# Electrify GT Landscaping

The Feasibility of Electric Landscaping and Lawn Equipment


EGO Electric Zero-Turn Lawnmower


## Electrify GT

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# Table of Contents

# Introduction

The majority of gas-powered landscaping equipment utilizes two-stroke engines that spew out gaseous pollutants at alarming rates. Given the release of Georgia Tech's 2020-2030 Strategic Plan, Electrify GT hopes to help the Institute decarbonize campus emissions in the coming decade. This report explores the environmental and occupational health impacts of gas-powered landscaping equipment and presents an alternative, low-emission path for maintaining Georgia Tech's campus.

# Environmental Impacts

The two-stroke engines in most common landscaping tools used on campus drastically increase Georgia Tech's emissions profile, contributing to smog, acid rain, and anthropogenic climate change. The primary issue lies in the inefficiency of this technology. Burning fossil fuels always produces pollutants and greenhouse gasses, but **in small two-stroke engines, as much as 30% of the fuel fails to undergo complete combustion** and instead is released as a noxious swirl of carbon monoxide (CO), hydrocarbons, particulate matter ($PM_{2.5}$), and nitrous oxides ($NO_x$).[1]

Though the engines in question are small, they punch far above their weight in negative consequences. A frequently cited study from Edmunds found that **"a consumer-grade leaf blower emits more pollutants than a 6,200-pound 2011 Ford F-150 SVT Raptor,"** with the article comparing half an hour of leaf blower usage to driving from Texas to Alaska in the same truck in terms of emissions.[2] Similar findings were published from a Swedish study that claims that the **air pollution from mowing grass for an hour with a gasoline-powered lawnmower approximates that from a 100-mile drive in a gas car**.[3] In fact, the share of negative emissions is so disproportionately weighted toward small off-road engines (SOREs) that in California, where landscaping equipment accounts for two-thirds of this category, emissions from SOREs are higher than those from the state's 14.4 million cars.[4] On the scale of Georgia Tech's campus, landscaping equipment represents an unnecessarily large source of environmental damage.

The primary environmental concerns regarding the aforementioned emissions from two-stroke lawn equipment are their contribution to smog formation, climate change, and acid rain. Both $NO_x$ and vaporized hydrocarbons released by such equipment contribute significantly to smog formation, especially in cities.[5] Modest calculations for the carbon emissions associated with the

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1 https://www.washingtonpost.com/national/health-science/how-bad-for-the-environment-are-gas-powered-leaf-blowers/2013/09/16/8eed7b9a-18bb-11e3-a628-7e6dde8f889d_story.html
2 https://www.edmunds.com/about/press/leaf-blowers-emissions-dirtier-than-high-performance-pick-up-trucks-says-edmunds-insidelinecom.html
3 https://www.sciencedaily.com/releases/2001/05/010529234907.htm
4 https://ww2.arb.ca.gov/sites/default/files/2020-09/SORE2020_Technical_Documentation_2020_09_09_Final_Cleaned_ADA.pdf
5 https://www.washingtonpost.com/national/health-science/how-bad-for-the-environment-are-gas-powered-leaf-blowers/2013/09/16/8eed7b9a-18bb-11e3-a628-7e6dde8f889d_story.html

use of a leaf blower suggest 11 lbs of $CO_2$ per hour of operation,[6] and **the $NO_x$ emitted has a global warming potential of up to 300x that of $CO_2$ over a 100-year timescale**.[7] This means that even short lawn maintenance sessions bear climate consequences. $NO_x$ and $CO_2$ can also dissolve into water vapor in the air, lowering its pH and causing acid rain, which defaces the built landscape, damages crops, and harms wildlife.[8] Simply put, two-stroke emissions present grand environmental risks.

Electric landscaping equipment does not completely eliminate the harmful emissions associated with maintenance of the Georgia Tech grounds, but transitioning to electric equipment shifts the source of pollution to the grid–fossil fuel power plants with filtration systems that reduce the amount of pollution released as well as renewable and nuclear power which emit no air pollutants. As the electrical grid advances to incorporate more renewable energy sources, these remaining emissions will diminish.[9] **To mitigate Georgia Tech's contribution to local and global environmental degradation, campus equipment should reflect the best in zero-emission technology.**

# Occupational Health Impacts

As outlined above, the combustion of fuel by landscaping equipment is horribly inefficient and emits a staggering quantity of pollutants with direct human health effects. For example, a study of annual emissions in Newcastle, Australia estimates that lawnmowers alone "contribute 5.2% and 11.6% of CO and [hydrocarbon (HC)] emissions, respectively".[10]

This section explores the negative impacts on worker health from carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), and other harmful emissions from landscaping equipment. To ensure accuracy and transparency, all health effects related to CO and $PM_{2.5}$ come from the EPA's science assessments used to set National Ambient Air Quality Standards (NAAQS).[11]

## Exposure to Carbon Monoxide (CO) & Fine Particulate Matter ($PM_{2.5}$)

The most comprehensive analysis of pollutant exposure from landscaping equipment comes from the EPA's Small Engine Exposure Study (SEES).[12] Using sensors attached to workers, the SEES quantifies pollutants emitted by a variety of landscaping equipment against ambient levels.

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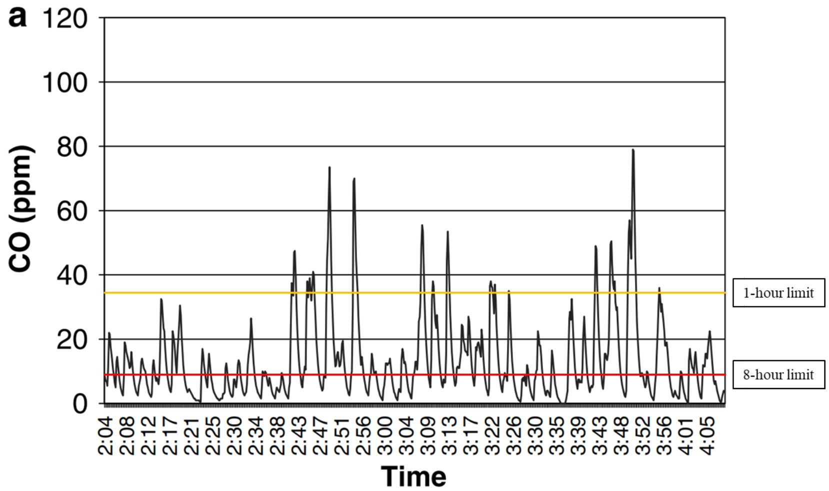
[6] https://www.nrdc.org/onearth/speed-sweet-spot
[7] https://www.epa.gov/ghgemissions/understanding-global-warming-potentials
[8] https://www.epa.gov/acidrain/what-acid-rain#:~:text=Acid%20rain%2C%20or%20acid%20deposition,even%20dust%20that%20is%20acidic.
[9] https://www.vox.com/2016/9/19/12938086/electrify-everything
[10] https://www.sciencedirect.com/science/article/pii/S1352231099001922?casa_token=_HzvW_tLsMUAAAAA:m1EMuLdizL7GYM_Pcskajdyyurkbf ZEJ7qLChyfW-X77PqFCow2FFnVJnkxFM4hkWsYfv1RKKfw
[11] https://www.epa.gov/criteria-air-pollutants/naaqs-table
[12] https://www.nature.com/articles/7500471

Importantly, actual **emissions from Georgia Tech's landscaping equipment are likely to be *higher* than those in the SEES** as the study uses modern, more efficient landscaping equipment. The SEES plots below show concentration (ppm or mg/m$^3$) vs time data for CO and $PM_{2.5}$ recorded by a worker operating a riding lawnmower (comparable to other tested equipment). National Ambient Air Quality Standards (NAAQS) are overlaid on the plots. Note, the NAAQS are given in terms of dose and time. For example, exposure to 9 ppm of CO averaged over 8 hours should not be exceeded more than once per year. By extrapolating data to the appropriate timescale, **it is highly likely 8-hour CO and 24-hour $PM_{2.5}$ exposure experienced by Georgia Tech landscaping workers is far above safe NAAQS limits**.

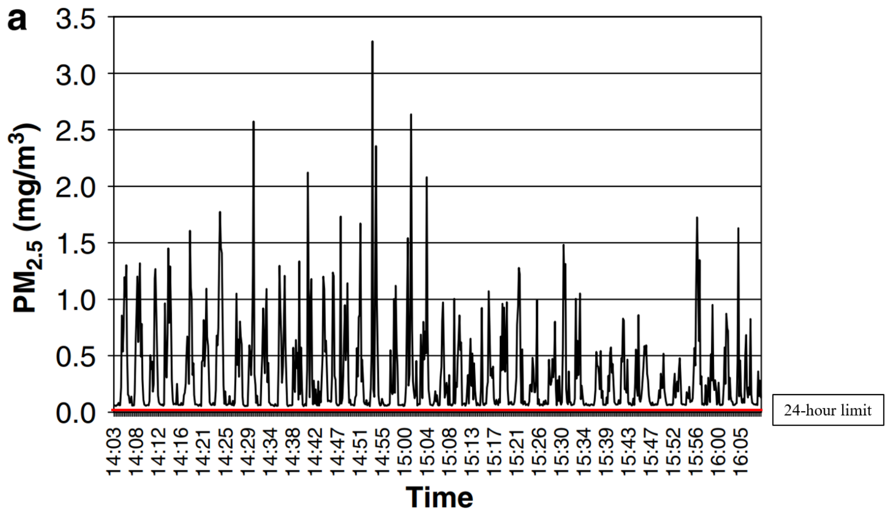
| | | |
|---|---|---|
| 8 hours | 9 ppm | Not to be exceeded more than once per year |
| 1 hour | 35 ppm | |



RLA (n=751; avg.=13.3 ppm; time=125 mins)

**Figure 1.** Exposure to carbon monoxide during small engine use according to the EPA's SEES study.

| | | |
|---|---|---|
| 24 hours | 0.035 $mg/m^3$ | 98th percentile, averaged over 3 years |




RLA (n=752; avg.=328 $\mu g/m^3$; time=125 min)

**Figure 2.** Exposure to fine particulate matter during small engine use according to the EPA's SEES study.

## Health Impacts of Carbon Monoxide (CO)

Carbon monoxide (CO) elicits health effects by binding to heme proteins and **blocking their ability to transport oxygen throughout the body.** Notably, at CO concentrations 1-2 orders of magnitude higher than those experienced by landscaping workers, the same mechanism causes tissue damage or death from carbon monoxide poisoning. Although heme proteins can unbind from CO over modest timescales, **cardiovascular effects are causally linked to short-term exposure to CO at modest concentrations**. The best-characterized health effect associated with CO exposure is hypoxia (reduced oxygen availability) in individuals with impaired cardiovascular systems. Of particular concern are individuals with coronary heart disease (the leading cause of death in the United States), anemia, history of heart attacks, or sickle cell disease. For instance, epidemiological studies report **associations with CO concentration and emergency room visits for individuals with coronary heart disease**.

## Health Impacts of Fine Particulate Matter ($PM_{2.5}$)

Although fine particulate matter ($PM_{2.5}$) enters the body via inhalation, **short-term and long-term exposure has been causally linked to severe respiratory, cardiovascular, nervous system, and carcinogenic health effects**. For example, epidemiological studies controlled for co-pollutants repeatedly provide strong evidence for a relationship between $PM_{2.5}$ exposure and respiratory health outcomes ranging from asthma exacerbation, lung function decline, and increased respiratory mortality (i.e., death). Unlike CO exposure, **long-term $PM_{2.5}$ exposure has been causally linked to irreversible, severe health effects** such as neurodegeneration, cognitive effects, changes in brain morphology, dementia, carcinogenic potential (particularly lung cancer), and genotoxic (DNA damaging) effects. Most significantly, epidemiological and experimental **evidence repeatedly provides consistent, strong associations between short-term $PM_{2.5}$ exposure and total mortality (i.e., death rate)**.

**Due to the severity and irreversibility of short-term $PM_{2.5}$ exposure health effects, Georgia Tech should electrify landscaping equipment and eliminate this occupational work hazard.**

## Health Impacts of Common Landscaping Emissions

| Pollutant | Health Impact |
|---|---|
| Carbon Monoxide (CO) | Reduced blood oxygen; Cardiovascular effects; Chest pain[13] |
| Particulate Matter ($PM_{2.5}$ & $PM_{10}$) | **Causally linked to mortality (i.e., death rate)** due to respiratory, cardiovascular, and nervous system effects[14] |
| Nitrous Oxides ($NO_x$) | Respiratory effects including coughing, irritated airways, and aggravated asthma[15] |
| Volatile Organic Compounds (VOCs) | Organ damage (liver, kidney, central nervous system); Known & suspected carcinogens; Irritation[16] |

Note: Volatile organic compounds (VOCs) are a category of molecules. Health effects differ depending on the particular molecule of exposure.

## Miscellaneous Health Considerations

Beyond gaseous emissions, gas-powered landscaping equipment presents unique occupational work hazards not found in their electric counterparts. For example, while difficult to precisely quantify, on average **gas-powered landscaping equipment is heavier than electric landscaping equipment**. This difference stems from the high complexity of combustion engines compared to electric motors and the weight of high-density gasoline. Worker injuries are more common when operating bulky, cumbersome equipment. Furthermore, as anyone who has driven an electric vehicle knows, **gas-powered engines are significantly louder than electric motors**. For example, gas-powered leaf blowers are approximately **25 decibels louder** than electric equivalents (some of which produce 65 dB - noise equivalent to normal conversational levels).

[13] https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=347534
[14] https://www.epa.gov/sites/default/files/2020-07/documents/co-rea-amended-july2010.pdf
[15] https://www.epa.gov/no2-pollution/basic-information-about-no2
[16] https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality

Even brief exposure to loud noises causes damage to the hair cells of the inner ear and can contribute to hearing loss and premature deafness.[17]

# Kendeda

The Kendeda Building and surrounding EcoCommons prove that utilizing electric landscaping equipment is not only feasible but advantageous. The Kendeda grounds crew primarily uses EGO electric landscaping equipment, meaning they have similar power performance to gas-powered equipment (see "Recommended Tools" section) and improved maneuverability. According to Steve Place, a horticulturist at the Kendeda building, breaking up the required work into smaller tasks is the most efficient way to structure a day using electric landscaping equipment given battery capacity limitations. This allows the landscaping crew to plan the day's work around battery charge cycles while still accomplishing the same amount of work. For every piece of equipment, Kendeda buys extra batteries so that they can be cycled out, increasing efficiency. While one set of batteries is in use, an extra set is charging, stretching the life of the batteries and boosting productivity.

The Kendeda building has also adopted some novel landscaping practices that decrease the required workload and improve the functionality of the space. For example, the landscaping crew at Kendeda does not use leaf blowers as much as other buildings do. This is because constant leaf-blowing not only gets rid of leaves but also a layer of rich topsoil that sequesters carbon and is critical for the growth of many plants. Increased disruption of the area around vegetation makes it more difficult for these plants to grow, making the soil dependent on artificial fertilizers. Instead, these leaves are shredded and redistributed on top of the soil, increasing organic matter and retaining the water it contains. Kendeda's use of electric lawn equipment, as well as its novel landscaping practices, has drastically improved the quality of the surrounding landscape.

The popularity of the well-kept EcoCommons surrounding the Kendeda Building is a testament to the preeminence of electric landscaping equipment. Although the building is one of the newest additions to campus, it is rare to pass by without seeing students lounging in open-air hammocks, studying under the shade of solar panels, and gathering to socialize with their peers. By intentional design, the serenity and peacefulness of the green space encourage this behavior. Electric landscaping equipment is integral in creating and maintaining this calming environment. Owing to the comparatively low noise production of electric equipment, the Kendeda grounds crew is able to successfully maintain the beauty of the EcoCommons while students study and socialize with only the fair whir of electric motors in the background. The Kendeda Building and EcoCommons provide a model for a more sustainable, enjoyable, and inviting way to upkeep Georgia Tech's natural environment.

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[17] https://www.nidcd.nih.gov/health/noise-induced-hearing-loss

# The Rest of Campus

The Kendeda Building and the EcoCommons are an excellent case study for landscaping electrification. Expanding the work and practices employed there would mean a quieter, healthier campus, full of natural beauty. Students studying in Harrison Square would not have to shout over the deafening rumble of gas equipment. Landscape maintenance technicians would see improvements to their cardiovascular, pulmonary, and joint health thanks to cleaner, lighter equipment. Georgia Tech would be a leader in campus emissions reductions and environmental justice. Electrification propels forward the vision of the 2020-2030 Strategic Plan and grounds it in the everyday experiences of campus life.

However, such a shift in operations is not insignificant. Due to the differences between gas-powered and electric equipment, the nature of landscaping work on campus would change to account for the appropriate techniques for the operation and maintenance of this equipment. But with the help of organizations like the American Green Zone Alliance (AGZA), Georgia Tech landscaping professionals can select the best equipment for our campus and integrate it seamlessly over time. AGZA offers workshops and consultations that help institutions identify the best approach to electrification for their specific use case.[18] Plus, thanks to the experience of the Kendeda Building and EcoCommons staff, Georgia Tech already has much of the institutional knowledge necessary to train landscapers responsible for other areas of campus. Coordination between administrators, landscaping technicians, and third-party resources would allow Georgia Tech to be on the cutting edge, not the bleeding edge of green landscaping.

# Recommended Tools

With recent investment in high-performance electric lawn equipment, there have never been better electric alternatives to gas-powered lawn equipment on the market. **Currently, EGO Power+ produces the most capable and extensive line of personal and commercial electric lawn care equipment, however, we expect other companies to compete as the technology matures.** Our research has shown that modern electric offerings from EGO can match or beat the performance of gas equipment while maintaining comparable runtime. **From a performance perspective, these electric products are well prepared to meet Georgia Tech's campus lawn care needs.**

There are two primary types of lawn care equipment in-use at Georgia Tech: lawnmowers and small equipment (e.g., backpack-mounted leaf blowers and string trimmers). The available electric options in both of these categories excel. In the space of ride-on gas mowers, there is little disadvantage to choosing electric over gas. A typical gas ride-on mower such as the Cub Cadet ZT1 42 inch blade quotes a typical cutting acreage of approximately two acres on a single

[18] https://agza.net/services/

tank of gas. A comparable electric alternative from EGO, **the EGO 42” Z6, can match this cutting area, cutting Tech Green’s two acres on a single charge** of its standard four batteries. The EGO can carry an additional two batteries, bringing its total range to three acres, or approximately the area of Tech Green and surrounding lawn. While the Cub Cadet can be quickly refilled, **the EGO can reach full charge on four of its batteries in two hours**, making it feasible to execute multiple large cuts in a single day if necessary. The EGO also matches the horsepower of the gas mower, while producing less noise and no emissions and requiring less regular maintenance.

### Comparison of Prototypical Electric and Gas Ride-On Mower

| Ride-On Mower | Electric / Gas | Quoted Acreage | Horsepower (eq.) | Charge Time | Maintenance | Cost |
|---|---|---|---|---|---|---|
| Cub Cadet ZT1 42[19] | Gas | 2 acres | 22 hp | gas refill | Belt & motor | $3,100 |
| EGO 42" Z6[20] | Electric | 2 acres (4 batt)<br>3 acres (6 batt) | 22 hpe | 2hr / 4 batt | Limited | $5,000 |

The commercial line of small lawn care equipment from EGO reports industry-leading battery capacity and performance. Both the EGO commercial leaf blower and commercial string trimmer are designed to interface with a standard EGO backpack-mounted battery for improved ergonomics. The leaf blower has four power levels, and its runtime varies with its power level, from 5.8 hours of sustained usage at level 1 to 1.2 hours of sustained usage at “boost.” These runtimes are competitive with commercial gas backpack-style blowers that require refueling after less than an hour of use.[21] Generally, gas blowers are more powerful than electric blowers, but EGO’s commercial line more closely rivals its gas counterparts than most consumer electric models.[22]

### EGO Commercial Battery Pack - BAX1501[23]

| EGO BAX1501 | |
|---|---|
| Capacity | 1568Wh 56V |
| Battery Weight | 19.8 lbs |
| Cycle Life | ≤ 1000 cycles |
| Cost | $1299 |

[19] https://www.cubcadet.com/en_US/prior-year-models/zt1-42/17AREACS010.html
[20] https://egopowerplus.com/zero-turn-riding-mower-zt4204l
[21] https://www.quietcleanpdx.org/wp-content/uploads/2019/11/Gas-Powered-Leaf-Blower-Emissions-Factsheet-11.12.pdf, 4.
[22] https://www.protoolreviews.com/gas-vs-battery-powered-leaf-blowers/
[23] https://egopowerplus.com/media/contentmanager/content/22_0109_EGO_2022-Product-Catalog_LN-opt.pdf, 55.

## EGO Commercial Leaf Blower - LBX6000[24]

| LBX6000 | |
|---|---|
| Run time with BAX1501 | 350-70min (power level 1 to 4+) |
| CFM | Up to 600 |
| MPH | Up to 170 |
| Cost | $399 |

## EGO Commercial String Trimmer - STX3800[25]

| STX3800 | |
|---|---|
| Run time with BAX1501 | ≤ 300min |
| Cost | $399 |

## EGO Commercial Backpack Charger - CHX5500[26]

| CHX5500 | |
|---|---|
| Rapid Charge | Yes |
| BAX1501 Rapid Charge Time | 210 min |
| Cost | $199 |

In addition to performance, a key consideration for electric equipment is battery lifetime. As batteries are fully drained and recharged (this is called a cycle), their maximum capacity degrades. This phenomenon is common to all battery-powered products, and it is important to understand how the capacity of purchased batteries will vary over their lifespan. EGO reports battery lifetime that averages around 950 cycles before 40% degradation occurs (see graph below). However, battery year-to-year cycle life has routinely increased due to innovation in the electric vehicle and lithium-ion battery industries, meaning the longevity of new batteries will likely improve.

[24] Ibid, 63.
[25] Ibid, 57.
[26] https://egopowerplus.com/commercial-series-charger-chx5500

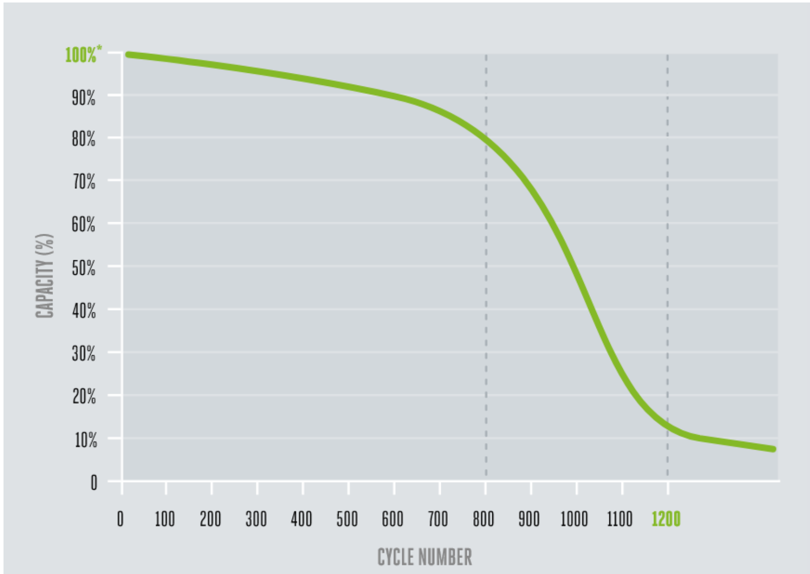


**Figure 3.** Average battery performance decay for an EGO battery[27]

# Cost Analysis

Given the extreme variability in the costs associated with operating smaller gas-powered landscaping equipment such as leaf blowers, this analysis primarily considers the cost savings from the procurement of electric lawnmowers. As seen in the comparison in the previous section, electric mowers present higher upfront capital costs to achieve similar performance. However, the operating costs are significantly lower. One tank of gas and one full charge will both cut around two acres of grass. The average electricity cost in Georgia is 9.93 cents/kWh,[28] and the average gas price in Georgia is $3.321/gal.[29] Using the EGO and Cub Cadet models described above as examples, it costs around $11.62 to refuel the gas mower (plus the cost of any required fuel additives) and $0.22 to recharge the electric mower.

The following figures were created to compare the ongoing cost of ownership of the gas-powered Cub Cadet ZT1 42 ride-on mower with its competitor, the electric EGO 42 Z6. Although the EGO mower has a substantially higher initial cost, the reduced price of electricity compared to gasoline results in a break-even point after 333 acres mowed. This trend can be seen in Figure 4, where the ongoing gas cost associated with the Cub Cadet increases at a much higher rate per acre than the cost of electricity needed to run the EGO. Figure 4 assumes that new batteries will be purchased when the current set of batteries has degraded to 80% of their original capacity. On average, the total cost of ownership for a gas mower is 47% higher than that of its

[27] https://egopowerplus.co.uk/sites/default/files/2018-10/41891-EGO-Battery-FAQs_Interactive_AW_FINAL-compressed_0.pdf
[28] https://www.eia.gov/electricity/state/georgia/
[29] https://gasprices.aaa.com/?state=GA

electric counterpart. In reality, the increased maintenance costs of operating a gas mower over an electric mower further exacerbate this trend.

| Cost Analysis Assumptions | |
|---|---|
| Electric Mower Cost | $5000 |
| Gas Mower Cost | $3100 |
| Georgia Gasoline Price | $3.321/gal |
| Georgia Electricity Price | 9.93 cents/kWh |
| Gas Mower Fuel Capacity | 3.5 gallons |
| Electric Mower Battery Capacity | 2.24 kWh |
| Area Cut in One Tank of Gas | 2 acres |
| Area Cut in One Charge | 2 acres |

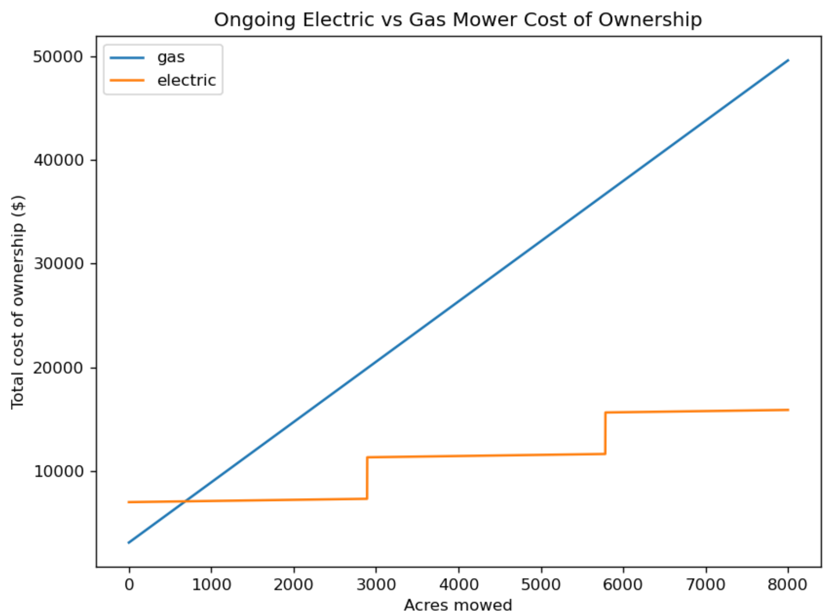


**Figure 4.** Ongoing electric vs gas mower cost of ownership (2 sets of 4 batteries repurchased after 20% battery degradation).

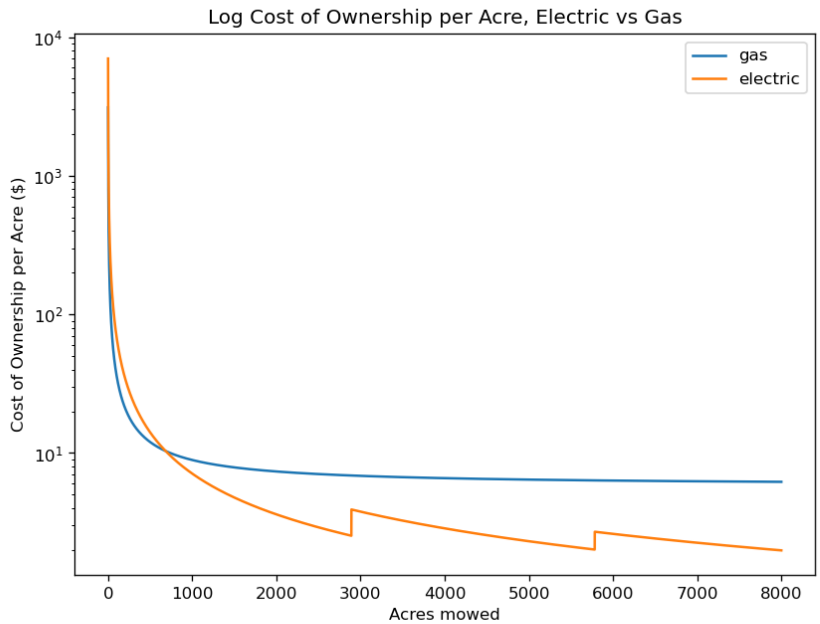


**Figure 5.** Cost of ownership per-acre for electric vs gas zero-turn mowers (2 sets of 4 batteries repurchased after 20% battery degradation).

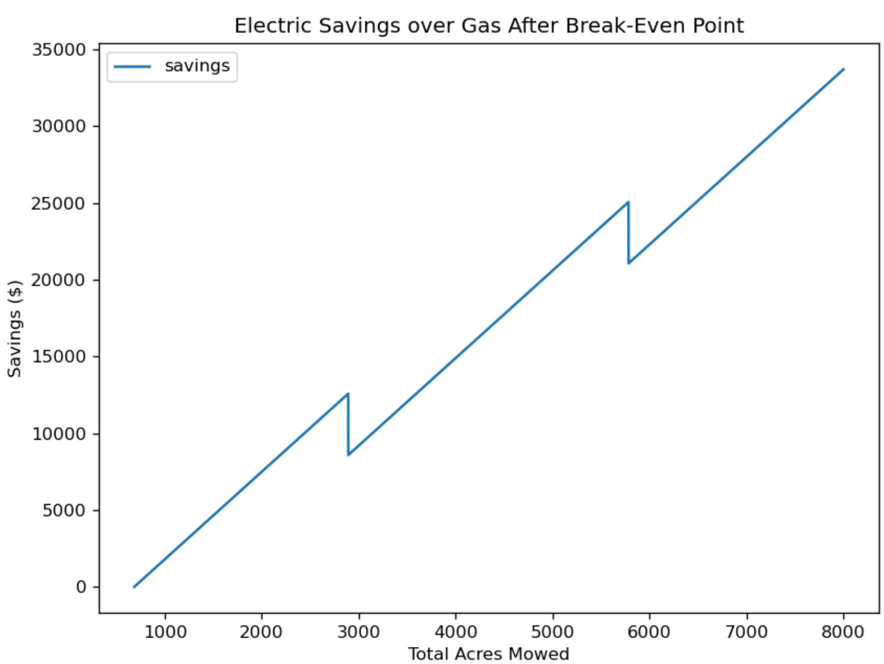


**Figure 6.** Electric mower cost savings after break-even point (684 acres).

# Conclusions

Inefficient two-stroke landscaping equipment degrades the environment, deteriorates the health of individuals, and unduly costs the Institute money. Advances in electric alternatives have finally made electrified landscaping feasible and advantageous. The phase-out of two-stroke engines on campus is a relatively low-cost, high-impact solution for improving the GT atmosphere. With electric equipment comes a quieter, healthier campus for every member of the GT community. In line with Georgia Tech's efforts to reduce its negative impact on the community over the coming decade, **we, Electrify GT, highly recommend that the Institute transition away from fossil fuel-powered equipment to electric alternatives**.