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Energy Consumption in Transport Sector in Nigeria: Current situation and ways forward

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1.Abstract:
Energy use in the transportation sector includes the energy consumed in moving people and goods by road, rail, air, water, and pipeline. Transportation sector energy demand hinges on growth rates for both economic activity and the driving-age population. Economic growth spurs increases in industrial output, which requires the movement of raw materials to manufacturing sites, as well as the movement of manufactured goods to end users. Nigerian transportation fuel use, much of it in the form of liquid fuels increased over the period from 2005 to 2009. Passenger transportation energy use includes fuels used in light-duty vehicles, buses, aircraft, and passenger trains. Freight transportation energy use includes fuels used by large trucks, freight trains, and both domestic and international marine vessels. This paper discusses among other things, the transport modes and their energy consumption pattern looking at the implications of the trend in energy utilization to the national energy consumption. It also looks at the share of the transport sector energy consumption in the country and recommended the possible ways of improving it.
Keywords: Energy Consumption, Energy Balance, fossil fuel, Transportation modes, etc.

2. INTRODUCTION

Central to any study on energy is the development of reliable statistics that identify and quantify the energy supplied and consumed in an economy. Energy is essential to our way of life. It is consumed by nearly all the activities of our economy, and households consume it every day for our personal comfort and for most of our travel. Energy is consumed in different forms. The most common are gasoline, natural gas, and electricity, but other forms also exist, such as biomass and solar energy. Accounting for all forms of energy that supply our economy and identifying all sources of energy demand are essential steps in composing a complete picture of an economy's energy situation. This accounting is also necessary for designing, implementing and monitoring energy policies.
All human activities are closely dependent on the usage of several forms and sources of energy to perform work.

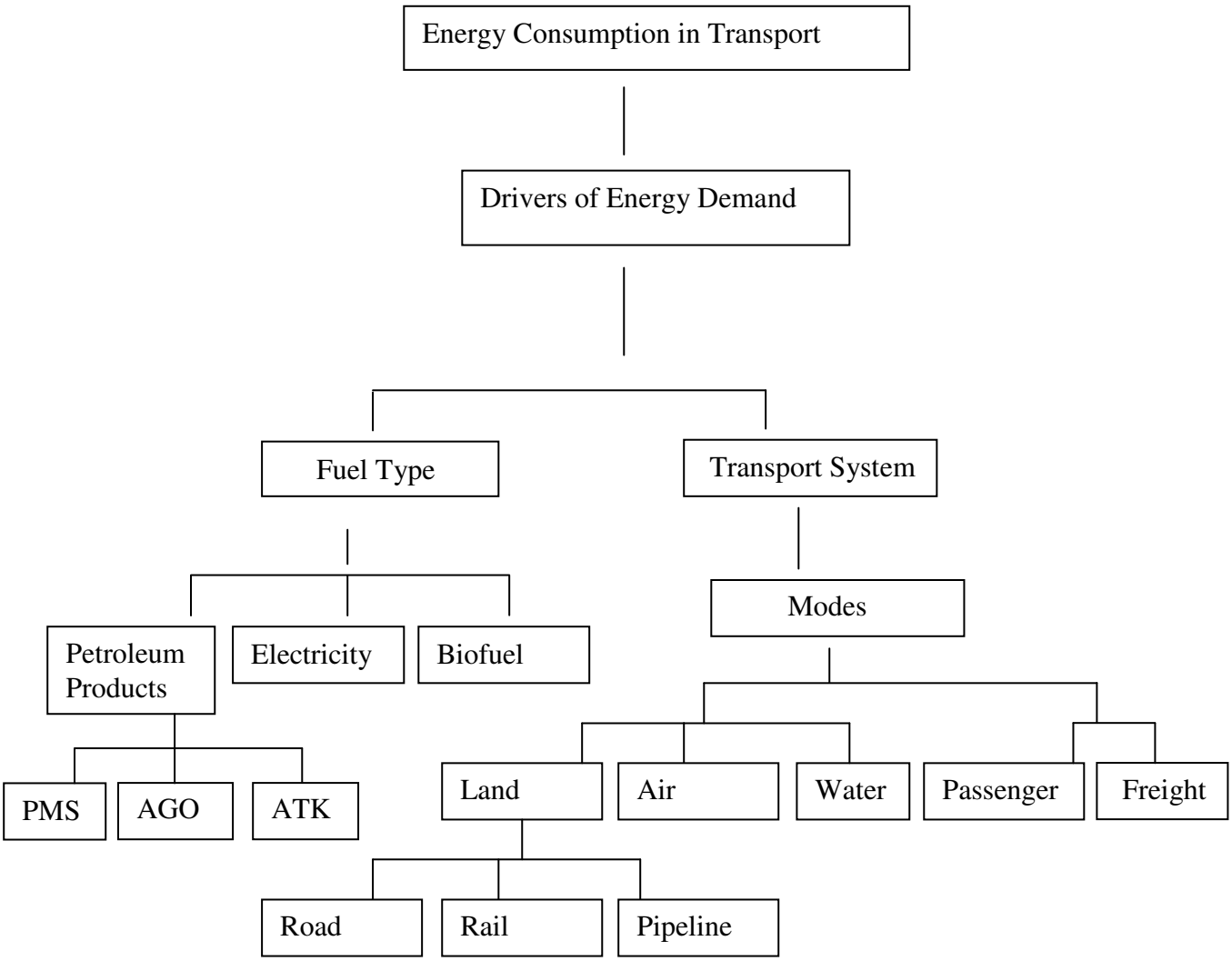
The energy content of an energy source is the available energy per unit of weight or volume, but the challenge is to effectively extract and use this energy. Thus, the more energy consumed the greater the amount of work realized and it is an obvious fact that economic growth and development have strong correlation with energy consumption. Energy is basically consumed in doing physical work which is related to human activities. Modification of the environment, as one of such activities involves making space suitable for human activities, like clearing land for agriculture, modifying the hydrographs (irrigation), and establishing distribution infrastructures, as wells as constructing and conditioning (temperature and light) enclosed structures. There is also the appropriation of resources which involves the extraction of agricultural resources from the biomass and raw materials (minerals, oil, lumber, etc.) for human needs. It also includes the disposal of wastes, which are in an advanced industrial society very work intensive to safely dispose of (e.g. collection, treatment and disposal). Energy is further consumed in processing resources which involves the modification of products from the biomass, of raw materials and of goods to manufacture according to economic needs. Transportation is another area where energy is consumed. It involves the movement of freight, people and information from one location to another. It aims to attenuate the spatial inequities in the location of resources by overcoming distance. The less energy costs per ton or passenger - kilometer, the less importance have transfers. Overcoming space in a global economy requires a substantial amount of work and thus energy and has consequently been subject to massive economies of scale. The focus of this paper is on the energy consumption in the transport sector.

Energy use in the transportation sector includes the energy consumed in moving people and goods by road, rail, air, water, and pipeline. The road transport component includes light-duty vehicles, such as automobiles, cars, sport utility vehicles, minivans, small trucks, tricycles and motorbikes, as well as heavy-duty vehicles, such as large trucks used for moving freight and buses used for passenger travel. Consequently, transportation sector energy demand hinges on growth rates for both economic activity and the driving-age population. Economic growth spurs increases in industrial output, which requires the movement of raw materials to manufacturing sites, as well as the movement of manufactured goods to end users. The transport sector, particularly in Nigeria,

plays a critical role in National energy consumption and has a strong implication to the Energy balance of the country.

In this study, efforts were made to examine all the available energy sources for transportation in Nigeria as the availability is one of the factors which determines the choice of fuel and mode to be adopted for a given transportation need. The transport system of Nigeria is also highlighted in this work to look at the historical trend in its development and how it has affected the energy consumption pattern in the country over the years. All planners including those at the energy sector are aware of the rising trend in the population and rate of urbanization which all have strong overbearing strain in the available energy resources in Nigeria. Energy consumption in the transport sector is so enormous that its study cannot be so exhaustive especially looking at the nature of transport system, the modal splits and the transport policy in the country.

3.0 FRAMEWORK FOR ANALYZING ENERGY CONSUMPTION IN THE TRANSPORT SECTOR IN NIGERIA.



4.0 ENERGY CONSUMPTION IN THE TRANSPORT SECTOR

In 2005, Nigerian National Petroleum Corporation (NNPC) recorded domestic consumption of Premium Motor Spirit (PMS) as 9,572,014,330 billion litres, while 2,361,480,530,000 billion litres of Automotive Gas Oil (AGO) were equally recorded. In 2009, transport sector alone consumed a total of 7,633,032,000 litres of petroleum products with s share of 6,835,183,000, 672,252,000 and 125,597,000 litres which PMS, AGO and ATK respectively (NNPC ASB 2009).

Even when biomass and other renewable energy forms for which data are available are included in the Nigerian national energy demand profile, the transport sector still accounted for about one third of the country's energy demand in almost all the years in focus. Petroleum products, petroleum motor spirit, diesel, fuel oil and dual purpose kerosene are the main fuels consumed in the sector. The sector is responsible for the highest portion of petroleum fuels consumed in the country in the past two decades. It is also the sector responsible for the highest consumption of fossil fuel in the country in all the historical years. In 1990 for example, about 287.34 PJ of energy, all petroleum products was consumed in the transport sector. This was about 67% of all the fossil fuels consumed in the country (excluding those consumed for electricity generation) in that year. Corresponding figures for the sector during the years 2000 and 2005 on a final energy and fossil fuel basis are presented in Table 1.

Table 1: Final Energy and Fossil Fuel Consumption in the Transport Sector Years

Year	Final Energy in Transport Sector (PJ)	% of Total Final Energy	% of Fossil Fuel(1)	% that is Petroleum Products
1990	287.34	35.03	66.96	100
1995	278.76	20.45	75.63	100
2000	357.21	17.18	59.84	100
2005	486.34	15.55	48.18	100

Excluding Fossil fuel consumed for power generation
Source: F.B. Dayo 2004, 2007

Almost 20 percent of the world's total delivered energy is used in the transportation sector, where liquid fuels are the dominant source (IEA 2007). Transportation alone accounts for more than 50 percent of world consumption of liquid fuels, and its share is likely to increases over years in the future. IEA's projection shows that from 2007 to 2035, growth in transportation energy use accounts for 87 percent of the total increase in world liquids consumption.

4.1 Drivers of Energy Demand in Transport Sector

Modes of transport: The mode of transport has correlation with the type and amount of energy to be consumed to transport a ton-kilometer for freight, or passenger kilometer for both modes of transport. The rate of consumption of motor fuel is far higher for freight than for most passenger vehicles. This is obvious in air transport where the rate of consumption is very high due to the high speed of airplanes. The mode of transport is a major driver of energy demand in the transport sector as different modes have varying capacities which depends on the work done by such vehicles.

Efficiency and Age of vehicle: The efficiency and age of a particular mode of transport determines the rate and quantity of energy it will likely consume. More efficient cars for example, consume less quantity of motor fuels. The efficiency of a car is largely dependent on its age. The older the car, the less efficient it becomes. This also is a factor that determines how energy is consumed in the transport sector in a country. In Nigeria, most of the cars, trucks and buses used for transportation are mostly second-hand vehicles whose age is usually more than 7 years from manufacturing date, and this has been linked to the high rate of motor fuel consumption and low efficiency of vehicles found in our roads.

Transport Infrastructure: The state and availability of transport infrastructure in a country is one of the factors that determine the pattern of energy consumption. If the state of roads, rails, airports and ports (jetty) are properly designed and in good shape, it affects the level of energy consumed in the transport sector. If for example the road network of a particular city is properly designed and in good condition, the vehicles used will get to their destinations in fewer time than would have spent if the design is not good. It will also lead to consumption of fewer motor fuels. Good roads will also reduce the level of decay of a given vehicle which in turn is a factor affecting the efficiency of the vehicle. The state of transport infrastructure in Nigeria is not a model for a good and well designed masterpiece. This could be observed from the nature of our roads especially the highways linking major cities in the country which are usually poorly maintained making them to be nightmares for users, thereby leading to wastages of both man hours and higher consumption of motor fuels.

Lifestyle: The lifestyle of citizens of Nigeria is another major driver of energy demand in the transport sector. Car ownership in Nigeria is still been perceived as luxury and most people strive to acquire more cars even when they already have cars that can serve them and their families. This lifestyle and the choice of transport mode contribute significantly in the amount of energy consumed in the transport sector in Nigeria. The use of personal

cars for transportation where there is existence of a good transport scheme. Apathy on the use of train for passenger as well as freight is another factor being driven by lifestyle. This most often leads to high consumption of energy because train uses less energy to convey the same amount of both passengers and freight as would have done by other modes.

Urbanization: The migration of people from rural to urban areas and the urbanization of most cities increase the demand for transportation, and this invariably increases the energy demand in the sector. This factor is solely responsible for most of the traffic jams usually experienced in most cities, which leads to high consumption of motor fuels usually wasted in traffic hold-ups as a result of congestion in such cities.

Population growth rate: The number of people in a given location and the level of economic activities correlate the amount of energy consumed in the transport sector. Nigerian population growth rate is put at about 3.2 % in 2008. This implies that, Nigerian population which was estimated to be at about 154 million in 2009 is projected to be 227 million in 2020 at a linear growth rate of 3.2%. This trend shows that car ownership will increase, more buses will be introduced, and higher number of tone-kilometre freight vehicles will come on board. All these will definitely increase the energy demand in the country.

4.2 Transport Modes in Nigeria

Land transportation: This accounts for the great majority of energy consumption. Road transportation alone is consuming on average 90% of the total energy used by the transport sector in Nigeria. This trend is not however uniform within the land transportation sector itself, as road transportation is almost the sole mode responsible for the greater chunk of the energy demand in the past two decades. Land transport in Nigeria is characterized by road, rail and pipeline systems. Road transport is further subdivided into cars, trucks, buses, motor-bikes, tricycles and military vehicles. Rail transport remains the most energy efficient land transport, and used for long-distance freight and all distances of passenger transport. Despite a falling market share, rail transport, on the basis of 1 kg of oil equivalent, remains four times more efficient for passenger than and twice as efficient for freight movement as road transport (IEA, 2005). Pipeline is another mode of land transportation which is used to transport fluids like oil and gas in Nigeria.

Water transportation: In Nigeria is far the least developed looking at all the modes of transport in the country. The percentage of energy consumed in the sector is far less than what is obtainable in other modes. Nigeria has 8,600 kilometers of inland waterways. The longest are the Niger Rive and its tributary, the Benue River but the most used, especially by larger powered boats and for commerce, are in the Niger Delta and all along the coast from Lagos Lagoon to Cross River. This mode of transport is being developed so as to improve the transportation of goods and passengers across the country. There has been dredging of some Rivers and revitalization of Inland Water Ways to enhance marine transport. Energy consumed in the marine transport accounts for less than 1 percent of the total energy consumed in the transport sector in Nigeria.

Air transportation: This plays an integral part in the development of transportation networks. The aviation industry accounts for 8% of the energy consumed by transportation in Nigeria. There are about 26 airports in Nigeria with paved runways. There are also about 21 Airstrips built mainly by the Nigerian airforce and multinational oil companies scattered about the country. Air transport has high energy consumption levels, linked to high speeds. Fuel is the second most important budget for the air transport industry accounting for 13-20% of total expenses. Technological innovations, such as more efficient engines and better aerodynamics, have led to a continuous improvement of the energy efficiency of each new generation of aircrafts. Over the years, the aviation industry has improved significantly, thereby increasing the number of airlines as well as passengers in Nigeria.

Further distinctions in the energy consumption of transport can be made between passenger and freight movement:

Passenger transportation: This mode accounts for about 60 to 70% of energy consumption from transportation activities. The private car is the dominant mode but has a poor energetic performance, although this performance has seen substantial improvements since the 1990s, mainly due to growing energy prices, regulations and government policies. Only 12% of the fuel used by a car actually provides momentum. There is a close relationship between rising income, automobile ownership and distance traveled by vehicle. In the 1997 estimate by the World Bank, Number of motor vehicles per 1,000 people is 12. Hence, a derivative estimate shows that over 15 millions Nigerian owns motor vehicles and the traffic volume and number of which about 44% are passenger cars, 20% are buses and 30% lorries and vans, 1% road tractors and 5% motorcycles. This figure increased to 30.91 cars per 1000 persons in 2009 as estimated by Energy Commission of Nigeria which also

implies 32.31 persons per car. A more disturbing trend has been the increasing rise in ownership of motor-bikes especially for commercial passenger services in most of our urban and rural areas and the corresponding decline in fuel economy of these vehicles. **Freight transportation** is dominated by rail, pipeline and trucks. Coastal and inland waterways also provide an energy efficient method of transporting cargoes. An estimate by UNESCO-Nigeria TVE project shows that a tow boat moving typical 15-barges in tow holds the equivalent of 225 rail car loads or 870 truck loads. The freight transportation in Nigeria is still being developed as more than 70% of cargos transported in the country is done by local and long distance trucks. The energy consumption in freight transportation is high because the means which is majorly truck, consumes more energy than train and pipeline.

Table 2: Stock of Vehicles in Nigeria (Thousands)

Vehicle Type	2000	2005	2006	2007	2008	2009
Luxury Buses	8.09	33.174	35.175	36.059	38.543	41.2
Medium Buses	24.23	99.357	105.35	108	115.439	123.39
Mini Buses	48.56	199.125	211.134	216.446	231.355	247.29
Car (Gasoline)	722.36	2962.105	3140.749	3219.77	3441.546	3678.6
Motor Bikes	643.48	2638.65	2797.787	2868.179	3065.737	3276.9
Trailers	5.1	20.913	22.174	22.732	24.298	25.97
Big Trucks / Lorries	16.31	66.881	70.914	72.698	77.706	83.06
Fuel Tankers	6.64	27.228	28.87	29.596	31.635	33.81
Small Trucks and Pick-Up	24.05	98.619	104.567	107.198	114.582	122.47
Water Tankers	1.17	4.798	5.087	5.215	5.574	5.96
Tippers	5.44	22.307	23.653	24.248	25.918	27.7
Pick Up Vans	56.12	230.125	244.004	250.143	267.373	285.79
Vans	8.91	36.536	38.74	39.714	42.45	45.37
Boats						
Planes						
Total	**1,570.46**	**6,439.82**	**6,828.20**	**7,000.00**	**7,482.16**	7997.52

Source: Energy Commission of Nigeria (MAED 2009)

5.0 Consumption Trend of Petroleum Products in Nigeria Consumption of petroleum products grew at an average annual rate of about 18.63% during the period 1970-1979, by about 6.32% during the period 1980-1989. A decline in consumption averaging about 0.97% per annum was recorded during the period 1990-1999, a substantial period of which was characterized by political instability and unprogressive military rule. The period 2000-2002 was characterized by rebounded petroleum product consumption with an average growth rate of about 7.7% per annum. This later period was the beginning of the new democratic dispensation in the country. The average changes in petroleum product consumption mentioned above however shield the fluctuating demand sequence experienced during the periods.

The fluctuating series is a strong indication of an unstable market where there were appreciable levels of un-served demand, and where the supply sequence is also unstable. In terms of product

utilization, gasoline which is a transportation sector fuel accounted for the biggest share of consumption, accounting for about 34% of total petroleum product consumption in 1970, 42% in 1980, 40% in 1990, 52% in the year 2000, rising to about 58% in 2002 and stabilized around this share of the market during the period 2003-2006. Diesel, another transportation fuel, which is also utilized in on-site power generation, follows with a share of about 26% in 1970, 29% in 1980, 25% in 1990, 29% in 2000 and 24% in 2002. The share of diesel stabilized around 24% during the period 2003-2006.

5.1 Energy Balance in Transport sector

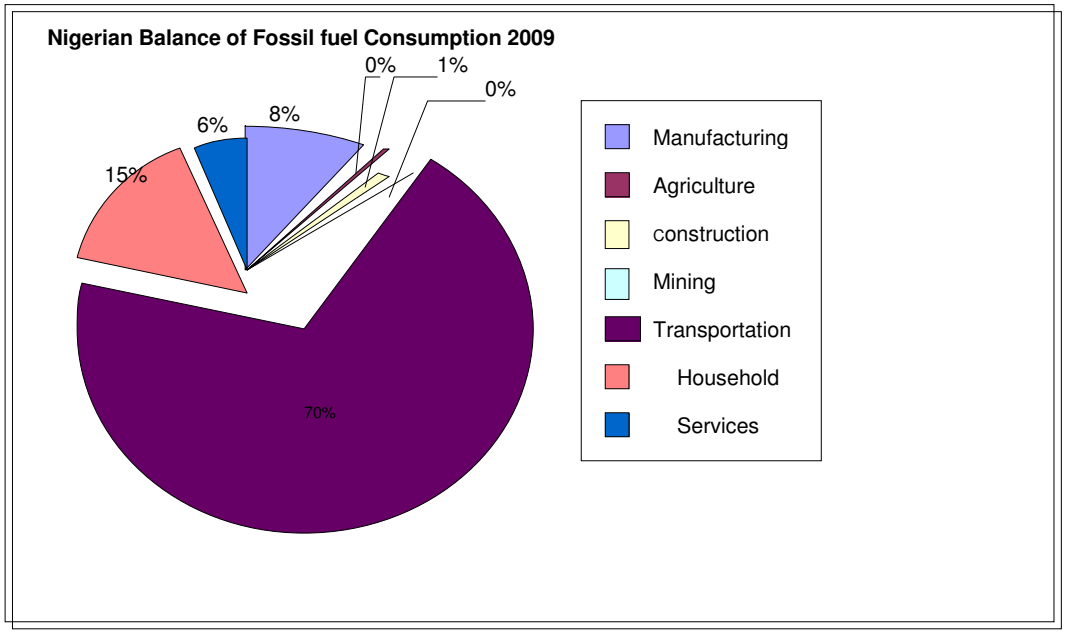
The energy balance is a snapshot of the annual energy flows in a country showing energy production, trade, conversion and consumption of fuels, including electricity profiles with detailed information on the production, trade and consumption of electricity, net installed capacity and power plant input and efficiency" …(United Nations Statistics Dept.). The final fossil fuel consumed in Nigeria in 2009 by the different sector of the economy including the quantity used for electricity generation in all the economic sectors is estimated to be 8872.9 toe. Table 3 below shows that transport sector alone consumed 6154.4 toe of fossil fuel which amounts to 70% of the total fossil fuels consumed in the country in 2009.

Table 3: Nigerian Balance of Final Fossil Fuel Consumption by Sectors in 2009 (10^3 toe)

Economic Sector	Fossil fuel (10^3 toe)
Manufacturing	744.4
Agriculture	15.6
Construction	67.2
Mining	3.8
Transportation	6154.4
Household	1320.2
Services	567.2
TOTAL	**8872.9**

Source: Energy Commission of Nigeria MAED 2010

Figure 1: Nigerian balance of Fossil fuel consumption by sectors 2009



The total amount of fossil fuel consumed by the transport sector by mode and source is estimated to be 6192.18 toe, out of which passenger urban is 47% (2915.47 toe), Passenger intercity is 30% (1866.44 toe), freight is 18% (1115.26 toe) and Miscellaneous is 5% (295 toe). The cars for passenger urban transportation consumes the highest quantity of fossil fuel which is 2219.65 toe, this accounts for about 76 % of the motor fuel used in the passenger urban transport for 2009, while Public buses consumed about 516 toe of fossil fuel in the same year, accounting for about 18% and others including motor-bikes consumed 180.24 toe which was about 6%. In

intercity passenger transportation in 2009, the total fossil fuel consumed was 1866 toe, and the percentage consumption of the various means of intercity transport shows that cars consumed 61% (1158.09 toe), buses used 30% (558.49), then diesel Trains consumed 1% (0.156 toe) and Planes used 8% (149.68 toe). Table three below also shows the consumption of motor fuels by modes used for freight transportation and miscellaneous (military, international etc) in 2009.

Table 3: Structure of Energy Consumption in Transportation by Mode and by Sources, 2009 (000 toe)

Type	Mode	Fossil Fuel as a Motor Fuel	Steam Coal	Electricity	Total
Pasenger Urban	Car	2219.65	0	0	2220.0
	Public (bus)	515.49	0	0	515.5
	Others (Motor Bikes, etc)	180.24	0	0	180.2
	Subtotal	2915.47	0	0	2915.5
Passenger Intercity	Car	1158.09	0	0	1158.1
	Bus	558.52	0	0	558.5
	Train (Diesel)	0.156	0.00	0	0.156
	Train (Steam)	0.00	0	0.00	0.0
	Train (Electrical)	0.00	0	0	0.0
	Plane	149.68	0	0	149.68
	Subtotal	1866.44	0	0	1866.4
Freight	Truck Local	336.96	0	0	337.0
	Truck Long Dist	770.21	0	0	770.2
	Train (Diesel)	0.38867	0	0	0.38867
	Train (Steam)	0.00	0	0	0.0
	Train (Electrical)	0.00	0	0	0.0
	Ship	0.00	0	0	0.0
	Pipeline	7.70	0	0	7.70
	Subtotal	1115.26	0	0	1115.26
Miscellaneous		295.00	0	0	295.0
GRAND TOTAL		6192.18			6192.18

Source: Energy Commission of Nigeria (MAED 2010)

Petroleum products dominate Nigeria's energy consumption mix, averaging 77% of the total over the last five years (TradeInvest Nigeria 2011). The transport sector consumes about 70% of the total petroleum products in the country.

6.0 RECOMMENDATIONS

Utilization of Compressed Natural Gas (CNG) as a transport fuel: The appreciable endowment of natural gas and especially the fact that about 40% of associated natural gas produced in the country‘s oil and gas sector is still flared (NNPC 2005), should be a catalyst for the promotion of increased domestic use of natural gas. The introduction of CNG as a fuel in road and rail transportation should contribute to this goal. The Nigerian Gas Company built a CNG fuelling station in Warri, Nigeria and converted some of the cars in the company‘s fleet to CNG fuelled cars to demonstrate the feasibility of the venture. This should be replicated in other parts of the country.

Use of bio-fuels as transport fuel: Ethanol produced from Cassava feedstock is likely to be blended with petroleum motor spirit and introduced into the transportation sector fuel market as E10 .which is produced by blending 10% by volume of ethanol with 90% of petroleum motor spirit. Because E10 is partially a biomass fuel, it has a lower carbon footprint compared to the alternative PMS that will be partly displaced. The Energy Commission of Nigeria has produced Renewable Energy Master Plan which spells out the utilization of renewable in all our economic sectors for optimal energy mix.

Utilization of bio-diesel as transport fuel: Another clean energy fuel that ECN is seriously canvassing for its introduction into the Nigerian transport fuel market is bio-diesel. The plan is to produce bio-diesel from the transesterification of pure plant oil that will be extracted from Jatropha, which is subsequently blended with petro-diesel in a 10:90 volume ratio to produce transportation fuel B10. Energy Commission of Nigeria has been promoting the plantation of Jatropha and production of bio-diesel in the country through establishment of pilot projects and partnership with UNDP, sensitization workshops and seminars. It is therefore recommended that private investors and other Government agencies including the Federal ministry of Agriculture should step up their campaign and participation towards bio-diesel production and promotion in Nigeria.

Introduction of Bus Rapid Transit (BRT) Systems: Introduction of BRT systems in big cities in Nigeria is a potential transport sector energy efficiency program that can be introduced with significant reduction in energy consumption. That this type of system, when developed will not only help in maintaining the a reduction in fuel consumed for passenger urban and intercity transportation, but can also be developed as a clean energy investment.

Use of more efficient vehicles: The use of more efficient vehicles in the country will go a long way in minimizing the level of losses and this invariably will lead to lower consumption of petroleum products as more efficient cars consume less with fewer emissions. Government should come up with policies that encourage the use of more efficient vehicles and laws that restrict people from using old and inefficient vehicles especially as private cars which have the greatest population among transport means in Nigeria.

Levies and tax on private car usage: Government should introduce levies or taxes on the use of private cars to discourage people from buying many cars just for show-off. This could be done by establishing car ownership rates, which could be designed in such a way that the number of cars in your fleet determines what you will be paying to Government annually. This can control the number of vehicles in Nigeria, thereby reducing the quantity of petroleum products consumed in the transport sector of the country.

Transportation Infrastructural Development: There is need to develop the transport infrastructure in Nigeria, especially the rail and pipeline which will surely reduce the use of both long distance and local truck services in the country. Rail transport when fully developed in Nigeria will definitely reduce the use of trucks for conveying most of the solid goods excluding heavy equipments. Train can use the energy ought to be used by 2 trucks to transport what 5 trucks would have carried to the same destination earlier. This will lead in huge saves in terms of petroleum products consumption. The same is applicable with pipeline as compared with tankers.

7.0 Conclusion

Transport is a key element in the social and economic development of any country. An efficient transport system provides access to points of employment, health and education. However, despite the important contributions of transport to national development, the environmental and social costs of transport are significant. Their range of impact includes congestion, high energy consumption, local and global air pollution, noise pollution, traffic accidents and social inequities.

Transportation accounts for approximately 25 per cent of world energy demand and more than 55 per cent of oil used each year. Transportation is almost completely reliant upon petroleum products mostly PMS, AGO and ATK. Globally, energy consumption in the transport sector has increased.

In Nigeria, more than 70 per cent of energy consumption is in the transport sector. Households and industry account for a large share of the remainder. In 2009, petroleum products consumption amounted to 8872.9 toe. A breakdown of energy consumption among various modes of transport shows that highway traffic is by far the single largest consumer of transportation energy. This is because at present, the principal means of transporting people and goods are private cars and commercial vehicles. The transport system in Nigeria reveals that cars for passenger urban transportation consume the highest amount of petroleum products. It is also observed that biomass and electricity has little or no contribution in the share of fuels for transport in Nigeria. The drivers of energy demand in Nigerian transport sector include the age and efficiency of vehicle being used in the country, the lifestyle of the populace, and state of transport infrastructure in the country, the rate of urbanization of most of our cities and the population growth rate. These factors shape how energy is consumed in the transport sector and are responsible for the present and future trend of energy consumption in the sector. Energy demand in the transport sector as was seen in the balance of final fossil fuel consumption and the Nigerian energy balance shows that more than 70 percent of petroleum products in the economic sectors of the country are consumed in

the sector. This implies that higher proportion of the total energy consumed in Nigeria goes to the transportation sector, and for this trend to change, some recommendations has been proffered which includes but not limited to the utilization of Compressed Natural Gas (CNG) as a transport fuel, Use of bio-fuels and bio-diesel as transport fuel and introduction of Bus Rapid Transit (BRT) Systems, improving the transport infrastructure and the use of more efficient vehicles in the country, which is most likely going to effect the reduction in the energy consumption in the transport sector.

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