Methane as a transportation fuel can address 2050 goals through total vehicle system improvements and RNG fuel blends.
Fuel economy improvement will be critical for all vehicle platforms -- Natural Gas platforms have similar fuel economy potential to diesel platforms.

### Breakdown of Energy Loss for Long Haul

<table>
<thead>
<tr>
<th>Source</th>
<th>Highway</th>
<th>Urban Vocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>15% - 20%</td>
<td>15% - 20%</td>
</tr>
<tr>
<td>Hybridization</td>
<td>10%</td>
<td>30% - 35%</td>
</tr>
<tr>
<td>Aerodynamics</td>
<td>12%</td>
<td>0% - 6%</td>
</tr>
<tr>
<td>Transmission</td>
<td>7%</td>
<td>4%</td>
</tr>
<tr>
<td>Rolling Resistance</td>
<td>11%</td>
<td>2% - 3%</td>
</tr>
<tr>
<td>Weight</td>
<td>1%</td>
<td>1% - 4%</td>
</tr>
</tbody>
</table>

Source: Department of Energy “Super Truck” program

Source: National Petroleum Council
Virtually all vocations show positive payback for fuel economy improvements of 50%+ for both NG and diesel.
Netting technology improvements, cost of fuel economy and cost of emissions control, natural gas truck costs will converge with diesel.
Elements of Cost Differential to Diesel

Components of Change in Cost Differential (Spark Ignited Long-Haul NG vs Diesel)

- Engine and other
- Tanks (Size & Cost/DGE)
- Engine and After Treatment
- Fuel Economy + CH4 Emissions
- 2030 Delta

Cost Differential

2015 Delta

Cost Element
GHG Trade-offs
Elements of CI difference between natural gas (and NG-derived hydrogen) and diesel

- **Diesel Reference**
  - Base Carbon Intensity Difference (nearly 100% for RNG)
  - Fuel Economy and Other
  - Methane Well to Pump
  - Methane Pump to Wheels

- **CNG Full Cycle Carbon Intensity**
Methane emissions are an issue to address but policy needs to consider mitigation potential and “cause and effect” relative to new uses of Natural Gas

• **Time.** What is the short, medium and long-term potential for reduction in system leakage?

• **Marginal Impact.** How much will methane emissions increase with deployment of DG and NGV technologies and how much is not driven by throughput (event-based emissions / time based emissions)?
Time Dimension -- National data shows methane emissions declining

**U.S. Methane Emissions by Source**

- Petroleum Systems: 6%
- Manure Management: 9%
- Other: 9%
- Coal Mining: 10%
- Landfills: 18%
- Natural Gas Systems: 23%
- Enteric Fermentation: 25%

**Natural Gas System Emissions**

(Million Metric Tons of CO2 Equivalent)

- **2012 Inventory**
- **2013 Inventory**

**Chart Details**

- **Field Production**
- **Processing**
- **Transmission & Storage**
- **Distribution**
- **Total**
“Cause and Effect” Dimension – will not deploying NGV’s reduce upstream emissions?

Need economy wide scenario analysis to determine marginal impact on methane emissions of aggressive NGV deployment versus base case.