Natural Gas as an Alternative to Diesel

Chris Kroeker,
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Joint Task Force on Supporting Businesses in Reducing Diesel Emissions
Natural Gas as a Transportation Fuel

Compression

Vehicle Fueling

Photo source NW Natural

Photo source Bauer Compressors

Photo source Michigan State University

Photo source NW Natural

Photo source CNG United

Photo source CNG United
# Current Market

28 million CNG vehicles, 33,000 fueling stations globally

<table>
<thead>
<tr>
<th>Region</th>
<th>NGVs</th>
<th>Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia-Pacific</td>
<td>19,841,688</td>
<td>19,606</td>
</tr>
<tr>
<td>Europe</td>
<td>2,013,693</td>
<td>5,116</td>
</tr>
<tr>
<td>North America</td>
<td>224,500</td>
<td>1,856</td>
</tr>
<tr>
<td>Latin America</td>
<td>5,417,146</td>
<td>5,789</td>
</tr>
<tr>
<td>Africa</td>
<td>268,349</td>
<td>210</td>
</tr>
</tbody>
</table>
Fleet Growth

CNG vehicles worldwide has grown annually at 30% for the past five years, anticipated to grow at a CAGR of 11.9% between 2018 and 2026.

Currently only have about 400 CNG vehicles in Oregon – why so few?

- Diesel fuel is inexpensive
- Perceived Risk (fleet managers)
- Policy (technology specific)

Photo source truckinginfo.com
Natural Gas Benefits
EPA Engine Certifications

EPA NOx Emission Standard (0.2 g/bhp-hr)

Source UC Riverside
Natural Gas Engines Stay Clean

Cycle Average NO\textsubscript{x} Emissions

- **2010 Diesel with SCR Vehicles**: 0.5 g/bhp-hr (EPA 2010 Certification Standard)
- **Near-Zero Natural Gas Vehicles**: 0.014 g/bhp-hr (Regional), 0.013 g/bhp-hr (Local), 0.002 g/bhp-hr (Near-dock)

Source UC Riverside
Renewable Natural Gas (RNG)

- Animal waste
- Agricultural waste
- Food Waste

Anaerobic digester → Conditioning Equipment → Renewable Natural Gas

- Heat
- Fuel
Carbon Intensity Values of Fuels

Source: CARB
Annual RNG Technical Potential

Oregon: 48 BCF

Total OR annual natural gas consumption: 236 BCF
Total NWN annual natural gas sales: 69 BCF

(1) "Wood and Agricultural Residues" is defined differently by different studies but generally includes urban waste wood, primary and secondary mill residues, and residues left after logging operations (e.g., trees cut or killed and left on the ground). It assumes a large amount (35%-50%) is left on the forest floor to “maintain ecological functions.” Sources for data: https://www.nrel.gov/docs/fy14osti/60178.pdf, NREL Bioenergy Database, U.S. EPA LMOP Database, Oregon DEQ Material Recovery and Waste Generation Survey, Oregon Department of Agriculture, and Oregon Department of Energy.
Resilient Supply

The natural gas energy delivery system is more resilient than any other distribution method:

• **Flexible infrastructure** – performs well in earthquakes, easily reconfigured to route around damage

• **Protected** – Underground pipelines are not affected by wind and ice storms, nor road damage

• **Distributed supply** – Significant storage and renewable sources exist throughout the region
Resiliency Hubs: City of Portland

Biogas (methane) forms in digesters → Biogas (methane) sent to processing → Renewable natural gas produced → Distributed through NW Natural → And on-site fueling station built for City vehicles

Source: City of Portland BES
# Works for Med/Heavy Duty Fleets

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Specific Energy kWh/kg</th>
<th>Energy Density Wh/L</th>
<th>Range Miles/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>13.3</td>
<td>9944</td>
<td>3.9</td>
</tr>
<tr>
<td>LNG</td>
<td>14.9</td>
<td>6167</td>
<td>2.4</td>
</tr>
<tr>
<td>RNG</td>
<td>15.4</td>
<td>2500</td>
<td>1.0</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>39</td>
<td>1555</td>
<td>0.6</td>
</tr>
<tr>
<td>Battery</td>
<td>0.693</td>
<td>600</td>
<td>0.2</td>
</tr>
</tbody>
</table>

*Source: Peterbuilt*
Low Cost of Fuel

RNG used in vehicles creates value from RINs nation-wide

RNG used in Oregon vehicles creates value from the Oregon Clean Fuels Program

This value can be shared with fleets: $0.30-$0.60/GGE

Commodity cost of NG: $0.50/GGE
RNG Benefits

- Clean burning:
  - Near zero emissions
    - 90-99% less NOx and particulate matter than cleanest diesel
    - Up to 500% less GHG with RNG
  - Lower maintenance (no DPF)
  - Consistently clean
- Most cost effective NOx emissions reductions
- Renewable sources
- Resiliency solution
- Available today – proven technology
Natural Gas Costs
Vehicle Incremental Costs

Cost is highly dependent on range and duty cycle
## Fueling Station Costs

<table>
<thead>
<tr>
<th>Size</th>
<th>Fill Speed</th>
<th>GGE/day</th>
<th>Cost Range ['000s]</th>
<th>Example Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter</td>
<td>Fast</td>
<td>20-40</td>
<td>$45-$75</td>
<td>Four sedans/pickups fueling 10 GGE/day</td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>20-40</td>
<td>$35-$50</td>
<td>Four delivery vehicles fueling 10 GGE/night</td>
</tr>
<tr>
<td>Small</td>
<td>Fast</td>
<td>100-200</td>
<td>$400-$600</td>
<td>15–25 pickups/delivery vans fueling 7 GGE/day</td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>100-200</td>
<td>$250-$500</td>
<td>10–20 school buses fueling 10 GGE/night</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5–10 refuse vehicles fueling 20 GGE/night</td>
</tr>
<tr>
<td>Medium</td>
<td>Fast</td>
<td>500-800</td>
<td>$700-$900</td>
<td>Public retail station serving 50–80 light/medium-duty vehicles fueling 10 GGE/day</td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>500-800</td>
<td>$550-$850</td>
<td>25–40 refuse trucks fueling 20 GGE/night</td>
</tr>
<tr>
<td>Large</td>
<td>Fast</td>
<td>1,500-2,000</td>
<td>$1,200-$1,800</td>
<td>Large retail station serving light- to heavy-duty vehicles such as delivery vans, work trucks, refuse trucks, class 8 tractors, and local fleets</td>
</tr>
</tbody>
</table>

GGE = gasoline gallon equivalents

Source: US DOE
Building Accommodations

Minor garages – existing ventilation may already comply:

- Lubrication, Inspection
- Minor automotive maintenance work, such as engine tune-ups, replacement of parts, fluid changes, etc.

Major garages - $75k-$100k per bay for retrofits

- Engine overhauls, painting, body and fender work
- Repairs that require draining of the motor vehicle fuel tank

Photos source Gladstein, Neandross & Associates, NREL
Recommendations
Oregon Needs Funding

$460 Million in CNG Vehicle Funding Opportunities

Graphic source Gladstein, Neandross & Associates
Policy Strategies

Policy that supports all viable solutions for reducing carbon in transportation sector – not technology specific

Allow utilities to recover alternative fueling infrastructure costs and vehicle incentives

Use alternative fuels to improve resiliency - create policy that incentivizes essential service fleets to use them

SB 98 (RNG bill) has paved the way for supply – need to keep RNG here in Oregon through policy that supports vehicles
Summary

Great air quality and GHG benefits

Proven, mature technology

Significant dollar savings for fleets

Need incentives or policies to grow the market
Thank you!