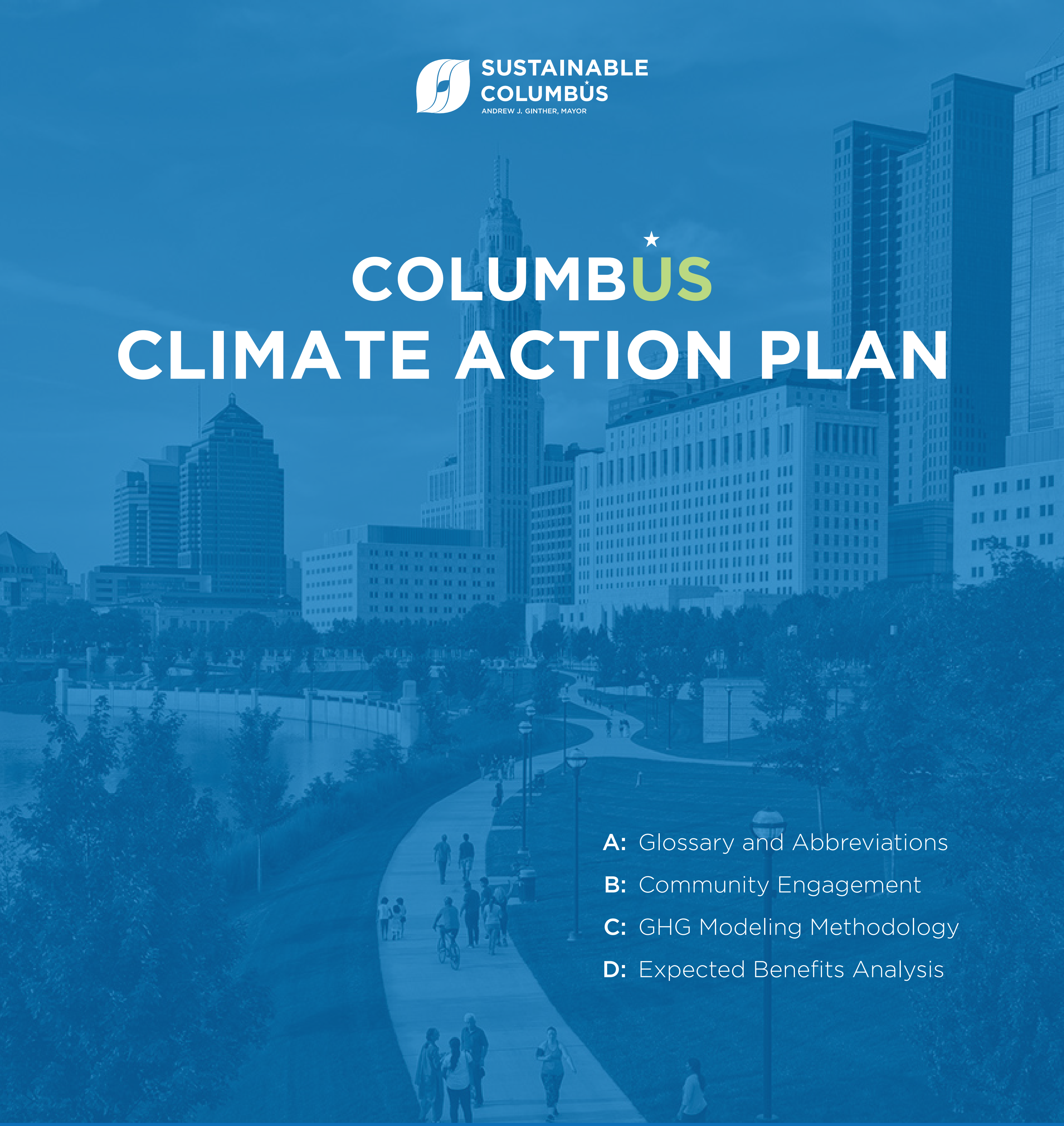

SUSTAINABLE COLUMBUS
ANDREW J. GINTHER, MAYOR

COLUMBUS CLIMATE ACTION PLAN

APPENDIX

GLOSSARY AND ABBREVIATIONS

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ACCC: American Cities Climate Challenge

Adaptation: the ability to respond to change and uncertainty

AEP: American Electric Power

Baseline inventory: GHG emissions chosen for a specific year against which a community's emissions are compared over time.

CAP: Climate Action Plan

Carbon dioxide: the most common of six primary GHGs, consisting of a single carbon atom and two oxygen atoms, which provides the reference point for th global warming potential of other gases.

Carbon footprint: the total volume of GHG emissions caused by a community, organization, event, product, or person.1

Carbon offsets: a credit or financial instrument that an individual, organization, or other entity may purchase to negate carbon emissions. Revenue from carbon offsets is typically used to fund climate change mitigation or adaptation efforts.

Carbon neutrality: the act of removing equal amounts of CO_2 from the environment as was released or produced by an organization or entity.

CCCWG: Columbus Climate Committee Working Group

Circular economy: an economy that creates value from natural resources in new ways, coupling growth to positive environmental and social outcomes by using new business models, design principles and logistics strategies which deliver against three key principles: design out waste and pollution wherever possible, keep products and materials in use for as long as possible, and regenerate natural systems.

Clean energy procurement: the action of obtaining power contracts from renewable energy sources.

Climate change: long-term changes in the Earth's average weather patterns primarily driven by human activities, particularly fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere, raising Earth's average surface temperature.

Community choice aggregation (CCA): programs that allow local governments to procure power on behalf of their residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider.

Community-scale inventory: annual report focused on select GHG emissions occurring within the jurisdictional boundary, as well as certain trans-boundary sources associated with community activities.

Community: residents, businesses, industries, and government co-located within a jurisdictionally defined area.

Composting: the decomposition of organic waste matter (ex. food scraps and yard waste) till it can be used as a fertilizer to help plants grow.

Cooling degree days (CDD): the number of degree that a day's average temperature is above 65°F.

CO_2e: Carbon dioxide equivalent, typically measured in metric tons.

Decarbonization: the process of reducing carbon by using low or zero emitting sources.

DOP: Columbus Department of Power

DPU: Columbus Department of Public Utilities

Embodied energy: the total expenditure of energy in the creation of a product's full life cycle to extract, process, package, transport, install and recycle or dispose of materials.

Emissions factor: a unique value for determining an amount of a GHG emitted on a per unit activity basis.

Emission scopes:

- **Scope 1**: direct emissions (e.g., smokestacks or tailpipes that release emissions within an organizational boundary.)

- **Scope 2**: indirect energy-related emissions (e.g., the use of purchased or acquired electricity, heating, cooling, or steam regardless of where the energy is generated.)

- **Scope 3**: other indirect emissions not covered in scope 2 (e.g., upstream, and downstream emissions from the extraction and production of purchased materials and fuels.)

Energy efficiency: using less energy to complete a task or service at the same level.

EPA eGRID: a database created by the EPA to track the emissions of the power grid across the US. The EPA breaks down the US into subregions where the emissions from all the power plants within the specific subregion are averaged to determine its overall emission factor.

Equitable: fair and impartial treatment regardless of age, race, sexuality, gender identity, socioeconomics, etc.

EV: Electric Vehicle

Expected benefits: Gains for the community associated with CAP strategies other than GHG emissions reductions.

Fossil fuel: a fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient plants and animals.

Fugitive emissions: emissions that are not physically controlled but result from the release of GHGs - they commonly occur from processing, transmission and storage of fuels.

Green bank: a publicly established entity to facilitate private investment into low carbon, clean energy and climate resilient infrastructure and buildings projects.

Greenhouse gas emissions (GHGs): Gases that trap heat in the atmosphere, primarily carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) due to both natural processes and human activities.

GPC: Global protocol for community-scale greenhouse gas inventories.

Growth scenario: GHG future projections models which use specific growth factors (ex. population growth) to project future forecasts

GWh: Gigawatt hours = 1,000 MWh

Heating degree days (HDD): the number of degree that a day's average temperature is below 65°F.

ICLEI: International Council for Local Environmental Initiatives

Implementation partner: local organizations and businesses who will assist Lead Agencies in the implementation of the Climate Action Plan.

Inventory: a comprehensive, quantified list of a community's or organization's GHG emissions and sources.

IPCC: Intergovernmental Panel on Climate Change

Lead agency: government agencies responsible for overseeing the implementation of climate actions assigned to them. Responsibilities include tracking overall progress, managing implementation partners and identifying and closing gaps between current progress and established goals.

LED: Light Emitting Diode

Microgrid: a decentralized network of electricity generating sources that have the capability of disconnecting from the traditional grid and operate autonomously.

Micromobility: a category of lightweight modes of transportation designed to travel short distances, typically under 5 miles - examples include bicycles, electric scooters, and electric bicycles.

$MMtC0_2e$: Million metric tons of CO_2 equivalent

Mitigation: the ability to reduce the potential harm or risk a hazard or event poses.

Megawatt (MW): measure of electricity capacity. One MW is sufficient to power up to 1,000 homes.

MWh: Megawatt hours of energy = 1,000 kilowatt hours (kWh) = 1,000,000 watt hours (Wh)

MT: Metric ton

Natural gas: a naturally occurring mixture of hydrocarbons (e.g., methane, ethane, or propane) produced in geological formations beneath the earth's surface that maintains a gaseous state at standard atmospheric temperature and pressure under ordinary conditions.

No further action: a GHG emissions forecast assuming no further climate actions are taken place from a determined time.

Organic waste: any biodegradable material that comes from a plant or animal.

Passenger miles: one mile traveled by one passenger using public transportation.

Photovoltaics (PV): a renewable source of energy that utilizes the Sun's photons to excite the electrons of specific materials to produce clean electricity.

Power purchase agreement (PPA): a long-term electricity supply contract between a power producer and a customer, typically for clean energy procurement.

Property assessed clean energy (PACE): an innovative mechanism for financing energy efficiency and renewable energy improvements on private property.

Pre-industrial levels: The time period prior to the onset of large-scale industrial activity, for climate action planning the reference period 1850-1900 is used to approximate the global mean surface temperature used for measuring climate change impacts.

Proxy: a figure that can be used to represent the value of something in a calculation.

Regional transmission organization (RTO): an electric power transmission system operator that coordinates, controls, and monitors a multi-state electric grid.

Regulation: the creation or enforcement of rules set through a legislative process.

Renewable energy credit (REC): a market tradable commodity that represents proof that one megawatt-hour (MWh) of electricity was generated from a third-party verified renewable energy resource, such as a solar renewable energy certificate (SERC) that is generated from a PV system.

Renewable energy: energy that is produced from natural sources or processes that are constantly replenished.

Renewable portfolio standard (RPS): policies or regulations that are meant to increase the renewable energy generation in an area, typically a state.

Resilience hub: locations throughout the city designed to help the community during emergencies such as severe flooding, utility outages and extreme heat days.

Rideshare: an arrangement in which a passenger travels in a private vehicle driven by its owner, for free or for a fee

Source: a process or activity that releases GHGs into the atmosphere.

SOV: Single Occupant Vehicle

SWACO: Solid Waste Authority of Central Ohio

Teleworking: employment at home while able to communicate with the workplace by phone or internet.

Vehicle miles traveled (VMT): the total number of miles traveled by vehicles within a specific boundary.

Waste diversion: reused, repurposed, recycled and composted materials kept out of the landfill.

Wastewater: water that has been used, also known as sewage.

Water use intensity: a unit of measurement where all the water being used in a building is divided by the total area (gallons/ft^2)

Zero carbon: causing or resulting in no net release of carbon dioxide emissions.

Zero emission Vehicle (ZEV): vehicles that produce zero GHG gases or other pollutants from the onboard source of power.

Zero net energy: balancing annual energy demand with on-site and/or procurement of clean energy, typically for a building or portfolio of buildings.

COMMUNITY ENGAGEMENT

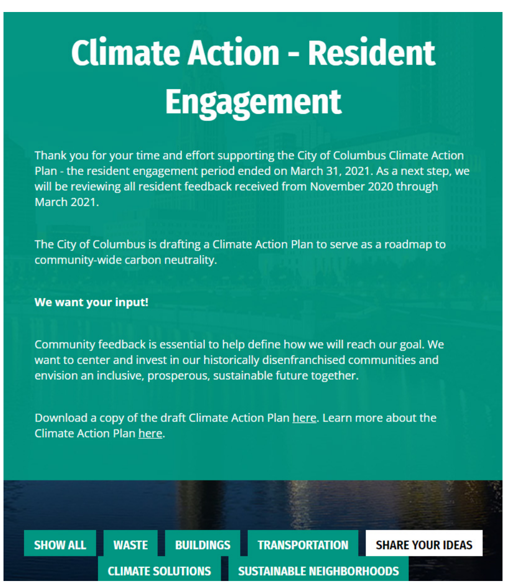
BACKGROUND

The City of Columbus released the Draft Columbus Climate Action Plan in November 2020 for public comment and input. While COVID-19 presented challenges with in person meetings and feedback, creative strategies were used to engage the community.

Centering equity and utilizing best practices was a key focus for the public engagement period on the Draft Plan. The City utilized supports from the American Cities Climate Challenge to develop a Train-the Trainer Toolkit and host Training sessions to help community leaders and residents learn how to host their own virtual community meetings on the Draft Climate Action Plan. Community leaders who conducted a Training using the Toolkit materials were compensated $150 and residents who participated in the Training sessions were compensated with a $15 check for one hour of their time, as simply volunteering time can be a barrier to participation for lower-income residents and many communities of color. The City held three Train-the-Trainer sessions and **trained 18 community leaders across 14 neighborhood commissions** on how to host their own meetings.

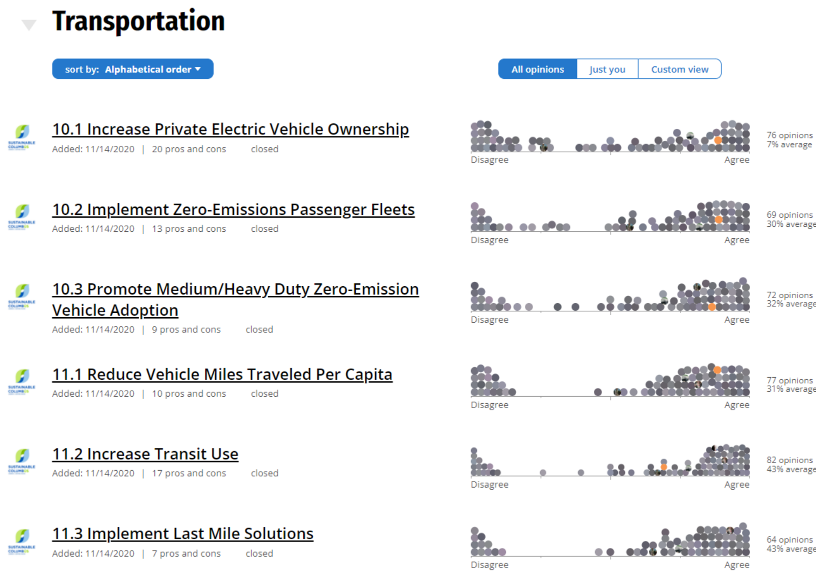
The City also partnered with IMPACT Community Action to host Virtual Meetings on the Draft Climate Action Plan and gather feedback and input from residents. IMPACT is a local non-profit organization with a mission "to fight poverty by providing hope-inspiring help and real opportunities for self-sufficiency, and is a trusted community voice with deep relationships in the Black community and our Opportunity neighborhoods. Over **100 residents** attended Climate Action Plan focused community meetings led by IMPACT.

A total of **10 virtual meetings** were held on the Draft Climate Action Plan, and a Google Survey was deployed to participants of those meetings. Over 50% of respondents were people of color and around 50% of respondents had a household income of less than $50,000 a year.



Another key creative mode of receiving input was through the Consider.It website, where residents could weigh in on each action, goal & tracking metric within the Draft Plan and share their own ideas around climate action. Through the platform over **850 opinions and comments** were collected on the Draft Climate Action Plan.

While the public input phase was planned to end in February of 2021, the City did extend that period through March in response to feedback received from residents. A Public Hearing was held in early March on the Draft Climate Action Plan as another mode of soliciting input from the public, and there were 18 Public Speakers.



Participant opinions on the Consider.it website for the Transportation section.

PUBLIC ENGAGEMENT MESSAGES

Robust engagement and feedback from residents made it clear that climate action is a top priority and need for our community. Many expressed a desire to see **stronger action** in a **shorter timeframe** due to the urgency of the issue and understanding that climate change is already impacting our most vulnerable residents right now. Because of that understanding, ensuring equity and environmental justice was not only at the core of the Climate Action Plan but also woven throughout was critically important to the community. Along those lines, residents expressed the need to explicitly and clearly address why we are acting on climate and show what kind of impact climate change has on the community. Another key takeaway from the engagement period was the importance of safe, clean drinking water and watersheds in our community. It was clear that water and water protections need to be featured more prominently in the Climate Action Plan.

GHG MODELING METHODOLOGY

MODELING METHODOLOGY

CLEARPATH INVENTORY TOOL

The City of Columbus, Ohio has been tracking its community-wide GHG emissions annually in ClearPath since 2013. The software platform has the capability of establishing yearly inventories, forecasting future annual emissions and monitoring progress towards set targets.

ClearPath was developed in response to local governments' need for a standardized methodology for accounting and reporting GHG emissions associated with individual communities.[i] Many of ClearPath's protocols reference existing emission accounting methodologies from the Intergovernmental Panel on Climate Change (IPCC) and Environmental Protection Agency (EPA) along with utilizing insight from the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC) which was developed concurrently.

GHG emissions are divided into seven main categories: residential, commercial, industrial, transportation, solid waste, water and wastewater and fugitive emissions – each composed of data gathered by their respected governmental and public agencies. All electricity and natural gas data were obtained from the main two utility providers in Columbus: American Electric Power (AEP) and Columbus Division of Power. Franklin county's total waste was provided by Solid Waste Authority of Central Ohio (SWACO) and transportation data was provided by the Mid-Ohio Regional Planning Commission (MORPC), the Central Ohio Transit Authority (COTA) and Columbus Regional Airport Authority. With a completed inventory, ClearPath allows users to apply growth rates and energy reducing measures to approximate where future emissions are projected to be. ClearPath's energy measures along with external calculations in Excel are used to model Columbus' 2030 and 2050 goals.

2018 PROXY FOR 2013 INVENTORY

Columbus began tracking its community-wide GHG emissions in 2013, the base year selected to set carbon reduction goals. Upon reviewing 2013's inventory, information gaps were found in the transportation, municipal, water and wastewater, and solid waste categories. For this reason, the 2018 inventory, the most updated inventory at the time of this report, was used as a proxy for its accuracy and confidence in robust and complete data collection.

To generate the proxy, 2018 usage data for the low resolution categories, denoted by asterisks, were scaled back using the population growth between 2013 and 2018, listed as 822,553 and 891,751 respectively in their inventories. The result is an annual growth rate of 1.628%. CO_2 emissions were also scaled back using the annual growth rate except for those that consumed electricity (municipal, residential, commercial, and industrial) as 2013's grid emission factor was used instead. For the simplicity of keeping seven main categories, municipal data will be merged into the commercial category for future calculations. Table 1 compares the 2018 inventory with the new 2013 proxy.

The CO_2 emissions for the solid waste category are higher in the scaled 2013 inventory than 2018's inventory despite the waste tonnage being smaller. This is due to the 2018 Inventory listing all waste under a single municipal solid waste (MSW) category instead of breaking down by type. For accuracy, the scaled 2013 Inventory waste is broken into different waste type (yard trimmings, plastics, food scraps, etc.) to factor in their unique GHG emission factors. A further explanation can be found in the waste modeling section. Categories that are scaled are denoted by an asterisk.

Category	Starting Inputs	2018 Inventory	Scaled 2013 Inventory
Residential	Electricity Usage (kWh)	2,969,872,111	2,365,168,624
	CO_2 Emissions (MT)	1,580,973	1,491,331
	Natural Gas (MMBtu)	20,280,912	19,096,099
	CO_2 Emissions (MT)	1,078,433	1,015,655
***Municipal**	Electricity Usage (kWh)	90,017,517	98,062,101
	CO_2 Emissions (MT)	47,613	61,817
	Natural Gas (MMBtu)	656,413	688,005
	CO_2 Emissions (MT)	34,803	36,478
Commercial	Electricity Usage (kWh)	5,266,491,122	5,218,890,999
	CO_2 Emissions (MT)	2,803,854	3,289,928
	Natural Gas (MMBtu)	9,384,022	14,747,553
	CO_2 Emissions (MT)	499,213	784,543
Industrial	Electricity Usage (kWh)	639,914,857	610,094,076
	CO_2 Emissions (MT)	340,650	384,596
	Natural Gas (MMBtu)	161,932	5,410,317
	CO_2 Emissions (MT)	8,594	287,150
***Transportation**	Gas On Road (VMT)	7,847,697,197	7,238,732,418
	CO_2 Emissions (MT)	2,810,513	2,592,424
	Diesel On Road (VMT)	488,020,598	450,151,227
	CO_2 Emissions (MT)	815,076	751,828
	Aviation (MMBtu)	8,799,160	8,116,364
	CO_2 Emissions (MT)	702,362	661,613
	Diesel Transit (VMT)	11,883,694	15,155,757
	CO_2 Emissions (MT)	22,970	27,198
	Energy Equivalent (MMBtu)	292,706	269,992
	CO_2 Emissions (MT)	21,835	20,140
	CNG Transit (VMT)	8,388,592	760,321
	CO_2 Emissions (MT)	851	77
	Gas Transit (VMT)	511,987	0
	CO_2 Emissions (MT)	250	0
***Solid Waste**	Waste generated (Wet Tons)	859,562	792,862
	CO_2 Emissions (MT)	324,914	578,162
***Water and Wastewater**	Wastewater (MMBtu)	404,510	373,121
	CO_2 Emissions (MT)	56,139	60,527
	Water Supply (MMBtu)	280,791	259,002
	CO_2 Emissions (MT)	38,487	41,449
	Digester (scf/year)	551,527,500	508,730,127
	CO_2 Emissions (MT)	1,713	1,580
	Gas Production (scf/year)	551,527,500	508,730,127
	CO_2 Emissions (MT)	86	79
***Process & Fugitive**	Natural Gas (MT)	2,022	1,865
	CO_2 Emissions (MT)	52,887	48,783

Table 1. Starting Values Exported from 2013 Proxy and 2018 Inventory in ClearPath

GRID DECARBONIZATION

Over the past two decades, the electricity portfolio serving Columbus has become significantly cleaner, largely due to the retirement of coal plants reaching the end of life being replaced with natural gas facilities. To achieve Columbus' carbon neutrality goals, a steady decarbonization of the power grid will be necessary by 2050. To establish the emission factor from electricity used in Columbus, the EPA's grid emission data is used as federally mandated by the Federal Energy Regulatory Commission (FERC).[ii] Ohio falls in the RFC West eGrid subregion along with West Virginia, Indiana and parts of Pennsylvania, Illinois, and Virginia. The EPA releases its grid emission data on a two-year basis, aligning with even numbers, causing 2012 RFC West data to be used for the 2013 baseline.

The projection for the future makeup for the RFC West grid (Figure 1) is reliant on aggressive implementation of clean energy from renewables and simultaneous retirement of the fossil fuel facilities with highest emissions prioritized, which in this case is coal. Between 2005 – 2012 coal's proportion of the fuel mix fell from 72.8% to 58.7 %, falling again between from 58.7% to 37.4% between 2012 – 2019. Nuclear power plants are predicted to continue operation until 2045, with a projection that half being decommissioned by 2030 as they are reaching end of life.

AEP Ohio's largest public utility, has committed to 51% of their generating resource mix to come from renewable sources by 2030 with 5,910 MW coming from solar and 10,685 MW from wind.[iii] It is important to note that the nameplate capacity for the RFC West region in 2019 was 192,931 MW therefore the additional 16,595 MW of clean energy from AEP will only make up 9% of the potential generation. PJM Interconnection, a regional transmission organization that serves over 65 million customers including those in Columbus, will have the responsibility of ensuring that the growing share of renewables will be integrated into the grid in a reliable and economically efficient way.

For the Climate Action Plan, the following scenarios for future electric grid fuel mix has been established.

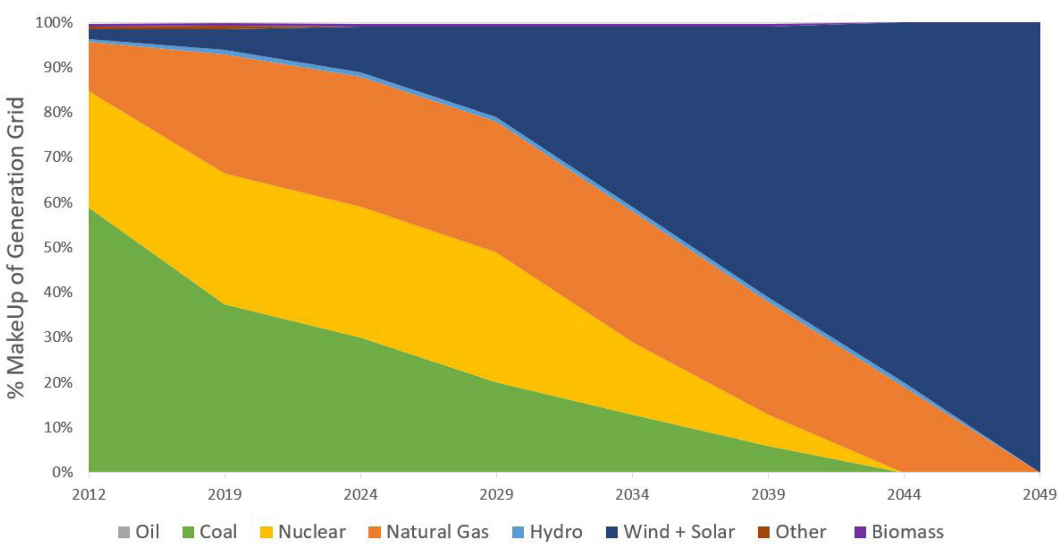


Figure 1. Makeup of RFCW Grid - Historical 2012-2018, projected 2018-2050.

Table 2 shows a more detailed breakdown of each fuel sources' makeup in 5-year intervals along with their emission factor. Years 2012 and 2019 breakdown align with the historical percentages outlined in EPA eGrid RFC West data. Emission factors for each fuel type can vary year to year due to various factors like temperature, age of equipment and human error. For example, in 2019, natural gas had an emission factor of 903.85 lbs CO_2/MWh in the RFC West subregion but a value of 850.53 lbs CO_2/MWh in CAMX – an eGrid subregion within California. For this reason, emission factors can fluctuate a considerable amount affecting the total emissions for Community-scale Inventories. The 'Other' category's emissions factor was strategically assigned to keep the model's 2012 and 2019's blended factors as close to their true EPA eGrid RFC West values as possible (1,379.5 lbs CO_2/MWh for 2012 and 1,067.7 lbs CO_2/MWh for 2019). 2019's value is kept more aligned to retain accuracy between the estimates in Table 2. and how ClearPath applies it to the forecast.

Grid Makeup for RFCW	**Emission Factor (lbs CO_2/MWh)**	**2012**	***2019***	***2024***	***2029***	***2034***	***2039***	***2044***	***2049***
Wind + Solar	0.00	2.1%	4.5%	10%	20%	40%	60%	80%	100%
Biomass	0.00	0.5%	0.6%	0.6%	0.6%	0.6%	0.6%	0%	0%
Hydro	0.00	0.7%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0%
Nuclear	0.00	25.7%	29.0%	29.0%	29.0%	16.0%	7.0%	0%	0%
Natural Gas	903.85	11.1%	26.5%	29%	29%	29%	25%	19%	0%
Oil	2779.00	0.5%	0.2%	0%	0%	0%	0%	0%	0%
Coal	2161.96	58.7%	37.4%	30%	20%	13%	6%	0%	0%
Other	1650.00	0.7%	0.8%	0%	0%	0%	0%	0%	0%
	Blended Factor (lbs CO_2/MWh)	1,395	1,067	911	695	543	356	172	0

Table 2. RFCW Grid Makeup by Energy Source ClearPath

GROWTH RATES AND PROJECTIONS

Columbus has more than doubled in size since the 1960's and is projected to continue growing throughout the metropolitan area's 15-county region to reach over 3 million people by 2050. Inputs for the future population growth factors utilizes the Insight 2050 Study and MORPC's 2018-2050 Population Growth Projections, with a narrowed focus for growth solely within the city limits of Columbus. Table 3 outlines key metrics used in calculations with grid emissions reflecting the projected grid fuel mix and growth rates.

Year	Grid Emission (MMBTU/ton)	Population Growth Rate	Population
2013	0.1833	-	822,553
2019	0.1417	0.02	909,586
2020	0.1373	0.012	920,501
2021	0.1331	0.012	931,547
2022	0.1289	0.012	942,726
2023	0.1249	0.012	954,038
2024	0.1211	0.012	965,487
2025	0.1147	0.012	977,073
2026	0.1086	0.012	988,798
2027	0.1029	0.012	1,000,663
2028	0.0975	0.012	1,012,671
2029	0.0923	0.012	1,024,823
2030	0.0879	0.007	1,031,997
2031	0.0837	0.007	1,039,221
2032	0.0797	0.007	1,046,495
2033	0.0758	0.007	1,053,821
2034	0.0722	0.007	1,061,198
2035	0.0663	0.007	1,068,626
2036	0.0610	0.007	1,076,106
2037	0.0560	0.007	1,083,639
2038	0.0515	0.007	1,091,225
2039	0.0473	0.007	1,098,863
2040	0.0409	0.004	1,103,259
2041	0.0353	0.004	1,107,672
2042	0.0305	0.004	1,112,102
2043	0.0264	0.004	1,116,551
2044	0.0228	0.004	1,121,017
2045	0.0129	0.004	1,125,501
2046	0.0073	0.004	1,130,003
2047	0.0041	0.004	1,134,523
2048	0.0023	0.004	1,139,061
2049	0.0013	0.004	1,143,617
2050	0.0000	0.004	1,148,192

Table 3. Projections from 2013 to 2050

BUILDINGS

RENEWABLE ENERGY GENERATION

NREL's PVWatts calculator was used to determine the generation potential for solar panels in Columbus, Ohio. Assumption for residential homes and commercial panels are listed in the table below. The final generation potential factors in the 14.08% loss which is composed of 2% from soiling, 3% from shading, 2% from mismatch, 2% from wiring, 3% from availability and 2% from other means. The ClearPath calculator only requires the generation potential and yearly increase in solar capacity to complete its calculation. The electricity saved from solar generation is multiplied against the year's emission factor to determine the GHG emission savings. Note that the ClearPath calculator does not factor in degradation due to aging of equipment components.

Sector	Module Type	Array Type	System Loss (%)	Tilt (Deg)	Azimuth (Deg)	Generation Potential (kWh/kW)
Residential	Premium	Fixed Roof Mount	14.08	20	180	1,304
Commercial		Fixed Open Rack				1,316

Table 4. PV Output [iv]

ENERGY EFFICIENCY

Energy reduction goals will be tracked by comparing future inventories' energy usage to the 2013 baseline. Table 5 outlines the baseline electricity and natural gas usage per sector, along with their new 2030 and 2050 goals. Goals are derived from reductions outlined in the CAP; 20% for residential, 15% for commercial, and 25% in municipal by 2030 and by 50% across all sectors by 2050.

Electricity (kWh)			
Goals	**Residential**	**Commercial**	**Municipal**
2013 Baseline	2,365,168,624	5,218,890,999	98,062,101
2030 Goal	1,892,134,899	4,436,057,349	73,546,576
2050 Goal	1,182,584,312	2,609,445,499	49,031,051

Gas (MMBtu)			
Goals	**Residential**	**Commercial**	**Municipal**
2013 Baseline	19,096,099	14,747,553	688,005
2030 Goal	15,276,879	12,535,420	516,004
2050 Goal	9,548,050	7,373,777	344,003

Table 5. Energy Use for Residential, Commercial and Municipal Sectors

	2013	2014	2015	2016	2017	2018	2019	Average
HDD	5,252	5,753	5,243	4,965	4,508	5,298	5,136	5,165
CDD	1,112	1,129	968	1,256	1,056	1,427	1,246	1,171
Total	6,364	6,882	6,211	6,221	5,564	6,725	6,382	6,336

Table 6. Heating and Cooling Degree Days for Columbus, Ohio [v]

Since the energy data is not weather normalized, Table 6 is provided to give a historical reference for the number of heating degree days (HDD) and cooling degree days (CDD) experienced in Columbus between 2013 and 2019. ASHRAE defines HDD and CDD as the number of degrees of heating and cooling that is required for an area based on a set point temperature of 65°F. These values can be a good indicator on how much heating and cooling system energy usage can change due to the varying intensities of summer, winter, and shoulder months. Based on the data in Table 6, 2013's HDD and CDD are relatively aligned with historical averages, suggesting no extreme weather patterns were experienced during 2013 that would have skewed its baseline energy usage.

CLEAN ENERGY PROCUREMENT

Clean energy procurement was modeled after energy efficiency measures were applied to the CAP forecast, as shown in Table 7. In 2020, Columbus passed a community choice aggregation (CCA) regulation that allows eligible residents to receive 100% of their electricity from renewable sources. At the time of this report, about 85% of residents remained opted in the CCA, however as renewable energy becomes cheaper, this number is targeted to be 100% by 2030. Municipal buildings are expected to be at 100% energy procurement starting 2022 till 2050 using Renewable Energy Credits (RECs) and Power Purchase Agreements (PPAs). 25% of commercial buildings were modeled to be receiving their electricity from RECs and PPAs between 2022 - 2030 and then a steady increase to 100% between 2030 and 2050.

Residential				Commercial			
Year	Electricity Usage (kWh)	Efficiency Contribution ($MTCO_2e$)	CCA (kWh)	Year	Electricity Usage (kWh)	Efficiency Contribution ($MTCO_2e$)	RECs and PPAs (kWh)
2022	2,710,124,674	-119,328,726	2,202,176,556	2022	5,960,759,951	-231,866,140	1,432,223,453
2023	2,742,646,066	-238,657,452	2,175,340,109	2023	6,032,289,004	-463,732,281	1,392,139,181
2024	2,775,557,827	-357,986,177	2,145,594,839	2024	6,104,676,393	-695,598,421	1,352,269,493
2025	2,808,864,647	-477,314,903	2,112,966,955	2025	6,177,932,476	-927464,562	1,312,616,979
2026	2,842,570,920	-596,643,629	2,077,482,745	2026	6,252,067,899	-1,159,330,702	1,273,184,299
2027	2,876,681,924	-715,972,355	2,039,169,656	2027	6,327,092,721	-1,391,196,842	1,233,973,970
2028	2,911,202,053	-835,301,080	1,998,054,686	2028	6,403,017,583	-1,623,062,983	1,194,988,650
2029	2,946,136,583	-954,629,806	1,954,166,025	2029	6,479,854,007	-1,854,929,123	1,156,231,221
2030	2,966,759,333	-1,073,958,532	1,892,800,801	2030	6,525,212,982	-2,086,795,264	1,109,604,430
2031	2,987,526,859	-1,128,206,375	1,859,320,484	2031	6,570,889,521	-1,128,206,375	1,259,444,018
2032	3,008,439,455	-1,182,454,218	1,825,985,237	2032	6,616,885,631	-1,182,454,218	1,402,472,062
2033	3,029,498,586	-1,236,702,061	1,792,796,525	2033	6,663,203,910	-1,236,702,061	1,538,727,362
2034	3,050,704,838	-1,290,949,904	1,759,754,934	2034	6,709,846,364	-1,290,949,904	1,668,248,889
2035	3,072,059,970	-1,345,197,748	1,726,862,222	2035	6,756,815,298	-1,345,197,748	1,791,076,062
2036	3,093,564,274	-1,399,445,591	1,694,118,684	2036	6,804,113,011	-1,399,445,591	1,907,248,663
2037	3,115,219,217	-1,453,693,434	1,661,525,783	2037	6,851,741,805	-1,453,693,434	2,016,806,838
2038	3,137,025,676	-1,507,941,277	1,629,084,399	2038	6,899,703,982	-1,507,941,277	2,119,791,096
2039	3,158,985,118	-1,562,189,120	1,596,795,998	2039	6,948,001,840	-1,562,189,120	2,216,242,309
2040	3,171,620,831	-1,616,436,963	1,555,183,868	2040	6,975,793,666	-1,616,436,963	2,292,762,806
2041	3,184,307,538	-1,670,684,806	1,513,622,732	2041	7,003,697,107	-1,670,684,806	2,361,031,054
2042	3,197,044,654	-1,724,932,650	1,472,112,004	2042	7,031,711,861	-1,724,932,650	2,421,060,052
2043	3,209,832,763	-1,779,180,493	1,430,652,270	2043	7,059,838,507	-1,779,180,493	2,472,863,423
2044	3,222,672,160	-1,833,428,336	1,389,243,824	2044	7,088,077,915	-1,833,428,336	2,516,455,115
2045	3,235,562,844	-1,887,676,179	1,347,886,665	2045	7,116,430,370	-1,887,676,179	2,551,848,723
2046	3,248,505,108	-1,941,924,022	1,306,581,086	2046	7,144,895,862	-1,941,924,022	2,579,057,625
2047	3,261,499,246	-1,996,171,865	1,265,327,380	2047	7,173,475,557	-1,996,171,865	2,598,096,279
2048	3,274,545,257	-2,050,419,708	1,224,125,548	2048	7,202,169,445	-2,050,419,708	2,608,978,202
2049	3,287,643,434	-2,104,667,552	1,182,975,883	2049	7,230,978,105	-2,104,667,552	2,611,717,493

Table 7. Electricity Covered by Clean Energy Procurement between 2022 - 2050

Municipal			
Year	Electricity Usage (kWh)	Efficiency Contribution ($MTCO_2e$)	RECs and PPAs (kWh)
2022	112,388,692	-5,440,258	106,948,434
2023	113,737,357	-10,880,517	102,856,840
2024	115,102,205	-16,320,775	98,781,430
2025	116,483,431	-21,761,034	94,722,398
2026	117,881,233	-27,201,292	90,679,941
2027	119,295,807	-32,641,550	86,654,257
2028	120,727,357	-38,081,809	82,645,548
2029	122,176,085	-43,522,067	78,654,018
2030	123,031,318	-48,962,326	74,068,992
2031	123,892,537	-50,948,754	72,943,783
2032	124,759,785	-52,935,183	71,824,602
2033	125,633,103	-54,921,611	70,711,492
2034	126,512,535	-56,908,040	69,604,496
2035	127,398,123	-58,894,468	68,503,655
2036	128,289,910	-60,880,896	67,409,013
2037	129,187,939	-62,867,325	66,320,614
2038	130,092,255	-64,853,753	65,238,501
2039	131,002,901	-66,840,182	64,162,719
2040	131,526,912	-68,826,610	62,700,302
2041	132,053,020	-70,813,039	61,239,981
2042	132,581,232	-72,799,467	59,781,765
2043	133,111,557	-74,785,896	58,325,661
2044	133,644,003	-76,772,324	56,871,679
2045	134,178,579	-78,758,753	55,419,826
2046	134,715,293	-80,745,181	53,970,112
2047	135,254,155	-82,731,610	52,522,545
2048	135,795,171	-84,718,038	51,077,133
2049	136,338,352	-86,704,466	49,633,885

Table 7 (cont.). Electricity Covered by Clean Energy Procurement between 2022 - 2050

INCREASE WATER EFFICIENCY

ClearPath does not have a specific measure to account for energy efficient measures applied in the water and wastewater category, so a manual calculation was carried out in Excel. To do this, the modeled water and wastewater future energy consumption was exported from ClearPath and a steady reduction reflecting the 2030 and 2050 goals were applied. ClearPath uses a CO_2 emissions factor of 0.1622 MT/MMBtu for wastewater energy and 0.160 MT/MMBtu for water supply energy to calculate GHG emissions. Approximately 80% of the energy used by water and wastewater treatment plants comes from electricity which will benefit significantly from the decarbonization of the grid, however carbon savings resulting from this was not calculated as this category makes up less than 1% of total emissions. The remaining 20% of energy comes from natural gas which may require carbon offsets to reach a complete reduction depending on technological advancements in heating systems.

	Wastewater Energy		Water Supply Energy	
Year	Projected Energy Usage (MMBtu)	Reduction (MMBtu)	Projected Energy Usage (MMBtu)	Reduction (MMBtu)
2022	426,086	2,367	295,768	1,643
2023	431,199	4,791	299,317	3,326
2024	436,373	7,273	302,909	5,048
2025	441,610	9,814	306,544	6,812
2026	446,909	12,414	310,222	8,617
2027	452,272	15,076	313,945	10,465
2028	457,699	17,799	317,712	12,355
2029	463,191	20,586	321,525	14,290
2030	466,434	23,322	323,776	16,189
2031	469,699	25,222	326,042	17,508
2032	472,987	27,278	328,324	18,935
2033	476,298	29,501	330,623	20,478
2034	479,632	31,906	332,937	22,147
2035	482,989	34,506	335,268	23,952
2036	486,370	37,318	337,614	25,904
2037	489,775	40,360	339,978	28,016
2038	493,203	43,649	342,358	30,299
2039	496,656	47,206	344,754	32,768
2040	498,642	51,053	346,133	35,439
2041	500,637	55,214	347,518	38,327
2042	502,639	59,714	348,908	41,451
2043	504,650	64,581	350,303	44,829
2044	506,668	69,844	351,705	48,483
2045	508,695	75,537	353,111	52,434
2046	510,730	81,693	354,524	56,707
2047	512,773	88,351	355,942	61,329
2048	514,824	95,552	357,366	66,327
2049	516,883	103,339	358,795	71,733

Table 8. Wastewater and Water demand 2022-2050

SUSTAINABLE NEIGHBORHOODS

LED STREETLIGHT RETROFITS

All streetlights in Columbus, estimated at 54,000, are modeled to be replaced by LEDs by 2030. Table 9 shows the estimated share of streetlight by bulb type with their respective wattage. ClearPath replaces all the lamps with LEDs, subtracting the difference in their wattages to determine the carbon savings. Since the grid becomes cleaner with time, the GHG savings is dependent on the year calculations are conducted. The annual energy savings from converting all streetlights to LEDs is 28,462,817 kWh.

Type of Lamp	Wattage	Share of Existing Streetlights
Mercury Vapor	182	20%
Metal Halide	200	6%
High Pressure Sodium	192	64%
Low Pressure Sodium	180	10%
LED	58	0%

Table 9. 2018 Columbus Streetlight Inventory [vi]

DEVELOPMENT DENSITY

Focusing development where there are multi-modal transportation options reduces the impact of a growing population. This is modeled by shifting vehicle traveled miles (VMT) from personal vehicles to alternative modes of transportation. Table 10 shows the breakdown of transportation by mode and the average distance travel, provided by Google Environmental Insight Explorer,[vii] for Columbus in 2019.

Mode of Transportation	Baseline % Breakdown	Average Distance Traveled (Miles)
Walk	1.1%	0.47
Bike	2.0%	1.63
Transit	2.4%	4.77
Teleworking	4.8%	0.00
Personal Vehicle	89.7%	10.31

Table 10. Transportation Mode Distribution

The number of new homes between 2020 – 2030 and 2030- 2050 is projected to be 50,720 and 40,368 respectively. With the 2030 goal outlining 40% of these new homes to be within 1/4 mile of employment centers, our model assumes 25% of its occupants will utilize human powered multi-modal transportation options. Increasing to 50% as better infrastructure is implemented and social values begin to shift.

Year	New Residents	% Residents Near Employment Centers	People Near Employment Centers	Utilization Rate	Number of People Utilizing Multi-modal Transport
2030	111,496	40%	44,598	25%	11,150
2050	111,620	60%	66,972	50%	33,486

Table 11. Development Density Projections

The number of new residents using transportation was evenly divided amongst biking and transit use (note that the biking category also includes the use of electric bicycles and scooters). Table 12 outlines how mode share will change with the implementation of additional development density.

Mode Share	Baseline Breakdown	2030 % Breakdown	2050 % Breakdown
Walk	1.10%	1.10%	1.10%
Bike	2.00%	2.54%	4.00%
Transit	2.40%	2.94%	4.40%
Teleworking	4.80%	4.80%	4.80%
Personal Vehicle	89.70%	88.75%	85.84%

Table 12. Mobility Mode Distribution [viii]

TRANSPORTATION

REDUCE SINGLE OCCUPANT VMT

Beyond increasing the use of public transit and biking, changes in residential and commercial behaviors will be necessary to reach Columbus' VMT reduction goals. The modeling estimates that teleworking will need to increase from 4.8% to 10.8% by 2030 and to 30% by 2050. A study from the University of Chicago estimates that about 37% jobs in the United States are eligible to work from home full-time.[iv] In addition to teleworking, additional options virtual learning environments were considered as another pathway for reducing the VMT. As a result of the global pandemic, the United States has been able to start quantifying the positive economic impact on the economy from virtual platforms.[v]

Passenger vehicle occupancy has been modeled to increase by 10% by 2030 and 20% by 2050 as carpool and rideshare incentives could be implemented. The use of rideshare services such as Uber and Lyft will continue to increase vehicle occupancy rates within the city, contributing to the increase in personal vehicle occupancy. Incentives for carpooling from public or private sector could also increase vehicle occupancy.

	Baseline	2030	2050
Teleworking	4.8%	10.8%	30.0%
Personal Vehicle Occupancy	1.67	1.84	2.09

Table 13. Telework and Vehicle Occupancy Projections

TRANSIT USE

Beyond the increase in transit use resulting from development density, teleworking and passenger vehicle occupancy increases, transit usage is modeled to increase passenger vehicle miles 20% by 2030 and 50% by 2050 from baseline levels, resulting in a transit mode share of 2.88% and 3.6% respectively. This measure was modeled independently from the development density and mode shift strategies.

ZERO EMISSIONS VEHICLE TRANSITION

Since the VMT calculations include passenger vehicle use as a mode share, the reductions from other mode shift strategies are subtracted before modeling ZEV adoption to avoid double counting of reductions. Once the remaining VMT was determined, it was split between passenger vehicles from private ownership, government, commercial (corporate owned) and rideshare. Note that only EVs were modeled in this measure as other ZEV technology (such as hydrogen vehicles) are still early in development. ZEV refers to zero emissions out of the tail pipe in operation, whereas EVs currently are accounting for emissions from electric charging from grid emissions.

A study conducted by Lyft and Uber in 6 major U.S. cities provided the modeling inputs with an estimate of the rideshare service's VMT percentage in Columbus.[vi] Our model uses Los Angeles' and Seattle's values as a reference as their population and size are most similar to Columbus', resulting in a predicted share of 2%. Another study from Deloitte estimates 18% of all VMT come from corporate vehicles – which they quantify as a combination of commercial and governmental vehicles.[vii] Since Columbus' government track inventory already contains the government VMT, commercial VMT was able to be determined from the remaining value.

Source	2030 (Miles)	2050 (Miles)
Privately Owned	6,233,389,396	3,395,874,289
Commercial	1,384,027,043	760,533,229
Government	15,098,691	1,633,070
Rideshare	140,405,616	76,216,630

Table 14. Passenger vehicle VMT by ownership

The goal of making 15% of all cars in Columbus EVs by 2030 is projected to increase annually as additional new vehicle models and used vehicles become available. The forecasted sales are informed by a United States EV sales forecast research study published in partnership with IHS Markit.[viii] These percentages along with assuming a new car turnover rate of 10%, EVs are modeled to make up 15% of Columbus' vehicle fleet by 2030.

Year	Forecasted EV Sales	% Total Vehicle Fleet
2022	4.8%	1.3%
2023	6.5%	2.0%
2024	8.6%	3.0%
2025	11.2%	4.3%
2026	14.3%	5.9%
2027	16.3%	7.8%
2028	20.2%	10.1%
2029	23.4%	12.7%
2030	26.6%	15.6%

Table 15. New EV Sales Forecast

ClearPath sets the average miles per gallon (MPG) for gas-powered passenger vehicles at 23.96 with an emission factor of 0.000358 $MTCO_2e$/miles. For EVs, the average miles per gallon gas equivalent (MPGe) is set at 114 with an emission factor of 0.0001574 $MTCO_2e$/mile. The modeling also accounts for the reduced grid emissions factor associated with the vehicle charging over time . All electrified VMT are multiplied by gasoline's emission factor to determine carbon savings, however since the grid will not be fully clean until 2050, the grid's emission factor needs to be used as well to account for charging. Table 15 has been included to provide an example of how emission savings for VMT electrification was calculated.

Year	VMT Reduced	$MTCO_2e$ Gas Savings	$MTCO_2e$ from Charging	Total $MTCO_2e$
2022	-103,889,823	-37,206	11,497	-25,709
2023	-103,889,823	-37,206	11,141	-52,130
2024	-103,889,823	-37,206	10,796	-79,230
2025	-103,889,823	-37,206	10,226	-107,920
2026	-103,889,823	-37,206	9,687	-137,595
2027	-103,889,823	-37,206	9,175	-168,186
2028	-103,889,823	-37,206	8,691	-199,605
2029	-103,889,823	-37,206	8,233	-231,784
2030	-103,889,823	-37,206	7,838	-264,312

Table 16. Electric Vehicle Charging Emissions

It is important to note that the Federal Corporate Average Fuel Economy (CAFE) standards were not used in any transportation calculations to decrease the carbon intensity of gas-powered vehicles. The CAFE standards are a set of government mandates requiring automakers to increase their yearly average MPG fleet-wide in an attempt to reduce the carbon impact of the transportation sector. Since internal combustion engine cars have started to plateau in efficiency, manufactures are marketing more electric vehicles to increase their average fleet MPG (including MPGe for EVs) for the year to avoid fines. The CAP model includes the increase in EV sales from the ZEV adoption measures which account for the increase in car manufacturer's fleetwide MPG efficiency.

MEDIUM AND HEAVY DUTY ZERO EMISSION VEHICLE ADOPTION

All heavy duty diesel power vehicles account for a total of 450,151,227 VMT in the 2013 Baseline. The adoption of zero emission medium and heavy-duty vehicles are modeled as a steady phase out of 2% of diesel VMT between 2022 and 2030, and 100% of remaining diesel VMT between 2030 and 2050. The emission factor for diesel is set at 0.00167 $MTCO_2e$/mile in ClearPath. ClearPath does not yet have an existing measure that models the electrification of diesel-powered vehicle since the MPGe for medium/heavy duty ZEVs are still early in their research. For this reason, the carbon emissions resulting from charging medium/heavy ZEVs was omitted from calculations at this time. The end goal of 2050 is unaffected by this omission since the electric grid will be decarbonized, but the 2030 midpoint goals should be updated as further technology and ClearPath measures are developed.

WASTE

ORGANIC & RECYCLABLE WASTE

The total waste generated by Columbus was broken down according to the waste characterization provided by SWACO.[xiv] Reductions were applied to the total waste generated in each category. Organic waste was defined as food scraps, grass, and leaves and recyclable waste was defined as newspaper, office paper, cardboard and lumber. All remaining waste was listed as municipal solid waste (MSW). Table 17 shows the emissions factors ClearPath assigns to each waste category.

Resource	SWACO Breakdown	Emissions ($MTCO_2e$/Wet Ton)
Newspaper	7.7%	0.4339
Office Paper	6.7%	1.6077
Cardboard	10.4%	1.1620
Food Scraps	14.7%	0.7838
Leaves	1.5%	0.334
Lumber	7.3%	0.0720
Grass	1.5%	0.339
MSW	50.1%	0.6532

Table 17. Waste Emissions Factors

ADDITIONAL MEASURES MODELED

AVIATION

Most of the remaining transportation emissions are from aviation. Airlines for America (A4A), an industry trade organization comprised of major U.S. airlines, has developed a commitment to achieve net-zero emissions by 2050.[xv] The first step is to increase the production of sustainable aviation fuel (SAF) to 2 billion gallons by 2030, increasing its market share from less than 1% to about 9.3%. To be conservative, the model assumes SAF is 50% cleaner than standard jet fuel - a minimum set by the Roundtable of Sustainable Biomaterials (RSB).[xvi] The model captures A4A commitments by modeling the 9.3% increase in SAF by 2030 and becoming net-zero by 2050. Remaining emissions from SAF will be covered by carbon offsets, or further technology advances in the future around electrification options.

ELECTRIFICATION

While the electric grid moves towards decarbonization, the remaining carbon emissions produced from buildings will come from natural gas heating and cooking uses. To achieve carbon neutrality, Columbus will need to phase out natural gas by electrifying all new buildings. The CAP model steadily phases out remaining natural gas between 2030 and 2050.

AMBITION 2025

Ambition 2025 was included as a part of Columbus' initiative to achieve a total reduction goal of 45%. The model estimates an additional 720,000 tons of $MTCO_2$ will need to be removed to achieve this. The CAP model takes an equivalent percentage from each sector to reach this target in 2030. Updated modeling should reflect accurate increases for each sector, as they will have reciprocal impacts on the 2050 modeling.

SUMMARY OF RESULTS

The table below summarizes the CAP modeled direct GHG emissions reductions by each measure.

Measure	2030 (MT/CO_2e)	% Reduction	2050 (MT/CO_2e)	% Reduction
3.3	-720,000	8.48%	-	-
5.1	-11,088	0.13%	-20,284	0.13%
5.2	-8,572	0.10%	-129	0.00%
7.1	-19,629	0.23%	-2,956	0.02%
7.2	-316,955	3.73%	-11,931	0.07%
7.3	-924,222	10.89%	-17,438	0.11%
8.1	-1,755,945	20.69%	-1,656,781	10.38%
8.2	-6,374	0.08%	-28,243	0.18%
10.1	-264,312	3.11%	-1,546,108	9.69%
10.2	-220,428	2.60%	-578,214	3.62%
10.3	-20,826	0.25%	-1,041,487	6.52%
11.2	-439,011	5.17%	-1,421,539	8.91%
11.3	-6,903	0.08%	-18,873	0.12%
12.1	-65,869	0.78%	-133,784	0.84%
12.2	-105,979	1.25%	-278,687	1.75%
Grid	-3,395,556	40.01%	-7,174,224	44.95%
Aviation	-187,941	2.21%	-911,355	5.71%
Electrification	0	0.00%	-893,000	5.59%
Industrial	-18,000	0.21%	-227,000	1.42%

Table 18. Modeled GHG Emissions Reductions

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EXPECTED BENEFITS EVALUATION

EXPECTED BENEFITS ANALYSIS

Expected benefits are evaluated using the suite of questions included on pg. 31 of the CAP. The scoring measures are outlined below for the positive, negative or neutral impacts, including where there are places to refine implementation plans for positive community outcomes.

- -1 : Strategy will have a negative impact on the expected benefit category
- -0.5 : Strategy is likely to have a negative impact on the expected benefit category, but the impact is dependent on how the measure is implemented
- 0 : Strategy is unlikely to have an impact on the expected impact category, or has a neutral impact balance
- 0.5 : Strategy is likely to have a positive impact on the expected benefit category, but the impact is depended on how the measure is implemented
- 1 : Strategy will have a positive impact on the expected benefit category

Actions		Climate Justice						Environmental Quality				
		Affordable/energy Burden	strong community / improve accessibility	inclusive and expand infrastructure	address historical disparities / cultures	limits displacement	lower utility bills	impr outdoor AQI	reduce noise / light pollution	reduced natural demands	promotes smart behavior	incr ecosystem services
1.1	Incorporate climate action programs into Green Spot	0.5	1	1	0.5	0	1	0.5	0.5	1	1	0.5
2.1	Support green business initiatives	0	0.5	0.5	1	0.5	0.5	0.5	0	0.5	0	0.5
2.2	Increase annual sustainable development funding	0.5	1	0.5	0	-0.5	1	0.5	0.5	0.5	0.5	0
3.1	Develop a regional adaptive management plan	0	1	1	1	0	0	0	0	1	0.5	0
3.2	Advocate for state policies that align with low carbon and resilient solutions	0.5	0	0.5	0	0	0.5	1	1	1	0	0
3.3	Ambition 2025	0	1	0	0.5	0.5	0.5	0.5	0.5	0	0.5	0
4.1	Establish coordinated network of resilience hubs	0.5	1	0.5	1	1	0	0	0	0.5	0.5	0
4.2	Establish emergency alert system for natural hazards	0	1	1	0.5	0.5	0	0	0	1	0.5	0
5.1	Increase development density	0	1	0.5	0	-0.5	0	0.5	-0.5	0	1	0
5.2	LED streetlight retrofits	0	0.5	1	0.5	0	1	0.5	0.5	0.5	0	0
5.3	Increase equitable access to green space	0	1	1	1	1	0	1	0.5	0.5	0.5	0.5
5.4	Implement water adaptation strategies	0	1	1	0.5	1	0.5	0.5	0	1	0.5	1

Actions		Climate Justice						Environmental Quality				
		Affordable/energy Burden	strong community / improve accessibility	inclusive and expand infrastructure	address historical disparities / cultures	limits displacement	lower utility bills	impr outdoor AQI	reduce noise / light pollution	reduced natural demands	promotes smart behavior	incr ecosystem services
6.1	Assess and protect assets from the impacts of climate change	0	1	1	1	0.5	0	1	0.5	1	1	0.5
6.2	Reduce urban heat with tree canopy cover	0.5	1	0.5	0.5	0	0.5	1	1	0.5	0	1
6.3	Evaluate microgrid + storage projects	0.5	1	1	0.5	0	0.5	0.5	0.5	0.5	0	0
7.1	Increase residential on-site solar	0.5	0.5	1	0	0	1	0.5	0.5	1	1	0
7.2	Increase commercial on-site solar	0	0.5	1	0	0	1	0.5	0.5	1	1	0
7.3	Implement clean energy procurement	-0.5	0	0	0	0	-0.5	1	0.5	1	0.5	0
8.1	Increase energy efficiency	1	0	0	0.5	0.5	1	0.5	0.5	0.5	1	0
8.2	Increase water efficiency	0	0	0	0.5	0.5	1	0	0	1	1	0.5
9.1	Prototype zero carbon buildings	0	0	0.5	0	0	1	1	0.5	1	1	0.5
9.2	Adopt resilience standards	0	0	0.5	0.5	0.5	0.5	0	0	1	1	0
10.1	Increase private vehicle ZEV adoption	-0.5	0.5	1	0	0	-0.5	1	1	1	0.5	0
10.2	Implement ZEV fleets	0	0.5	1	0.5	0	-0.5	1	1	1	1	0
10.3	Promote medium/heavy duty ZEV adoption	0	1	1	0.5	0	-0.5	1	1	1	1	0
11.1	Implement comprehensive multi-modal network	0.5	0.5	1	0.5	-0.5	0	1	0.5	0	1	0
11.2	Reduce single occupant vehicle miles traveled	0.5	1	0	0	0	0	1	1	0.5	1	0
11.3	Increase transit use	0.5	0.5	1	0.5	-0.5	0	1	-0.5	0.5	1	0
11.4	Support active transportation infrastructure	0.5	1	0.5	0.5	0.5	0	0.5	0.5	0.5	1	0
12.1	Reduce landfilled organic waste	0	0	0.5	0	0	0.5	0.5	0	1	1	1
12.2	Reduce recyclable waste sent to the landfill	0	0	0.5	0	0	0.5	0.5	0	1	1	1
13.1	Support circular economy organizations	0	0.5	0.5	0.5	0	0.5	0.5	0	1	1	0.5

Actions		Human health						Economic prosperity					
		improves indoors	encourage physical activity	incr public safety	inc access to healthy food	improve mental health	health outcomes and costs	job creation	quality and diverse jobs	connection to education and jobs	inc job security	lower business operational costs	mitigate infrastructure risks
1.1	Incorporate climate action programs into Green Spot	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	1	0
2.1	Support green business initiatives	0.5	0	0	0.5	0.5	0	1	1	1	1	0.5	0
2.2	Increase annual sustainable development funding	1	0	0	0	0.5	0.5	0.5	1	0.5	0.5	1	0.5
3.1	Develop a regional adaptive management plan	0	0	1	0	0.5	0	0.5	0.5	0	0.5	0.5	1
3.2	Advocate for state policies that align with low carbon and resilient solutions	1	0	0.5	0	0	0.5	1	1	0.5	0.5	-0.5	1
3.3	Ambition 2025	0	0	0	0.5	0.5	0.5	0.5	0.5	0	0	0.5	0
4.1	Establish coordinated network of resilience hubs	0	0.5	1	1	1	0.5	0	0	1	0.5	0	0.5
4.2	Establish emergency alert system for natural hazards	0	0	1	0	1	0	1	0.5	0	1	0.5	1
5.1	Increase development density	0	1	0.5	0.5	0	0.5	1	0.5	0.5	0	0	0.5
5.2	LED streetlight retrofits	0	0	1	0	0	0	1	0.5	0	-0.5	1	0.5
5.3	Increase equitable access to greenspace	0	1	1	0.5	1	1	0	0.5	0.5	0.5	0	0.5
5.4	Implement water adaptation strategies	0	0	1	0	0.5	0.5	1	0.5	0	0.5	0.5	1
6.1	Assess and protect assets from the impacts of climate change	0	0	1	0.5	0.5	1	1	1	0	0.5	0.5	1
6.2	Reduce urban heat with tree canopy cover	0	0.5	1	0.5	1	1	0.5	0	0	0	0.5	0.5
6.3	Evaluate microgrid + storage projects	0	0	0.5	0	0	0	1	0.5	0.5	0	0.5	1
7.1	Increase residential on-site solar	0.5	0	0	0	0	0.5	1	1	0.5	1	0.5	0.5

Actions		Human health						Economic prosperity					
		improves indoors	encourage physical activity	incr public safety	inc access to healthy food	improve mental health	health outcomes and costs	job creation	quality and diverse jobs	connection to education and jobs	inc job security	lower business operational costs	mitigate infrastructure risks
7.2	Increase commercial on-site solar	0.5	0	0	0	0	0.5	1	1	0.5	1	0.5	0.5
7.3	Implement clean energy procurement	0.5	0	0	0	0	0.5	1	0.5	0	0	-0.5	0.5
8.1	Increase energy efficiency	0.5	0	1	0	0.5	0.5	1	1	0.5	0.5	1	0.5
8.2	Increase water efficiency	0.5	0	1	0	0.5	0.5	1	1	0.5	0.5	1	0.5
9.1	Prototype zero carbon buildings	1	0.5	0.5	0	0.5	0.5	1	0.5	0	0.5	1	0.5
9.2	Adopt resilience standards	1	0.5	1	0	0.5	1	1	1	0.5	0.5	0	0.5
10.1	Increase private vehicle ZEV adoption	0	0	1	0	1	1	0.5	0.5	1	0	1	0.5
10.2	Implement ZEV fleets	0	0.5	0.5	0	0.5	1	1	0.5	1	0	1	0.5
10.3	Promote medium/heavy duty ZEV adoption	0	1	0	0	0	1	1	0.5	1	1	1	0.5
11.1	Implement comprehensive multi-modal network	0	1	0.5	0.5	0.5	1	1	0.5	0.5	0.5	0	0.5
11.2	Reduce single occupant vehicle miles traveled	0	0.5	0.5	0.5	0.5	1	0.5	0	0.5	0	0.5	0
11.3	Increase transit use	0	0.5	0.5	0.5	0.5	0.5	1	0.5	1	0.5	0	0.5
11.4	Support active transportation infrastructure	0	1	0.5	0.5	1	1	0.5	0	0.5	0	0.5	0
12.1	Reduce landfilled organic waste	0	0	0.5	1	0.5	1	1	0.5	0.5	0.5	-0.5	0.5
12.2	Reduce recyclable waste sent to the landfill	0	0	0.5	1	0.5	1	1	1	0.5	0.5	-1	0
13.1	Support circular economy organizations	0	0	0	0.5	0.5	0.5	1	1	0.5	1	1	0.5

SUSTAINABLE COLUMBUS
ANDREW J. GINTHER, MAYOR

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