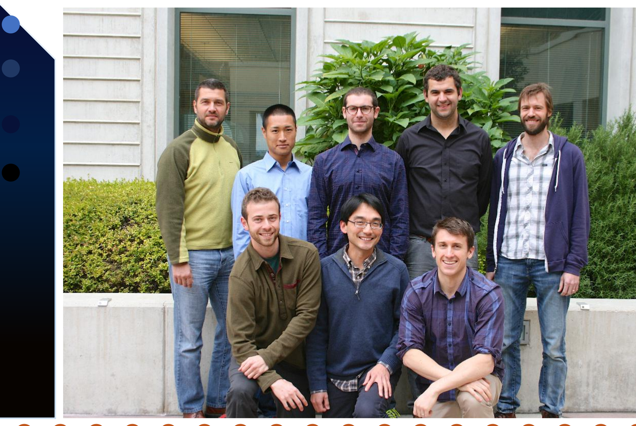
FEAT: A Tool to Reduce Patagonia's Freight Emissions



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Background

Patagonia, an outdoor apparel company, has long been dedicated to promoting environmental stewardship both with its operations and in the greater business landscape. However, because Patagonia does not own or operate its own distribution fleet, the fuel-use greenhouse gas (GHG) emissions associated with moving products remains poorly understood. Due to increasing stakeholder concern over carbon-intensive fuels, such as diesel derived from tar sands, Patagonia has committed itself to evaluating the carbon emissions of its existing distribution network and exploring the use of fuel technologies with a lower global warming potential (GWP).

Inbound freight moves from the ports of Long Beach and San Francisco to the distribution center in Reno, NV. From the distribution center, Patagonia products are dispersed to customers through three channels: Retail, Direct-to-Customer, and Wholesale. Retail shipments go to 30 nationwide Patagonia stores, Direct-to-Customer shipments go directly to customers' doorsteps, and Wholesale shipments are delivered to non-Patagonia-owned retail locations such as EMS and REI.

Objectives

To address these questions, we set the following objectives for our project:

- Conduct a well-to-wheel fuel cycle assessment of the greenhouse gas emissions associated with Patagonia's freight.
- Construct a transparent, user-friendly freight emissions assessment tool that includes current and near-term transportation technologies, fuel types, and emission profiles.
- Develop recommendations for reducing Patagonia's freight GHG emissions.

Fuel Cycle

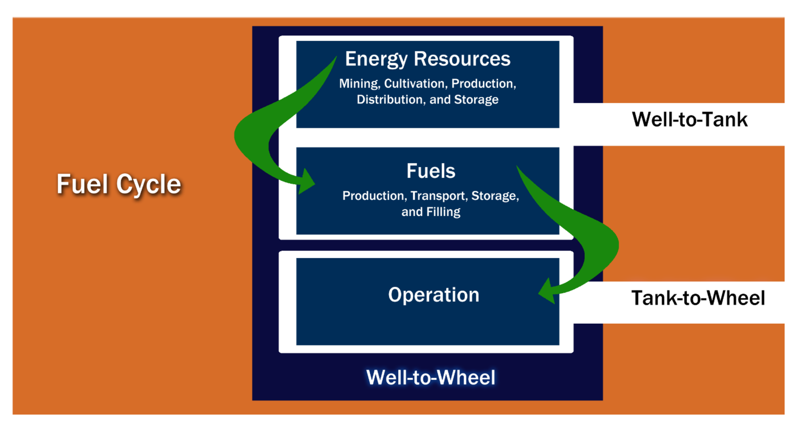
The fuel cycle is defined as the combination of Well-to-Tank and Tank-to-Wheel emissions.

Well-to-Tank (WTT) emissions are the emissions associated with upstream fuel recovery, production, refining, and transport to point-of-use.

While Tank-to-Wheel (TTW) emissions are the use phase emissions associated with the refueling, consumption, and evaporation of the fuel.

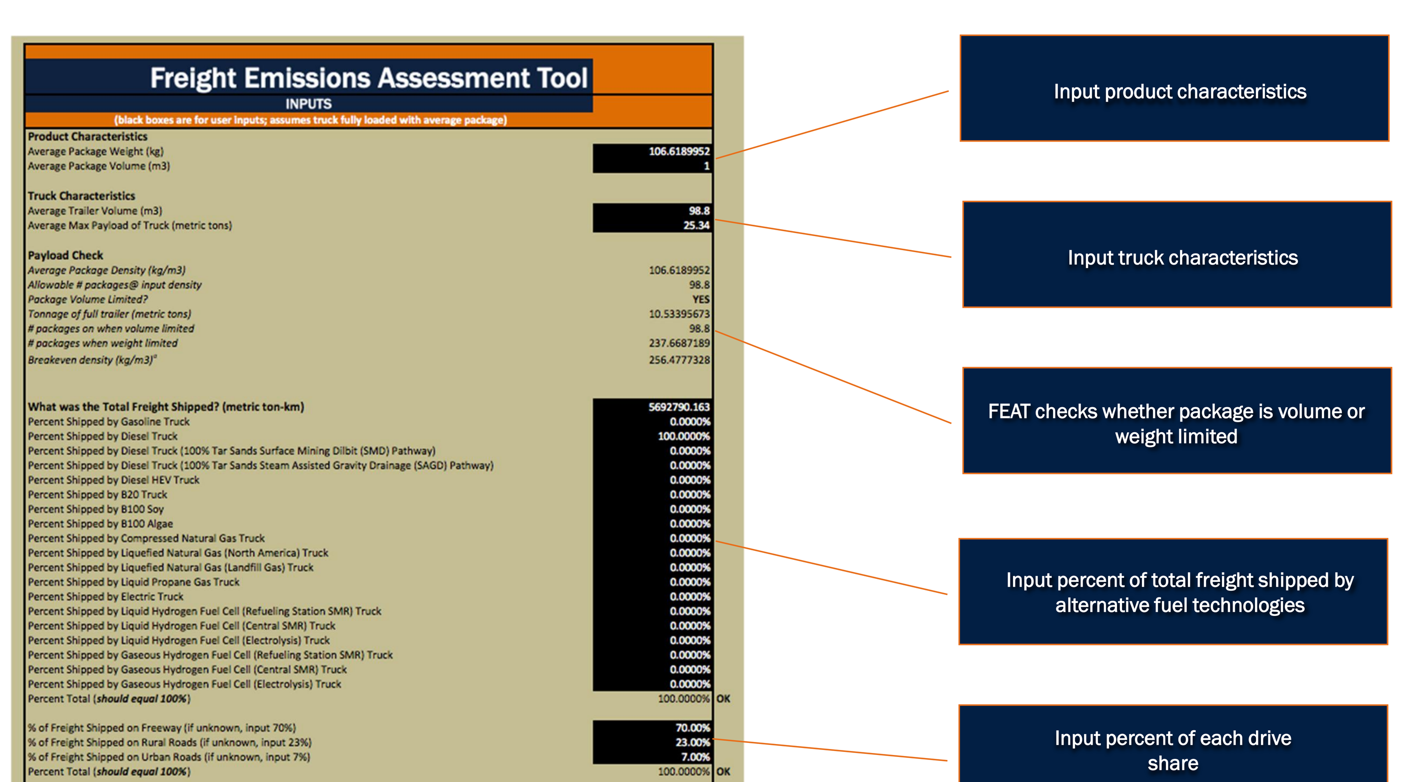
Overall, the entire fuel cycle is simply expressed as:

WTT + TTW = Well-to-Wheel (WTW)



FEAT

The project developed the Freight Emissions Assessment Tool (FEAT), a user-friendly logistics tool that quantifies total fuel consumption and GHG emissions from US Class 8 heavy-duty vehicles (HDVs) over the entire fuel life cycle. In addition, the tool maintains a comprehensive inventory of alternative fuels, enabling users to compare emissions from both existing and alternative fuel systems. Using Patagonia's FY 2012 domestic freight data (excluding Hawaii), a baseline GWP emissions assessment was conducted for the company using FEAT, and actionable recommendations were made based on the project findings. In addition to a primary analysis of Patagonia's existing freight emissions, the project provides a critical review of conventional and alternative transportation fuel technologies.



Freight Emissions Assessment Tool

INPUTS

(black boxes are for user inputs; assumes truck fully loaded with average package)

Product Characteristics	
Average Package Weight (kg)	106.6189952
Average Package Volume (m3)	1
Truck Characteristics	
Average Trailer Volume (m3)	98.8
Average Max Payload of Truck (metric tons)	25.34
Payload Check	
Average Package Density (kg/m3)	106.6189952
Allowable # packages@ input density	98.8
Package Volume Limited?	YES
Tonnage of full trailer (metric tons)	10.53395673
# packages on when volume limited	98.8
# packages when weight limited	237.6687189
Breakeven density (kg/m3)[a]	256.4777328
What was the Total Freight Shipped? (metric ton-km)	5692790.163
Percent Shipped by Gasoline Truck	0.0000%
Percent Shipped by Diesel Truck	100.0000%
Percent Shipped by Diesel Truck (100% Tar Sands Surface Mining Dilbit (SMD) Pathway)	0.0000%
Percent Shipped by Diesel Truck (100% Tar Sands Steam Assisted Gravity Drainage (SAGD) Pathway)	0.0000%
Percent Shipped by Diesel HEV Truck	0.0000%
Percent Shipped by B20 Truck	0.0000%
Percent Shipped by B100 Soy	0.0000%
Percent Shipped by B100 Algae	0.0000%
Percent Shipped by Compressed Natural Gas Truck	0.0000%
Percent Shipped by Liquefied Natural Gas (North America) Truck	0.0000%
Percent Shipped by Liquefied Natural Gas (Landfill Gas) Truck	0.0000%
Percent Shipped by Liquid Propane Gas Truck	0.0000%
Percent Shipped by Electric Truck	0.0000%
Percent Shipped by Liquid Hydrogen Fuel Cell (Refueling Station SMR) Truck	0.0000%
Percent Shipped by Liquid Hydrogen Fuel Cell (Central SMR) Truck	0.0000%
Percent Shipped by Liquid Hydrogen Fuel Cell (Electrolysis) Truck	0.0000%
Percent Shipped by Gaseous Hydrogen Fuel Cell (Refueling Station SMR) Truck	0.0000%
Percent Shipped by Gaseous Hydrogen Fuel Cell (Central SMR) Truck	0.0000%
Percent Shipped by Gaseous Hydrogen Fuel Cell (Electrolysis) Truck	0.0000%
Percent Total (***should equal 100%***)	100.0000% OK
% of Freight Shipped on Freeway (if unknown, input 70%)	70.00%
% of Freight Shipped on Rural Roads (if unknown, input 23%)	23.00%
% of Freight Shipped on Urban Roads (if unknown, input 7%)	7.00%
Percent Total (***should equal 100%***)	100.0000% OK

[a]Optimum package density @ trailer volume

Results

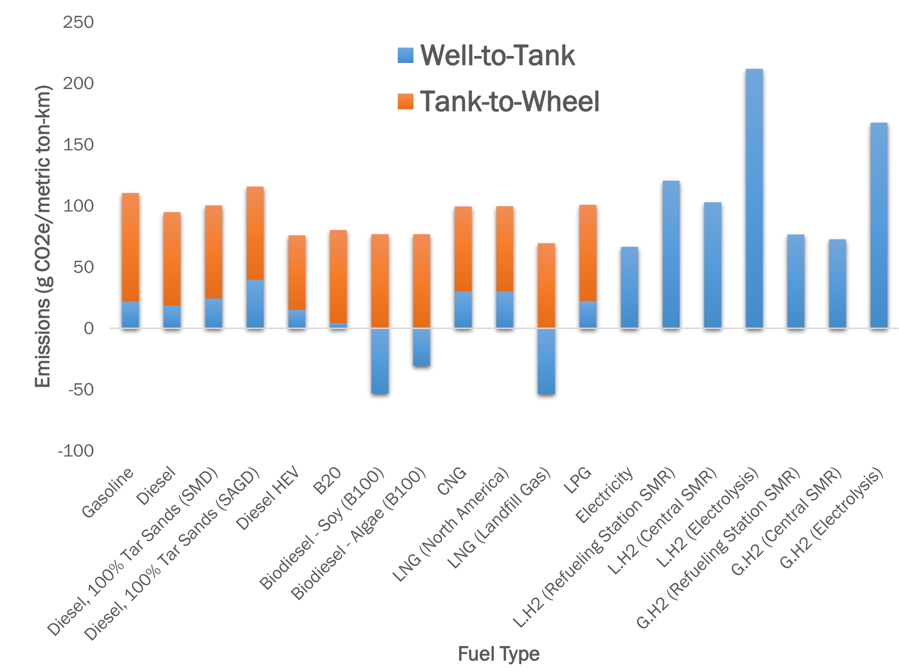


Figure 1

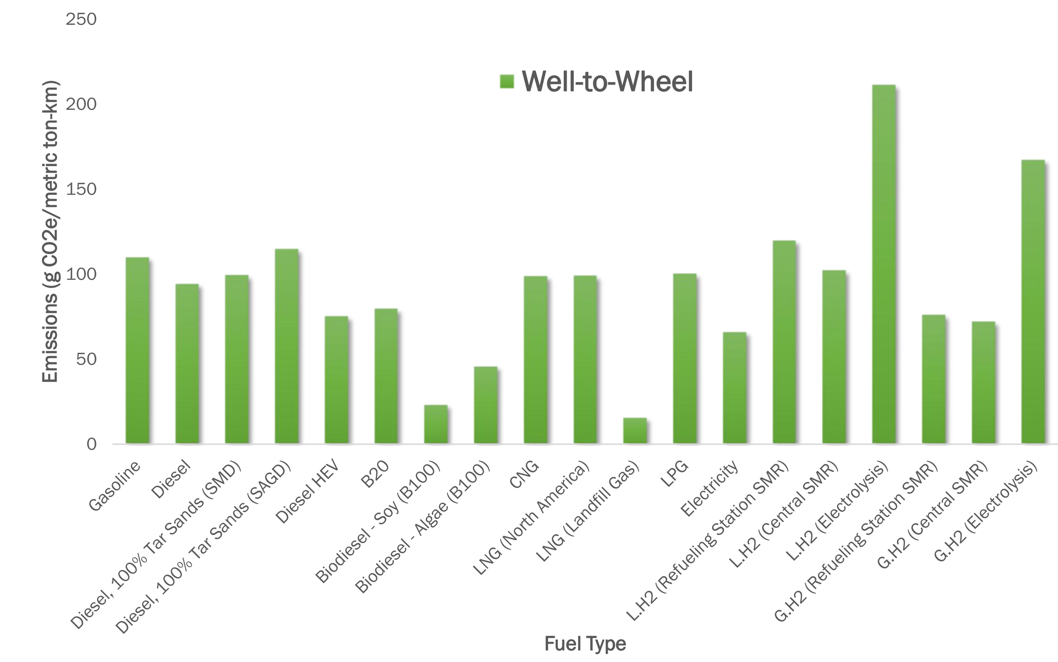


Figure 2

Both Figure 1 and Figure 2 illustrate GHG emissions per unit of freight as a function of fuel type. Emission factors are shown in grams of CO_2-equivalents per metric ton-km.

In Figure 1, the orange segments of each bar show WTT emissions. Some upstream emissions are negative because biofuels such as biodiesel sequester carbon during production and natural gas from landfills is credited for avoided flaring emissions. The blue segments show the TTW emissions. Some fuels do not have use-phase emissions since electric or hydrogen vehicles do not emit any GHGs during operation.

Figure 2 illustrates WTW emissions related to the entire fuel cycle, from extraction to consumption.

To address Patagonia's interest in tar sands, emission factors for diesel produced from tar sands are included. Three emission factors for diesel used in conventional trucks are shown. The first diesel value is based on the average consumptive mix in the US, which comes from a number of production sources, both conventional and unconventional. The other two diesel emission factors are based on two different production pathways, representing the low and high end of emissions associated with tar sands. It is observed that the GHG levels from tar sands are higher than the average consumptive mix, suggesting that Patagonia's interest in avoiding tar sands was justified.

With the emissions associated with moving a unit of freight via diesel truck, the total GHG emissions from transporting Patagonia freight in 2012 can be calculated, shown in Figure 3.

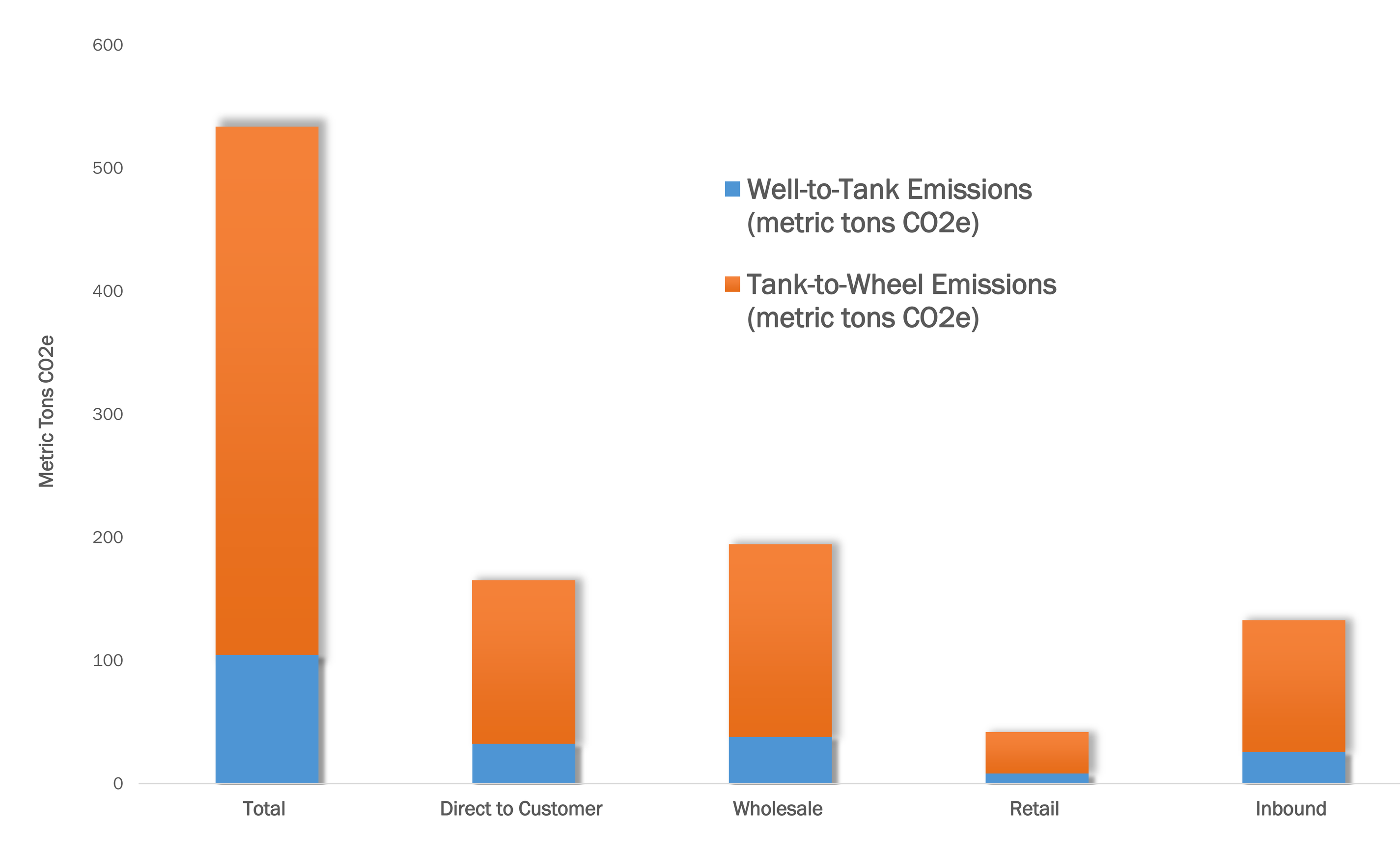


Figure 3

The total GHG emissions associated with moving all domestic Patagonia freight by Class 8 conventional diesel trucks is 534 metric tons of CO_2-equivalents. The other bars show the emissions broken down by distribution leg, described in the Background section.

Ultimately, there is a concern of whether or not integrating alternative fuel technologies is feasible for Patagonia given that the company does not own its own truck fleet and contracts with third-party shipping companies. Alternatively, GHG emissions can be altered through other parameters unrelated to fuel type. A sensitivity analysis of FEAT suggests that package density has a large impact on GHG emissions.

Conclusions

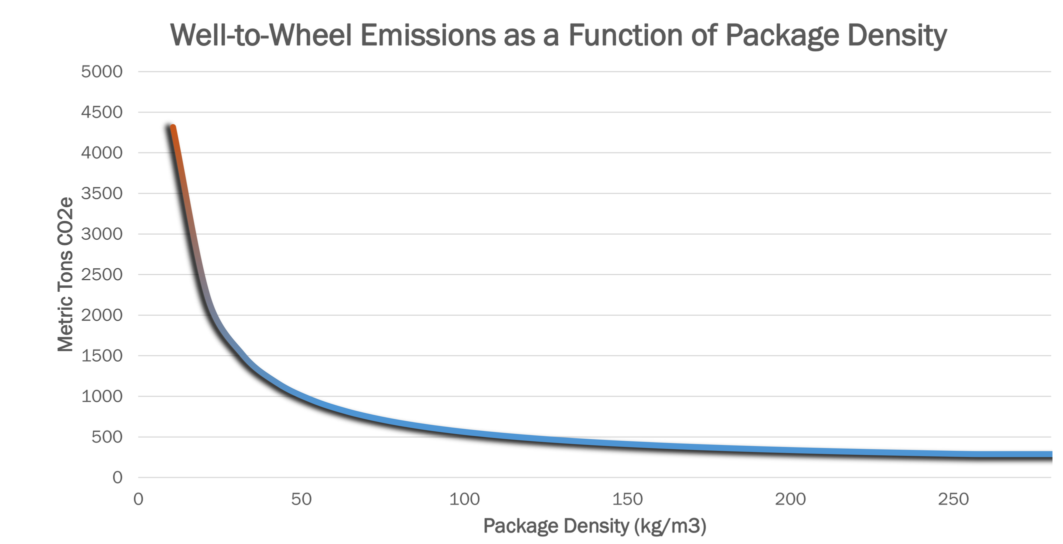


Figure 4

Figure 4 suggests that the density can have a large impact on GHG emissions, ranging from over 4,000 metric tons of CO_2-equivalents at a low package density to less than 500 metric tons at high package densities.

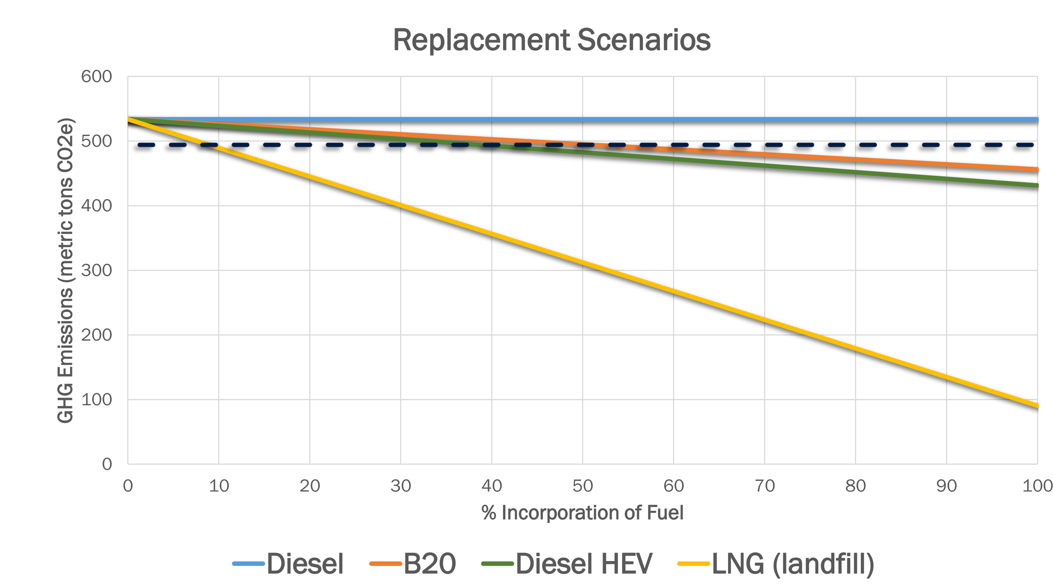


Figure 5

Figure 5 illustrates the effect of increasing the replacement of diesel vehicles with fuels that were observed to have lower emission factors than diesel and for which trucks are currently available. The dotted line shows how diesel GHG emissions would compare if package density were increased by 10%. It is observed that 50% of Patagonia packages would have to be shipped by trucks using B20, 38% by diesel hybrid electric vehicles, or 9% by LNG trucks fueled by natural gas derived from landfills to match the GHG emission reductions achieved by increasing package density by 10%.

As such, the project's most feasible recommendation is to increase the density of shipped packages as much as possible. Not only does an increased density have a large GHG emissions reduction potential, but Patagonia has direct control over this parameter.

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