Assessment of Potential Reductions in Greenhouse Gas (GHG) Emissions in Freight Transportation

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Objectives

- Identify and characterize potential best practices for reduction of greenhouse gas (GHG) emissions from the freight transportation sector
- Quantify and compare the potential reductions in GHG emissions
- Analyze cost effectiveness of each best practice if quantitative cost information is available
- Develop a guidebook regarding these best practices
Outline

• Definition of Key Concepts
• Study Methodology
• List of Best Practices
• Total Modal GHG Emissions Reductions
• Comparisons of Best Practices Whose Costs Are Assessed Quantitatively
• Inter-modal Substitutions
• Overview of the Guidebook
• Conclusions and Recommendations
GHG Emissions in U.S. Freight Transportation, 2003

*B.U.S. Total includes bunker fuel for international aviation and marine
Distribution of GHG Emissions by Mode within the U.S. Freight Sector, 2003

Total GHG Emissions: \(7.20 \times 10^8\) Tons CO\(_2\) Equivalent

- Truck, 59.4%
- Pipeline, 16.0%
- Water, 13.4%
- Rail, 6.1%
- Air, 5.1%
Estimated Baseline GHG Emissions from Freight Transportation from 2003 to 2025

Million Tons CO₂ eq.

2003

2025 without Best Practices

52%
Definitions and Concepts

Best Practices:

- Technological or operational strategies
- Existing or developing
- Reduce GHG emissions
- Reduce energy use or increase use of alternative fuels
- Reduce refrigerant leakage or increase use of low Global Warming Potential (GWP) refrigerants
Definitions and Concepts

Subgroup:
- A collection of best practices in a mode that have either similar objectives or methods

Greenhouse Gas Emissions:
- Focus on CO₂, CH₄, and hydrofluorocarbons (HFCs)
- Global Warming Potential (GWP):
  - GWP = 1 for CO₂
  - GWP = 21 for CH₄
  - GWP = 1,300 for HFC-134a

Developmental Status: New concepts, pilot tests, and commercially available systems
Study Methodology

(1) Identify best practices based on literature review
(2) Assess maximum reductions in 2025 GHG emissions and energy or refrigerant use
(3) Assess cost savings (where data are available)
(4) Summarize and report assessment results
Assessment of Potential GHG Emissions Reductions for Individual Best Practices

*Life cycle inventories were assessed for alternative fuels*
Assessment of Potential GHG Emissions Reductions for Multiple Best Practices

Aggregate reductions for a subgroup:
- Linear combination of individual best practices
- Mutual exclusion
  - Some BPs cannot be used simultaneously
  - Based on BP with the highest reduction potential
  - The estimates do not double count mutually exclusive BPs

![Modal GHG Emissions Diagram]
Assessment of Potential GHG Emissions Reductions for Multiple Best Practices

Aggregate reductions for a subgroup:
- Interaction:
  - Some BPs can be used together but interact
  - Quantification of interaction is unknown or not reported
  - Used a linear combination as an estimate
  - May overestimate the maximum possible reduction for the subgroup
Assessment of Best Practices With or Without Cost Data

Quantitative Estimates for All BPs for Reductions in GHG Emissions, Energy Use and Refrigerant Use

Are Cost Data Available?

Yes → Quantitative Cost Estimates for BPs → Standardized Reporting Table

No → Performance Estimates Only for BPs → Simplified Summary Table
# Summary of Best Practices for Freight Transportation

A total of 59 potential best practices have been identified

<table>
<thead>
<tr>
<th>Mode</th>
<th>Number of Best Practices</th>
<th>Names of Subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck</td>
<td>33</td>
<td>Anti-idling; Air Conditioning System Improvement; Aerodynamic Drag Reduction; Tire Rolling Resistance Improvement; Hybrid Propulsion; Weight Reduction; Transmission Improvement; Diesel Engine Improvement; Accessory Load Reduction; Driver Operation Improvement; Alternative Fuel</td>
</tr>
<tr>
<td>Rail</td>
<td>6</td>
<td>Anti-idling; Weight Reduction; Rolling Resistance Improvement; Alternative Fuel</td>
</tr>
<tr>
<td>Air</td>
<td>10</td>
<td>Aerodynamic Drag Reduction; Air Traffic Management Improvement; Weight reduction; Ground Support Equipment Improvement; Engine Improvement</td>
</tr>
<tr>
<td>Water</td>
<td>5</td>
<td>Propeller System Improvement; Anti-idling; Alternative Fuel</td>
</tr>
<tr>
<td>Pipeline</td>
<td>5</td>
<td>Process Control Device Improvement; Connecting Method; Maintenance</td>
</tr>
</tbody>
</table>
Total 2025 Modal GHG Emissions Reductions Compared to 2025 Without Best Practices

Reductions in Total Modal GHG Emissions (%)

- **Truck**
  - New Concepts
  - Pilot Tests
  - Commercially Available Systems

- **Rail**
  - New Concepts
  - Pilot Tests
  - Commercially Available Systems

- **Air**
  - New Concepts
  - Pilot Tests
  - Commercially Available Systems

- **Water**
  - New Concepts
  - Pilot Tests
  - Commercially Available Systems

- **Pipeline**
  - New Concepts
  - Pilot Tests
  - Commercially Available Systems
Total 2025 Modal GHG Emissions Reductions Compared to 2025 Without Best Practices

Reductions in Total Modal GHG Emissions (Million Tons CO₂ eq.)

- New Concepts
- Pilot Tests
- Commercially Available Systems

Modal Breakdown:
- Truck
- Rail
- Air
- Water
- Pipeline
Changes in GHG Emissions from 2003 to 2025 with Best Practices

2003 Modal GHG Emissions

2025 Modal GHG Emissions with Best Practices

11%

28%
Comparisons of Best Practices Whose Costs Are Assessed Quantitatively

- To date, sufficient cost information has been obtained to assess the costs of 13 practices quantitatively.

<table>
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<th>Mode</th>
<th>Name of Best Practices</th>
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<tr>
<td>Water</td>
<td>10. B20 biodiesel</td>
</tr>
</tbody>
</table>
Comparison of Best Practices Whose Costs Are Assessed Quantitatively (Continued)

- Truck
- Rail
- Water
- Pipeline

GHG Emissions Reductions (Million Tons CO₂ eq. / Year)

- Hybrid Trucks
- B20 Biodiesel
- Auxiliary Power Units
- Direct-Fired Heaters
Comparisons of Best Practices Whose Costs Are Assessed Quantitatively (Continued)

Net Cost Savings (Million $ / Year)

-3500 -3000 -2500 -2000 -1500 -1000 -500 0 500 1000 1500 2000 2500 3000 3500 4000 4500

1 2 3 4 5 6 7 8 9 10 11 12 13

Truck Rail Water Pipeline

Auxiliary Power Units
Direct-Fired Heaters
Hybrid Trucks
B20 Bio-diesel
Inter-Modal Comparison of Average Modal GHG Emission Rates

For example, GHG emissions reductions of 85% are possible if long-haul truck transport is replaced with a combination of rail and truck transport.
Conclusions

• Aggressive implementation of best practices may lead to a *net decrease* in total GHG emissions in freight transportation.

• Even larger percentage reductions are possible if inter-modal shifts (e.g., substitute rail for truck) are encouraged.
• There is limited quantitative cost data upon which to base assessments of the costs of best practices
• For 13 best practices for which adequate cost data are available:
  ▪ The normalized cost savings per unit of GHG emissions reduction was highly variable
  ▪ The variability mostly depends on the magnitudes of their energy cost savings
Conclusions (Continued)

• Some best practices (e.g., biodiesel for trucks) offer potential for large magnitudes in GHG emissions reductions, but may not be as cost-effective
  – From a national policy perspective, governments should promote research, development, and demonstration (RD&D) to foster best practices that lead to large absolute reductions in GHG emissions

• Some best practices may lead to “no regrets”
  – e.g., net cost savings to an operator
  – Additional benefits of GHG emissions or energy use reduction
Recommendations

• Update information as new information becomes available
• Revise or develop cost estimates as new data become available
• Evaluate key assumptions (e.g., market penetration rates) that influence the selection of best practices via sensitivity analysis
• Develop tools (e.g., a decision tree, a decision support framework) to support decision making regarding best practices
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