Appendix B

Potential Emission and Health Impacts of Glider Kits

EPA is proposing to allow glider kits to be sold without meeting the emission standards currently applicable to new heavy-duty engines. Glider kits are new heavy-duty diesel vehicles equipped with rebuilt older engines. EPA testing of glider kits shows that their emissions are more than an order of magnitude higher than those of other new vehicles with engines meeting current standards.[1] In its Phase 2 medium- and heavy-duty truck rule, EPA projected the excess emissions and increased health impacts should glider sales remain at the current estimated sales level of 10,000 units per year. This report extends EPA's analysis by considering the impact of even greater annual sales of glider kits to 30,000 and 50,000 units per year. In the 2016 Phase 2 final rule, EPA acknowledged that glider vehicle sales could be greater than the 10,000 unit estimate,[2] and several stakeholders who testified at EPA's December 4, 2016 hearing indicated that if the glider provisions were repealed, sales would be much higher.[3] In fact, several truck dealers and truck repair facilities testified that gliders sales could reach 25 to 30% of annual truck sales or up to 60,000 units.[4]

[1] Chassis Dynamometer Testing of Two Recent Model Year Heavy-Duty On-Highway Diesel Glider Vehicles, November 20, 2017, National Vehicle & Fuel Emissions Laboratory, U.S. Environmental Protection Agency, Ann Arbor, Michigan.
[2] 81 Fed. Reg. at 73,943; HDP2 RTC pg. 1960.
[3] Testimony of John C. Doub, TMI Truck and Equipment, Docket ID No. EPA-HQ-OAR-2014-0827-4285 (Dec. 4, 2017), available at https://www.regulations.gov/document?D=EPA-HQ-OAR-2014-0827-4285 ("If [EPA repeals the glider provisions], our lost sales to Glider Kits each Month could grow from the 10% it is today to what could be 30+%.").
[4] See id. See also Testimony of Michael P. McMahon, McMahon Truck Centers, Docket ID No. EPA-HQ-OAR-2014-0827-4300 (Dec. 4, 2017), available at https://www.regulations.gov/document?D=EPA-HQ-OAR-2014-0827-4300 ("We estimate losing approximately 25% of our annual New Truck retail volume to Glider Kits.").

Table 1 shows historic and projected future sales under EPA's 2016 estimate and two scenarios reflecting higher sales of glider kits.

Table 1: Glider Sales			
Calendar Year	EPA Projection	Scenario 1	Scenario 2
2009 and earlier	500	500	500
2010	1250	1250	1250
2011	2000	2000	2000
2012	2750	2750	2750
2013	3500	3500	3500
2014	4250	4250	4250
2015	10000	10000	10000
2016	10000	15000	15000
2017	10000	20000	20000
2018	10000	23100	25000
2019	10000	26500	30000
2020	10000	28400	35000
2021	10000	29700	40000
2022	10000	30000	45000
2023 and beyond	10000	30000	50000

As can be seen from Table 1, EPA's projection reaches 10,000 units in 2015 and remains constant thereafter. This scenario implicitly assumes that granting the petition to allow unabated glider kit sales will not result in higher sales of glider kits than has already occurred. The two other sales scenarios shown in Table 1 assume that allowing unregulated glider kit sales will result in greater sales. Scenario 1 projects that sales increase to 30,000 units by 2022. Scenario 2 projects that sales increase to 50,000 units by 2023.

EPA made two kinds of emission estimates that would result from their projection of increased glider sales. The first estimated incremental emissions over the life of a glider vehicle relative to those of a vehicle powered by an engine meeting current emission standards. The second estimated the total emissions from glider kit vehicles in 2025 and 2040 if they were unregulated and if their sales were limited to roughly 1000 units per year. All types of emissions from glider vehicles increase relative to vehicles equipped with new engines: hydrocarbons (HC), carbon monoxide (CO), nitrogen oxide (NOx), and particulate matter (PM). This analysis will focus on NOx and PM emissions, as these are the most serious from a health and welfare point of view.

Table 2 shows the vehicle lifetime NOx and PM emissions from 2017 glider vehicles and vehicles with new engines.

Table 2: EPA Projections of Excess Emissions from Glider Vehicle Sales		
	NOx	PM
Lifetime Emissions (U.S. tons per 1000 vehicles)		
Glider Vehicles	43,800	710
Vehicles equipped with New Engines	2,300	30
Difference	41,500	680

As can be seen in Table 2, lifetime NOx and PM emissions from glider vehicles ae roughly 20 times those of vehicles with new engines. Since these emission estimates pertain to a specific number of vehicle sales, they apply regardless of whether glider kit sales reach 10,000 units per year or 30,000-50,000 units per year.

Table 3 shows the impact of limiting unregulated glider vehicle sales to 1,000 units per year.

Table 3: Nationwide Emissions From Glider Vehicles with and without Control (U.S. tons per year)		
2025	NOx	PM
Without Controls	295,000	7,800
With Controls	104,800	2,750
Difference	190,200	5,050
2040		
Without Controls	371,100	9,960
With Controls	52,600	1,410
Difference	318,600	8,550

As can be seen, regulation reduces the NOx and PM emissions impact of glider vehicles by roughly 65% in 2025 and roughly 85% in 2040.

The emissions of a specified set of vehicles in a calendar year has traditionally been estimated by determining the number of vehicles on the road, their annual mileage, and the emission rate per mile (the emission factor). More recent and advanced models, like EPA's MOVES model, estimates emissions based on specific vehicle operating conditions, such as acceleration rate.

The number of vehicles on the road is estimated from the number of new vehicles sold in each of the current and previous 29 model years coupled with estimates of the scrappage rate of these vehicles by age. Annual mileage is also a function of age, being highest when the vehicles are newer and decreasing with age. The emission factor is affected by a wide range of factors, ranging from ambient conditions, the vehicle's driving cycle, vehicle age, and others. For the purposes of this analysis, the two more aggressive glider vehicle sales scenarios primarily affect the first factor listed above: the number of glider vehicles on the road. Mileage per year is affected to a small degree, since the average age of glider vehicles changes slightly under the

three scenarios. The two more aggressive sales scenarios increase glider sales in the later years more than earlier years, so the average age of glider vehicles decreases and the average mileage of glider vehicles in any specific calendar year increases. Emissions from glider vehicles at any of the operating conditions modeled in MOVES are not affected.

In MOVES, the simplest factor to reproduce outside of the model is the vehicle scrappage rate. MOVES uses the same scrappage rate by age for all heavy-duty vehicles (Table 7-2).[5] We obtained the annual vehicle miles travelled for heavy-duty vehicles by age and the fraction of heavy-duty vehicles still on the road by age (Table 7-2) used in MOVES. EPA stated that their glider kit sales projection would result in 128,750 glider vehicles being on the road in 2025. When we combine the scrappage fractions in MOVES with the glider kit sales shown in Table 1, the result is 127,828 vehicles being on the road in 2025, which is within 1% of the MOVES-based estimate. This is strong confirmation that we have the appropriate rate of scrappage for glider vehicles.

A very good first order estimate of the impact of higher glider vehicle sales on emissions results from estimating the number of glider vehicles on the road in 2025 and 2040 under the three sales scenarios and scaling the EPA emission impacts accordingly. These would be conservative estimates, however. As mentioned above, the average age of glider vehicles decreases slightly under the two more aggressive sales projections, increasing average mileage per year and thus, emissions.

In order to include the impact of higher annual mileage, we estimated the degree to which annual mileage changes with age. This relative change in annual mileage with age is coupled with the distribution of glider vehicles on the road in 2025 and 2040 to estimate the degree to which the more aggressive projections of glider vehicle sales increases total glider vehicle emissions in these years. Implicit in this methodology is the assumption that glider vehicle emissions are not affected by vehicle age. Vehicular emissions often increase with age due to inadequate maintenance and deterioration in the efficiency of emission control equipment. However, deterioration in emissions from heavy-duty diesel vehicle is very low, especially from vehicles without aftertreatment equipment, which is the case for glider vehicles. Thus, the assumption of similar emission rates over the slight differences in vehicle age seen here is reasonable.

MOVES uses discrete estimates of annual vehicle miles travelled by age for seven different categories of heavy-duty vehicles. However, EPA stated in their glider analysis that they assumed that glider vehicles were used in tractor-trailers. Two of the seven heavy-duty vehicle categories apply to tractor trailers: short-haul combination (tractor-trailer) trucks and long-haul combination trucks. In MOVES, the annual mileage of new vehicles ranges from 61,000 for short-haul combination trucks to 117,000 for long-haul combination trucks. From the MOVES input files published with the consideration of this petition, EPA spread glider kit sales across short and long-haul combination trucks according to their presence in the on-road fleet. From Table 17-1 of the above cited MOVES population and activity report, long-haul combination

[5] "Population and Activity for On-Road Vehicles in MOVES2014," Assessment and Standards Division, Office of Transportation Air Quality, U.S. EPA, EPA-420-R-20-16-003, January 2016.

trucks represent 56.4% and 56.5% of all combination trucks on the road in 2025 and 2040, respectively. (Short haul combination trucks therefore represent 43.6% and 43.5% of all combination trucks on the road in 2025 and 2040, respectively.)

We then proceeded to estimate total glider vehicle mileage in the on-road fleet in 2025 and 2040 for the three glider vehicle sales projections shown in Table 1. Glider vehicle sales were taken from Table 1. (For example, for the 2025 analysis, this meant glider vehicle sales from 2025 back to 1995.) Vehicle scrappage by age was taken from Table 7-2 of the MOVES population and activity report. Vehicle mileage by age was a weighted average of the mileages by age for short- and long-haul combination trucks shown in Tables 7-5 and 7-7 of the MOVES population and activity report. The number of glider vehicles estimated to be on the road and their mileage under the three sales projections are shown in Table 4.

Table 4: Relative Emission Impacts of Uncontrolled Glider Kit Emissions			
	EPA Sales	Sales Scenario 1	Sales Scenario 2
	2025		
Vehicle on the road	127,828	288,790	385,728
Ratio to EPA Sales	---	2.3	3.0
Million Vehicle Miles Travelled	9,311	22,968	31,710
Ratio to EPA Sales		2.5	3.4
	2040		
Vehicle on the road	259,178	702,381	1,085,628
Ratio to EPA Sales	---	2.7	4.2
Million Vehicle Miles Travelled	12,688	37,071	60,257
Ratio to EPA Sales		2.9	4.7

As can be seen, the impact of the more aggressive glider vehicle sales scenarios has a growing impact on the number of glider vehicles on the road over time. In 2025, the number of glider vehicles on the road are 2.3-3.0 times that under the EPA sales scenarios. Note that these factors are well below the ratios of ultimate maximum sales of glider vehicles in these two scenarios of 3 and 5, respectively, because the maximum sales of glider vehicles has only been occurring for 2-3 years. The impact of more aggressive glider vehicle sales grows further by 2040, to factors of 2.7-4.2 over that of the EPA sales scenario. It will take another 10 years for the full impact of the maximum projected glider vehicle sales to be fully felt in the on-road fleet.

As also shown in Table 4, the impact of increased glider vehicle sales on vehicle miles travelled is slightly larger than on sales due to the higher mileage of new vehicles. However, the ratio of vehicle miles travelled under the two more aggressive glider kit sales scenarios are still below the long-term sales ratios of 3-5.

Table 5 shows total NOx and PM emissions from uncontrolled glider vehicles in 2025 and 2040 under the three sales scenarios. Emissions for the two more aggressive glider vehicle sales scenarios are simply those under the EPA scenario multiplied by the ratios of vehicle miles travelled, shown in Table 4. Table 5 also shows emissions should these glider vehicles be controlled starting in 2018. In this latter case, the emission levels are nearly the same under all three scenarios, as EPA's controls would limit glider vehicle sales to roughly 1,000 vehicles per year. However, in 2015-17, glider vehicle sales are higher under the more aggressive sales scenarios than under EPA's sales projection. Thus, we again estimated the relative level of total vehicle miles travelled by glider vehicles in 2025 and 2040 using the sales up to 2017 from Table 1 and then limited sales to 1,000 per year thereafter. We found that vehicle miles travelled under the two more aggressive sales scenarios were 30% higher than under EPA's scenario in 2025 and 22% higher in 2040. We adjusted EPA's emission projections for controlled glider vehicles accordingly.

Table 5: Glider Vehicle Emission Impacts Under Three Sales Scenarios						
	EPA Sales		Sales Scenario 1		Sales Scenario 2	
2025	NOx	PM	NOx	PM	NOx	PM
Without Controls	295,000	7800	727,723	19,241	1,004,698	26,565
With Controls	104,800	2750	131,766	3,458	131,766	3,458
Difference	190,200	5050	595,957	15,784	872,933	23,107
2040						
Without Controls	371,100	9960	1,078,731	28,952	1,745,242	46,841
With Controls	52,600	1410	64,406	1,726	64,406	1,726
Difference	318,600	8550	1,014,325	27,226	1,680,836	45,114

As can be seen in Table 5, the benefits of glider vehicle control increase 3.1-4.6 times under the more aggressive sales scenarios in 2025. In 2040, the benefits of control increase 3.2-5.3 times under the more aggressive sales scenarios.

Moving to health effects and monetized health benefits, EPA estimated the monetized health benefits and reduction in premature mortality associated with the control of glider vehicle emissions. EPA specifically estimated these benefits over the lifetime of 1000 2017 glider vehicles. EPA found that controlling the emissions of these vehicles would reduce 70-160 premature deaths and generate $0.3-1.1 billion worth of health benefits. (Health benefits are valued in $2013. The range shown includes two distinct methodologies, as well as two societal discount rates (3% per year and 7% per year)). EPA notes that these estimates do not include all of the health-related benefits associated with glider vehicle control. EPA points out that the regulation of glider vehicles would reduce sales by 5000-10,000 units per year and produce health benefits having a value of $1.5-11 billion ($2013).

EPA's estimates were based on a relationship between annual emissions from 17 distinct emission sources and PM-related health impacts (and their monetary benefits).[6] These relationships were developed using a three-step process (cited directly from the EPA report):

1) Use source apportionment photochemical modeling to predict ambient concentrations of primary PM2.5, nitrate and sulfate attributable to each of 17 emission sectors across the Continental U.S. (On-road emission sources are one of the 17 sectors addressing by the modeling);
2) For each sector, estimate the health impacts, and the economic value of these impacts, associated with the attributable ambient concentrations of primary PM2.5, sulfate and nitrate PM2.5 using the environmental Benefits Mapping and Analysis Program (BenMAP v4.0.66);
3) For each sector, divide the PM2.5-related health impacts attributable to each type of PM2.5, and the monetary value of these impacts, by the level of associated precursor emissions. That is, primary PM2.5 benefits are divided by direct PM2.5 emissions, sulfate benefits are divided by SO2 emissions, and nitrate benefits are divided by NOx emissions.

This modeling tool was developed for use in support of various regulatory actions being considered or taken by EPA. It provides mid-range health effects and benefits, as opposed to worse-case estimates (e.g., 90^{th} or 95^{th} percentile effects).

As part of this health assessment, EPA found that glider vehicle controls would reduce 70-160 premature deaths per 1000 glider vehicles. This represents a reduction of 350-1600 premature deaths across the 5000-10000 glider vehicle sales projected to be affected by regulatory controls per year. Put another way, EPA's proposal would result in the death of one person in the U.S. for every 10 glider vehicles sold (over the lifetime of their use). Also, as mentioned above, EPA only presented two of the many health effects generated from the national regulatory assessment tool. Table 6 presents the complete set of health effects generated by this tool. Again, this is not a complete list of the known health effects of PM and NOx emissions, nor does it include any health effects of other pollutants which differ with the sale of uncontrolled of glider vehicles. As can be seen, many of these health effects occur at significant levels. Finally, EPA presented only the monetized health impact of the increase in PM emissions.

[6] Technical Support Document, "Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors," U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, January 2013.

Table 6 shows the monetized health costs of the increase in both PM and NOx emissions. This basically doubles the health costs of allowing glider vehicles to go unregulated.

Table 6: Lifetime Health Impacts From 1000 2017 Glider vehicle Sales: EPA Methodology	
Emissions (U.S. tons): NOx	41,500
PM	680
Monetized Health Costs ($2013 billion)	0.6-1.3
Premature Mortality[7]	68-156
Morbidity	
Respiratory emergency room visits	39
Acute bronchitis	107
Lower respiratory symptoms	1373
Upper respiratory symptoms	2005
Minor Restricted Activity Days	54625
Work loss days	9196
Asthma exacerbation	4942
Cardiovascular hospital admissions	26
Respiratory hospital admissions	21
Non-fatal heart attacks (Peters)	82
Non-fatal heart attacks (All others)	9

Table 7 shows the results of extending this methodology to the impact of controlling glider vehicle sales in calendar year 2025 under the EPA and more aggressive sales scenarios. (The EPA report presented the value of health effects in 2010 dollars. We converted $2010 to $2013 using a conversion factor of 0.9467, which was taken from EPA's costing methodology for its recent Final Determination on the appropriateness of the 2022-2025 light-duty greenhouse gas emission standards.) Benefits are presented for the reductions in both NOx and PM emissions. We only present such estimates for the 2025 calendar year. It should be noted that these 2025 estimates represent the impact of not regulating 2018 and later glider vehicle sales through 2025 emissions and their related health effects. They do not include the impact of the use of these glider vehicles over their entire vehicle life. EPA presented the emission impacts of glider vehicles on emissions in 2040, as shown in Table 5 above. However, the health effects tool only includes health effect factors through calendar year 2030. We did not project health impacts for 2030, as EPA did not present emission impacts for this year, which we would have used for the basis of our estimates of the emission impacts for the two more aggressive glider vehicle sales scenarios.

[7] Note that EPA found slightly higher levels of premature mortality of 70-160 deaths. It is not clear whether this is due to simple round off, or a slight difference in methodology. In any event, the similarity of these projections indicates a high degree of similarity in methodology between EPA's and that used here.

Table 7: Health Benefits and Health Improvements From Glider Vehicle Controls in 2025: EPA Methodology			
Glider Vehicle Sales Scenario	EPA	Scenario 1	Scenario 2
Emission Reductions due to Controls: NOx	190,200	596,497	873,960
(U.S. tons per year) PM	5,050	15,798	23,134
Monetized NOx+PM Benefits ($2013 billion)	3.2-8.0	10.0-24.9	14.6-36.5
Premature Mortality	396-914	1240-2862	1816-4162
Morbidity			
Respiratory emergency room visits	228	715	1,047
Acute bronchitis	630	1,973	2,889
Lower respiratory symptoms	8,070	25,271	37,015
Upper respiratory symptoms	11,700	36,643	53,672
Minor Restricted Activity Days	321,892	1,008,045	1,476,488
Work loss days	54,134	169,528	248,309
Asthma exacerbation	29,028	90,906	133,151
Cardiovascular hospital admissions	151	471	690
Respiratory hospital admissions	124	388	569
Non-fatal heart attacks (Peters)	477	1,493	2,187
Non-fatal heart attacks (All others)	52	162	237

As can be seen, all the projected health impacts increase dramatically compared to the impact of simply selling 1000 uncontrolled glider vehicles. Under EPA's sales projections, the partial set of health benefits are valued at $3.2-8.0 billion per year in 2025. It is important to note that the on-road heavy-duty diesel fleet has not even reached equilibrium with respect to the peak sales of 10,000 glider kits, as these sales just reached 10,000 units in 2015. Glider vehicles will continue to increase as a fraction of the on-road fleet for another 20 years. Under the two more aggressive sales scenarios, the health benefits of control increase even further to at least $10 billion to nearly $40 billion per year.

The same trends are seen in the reduction of premature deaths. With peak sales of 10,000 units, premature deaths range from 400-900, but increase to 1200-4200 with peak sales of 30,000-50,000 units. Again, in all these cases, the on-road fleet in 2025 is far from its equilibrium point with respect to the emissions and health impact of glider vehicles.

Another similar tool, which has been developed for screening the impact of changes in emissions on health effects is an EPA model referred as COBRA.[8] COBRA was developed specifically for use in local and state assessments of energy and environmental programs. The steps used in its development are very similar to those listed above for the regulatory impact analysis tool used by EPA. One advantage of COBRA over the modeling tool used by EPA in its glider vehicle

[8] User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), Version: 3.0, U.S. EPA, September 2017.

analysis is that on-road mobile sources are broken down into several finer categories, including heavy-duty diesel vehicles.

Table 8 presents the estimated health impacts of the increases in emissions that could occur should glider vehicles go unregulated. As can be seen from a comparison of the figures in Table 7 and Table 8, the projected health impacts are very similar and substantial. EPA should complete even more sophisticated atmospheric and health effects modeling to elucidate the full extent of harm associated with the agency's Proposed Rule, but these results indicate that the proposal is flawed, will result in substantial harm, and should be abandoned.

Table 8: Health Benefits and Health Improvements From Glider Vehicle Controls in 2025: EPA COBRA Model			
Glider Kit Sales Scenario	EPA	Scenario 1	Scenario 2
Emission Reductions due to Controls: NOx	190,200	596,497	873,960
(U.S. tons per year) PM	5,050	15,798	23,134
Monetized NOx+PM Benefits ($2013 billion)	3.5-7.8	9.7-24.6	14.2-36.0
Premature Mortality	386-874	1210-2740	1771-4012
Morbidity			
Respiratory emergency room visits	210	659	964
Acute bronchitis	588	1,845	2,703
Lower respiratory symptoms	7,500	23,515	34,443
Upper respiratory symptoms	10,711	33,563	49,138
Minor Restricted Activity Days	293,263	919,127	1,345,794
Work loss days	49,595	155,422	227,556
Asthma exacerbation	11,050	34,627	50,697
Cardiovascular hospital admissions	138	433	634
Respiratory hospital admissions	114	356	521
Non-fatal heart attacks	47-441	149-1382	218-2025