**LEEP Technical Appendix**

March 31, 2024

*Emissions Estimates*

The Lake Michigan Air Directors Consortium (LADCO) estimated LGE activity and GHG, CAP, and HAP emissions by county for the Chicago area using the U.S. EPA Office of Transportation and Air Quality Motor Vehicle Emission Simulator: MOVES4. Year 2020 activity data for the MOVES simulations came from U.S. EPA’s MOVES-Nonroad in default scale mode for county emissions. LADCO ran the emissions by source classification code (SCC) and equipment type with all activity data available. LADCO used the standard U.S. EPA post processing scripts to extract the results. Equipment categories (by SCC) were validated with assistance from ILCA.

To estimate the GHG emissions reductions from LEEP’s buy-back strategy we assumed that the replacement of a gasoline-powered LGE unit with an electric unit would reduce the GHG emissions to zero. The scenario is built around MOVES results that estimate LGE sources for commercial and residential units of different types.

Methodologies and assumptions for each target period are described below. These calculations are presented in the GHG Calculations Caucus LEEP spreadsheet attached which contains the following worksheet:

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| --- | --- |
| PCAP Decision Tool | Model to set a CO2 reduction target and identify the adoption rates of electrification for different classes of equipment |
| Res Comm Analysis | Ratios of residential to commercial LGE activity and emissions |
| Activity Analysis | Table and chart of 2020 LGE activity (population and hours) by commercial and residential equipment categories |
| Emissions Analysis | Table and chart of 2020 LGE emissions (tons/year) by commercial and residential equipment categories |
| Equipment Costs | Gas and electric equipment cost estimates for common units; provided by the Illinois Landscape Contractors Association |
| MOVES Activity Data | Raw MOVES output activity data used for analysis |
| MOVES Emissions Data | Raw MOVES output emissions data used for analysis |
| Emissions\_Month\_Pivot | Chart of emissions by month by county/LGE equipment type |
| Lookup | days/month look up table for converting average weekday activity/emissions to annual values |

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| **Source of Data:** | Mark Janssen of LADCO ran MOVES4 to generate average 2020 weekday activity and emission by month for lawn and garden equipment (LGE) |

## B. Magnitude of GHG Reductions from 2025-2030

LEEP elements focus on LGE categories that have both emissions reduction potential and plausible implementation feasibility. **The cumulative impacts of the LGE buy-back program for the 2025-2030 period is 9,738.62 metric tons (10,735 tons) of CO2 reduced.** This impact will be realized across the entire period that the grant funding is available through LEEP to incentivize equipment replacement in the Chicago area. We can assume that the first year of the program will see less emissions reductions as LEEP is initiated, set-up, and publicized. Starting in year two, once the programmatic and logistical infrastructures are in place to run the buy-back program, we anticipate realizing steady emissions reductions as the grant funding is used to replace and scrap gas-powered LGE with ZEE.

All-residential equipment: we estimated the baseline emissions for residential LGE equipment by summing the GHG, CAP, HAP pollutant emissions across all equipment types identified as residential by MOVES. The table below shows the estimates of baseline 2020 residential LGE emissions, the cumulative 2025-2030 emissions reductions, and annual 2025-2030 emissions reductions for the seven Chicago area counties.

|  |  |  |  |
| --- | --- | --- | --- |
| **Residential LGE** | | | |
| **Pollutant** | **Baseline 2020 Emissions**  **metric tons (tons)** | **Cumulative Emissions**  **metric tons (tons)** | **Annual Emissions**  **metric tons (tons)** |
| CO2 | 135,407 (149,260) | 4,227 (4,660) | 845 (932) |
| NOx | 272 (300) | 9 (9) | 2 (2) |
| VOCs | 1,787 (1,970) | 54 (60) | 11 (12) |

Commercial hand-held equipment: as with the all-residential equipment category, we summed the emissions for the units estimated by MOVES as commercial gasoline hand-held equipment. We defined hand-held equipment as the following MOVES equipment types: 2-Str Leafblowers/Vacuums (com), 2-Str Trimmers/Edgers/Brush Cutter (com), 2-Str Chain Saws < 6 HP (com), 4-Str Leafblowers/Vacuums (com). The table below shows the estimates of baseline 2020 commercial hand-held LGE emissions, the cumulative 2025-2030 emissions reductions, and annual 2025-2030 emissions reductions for the seven Chicago area counties.

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| --- | --- | --- | --- |
| **Commercial Hand-Held LGE** | | | |
| **Pollutant** | **Baseline 2020 Emissions**  **metric tons (tons)** | **Cumulative Emissions**  **metric tons (tons)** | **Annual Emissions**  **metric tons (tons)** |
| CO2 | 93,286 (102,830) | 2,331 (2,570) | 466 (514) |
| NOx | 200 (220) | 5 (6) | 1 (1) |
| VOCs | 3,937 (4,340) | 100 (110) | 20 (22) |

Commercial mowers and tractors: as with the all-residential equipment category, we summed the emissions for the units estimated by MOVES as commercial gasoline mowers and tractors. We defined commercial mowers and tractors as the following MOVES equipment types: 4-Str Rear Engine Riding Mowers (com), 4-Str Front Mowers (com), 4-Str Lawn mowers (Com), 4-Str Lawn & Garden Tractors (com), 4-Str Commercial Turf Equipment (com). The table below shows the estimates of baseline 2020 commercial tractor mowers LGE emissions, the cumulative 2025-2030 emissions reductions, and annual 2025-2030 emissions reductions for the seven Chicago area counties.

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| --- | --- | --- | --- |
| **Commercial Mowers/Tractors LGE** | | | |
| **Pollutant** | **Baseline 2020 Emissions**  **metric tons (tons)** | **Cumulative Emissions**  **metric tons (tons)** | **Annual Emissions**  **metric tons (tons)** |
| CO2 | 434,950 (479,450) | 3,175 (3,500) | 635 (700) |
| NOx | 1,080 (1,190) | 8 (9) | 2 (2) |
| VOCs | 2,368 (2,610) | 20 (20) | 4 (4) |

The table below shows the total emissions reductions for all of the LGE strategies proposed through LEEP.

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| --- | --- | --- | --- |
| **Total LGE Emissions Impacts from LEEP** | | | |
| **Pollutant** | **Baseline 2020 Emissions**  **metric tons (tons)** | **Cumulative Emissions**  **metric tons (tons)** | **Annual Emissions**  **metric tons (tons)** |
| CO2 | 663,643 (731,540) | 9,734 (9,734) | 1,947 (2,146) |
| NOx | 1,551 (1,710) | 21 (24) | 4 (5) |
| VOCs | 8,092 (8,920) | 172 (190) | 34 (38) |

## C. Magnitude of GHG Reductions from 2025-2050

The cumulative impacts of the LGE program for the 2025-2050 period can only be forecast qualitatively due to the uncertainty of funding and market forces that will prevail after the incentives from LEEP end in 2029. The market for electric LGE is already rapidly evolving. Representatives of the outdoor power equipment industry were unable to provide ZEE adoption forecasts for the period requested. But the Outdoor Power Equipment Institute (OPEI) reports new product shipments of hand-held equipment (leaf blowers, etc.) were 63% electric in 2021. According to OPEI U.S. shipments of 5-6 million units of residential walk-behind (push) lawn mowers, have transitioned from 11% ZEE in 2016 to 37% in 2021.[[1]](#footnote-1)

The stimulus that the LEEP buy-back program will bring to the Chicago area LGE market during 2025-2030 will likely have the effect of increasing the pace of adoption and demand in the region. We anticipate that the incentives from this program will motivate operators to change over their equipment more rapidly than without the available funding. This program will thus provide demand stimulus that will signal original equipment manufacturers (OEMs) and suppliers of both residential and commercial electric LGE to ensure that sufficient supply is available to meet the rising pace of demand. We can expect that a competitive supply market will extend into the 2030-2050 period, and that the competition for sales will drive down prices and make adoption of ZEE more appealing to buyers.

The gasoline equipment scrappage component of LEEP will produce CO2 emissions reduction impacts that extend beyond the end of the initial grant period by ensuring that old gasoline LGE is permanently taken out of service. A buy-back program without scrappage would likely lead to a secondary market for the used gasoline equipment. Keeping the old gasoline equipment in-service would offset the CO2 emissions reductions from the new electric LGE. The scrappage component of LEEP will eliminate the CO2 emissions from the old equipment, some of which would be in-service for many years after 2030.

Other factors to consider in forecasting LEEP emissions reduction impacts into 2050 are the long life of the lithium-ion phosphate batteries to be supplied through LEEP. Conservatively, these batteries are rated for approximately 4500 to 5000 charge cycles with an impressive 80% depth of charge. Batteries in seasonal use for landscape LGE can be expected to be charged 200 cycles year. Therefore, batteries purchased through LEEP can be expected to last 20 years. By comparison, gasoline powered commercial lawnmowers have median life expectancy of 2 years and residential mowers have a median life expectancy of 5.9 years. [[2]](#footnote-2)

If components of ZEE LGE purchased through LEEP will last for at least 15 years, cumulative emissions reductions expected through LEEP are projected below.

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| --- | --- | --- | --- |
| **Pollutant** | **Baseline 2020 Emissions**  **(metric tons)** | **2026-2050 Emissions Reductions**  **(metric tons)** | |
| **Cumulative** | **Annual** |
| CO2 | 9,954,641 | 146,012 | 29,202 |
| NOx | 23,269 | 321 | 64 |
| VOCs | 121,381 | 2,585 | 517 |

**Cost Effectiveness**

The cost effectiveness (CE) of the proposed lawn and garden equipment (LGE) buy-back program is about $3,841.04/metric ton reduced CO2. ($37,407,000/10,735 tons = $3,484.54/ton CO2 reduced)

The CE calculation is based on the program cost ($37,407,000,) divided the mass of CO2 reduced (9,739.76 metric tons) from replacing gasoline powered equipment with battery-electric equipment. This CE estimate only considers the scope 1 emissions from electrifying LGE in Chicago. As this program results in a reduction of gasoline use, it will also yield greenhouse gas reductions along the entire “well to engine” gasoline supply chain. While we did not estimate the scope 2 and scope 3 impacts of this program, qualitatively, this CE for this strategy is likely lower than the $3,484.54/ton estimated here because of the CO2 reductions along the entire gasoline supply chain.

**Outcomes**

The MMC buy-back program to incentivize a more rapid transition from gasoline to electric-powered LGE will reduce GHG, CAP, and HAP emissions in the Chicago area. The table below shows the annual and cumulative impacts from 2025-2030 to CO2, NOx, total VOCs, and gasoline-related HAPs from this program. We estimated HAP emissions from the total VOC inventory using weight fractions from SPECIATE5.3 (profile 95330) for a 4 Stroke engine burning E90 gasoline.

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| --- | --- | --- | --- |
| **Pollutant** | **Baseline 2020 (tons)** | **2025-2030 Emissions Reductions (tons)** | |
| **Cumulative** | **Annual** |
| CO2 | 731,540 | 37,620 | 7,524 |
| NOx | 1,710 | 83 | 17 |
|  |  |  |  |
| VOCs | 8,920 | 1,020 | 204 |
| Benzene | 1129 | 129 | 26 |
| Toluene | 1062 | 121 | 24 |
| Xylenes | 1073 | 123 | 25 |
| Acetaldehyde | 9 | 1 | - |

1. Outdoor Power Equipment Institute <https://www.opei.org/zero-emission-equipment/> March 28, 2024 [↑](#footnote-ref-1)
2. USEPA [Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling NR-005c](https://nepis.epa.gov/Exe/ZyNET.exe/P10001T3.txt?ZyActionD=ZyDocument&Client=EPA&Index=2000%20Thru%202005&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C00THRU05%5CTXT%5C00000013%5CP10001T3.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=7&slide) [↑](#footnote-ref-2)