Roadmap for the Promotion of Cleaner Buses in Accra, Ghana

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LIST OF ABBREVIATIONS

ATCS	Area Traffic Control System
BAU	Business As Usual
BRT	Bus Rapid Transit
CBA	Cost Benefit Analysis
CCAC	Climate Clean Air Coalition
CEPS	Customs Excise Preventive Services
CIF	Cost Insurance Freight
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
DVLA	Driver Vehicle Licensing Authority
EC	European Commission
ECOWAS	Economic Commission of West African State
EPA	Environmental Protection Agency of Ghana
EU	European Union
GAR	Greater Accra Region
g/km	Gramm per kilometer
GHG	Green House Gas
HOV	High Occupancy Vehicles
HME	Health Matrix Evaluation
IARC	International Agency for Research on Cancer
IOC	Institute of Occupational Medicine
IOSH	Institute of Occupational Safety and Health

ITCS	Intelligent Transport Management System
LPG	Liquefied Petroleum Gas
MMDAs	Metropolitan, Municipal and District Assemblies
MMT	Methyl Chloropentadienyl Manganese Tricarbonyl
NIH	National Institute of Health
NOx	Oxides of Nitrogen
NPA	National Petroleum Authority
NPV	Net Present Value
NTP	National Toxicological Programme
$PM_{2.5}$	Particulate Matter with Effective Size of less than 2.5 microns
PM_{10}	Particulate Matter with Effective Size of less than 10 microns
PPM	Part Per Million
SDG	Sustainable Development Goal
SLCP	Short Lived Climate Pollutants
SO_2	Sulphur Dioxide
TEL	Tetra Ethyl Lead
TSP	Total Suspended Particulate
USEPA	United States Environmental Protection Agency
VKS	Vehicle Kilometers Saved
VMT	Vehicle Miles Travelled
VOC	Volatile Organic Compounds
VSL	Value of Statistical Life
WHO	World Health Organisation
WTP	Willingness To Pay

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1.0 BACKGROUND INFORMATION

Transport is a vital part of modern life as it serves as a means by which societies interact. Efficient transportation provides economic and social benefits that result in multiplier effects such as better accessibility to markets, employment and industrial growth among others. Owing to this flexibility, road transport has played a pivotal role as a major transport mode, and vehicles are objects of desire and pride in many societies (Krzyżanowski M. et al, 2005).

Despite the benefits of transport especially road transport, the negative impacts on the environment and human health to a large extent offset the benefits (Dora, C. and Phillips, M. eds., 2000). Research conducted in recent decades has revealed that outdoor air pollution harms health and the evidence points to air pollution that stems from transport as an important contributor (Krzyżanowski M. et al, 2005). The present trend in Ghana shows an increase in fleet population over the past 20 years with a resultant negative impact on local air quality and increase in greenhouse gas emissions which has global warming potential.

2.0 INTRODUCTION

The general economic development experienced in major urban areas in Ghana over the years has brought high urbanization. Ghana's population is estimated at 24 million with the Greater Accra Region which is the administrative capital having an estimated population of four million, ten thousand and fifty four (4,010,054) people (National Population and Housing Survey, 2012). Apart from the resident population, an estimated daily influx of between 2.5 million and 3.0 million people commute to Accra on a daily basis. The high growth rate of Accra has brought about some level of prosperity (better standard of living). the urban productivity is hindered by low density based on urban sprawl which increases the cost of commuting with its attendant negative environmental impacts.

Over the years, the number of vehicles registered annually in Ghana has been increasing. Available statistics shows an increase in vehicle fleet of 511,755 in 2000 and 2,098,726 in 2016 representing an increase of over 300% (DVLA, 2016). The Greater Accra Region has the largest share of registered vehicles and has similarly witnessed remarkable growth in vehicle fleet numbers over the same period. The total number of registered vehicles in the region stood at 1,134,599 as at the beginning of the first quarter of 2017 (estimated at 50%). The growth in the number of registered vehicles contribute to the rising traffic congestion, noise pollution, accidents, poor air quality and its attendant health related problems and global warming (Armah, et al., 2010). The transport emissions in Ghana is estimated as 20% of the national total GHG emissions as at 2012 (EPA, 2015).

It is estimated that about 84% of passenger trips are made with public transport (Morrison, G.M. and Rauch, S. eds., 2007). Public transport fleet in Ghana is characterized by mainly low occupancy mini busses and vans converted into buses which are poorly maintained and contribute to pollution. These vehicles are inefficient with respect to the amount of road space they occupy. The driving patterns and the poor performing vehicles have led to increases in road transport emissions at a much faster rate than anticipated.

With respect to the its mandate to protect the environment and human health, the Environmental Protection Agency of Ghana has been implementing an air quality monitoring programme since 2005 in the Greater Accra Region along major road corridors and selected commercial, industrial and residential locations. The results from the monitoring programme along the roadside sites has consistently showed high particulate concentrations (PM_{10}) above the Ghana EPA 24-hour mean limit value of 70μg/m^3. There are concerns at the National level about the high concentrations of air pollutants in major urban areas especially along major arterial route to the Central Business District (CBD) of Accra over the past ten (10) years.

Pollutants from diesel engines have been classified by the International Agency for Research on Cancer (IARC) as Class one (1) carcinogen (IARC, 2013). It is also directly responsible for other respiratory diseases even at the lowest level of exposure. Actions to reduce exposure to outdoor air pollution should therefore be focused on effective policies and strategies in order to reduce the debilitating impacts on health especially for the vulnerable groups.

The EPA Ghana is collaborating with the US Environmental Protection Agency and the Ghana Health Service to estimate the health implications of air quality using the BenMAP-CE air quality impact estimation tool and the results so far has revealed that the high levels of particulate has debilitating effect on health.

2.2 Implications to Local Air Quality

Gasoline and diesel are the most common types of road transport fuels used in Ghana. Vehicle emissions mainly result from fuel combustion and or evaporation emissions. The major by-product of complete combustion from vehicles are CO_2 and water vapor (H_2O). The use of poor quality fuels result in incomplete combustion and the generation of pollutants such as Black Carbon, NO_x and CO (SLCP). The presence of sulphur compounds in fuels results in the emissions of sulphur dioxide (SO_2) and Particulate Matter (PM). To reduce air pollution and improve commuting time and public health, Ghana has developed a project to promote soot-free bus standards and sustainable transport in Accra.

2.3 Project Objectives and Outputs

The main aim of the project is to promote Soot-Free Bus and Sustainable Public Transport in Accra. The specific objectives of the project are to:

1. Support the development of cleaner, soot-free bus standards in Accra.
2. Build the capacity of public transport operators and regulators in Ghana and sub-region
3. Develop awareness creation materials for educating the public on soot-free bus system in Ghana
4. Initiate the dissemination of the draft policy options of soot-free buses in Ghana.

3.0 POLICY INTERVENTIONS

In Ghana, the road transport sector continues to play a significant role in socio-economic development. The effectiveness of the transport sector is therefore dependent on the implementation of sound policy framework and institutional governance.

The main challenges currently faced by Ghana's road transport sector are as follows:

- Poor and inadequate development of intermodal transfer facilities/infrastructure,
- Lack of proper enforcement of transport regulations,
- Inefficient and awkward relationship between land-use and transport planning and traffic congestion among others.
- Emergence of two stroke motorcycle engines in urban areas
- Poor state of public transport vehicles resulting from mainly poor maintenance culture and ageing fleet
- Limited road space and bad driver behaviour

To address these challenges, there is the need to implement appropriate measures to ensure an effective and efficient road transport system in the Greater Accra Metropolitan Area. The Bus Rapid Transit system being piloted in Accra presents a unique opportunity for the reduction of traffic congestion which could also result in journey time savings and improve the well-being of the public in line with Sustainable Development Goal Three (SDG 3). The BRT initiative could be replicated in other areas of the city.

The expansion of the BRT system coupled with the introduction of efficient, high occupancy and low carbon clean bus technologies in Ghana will reduce traffic congestion, improve local air quality and reduce the burden of diseases associated with transport related air pollution.

This policy intervention therefore focuses on the introduction of cleaner fuel and engine technologies that promote soot- free urban bus fleet for public transport. Key issues being considered include the following:

- Fuel options and availability for urban bus fleet
- The advantages and disadvantages of various types of fuel and engine technology
- The costs and benefits of these options (ie. Cost, remains the primary decision factor for public authorities (life cycle cost/ total cost of ownership of a vehicle)
- The infrastructure requirement to support cleaner buses including availability of a refueling infrastructure.

These issues are to appraise the different bus technologies and energy sources in Ghana.

3.1 Drivers and Challenges

In response to the poor air quality and increase in GHG emissions, Ghana has already made commitment at the national and global level to reduce air pollution especially from road transport. One of the key interventions is to convert the current air quality guidelines to standards for the development of vehicle emissions regulation. Whiles other sectors such as Agriculture, Forestry, Waste etc are equally important, emissions from transport alone constitute about 25% to global GHG emissions. The negative public health impact of short-lived climate pollutant and rising concerns about the air quality levels in urban areas especially along major arterial roads have necessitated the need to shift to cleaner and more efficient energy sources to fuel urban bus fleet which makes more trips than single occupancy vehicles.

3.2 Policy Measures

Several policy initiatives have been undertaken to improve transport infrastructure and services, fuel economy and fuel quality specifications and also to improve urban mobility. Some of these policy initiatives includes the following:

- West and Central Africa Regional Framework Agreement On Air Pollution (Abidjan Agreement), 2009
- Abuja Communiqué on low sulphur fuels, 2016
- Phased-out of leaded gasoline (petrol), 2003
- Introduction of age-based tax system for imported vehicles, 2002
- Introduction of petroleum and pricing deregulation policy, 2005
- Petroleum pricing policy, 2015
- Transport Policy, 2008
- Fleet renewal policy, 2010
- Urban Transport Policy, 2008
- Energy sector policy, 2010
- Ghana National Climate change policy, 2013
- Gas master plan, 2015
- Directive on fuel quality, 2016
- National Environment Policy, 2014

3.2.1 West and Central Africa Regional Framework Agreement On Air Pollution (Abidjan Agreement), 2009

The framework requires for improvement in fuel quality and the development/implementation of vehicle standards under the transport sector. The agreement details out actionable targets for transport, industry and mining; household pollution; waste disposal; bush fires, uncontrolled burning and deforestation; urban planning; management and national and regional environmental governance. In terms of vehicle standards, the agreement among others, seeks to facilitate the enactment of regulations to restrict the age of imported vehicles. The agreement also seeks to support the establishment of pilot vehicle emission testing programs and harmonization of emission standards for the different categories of motor vehicles in line with available fuel quality standard. In line with this Agreement, Ghana piloted a vehicle emission testing programme and is in the process of gazzeting the vehicle emission standards for implementation. The agreement seeks to support a transition to a lower sulphur levels in fuel (50ppm for diesel by 2020). Ghana has subsequently put in place a programme to transition to a maximum of 50ppm sulphur level. This would mean that emission standards could be pegged at Euro IV and above especially for new vehicle imports.

3.2.2 Abuja Communiqué on Promotion of Low Sulphur Fuels in ECOWAS Countries, 2016

The Federal Ministry of Environment of Nigeria in collaboration with the United Nations Environment, Climate and Clean Air Coalition (CCAC) and Partnership for Clean Fuels and Vehicles organized a-Regional Workshop on the Promotion of low sulphur fuels to facilitate the following;

- To develop a road map towards achieving a standard of 50ppm maximum of Sulphur in fuels in the ECOWAS sub-region by 2020.
- To import only low sulphur fuels (50ppm maximum) into countries in the sub-region.
- To collaborate with ECOWAS Countries for the harmonization of Clean Fuel and Air Emission Standards

This communiqué relied on the success of lower sulphur level in fuels achieved by some African countries like Morocco and East African community which have already implemented 10ppm and 50ppm sulphur level in fuels respectively. ECOWAS countries resolved to review, upgrade and domesticate common laws, regulations and standards across the region to promote low sulphur level in fuels (50ppm maximum) and reduce emissions. Countries also resolved to reduce tax on new vehicles, restrict importation of used vehicles to eight (8) years.

Ghana already has aged-based restrictions but does not ban vehicle imports older than 10 years. The policy of reducing the age to conform to the Abuja Communiqué is under consideration. The resolution when fully implemented would enable Ghana transition to a higher fuel economy and vehicle standard.

3.2.3 Phase-Out Leaded Petrol Porgramme

In 1998, the World Bank launched the Clean Air Initiative for Sub-Saharan African Cities. The overall goal of the initiative was to phase-out leaded gasoline in sub-Saharan Africa by 2005 to pave way for further reduction of other transport pollutants. Subsequently, the Government of Ghana phased out tetraethyl lead (TEL) the organic lead content of gasoline, as an octane enhancer in the production of gasoline and introduced a less harmful octane-enhancing additive methyl chloropentadienyl manganese tricarbonyl (MMT). Activities that were outlined as part of the programme include baseline assessment of lead in air, soil and blood of high-risk groups. Ghana therefore undertook plant modifications and use of additives as well as imported high Octane Unleaded Gasoline for blending with local refinery blend stocks. Ghana has therefore successfully phased-out lead in Gasoline.

3.2.4 Age-Based Tax System for Imported Vehicles, 2002

Ghana implemented an import ban on all vehicles older than 10 years in order to avert the danger posed by these vehicles to the environment. However, following the Amendment of the Customs, Excise and Preventive Service (CEPS) Act 634 in 2002, this ban was lifted, and replaced with the imposition of import penalties on cars exceeding 10 years old. These penalties increased in strata, allowing older vehicles to be imported whilst maintaining a disincentive to the importations of older vehicles. For instance, whilst vehicles older than 10 years but less than 12 years attract a penalty of 5 percent of the Cost Insurance and Freight (CIF) value, those aged between 12 and 15 years attract a penalty of 20 percent of the CIF value. Any vehicle older than 15 years would be required to pay a 50 percent penalty of the CIF value. The ban and the subsequent amendment had so far not had any significant impact on the importation of over-age vehicles,. There is therefore the need for alternative policies to reduce import of older vehicles rather than imposing a ban or other stringent control laws.

3.2.5 Petroleum and Pricing Deregulation Policy, 2005

In 2005, Ghana commenced the deregulation of the petroleum sector. The deregulation was aimed at removing the inefficiencies in the sector by allowing private sector participation in the procurement of crude oil and petroleum products, which has previously been limited to the only state refinery, Tema Oil Refinery. Under the deregulated regime, the private sector can now import and distribute finished petroleum products in Ghana. The activities of the importers and distributors in the industry are however regulated by an independent authority, the National Petroleum Authority (NPA) under the NPA Act, 2005 (Act 691). This policy has helped in the opening up of the imports of refined petroleum products and has brought about competition among the Oil Marketing Companies. This has resulted in the importation of lower sulphur fuels often below the national standards.

Ghana subsequently, reduced its maximum specification for sulphur content in diesel from 5000ppm to 3000ppm in 2014. The National Petroleum Authority and the Ghana Standards Authority have recently revised the standards from 3000ppm to 500ppm (for refineries) and a maximum of 50ppm sulphur for imports. Ghana aims to set the oil refinery limit for sulphur in fuel at 50ppm or lower by 2020. These actions coupled with the successful elimination of lead in gasoline will improve fuel economy, engine performance and roadside air quality. This will enable Ghana to move to a higher engine technology standard of Euro IV applied globally since 2005 with a maximum of 50 ppm of sulphur level in diesel fuel.

3.2.6 Petroleum pricing policy, 2015

In 2015, pricing of petroleum product was also deregulated to allow marketers and importers of Petroleum products to set their own prices and bring an end to government subsidy on the commodity.

3.2.7 National Transport Policy, 2008

The National Transport Policy is the guiding document for the development of transport in Ghana. With regards to sustainable development, the policy recognizes the following issues:

- Inadequate evidence-based analysis and comparison of social, environmental and economic impacts of modal solutions
- Lack of comprehensive measures for minimizing environmental damage.
- High gasoline consumption (99.7 %) in the economy.
- Major contributor to greenhouse gas emissions (60% of non-biomass carbon dioxide and over 50% of Nitrogen Oxide emissions)

The policy seeks to create a sustainable, accessible, affordable, reliable, effective and efficient transport system that meets user needs by providing cost effective and environmentally friendly solutions.

3.2.8 Fleet Renewal Policy, 2010

To address the increasing fleet of old and ageing mini-buses, deepening traffic congestion, poor air quality levels along major road corridors with high fuel consumption and consequently high cost of travel per passenger/kilometer. A policy on fleet renewal was introduced in 2010. The aim of the policy is to assist public transport operators to renew their vehicle fleets for improvement of the safety and comfort of passengers. Transport operators in most cases find it difficult to provide the needed collateral necessary for acquisition of newer vehicles. The arrangement was therefore for Government to utilize its financial engineering capabilities to procure higher occupancy buses to replace existing minibuses (tro-tro) most of which were unfit for road use. This led to the procurement of about 400 high capacity buses in 2010, 200 in 2013 and another 200 in 2014. In 2016, another batch of 150 buses, 200 taxis were procured to improve public transportation.

The importation and use of this high occupancy soot free urban buses will help reduce congestion, improve air quality, lower transport related emissions, reduce public health cost, lower cost per passenger/kilometer and therefore have positive socio-economic and environmental impact. There is an urgent need for Government to scale-up the implementation of this policy.

3.2.9 Urban Transport Policy, 2008

The Urban Transport Policy recognizes that mass transport systems for moving large numbers of people at low cost needs special attention to reduce traffic congestion and improve mobility in urban areas. The policy therefore focuses on moving at least 80% of passengers using higher occupancy buses. The main objectives of these strategies was to improve mobility through a combination of traffic engineering measures, management improvements, regulation of the public transport industry and implementation of a Bus Rapid Transit System. The project was also geared towards promoting a shift to more environmentally sustainable transport modes and lower transport-related GHG emissions along the Pilot BRT corridor. The major components of the Project are as follows:

- Develop and operate a Pilot Bus Rapid Transit (BRT) System
- Regulate Urban Passenger Transport in the Participating Assemblies
- Traffic engineering, management and safety including the development of an Area-Wide Traffic Signal Control System in Accra and Kumasi
- provide support for the development of stakeholder institutions in the Project
- Integrate Urban Development and Transport Planning

Though the project delayed, a pilot BRT scheme has commenced on one of the proposed corridors and is being scaled up to cover other proposed routes. The overall implementation status has been documented to be moderately unsatisfactory because the system is of mixed traffic with just about a 10% dedicated bus-ways and the benefits of reduced environmental effects have not been attained. In spite of these strategies, a clear guideline on how urban areas can transition to a cleaner bus system has not been addressed. Urban buses account for about 25% of black carbon emissions in most cities. It is important that modern technologies allow the removal of black carbon from diesel engines.

3.2.10 Gas Master Plan, 2015

The Gas Master Plan forecast demand is derived from three main sectors: power generation, industrial demand and gas use in transport. The recommendation focuses on power generation for gas usage is in line with the current gas utilization strategy as per the National Gas Pricing Policy. There is also a focus on the transport sector where gas usage is also feasible, although the development of this market for gas is harder to achieve due to high capital requirement and limited infrastructure to support it.

Ghana has an undocumented fleet of LPG-fuelled vehicles (including locally retrofitted vehicles), a trend that has been driven by the cost savings from cheap LPG, which was subsidized to incentivize residential and commercial use. According to NPA, in 2015 there are 603 LPG filling stations, over a third of which were in Accra, with taxi and bus fleets prominent among users. The popularity of LPG may help provide a model and natural market for CNG-fuelled vehicles.

Ghana is planning to put in place infrastructure framework for CNG production, mother and daughter filling stations in Accra. Natural gas for transportation as an alternative to petrol and diesel fuels has proved popular in a number of markets where its growth has received targeted support and the cost of standard fuel options is high. Environmental benefits and the potential gap between natural gas and petroleum product prices further incentivize CNG growth.

3.2.11 Energy sector policy, 2010

The document provides a concise outline of the Government's policy direction in order to contribute to a better understanding of Ghana's Energy Policy framework. The Policy covers the broad spectrum of issues and challenges relating to the power sub-sector, petroleum sub-sector, renewable energy sub-sector, waste-to-energy, energy efficiency and conservation, energy and environment, energy and gender. In the case of petroleum, the policy focuses on the regulation of the petroleum industry with respect to licensing and operation of the oil and gas companies; improving Ghana's institutional and human resource capacity; enhancing local content; and fiscal incentives that will ensure maximum benefits to the people of Ghana.

In order to ensure efficient use of available energy sources, the policy also focus on removing the obstacles that have constrained the promotion and implementation of energy efficiency and conservation measures. The policy measures required to promote energy efficiency and conservation are fiscal incentives, awareness creation, institutional and human resource capacity development, and financial intermediation.

3.2.12 National Environment Policy, 2014

One of the main aims of the National Environment Policy is to improve Air quality in Ghana. The policy recognizes the sources and health problems with respect to human health, biodiversity and health of ecosystem as a whole. The policy identifies the following:

- the persistent poor emissions of air pollutants in the major cities of Ghana, namely Accra, Kumasi, Tema and Takoradi.

- Key sources of air pollution emanates from Transport, Deforestation, Energy production, Agriculture, Bush burning and industry (both manufacturing and construction), Waste management and Mining.
- Pollutants of major concern are particulate matter (PM10 and TSP), ground level ozone, oxides of nitrogen, Carbon monoxide, Sulphur dioxide, Carbon dioxide, ammonia, VOCs, heavy metals and Persistent Organic Pesticides etc.
- Range of health-related complications such as arrhythmias, myocardial infarction, stroke, respiratory symptoms, Asthma, chronic obstructive pulmonary disease, lung cancer, low birth rate, pre-term delivery and adverse cognitive development of infants (COPD).

3.2.13 Ghana National Climate change policy, 2013

The vision of the national climate policy is to ensure climate-resilience, and climate-compatible economy while achieving sustainable development through equitable low carbon economic growth of Ghana. The objectives of the policy include:

- ensuring effective adaptation,
- promoting social development and
- GHG mitigation

The policy objectives that related to energy and infrastructural development (transport) will be achieved through expansion of inter and intra-city mass transportation mode (rail and bus transit systems) in four (4) cities including Accra.

This policy intervention is captured in Ghana's Nationally Determined Contributions (GH-NDCs) of which its implementation is expected attain the country's commitment under the Paris Agreement.

3.3 What are the Soot- Free Bus Options

There are three main energy sources available to power urban buses in Ghana which include fossil fuels (petrol, diesel, Liquefied Petroleum Gas and Compressed Natural

Gas), bio-fuels and electricity. For these energy sources, different bus technologies exist which can use one or a combination of fuels. Buses that run on Compressed Natural Gas (CNG), bio-fuels and electricity or a combination of fuels have been considered as very efficient in terms of emissions savings when compared to those that run on diesel and petrol.

3.3.1 Urban Buses Fleet and Energy Sources

3.3.1.1 Urban Bus Technology

There are several types of low emitting and soot-free urban buses currently used worldwide. In some cities in the developed countries, diesel and biodiesel buses constitute the largest proportion of the urban bus fleet. Over the years, vehicle emission standards have been reviewed in accordance with European Union Directive (98/69/EC/ and 1999/96/EC) to more stringent emission standards (see table 1). The standards vary depending on fuel type and vehicle size. These standards are enforceable in each EEA member state. Vehicle manufacturers are expected to comply with the directives by ensuring that appropriate types of emission control devices are installed on vehicles to meet the required standards in order to sell in the European market (Transport policy.net, 2017).

Table 1 EU Directive on Vehicle Technology

VEHICLE CLASS	TECHNOLOGY CLASS	YEAR OF IMPLEMENTATION	EU DIRECTIVES(s)	FUEL TYPE
Cars Light Duty Vehicle Heavy Duty Vehicles Buses Coaches	Euro 0	<1992	70/220/EEC	Petrol Diesel LPG
	Euro 1	>1992 or 1997	91/441/EEC 93/59/EEC	
	Euro 2	<1996 or 1997	94/12/EC 96/44/EC 96/69/EC	
	Euro 3	>2000	98/69/EC 98/77/EC 1999/102/EC 2001/1/EC	

			2001/100/EC 2000/80/EC 2002/80/EC	
	Euro 4	>2005 or 2006	2003/76/EC 2006/96/EC	
	Euro 5	>2011 or 2013	715/2007 692/2008	
	Euro 6	>2014 or 2015		

Despite these policy directives on engine technology, diesel buses are seen as gross emitters of climate pollutants. In Ghana, over 80% of imported buses are second-hand with engine technology ranging from Pre-Euro, Euro 0 to Euro III. Whiles there are no established standards for vehicle import into Ghana, the age-restrictions policy that aims to restrict importation old vehicles (not exceeding 10 years) into the country has not been effective. Government policy of fleet renewal has not been very successful as it's only supported less than a 1,000 buses over 5 a year period. Similarly, the technology onboard the replacement fleets were of low Euro standards and did not have a significant impact on emission. It is important to note that fleet renewal with substitution for Euro VI and above and alternatively fuelled buses has the potential to trigger a reduction in climate pollutants.

3.3.1.2 Alternative Bus Technologies

Replacement of diesel fueled buses with an alternative (low emissions) fueled buses or a combination of different fuels is gaining popularity due to its eco-friendly nature. Most advanced and developed cities have experimented with alternative bus technologies that use bio-diesel, bio gas, bio ethanol, CNG, and LPG. There are also new and emerging technologies, such as hydrogen and bio-waste. Though such buses are not available in Ghana, these energy sources could be produced locally. Ghana is currently producing commercial quantities of natural gas which could be explored for possible uptake of CNG buses. The use of LPG as fuel for low occupancy vehicles such as taxis and minibuses have been on the increase due to its lower cost than the other fuel types.

Hybrid technologies are also available especially for small and medium sized vehicles. The hybrid technology for urban bus fleet has not been fully explored in developing cities including Accra. There is growing support for diesel hybrid buses due to its potential CO_2 savings when compared to conventional diesel engines. The diesel hybrid technology which uses a combination of diesel and electric motors could enable a transition to full electric powered buses in future. The support for electric buses for public transport has grown over the years due to its zero emissions and low noise capabilities.

The uptake of alternative fuel buses have been low and in most cases not in existence in Ghana, due to its high capital requirement. The choice of bus technology for public transport would be dependent on its operational performance, infrastructure required and cost and is summarized in table 2 below:

Table 2 Table showing vehicle technology, operational performance & Infrastructure

	Operational Performance	Infrastructure Requirement	Cost	Remarks
Conventional Diesel buses (From Euro IV and above in line with plans to reduce sulphur content to a maximum of 50ppm)	• widespread coverage of garages • inadequate and lack of technical expertise • High range on full tank capacity • Higher route flexibility	• widespread fuel filling and service stations in Ghana Operating environment adapted for diesel buses	US$150,000- 250,000	• Growing concerns about sulphur levels in diesel fuels
Compressed Natural Gas Buses	• Low range and dependent on tank capacity • Flexibility of the route is	• Requires specific fuel dispensing infrastructure (Re-gasification	US$200,000- 350,000	• Available energy sources in dependent on the national reserves

	Operational Performance	Infrastructure Requirement	Cost	Remarks
	dependent on available fuel dispensing points	unit, mother stations, daughter stations, tube stations, tube trailers for the transfer of gas to daughter stations		• There is the potential to import and re-gasify to meet demand • Possible gas leaks and safety concerns
Hybrid Diesel buses	• Flexible routes • High maintenance cost • Lack of technical expertise to maintain the vehicles	• widespread fuel filling and service stations in Ghana Operating environment suitable for hybrid diesel	US$150,000- 250,000	• Inadequate technical expertise on hybrid technology • Potential savings on fuel. • less polluting compared with

	Operational Performance	Infrastructure Requirement	Cost	Remarks
		buses		conventional diesel vehicles
Electric Buses	• Limited range per charge • High cost of replacement of batteries • High maintenance cost • lack of technical expertise	• Require special charging points which are currently not available	Not yet determined	• Frequent charging • Unstable and unpredictability of electricity supply • low ambient noise levels

3.4 Vision for cleaner bus in Ghana

All high occupancy and medium size buses for public transport service provision in urban areas are emission free by 2037.

3.4.1 Policy Objectives and Strategies

Policy Objective 1

Ensure fuel efficient and "environmentally friendly" levels of exhaust emissions for new vehicles sold within Ghana to minimize GHG emissions and air pollution.

Strategies

- Prioritize the development of vehicle emissions standards in line with available fuel standards
- Ensure that all new vehicles (buses) in use within Ghana meet the minimum requirements of Euro Engine IV standard. Develop a regulatory framework to restrict the import of vehicles that do not meet minimum safety and emission standards Harness potential synergies through non-technical measures that seek to further reduce emissions (i.e. through a reduction in vehicle ownership, or vehicle kilometers driven and improve mass transport etc).
- facilitate the development and implementation of vehicle standards for public transport service provision

Policy Objective 2

Promote the use of alternative eco-friendly fuels in light, medium, and heavy-duty vehicles for public transport.

Strategies

- Promote investment in Compressed Natural Gas (CNG) fueling Infrastructure

- Target Diesel Vehicles and encourage the conversion of buses to CNG compatible vehicles in order to minimize CO_2, NO_x and SO_2.
- Introduction of stringent fuel regulations that require maximum Diesel sulfur content of 50ppm in line with the Abidjan Agreement on Air Pollution (2009) and the ECOWAS Communiqué (2016)
- Facilitate technical and policy exchange among MDAs and MMDAs to promote a shift to soot-free engines for all categories of vehicles both new and second hand-vehicles import.

Policy Objective 3

Minimize the concentration of GHG emissions through encouraging and prioritizing High Occupancy Vehicle (HOV) system.

Strategies

- Promote and prioritize High Occupancy Vehicle (HOV) dedicated lanes in urban areas
- Promote the implementation of mass transport system in Ghana

Policy Objective 4

Support the procurement of soot-free urban bus fleets as a critical component of any future low carbon transport strategy.

Strategies

- Support the identification of soot-free engine technologies and the fuels that enable them
- Accelerate the transition of diesel urban bus fleets towards soot-free engine technologies
- Investments in low-carbon public transport

- Promote public awareness and secure their commitment to soot-free bus fleet
- accelerate the implementation of fleet renewal policy

4.0 HEALTH BENEFITS OF SOOT-FREE BUS SYSTEM IN ACCRA

4.1 Health Benefits of Soot-Free Bus System

4.1.1 Introduction

Transport is a vital part of modern life. The freedom to travel short and long distances opens the horizons for personal development and professional activities, increases the options for leisure and holidays, and allows better contact and understanding between people. The economic development of entire regions depends on the easy access to people and goods ensured by contemporary transport technology. Owing to this flexibility, road transport is a major transport mode, and cars are objects of desire and pride in many societies.

Unfortunately, these positive aspects are closely associated with hazards to the environment and human health caused by transport, particularly road transport (Dora and Phillips, 2000). One of the leading concerns is the adverse effects on health of air pollution emitted by transport. Research in recent decades indicates that outdoor air pollution harms health and the evidence points to air pollution that stems from transport as an important contributor. The present trend towards increasing transport volume and the associated risks of harm to air quality and health, threaten the policy objectives of many countries, also stated by the European Union (EU) in its 6^{th} Environment Action Programme to achieve pollution levels that do not give rise to harmful effects on human health and the environment (European Commission, 2001). A multitude of air contaminants of varying toxicity comes from road transport, which originates from the tailpipes of vehicles with internal combustion engines, especially, the diesel engine.

Diesel fuel is used in most large engines, including those used in many trucks, buses, trains, construction and farm equipment, generators, ships, and in some cars. With the growing popularity of diesel-fueled engines in mass transportation systems, they have become widespread in densely populated urban centers. The chief advantages of the diesel engine over the gasoline engine are its fuel economy and durability. Diesel

Engines, however, emit more Particulate Matter per mile driven compared with gasoline engines of a similar weight. Over the past decade, modifications of engine components have substantially reduced particle emissions from both diesel and gasoline (Hammerle et al., 1999; Sawyer and Johnson, 1995). Diesel engine exhaust emissions are however, said to be among the most prevalent anthropogenic pollutants worldwide.

With diesel engines penetrating the private transportation sector, their emissions are brought into the urban centres, inevitably resulting in a high and continuous exposure of a large part of the population. In 2010, 95% of the urban atmospheric background mass concentration of particulate elemental carbon, and between 10 and 35% of the atmospheric organic carbon mass in the ambient air of Birmingham (UK), could be attributed to diesel engines (Yin et al., 2010). In Delhi, India, many studies have source-apportionment PM and found up to 28 percent of total PM originating from diesel vehicles (Pant and Harrison, 2012).

According to Steiner et al., (2016), it is figures like these that bring the health effects of diesel engine emissions into focus, particularly since in many regions of the world (e.g. India) adequate emission legislations are introduced with a significant time lag compared to more developed countries. Not surprisingly in an era of strong scientific, economic and regulatory interest in Public Health, diesel engine emissions happen to be among the most thoroughly investigated anthropogenic pollutants. This is reflected in the large number of scientific publications available in this field.

4.2 Sources of Exposure

Exposures are highest where diesel traffic is heaviest, such as along major highways and in cities. Exposure to diesel exhaust may be higher, especially when traveling on roads with heavier truck or bus traffic. Commuting for work is a potential source of diesel exhaust exposure for many people. One particular area of concern is children’s exposures to diesel exhaust and other pollutants while riding in school buses, as the buses themselves typically run on diesel fuel. Children are especially vulnerable to air pollution because their lungs are still in the developmental phase and they breathe, on average, 50 percent more air per pound of body weight than adults (USEPA, 2002).

Research conducted in US state of California has shown that school children who ride on old diesel school buses that lack pollution control have a 4% increased likelihood of developing cancer due to diesel particulate matter in their lifetime (Fitz et al., 2003). Although bus commutes only comprise a fraction of a child's day, the bus ride can represent up to 1/3 of the child's daily diesel pollution exposure. People are exposed to diesel exhaust by breathing in the soot and gases, and the amount of diesel exhaust people are exposed to vary greatly. Measuring these exposures is not easy because diesel exhaust is chemically complex and many of its constituents are also found in a lot of other sources. (Behrentz et al., 2005).

WHO,2014 report estimated that humans breath 20,000 litres of air each day, this means that the more polluted the air is the more humans breath in dangerous chemicals into the lungs.

The Institution of Occupational Safety and Health, (IOSH) has stated that around the world, there are limited statistics about the number of workers exposed to diesel exhaust fumes, and the number of cancer cases caused by exposure (IOSH, 2014). In Europe, the Institute of Occupational Medicine (IOM) has estimated that there may be more than 3.6 million workers exposed to diesel engine exhaust emissions above the background levels found in their cities.

In the UK, the Health and Safety Executive estimates that more than 100,000 workers could be exposed to high levels of diesel engine exhaust fumes, but Imperial College, the IOM and others put the figure closer to 500,000.

4.3 Effect of Diesel Exhaust on Human Health

The type and severity of effect of air pollution usually depends on the length of time of exposure, as well as the kind and concentration of chemicals and particles persons are exposed to. Breathing in high quantities of diesel exhaust fumes can cause irritation in the respiratory tract within a few minutes of exposure, but prolonged exposure over many years may be more harmful. The health effects will depend on the type and quality of diesel fuel being used (for example, its sulphur content), the type and age of the engine, where and how it is used and maintained, and whether a combination of different diesel-powered engines are contributing to overall exposure (IOSH, 2014).

Short term effects include irritation to the eyes, nose and throat and upper respiratory infections such as bronchitis and pneumonia. Other effects include headache, nausea, and allergic reactions. Short term air pollution can also aggravate the medical conditions of individuals with asthma and emphysema. Long term health effects can include chronic respiratory diseases, lung cancer, heart disease and even damage to the brain nerves, liver or kidneys. Continual exposure to air pollution affects the lungs of growing children and may aggravate or complicate medical conditions in the elderly.

A large number of toxicological studies have shown that diesel engine exhaust emissions adversely affect human health (Steiner et al., 2016).

Based on the proven geno-toxicity of its constituents, exhaust emissions from diesel-fueled engines have been judged as mutagenic and carcinogenic by the World Health Organization (WHO, 2010). Diesel engine exhaust fumes were classified as "probable carcinogens" back in 1988, by the International Agency for Research on Cancer (IARC) a part of the World Health Organization (WHO) whose major goal is to identify causes of cancer. The IARC has recently (2013) upgraded them to a Group 1 carcinogen, so these emissions are now treated as a definite cause of cancer in humans based on sufficient evidence that it is linked to an increased risk of lung cancer. The evidence backing this categorization is predominantly from epidemiological studies, supported by a large number of experimental studies. IARC also notes that there is "some evidence of a positive association" between diesel exhaust and bladder cancer.

The National Toxicology Programme (NTP) (formed from parts of several US government agencies, including the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA) has classified exposure to diesel exhaust particulates as "reasonably anticipated to be a human carcinogen," based on limited evidence from studies in humans (mainly linking it to lung cancer) and supporting evidence from laboratory studies.

The US Environmental Protection Agency (USEPA) maintains the Integrated Risk Information System (IRIS), an electronic database that contains information on human health effects from exposure to various substances in the environment. The EPA classifies diesel exhaust as "likely to be carcinogenic to humans."According to the US Environmental Protection Agency (USEPA) Study Report (2002),exposure to diesel engine causes cancer, increases the risk of heart attack, stroke, and cardiovascular disease, exacerbates asthma and can lead to low weight and preterm births.

The National Institute for Occupational Safety and Health (NIOSH) is part of the CDC that studies exposures in the workplace. NIOSH has determined that diesel exhaust is a "potential occupational carcinogen".

While people are more likely to be diagnosed with a cancer caused by long term exposure to diesel exhaust fumes in later life, many workers will suffer respiratory symptoms at a much younger age, a situation which can seriously affect the quality of life.

4.4 Magnitude of the Impact of Diesel Exhaust on Human Health

The WHO 2012 report indicates that over 6.5 million people died (one in eight of total global deaths) as a result of air pollution exposures. This finding more than doubles previous estimates and confirms that air pollution is now the world's largest single environmental health risk. Reducing air pollution therefore could save millions of lives**.**

Urban outdoor air pollution is estimated to cause 1.3 million deaths worldwide. According to the WHO 2014 report, India has the highest death rate due to air pollution. In December 2013, air pollution was estimated to kill 500,000 people in China. The same report estimated that South East Asia and western pacific regions had the largest air pollution related burden with a total of 3.3 million deaths linked to indoor air pollution and 2.6 million deaths related to outdoor air pollution. It is estimated that in Britain, more than 650 people a year die of lung or bladder cancer as a result of being exposed to diesel exhaust fumes at work. Around 800 new cases of cancer linked to diesel exhaust fume exposure are registered each year. (IOSH, 2014)

Tables 3-4 below shows the breakdown of deaths attributed to specific diseases indicating the causes of the vast majority of air pollution deaths. (WHO, 2014).

Table 3 Effects of Outdoor air pollution

Causes of deaths	**Break down**
Ischemic heart disease	40%
Stroke	40%
Chronic Obstructive Pulmonary Disease(COPD)	11%
Lung Cancer	6%
Acute Lower Respiratory Infection in children (ALRI)	3%

Table 4 Effects of Indoor air pollution

Causes of deaths	**Breakdown**
Stroke	34%
Ischemic heart disease	26%
COPD	22%
ALRI	12%

In Ghana, not many studies have been done to ascertain the exact estimates of diseases and deaths attributable to air pollution. However, Ghana Health Service data for the years 2014-2016 shows a general increase in prevalence (with exception of asthma) of diseases related to air pollution exposures (see table 5 below).

Table 5 Air pollution related disease trends for Greater Accra Region (GAR) period 2014-2016

Diseases	2014	2015	2016
Stroke	763	980	1,168
Cardiovascular disease	5,910	3,257	4022
COPD	29	74	92
Asthma	14,380	14,701	12,513
Upper Respiratory Tract Infection	257,222	289,576	294,827
Pneumonia	14,652	17,068	15,962

Source – National Centre for Health Information Management (CHIM) Ghana Health Service

4.5 Measures to Reduce Exposure to Diesel Fumes

In many countries, control of exposure to hazardous substances is covered by the law. In the UK, employers are legally required to consider the risk of cancer. Diesel fumes are covered by the control of substances hazardous to health (COSHH) regulations, as well as by the more generic Health and Safety at Work Regulations. By law, employers should assess the risk of people being affected by diesel fumes and then work to either stop exposure or reduce it with suitable control measures. Ghana however, has no such laws to control exposure to hazardous substances.

Strategies that could be adopted by Ghana to control exposures include;

- Switching to other forms of fuel, either gas or electricity or by replacing old engines with newer versions which produce lower emissions.
- Making sure that engines are maintained properly; especially fuel delivery systems.
- Making sure diesel engine exhausts have filters and using local exhaust ventilation in fixed or enclosed workplaces.
- Using forced ventilation to draw fresh air into the workplace.
- Using connecting extraction pipes for vehicle exhaust in workshops.
- filtering air in vehicle cabins
- Making sure that engines are turned off when they are not needed.
- Rotating jobs between different employees to minimize exposure.

The use of improved measurements and technology in Ghana will pave way for detailed analysis of health risks from wider demographic spread covering both urban and rural areas.

4.6 Benefits of Reducing Exposure to Diesel Exhaust Fumes

According to the WHO (2012), cleaning up the air we breathe prevents non-communicable diseases as well as reduces disease risk among women and vulnerable groups including children and the elderly.

4.7 Cases of ill-health and Deaths Averted

Improving air quality should reduce the number of episodes of acute illness (such as asthma attacks) experienced each year, as well as the number of cases of chronic respiratory illnesses that occur. The value of avoiding an illness episode especially an asthma attack consists of four (4) components as follows:

(1) The value of the work time lost due to the attack,

(2) The medical costs of treating the attack,

(3) The amount an asthmatic (or in the case of a child, the child's parents would pay to avoid the pain and suffering associated with the attack, and

(4) The value of the leisure time lost due to the attack.

In the case of a serious but infrequent illness such as a stroke, reducing air pollution reduces the risk of a person suffering from a stroke (A.M. Freeman, 2003).

According to the South Asian Urban Air quality management briefing note No.11(2003), studies of the air pollution effects on premature mortality predict how many fewer people are likely to die if air pollution is reduced. Ten (10) percent reduction in PM in Delhi, India, resulted in 1,000 fewer deaths each year. This implies saving 1,000 lives by improving air quality. The risk therefore of dying is reduced by a small amount for all people living in Delhi. This is equivalent on average to reducing risk of death annually by 1in 10,000 (0.0001) for each person in the population (calculated from dividing 1,000 deaths by 10 million people or 0.0001). In Beijing or Delhi on a bad air pollution day, the number of fine particles ($PM_{2.5}$) can be higher than 300 micro grams per cubic meter "explained (Dan Green Baum from the Health Effects Institute, in Boston US)". Normal is 25 or 35 micro grams per cubic meter.

The USEPA estimates that a proposed set of changes in diesel engine technology could result in 12,000 fewer pneumonia mortalities, 15,000 fewer heart attacks, 6,000 fewer emergency room visits by children with asthma and 8,900 fewer respiratory- related hospital admissions each year in the United States.

4.8 Reduction of Loss in Production

According to a joint study by the World Bank and Institute for Health Matrix and Evaluation (HME) in 2016, air pollution costs the world economy 5 trillion per year as a result of productivity losses and degraded quality of life and these losses in productivity are caused by deaths due to air pollution related diseases.

Reduction in ambient levels of the common air pollutants (such as Particulate Matter and ozone) have been associated with reductions in premature mortality from heart and lung disease, as well as reduction in chronic bronchitis, asthma attacks, and other forms of illnesses.

4.9 Initiatives to Improve Urban Health

The WHO in collaboration with Ghana Health Services has initiated a project in Ghana dubbed Urban Health Initiative (UHI). The aim of the project is to promote reduction of air pollution and short-lived climate pollutants (SLCPs) strategies, by mobilising and empowering the health sector and its collaborators to demonstrate and communicate effectively on the full range of health and economic co-benefits that can be achieved from these strategies particularly in the urban areas. It is hoped that the UHI will help improve upon the current data collection system and monetize economic benefits of reducing air pollution (see recommendations in section 5.7).

5.0 ECONOMIC BENEFITS

5.1 Introduction

Public transportation services are important in many ways. They provide mobility, can shape land use and development patterns, generate jobs and enable economic growth, and support public policies regarding energy use, air quality and carbon emissions. All of these characteristics can be important when considering the benefits, costs and optimal investment levels for public transportation.

Diverting current passenger traffic to the BRT from other transport modes. This immediate impact of the BRT would provide widespread benefits, such as reduction of air pollution, travel time, road accidents and traffic congestion. The pilot BRT could contribute to the diversion of a very high proportion of current passenger ridership from trotro, taxi, bus and private vehicle to the BRT, which would accommodate the growing passenger traffic demand in Accra (Okoye, et. al., 2010).

Investment in public transportation expands service and improves mobility, and, if sustained over time, can potentially affect the economy by providing:

- travel and vehicle ownership cost savings for public transportation passengers and those switching from automobiles, leading to shifts in consumer spending;
- reduced traffic congestion for those traveling by automobile and truck, leading to further direct travel cost savings for businesses and households;
- business operating cost savings associated with worker wage and reliability effects of reduced congestion;
- business productivity gained from access to broader labour markets with more diverse skills, enabled by reduced traffic congestion and expanded transit service areas; and
- additional regional business growth enabled by indirect impacts of business growth on supplies and induced impacts on spending of worker wages. At a national level, cost savings and other productivity impacts can affect competitiveness in international markets.

Table 6 Justification for Cost Benefit Analysis (CBA) for BRT_S

Srn	Urban transport project	CBA done or not
1	Roads	No
2	Footpaths	No
3	Bus system	No
4	Flyover/bridges	No (sometimes)
5	parking	No
6	BRT_S	Yes
7	MRT_S/Mono	Yes

5.2 Benefits of BRT

Reduction in road congestion - Increased capacity (widen road, missing link development – new links, bridges, Rail over-bridges) will:

- Improve performance - Increase travel speeds, by minimising jay walking, turning movements, segregation, signal management, level boarding, pre-board ticketing etc.,
- Reduce operating costs (Trunk-feeder, more km/bus)
- Reduce accidents - through the adoption of safety measures
- Improve Environment & Health (Mode Shift from polluting to non-polluting, Reduced Vehicle Kilometer Travelled (VKT) and Cleaner Vehicles
- Reduce GHG emissions, Local Air Quality, Increased physical activity (Health)
- Lead to mode Shift - In favour of walking, bicycles, bus (Mode Balance)
- Lead to economic development - More competitive city, Productivity
- Lead to affordable transport within a certain distance (Core city; Periphery)

5.3 Methodology

In order to compare the benefits, which are economic, social, and environmental to the costs, benefits and costs are expressed in monetary terms. We take a societal perspective when calculating costs and benefits: that is, we consider all costs and benefits without considering who the payer or beneficiary is. Under this perspective, transfers like taxes or interest are not included in the cost-benefit calculation, because the cost to the payer is equal to the benefit to the recipient, with a zero net cost to society. This study adopts the Cost-Benefit Analysis (CBA) methodology to assess the viability or otherwise of the BRT project.

The CBA is the implicit or explicit assessment of the benefits and costs (i.e., advantages and disadvantages) associated with an investment project. Benefits and costs may be monetary (pecuniary) or non-monetary (non-pecuniary, "psychic").

5.4 Quantitative Benefits

A bus rapid transit system can provide a number of benefits to a diverse set of local and global stakeholders, from reduced greenhouse gas emissions to increasing social cohesion. Some of these benefits have a larger economic value than others, and some can be translated into monetary terms more easily than others. However, we choose to also estimate time saved because we expect it will contribute an important portion of total benefits. Thus, in this analysis the following benefits are quantified:

- Reduction in greenhouse gas emissions
- Reduction in local emissions and health impacts
- Reduction in travel time during peak hours
- Employment benefits
- Health benefits

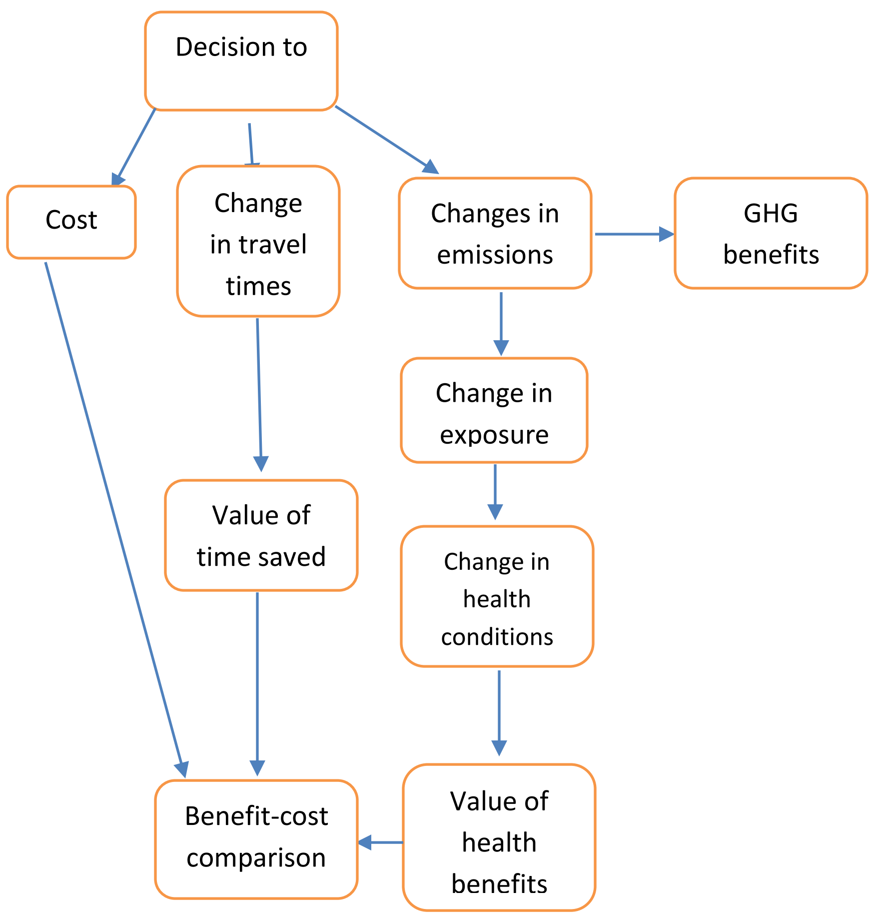
Other benefits may also be important contributors to the total benefits of the BRT system, however, it is out of the scope of the current analysis to attempt to quantify all benefits that may result from the system.

Table 7 Social benefits of a BRT system

Category	Description
Economic	Reduced travel times
	More reliable product deliveries
	Increased economic productivity
	Employment creation
	Improved work conditions
	More equitable access throughout the city

Category	Description
Social	Reduced accidents and injuries
	Increased civic pride and sense of community
Environmental	Reduced emissions of air pollutants
	Reduced noise Levels
	Sustainable urban form, including densification along major corridors
Urban form	Reduced cost of delivering services such as electricity, water and sanitation

Figure 1 The analysis frame work adopted for the study



5.5 Change in Vehicle Activity (Travel Time Benefit)

Three variables related to vehicle activity are quantified in this section: total vehicle kilometers travelled per year, total fuel used per year, and average vehicle speed. These three outputs are used to calculate changes in costs, emissions, and travel times. For most studies, the following data are needed to calculate the change in vehicle activity:

- Number of articulated buses, or number of buses, microbuses and private vehicles replaced by articulated buses
- Average number of kilometers per day by vehicle type
- Average traveling speed
- Average fuel economy

In this section, we first discuss the activity of buses and microbuses in the baseline scenario. Then, we discuss the mode change: the private vehicles that are present in the baseline scenario, but are eliminated in the BRT scenario.

Table 8 Time saved for BRT option

Data used in calculating time saved per year by BRT users	
	value
trips per week day	
former users of public transportation	42,507
average trip length	20
total time saved per year (Mil Hrs)	12.9
unit monetary value ($/Hour)	0.22
annual value of total money saved ($ Mil)	2.77

The average time that it takes a bus rider to make his or her trip would decrease with the implementation of a BRT system. These time savings are monetized and included as benefits in our model. The value of a person's time while traveling depends on the purpose of the trip (commuting versus non-commuting), the mode of transit (car versus bus), and the component of the trip being considered (in-vehicle time versus "excess" time for walking, waiting or transferring).

Table 9 Benefit parameters

Variable	**Unit**
Reduced Travel Time	Value of travel time in dollars per hour
Reduced vehicle user costs	Marginal vehicle user cost per Vehicle Miles Travelled (VMT)
Reduced vehicle emissions	Cost of emissions per VMT
Reduced accident cost	Cost of accidents per VMT

5.6 Change In Emissions

Vehicles and buses release hydrocarbons, nitrogen oxides, carbon monoxide, and carbon dioxide into the air (EPA, 2007). Implementing a BRT system would slightly increase air emissions by buses, but substantially decrease air emissions from automobiles. This analysis estimates the reduction in social costs caused by the net decrease of such emissions. We reach this estimate through consideration of the effects that emissions have on human health, the environment, and ability to participate in outdoor activities. Vehicle emission levels vary widely depending on make and model. Accurately determining the emissions released from vehicles in Madison requires knowledge of car type and model year for each vehicle mile travelled. Because of the complexities of gathering this information, we use average emissions cost per VMT based on estimates from the Victoria Transport Policy Institute and the California Department of Transportation.

Emissions factors were developed for this project and are detailed in the report. A summary of the methods used and updates to the original report is as follow:

Table 10 Emissions cost per Mile Travelled, 2010

Vehicle type	**Estimate**	**Plausible Range**
Personal vehicles	\$ 0.08	\$ 0.04 – \$ 0.15
Conventional diesel bus	\$ 0.16	\$ 0.11 – \$ 0.19
BRT bus	\$ 0.13	\$ 0.09 – \$ 0.15

$$\boldsymbol{E_K = \sum_i KRV_i \times FE_{ik} \times N_i}$$

.. (1)

Where:

E_k = total vehicular emissions of pollutant, *k* (g/year)
KRV_i = Average vehicle kilometers traveled for vehicle type *i* [km/year]
FE_{ik}= emission factor for vehicle type, *i,* and of pollutant, *k* (g/km)
N_I = number of vehicles (number of trips) of type *i*

Table 11 Emission Factors (g/km) Ghana (2000-2005)

Sector	**Sub-sector**	**CO_2**	**CH_4**	**N_2O**	**NO_X**
Passenger	Gasoline	318.14	0.02	0.03	1.62
Passenger	Diesel	313.44	0.00	0.03	0.79
Passenger	LPG	366.29	0.03	0.01	0.78
Light Duty	Gasoline	318.14	0.03	0.03	1.67
Light Duty	Diesel	313.44	0.00	0.02	1.03
Heavy Duty	Diesel	318.44	0.03	0.03	0.94
Urban Buses	Diesel	318.44	0.06	0.03	2.27

5.7 Health Benefits

The health benefits associated with controlling vehicular pollution may be realised in diverse ways usually evident in reductions in mortality and morbidity cases. Few studies have been published using data for South Asia that estimate Willingness To Pay (WTP) to reduce mortality or morbidity. This implies that monetization of health benefits must, in the immediate future, rely on transferring WTP estimates from one country to another or must calculate a lower bound to benefits based on foregone earnings (for mortality benefits) or the cost of illness (for morbidity benefits). The standard approach to benefits transfer implicitly assumes that preferences are the same in the two countries, including attitudes toward risk when estimates of the Value of a Statistical Life (VSL) are transferred. WTP is assumed to differ only as a result of differences in income between the two countries. If this is true, U.S. WTP can be transferred to Ghana after accounting for income differences as shown in equation (1)[1]:

$$\boldsymbol{WTP_{GH}} = \boldsymbol{WTP_{US}}\left({}^{\boldsymbol{Y_{GH}}}\!/\!_{\boldsymbol{Y_{US}}}\right)^{\epsilon} \quad \textbf{.......... (2)}$$

Where:

WTP_{GH} = Willingness to pay in Ghana

WTP_{US} = Willingness to pay in US

ϵ = income elasticity of willingness to pay[2].

5.7.1 Cost

The cost of a modern BRT system is also subject to cost escalation, but since the total project cost of a modern BRT system is likely to be anywhere from one half to one fifth as much as the total project cost of the Business As Usual (BAU) technology, the base-level cost differential between the two systems is enormous regardless of how fast the costs or either system escalate. It is believed that the initial cost the BRT project will be high but over the period the cost will stabilize and will be comparatively lower than the BAU option.

5.7.2 Life cycle cost/total cost of ownership

Cost, of course, remains the primary decision factor for the majority of public authorities. However the extent to which authorities are able to take into account the life cycle cost/total cost of ownership of a vehicle can have a major bearing on the selection of vehicle type. Many alternative fuel/technology options have higher upfront

[1]The above model was adopted from a study conducted by the World Bank for South East Asia.

[2]A conservative approach to benefits transfer is to use an income elasticity of 1.0, including smaller and larger values for sensitivity analysis.

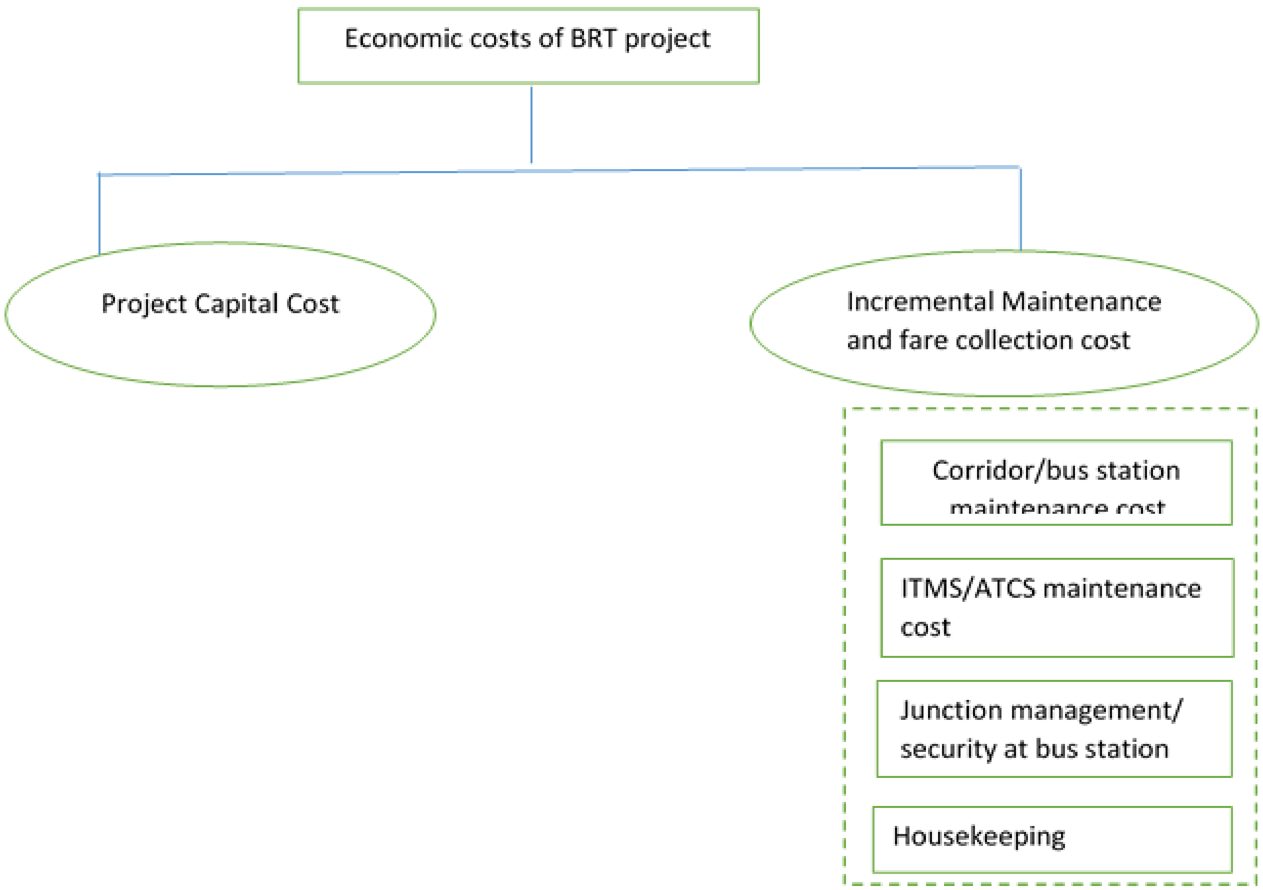
investment costs, both in terms of the vehicles, and the infrastructure required, but can demonstrate cost savings over the life cycle of the vehicle due to lower fuel consumption/prices, and potentially longer life-spans and lower maintenance costs.

The life cycle cost and emissions model was developed to evaluate the total cost of ownership and total exhaust emissions over the useful lives of transit buses with different types of propulsion systems. Elements of total cost included in the model are:

- bus purchase,
- purchase/installation of required fuelling infrastructure,
- purchase/installation of required depot modifications and special tools,
- annual operator labour,
- annual bus maintenance and fuel costs,
- annual maintenance and operating cost of required fuelling infrastructure, depot modifications, and special tools, and
- periodic bus overhaul costs.

The analysis does not include full overhead for management functions such as road supervision, procurement, etc.

Figure 3 Conceptual Framework for Economic Costs of BRT Projects



5.8 Cost-Benefit Comparison

Cost-benefit analysis was used to assess the viability of the BRT option. It must be acknowledged that due to the unavailability of the projected values of the variables used in the study, the future values were used and discounted (see spreadsheet in Appendix 1).

5.9 Sensitivity Analysis

Due to lack of data we did sensitivity analysis using different discount rates of 7.5% and 10%. The results indicated that Net Present Value (NPV) was positive and the benefit-cost ration was greater than 1 in both scenarios. NPV was $37.32 million at a discount rate of 7.5% and it increased to $151.58 million when a discount rate of 10% was used. The sensitivity analysis could further be enhanced when ridership or number of buses among other sensitive variables are varied.

5.10 Assumptions for the study

1. No major road network improvements in BRT enclave
2. Constant inflation
3. Straight line depreciation of 10%
4. Average useful life of a soot free bus (20 years)
5. Number of BRT buses
6. Assumption of VKT for BRT (50,000km in Kenya)
7. Load factor for BRT
8. Modes from which BRT buses pull
9. Real discount rate of 7.5%
10. Inflation of 16.5%
12. Adopted health benefit value from Mexico
13. Project period = 20 years
14. Assumed constant operational cost

From the cost-benefit analysis, the project is viable. It must be acknowledged that the positive Net Present Value (NPV) was based on the assumption that there is not going to be a mixed traffic on the BRT corridor. This means that as a matter of policy, the BRT should not compete with the minivans on corridor. Since the study made a lot of assumptions and adopted some data from other studies, further work must be done as and when appropriate data is available.

6.0 COMMUNICATION STRATEGY

6.1 Rationale /purpose

This communication plan has been developed to assist the project team to coordinate advocacy efforts based on existing information, which will be shared with stakeholders and the general public.

The communication strategies to be adopted shall seek to actualize the main objectives of the project.

6.1.1 Communication objectives

- Engage with and sensitize stakeholders
- Demonstrate the success of the project to stakeholders and the public
- Change behavior and perceptions of the general public on the operations of soot-free bus system in Ghana.
- Enhance public awareness on the effects of Soot-free Bus Standards in Accra.
- Advocate for the introduction of soot-free Bus Standard options for Ghana; a key policy issue worth integrating into National Planning and Development.

6.2 Expected Outcomes

- Communication Plan on soot free Bus Standards in Accra developed.
- Awareness on soot-free Bus Standards in Accra created.
- Information on soot-free Bus Standards for public transport disseminated.

Information products and activities including posters, website updates, fact sheets, television and radio programmes , media releases, workshops, focused group discussions, feature articles, courtesy calls, interviews and fora, produced or developed.

6.3 Project Implementation Period

The communication plan will be implemented by the various relevant institutions, including EPA, Ministry of Transport and Ghana Health Services. The first phase of the implementation of the communication plan will commence on July to December 2017. Funding will be sort to implement the plan.

6.4 Governance Structures

i. Project

Owners:

The project is owned by Environmental Protection Agency, Ghana Health Service and Ministry of Transport. .

ii. Implementation partners

- The project implementation partners include the following: Ministry of Environment, Science, Technology and Innovation,
- Ghana Health Service,
- Ministry of Transport,
- Driver Vehicle Licensing Authority (DVLA),
- Ministry of Local Government and Rural Development,
- Energy Commission,

- Ministry of Finance
- Environmental Protection Agency (EPA Ghana)
- Ghana Road Transport Coordinating Council (GRTCC)
- Ghana Private Road Transport Union (GPRTU)

iii. Communication Team

A Communication team will formed to implement the following:

- Plan and implement an awareness creation programme to achieve the set goals/objectives
- Evaluate the communication plan at intermittent intervals to assess the progress made

6.5 Methodology

The major communication activities and strategies are as follows:

- Stakeholder Mapping;
- Dialogue and Engagements
- Advocacy programmes
- Media engagements
- Public outreach programmes

6.6 Stakeholder Mapping

This involves the identification of stakeholders and their various roles they will play in achieving the project objectives.

The envisaged stakeholders that could be engaged in dialogue include: Ministry of Environment, Science, Technology and Innovation (MESTI), Environmental Protection Agency (EPA), Ministry of Transport, DVLA, Ministry of Roads and Highways, Ghana Road Transport Coordinating Council (GRTCC), Ministry of

Education, Ministry of Energy, Ghana Health Service, Parliament, Ministry of Finance, Ministry of Gender, Children and Social Protection, Non- Governmental Organisation (NGOs), Ministry of Local Government and Rural Development, National Development Planning Commission (NDPC), the Media and the general public among others.

6.7 Public Outreach Programmes /Strategies

To develop communication programmes on the effects of sustainable soot-free Bus Standards in Ghana,

Some of the public outreach strategies include preparation and distribution of posters, Fact sheets//Brochures; Fora, Website update, Radio and TV talk shows, Media release and Workshops.

6.8 Mode of Administration

Considerations for the communication action to be undertaken.

- What is the message that the project team wants to disseminate?
- Who will develop the message?
- Is the same message to be used for all the targets?
- How can the message be varied without losing the meaning?
- What does the message seek to communicate and what is the expected reaction?
- How clear and concise is the message? Does is contain any nuances that will be received negatively by any of the target audiences?
- What is the appeal of the message to the different categories of stakeholders?

- How should the message be packaged for policy makers?

- What is the Purpose of the specific message? To inform, educate or warn others?

- Which format should the message take to make a better impact? Words or pictures?

- What are the likely barriers to the message being received the way it should?

- What message should be sent through which medium?

6.9 Monitoring and Evaluation

Evaluation forms will be designed to source relevant feedback from stakeholders. Interviews may be used for wider audiences to solicit such feedback which will assist the institutions in determining the effectiveness of the communication plan.

6.10 Conclusion

This communication plan has offered a wide range of options for implementation. The success of these strategies will depend on the availability financial resources. It is anticipated that when the communication plan is implemented effectively, it will reduce road congestion and improve health and sustainable low emission transport system in Ghana.

7.0 ROADMAP FOR CLEANER BUS STANDARD IMPLEMENTATION IN ACCRA

The roadmap for the project implementation is as follows:

Table 12 Project Implementation period

No.	Activity	Timeframe	Responsible
1	Develop a paper/report on cleaner bus options and draft Roadmap to cleaner buses in Accra	31 May 2017	EPA, MoT, MoF, MoH, GAPTE, Delin Consult
2	Finalise implementation of roadmap for cleaner bus programme in Accra	By 30 June 2017	EPA, MoT, MoF, MoH, GAPTE, Delin Consult
3	review existing regulations on the importation of vehicles	by December 2018	Customs, MoT, MoF, DVLA, NRSC, EPA, GSA, MESTI, MRH
4	Policy Approval and Implementation period	30 November 2017-2030	MoT, MoF, MESTI, EPA
5	National Awareness on the benefits of soot-free bus in Ghana	By December 2018	NCA, Customs, MoT, MoF, MoI, DVLA, NRSC, EPA, MESTI
6	Development of financing strategies for the introduction of soot-free bus system Ghana	By December 2018	MoT, MoF, MESTI
7	develop bus standards that aligns with the new fuel quality standards (Euro 4 and above) for new imports	By January 2019	MoT, MoF, MESTI, GPRTU, GRTCC, GAPTE, DVLA
8	develop vehicle emission standards and regulations in line with the new fuel quality standards	By June 2018	MoT, MoF, MESTI, GPRTU, GRTCC, GAPTE, DVLA
9	conduct institutional assessment to identify capacity needs and gaps, overlaps in mandates, etc.	By December 2018	MoT, MoF, MESTI, MoE & Petroleum
10.	Ensure that all diesel-powered buses are fitted with particulate filters.	By December 2019	MoT, DVLA

8.0 CONCLUSIONS AND RECOMMENDATIONS

In line with global commitment to cut down transport related emissions as outlined in the Paris Agreement on Climate Change, there is the need to improve urban transport systems to facilitate transition to a clean urban environment and reduce negative environmental and health impacts. Government of Ghana has successfully implemented a pilot Bus Rapid Transit (BRT) system in Accra. The objective is to provide a core network for rapid and comfortable mobility in the Greater Accra Metropolitan Area of Ghana.

With the discovery of natural gas reserves in Ghana, the introduction of buses fitted with Compressed Natural Gas (CNG) technology, aligns well with the concept of the BRT system.

The introduction of CNG buses will lead to meaningful reductions in greenhouse gas emissions from short and long-lived climate pollutants. It is expedient to accelerate the development and deployment of CNG buses, with the long-term goal of retrofitting already existing diesel engines to run on CNG.

Government by way of policy can develop CNG infrastructure and provide incentives for the procurement of CNG fueled buses. This will in the long term lead to a reduction in the number of diesel-powered buses in the country, with the potential savings in fuel cost and reduction in pollution.

To facilitate the implementation of this roadmap, there is the need to undertake the following:

- Review existing regulations on the importation of vehicles.
- Develop financing strategies for the introduction of soot-free bus system Ghana
- Create national awareness on the benefits of using soot-free buses in Ghana.
- Develop bus standards that aligns with the new fuel quality standards (of 50ppm Sulphur content (Euro 4 and above that will reduce black carbon

emissions by 75 percent compared against a baseline Euro III vehicle commonly found on international markets today).

- Develop vehicle emission standards and regulations in line with the new fuel quality standards
- Conduct institutional assessment to identify capacity needs and gaps, overlaps in mandates, etc.
- Enhance technical and logistical capacity and expertise (ie. technical capacity for automobile engineers, technicians, drivers, etc).
- Ensure that all diesel-powered buses are fitted with particulate filters.

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APPENDIX 1

Table 13 Cost-benefit analysis at 7.5%

Future Values ($ Milllions)																						
																						NPV
Benefits	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	55.64
value of time saved	0.00	2.77	3.20	3.98	3.70	3.98	4.27	4.60	4.94	5.31	5.71	6.14	6.60	7.09	7.62	8.20	8.81	9.47	10.18	10.95	11.77	59.79
value of health benefits	0.00	3.00	3.47	3.73	4.01	4.31	4.63	4.98	5.35	5.75	6.18	6.65	7.15	7.68	8.26	8.88	9.54	10.26	11.03	11.85	12.74	199.60
employment created	0.00	10.05	11.61	12.49	13.42	14.43	15.51	16.67	17.92	19.27	20.71	22.27	23.94	25.73	27.66	29.74	31.97	34.36	36.94	39.71	39.71	199.60
reduction in emissions	0.00	100.00	115.56	124.23	133.55	143.56	154.33	165.90	178.35	191.72	206.10	221.56	238.18	256.04	275.24	295.89	318.08	341.94	367.58	395.15	424.79	1993.02
Total Benefits																						2507.65
Costs																						
capital cost	118.50	127.39	136.94	147.21	158.25	170.12	182.88	196.60	211.34	227.19	244.23	262.55	282.24	303.41	326.16	350.63	376.92	405.19	435.58	468.25	503.37	2314.884
operational cost	0.00	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	155.1459
																						2470.03
NPV	37.62																					
B-C Ratio	1.02																					

Table 14 Sensitivity Analysis using discount rate of 10%

sensitivity Analysis																						
Future Values ($ Milllions)																						
																						NPV
Benefits	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	
value of time saved	0	2.77	3.35	4.46	4.06	4.46	4.91	5.40	5.94	6.53	7.18	7.90	8.69	9.56	10.52	11.57	12.73	14.00	15.40	16.94	18.64	71.51
value of health benefits	0	3.00	3.63	4.83	4.39	4.83	5.31	5.85	6.43	7.07	7.78	8.56	9.42	10.36	11.39	12.53	13.78	15.16	16.68	18.35	20.18	77.45
employment created	0	10.05	12.16	16.19	14.71	16.19	17.80	19.58	21.54	23.70	26.07	28.67	31.54	34.70	38.16	41.98	46.18	50.80	55.88	61.46	67.61	259.46
reduction in emissions	0	110.00	133.10	177.16	161.05	177.16	194.87	214.36	235.79	259.37	285.31	313.84	345.23	379.75	417.72	459.50	505.45	555.99	611.59	672.75	740.02	2839.83
Total Benefits																						3248.25
Costs																						
capital cost	118.50	130.35	143.39	157.72	173.50	190.85	209.93	230.92	254.02	279.42	307.36	338.09	371.90	409.09	450.00	495.00	544.50	598.95	658.85	724.74	797.21	2941.52
operational cost	0	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	16.36	155.15
																						3096.66
NPV	151.58																					
B-C Ratio	1.05																					