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November 29, 2021

California Air Resources Board
1001 I Street
Sacramento, CA 95814

Dear CARB Board Members,

The California Landscape Contractors Association (CLCA) represents California's licensed landscape contractors and those allied tradespeople who provide support, goods and services to them. CLCA's member companies specialize in lawn care, landscape maintenance, landscape construction, tree care, irrigation, and water management. Landscape professionals throughout California work daily performing essential services to homes and businesses to maintain their landscapes, sustain the environment, and enhance and maintain healthy and safe green spaces.

CLCA writes to you on behalf of our members concerning Proposed Amendments to the Small Off-Road Engine Regulations: Transition to Zero Emissions, Initial Statement of Reason (ISOR) published October 12, 2021. CLCA respectfully requests your support for an amendment to the ISOR and delay implementation of the transition to Zero Emissions Equipment (ZEE) SOLELY for commercial/professional grade small off-road engines (SORE) until model year 2028 or later.

The intent to reduce carbon emissions from gas-powered landscape equipment as quickly as possible is one CLCA shares. However, we must do so responsibly and in a way that mitigates the negative financial impact on the landscape industry. The landscape industry in California is a $9 billion industry annually with more than 55,000 companies employing over 133,000 employees; 99% of these businesses are considered small businesses and a vital industry for entrepreneurs throughout the state of California, many of which are Latino or minority owned.

Landscape professionals work daily caring for California's green spaces – we care deeply about the environment – so we support a responsible transition to zero-emission equipment. However, the two-year timeline is simply too fast a transition for commercial users. Additionally, the commercial-grade battery-powered equipment currently on the market has performance issues, cost issues, and infrastructure issues. Because of these reasons, the transition is NOT technically feasible for commercial/professional grade use.

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One of the largest data sources used by CARB staff was a survey conducted by California State University of Fullerton (CSUF)[1]. Within this survey it was concluded that only 3% of chainsaws, 3.5% of lawn mowers, 0.3% of riding mowers, and 5.9% of trimmers used by professional landscape companies in California are ZEE, compared to over 50% for residential homeowners. This low adoption rate is not due to an unwillingness to use ZEE equivalents but rather is evidence that the equipment is not technologically capable to be the exclusive equipment used by commercial landscape companies at this time.

CLCA supports the ability of our landscape professionals to source the products that best fit their needs. In some cases, they can and have integrated ZEE into their equipment mix. In other cases, they have not because performance and cost remain tremendous hurdles, specifically for the larger commercial landscaping equipment which requires significant more run time and power.

From a performance perspective, CLCA continues to hear from landscape professionals about ZEE landscape equipment:

- The power is just not comparable yet
- Impossible to use exclusively on large scale commercial jobs like HOAs, resorts, business parks and other public and commercial green spaces
- Requires too many batteries to conduct their job function in an efficient manner
- Charging issues in the field and in the workshop
- Durability concerns
- Batteries are too heavy
- Cannot mow slopes on riding mowers because of the weight issue
- Mow times are longer, and batteries cannot last a full workday
- Leaf removal during seasonal changes is very difficult
- Debris removal to mitigate fire spread is significantly more difficult
- Shortage of dealers and maintenance shops to support transition
- Batteries are not interchangeable between brands

This is a non-exhaustive list of concerns we hear from landscape professionals, but these are the types of concerns that we believe CARB staff have not fully considered in their analysis. Furthermore, these concerns explain the low rate of adoption of commercial ZEE by landscape professionals.

The first question asked by landscape professionals before buying any piece of equipment is ‘can it meet the performance needs we ask of it?’ With commercial grade landscape ZEE, the answer is usually ‘not yet.’ A major international manufacturer of commercial grade landscape

[1] CSUF SSRC. 2019. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. Prepared by the Social Science Research Center (SSRC) at California State University, Fullerton (CSUF), for CARB and the California Environmental Protection Agency, under CARB Agreement 16MLD011. May 15, 2019.

equipment did a side-by-side analysis of the performance, power and battery run time of a ZEE blower and a gas-powered blower[2]. Please note that the models are the same handheld leaf blowers compared in the ISOR[3]. The results were illuminating. We learned:

1. The "advertised" performance of the ZEE blowers are at "turbo" and degrade constantly until the batteries die. After just 7 minutes of run time, ZEE blower force drops below the gas-powered blower.

2. In "turbo" mode (roughly average performance equivalent to gas-powered), ZEE batteries need to be replaced every 18 minutes – where the gas-powered blower can run continuously for an hour. Turbo mode requires 4 batteries to run for an hour to match gas-powered continuous performance.

When looking at these results, it appears CARB staff based the comparisons solely on marketing data which may not reflect the equipment performance beyond a snapshot in time or may have inaccurately depicted equivalence in performance and run time.

From a cost perspective, a complete transition is a significant impediment for the landscape industry, specifically to undertake such in only two years. Data from manufacturers shows that commercial ZEE can have an upfront cost of as much as 2 to 4 times that of their gas-powered counterparts. Some examples:

1. One popular manufacturer's commercial-grade electric leaf blower retails for approximately $350 - $400, similar to the same manufacturer's gas-powered unit. However, to use this electric leaf blower for an entire workday requires the purchase of extra batteries and chargers thus, driving the up-front cost to exceed $2,000.

2. One of the most popular commercial gas-powered riding mowers cost ranges from approximately $10,000 to $11,000 while its ZEE counterpart cost starts at approximately $21,000 (all prices MSRP).

3. A commercial grade gas-powered string trimmer from a leading manufacturer starts at $329 but a commercial grade battery-powered unit from the same manufacturer (including the extra batteries and chargers needed to complete a day's work) exceeds $1,000.

Unfortunately, battery technology is not yet qualified to meet the needs of all day ZEE use without either frequent recharges (which is challenging, particularly for landscape maintenance

[2] Report: Blowing Force Comparison EGO EB6500 VS ECHO PB-2520. November, 2021.

[3] Small Off-Road Engines: Transition to Zero Emissions. CARB Staff Report: Initial Statement of Reasons, page 15, Table I-4. October 12, 2021.

professionals who tend to multiple sites each day) or multiple batteries. Using CARB SORE2020 performance data, an average landscape professional that does not use a chainsaw would need an estimated 36.68 batteries a day[4]. This assumes the average landscape professional is using a walk behind mower, leaf blower, string trimmer, and a hedge trimmer. A conservative estimate is that these extra batteries and chargers would require an additional investment of at least $7,562.16. If that average landscaper professional also used chainsaws as part of their daily landscape maintenance work, they would need 49.17 batteries a day with a start-up battery and charger cost of $11,064.32. Please note, all cost totals cited are for batteries and chargers only.

With an estimated 36.68 batteries to handle a single day's landscape maintenance work, all batteries must be charged and ready to go at the start of your workday. Many companies will need to upgrade their building electrical system to handle the load. In speaking with power equipment manufacturers, they estimate another 100A circuit would be needed to support this type of charging, plus consideration of safety for charging these batteries each night (additional fire safety and/or full-time monitoring staff).

In our reading of the ISOR, it appears CARB staff assume batteries will last the life of the product. This is not consistent with lithium-ion battery technology. Lithium-ion batteries start to degrade after 500 recharge cycles[5]. Battery capacity then continues to degrade until it must be replaced. CARB models 210 starts/year (days) and models the median age of leaf blowers as 5 years. As a result, by needing to replace batteries at 500 recharge cycles, landscape professionals would need to replace 7-9 batteries at least twice (3 sets of batteries to achieve the median blower age). Replacing batteries after 500 recharge cycles would add an additional $10,000 to the ongoing cost of utilizing commercial grade landscape ZEE. In total, for the average landscaper as modeled by the survey and CARB, battery and charger costs could reasonably be $18,000 - $22,000 over the 6-year useful life of the combined products.

In the ISOR, CARB staff states "It is projected that from 2010 to 2030, the price of a battery holding a kilowatt-hour of energy will decrease by over 90 percent (Martin, 2019)."[6] However, CARB staff omitted an important point: in reading the actual article, the overwhelming drop in battery prices has already taken place by 2021 as shown in the graph[7] on the next page.

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[4] CARB SORE2020 Equipment Use Battery Comparison 211122.

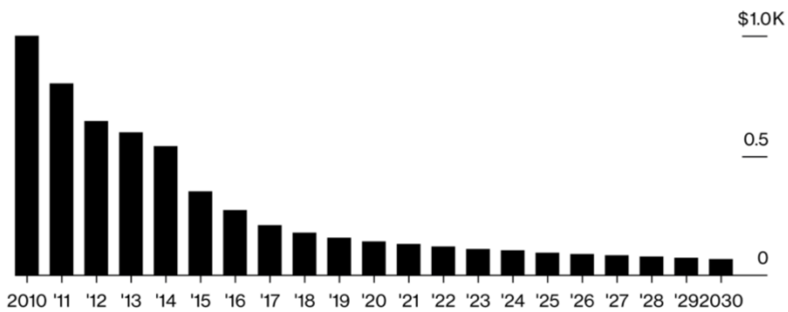
[5] GrePro Blog "The Charging Cycles of Lithium-Ion Polymer Batteries" March 25, 2020 https://www.grepow.com/blog/charging-cycles-of-lithium-ion-polymer-batteries/

[6] Small Off-Road Engines: Transition to Zero Emissions. CARB Staff Report: Initial Statement of Reasons, page 11. October 12, 2021.

[7] Graphic from Martin, Chris. Better Batteries. Bloomberg. October 11, 2019.

Cheaper Batteries

The cost of storing a kilowatt-hour of electricity has plunged and is expected to drop further



Source: BNEF
Note: Figures for 2018 and beyond are projections

As you can clearly see, the initial costs to transition to commercial grade landscape ZEE represent real and significant up-front investments for landscape professionals. There is no guarantee that landscape professionals will recover the cost difference particularly when you realize the above cited costs do not include the daily cost of electricity to charge the batteries. For the landscape industry, this is highly concerning because the majority of landscape maintenance professionals who are sole-proprietor (single employee) businesses have an average revenue of just $32,000 per year[8].

Maintenance of commercial grade landscape ZEE has been woefully under examined as evidenced by CARB's failure to acknowledge the lack of dealers and repair shops currently in California that have the expertise or are prepared to handle repairs and maintenance issues. Equipment maintenance shops and their staff need more time to acquire the training and materials to be able to handle and perform repairs and maintenance on commercial grade landscape ZEE. In an October 13, 2021 meeting with CARB staff, a San Fernando valley landscape maintenance contractor shared that his ZEE riding mower had been in the repair shop for three months due to the lack of expertise and applicable repair materials. As of the date of this letter, it still has not been repaired.[9]

CLCA represents the end users, licensed landscape contractors, and we cannot strongly enough state that it is NOT technically feasible to transition commercial/professional grade landscape equipment to ZEE by 2024. However, we believe there is a solution and one we urge CARB to adopt on this very important proposal.

SOLUTION - Extend the time period to transition to zero emission "commercial/professional grade" equipment beyond 2024 but maintain the 2024 end of sale date for zero emission residential SORE.

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[8] Small Off-Road Engines: Transition to Zero Emissions. CARB Staff Report: Initial Statement of Reasons, page 97. October 12, 2021.

[9] CARB staff meeting with CLCA, NALP and various landscape professionals. October 13, 2021.

CARB's ISOR admits that in a considered Alternative 2, changing the date of 2024 to 2026 for both residential and commercial grade equipment would still meet targeted emissions goals:

> *"Alternative 2, only 89.3 percent of the small off-road equipment population subject to the SORE regulations would be ZEE in 2035, as compared to 93.4 percent under the Proposed Amendments. The remaining 10.7 percent would continue to turnover to ZEE over the following years, reaching 98.8 percent ZEE in 2043. Emission benefits under Alternative 2 in 2031 would be 6.8 tpd and 50.2 tpd of NOx and ROG, respectively. These emission reductions are both smaller than those that would occur with the Proposed Amendments.* ***While these emission reductions would meet the 2016 State SIP Strategy expected emission reductions for SORE****. . ."*[10] *(emphasis CLCA)*

According to CARB's own analysis, waiting until 2026 would still enable CARB and Governor Newsom to accomplish their 2031 and 2035 targeted goals. A primary goal is to reduce the amount of non-ZEE SORE in California by the year 2031 and 2035. Understanding the universe of equipment we are currently dealing with in California is an important consideration towards achieving these goals.

Our proposed amendment would only delay the transition to commercial grade landscape ZEE which would make CARB's analysis significantly more different. Manufacturers certify professional grade SORE to the highest durability periods, therefore implementing different dates to transition to ZEE based on how the equipment is typically used should not be an impediment for CARB or retailers/dealers.

According to the CSUF survey[11] the current universe of SORE in California that is gas powered and needs to be transitioned out is 12,813,596 pieces of equipment. Of this number, 10,902,041 (85%) is used by residential users. The remaining 1,911,555 (15%) is used by businesses and landscape professionals. Further looking at the CSUF data, only 738,875 (6%) of existing non-ZEE SORE is used by the landscape industry. Of the estimated 1,911,155 pieces of non-ZEE SORE used by commercial businesses, we recognize a small percentage may not be commercial/professional grade equipment. In speaking with CARB staff, we understand the determination of the amount of commercial/professional grade equipment is not available, but it is certainly LESS than 15% of all the non-ZEE SORE in California today.

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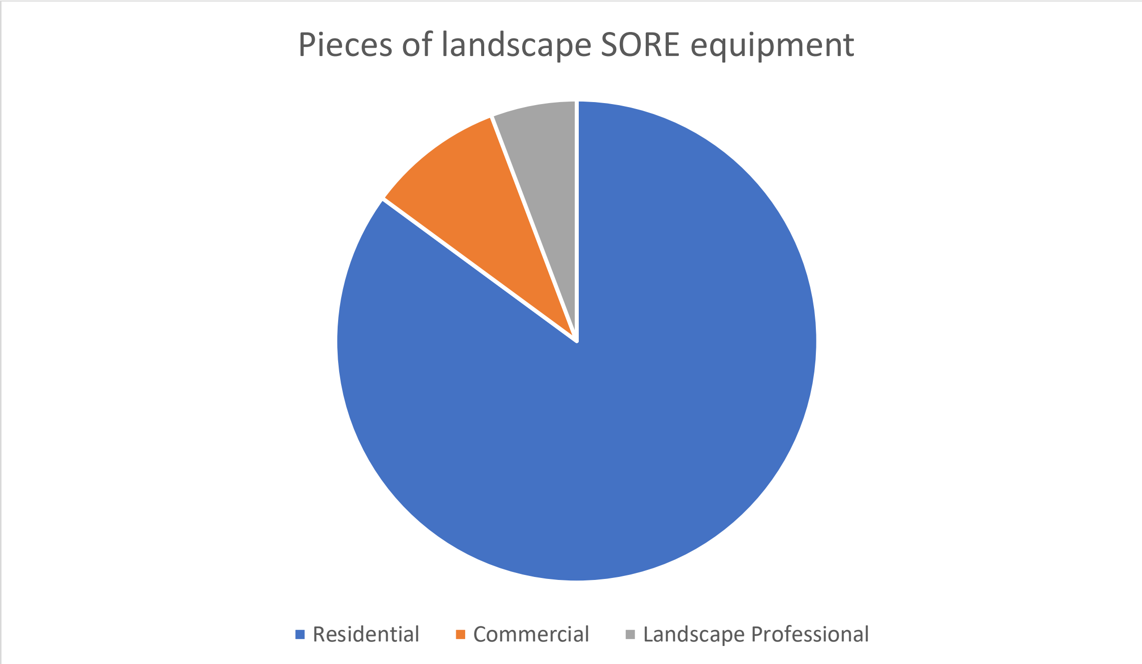
[10] Small Off-Road Engines: Transition to Zero Emissions. CARB Staff Report: Initial Statement of Reasons, page 126. October 12, 2021.

[11] CSUF SSRC. 2019. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. Prepared by the Social Science Research Center (SSRC) at California State University, Fullerton (CSUF), for CARB and the California Environmental Protection Agency, under CARB Agreement 16MLD011. May 15, 2019.



The proposed rule has a stated target for ZEE SORE market share of 93.4% by 2031. In the ISOR, the considered Alternative 2 states a target of 89.3% by 2013[12]. This 4% difference could certainly be narrowed and/or mitigated when residential equipment (representing 85% of the pieces in use per the CSUF data) begins to be phased out in 2024 and the remaining 15% (or likely less) of professional/commercial equipment is extended beyond the 2024 date.

Commercial grade equipment has a much shorter life cycle than residential equipment, typically by half. This life cycle difference would support extending the sale of professional/commercial equipment until closer to 2028 or 2029, by which the stated 2031 targets can still be achieved. Our proposed amendment, which would extend the sale of non-ZEE to 2028 or a later date, we believe would produce very similar results to the current proposal in the ISOR and would certainly meet the 2016 State SIP plus Governor Newsom's Executive Order on climate change.

CLCA also asserts that CARB has a statutory requirement to further analyze this difference between residential and commercial use of SORE. This year, Assembly Member Berman introduced Assembly Bill 1346 which codified much of what CARB had detailed in a March 2021 workshop. CLCA and other industry groups worked with members of the legislature to make amendments to reduce the harm on landscape professionals. The amendments below were added in August 2021.

> *(2) In determining technological feasibility pursuant to paragraph (1), the state board shall consider all of the following[13]:*

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[12] Small Off-Road Engines: Transition to Zero Emissions. CARB Staff Report: Initial Statement of Reasons, page 126. October 12, 2021.

[13] Assembly Bill 1346 (Berman), chaptered October 9, 2021.

(A) Emissions from small off-road engines in the state.
(B) Expected timelines for zero-emission small off-road equipment development.
(C) Increased demand for electricity from added charging requirements for more zero-emission small off-road equipment.
(D) Use cases of both commercial and residential lawn and garden users.
(E) Expected availability of zero-emission generators and emergency response equipment.

CLCA contends these amendments require CARB to conduct a deeper examination and analysis of commercial and residential lawn and garden uses of SORE. Further underscoring this legislative intent, at the April 28th hearing on AB 1346 Assembly Member Luz Rivas spoke candidly about her support for the bill but also said that the legislation should take into consideration the concerns raised in the analysis regarding commercial application. Assembly Member Rivas stated concerns over those who also need to make a living, specifically the large number of landscapers and gardeners that live in her district that use lawn equipment and potentially could not afford the new ZEE technology.

Governor Newsom signed AB 1346 into law just three days before the release of the ISOR and in talking with CARB staff, we don't feel the analysis of the technical feasibility to the degree mandated by AB 1346 was conducted, nor were alternatives, like our proposal to extend only commercial/professional grade equipment, properly explored and vetted.

Because of the aforementioned higher cost of commercial grade landscape ZEE, any transition means a robust rebate and tax incentive program is necessary. While we appreciate that the California Legislature approved $30 million[14] to support AB 1346 and this transition, that amount is woefully inadequate. Based on the CSUF data mentioned above, if all that money went to only commercial businesses, who use an estimated 1,911,555 pieces of gas-powered SORE landscape equipment, that would mean a scant $15 would be provided per piece of equipment traded in. As mentioned earlier, replacing a $350 gas powered leaf blower with comparable ZEE (and the batteries necessary to handle a full workday) costs upward of $2,000. It is abundantly clear that $15 does not come close to supporting the equipment transition for the landscape industry and our majority small business demographic. This also supports how a delayed transition for commercial grade landscape ZEE will make this transition easier and less costly for all those involved.

CLCA represents end users of commercial landscape equipment and, as such, we have been working closely with the Outdoor Power Equipment Institute (OPEI) and the Far West Equipment Dealers Association (FWEDA). OPEI and FWEDA have much more experience and expertise with manufacturing this equipment and going through the CARB certification process. Because of this, CLCA apologizes if some the jargon is inexact but also publicly endorses the

[14] Senate Bill 170 (Skinner), page 96; chaptered September 23, 2021.

proposals coming from OPEI and FWEDA that also delays implementation timelines and would ease the transition on professional users of SORE.

In conclusion, CLCA and the landscape industry care deeply for our California environment, and we genuinely want to support a transition to commercial grade landscape ZEE. We believe that time is coming but that implementing a ban on gas SORE starting in model year 2024 for a complete transition is way too soon. Adopting an amendment allowing commercial grade landscape SORE to continue to be purchased until 2028, will lessen the jarring impacts on the industry and still allows for the targets of 2031 and 2035 to be achieved. In all, this would be a win for all parties involved. We would be happy to work with the Governor, CARB, the legislature, and air districts throughout California to promote and assist in this transition.

Sincerely,

Sandra Giarde

Sandra Giarde, CAE
CLCA Executive Director

Blowing Force Comparison
EGO EB6500 VS ECHO PB-2520

Blower Performance Parameters

- The following parameters are indicators of a blower’s ability to do work
  - Air Velocity (Speed) – Speed of the blower air in mph – How fast debris can be moved, which is a factor in time on the job.
  - Air Flow (Rate) – The volumetric rate of the blower in ft^3/min – How much volume of debris can be moved at a given speed, which is a factor of time on the job.
  - Force Measurement – The force of the blower in Newtons (N) – How much mass of debris can be moved, which is a factor of time on the job.
  - Run-time – The time a blower runs in minutes (before refueling or changing batteries)
- For landscapers, time is money so if the amount of work is less than more time is spent on the job which means less jobs per day

Intern | Internal

Blower Performance Parameters

- CARB includes these parameters when comparing the subject blowers in the ISOR
  - “Staff compared leaf blowers that can move similar amounts of leaves based on air flows stated in equipment specifications. The SORE equipment considered moves air at 453 ft^3/min, while the ZEE ranges from 250 to 500 ft^3/min. The blower force of the SORE blower is 15.8 Newtons. The zero-emissions leaf blower has a blowing force of 21 Newtons
  - Despite a plan to conduct ZEE durability testing, CARB conducted no technology feasibility comparisons. CARB based comparisons solely on marketing data which may not reflect the equipment performance beyond a snapshot in time or may have inaccurately depicted equivalence in performance and run time

Blower Performance Parameters

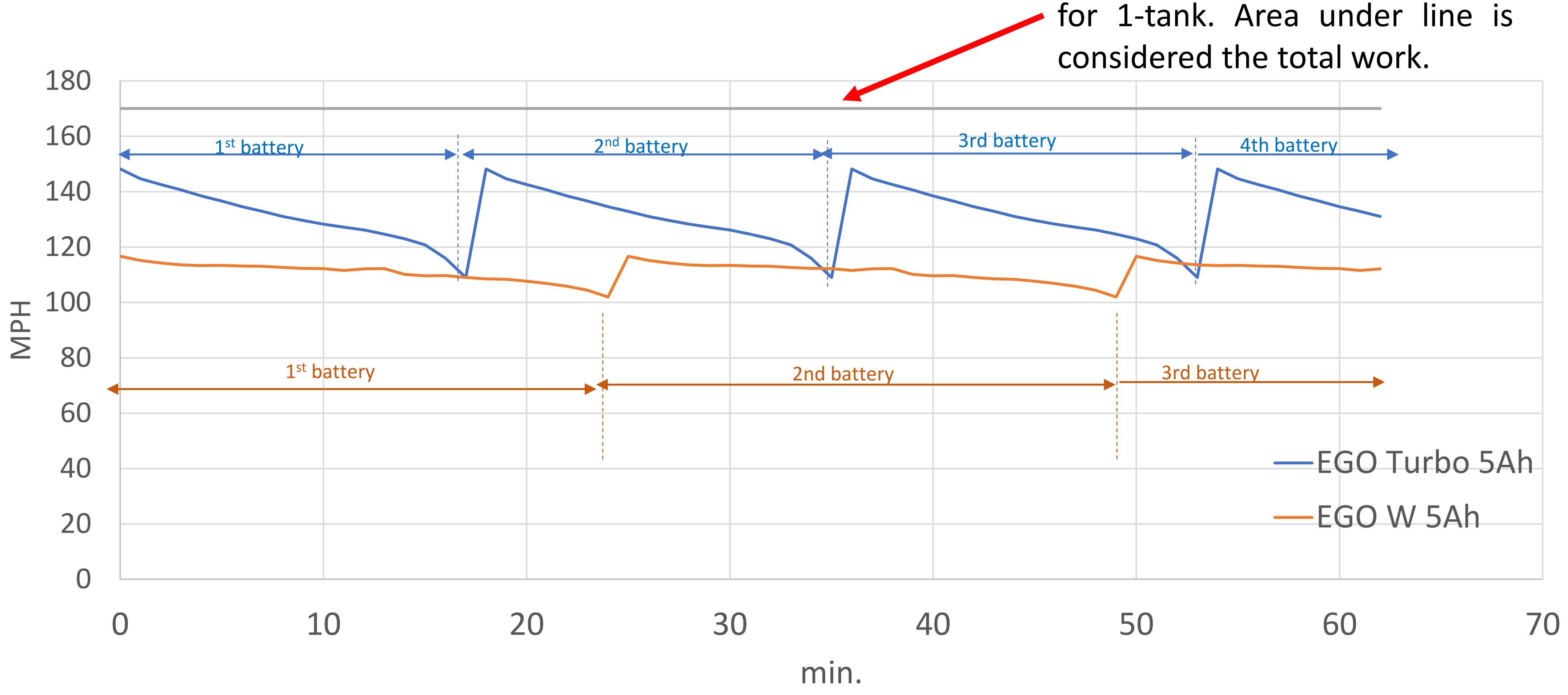
- Conclusions
  - While the CARB noted performance values are confirmed by industry testing, the performance of the ZEE blower in all three performance metrics degrades from the moment the blower is started until the battery dies. The ZEE battery lasts just 18 minutes in the "turbo" mode, the mode that reflects the maximum performance values noted in the marketing info, while the gas-powered blower maintains it performance in all three metrics for the full 1-hour test (the equivalent of 1-tank of fuel or approximately one pint of fuel).
  - CARB SORE2020 models average blower use at 1.15 hours/use (per day), and that on average each landscaper that uses a blower owns 2.17 blowers. According to CARB SORE2020, the average landscaper who operates a blower(s) uses them 2.5 hours/use (per day). In the low performance mode (24min/battery) the landscaper would require (7) 5 Ahr batteries (or charges) a day *just* for blowers. In the high performance mode (18min/battery), the mode by which the maximum air-flow and force are measured, the landscaper would require (9) 5-A-hr batteries (or charges) a day just for blowers. In HD commercial applications the performance stated in CARB's ISOR is not sufficient and in fact no battery powered blowers of this size exist on the market today.

Blower Performance Parameters

- Conclusions
  - Battery performance starts to degrade after 300 charges. Most battery makers state a goal of 85% capacity at about 300 charges. Battery capacity continues to degrade until it must be replaced. CARB models 210 starts/year (days). CARB models the median age of leaf blowers as 5 years. As a result, replacing batteries at 500 hours, landscapers would need to replace 7-9 batteries at least 2 times (3 sets of batteries) in order to achieve the median blower age.
  - Battery costs for a typical handheld blower may be $150 for 2.5 Ahr to 250 for a 5 Ahr – In the CONSERVATIVE case, no “turbo” used, total battery cost $250 x 5 (machines come with one battery to start, 5 extra batteries needed) + $250 x 7 x 2 = $4750+ over the life of the blowers. The cost of Fuel and oil over this time is far less.

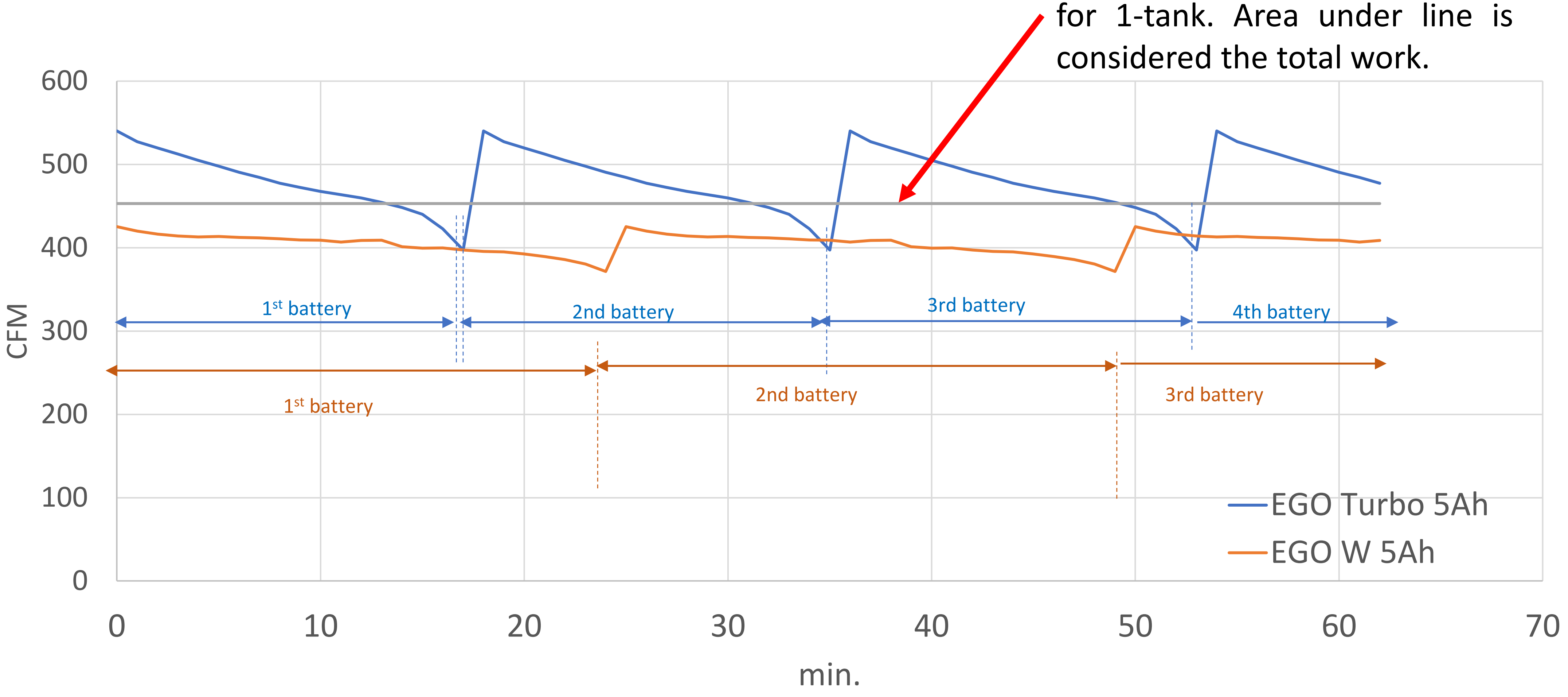
Air Velocity (speed)

PB-2520 (gray) Performance for for 1-tank. Area under line is considered the total work.



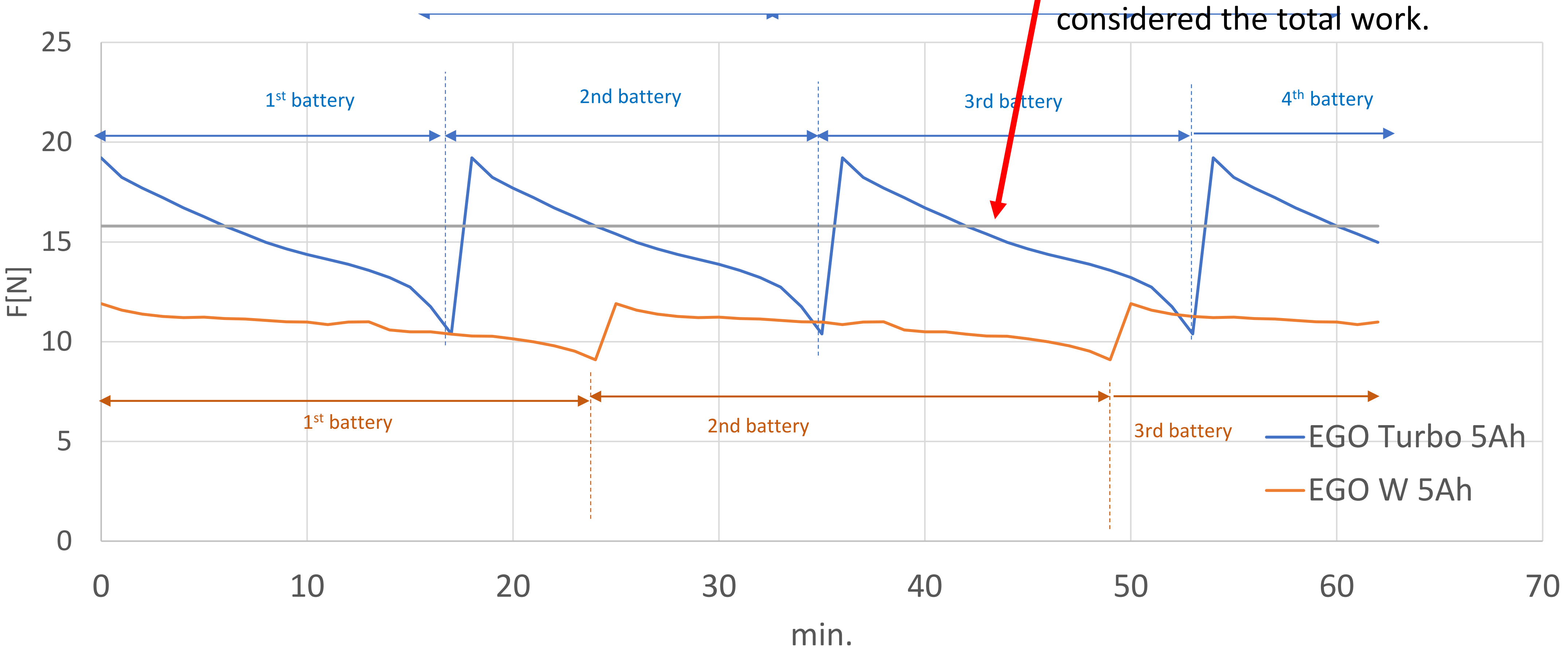
Air Volume

PB-2520 (gray) Performance for for 1-tank. Area under line is considered the total work.



Blower Force

PB-2520 (gray) Performance for for 1-tank. Area under line is considered the total work.



PER CARB CSU-F SURVEY & SORE2020 MODEL

Landscaper ZEE Cost Analysis

Eqiupment Type	Power (kW)[1]	Load Factor[1]	Annual Use[1]	Uses/Year[1]	Hr/Use[1]	Avg # Units/Landscaper[2]	Total kW/day for Equipment Type	# Batteries Day[4]	# Batteries Rounding Up[5]	Start-Up Battery Cost[6]	Additional Battery Cost Per Repower[7]	Additional Charger Cost[8]
Walk Behind Mower	2.86	0.36	240	210	1.14	2.04	2.40	8.00	8	1341.33	1800.33	350.07
String Trimmer	0.8	0.94	162	184	0.88	2.29	1.52	5.05	6	621.88	1137.13	202.70
Leaf Blower	2.36	0.94	240	210	1.14	2.17	5.50	18.34	19	3637.97	4126.22	866.94
Hedge Trimmer	0.8	0.94	126	107	1.18	1.79	1.59	5.28	6	786.08	1188.83	214.18
Chain Saw	1.23	0.7	140	127	1.10	3.95	3.75	12.50	13	1923.06	2811.81	574.85
	2.36					TOTAL W/O Chain Saw[3]	11.00	36.68	39	6387.27	8252.52	1633.89
						TOTAL W/ Chain Saw	14.75	49.17	52	8310.32	11064.32	2208.74
Commercial Riding Mower	16.90	0.38	246	160	1.54		9.87	1.00		0.00	UNK	
Residential ZEE Cost Analysis												
Walk Behind Mower	2.86	0.36	19	25	0.76		0.78	2.61		361.87		0.00
String Trimmer	0.8	0.94	15	18	0.83		0.63	3.13		320.00		0.00
Leaf Blower	0.80	0.94	15	30	0.50		0.38	1.88		131.37		0.00
Hedge Trimmer	0.8	0.94	10	13	0.77		0.58	2.89		283.85		0.00
Chain Saw	1.23	0.7	18	10	1.80		1.55	7.75		1012.35		0.00
						TOTAL Turf W/O Chain Saw[3]	2.36	11.81		1097.09		0.00
						TOTAL Turf W/ Chain Saw	3.91	19.56		2109.44		0.00
Residential ZEE Generator Cost Analysis												
Generator (2-5hp category)	2.33	0.68	50	13	3.85		6.11	20.36		4355.15		967.81
Commercial ZEE Generator Cost Analysis												
Generator (2-5hp category)	2.33	0.68	146	49	2.98		4.73	15.77		3323.22	3548.22	738.49
Generator (5-15hp category)	7.05	0.68	146	49	2.98		14.28	47.61		10487.67	10712.67	2330.59

[1] Per CARB SORE2020

[2] Per CSU-F survey. Not all landscapers own each type of equipment, but those that do on average own this many pieces

[3] Per the CSU-F survey it is reasonable many professional landscapers use at least these items - WBM, ST, LB & HT. Some may additionally use chainsaws, so these summaries have been analyized separately.

[4] Assumes 300 W-hr battery and that batteries are charged once per day of use for landscape and commerical use, and generators. Assumes 200-W-hr battery charged once per day of use for residential use, excluding walk-behind mowers and generators wh

[5] For reference only. The batteries calcluated in column result in fractions of a battery, so it could be argued that actual batteries need to be rounded up. However, since the other calculations rely on fractions of units/landscaper, this is just for reference a

[6] Assumes retail cost $0.75 per W-hr. This is a conservative estimate for professional products (low cost estimate). A 40V 5amp-hour (200 w-hour) battery from the leading brand at The Home Depot retails for $179. This assumes 1 battery is included for in

[7] Assumes batteries are replaced after 500 charge cycles. Assumes retail cost $0.75 per W-hr. This is a conservative estimate for professional products (low cost estimate). Replacing all original batteries (ie.. Including battery originally provided with machi

8 Assumes reatil cost of $50 per charger and that the chargers do not need to be replaced over the useful life. Assumes no additional chargers needed for residential (one comes with product). This is a conservatie estimate for professionals products (low cc

[9] Per CARB SORE 2020 the average useful life (Age at which 50% of the population is no longer in use) is 6-7 years for these products. For the purpose of estimating total landscaper cost over one period, 6 years was used for all points.

[10] Does not include initial cost of equipment. Sum of new batteries and chargers purchased to achieve useful life. This cost will be less for units that do not achieve useful life, and more for products that do.

Age Where Less Than 50% of Population Remains ("Useful Life")[9]	Age-Hours at Useful Life	Number of Battery Repowers	Total Repower Batteries	Total Repower Baattery Cost	Total Batteries	Total Battery Cost	Final Total Battery & Charger Cost Per Equipment Cycle[10]	Start-up Battery Per Unit
6	1440	1.52	12.16	2736.50	20.16	4077.83	4427.90	657.51
6	972	1.21	6.11	1373.66	11.16	1995.54	2198.24	271.57
6	1440	1.52	27.87	6271.86	46.21	9909.83	10776.77	1676.49
6	756	0.28	1.50	337.63	6.78	1123.70	1337.89	439.15
6	840	0.52	6.55	1473.39	19.05	3396.45	3971.29	486.85
8021.16			47.64	10719.65	84.32	17106.91	18740.80	
10519.06			54.19	12193.03	103.37	20503.36	22712.10	
							361.87	
							320.00	
							131.37	
							283.85	
							1012.35	
							1097.09	
							2109.44	
							5322.96	
6	876	0.00	0.00	0.00	15.77	3323.22	4061.71	
6	876	0.00	0.00	0.00	47.61	10487.67	12818.26	

ıich are assume 300 W-hr battery. Assumes 13-19 kW battery for commercial mowers based on product comparison of one brand.
nd is not used the other calcluations in this table.
the cost of the machines - Those batteries are not included in "start-up battery cost".
ne).
ɔst estimate). A 40V battery charger from the leading brand at The Home Depot retails for $55. "Fast chargers" a significanltly more expensive.

Grepow Blog

The Charging Cycles of Lithium-ion Polymer Batteries

Tips — March 25, 2020

Lithium batteries, or Lithium-ion Polymer (LiPo) batteries, are batteries that use Lithium as a negative electrode material and use a non-aqueous electrolyte solution. In 1912, Lithium metal batteries were first proposed and studied by Gilbert N. Lewis. In the 1970s, M.S. Whittingham proposed and started researching Lithium-ion batteries. However, due to the complications of using the unstable Lithium metal, the batteries were not popular at the time.

It is now with further development that Lithium-ion Polymer batteries have fast become a preferred power source for many applications and industries. It is for this reason that we will explore the charging cycles of lithium-ion polymer batteries in-depth in this article.

Table of Contents

What is a charging cycle?

Some consumers may have that the charge and discharge life of lithium-ion polymer batteries is "500 times." But what is "500 times?" It refers to the number of charge and discharge cycles of the battery.

Let us look at an example: Let us say there is a lithium battery that uses only half of its charge in one day and is then charged fully. On the next day, it again only uses half of its power. Although the battery has been charged twice, this does not count as one charge cycle but two.

A charging cycle is when a battery goes from being fully charged to empty and then from empty to fully charged; this is not one single charge. Just based on the previous example, it's clear that it can usually take several charges to complete a cycle.

Every time a charging cycle is completed, the battery capacity decreases a bit. However, the reduced capacity is very small. High-quality batteries will still retain 80% of their original capacity after many cycles of charging. Many lithium battery products will still be used after two or three years. Of course, after the end of the lithium battery life, it still needs to be replaced.

Ultimately, a 500-cycle life means that a manufacturer has achieved about 625 recharge times at a constant discharge depth (such as 80%) and reached 500 charging cycles. In other words, if we ignore other factors that could reduce the Lithium-ion battery capacity and we take 80% of 625, we receive 500.

However, due to various factors in life, especially considering how the depth of discharge (DOD) during charging is not constant, "500 charging cycles" can only be used as a reference to battery life.

Overall, it is better to think of the life of the lithium battery as related to the number of times the charging cycle is completed and not as directly related to the number of charges.

Deep and shallow charging

Here is another way to think of the cycle lives of lithium-ion polymer batteries: the life of a Lithium battery is generally 300 to 500 charging cycles. Assume that the capacity provided by a full discharge is Q. If the capacity reduction after each charging cycle is not considered, lithium batteries can provide or supplement 300Q-500Q power in total during its life. From this we know that if you use 1/2 each time, you can charge 600-1000 times; if you use 1/3 each time, you can charge 900-1500 times. By analogy, if you charge randomly, the number of times is uncertain. In short, no matter how a Lithium battery is charged, it is constant to add a total of 300Q to 500Q of power. Therefore, we can also understand this: the life of a Lithium battery is related to the total charge of the battery and has nothing to do with the number of charges. The effects of deep charging and shallow charging on lithium battery life are similar.

In fact, shallow discharge and shallow charges are more beneficial to lithium batteries. It is only necessary to deep charge when the power module of the product is calibrated for lithium batteries. Therefore, lithium-ion-powered products do not have to be constrained by the process: they can be charged at any time without worrying about affecting the battery life.

Effects of temperature on battery life

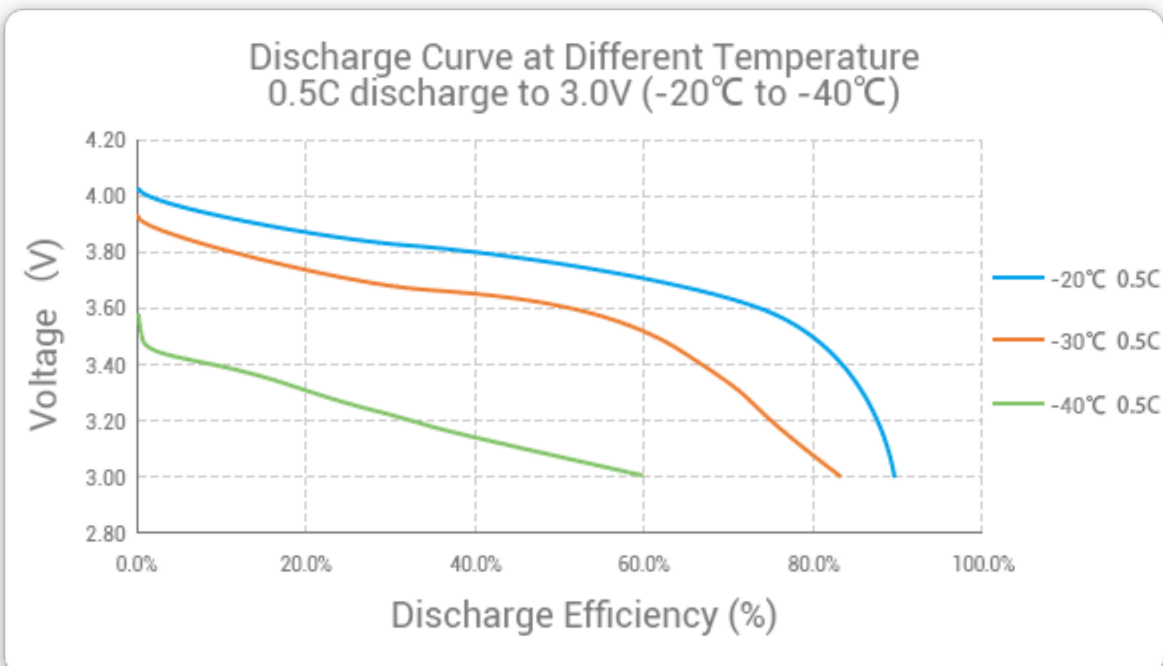
If a Lithium-ion Polymer battery is used in an environment higher than the specified operating temperature (above 35°C), the battery's power will continue to decrease. In other words, the battery's power supply time will not be as long as usual. If a device is charged at such temperatures, the damage to the battery will be greater. Even if the battery is stored in a hot temperature environment, it will inevitably cause damage to the battery. Therefore, it is a good idea to extend the life of lithium-ion polymer batteries by using it under normal operating temperatures as often as possible.

If you use Lithium batteries in a low-temperature environment (below 4°C), the battery life will also be reduced. Some older Lithium batteries of mobile phones cannot even be charged under low temperatures. However, unlike in high temperatures, once the temperatures rise, the molecules in a battery will heat up and immediately return to the previous charge.

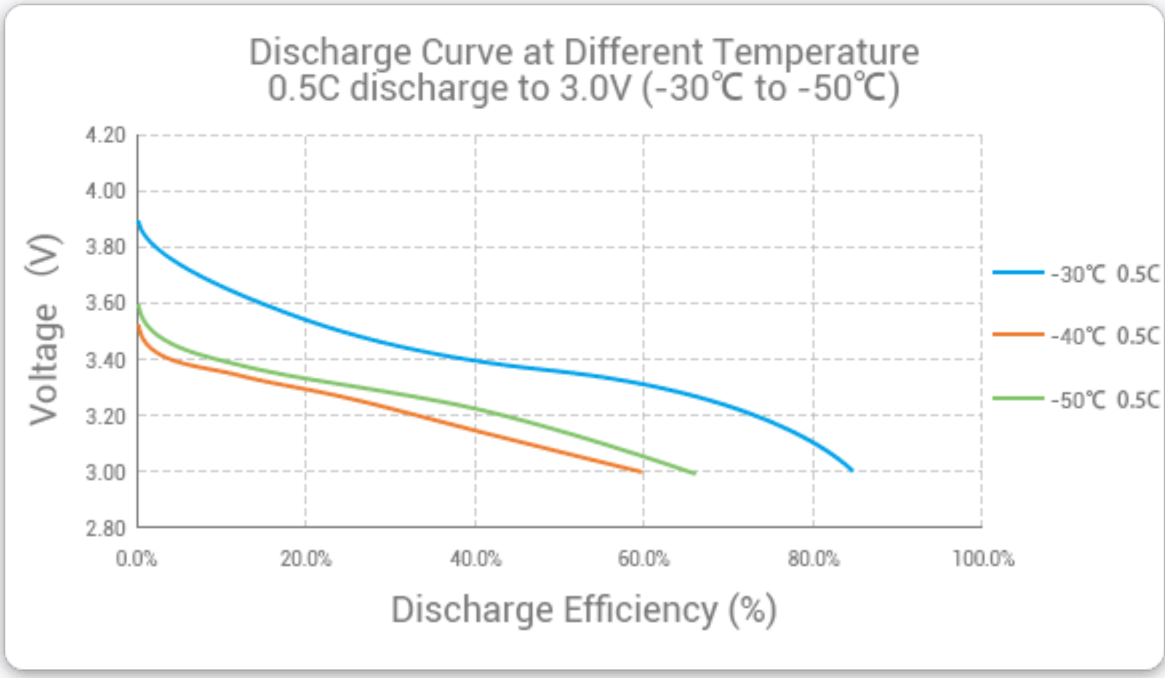
Having explored battery performance under these extreme temperatures, the question now becomes if there are any batteries that can be used in environments with low or high temperatures.

Currently, GREPOW's batteries can be used at temperature ranges of -50 °C to 50 °C or 20 °C to 80 °C. Our low-temperature Lithium batteries' discharging current of 0.2C at -50°C is over 60% efficiency, over 80% efficiency at -40°C, and around 80% efficiency at -30°C.

We can further custom-make batteries depending on your specifications.



The graphs source by Grepow Low-temperature lithium battery



The graphs source by Grepow Low-temperature lithium battery

Charge-discharge cycle

To get the most out of lithium-ion batteries, you need to use it often so that the electrons in the Lithium batteries are always in a flowing state. If you do not use lithium batteries often, please remember to complete a charging cycle every month and do a power calibration, i.e. deep discharge and deep charge, once.

After the nominal number of charge and discharge cycles is used up, a battery's ability to store power will drop to a certain level, but the battery can continue to be used.

Lithium batteries have no limit on the number of times they can be recharged. Regular manufacturers can charge and discharge batteries at least 500 times, and the capacity is maintained at more than 80% of the initial capacity. If charged and discharged once a day, batteries can be used for two years. Usually, batteries in mobile phones are charged 1000 times or more, which causes the batteries to be severely non-durable.

Below is a proper method of maintaining your mobile device's battery:

1. When you charge your phone, fully charge it each time.
2. Do not fully discharge the battery. The battery needs to be charged when the power is less than 10%.
3. Charge with the original charger; do not use a third-party charger.
4. Do not use your mobile phone while it is being charged.
5. Don't overcharge: stop charging after the battery is full.

According to the experimental results, the life of a lithium battery continuously declines with an increase in the number of charges.

Lithium battery cycle specified by the national standard

In order to measure how long the rechargeable battery can be used, the definition of the number of cycles is specified. Actual users use a wide variety of tests because tests with different conditions are not comparable, and the comparison must define the definition of cycle life.

Lithium battery cycle life test conditions and requirements specified by the national standard are as follows:

Charge at 1C under the environment temperature of 20 ° C ± 5 ° C. When the battery terminal voltage reaches the charging limit voltage of 4.2V, change to constant voltage charging until the charging current is less than or equal to 1 / 20C, stop charging, leave it for 0.5h to 1h, and then discharge it at 1C to the termination voltage of 2.75V.

After the discharge is completed, leave it for 0.5h to 1h, and then perform the next charge and discharge cycle two consecutive times. Less than 36min, the end of life is considered, and the number of cycles must be greater than 300 times.

Having gone over the national standard, we should explain the following:

1. The standard specifies that the cycle life test is performed in a deep charge and deep release mode.
2. The cycle life of the lithium battery is specified. According to this model, the capacity is still more than 60% after ≥300 cycles.

However, the number of cycles obtained by different cycling systems is quite different. For example, the other conditions above are unchanged, and only the constant voltage of 4.2V is changed to a constant voltage of 4.1V for the cycle life of the same type of battery. In this way, the battery is no longer under a deep charge, and the cycle of life can be increased by nearly 60%. Then if the cut-off voltage is increased to 3.9V for testing, the number of cycles should be increased several times.

With regard to this statement that the charge and discharge cycle is one less life, we should pay attention to the definition of the charging cycle of a lithium battery: a charging cycle refers to the full charge of the lithium battery from empty to full, and then from empty to full the process of. And this is not the same as charging once.

In addition, when we talk about the number of cycles, we cannot ignore the conditions of the cycle. It is meaningless to talk about the number of cycles aside from the rules because the number of cycles is just a way to measure battery life.

If you want to learn more about batteries or our custom-made batteries, please contact us at info@grepow.com and visit our website: https://www.grepow.com/.

How is the lithium battery charged?

Lithium-ion batteries generally use lithium alloy metal oxide as the positive electrode material, graphite as the negative electrode material, and the Read more

Overcharging Lithium-ion Polymer Batteries

There are many advantages to using Lithium-Ion Polymer (LiPo) batteries: High working voltage, high energy density, long cycle life, low Read more

Lithium vs Alkaline is better?

An Increasing Number of Reliable Power The worl phenomenal explosion in ucts Read more

QuickTake

Better Batteries

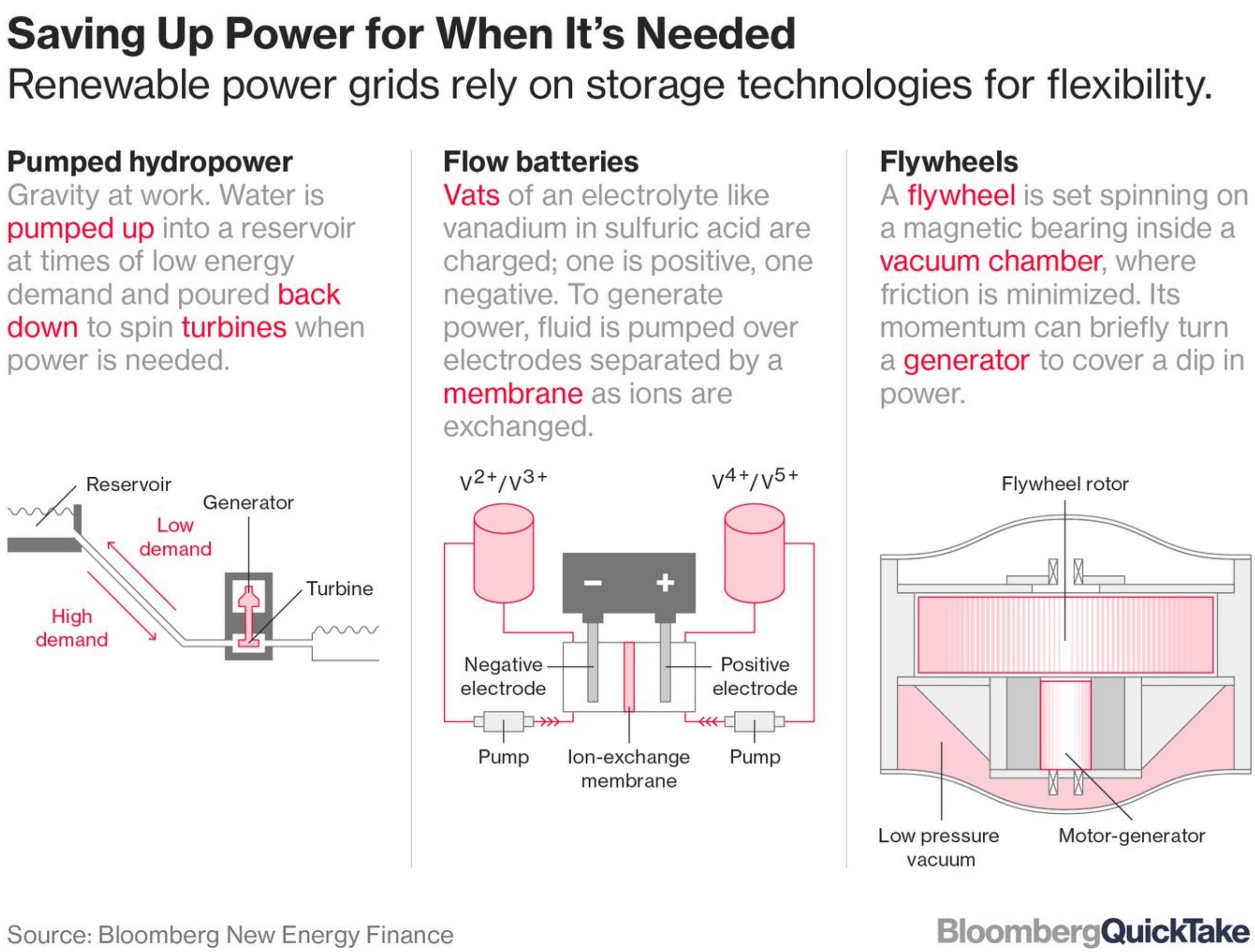
By Chris Martin +Follow

Updated on October 11, 2019, 1:27 PM PDT

Hopes that renewable energy could blunt the worst of climate change used to face a seemingly insurmountable hurdle: the need for better batteries. After all, the wind doesn't always blow and the sun doesn't always shine. But those better batteries are on their way, thanks to a myriad of small improvements that will both add life to the phone in your pocket and speed the day when electric vehicles (EVs) overtake those that run on gasoline. Now there's a different worry: Can we turn batteries out fast enough? Fulfilling a vision of a clean-energy future – where wind turbines and solar panels are knit into a new kind of power grid – depends on creating an almost entirely new industry.

The Situation

In China, where the government is throwing its weight behind the electric-car industry, plans have been announced for factories that could produce enough batteries every year to hold 120 gigawatt-hours of storage capacity – enough to tide Italy over an hour-long blackout. Those plans include a 10 million square-foot factory opened in 2018 by the world's biggest EV supplier, BYD Co., and another of similar size it broke ground on in February. That's enough to equip 1.2 million cars, according to the manufacturer, which is backed by Warren Buffett. That's larger than Tesla Inc.'s giant Gigafactory battery plant in the Nevada desert, though Tesla plans to expand that facility and build as many as four more big battery factories in the U.S. And General Motors proposed building a factory with Korea's LG Chem Ltd. if it can overcome union opposition to the shift to EVs, whose simpler workings could mean steep job cuts for manufacturers and suppliers. Giant battery plants are also planned in Germany and Sweden, and Europe is set to overtake the U.S. as the second-largest market for EVs in 2020. The price of a lithium-ion battery pack holding a kilowatt hour of electricity has already plunged and is expected to fall by more than 90 percent from 2010 to 2030. Utilities are also boosting battery installation. California is requiring power companies to install a combined total of close to 2 gigawatt-hours of storage by 2024 – more than twice what existed in the U.S. at the end of 2017. Not counting car batteries, global storage capacity is expected to rise from 7 gigawatt-hours now to 305 gigawatt-hours in 2030.

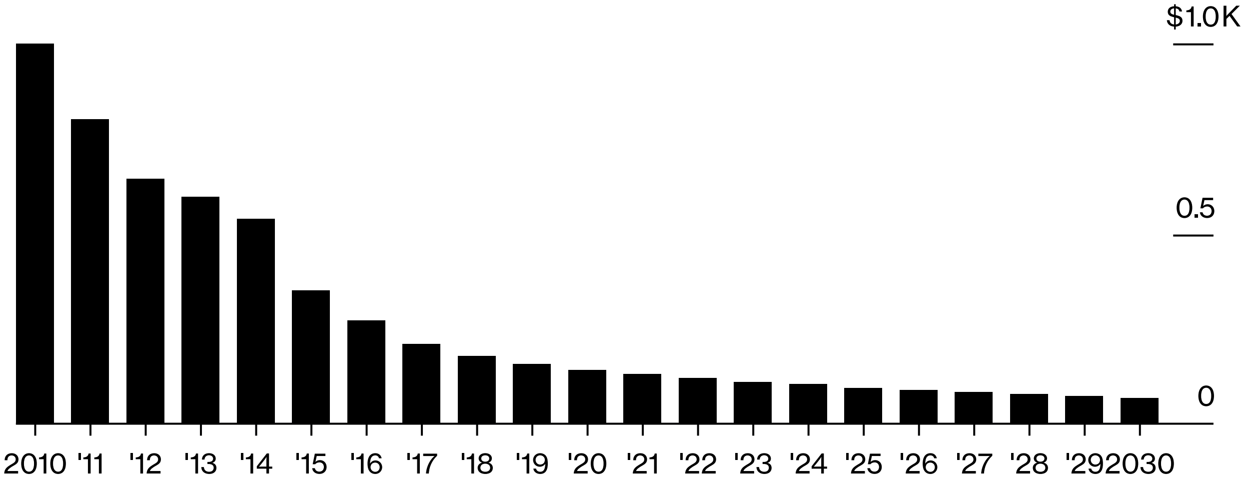


The Background

Benjamin Franklin and other inventors experimented with Leyden jars, now known as capacitors, which hold and release an electric charge. Alessandro Volta of Italy is credited with inventing the first electric battery in 1799, a stack of zinc and copper disks in brine. Thomas Edison created a nickel-iron battery for the earliest electric cars. The oil shocks of the 1970s spurred investment in new research that led to Stanley Whittingham's discoveries that made possible the first functional lithium ion battery – for which he and two other scientists were awarded a Nobel Prize in chemistry in 2019. Sony Corp. brought the technology to market in the early 1990s, and lithium ion batteries have underpinned the digital revolution ever since. They're durable, energy-dense and easy to recharge, even if manufacturing glitches have led to high-profile cases of fires in new products, such as Samsung Electronics Co.'s Galaxy Note 7 mobile phone and Boeing Co.'s 787 Dreamliner jet. Utilities that need large-scale storage are pursuing a variety of technologies, from pumps and reservoirs to solid-state lithium ion batteries to flywheels that store energy as momentum.

Cheaper Batteries

The cost of storing a kilowatt-hour of electricity has plunged and is expected to drop further



Source: BNEF
Note: Figures for 2018 and beyond are projections

The Argument

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Some countries, such as Germany and Japan, offer subsidies for batteries integrated into renewable energy systems. More often, demand for batteries has been indirectly fed by subsidies for wind and solar production. Those payments are now being phased out in the U.S. For homeowners, adding batteries to solar panels saves on electricity costs at night and provides security during blackouts. For power companies, adding batteries to solar panels or wind turbines may let them sell their electricity at a higher price by qualifying as a reliable energy source. Some new ventures are using batteries to create what's known as a virtual power plant, tying rooftop solar panels together and selling their output. It's an approach gaining popularity in Europe and being tried in new developments in the U.S. It's also creating conflict with utilities that say solar and wind producers are piggybacking on the billions of dollars spent to maintain and upgrade power grids. Proponents say the spread of household battery packs will lead to a decentralized network of microgrids that will be more resilient and efficient.

The Reference Shelf

- The International Energy Agency looks at the various types of energy storage and where they can be implemented around the world.
- The U.S. government-backed Joint Center for Energy Storage Research is leading studies in the search for a next-generation battery.
- A Bloomberg News story looks into the commercial uses of existing and future battery technologies, and the billionaires funding startups in the field.
- A Foreign Affairs overview of the search for better batteries.
- A history of the Leyden jar and how to make a voltaic pile. Did the Mesopotamians invent batteries? Maybe yes or probably not.

Logan Goldie-Scot contributed to this article.

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Assembly Bill No. 1346

CHAPTER 753

An act to add Section 43018.11 to the Health and Safety Code, relating to air pollution.

[Approved by Governor October 9, 2021. Filed with Secretary of State October 9, 2021.]

LEGISLATIVE COUNSEL'S DIGEST

AB 1346, Berman. Air pollution: small off-road engines.

Existing law imposes various limitations on the emissions of air contaminants for the control of air pollution from vehicular and nonvehicular sources. Existing law assigns the responsibility for controlling vehicular sources of air pollution to the State Air Resources Board.

This bill would require the state board, by July 1, 2022, consistent with federal law, to adopt cost-effective and technologically feasible regulations to prohibit engine exhaust and evaporative emissions from new small off-road engines, as defined by the state board. The bill would require the state board to identify and, to the extent feasible, make available funding for commercial rebates or similar incentive funding as part of any updates to existing applicable funding program guidelines to local air pollution control districts and air quality management districts to implement to support the transition to zero-emission small off-road equipment operations.

The people of the State of California do enact as follows:

SECTION 1. (a) The Legislature finds and declares all of the following:

(1) Small off-road engines (SORE), which are used primarily in lawn and garden equipment, emit high levels of air pollutants, including oxides of nitrogen (NOx), reactive organic gases (ROG), and particulate matter (PM). NOx and ROG together contribute to formation of ozone, a criteria pollutant with a national ambient air quality standard set by the United States Environmental Protection Agency (U.S. EPA) and a California ambient air quality standard and that has adverse impacts on health. Currently, California exceeds U.S. EPA and state standards for ozone in many areas, including the South Coast Air Basin, the San Francisco Bay area, and the County of Sacramento. NOx also contributes to formation of PM, which, along with directly emitted PM, has direct negative health impacts. PM also has an air quality standard set by the U.S. EPA and the state. Many areas in California also currently fail to meet PM standards, including the South Coast Air Basin and the San Joaquin Valley Air Basin.

(2) In 2020, California daily NOx and ROG emissions from SORE were higher than emissions from light-duty passenger cars. SORE emitted an average of 16.8 tons per day of NOx and 125 tons per day of ROG. Without further regulatory action, those emission levels are expected to increase with increasing numbers of SORE in California. Regulations of emissions from SORE have not been as stringent as regulations of other engines, and one hour of operation of a commercial leaf blower can emit as much ROG plus NOx as driving 1,100 miles in a new passenger vehicle.

(3) Currently, there are zero-emission equivalents to all SORE equipment regulated by the State Air Resources Board. The battery technology required for commercial-grade zero-emission equipment is available and many users, both commercial and residential, have already begun to transition to zero-emission equipment.

(4) The Governor's Executive Order No. N-79-20 of September 23, 2020, directs the state board to implement strategies to achieve 100 percent zero emissions from off-road equipment in California by 2035, where feasible and cost-effective. The state will not achieve that goal without further regulation of SORE, including a mandate to transition all sales of new equipment to zero-emission equipment.

(b) It is the intent of the Legislature to encourage the state board to act expeditiously to protect public health from the harmful effects of emissions of small off-road engines.

SEC. 2. Section 43018.11 is added to the Health and Safety Code, to read:

43018.11. (a) (1) By July 1, 2022, the state board shall, consistent with federal law, adopt cost-effective and technologically feasible regulations to prohibit engine exhaust and evaporative emissions from new small off-road engines, as defined by the state board. Those regulations shall apply to engines produced on or after January 1, 2024, or as soon as the state board determines is feasible, whichever is later.

(2) In determining technological feasibility pursuant to paragraph (1), the state board shall consider all of the following:

(A) Emissions from small off-road engines in the state.

(B) Expected timelines for zero-emission small off-road equipment development.

(C) Increased demand for electricity from added charging requirements for more zero-emission small off-road equipment.

(D) Use cases of both commercial and residential lawn and garden users.

(E) Expected availability of zero-emission generators and emergency response equipment.

(b) Consistent with the regulations adopted pursuant to this section and relevant state law, the state board shall identify, and, to the extent feasible, make available, funding for commercial rebates or similar incentive funding as part of any updates to existing, applicable funding program guidelines for districts to implement to support the transition to zero-emission small off-road equipment operations.

O