Sustainable Transportation Energy Pathways (STEPS)

Prospects for Reducing Energy Use and GHGs from Freight Transport

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Lew Fulton
STEPS Co-Director

www.steps.ucdavis.edu
STRATEGIES FOR TRANSITIONING TO LOW-CARBON EMISSION TRUCKS IN THE UNITED STATES

A White Paper from the Sustainable Transportation Energy Pathways Program at UC Davis and the National Center for Sustainable Transportation

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Lew Fulton and Marshall Miller
Sustainable Transportation Energy Pathways Program
Institute of Transportation Studies – University of California, Davis

EXPLORING the ROLE of NATURAL GAS in U.S. TRUCKING

A NextSTEPS white paper by: Amy Myers Jaffe,³ Rosa Dominguez-Faus,¹ Allen Lee,¹ Kenneth Medlock,² Nathan Parker,¹ Daniel Scheirum,¹ Andrew Burke,¹ Hengbing Zhao,¹ Yueyue Fan¹

NextSTEPS
(Sustainable Transportation Energy Pathways) Program
UC Davis Institute of Transportation Studies
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¹ Institute of Transportation Studies, UC Davis
² Rice University
These suggest that with Phase I standards we get a flattening of energy use, but not a decline; Phase II might get us to 30-40% overall reduction in energy intensity and close to a return to 2012 levels of energy use.

It will take a 40% reduction in truck energy intensity to get back to 2012 levels of fuel use.
Large potential, but also major challenges with technology/fuel options

<table>
<thead>
<tr>
<th>Vehicle Technology</th>
<th>Commercial status</th>
<th>Efficiency, Range, and Vehicle Cost</th>
<th>Barriers/issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional diesel/gasoline</td>
<td>Presently dominate all truck types</td>
<td>(baseline technology)</td>
<td>Relatively heavy emitters of GHGs</td>
</tr>
<tr>
<td>Hybrid, plug-in hybrid</td>
<td>Commercial in heavy-duty pickups and buses. Expected to play a significant role in all types</td>
<td>Increase in efficiency</td>
<td>Reduce GHGs but reductions are modest compared to fuel cell and electric</td>
</tr>
<tr>
<td>LNG/CNG</td>
<td>Commercial in almost all types. Significant market in buses, MD urban.</td>
<td>SI NG engines have lower efficiency, Likely decrease in range Increase in first cost</td>
<td>At best, small GHGs benefit except with RNG. Infrastructure immature</td>
</tr>
<tr>
<td>Fuel cell</td>
<td>Extensively tested in buses and cars. Timeline for commercialization in other vehicle types could be 10-20 years</td>
<td>Large increase in efficiency Decreased range Increase in cost</td>
<td>Hydrogen infrastructure lacking. Fuel cell durability/life span is a concern</td>
</tr>
<tr>
<td>Battery electric</td>
<td>Near commercial in some applications, mainly medium duty urban</td>
<td>Large increase in efficiency, but large decrease in range Currently high cost</td>
<td>Vehicles with significant annual mileage may not be able to adopt. Battery life an issue</td>
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</tbody>
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Long-haul truck lifecycle costs: near term and long term

- Using a societal cost approach, fuel costs dominate
- Natural gas competitive, Biodiesel and H2 FCEVs less so
Abundant natural gas is changing the economics and creating opportunities in the medium/heavy duty trucking sectors, but...

- STEPS (Jaffe et al, 2015) study finds that natural gas fuel cost advantage (over petroleum) is not sufficient to launch a national network for long-haul trucking in US

- Likely would need support to get well over 1% long-haul truck share to have a chance to sustain the market.

- Barriers to development for LNG national fueling network include high station network costs and high cost/emissions issues of CNG engines.

- Heavy traffic, high volume markets such as California and the U.S. Great Lakes region would be easiest location to overcome chicken egg barriers.

Major players are reassessing market potential; policy context may be critical aspect to launch of successful US national network.
Our WP - fuel requirements and assumptions

- By 2030, much lower GHG feedstock production/fuel supply pathways would need to be well on their way to replacing current higher GHG pathways, with >80% reductions per unit of fuel by 2050.

- California has a significantly cleaner grid than the US average, so has a “head start” for both electricity and hydrogen decarbonization.

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>100% from natural gas reforming</td>
<td>50% from NG, 50% from electrolysis from grid electricity</td>
<td>100% from very low carbon electricity</td>
</tr>
<tr>
<td>Electricity</td>
<td>Average grid mix</td>
<td>Average grid mix, significantly decarbonized</td>
<td>Grid must be almost completely decarbonized</td>
</tr>
<tr>
<td>Biofuel</td>
<td>Mostly soy-based biodiesel</td>
<td>Renewable diesel, 50% from cellulosic pathways</td>
<td>100% very low GHG renewable diesel</td>
</tr>
</tbody>
</table>
With those assumptions, CO2 reduced dramatically in 2030 (or post 2030) time frame

- Advanced biodiesel, H2/FCEV and Electricity reach very low levels
Here are two ways to achieve an 80% reduction by 2050 in GHG in trucking...both are very challenging:

- Mixed case would require a doubling of current US biofuels use for all purposes and must provide at least 80% reductions in GHG compared to base fuel.
- Hydrogen use in the ZEV case would be about twice U.S. production for all purposes and must be deeply decarbonized, e.g. from “waste” wind/solar power.
ZEV scenario sales must ramp up very quickly after 2025...

Slower ramp up needed in Mixed case (along with biofuels ramp-up), or for a substantially lower GHG reduction target (e.g. 50% rather than 80%)
Conclusions and Policy Considerations

• National and CA efficiency/GHG standards will hopefully help offset truck travel growth to keep CO2 stable

• If we don’t have large quantities of very low net GHG biofuels, we will need large numbers of ZEV trucks
  – In CA, given air quality standards, ZEVs may be needed anyway

• This probably means fuel cell trucks, at least for long haul

• The ramp up for these trucks would need to be dramatic for an 80% scenario in 2050, and would need to start soon.
  – Lower percentage targets may be needed.

• Either strong fiscal incentives or something like a ZEV mandate for trucks might be needed to get us on this path.