Workshop on

Improving Fuel Efficiency of City Bus Services through ESMAP Approach in Select NURM Cities

Date 17.11.2019

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Dy. Director (Transport) - PCRA
In This Workshop

• **Problem** – Fuel Efficiency is **Not at Optimum Level** in Many City Bus Service

• **Solution** – Fuel Efficiency Improvement Through **Targeted Bus Maintenance and Targeted Driver Training** (Methodology - ESMAP Approach)

• **Demonstration** – **Fuel Saving at Depots** Who Volunteered for this Program
PCRA OFFICES

National HQ – New Delhi
- Northern Region – New Delhi
  - Chandigarh
  - Jaipur
  - Lucknow
  - Dehradun
- Eastern Region – Kolkata
  - Guwahati
  - Bhubaneswar
  - Patna
  - Ranchi
- Western Region - Mumbai
  - Rajkot
  - Ahmedabad
  - Pune
  - Nagpur
  - Raipur
  - Bhopal
- Southern Region – Chennai
  - Bangalore
  - Vishakhapatnam
  - Kochi
  - Coimbatore
  - Hyderabad
PCRA ACTIVITIES
MAIN FOCUS ON DEMAND SIDE MANAGEMENT (DSM)
PCRA – Major Policy Initiatives

- Fuel Economy Norms for Passenger Cars
- Fuel Economy Norms for Light Medium and Heavy Commercial Vehicles
- Standard and Labelling Program for Agriculture Tractors
- Standard and Labelling Program for Tyres
- Mandatory Fuel Efficient Driver Training for the Heavy Duty Vehicle Driving License
About ESCBS Project

Global Environment Facility Funded: **Efficient & Sustainable City Bus Service (ESCBS) Project** - initiative of Ministry of Housing and Urban Affairs (MoHUA) with support of World Bank.

Component - Improving Fuel Economy of City Bus Services Using ESMAP Approach

- **65 Cities** under NURM Project
- **50% Cities** covered under ESCBS project
- **34 depots** Volunteered for Fuel Efficiency Program

65 Cities under NURM Project

50% Cities covered under ESCBS project

34 depots Volunteered for Fuel Efficiency Program
Brief About PCRA Program

Number of Round – 2

Number of Depots – 15/18

Number of Buses – 2883

Number of Drivers – 5753
List of Bus Depots - Volunteered for Program

1. Rajghat-1 Depot, New Delhi
2. Vasant Vihar Depot, New Delhi
3. Rohini - II Depot, New Delhi
4. Gazipur Depot, New Delhi
5. Orange Street Depot, Nagpur
6. Market Yard Depot, Pune
7. Katraj Depot, Pune
8. Pune Station Depot, Pune
9. Rajiv Circle (BRTS) Depot, Indore
10. Khajrana Depot, Indore
11. Chandola Depot, Ahmedabad
12. Kolhapur Depot, Kolhapur
13. Amanaka Depot, Raipur
14. Pandari Depot, Raipur
15. Noonmati Depot, Guwahati
16. Kasba Depot, Kolkata
17. Tollygunj Depot, Kolkata
18. Sums Hospital Depot, Bhubaneswar
Program Objective

• **To Encourage** city bus fleet operators initiate and adopt fuel efficiency program based on the ESMAP Approach

• **To Share**
  – the experience regarding effectiveness of the ESMAP Approach
  – the potential or actual improvements that could be made to the ESMAP Approach.
PCRA Team

HoD Transport
Mr. Rajiv Khanna

3 Officers

Team Lead-North
1 Officer
2 Bus Maintenance Engineer
2 Driver Trainer

Team Lead-West
4 Officer
7 Bus Maintenance Engineer
7 Driver Trainer

Team Lead-East
3 Officer
3 Bus Maintenance Engineer
4 Driver Trainer
Why Fuel Efficiency?
India’s Petroleum Consumption

CAGR – 4.9 %
Diesel Consumption – End Use Sector Wise

Transport, 73.6% (61.5 MMT)

Agriculture, 14.1%

Industry, 8.2%

Others, 4.1%

Total Diesel Consumption (2018-19)- 83.5 MMT
Typical Cost of Fuel for a Depot with 100 Bus

- Number of Bus = 100
- Depot’s Total km Run = 350 Days x 200 km x 100 Bus = 70 lac km per year
- Depot’s Fuel Consumption = 70 lac km/3.5 kmpl = 20 lac liter
- Depot’s Operating Cost/km = 50 INR
- Fuel Cost/Liter = 65 INR

Depot’s Operating Cost 35 cr.

Fuel Cost 13 cr.

37% Fuel Cost
Typical Operating Cost of City Bus Service

Operating cost breakup?

**Fuel**
- Single Largest Cost Item
- Price Volatility Significantly Affect Budget

Therefore Fuel Efficiency is Very Important in City Bus Service
Potential of Energy Conservation in CO\textsubscript{2} Emission Reduction

1 L Diesel Emits – 2.68 kg CO\textsubscript{2}

Source: International Energy Agency - 2009
Major Benefits of Fuel Saving-City Bus Service

Long Term Sustainability

- Reduced Fuel Consumption
- Reduced Operating Cost

Improved Air Quality

- Reduced Level of Air Pollutant (e.g. PMx, NOx)
- Reduced Green House Gas (GHG) Emissions

Short Term Benefit

- Cost Saving
Global Experience- ESMAP Approach

- **Edmonton, Canada**
  - 1,000 buses
  - Fuel-saving training program for all drivers
    - *Fuel economy improved 5.5%*

- **Jakarta, Indonesia**
  - Improved inspection program for engines, exhaust
    - *Fuel economy improved 5%*
  - Trained drivers on fuel-saving operating practices
    - *Fuel economy improved an added 10%*

- **Hyderabad, India**
  - Targeted maintenance of 10% low-performing buses
    - *Fuel economy improvement of 4-5%*
  - Targeted training of 5% low-performing drivers
    - *Fuel economy improvement of 6-8%*
ESMAP Approach for Improving Fuel Efficiency in City Bus Services
Factors Affecting Fuel Consumption

Route Characteristics
- Speed, Number of Stops, Traffic Condition
- Passenger Load, Terrain (Plane or Hilly) etc.

Bus Characteristics
- Engine HP, Bus Size, Transmission Type
- Use of Air-conditioning, Age of Fleet etc.

Bus Maintenance
- Facility, Spare Availability, Quality and Periodicity, Preventive Maintenance

Driving Skill
- Lack of Institutional Training (Focus-unlearning of inefficient driving habits)
Why Bus Targeting?
Bus Targeting

Identical Bus: 4.0 kmpl

Same Route: 3.7 kmpl
Bus Targeting

Identical Bus

Different Route

Total Buses = 10,
Route KMPL= 4.2,
Relative KMPL= -0.2 - Poor

Total Buses = 10,
Route KMPL= 3.4,
Relative KMPL= 0.1
Bus Targeting

- **Same Route**
- **Different Bus Type**

**Bus KMPL(1)** = 4.0
**Route KMPL(1)** = 3.8
**Rel. KMPL(1)** = 0.2

- Poor

**Bus KMPL(2)** = 4.8
**Route KMPL(2)** = 4.7
**Rel. KMPL(2)** = 0.1

**BUS 1**
**BUS 2**
| Bus  | Route | Bus Type | KM  | Liters | (Step 1) Average kmpl | (Step 2) Route/Bus Type Average (kmpl) | (Step 3) Relative Fuel Economy (kmpl) | Rank (1=Lowest) |
|------|-------|----------|-----|--------|-----------------------|----------------------------------------|----------------------------------------|----------------|----------------------------|
| 101  | 12    | 1        | 4,435 | 1,341  | 3.31                  | 3.45                                   | -0.14                                  | 3              |                            |
| 102  | 12    | 1        | 4,689 | 1,256  | 3.73                  | 3.45                                   | 0.28                                   | 9              |                            |
| 103  | 12    | 1        | 4,325 | 1,299  | 3.33                  | 3.45                                   | -0.12                                  | 4              |                            |
| Average | 12    | 1        | 13,449 | 3,896 | 3.45                  |                                        |                                        |                |                            |
| 104  | 12    | 2        | 4,897 | 1,404  | 3.49                  | 3.22                                   | 0.26                                   | 8              |                            |
| 105  | 12    | 2        | 4,478 | 1,501  | 2.98                  | 3.22                                   | -0.24                                  | 2              |                            |
| 106  | 12    | 2        | 4,690 | 1,459  | 3.21                  | 3.22                                   | -0.01                                  | 5              |                            |
| Average | 12    | 2        | 14,065 | 4,364 | 3.22                  |                                        |                                        |                |                            |
| 107  | 14    | 1        | 4,890 | 1,267  | 3.86                  | 3.62                                   | 0.24                                   | 7              |                            |
| 108  | 14    | 1        | 4,550 | 1,356  | 3.36                  | 3.62                                   | -0.27                                  | 1              |                            |
| 109  | 14    | 1        | 4,724 | 1,289  | 3.66                  | 3.62                                   | 0.04                                   | 6              |                            |
| Average | 14    | 1        | 14,164 | 3,912 | 3.62                  |                                        |                                        |                |                            |
Why Driver Targeting?
Driver Targeting

- Same Route
- Identical Buses
- Different Drivers

Driver 1

4.5 kmpl

Driver 2

4.2 kmpl
Driver Targeting

Identical Buses
Different Driver
Different Route

Driver 1

Total Driver = 10, Route KMPL= 4.2, Relative KMPL= -0.2 - Poor

Driver 2

Total Driver = 10, Route KMPL= 3.4, Relative KMPL= 0.1
Driver Targeting

- Same Route
  - Driver KMPL(1) = 4.0, Route KMPL(1) = 3.8, Rel. KMPL(1) = 0.2
  - Driver KMPL(2) = 4.8, Route KMPL(2) = 4.7, Rel. KMPL(2) = 0.1 – Poor

- Different Bus Types

- Different Drivers

Driver 1

Driver 2
# Driver Targeting

<table>
<thead>
<tr>
<th>Driver</th>
<th>Route</th>
<th>Bus Type</th>
<th>KM</th>
<th>Liters</th>
<th>(Step 1) Average kmpl</th>
<th>(Step 2) Route/Bus Type Average (kmpl)</th>
<th>(Step 3) Relative Fuel Economy (kmpl)</th>
<th>Rank (1=Lowest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>512</td>
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<td>1</td>
<td>4,456</td>
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<td>3.45</td>
<td>0.16</td>
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<td>4,678</td>
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<td>Average</td>
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<td>1,489</td>
<td>3.01</td>
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<td>-0.21</td>
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<td>3.22</td>
<td>-0.04</td>
<td>4</td>
</tr>
<tr>
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<td>14,065</td>
<td>4,364</td>
<td>3.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>4,980</td>
<td>1,276</td>
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<td>3.62</td>
<td>0.28</td>
<td>9</td>
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<tr>
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<td>14</td>
<td>1</td>
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<td>1,245</td>
<td>3.65</td>
<td>3.62</td>
<td>0.03</td>
<td>5</td>
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<td>1,391</td>
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<td>3.62</td>
<td>-0.28</td>
<td>2</td>
</tr>
<tr>
<td>Average</td>
<td>14</td>
<td>1</td>
<td>14,164</td>
<td>3,912</td>
<td>3.62</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ESMAP Approach
Implementation
ESMAP Approach - Action Points

Management Actions
- Management Commitment and Ownership
- Employee Communication & Recognition

Technical Actions
- Data Collection and Analysis to Identify Bus & Drivers
- Targeted Bus Maintenance of Low-fuel Efficient Buses
- Training of Low-Performing Drivers
Technical Actions

Data Collection and Analysis using FEAT software to Identify

- 10% Low-fuel Efficient Buses
- 5% Low-Performing Driver

Level-1 Maintenance
- 20 Point Checks

Level-2 Maintenance
- 19 Point Checks if KMPL improvement <=3%

Classroom and On-road Training

Follow-up Monitoring for 3 Successive Weeks
Total 4 Rounds of Activity

Round-1
- Conducted by PCRA
- Train the Trainer Approach

Round-2
- Conducted by PCRA
- Present Finding and Share Learning

Round-3
- Conducted by Depot
- Supported by PCRA

Round-4
- Conducted by Depot
- Supervision by PCRA

Sustain
- Continuous Implementation by Depot

Pre-engagement
- Outreach
- Manpower Deployment
- Data Collection and Training

Time Required for Activities Per Round – 6 to 8 weeks
Pre-Engagement Task
Pre-Engagement Task
### “Train the Trainer” Approach

<table>
<thead>
<tr>
<th>Depot Executive</th>
<th>Number of Executives Trained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodal Officer in Each Depot</td>
<td>18</td>
</tr>
<tr>
<td>Data Operator cum Analyst</td>
<td>20</td>
</tr>
<tr>
<td>Bus Maintenance Manager</td>
<td>23</td>
</tr>
<tr>
<td>Bus Driver Trainer</td>
<td>19</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>80</strong></td>
</tr>
</tbody>
</table>
### Bus Inventory

<table>
<thead>
<tr>
<th>Bus Code</th>
<th>Bus Type</th>
<th>Bus Registration Number</th>
<th>Manufacturer</th>
<th>Manufacturing Year</th>
<th>Seats</th>
<th>AC / NonAC</th>
<th>Floor Type</th>
<th>Horse Power</th>
<th>Transmission Type</th>
<th>Lifetime Bus KM</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>3</td>
<td>KA5F-0101</td>
<td>LEYLAND</td>
<td>2013</td>
<td>48</td>
<td>NON AC</td>
<td>SEMI</td>
<td>130</td>
<td>MANUAL</td>
<td>485266</td>
</tr>
</tbody>
</table>

### Driver Inventory

<table>
<thead>
<tr>
<th>Driver Code</th>
<th>Driver Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>512</td>
<td>Ravi Kumar Sahu</td>
</tr>
</tbody>
</table>
## Data Collection - Formats

<table>
<thead>
<tr>
<th>Route Code</th>
<th>One Way Length KM</th>
<th>One Way Std Trip Time Min</th>
<th>Buses Operated</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>17.80</td>
<td>70</td>
<td>6</td>
</tr>
</tbody>
</table>
### Data Collection - Formats

#### Fuel Consumption

<table>
<thead>
<tr>
<th>Input Date</th>
<th>Route Code</th>
<th>Bus Code</th>
<th>Driver1 Code</th>
<th>Driver2 Code</th>
<th>Driver3 Code</th>
<th>Daily Operated KM</th>
<th>Fuel Added Liters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Jul-19</td>
<td>12</td>
<td>101</td>
<td>512</td>
<td>514</td>
<td></td>
<td>207.2</td>
<td>45</td>
</tr>
</tbody>
</table>

- Daily one entry for each bus - In depot with 100 buses
- Typically 3000 data points are to be carefully analyzed
# Data Validation

<table>
<thead>
<tr>
<th>Type of Error</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Missing or incorrect entry during manual recording in paper</td>
<td>1. Raised awareness among executives at all level</td>
</tr>
<tr>
<td>2. Error while transcribing in electronic format</td>
<td>2. Training provided to data entry operator</td>
</tr>
<tr>
<td></td>
<td>3. Verified and corrected erroneous data</td>
</tr>
</tbody>
</table>
Data Analysis Using FEAT Tool

Simple MS Access based Program
### Data Analysis Using FEAT Tool

**Fuel Efficiency Analysis Tool - FEAT**

#### Routes

To insert a new record, click on the last row (New) and enter the data in the white spaces.

<table>
<thead>
<tr>
<th>ID</th>
<th>Route Number</th>
<th>One Way Length</th>
<th>Trip Time Minutes</th>
<th>Buses Operated</th>
<th>Import Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>127</td>
<td>165A</td>
<td>118.5</td>
<td>80</td>
<td>7</td>
<td>11/13/2019 10:30:31 AM</td>
</tr>
<tr>
<td>181A</td>
<td></td>
<td>128</td>
<td>80</td>
<td>15</td>
<td>11/13/2019 10:30:31 AM</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>106.4</td>
<td>80</td>
<td>6</td>
<td>11/13/2019 10:30:31 AM</td>
</tr>
<tr>
<td>879</td>
<td></td>
<td>123</td>
<td>80</td>
<td>24</td>
<td>11/13/2019 10:30:31 AM</td>
</tr>
<tr>
<td>889</td>
<td></td>
<td>137</td>
<td>80</td>
<td>4</td>
<td>11/13/2019 10:30:31 AM</td>
</tr>
<tr>
<td>954</td>
<td>957</td>
<td>112.6</td>
<td>80</td>
<td>9</td>
<td>11/13/2019 10:30:31 AM</td>
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<tr>
<td>975</td>
<td>990EXT</td>
<td>116</td>
<td>80</td>
<td>3</td>
<td>11/13/2019 10:30:31 AM</td>
</tr>
<tr>
<td>122</td>
<td>OMS (+)</td>
<td>125</td>
<td>120</td>
<td>20</td>
<td>11/13/2019 10:30:33 AM</td>
</tr>
</tbody>
</table>

**Instructions**

1. Enter a file name.
2. Select one of the three options:
   - Routes
   - Grouping Routes
   - Splitting Routes
3. Click on the corresponding button.

**Note:** The tool analyzes the fuel consumption data in the `C:\BusFuelData` folder.
## Data Analysis Using FEAT Tool

![Image of FEAT Tool interface](image-url)

### Bus inventory

To insert a new record, click on the last row (New) and enter the data in the white spaces.

<table>
<thead>
<tr>
<th>ID</th>
<th>BusNumber</th>
<th>category</th>
<th>BusInventoryNumber</th>
<th>Manufacturer</th>
<th>Year</th>
<th>Seats</th>
<th>ACorNonAC</th>
<th>SemiLowFloororLowFloor</th>
<th>HorsePower</th>
<th>TransType</th>
<th>LifetimeEngineKM</th>
<th>Life</th>
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<tbody>
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<td>7103</td>
<td>TATA</td>
<td>2010</td>
<td>35+01</td>
<td>AC</td>
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<td>230</td>
<td>Automatic</td>
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<td>1398</td>
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<td>7728</td>
<td>TATA</td>
<td>2010</td>
<td>35+01</td>
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<td>LOW FLOOR</td>
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<td>35+01</td>
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<td>LOW FLOOR</td>
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<td>Automatic</td>
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<td>1400</td>
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<td>2</td>
<td>7616</td>
<td>TATA</td>
<td>2010</td>
<td>35+01</td>
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<td>LOW FLOOR</td>
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<td>Automatic</td>
<td>7,50,000.0</td>
<td>560</td>
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<tr>
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<td>Automatic</td>
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<tr>
<td>1406</td>
<td>7653</td>
<td>2</td>
<td>7653</td>
<td>TATA</td>
<td>2010</td>
<td>35+01</td>
<td>AC</td>
<td>LOW FLOOR</td>
<td>230</td>
<td>Automatic</td>
<td>7,50,000.0</td>
<td>612</td>
</tr>
<tr>
<td>1407</td>
<td>7654</td>
<td>2</td>
<td>7654</td>
<td>TATA</td>
<td>2010</td>
<td>35+01</td>
<td>AC</td>
<td>LOW FLOOR</td>
<td>230</td>
<td>Automatic</td>
<td>7,50,000.0</td>
<td>589</td>
</tr>
<tr>
<td>1335</td>
<td>7659</td>
<td>1</td>
<td>7659</td>
<td>TATA</td>
<td>2010</td>
<td>35+01</td>
<td>NON AC</td>
<td>LOW FLOOR</td>
<td>230</td>
<td>Automatic</td>
<td>7,50,000.0</td>
<td>550</td>
</tr>
<tr>
<td>1336</td>
<td>7662</td>
<td>1</td>
<td>7662</td>
<td>TATA</td>
<td>2010</td>
<td>35+01</td>
<td>NON AC</td>
<td>LOW FLOOR</td>
<td>230</td>
<td>Automatic</td>
<td>7,50,000.0</td>
<td>600</td>
</tr>
</tbody>
</table>
### Result after Analysis from FEAT

#### Route Average

<table>
<thead>
<tr>
<th>Route Number</th>
<th>Bus Type</th>
<th>Bus HP</th>
<th>Route KM</th>
<th>Route Fuel Added</th>
<th>Route Avg. KMPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1</td>
<td>110</td>
<td>20500</td>
<td>5380</td>
<td>3.81</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>140</td>
<td>27300</td>
<td>9039</td>
<td>3.02</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>110</td>
<td>23800</td>
<td>7100</td>
<td>3.35</td>
</tr>
</tbody>
</table>
Result after Analysis from FEAT

Bus Ranking – Lowest Performing Buses on the Basis of Relative Economy

<table>
<thead>
<tr>
<th>Bus Number</th>
<th>Bus Type</th>
<th>Bus KMPL</th>
<th>Route Avg. KMPL</th>
<th>Relative KMPL</th>
<th>Bus Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>1</td>
<td>3.45</td>
<td>3.81</td>
<td>-0.36</td>
<td>1</td>
</tr>
<tr>
<td>102</td>
<td>1</td>
<td>3.31</td>
<td>3.45</td>
<td>-0.14</td>
<td>2</td>
</tr>
<tr>
<td>103</td>
<td>2</td>
<td>2.93</td>
<td>3.02</td>
<td>-0.09</td>
<td>3</td>
</tr>
<tr>
<td>104</td>
<td>1</td>
<td>3.86</td>
<td>3.81</td>
<td>0.05</td>
<td>4</td>
</tr>
<tr>
<td>105</td>
<td>2</td>
<td>3.15</td>
<td>3.02</td>
<td>0.13</td>
<td>5</td>
</tr>
<tr>
<td>106</td>
<td>1</td>
<td>3.73</td>
<td>3.45</td>
<td>0.28</td>
<td>6</td>
</tr>
</tbody>
</table>
Result after Analysis from FEAT

Driver Ranking – Lowest Performing Driver on the Basis of Relative Economy

<table>
<thead>
<tr>
<th>Driver Code</th>
<th>Bus Type</th>
<th>Driver KMPL</th>
<th>Route Avg. KMPL</th>
<th>Relative KMPL</th>
<th>Driver Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>512</td>
<td>1</td>
<td>3.43</td>
<td>3.79</td>
<td>-0.36</td>
<td>1</td>
</tr>
<tr>
<td>514</td>
<td>1</td>
<td>3.29</td>
<td>3.43</td>
<td>-0.14</td>
<td>2</td>
</tr>
<tr>
<td>513</td>
<td>2</td>
<td>2.91</td>
<td>3.00</td>
<td>-0.09</td>
<td>3</td>
</tr>
<tr>
<td>516</td>
<td>1</td>
<td>3.84</td>
<td>3.79</td>
<td>0.05</td>
<td>4</td>
</tr>
<tr>
<td>580</td>
<td>2</td>
<td>3.13</td>
<td>3.00</td>
<td>0.13</td>
<td>5</td>
</tr>
<tr>
<td>509</td>
<td>1</td>
<td>3.71</td>
<td>3.43</td>
<td>0.28</td>
<td>6</td>
</tr>
</tbody>
</table>
Bus Maintenance – Level-I Checks - 293 Buses

- Air Filter
- Wheels
- Tyre Pressure
- Driveshaft and Differential
- Lubrication
- Engine
- Air Conditioner
- Clutch and Brakes
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Level 1 checks</th>
<th>Sr. No.</th>
<th>Level 1 checks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tyre inflation as per Inflation chart</td>
<td>11.</td>
<td>Condition of Clutch pedal linkages</td>
</tr>
<tr>
<td>3.</td>
<td>Wheel Bearing condition &amp; Lubrication</td>
<td>13.</td>
<td>Accelerator Return spring condition</td>
</tr>
<tr>
<td>4.</td>
<td>Brake Pedal Free play</td>
<td>14.</td>
<td>Air cleaner condition (Choke indicator)</td>
</tr>
<tr>
<td>5.</td>
<td>Gap between Brake Liner and Drum/Disc</td>
<td>15.</td>
<td>Exhaust pipes/ muffler blockage</td>
</tr>
<tr>
<td>6.</td>
<td>Caliper boot &amp; Wear Adjuster cap</td>
<td>16.</td>
<td>Fault codes displayed from On-board diagnostics</td>
</tr>
<tr>
<td>7.</td>
<td>Brake Retraction after pedal release</td>
<td>17.</td>
<td>Visible Smoke level on snap acceleration</td>
</tr>
<tr>
<td>8.</td>
<td>Lubrication of Driveshaft joints &amp; Bearings</td>
<td>18.</td>
<td>A/C Compressor belt tension</td>
</tr>
<tr>
<td>10.</td>
<td>Tightness of Driveline &amp; Gearbox mounting bolts</td>
<td>20.</td>
<td>Compressor working condition</td>
</tr>
</tbody>
</table>


Bus Maintenance – Level-I Checks
Bus Maintenance – Level-I Checks
Level-I Observations

% of Buses Having Defects (Bus Checked – 293/2883)

- Air Filter found choked: 66%
- Tyre inflation not maintained as per Inflation chart: 54%
- Wheel Bearing Condition & Lubrication Poor: 36%
- Lubrication of Driveshaft Joints & Bearings Poor: 33%
- Tightness of Driverline & Gearbox Mounting not proper: 29%
Level-I Observations

% of Buses Having Defects (Bus Checked – 293/2883)

- Lubrication of Differential not proper: 27%
- Gap between Brake Liner and Drum/Disc not as per recommended clearance: 27%
- Condition of Caliper Boot & Wear Adjuster Cap not as per recommended lining thickness: 27%
- Brake Pedal Free Play not as per recommended free play: 25%
- Blockage observed in Exhaust Pipes/Muffler: 23%
- Condition of Clutch Pedal Linkages not as per recommended play: 22%
- Accelerator Return Spring Condition not as per recommended free play: 18%
- Brake Retraction not quick after Pedal Release: 17%
- No Free Rolling of Wheels: 16%
- Improper Smoke Level observed on Snap Acceleration: 12%
- Condition of Accelerator Linkages & Lubrication not as per recommended play: 9%
- A/C Compressor Belt Tension not proper: 7%
- Fault Codes found displayed on dashboard (On-board Diagnostics): 4%
- Refrigerent Pressure not adequate: 1%
- Compressor Working Condition not proper: 0%
Bus Maintenance – Level-II Checks - 61 Buses

- Clutch
- Wheels
- Leakages
- Fuel Injection System
- Engine Oil
- Turbocharger
- Engine Cylinder
- Exhaust System
- Overheating
## Bus Maintenance Level II Checklist

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Level-II Checks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Wheel Alignment</td>
</tr>
<tr>
<td>2.</td>
<td>Tyre Camber</td>
</tr>
<tr>
<td>3.</td>
<td>Wheel Bearing Play</td>
</tr>
<tr>
<td>4.</td>
<td>Condition of Clutch Facing</td>
</tr>
<tr>
<td>5.</td>
<td>Condition of Pressure Plate &amp; Flywheel Facing</td>
</tr>
<tr>
<td>6.</td>
<td>Condition of Release Bearing &amp; Linkages</td>
</tr>
<tr>
<td>7.</td>
<td>Leakage of Fuel from Fuel Tank / Fuel Lines</td>
</tr>
<tr>
<td>8.</td>
<td>Leakage of Gas (with smoke Detector)</td>
</tr>
<tr>
<td>9.</td>
<td>Tightness of Tanks Mounting &amp; Pipes Clamps</td>
</tr>
<tr>
<td>10.</td>
<td>Fuel Injection Pump Timing &amp; Max Fuel Stop Setting</td>
</tr>
<tr>
<td>11.</td>
<td>Fuel Injection Pump Working Condition</td>
</tr>
<tr>
<td>12.</td>
<td>Condition of Injectors (Spray / Pressure Test)</td>
</tr>
<tr>
<td>13.</td>
<td>Condition of Turbo Charger</td>
</tr>
<tr>
<td>14.</td>
<td>Tightness of Cylinder Head Bolts/ Nuts &amp; Cylinder Head Condition</td>
</tr>
<tr>
<td>15.</td>
<td>Engine oil consumption / Engine Blow- by condition</td>
</tr>
<tr>
<td>16.</td>
<td>Cylinders Compression Values (for High Oil Consumptions)</td>
</tr>
<tr>
<td>17.</td>
<td>Engine Overheating / Coolant Loss (Flush if Required)</td>
</tr>
<tr>
<td>18.</td>
<td>Condition of Muffler &amp; Catalytic Converter</td>
</tr>
<tr>
<td>19.</td>
<td>Exhaust Brake Butterfly Operation</td>
</tr>
</tbody>
</table>
Bus Maintenance – Level-II Checks
Bus Maintenance – Level-II Checks
Level-II Observations

% of Buses Having Defects (Bus Checked – 61/293)

- Wheel Alignment not proper: 48%
- Engine Overheating / Coolant Loss observed: 39%
- Condition of Muffler & Catalytic Converter not proper: 36%
- Wheel Bearing Play not proper: 34%
- Condition of Pressure Plate & Flywheel Facing not proper: 34%
Level-II Observations

% of Buses Having Defects (Bus Checked – 61/293)

- Condition of Release Bearing & Linkages not proper: 30%
- Condition of Injectors (Spray / Pressure Test): 30%
- Condition of Clutch Facing not proper: 25%
- Leakage observed from Fuel Tank / Fuel Lines: 25%
- Fuel Injection Pump Timing & Max Fuel Stop Setting not proper: 20%
- Fuel Injection Pump Working Condition not proper: 20%
- Engine oil consumption / Engine Blow-by condition not proper: 18%
- Condition of Turbo Charger not proper: 15%
- Tightness of Tanks Mounting & Pipes Clamps not proper: 15%
- Tightness of Cylinder Head Bolts/ Nuts & Cyl Head Condition not proper: 11%
- Exhaust Brake actuator & Butterfly valve not proper: 11%
- Tyre Camber not as per recommended values: 11%
- Cylinders Compression Values (for High Oil Consumptions) not proper: 10%
- Leakage of Gas observed (with smoke Detector): 8%
- % of Buses Having Defects (Bus Checked – 61/293)
Driver Training Program

One day classroom training

• Motivational Training
• Presentation on eco-driving techniques
Eco-Driving Techniques

- Bus Starting
- Accelerator Use
- Gear Shifting
- Proper Braking
- Concentration
- Anticipation
Driver Training- On-the Road

Driver Trainer Demonstrates the eco-driving technique – then drivers try and demonstrates those techniques
Driver Follow-up Monitoring for 3 weeks

Driver Trainer accompany drivers on actual route and observe driving behavior
## Weekly Follow-up Monitoring Checklist

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Driving Checklist</th>
<th>Sr. No.</th>
<th>Driving Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Did the driver check BEFORE STARTING THE IGNITION whether the pressure in both the &quot;AIR METERS&quot; are correct?</td>
<td>7.</td>
<td>Did the driver use FOURTH GEAR for driving up to a speed of 40kmph and keep the ACCELERATOR at 3/4 position?</td>
</tr>
<tr>
<td>2.</td>
<td>Did the driver keep the FEET ON THE FOOT REST NEAR ACCELERATOR?</td>
<td>8.</td>
<td>Did the driver use FIFTH GEAR for driving at TOP SPEED and keep the ACCELERATOR in FULL position?</td>
</tr>
<tr>
<td>3.</td>
<td>Did the driver start the bus in &quot;IDLING&quot; condition without pressing accelerator?</td>
<td>9.</td>
<td>Depending upon road or traffic condition, did the driver use the POWERPOINT POSITION on the ACCELERATOR when driving at maximum speed?</td>
</tr>
<tr>
<td>4.</td>
<td>Did the driver set the bus in the motion using FIRST GEAR WITHOUT ACCELERATOR?</td>
<td>10.</td>
<td>Did the driver use his/ her TOES for PRESSING the ACCELERATOR?</td>
</tr>
<tr>
<td>5.</td>
<td>Did the driver use SECOND GEAR for driving up to a speed of 20kmph and keep the ACCELERATOR at 1/4th position?</td>
<td>11.</td>
<td>Did the driver REMOVE THE FEET FROM THE ACCELERATOR 100 meters BEFORE the stoppage point such as bus stops, traffic signals etc. and for slowing down at speed breakers and turnings?</td>
</tr>
<tr>
<td>6.</td>
<td>Did the driver use THIRD GEAR for driving up to a speed of 30kmph and keep the ACCELERATOR at 1/2 position?</td>
<td>12.</td>
<td>Did the driver DRIVE WITHOUT PRESSURE AND WITH CONCENTRATION?</td>
</tr>
</tbody>
</table>
## Driving Behavior Observations

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Driving Flaw (Targeted drivers 294)</th>
<th>% of Drivers Committing Flaw</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Week</td>
</tr>
<tr>
<td>1</td>
<td>The driver did not use his/ her TOES for PRESSING the ACCELERATOR?</td>
<td>42%</td>
</tr>
<tr>
<td>2</td>
<td>The driver did not REMOVE THE FOOT FROM THE ACCELERATOR 100 meters BEFORE the stoppage point such as bus stops, traffic signals etc. and for slowing down at speed breakers and turnings?</td>
<td>27%</td>
</tr>
<tr>
<td>3</td>
<td>The driver did not keep the Foot ON THE FOOT REST NEAR ACCELERATOR?</td>
<td>26%</td>
</tr>
<tr>
<td>4</td>
<td>The driver did not set the bus in the motion using FIRST GEAR WITHOUT ACCELERATOR?</td>
<td>26%</td>
</tr>
<tr>
<td>5</td>
<td>The driver did not start the bus in &quot;IDLING&quot; condition without pressing accelerator?</td>
<td>26%</td>
</tr>
<tr>
<td>6</td>
<td>The driver did not use the FOURTH GEAR for driving upto a speed of 40kmph and did not keep the ACCELERATOR at 3/4 position?</td>
<td>24%</td>
</tr>
</tbody>
</table>
# Driving Behavior Observations

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Driving Flaw (Targeted drivers 294)</th>
<th>% of Drivers Committing Flaw</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Week Follow-up</td>
</tr>
<tr>
<td>7</td>
<td>The driver did not use the THIRD GEAR for driving upto a speed of 30kmph and did not keep the ACCELERATOR at 1/2 position?</td>
<td>22%</td>
</tr>
<tr>
<td>8</td>
<td>The driver did not use the POWERPOINTER POSITION on the ACCELERATOR when driving at maximum speed?</td>
<td>22%</td>
</tr>
<tr>
<td>9</td>
<td>The driver did not use the SECOND GEAR for driving upto a speed of 20 kmph and did not keep the ACCELERATOR at 1/4th position?</td>
<td>18%</td>
</tr>
<tr>
<td>10</td>
<td>The driver did not use the FIFTH GEAR for driving at TOP SPEED and did not keep the ACCELERATOR in FULL position?</td>
<td>16%</td>
</tr>
<tr>
<td>11</td>
<td>The driver did not check BEFORE STARTING THE IGNITION whether the pressure in both the &quot;AIR METERS&quot; are correct?</td>
<td>8%</td>
</tr>
<tr>
<td>12</td>
<td>The driver did not DRIVE WITHOUT PRESSURE AND WITH CONCENTRATION?</td>
<td>6%</td>
</tr>
</tbody>
</table>
Impact Analysis
Program Summary

Number of Depots – 15/18

Number of Buses Attended – 293

Number of Drivers Trained – 294
# Impact Analysis - After 2 Rounds

<table>
<thead>
<tr>
<th>Buses Attended Level-I Checks</th>
<th>Buses Attended Level-II Checks</th>
<th>Relative Performance Improved</th>
<th>% Avg. Fuel Economy Improved</th>
<th>Fuel Saving in Two Months</th>
<th>Monetary Saving in Two Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>293</td>
<td>61</td>
<td>241</td>
<td>12.5%</td>
<td>38 kl HSD 8.7 T CNG</td>
<td>28.6 Lac</td>
</tr>
</tbody>
</table>

82% Buses Improved

10 % Targeted Buses in Each Round
**Impact Analysis**

<table>
<thead>
<tr>
<th>Driver Trained</th>
<th>Relative Performance Improved</th>
<th>% Avg. Fuel Economy Improved</th>
<th>Fuel Saving in Two Months</th>
<th>Monetary Saving in Two Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>294</td>
<td>241</td>
<td>12.6%</td>
<td>14 kl HSD 8.5 T CNG</td>
<td>13.2 Lac</td>
</tr>
</tbody>
</table>

75% Driver Improved

5% Targeted Drivers in Each Round
Impact Analysis on 15 Depot

Saving in Two Months

- 80.5 KL Diesel Saved
- 52.3 Lacs Rupees Saved
- 215.7 T CO2 Emission Reduced
लोकसत्ता

दोन महिन्यांतिल स्थिती : वायुप्रदूषण घटते; उपन्यास दरम्यान सात लाखांटी वाह वीस हजार लिटर इंधनची बचत

नाताजी पोवार।
लोकसत्ता मुख स्टेडियां

कोल्हापूर : फेंड साजरलेल्या वायुसंतत्तील
वायुप्रदूषण घटते; उपन्यास दरम्यान सात लाखांटी वाह वीस हजार लिटर इंधनची बचत होऊन ‘पीसीआरए’च्या अपनावर दाखल सातवी सात लाखांची वाह जाली आहे. तात्पूर्वी वायुप्रदूषण आहे तर परिसर उपकरण ही वायूच्या ‘दुर्दर’ द्वारे निर्धार. ‘पीसीआरए’च्या वायुप्रदूषणाच्या विषयात मार्गदर्शन करण्यासाठी उपयोगी उपकरण हा दुर्दर निर्धार. परिसरात उपयुक्त उपकरण हा दुर्दर निर्धार. परिसरात उपयुक्त उपकरण हा दुर्दर निर्धार.

‘पीसीआरए’याच्या वायुप्रदूषणाचा विषयात मार्गदर्शन करण्यासाठी उपयोगी उपकरण हा दुर्दर निर्धार. परिसरात उपयुक्त उपकरण हा दुर्दर निर्धार.

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केमर्टी सुसाड : मुंबई २
उपन्यास वाह, डिजिलव्याची बचत
+ मध्य : ६ लाख ५५ लिटर वाह (दिनांक : ४० हजार ५५० लिटर बचत)
+ प्रशिक्षण : ५ लाख ५५ हजार वाह (केमर्टीच्या दिनांक : १० हजार ५५ प्रशिक्षण)

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वॉर्ड वाह, मुंबई २
उपन्यास वाह, डिजिलव्याची बचत
+ मध्य : ६ लाख ५५ लिटर वाह (दिनांक : ४० हजार ५५० लिटर बचत)
+ प्रशिक्षण : ५ लाख ५५ हजार वाह (केमर्टीच्या दिनांक : १० हजार ५५ प्रशिक्षण)

24/०८/२०१९
लोकसत्ता मुख स्टेडियां
Challenges Faced

- Some depots are hiring drivers on ad-hoc basis, so at times targeted drivers could not complete training program.

- Data maintained by the depot is not in standard format.

- Due to operational constraints buses/drivers could not be made available during working hours.

- Due to various constraints depot delayed in attending maintenance issues

- Some Depots do not have practice of daily topping of fuel tank

- Depot management is occupied with routine operations
Lessons Learnt

✓ Modification of preventive bus maintenance schedules has been suggested as per Level-I & Level-II observations.

✓ Corrective actions, for faults identified in buses and skill deficiency in drivers observed, should be replicated in all buses/drivers.

✓ Depot should continue training and follow-up monitoring to reinforce eco-driving techniques amongst drivers.

✓ Depot should strengthen data recording and analysis
CONSERVE FUEL
SAVE FUTURE

Q&A

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