Lawn and Garden Demonstration Project

FINAL REPORT

GRANT NUMBER: G10-AQIP-15

Prepared for:

South Coast Air Quality Management District
21865 E. Copley Drive
Diamond Bar, CA 91765

University of California, Riverside
Bourns College of Engineering
Center for Environmental Research and Technology

June, 2013

Disclaimer

The statements and conclusions in this Report are those of the contractor and not necessarily those of the South Coast Air Quality Management District. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Acknowledgments

The authors would like to acknowledge the California Air Resources Board for providing funding to conduct this project. We would also like to acknowledge Shashi Singeetham from the South Coast Air Quality Management District for providing direction and project oversight.

We would like to thank and acknowledge the following representatives and companies for their cooperation in demonstrating the test units:

Mr. Henry Maestas – Steadfast Landscaping

Mr. Brandon Walker – Valley Crest Landscape Maintenance

Mr. Joe Espinoza – TruGreen Landcare

Mr. Steve Seely – Stay Green, Inc.

In particular, we would like to thank Dan Mabe of the Greenstation for his help in identifying and contacting end users to participate in the project.

This Report was submitted in fulfillment of SCAQMD Contract No. 123791, "Lawn and Garden Demonstration Project," by the University of California, Riverside under the sponsorship of the California Air Resources Board. Work was completed as of June, 2013.

Table of Contents

Table of Tables

Table of Figures

Abstract

The University of California, Riverside conducted a project to develop and demonstrate zero-emission electric lawn and garden equipment for commercial gardening and landscaping operations. Two battery-operated electric riding lawn mowers and two battery-operated walk-behind lawn mowers were deployed for use in commercial gardening and landscaping operations in the South Coast Air Basin. The lawn mowers were operated in normal commercial gardening and landscaping service for a period of up to three months. During operation, UCR worked with the commercial lawn mower manufacturer (Mean Green Products, Inc.) to monitor the lawn mowers and batteries for performance, run time, wear, loose elements, structural integrity, and any other maintenance issues.

UCR fitted the equipment with time-lapse cameras and global positioning systems in order to assist in the data collection effort. In addition, UCR personnel questioned end-users to assess their impressions of performance, durability, ease of use, and applicability to job requirements.

The widespread deployment of electric commercial lawn and garden equipment has the potential for providing substantial reductions of oxides of nitrogen, gaseous hydrocarbons, and carbon monoxide. This demonstration project is a first step in assisting market penetration of commercial battery operated zero-emission electric lawn mowers.

Executive Summary

Background

The Air Quality Improvement Program (AQIP) at the California Air Resources Board (CARB) is a voluntary incentive program created under the California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007 to fund clean vehicle and equipment projects, air quality research, and workforce training. A significant portion of NO_x, PM, and CO emissions from gasoline-fueled lawn and garden equipment can be attributed to the commercial sector. Over the years, many of the gasoline-fueled residential lawn mowers in the South Coast Air basin have been replaced by zero-emission cordless electric lawn mowers under AQMD's Lawn Mower Exchange Program. The electric lawn mower works well in residential gardening and landscaping operations, but its motor and battery pack needs to be enhanced to perform reliably in a commercial application. In June 2011, the AQMD received an award from CARB under the AB 118 AQIP Advanced Technology Demonstration Project to design, develop, and demonstrate cordless zero-emission commercial lawn and garden technology equipment.

Methods

In conjunction with the SCAQMD and Greenstation, UCR identified four commercial landscaping services that were willing to deploy battery operated electric lawn and garden equipment in place of their currently used gasoline powered equipment.

The demonstration units were equipped with data logging technology, including time-lapse cameras and global positioning satellite units. UCR arranged for the delivery, operation, deployment, and data logging capability of the experimental units. Data was downloaded from the 4 equipment units on a weekly basis. The data was compiled, using position, ambient conditions, time of operation, and visual landscape assessment. This data was used to estimate gasoline-equivalent emission factors for each of the two types of equipment tested.

Based on the collected data, UCR estimated overall average emission factors for each of the two types of equipment tested, using the actual activity determined via data logging. The results were compared with published emission factors. A comparison was made of the emissions difference between the battery operated electric equipment versus comparable gasoline equivalent for the 4 units tested. These results were used to estimate the overall potential emission reduction in the South Coast Air Basin if all commercial gasoline powered equipment were replaced by cordless electric equipment.

Results

Two zero-turn 60" lawn mowers and two 33" walk-behind mowers were deployed with commercial landscaping firms. The mowers were operated between 44 and 102 hours each. End users provided positive feedback in terms of appearance, quality of cut, ride comfort, low noise, and lack of exhaust emissions.

Some difficulties were reported by operators, including trouble mowing thick grass and incomplete mulching on turf with leaves. Some challenges were also reported regarding the LEMs. A few operators forgot to plug the units into the charger at the end of the day, and were unable to use the unit the following day. It is expected that this problem will be minimized over time, as operators adjust to the new operating procedures. One end-user was challenged by jobs that require long mowing times without convenient access to electrical outlets.

Fuel savings were estimated to be 1.5 gal/hr for the 60” zero turn mower and 1.1 gal/hr for the 33” walk-behind mower. Based on the retail cost of the units provided for the study, the differential cost payback periods were calculated to be 4.3 years for the 60” zero turn electric mower and 2.9 years for the 33” walk-behind mower.

Emission factors were determined for equivalent gasoline mowers based on 2010 ARB OFFROAD model. Calculations show that replacing commercial riding mowers with electric units could reduce the emissions inventory in the South Coast Air Basin by 15,147 tons/year of carbon monoxide, 132 tons/year of nitrogen oxides, and 198 tons/year of volatile organic compounds. Replacing commercial walk-behind mowers with electric units could reduce the emissions inventory in the South Coast Air Basin by 62,978 tons/year of carbon monoxide, 700 tons/year of nitrogen oxides, and 980 tons/year of volatile organic compounds.

Conclusions

Results from the current study suggest that the electric lawn mowers tested under this project are a possible alternative to gasoline powered mowers in landscaping operations. The mowers were operated in actual commercial settings, and showed satisfactory performance in most applications. The length of the study did not allow for a thorough examination of durability of the equipment.

Operators provided positive feedback on the appearance, low noise, ease of handling, cut quality, and lack of emissions. For the CXR-60 model, operators appreciated the electric deck height adjustment. Some challenges were reported in mowing heavy grass, mulching with moist leaves, and battery management. There were a few mechanical problems that were fixed.

While the initial capital cost of the electric lawn mowers is substantially higher than their gasoline equivalents, the reduced fuel costs can offset the initial payment. Incentive programs similar to the residential lawn mower program may be effective in developing market penetration in the commercial sector.

1 Introduction

Currently, the available data to provide an assessment of commercial electric lawn and garden equipment is limited. A significant portion of NOx and PM emissions from gasoline-fueled lawn and garden equipment can be attributed to the commercial sector. Over the years, many of the gasoline-fueled residential lawn mowers in the South Coast Air basin have been replaced by zero-emission cordless electric lawn mowers under AQMD's Lawn Mower Exchange Program. The electric lawn mower works well in residential gardening and landscaping operations, but its motor and battery pack needs to be enhanced to perform reliably in a commercial application.

The project conducted was to demonstrate zero-emission electric lawn and garden equipment for commercial gardening and landscaping operations. Equipment purchased from Mean Green Products, Inc. included two battery operated electric riding lawn mowers and two battery-operated walk-behind lawn mowers. The lawn mowers were operated in normal commercial gardening and landscaping service for a period of up to three months. During operation, UCR monitored the lawn mowers and batteries for performance, run time, wear, loose elements, structural integrity, and any other maintenance issues.

The goal of the project was to demonstrate the potential for substantial reductions of oxides of nitrogen, gaseous hydrocarbons, and carbon monoxide. The demonstration is expected to help market penetration of commercial battery operated zero-emission electric lawn mowers.

Due to the short time frame involved in the project, information usually provided in monthly status reports has be incorporated into this report.

2 Methods

The overall approach for this program was to deploy commercial electric lawn mowers to landscaping companies in the South Coast Air basin to be used in place of gasoline powered equivalents.

2.1 Commercial Electric Lawn Mowers

In conjunction with the SCAQMD, Mean Green Products provided four commercial electric lawn mowers for use in the demonstration program. Two of the units were 60” zero-turn riding lawn mowers, and the other two units were 33” walk-behind lawn mowers.

For commercial users needing large area mowing capabilities, the Mean Green CXR-60 Mower were deployed (Figure 1).

Figure 1 - Mean Green CXR-60

These units are equipped with four cutting blades, providing a cutting deck size of 60”. The units were provided with four (4) 80 amp-hour lithium energy modules (LEM), enabling a continuous mow time of up to 4 hours. Batteries can be recharged in 2-4 hours or overnight. The top transit speed is 8-9 mph.

The company estimates operational savings compared to gasoline equipment at $7/hour. The battery manufacturer estimates that each LEM will retain 90% of its full charge after 1500 charge cycles, and 80% of its full charge after 3000 charge cycles. The sound level measured by the manufacturer is 82 db, compared to a gasoline powered mower at 90-95 db. The peak power 36 Hp.

The mower’s retail cost is $11,400.00. Each 80 amp hour LEM retails for $2000.00, bringing the total cost as delivered to $19,400.00

For commercial users needing smaller area mowing capabilities, the Mean Green WBX-33 Mowers were deployed (Figure 2). These units are designed for residential use or commercial applications using two (2) LEM units each.

Figure 2 - Mean Green WBX-33

Each unit is designed to be capable of mowing up to 4 acres on a single charge using two LEM80 units. There is no gear shifting, and the WBX-33 is operated using an instant fingertip variable speed control up to 5 mph forward and 2.5 mph in reverse. Each unit is also equipped with an operator drive speed dial on the control panel to adjust the speed that suits the end-users walking speed.

The units are equipped with a feature to automatically shut down the mowing blades before LEMs are fully depleted to allow the user to transit back to a charging area. The blades can be adjusted for mowing heights from 1-4".

Each WBX-33 has a retail cost of $4195.00. The units were each provided with two (2) LEM80s, leading to a total cost of $8195.00

2.2 Time Lapse Cameras

For assistance with the data collection efforts, each lawn mower was outfitted by UCR with a time lapse camera.

The Day6 PlotWatcher Pro (Figure 3) was originally designed as a game surveillance system for hunters. Mounted on the lawn mowers, it records HD video of all the activity that happens in front of the camera. Images are captured and stored as video frames every 5 seconds, from dawn until dusk, creating a time-compressed HD video of each day's activity. The video file for each day can then be reviewed in just a few minutes.

Figure 3 - PlotWatcher Pro

The PlotWatcher Pro can record up to 120 days of activity onto an SDHC memory card. The unit includes an LCD status screen that displays camera and battery parameters, and allows the user to take a preview picture for aiming. It also includes 3 slide switches for the main camera settings.

2.3 Global Positioning Satellite

Each lawn mower was also equipped with a location tracking logger. The E-TEK EB85A GPS engine (Figure 4) uses recent advanced technology to get a signal in areas of dense foliage, canyons, and even inside buildings. Data from the GPS engine can be stored on an SD or SDHC memory card (64 Mb to 32 GB). A file system has been implemented that allows for up to 255 folders, with each folder holding 255 files. The size of these files is not limited and can hold tens of thousands of positions. The time and date of each file is also recorded when the file is created and updated. The memory card can be formatted in either FAT16 or FAT32 format.

Data can be stored in two formats:

1. NMEA Mode – where the data is simply received from the GPS engine in NMEA 0183 format and recorded.
2. EXCEL Mode – where the NMEA sentences are parsed and data requested by the user is recorded.

Figure 4 - ETEK EB85A GPS

Power is supplied from a rechargeable 1800 mAh 3.6V lithium ion battery that contains a protection circuit module. Testing has shown that the logger can operate continuously for ~36 hours on a full charge. Increased run times can be achieved using sampling intervals from 1-29 seconds. During these intervals the main microprocessor of the logger is placed into a low power sleep mode for the sampling interval.

Sampling intervals from 30-65535 seconds will achieve the longest run times by shutting off power to the GPS engine and having the microprocessor being sleep mode. When power is reapplied to the GPS Engine it is forced to perform a cold restart. Depending on the time the GPS engine remained off it could take from 8 to 48 seconds to reacquire a GPS fix. The miroprocessor waits for the GPS engine to regain a fix before recording a sample.

2.4 Manufacturer and End User Surveys

Information was collected from the manufacturer and field surveys regarding the equipment, pricing, testing environments, terrain, battery performance.

A survey was also conducted with end users in order provide feedback on the operation of the mowers in an actual commercial environment. Users were asked about the performance of the mowers and batteries, noise, ease of use, durability, likes/dislikes, and comparison to gasoline powered equipment.

3 Results

Unit #1 (CXR-60) was deployed to TruGreen Landcare in Rosemead, CA. To date, the unit has been operated for 87 hours. End users have provided positive feedback in terms of ride comfort, low noise, and lack of exhaust emissions. They have had some difficulty when using the mulching option at a park with leaves on the ground. The moist leaves caused blade stoppage on a few occasions, and the mower was unable to completely mulch the leaves (requiring them to rake afterwards). Most of the grasses mowed by this unit were fescue blends, with some Bermuda and centipede grasses. This unit had a problem with the right rear drive motor, which prevented the wheel from moving properly. The manufacturer sent a new motor assembly, and the faulty part was replaced. No further problems were encountered.

Figure 5 - Unit #1 Time Lapse Screen Capture

Unit #2 (CXR-60) was deployed to Stay Green Landscaping in Santa Clarita, CA. To date, the unit has been operated for 44 hours. End users were positive about the appearance of the machine, low noise, the deck height adjustment feature, and handling. The only difficulty reported to date is the inability to charge the batteries in the field. A few of their crews mow street medians, and require about 7 hours of continuous operation. They have reported charge depletion times of 3 to 4.5 hours with the electric unit. In these situations, without easy access to electrical outlets, they completed the job with gasoline powered units. They are working to arrange deployment of Unit #2 with crews that have shorter jobs or have access to battery charging capabilities. This unit mowed fescue blends, Bermuda and St. Augustine grasses.

Figure 6 - Unit #2 Time Lapse Screen Capture

Unit #3 (WBX-33) was deployed to Steadfast Landscaping in Riverside, CA. To date, the unit has been operated for 102 hours. End users were positive about the low noise, quality of cut, and handling. To date, they have not reported any negative feedback. This unit mowed fescue blends, mutt mixtures, Bermuda and centipede grasses.

Figure 7 - Unit #3 Time Lapse Screen Capture

Unit #4 (WBX-33) was deployed to Valley Crest Landscaping in Riverside, CA. To date, the unit has been operated for 98 hours. End users were positive about the low noise, lack of emissions, and handling. On a few occasions, crews have forgotten to plug the mower into the charger at night. They have had some difficulty with mowing thick grass, but overall have a positive impression. This unit mowed fescue blends, mutt mixtures, Bermuda and centipede grasses.

Figure 8 - Unit #4 Time Lapse Screen Capture

4 Discussion

The following Table summarizes the use of the commercial electric lawn mowers in the demonstration program.

Unit	Model	Location	Total Hours	Hours/wk	Ambient Temp	Mechanical Problems
1	CXR-60	South Pasadena	87	11	37 - 92 °F	Rear Drive Motor
2	CXR-60	Santa Clarita	44	11	42 - 98 °F	None
3	WBX-33	Riverside	102	14	42 - 101 °F	Bent Blade Shaft
4	WBX-33	Riverside	98	13	45 - 98 °F	None

Table 1 - Summary of Operation

Overall, the mowers performed well in most circumstances. Operators provided positive feedback on the appearance, low noise, ease of handling, cut quality, and lack of emissions. For the CXR-60 model, operators appreciated the electric deck height adjustment.

Some difficulties were reported by operators, including trouble mowing thick grass and incomplete mulching on turf with leaves. It should be noted that the units provided were equipped with standard mowing blades. The manufacturer offers alternative blades that are designed for heavy grasses and mulching.

Some challenges were also reported regarding the LEMs. A few operators forgot to plug the units into the charger at the end of the day, and were unable to use the unit the following day. It is expected that this problem will be minimized over time, as operators adjust to the new operating procedures. One end-user was challenged by jobs that require long mowing times

without convenient access to electrical outlets. This problem could be minimized with extra LEMs or by installing charging capabilities on their work trucks.

Fuel savings were estimated to be 1.5 gal/hr for the 60” zero turn mower and 1.1 gal/hr for the 33” walk-behind mower. Based on the retail cost of the units provided for the study, the differential cost payback periods were calculated to be 4.3 years for the 60” zero turn electric mower and 2.9 years for the 33” walk-behind mower.

Emission factors were determined for equivalent gasoline mowers. Calculations show that replacing commercial riding mowers with electric units could reduce the emissions inventory in the South Coast Air Basin by 15,147 tons/year of carbon monoxide, 132 tons/year of nitrogen oxides, and 198 tons/year of volatile organic compounds. Replacing commercial walk-behind mowers with electric units could reduce the emissions inventory in the South Coast Air Basin by 62,978 tons/year of carbon monoxide, 700 tons/year of nitrogen oxides, and 980 tons/year of volatile organic compounds. Fuel savings and emissions reductions calculations are shown in Appendix D.

5 Summary and Conclusions

Results from the current study suggest that the electric lawn mowers tested under this project are a possible alternative to gasoline powered mowers in landscaping operations. The mowers were operated in actual commercial applications for 40 – 100 hours each, and showed satisfactory performance in most applications. The length of the study did not allow for a thorough examination of durability of the equipment.

Operators provided positive feedback on the appearance, low noise, ease of handling, cut quality, and lack of emissions. For the CXR-60 model, operators appreciated the electric deck height adjustment.

Some challenges were reported in mowing heavy grass, mulching with moist leaves, and battery management. There were a few mechanical problems that were fixed.

While the initial capital cost of the electric lawn mowers is substantially higher than their gasoline equivalents, the reduced fuel costs can offset the initial payment. Incentive programs similar to the residential lawn mower program may be effective in developing market penetration in the commercial sector. Successful deployment of commercial electric lawn mowers can lead to substantial reductions of CO, NO_x, and VOC emissions.

APPENDIX A
SUMMARY OF BUDGET EXPENSES

Salaries	$16,918
Benefits	$5,841
Travel	$420
Facilities	$5,795
Indirect	$6,026
Total	$34,999

APPENDIX B
MANUFACTURER SURVEY

	WBX-33	CXR-60
Deck Size	33"	60"
Voltage	36 Volts	36 Volts
Batteries	1-2ea LEM40, 60, or 80	2-4ea LEM80s
Acres Cut/Charge	LEM80 (4acres)[1]	4ea LEM80s (7acres)[1]
Mow Time/Charge	LEM80 (4hrs)[1]	4ea LEM80s (3.5hrs)[1]
Blades/Deck	2	4
Battery Recharge Time	2hrs-Overnight[2]	4hrs-Overnight[2]
Speed	4-5 mph	7-8 mph
Operational SAVINGS/hr (compared to gas)	$5.09/hr[3]	$7.02/hr[3]
Battery life	up to 1500 Charge cycles[4]	up to 1500 Charge cycles[4]
EMISSIONS	ZERO	ZERO
Sound Level	73 db (gas engine 88 db)	82 db (gas engine 95-100 db)
Peak Horsepower	16 HP	36 HP
Weight	365lbs (compared to 480lbs gas mower)[5]	780lbs (compared to 910lbs gas mower)[5]

1 - Varies with LEM size, terrain, operator performance, and grass height/thickness
2 - LEMs can be exchanged in about one minute to extend the run time
3 - includes battery depreciation and maintenance
4 - approximately 6000 hours with 1ea LEM80) or 10-12 years
5 - approximately 5250hrs with 4ea LEM80s)or 10-12 years
6 - does not include battery weight (60 lbs/LEM80)

Item	Qty	Price/Unit	Price
CXR-60	1	$11,400	$11,400
Charger	1	$130	$130
LEM80	4	$2,000	$8,000
		Total:	$19,530

Item	Qty	Price/Unit	Price
WBX-33	1	$4,195	$4,195
Charger	1	$130	$130
LEM80	2	$2,000	$4,000
		Total:	$8,325

APPENDIX C
END-USER SURVEYS

Company: Trugreen Landcare
Unit: CXR-60

A. How did the zero-emission equipment compare overall to the gas-powered equipment?

The machine worked well for most jobs. It had some trouble with thick grass and wet grass. Overall would rate at70% compared to gas mower

B. What was the usability of the equipment (easy or difficult)? Why?

The machine was very easy to use. The controls were responsive and user-friendly.

C. What was the durability/reliability of the equipment?

One of the four blade motors failed during the program.

D. What did you like about the equipment? What did you dislike?

We liked the low noise, no exhaust, and appearance of the equipment. We did not like the mulching performance on lawns with moist leaves. We had to go back and rake leaves after mowing.

E. What are some improvements you would like to see?

It would be nice if the machine had more power and longer battery life. The machine should be equipped with a roll bar and seat belts.

F. Would you buy/use this equipment again?

Yes

G. How was the noise level when compared to a gas-powered unit? Was it quieter? Louder? About the same?

Much quieter

Company: Staygreen Landscaping
Unit: CXR-60

A. How did the zero-emission equipment compare overall to the gas-powered equipment?

The machine worked well. It had some trouble with thick grass. Overall would rate at 70% compared to gas mower

B. What was the usability of the equipment (easy or difficult)? Why?

The machine was difficult to get used to. The controls are very touchy compared with a gas machine. It got easier over time.

C. What was the durability/reliability of the equipment?

In thick grass, the right side blade motor (motor #4) would shut down due to overheating. It would work again after it cooled down.

D. What did you like about the equipment? What did you dislike?

The low noise allowed us to start work early at homeowner's association jobs. It also saves money on gas. We also liked the appearance of the machine; especially the rims. Some operators did not like the position of the deck height indicator needle. It frequently snagged operator's clothing.

E. What are some improvements you would like to see?

The two motors on the right hand side of the machine (#3 and #4) should be more powerful. Grass clippings are blown from left to right by the blades, making the right side motors work harder. The machine should be equipped with a roll bar and seat belts.

F. Would you buy/use this equipment again?

Yes

G. How was the noise level when compared to a gas-powered unit? Was it quieter? Louder? About the same?

Much quieter

Company: Valley Crest Landscaping
Unit: WBX-33

H. How did the zero-emission equipment compare overall to the gas-powered equipment?

The machine worked well for the most part. It had trouble with thick grass. Operators sometimes forgot to charge batteries at the end of the day.

I. What was the usability of the equipment (easy or difficult)? Why?

The machine was easy to use. Operators liked the forward/reverse feature on the handle that made it easy to back up compared to gas machine.

J. What was the durability/reliability of the equipment?

The right side blade motor controller failed during the program.

K. What did you like about the equipment? What did you dislike?

The low noise was very nice. It also saves money on gas. We did not like the battery life. Some days, the battery went dead and we had to finish the job with a gas mower. Sometimes this was because the crews forgot to put the battery on the charger the previous night.

L. What are some improvements you would like to see?

The throttle control seems more like an on/off switch. It would be nice if the throttle control could be more like a clutch to slowly engage the wheels.

M. Would you buy/use this equipment again?

Yes

N. How was the noise level when compared to a gas-powered unit? Was it quieter? Louder? About the same?

Much quieter

Company: Steadfast Landscaping
Unit: WBX-33

O. How did the zero-emission equipment compare overall to the gas-powered equipment?

The machine worked very well, and did every job we use our gas machine for.

P. What was the usability of the equipment (easy or difficult)? Why?

The machine was easy to use. It was very easy to adjust the deck height. The wheel speed can be adjusted to the walking pace of each operator.

Q. What was the durability/reliability of the equipment?

One of the blade shafts was misaligned after hitting a stump.

R. What did you like about the equipment? What did you dislike?

Operators liked the low noise, deck adjustment mechanism, lightweight aluminum grass catcher, and mulching plate. The electric mower is more difficult to turn than the gas mower. The gas mower has separate throttles for each wheel that gives us power assist when turning. The electric mower has to be turned manually.

S. What are some improvements you would like to see?

Separate throttles for each wheel.

T. Would you buy/use this equipment again?

Yes

U. How was the noise level when compared to a gas-powered unit? Was it quieter? Louder? About the same?

Much quieter

APPENDIX D
FUEL SAVINGS AND EMISSIONS BENEFITS

CXR-60 Cost Comparison	
gal/hr	1.5
hr/year[1]	572
gal/year	858
$/yr saved[2]	$ 3,389
CXR-60 price[3]	$19,530
Avg. 60" gas mower price	$ 5,000
Difference	$14,530
Payback period (years)	4.29

1 - average of 11 hours/week

2 - assume $3.95/gal gasoline

3 - includes 4 LEM80 and charger

WBX-33 Cost Comparison	
gal/hr	1.1
hr/year[1]	572
gal/year	629.2
$/yr saved[2]	$ 2,485
WBX-33 price[3]	$ 8,325
Avg. 33" gas mower price	$ 1,200
Difference	$ 7,125
Payback period (years)	2.87

1 - average of 11 hours/week

2 - assume $3.95/gal gasoline

3 - includes 2 LEM80 and charger

60" Gasoline Riding Mower Emissions

	CO	NOx	VOC
Emission Factors (lbs./yr/unit)[1]	460	4	6
SCAB Emissions Inventory (tons/yr	15147	132	198

1 - from 2010 ARB OFFROAD model

2 - riding mower population of 65,857

33" Gasoline Wak Behind Mower Emissions

	CO	NOx	VOC
Emission Factors (lbs./yr/unit)[1]	900	10	14
SCAB Emissions Inventory (tons/yr	62978	700	980

1 - from 2010 ARB OFFROAD model

2 - walk behind mower population of 139,952