Greenhouse Gas Emissions: Calculations & Management

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Introduction

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1. Calculating your Carbon Footprint

2. Climate Leaders & Climate Leaders in Parks (CLIP)

3. General Calculation Guidelines

4. Case Study: Shoshone National Forest

5. Exercise: Fleet Selection & Management Game
Calculating your Carbon Footprint

What is a Carbon Footprint?

“A carbon footprint is a measure of the impact our activities have on the environment, and in particular climate change.

It relates to the amount of greenhouse gases produced in our day-to-day lives through burning fossil fuels for electricity, heating and transportation etc.”

Source: http://www.carbonfootprint.com/carbonfootprint.html
Calculating your Carbon Footprint

What is a Carbon Footprint?

- Three components
  - Direct emissions – Scope 1 – Onsite combustion & mobile sources
  - Indirect emissions – Scope 2 – Purchased electricity & steam
  - Optional emissions – Scope 3 – Product transport, employee travel

- Six major greenhouse gases
  - Carbon Dioxide (CO\textsubscript{2})
  - Methane (CH\textsubscript{4})
  - Nitrous Oxide (N\textsubscript{2}O)
  - Hydrofluorocarbon (HFC)
  - Perfluorocarbons (PFC)
  - Sulphur Hexafluoride (SF\textsubscript{6})
Calculating your Carbon Footprint

Methodologies/Tools for Calculating Greenhouse Gas Emissions from Vehicles

- Several tools are currently in existence
  
  - Greenhouse Gases, Regulated Emissions, and Energy use in Transportation (GREET)
  - GREET Fleet Footprint
  - EPA Climate Leaders
  - Climate Leadership in Parks (CLIP)

- The tools vary in scope, capabilities & emissions factors used
  
  - Vehicle life-cycle considerations
  - Indirect impacts of biofuels
Climate Leaders

EPA Climate Leaders Simplified GHG Emissions Calculator
- Microsoft Excel-based workbook
- Climate Leaders Greenhouse Gas Inventory Protocol
- Mobile source inputs:
  - Vehicle type
  - Vehicle model year
  - Fuel type
  - Fuel quantity used
  - Miles traveled or hours operated
Climate Leadership in Parks (CLIP) Tool

- Microsoft Excel-based workbook
- “Activity Data” is collected and entered into the tool
- Estimates GHG and CAP emissions from park sources (e.g., mobile sources)
General Calculations Guidelines

Measuring Vehicle Emissions

– Emission factors

• Specific to the vehicle and fuel combination
• Change as emissions standards are created and new control
  technologies are adopted
• $\text{CO}_2$ emission factors require a fuel analysis to determine the
  carbon content of the fuel
• $\text{CH}_4$ and $\text{N}_2\text{O}$ emissions are measured over the Federal Test
  Procedure (FTP) cycle

$$\text{CO}_2 \text{ Emission Factor} \frac{\text{kg} \text{CO}_2}{\text{gal}} = \text{Carbon Content} \frac{\text{kg} \text{C}}{\text{gal}} \times \text{Fraction Oxidized} \times \frac{\text{Molecular Weight CO}_2}{\text{Molecular Weight C}}$$
General Calculations Guidelines

Measuring Vehicle Emissions

- CO₂ emission factors depend on:
  - Fuel consumption

- CH₄ and N₂O emission factors depend on:
  - Fuel consumption
  - End-use technology
  - Combustion conditions
  - Emissions control technology
Measuring Vehicle Emissions

- Methodology

- A fuel’s impact is calculated by multiplying its emission factor by the measure of activity

- 100-year global warming potentials are used to convert all emissions to carbon dioxide-equivalent, or \( \text{CO}_2\text{e} \)

\[
\text{CO}_2 \triangleq \text{Emission Factor} \left( \frac{\text{kg} \ \text{CO}_2}{\text{gal}} \right) * Y \left( \frac{\text{gal}}{\text{yr}} \right)
\]

\[
\text{CO}_2\text{e}_{\text{N}_2\text{O}} \triangleq \text{Emission Factor} \left( \frac{\text{g}}{\text{mile}} \right) * \text{g to kg conversion} \left( \frac{\text{kg}}{\text{g}} \right) * Z \left( \frac{\text{miles}}{\text{yr}} \right) * 298
\]

\[
\text{CO}_2\text{e}_{\text{CH}_4} \triangleq \text{Emission Factor} \left( \frac{\text{g}}{\text{mile}} \right) * \text{g to kg conversion} \left( \frac{\text{kg}}{\text{g}} \right) * Z \left( \frac{\text{miles}}{\text{yr}} \right) * 25
\]

\[
\text{Total Emissions}_{\text{vehicle operating}} = \text{CO}_2 + \text{CO}_2\text{e}_{\text{N}_2\text{O}} + \text{CO}_2\text{e}_{\text{CH}_4}
\]
Measuring Vehicle Emissions

– Blended Fuels

• For blended fuels, emissions from both the biogenic and fossil elements are calculated and summed

• The same methodology is used, but weighted based on percent composition
General Calculations Guidelines

Measuring Vehicle Emissions: Blended Fuels

\[
\text{CO}_2 \sim_{\text{fossil}} = \text{Emission Factor} \ \frac{\text{kg} \ \text{CO}_2}{\text{gal}} \ast \% \text{ fossil composition} \ast Y \ \frac{\text{gal}}{\text{yr}}
\]

\[
\text{CO}_2 e_{\text{N}2\text{O}} \sim_{\text{fossil}} = \text{Emission Factor} \ \frac{\text{g}}{\text{mile}} \ast \text{g to kg conversion} \ \frac{\text{kg}}{\text{g}} \ast \% \text{ fossil composition} \ast Z \ \frac{\text{miles}}{\text{yr}} \ast 298
\]

\[
\text{CO}_2 e_{\text{CH}_4} \sim_{\text{fossil}} = \text{Emission Factor} \ \frac{\text{g}}{\text{mile}} \ast \text{g to kg conversion} \ \frac{\text{kg}}{\text{g}} \ast \% \text{ fossil composition} \ast Z \ \frac{\text{miles}}{\text{yr}} \ast 25
\]

\[
\text{CO}_2 \sim_{\text{biogenic}} = \text{Emission Factor} \ \frac{\text{kg} \ \text{CO}_2}{\text{gal}} \ast \% \text{ biogenic composition} \ast Y \ \frac{\text{gal}}{\text{yr}}
\]

\[
\text{CO}_2 e_{\text{N}2\text{O}} \sim_{\text{biogenic}} = \text{Emission Factor} \ \frac{\text{g}}{\text{mile}} \ast \text{g to kg conversion} \ \frac{\text{kg}}{\text{g}} \ast \% \text{ biogenic composition} \ast Z \ \frac{\text{miles}}{\text{yr}} \ast 298
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\[
\text{CO}_2 e_{\text{CH}_4} \sim_{\text{biogenic}} = \text{Emission Factor} \ \frac{\text{g}}{\text{mile}} \ast \text{g to kg conversion} \ \frac{\text{kg}}{\text{g}} \ast \% \text{ biogenic composition} \ast Z \ \frac{\text{miles}}{\text{yr}} \ast 25
\]

Total Emissions_{vehicle \ operating} = \text{CO}_2 + \text{CO}_2 e_{\text{N}2\text{O}} + \text{CO}_2 e_{\text{CH}_4} \sim_{\text{biogenic}} + \text{CO}_2 + \text{CO}_2 e_{\text{N}2\text{O}} + \text{CO}_2 e_{\text{CH}_4} \sim_{\text{fossil}}
Case Study

Shoshone National Forest

- Review FY07 and FY09 fleet compositions
- Provide an example GHG emissions calculation
Case Study

Shoshone National Forest Fleet Make-Up

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>FY07</th>
<th>FY09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline Light-Duty Trucks</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Gasoline Heavy-Duty Vehicles</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Gasoline Passenger Cars</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Diesel Heavy-Duty Vehicles</td>
<td>15</td>
<td>18</td>
</tr>
</tbody>
</table>
Case Study

Shoshone National Forest Mobile Source GHG Emissions by Vehicle Type

Gasoline heavy-duty vehicle activity was miss reported

Total MTCE: 218
# Case Study

## Emissions Factors

*Gasoline Heavy-Duty Vehicles (2005)*

<table>
<thead>
<tr>
<th>Emissions Factor</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>kg CO₂/gal</td>
<td>8.81</td>
</tr>
<tr>
<td>Nitrous Oxide (N₂O)</td>
<td>g N₂O/mile</td>
<td>0.0177</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>g CH₄/mile</td>
<td>0.0326</td>
</tr>
</tbody>
</table>

## Global Warming Potential

<table>
<thead>
<tr>
<th>Emissions Factor</th>
<th>GWAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>1</td>
</tr>
<tr>
<td>Nitrous Oxide (N₂O)</td>
<td>21</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>310</td>
</tr>
</tbody>
</table>

## Activity Data

<table>
<thead>
<tr>
<th></th>
<th>Fuel Used (gal)</th>
<th>Vehicle Miles Traveled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td>5,590</td>
<td>55,899</td>
</tr>
<tr>
<td>Corrected</td>
<td>590</td>
<td>5,899</td>
</tr>
</tbody>
</table>

**Total Emissions:**

- Original: 112 MTCe
- Corrected: 99 MTCe

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**Image:**

- Illustration of a car on a road with a cloud symbol,
- Graph showing emissions data,
- Calculation of total emissions.
Case Study

Shoshone National Forest Mobile Source GHG Emissions by Vehicle Type – Corrected

Total MTCE: 218 205
Fleet Selection & Management Game

Who can reduce their GHG emissions the most while still fulfilling their missions and meeting federal mandates?