

0gCO<sub>2</sub>/km



# Cost Impact Study for Potential Next-Tier EPA HDOH Emission Regulations

Final report

October 15, 2021

C022563-003

[www.ricardo.com](http://www.ricardo.com)

# Ricardo's cost impact study provides the incremental cost for HD engines to comply with potential next-tier EPA HDOH emission regulations



## Summary

- Ricardo performed a cost impact study for assessing the impact of potential next-tier EPA HDOH (heavy-duty on-highway) emission regulations for three engine platforms – HHDDE (heavy heavy-duty diesel engines), MHDDE (medium heavy-duty diesel engines), and LHD Gas (light heavy-duty gasoline engines)
- Study investigated costs directly associated with cost drivers like technical solution, useful life, warranty, R&D, OBD, laboratory investments, and in-use compliance
- Ricardo's proven methodology for technology cost assessment was used for this study
  - Developed scenarios defining potential next-tier EPA emission regulations
  - Engine and truck manufacturing OEMs were then requested to share incremental cost information based on identified cost drivers
  - Responses from OEMs were analyzed and validated using Ricardo's experience with engine and after-treatment technology assessments, interviews with industry experts, public reports, and desk research

- Based on extensive experience conducting similar studies regarding regulation-driven costs, Ricardo is confident in the methodology and accuracy of the incremental costs we have projected



Incremental cost analysis for potential next-tier EPA HDOH emissions regulations						
Platforms	Scenario 1: 90% NOx reduction, ~50% Extended UL and CARB "Step 1" Warranty		Scenario 2: 50% NOx reduction, UL and Warranty aligned with CARB Omnibus		Scenario 3: 90% NOx reduction, UL and Warranty aligned with CARB Omnibus	
	MY 2027	MY 2031	MY 2027	MY 2031	MY 2027	MY 2031
HHDDE	\$5,882	\$18,007	\$18,483	\$31,153	\$21,214	\$34,682
MHDDE	\$4,255	\$7,323	\$6,648	\$9,377	\$8,628	\$11,494
LHD Gasoline	\$2,274	\$2,475	\$1,572	\$1,718	\$2,521	\$2,713

All incremental costs are relative to MY21 baseline

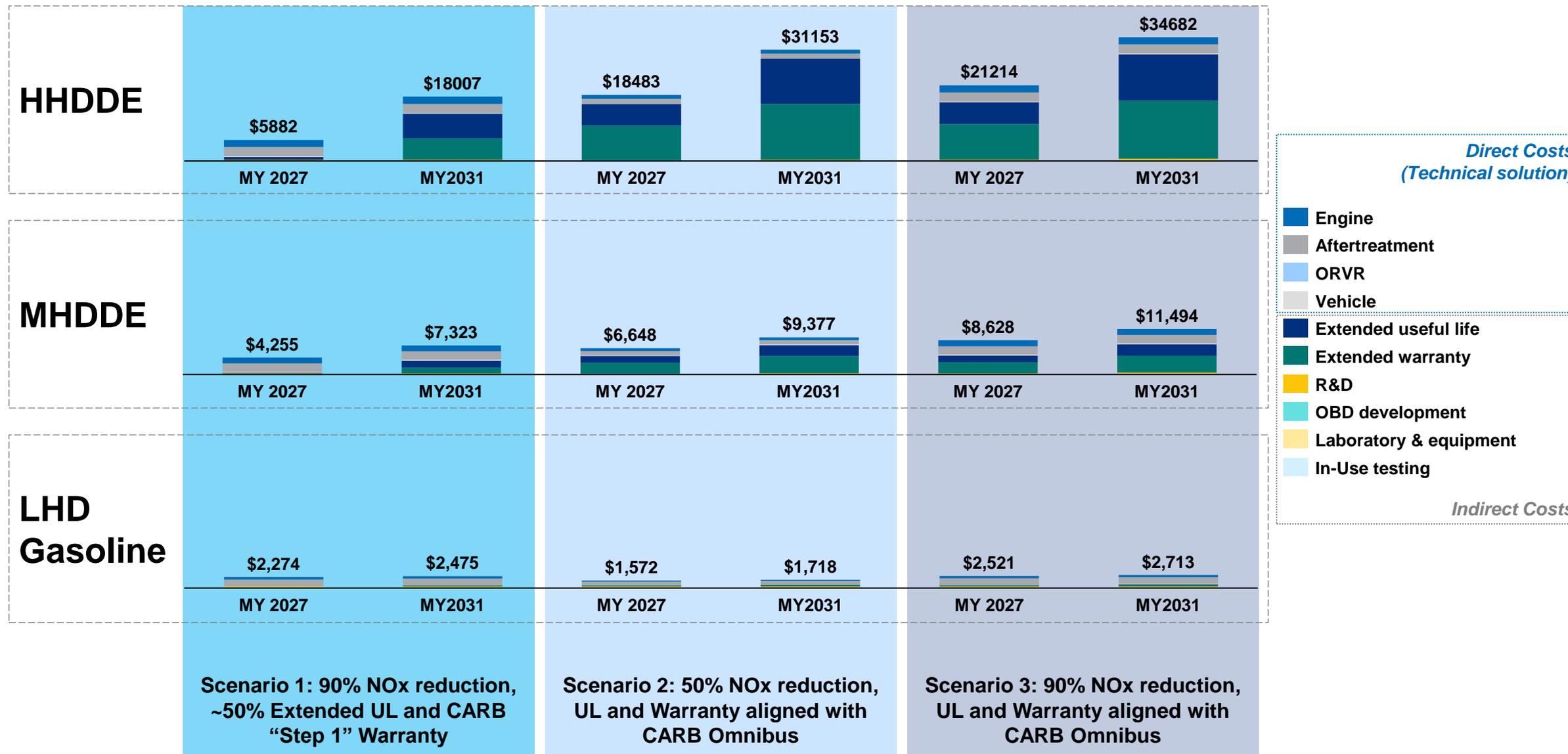
# Incremental cost analysis for potential EPA next-tier HDOH emissions for HHDDE, MHDDE and LHD Gasoline platforms under 3 different scenarios of assumptions



<p><b>HHDDE</b> Class 8 &gt; 33k lbs. 12-13L</p>	<p><b>NOx Stringency:</b> 0.02g/bhp-hr. <b>Useful life:</b> MY27 - No change; MY31 - 11yr/650k mi <b>Warranty:</b> MY27 - No change; MY31 - 5yr/350k mi</p>	<p><b>NOx Stringency:</b> 0.1g/bhp-hr. <b>Useful life:</b> MY27 - 11yr/600k mi; MY31 - 12yr/800k mi <b>Warranty:</b> MY27 - 7yr/450k mi; MY31 - 10yr/600k mi</p>	<p><b>NOx Stringency:</b> 0.02g/bhp-hr. <b>Useful life:</b> MY27 - 11yr/600k mi; MY31 - 12yr/800k mi <b>Warranty:</b> MY27 - 7yr/450k mi; MY31 - 10yr/600k mi</p>
<p><b>MHDDE</b> Class 6-7 &gt; 19,501-33k lbs. 7-9L</p>	<p><b>NOx Stringency:</b> 0.02g/bhp-hr. <b>Useful life:</b> MY27 - No change; MY31 - 11yr/270k mi <b>Warranty:</b> MY27 - No change; MY31 - 5yr/150k mi</p>	<p><b>NOx Stringency:</b> 0.1g/bhp-hr. <b>Useful life:</b> MY27 - 11yr/270k mi; MY31 - 12yr/350k mi <b>Warranty:</b> MY27 - 7yr/220k mi; MY31 - 10yr/280k mi</p>	<p><b>NOx Stringency:</b> 0.02g/bhp-hr. <b>Useful life:</b> MY27 - 11yr/270k mi; MY31 - 12yr/350k mi <b>Warranty:</b> MY27 - 7yr/220k mi; MY31 - 10yr/280k mi</p>
<p><b>LHD Gasoline</b> &gt; 14,000 lbs. 6-8L</p>	<p><b>NOx Stringency:</b> 0.02g/bhp-hr. <b>Useful life:</b> MY27 - No change; MY31 - 12yr/155k mi <b>Warranty:</b> MY27 - No change; MY31 - 5yr/75k mi</p>	<p><b>NOx Stringency:</b> 0.1g/bhp-hr. <b>Useful life:</b> MY27 - 12yr/155k mi; MY31 - 15yr/200k mi <b>Warranty:</b> MY27 - 7yr/110k mi; MY31 - 10yr/160k mi</p>	<p><b>NOx Stringency:</b> 0.02g/bhp-hr. <b>Useful life:</b> MY27 - 12yr/155k mi; MY31 - 15yr/200k mi <b>Warranty:</b> MY27 - 7yr/110k mi; MY31 - 10yr/160k mi</p>
<p><b>Scenario 1: 90% NOx reduction, ~50% Extended UL and CARB "Step 1" Warranty</b></p>		<p><b>Scenario 2: 50% NOx reduction, UL and Warranty aligned with CARB Omnibus</b></p>	<p><b>Scenario 3: 90% NOx reduction, UL and Warranty aligned with CARB Omnibus</b></p>

*Assumptions for 3 engine platforms across 3 scenarios*

# HD diesel platforms will experience significant cost increase primarily due to extended UL and warranty; LHD gasoline costs predominately driven by AT costs



All incremental costs are relative to MY21 baseline

# Incremental costs due to increased stringency of NOx emission standards and extended warranty & UL requirements are expected to cause a pre-buy phenomenon

## Expected pre-buy volume as % of market

	2027		2031		2027		2031		2027		2031		New Standards Year
	2025	2026	2029	2030	2025	2026	2029	2030	2025	2026	2029	2030	Calendar Year
<b>HHDE</b>	0.67%	9.83%	2.85%	18.55%	2.09%	30.88%	2.98%	19.38%	2.40%	35.45%	3.17%	20.60%	<b>Pre-buy volume as % of market</b>
<b>MHDDE</b>	2.05%	16.13%	1.24%	4.34%	3.21%	25.20%	1.10%	3.86%	4.17%	32.71%	1.16%	4.06%	
<b>LHD Gasoline</b>	Estimated pre-buy volumes is lower than 1% for MY27 and MY31 for all scenarios												
	<b>Scenario 1: 90% NOx reduction, ~50% Extended UL and CARB “Step 1” Warranty</b>				<b>Scenario 2: 50% NOx reduction, UL and Warranty aligned with CARB Omnibus</b>				<b>Scenario 3: 90% NOx reduction, UL and Warranty aligned with CARB Omnibus</b>				

- ACT Research performed pre-buy analysis to assess the impact of CARB’s Omnibus Low NOx rulemaking (Omnibus regulations) on heavy duty and medium duty trucks
- Ricardo analysis makes use of the ACT Research pre-buy analysis and scales it appropriately based on incremental costs of technology for different scenarios
  - Assumes all other factors (micro or macro economic) remain the same

# Incremental costs due to increased stringency of NOx emission standards and extended warranty & UL requirements are expected to cause a pre-buy phenomenon

## Expected pre-buy volume

	2027		2031		2027		2031		2027		2031		New Standards Year
	2025	2026	2029	2030	2025	2026	2029	2030	2025	2026	2029	2030	Calendar Year
<b>HHDE</b>	1,472	21,755	6,574	42,729	4,626	68,360	6,869	44,649	5,309	78,461	7,302	47,461	<b>Pre-buy volume</b>
<b>MHDDE</b>	2,529	19,852	1,589	5,563	3,951	31,017	1,414	4,948	5,127	40,254	1,485	5,196	
<b>LHD Gasoline</b>	Estimated pre-buy volumes is lower than 1% for MY27 and MY31 for all scenarios												
	<b>Scenario 1: 90% NOx reduction, ~50% Extended UL and CARB "Step 1" Warranty</b>				<b>Scenario 2: 50% NOx reduction, UL and Warranty aligned with CARB Omnibus</b>				<b>Scenario 3: 90% NOx reduction, UL and Warranty aligned with CARB Omnibus</b>				

- ACT Research performed pre-buy analysis to assess the impact of CARB's Omnibus Low NOx rulemaking (Omnibus regulations) on heavy duty and medium duty trucks
- Ricardo analysis makes use of the ACT Research pre-buy analysis and scales it appropriately based on incremental costs of technology for different scenarios
  - Assumes all other factors (micro or macro economic) remain the same

# Low-buy phenomenon is expected in 2027 and 2031 due to expected pre-buy phenomenon prior to MY2027 and MY2031 in HHDDE and MHDDE segment

## Expected low-buy volume

	2027	2031	2027	2031	2027	2031	New Standards Year
	2027	2031	2027	2031	2027	2031	Calendar Year
<b>HHDDE</b>	23,227	49,303	72,986	51,518	83,770	54,763	<b>Low-buy volume</b> <i>(Vehicles that won't be bought due to pre-buy in years preceding to introduction of regulation)</i>
<b>MHDDE</b>	22,381	7,152	34,968	6,362	45,381	6,681	
<b>LHD Gasoline</b>	Low-buy phenomenon not anticipated						
	<b>Scenario 1: 90% NOx reduction, ~50% Extended UL and CARB "Step 1" Warranty</b>		<b>Scenario 2: 50% NOx reduction, UL and Warranty aligned with CARB Omnibus</b>		<b>Scenario 3: 90% NOx reduction, UL and Warranty aligned with CARB Omnibus</b>		

- Ricardo analysis assumes that the low-buy scale (volume) will be similar to the pre-buy and will occur in the year of introduction of the new regulations