Baseline Setting for Vehicle Fuel Efficiency Improvement and CO2 Emission

By
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Outline

- Background
- Policy review
- Objective
- Collect vehicle registration data
- Cleaning data
- Structuring data
- Estimate baseline fuel economy
- Policy Measure for Fuel Efficient Vehicles
Background

- It is estimated that the vehicle population in Ethiopia has exceeded 450,0000 and growing with above 8% annually. Among this about 300,000 are light duty vehicles which emit about 2.3 million ton of CO2 per annum.
- Most of the light duty vehicles are older than 10 years and beyond their useful service life. As a result, high fuel consumption, emission of pollutants and road accident prevail.
- Hence, Ethiopia is working with United Nations Environment Program (UNEP) to increase vehicle fuel efficiency by identifying and implementing relevant policy packages and this study is part of that.
Objective

- The main objective for this study, setting a baseline and developing a national vehicle database,
  - indicate the trend in fuel economy
  - determine the trend in Carbon dioxide emission level.
Review of Policy and Legislation

- Ethiopia’s taxation system of imported vehicles is progressive with cylinder volume.
- There is no regulation that the limit age of import of second-hand vehicles.
- There is no regulation that encourage cleaner and fuel efficient vehicles such as Hybrid and electric vehicles.
- There is no regulation that limits emission of pollutants from vehicles such as Euro standards for catalytic converter and diesel particle filters.
Collection of Vehicle Data

• Records of LDVs at ERCA are the main sources of data for the study of pilot GFEI project in Ethiopia

• LDVs data are also collected from new brand vehicle importer and assembler

  • LDVs incorporate those which are
    • Newly registered in the year 2005, 2008 and 2010
    • With gross weight less than 3500kg
    • Whose seat capacity ranges b/n 2 and 15
    • Brand new as well as the used one
Classification of Light Duty Vehicles

- Based on body type LDVs classified as
  - Compact car
  - Saloon
  - SUV
  - Minivan and Van
  - Pick-up
## LDVs Registered by Year from ERCA and Assembler s

### ERCA data

<table>
<thead>
<tr>
<th>Import Years</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>5598</td>
<td>10254</td>
<td>14931</td>
</tr>
<tr>
<td>Quantity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Local Assembler

<table>
<thead>
<tr>
<th>Assembled Years</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles Quantity</td>
<td>0</td>
<td>257</td>
<td>450</td>
</tr>
</tbody>
</table>
Total LDVs versus Registration Year

<table>
<thead>
<tr>
<th>Registration Year</th>
<th>LD Vehicle Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>6000</td>
</tr>
<tr>
<td>2008</td>
<td>12000</td>
</tr>
<tr>
<td>2010</td>
<td>18000</td>
</tr>
</tbody>
</table>
Total Registered LDVs by Condition

<table>
<thead>
<tr>
<th>Year</th>
<th>New</th>
<th>Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>2000</td>
<td>4000</td>
</tr>
<tr>
<td>2008</td>
<td>3394</td>
<td>6653</td>
</tr>
<tr>
<td>2010</td>
<td>5391</td>
<td>10116</td>
</tr>
</tbody>
</table>
Major Data Attributes for the Baseline Setting

- Vehicle make and model,
- Model production year
- Year of first registration, if different from model year
- Fuel type
- Engine size
- Domestically produced or imported
- New or second hand import
- Rated Fuel Economy per model and test cycle basis.
- Number of sales by model
Nature of Raw Data from ERCA

Data collected from custom authority has severe irregularities and un registered information

Raw Vehicle Data

<table>
<thead>
<tr>
<th>Car Model</th>
<th>Vehicle Number</th>
<th>Engine</th>
<th>Model</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOYOTA COROLLA</td>
<td>CH#JT1EOEE9000447281, M/Y1992 MODEL-EE90L-AEMDEW, ENG-2E-2451657</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGINE 3L-5475634, MODEL LN166L-PRMDS, M/Y2004</td>
<td>TOYOTA HILUX DOUBLE CABINE PICKUP CH.NO. JTFDE626X00128020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NISSAN X-TRAIL MOD.TVHNLAYT30URAY062Z (CH.NO. JN1TENT30Z0005735 EN.NO. YD22146725)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1*2ND HAND CAR TOYOTA COROLLA, M.Y 1992</td>
<td>(CH#. JT1LOEE9007143710, CC 1295 MOD#. EE90L-ALMDEW, ENG#. 2E-2441128)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOYOTA CORLLA, CH.NO. JTFDE626X00128021</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td>Model</td>
<td>Condi.</td>
<td>Body Type</td>
<td>Engine Type</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>--------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>TOYOTA</td>
<td>Corolla</td>
<td>USED</td>
<td>Saloon</td>
<td>Petrol</td>
</tr>
<tr>
<td>TOYOTA</td>
<td>Corolla</td>
<td>USED</td>
<td>Saloon</td>
<td>Petrol</td>
</tr>
<tr>
<td>FORD</td>
<td>Fiesta</td>
<td>NEW</td>
<td>Compact</td>
<td>Petrol</td>
</tr>
<tr>
<td>HYUNDA</td>
<td>Getz</td>
<td>NEW</td>
<td>Compact</td>
<td>Petrol</td>
</tr>
<tr>
<td>NISSAN</td>
<td>Hardbody</td>
<td>NEW</td>
<td>Pick Up</td>
<td>Diesel</td>
</tr>
<tr>
<td>TOYOTA</td>
<td>Hilux</td>
<td>USED</td>
<td>Pick Up</td>
<td>Diesel</td>
</tr>
<tr>
<td>TOYOTA</td>
<td>Land cruiser</td>
<td>NEW</td>
<td>S.Wagon</td>
<td>Diesel</td>
</tr>
</tbody>
</table>
## Volume Classification by Engine

<table>
<thead>
<tr>
<th>Volume (cc)</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>PETROL</td>
<td>DIESEL</td>
<td>PETROL</td>
<td>DIESEL</td>
</tr>
<tr>
<td>≤ 1000</td>
<td>204</td>
<td>0</td>
<td>142</td>
</tr>
<tr>
<td>1001-1300</td>
<td>1834</td>
<td>8</td>
<td>3378</td>
</tr>
<tr>
<td>1301-1800</td>
<td>309</td>
<td>8</td>
<td>417</td>
</tr>
<tr>
<td>1801-2000</td>
<td>260</td>
<td>2</td>
<td>122</td>
</tr>
<tr>
<td>2001-2500</td>
<td>72</td>
<td>146</td>
<td>68</td>
</tr>
<tr>
<td>≥ 2500</td>
<td>115</td>
<td>1953</td>
<td>192</td>
</tr>
</tbody>
</table>
Registered LD Vehicles by Age Group

![Bar chart showing the number of LD vehicles registered by age group for 2005, 2008, and 2010. The chart includes age ranges 1 to 5, 6 to 10, 11 to 15, and > 15, with the highest quantity in the 1 to 5 age group for 2010, followed by 6 to 10 for 2005 and 2008, 11 to 15 for 2008, and > 15 for 2005 and 2008.]
Classification of Regist. Vehicles by Body Type
Quantity of Imported Vehicles by Brand

- **TOYOTA**
- **NISSAN**
- **DAIHATSU**
- **SUZUKI**
- **MITSUBISHI**
- **LIFAN**
- **HYUNDAI**
- **DONGFENG**
- **FORD**
- **LADA**

The chart shows the quantity of imported vehicles by brand for the years 2005, 2008, and 2010.
Classification by Fuel Type

- **2005**: Diesel: 2000, Petrol: 3000
- **2008**: Diesel: 5000, Petrol: 4000
- **2010**: Diesel: 7000, Petrol: 8000
Average Fuel Economy and Emission

Harmonic average annual fuel economy = \[
\frac{\text{Total sales in the year}}{\sum_i \text{sales model } i \times \text{fuel economy model } i}
\]

Average annual CO2 emission = \[
\frac{\sum_i \text{sales model } i \times \text{emission model } i}{\text{Total sales in the year}}
\]
Fuel Economy

- All auto fuel economy records included in this database are in compliance with European Driving cycle.

- The urban driving cycle known as ECE which is devised to represent city driving conditions.

- The extra urban driving cycle represents high way driving condition.
## HAAFE Vs Registration Year for all LDVs

<table>
<thead>
<tr>
<th>Registration Year</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonic Average Annual Fuel Economy (L/100Km)</td>
<td>8.4</td>
<td>8.4</td>
<td>7.9</td>
</tr>
</tbody>
</table>

![Graph showing HAAFE vs registration year](image)
## AA CO₂ Vs Registration Year for all LDVs

<table>
<thead>
<tr>
<th>Registration Year</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Annual CO₂ Emission (g/Km)</td>
<td>217</td>
<td>221</td>
<td>212</td>
</tr>
</tbody>
</table>

![Graph showing AA CO₂ Emission vs Registration Year](image-url)
Average Fuel EConomy Vs Registration Year for Diesel LDVs

<table>
<thead>
<tr>
<th>Registration Year</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonic Average Annual Fuel Economy (Km/L)</td>
<td>9.3</td>
<td>9.4</td>
<td>9</td>
</tr>
</tbody>
</table>

![Graph showing the decrease in Harmonic Average Annual Fuel Economy (HAAFE) for Diesel LDVs from 2005 to 2010.](image)
AA CO₂ Vs Registration Year for Diesel LDVs

<table>
<thead>
<tr>
<th>Registration Year</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Annual CO₂ Emission (g/Km)</td>
<td>251</td>
<td>255</td>
<td>245</td>
</tr>
</tbody>
</table>

![Graph showing CO₂ emissions over registration years](image-url)
HAAFE Vs Registration Year for Petrol LDVs

<table>
<thead>
<tr>
<th>Registration Year</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonic Average Annual Fuel Economy (Km/L)</td>
<td>7.8</td>
<td>7.4</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Registration Year

Harmonic Average Annual Fuel Economy (Km/L)
### AA CO₂ Vs Registration Year for Petrol LDVs

<table>
<thead>
<tr>
<th>Registration Year</th>
<th>2005</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Annual CO₂ Emission (g/Km)</td>
<td>191</td>
<td>180</td>
<td>173</td>
</tr>
</tbody>
</table>

![Graph showing the decrease in average annual CO₂ emission for Petrol LDVs over different registration years.]
Comparison of Average Vehicle CO2 Emission data with the International Trend.
Policy Measures: Vehicle Efficiency Improvement

- Mandatory requirement of fuel efficiency and emission certificate for vehicles to be imported or assembled in the country.
- Banning of import of old second hand vehicles
- Introduction of hybrid and electric vehicle by offering tax incentives (Excise and Sur Tax)
- Improvement of maintenance infrastructure of vehicles and
- Increasing awareness on Eco driving
Technology Options: Electric vehicle
Policy Measures: Imported Vehicles Age Limit

- Algeria - must be less than 3 years old.
- Brazil Imports of used vehicles are not allowed
- South Africa does not allow
- Sudan new (except migrants)
- Jordan, less than 5 years old.
- Kenya 8 years
- Lesotho 8 years
- Gabon 5 years
- Mozambique cars – 5 Vans -9
- Niger 5 years (Diesel=360 ppm sulfur petrol=160 sulfur)
Policy Measures: Awareness for ECO Driving

- Start slowly, avoiding rapid acceleration.
- Gear-up, use the highest gear possible, and lower the engine speed.
- Maintain a constant speed
- Anticipate traffic conditions, and accelerate and decelerate smoothly – it is safer, uses less fuel, and reduces brake wear.
- Drive at posted speed limits.
- Avoid idling for any stop of more than 60 seconds reduces fuel consumption and carbon dioxide emissions.
- Avoid excessive weight - on roof of car or boot causes additional fuel consumption.
- Check the tire pressure monthly with cold tires.
- Replace air filters regularly - saving up to 10% fuel consumption.
Policy Measures: *Promoting Use of Cleaner Fuels*

- Amending the Ethiopian standard for limiting sulfur to 50 ppm maximum in diesel fuel by 2015 so that modern vehicles with diesel engines with lower particulate emissions can effectively use particulate filter for cleaning exhaust.

- Preparation of incentive package to promote biodiesel production such as VAT exemption
Policy Measures: Cleaner Vehicles

- Legislation Emission Standards by 2016 or by adopting Euro IV standard taking a transition with Euro III.
- Emission certificate shall be presented as per European Driving Cycle.
- The Standard shall not be applicable Three wheel vehicles which will be used outside Addis Ababa
- Three wheel vehicles shall have 4 stroke engines.
- Tail pipe CO emission test shall be conducted to check functionality of Catalytic converters.
Conclusions

- This study indicates that the average fuel economy for LDVs in Ethiopia in 2005 and 2008 were 8.4 L/100Km with corresponding CO₂ emission of 217 and 221 gCO₂/km.

- The same study shows that in 2010 the fuel economy slightly decreased to 7.9 L/100Km with a corresponding CO₂ emission of 212 gCO₂/km.

- Diesel fueled LDVs were found to travel less kilometer per liter of fuel as compared to petrol engine vehicles and emit more CO₂ than petrol fueled vehicles.

- This results are in lower regime when compared to that of reported in the literature [ICT,2012], which is caused by importation of second hand vehicles and relatively larger share of Vans, SUVs and Pick-ups in the total import of LD Vehicles.