Modeling Assumptions

Emissions reductions from GHG and co-pollutants were estimated for the 4 priority measures identified in the CPRG Implementation Application. Projected changes in GHG emissions and co-pollutant emissions for measures 1.1, 1.1.1, 1.2, and 1.3 were modeled using the Rocky Mountain Institute's EPS tool.[1] Resulting impacts in 2025 to 2050 are quantified through December 31, 2049.

The measures modeled in EPS comprised of a "business-as-usual" (BAU) and a "policy" scenario developed by the BG MSA to project assumptions and key inputs related to the measure through 2050. The BAU scenario assumes no implementation of the GHG reduction measure but may consider impacts of existing initiatives in the BG MSA.[2] The BAU scenario projects GHG emission impact on the current course, leveraging publicly available population and development projections through 2050. The policy scenario aims to estimate an aggressive rate of measure implementation.

EPS estimates emissions impacts from a provided list of emissions reduction policies pre-populated in the tool. The EPS policy that corresponds best to each priority measure was selected to model emissions reductions potential. If the EPS policy did not meet the full intent of the measure, the model was modified and adjusted to calculate the proper outputs. The corresponding EPS policy to each measure is indicated below, where applicable. The corresponding policies in the EPS are provided in the desktop model using the BAU and policy scenarios and their key inputs. The difference in impact between the two scenarios was then used to quantify the impact of the measure.

The section below provides an overview of the scenarios, assumptions, and metrics that served as key inputs to modeling the priority measures utilizing one of the following tools: EPS or manual calculation.

Measure 1.1: Electrify public transit fleet

Overview

The EPS policy 'Electric Vehicle Sales Standard' was used to quantify the impact of the 'electrify public transit fleet' measure. This measure aims to replace the current public/private BG MSA and Western Kentucky University transportation fleet (consisting of buses, cutaways, vans, and minivans) with electric vehicles to reduce GHG emissions in the transportation sector. In this EPS policy, a the purchase and installation of the new Electric Vehicles is compared to typical diesel buses and gasoline cars/SUVs. To meet the Electrical Vehicle Sales Standard, the BG MSA public transport buses and cutaways were equated to Passenger Buses and the BG MSA public transport vans and minivans were equated to Passenger Cars and SUVs. The use of this standard will help quantify the impact in GHG emission reductions if our measure is implemented.

This policy models the adoption of electric vehicles for commuter transportation by multiple entities. The entities included in this model are GoBG Transit (City of Bowling Green), Bowling Green Transit, Topper Transit (Western Kentucky University), Warren County/Warren County Community Services, Inc.,

[1] Energy Innovation Policy & Technology LLC, Energy Policy Simulator. 2024.

[2] County Strategic Plans were considered in the development of the BAU scenario for each policy. BAU scenarios may see impact where existing initiatives in the BRADD strategic county plans correspond to a priority measure. See: Barren River Area Development District (BRADD), County Resources. 2022.

and Scottsville Transit. Asset data was collected from the National Transit Database from the Federal Transit Administration.[3]

Public transit electrification goals in BG MSA

There is currently no policy or initiative in the BG MSA for the electrification of their public transportation fleet. There have been strides towards electrification of school buses, such as the 13 electric school buses that have been supplied to the Bowling Green Independent School District[4], however, there have been no such strides for commuter buses to date. This electrification was made possible by the EPA's Clean School Bus Rebate Program, which provided a $5,135,000 grant.

The business-as-usual scenario aims to project the total public transit fleet requirement, leveraging population growth data. Additionally, there is no evidence of acquisition or use of electric buses, cutaways, vans, or minivans in the BG MSA for commuter purposes and are there currently no policies or incentives for the electrification of public transportation vehicles, specific to the BG MSA. The policy scenario attempts to replace the entire BG MSA public transportation fleet with electric vehicles by the year 2050. Details of how the business-as-usual (BAU) and policy scenarios were estimated are below:

BAU scenario

According to the National Transit Database, there were 25 buses/cutaways and 27 vans/minivans in the BG MSA in 2022. Leveraging 2022 population estimates from the United States Census Bureau [5] and population projections from the Kentucky State Data Center[6], the future requirement for public transportation vehicles in the BG MSA was estimated. Assuming the population to public transportation ratio will remain the same between 2022 and 2050, and the ratio of buses/cutaways to vans/minivans will also remain the same, the 2050 public transportation requirement of 36 buses/cutaways and 40 vans/minivans was projected.

Year	Total Buses/Cutaways	Total Vans/Minivans
2022	25	27
2025	26	28
2030	28	30
2040	32	35
2050	36	40

Policy scenario

There are currently no electric public transportation vehicles used in the BG MSA and a starting year of 2026 for electric vehicle acquisition was assumed. The policy scenario assumes a total acquisition of 25 buses and 4 light/medium-duty EV's, yearly acquisition of about 6 electric buses/cutaways and about 1 vans/minivans, to be implemented over the designated period of performance.

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[3] National Transit Database, 2022 Revenue Vehicle Inventory. *Federal Transit Administration.* February 2024.
[4] Barclay, J, Blue Bird Delivers 13 Electric School Buses to Bowling Green Independent Schools in Kentucky. *Blue Bird.* September 2023.
[5] United States Census Bureau, U.S. Census Bureau QuickFacts: Butler County, Kentucky; Allen County, Kentucky; Edmonson County, Kentucky; Warren County, Kentucky. February 2024.
[6] Kentucky State Data Center, Population and Household Projections in Kentucky, Kentucky Counties, and Area Development Districts. *University of Louisville.* August 2022.

Year	Electric Buses/Cutaways	Electric Vans / Minivans
2022	0	0
2025	0	0
2030	25	4
2040	25	4
2050	25	4

Measure 1.1.1: Expand public transit and improve routes

Overview

The EPS policy 'Mode Shifting' is used to quantify the impact of the 'expand public transit and improve routes' measure. To focus on the impact of mode shifting from passenger vehicles to public buses, the specific key input selected under this policy is passenger cars and SUVs.

To select a realistic target for this policy, changes in public transit ridership under two scenarios were estimated: (1) BAU scenario and (2) policy scenario.

Details of how the BAU and policy scenarios were estimated are below:

Public transit expansion goals in BG MSA and WKU

Currently, Warren County has an objective to increase the area serviced by Go BG public transit by 30% by 2027.[7] Thus, the public transit ridership is assumed to increase by 5% in Warren County by 2030, 10% by 2040, and 15% by 2050, under the assumption that implementation will begin to take affect by 2026.[8]

Population growth in BG MSA and WKU

The Kentucky State Data Center is responsible for the demographic and population projections for each county in Kentucky.[9] Projections for the residential population of Allen County, Butler County, Edmonson County, and Warren County are available through 2050.

BAU scenario

The variables used to project the business-as-usual scenario for expanding public transit and improving routes in the BG MSA are (1) increase in public transit ridership and (2) VMT reduced from passenger cars.

Impact of VMT in the BG MSA

In 2023, the total number of passengers on GoBG Transit's bus routes was 54,100[10]. Assuming this number is the number of unique rides taken on public transit in the year, it is estimated that 19 to 29 Daily Vehicle Miles Traveled (DVMT) in a passenger car is reduced for each public transit ride. DVMT in passenger cars per capita is determined utilizing the following data sources: DVMT per county published by the Kentucky

[7] Barren River and Development District, Warren County Strategic Objectives. 2022.

[8] As Go BG makes up only 67% of Warren County's public fleet, an increase in area serviced is not assumed to equate an equivalent increase in ridership in the whole county. See: National Transit Database, 2022 Revenue Vehicle Inventory. *Federal Transit Administration*. February 2024.

[9] Kentucky State Data Center, Population and Household Projections in Kentucky, Kentucky Counties, and Area Development Districts. *University of Louisville.* August 2022.

[10] Novoselia, M., Bowling Green's growth outpaces public transportation. *WKU Journalism.* March 2023.

Transportation Cabinet,[11] county population published by the U.S. Census,[12] commuting characteristics by county published by the U.S. Census.[13]

Scenario	Item	Current state	2025	2030	2040	2050
BAU	Increase in public transit ridership (%) - Warren County	0%	0%	5%	10%	15%
	VMT in passenger cars reduced	1,552,518	1,552,518	1,630,143	1,707,769	1,785,395

Policy scenario

Under the policy scenario, public transit ridership is assumed to increase in all counties to 15% by 2050. This follows GoBG Transit's goal of increasing areas serviced by 30% by 2027 in the BAU scenario. This policy assumes the number of vehicles would remain constant, [14] and that the current routes will improve to connect residents to the urban center.

Scenario	Item	Current state	2025	2030	2040	2050
POLICY	Increase in public transit ridership (%) – Allen, Butler, Edmonson, and Warren County	0%	0%	5%	10%	15%
	VMT in passenger cars reduced	1,552,518	1,552,518	1,659,381	1,779,531	1,881,041

Measure 1.2: Expand green spaces and mixed-use paths

Overview

This measure projects emissions changes from both mode shifting and carbon sequestration. Two EPS policies were used to quantify emissions impacts: 'carbon sequestration through afforestation and reforestation' is used to quantify impacts of expanding green spaces, and 'mode shifting' is used to estimate impacts of mixed-use paths under the assumption that this will replace VMT by car to VMT by foot. The sum of emissions reductions from these two EPS policies are combined to provide total emissions impacts for this measure.

This measure develops multi-use paths to connect residents with important locations and services in their neighborhoods, such as schools, bus stops, grocery stores, and recreational activities. These paths encourage active transport and community connectivity by accommodating micro-mobility, such as walking and cycling, as a form of commute. In addition to the expansion of mixed-use paths, the City of BG will look to acquire additional green spaces. The City of BG plans to dedicate roughly $9.2 million for this effort. The agriculture and land management sector in the City of BG emits an estimated 8% of overall emissions. This measure focuses on expanding green spaces and enhancing them with native vegetation, such as low-lying shrubs that do not interfere with overhead power lines. The City of BG will also examine the potential for creating green rooftops through the region. Opportunities for green space expansion will

[11] Sanford, G., Planning Highway Information (HIS Database) | KYTC. *Team Kentucky Transportation Cabinet.* 2022.
[12] United States Census Bureau, QuickFacts Kentucky. December 2022.
[13] United States Census Bureau, Commuting Characteristics. December 2022.
[14] See measure 1.1 for details on public fleet vehicles per county.

continue to present themselves in the near future and the City of BG will ensure efficient and effective investments are made when acquiring land.

EnviroAtlas[15] was used to pull 2019 land use statistics for each county including the total county area, developed land, undeveloped land, and increase in developed land over the previous three years. These statistics were leveraged to sum the total areas, total developed areas, and total undeveloped areas in the combined counties. Details of how the BAU and policy scenarios were estimated are below.

Details of how the BAU and policy scenarios were estimated are below:

Sidewalk expansion goals in BG MSA

Currently, Warren County has objectives identify connectivity measures to and from downtown areas and aims to seek funding for sidewalk repairs in 2024.[16] Additionally, the Bowling Green Public Works Department has established a sidewalk plan with an associated set of "prioritized projects" that will create a basic skeletal framework of sidewalks to provide safe routes to schools and parks within all the City's neighborhoods.[17]

Commuting by walking in the BG MSA

As of 2022, the US Census estimates that 1.8% of people in the BG MSA walk to work[18]. This applies to the total number of workers in the MSA (35% of total population).[22] This measure uses this data to assume that 1.8% of people in the BG MSA commute by walking.

Population growth in the BG MSA

The Kentucky State Data Center is responsible for the demographic and population projections for each county in Kentucky.[19] Projections for the residential population of Allen County, Butler County, Edmonson County, and Warren County are available through 2050.

BAU scenario for mixed use paths

The variables used to project the business-as-usual scenario for expanding mixed-use paths in the BG MSA are (1) percentage increase in commuting by walking and (2) VMT reduced from passenger cars.

Impact of VMT in the BG MSA

In 2023, the total amount of the BG MSA population using walking as a form of commute was estimated to be 1.8% according to US Census estimates of means of transportation to work. As Warren County currently has objectives in place for measures related to sidewalk expansion measures, as mentioned in "sidewalk expansion goals" above, a 7% increase in walking as a form of commute is attributed to the BAU scenario by 2030 and remains consistent through 2050. Thus, 8.8% Warren County's population is estimated to commute by walking every year between 2030-2050.[20]

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[15] EnviroAtlas, EnviroAtlas Summarize My Area. *United States Environmental Protection Agency*. 2019.
[16] Barren River and Development District, Warren County Strategic Objectives. 2022.
[17] City County Planning Commission, Focus 2030 Comprehensive Plan for Warren County. January 2023.
[18] United States Census Bureau, Commuting Characteristics. 2022.
[19] Kentucky State Data Center, Population and Household Projections in Kentucky, Kentucky Counties, and Area Development Districts. *University of Louisville.* August 2022.
[20] A 7% increase in walking to commute to work over the period of 2025-2030 under the BAU scenario for this measure references the impact of a similar measure in Minneapolis's walking and biking improvement plan. This

VMT impact is calculated by reducing the annual per capita passenger vehicle miles for the expected percentage of the population commuting by walking that year. VMT in passenger cars per capita is determined utilizing the following data sources: DVMT per county published by the Kentucky Transportation Cabinet,[21] county population published by the U.S. Census,[22] commuting characteristics by county published by the U.S. Census.[18]

Scenario	Item	Current state	2025	2030	2040	2050
BAU	Increase in commuting by walking (%) - Warren County	0%	0%	7%	0%	0%
	VMT in passenger cars reduced	29,816,897	30,712,614	191,417,466	177,760,332	198,916,912
	VMT in motorcycles reduced	1,170,303	1,205,459	7,513,069	6,977,031	7,807,420

Policy scenario for mixed use paths

The EPS policy 'Mode Shifting' is used to quantify the impact of the 'mixed-use shared use paths' portion of this measure. Under the policy scenario, commuting by walking is estimated to increase by 10% in the BG MSA for a total of 11.8% in the year 2050. The difference between the BAU and policy scenario for this measure accounts for a 3% (7% to 10%) increase in commuting by walking in 2050 in all counties.[23] The corresponding decrease in passenger vehicle miles from pedestrians replacing cars is shown in the table below. It is implied that the shared use paths will be built primarily in densely populated areas, like the City of Bowling Green, to connect residents to the urban center. Population growth is accounted for in the emissions projections.

Scenario	Item	Current state	2025	2030	2040	2050
POLICY	Increase in commuting by walking (%) – Allen, Butler, Edmonson, and Warren County	0%	0%	10%	0%	0%
	VMT in passenger cars reduced	29,816,897	30,712,614	213,087,368	238,360,445	266,729,495
	VMT in motorcycles reduced	1,170,303	1,205,459	8,363,605	9,355,565	10,469,040

BAU scenario for expand green spaces

plan saw a walking as a form of commute increase 7% between 2012-2016. Differences in Minneapolis's geographic, regulatory, and political landscape from that of the BG MSA that can affect the impacts of this measure were not evaluated. See: Longenecker, P., Walking and Biking in Numbers. *Minneapolis City of Lakes.* 2018.

[21] Sanford, G., Planning Highway Information (HIS Database) | KYTC. *Team Kentucky Transportation Cabinet.* 2022.

[22] United States Census Bureau, QuickFacts Kentucky. December 2022.

[23] Warren County comprises nearly 70% of the population of the BG MSA, which is expected to make up the largest portion of commuters walking. Therefore, the relative increase in commuting by walking in the other counties is proportionate to the population: Allen, Butler, and Edmonson counties comprise about 30% of the BG MSA population, thus this measure estimates a 3% increase in commuting by walking, proportionate to population.

The EPS policy 'Carbon sequestration' is used to quantify the impact of the 'expand green spaces' portion of this measure. According to the data from EnviroAtlas, developed land in the BG MSA has increased by 7.81 km² between 2016-2019. By dividing that increase by three (number of years), the BG MSA is projected to increase its developed land by approximately 2.6 km² per year, or 643 acres. This growth rate was used to estimate the growth of developed land in the BG MSA in 2025, 2030, 2040, and 2050 for the BAU scenario:

Year	Total Developed Land in BG MSA (acres)	Less Green Space from previous year (acres)
2023	28,358	-
2025	29,644	1,287
2030	32,861	3,216
2040	39,294	6,433
2050	45,727	6,433

Policy scenario for expand green spaces

The World Health Organization has recommended an ideal value of 50m² of green space per individual.[24] Assuming a starting year of 2026, the green space recommendation was multiplied by the population projections for the BG MSA in 2030, 2040, and 2050 from the Kentucky State Data Center to project the estimate space requirements for the policy scenario. The result estimates an average of .62 MT CO2e of GHG reduction per acre of land and is applied to the 257 acres of land BG MSA anticipates purchasing [25]

Year	Total Green Space Requirements in the BG MSA (acres)
2030	Minimum: 257, Maximum: 2,501
2040	Minimum: 257, Maximum: 2,798
2050	Minimum: 257, Maximum: 3,131

[24] Russo, A and Giuseppe, C., Modern Compact Cities: How Much Greenery Do We Need?. *Department of Landscape Design and Sustainable Ecosystems, Peoples' Friendship University of Russia, RUDN University*. October 2018.

[25] Kentucky State Data Center, Population and Household Projections, Kentucky, Kentucky Counties, and Area Development Districts. *University of Louisville*. August 2022.

Measure 1.3: Developing and distributing solar energy generation

Overview

The EPS policy "Distributed Solar Carve-Out" was utilized to quantify the elevation in electricity production stemming from developing and distributing solar energy generation because of this initiative. This model obliges an expressly defined percentage of the total retail electricity demand to be supplied by distributed solar systems. In the process of modeling this measure, the pivotal variable subject to analysis will be the difference in electricity manufactured by developing and distributing solar energy generation between a BAU and policy scenario.

This measure focuses on electricity generation solely by solar PVs in two categories: (1) generation from small-scale solar PVs, and (2) generation from community solar PV systems.

Solar PV generation in the BG MSA today

In 2024 in the BG MSA, Solar PV generating capacity is 650 kilowatts (kW) from 28 houses that have small-scale solar PVs. There is currently only one county in the BG MSA that has ordinances for community solar projects, Warren County.[26] Although Warren does have an ordinance for community solar, there have not been projects to date.[27] Therefore, the current Solar PV generating capacity from community solar projects is zero. For broader context on the State of Kentucky's community solar project, there is only five projects with the most recent two being completed in 2019. [27]

BAU

In this analysis, it is posited that the growth of small-scale PV capacity in the BAU scenario within the BG MSA will align with the projected expansion rate for PVs in end-use sectors across the United States,[28] as posited by the Annual Energy Outlook (AEO) 2023 Reference case.[29] According to this scenario, the annual average growth rates for PV capacity in end-use sectors stands at 7.4% from 2025 to 2030, 6.1% from 2030 to 2035, 5.2% from 2035 to 2040, 4.5% from 2040 to 2045, and 4.1% from 2045 to 2050. Applying these growth rates to the small-scale PV capacity within the BG MSA can produce a projection of electricity generation under the BAU scenario from 2022 to 2050, as displayed below.

As for the growth in community solar PV capacity in the BAU scenario within the BG MSA is anticipated that there would not be any community solar projects. Due to the limited scope of community solar within Kentucky, the lack of ordinances in three of the four counties to implement these projects, and current lack thereof, this was an assumption that was drawn for the current modeling for the PCAP.

Policy	Item	2022	2025	2030	2035	2040	2045	2050

[26] Mattingly, H., KY Solar Ordinances (arcgis.com). *Kentucky Office of Energy Policy. 2024.*

[27] Chan, G., Heeter, J., Xu, K., Sharing the Sun Community Solar Project Data. *United States Department of Energy*. December 12, 2023

[28] The EIA defines end-use sectors as including combined-heat-and-power plants and electricity-only plants in the commercial and industrial sectors that have a non-regulatory status. It also includes small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.

[29] The reference case represents EIAs best guess under nominal conditions, which presumes no new policy or laws over the modeled time horizon. See: United States Energy Information Administration, Narrative 2023 - U.S. Energy Information Administration (EIA). March 2023.

BAU	End-use sector solar PV generating capacity each year (kW)	48,590,000	67,560,000	68,000,000	120,790,000	151,867,000	185,800,000	224,260,000
	Small-scale PV generating capacity in Georgia each year (kW)	650	752.55	1,008.76	1,343.59	1,798.03	2,498.34	3,327.61
	Community solar PV (kW)	0	0	0	0	0	0	0
	Total solar PV potential (kW)	48,590,650	67,560,753	68,001,009	120,791,344	151,868,798	185,802,498	2,242,603,328

Policy scenario

Within the policy scenario, there is a prediction of more accelerated growth rates for both small-scale PV capacity and community solar capacity in the BG MSA, when compared to the growth rates without policy intervention. This assumption is mainly due to the introduction of a measure that encourages small-scale PV generation and community solar PV generation.

The AEO 2023 Low Zero-Carbon Technology Cost case's projections for generating capacity of PVs in end-use sectors from 2025 to 2050 serves as a reference for this policy scenario, as presented in below. This case was chosen mainly because the incentives for community solar projects would likely be in the form of an investment tax credit or production tax credit, thereby reducing the costs of solar PVs.

Subsequently, it is posited that the amount of small-scale solar PVs' generating capacity within the BG MSA in the policy scenario will grow at the same rate as that of the PVs in the U.S end-use sectors, as predicted by the AEO 2023 Low Zero-Carbon Technology Cost case.[30] According to this policy intervention there will be a further 10 MW of utility scale solar deployed over the course of 2025 through 2050.

These growth averages are applied to the small-scale PV generating capacity within the BG MSA to project its electricity generation capacity in the policy scenario from 2022 to 2050.

There is a further assumption that the generating capacity of community solar PV within the BG MSA in the policy scenario will grow at the same pace as the project growth of PVs in the U. S's electric power sector according to the AEO 2023 Low Zero-Carbon Technology Cost case. As per this case, the average annual growth rate stands at 21.8% from 2025 to 2030, 8.6% from 2030 to 2035, 4.2% from 2035 to 2040, 4.7% from 2040 to 2045, and 4.2% from 2045 to 2050. These rates are applied to the community solar PV capacity in the BG MSA to project its generating capacity inside the policy scenario from 2022 to 2050, which is illustrated in below.

Policy	Item	2022	2025	2030	2035	2040	2045	2050

[30] The AEO 2023 Low Zero-Carbon Technology Cost case assumes technology costs of power generation technologies that produce zero emissions are lower than the Reference case. Specifically, it is assumed that overnight capital costs and fixed operating and maintenance costs decline more rapidly than in the Reference case.

POLICY	End-use sector solar PV generating capacity each year (kW)	48,590,000	67,560,000	68,000,000	120,790,000	151,867,000	185,800,000	224,2600,000
	Small-scale PV generating capacity in Georgia each year (kW)	650	753	10,000	10,000	10,000	10,000	10,000
	Community solar PV generating capacity each year (kW)	0	0	0	0	0	0	0
	Total solar PV generating capacity each year (kW)	48,590,650	67,560,753	68,010,000	120,800,000	151,877,000	185,810,000	224,270,000