Evaluating the Role of Mass Transit and its Effect on Fuel Efficiency in the Kumasi Metropolis, Ghana

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ABSTRACT

The priority of every government is to develop the economy of its country to raise the living standard of the citizenry. Mass transit system plays a vital role in this quest. The energy demand within the transport subsector is immense. Indeed Ghana subsidises petroleum products by GH¢45 million monthly and the government of Ghana is faced with the dilemma of whether or not this subsidy be removed as it is putting pressure on national budget. For this reason the need for energy efficiency management has become imperative. This study assessed the role of mass transit in urban transportation system and how it affects energy demand. Secondary data was used for the study. The study revealed that the use of mass transit would reduce energy demand within the transport sector due to its fuel efficiency potentials. Therefore expanding the intra-city mass transit services within Kumasi Metropolis could offer one of the most effective, efficient and feasible strategy for improving fuel efficiency within the transport sub sector. Therefore policy decision should give attention to metro mass transit services within metropolitan areas.

Key words: Mass transit, Energy demand, Fuel efficiency, Urban transportation system, Kumasi

1. Introduction

The priority of every government is to develop the nation's economy to raise the living standard of the citizenry. Mass transit plays vital role in social and economic development of a nation. In Ghana, fuel consumption from the transport sub sector is immense. Indeed available statistics shows that the average demand for crude oil annually is between 5% to 7%, and it is expected to increase due to continuous rise in car ownership in the country (Ministry of Energy, 2010, Bank of Ghana, 2012). Therefore, effort to address the traffic congestion situation to reduce the rate of fuel consumption has been of concern to the nation. Indeed Ghana spent about 450 million Ghana cedis ($276 million) on fuel subsidies in 2011. This translates to about 45 million Ghana cedis monthly (The Integrated Social Development Centre (ISODEC), 2012, Ghana Oil Watch, 2012).

Energy, in addition to transportation, is another essential socio-economic factor to national development. It plays a critical role in all aspects of national development particularly in transportation, infrastructure, agriculture and industry sectors. It is scarce and non-renewable and needs to be used on sustainable basis. The relationship between transport and energy in national development is a direct one although the extent of relationship depends on a particular mode and the need for the sector (Haldenbilen, 2006; Kulash, 1999; Rodrigue, Comtois and Slack, 2009).

Transportation accounts for a growing share of the total amount of energy used on international range of human activities. Among developed countries, transportation accounts for between 20-25% of total energy being consumed (Rodrigue *et al*. 2009). Armah (2002) states, in Economic Analysis of the Energy sector of Ghana, that the transport sector accounts for 23.9% of total energy demand in Ghana. In Ghana, fossil fuel, notably petroleum products are the main sources of energy in the transport sector. Energy consumption varies with the mode of transportation. Out of total average of land transportation consumption of 85%, passenger transport accounts for 60-70% in developed countries and that private cars are the dominant mode of passenger transportation. Increased use of mass transit offers the most effective strategy available for reducing traffic congestion and its associated high fuel consumption rate (Shapiro, Hasset and Anold, 2002). However, the use of mass transit in Ghana, particularly in cities, as a measure to improving energy efficiency seems to be under appreciated. This coupled with continuous rise in car ownership has contributed in the rise in the demand for crude oil (Ministry of Energy, 2010, Bank of Ghana, 2012), and increasingly exposes the country to high crude oil importation bill. Such high oil import bill puts pressure on annual budgets and leads to huge trade deficits.

It is in the light of these problems and their precarious implications on national development that the researchers intend to embark on this study to examine how mass transit can contribute to urban transportation system to improving fuel efficiency.

2. Related Studies

2.1 The Mass Transit System

Mass transit, also referred to as public transit or Public transportation is a shared passenger transportation services which is available for use by the general public as distinct from the saloon cars and sports utility vehicles (SUVs) used by the individuals (Wells, 1975). Public transit modes include buses, trams and trains. Most public transits run to scheduled time tables. Urban public transit may be provided by a transit authority or by one or more private transport operators. Public transit services are usually funded by fares charged to each passenger. In most cases, services are regulated and sometimes subsidized by government (Wells, 1975). Smerk, (1991) and Cheape, (1980), refer to mass transit as "the movement of people within urban areas using group travel technologies such as buses and trains". It is characterised by the fact that many people are carried in the same vehicle such as buses or trains, making it efficient to use. Mass transit systems may be owned by private, profit-making companies or by governments or quasi-government agencies that may not operate for profit.

The cost of running automobile based transport system is alarming in terms of congestions in our cities, energy requirements and ecological consequences. Aware of these factors, most metropolitan areas are moving to coordinate and streamline their transportation systems and to provide mass transit as an alternate system to smaller cars. Most developing countries, including Ghana, use buses in their public transportation system. The flexibility of buses in terms of its operation, probably accounts for its frequency of use in most developing countries (McFadden, 1975). As cities increase in size and in population, walking can no longer satisfy trip requirements of the citizens, mass transit becomes the major mode of transport for the citizens especially for the poor (World Bank, 2002). In their paper, 'Economic Impact of Public Transportation Investment', Weisbrod and Reno, (2009) argue that availability of quality mass transit services leads to reduction in rates of private car usage in cities. They affirm that the cost savings that accrue from lower rate of car usage as a result of availability of reliable and quality mass transit service are substantial. They continue to say that such a saving can only be realised when there is an investment to improve the level of quality of mass transit.

The argument by Weisbrod and Reno means that Ghana, and in particular Kumasi Metropolitan Assembly (KMA), must invest in its public transit system to improve upon the quality of service to benefit economically from its transportation system. The public transportation service in KMA is not reliable. For example inadequate terminals and parking places for buses at the downtown is a big challenge for the Metro Mass Transits in Kumasi. This obviously, affects the operation of buses in the Central Business District (CBD) (Urban Roads Report, 2004). Weisbrod and Reno (2009) conclude that benefits that accrue at a metropolitan level from mass transit will reflect in the bottom line of national growth in productivity and economic prosperity.

2.2 Mass transit system in Ghana

Public bus services have operated in Ghana since the Omnibus Service Authority (OSA) started its operation in 1927 (Metro Mass Transit, 2003). The OSA contributed a lot to Ghanaian economy through the provision of transport service to passengers to satisfy their travelling needs. However the assets of the authority were divested in 1995. Since then, public mass transport has not been effective enough to meet the travelling needs of passengers in Ghana until 2003. In 2003, the government of the republic of Ghana reintroduced public mass transit system in the metropolitan and municipal areas to ensure safe, affordable, efficient and reliable transport in an attempt to meet the increasing travelling needs of teeming passengers in Ghana. Subsequently, the Metro Mass Transit (MMT) limited was officially incorporated in 2003 with the state insurance company, National Investment Bank, Ghana Oil Company Ltd, Agriculture Development Bank, Prudential Bank and Social Security and National Insurance Trust (SSNIT) as partners owning 55% shareholding whilst the government of Ghana owns the remaining 45% shares (MMT, 2003). As per its mandate, MMT was to focus on the provision of transport service to commuters on the short and medium distance i.e., intra-city transport. However by its current operation, the MMT seems to have shifted from its focus of providing intra-city transport services to long distance inter-city and metropolitan transport services. According to the Urban Roads Report (2004), mass transit services in Kumasi metropolis is inadequate and has influenced the dominant use of private cars, taxicabs and mini buses (trotro) as the mode of transport for commuters in Kumasi metropolis.

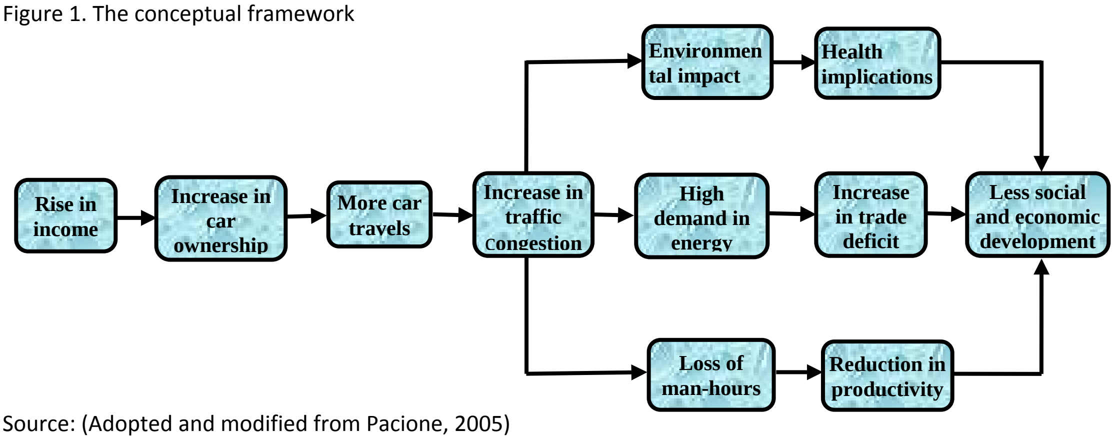
2.3. Transportation and Energy Demand

The energy demand problem has become a major issue across the globe in recent times and the need for a well-established transportation systems that seek to address this problem has become imperative (Zheng, Oh, Park and Cha, 2012; Lu, Lewis and Lin, 2009). The relationship between transport and energy is a direct one even though the degree of the dependency varies with a particular mode. Passengers and high value goods can be transported by rapid but energy intensive mode since the time component of their mobility tends to have a high value which motivate and convey the desire to use more energy. (Haldenbilen, 2006, Rodrigue *et al*., 2009). Shapiro *et al.* (2002) affirm that the role of transportation in our nation's fuel consumption is intense. As essential as petroleum energy is to the socio-economic development of a nation, effort should be made to manage its use to ensure efficiency, particularly in the transport sector since transport activities account for a significant consumption of fuel (Schreffler, Deepak, Egan and Berman, 2012).

Globalization has also intensified transport activities and that transportation is accounting for a growing share of the total amount of energy spent for implementing, operating and maintaining the international range of scope of human activities. The argument continues that energy consumption has a strong correlation with the level of economic development and that among the developed countries, transportation now accounts for between 20% and 25% of the total energy being consumed. Land transportation accounts for the great majority of fuel consumption. Road transportation alone is consuming on the average, 85% of the total energy used by the transport sector in developed countries. In the land transport sector, passenger transportation accounts for 60% to 73% of the energy consumption from transportation activities (Murat and Ceylan, 2006, Rodrigue *et al*., 2009). Again, population rise and improved lifestyle have also influenced the demand for energy. Thus the increasing rise in oil demand across the globe can be attributable but not limited to, the growth in the demand for transport, particularly land transportation sub-sector, population rise and improved lifestyle (Murat and Ceylan, 2006, Rodrique *et al.,* 2009). If the assertions made above is anything to go by, then it suffices to reason that consumption rate in the transport sector is expected to increase in Ghana since it has just attained middle lower income status and is bent on improving its socio-economic development to raise the living standards of its citizens.

2.4. Mass Transit and Fuel Efficiency

Figure 1. The conceptual framework



Source: (Adopted and modified from Pacione, 2005)

The conceptual framework in figure 1 gives a graphical model of transportation situation in Ghana and its potential outcome. It seeks to explain that rise in income leads to increase in automobile ownership which will culminate in increased traffic congestion. The potential results of this situation are high energy demand, environmental implication and reduction in productivity, a situation that adversely affects the national socio-economic development. However, with effective mass transit system, and adequate infrastructure, energy efficiency could be improved.

Fuel efficiency is concerned with the optimum use of fuel for economic activities, especially at the transport sector. Fuel efficiency is underpinned by weight of load, speed, use of air conditioning, inflation level of tyre and even the colour of vehicle (Kuo and Wang, 2011). Rentziou, Gkritza and Souleyrette, (2012) found that rise in car population also affects energy demand, as a 1% increase in vehicle leads to 1.333% increase in Vehicle Miles Travelled (VMT). Transportation is said to be dependent on petroleum products by 95% with exception of railways using electrical power. In the passenger transport sector, cars are the dominant modes but have poor energy efficiency performance and that the use of mass transit offers great potential in reducing fuel consumption to ensure fuel efficiency (Kuo and Wang, 2011, Bonilla, 2009, Rodriquez *et al*. 2009).

Shapiro *et al.* (2002) support the assertion that, the use of public transit offers the most effective strategy available for reducing fuel consumption and improving economic growth. They continue to say that travelling by public or mass transit, per person and per mile uses significant less fuel than comparable travel by cars (private and taxi) and SUVs. They state "moving a person over a given distance by mass transit consumes, on average, about half the energy of moving a person the same distance by private automobiles, sports-utility vehicle (SUV) or light truck". Sharpiro *et al*. (2002) further delineate that increasing the average passenger loads of buses or private vehicle will directly improve fuel efficiency because carrying additional passengers would increase the energy consumed only marginally, if at all. According to them, one difference which points to mass transit's greater potentials for fuel savings, compared to cars is that, shifting passenger from cars to mass transit would not require additional trips by mass transit, whilst a shift in other direction often would mean more car trips and more fuel demand. Thus mass transit is nearly twice as fuel-efficient as private cars and SUVs since public transit on average carries many more passengers at once than cars and SUVs.

The transportation system in Ghana, especially Kumasi metropolis is dominated by cars and SUVs. By Shapiro's assertion about the use of mass transit and its fuel saving potentials, it stands to argue that Ghana will make a great deal of savings from energy by increasing bus ridership, particularly in metropolitan areas. Thus making a greater use of mass transit may be one of the most effective strategies to reduce fuel consumption.

Fuel saving as a benefit from the use of mass transit usage is further supported by Inner City Fund (ICF) international (2007), that United State makes household savings of gasoline from public transportation by 1.4 billion gallons per year. This figure represents the direct substitution of public transit passenger miles with car travel considering average rate of vehicle occupancy (ICF, 2007). Thus the use of high occupancy vehicles reduces energy demand (Bonilla, 2009, Kavelec, 1998, Haldenbilen, 2006).

2.5. Fuel Efficiency and Economic Growth

Fuel as an energy is one of the essentials of national development. It plays a crucial role in all aspect of national development especially in infrastructure, agriculture and transport sectors of the economy. Thus there is a likely relationship between fuel efficiency and economic development. Overall demand for energy used for road transport continues to rise. This calls for efficient use of fuel especially from the road transport sector to reduce the demand for energy and delay investment in energy supply infrastructure which is capital intensive (Broadstock, Collins and Hunt, 2009; Shapiro *et al*., 2002; and Jackson, Trauger, Plyler and Randolph, 2010). According to Ministry of Energy, Ghana, (2010) and Bank of Ghana (2012), the consumption rate of the petroleum product is estimated to increase by between 5% to 7% per annum. To the Ministry, energy efficiency and conservation intervention can help reduce this high growth rate.

Armah (2002) reports that the transport sector accounts for 23.9% of total energy demand in Ghana. According to Bank of Ghana (2012), the total volume of crude oil requirement increased from 6,567,460 bbl in 2009 to 11,397,312 bbl in 2011, represents an increase of 7.9%. In terms of value, the total crude oil imported into the country rose from US$ 1,472.06 million in 2009 to US$ 3,159.13 million in 2011. Indeed Ghana spends about 450 million cedis ($276 million) on fuel subsidies in 2011, about 45 million Ghana cedis every month (The Integrated Social Development Centre, 2012, Ghana Oil Watch, 2012, Bank of Ghana, 2012).

Murat and Ceylan (2006), cited growth in transportation as a contributing factor to the growth in oil demand. Crude oil prices on the world market is characterised by price uncertainties and volatilities and therefore meeting petroleum requirement of about 5% to 7% annual increase puts pressure on government budget and potentially lead to huge trade deficit. (Bank of Ghana, 2010, Armah, 2002).

Furthermore, the price volatilities that is associated with crude oil on the world market usually force government to subsidise petroleum products at the expense of development in the other sectors of the economy and increasingly exposing the country to high trade deficit (Ghana Ministry of Energy, 2010 Armah, 2002). The economic consequences of high oil demand on a country will ramify into every corner of national life. With this situation, it is imperative to make every effort, as a country, to address high fuel consumption rate to reduce the level of dependency on foreign oil which has been characterised by supply and price volatilities in recent years. To that extent, mass transit offers the most effective and feasible strategy for reducing fuel consumption (Crowther, Holford, Kerensky, Pollard, Dan Smith, Wells and Heaton,1963; Shapiro *et al.* 2002 and Jackson *et al.* 2010).

3. Methodology

3.1. Data Collection and Analysis

Secondary data was collected from Toyota Ghana Limited and Metro Mass Transit Limited. The model used to estimate the effect of fuel consumption of public transportation (bus) and that of cars, SUVs and mini bus of not more than 15 passenger-capacity including driver, was adopted from Sharpiro *et al.'s* study: *conserving energy and preserving the environment: the role of public transportation* (2002). In estimating the fuel consumption rate of various vehicles, factors other than the engine capacity of the vehicles were held constant, and with the assumption that all the vehicles run at full load capacity.

Data on fuel consumption rates of saloon cars, SUVs and mini bus was collected from Toyota Ghana Limited whilst that of large bus was collected from Metro Mass Transit Limited. Toyota vehicles were used because of the availability of data and the fact that they are widely used in Ghana. For the purpose of this study, average consumption rate of saloon cars and SUVs were used for the computation. The fuel consumption analysis was based on a 100km trip of city drive and with 63 passenger bus as benchmark. Vehicle and person/passenger mile for the 100km (VMT and PMT) were calculated. VMT is Km travelled by vehicle. PMT is calculated by multiplying VMT by the number of passengers in the vehicle. Fuel consumption of 63 seater-bus for 100km trip with VMT of 100km was calculated. This was done by multiplying average litre of fuel per km by 100km. Consumption per passenger mile was arrived at by dividing the quantity of fuel required for the 100km by the total passenger miles covered.

The quantity of fuel required by car, SUV and mini- bus to replace metro mass transit is calculated the same way. Energy savings from the use of metro mass transit is then estimated by subtracting the quantity of fuel used by metro transit from that used by car, SUV and mini bus and presented in percentages.

4. Results and Discussions

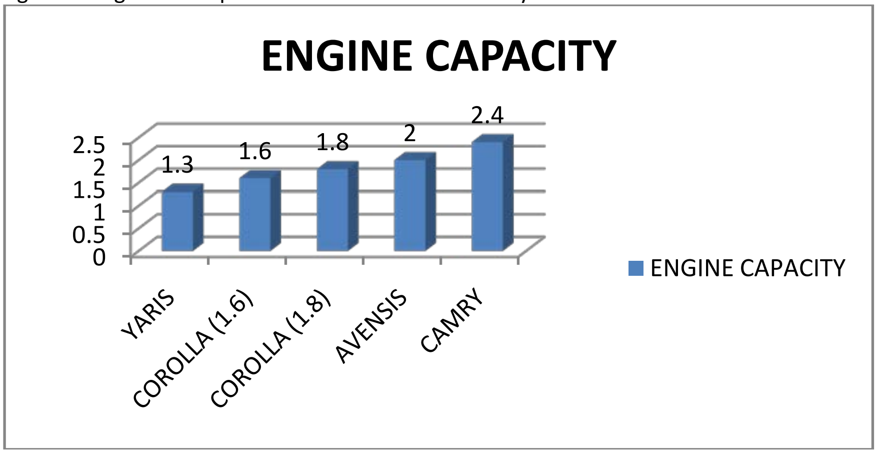
4.1 Energy Efficiency Analysis of Mass Transit, Saloon Car, SUV and Mini Bus

TABLE 1. Fuel Consumption of Toyota Saloon Cars Based On City

Description	Yaris	Corolla	Corolla	Avensis	Camry	Total	Average
Engine capacity	1.3	1.6	1.8	2.0	2.4	9.1	1.8
Litre per 100km	6.4	7.8	7.8	8.4	9.0	39.5	7.9
Km per gallon	70	58	58	54	50	290	58

Source: Adopted and modified from Toyota Ghana Limited (2012)

Fig. 1 Average consumption rates of cars based on city drive



Source: Toyota Ghana Limited,(2012)

TABLE 2 Fuel Consumption of Sports Utility Vehicle (SUV) And Mini- Bus Based On City Drive

Description	Hilux/Hiace/Prado	LC GX	Total	Average
Engine capacity	3.0	4.5	7.5	3.75
Litre per 100km	9.0	11.7	20.7	10.35
Km per gallon	50	38	88	44

Source: Adopted and modified from Toyota Ghana Limited (2012)

TABLE 3 - Fuel Consumption of Large Bus

Engine Capacity	Average Km Per Littre	Average Litres Per 100km	Average Km Gallon
	3.2KM	31.3	14.4

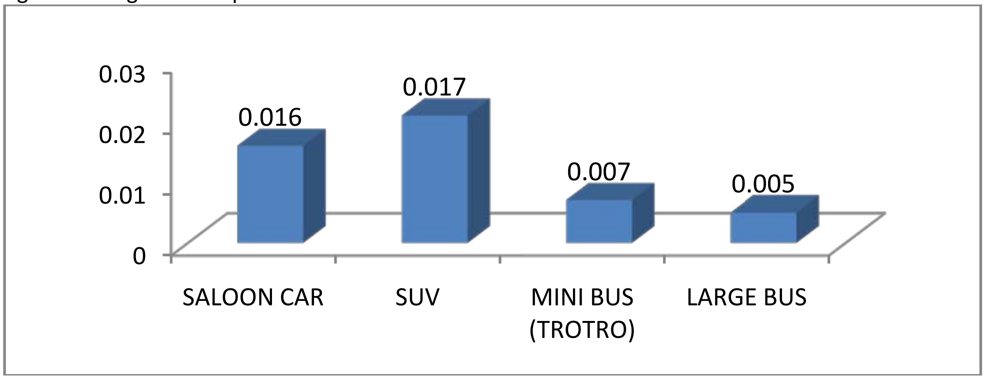
Source: Adopted and modified from Metro Mass Transit Limited (2012)

TABLE 4 - Fuel Consumption Analysis of Car, SUV, Mini Bus and Large Bus per 100 Km Vehicle Miles Trip

Type of vehicle	Rate of occupancy	Vehicle miles traveled (VMTKM)	Passenger miles travelled (PMT KM)	Litres of fuel used	Gallon of fuel used	Consumption per passenger mile (litres)
Saloon Car	5	100	500	7.90	1.76	0.016
Suv	6	100	600	10.35	2.30	0.017
Mini bus (trotro)	15	100	1500	10.35	2.30	0.007
Large bus	63	100	6300	31.30	6.96	0.005

Source: Researchers Computation, 2012 (Adopted from Shapiro et al, 2002)

Fig. 2 - Average consumption rates of vehicles Per PMT.



Source: Researchers Computation, (2012)

Table 4 shows the average fuel used by car, SUV, mini bus and large bus per PMT vehicle miles trip. The figures in the table indicate that for every 100km vehicle miles, metro mass transit uses 31.3 litres of fuel (6.96 gallons) to convey 63 passengers. This covers 6,300 Passenger Miles T raveled (PMT). Saloon car and SUV use an average of 7.9 and 10.35 litres of fuel respectively to convey 5 passengers with PMT of 500, whilst mini bus use an average of 10.35 litres of fuel to convey 15 passengers for 100km strip with PMT of 1500. To estimate the energy saving, the amount of fuel required by saloon car, SUV and mini bus each to replace 63 passengers conveyed by the metro mass transit with 6,300 PMT per 100km is calculated, using metro mass transit as benchmark. This is presented below:

Saloon car	6,300/500 * 7.9 = 99.54 litres
SUV	6,300/600 * 10.35 = 108.68 litres
Mini Bus	6,300/1,500 * 10.35 = 43.47 litres
Average (car, SUV and mini Bus):	99.54+130.44+43.47/3 = 60.30 litres.

This is shown in tables 4.5 – 4.8.

TABLE 5 - Comparing fuel Consumption of large Bus with Saloon Car per 6,300PM

DESCRIPTION	BUS	SALOON CAR
Vehicle miles travelled (VMT in km)	100	1,260
Passenger miles travelled (PMT in km)	6,300	6,300
Fuel consumed in litres	31.30	99.54

Difference in fuel consumption/ fuel saving (68.24 litres) 68.24/31.30*100 = **218.0%**
Source: Researchers field work, (2012)

TABLE 6 - Comparing fuel Consumption of large Bus with SUV per 6,300PM

DESCRIPTION	BUS	SUV
Vehicle miles travelled (VMT in km)	100	1,050
Passenger miles travelled (PMT in km)	6,300	6,300
Fuel consumed in litres	31.30	108.68

Difference in fuel consumption/ fuel saving (77.38 litres) 77.38/31.30*100 = **247.2%**
Source: Researchers field work, (2012).

TABLE 7 - Comparing fuel Consumption of large Bus with mini-bus Per 6,300PM

DESCRIPTION	BUS	MINI BUS
Vehicle miles travelled (VMT in km)	100	420
Passenger miles travelled (PMT in km)	6300	6,300
Fuel consumed in litres	31.30	43.47

Difference in fuel consumption/ fuel saving (12.17 litres) 12.17/31.30*100 = **38.9%**
Source: Researchers field work, (2012)

TABLE 8 - Comparing fuel Consumption of large Bus with Saloon Car, SUV and mini-bus Per 6,300PM

DESCRIPTION	BUS	AVERAGES(SALON, SUV, MINI BUS)
Vehicle miles travelled (VMT in km)	100	910
Passenger miles travelled (PMT in km)	6300	6300
Fuel consumed in litres	31.30	83.90

Difference in fuel consumption/ fuel saving (52.6 litres) 52.6/31.30 * 100 = **168.05%**
Source: Researchers field work, 2012

The estimated fuel consumption figures of various vehicles understudy in tables 5 - 8 show that metro mass transit(large bus) averagely consumes 31.3 litres (6.96 gallons) of fuel per 100KM VMT and 6,300 PMT, with full capacity of 63 passengers including the driver, all things being equal. Car, SUV and mini-bus, conveying the same number of passengers and covering the same 6,300 PM, will consume 99.54 litres (22.12 gallons), 108.68 litres (24.15 gallons) and 43.47 litres (9.67 gallons) of fuel respectively, all things being equal.

This means that for every 6,300 PMT, a saving of 68.24 litres (15.16 gallons) will be made for using metro mass transit over saloon car, representing 218%. Against SUV and mini-bus, using metro mass transit will save 77.38 litres (17.2 gallons), and 12.17 litres (2.7 gallons) of fuel, representing 247.2 % and 38.9% respectively, all things being equal. The fact is, it will take an average of 83.9 litres of fuel for car, SUV and mini-bus to replace metro mass transit for every 6,300 PMT. This means that for every 100km, an average of 52.6 litres of fuel savings would be made if mass transit is used as against cars SUVs and mini buses. This corroborates the theory that large bus is twice energy efficient as average of car, SUV and mini-bus (Sharpiro et al, 2002).

Based on the above analysis, therefore, a conclusion could be made that, by holding all other things constant, an increase in metro mass transit ridership in the metropolis will reduce energy demand within the transport sub-sector.

5. Conclusion

From the analysis it was revealed that the use of mass transit was seen to be more fuel efficient compared with car, SUV and mini bus. That, relying more on the use of mass transit, which offers more energy efficient means, is key to achieving energy efficiency. It was clear from the analysis that for every passenger mile travelled (in km) by commuters, mass transit consumes about half of the fuel consumed by saloon cars, SUV and mini- bus. Therefore, by holding other things constant, increase in mass transit ridership in the metropolis will offer one of the most effective, efficient and feasible strategy, under the current circumstance, to reducing energy demand within the transport subsector. Thus adequate use of mass transit reduces energy demand due to its energy efficient potentials. This confirms the conclusions that have been made by other researchers such as Sharpiro *et al*. (2002) and ICF International (2007). Based on these findings, we recommend the following: 1. The metropolitan authority should improve upon the mass transit services within the metropolis by increasing the number of metro buses that ply within the city, especially during peak hours to improve access to transportation within the metropolis. 2

Management of the urban transport system should implement road and parking pricing policy for private vehicles to discourage high use of private vehicles, especially at the CBD, but not without effective, efficient and reliable mass transit in place. 3. They also should also construct special bus lanes to improve the mass transit system within the city. 4. There should be further studies into the implementation and possible challenges of road pricing policy as a means of encouraging mass transit ridership in Kumasi Metropolis.

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