia.

Economics create another major challenge in developing a world car. For example, the disparities in the price of gasoline in the different regions of the world. Europeans are obsessed with fuel economy contrasting to Americans who for the most part are more concerned about acceleration and performance.

Overcoming the economic hurdles to the development of a World Car is foreseeable in the near future as economic integration increases in European,

North American and Asian markets come more into conformance. However, overcoming the infrastructure disparities is not foreseeable in the near future and will continue to create a significant hurdle since the infrastructures present in the different regions of the world were created over centuries in time and are not going to change overnight.

Rules and Regulations

Rules and regulations are also forming hurdles to the success of a world car. For example, safety and emissions regulations vary significantly across national markets as discussed earlier. In less developed countries such as those of Southeast Asia, Africa, regulations are more lax or not strict as compared to the developed countries of Europe and North America. Significant differences exist in safety and emissions regulations. As a consequence of these discrepancies, automotive industries have found tailoring their products to the specific requirements of these markets to be the most cost effective to compete. That is, vehicles are tailored by local design and engineering off on a common platform for each market.

As the developing world emerges and as globalization influences the developed world the differences in rules and regulations will start to fade; however, this change will take time.

A study carried out by the consulting firm Rollen Berger predicts by 2010, 82% of all car models will share a common platform compared to 65% today (Chandler, 2000). This global platform strategy is an interim that will eventually be succeeded by a "world car" strategy.

The under listed questions are pertinent and meant for proper digestion.
Will the petroleum and automobile industries and the government be able to agree on a common goal for automotive emission standards?
Given the current situation in Nigeria, many pertinent questions arise out of the key issues related to this area.

- ☐ What are the methods available for reducing emissions from vehicles currently in use?
- ☐ What are the economic implications of upgrading fuel quality?
- ☐ What are the new vehicle technologies available in Nigeria and elsewhere in the world?

- ☐ What are the oil-refining technologies available for producing fuels of required quality and specifications?
- ☐ What are the measures required to promote the use of cleaner fuels?

To effectively tackle these issues, there is need to focus on automotive technology and fuel quality; institutional, regulatory, and enforcement issues; and environmental policy.

WHAT YOU CAN DO ABOUT CAR EMISSIONS

Better car maintenance can save money, improve safety, and reduce pollution

The followings are possible ways:

- ☐ Car Emissions A Problem?
- ☐ What pollutants do motor vehicles emit and what are the health effects?
- ☐ Where do these pollutants come from?
- ☐ What can motorists do to reduce Emissions?
- ☐ How much can I save?
- ☐ What else is being done?

Car Emissions A Problem?

According to U.S. Environmental Protection Agency (EPA), driving a car is the single most polluting thing that is carried out everyday. Motor vehicles emit millions of tons of pollutants into the air each year. In many urban areas, motor vehicles are the single largest contributor to ground-level ozone, a major component of smog. Ground-level ozone is the most serious air pollution problem in the northeast and mid-Atlantic states. Cars also emit several pollutants classified as toxics, which cause as many as 1500 cases of cancer in the U.S.A. each year. Auto emissions also contribute to the environmental problems of acid rain and global warming.

Pollution control measures have drastically reduced emissions per vehicle in the past 20 years. However, during that time the total kilometres travel has doubled, resulting in higher levels of air pollutants in many parts of U.S.A and the entire world..

What Pollutants Do Motor Vehicles Emit and What Are the Health Effects?

Motor vehicles generate three major pollutants: hydrocarbons, nitrogen oxides, and carbon monoxide.

- ☐ Hydrocarbons react with nitrogen oxides in the presence of sunlight and elevated temperature to form ground-level ozone. It can cause eye irritation, coughing, wheezing, and shortness of breath and can lead to permanent lung damage.
- ☐ Nitrogen oxides (NOx) also contribute to the formation of ozone and contribute to the formation of acid rain and to water quality problems.
- ☐ Carbon monoxide is a colourless, odourless, deadly gas. It reduces the flow of oxygen in the bloodstream and can impair mental functions and visual perception. In urban areas, motor vehicles are responsible for as much as 90% carbon monoxide in the air.

Motor vehicles also emit large amounts of carbon dioxide, which has potential to trap the earth's heat and cause global warming.

Where Do these Pollutants Come From?

Car release pollutants from the tailpipe as the result of the fuel combustion process, and from under the hood and throughout the fuel system when heat causes fuel evaporation. Evaporative emissions occur at these times:

- ☐ When outside temperatures on hot, sunny days cause car's fuel to evaporate
- ☐ When the hot engine and exhaust system of a running car cause the fuel to become heated
- ☐ When the car is shut off and remains hot enough to cause fuel to evaporate
- ☐ During refuelling, when gasoline vapours escape into the air from the gas tank and the nozzle

The greatest amount of tailpipe pollutants are released during the "cold star" phase, or the first few minutes it takes a car to warm up. Since a car warms up faster when it is moving, drivers are advised to limit warm-up time.

What Can Motorists Do to Reduce Emissions?

Drivers can help reduce motor vehicle emissions in the following ways:

- ☐ **Reducing the number of vehicle kilometres travelled** by car pooling, using public transportation, and planning ahead to combine trips. One person using mass transit for an entire year, instead of driving to work, can keep an average of 9.1 pounds of hydrocarbons, 62.5 pounds of carbon monoxide, and 4.9 pounds of nitrogen oxides from being discharged into the air. One full, 40-foot bus also takes 58 cars off the road. A 10 percent nationwide increase in transit ridership would save

608 million litres of gasoline a year.

- ☐ **Travelling at moderate, steady speeds**. High speed results in greater emissions. Idling for more than half a minute burns more gas than it takes to restart the engine. Therefore, reducing idling time is better.
- ☐ **Keeping vehicles in good running condition**. Poorly maintained or malfunctioning vehicles can release as much as 10 times the emissions of a well-maintained one. Motorists should follow the manufacturer's instructions on routine maintenance, such as oil and filter changes. Use an energy saving grade of motor oil.
  - o Don't tamper with the pollution controls and have the vehicle inspected regularly.
  - o Keep track of fuel economy. A loss in economy usually means an increase in emissions. Poorly inflated tires can also cause loss in fuel economy.
  - o Watch the exhaust. If it is black, there is too much gas in the mixture and the fuel injection system needs to be checked. If the exhaust is blue, the car is burning oil and releasing excess hydrocarbons.
  - o Fix air conditioning leaks immediately.
  - o Pay attention to dashboard warning lights. Have the car checked out as soon as possible.

- ☐ **Not topping off the tank when refuelling**. Make sure the gas cap fits properly to avoid spills.
- ☐ **Using clean fuels, when available.** Clean fuels include reformulated gasoline, oxygenated, and alternative fuels.
  - o Oxygenated gasoline is federally mandated in area that do not meet the federal health standard for carbon monoxide. It contains at least 2.7 percent oxygen on average. It is sold during the colder months of the year when carbon monoxide is more of a problem in U.S.A.
  - o Alternately fuelled vehicles run on the variety of fuels, including methanol, ethanol, compress natural gas, and electricity, all of which reduce emissions.

Going with newer, less polluting cars, such as low-emission and alternatively fuelled vehicles. When buying a car.

- o Check the posted fuel-efficiency rating. The greater the efficiency, the lower the carbon dioxide emission per kilometer.

- Older cars pollute more. When buying a used car, have a mechanic check the catalytic converter and other pollution controls to be sure they are working properly. Be sure to keep the vehicle well maintained.
- Low emission vehicles, sometimes called "California cars," will increasingly become available over the next few years. These vehicles are different because they have additional emissions control equipment.

How Much Can I Save?

The federal highway administration in U.S.A estimates that it costs people between 22 and 29 cents per mile to operate a car, depending on the size. By ridesharing everyday, commuters can save up to $3,000 a year on gas, insurance, parking, and wear and tear on their car. By designating an automobile for pleasure use only, the insurance premiums on that car can go down as much as 20 percent.

It is also estimated that the idling and stop-and-go traffic cost motorists 735million gallons of gasoline a year, or $1,194 per driver in wasted fuel and time. People commuting by computer from home two or three days a week, or working an alternative work week, could save up to three week's worth of driving a year.

What Else Is Being Done?

Other measures to control motor vehicle emissions already have been introduced, or will be in the next few years, in areas with severe ozone problems. These include the use of special nozzles at gas pumps to recover gasoline vapours before they can escape into the air; improved inspection and maintenance programs, with more comprehensive testing; and various transportation control measures, including mandatory programs in some areas to reduce the number of motor vehicle trips made by employees and encourage mass transit use.

Even with all the above measures, meeting federal air quality standards will be a close call for some of the more seriously affected areas. Every effort to reduce motor vehicle emissions helps, whether it is carried out by the government, corporations, or individual motorists.

Among the automobile technology advances that seem likely within the next few years are:

- ☐ Every new car will come with a computer-like screen mounted on the dash. It will display a navigation system that uses a global positioning satellite plus on board DVDs to provide directions, maps and information on hotels, hospitals and restaurants.
- ☐ Many cars will be programmable: be it sporty or luxurious.
- ☐ Brake-by-wire and accelerate-by-wire when pressing the pedal sends an electronic signal rather than activating a physical connection to the engine or brakes will become common.
- ☐ Cars will increasingly collect data that can be shared with dealers, manufacturers, and others. Manufacturers or dealers for instance may do remote diagnosis to help troubleshoot a roadside breakdown.
- ☐ Many cars may have cameras in the front bumper to see around corners as driver eases out of a driveway or **alley**. (Narrow Street).
- ☐ Voice commands already used in some BMWs, Jaguars and Lexus will become far more common to help drivers juggle the proliferating functions in their cars.
- ☐ Cars with 40-volt electrical systems will become the standard because today's 12-volt systems can't easily accommodate all the new electronics gizmos.
- ☐ Engines with new more advanced variable valve controls from BMW and other manufacturers will result in further fuel savings.
- ☐ The continuously variable automatic transmission is another innovation which can cut fuel consumption by 70% to 11%.
- ☐ A system that can instantly restart the engine when the driver hits the gas pedal by igniting the combustion mixture in the fuel-injection system without engaging the starter motor. Thus cut a vehicle's fuel consumption by about 5%.
- ☐ Clean diesel consumption technology is one example of innovative engine concepts that are simultaneously clean, efficient, and cost effective. Further research is still in progress.

All of these changes will arrive at different times in different countries, in part because of geographic and cultural differences.
The whole world is in the midst of a global information revolution driven by the convergence and proliferation of information and communication technologies.

CONCLUSIONS

The need for an integrated holistic approach for controlling automobile emission can not be overemphasised. This study recognized that improved automobile technology and cleaner fuels are not by themselves sufficient to bring about the desired reduction in vehicular emissions. The measures have to be accompanied by an integrated transport policy. Without such a policy, it is possible that the growth in the motor vehicle fleet would partially or fully offset the improvements obtained from the increase in energy efficiency and the reduction in emissions output of individual vehicles.

Various short, medium and long term actions for achieving air quality improvements have been identified by the relevant governments and their instrumentalities, and some of them have been implemented with varying success. Yet, there has been no discernible impact on pollution levels; nor is there an integrated and well thought out strategy to bring about a quantified reduction in the pollution levels in the coming years. In the Tata Energy Research Institute's (TERI) view what is important is not to reiterate these well known actions or policy interventions, but to establish a methodology which the key stakeholders together can adopt to arrive at an appropriate policy framework, an optimum strategy to implement that policy framework with a view to establishing an environmentally friendly and sustainable transportation system for Nigeria and the entire world.

Providing citizens with clean air will ultimately become as clear and important a mandate as providing clean water. No big city can prosper without decent sanitation systems because the consequences are too ugly and too apparent.

Advanced technologies can solve the air pollution problem and substantially help reduce greenhouse gases. But auto companies will not push those technologies without unambiguous signals from public officials, and piecemeal regulation is insufficient.

Those officials charged with cleaning the air and protecting the public health must take a more aggressive, holistic, and longer-term view of the world, and build a system that can actually win the day.

1 Automobiles need continuous improvement to reduce the quality of pollutants they emit with a view of resolving the environmental problems on emission control both in engine internal and external.
2 The dependence on finite fuels such as petroleum (hydrocarbon) should be reduced and totally new technologies should be developed for automobiles.

3 Continuous evaluation of technology education and scientific programmes in schools, colleges, polytechnics and universities and research institutes is essential in order to render these programmes appropriate to the changing international situation in automobile industries.
4 Exploration of a cost-effective means of using sustainable fuels to achieve both low emission and high fuel economy is essential.

Though many difficulties can be expected, their implementation is essential if as many people as possible are to enjoy the benefits of the automobile industries.

Recommendations for advanced automobile technologies and challenges

- ☐ Encourage high-compression engines together with higher-octane fuels to reduce emission of pollutants per kilometre traversed.
- ☐ Improve traffic management using state-of-the-art techniques.
- ☐ In the case of trucks and buses, upgrade in-use technologies to make them more fuel efficient.
- ☐ Introduce particulate traps to mitigate particulate emissions.

Recommendations for fuel and emission standard

- ☐ Establish an advisory body to review the fuel quality specifications with reference to emission standards.
- ☐ Prescribe emission standards of in-use vehicles as lay down maintenance and fitness testing schedules to achieve these standards.
- ☐ Investigate the relationship between mass emission standards and emission while idling.
- ☐ Develop air quality models as a tool for the auto industry and regulatory agencies.

Recommendations for enhancing environmental performance of in-use vehicles

- ☐ Make inspection and maintenance programmes and genuine certification by the authorised service stations mandatory.
- ☐ Set up stringent exhaust emission standards for different categories of in-use vehicles.
- ☐ Encourage regular replacement of old vehicles that do not conform to emission standards through appropriate fiscal and financial incentives such as a higher provision for depreciation.

RECOMMENDATIONS FOR ALL STAKEHOLDERS

It is recommended that researches should be conducted on air quality together with the estimation of emissions in partnership with relevant government authorities, international organizations and also corporate sector.

The environmental impact of energy use in the transportation sector in Lagos, Ibadan, Abuja, Kaduna, Kano, Enugu, Onitsha, Port-Harcourt, Jos, Maiduguri, wherein vehicular emissions are to be quantified and mitigation options explored is urgently required.

Efforts should be made through print and visual media and through workshops and seminars to sensitize the public, especially students, in reducing vehicular pollution.

It is my believe that a comprehensive policy framework and an effective strategy to combat pollution cannot be developed unless integrated action is taken on the following lines.

- ☐ establish a comprehensive and credible data base, and the methodology for setting it up;
- ☐ critically evaluate and prioritize measures to reduce pollution to the targeted level, including amongst others, cost of abatement measures;
- ☐ draw up a regulatory framework to prescribe and enforce pollution control measures;
- ☐ Establish a unified institutional framework to make transportation system in Nigeria environmental friendly.
- ☐ Government should encourage industry to seek low CO2 emissions fuels by means of grants and tax breaks on research rather than penalize the end user.
- ☐ There is need for manufacturing sector to invest substantially more in new technology and to be more proactive towards the issue of climate change from automobile emissions
- ☐ The manufacturing sector should be accountable for their impact on the climate and therefore seek to reduce their negative environmental impact.
- ☐ Government should ensure that major companies donate a percentage of their profits to research into green technology and put mechanisms in place to generate innovation in green technology of all types.
- ☐ There is a need for government/industry partnership scheme setup to discuss and monitor automotive industry's potential developments in

terms of reducing carbon emissions and developing new technologies.

- ☐ Car, transport and fuel markets are global. They need to work at a global industry level to set targets to deliver energy efficient solutions
- ☐ Haulage firms should be committed to purchasing low emission vehicles where possible.
- ☐ Fuel suppliers should invest in alternative fuels in collaboration with the car manufacturers. Vehicle manufacturers should be obliged to meet efficiency requirements.
- ☐ Improvement of both access to technology education for all segments of society and the dissemination of information on the use of technology education for development of automobile industries should be pursued to logical conclusion.
- ☐ Effective involvement of industries in training and provision of training needs and research and development grants to control the effects of motor transport on Nigerian roads in particular and the whole world in general.
- ☐ Establishment of Auto-Banks should be put in place to be investment-oriented but not solely profit-oriented.
- ☐ Address adulteration issues with appropriate tax structures and other measures.
- ☐ Evolve strategy and allocate responsibility for environmental compliance and meeting the cost thereof.
- ☐ Methodology for collection of credible vehicular emissions data that emerge from inspection and maintenance programme of in-use vehicles and scientific analyses of this database to draw meaningful conclusions should be encouraged.

If all these challenges are effectively implemented, the automobile industries will improve in the solution of climate change issues which are affecting human development world wide and Nigeria in particular.

ACKNOWLEDGMENTS

I appreciate most sincerely and humbly the Almighty Allah for bestowing His mercies, blessing, knowledge, protection, good health and wisdom on me. I thank the Almighty Allah the cherisher, the sustainer, the avenger and the compassionate. I wish to acknowledge and appreciate my parents, my father Abdussalam Ayinla (late) may his soul rest in perfect peace (Innalillahi wahina illahi rajihun) and my mother Seliatu Asande Salami who could not be here due to old age.

I wish to acknowledge my wonderful wife Mrs Khadijat Adenihun Salami who always be at my side for success. My children, Mrs Ganiyat Adebola Oyeniran, Mr. Shakirullah Ademola, Mr.Monsur Adeola (late), Master Ismail Olalekan (late) (Innalillahi wahina illahi rajihun) may their souls rest in perfect peace. Miss Shakirat Folashade Salami and Muyideen Abdussalam Oladejo all have always been my source of joy.

I wish to acknowledge all my teachers and lecturers from primary to this level especially S.C. Mudd of the Huddersfield Polytechnic now University of Huddersfield, U.K and Dr. H.D. Plunkett, from University of Southampton, U.K. Professors S.O. Olaitan and R.N. Oranu from University of Nigeria, Nsukka to a mention a few.

I appreciate the various assistance of Professors A.A Oladimeji F.O. Akinbode, D.O.Adefolalu, G.D. Momoh, (Mrs) H.O.Akanya, O. Solanke, J.A. Abalaka, M.A.Olatunji, K.R. Adeboye and others numerous to mention.

I also wish to thank Professor Mohammed A. Daniyan the former Vice-Chancellor of this University who employed me during his tenure. I particularly appreciate Professor Hamman Tukur Sa'ad, the current Vice-chancellor of this great Institution during whose tenure I have the opportunity to be crowned a

Professorial chair, and to deliver this 10th Inaugural lecture may Allah bless you (Amen).

I also acknowledge my colleagues, friends', students and well wishers amongst others Messrs Dr O.K. Abubakre, Engr Dhikrullah Oritola, Raimi O. Oseni, Allhaji Bola Sulola .

The chairman, Mr. Vice-Chancellor sir, distinguished audience; I sincerely hope that we should all earnestly work toward national integration to reduce effects of global warming through fuel emission reduction.

I appreciate the efforts of Professor K.R. Adeboye Chairman Inaugural lecture and Seminar Committee and his team for making this inaugural lecture a huge success.

I thank you all for listening to me patiently. May Allah Almighty bless you all (Amen).

BIBLIOGRAPHY

1. Brodes, F (1968). The old stone age. New York; McGraw Hill

2. Bryant, L. (1966). "The Silent Otto", Technology & Culture 7: 184-200

3. Cater, A. (1966). The economics of Technological change. U.S.A.; Scientific America. April, 1966.

4. Chandler, A.D. (ed) (1964). Giant Enterprise: Ford, General Motors, and the Automobile Industry. New York; Harcourt Brace & World.

5. Chandler, C. (2000). Globalization will Continue to Drive Consolidation, PR Newswire, May 22.

6 Cusumano, M.A. (1985). The Japanese Automobile Industry: Technology and Management at Nissan and Toyota. Cambridge: Harvard University Press

7. Duffy, J.E. and Smith, H.B. (1992): Auto Fuel and Emission Control System Technology. Holland, Illinois; The Good heart Willcox Company.

8. European Road Safety (1998). Key areas of Traffic Safety Work Sweden; Nordic Road and Transport Research. (NR & TR) No. 2

9. Farley, P. (April, 2004). "Hybrids" Rising Sun. Technology Review, p. 36

10. Fafunwa, A.B. (1974). History of Nigerian Higher Education. Lagos, Nigeria: Macmillan publisher.

11. Federal Republic of Nigeria (1993) National Automotive Policy Guidelines. Lagos, Federal Ministry of Industry, June, 1993.

12 Federal Ministry of Education (1995). Mid-Decade Review of Progress Towards Education For All. Lagos, FME

13. Federal Republic of Nigeria (2004) National Policy on Education

(Revised). Abuja, Nigeria; NERDC Press.

14. Flink, J.J. (1975). The Car Culture Cambridge: MIT Press

15. Flink, J.J. (1988). The Automobile Age. Cambridge: MIT Press

16. Haque, I.U. (1995). Trade Technology and International Competitiveness. Washington. Economic Development Institute of the World Bank.

17. Igbinosa, G. (Sept., 2002): Africa Environment Outlook.

18. International Trade Commission.(2002) Industry and Trade summary: Motor Vehicle. Washington, D.C.; U.S. International Trade Commission 3545, September, 1:2. P.37.

19 Jacobson,(2002) (http//:www.stanford.ed/dept/news/pr/02/ Jacobson VGR 1023.htm/Particulate Emissions)

20. Marshall, K. (1983). Package deals; A Study of Technology and Development Transfer. London; Intermediate Technology Publication.

21. May, G.S.(ed) (1989). The Automobile Industry, 1896-1920. New York, Facts on File/Encyclopaedia of American Business History and Biography.

22. May, G.S.(ed) (1990). The Automobile Industry, 1920-1980. New York, Facts on File/Encyclopaedia of American Business History and Biography.

23. National Aeronautics & Space Administration(2003). NASA helps reduce automotive emissions. Advanced Technology Innovation.1(1) Spring 2003, 1-2.

24 Newton, K., Steeds W. & Garreth, T.K (1996) The Motor Vehicle Oxford; Butterworth-Heinemann.

25. Okuda, H. (1997). Toyota and Automobiles in the Twenty-First Century; Tackling Environment Issues in Sakaguchi. Hajime (ed) The Wheel Extended. Japan; Toyota.

26. Salami, K.A. (1985). Methodology of Teaching Auto mechanics in Nigeria

Secondary Schools. In 'Bayo Ayelaagbe et al (eds) Ila-Oragun Education Series 1: towards Improved Teaching. Oyo State (Now Osun state) College of Education,
Ila-Orangun. Chapter 19; 153-178.

27. Salami, K.A. (1992). Planning Vocational and Technical Education Programmes for Manpower Development. In E.U. Anyakoha and R.N. Oranu (eds). Vocational Technical Education and manpower Development: Journal Nigerian Vocational Association (NVA). Nsukka, University of Nigeria Chapter 6; 36-42.

28. Salami, K.A. (1992). Technology Teacher Training for Development in Nigeria: Problems and Remedies.
In P.O. Awotunde (ed.) Issues in Technology Education for National Development, Nigerian association of Teachers of Technology, 1, 39-46.

29. Salami, K.A. (1993). Utilization of Locally Available Resources by NCE Technical programmes in Oyo and Osun state of Nigeria Journal of the Nigerian Vocational Association, (NVA) Nsukka. University of Nigeria. vii: 200-205.

30. Salami, K.A. (1994). Innovation, Creativity and Design in technology Education. Empire: Journal of Vocational and Technical Education, St. Andrew's college of Education, Oyo.1 (i), 22-32

31. Salami, K.A. (1994). An appraisal of the leadership competencies for administrators in Technical and Vocational Education in Oyo State. In E.U. Anyakoha and R.N. Oranu (eds)Vocational/Technical Education and Manpower Development Journal of the Nigeria Vocational Association (NVA). Nsukka: university of Nigeria VII; 35-.42.

32. Salami, K.A. (1994) A flow chart approach towards creative Teaching of Technical Drawing In Schools. The college Review. Journal of Osun state College of Education,
Ila-Orangun, Nigeria. 5 (1 & 2); 157-163.

33. Salami, K.A.(1995). Towards Identification of creative Teaching and Learning in Introductory Technology in Nigeria Secondary Schools. The VAS Journal of the school of Vocational and Technical Education Studies. Tai Solarin College of Education, Ijebu-ode, Ogun state. 4(1); 56-62.

34. Salami, K.A. (1995) Effective Management of Skills for Reducing Wastage In Vocational Technical Education in Nigeria. In T.I. Eze (ed) Empirical Studies on Social and Economic. Implication of Vocational and Technical Education in Nigeria. Federal College of Education (Technical), Umunze Anambra state, Nigeria. Chapter 1; 1-13.

35. Salami, K.A. (1995). The techniques of Teaching Introductory Technology in the Junior Secondary Schools. Andrian Forum. Journal of St. Andrew's college of Education. Oyo 8 (2); 101-112.

36. Salami, K.A. (1995).Technical and Vocational Education as the Bedrock of National Development in Nigeria. LAJOVTED Journal of Lagos state {now Adeniran Ogunsaya}College of Education, Vocational and Technical Education, Oto-Ijanikin, Lagos.2 {1}; 28-36

37 Salami, K.A.{1995}. Strategies of funding Technology Education in Nigeria. Nigeria Journal of health Education and Welfare of special people. University of Ibadan. 1 (2); 62-63.

38. Salami, K.A. (1995). Occupation Skills Development Techniques for Reducing Wastage in Vocational Technical Education Programmes: Automobile. Oyo; Journal of Technical and Vocational Studies. SIWES, 1 (1 & 2); 6-13.

39. Salami, K.A. (1996). Management of Conflict for Peace in Technical Institutions in Nigeria. Andrian Forum Journal of St. Andrew's College of Education, Oyo. 9 (1 & 2); 157-160.

40. Salami, K.A. (1996). Current Issues and Implications of Assessment for Qualifications in Automobile Technology in Nigeria: The way ahead. Journal of Education and Society. Faculty of Education, Obafemi Awolowo University. Ile-Ife 3 (1); 41-49.

41. Salami, K.A. (1996). Auto-Technology Fundamentals Series II Lagos, Inland Printing and publishers.

42. Salami, K.A. (1997). Sources and Control of Wastage in Vocational Technical Education For Manpower Development. The Nigeria Teacher Today TNTT. Journal of Teacher Education, NCCE, Kaduna. 5 (1 & 2); 71-79.

43. Salami, K.A. (1997). Assessment for Qualification in Automobile Technology in Nigeria: The way ahead. NATT Research series Lagos, Adeniran Ogunsanya college of Education 2 (1 & 2); 16-18.

44. Salami, K.A. (1997). Strategies for Effective implementation of Vocational and Technical Education in the 6-3-3-4 systems. The Moulder: Journal of School of Education, St. Andrew's College of Education, Oyo. 2, (1); 91-97.

45. Salami, K.A. (1997). Systematic Approaches to Development of Vocational Apprenticeship Training in Nigeria. ILA VOCTECH JOURNAL: School of Vocational and Technical Education, Osun state College of Education, Ila-Orangun. 1(1) 33-41.

46. Salami, K.A. (1997). The place of Automobile Technology and Industry in the Curriculum of Technical Colleges in Nigeria: Implications for the next decade. In K.A. Salami, T.A.G. Oladimeji and A.W. Ajetunmobi (eds). Technology Education In Nigeria; Lagos, Nigerian Association of Teachers of Technology (NATT).Chapter 49; 280-285.

47. Salami, K.A. (1998). Strategies towards enhancing Instructional efficiency in technology education programmes. JONATT, Journal of the Nigerian Association of Teachers of Technology 2, (1); 81-87.

48. Salami, K.A. (1998). Technology education towards improved performance of automobile Technology training in Nigeria. Journal of Vocational and Technical studies. VOCTECH. Kwara state College of Education, Ilorin.1 (1); 209-215.

49. Salami, K.A. (1998). Sustainability of economic growth in an increasingly global technological environment. Nigerian Journal of Health Education and Welfare of Special People. University of Ibadan. 2 (2); 107-114.

. Salami, K.A. (1998). Tackling environmental issues for human beings by automobile industry in the 21st century. In A.W. Ajetunmobi, T.A.G. Oladimeji and K.A. Salami (eds), Technology Education and Realization of Vision 2010. Proceedings of Annual conference of Nigerian association of Teachers of Technology (NATT).

. Salami, K.A.(1999). Study of the attitude of secondary school students to Introductory Technology in Niger state. Journal of Nigerian Association of Teachers of Technology (JONATT). 3(1); 168-173.

. Salami, K.A. (1999). Towards effective utilization of facilities in the automobile Engineering programme in technical Colleges Journal of Applied science and Education (JASAE) Minna, Department of Biological sciences, Federal University of Technology. 1 (3); 1-6.

. Salami, K.A. (1999). A systematic approach towards engineering product development and manufacture. In J.O. Odigure and M.G. Yisa (eds). Proceedings of the 1st National Engineering Conference, Engineering and Technology for 21st century. Minna, School of Engineering and Engineering Technology, Federal University of Technology. 31-35.

. Salami, K.A. (2001). Mechanisms for development of automobile industry; The 21st century challenge. Journal of Science, Technology and Mathematics Education (JOSTMED) Department of Science Education; Federal University of Technology, Minna, Nigeria. 4(1); 15-21.

. Salami, K.A. (2001). Mechanisms for appropriate technology adaptation for sustainable poverty alleviation in Nigeria In T.A.G. Oladimeji, O.T. Ibeneme, O.M. Adesope, M.A.Ogunyemi and H.M. Tukura (eds). Technology Education and sustainable poverty alleviation in Nigeria.Nigerian Association of Teachers of Technology (NATT). Paper 9; 41-45.

. Salami, K.A. (2001). Towards effective skills management techniques in technology education in Nigeria. In E.A.C. Okeke and D.U. Egonu (eds). Educational Alternative for Nigeria. Nsukka, Nigeria. Institute of Education, University of Nigeria. Chapter 14; 156-167.

. Salami, K.A. (2001). The rationale for quality control management as a determinant success in Engineering products and processes. Nigerian Journal of Development Issue: Education,Socio-Political and

Economic Development. Faculty of Education, University of Ibadan, Nigeria. 5 (1 & 2): 123 136.

58. Salami, K.A. (2002). The concept of Environment friendly design and replication in automobile industry manufacturing processes. In T.A.G. Oladimeji, O.T. Ibeneme, S.I. Akinseinde, M.A. Ogunyemi and H.M. Tukura (eds). Technology Education and Environmental Issue in Nigeria.Proceedings of the 15th Annual conference of NATT 18th - 22nd November, 2002. Paper 13; 410-414.

59. Salami, K.A. (2003). Sustainability of the Approaches to Managing Technology Education in a Democratic Society. In N.G. Nneji, M.A.A. Ogunyem, F.O.Onyenkwu, and M.A. Ukponson (eds). Technology Education in a Democratic Nigeria.A lead paper presented Nigerian Association of Teachers of Technology (NATT).
Part 1; 10-124.

60. Salami, K.A. (2004). Incorporating Entrepreneurship Education into Technology education Programmes: Issues and Strategies. In O. A. Abubakar and B.A. Alabadan. (eds) proceedings of the 5th National Engineering conference on Engineering and Technology in a privatized economy. Minna school of Engineering Technology,Federal University of Technology.

61. Salami, K.A. (2004). Auto-Technology Fundamental Series I. Ibadan: University Press.
62. Salami, K.A. (2004). Auto-Technology Fundamental Series III. Ibadan: University Press.

63. Salami, K.A. (2005). Environmental influence on High Technology in future of the Automotive Industry. In I.N. Mogbo, A.A Oladimeji, S. Jonah and G.A. Okoli. (Eds) Current Trend in Science and Environmental Management. Proceeding of the 1st Annual School of Science and Science Education Conference, Federal University of Technology, Minna. 24th-27th November, 2005. 264-268.

64. Salami, K.A.(2006). Strengthening School Enrolment in Technology Education for National Development. In G.N. Nneji, F.O.N. Onyeukwu,

E.A. Nneji, B.M. Ndomi and M. Ukponson (Eds) Consolidating the gains of Technology Education for national development in Nigeria. A lead paper presented Proceeding of the 19th Annual Conference Kwara 2006 of Nigerian Association of Teachers of Technology (NATT);6th-9th November, 2006. 439-446.

65. Stockel, M.W., Stockel, M.T & Johanson, C (1996) Auto Service and Repair. Illinois, USA. The Goodheart-Willcox Company.

66. UNESCO (1986). Technology of Technical and Vocational Education (Rev. ed.) Paris UNESCO.

67. UNESCO (1988). International year book on education: secondary education in the world today. Paris.

68. World Bank (2001). Cities on the move. Urban Transport Strategy Review Draft Document. October 17, 2001

69. Wikipaedia, (2005).