UNIVERSITY OF NAIROBI ENTERPRISES AND SERVICES LTD

REPORT ON COST BENEFIT ANALYSIS (CBA) FOR POLICY INTERVENTIONS

CONSULTING SERVICES ON THE PILOT PROJECT OF THE GLOBAL FUEL ECONOMY INITIATIVE (GFEI): NO: ERC/PROC/4/3/12-13/189

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MARCH 2014

28th March, 2014

The Director General
Energy Regulatory Commission
3rd Floor, Eagle Africa, Longonot Road, Upper Hill
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Dear Sir/Madam,

SUBMISSION OF COST BENEFIT ANALYSIS REPORT

Please receive the revised Cost Benefit Analysis (CBA) Report for the Consulting Services on the Pilot Project of the Global Fuel Economy Initiative (GFEI): Proposal No: ERC/PROC/4/3/12-13/189. We are available at your convenience to discuss the contents of this report and seek concurrence on the way forward on the gaps, comments and suggestion to improve the report.

Yours sincerely,

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EXECUTIVE SUMMARY

Background

It is projected that the global vehicle fleet will significantly rise by the year 2050. This presents an opportunity for policy makers to design tools that will respond to the expected challenges while ensuring overall economic and environmental efficiency. Reduction in the level of CO_2 emission and the average fuel consumed per kilometer is therefore necessary in ensuring fuel efficiency to the vehicles within an economy. Based on the data of the Kenya motor vehicle inventory, the estimated CO_2 emission is 185 gCO_2/km and 7.61 L/100Km (litres per 100 km travelled). The global target termed "50by50" implies having a 50 per cent CO_2 emission level and average fuel consumption reduce by the year 2050. In view of these, various policy interventions have to be specified and implemented to attain the ambitious targets.

Main Objective

The main objective of the Cost Benefit Analysis report is to identify, measure and value the economic, financial and social benefits and costs of identified policy interventions in reducing CO_2 emissions and average fuel consumption.

Methodology

In this section the Cost Benefit Analysis (CBA) is utilized to identify, measure, and value in monetary terms the benefits and costs of identified policy interventions. The methodology is based on a discounting rate of ten (10) per cent, fuel efficiency costs and benefits based on pump prices; environmental costs and benefits based on CO_2; and public health costs based on the direct medical costs of treating respiratory illnesses. The Kenya vehicle inventory data was utilized for the purposes of estimating the expected CO_2 emission and the average fuel consumed per kilometer up to the year 2050 using the GFEI toolkit. Additionally, the Net Present Value (NPV) and Internal Rate of Return (IRR) are used as the criterion for accepting or rejecting a policy intervention. However, one of the main limitations of the study is that GFEI toolkit that was used is somewhat restrictive in the scope of suggested policy interventions and hence recommends adoption of other tools and models to be used in projecting future CO_2 emissions and average fuel consumption by the vehicle inventory.

Results

The analysis shows that at the current fuel economy level (7.61 L/100km), it costs the economy approximately Kshs 29 billion per year in fuel consumption based on prevailing pump prices. The estimates for diesel were computed using the same approach, yielding a cost of Kshs. 3.6 billion. Expenditure on motorcycle fuel consumption was estimated at Kshs 20 billion. At the same time, estimation of vehicle CO_2 emissions based on an average of 185.35 gCO_2/Km in the year 2012 reveals that total emissions of 717 thousand tonnes of CO_2 valued at Kshs 609 Million. In brief, the results show that adopting a mix of policies encompassing both fuel tax and vehicle labeling options yield Internal Rate of Return (IRR) that is higher than discount rate hence higher savings to the public.

Recommendations

The Cost Benefit Analysis recommends the following;

- A strategic mix of vehicle policy options and fuel tax options should be implemented as demonstrated in the CBA analysis.
- Vehicle policy options such as a high CO_2 based vehicle ownership tax are seen to have a very high policy impact and are proposed. However, fuel tax options should not be implemented as stand-alone interventions.
- Before implementation of any policy instruments, thorough consultation with a broad spectrum of stakeholders should be undertaken. This should be done to fully capture financial and economic costs/benefits from a varied array of perspectives.
- Further analysis of the policy interventions adopting the Multi-Criteria Evaluation (MCE) methodology is recommended.

LIST OF ABBREVIATIONS

CBA	Cost Benefit Analysis
CO_2	Carbon Dioxide
ERC	Energy Regulatory Commission
FEPit	Fuel Economy Policies Impact tool
gCO_2/km	Grams of carbon dioxide emitted per kilometer travelled
GFEI	Global Fuel Economy Initiative
IEA	International Energy Agency
IRR	Internal Rate of Return
L/100km	Litres per 100 Kilometers
NPV	Net Present Value
UNES	University of Nairobi Enterprises and Services Limited
UNFCCC	United Nations Framework Convention on Climate Change

INTRODUCTION

1.1 Background

According to the International Energy Agency (IEA, 2012), the fuel demand and CO_2 emissions are likely to double by 2050 from the base year of 2010. This implies that cost effective measures have to be put in place to improve the fuel efficiency of which nearly 50 per cent is accounted for by the vehicles. It is worth noting that as at 2005, the global average fuel economy was estimated at 8L/100km and there are current efforts to half the level by the year 2050 (Global Fuel Economy Initiative GFEI 2013).

Although there are several Nations that have put in place or are currently working towards enhancing the energy efficiency standards in their jurisdictions, there are countries that lack policies to promote fuel efficiency. Notwithstanding, these countries are key markets to commodities that require a lot of energy to operate. It is against this backdrop that the Global Fuel Economy Initiative (GFEI) seeks to assist individual countries to adopt fuel economy policies in relation to the energy security, CO_2 emissions and climate change while at the same time ensuring economic stability (IEA 2012). Importantly, before adopting these set of policies there is need to test the viability and suitability of the proposals based on their estimated cost and benefits to the public.

Cuenot (2013) defines Cost-Benefit Analysis as a set of generally accepted methodological rules that seek to identify, analyze and present economic information to decision-makers as a basis to make choices between options having the potential to address a problem or opportunity. The methodology has widely been used in situations where, if a problem identified as having a potentially serious public policy concern to analyze the problem and determine how significant it is from an economic perspective. Secondly, Cost Benefit Analysis is of great importance to comparatively analyze practical options for responding to the problem in terms of options providing the greatest benefits to problem at the lowest cost.

The Cost-Benefit Analysis (CBA) framework was applied in this project as a tool to aid in decision making, by defining and comparing the benefits and costs of the various policy interventions which promote automotive fuel economy. CBA was used to assist in identifying, measuring and valuing in monetary terms the benefits and costs of identified policy interventions.

1.2 Objectives

In this project, CBA was deployed from the perspectives of: economic analysis; financial analysis and social analysis. The main objective for this was to take into account the perspectives of the society (public - welfare).

1.2.1 Specific Objectives

a) To define the policy intervention and instruments used under the CBA framework.
b) To identify and measure the expected costs and benefits from the policy interventions
c) To estimate the indicators of policy instrument feasibility
d) To select the feasible policy instrument using the CBA decision criterion.

1.3 Outcomes

It is intended that the CBA will aid in narrowing the margin for pure judgment in decision making on the proposed interventions for fuel efficiency, vehicle emissions and public health. The primary outputs and utility of the CBA include recommendations on the acceptance or rejection of the policy interventions. Table 1.1 presents the criteria used for accepting or rejecting a policy intervention (Groenendjik and Dopheide, 2003) and (Conway, 2009).

Table 1.1: Criteria for accepting or rejecting a policy intervention.

Indicator	Decision	
	Accept	Reject
NPV	NPV>0	NPV<0
IRR	IRR>discount rate (10%)	IRR<discount rate
BCR	BCR>1	BCR<1

It can be seen from the table that a combination of positive Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) that is higher than the selected discount rate is a preferred criterion for selecting a policy intervention.

1.4 Scope of the CBA

a) The time horizon for the CBA covered short, medium and long terms taking into account the GFEI framework and the 50 by 50 target.
b) The policy interventions have been categorized into fuel tax interventions and vehicle options.
c) The CBA was limited to the direct costs and benefits of the policy interventions.

1.5 Purpose of the study

In view of the current debate on developing mechanisms geared towards enhancing energy efficiency, there has been need to design policies that are effective in reducing the level of average fuel economy, the CO_2 emissions and at the same time enhancing economic sustainability for governments. It is therefore important to undertake a Cost benefit study of some of the proposed fuel economy policy instruments to help policy makers in decision making going forward.

The remaining part of report is divided into the following sections; Section 2 - operationalizing the Cost Benefit Analysis, Section 3 - conclusions and, Section 4 – the recommendations.

2 OPERATIONALIZATION OF THE CBA

2.1 Step 1: Definition of the policy intervention / project

2.1.1 Identification of policy instruments/ options

The first step of the CBA entailed definition and identification of policy instruments that were to be tested through the CBA framework. The policy instruments were identified from the International Energy Agency (IEA) - Fuel Economy Policies Impact tool (FEPit) and were categorized into: regulatory instruments; economic instruments; education/information instruments and other instruments.

In particular, the CBA considered the following policy options:-

- **Fuel tax options** which essentially deal with the tax and levies on the amount of fuel consumed by the vehicle. It is worth noting that fuel consumption characteristics of the vehicle fleet in a country and determines the average fuel consumption for every kilometer travelled. Therefore imposing a tax or levy on fuel used is expected to have a high policy impact at all levels of the economy. The fuel options include;
    a. Fuel Tax
    b. Fuel tax differentiation (lower tax for diesel or for petrol)
- **Vehicle Options** this include the following interventions such as labeling requirement for the fleet, CO_2-based Vehicle acquisition and ownership tax and used vehicle import restrictions that have been applied previously in the country.

The CBA was limited to the direct costs and benefits of the policy interventions. The analysis was conducted separately for independent policy interventions as well as simultaneously for the complete set of interventions. The CBA focused on the differences between the situation with and the situation without the policy intervention. The costs and benefits in the CBA were interpreted as incremental hence justifying the need to analyze the situation of what would have happened without the policy intervention (status quo).

2.1.2 Definition of the time horizon and physical boundary

The time horizon for the CBA was tailored to cover medium and long terms taking into account the GFEI framework and the 50 by 50 target. It also reflects Kenya's long term development blue print, Kenya Vision 2030. The physical boundary was the National context given that the interventions analyzed were treated as National Policies.

2.1.3 Specification of perspective and approach

With and without approach-The CBA focused on the differences between the situation with and the situation without the policy intervention. The costs and benefits in the CBA were interpreted as incremental hence justifying the need to analyze the situation of what would have happened without the policy intervention (status quo).

Economic Analysis-The economic CBA was undertaken to adopt a wider societal perspective in order to determine whether the policy intervention contributes to the economic welfare of the Nation. External effects attributable to the policy interventions were included in the form of public health and environmental parameters.

Social analysis-The CBA also included a social analysis of emission related illnesses. The main objective of the social analysis component in the CBA was to evaluate the health hazards associated with vehicle emission related to air pollution.

2.2 Step 2: Identification and measurement of costs and benefits

2.2.1 Identification of policy specific effects (incremental costs and benefits)

The International Energy Agency - Fuel Economy Policies Impact tool (FEPit) was used to determine the policy specific effects in relation to fuel efficiency –liters of fuel per 100 kilometers (L/100km) and vehicle emissions – grams of carbon dioxide emitted per kilometer travelled (gCO_2/km). The use of the IEA-FEPit framework was informed in keeping with the ToR requirement to apply a methodology that creates uniform and standard outputs that are interoperable, comparable and shareable globally. Table 2.1 captures the policy options and scenarios in the tool kit.

Table 2.1: Policy Scenarios for both fuel and vehicle options

State	**Fuel Options**		**Vehicle Options**			**State**
	Fuel Tax	Fuel Tax differentiation	Acquisition Tax	Ownership Tax	Import Restriction	
None	Heavy fuel subsidy	All fuels taxed the same way	No vehicle tax, or vehicle tax not depending on fuel economy			None
Low	5% subsidy to 20% tax	Diesel 5-15% cheaper than gasoline	0-5% of average vehicle price between most and least efficient vehicle		> 10 years	Low
Medium	20-50% tax on fuel price	Diesel 15-25% cheaper than gasoline	5-15% of average vehicle price between most and least efficient vehicle		5 years - 9 years	Medium

Data from the Kenya Vehicle Inventory was used to update the FEPit toolkit to reflect local and current conditions. Each policy instrument was tested for its effect on (L/100Km) and (gCO_2/km).

Table 2.2 summarizes the effects using with and without approach for three time steps namely: 2012, 2030 and 2050. It gives the projected fuel consumption and carbon emissions under the options of first, the status quo remains, combined fuel tax and vehicle labeling, vehicle labeling options only and implementing fuel tax options only.

Table 2.2: Identification of Direct Policy Effects on Fuel Efficiency and Vehicle Emissions

OPTION 1	2012	2030	2050
If Status quo (gCO2/Km)	185.35	137	105
(L/100km)	7.73	5.82	4.51
OPTION 2	**2012**	**2030**	**2050**
All Policies Implemented (gCO2/Km)	185.35	113	69
(L/100km)	7.73	4.79	2.95
OPTION 3	**2012**	**2030**	**2050**
Vehicle Options (gCO2/Km)	185.35	123	82
(L/100km)	7.73	5.21	3.49
OPTION 4	**2012**	**2030**	**2050**
Fuel tax Options (gCO2/Km)	185.35	138	104
(L/100km)	7.73	5.88	4.48

***Data source**: KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory*

Table 2.2 indicates that if status quo remains, the level of carbon emissions from vehicles is projected to be 105 gCO2/Km and the fuel consumption 4.51 L/100Km in the year 2050. Also, the results show that if a combination of fuel tax and vehicle labeling options are implemented, the level of carbon emissions and fuel emissions is projected to be 69 gCO_2/Km and 2.95L/100Km respectively. The level of carbon emission and fuel consumption is projected at 82 gCO_2/Km and 3.49 L/100Km respectively if vehicle labeling option only is implemented. Lastly, the level of fuel emission and fuel consumption is projected at 104 and 4.48 L/100Km respectively if fuel tax options are implemented. Further, non-monetized effects are described in a qualitative way and noted in discussion of results.

2.3 Step 3: Putting monetary values on costs and benefits

a. Application of monetization method and estimation of monetary costs and benefits

Using the vehicle inventory data (fleet characteristics) and the Fuel Economy Policy Impact tool (FEPIt), a baseline for the fuel efficiency and CO_2 emissions was developed (Cuenot 2013). The base years was 2012. It is worth noting that the vehicle inventory data indicates that 99 per cent of the new registrations are used imports. At the same time, the share petrol driven vehicles increased to 88.98 per cent in 2012 from 84.38 per cent in 2010. Hybrid vehicles constitute less than 0.05 per cent of total registrations in both 2010 and 2012.The important fleet characteristics that were utilized in the FEPit toolkit were: fuel type split used by vehicles; the vehicle class that is based on the engine size; the average age and share of used vehicles in the inventory.

2.3.1 Fuel efficiency costs and benefits

The Table 2.3 indicates the estimates of costs based on the total fuel consumption and the petrol price. The estimates are based on an average pump price of Kshs 113.75 and an average fuel consumption of 7.61 L/100Km. Importantly, is the estimated average daily kilometer travel of 101 km based on data from the KIPPRA transport data compendium.

Equation 2.1 was applied in computing the estimated financial costs based on fuel consumption vehicle kilometers travelled and prevailing pump prices, with variables in Table 2.3.

Estimated Financial Cost = annual fleet KM travelled * amount in Khs per KM
[2.1]

Where :

- Annual fleet Km = average daily Km*number of vehicles using petrol *365
- Amount in Kshs per Km = Average fuel economy * average fuel price/ 100

Note: The formula is applied with adjustments when computing for diesel vehicles and motor cycles.

Table 2.3: Estimation of costs 2012 based on total fuel consumption and pump price (petrol)

Estimation of Financial costs 2012 based on total fuel consumption and pump price - Petrol	
Average fuel economy (L/100Km)	7.61
Average fuel price (petrol)	113.75
Total amount (Kshs/100Km)	865.64
Conversion factor	100.00
Amount in Kshs per Km	**8.66**
Calculation of the Average km travelled per day per vehicle (2011 data)	
Average daily Km travelled	**101.5838837**
Number of vehicles using petrol (inventory 2012)	92,830.00
Daily Fleet Km travelled	9,430,031.92
Annual fleet km travelled (365)	3,441,961,651.71
Estimated Financial Cost	**29,794,910,792**

Data source: *KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory*

Table 2.3 captures the parameters and approach applied in monetizing the baseline scenario and the policy specific effects identified above. It reveals that at the current fuel economy level (7.61 L/100km), it costs the economy approximately Kshs 29 billion per year in fuel consumption based on prevailing pump prices.

Table 2.4 indicates the estimates of costs based on the total fuel consumption and the diesel price. The estimates are based on an average pump price of Kshs 105.31 and an average fuel consumption of 8.10 L/100Km.

Table 2.4: Estimation of Financial costs 2012 based on total fuel consumption and pump price – (diesel)

Estimation of Financial costs 2012 based on total fuel consumption and pump price -diesel	
Average fuel economy (L/100Km)	8.10
Average fuel price (diesel)	105.31
Total amount (Kshs/100Km)	853.03
Conversion factor	100.00
Amount in Kshs per Km	**8.53**
Calculation of the Average km travelled per day per vehicle (2011 data)	
Total Km travelled (National)	60,303,108,813.00
Total vehicle (fleet) population in Kenya	1,626,380
Average annual Km travelled (per vehicle)	37,078.12
Number of days in a year	365
Average daily Km travelled	**101.5838837**
Total number of newly registered vehicles (2012)	104,332.00
Number of vehicles using petrol	11,476.52
% of vehicles using diesel	11.00%
Daily Fleet Km travelled	1,165,829.47
Annual fleet km travelled (365)	425,527,757.57
Estimated Financial Cost	**3,629,867,515.61**

***Data source**: KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory*

The estimates for diesel were computed using the same approach as petrol, yield a cost of Kshs. 3.6 billion. The number of newly registered vehicles using diesel constitute 11 per cent of the total vehicle registered in 2012.

Table 2.5 indicates the estimated financial cost of fuel consumption of motor cycles based on an average fuel economy of 2.60L/100Km and the average daily travel distance estimated at 200km.

Table 2.5: Estimation of Financial costs 2012 based on total fuel consumption and pump price – (motor cycles)

Estimation of Financial costs 2012 based on total fuel consumption and pump price – (motor cycles)	
Average fuel economy (L/100Km)	2.60
Average fuel price (petrol)	113.75
Total amount (Kshs/100Km)	295.75
Conversion factor	100.00
Amount in Kshs per Km	**2.96**
Number of days in a year	365
Average daily Km travelled	**200**
Total number of newly registered motor cycles (2012)	97,052.00
Number of motor cycles using petrol	97,052.00
% of motor cycles using petrol	100.00%
Daily Fleet Km travelled	19,410,400.00
Annual fleet km travelled (365)	7,084,796,000.00
Estimated Financial Cost	**20,953,284,170.00**

Data source*: KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory*

The results in Table 2.5 estimate that expenditure on motorcycle fuel consumption at Kshs 20 billion. In summary, the total expenditure is estimated at Kshs. 52 billion annually, from this the government revenue from fuel sales at pump prices is estimated at 15.8 billion, assuming a 30% share of government taxes and levies. For the purposes of the CBA, the government revenue that will be foregone due to implementation of fuel economy policies will be treated as a cost, while the reduction in annual expenditure on fuel will be treated as a benefit.

2.3.2 Vehicle emissions costs and benefits

Estimation of vehicle CO_2 emissions based on an average of 185.35 gCO_2/Km in 2012 reveals that a total of 717 thousand tonnes of CO_2 was emitted, as shown in Table 2.6. In order to monetize the emissions for the CBA, an average price of verified Carbon Standard is estimated at USD 1 per ton of CO_2 was applied based on the Carbon Trade Exchange (CTE) and the Intercontinental Exchange (ICE). This exchange serves the United States, Europe, Australia and China.

Table 2.6: Estimation of benefit of foregone CO_2 Emissions - Vehicles

Estimation of Financial benefit of foregone CO_2 Emissions	
Average CO_2 Carbon credit per ton (USD)*	**1.00**
Exchange rate (1US$ to Ksh)	85.00
Average CO_2 emission gCO_2/Km (in 2012)	185.35
Calculation of the Average km travelled per day per vehicle (2011 data)	
Total Km travelled (national)	60,303,108,813.00
Total vehicle (fleet) population in Kenya	1,626,380
Average annual Km travelled (per vehicle)	37,078.12
Number of days in a year	365
Average daily Km travelled	**101.5838837**
Total number of newly registered vehicles (2012)	104,332.00
Daily Fleet Km travelled	10,598,449.75
Annual fleet km travelled (365)	3,868,434,159.72
Average gCO_2 emitted in 2012	**71,701,427,150.325**
Conversion factor	1,000,000.00
Tonnes emitted (1/1000,000)	717,014.27
Average Carbon credit per ton	850.00
Estimated Financial Benefit	**60,946,213.078**

Data source: *KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory; World Bank*

Based on this criterion and working with estimated annual fleet kilometers travelled, the emissions in 2012 were valued at Kshs 60.9 Million. The policy interventions were analyzed to establish their effect on reducing emissions. The benefits to the economy lie in establishing the amount of CO_2 emissions avoided and the value accrued upon registering and selling the carbon credits.

Table 2.7 shows the estimation of benefit of foregone CO_2 emission from motorcycles based on carbon emission estimates of 44.50 gCO_2/Km and average daily kilometer travelled estimated at 200 Km.

Costs associated with vehicle emissions were drawn from the medical report of this project. The costs are associated with direct costs of treating patients of no-communicable respiratory illnesses. As per the medical report, the costs are derived from typical fees and charges at Kenyatta National Hospital. Based on the methodology and assumptions of the medical report, approximately Kshs 115 billion was spent on treating patients with respiratory illnesses assumed to emanate from exposure to vehicle emissions. The benefits to accrue from the policy interventions are treated as the savings on treatment costs for respiratory illnesses.

Table 2.7: Estimation of benefit of foregone CO_2 Emissions – Motor cycles

Estimation of Financial benefit of foregone CO_2 Emissions (Motor Cycles)	
Average CO_2 Carbon credit per tonne (USD)*	1.00
Exchange rate (1US$ to Kshs)	85.00
Average CO_2 emission gCO_2/Km (in 2012)	44.50
Calculation of the Average km travelled per day per vehicle (2011 data)	
Number of days in a year	365
Average daily Km travelled	200
Total number of newly registered vehicles (2012)	92,052.00
Number of vehicles using petrol	92,052.00
% of vehicles using petrol	100.00%
Daily Fleet Km travelled	18,410,400.00
Annual fleet km travelled (365)	6,719,796,000.00
Average gCO2 emitted in 2012	299,030,922,000.00
Conversion factor	1,000,000.00
Tonnes emitted (1/1000,000)	299,030.92
Average Carbon credit per tonne	850.00
Estimated Financial Benefit	**254,176,283.70**

Data source: *KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory; World Bank*

b. Selection of appropriate discount rate and Discounting of costs to present value

In order to estimate the economic value of the policy interventions in 2050, the CBA made use of a discounting rate of 10% based on best practice references. The interpretation of the consultant was that future costs and benefits weigh less in the decision making framework than those occurring nearer the present time. This perception was guided by concern for issues such as inflation, risk, consumption preferences and alternative investment opportunities. Equation 2.2 captures the application of the discount rate (Groenendjik and Dopheide, 2003).

$$\text{Discount Factor} = \frac{1}{(1+i)^t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\text{Where } i = \text{discount rate in decimals}\,(0.1 \text{ for rate of } 10\%)$$

$$t = \text{the future year}$$

$$\text{Present value}\,(PV) = \text{Future value } x \text{ discount factor} \qquad [2.2]$$

2.4 Step 4: Calculation of indicators of feasibility

2.4.1 CBA Indicators

In undertaking the CBA the following indicators were derived: Net present Value (NPV); Internal Rate of Return (IRR); Benefit-Cost Ratio (BCR) and Net benefit-investment ratio (N/K ratio). The mathematical formulations are captured in Equations 2.2 to 2.6 (Groenendjik and Dopheide, 2003).

$$\text{Net Present Value} = \sum_{t=1}^{T} \frac{(\text{Benefit}_t - \text{Cost}_t)}{(1+r)^t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\textit{Where: } B_t \quad \textit{is periodic benefit}$$

$$C_t \quad \textit{is periodic cost}$$

$$\sum \quad \textit{is the summation sign} \qquad [2.3]$$

Internal Rate of Return (IRR)

$$\text{The Discount Rate is such that} = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

[2.4]

$$\text{Net Benefit Investment (N / K)Ratio} = \frac{\sum_{t}^{T} \frac{N_t}{(1+r)^t}}{\sum_{t}^{T} \frac{K_t}{(1+r)^t}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where : B_t is benefit in each year

C_t is cost in each year

$\sum$ is the summation sign

N_t is the incremental net benefit in each year after the stream has turned positive

K_t is the incremental net benefit in initial years when the stream is negative

$t = 1, 2, \ldots\ldots\ldots\ldots n$

n is the number of years

i is the (discount) rate [2.5]

2.4.2 Results of feasibility analysis 2050

In this study, as previously mentioned and utilizing the GFEI toolkit, option 1 assumes a status quo where no policy is implemented but there are improvements in the vehicle making industry that lead to reduced CO_2 emissions and fuel consumption per kilometer travelled. As shown in Table 2.8, option 1 gives an IRR of 18%.

However, Option 2 considered the scenario when combinations of the various policies are implemented both for fuel tax options and vehicle options. These resulted in the highest IRR of 19%. Option 3 includes implementing vehicle policies only that yield at least some policy impact while; the results give an IRR of 18%. While option 4 assumes that only the fuel tax options are implemented with no vehicle options. These include high fuel tax and differentiation that yields at least some policy impact when applied; the result is IRR 17%.

Testing for the Cost Benefit Analysis various policy options that have been presented under the GFEI Framework yields the following Net Present Value and the IRR (Table 2.8).

Table 2.8: Estimated NPV and IRR results from the Benefit Analysis in 2050

Option	NPV (Kshs)	IRR (%)	BCR	PV Savings (Kshs)
Option1	58,220,092,953.67	18	4.17348	6,102,057,419.54
Option 2	62,792,500,526.38	19	6.32216	9,243,641,686.06
Option 3	58,247,533,227.87	18	5.25347	7,681,111,961.41
Option 4	54,455,400,505.78	17	3.82909	5,598,514,317.28

NB: *Discount rate is estimated at 10%, based on Central Bank discounting rates and best practice.*

From the medical report, estimations of reducing the respiratory disease burden by 50% by 2050 indicate a savings of approximately Kshs 1.5 billion.

2.4.3 Sensitivity Analysis

Without tax consideration

Table 2.9 shows the sensitivity of the IRR to changes in the benefits. The interest is by how much can the benefits decrease and still obtain an IRR that is equal to or higher than the discount rate. For instance, we can observe that the expected benefits in Option 2 can decrease by a greater margin of 30.60 per cent and still have an IRR that is equal to the discount rate of 10 per cent.

Table 2.9: Sensitivity analysis without tax consideration

Sensitivity Analysis (Without tax)					
Policy Alternatives	% Increase in benefits	% IRR	% Decrease in benefits	% IRR	% Discount Rate
Option 1	3.70	10.03	-1.00	9.67	10.00
Option 2	0.45	13.16	-30.60	10.05	10.00
Option 3	0.50	11.26	-19.95	9.55	10.00
Option 4	6.00	9.23	-1.30	8.74	10.00

However, we find that in Option 1 and 4 a decline in the expected benefits by 1 per cent, will lead to an Internal Rate of Return that is lower than the discount rate. This implies that the expected benefits need to increase by a higher margin of up to 6 per cent for option 4 to break even. In this case, **Option 2 is more suitable** since it accommodates greater declines in expected benefits by up to 30 per cent. Table 2.10 indicates the policy effect on the expected benefits when tax costs are considered.

Table 2.10: Sensitivity analysis with tax consideration

Sensitivity Analysis (With tax)					
Policy Alternatives	**% Increase in benefits**	**% IRR**	**% Decrease in benefits**	**% IRR**	**% Discount Rate**
Option 1	29.88	9.05	-2.01	7.14	10.00
Option 2	0.54	10.16	-3.01	9.89	10.00
Option 3	12.00	9.21	-0.50	8.41	10.00
Option 4	78.00	10.09	-1.10	10.09	10.00

Source: Author calculations

When a tax rate of 30 per cent to the government is included and subtracted from the benefits, it can be observed that to obtain Internal Rates of Return that is equal or higher than the discount rate, option 1 and 4 have to increase by a higher margin to break even. However, the benefits in Option 2 can decline by 3 per cent and still yield IRR that is equal to the discount rate. In summary, **option 2 is chosen** since it can withstand declines of greater margin compared to the other options.

3 CONCLUSION

The CBA analysis was undertaken taking into account three broad categories of interest, namely: Fuel efficiency costs and benefits based on pump prices; Environmental costs and benefits based on CO_2; and public health costs based on the direct medical costs of treating respiratory illnesses. The economic perspective was applied with focus on public interest. Based on the rejection criteria and applying the results of the sensitivity analysis, option 2 gives the best results for implementation. The option considered the scenario when combinations of the various policies are implemented both for fuel tax options and vehicle options. The results yield a greater NPV and IRR compared to the other options and is also more resilient to declines in expected benefits.

Thus, it is evident that adopting a policy mix is essential in obtaining highest savings to the society as depicted by the present values. However, beyond looking at the NPV and IRR that, there are other components of benefits to the society such as public health and reduced air pollution issues that need to be considered. These may not be accurately captured in monetary terms but their value can be alluded to in qualitative /scenario based means. The aspect of Disability Adjusted Life Years (DALY) as per the medical report component and global warming can be grouped into this category of effects.

4 RECOMMENDATIONS

Based on the foregoing analysis, the following policy recommendations are derived:

- A strategic mix of vehicle policy options and fuel tax options should be implemented as demonstrated in the CBA analysis. The implementation should be done simultaneously to yield affirmative impacts. However, based on prevailing socio-economic conditions, fuel tax options can be relaxed to moderate levels taking into account the cost of living and the cost of doing business in the economy.
- Vehicle policy options such as a high CO_2 based vehicle ownership tax are seen to have a very high policy impact and are proposed. Vehicle labeling options and CO_2 based vehicle acquisition taxes are also recommended. The analysis reveals that high used imports restrictions yield very small policy impacts and are therefore not proposed. It should be noted that vehicle options can be implemented individually. However, fuel tax options should not be implemented as stand-alone interventions.
- Before implementation of any policy instruments, thorough consultation with a broad spectrum of stakeholders should be undertaken. This should be done to fully capture financial and economic costs/benefits from a varied array of perspectives. The consultation process is anticipated to improve the CBA analysis by enriching the scope of estimated policy effects.
- Further analysis of the policy interventions adopting the Multi-Criteria Evaluation (MCE) methodology is recommended. It is anticipated that the use of alternative approaches will enrich the decision making process and identify qualitative effects that cannot be monetized rationally.

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