Technical Appendix for Northeast Ohio Regional Complete and Green Streets Program

GHG Reduction Measure 1: Regional E-Bike Rebate Program

E-Bike Environment and Economics Impact Assessment Calculator[1]

RMI's E-Bike Environment and Economics Impact Assessment Calculator for Cities simplifies the process of assessing the impact of mode-shift from electric bikes (e-bikes) for policymakers, transportation officials, advocates, and other interested stakeholders. The tool estimates the impact of e-bikes as a substitute for short vehicle trips, based on a city-wide mode-shift to e-bikes goal; it also estimates the impact of an e-bike incentive program.
Environmental and economic impacts include:

- Reductions in greenhouse gas (GHG) emissions and air pollutants (NOx, PM2.5, and carbon monoxide) from reduced vehicle trips.
- Reductions in vehicle miles traveled (VMT) for short vehicle trips and total trips within a given city.
- Consumers' economic savings due to reduced driving, realized by reduced fuel and maintenance costs.

The scenarios draw upon a similar approach. Trip data for each city is downloaded from Replica for a Thursday and Saturday in Fall 2022, with outgoing trips from the urban area selected. Data is then cleaned of any trips not taken by vehicles (i.e. no trips in the calculator are taken by pedestrians or transit), and then organized by the number of trips per tenth of a mile between 0 and 5 miles. RMI multiplied Thursday data by five and Saturday data by two to construct a complete week. Trips were limited to adults between the ages of 18 and 75. Additionally, all vehicle miles out of the urban area were summed to calculate the total VMT reduction.

RMI collected information about the breakdown of four different types of light-duty vehicles – pickup trucks, sedans, SUVs, and sedans – and their relative proportion across states, as well as the percentage of electric vehicles (EVs) currently in use in each state. RMI assumed that the split of internal combustion engine (ICE) vehicles (the percent of pickup trucks, sedans, SUVs, and sedans) and EVs would be the same (i.e. every ICE truck taken off the road was replaced with an EV truck), even as the number of EVs grew.

RMI utilized the Energy Policy Simulator to project EV adoption, developing a Business-as-Usual (BAU) and a 1.5^{o}C Climate Aligned EV policy scenario for EV adoption. The models do not account for the Inflation Reduction Act, ensuring that BAU case is relatively conservative. To provide additional nuance, RMI developed an additional scenario, Mid-EV Growth, which was an average between the two EPS scenarios. It then used data from the U.S. Energy Information Administration to assess the historical cost

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[1] Bryn Grunwald, a Senior Associate for Carbon-Free Transportation with RMI, provided the written methodology for the E-Bike Calculator to the applicants via email. The applicants have edited it for clarity and updated it to include the specific details of the proposed e-bike rebate program.

increases in fuel and electricity costs and scale the cost per year to reflect costs increases. RMI applied an historical average inflation rate to the cost of vehicle maintenance in order to reflect annual price increases.

The calculator projects data across a ten-year period in order to assess the impact of the e-bike rebate program. RMI collected state population growth data to account for projected changes, and it assumed that municipalities will experience the same projected annual population growth as their states. The model assumes that trips will increase in line with the population growth.

In a BAU scenario, the calculator assumes vehicles will continue to be the mode for all trips. In the simulation, users set the parameters for an e-bike rebate program, including number of program years, total budget, the value of different rebate classes (market-rate/low-income and cargo bike/commuter bike), the share of low-income rebates, and the average number of e-bike miles traveled per week for market-rate and low-income recipients. The calculator assumes all e-bike users take 14 e-bike trips per week, equal to two trips a day. The model assumes that any shifted vehicle trip occurs via e-bike, and it calculates the changes in VMT, travel costs, greenhouse gas emissions, and co-pollutant emissions in the BAU and reference scenarios.

Applicants worked with RMI to customize the E-Bike Calculator for the proposed rebate program. RMI created a Cleveland-Elyria MSA option, which reflected the regional population, VMT, and share of trips under five miles. Applicants set up the calculator to reflect the rebate program parameters, specifically:

- Total Budget: $6,440,000
- Market value e-bike rebate: $400
- Market value cargo e-bike rebate: $900
- Low-income e-bike rebate: $1,200
- Low-income cargo e-bike rebate: $1,700
- Adaptive e-bike rebate: $1,400
- Share of market-rate rebates: 50%
- Share of low-income rebates: 50%
- Estimate of average miles biked per week (low-income participants): 32
- Estimate of average miles biked per week (market-rate participants): 22

Because the calculator estimates benefits over a 10-year period, it does not account for the full lifespan of e-bikes purchased in program years 2 and 3, as these bikes would remain in operation into years 11-12. To account for this, applicants set up the calculator to run a one-year rebate program with a total budget of $6,440,000. Applicants then took the model outputs and adjusted them to reflect the benefits of a three-year rebate program. To do this, applicants reduced total benefits from year 1 and year 2 by 67% and 33%, respectively. They then calculated the average annual change in emissions, per mile, for GHGs and air pollutants and used these averages to estimate emissions for program years 11 and 12. Applicants then estimated total program benefits for years 11 and 12, reducing the benefits by 33% and 67%, respectively, to account for the three-year structure of the program.

Results are discussed in Section 2. The RMI E-Bike Calculator tool and the modified tool outputs are in the attached spreadsheets.

U.S. EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)[2]

In order to quantify the health benefits of the criteria air pollutant (CAP) reductions estimated through the RMI E-Bike Calculator, applicants utilized U.S. EPA's COBRA model. COBRA is a peer reviewed screening tool that estimates the air quality, public health, and economic impacts of different emission reduction scenarios. COBRA employs rigorous methods developed for EPA's health benefits assessments. It enables users to create a first order approximation of the costs and benefits of different emission scenarios based on user-input changes in emissions of ammonia (NH_3), fine particulate matter ($PM_{2.5}$), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and volatile organic compounds (VOCs) across different economic sectors. COBRA then estimates both the total health incidences avoided and the economic value of the following health endpoints:

- Adult Mortality
- Infant Mortality
- Non-fatal Heart Attacks
- Respiratory Hospital Admissions
- Cardiovascular-related Hospital Admissions
- Acute Bronchitis
- Upper Respiratory Symptoms
- Lower Respiratory Symptoms
- Asthma Exacerbations (attacks, shortness of breath, & wheezing)
- Asthma Emergency Room visits
- Minor Restricted Activity Days
- Work Loss Days

In order to estimate the health benefits of CAP reductions from the e-bike rebate program, applicants ran COBRA using 2023 as the scenario year. They selected the five counties in the Cleveland-Elyria MSA (Cuyahoga, Geauga, Lake, Lorain, and Medina) as the location, and set the model for emissions reductions under Highway Vehicles as the sector, gas vehicles as the primary subsector, and light duty as the secondary subsector. Applicants entered the emissions reductions NO_x and $PM_{2.5}$ projected over 10 years from the RMI E-Bike Calculator. They then selected a 3% discount rate for total economic benefits. Results are discussed in Section 3.a, and the model outputs are located in the attached spreadsheets.

World Health Organization's (WHO) Health Economic Assessment Tool (HEAT) Model[3]

HEAT is a tool that enables users to estimate the economics of the health effect of walking or cycling. The tool, which is based on the best available, allows an array of professionals to assess walking and cycling

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[2] COBRA methodology is drawn from: U.S. EPA, March 2021, "Estimating the Co-Benefits of Clean Energy Policies CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool: How COBRA Works," Washington, DC: U.S. EPA, https://www.epa.gov/sites/default/files/2021-03/documents/how_cobra_works_mar2021_508.pdf, accessed March 31, 2024.

[3] HEAT methodology is drawn from: WHO, 2017, *Health economic assessment tool (HEAT) for walking and for cycling: Methods and user guide on physical activity, air pollution, injuries and carbon impact assessments*, Copenhagen: WHO Regional Office for Europe, https://cdn.who.int/media/docs/default-source/air-pollution-documents/heat.pdf?sfvrsn=ba0969b9_1&download=true, accessed March 24, 2024.

interventions at the national or city level. HEAT estimates the value of reductions in premature mortality due to user-defined amounts of walking or cycling. HEAT can also estimate the health effects of traffic crashes, air pollution, and GHG emissions. The HEAT model generates estimates of the order of magnitude of the expected effect rather, not precise estimates.

HEAT is a health impact assessment model, which is a type of quantitative tool that estimates the health effects of active transportation. The model quantifies the number of deaths occurring in a population over a given period of time by multiplying a mortality rate by the population size and the assessment time. HEAT applies the comparative risk assessment approach, to compare mortality rates between two cases: a reference case and a comparison case. The model employs well-established and vetted relationships from epidemiological research between an exposure (e.g a set amount of walking) and an outcome (all-cause mortality). Applicants ran the model in a single-case scenario, which assumes a steady-state situation. In other words, the assessed level of active travel is assumed to having been prevalent for several years, allowing individuals to reap the full benefits of long-term active travel.

In order to use HEAT to estimate the health benefits of the proposed e-bike rebate program, applicants setup the model using the following parameters:

- User Interface: Flexible Interface
- Active travel mode: E-bike
- Country: United States of America
- City: Cleveland
- Reference case year: 2025
- Length of assessment: 10 years
- E-biking amount: 3.54 miles per person, per day
- Age range: Adult population, aged 20-74
- Population size for assessment: 8,140 (total number of rebates from RMI E-Bike Calculator)
- Currency: US Dollars
- Value of Statistical Life: $5,585,000
- Discount rate: 3%
- USD Year: 2020

Results from the HEAT analysis are discussed in Section 3.a, and the model outputs are located in the attached spreadsheet.

GHG Reduction Measure 2: Regional Complete and Green Streets Program

Tree Planting Along Multimodal Transportation Corridors

Tree benefits were calculated using i-Tree Planting Calculator version 2.7.0.[4] Two separate models were run to estimate the benefits of 1,540 street right-of-way plantings (model 1) and 5,822 residential front yard plantings (model 2).

Tree Species List

The species list for both models was assembled from lists used by Western Reserve Land Conservancy and a local tree care company. A list of 36 species was pared down to 25 species so that each model included only one representative from each distinct taxonomic group for which the i-Tree model has a growth equation.[5] Species composition started as (model 1) 50% large tree species, 10% medium trees, and 40% small trees and (model 2) 40% large trees, 30% medium trees, and 30% small trees. This is the approximate size distribution that is a goal of local urban tree planting and residential giveaway programs, where the largest possible tree species that is appropriate for the site is selected. Initially, trees within each size category were evenly divided; however, as taxonomic groups were combined, the quantities of trees within each group were summed.

Large-Stature Trees
*Carya glabra**
Celtis occidentalis
Ginkgo biloba
Gymnocladus dioica
Liriodendron tulipifera
Quercus alba
Quercus species
Quercus rubra
Platanus x hybrida
Taxodium distichum
Tilia americana
Ulmus species
Zelkova serrata

Medium-Stature Trees
Aesculus glabra
Betula nigra
Carpinus caroliniana
Gleditsia triacanthos
Nyssa sylvatica
Ostrya virginiana

Small-Stature Trees
Amelanchier x grandiflora
Crataegus viridi
*Halesia carolina**
Malus spp.
Pistacia chinensis
Syringa reticulata

[4] USDA Forest Service. n.d. i-Tree Planting. Accessed March 26, 2024 from https://planting.itreetools.org/
[5] Nowak, David J. 2020. Understanding i-Tree: Summary of Programs and Methods (GTR-200). Appendix 13. USDA Forest Service.

* Denotes species that are not appropriate for street ROW planting; these were only used in Model 2.

Model 1: 1,540 Street Right-of-Way Plantings: Parameters

Location: Ohio, Cuyahoga County, Cleveland

Electricity Emissions Factor: 807.8 (default)

Fuel Emissions Factor: 92.61 (default)

Lifetime: 25 years

Annual Tree Mortality: 2.6%[6]

Run Date: 3-26-2024

Tree Planting Configurations

Tree species—as above.

DBH in inches: 1

Distance from Nearest Building in feet: 20-39

Tree is ____ of Building: Four lines were created for each tree species; each species was divided evenly into North, South, West, and East.

Building Vintage: Built 1950-1980.

Building Climate Control: Heat and Cool

Condition (of the tree at planting): Good

Exposure to Sunlight: Full Sun

Number of Trees: Varied among species from 7-58 per line, which was the total quantity of trees by species, divided evenly into four cardinal directions (see line, “Tree is ____ of Building”).

Model 2: 5,822 Residential Yard Trees: Parameters

Model 2 was run as above with the following exceptions:

Annual Tree Mortality: 4.6%[7]

Number of Trees: Varied among species from 15-245 per line, which was the total quantity of trees by species, divided evenly into four cardinal directions (see line, “Tree is ____ of Building”).

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[6] Hilbert, D. R., Roman, L. A., Koeser, A. K., Vogt, J., & van Doorn, N. S. (2019). Urban Tree Mortality: A Literature Review. Arboriculture & Urban Forestry, 45 (5), 167-200. [Table 3]

[7] Roman, L. A., Battles, J. J., & McBride, J. R. (2014). Determinants of establishment survival for residential trees in Sacramento County, CA. *Landscape and Urban Planning,* 129, 22-31.

Model Outputs

Model outputs are included in the attached spreadsheet. To account for a 5-year lag in tree planting, annual GHG reductions were divided by 5; each fifth began in a subsequent Year 1-5; and yearly outputs for Years 1-25 were summed.