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California Air Resources Board

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RE: STIHL Comments to Proposed Amendments to the Small Off-Road Engine Regulations: Transition to Zero Emissions

Dear Ms. Chang,
Dear Mr. Burford,
Dear Ms. Fibiger,
Dear Mr. Dilbeck,
Dear Ms. Singh,

As a leading manufacturer of outdoor power equipment, the worldwide STIHL Group ("STIHL") designs, manufactures and sells millions of battery, electric and combustion engine powered equipment each year. STIHL is committed to sustainability and environmental responsibility, and is continuously developing new technologies and innovations that support the transition to low emission technologies. As a technology front-runner, STIHL has a vital interest in moving its product portfolio to new technologies in order to fight climate change, support sustainability, foster biodiversity and respond to customers' expectations. Our core values for business strategies are leading the handheld equipment industry by innovations. Indeed, STIHL has invested more than 680 Mio USD to develop low emission products, most recently resulting in thirty-two (32) CARB certified emission families in California and fifty-seven (57) EPA-certified emission families.

STIHL Incorporated, the STIHL Group's U.S. headquarters and manufacturing facility manufactures over 75% of STIHL products sold in the United States, and employs almost 2,500 employees

Kommanditgesellschaft mit Sitz in Waiblingen, HRA 260269, Amtsgericht Stuttgart • Persönlich haftende Gesellschafter: Hans Peter Stihl und STIHL AG mit Sitz in Waiblingen, HRB 263722, Amtsgericht Stuttgart • Vorstand der STIHL AG: Dr. Bertram Kandziora (Vorstandsvorsitzender), Karl Angler, Anke Kleinschmit, Norbert Pick, Dr. Michael Prochaska, Martin Schwarz • Vorsitzender des Aufsichtsrats der STIHL AG: Dr. Nikolas Stihl

nationwide and distribute STIHL products to more than 10,000 US dealers. STIHL Inc. and Andreas STIHL AG & Co., KG (STIHL Inc.'s founding company and developer of STIHL products) are both active members of the Outdoor Power Equipment Institute ("OPEI"), the industry trade group responsible for advocating for the outdoor power equipment industry that represents more than 85% of the U.S. market for all outdoor power equipment categories. STIHL has signed on to the comments filed by OPEI, and respectfully submits the following supplemental comments to CARB's proposed regulatory language published on October 12th, 2021 (the "Proposed Amendment").

STIHL encourages additional cooperation and discussion between CARB and industry members to meet the 2016 SIP goals with a more holistic approach that addresses small business, consumer, and industry needs, while furthering the goal of a transition to ZEE technology. STIHL is concerned that CARB's current Proposed Amendment focuses too narrowly on the outright ban of a single type of product (combustion engines) without considering other alternatives that may still meet CARB's goals[1] and encourage the development of more advanced ZEE technology, and without recognizing the need for SORE products in certain professional applications. STIHL is also concerned that no true feasibility study has been conducted, which could objectively assess the limits of application of professional battery products and that, the studies and modeling that have been conducted to date often appear to be based on unreliable or overstated data.[2]

STIHL comments to the Proposed Amendments

Comment 1: Design-based certification is effective, and CARB should not change the EVAP emissions testing procedures for SORE ≤80 cc.

CARB's Proposed Amendment sets the evaporative emission standards for all SORE except generator engines to zero beginning in MY 2024 by simultaneously changing the certification requirements from CP-901 towards CP-902 and test procedure TP-901 towards TP902 specific for engines with displacement of less than or equal to 80cc. These new EVAP testing requirements effectively prevent sustainably minded companies, like STIHL, that have spent significant resources and time developing ZEE certified products and environmentally-friendly technologies, from using their ABT exhaust emission credits earned over the previous 5 model years. There is no apparent benefit to this change (as reflected by the exhaust testing procedures all

[1] As explained in greater detail in OPEI's comment, multiple alternative technologies exist that, in combination, could meet the 2016 SIP goal, including use of alkylate fuels and other regenerative fuels, delayed implementation of the current Proposed Amendment, emissions reduction to 35/50 g/kW-hr HC+NOx (as explained herein), or even, a professional 4-stroke engine compromise that takes advantage of cleaner 4-stroke engine technology, while still meeting professional needs.

[2] See OPEI comments November 29th, 2021

remaining the same), and the resulting testing requirements appear inconsistent with other CARB testing requirements and regularly accepted EPA testing procedures. These changes to performance-based certification (hot soak plus 24-hr diurnal) are not necessary, as design-based certification is effective.

CARBs OFFROAD2007 emission factors were based on emission testing done in the early 2000s time frame and primarily focused on uncontrolled engines. To update these emission factors in SORE2020, CARB staff relied on the results from baseline as well as validation and compliance testing of a large number of small gasoline engines, ranging from lawn mowers to generators, performed from year 2016 to present. CARB SORE2020 final report tables 20 and 25 summarize the evaporative emission test results, respectively (see enclosure figure 1 and 2).

CARB workshop presentation from March 25, 2020, slide 28 (see enclosure figure 3) and SORE 2020 tables 20 and 25 show the updated evaporative emission factors (hot soak plus 24-hr diurnal) utilized by the SORE2020 Model. The basis for the update was derived from the CARB compliance and validation evaporative emission test found in table 20. The test program did not test all equipment types included in the SORE2020 Model, therefore some equipment utilized a surrogate or the average of several equipment types to derive an updated evaporative emission factor. In addition, since running loss data was not collected, the emission factors were carried over from OFFROAD2007.
The U.S. Consumer Product Safety Commission (CPSC) study, published in September 2015 titled "Study of Fuel Leaks Associated with Outdoor Ground-Supported Gasoline-Powered Equipment", does not mention any gasoline fuel leakages, anomalies and fire hazards from small spark ignited handheld engines (SSIE ≤ 80cc).
(see https://www.cpsc.gov/s3fs-public/pdfs/FuelLeakOutdoorGasolineEquipmentSept2015.pdf). As there is no leakage issue with handheld outdoor power equipment (that operate multi-positionally and are therefore designed to prevent such leakage), there is no need for hot soak plus 24-hr diurnal testing for these products, or any change for the existing testing method.

Evaporative emission factors accepted by and applied in the CARB SORE2020 model prove that evaporative emissions from small off-road equipment with displacement of less than or equal to 80 cc, which are based on a design-based certification, are already at the same level as those projected for generators for MY 2024 to 2027 in the "Proposed Amendments to the Small Off-Road Engine Evaporative Emission Regulations, California Code of Regulations, Title 13, Division 3, Chapter 15. Additional Off-Road Vehicles and Engines Pollution Control Requirements, Article 1. Evaporative Emission Requirements for Off-Road Equipment", Table 3. STIHL evaporative emission measurements on chainsaws, backpack blowers and trimmers (see enclosure Figure 4) likewise confirm the CARB results from the validation and compliance testing's published in the SORE2020

model final report from September 2020, tables 20 and 25. The STIHL physical test results for hot soak plus 24-hr diurnal physical testing had excellent correlation with the design based testing currently used by CARB.[3]
Therefore, STIHL believes the current design-based certification is effective and necessary for all types of handheld equipment, as there does not appear to be any tangible benefit to changing the test procedure as proposed in the Proposed Amendment. The enforcement of the 2017 evaporative amendments have addressed non-compliance with ground-supported products. CARB has not conducted further testing or provided further data to show that the 2017 evaporative amendments are not effective for handheld product with displacement of less than or equal to 80cc.
Furthermore, the adopted evaporative emission amendments from 2017 are not in alignment with the section 209 of the Federal Clean Air Act (CAA). There is no clear explanation as to why the evaporative certification/testing requirements would change in contradiction to the CAA, while the emissions certification/testing requirements all remain the same. STIHL believes that these new and inconsistent evaporative standards and accompanying enforcement procedures are arbitrary, capricious, and therefore inconsistent with section 209 of the CAA.
CARBs SORE2020 final report and STIHL's validation study show that handheld products are significantly below the current diurnal emission standard for engines with displacement categories greater than 80cc based on design-based certification. This confirms that handheld equipment complies with the regulations without the need for alternative testing, like hot soak plus 24-hr diurnal testing requirements.

In addition, new hot soak plus 24-hr diurnal testing for handheld equipment would require additional SHED costs and compliance lead-time that is not addressed in the Proposed Amendments. There will be no opportunity to recover the investments and costs based on the Proposed Amendment.
Therefore, current design-based standards (CP-901 and TP-901) need to be retained to allow manufacturers to use currently earned and banked exhaust emission credits. Ultimately, the exhaust emission credits will be limiting the number of sales for new products beyond 2024 to a very short period of time, hence evaporative limits do not need to change.

Lastly, there is currently no ABT program in place or proposed for handheld evaporative emissions. Therefore, a zero HC evaporative standard would prohibit the sale of gas-powered handheld equipment starting in 2024, despite available exhaust emission ABT credits that had been earned by companies through investments in sustainable technologies. At a minimum, handheld equipment standards should be retained on a design-based certification to allow manufacturers to continue using existing exhaust emission credits.

[3] See Figure 1 and Figure 4 for a comparison of CARB and STIHL physical testing results.

The Proposed Amendment would require hot soak plus 24-hr diurnal emission testing for handheld equipment, which is unjustifiable for this limited period of time. The introduction of certification procedure CP-902 and test procedure TP-902 for handheld products (less than or equal to 80cc) is unnecessary and disproportionate, as the sale of combustion engines is in any case limited in time by the use of exhaust emission credits. Therefore, STIHL proposes test procedure TP-901 as an alternative to test procedure TP-902 for engines with displacement of less than or equal to 80cc certified during MY 2023 or earlier, if the application is in dry weight below 12 kg or for multi-position engines, to exclude generators, who are not handheld.

Comment 2: Revised Engine Definition §2401.

CARB's definition of an "engine" in section §2401. (a) (19) should be revised for the following reasons:

1. A crankshaft constitutes an essential component of an engine.
2. Only an entity with fully integrated parts should be considered an engine. A mere kit of components could be considered a replacement engine for regulatory purposes under the current Proposed Amendment, and thus banned, preventing customers from being able to repair their equipment.

For regulatory purposes, the definition should be fully harmonized with EPA Part 1054.801 and Part 1068.30.

The Proposed Amendment definition itself is inconsistent. First, it defines an engine as a "complete, operational engine", but also suggests, "any engine block or kit with the parts necessary to assemble an engine block with or without an installed crankshaft is also considered an engine." STIHL is also concerned how or why an engine block would be assembled without a crankshaft. In addition the definition and rational will prevent users from servicing and maintaining their products, even with "authorized" parts. Furthermore, the Proposed Amendment ignores the manufacturer's need to apply the emissions label. Emissions labels may not be able to be affixed to components due to durability (temperature above 392°F) and legibility requirements as well as material compatibility (rough and fluorinated surfaces, exposure with oil and liquid sealant) of the parts that are by the proposed definition considered an engine.

To avoid inconsistency with EPA requirements, and to prevent an unintended restriction on end users' ability to repair their own equipment, the "engine" definition must be harmonized with current EPA Part 1054.801 and Part 1068.30.

Comment 3: Harmonization to future European exhaust emission standard 35/50 g/kW-hr HC+NOx for Non Road Mobile Machinery for professional use

STIHL proposes the following phase-in emission reduction approaches:

1. *A zero emission standard for combustion engines with EDP 50/125 hrs in 2024*
   Replacing combustion engines with moderate (50 hrs) and intermediate (125 hrs) EDP by 100% battery driven equipment will result in an additional significant emission reduction. Only for STIHL this will result in an emission reduction of approx. 30% beginning in 2024 (value based on the credit forecast for MY 2021).
   Analyzing the MY 2020 EPA certification database for handheld equipment, a replacing of engines with moderate (50 hrs) and intermediate (125 hrs) EDP will result in approx. 60% less engine families in total. In addition, this will lead to a tremendous push in a market shift to battery driven equipment for moderate and intermediate use.

2. *Introduction of 35/50 g/kW-hr for HC+NOx for professional use (EDP of 300 hrs) in 2027*
   The current international development of limit values including best available technology is published by several organizations such as the Joint Research Center (JRC) of the European Commission as outlined in "In-service monitoring for small utility engines" published 2018[4].
   We do understand that Europe and California have different emission averaging, banking & trading schemes. The proposed European standard of 35/50 g/kW-hr HC+NOx – without any compensation scheme - are based on best available technology: these values would give a reasonable emission reduction of 30% to meet the 2016 State Implementation Plan and 2031 federal air-quality standards.
   STIHL proposes to introduce 35/50 g/kW-hr HC+NOx limit values including the existing EDP value of 300 hrs in 2027 to align internationally and avoid hardships for manufacturers.

Both scenarios result in a total reduction of more than 50% HC+NOx reduction and this does not yet include a possible mandatory introduction of alkylate fuel, which contains additional high reduction potential for the relevant ROGs.[5]

[4] In-service monitoring for small utility engines: Pilot programme for procedure development; JRC; European Commission; 2018

[5] See OPEI's comment for further explanation regarding alternatives to reduce emissions that should have been explored by CARB.

Comment 4: ZEE certified products

STIHL has gone to great lengths to certify many professional ZEE products under CARB Final Regulation Order[6]. For MY 2022, STIHL is certifying 12 ZEE products according to section §2408.1. Certification of ZEE products involves significant investment in technology and time – an investment that does not appear to be made by other manufacturers as it relates to professional use.
The proposed incentive package of $30 Mio underestimates the true cost and extensive needs of professional users. A financially attractive exchange program for certified ZEEs, similar to those already established throughout California must be established in a timely manner in conjunction with the Proposed Amendment. Nevertheless the additional investments for professional users into a large quantity of batteries is a barrier for the acceptance of this ZEE technology. Therefore focused incentives are needed to foster the transition to ZEE products. We therefore propose to establish a program for ZEE certified products of $210 Mio to address the baseline needs of a functional transition.

Comment 5: The Proposed Amendment does not provide technology openness

The current rule-making proposal from CARB is based on a single drive technology only. STIHL expects a "fair of share" of emission targets that guarantee a future-orientated openness to technology. Global warming needs pluralism of technology e.g. Hydrogen, Carbon Capture and Reuse (CCR), Hydrogen based synthetic fuels in which also the combustion engine has its justification for mobile source applications.

STIHL proposes a technology open regulation approach including:

1. *Alkylate fuels:*
   The benefits of alkylate fuel should be considered, as they have a significant reduction potential regarding Reactive Organic Gases (ROGs), without necessitating a straight ban of a wide range of essentially needed products. According to the study of William P. L. Carter et al, the analysis of an alkylate manufacturer showed a reduction potential of approximately 60% in ROG. In addition, alkylate fuels are fully compatible with older products that are already on the market, which will be un-impacted by the SORE regulations as written – on the other hand, encouragement of alkylate fuel would result in reductions of ROGs in new and existing equipment. Indeed, if 100% of the entire SORE fleet was converted to alkylate fuel from 2022, based on 2016 State SIP Strategy for SORE (Baseline Scenario emissions in 2016: 108 tpd of ROG), there would be ROG savings of approximately 65 tpd.
   Alkylate fuel is a near drop-in for today's SORE technology and offers short term and long-term emission reductions, plus other customer-friendly benefits such long shelf life and

[6] CARB Final Regulation Order, SORE, Title 13, CCR section §2400 - §2409 (2010)

increased engine performance. Use of alkylate fuel has been adopted, and even mandated, in other regions of the world, and is readily available throughout the United States. In Switzerland, for example, alkylate fuel is mandatory for certain use-cases. Customers are well informed about the environmental and quality benefits, resulting in a majority of users switching to alkylate fuel in their small engines. Market acceptance of alkylate fuel for small engines in California would likewise not require the development of any new technologies, or the wasteful replacement of existing equipment. Alkylate fuels are already available on the shelves of local dealers and retail stores throughout California, priced reasonably, and well accepted by sophisticated users. Given the significant environmental benefits, ease of implementation and reasonably low burden it would impose on users, retailers and manufacturers.
CARB should have thoroughly explored alkylate fuels like the European Commission, as an alternative to its proposed regulations. By its availability and effectiveness the introduction of alkylate fuel alone would exceed the required emission reduction goal according to the 2016 SIP.
Blowers, brush cutters and split-booms in particular are suitable for use with low-emission 4-stroke engines. An example is STIHLs BR 800 with a HC+NOx FEL 13 g/kW-hr. In combination with an alkylate fuel that is already available for many years, this blower significantly undercuts ROG+NOx less than 10 g/kW-hr without technical modification.

2. *Regeneratively produced fuel such as E fuels or other synthetic fuels:*
To address global warming variety of energy sources and technologies are needed. Including wind, solar and hydrogen as well as hydrogen based synthetic fuels. We would like to urge CARB not to ban combustion engines running on hydrogen and hydrogen based synthetic fuels. These technologies would be necessary to allow the transition to a de-fossilized or decarbonized society. We therefore propose a waiver procedure or exemption to allow combustion engines running on hydrogen, ammonia or other synthetic fuels. Similar exemption is built in the EU Exhaust Emission Regulation for Non-Road Mobile Machinery[7] for new technology engines. The use of hydrogen, ammonia and hydrogen based synthetic fuels would be necessary to fully benefit from new technologies' potential to significantly reduce emissions. This would allow an efficient and effective transition to a de-fossilized or decarbonized society.
We therefore propose to allow combustion engines running on hydrogen, ammonia or other synthetic fuels. A similar differentiation has been successfully integrated in several other

[7] REGULATION (EU) 2016/1628 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for Non-Road Mobile Machinery, amending Regulations (EU) No 1024/2012 and (EU) No 167/2013, and amending and repealing Directive 97/68/EC

constituencies.

3. *No Feasibility Study has been conducted to objectively assess the limits of application of professional battery products:*
   A Feasibility study was planned in 2017[8] with several battery products (see Figure 5), however the study was never performed. This study was supposed to show the feasibility but also the limits of battery products and the batteries themselves in order to obtain a realistic assessment of the application possibilities of these products that are currently on the market, to provide valuable quantitative results and to focus further development needs together with the manufacturers. Unfortunately, this study was never carried out.
   Current battery technology (state of the art: 100 up to 170 W-hr/kg for a whole battery package) with an optimistic energy density up to 280 W-hr/kg in the next 8 to 10 years cannot compete with liquid fuel (11,600 W-hr/kg) with more than 40 times higher energy density. Especially for handheld equipment, the weight of the equipment is essential for professional use where the equipment has to be carried by the user during operation. Whereas for ground-supported equipment, the weight is not relevant because the operator has not to carry the equipment during operation.
   For professional use, in remote areas, under extreme climate conditions and for high power/energy applications, internal combustion engines will still be needed in the future (see comparison of professional battery vs combustion product in Figure 6).

Conclusion:

Sustainability is an integral part of a long tradition at STIHL, where continuity and long-term thinking have always been key elements of our business approach. We feel a special sense of obligation to our staff, the environment and society. Our sense of responsibility has evolved over a period of decades and is firmly rooted in our corporate culture, as reflected in STIHL's significant investment in ZEE and other sustainable technologies.
Against this backdrop, we are convinced that the above-mentioned measures would guarantee the 2016 State Implementation Plan and 2031 federal air-quality standards to be met.
The abrupt shift from combustion engines to ZEE products would come at a high cost – without sufficient justification or analysis. The biased approach to bet on electric machinery only is arbitrary and capricious and ignoring the potential of alternative ready-to use technologies. The Clean Air Act (CAA) is explicitly referring to technologies like synthetic fuels because i) synthetic fuels carry

[8] Testing to Establish Up-to-Date Exhaust Emission and Deterioration Factors for Small Off-Road Engines Using E10 Fuel (CARB Draft); Emissions Compliance, Automotive Regulations and Science Division Monitoring and Laboratory Division; 10/04/2017

an enormous potential to reduce emissions with the existing fleet and ii) synthetic fuels are an accepted alternative across the globe. That way, CAA take the principle of proportionality into account whilst fostering global harmonization at the same time. For this reasons, EPA might not be in a position to grant the waiver.
To be clear and transparent, STIHL wholeheartedly supports the transition towards zero-emission equipment. In order to make the transition a success, the potential underlying regulatory framework needs to be technology-neutral and the feasibility of the transition must be adequately examined and prepared to ensure market acceptance and supply chain capabilities.
As other jurisdictions worldwide (e.g. Europe) have successfully proven, the 35/50 g/kW-hr HC+NOx solution would be an appropriate approach. CARB's new SORE emission legislation should be synchronized with the CARB's Non-Road Mobile Machinery Regulation sets the phase-out for combustion engines beyond 2035[9]. Until then, all technical solutions should be realized to reduce exhaust emissions in a speedy manner.

STIHL would be grateful if CARB would consider the above-mentioned comments. STIHL is prepared to jointly develop a regulatory plan for a transition towards ZEE that effectively reduces emissions, responds to the needs and expectations of customers and small businesses, and allows innovative solutions to be developed and businesses to implement and adapt accordingly.

Yours sincerely,

ANDREAS STIHL AG & Co. KG
2/CIZ

i. V. J. Hoffmann

Jürgen Hoffmann (Ph.D.)
(Director Emission and Regulatory Affairs)

Enclosures
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[9] 2020 Mobile Source Strategy; published in October 7th 2020

Enclosures:

Table 20. Average Evaporative Emission Results (grams and g/day)

Technology	Equipment (Model Year > 2010)	HP Bin	Number of Tests	Evaporative Emissions Test Data*	
				Hot Soak (g)	24-hour Diurnal (g/day)
Gasoline 4-stroke	Blower		9	0.126	0.529
	Generator	2	3	0.847	12.366
	Trimmer		18	0.078	0.593
	Generator	5	15	1.387	2.747
	Lawn Mower		65	0.157	0.823
	Pressure Washer		10	0.136	0.608
	Trimmer		6	0.082	0.545
	Generator (49-state)		1	0.537	1.881
	Chipper/Stump Grinder		3	0.160	1.488
	Compressor	15	10	0.411	8.178
	Generator		36	0.831	2.922
	Lawn Mower		10	0.195	0.796
	Pressure Washer		10	0.164	1.171
	Riding Mower		6	0.135	0.965
	Tiller		14	0.107	0.839
	Chipper (49-state)		1	0.319	2.476
	Chipper/Stump Grinder		5	0.177	0.896
	Riding Mower	25	21	0.379	2.122
	Tractor		9	0.582	1.769
Gasoline 2-stroke	Blower		3	0.138	0.460
	Chainsaw		3	0.129	0.390
	Generator	All	1	1.031	1.931
	Tiller		1	0.724	2.624
	Trimmer		4	0.086	0.431

* Emissions test data for tests with E10 fuel are converted to E0 for use in the model

Figure 1: CARB 2020 Emissions Model for Small Off-Road Engines – SORE2020 final report

Table 25. Hot Soak and Diurnal Emission Factors (SORE2020)

Category	Equipment	Tech Type	HP	Evap Emission Factors	
				Hot Soak (g/start)	24-hr Diurnal (g/day)
Lawn & Garden	Chainsaws	G2-Carb	2	0.129	0.390
			5	0.129	0.390
	Chainsaws Preempt	G2-Carb	2	0.129	0.390
			5	0.129	0.390
	Chippers/Stump Grinders/Shredders	G4-Carb	2	0.160	1.488
			5	0.160	1.488
			15	0.177	0.896
	Lawn Mowers	G4-Carb	2	0.157	0.823
			5	0.157	0.823
			15	0.195	0.796
			25	0.195	0.796
	Leaf Blowers/Vacuums	G2-Carb	2	0.138	0.460
			5	0.138	0.460
		G4-Carb	2	0.126	0.529
			5	0.126	0.529
			15	0.378	3.278
			25	0.378	3.278
		G4-FI	25	0.378	3.278
	Other Lawn & Garden Equipment	G4-Carb	5	0.157	0.823
			15	0.195	0.796
			25	0.195	0.796
	Riding Mowers/Tractors	G4-Carb	5	0.135	0.965
			15	0.135	0.965
			25	0.480	1.945
		G4-FI	25	0.480	1.945
	Snow Blowers	G4-Carb	5	0.126	0.529
			15	0.378	3.278
			25	0.378	3.278
	Tillers	G2-Carb	2	0.724	2.624
		G4-Carb	2	0.157	0.823
			5	0.157	0.823
			15	0.195	0.796
	Trimmers/Edgers/Brush Cutters	G2-Carb	2	0.086	0.431
			5	0.086	0.431
		G4-Carb	2	0.078	0.593
			5	0.082	0.545
			15	0.378	3.278
	Wood Splitters	G4-Carb	2	0.160	1.488
			5	0.160	1.488
			15	0.177	0.896
			25	0.177	0.896

Figure 2: CARB 2020 Emissions Model for Small Off-Road Engines – SORE2020 final report

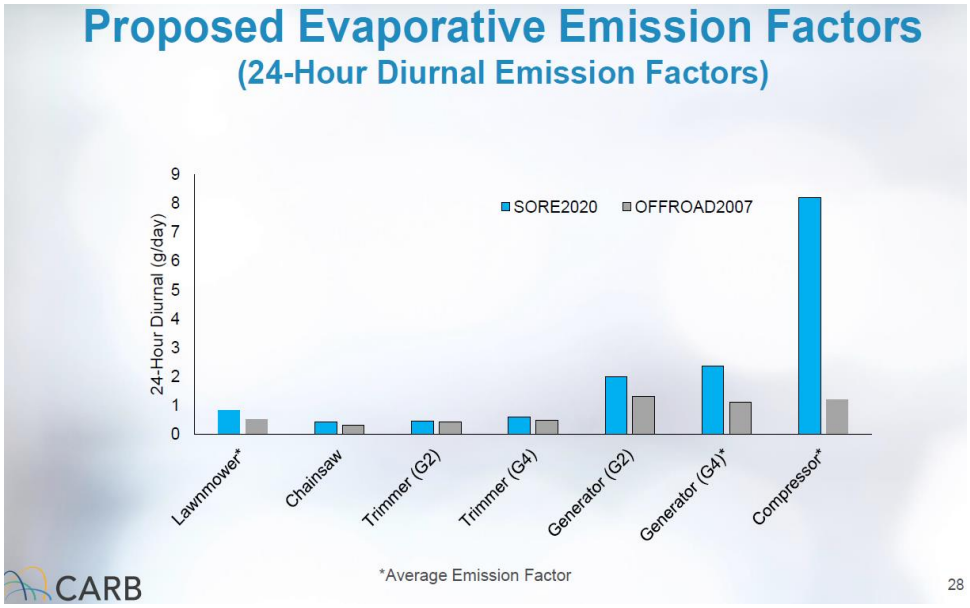

Figure 3: CARB workshop presentation from March 25, 2020

Technology	Equipment (Model Year > 2010)	HP Bin	Number of Test Data	Evaporative Emissions Test Data	
				Hot Soak (g)	24-hour Diurnal (g/day)
Gasoline 4-stroke	Blower	5	5	0,147	0,548
	Trimmer	2	5	0,037	0,480
Gasoline 2-stroke	Chainsaw	5	3	0,087	0,349
	Chainsaw	2	2	0,092	0,224

Figure 4: STIHL hot soak plus 24-hr diurnal evaporative emission test results

Attachment V: List of Zero Emission Test Equipment (TBD)

NUMBER	TYPE	BRAND	MODEL	MODEL YEAR	SERIAL #	Engine Model #	ENG MFR	Required Durability Period	Governor (Y/N)	Power	Equivalent DISP (CC)	CARB PROP #	SPECIAL FEATURES
ZEE-1	BRUSHCUTTER							300		< 5 hp	≤ 80		
ZEE-2	CHAINSAW							300		< 5 hp	≤ 80		
ZEE-3	EDGER							300		< 5 hp	≤ 80		
ZEE-4	BLOWER (HANDHELD)							300		< 5 hp	≤ 80		
ZEE-5	BLOWER (BACKPACK)							300		< 5 hp	≤ 80		
ZEE-6	HEDGE CLIPPER							300		< 5 hp	≤ 80		
ZEE-7	SPLIT BOOM SYSTEM							300		< 5 hp	≤ 80		
ZEE-8	WALK-BEHIND LAWNMOWER							500		< 5 hp	81-224		
ZEE-9	WALK-BEHIND LAWNMOWER							500		< 5 hp	81-224		
ZEE-10	RIDING LAWNMOWER							1000		<25 hp	≥ 225		

Figure 5: List or Zero Emission Test Equipment out of "Testing to Establish Up-to-Date Exhaust Emission and Deterioration Factors for Small Off-Road Engines Using E10 Fuel (CARB Draft); Emissions Compliance, Automotive Regulations and Science Division Monitoring and Laboratory Division; 10/04/2017"

Comparison of professional battery vs. combustion product: A typical professional handheld products operating an eight-hour workday such as a typical gasoline driven backpack blower (BR 800) used in fire line clearing or an equivalent battery driven backpack blower (BGA MAX; no comparable product on the market so far, not even from competitors).
BR 800: Power output 3.3 kW; fuel consumption eight-hour workday: 12 liter per 8 hrs or 9 kg per 8 hrs
BGA MAX: Power output 3.3 kW; mechanical energy demand 8 hrs per day: 22.5 kW-hr electric energy demand 8 hrs per day: 26.4 kW-hr (85 % efficiency) STIHL AR 3000 L battery: 1.52 kW-hr per battery; weight of the battery 9.5 kg **→ 18 units of AR 3000 L batteries with a total weight of approx. 170 kg per 8 hrs per day (w/o possibility of recharging)**
CONCLUSION: Battery products are not a viable alternative in this case. Therefore for professional mobile applications (EDP 300 hrs), the high energy density of liquid fuels is essential to operate in e.g. remote areas, during power outage or emergency cases.

Figure 6: Comparison of professional battery vs combustion product