The background of the cover is a photograph of a large steel truss bridge spanning a wide river. The bridge has multiple concrete piers supporting its structure. The sky is filled with white, fluffy clouds. In the foreground, there is a concrete embankment with some green grass and weeds. A dark blue, semi-transparent graphic overlay with rounded corners is positioned in the center, containing the title text.

MEMPHIS AREA
CLIMATE ACTION
PLAN



FROM MAYOR JIM STRICKLAND, CITY OF MEMPHIS



A handwritten signature in black ink that reads 'Jim Strickland'.

Jim Strickland, Mayor

In partnership with Mayor Harris, I am pleased to present the Memphis Area Climate Action Plan, Memphis' first effort to comprehensively address our community's contributions to climate change. Since 2015, our city has been part of the Global Covenant of Mayors for Climate & Energy, a formal commitment of city leaders across the world to tackle climate change by taking steps to reduce greenhouse gas emissions and enhance the resilience of their communities. I am proud that Memphis is part of this global commitment, as well as other regional partnerships such as the Mississippi River Cities & Towns Initiative that support sustainable development, strong economies, environmental protection, and resilience to climate change.

This Climate Action Plan is aligned with our city's renewed focus on long-range planning. Memphis 3.0 – the city's first Comprehensive Plan in 40 years – lays out a strong vision for future growth and development that focuses on building up, not out, anchoring growth on the strengths of our core and neighborhoods, enhancing connectivity and access, and improving opportunity for all our residents. This vision is fundamental to taking action on climate change. Encouraging walkability, transit access, and denser, mixed-use development will reduce our community's climate change impacts and improve quality of life for our residents.

Climate change poses real threats to our community. Increased flooding, more frequent heat events & drought, and severe storms are all risks our city faces. Addressing climate change locally not only helps reduce these risks, but also presents exciting opportunities to positively impact everyone in our city. These actions will improve our air and water quality, lead to better health outcomes for our residents, and encourage the growth of new green businesses and jobs. Most important, these actions focus on creating a more equitable city. Climate change most impacts vulnerable populations, and it is necessary to prioritize programs and investments that will reduce disparities and increase opportunities for these communities.

Successful implementation of this plan will require the efforts of our entire community. While city and county government leadership is essential, we must collaborate with the private sector – nonprofit and advocacy groups, businesses, neighborhood organizations, faith communities and others – to achieve these ambitious goals. I look forward to the challenge, and invite you to join us in this important, transformative work.

FROM MAYOR LEE HARRIS, SHELBY COUNTY



A handwritten signature in blue ink that reads "Lee Harris".

Lee Harris, Mayor

Ten years ago, a diverse group of stakeholders came together to create the Memphis region's first long-range sustainability plan, Sustainable Shelby. Since then, we have seen real progress toward reaching our vision of a sustainable community. Shelby County Government has led by example through energy efficiency, recycling, and green storm water management efforts in our facilities. Active transportation infrastructure – bicycle lanes, greenway trails, and pedestrian paths – has increased dramatically across Shelby County and the broader region. The private and public sector have worked to increase investments in healthy and energy efficient housing for our residents. Recent long-range planning efforts such as the Mid-South Regional Greenprint and Memphis 3.0 provide a framework for enhancing green infrastructure, improving community resilience, and reinvesting in our existing neighborhoods.

The Memphis Area Climate Action Plan seeks to accelerate these efforts to foster a more sustainable region. This plan provides detailed goals and objectives for reducing our carbon footprint and outlines key actions that will not only help us achieve these goals but will also lead to a healthier, more prosperous, and more equitable community. It is no secret that the most effective strategies for fighting climate change - reducing reliance on fossil fuels, increasing our use of clean, renewable energy sources, changing our land use to bring destinations closer together, improving transit and active transportation options, and reducing waste – will deeply benefit our environment, the health of our residents, and our long-term bottom line. In tandem with the Mid-South Regional Resilience Master Plan, we now have a comprehensive strategy that looks at how we mitigate our contributions and adapt to a changing climate.

Climate change is a global issue, and the scale of efforts needed to address it can seem daunting. Despite these challenges, it is important that our region acts now. I am excited to work with Mayor Strickland, other elected officials, major employers, nonprofits, neighborhood organizations, and every resident in our region to implement this strategy. Through collaboration and partnership, we can ensure a brighter, safer, healthier future for our children and grandchildren.

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EXECUTIVE SUMMARY

Climate change has real consequences for our community, the nation, and the world, and action is necessary. The Memphis area faces several climate threats – such as flooding, extreme heat and drought, and damaging wind - that are projected to become more frequent and more severe over the next 50 years. These events can have substantial impacts on our community related to property damage, compromised public health, environmental degradation, and lost economic activity.

Developing a plan to reduce our community's contributions to climate change not only helps mitigate these negative effects, but also has the potential to positively impact our residents' quality of life in multiple ways. For example, reducing greenhouse gas emissions also reduces other harmful air pollutants, leading to improved air quality, cleaner neighborhoods, and better health outcomes. Since the impacts from climate change are most acutely felt by low-income communities, the Memphis area can also work toward becoming a more equitable and just community by taking action on climate change.

Cities are leading the way on this effort, and Memphis has pledged to track its carbon emissions and develop plans to mitigate and adapt to climate change by joining the Global Covenant of Mayors, a formal commitment of over 9,000 city leaders across the world to tackle climate change. To meet its commitment, Memphis began the climate action planning process in June 2018 under the umbrella of the Memphis 3.0 comprehensive planning process. The land use and transportation focus of Memphis 3.0 is fundamental to addressing climate change and creating a more sustainable community. This climate action plan also carries forward the vision and goals of the 2008 Sustainable Shelby Plan, the region's first long-range sustainability planning effort. To measure emissions and provide guidance to City and County government on climate action, this plan uses Shelby County as the boundary. This builds on past and current work locally that addresses sustainability in a regional manner and recognizes the connection between the regional economy and emissions.

The Memphis area's greenhouse gas emissions for the baseline year of 2016 totaled 17,191,915 metric tons (MT) CO₂e/year. **The Climate Action Plan outlines how the Memphis area could reduce greenhouse gas emissions below 2016 levels 15% by 2020, 51% by 2035, and 71% by 2050.** While the vast majority of the 2020 reductions are projected as a result of actions outside of our local control - for example, a planned increase in carbon-free energy sources in the Tennessee Valley Authority's (TVA) energy portfolio and projected efficiency improvements in vehicles due to federal requirements - the mid-term and long-term targets will require concerted local action, collaboration, and investment.

The Memphis Area Climate Action Plan aims to provide community members, businesses, and local government with a framework for achieving significant reductions in greenhouse gas emissions and fostering a more equitable, healthy, and prosperous community. The framework outlines specific actions in three sectors - energy, transportation, and waste - to achieve these goals.

Priority Actions



Action Area 1: Improve Energy Efficiency of Buildings And Key Infrastructure

- ▶ Priority Action E.1 Implement Green Building Standards and Incentivize Innovative Green Building Design
- ▶ Priority Action E.2 Improve Low-Income Housing Energy Efficiency
- ▶ Priority Action E.3 Enhance and Expand Energy Outreach and Education Programs
- ▶ Priority Action E.4 Retrofit Outdoor Streetlights to LED
- ▶ Priority Action E.5 Expand Financing Options for Residential Energy Efficiency Retrofits

Action Area 2: Transform Our Energy Supply

- ▶ Priority Action E.6 Decarbonize the Electric Grid with Renewable Energy

Action Area 3: Increase Green Infrastructure and Community Resilience

- ▶ Priority Action E.7 Nurture and Expand the Urban Tree Canopy
- ▶ Priority Action E.8 Ensure Alignment of Climate Change Mitigation and Adaptation Efforts



Action Area 1: Shift to Low-Carbon Transportation Modes and Reduce Reliance on Motor Vehicles

- ▶ Priority Action T.1 Implement Land Use Patterns that Support Active Transportation and Transit
- ▶ Priority Action T.2 Create Complete Streets that Prioritize Walking and Bicycling
- ▶ Priority Action T.3 Enhance Public Transit

- ▶ Priority Action T.4 Reduce Commute Trips through Transportation Demand Management Strategies

Action Area 2: Set the Stage for Vehicle Electrification

- ▶ Priority Action T.5 Encourage Electric Vehicle Adoption and the Development of Charging Infrastructure

WASTE



Action Area 1: Reduce Waste and Move Toward a Zero-Waste Future

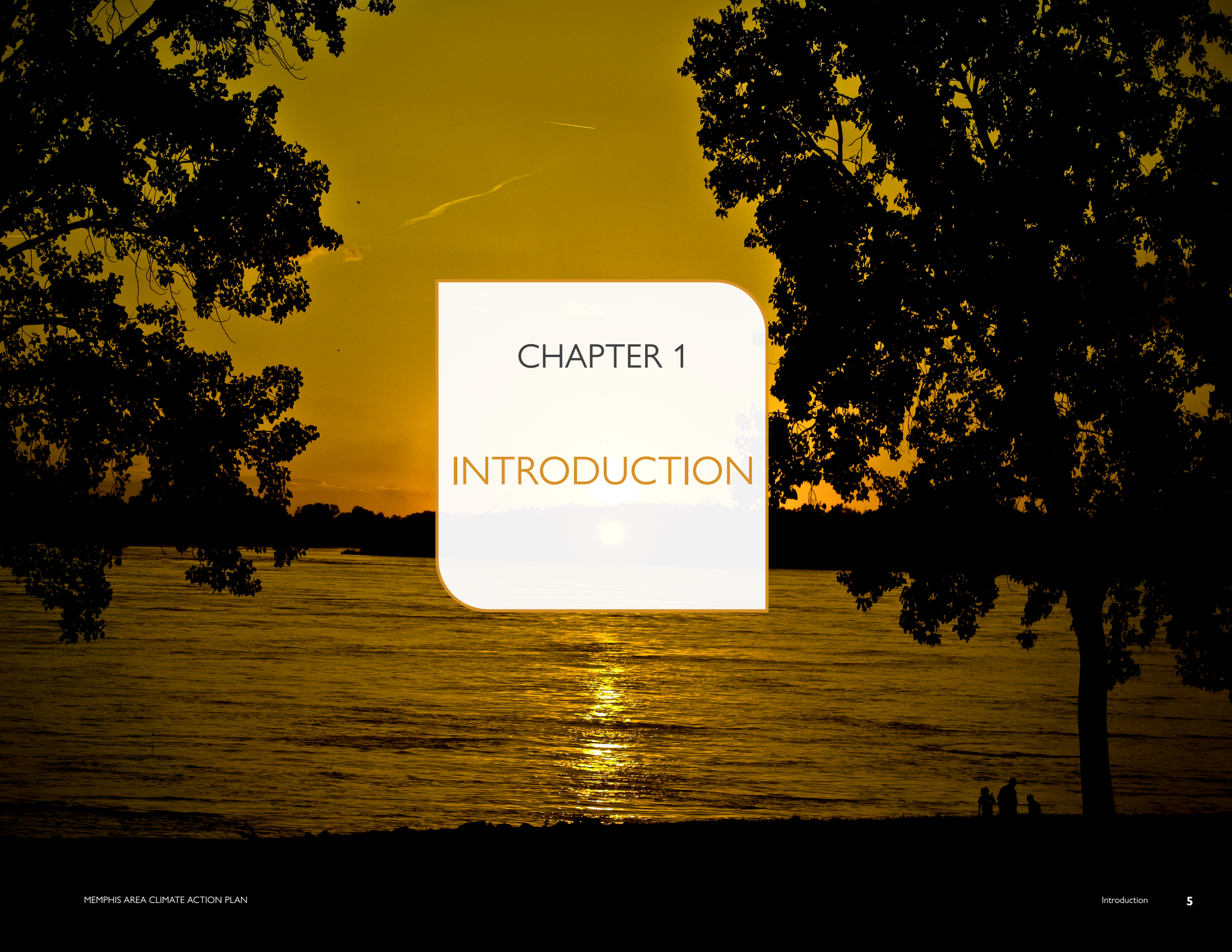
- ▶ Priority Action W.1 Divert Greater Amounts of Organic Waste from Landfills
- ▶ Priority Action W.2 Reduce the Overall Amount of Waste Generated
- ▶ Priority Action W.3 Divert Greater Amounts of Inorganic Materials from Landfills

Action Area 2: Promote a Cultural Shift in Our Community's Approach to Waste

- ▶ Priority Action W.4 Improve Tire Management and Collection Practices
- ▶ Priority Action W.5 Expand Education and Outreach Efforts to Encourage Behavior Change

Action Area 3: Improve Practices and Technology at Wastewater Treatment Facilities and Landfills

- ▶ Priority Action W.6 Enhance Methane Recovery and Landfill Gas Destruction



CHAPTER 1

INTRODUCTION

INTRODUCTION

Purpose of the Climate Action Plan

The Memphis Area Climate Action Plan serves as a tangible roadmap to reducing greenhouse gas emissions and improving our community. Climate change is a pressing concern and although its impacts on society are broad in scope, they should not be overlooked or considered impossible to mitigate. Expected future impacts for our region include higher frequencies of extreme weather events including severe flooding, wind storms, 100+ degree days or heat events, and increased incidences of winter weather and precipitation. Addressing climate change can result in air quality improvements, better health outcomes, economic growth, greater protection for vulnerable communities, and improved racial and social equity, while also reducing our reliance on finite resources.

Together with area stakeholders, Memphis and Shelby County government value the importance of this effort and will serve as catalysts to promote implementation of the actions outlined in the plan. This plan and support from the Office of Sustainability and Resilience and other key stakeholders will ideally guide reassessments and revisions of these goals, as funding streams or new projects contribute to redefining what is possible. Realistic yet inspiring goals are set out in this Plan, demonstrating an environmentally and socially meaningful approach to a sustainable future for the Memphis area. This approach and broad commitment to sustainability is shared in the Memphis 3.0 comprehensive plan and continues the work of the initial Sustainable Shelby Plan started over a decade ago. This effort also complements the Mid-South Regional Resilience Master Plan that will address long-term objectives for adapting to and reducing risks from climate hazards. This ongoing collaboration demonstrates the comprehensive nature of resiliency and sustainability – working from all sides to address complex climate-related problems with goals and actions focused on improving opportunity and quality of life for all residents.

The Global Covenant of Mayors for Climate and Energy

In 2015, the City of Memphis signed on to the Global Covenant of Mayors for Climate and Energy (GCoM) – a formal commitment of city leaders across the world to tackle climate change by taking steps to reduce greenhouse gas (GHG) emissions and enhance resilience and adaptation in their communities. Signatory cities and local governments act to voluntarily meet targets for GHG emissions reductions (or low emission development targets) for their whole community, identify climate risks and vulnerabilities, and implement mitigation and adaptation measures. The completion of this Memphis Area Climate Action Plan enables the City of Memphis to demonstrate compliance with the mitigation requirements of the GCoM framework across all four phases: commitment, inventory, target and plan.

Global Covenant of Mayors Requirements



Source: Global Covenant of Mayors for Climate and Energy, Full Guide to Compliance, July 2015

The Stakeholder Planning Process

In response to the City of Memphis committing to the GCoM, the Memphis and Shelby County Office of Sustainability and Resilience launched a stakeholder-driven Climate Action Planning process in June of 2018. This process, which led to the creation of the Memphis Area Climate Action Plan, sought to address three objectives:

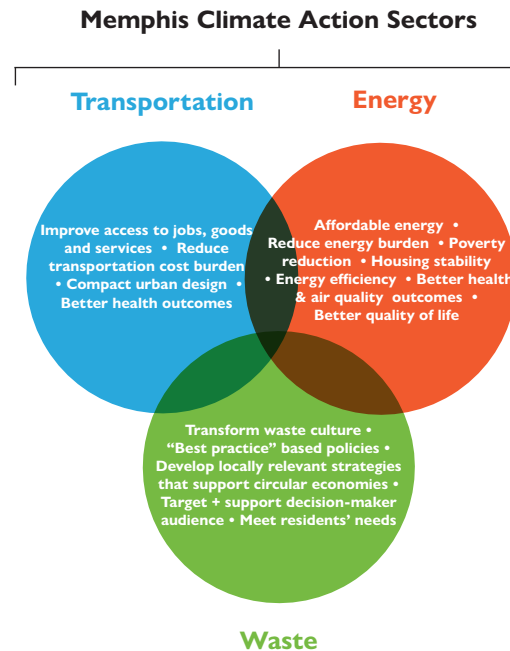
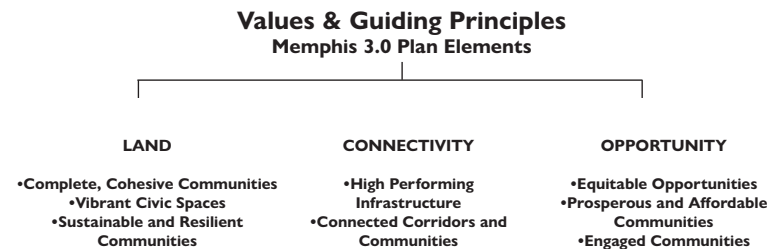
1. Implement the long-term goals and values outlined in the Memphis 3.0 and Sustainable Shelby plans
2. Identify recommendations and strategies to be carried out by public and private actors
3. Fulfill the City of Memphis' commitment as a member of the Global Covenant of Mayors for Climate and Energy

In alignment with other planning efforts in Memphis and Shelby County, the stakeholder planning process was designed with the explicit intention of addressing equity through both diverse stakeholder participation and consideration of the impacts that the recommendations outlined in this plan may have on vulnerable populations.

The stakeholder-driven planning process consisted of two in-person meetings with stakeholders selected from a broad range of public and private institutions. Some of the groups represented included City of Memphis government, Shelby County government, utility companies, academic institutions, business/industry, nonprofits, advocacy groups, and community development organizations. The stakeholder planning process began with an inaugural meeting on August 30th, 2018. At this meeting, stakeholders were briefed on the greenhouse gas inventory and forecast findings conducted for a base year of 2016 in the City of Memphis and Shelby County. Before considering potential actions for reducing emissions, stakeholders discussed and identified guiding principles with which they would analyze potential actions. These principles were developed by the stakeholders in line with the

plan elements and values of Memphis 3.0 and play a critical role in ensuring that considerations of racial and social equity were embedded throughout the climate action planning process.

As illustrated in the figure below, the values and guiding principles



connect to the elements of Memphis 3.0, while also focusing specifically on equity. For instance, stakeholders in the energy sector chose to evaluate how potential actions would increase access to affordable energy, reduce poverty, and reduce energy burden. Using this defined set of guiding principles, stakeholders began to discuss reduction targets and were introduced to a preliminary menu of potential emission reduction strategies and actions. The preliminary menu of actions also provided information to stakeholders on the difficulty of implementation, implementation cost, return on investment, and 'high,' 'medium,' or 'low' emission reduction potential.

The second in-person stakeholder meeting occurred on October 4th, 2018. This meeting built on the objectives discussed at the first meeting and centered stakeholder discussion around a plausible greenhouse gas abatement range for the Memphis area followed by the selection of priority actions to achieve reductions. Stakeholders recognized that it would be more realistic to develop a list of priority emission reduction actions and evaluate them based on the defined values and guiding principles, rather than starting with a fixed energy or carbon reduction goal and then determining how to meet it. To prepare for this meeting, stakeholders were given the opportunity to review the catalogue of actions - revised with feedback incorporated from the first meeting - ahead of time and make a preliminary selection of priority actions. At the meeting, stakeholders were presented with the results of their preliminary selections and discussed which actions to move forward in sector-specific groups. During discussions, stakeholders reviewed the values and guiding principles defined at the first meeting to aid in making final action selections. The final recommended set of actions included eight from the energy sector, five from the transportation sector, and six from the waste sector. Designated action design leaders from the stakeholder group provided more detail on implementation, which the project team then analyzed for emission reduction potential and cost effectiveness.

Target Setting and Priority Actions

To determine the proper emission reduction target for Memphis and Shelby County, the project team examined approaches internationally, nationally, and in different cities across the US. In the initial international Paris Agreement, the US pledged to achieve an economy-wide target of reducing its greenhouse gas emissions by 26-28% below 2005 levels by 2025 and to make its best effort to reduce its emissions by the higher target of that range. This 2025 target will require a substantial acceleration of the current pace of greenhouse gas emission reductions seen between 2005 and 2016. The emissions reductions projected by 2020 were primarily the result of programs launched during the Obama administration such as the Clean Power Plan to reduce the carbon in the electricity grid and fuel economy standards for light- and heavy-duty vehicles. These programs will reduce emissions in Memphis and Shelby County if they remain in place at the federal level.

The project team also analyzed benchmarks included in climate action plans for cities with similar characteristics to the Memphis area: Atlanta, Baltimore, Birmingham, Louisville, Nashville, Raleigh, and St. Louis. Two of these cities, Birmingham and Raleigh, did not have a clear timeline for their GHG reduction targets. St. Louis and Louisville have relatively long-term goals of an 80% reduction by 2050. Many cities also set reduction targets with a relatively short time-frame. These short-term reduction targets ranged between a 10% reduction in Nashville to a 20% reduction for Atlanta, with Baltimore in between at 15%. Some of these cities also have mid-term and long-term reduction goals. Atlanta aims to reduce emissions by 40% by 2030, and Nashville aims to reduce emissions by 30% by 2030 and 70% by 2050. Stakeholders for the Memphis area CAP were presented with these national and local mitigation target profiles to inform the level of GHG reductions that could be achieved in Shelby County. At the culmination of the climate planning process, stakeholders identified nineteen priority climate actions that in the aggregate could achieve GHG reductions of 15% by 2020, 51% by 2035, and 71% by 2050 relative to the 2016 base year.

As shown in the table on the following page, priority actions were quantified by both their CO₂ abatement potential, how cost effective they were at abating emissions, and their alignment and potential beneficial impact on goals in the Memphis 3.0 Comprehensive Plan. Actions with negative values in the cost effectiveness column indicate cost savings for each ton of CO₂ equivalent abated. In general, when developing the estimated cost for these actions, differences between the business-as-usual baseline and the selected action were identified and quantified where possible as either additional costs

or cost savings. The cost figures shown in Table 1 and in subsequent impact summary tables throughout the plan are cumulative (2019-2050) and include capital or programmatic implementation costs, as well as savings associated with reduced energy/fuel consumption or increased revenue. More detail on the cost assessment for each action can be found in the plan appendices. Actions with an “NQ” were not quantified due to their role as supporting actions that lack clearly identifiable impacts on GHG emissions.

Benchmarks for GHG Emissions Reduction Targets



Priority Action Carbon Reduction Potential, Cost Effectiveness, and Alignment with Memphis 3.0 Elements

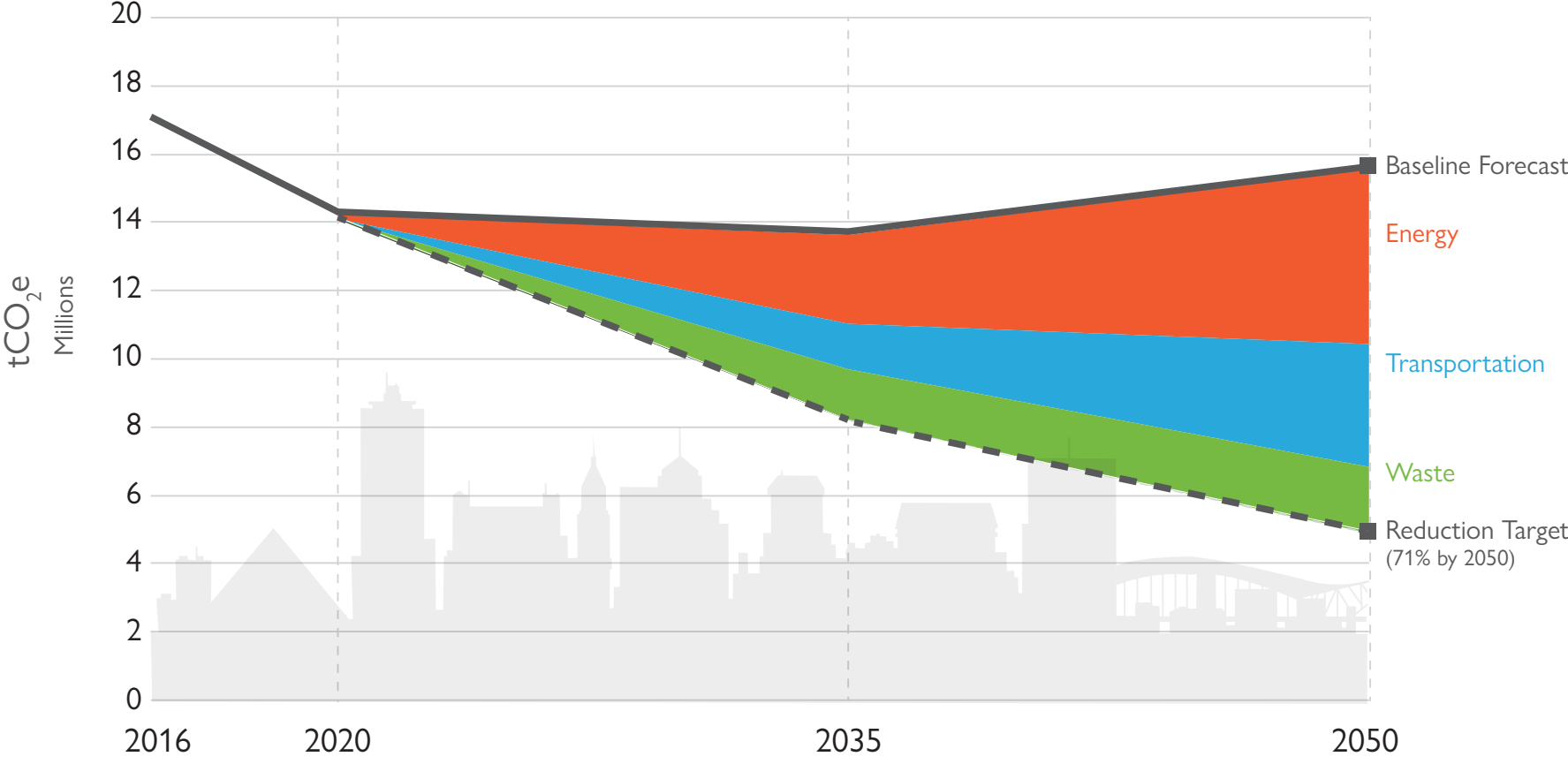
Priority Action	GHG Reductions				Cost, NPV		Cost Effectiveness \$/tCO ₂ e	Memphis 3.0 Elements		
	2020 tCO ₂ e	2035 tCO ₂ e	2050 tCO ₂ e	Cumulative tCO ₂ e	Cumulative 2018 Dollars	Land		Connectivity	Opportunity	
E1. Green Building Standards	0	178,795	69,775	3,797,441	\$216,433,008	\$57	High	Low	Medium	
E2. Low-Income Housing Energy Efficiency	3,448	27,209	16,110	618,379	\$78,035,768	\$126	High	Low	High	
E3. Outreach and Education	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	
E4. LED Streetlight Retrofit	0	10,822	0	191,984	-\$2,614,337	-\$14	Medium	Medium	Medium	
E5. Retrofitting Existing Buildings	11,744	33,925	0	892,189	-\$245,336,527	-\$275	Low	Low	High	
E6. Grid Decarbonization	0	2,205,241	4,811,919	75,992,009	\$370,389,930	\$5	Medium	Low	Medium	
E7. Urban Tree Canopy	16,636	135,781	246,759	4,174,555	\$35,127,597	\$8	High	Low	Low	
E8. Nexus Between Climate Change Mitigation and Adaptation	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	
T.1 Low-Carbon Land Use	Overlap	Overlap	Overlap	Overlap	Overlap	Overlap	High	High	Medium	
T.2 Complete Streets	0	102,273	256,490	3,566,189	\$42,947,890	\$12	High	High	Medium	
T.3 Enhancing Public Transit	941	7,636	19,847	283,589	\$434,262,717	\$1,531	Medium	High	High	
T.4 Demand Management	0	307,635	564,246	9,756,323	-\$83,836,344	-\$9	Low	Medium	Medium	
T.5 Electric Vehicles (EVs)	24,383	921,048	3,027,741	34,857,980	\$1,608,706,106	\$46	Low	Medium	Low	
W.1 Organic Waste Diversion	0	34,549	36,578	789,203	\$8,775,676	\$11	Medium	Low	Medium	
W.2 Waste Reduction Program	3,807	44,868	48,074	1,172,844	\$234,357,677	\$200	Medium	Low	Medium	
W.3 Inorganic Waste Diversion	non-BASIC	non-BASIC	non-BASIC	non-BASIC	non-BASIC	non-BASIC	non-BASIC	non-BASIC	non-BASIC	
W.4 Tire Management	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	
W.5 Education and Outreach	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ	
W.6 Methane Recovery	42,403	1,450,009	1,552,167	33,620,942	\$9,966,242	\$0.30	Low	Low	Low	

NQ = Not quantified; supporting action with less clearly identifiable GHG emissions impacts

Overlap = Has overlapping emission reduction benefits with other actions

Non-BASIC = Not required as part of Covenant of Mayors reporting; GHG emissions and benefits occur outside of boundary

Carbon Reduction Impact of Priority Actions



Long-Term Target Setting

The actions listed in Table 1 combined represent an emission reduction potential of 15% by 2020, 51% by 2035, and 71% by 2050. In order to reach a more aggressive target such as 80% by 2050, Memphis will need to continue to implement more stringent actions in future cycles of climate action planning.

Other cities such as Portland, Oregon aim to cut GHG emissions by 80% by 2050 compared to 1990 levels. Although Portland was the first US city to outline a carbon-reduction plan in 1993 and has been working towards these goals for some time, their vision and forward thinking have resulted in substantial gains in reducing per capita and total carbon emissions since 1990. Oberlin, OH plans to cut emissions to 50% beginning in 2015, 75% by 2030, and 100% by 2050. Minneapolis, MN is planning to cut 30% by 2025 and 80% by 2050. The Southeast Florida Regional Climate Change Compact plans to work regionally with a goal of reaching 80% of 2010 levels by 2050. With many jurisdictions across the US and globally setting higher standards and aiming to work tangibly towards these ambitious emissions reductions, Memphis and Shelby County can and should consider what steps are necessary to work towards this more ambitious reduction target.

Although ambitious, it serves our community and long-term sustainability efforts to strive for challenging yet plausible future scenarios and emission reduction standards. This Climate Action Plan and the goals we set provide opportunities for Memphis to move forward as a leader in climate adaptation and mitigation measures, holding standards that go beyond a business-as-usual approach. In supporting these efforts, the Office of Sustainability and Resilience strives to maintain focus on a long-term vision that demonstrates our commitment to these climate mitigation and adaptation goals. While challenging the status quo and business-as-usual models is not without its challenges, the long-term impacts and multiple benefits possible from a more ambitious outlook will provide greater opportunity for gains and improvements to efficiency and cost-savings. Furthermore, this effort

encourages community organizations and local government to serve as leaders in climate action and adaptation, demonstrating that green initiatives offer greater rewards for a long term, sustainably-minded future.

Public Engagement and Survey Results

Meaningful local action on climate change is only possible with public awareness and support. Over the fall of 2018, planning staff conducted several public pop-up engagement events to share information on the climate action planning process, gather input on residents' attitudes and perceptions on climate change, and solicit feedback on how Memphis and Shelby County can collectively act on climate change. These pop-up engagements took place at the Benjamin L. Hooks Central Library, Court Square (Downtown), and





Photo: Memphis-Shelby County Office of Sustainability

the Shelby Farms Greenline. Staff also attended community festivals, including the Soulsville USA Festival in South Memphis, PrideFest at Tom Lee Park, and Tiger Blue Goes Green at the University of Memphis. Comments received at these events and through the online survey (see detailed discussion of survey results below) indicate that Memphis and Shelby County residents are concerned about the impacts of climate change and support taking local action to reduce our community's contributions to this global issue.

A total of 237 participants provided feedback about their climate change perceptions through an administered survey either online, in person via tablet or in person on paper. The survey was based on the City of Edmonton's

Climate Change & Energy Perceptions Survey (Corporate Research Associates, 2018) with modifications made for use in the Memphis region. Over 77% of participants agree or strongly agree that climate change is caused mostly by human activities, and most (59%) strongly agree that people in the Memphis area should be doing more to help prevent climate change. Only 25% strongly agree that they are taking action to help prevent climate change, perhaps suggesting we should offer ideas, solutions, or tangible actions that individuals can take to reduce the impacts of climate change.

Fewer respondents were convinced that their neighbors in the Memphis area were as concerned about climate change, as only 12% strongly agreed that Memphis residents considered climate change at all a concern. Only 13% of survey respondents strongly agreed that Memphis residents saw climate change as harmful to future generations, and only 13% strongly agreed that people in the Memphis area think we need to act now to address climate change. Overall, respondents were less convinced that the general population in the Memphis area was aware of or concerned about climate change or its impacts.

Three quarters of participants felt that Memphis and Shelby County government should be doing more than they currently are to address climate change, suggesting that efforts with the public should be highlighted and outreach should perhaps address ongoing efforts on the part of local government to address climate change. Most respondents also noted that they have become more supportive of taking action on climate change (55%) within the last year, perhaps indicating that climate change is becoming a greater concern or at least more common in dialogue among Memphis area residents.

The majority of participants either agree or strongly agree that efforts to prevent climate change represent an economic opportunity for the area, and almost half strongly agree that investing in energy efficiency provides job opportunities.

In terms of gauging potential support for specific actions to tackle climate change, over half strongly agree that energy efficient homes help reduce greenhouse gas emissions but are slightly less convinced that their own home electricity use contributes to greenhouse gas emissions. Overall, about half felt that workplace electricity use contributed to greenhouse gas emissions. 55% strongly agreed that solid waste sent to the landfill contributes to emissions.

Survey Respondent Demographics

The team made efforts in gathering survey respondents from a range of socioeconomic and demographic backgrounds. The gender of our survey respondents was skewed female, with 67% female, 30% male, and 3% other (compared to the Shelby County general population reporting 48% male, 52% female). Age distribution also showed differences from the general Shelby County population. Only 15% of survey respondents were over the age of 55 and 44% under age 24, compared with 25% 55+ and 28% under age 24 in Shelby County. Respondents aged 25-34 made up 19% of the sample while those aged 35-44 comprised 14% of the total.

The vast majority of respondents were not Hispanic or Latino (92%), similar to the broader population in Shelby County (93%). Of the 223 respondents that identified their race, 43% were Black or African American and 41% were White – compared to 36% White and 53% Black or African American in the broader population. Other races reported include Asian (5%), American

Indian or Alaska Native (2%), Native Hawaiian or Pacific Islander (1%) and those identifying as 'Other' amounted to 8% of the respondents.

Most respondents reported household income was low to moderate income, with 39% reporting less than \$25,000 annual household income, compared to 27% in Shelby County as a whole. Those reporting at least \$25,001-\$50,000 and \$50,001-\$100,000 were 22% and 21%, respectively. Respondents with over \$100,001 annual household income amounted to 17% of the sample, compared to 21% in Shelby County.



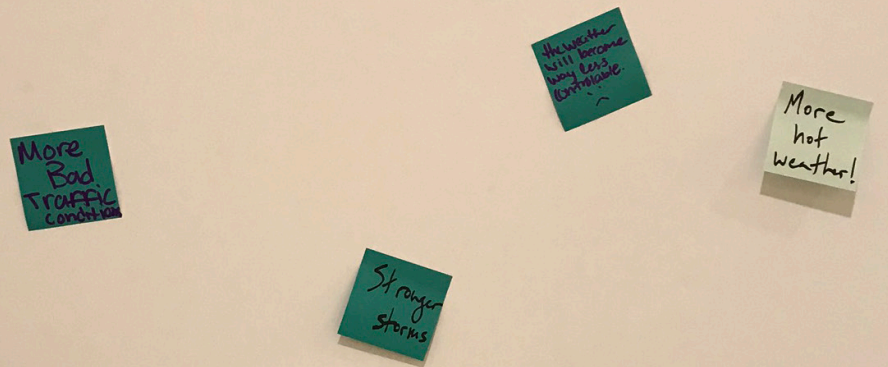
Photo: Memphis-Shelby County Office of Sustainability



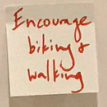
WANT YOUR HELP TO CREATE THE MEMPHIS AREA'S FIRST CLIMATE ACTION PLAN




HOW WILL CLIMATE CHANGE IMPACT MEMPHIS?



HOW CAN MEMPHIS CURB CLIMATE CHANGE?



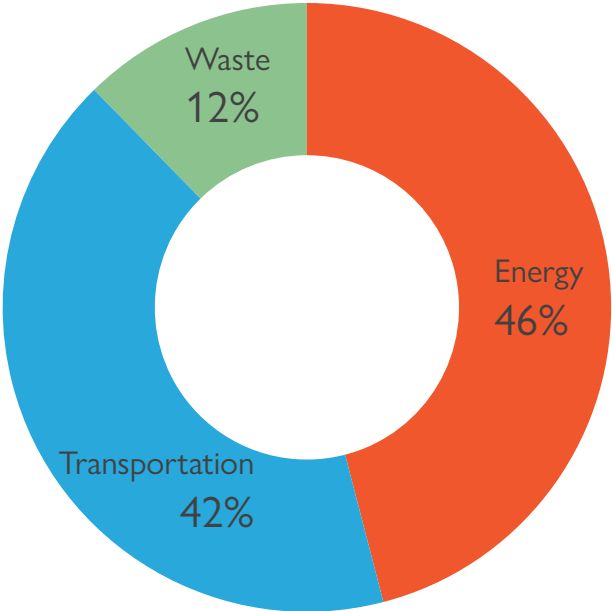


CHAPTER 2
COMMUNITY
INVENTORY
AND
FORECAST

GREENHOUSE GAS EMISSIONS INVENTORY AND FORECAST

The first step in taking action on climate change is to understand where our community stands on current and future greenhouse gas emissions. To aid in this process, the project team developed a 2016 baseline greenhouse gas inventory and forecast using data from a variety of local, regional, and national sources. Given the interconnectedness of the regional economy and emissions, as well as past and current work locally that addresses sustainability in a regional manner, this plan uses Shelby County as the boundary for measuring emissions.

The results of the inventory, carried out in accordance with the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventory or GPC (World Resources Institute, 2014), show that our community's emissions come from three major sectors – energy, transportation, and waste. Energy – which includes emissions from energy used in residential, commercial/institutional, and industrial buildings – accounts for 46% of total emissions. Transportation – which includes passenger, freight, on-road and off-road vehicles – accounts for 42% of emissions. Waste – which includes solid waste disposal in landfills and wastewater treatment processes – accounts for the remaining 12% of community-wide emissions. Energy and transportation – the two largest sources of emissions, accounting for 88% of total emissions – clearly present the most opportunities for reducing our community's contributions to climate change.



Total 2016 Memphis Area Greenhouse Gas Emissions:

17,191,915
metric tons CO₂e

The Memphis area's per capita emissions are fairly comparable to, and even lower than, several other peer cities, including Nashville, Atlanta, Louisville, and St. Louis. Given that Memphis' baseline is well within the emissions per capita of other comparison cities, a similar or comparably aggressive

reduction target should be considered reasonable and attainable. Although each city has their own unique context and locally-relevant concerns, these targets are broadly similar and the goals reasonably comparable.

Peer City Greenhouse Gas Emissions Comparison

	Memphis	Nashville	Raleigh	Atlanta	Baltimore	Louisville	St. Louis
Inventory year	2016	2014	2014	2013	2010	2006	2015
Boundary	County	County	City	City	City	County	City
Population	936,691	678,889	439,896	447,888	621,125	703,998	314,875
GHG Emissions <small>(tCO₂e)</small>	17,191,915	13,461,292	5,489,378	8,857,265	7,579,144	19,249,306	7,219,170
Emissions per capita <small>(tCO₂e)</small>	18.35	19.83	12.48	19.78	12.20	27.34	22.93


Forecast

The project team also developed short-term (2020), mid-term (2035), and long-term (2050) emissions forecasts to better understand our community's future impacts on climate change if no new action is taken, also known as a business-as-usual (BAU) forecast. Using data on population growth, growth in vehicle miles traveled, expected technological improvements, and changes in the energy supply provided by the Tennessee Valley Authority (TVA), the BAU forecast shows that the Memphis area's emissions are expected to

decrease. Most of this projected decrease is due to two factors: 1) TVA's planned changes in their energy generation resulting in less reliance on fossil fuels and increasing the nuclear and renewable energy share of their portfolio, and 2) improvements in vehicle efficiency standards. While this projected decrease in our community's emissions is encouraging, it does not negate the need for local actions that will lead to even deeper reductions and positive impacts for our community and our residents' quality of life.

Community GHG Emissions Forecast

	2016	2020	2035	2050
Energy	7,900,671	6,282,301	6,200,552	6,674,442
Stationary Energy, Commercial and Institutional Buildings	3,692,414	2,863,435	2,789,344	3,013,517
Stationary Energy, Manufacturing and Construction	838,632	717,032	744,865	775,581
Stationary Energy, Residential Buildings	3,369,625	2,701,834	2,666,343	2,885,344
Transportation	7,171,416	6,236,170	5,357,523	6,566,940
Transportation, Aviation	352,392	351,547	348,396	345,274
Transportation, On-road	6,686,472	5,751,782	4,879,134	6,094,239
Transportation, Railway	88,591	89,718	89,873	90,100
Transportation, Waterborne navigation	43,961	43,123	40,120	37,327
Waste	2,119,828	2,158,243	2,308,604	2,469,441
Waste, Biological Treatment of Waste	101,766	103,610	110,829	118,550
Waste, Solid Waste Disposal	1,933,456	1,968,494	2,105,635	2,252,331
Waste, Wastewater Treatment and Discharge	84,606	86,139	92,140	98,560
Grand Total	17,191,915	14,676,714	13,866,679	15,710,823



CHAPTER 3
GOVERNMENT
INVENTORY
AND
RECOMMENDATIONS

LEADING BY EXAMPLE: LOCAL GOVERNMENT INVENTORY, REDUCTION TARGETS AND RECOMMENDATIONS

As part of the climate action planning process, the project team also completed a GHG emissions inventory for local government operations (LGO) for both the City of Memphis and Shelby County. While this plan focuses on reducing emissions and improving quality of life community-wide, it is important for local government to lead by example and provide services in a way that contributes to the long-term financial, social, and environmental health of the Memphis area. This section outlines the results of the LGO inventories, sets targets for reducing emissions, and identifies key actions that Memphis and Shelby County should take to reduce local government emissions and contribute to sustainability goals.

The LGO inventories were completed using the Local Government Operations Protocol (LGOP), Version 1.1 (California Air Resources Board, California Climate Registry, ICLEI - Local Government for Sustainability, & The Climate Registry, 2010). These inventories used data from 2016 – the same baseline year used in the community-wide inventory – and took an operational control approach. The LGOP defines this approach in the following manner: “A local government has operational control over an operation if the local government has the full authority to introduce and implement its operating policies at the operation” (California Air Resources Board, 2010, p. 14). The project team selected this approach as opposed to a financial control approach – where operations that the government has fully consolidated in financial accounts are included – as it considers only operations that are directly controlled by local government and thus provides the most opportunity to impact emissions reductions. Per this operational control approach, emissions from entities where the local governments

have financial control or some financial relationship were not included. On the county side, this means that emissions from Shelby County Schools operations were not included; on the City side, emissions from MLGW and MATA were also not included. These entities should consider crafting climate action strategies for their operations with support from local government.

The two local government operations inventories focus on emissions from two sectors: 1) energy use at government buildings and facilities, and 2) fuel use in government vehicle fleets. Emissions from solid waste generated at government facilities were not included due to a lack of data. Future local government operations inventories should look at incorporating emissions from solid waste generation.

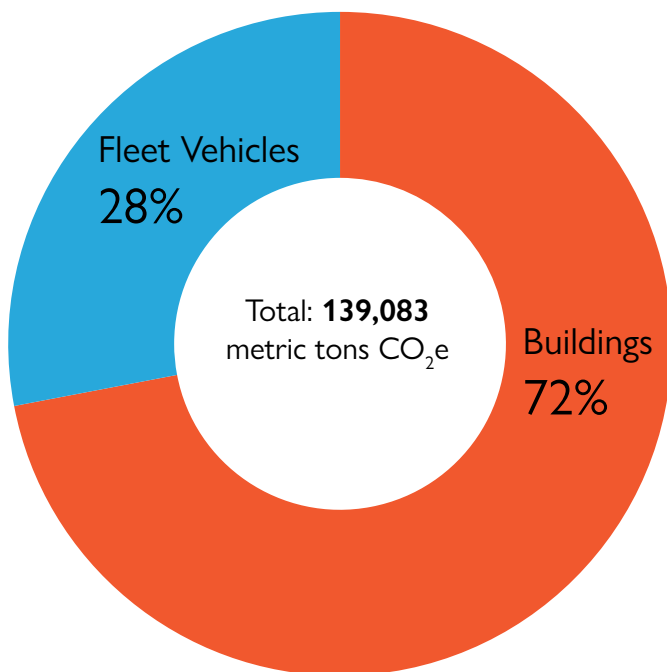
City of Memphis Government

Energy use – natural gas and electricity consumption – at buildings and facilities accounts for 72% of Memphis' operations GHG emissions. The remaining 28% of emissions come from fuel use in fleet vehicles. Memphis' operations emissions account for 0.80% of overall community-wide emissions.

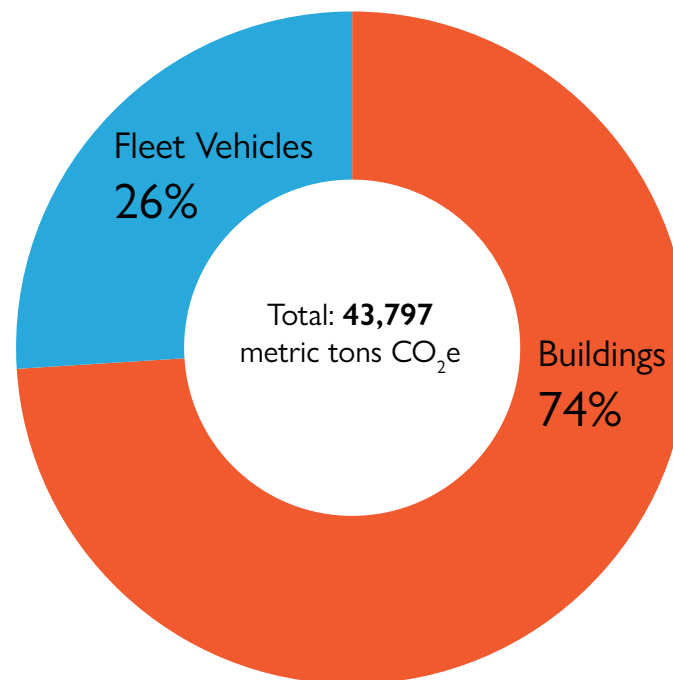
Shelby County Government

Energy use – natural gas and electricity consumption – at buildings and facilities accounts for 74% of Shelby County government's GHG emissions. The remaining 26% of emissions come from fuel use in fleet vehicles. Shelby County's operations emissions account for 0.25% of overall community-wide emissions.

City of Memphis Government
2016 GHG Emissions



Shelby County Government
2016 GHG Emissions





Targets

Memphis and Shelby County should set GHG reduction targets that exceed the community-wide targets (see Chapter 1). Proposed reduction targets for both City and County government operations are as follows:

Table 4. Local Government GHG Reduction Targets

Year	Reduction Targets	
	Buildings	Fleet Vehicles
2020	20%	15%
2035	55%	45%
2050	80%	80%

As noted in the discussion of community-wide reduction targets, a large portion of the 2020 reductions are expected as a result of actions outside of local control - for example, TVA's planned increase in carbon-free energy sources in their energy portfolio - but these ambitious mid-term and long-term reduction targets will require coordinated action and investment by local government.

Actions

Given the inventory results, Memphis and Shelby County have the most opportunity to reduce GHG emissions through building energy use. City and County government have already taken some steps to improve energy efficiency and reduce the carbon footprint of government operations. For example, the City of Memphis is investing in light-emitting diode (LED) retrofits for some fire stations and is working with an energy performance contractor to renovate City Hall to make it more efficient. The City first tackled Benjamin Hooks Library, once the largest energy consumer of city

buildings (not including wastewater treatment facilities), to implement energy efficiency upgrades including LED lighting, HVAC and lighting controls, and water conservation measures. City Hall is now the largest energy consumer of city buildings (not including wastewater treatment facilities).

Shelby County Government requires that every Capital Investment Plan (CIP) project for building renovation compare the cost of reuse/renovation versus new construction. The County also recently completed large-scale retrofits for two office buildings downtown (Vasco Smith Administration Building in 2015 and Shelby County Office Building/157 Poplar in 2011) that incorporated upgrades to multiple systems (HVAC, replacement of electrical infrastructure, window replacement, boiler plant replacement). In addition, the County's Green Prisons Initiative has resulted in energy efficiency upgrades at Division of Corrections facilities, including LED lighting retrofits, installation of UV Solar Thermal Collection Panels and an Ozone Laundry System to reduce use of domestic hot water, and the purchase of food waste dehydrators to reduce food waste and associated landfill costs. Local government should build off these successes to achieve deeper and more widespread energy reductions.

To lead by example on climate action, the City and County should take the following actions in the building sector:

- Dramatically increase energy efficiency at existing buildings and facilities and set ambitious energy efficiency standards for all new facilities and major renovations
 - Implement a comprehensive energy management system for both City and County facilities to track energy use trends and better understand opportunities for reductions in energy consumption
 - Train and/or hire staff dedicated to energy management and achieving energy use reduction targets



Photo: Memphis-Shelby County Office of Sustainability

- Develop a portfolio-wide strategy for implementing energy efficiency improvements and promoting energy conservation
- Adopt green building standards for all new government facilities and major redevelopments, such as LEED Silver or Net Zero Energy
- Commit to developing renewable energy generation at key facilities and/or commit to purchasing renewable energy
 - Commit to a Renewable Portfolio Standard for local government operations and explore options for achieving these renewable energy goals, such as solar installations on government facilities, Renewable Energy Certificates, participating in community shared solar projects, and green tariff products
 - Evaluate the economic and technical feasibility of installing solar generation at government buildings and facilities
 - Work with TVA and Memphis Light, Gas, and Water (MLGW) to explore the use of green tariffs – or a similar type of bundled green energy product – to reduce our municipal carbon footprint
- Determining a timeline for implementation including identifying the best departmental candidates to begin this transition
- Exploring new purchasing methods such as joint procurement on the State of Tennessee’s fleet vehicle contract and with other large cities in Tennessee
- Identifying other potential funding sources that can help defray higher initial capital costs

Although fleet fuel use makes up a smaller share of LGO emissions, the transportation sector still presents opportunities for Memphis and Shelby County governments to lead by example on climate action. While turnover to new vehicles has resulted in increased efficiency and lower emissions over the last decade, the City and the County fleet have yet to make significant strides in transitioning to low and zero emission vehicles such as hybrids and electric vehicles. Local government should take advantage of improved technology and batteries, more competitive price points, and expanding vehicle choices to lead the way by electrifying its fleet.

- Develop a comprehensive strategy for electrifying fleets
 - Key issues to consider include:
 - Installation of electric charging infrastructure at government facilities

CHAPTER 4

ENERGY



Memphis is

TENNESSEE



ENERGY SECTOR RECOMMENDATIONS

The energy sector – which includes energy used to power, heat and cool stationary infrastructure such as buildings and streetlights – makes up the largest source of emissions in the Memphis area. The recommendations for this sector are designed to significantly reduce greenhouse gas (GHG) emissions while simultaneously achieving other important goals for our community, including: improving energy affordability, reducing energy burden for the most vulnerable residents in our community, providing housing stability, enhancing health and air quality, and creating new job opportunities. Implementing these recommendations is projected to reduce our community's stationary energy emissions by 21% by 2020; 54% by 2035; and 81% by 2050.

1 IMPROVE ENERGY EFFICIENCY OF BUILDINGS AND KEY INFRASTRUCTURE

- ▶ Implement Green Building Standards and Incentivize Innovative Green Building Design
- ▶ Improve Low-Income Housing Energy Efficiency
- ▶ Enhance and Expand Energy Outreach and Education Programs
- ▶ Retrofit Outdoor Streetlights to LED
- ▶ Expand Financing Options for Residential Energy Efficiency Retrofits

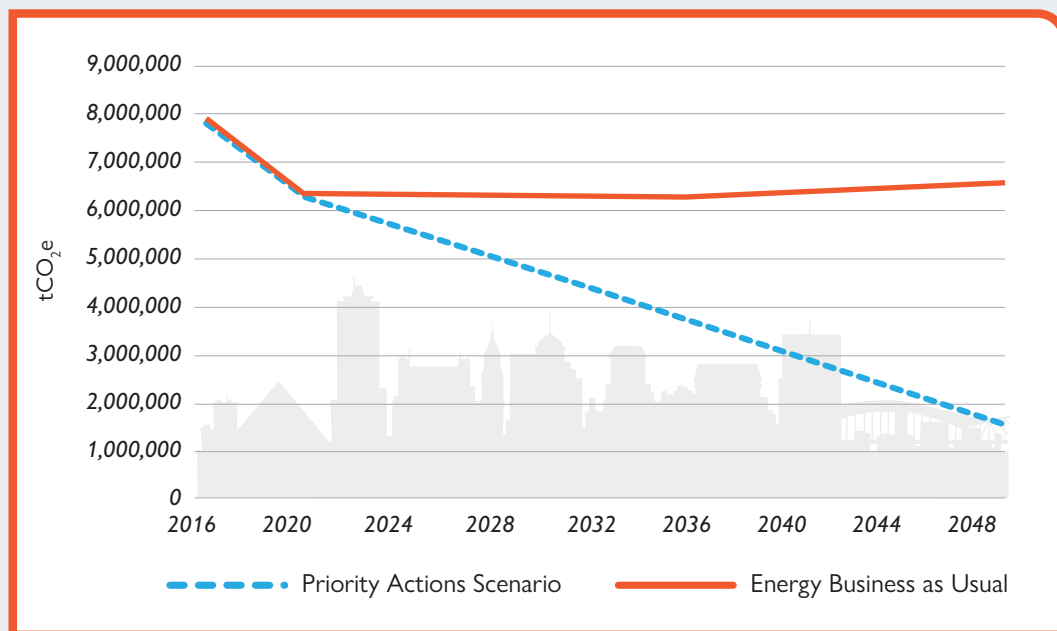
2 TRANSFORM OUR ENERGY SUPPLY

- ▶ Decarbonize the Electric Grid with Renewable Energy

3 INCREASE GREEN INFRASTRUCTURE AND COMMUNITY RESILIENCE

- ▶ Nurture and Expand the Urban Tree Canopy
- ▶ Ensure Alignment of Climate Change Mitigation and Adaptation Efforts

Greenhouse Gas Emissions Reductions in the Energy Sector



The two figures to the left provide more detail on the projected carbon emissions reduction impact of the energy-related recommendations in this plan. The graph shows the potential cumulative emissions reductions for these actions over the next 30 years compared to the business-as-usual scenario, while the table below lists the emissions reductions for each individual action.

Based on the current analysis, grid decarbonization - or increasing the carbon-free energy sources in our electricity supply - has the greatest impact on reducing greenhouse gas emissions in our community. Increasing the urban tree canopy and implementing green building standards are the next most impactful actions for carbon emissions reductions. Two energy-related actions were not quantified in the analysis as they are envisioned as supporting actions without direct greenhouse gas benefits. While the analysis on this page focuses on carbon emissions reduction potential, it is important to note that these actions have multiple beneficial impacts and can help our community meet other goals related to equity, resilience, and quality of life in our community.

For more information on the data sources, calculations, and assumptions used for this analysis, please refer to Appendix 2.

(tCO ₂ e)	2016	2020	2035	2050
Energy Business as Usual Emissions	7,900,671	6,282,301	6,200,552	6,674,442
E1. Green Building Standards		0	-178,795	-69,775
E2. Low-Income Housing Energy Efficiency		-3,448	-27,209	-16,110
E3. Outreach and Education		NQ	NQ	NQ
E4. LED Streetlights		0	-10,822	0
E5. Subsidies and Financing for Retrofitting		-11,744	-33,925	0
E6. Grid Decarbonization		0	-2,205,241	-4,811,919
E7. Urban Tree Canopy		-16,636	-135,781	-246,759
E8. Align Climate Change Mitigation and Adaptation		NQ	NQ	NQ
Priority Actions Scenario Emissions		6,250,473	3,608,779	1,529,878

NQ = Not quantified; supporting action with less clearly identifiable GHG emissions impacts

1 IMPROVE ENERGY EFFICIENCY OF BUILDINGS AND KEY INFRASTRUCTURE

Emissions from energy use in buildings and stationary infrastructure make up the largest source of greenhouse gas emissions in the Memphis area. Commercial/institutional and residential buildings alone make up 41% of total community-wide emissions. While transitioning to cleaner, renewable sources of energy is an important part of reducing emissions, improving energy efficiency in new and existing buildings and infrastructure is also essential to achieving a more sustainable, prosperous, and equitable region. The strategies under this goal include a mix of approaches, from strengthening building codes

to improving educational programs around energy efficiency. In particular, these recommendations focus on how to spread the economic and health benefits of energy efficient buildings to more Memphis area residents. Energy burden – the share of income that goes toward paying energy costs – is a major issue in Memphis, particularly for low-income residents, and ensuring that our residents have healthy, affordable housing is vital to our community's future.



Photo: Brandon Dill; Big River Engineering and Manufacturing, Memphis (LEED Silver)

1 ACTION AREA SUMMARY

PRIORITY ACTION

E.1 Implement Green Building Standards and Incentivize Innovative Green Building Design

OBJECTIVE

Codify and implement green building standards by 2022, with 100% compliance by 2025

IMPLEMENTATION STEPS

- ▶ Require that all new municipal buildings and major renovations for the City and County meet LEED Silver or Net Zero Energy standards.
- ▶ Review approaches to implementing green building codes in other cities to assess best practices for adoption.
- ▶ Gather input on the design and scale of mandatory green building standards in Memphis and Shelby County from the Memphis-Shelby County Building Code Board and other stakeholders in the building and development industry.
- ▶ Adopt green building and energy codes that improve upon the requirements of model codes; consider standards such as the International Green Construction Code, ASHRAE Standard 189.1, and stretch codes implemented in other jurisdictions.
- ▶ Explore the adoption of Net Zero building standards to achieve deeper energy savings and GHG reductions in the long-term.
- ▶ Establish a regular and frequent review process for updating building and energy codes to ensure compliance with the latest green building standards.
- ▶ Evaluate the feasibility of implementing benchmarking and transparency requirements for energy use in large commercial and multi-family buildings to encourage improved energy efficiency and to connect property owners to resources.
- ▶ Consider requiring development projects that receive PILOTs (Payment in Lieu of Taxes) or other public incentives to meet minimum green building design standards such as LEED certification or Net Zero Energy.
- ▶ Consider expanding existing green building incentives in the PILOT (Payment in Lieu of Taxes) program to encourage innovative, sustainable design in projects that receive public assistance.

1 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
E.1 Implement Green Building Standards and Incentivize Innovative Green Building Design (cont.)	Codify and implement green building standards by 2022, with 100% compliance by 2025	<ul style="list-style-type: none"> ▶ Explore the adoption of other incentives to encourage green building above mandatory standards, such as density bonuses, reduced minimum parking requirements, expedited review and permitting, reduced fees, and marketing assistance. ▶ Develop educational materials for the building/development community and the public on the benefits and implementation details of green building standards.
E.2 Improve Low-Income Housing Energy Efficiency	Increase the number of low-income residences served by weatherization and retrofit programs annually by 500% over 10 years, with a 30% reduction in energy usage target per household	<ul style="list-style-type: none"> ▶ Aggressively pursue additional funding sources – both public and private - to expand existing weatherization programs for low-income residents. ▶ Leverage existing efforts such as the Healthy Homes Partnership (HHP), the Green & Healthy Homes Initiative (GHHI), and other public and private energy efficiency investments to improve coordination and maximize the benefit of existing programs. ▶ Work with public and private partners to foster a skilled, quality workforce in the weatherization/energy efficiency field with a particular focus on creating jobs for residents in energy-burdened communities. ▶ Strengthen complementary education programs for residents who receive weatherization assistance to encourage behaviors and practices that maximize energy efficiency and cost savings. ▶ Develop more robust marketing, outreach, and engagement efforts in collaboration with residents in energy-burdened neighborhoods to provide information on existing programs and encourage participation. ▶ Explore how new tools and programs– such as the Affordable Housing Trust Fund – can incorporate energy efficiency goals and standards.
E.3 Enhance and Expand Energy Outreach and Education Programs	Attain a 10% or greater reduction in average electricity consumption for residential and commercial sectors	<ul style="list-style-type: none"> ▶ Research best practices from effective residential and commercial campaigns encouraging energy efficiency and energy conservation.

1 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
<p>E.3 Enhance and Expand Energy Outreach and Education Programs (cont.)</p>	<p>Attain a 10% or greater reduction in average electricity consumption for residential and commercial sectors</p>	<ul style="list-style-type: none"> ▶ Develop programs and materials with community members to determine what effective outreach looks like in terms of types of materials and delivery methods, content, and who is delivering information and messages to the community. ▶ Engage high-profile leadership and well-known Memphians to promote energy efficiency/conservation campaigns. ▶ Collaborate with community-based organizations, nonprofits, advocacy groups, faith communities, and large employers to raise awareness and encourage participation in energy efficiency campaigns or challenges. ▶ Provide resources to the commercial sector on energy tracking tools in preparation for a commercial energy reduction challenge.
<p>E.4 Retrofit Outdoor Streetlights to LED</p>	<p>Replace all existing non-LED streetlights and leased outdoor lighting with LED bulbs by 2030 or sooner, beginning in 2025</p>	<ul style="list-style-type: none"> ▶ Prepare an up-to-date, full life cycle cost/benefit analysis for retrofitting streetlights and leased outdoor lighting that includes operations and maintenance costs, energy use and costs, and other economic considerations. ▶ Research best practices and approaches for comprehensive streetlight retrofit programs in other cities. ▶ Explore financing options for the retrofit program, including bond issuances and loans that can be repaid with operations and maintenance savings. ▶ Ensure that new LED streetlights are designed with an appropriate color temperature of 3,000 Kelvin or lower and are properly shielded. ▶ Develop a public education and communications campaign to explain project implementation and up-front costs as well as the short- and long-term community-wide benefits.

1 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
<p>E.5 Increase Financing Options for Residential Energy Efficiency Retrofits</p>	<p>By 2025, 15% of all residences will have energy-efficient space heating and cooling equipment and major appliances</p>	<ul style="list-style-type: none"> ▶ Work with MLGW and other partners to develop a tariffed on-bill financing program for residential energy retrofits. Major steps include identification of initial capital to seed the program, utility and property data assessment to identify candidates, intake design, marketing materials development, and the potential implementation of a pilot project to test the concept. ▶ Advocate for state legislation that allows the implementation of a local Residential Property Assessed Clean Energy (PACE) program. Work with local officials and other partners to develop policies and procedures for a local PACE program. ▶ Work with MLGW, elected officials, and other partners to explore the feasibility of changing MLGW's charter to allow residential energy efficiency rebates. ▶ Enhance existing local education and marketing efforts that provide information on home energy audits, energy-efficient equipment and appliances, and renewable energy installation. ▶ Develop a system to collect local data on sales and installations of energy-efficient appliances and other energy efficiency measures. This could involve public surveys, more comprehensive monitoring and assessment information from existing weatherization programs, or other data collection methods. ▶ For future efforts focusing on the commercial sector, develop local marketing campaigns to provide information on existing products such as Pathway Lending's Low-Interest Energy Efficiency and Renewable Energy Loans and TVA's EnergyRight Solutions energy efficiency incentives.

Priority Action E.1: Implement Green Building Standards and Incentivize Innovative Green Building Design

OBJECTIVE: CODIFY AND IMPLEMENT GREEN BUILDING STANDARDS BY 2022, WITH 100% COMPLIANCE BY 2025

Background: Energy used to power, heat, and cool buildings is the largest source of greenhouse gas emissions in the Memphis area, making up 46% of the region's carbon footprint. To achieve our 2035 GHG reduction target of 51% – as well as potentially more aggressive long-term reductions – our community must take action to implement building and energy standards that go beyond model codes. Memphis and Shelby County recently adopted the 2015 International Building Code, the 2015 International Energy Conservation Code, and other associated 2014/15 model codes, a step in the right direction from the 2009 codes that were previously in effect. Despite this recent progress, now is the time to plan for more aggressive action in the short- and mid-term. Although adoption of more advanced building and energy codes presents operational and political challenges, this action has strong potential to positively impact our economy, environment, and quality of life.

Approach: This priority action aims to reduce energy demand in newly constructed buildings and major renovations. Implementation of this action will involve the adoption of green building and energy codes, as well as the development of incentives to support innovative design that goes beyond these new standards. An important part of implementation will involve determining green building standards that best fit our local context. Options include the International Green Construction Code, Stretch Codes that include energy saving standards that go beyond current model codes, or some other variation on model codes that goes beyond minimum requirements. While local government, namely the Division of Planning and Development and its Construction Code Enforcement Department, will serve as the lead implementation party, key stakeholders in the land development sector and business community must also be involved in the development, design, and successful adoption of these new regulations and incentives.

IMPLEMENTATION STEPS

Require that all new municipal buildings and major renovations for the City and County meet LEED Silver or Net Zero Energy standards.

Review approaches to implementing green building codes in other cities to assess best practices for adoption.

Gather input on the design and scale of mandatory green building standards in Memphis and Shelby County from the Memphis-Shelby County Building Code Board and other stakeholders in the building and development industry.

Adopt green building and energy codes that improve upon the requirements of model codes; consider standards such as the International Green Construction Code, ASHRAE Standard 189.1, and stretch codes implemented in other jurisdictions.

Explore the adoption of Net Zero building standards to achieve deeper energy savings and GHG reductions in the long-term.

Establish a regular and frequent review process for updating building and energy codes to ensure compliance with the latest green building standards.

Evaluate the feasibility of implementing benchmarking and transparency requirements for energy use in large commercial and multi-family buildings to encourage improved energy efficiency and to connect property owners to resources.

Consider requiring development projects that receive PILOTs (Payment in Lieu of Taxes) or other public incentives to meet minimum green building design standards such as LEED certification or Net Zero Energy.

Consider expanding existing green building incentives in the PILOT (Payment in Lieu of Taxes) program to encourage innovative, sustainable design in projects that receive public assistance.

Explore the adoption of other incentives to encourage green building above mandatory standards, such as density bonuses, reduced minimum parking requirements, expedited review and permitting, reduced fees, and marketing assistance.

Develop educational materials for the building/development community and the public on the benefits and implementation details of green building standards.

Photo: Paul Sableman

ACTION E.1 IMPACT SUMMARY

Objective	Codify and implement green building standards by 2022, with 100% compliance by 2025.
Implementation Partners	<p>City of Memphis and Shelby County (Division of Planning and Development and Construction Code Enforcement Department)</p> <p>Building/development community (developers, architects, realtors, contractors), local economic development groups (Greater Memphis Chamber, EDGE)</p>
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$ \$ \$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

\$ \$ \$

Benefits (High Potential Impact):

- Equity
- Health
- Resilience
- Economic Development
- Environmental

Major Challenges:

- Financial
- Operational
- Education/Behavior Change
- Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

Green building construction in Memphis and Shelby County is limited and has been primarily driven by voluntary decisions made by individual private property owners/developers. There are 52 LEED projects in the County, though there have been some high-profile projects in the last few years, most notably the Crosstown Concourse development which achieved LEED Platinum certification. There are just over 100 Energy Star certified buildings in the area, and a handful of buildings that have attained Green Globes certification. MLGW offers EcoBUILD, a voluntary green building program for single-family and new multi-family construction, which features building standards, inspections, and performance testing. Adoption of EcoBUILD has been limited as builders often focus on short-term cost and market demand for upgraded finishes rather than energy efficiency. The Uptown community - a mixed-income area just north of downtown redeveloped under the US Department of Housing and Urban Development's (HUD) HOPE VI program - has the highest concentration of EcoBUILD-certified

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Along with affordable housing tools and programs, implementation of green building standards has the potential to result in utility savings and improved household comfort for low-income and moderate-income households. Implementation of green building codes must take into consideration the potential negative impacts these standards could have on vulnerable populations through increased housing costs and incorporate tools that will mitigate this risk.

Health: Green building standards have a more explicit focus on designing for the health and comfort of building occupants.

homes in Shelby County demonstrating that meaningful energy efficiency and sustainability can be achieved at any price point. MLGW also has an incentive program for LEED-certified commercial projects. Developed and administered in partnership with the US Green Building Council-Tennessee Chapter, this program provides cash awards to help increase awareness and adoption of green building practices. The Downtown Memphis Commission (DMC) and the Economic Development Growth Engine for Memphis and Shelby County (EDGE) have incorporated some green building incentives into their Payment in Lieu of Taxes (PILOT) programs, but few projects have taken advantage of this particular offering. The DMC program offers the option of longer tax abatement periods for projects that are LEED certified, attain Net Zero Energy Building certification, or attain MLGW's EcoBUILD certification, while the EDGE Residential PILOT program offers longer tax abatement periods for LEED, Green Globes, or Energy Star certification.

Economic Development/Job Creation: Implementation of green building codes can result in new green businesses and job opportunities. Utility savings from energy efficiency measures also result in higher discretionary spending, which supports economic growth.

Environmental: Reductions in energy use and increased water conservation will help improve air quality and long-term drinking water supplies.

Resilience: Green building codes are increasingly focused on incorporating elements that enhance climate resilience and Memphis and Shelby County should ensure that any new codes address climate vulnerabilities in our region.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: There may be some initial upfront costs as developers, architects, and builders adjust to the new codes and get familiar with low-cost green options. Current research shows that upfront costs for green buildings are often comparable to conventional buildings. As builders require more efficient materials, supply houses also start to stock these materials instead of placing special orders, resulting in less of a price difference.

Operational: Initial implementation of green building codes that have never been used in this area may present some initial operational challenges in

terms of educating and training construction code enforcement staff and providing outreach and educational material to the building/development community. Training for builders and subcontractors will be necessary to ensure code compliance.

Education/Behavioral Change: Probably the biggest hurdle to implementing green building codes is the perception that green buildings are too expensive and won't be profitable in the Memphis market.

Policy Change: Building widespread political and public support for adopting new, and perhaps unfamiliar, green building standards will be challenging.



Priority Action E.2: Improve Low-Income Housing Energy Efficiency

OBJECTIVE: INCREASE THE NUMBER OF LOW-INCOME HOUSEHOLDS SERVED BY WEATHERIZATION AND RETROFIT PROGRAMS ANNUALLY BY 500% OVER 10 YEARS, WITH A 30% TARGET REDUCTION IN ENERGY USAGE PER HOUSEHOLD.

Background: According to a 2016 report from the American Council for an Energy-Efficient Economy, energy burden – the percentage of household income paid to energy costs - is a serious issue for Memphians, particularly low-income residents. Even with local electricity rates that are well below the national average, energy costs for low-income households remain high primarily due to poor housing conditions. While the average Memphis household pays around 6% of its annual income on energy costs, the average low-income household in Memphis uses close to 13% of its annual income on energy costs. Distressingly, a quarter of low-income households in Memphis pay more than 25% of their income to cover utility bills. With a poverty rate close to 20% in a region of 1.3 million people, there are clearly many households who are energy-burdened in the Memphis area. Promoting energy efficiency in low-income households has the effect of generating cost savings for households who need it the most, reducing demand for energy, and cutting greenhouse gas emissions.

Approach: This priority action aims to reduce energy usage among low-income households by improving weatherization and insulation, installing smart thermostats to reduce energy consumption, installing more energy efficient appliances and home products such as windows, roofs, and insulation, and providing complementary educational programs on energy efficient practices. Implementation of this action will involve expanding existing weatherization/energy efficiency programs offered by the public and private sector and potentially creating new programs to reach more residents. While identifying and pursuing additional funding is imperative for successful implementation, improving the operations of existing programs and better coordinating delivery of these services to residents is just as important. Complementary work focused on ensuring robust implementation of existing regulations and tools such as MLGW's Minimum Energy Efficiency in Rental Property ordinance and the recently adopted International Property Maintenance Code is also vital to the broader effort of increasing the health, safety, and energy efficiency of housing. Local government, housing agencies, community organizations, MLGW, and private contractors and energy auditors will serve as the key implementation partners for this action.

IMPLEMENTATION STEPS

Aggressively pursue additional funding sources – both public and private - to expand existing weatherization programs for low-income residents.

Leverage existing efforts such as the Healthy Homes Partnership (HHP), the Green & Healthy Homes Initiative (GHHI), and other public and private energy efficiency investments to improve coordination and maximize the benefit of existing programs.

Work with public and private partners to foster a skilled, quality workforce in the weatherization/energy efficiency field with a particular focus on creating jobs for residents in energy-burdened communities.

Strengthen complementary education programs for residents who receive weatherization assistance to encourage behaviors and practices that maximize energy efficiency and cost savings.

Develop more robust marketing, outreach, and engagement efforts in collaboration with residents in energy-burdened neighborhoods to provide information on existing programs and encourage participation.

Explore how new tools and programs– such as the Affordable Housing Trust Fund – can incorporate energy efficiency goals and standards.



Photo: MLGW, Share the Pennies Home Weatherization Program

ACTION E.2 IMPACT SUMMARY

Objective	Increase the number of low-income households served by weatherization and retrofit programs annually by 500% over 10 years, with a 30% reduction in energy usage target per household
Implementation Partners	City of Memphis and Shelby County (Housing and Community Development Division, Office of Sustainability & Resilience) Public housing agencies, housing service providers, community development corporations (CDCs), GHHI, MLGW, contractors
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$ \$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

Benefits (High Potential Impact):
 Equity
 Health
 Resilience
 Economic Development
 Environmental

Major Challenges:
 Financial
 Education/Behavior Change
 Operational
 Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

Memphis and Shelby County have a number of existing weatherization/energy efficiency programs that serve low-income residents. The four largest programs – MLGW’s Share the Pennies, the City of Memphis Weatherization Assistance Program, the Tennessee Housing Development Agency Weatherization Assistance Program, and the Shelby County Housing Rehabilitation Program – serve an estimated 433 households annually.

- City of Memphis Weatherization Assistance Program (administered by the Division of Housing and Community Development)
- Memphis Light, Gas, and Water’s Share the Pennies Low-Income Home Weatherization Program
- Shelby County Housing Rehabilitation Program (for low- and moderate-income residents outside of city of Memphis limits)

- Habitat for Humanity of Greater Memphis Aging in Place Program
- Healthy Homes Partnership / Green & Healthy Homes Initiative: Development of draft common intake forms for referrals and client services
- Neighborhood Preservation Incorporated: Code Enforcement Health Impact Assessment
- United Housing’s Home Improvement Loan Program (\$15,000, 3% IR, 10-year term)
- THDA’s Tennessee Repair Loan Program (\$25,000, 0% interest, forgivable in 5 Years)

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Directly impacted households with limited resources will save money on utility bills and experience enhanced comfort in the home.

Health: Directly impacted households can realize health benefits in homes that are more efficient, better protected from the elements, and less susceptible to conditions that breed mold and other asthma triggers.

Economic Development/Jobs: Additional contractors, energy auditors, and outreach/engagement specialists will be needed to successfully implement this action.

Environmental: Reductions in energy use means reduced greenhouse gas emissions and potentially improved air and water quality.

Resilience: This action could lead to lower financial losses for MLGW which could potentially be plowed back into infrastructure and maintenance investments in the distribution network to improve system resilience.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Identifying additional funding sources to expand reach of existing programs; identifying funding to address remediation and rehabilitation of homes beyond energy efficiency measures (i.e. new roof, structural issues).

Operational: Ramping up delivery of weatherization and retrofit projects, including identifying and training more contractors to complete the work; ensuring coordination across multiple agencies and organizations.

Education/Behavioral Change: Providing information to residents on behaviors that can help ensure the effectiveness of energy efficiency measures will be key to this action's success.

Policy Change: Implementation of this action may necessitate policy changes and/or new, innovative policies for entities that currently provide low-income energy efficiency services in order to expand their programs.



Priority Action E.3: Enhance and Expand Energy Outreach and Education Programs

OBJECTIVE: ATTAIN A 10% OR GREATER REDUCTION IN AVERAGE ELECTRICITY CONSUMPTION FOR RESIDENTIAL AND COMMERCIAL SECTORS

Background

Emissions from residential and commercial buildings in Shelby County account for 41% of total community-wide emissions, with 19% from the residential sector and 22% from the commercial sector. While the implementation of green building codes will help address energy use in new construction and major renovation projects, it is also necessary to look at how to reduce energy use in existing buildings. Average household and commercial electricity use in Shelby County is higher than the US averages based on US Energy Information Administration and MLGW consumption data, resulting in higher energy waste and utility bills. By promoting awareness through effective outreach and education programs, some of this waste can be reduced and residents and commercial customers can more fully understand the benefits of building improvements and behavior change.

Approach

This priority action aims to reduce energy use in existing residential and commercial buildings through outreach and education campaigns and an energy saving challenge. Depending on resources and capacity, the two sectors can be targeted at the same time or separately. Implementation of a residential energy challenge would entail: 1) establishing an existing energy consumption baseline by census block; 2) developing a communications campaign and effectively delivering resources through a variety of information channels; and 3) providing ongoing communications and support during a year-long energy challenge that aims to reduce overall residential energy consumption by 10%. A commercial building energy challenge could be open to all commercial customers or may take a more targeted approach that looks at commercial buildings in key areas and employment centers such as Downtown, the Medical District, the Memphis International Airport area, or the Poplar-240 office corridor. Local government, MLGW, TVA, elected officials, community organizations, the Greater Memphis Chamber, and large employers will be key partners in implementing this action.

IMPLEMENTATION STEPS

Research best practices from effective residential and commercial campaigns encouraging energy efficiency and energy conservation.

Develop programs and materials **with** community members to determine what effective outreach looks like in terms of types of materials and delivery methods, content, and who is delivering information and messages to the community.



Engage high-profile leadership and well-known Memphians to promote energy efficiency/conservation campaigns.

Collaborate with community-based organizations, nonprofits, advocacy groups, faith communities, and large employers to raise awareness and encourage participation in energy efficiency campaigns or challenges.

Provide resources to the commercial sector on energy tracking tools in preparation for a commercial energy reduction challenge.

Photo: City of Memphis Office of Comprehensive Planning

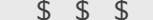
ACTION E.3 IMPACT SUMMARY

Objective	Attain a 10% or greater reduction in average electricity consumption for residential and commercial sectors
Implementation Partners	MLGW, TVA, elected officials, neighborhood groups and community organizations, faith communities, advocacy groups, large employers, Greater Memphis Chamber City of Memphis and Shelby County
GHG Reduction Impact (tCO ₂ e)	Not quantified
Estimated Net Cost (2018 \$; Cumulative)	Not quantified
Cost Effectiveness (\$/tCO ₂ e)	Not quantified
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness:

Low → High


Net Cost:

Low → High


Benefits (High Potential Impact):

Equity  Health  Resilience 
 Economic Development  Environmental 

Major Challenges:

Financial  Education/Behavior Change 
 Operational  Policy Change 

EXISTING PROGRAMS AND POLICIES

There are several existing campaigns or initiatives serving the greater Memphis area with the goal of reducing residential energy consumption. The MLGW website provides customers with tips for reducing their energy consumption, especially as needs change seasonally. MLGW's My Account website features a My Energy Plan section where customers can review/select options and then check off projects as they are completed. Additionally, smart meter data and optional residential electric Time-of-Use (TOU) rate can provide customer-specific information. During MLGW's Smart Grid Demonstration (2010-2012), participants who adopted the TOU rate used 5.6% less electricity than the non-TOU customers, who used 3.2% less than the baseline customers without smart meters. This was largely driven by education and awareness. In the past, MLGW has also engaged in a residential energy challenge to incentivize their customers to reduce energy consumption. The MLGW Smallest User challenge took place from 2009 to 2010. In addition, MLGW hosts EnergySmart Memphis workshops, which teach attendees about the benefits of energy efficiency and conservation, as well as provide hands-on demonstrations of basic home weatherization techniques.

The Tennessee Valley Authority (TVA) also provides information on how to reduce energy consumption via their website. Additionally, TVA offers an energy auditing service called eScore, which helps homeowners learn their current energy efficiency, which upgrades would make their home more energy efficient, and how to get connected to contractors who can complete these upgrades. The original eScore program costs homeowners about \$75, however homeowners can also complete a self-audit for free through TVA, which allows them to receive a customized report on energy savings and a free energy conservation kit.

For commercial customers, TVA and MLGW offer energy resources and incentives via the Energy Right Solutions program. The program includes free guides and customized advice on lighting, heating and cooling systems, electric forklifts, indoor agriculture, kitchen equipment, and industrial processes, information on qualified contractors in the TVA service area (Preferred Partners Network), and standard and tailored incentives for new construction, major renovations, and upgrades to existing facilities.

The Memphis-Shelby County Office of Sustainability also launched the Mayors' Energy Challenge, which created a partnership between the mayors of Memphis and Shelby County and Pathway Lending, a nonprofit commercial lender in Tennessee. While the Mayors' Energy Challenge is no longer active, the Pathway Lending loan program remains and a similar challenge could be designed for Shelby County in the future. The State of Tennessee, MLGW, and TVA were also partners. The goal of the Mayors' Energy Challenge was to provide tools and resources to motivate individuals in the community to make their homes and businesses more energy efficient. Program goals included: savings for residents and businesses, providing contractors with business opportunities, and reducing carbon emissions in the community. Results of the Mayor's Energy Challenge and other programs can inform development of this new initiative.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Developing outreach and educational programs in collaboration with residents – particularly those residents who are experiencing the highest energy burden in our community and are impacted the most by energy inefficiency – has the potential to improve equity through lower utility costs and household savings.

Health: Directly impacted households can realize health benefits in homes that are more efficient, better protected from the elements, and less susceptible to conditions that breed mold and other asthma triggers.

Economic Development/Jobs: Reducing energy waste yields utility savings resulting in increased discretionary spending for consumers. This

increased discretionary spending for goods and services can lead to more jobs in the community. In terms of job creation, energy efficiency experts and outreach/engagement specialists will also be needed to successfully implement this action.

Environmental: Reductions in the use of energy that is supplied by fossil fuels has the potential to improve air and water quality.

Resilience: Increased awareness of energy efficiency measures and behaviors can lead to increased resilience to climate hazards such as extreme heat and extreme cold.

CHALLENGES

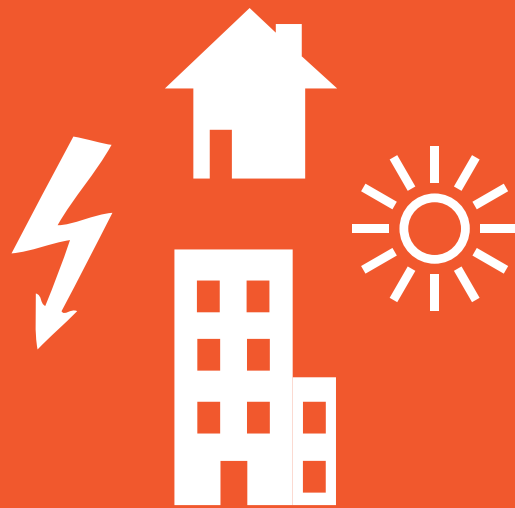
Challenges for successfully implementing this action include:

Financial: Identifying funding and/or adding staff capacity to develop educational and communications materials will be a significant hurdle.

Operational: For the residential energy challenge, it will be important to develop materials and methods in collaboration with energy-burdened and low-income communities. This approach may require more time and increased staff capacity.

Education/Behavioral Change: Behavioral change is the central challenge of this action; lessons learned from effective campaigns in other cities will be useful in overcoming this challenge.

Policy Change: Implementation of this action is not expected to involve any major policy changes.



Priority Action E.4: Retrofit Outdoor Streetlights to LED

OBJECTIVE: REPLACE ALL EXISTING NON-LED STREETLIGHTS AND LEASED OUTDOOR LIGHTING WITH LED BULBS BY 2030 OR SOONER, STARTING IN 2025

Background

Improving energy efficiency in streetlights presents a significant opportunity to reduce energy consumption, decrease operations and maintenance costs for MLGW, and save money for Memphis and Shelby County residents. Currently, there are 107,221 streetlights and 42,330 leased outdoor lights (LOLs) in the City of Memphis and Shelby County. Most of these lights are traditional high-pressure sodium (HPS) bulbs. Transitioning to LED bulbs will use less energy, reduce maintenance costs and electricity costs, and solve issues with HPS bulbs such as high failure rates and marginal light quality. Over time, MLGW and its customers can expect to see not only energy savings, but also an economic return on investment due to the durability and reduced maintenance associated with LED fixtures.

Approach

This action aims to replace all non-LED streetlights and leased outdoor lights in Memphis and Shelby County with LED bulbs. Implementation of this action will involve developing a full life cycle cost/benefit analysis of making the switch to LED bulbs, identifying the best financing model for the upfront replacement costs, and determining an efficient and feasible schedule for bidding, contracting and installation. Implementation should also include the development of public education and communications materials to explain the community-wide benefits of transitioning to more efficient streetlights. MLGW and local government will be the primary implementation partners for this action.

IMPLEMENTATION STEPS

Prepare an up-to-date, full life cycle cost/benefit analysis for retrofitting streetlights and leased outdoor lighting that includes operations and maintenance costs, energy use and costs, and other economic considerations.

Research best practices and approaches for comprehensive streetlight retrofit programs in other cities.

Explore financing options for the retrofit program, including bond issuances and loans that can be repaid with operations and maintenance savings.

Ensure that new LED streetlights are designed with an appropriate color temperature of 3,000 Kelvin or lower and are properly shielded.

Develop a public education and communications campaign to explain project implementation and up-front costs as well as the short- and long-term community-wide benefit.



Photo: Connor Ryan

ACTION E.4 IMPACT SUMMARY

Objective	Replace all existing non-LED streetlights and leased outdoor lighting with LED bulbs by 2030 or sooner, beginning in 2025
Implementation Partners	MLGW City of Memphis, Shelby County, and other local municipalities
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness:
 Low → High

Net Cost: Low → High
 \$ \$ \$

Benefits (High Potential Impact):
 Equity Health Resilience
 Economic Development Environmental

Major Challenges: Financial Education/Behavior Change
 Operational Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

With few exceptions, MLGW owns and maintains streetlights in Memphis and Shelby County. Prior to 2014, the City of Memphis owned streetlights within the city boundaries and paid an annual fee – using property tax revenues – to MLGW for energy use and maintenance costs. MLGW now collects streetlight fees directly from customers within Memphis. These fees vary depending on the property type.

MLGW recently installed over 600 LED streetlights in the South Cordova area as a pilot project. The utility has also performed some initial cost/benefit

analyses for an LED streetlight retrofit project that have showed a long payback period for the investment due to low energy rates. However, an updated full life cycle cost/benefit analysis that includes economic considerations such as operations and maintenance costs and the time value of money should provide a more comprehensive picture of the payback period/return on investment. Additional benefits such as improved safety with better lighting and fewer outages are also considerations that should be added to the cost/benefit analysis of this project.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Implementation of LED streetlights should bring down customer fees in the mid and long-term. Low-income customers will benefit from these cost savings.

Economic Development/Jobs: The installation process could create new jobs, but there are no mid- or long-term economic development/job creation benefits from this action.

Environmental: Installing LED streetlights with warmer color temperatures that are property shielded can help reduce light pollution, benefiting human and animal circadian rhythms and animal migrations.

Resilience: LED lights are more durable and longer-lasting which helps increase infrastructure resilience.

CHALLENGES

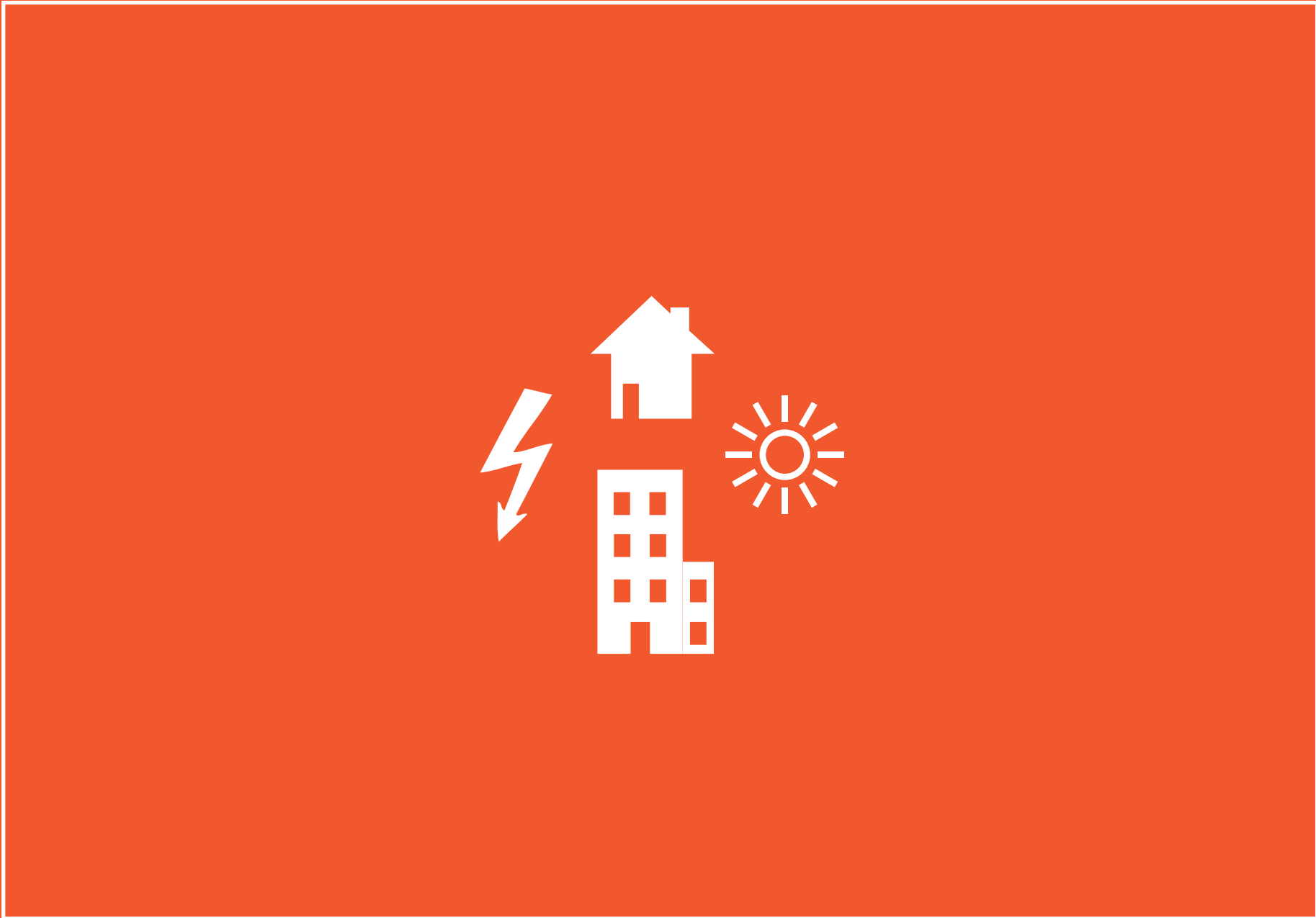
Challenges for successfully implementing this action include:

Financial: Determining the best financial model to pay for the upfront investment and gaining political support for the retrofit project will present challenges.

Operational: To meet the 2030 implementation goal, it will be necessary to determine a realistic timeline for completion of the full life cycle cost/benefit analysis and the financing, bidding, contracting, and installation process. There may also be some new training and education needed for MLGW employees for maintenance and operation of the new LED lights.

Education/Behavioral Change: Providing effective public education on the retrofit and communicating short and long-term benefits will be important to successful implementation.

Policy Change: Depending on the financing framework for implementation, MLGW or local governments may need to consider changes to existing policies.



Priority Action E.5: Expand Financing Options for Residential Energy Efficiency Retrofits

OBJECTIVE: By 2025, 15% of all residences will have energy-efficient space heating and cooling equipment and major appliances.

Background

Residential buildings account for 19% of total greenhouse gas emissions. Taking action to improve the energy efficiency of existing residential buildings is essential to achieving our climate action goals.

Space heating, air conditioning, water heating, refrigerators, and clothes dryers account for 73% of residential energy consumption, with the first three items accounting for the bulk of this consumption (62%). Energy efficient HVAC systems and appliances often have significant upfront costs that can discourage homeowners from purchasing these items, making the provision of subsidies, incentives, and other financial tools to help defray these costs attractive. Developing effective financing options for making energy efficiency upgrades to residences will provide direct economic and health benefits to the impacted households, reduce our use of fossil fuels, and enhance community resilience.

Approach

This priority action seeks to achieve installation of energy-efficient heating and cooling equipment and major appliances in 15% of existing residences by 2025. Implementation of this action will involve advocating for and providing additional financial tools and incentives for residential energy efficiency retrofits. Potential new tools include tariffed on-bill financing, Property Assessed Clean Energy (PACE), and residential utility incentives/rebates. Tariffed on-bill financing involves the provision of energy efficiency upgrades that are then repaid over time on a resident's utility bill. These programs are designed so that utility bills post-upgrade - even with the repayment portion included - are less than bills pre-upgrade. Tariffed on-bill financing offers a number of advantages in that it can benefit both renters and homeowners, it eliminates

barriers that traditional loans can pose to some residents, and it can benefit a broad cross-section of residents. Residential PACE programs provide financing to homeowners for energy upgrades which is then paid off through a property tax assessment. Eligible PACE energy upgrades typically include heating and cooling systems, hot water heaters, air sealing and insulation, doors, windows and roofing, and solar power systems; portable items such as light bulbs and standard refrigerators are not typically eligible for PACE financing ("Property Assessed Clean Energy Programs," n.d.). Currently, PACE programs are not allowed under Tennessee state law meaning that action from the state legislature would be necessary. In addition, the City of Memphis and/or Shelby County would have to adopt policies and develop procedures for implementing this type of program. Utility incentive programs could involve the provision of rebates for customers to buy energy efficient equipment and appliances. Implementation of a rebate program would involve a change to MLGW's charter, as the use of customer revenue for incentives that benefit individuals is currently not allowed.

While local government, MLGW, and TVA will be key implementation partners for this effort, collaboration with nonprofits, advocacy organizations, and neighborhood groups will be crucial to pushing for state-level policy change and designing new programs.

IMPLEMENTATION STEPS

Work with MLGW and other partners to develop a tariffed on-bill financing program for residential energy retrofits. Major steps include identification of initial capital to seed the program, utility and property data assessment to identify candidates, intake design, marketing materials development, and the potential implementation of a pilot project to test the concept.

Advocate for state legislation that allows the implementation of a local Residential Property Assessed Clean Energy (PACE) program. Work with local officials and other partners to develop policies and procedures for a local PACE program.

Work with MLGW, elected officials, and other partners to explore the feasibility of changing MLGW's charter to allow residential energy efficiency rebates.

Enhance existing local education and marketing efforts that provide information on home energy audits, energy-efficient equipment and appliances, and renewable energy installation.

Develop a system to collect local data on sales and installations of energy-efficient appliances and other energy efficiency measures. This could involve public surveys, more comprehensive monitoring and assessment information from existing weatherization programs, or other data collection methods.

For future efforts focusing on the commercial sector, develop local marketing campaigns to provide information on existing products such as Pathway Lending's Low-Interest Energy Efficiency and Renewable Energy Loans and TVA's EnergyRight Solutions energy efficiency incentives.

Photo: City of Memphis Office of Comprehensive Planning

ACTION E.5 IMPACT SUMMARY

Objective By 2025, 15% of all residences will have energy-efficient space heating and cooling equipment and major appliances.

Implementation Partners MLGW, TVA, state government, advocacy organizations, nonprofits, philanthropic organizations, neighborhood groups, utility customers
City of Memphis and Shelby County



Estimated Net Cost* (2018 \$; Cumulative) \$



Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

Benefits (High Potential Impact): Equity (👤), Health (+), Resilience (🏠), Economic Development (🏭), Environmental (🌿)

Major Challenges: Financial (\$) , Operational (⚙️) , Education/Behavior Change (👤) , Policy Change (📄)

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

TVA offers the eScore program which offers information, resources, and a list of certified contractors to carry out recommended energy efficiency work. Through this program, TVA previously offered rebates to residential customers for upgrades including windows and doors, air sealing, insulation, water heaters, heat pumps, and duct work. The vast majority of these rebates have ended, as TVA has focused more on incentives for switching to appliances/products that use electric power instead of another fuel.

Legislation to establish Commercial and Residential Property Assessed Clean Energy (PACE) financing programs has been under development at the state level for a number of years. PACE legislation would allow local jurisdictions to establish a funding source for property owners to finance clean energy projects through property taxes. When a property changes owners, the

BENEFITS

The potential benefits from implementing this priority action include:

Equity: The design of any financing, subsidy, and rebate programs for residential energy efficiency retrofits should focus on how low-income households can participate and take advantage of the cost savings and health benefits of these upgrades.

Health: Newer, more energy-efficient equipment and appliances can improve indoor air quality and lessen conditions that breed mold and pests.

improvements along with their outstanding loan value, would be assumed by the new owner. This financing mechanism helps defray risks to property owners who may be concerned about longer ROI/payback periods for certain energy efficiency and renewable upgrades.

Economic Development/Jobs: These financing and subsidy programs can create new job opportunities for contractors and other home improvement professionals.

Environmental: Reductions in energy use and increased water conservation will help improve air quality and long-term drinking water supplies.

Resilience: Increasing energy efficiency in households will help residents adapt to extreme heat and cold events more effectively and with longer-term reduced costs than would have otherwise been possible.

CHALLENGES

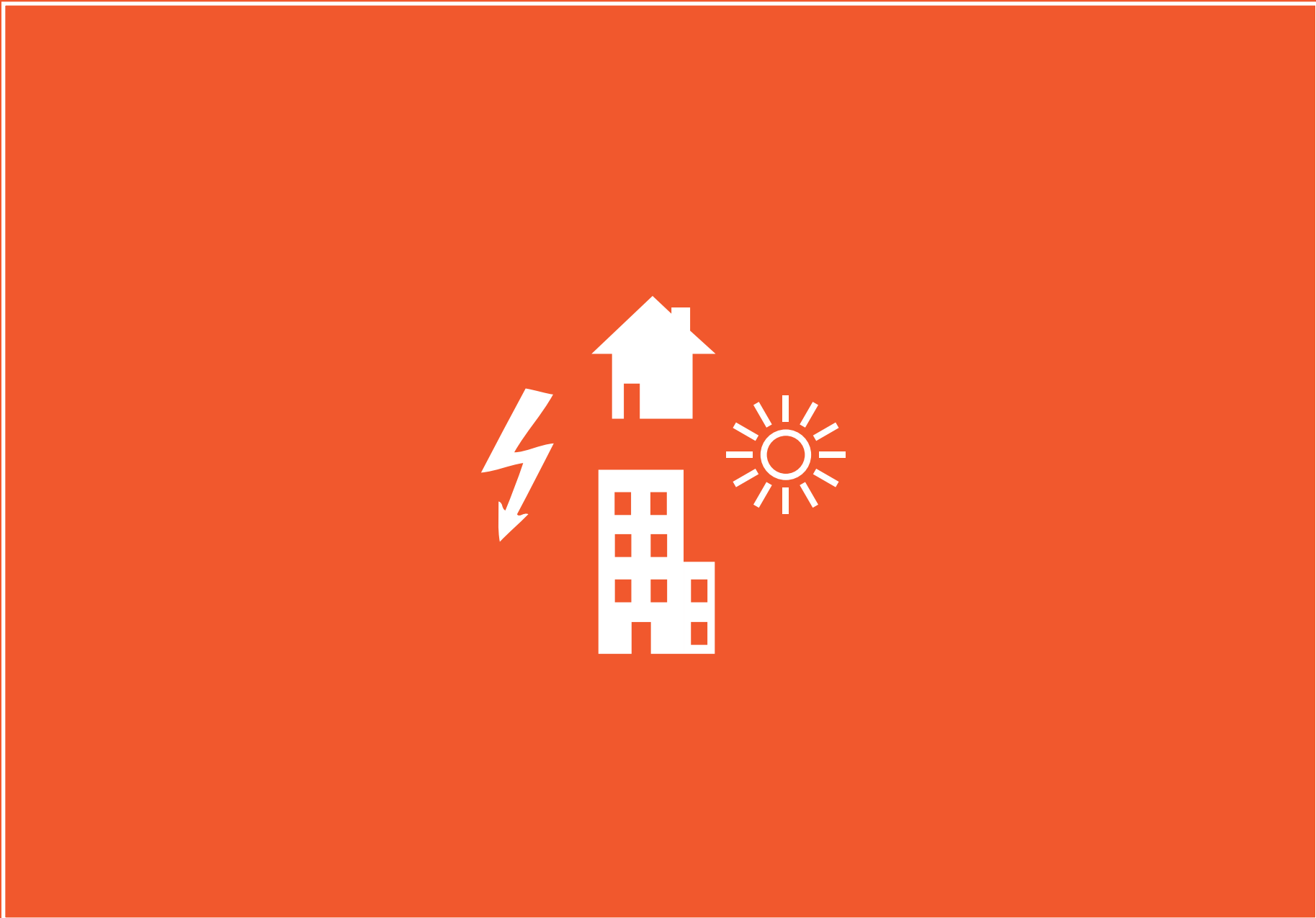
Challenges for successfully implementing this action include:

Financial: Although PACE programs provide a more readily-available funding source/mechanism (private financing paid back through property taxes), funding for a rebate or incentive program would have to be identified. The initial capital to fund a tariffed on-bill energy financing program would also have to be identified.

Operational: Any new financing mechanism and/or program focused on providing energy efficiency upgrades to residential customers would face challenges in terms of program design and marketing/outreach.

Education/behavioral change: Energy efficiency upgrade programs should include complementary educational material and information about maintenance and behaviors that can maximize efficiency of the new products.

Policy Change: Offering a local utility rebate program through MLGW would necessitate changes to MLGW's charter so that customer revenue could be used for providing incentives. Provision of a local PACE program would also require approval and policy changes at the state and local level.



2 TRANSFORM OUR ENERGY SUPPLY

Turning from a focus on cutting the amount of energy that we consume, this section directly addresses how we can increase the amount of clean, renewable sources in our energy supply. Greening our electric grid has the highest potential for achieving deep greenhouse gas emissions reductions, and the costs for renewable energy sources such as wind, solar, and biomass have decreased dramatically over the last several decades along with substantial improvements to the technology involved in these power sources.

While MLGW distributes power locally, the Tennessee Valley Authority (TVA) generates electricity distributed in the Memphis area – an arrangement that has been in place for 80 years. TVA has already taken steps toward a lower carbon future by decreasing the amount of coal generation in their portfolio and relying more on carbon-free sources such as hydroelectric, nuclear,

and wind/solar. Memphis and Shelby County must build off this carbon-free energy foundation and explore new, innovative ways to increase renewable energy sources such as solar and wind.

Transforming our energy supply over the next 30 years will need to take an “all-of-the-above” approach, with actions ranging from partnering with TVA to increase renewables in their portfolio, to encouraging and constructing local sources of renewable generation (particularly solar), to exploring purchasing agreements with other third-party renewable energy generators. Along with efforts to reduce energy consumption, transitioning to cleaner, renewable sources of electricity will help fulfill our community goals around health, quality of life, and resilience.



Photo: Silicon Ranch; Millington Solar Farm

2 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
<p>E. 6 Decarbonize the Electric Grid with Renewable Energy</p>	<p>Increase the percentage of carbon-free energy in our electricity supply to 80% by 2035 and 100% by 2050, focusing on renewable sources such as solar and wind</p>	<ul style="list-style-type: none"> ▶ Advocate for TVA to increase the amount of renewable energy sources – particularly wind and solar – in its portfolio, whether through Renewable Energy Certificates, Power Purchase Agreements for renewable power, or development/ownership of new renewable energy generation assets. ▶ Commit to a Renewable Portfolio Standard for City of Memphis and Shelby County local government operations and explore options for achieving these renewable goals, such as solar installations on government facilities, Renewable Energy Certificates, participating in community shared solar projects, and green tariff products. ▶ Work with TVA and MLGW to push for new tools and programs that enable interested customers – public and private – to purchase or develop renewable energy. ▶ Work with TVA and MLGW to explore changes to current contract terms that require all local power be purchased through TVA and explore the feasibility of purchasing renewable energy from other third-party providers. ▶ Encourage MLGW and local stakeholders to prioritize decarbonization and increasing renewable energy generation during internal resource planning processes. ▶ Implement at least one local community shared solar project that includes subsidies for low-income household participation in the Memphis area by 2022. ▶ Explore the implementation of a community shared solar program that includes policies and incentives to increase low-income household participation.

Priority Action E.6: Decarbonize the Electric Grid with Renewable Energy

OBJECTIVE: INCREASE THE PERCENTAGE OF CARBON-FREE ENERGY IN OUR ELECTRICITY SUPPLY TO 80% BY 2035 AND 100% BY 2050, FOCUSING ON RENEWABLE SOURCES SUCH AS SOLAR AND WIND

Background

MLGW purchases the electricity it distributes locally from TVA (Tennessee Valley Authority), a federally owned corporation that supplies power to most of Tennessee as well as parts of Alabama, Mississippi, Kentucky, Georgia, North Carolina, and Virginia. MLGW is the largest purchaser of electricity from TVA. Over the last 10-15 years, TVA has moved away from more carbon-intensive energy sources, such as coal, and has increased its share of carbon-free sources such as nuclear, hydroelectric, and renewables. Approximately 54% of TVA's current portfolio is carbon-free, and by 2020 this will increase to 56%. Increasing the amount of carbon-free energy sources in our energy mix – particularly clean, renewable sources such as solar and wind – will have a tremendous impact on reducing greenhouse gas emissions, improving air and water quality, increasing economic development/job opportunities, and enhancing community resilience.

Approach

This action aims to increase the share of carbon-free energy in our electricity supply by focusing on renewable sources such as wind and solar. With ambitious goals of 80% carbon-free energy by 2035 and 100% carbon-free energy by 2050 (from a 2020 baseline of 56%), implementation of this priority action will need to take a comprehensive approach. Successful implementation will involve working with TVA to advocate for increases in renewable energy sources in TVA's portfolio and exploring more flexible contract terms with TVA to potentially allow the purchase of renewable energy from other third-party providers. Implementation will also involve developing new tools and programs that support local purchasing or development of renewable energy. In addition, the City of Memphis and Shelby County should lead by example by setting renewable energy goals for local government operations. MLGW, TVA, and local government will be the primary implementation partners for this action.

IMPLEMENTATION STEPS

Advocate for TVA to increase the amount of renewable energy sources – particularly wind and solar – in its portfolio, whether through Renewable Energy Certificates, Power Purchase Agreements for renewable power, or development/ownership of new renewable energy generation assets.

Commit to a Renewable Portfolio Standard for City of Memphis and Shelby County local government operations and explore options for achieving these renewable goals, such as Renewable Energy Certificates, participating in community shared solar projects, or green tariff products.

Work with TVA and MLGW to push for new tools and programs that enable interested customers – public and private – to purchase or develop renewable energy.

Work with TVA and MLGW to explore changes to current contract terms that require all local power be purchased through TVA and explore the feasibility of purchasing renewable energy from another third-party provider.

Encourage MLGW and local stakeholders to prioritize decarbonization and increasing renewable energy generation during internal resource planning processes.

Implement at least one local community shared solar project that includes subsidies for low-income household participation in the Memphis area by 2022

Explore the implementation of a community shared solar program that includes policies and incentives to increase low-income household participation.

Photo: Brandon Dill

ACTION E.6 IMPACT SUMMARY

Objective	Increase the percentage of carbon-free energy in our electricity supply to 80% by 2035 and 100% by 2050, focusing on renewable sources such as solar and wind.
Implementation Partners	MLGW, TVA, utility customers City of Memphis and Shelby County
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$ \$ \$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

Benefits (High Potential Impact): Equity Health Resilience Economic Development Environmental

Major Challenges: Financial Education/Behavior Change Operational Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

TVA and MLGW offer several existing renewable energy programs and are working to develop more options. Residential and commercial customers can participate in Green Power Switch, an offset program where customers purchase blocks of renewable energy that are added to TVA's electricity mix. Green Power Switch also now offers the purchase of Southeastern Renewable Energy Certificates (generated at wind farms in other states) which allow the purchaser to make renewable energy claims or offset their carbon footprint. Customers may also interconnect to MLGW and generate power for use on-site (self-generation.)

The Dispersed Power Production program is available to residential and commercial customers and allows these customers with onsite renewable energy generation to sell all or part of this power to TVA at wholesale rates.

In the past, Green Power Providers has supported residential and small commercial renewable installations where TVA agreed to purchase the generated energy for 20-year terms. However, TVA will close this program to new applicants at the end of 2019.

- Existing TVA Renewable Energy Programs
 - Green Power Switch - offset/Renewable Energy Certificate (REC) program designed for residential/small commercial customers to purchase small quantities of RECs from renewable generation sources located within the Tennessee Valley, including customer-owned systems in Shelby County.
 - Southeastern Renewable Energy Certificates (REC) – program for large commercial and industrial customers to buy large volumes of RECs from existing TVA wind contracts
 - Dispersed Power Production – onsite renewable energy systems that

can sell all or part of their power output to TVA at short-term avoided costs; available to both residential and commercial customers

- Green Power Providers - small-scale renewable energy systems that sell power to TVA; available to residential and commercial customers (*soon to be retired; closed to new applicants at the end of 2019*)
- Renewable Investment Agreement - long-term, large-scale unbundled REC purchases associated with new solar projects located in the Tennessee Valley. This option gives customers the ability to select from bids received through TVA's RFP process, based on customer preferences for location, size, delivery date, price and other factors.

TVA recently released its 2019 Integrated Resource Plan, a comprehensive study that provides direction on how TVA can best meet future demand for power. The plan includes up to 14 gigawatts (GW) of new solar generation over this time period and continues recently-announced plans to retire two major coal plants in the next 4 years.

MLGW also recently retained a consultant to perform a study of available electricity supply options in preparation for its comprehensive, local integrated resources planning process. Since MLGW currently has an “all requirements” contract with TVA, the results of MLGW's IRP could have a substantial impact on future carbon free electricity options in Shelby County.

In terms of existing solar generation in Shelby County, there are 110 interconnected solar arrays as of May 2019, representing 75.7 megawatts (MW) of renewable generation. These systems generate enough electricity to meet the annual needs of 5,555 average households.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Implementation of this priority action will need to take into consideration how purchasing or developing renewable energy can benefit vulnerable populations and avoid potential negative impacts. Decreasing the use of fossil fuels for power production can positively impact air quality and health outcomes for vulnerable populations, but any investments in renewable energy that might raise rates for low-income residents are a concern. Implementation must aim to keep energy costs as low as possible for low-income area residents.

Health: Decreased reliance on fossil fuels for electricity generation will have benefits on public health through improved air and water quality.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Given our current energy supply framework, increasing the share of renewable energy sources will have a cost, whether spread among all customers (i.e. TVA includes more generation in its power supply) or concentrated among participants/supporters who make direct investments (i.e. Green Power Switch program, a Renewable Portfolio Standard for government buildings, a homeowner who installs solar, or future community solar generation). Local government, MLGW, and other partners must work together to determine how to incorporate renewable energy in an equitable and efficient manner.

Operational: Implementing new power purchase agreements, using tools such as green tariffs, or building local renewable energy generation

Economic Development/Jobs: Installation of renewable energy assets locally – particularly solar – can stimulate new economic activity and create new jobs in the clean energy field.

Environmental: Increasing clean, renewable energy generation can have broad air quality benefits for our community. Reducing our reliance on fossil fuels can also have positive environmental impacts in other parts of the country and world where mining and extraction activities occur.

Resilience: Increased energy from local, distributed renewable sources – in concert with battery storage - can enhance community resilience to extreme weather events that may tax the grid and transport of conventional fuels.

will require developing new processes, policies, and programs. In addition, implementation of a Renewable Portfolio Standard for local government operations should be preceded by energy efficiency and building envelope upgrades at government facilities.

Education/Behavioral Change: Providing effective public education on the process and benefits of transitioning to clean, renewable will present challenges given current dependence on fossil fuels, staffing limitations, and resistance to invest in longer-term solutions that may have larger upfront costs.

Policy Change: Achieving these renewable energy goals may involve updates and changes to MLGW's contractual arrangements with TVA.

3 INCREASE GREEN INFRASTRUCTURE AND COMMUNITY RESILIENCE

Reducing our community's contributions to climate change will take many different forms. While the previous sections looked at improving energy efficiency and increasing clean, renewable energy sources, this section explores strategies that can help us both mitigate our impact on climate change and adapt to climate risks that affect the Memphis area.

Traditionally, many urban areas have been defined by their gray infrastructure – roadways, piped stormwater and wastewater systems, and water treatment facilities. More recently there has been a growing recognition of the importance of enhancing green infrastructure in cities. Green infrastructure

can generally refer to the natural systems in an urban area, such as creeks and rivers, open space, and green space. The term also refers to an approach to development that focuses on working with – instead of against – natural systems, especially related to managing stormwater impacts and improving water quality. Increasing green infrastructure in the Memphis area can reduce greenhouse gas emissions, make our community more adaptable to climate risks such as flooding and extreme heat, and provide other positive impacts in terms of improved health and air quality. Green infrastructure can also provide social benefits by providing enhanced community gathering spaces, recreational opportunities, and other community amenities.



Photo: Melissa McMaster

3 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
<p>E.7 Nurture and Expand the Urban Tree Canopy</p>	<p>Plant or replant trees with the intention of increasing urban tree canopy to 60% coverage countywide by 2050</p>	<ul style="list-style-type: none"> ▶ Implement recommendations in the Memphis Regional Canopy Action Plan related to enhanced monitoring and data accessibility, improved regional and local management practices, and more robust public engagement/outreach and regional collaboration. ▶ Implement recommendations in the Mid-South Regional Resilience Plan related to developing standard design guidelines for street tree plantings, coordinating work across agencies and municipalities, encouraging and incentivizing tree plantings on public and private land, and selecting native/not invasive trees that can survive and thrive in an urban environment. ▶ Review, improve, and align current urban forestry and landscaping standards in development codes to encourage protection and expansion of the urban tree canopy. ▶ Develop a robust urban forestry program within the City of Memphis and/or Shelby County government and hire staff to implement. ▶ Establish partnerships with nonprofits and philanthropy groups to pursue additional funding sources for tree planting and maintenance. ▶ Work with MLGW to coordinate tree trimming needs for above-ground utility infrastructure with goals and standards for protecting the health of the urban tree canopy. ▶ Coordinate tree canopy expansion work with potential efforts to develop solar generation facilities on vacant land. ▶ Develop public education materials on tree standards, the benefits of the urban tree canopy, the impacts of invasive species on forest health, and proper care and planting procedures. ▶ Collaborate with community groups to enhance and expand stewardship programs for tree canopy maintenance/expansion.

3 ACTION AREA SUMMARY

PRIORITY ACTION

E.8 Align Climate Mitigation and Climate Adaptation Efforts

OBJECTIVE

Identify and prioritize cross-cutting strategies for climate change mitigation and adaptation

IMPLEMENTATION STEPS

- ▶ Implement projects and practices recommended in the Mid-South Regional Resilience Plan upon completion and adoption.
- ▶ Prioritize cross-cutting mitigation/adaptation investments that reduce risks to low-income, vulnerable communities and improve equity outcomes.
- ▶ Explore engineering designs and alternatives to traditional solutions that are more resilient to flooding and other severe weather events.
- ▶ Pursue afforestation and reforestation strategies to achieve better erosion control, promote ecosystem services, and improve community access to green spaces.
- ▶ Create additional institutional capacity to address changing climate adaptation needs as the effects of climate change are felt in the Memphis area.
- ▶ Develop and implement community/neighborhood-scale demonstration projects to increase awareness and local resilience to flooding and other climate events.

Priority Action E.7: Nurture and Expand the Urban Tree Canopy

OBJECTIVE: PLANT OR REPLANT TREES WITH THE INTENTION OF INCREASING URBAN TREE CANOPY TO 60% COVERAGE COUNTYWIDE BY 2050

Background

The urban tree canopy is an important part of our community's existing green infrastructure systems. A 2014 Urban Tree Canopy Assessment for the Memphis region (Shelby County and a small part of Tipton County, TN) estimates 37% tree canopy cover in the area. Remaining land cover falls into the categories of Other Vegetation (40%, mainly agricultural land), Bare Soil (3%), Impervious (15%), and Water (4%). The study also estimated that 29% of land cover could be converted to tree canopy. However, this estimate takes a conservative approach by excluding some areas that could potentially be converted to tree canopy in the long-term, such as golf courses and agricultural land. The 2014 assessment also identified priority planting areas throughout Shelby County. Based on this canopy assessment, a Canopy Action Plan for the Memphis region was completed in 2015. This action plan lays out goals and strategies for assessment, management, and collaboration designed to enhance and increase the area's urban tree canopy focusing on priority planting areas. Enhancing the Memphis area's urban tree canopy over the next 30 years can help mitigate climate change by reducing energy costs and removing carbon directly. Protecting larger trees - and encouraging development of larger canopy trees - is especially important as they remove much more carbon than younger, smaller trees.

Approach

This action aims to increase tree canopy coverage in the county from 37% to 60% by 2050. Based on the 2015 Memphis Regional Canopy Action Plan, implementation of this action will involve strengthening and enforcing standards that protect existing trees and encourage planting of native and other appropriate species to expand canopy cover, as well as planning, coordination, and outreach programs that focus on providing the resources and support to achieve this target. Tree canopy expansion efforts should focus on urban forests, where temperature and stormwater benefits are higher per capita, as well as strategic areas on the Mississippi River Corridor, agricultural lands along the Loosahatchie River, and areas in Millington. Local government – specifically the Parks and Neighborhoods Department, the Division of Planning and Development, and the Engineering Department – will be key implementation partners. The Memphis Tree Board, MLGW, nonprofits and community groups (e.g. the West Tennessee Urban Forestry Council), and philanthropic organizations will also need to be involved in implementation.

IMPLEMENTATION STEPS

Implement recommendations in the Memphis Regional Canopy Action Plan related to enhanced monitoring and data accessibility, improved regional and local management practices, and more robust public engagement/outreach and regional collaboration.

Implement recommendations in the Mid-South Regional Resilience Plan related to developing standard design guidelines for street tree plantings, coordinating work across agencies and municipalities, encouraging and incentivizing tree plantings on public and private land, and selecting native/not invasive trees that can survive and thrive in an urban environment.

Review, improve, and align current urban forestry and landscaping standards in development codes to encourage protection and expansion of the urban tree canopy.

Develop a robust urban forestry program within the City of Memphis and/or Shelby County government and hire staff to implement.

Establish partnerships with nonprofits and philanthropy groups to pursue additional funding sources for tree planting and maintenance.

Work with MLGW to coordinate tree trimming needs for above-ground utility infrastructure with goals and standards for protecting the health of the urban tree canopy.

Coordinate tree canopy expansion work with potential efforts to develop solar generation facilities on vacant land.

Develop public education materials on tree standards, the benefits of the urban tree canopy, the impacts of invasive species on forest health, and proper care and planting procedures.

Collaborate with community groups to enhance and expand stewardship programs for tree canopy maintenance/expansion.

Photo: City of Memphis Office of Comprehensive Planning

ACTION E.7 IMPACT SUMMARY

Objective	Plant or replant trees with the intention of increasing urban tree canopy to 60% coverage countywide in the next 30 years
Implementation Partners	<p>City of Memphis (Parks and Neighborhoods Division, Engineering Division), Shelby County (Division of Planning and Development)</p> <p>Memphis Tree Board, MLGW, nonprofits, neighborhood groups, philanthropic organizations, TN Environmental Council</p>
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$ \$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High
\$ \$ \$

Benefits (High Potential Impact): Equity Health Resilience
Economic Development Environmental

Major Challenges: Financial Education/Behavior Change
Operational Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

The Unified Development Code for Memphis and Shelby County (applies to City of Memphis and unincorporated Shelby County) has a number of regulations that address tree protection, new tree plantings, and landscaping maintenance:

- **Street Tree Repair:** For any existing street tree wells or street trees on a property, the owner must show that they are planted and in a healthy condition
- **Streetscape Standards:** Establishes streetscape design and elements based on frontage or type of zoning district. Each of these streetscape options requires trees or some type of planted buffer
- **Landscaping and Screening:** Requires submittal of landscape plans for all new, non-single family developments of 5 acres in size or larger and outlines landscaping maintenance standards
- **Open Space and Natural Resource Protection:** Detailed regulations that aim to encourage protection and preservation of existing trees and root systems and to encourage the planting of new trees. Specifies conditions and procedures for tree removal and provides standards for tree replacement

The Memphis Tree Board is an advisory board that provides recommendations to the Director of Parks and Neighborhoods and develops and promotes public education/awareness activities related to urban forestry issues. Members of the board are appointed by the Mayor, and three members are

required to be a certified professional arborist, horticulturalist, or forester. The Tree Board has also worked with the West Tennessee Chapter of the Tennessee Urban Forestry Council to create stewardship programs that recognize landmark and champion trees.

The City of Memphis Parks and Neighborhoods Division also employs a part-time urban forester who manages forestry issues on city-owned land and rights of way.

The Wolf River Conservancy hosts an annual tree planting that aims to replenish tree canopy in the Wolf River watershed. Several other tree planting/urban tree canopy campaigns have taken place over the last several years, including Plant the Parkways (restore the tree canopy in the planted parkway medians) and the 4 Million Trees Campaign led by a consortium of nonprofits, businesses, local government, and philanthropic organizations (plant 4 million trees across Memphis in the next 10-15 years).

The Shelby Farms Park Conservancy has a One Million Trees initiative that aims to cultivate and maintain a healthy urban forest through tree plantings and care/maintenance of forests in the park.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Focused planting efforts in low-income neighborhoods that lack tree canopy cover can result in direct benefits to residents, including lower energy costs due to increased shading, reduced urban heat island effect and temperatures, and improved air quality.

Economic Development/Job Creation: This action could lead to development of new, local businesses that grow native trees, install trees, and/or maintain trees. Recent research also shows strong links between tree canopy and increased property values.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Nurturing the existing tree canopy and increasing its extent will require financial investments from the private, public, and philanthropic sectors.

Operational: Establishing a robust urban forestry program and providing adequate staffing will require local government operational changes.

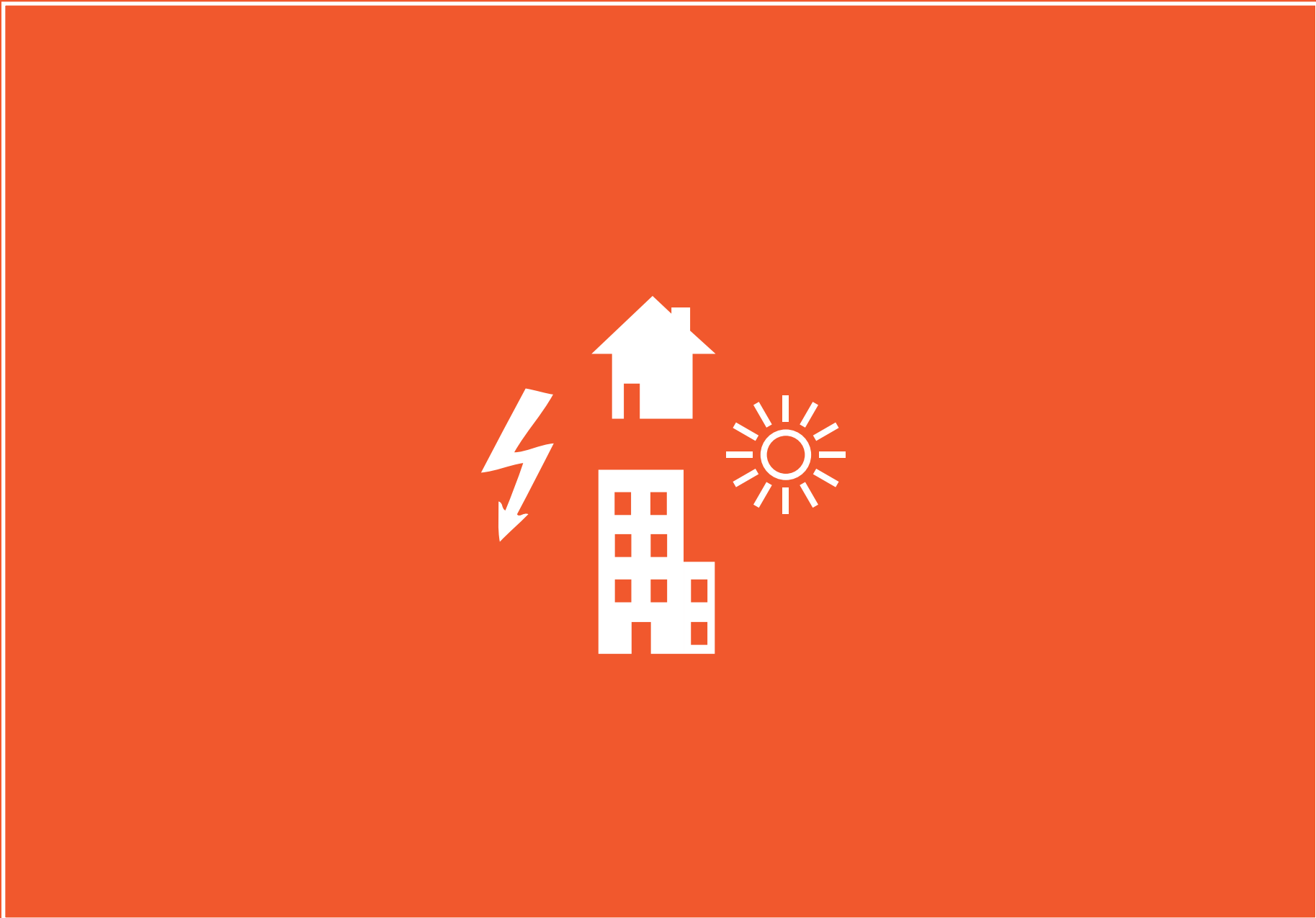
Educational/Behavioral Change: Successful stewardship of the tree canopy will require effective public education and outreach efforts, including communication of the benefits of alternative strategies such as underground

Environmental: Increases in urban tree canopy reduce urban heat island effects and improve air and water quality. Increasing tree species diversity by planting native and non-invasive trees that thrive in urban environments can improve ecological resilience.

Resilience: Green infrastructure such as tree canopy cover can slow down stormwater and reduce climate risks such as flash and river flooding. Changing infrastructure to improve and protect tree canopy - such as relocating utility lines underground - could also potentially benefit the resilience of the electric power grid.

lines to preserve tree canopy and withstand weather impacts to a greater degree.

Policy Change: Amendments/improvements to existing tree protection and planting standards in local development codes may be required. Updates to tree trimming practices related to utilities may also be necessary, as well as guidelines that focus on strategic placement of new plantings in areas where trimming would be limited or negligible.



Priority Action E.8: Align Climate Mitigation and Climate Adaptation Efforts

OBJECTIVE: IDENTIFY AND PRIORITIZE CROSS-CUTTING STRATEGIES FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

Background

While climate change mitigation – or the reduction of greenhouse gas emissions – is the focus of this plan, we know that our community has started and will continue to experience effects from extreme weather related to climate change. Adaptation efforts to reduce risks to our community from local climate hazards – flash and river flooding, extreme heat and cold, drought, and heavy winds – are already underway. As part of a federal National Disaster Resilience Competition grant from the Department of Housing and Urban Development (HUD) that was awarded to address impacts from major flooding in 2011, Memphis and Shelby County are implementing projects that use green infrastructure to reduce flood risk and improve resident quality of life. In addition to these physical infrastructure improvements, the grant also provided funding for a Mid-South Regional Resilience Plan that will provide a more comprehensive approach to climate adaptation. The regional scope of the resilience plan is intentional. Water and climate impacts go beyond jurisdictional lines and collaborative action is more valuable than trying to solve problems in isolation from one another. Aligning these resilience and adaptation efforts with the mitigation strategies in this plan will be crucial to our community's future.

Approach

This action aims to identify and prioritize cross-cutting strategies that address climate change mitigation and adaptation. Many of the strategies and recommendations in this plan have both mitigation and adaptation benefits. For example, improving energy efficiency in buildings not only reduces greenhouse gas emissions, but also reduces vulnerability to extreme heat

and cold events. Green infrastructure such as bioswales, floodable parks, rain gardens, tree cover, and green roofs can reduce flooding risks, reduce energy costs and absorb carbon and other atmospheric pollutants. In particular, this priority action should focus on cross-cutting strategies that can improve equity outcomes. Increasing low-income housing energy efficiency, using green infrastructure to reduce flooding risks to vulnerable low-income communities, and bringing housing, jobs, and services closer together through smarter land use and transportation planning should be priority cross-cutting strategies for the Memphis area. Implementation of this priority action will be an ongoing effort and will take coordination between local government, the private development sector, and the community at-large.

This action also calls for improvements in the science-policy-practice interface, finding ways to quantify the benefits of these projects along with developing research goals that help to capture their social and economic impacts. This boundary spanning initiative between academic institutions and planning practitioners in local government will help justify and encourage further resilience work through creating opportunities for research, potential for peer-reviewed or informal publications, and support meaningful collaborations in Memphis.



IMPLEMENTATION STEPS

Implement projects and practices recommended in the Mid-South Regional Resilience Plan upon completion and adoption.

Prioritize cross-cutting mitigation/adaptation investments that reduce risks to low-income, vulnerable communities and improve equity outcomes.

Explore engineering designs and alternatives to traditional solutions that are more resilient to flooding and other severe weather events.



Pursue afforestation and reforestation strategies to achieve better erosion control, promote ecosystem services, and improve community access to green spaces.

Create additional institutional capacity to address changing climate adaptation needs as the effects of climate change are felt in the Memphis area.

Develop and implement community/neighborhood-scale demonstration projects to increase awareness and local resilience to flooding and other climate events.

Photo: Jeff Roberson, AP

ACTION E.8 IMPACT SUMMARY

Objective	Identify and prioritize cross-cutting strategies for climate change mitigation and adaptation
Implementation Partners	<p>City of Memphis and Shelby County</p> <p>Other municipalities in Shelby County and the Mid-South region, private development community, neighborhood/community organizations, academic institutions</p>
GHG Reduction Impact (tCO ₂ e)	Not quantified
Estimated Net Cost (2018 \$; Cumulative)	Not quantified
Cost Effectiveness (\$/tCO ₂ e)	Not quantified
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High
\$ \$ \$

Benefits (High Potential Impact):

- Equity
- Health
- Resilience
- Economic Development
- Environmental

Major Challenges:

- Financial
- Education/Behavior Change
- Operational
- Policy Change

EXISTING PROGRAMS AND POLICIES

Existing plans and programs in the climate change mitigation/adaptation space include:

- Shelby County Multi-Jurisdictional Hazard Mitigation Plan: Federally-required plan that aims to improve community preparedness for severe weather events and disasters
- Resilient Shelby National Disaster Resilience Competition (NDRC) projects: Shelby County was awarded \$60 million to implement projects in three areas that were affected by severe flooding in 2011. These projects are located on Big Creek in Millington, the Wolf River in North Memphis and Raleigh, and South Cypress Creek in southwest Memphis. Each of these projects will use green infrastructure to reduce flooding risks, improve environmental health, enhance recreational amenities, and improve resident quality of life.
- Mid-South Regional Resilience Master Plan: In-process planning effort that focuses on infrastructure investments, policy updates, and regulatory changes that can comprehensively address community resilience to climate change risks

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Identifying and prioritizing investments that improve quality of life and reduce climate risks for vulnerable populations can improve racial and economic equity.

Health: Enhancing adaptation and resilience to climate risks can result in lower loss of life, illness, and injury caused by extreme weather events.

Economic Development/Job Creation: Implementing green infrastructure projects can lead to new businesses and job creation. In

- Local academic/research institutions are also working with government to support resilience and adaptation efforts. Engineers at the University of Memphis have developed a Hydrology Plan including modeling and hydraulic analysis of the Mid-South region that will be incorporated in the Mid-South Regional Resilience Plan and be used to help gauge potential impacts of projects. The Surface Water Institute at Christian Brothers University is working with the City of Memphis to update the city's stormwater drainage manual and provide new direction on stormwater management practices.
- Memphis is one of 7 Mississippi River cities participating in an infrastructure investment pilot that will help build a Mississippi River Investment Fund (MRIF) - an infrastructure financing option that will support projects that focus on climate risk, resilience, adaptation, sustainability, and natural capital capacities in addition to generating economic benefits.

addition, improving resilience to climate hazards can result in avoided costs from lost economic activity.

Environmental: Aligning mitigation and adaptation through efforts such as green infrastructure, energy efficiency, and smart growth can reduce pollution and improve air and water quality.

Resilience: Pairing mitigation and adaptation strategies makes our community as a whole less vulnerable to climate change impacts.

CHALLENGES

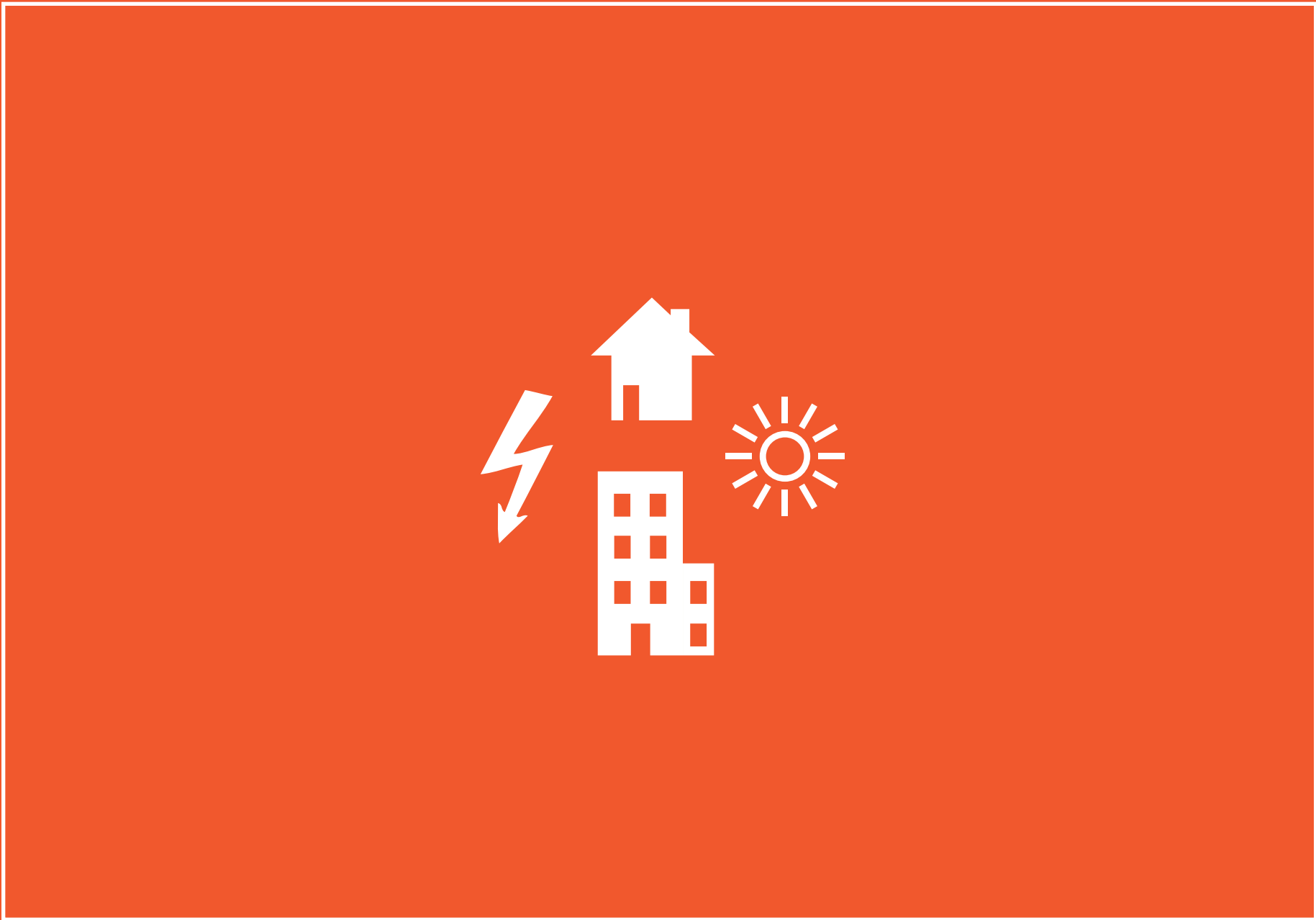
Challenges for successfully implementing this action include:

Financial: Climate adaptation will require infrastructure investments at the regional and neighborhood scale.

Operational: The coordination of various jurisdictions at the regional level presents implementation challenges.

Policy Change: Changes to local development regulations across the region may be needed to successfully implement a comprehensive resilience and mitigation strategy.

Education/Behavioral Change: Effective communication of how climate mitigation and adaptation work hand in hand to enhance community resilience will be key.



CHAPTER 5

TRANSPORTATION



TRANSPORTATION SECTOR RECOMMENDATIONS

The transportation sector – which includes energy used to power vehicles from personal cars and trucks to freight vehicles to planes and boats – makes up the second-largest source of emissions in the Memphis area. The priority actions recommended for this sector are designed to significantly reduce GHG emissions while simultaneously achieving other important objectives in our community, including: improving access to jobs, goods, and services, reducing transportation cost burden, achieving compact urban design, and improving health outcomes. The priority transportation actions are grouped into two major goals focused on shifting to low-carbon transportation modes, reducing our reliance on motor vehicles, and setting the stage for vehicle electrification. Implementing these recommendations is projected to reduce our community's transportation emissions by 13% by 2020, 44% by 2035, and 62% by 2050.

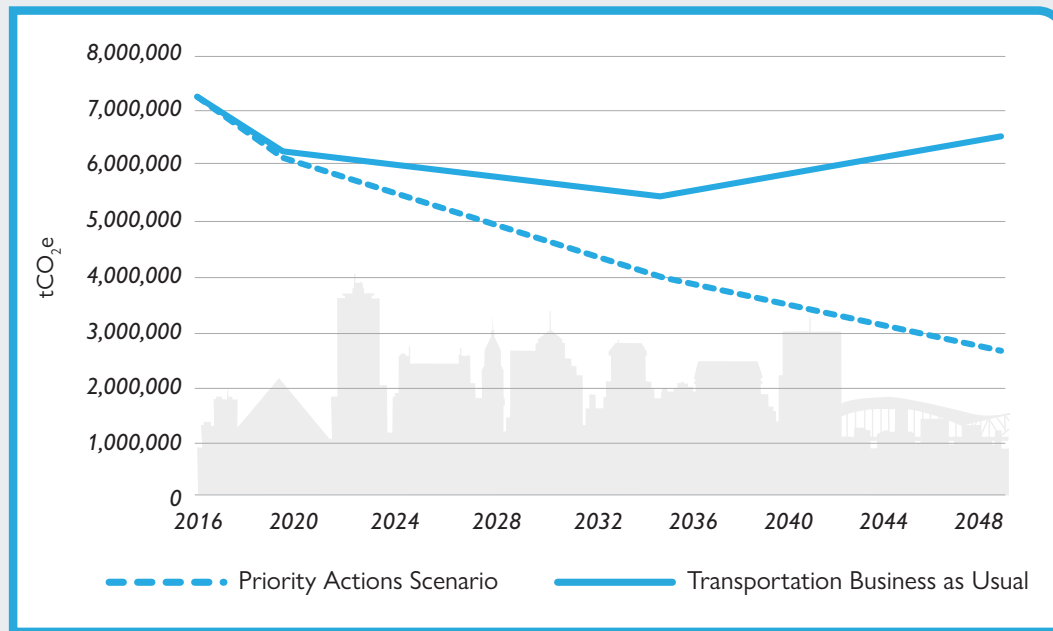
1 SHIFT TO LOW-CARBON TRANSPORTATION MODES AND REDUCE RELIANCE ON MOTOR VEHICLES

- ▶ Implement Land Use Patterns that Support Active Transportation and Transit
- ▶ Create Complete Streets that Prioritize Walking and Bicycling
- ▶ Enhance Public Transit
- ▶ Reduce Commute Trips through Transportation Demand Management Strategies

2 SET THE STAGE FOR VEHICLE ELECTRIFICATION

- ▶ Encourage Electric Vehicle Adoption and the Development of Charging Infrastructure

Greenhouse Gas Emissions Reductions in the Transportation Sector



The two figures to the left provide more detail on the projected carbon emissions reduction impact of the transportation-related recommendations in this plan. The chart shows the potential cumulative emissions reductions for these actions over the next 30 years compared to the business-as-usual scenario, while the table lists greenhouse gas reductions for each individual action.

Based on the current analysis, electric vehicle adoption, transportation demand management, and complete streets improvements have the highest potential to reduce greenhouse gas emissions. The land use priority action was not quantified separately for this analysis as the benefits from this measure likely overlap with the other four actions. Despite this lack of quantification, implementing land use patterns that support low carbon transportation modes and bring destinations closer together is fundamental to achieving significant reductions in carbon emissions. While the analysis on this page focuses on reducing emissions, it is important to note that these actions have multiple beneficial impacts and can help our community meet other goals related to equity, resilience, and quality of life.

For more information on the data sources, calculations, and assumptions used for this analysis, please refer to Appendix 2.

(tCO ₂ e)	2016	2020	2035	2050
Transportation Business as Usual Emissions	7,171,416	6,236,170	5,357,523	6,566,940
T1. Low-Carbon Land Use		Overlap	Overlap	Overlap
T2. Complete Streets		0	-102,273	-256,490
T3. Public Transit		-941	-7,636	-19,847
T4. Demand Management		0	-307,635	-564,246
T5. Electric Vehicles		-24,383	-921,048	-3,027,741
Priority Actions Scenario Emissions		6,210,846	4,018,931	2,698,616

Overlap = Has overlapping emission reduction benefits with other actions

1 SHIFT TO LOW-CARBON TRANSPORTATION MODES AND REDUCE RELIANCE ON MOTOR VEHICLES

Reducing emissions from the transportation sector starts with creating conditions where more trips can be completed by low-carbon and zero-carbon modes such as walking, biking, and transit. Transportation, in particular, is closely tied to land use and urban form. The vision of Memphis 3.0 – to build up, not out – and to focus investment and development in mixed-use anchor areas that bring residents closer to jobs and services is key to reducing the impact our community’s transportation choices have on climate change.

The goals and strategies in this section focus on getting land use right, investing in biking, walking, and transit improvements, and implementing a policy framework that prioritizes pedestrians, cyclists, and transit riders over cars. These recommendations should be implemented in a way that considers equitable access for low-income and underserved communities. Shortening the distance between housing and jobs, improving safety for biking, walking, and transit, and enhancing the frequency of transit service have high potential to positively impact health and economic outcomes for these communities.



Photo: The Greater Memphis Chamber

1 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
<p>T.1 Implement Land Use Patterns that Support Active Transportation and Transit</p>	<p>Encourage denser, mixed-use development to reduce vehicle trips and support walking, biking, and transit.</p>	<ul style="list-style-type: none"> ▶ Implement the Memphis 3.0 vision and growth strategy focused on building density and mixed uses around community and city-wide anchor areas. ▶ Update zoning and development codes to reflect the Memphis 3.0 vision and growth strategy, particularly focusing on regulations that support walkable, infill, mixed-use development and the implementation of Transit Oriented Development (TOD). Specific changes should include: <ul style="list-style-type: none"> - Require more robust bicycle parking/storage in commercial, multifamily, and mixed-use developments, and similarly shower and changing facilities in commercial developments. - Replace minimum parking requirements with maximum parking requirements, or consider eliminating parking requirements. - Develop incentives (e.g. reduced parking requirements) for developments that sponsor bike share stations and/or transit stop improvements. ▶ Prioritize public infrastructure investments in anchor areas to accelerate private investment and achieve land use and connectivity goals. ▶ Develop incentives that encourage housing and employment growth around anchors and transit corridors. ▶ Integrate high quality public spaces into anchor areas to encourage interaction and improve quality of life. ▶ Preserve and encourage high quality affordable housing to support equitable, mixed-income communities. ▶ Encourage small, local businesses to locate within anchor areas.

1 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
<p>T.2 Create Complete Streets that Prioritize Walking and Bicycling</p>	<p>Starting in 2020, convert 10% of vehicle trips to bicycle and pedestrian modes by 2030 and then increase this percentage linearly to 40% of vehicle trips by 2050.</p>	<ul style="list-style-type: none"> ▶ Implement Memphis 3.0's Comprehensive Streets Plan and the associated streetscape and road designs. ▶ Support implementation of the Greenprint network which includes greenway trails and on-street bicycle facilities. ▶ Establish a dedicated annual funding source of \$20 million for pedestrian and bicycle safety improvements, and implement priority projects identified in the Memphis Pedestrian and School Safety Action Plan and the Memphis MPO's Regional Bicycle & Pedestrian Plan. ▶ Prioritize pedestrian and bicycle safety infrastructure investments in the following: activity centers with higher numbers of pedestrians, cyclists, and transit riders; low-income communities; Memphis 3.0 anchors; and areas with high incidences of pedestrian/cyclist injuries and fatalities. ▶ Enhance driver education and enforcement programs to increase awareness of cyclist/pedestrian rights and safety considerations.
<p>T.3 Enhance Public Transit</p>	<p>Fully implement the Memphis 3.0 Transit Vision by 2022. Increase ridership and improve frequency to meet long-range (2040/2050) ridership objectives. Convert MATA's entire fleet to electric by 2050.</p>	<ul style="list-style-type: none"> ▶ Provide dedicated annual funding to MATA and increase immediate annual funding by \$30 million to implement the Memphis 3.0 Transit Vision. ▶ Improve the frequency of MATA's service to provide effective service and increase ridership. ▶ Consider the development of dedicated bus lanes and high-frequency Bus Rapid Transit service on targeted corridors. ▶ Develop a public communications and outreach campaign to provide information on proposed service improvements and foster support for increased, dedicated annual funding. ▶ Create a MATA fleet electrification plan focusing on implementation and identification of funding. ▶ Pursue grants and subsidies that can help cover the higher upfront capital cost of electric buses and charging infrastructure.

1 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
<p>T.4 Reduce Commute Trips through Transportation Demand Management</p>	<p>Reduce drive-alone commute trips 10% by 2022 and 40% by 2050.</p>	<ul style="list-style-type: none"> ▶ Implement Transportation Demand Management (TDM) programs at all major employers (500+ employees) in the Memphis area and encourage the inclusion of specific TDM strategies such as: <ul style="list-style-type: none"> • Create incentives for multi-modal trips and travel • Increase parking management and fees • Increase promotions and incentives for carpooling/vanpooling, including for workers with schedules outside of the traditional 9 to 5 work hours • Ensure that transit passes are easy to purchase and cost the same or less than parking • Provide and support shared use mobility options • Provide Guaranteed Ride Home program for family emergencies and unexpected overtime • Encourage/incentivize employers to offer flexible work hours and work-from-home options ▶ Consider updating development codes to reduce or eliminate minimum parking requirements. ▶ Building off of the Downtown Memphis Parking Study and the work of the Downtown Mobility Authority, implement "smart parking" programs such as demand pricing, shared use off-street parking, and parking space availability smartphone applications. ▶ Evaluate the allocation of a portion of parking revenue to transit and other multimodal improvements.



Priority Action T.1: Implement Land Use Patterns that Support Active Transportation and Transit

OBJECTIVE: ENCOURAGE DENSER, MIXED-USE DEVELOPMENT TO REDUCE VEHICLE TRIPS AND SUPPORT WALKING, BIKING, AND TRANSIT

Background

Sprawling development patterns and separated land uses are the main contributors to high numbers of vehicle trips and resulting emissions. Over the last 50 years, Memphis' population has remained virtually unchanged while the city's land area has grown by 50%. Outside of Memphis, low-density development has also increased as suburban communities have experienced population growth and increased development. Supporting a shift in land use patterns to encourage infill development, increased density, and a mix of uses is foundational to any community-wide strategy to reduce emissions from transportation. In addition to the positive climate action impacts, low-carbon urban design can also benefit public health, air and water quality, economic development, and community resilience.

Approach

This action sets out the broad goal of fostering land use patterns and urban development that better support walking, biking, and transit. Implementation of this action will largely involve following the vision and growth strategy laid out in the Memphis 3.0 Comprehensive Plan. The plan recommends focusing future growth and investments in community and city-wide anchor areas that will allow denser development and a mix of uses. Given the decades of low-density development in the Memphis area, achieving this new vision will take time. However, implementing more sustainable, efficient land use and urban design are crucial to taking real action on climate change and improving quality of life. Successful implementation of this action will involve the entire community, including local government, private business and philanthropy, nonprofits and advocacy organizations, neighborhood groups, and individual residents.

IMPLEMENTATION STEPS

Implement the Memphis 3.0 vision and growth strategy focused on building density and mixed uses around community and city-wide anchor areas.

Update zoning and development codes to reflect the Memphis 3.0 vision and growth strategy, particularly focusing on regulations that support walkable, infill, mixed-use development and the implementation of Transit Oriented Development (TOD). Specific changes should include:

- Require more robust bicycle parking/storage in commercial, multifamily, and mixed-use developments, and similarly shower and changing facilities in commercial developments.
- Replace minimum parking requirements with maximum parking requirements, or consider eliminating parking requirements.
- Develop incentives (e.g. reduced parking requirements) for developments that sponsor bike share stations and/or transit stop improvements.

Prioritize public infrastructure investments in anchor areas to accelerate private investment and achieve land use and connectivity goals.

Develop incentives that encourage housing and employment growth around anchors and transit corridors.

Integrate high quality public spaces into anchor areas to encourage interaction and improve quality of life.

Preserve and encourage high quality affordable housing to support equitable, mixed-income communities.

Encourage small, local businesses to locate within anchor areas.

Photo: City of Memphis Office of Comprehensive Planning

ACTION T.1 IMPACT SUMMARY

Objective	Encourage denser, mixed-use development to reduce vehicle trips and support walking, biking, and transit.
Implementation Partners	<p>City of Memphis and Shelby County</p> <p>Private business and philanthropy, nonprofits and advocacy organizations, neighborhood groups, and individual residents</p>
GHG Reduction Impact (tCO ₂ e)	Not quantified
Estimated Net Cost (2018 \$; Cumulative)	Not quantified
Cost Effectiveness (\$/tCO ₂ e)	Not quantified
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

Benefits (High Potential Impact): Equity, Health, Resilience, Economic Development, Environmental

Major Challenges: Financial, Operational, Policy Change, Education/Behavior Change

EXISTING PROGRAMS AND POLICIES

The Memphis 3.0 Comprehensive Plan is the main policy document that will implement this action. Existing zoning and development regulations in the Memphis-Shelby County Unified Development Code also address land use patterns and density, although updates to the code may be necessary to adequately implement the Memphis 3.0 vision. The UDC already contains elements that make more mixed use, dense, walkable development possible:

- Mixed Use zoning districts
- Pedestrian-focused streetscapes
- Block regulations to encourage connectivity
- Expanded use of accessory dwelling units
- More flexible parking requirements
- Form based guidelines with frontage standards that encourage higher quality,

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Along with affordable housing tools and programs and community collaboration, bringing destinations and housing closer together and improving the effectiveness and safety of walking, biking, and transit can save money and improve health outcomes for low-income communities.

Health: Low-carbon urban design that makes biking, walking, and transit more viable can improve health outcomes for residents.

pedestrian-friendly urban design

- Some zoning designations such as the University District Overlay have regulations that support improved land use patterns and urban design such as tree canopy requirements along new streetscapes, bicycle parking requirements, and reduced parking requirements to limit surface lots.

Other existing plans related to this priority action include:

- Mid-South Regional Greenprint and Sustainability Plan - recommends smarter regional land use, protection of natural resources, and the development of a regional network of trails and green spaces
- City of Memphis Pedestrian and School Safety Plan
- Memphis MPO Regional Bicycle and Pedestrian Plan

Economic Development/Job Creation: Increasing density and encouraging mixed use development in a strategic way can strengthen the market for businesses and result in quality of life improvements that attract employers.

Environmental: Building up instead of encouraging low-density, sprawling development can improve water and air quality and conserve sensitive natural habitat.

Resilience: Communities that are less reliant on vehicular transportation are better able to respond to extreme weather events and other disruptions.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Updating Capital Improvement Program (CIP) investment processes and identifying new sources of funding to support the Memphis 3.0 vision will be necessary.

Operational: Providing staff capacity to carry out Small Area Plans that will provide more detailed land use and transportation recommendations in specific districts may be challenging.

Educational/Behavioral Change: Changing negative perceptions of walking, biking, and public transit could present challenges to reducing car trips.

Policy Change: Developing and improving land use entitlement processes to implement the 3.0 vision could also present challenges.



Priority Action T.2: Create Complete Streets that Prioritize Walking and Bicycling

OBJECTIVE: STARTING IN 2020, CONVERT 10% OF VEHICLE TRIPS TO PEDESTRIAN AND BICYCLING MODES BY 2030, AND INCREASE THIS PERCENTAGE LINEARLY TO 40% OF VEHICLE TRIPS BY 2050

Background

Over the last 60 years, the Memphis area has developed in a low-density, car-centric manner. Existing land use patterns and transportation investments that prioritize the efficient movement of vehicles have made active transportation modes (walking and biking) and public transit less viable and less safe. Over the last 20 years, there has been a national shift in thinking – termed Complete Streets – in how we design our roads and streets and how we can make them safe and efficient for all people regardless of age, ability, or mode. In Memphis, this Complete Streets approach has been underway for the better part of the last decade, with early grassroots advocacy efforts, the adoption of a Complete Streets policy, dedicated staff (Bikeway and Pedestrian Program Manager), a Complete Streets Project Delivery Manual, and the implementation of bicycle facilities, sidewalk/intersection enhancements, and greenway trails.

Approach

This priority action aims to convert vehicle trips to low-carbon and zero-carbon trips over the next 30 years through infrastructure investments that improve the safety and viability of walking and biking. Implementation of this action will involve carrying out recommendations in the Memphis Pedestrian and School Safety Plan as well as the Regional Bicycle and Pedestrian Plan, and identifying a dedicated annual funding source. The implementation process should focus on infrastructure investments and improvements in low-income communities and neighborhoods with low vehicle ownership/higher reliance on walking/biking/transit. Local government – particularly the Engineering Division, the Division of Planning and Development, and the Memphis Metropolitan Planning Organization (MPO) – will be key implementation leaders. Building public support and buy-in from elected officials will also be crucial to success.

IMPLEMENTATION STEPS

Implement Memphis 3.0's Comprehensive Streets Plan and the associated streetscape and road designs.

Support implementation of the Greenprint network which includes greenway trails and on-street bicycle facilities.

Establish a dedicated annual funding source of \$20 million for pedestrian and bicycle safety improvements, and implement priority projects identified in the Memphis Pedestrian and School Safety Action Plan and the Memphis MPO's Regional Bicycle & Pedestrian Plan.

Prioritize pedestrian and bicycle safety infrastructure investments in the following areas: activity centers with higher numbers of pedestrians, cyclists, and transit riders; low-income communities; Memphis 3.0 anchors; and areas with high incidences of pedestrian/cyclist injuries and fatalities.

Enhance driver education and enforcement programs to increase awareness of cyclist/pedestrian rights and safety considerations.



Photo: Alta Planning + Design

ACTION T.2 IMPACT SUMMARY

Objective	Starting in 2020, convert 10% of vehicle trips to pedestrian and bicycling modes by 2030, and increase this percentage linearly to 40% of vehicle trips by 2050.
Implementation Partners	<p>City of Memphis and Shelby County (Engineering Division, Division of Planning and Development, Memphis Metropolitan Planning Organization, Capital Improvement Program managers)</p> <p>Elected officials, TN Department of Transportation, community organizations, individual residents</p>
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

Benefits (High Potential Impact): Equity Health Resilience Economic Development Environmental

Major Challenges: Financial Operational Education/Behavior Change Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

The Memphis area has a number of existing programs, plans, and policies related to Complete Streets, as well as organizations that could assist in achieving the goals of this action.

- The Streets Plan within Memphis 3.0 coordinates roadway and streetscape design with land uses, implementing the City's Complete Streets vision.
- Complete Streets Project Delivery Manual: This manual applies to all development projects that impact the public right of way, and formally implements a Complete Streets approach that prioritizes pedestrians, bicyclists, and transit in the design process.
- South Memphis The Big Jump 2020: This program is part of a national community development initiative. In South Memphis, it has the goals of improving the safety of multiple streets for walking, biking, and driving; planning a safe streets network; community programming; finding ways to develop stronger local businesses and non-profits; and providing widespread media attention on the projects.
- SPARCC (Strong, Prosperous, and Resilient Communities Challenge): North Memphis was one of 6 communities selected through a competitive process receiving significant funding to implement strategies to make the community more prosperous and equitable. It will advance local efforts to create neighborhood and systems-level change focused on racial equity, health, and climate.
- MMDC (Memphis Medical District Collaborative): This collaborative is a community development organization working with partners to strengthen the communities in the Memphis Medical District so that they are more livable, vibrant and safe.
- BLDG Memphis (Build. Live. Develop. Grow): This coalition developed the Memphis Complete Streets Project Delivery Manual using a grant through the Mid-South Regional Greenprint. BLDG Memphis regularly convenes community development corporations (CDCs) and other stakeholders to address public policy needs, including transportation mobility and access.
- Bike/Pedestrian Program: The City of Memphis staffs the Bikeway and Pedestrian Program within the Division of Engineering, which maintains the Bike/Ped Memphis website and blog.
- City of Memphis Pedestrian and School Safety Action Plan
- Memphis MPO Regional Bicycle and Pedestrian Plan
- Mid-South Regional Greenprint and Sustainability Plan: This sustainability plan envisions a network of parks, greenways, bike trails, walking paths, and open spaces and addresses the need for comprehensive land use planning in the Greater Memphis Area.
- The Downtown Memphis Commission offers a Downtown Core Sidewalk Repair Loan Program, providing 0% interest loans to property owners to perform sidewalk repairs within the downtown core.
- Transportation Alternatives: This federal program - administered by the TN Department of Transportation and the Memphis MPO - provides funding for projects and programs defined as transportation alternatives. This includes: on- and off-road pedestrian and bicycle facilities, safe routes to school projects, infrastructure projects that improve non-driver access to public transportation and enhanced mobility, recreational trail projects, and community improvement activities.
- As part of the Resilient Shelby infrastructure activities, Orchi Road in North Memphis will be reconstructed as a Complete Street with bicycle facilities that will connect surrounding neighborhoods to the Wolf River Greenway.
- Explore Bike Share and other shared mobility services: Memphis' new bike share system and other low-carbon shared mobility services (e.g. e-scooters) can contribute to Complete Streets and mode shift goals.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Low-income communities are often more reliant on walking, biking, and transit. Focusing Complete Streets infrastructure investments in these communities can positively impact equity outcomes.

Health: Making walking, biking, and transit use easier can lead to broad public health benefits.

Economic Development/Job Creation: Making biking and walking safer and easier can increase residents' disposable income due to decreased

transportation costs. Increased investment in pedestrian and bicycle infrastructure can lead to more construction jobs. Infrastructure investments to support walking and biking can also have indirect benefits in encouraging small businesses that benefit from increased foot and bike traffic.

Environmental: Reducing car trips and increasing low/zero-carbon trips can improve air and water quality.

Resilience: Reducing reliance on vehicles can lead to improved community resilience in the face of extreme weather or other disruptions.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Identifying annual dedicated funding for pedestrian and bicycle infrastructure improvements.

Operational: Adding staff capacity to manage implementation of construction projects. Redesigning streets to encourage walking and biking could also restrict freight delivery abilities and/or restrict freight traffic on certain roads. Freight driver training as well as considering freight and delivery needs early on in the design process should help address this challenge.

Educational/Behavioral Change: Developing public buy-in and support for investments in bike/ped infrastructure.

Policy Change: Updating Capital Improvement Program (CIP) processes to prioritize bike/ped investments



Priority Action T.3: Enhance Public Transit

OBJECTIVE: FULLY IMPLEMENT THE MEMPHIS 3.0 TRANSIT VISION BY 2022. INCREASE RIDERSHIP AND IMPROVE FREQUENCY TO MEET LONG-RANGE (2040/2050) RIDERSHIP OBJECTIVES. CONVERT MATA'S ENTIRE FLEET TO ELECTRIC BY 2050.

Background

The Memphis area's sprawling land use patterns present challenges to providing effective, efficient public transit service. Erratic funding and chronic underfunding of MATA (Memphis Area Transit Authority) over the last several decades has also resulted in reduced transit service and decreases in ridership. Neighborhood and grassroots advocacy efforts in combination with the Memphis 3.0 comprehensive planning process have brought renewed attention to transit issues in our community. While the provision of quality transit service inarguably provides climate change mitigation benefits, it is first and foremost a strategy that can improve racial and economic equity. Low-income residents without access to a vehicle need viable and high quality transit options to access employment opportunities and important goods and services. Fostering an effective and efficient public transit system can lead to a more prosperous, equitable, and sustainable future for our community.

Approach

This priority action aims to increase transit ridership and improve bus frequency by fully implementing the Memphis 3.0 Transit Vision. In addition, this action recommends fleet electrification targets for MATA. The essential components of the Transit Vision include investing in and expanding frequent transit service. 39% more jobs will be reachable within an hour and 79,000 more people will be near frequent bus service once the Transit Vision network is implemented. The Transit Vision also recommends improvements to weekend service and enhanced connections to other transportation modes. The mechanisms needed to implement this action include additional dedicated funding for MATA (Transit Vision recommendations will require another \$30 million annually), infrastructure improvement coordination, and public outreach and education on the proposed network changes and their benefits.

IMPLEMENTATION STEPS

Provide dedicated annual funding to MATA and increase immediate annual funding by \$30 million to implement the Memphis 3.0 Transit Vision.

Improve the frequency of MATA's service to provide effective service and increase ridership.

Consider the development of dedicated bus lanes and high-frequency Bus Rapid Transit service on targeted corridors.






Develop a public communications and outreach campaign to provide information on proposed service improvements and foster support for increased, dedicated annual funding.

Create a fleet electrification plan focusing on implementation and identification of funding.

Pursue grants and subsidies that can help cover the higher upfront capital cost of electric buses and charging infrastructure.

Photo: Memphis Area Transit Authority

ACTION T.3 IMPACT SUMMARY

Objective	Fully implement the Memphis 3.0 Transit Vision by 2022. Increase ridership and improve frequency to meet long-range (2040/2050) ridership objectives. Convert MATA's entire fleet to electric by 2050.
Implementation Partners	<p>MATA, City of Memphis and Shelby County</p> <p>Business community, Innovate Memphis, nonprofits and advocacy groups (e.g. Memphis Bus Riders Union, Memphis Transit Coalition), transit riders</p>
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	<p>\$ \$ \$</p>
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	
<p>Level of GHG Emissions Reduction Impact and Cost Effectiveness:</p> <p>Low → High</p> 	<p>Net Cost: Low → High</p> <p>\$ \$ \$</p> <p>Benefits (High Potential Impact):</p> <ul style="list-style-type: none"> Equity Health Resilience Economic Development Environmental <p>Major Challenges:</p> <ul style="list-style-type: none"> Financial Operational Education/Behavior Change Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

Memphis has existing programs and plans that support enhancing public transit, as well as organizations that could assist in achieving the goals of this action.

- Transit Vision : This is part of the Memphis 3.0 comprehensive planning effort and recommends changes to bus routes and frequency to improve transit service.
- Memphis Transit Coalition: This is a partnership between Innovate Memphis and numerous community organizations to educate and motivate experts and leaders by encouraging their involvement to advance transit, active transportation, and increased freedom of mobility in their communities.
- The Memphis Bus Riders Union is an advocacy group that pushes for high quality, equitable transit service.
- Other programs could assist in supporting the Transit Vision including: employers' Transportation Demand Management (TDM) and parking policies; City parking policy and regulations; and the Complete Streets Project Delivery Manual.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Transit service is essential to many Memphis residents who don't have resources for car ownership or have mobility issues. Enhancing transit service should increase job access and economic outcomes for low-income residents and other vulnerable populations.

Health: Trips taken by transit often involve walking or biking to reach a bus stop or a destination; increased transit use can positively impact public health outcomes.

Economic Development/Job Creation: The Transit Vision estimates that the enhanced network will improve connections to employment centers

and jobs (39% more jobs reachable within an hour) and where people live (79,000 more people will be near frequent bus service).

Environmental: Shifting trips from personal vehicles to transit can positively impact air quality. Electrification of MATA's bus fleet will also improve air quality.

Resilience: Better access to quality transportation options will enhance community resilience.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Raising the necessary funding to implement the Transit Vision and MATA's long-term goals will present challenges.

Operational: Updating routes and bus schedules will require increased staff capacity and resources.

Educational/Behavioral Change: Effectively communicating route and schedules changes to bus riders and the general public will be critical.

Policy Change: Funding enhanced transit service may require policy changes and new taxes/fees.



Priority Action T.4: Reduce Commute Trips through Transportation Demand Management

OBJECTIVE: REDUCE DRIVE-ALONE COMMUTE TRIPS 10% BY 2022 AND 40% BY 2050.

Background

For many Memphians, commutes to work and school make up the majority of their car trips. To reduce drive-alone commute trips and congestion, cities and major employers across the nation have implemented Transportation Demand Management (TDM) programs. As the name implies, these programs focus on the demand side of transportation instead of the provision of infrastructure. TDM essentially targets behavioral change to achieve broad goals related to improved functioning of transportation systems, environmental benefits, and health outcomes. Innovate Memphis manages a local TDM program called Commute Options in partnership with MATA, the TN Department of Transportation, and Memphis Area Rideshare. Working with major employers, Innovate Memphis provides information, resources, and incentives that make biking, walking, transit, and carpooling more appealing options for workers.

Approach

This action aims to reduce single-occupancy passenger vehicle commute trips by increasing the scope and reach of Transportation Demand Management strategies. Implementation will involve targeted outreach to the largest employers in Memphis to encourage implementation of TDM programs and policies such as: incentives for multi-modal trips, biking, walking, transit and carpooling/vanpooling; increasing fees for parking; providing shared use mobility options (carshare, bikeshare); and flexible work hours and telecommute options. Key implementation partners will be Innovate Memphis, major employers and institutions, Explore Bikeshare, and local government. Increasing the capacity of the Commute Options program through additional funding and staff will be key to achieving significant drive-alone commute trip reductions.

IMPLEMENTATION STEPS

Implement Transportation Demand Management programs at all major employers (500+ employees) in the Memphis area and encourage the inclusion of specific TDM strategies such as:

- Create incentives for multi-modal trips and travel
- Increase parking management and fees
- Increase promotions and incentives for carpooling/vanpooling, including for workers with schedules outside of the traditional 9 to 5 work hours
- Ensure that transit passes are easy to purchase and cost the same or less than parking
- Provide and support shared use mobility options
- Provide Guaranteed Ride Home program for family emergencies and unexpected overtime

- Encourage/incentivize employers to offer flexible work hours and work-from-home options

Consider updating development codes to reduce or eliminate minimum parking requirements.

Building off of the Downtown Memphis Parking Study and the work of the Downtown Mobility Authority, implement "smart parking" programs such as demand pricing, shared use off-street parking, and parking space availability smartphone applications.

Evaluate the allocation of a portion of parking revenue to transit and other multimodal improvements.

Photo: Alta Planning + Design

ACTION T.4 IMPACT SUMMARY

Objective	Reduce drive-alone commute trips 10% by 2022 and 40% by 2050.
Implementation Partners	City of Memphis and Shelby County Innovate Memphis (Commute Options program), MATA, EDGE, Downtown Memphis Commission, Greater Memphis Chamber, Memphis Tourism, major employers and institutions
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost (2018 \$; Cumulative)	\$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

Benefits (High Potential Impact):
 Equity Health Resilience
 Economic Development Environmental

Major Challenges: Financial Education/Behavior Change
 Operational Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

Launched in 2016, the Commute Options TDM program managed by Innovate Memphis is the obvious launching pad for expanding TDM strategies in the Memphis area. Other recent related efforts include the MMDC (Memphis Medical District Collaborative) Transportation Management Association that focuses on providing coordinated transportation and parking services to its members; expanding transportation options beyond commuting in a single-occupancy vehicle; and reducing parking demand throughout the Medical District.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Design and implementation of TDM strategies should consider potential negative equity impacts. Focusing on incentives and encouragement tactics instead of penalties or disincentives can expand benefits and reduce negative impacts to workers in vulnerable communities.

Health: Commuting by walking, biking, or transit can have direct health benefits for individual commuters. Reducing car commutes can also have beneficial impacts on public health by improving air and water quality.

Parking provision and cost are often important factors in choosing driving over other travel modes. Updates to parking requirements in development codes should be considered.

Economic Development/Job Creation: TDM strategies can improve employee quality of life and help major employers attract and retain talent.

Environmental: Reducing drive-alone commute trips improves air and water quality.

Resilience: Increasing workers' knowledge and ease of use of alternative transportation options can improve overall community resilience.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Expanding the scope and capacity of the existing Commute Options program will require increased funding.

Operational: Ramping up the Commute Options TDM program will require updated strategic planning and operational improvements. Implementation of TDM programs/strategies at major employers will also likely require operational updates at each organization.

Educational/Behavioral Change: Behavioral change is the central challenge of successfully implementing TDM strategies. Eye-catching marketing campaigns, effective incentives, and peer mentoring can all help with this challenge.

Policy Change: Implementation of TDM programs/strategies at major employers may require organizational policy changes to incentivize low carbon/zero-carbon transportation modes and disincentivize drive-alone trips.

2 SET THE STAGE FOR VEHICLE ELECTRIFICATION

While reducing passenger vehicle trips and increasing transit, walking, and bicycling trips are the focus of this plan, electric vehicles also present opportunities for lowering carbon emissions from the transportation sector. According to Bloomberg New Energy Finance, global electric vehicle sales were expected to be over 1.6 million in 2018, compared to around 300,000 as recently as 2014. Advances in battery technology, lower prices, increasing production commitments from automakers, and growing public policy support for electric vehicles have all contributed to the growing EV market, and forecasts show that adoption will increase dramatically over the next 12 years. Bloomberg forecasts that global EV sales will increase to 11 million in 2025 and 30 million in 2030.

The goals and strategies in this section seek to support increased adoption of electric vehicles through planning efforts, removing barriers to the development of charging infrastructure, and ensuring that local government leads by example in transitioning its fleets to electric. Equitable access must also be a guiding principle of any electric vehicle policies or plans to ensure that communities who could benefit the most from cost savings and air quality improvements have the ability to participate in this new market.



Photo: Memphis-Shelby County Office of Sustainability

2 ACTION AREA SUMMARY

PRIORITY ACTION

T.5 Encourage Electric Vehicle Adoption and the Development of Charging Infrastructure

OBJECTIVE

Increase passenger vehicle travel using electric vehicles to 5% by 2025; 30% by 2035; and 50% by 2050.

Increase freight vehicle travel using electric vehicles to 3% by 2025; 20% by 2035; and 50% by 2050.

IMPLEMENTATION STEPS

- ▶ To lead by example, Memphis and Shelby County government should commit to transitioning their fleets to electric and begin building necessary charging infrastructure.
- ▶ Develop a comprehensive community-wide electric vehicle strategy that looks at current and future needs, identifies information gaps and barriers, and develops policies, programs, and projects that will lead to an effective charging network and advance electric vehicle adoption.
- ▶ Make equitable access a guiding principle of any community-wide electric vehicle strategy and ensure that low-income and underserved communities can access infrastructure and participate in the EV market.
- ▶ Consider updates to zoning and building codes to ensure that new development can accommodate electric vehicles.
- ▶ Explore models and approaches to implementing a comprehensive network of public EV charging infrastructure, including curbside charging infrastructure, potential incentives or partnerships to provide dedicated EV charging stations, and potential funding sources that can help jumpstart a public charging network.
- ▶ Assess existing electric grid infrastructure and identify future needs to ensure the grid can provide increased service for EV charging infrastructure.



Priority Action T.5: Encourage Electric Vehicle Adoption and the Development of Charging Infrastructure

OBJECTIVE: INCREASE PASSENGER VEHICLE TRAVEL USING ELECTRIC VEHICLES TO 5% BY 2025; 30% BY 2035; AND 50% BY 2050. INCREASE FREIGHT VEHICLE TRAVEL USING ELECTRIC VEHICLES TO 3% BY 2025; 20% BY 2035; AND 50% BY 2050.

Background

Coupled with cleaner sources of electricity, electric vehicles (EVs) have the potential to dramatically reduce greenhouse gas emissions and improve air quality and health outcomes. Although private actors and federal policy have a significant impact in pushing new, beneficial technologies/products, local actions and policy play an important role in determining the speed, breadth, and equitableness of adoption. In the Memphis area, there has been little concerted effort to encourage and support EV adoption and develop charging infrastructure. In 2012, Memphis and Shelby County participated in the EV Project which resulted in the installation of several dozen Level 2 charging stations. Shelby Farms Park added a 10-spot, solar-assisted EV charging station with public access in 2012 as part of a research project sponsored by EPRI, TVA, and MLGW. Some local fleets have taken steps toward electrification: MLGW has incorporated electric vehicles in its fleet, and MATA recently received a grant to purchase 10 electric buses and install charging infrastructure. At the statewide level, the Drive Electric TN initiative and the recently released Tennessee Electric Vehicle Roadmap provide some guidance on potential actions the Memphis area can take to promote development of EV charging infrastructure and encourage use of EVs. The Roadmap also provides a framework to collaborate with other cities, agencies, and organizations in Tennessee to advance shared EV goals.

Approach

This action aims to dramatically increase passenger and freight vehicle travel using electric vehicles in the Memphis area over the next 30 years. While advances in technology and lower prices/financial savings will probably have the most impact on widespread EV adoption in the private market, the public sector can play a part by developing plans, policies, and regulations that support and remove barriers to EV adoption and the development of an EV charging network. The primary strategies for this action include: 1) crafting a community-wide EV strategy that sets the stage for an effective charging network and advances EV adoption by considering updates to zoning and building codes, public charging infrastructure, readiness of current and future electric infrastructure, and equitable access; and 2) transitioning local government fleets to electric. Primary implementation partners will be local government, MLGW, TVA, private businesses, the building/development community, and the community at-large.

IMPLEMENTATION STEPS

To lead by example, Memphis and Shelby County government should commit to transitioning their fleets to electric and begin building necessary charging infrastructure.

Develop a comprehensive community-wide electric vehicle strategy that looks at current and future needs, identifies information gaps and barriers, and develops policies, programs, and projects that will lead to an effective charging network and advance electric vehicle adoption.

Make equitable access a guiding principle of any community-wide electric vehicle strategy and ensure that low-income and underserved communities can access infrastructure and participate in the EV market.

Consider updates to zoning and building codes to ensure that new development can accommodate electric vehicles.

Explore models and approaches to implementing a comprehensive network of public EV charging infrastructure, including curbside charging infrastructure, potential incentives or partnerships to provide dedicated EV charging stations, and potential funding sources that can help jumpstart a public charging network.

Assess existing electric grid infrastructure and identify future needs to ensure the grid can provide increased service for EV charging infrastructure.

Photo: MLGW

ACTION T.5 IMPACT SUMMARY

Objective	Increase passenger vehicle travel using electric vehicles to 5% by 2025; 30% by 2035; and 50% by 2050. Increase freight vehicle travel using electric vehicles to 3% by 2025; 20% by 2035; and 50% by 2050.
Implementation Partners	City of Memphis and Shelby County MLGW, TVA, freight companies, car manufacturers and retailers, building/development community, consumers
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$ \$ \$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High \$ \$ \$

Benefits (High Potential Impact): Equity Health Resilience Economic Development Environmental

Major Challenges: Financial Operational Policy Change Education/Behavior Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

The Memphis-Shelby County Unified Development Code (UDC) currently allows electric vehicle charging units as a stand-alone accessory use in all zoning districts, and charging stations with significant structures are limited to Commercial and Industrial zones. Potential new regulations could take the form of requiring that all new parking garages, multi-family developments, and/or commercial buildings – or new developments above a certain size threshold (square footage, # of units, etc.) – include electric charging stations or make a certain percentage of their parking infrastructure EV-ready. Other cities around the country have started updating their codes to make their communities more prepared for EV adoption. For example, Atlanta recently passed an ordinance requiring all new residential homes and public parking facilities to accommodate EVs and 20% of the spaces in all new commercial and multifamily parking garages to be EV-ready. Denver also now requires all new single-family homes and duplexes to have the necessary electrical wiring in place for EV charging in their garages.

Drive Electric TN is a statewide collaboration that aims to make Tennessee an electric transportation leader in the Southeast and significantly advance EV Adoption. The effort is led by Tennessee Clean Fuels, the Tennessee

Department of Environment and Conservation, and the Tennessee Valley Authority with the participation of many other public entities, private companies, and other agencies interested in advancing electric vehicles in Tennessee. This collaboration led to the development of a Tennessee Electric Vehicle Roadmap, a plan that aims to increase EV adoption in the state from its current level of around 5,000 vehicles to approximately 200,000 vehicles by 2028. The Roadmap focuses on four opportunity areas to achieve this overarching goal: 1) EV Availability and Offerings, 2) Innovative and Supportive Policies, 3) Awareness, 4) Charging Infrastructure Availability.

Federal, state, or private grant funding can help offset the higher initial cost of electric vehicles. Currently, the state of Tennessee is offering funding through the Volkswagen Diesel Settlement to replace older diesel vehicles in public and private fleets with alternate fueled or electric vehicles. Local government should pursue these kinds of grant opportunities to electrify their fleets and encourage private entities (businesses, nonprofits, etc.) to apply for clean fleet funding opportunities as well.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Developing a community-wide electric vehicle strategy that focuses on equitable access so that low-income and underserved communities can benefit from EV technology and cost savings will be crucial to ensuring equitable outcomes for this action. While equitable distribution of charging infrastructure is key, Memphis and Shelby County should explore other innovative ways to make sure the benefits of EVs are available to disadvantaged communities. One potential idea comes from Los Angeles where the city recently introduced an EV car share system – BlueLA – that is designed to specifically serve low-income communities that are negatively impacted by air pollution.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Developing a comprehensive charging network will involve financial investments from the private sector, and potentially from the public sector.

Operational: Assessing the existing electric grid infrastructure and identifying future needs for providing increased service for EV charging will be necessary.

Economic Development/Job Creation: The transition to EV adoption and the installation/provision of public charging infrastructure could lead to new businesses and jobs.

Environmental: Transitioning to EVs will improve local air and water quality, especially when paired with energy sources that are clean and renewable.

Resilience: Decreasing our communities' reliance on fossil fuels for transportation can lead to increased resilience to market fluctuations and natural disasters.

Educational/Behavioral Change: Achieving these ambitious targets will likely involve raising public awareness of EV options and benefits.

Policy Change: Reaching these EV adoption targets will likely require changes to building and development codes to ensure that new construction is designed to accommodate EV charging infrastructure.



CHAPTER 6

WASTE



Photo: Michael Meister, TN Department of Environment and Conservation

WASTE SECTOR RECOMMENDATIONS

While waste contributes much less to our community's emissions as compared to energy and transportation, this sector still presents opportunities for improvement and transformation. The major goals and related priority actions on waste offer the chance to positively impact our community in terms of public health, environmental health, neighborhood aesthetics, quality of life, and increased economic opportunity. Implementing these recommendations is projected to reduce our community's solid waste emissions by 63% by 2035. In order to address Shelby County's waste reduction priority actions, it is important to consider context and locally-relevant solutions. Reducing both organic and inorganic waste comes from addressing household and commercial waste practices and changing the culture of waste-related choices. Another key recommendation involves supporting a circular economy through incentivizing and creating markets for the waste generated from one practice or industry to benefit the needs of another.

1 REDUCE WASTE AND MOVE TOWARD A ZERO-WASTE FUTURE

- ▶ Divert Greater Amounts of Organic Waste from Landfills
- ▶ Reduce the Overall Amount of Waste Generated
- ▶ Divert Greater Amounts of Inorganic Materials from Landfills

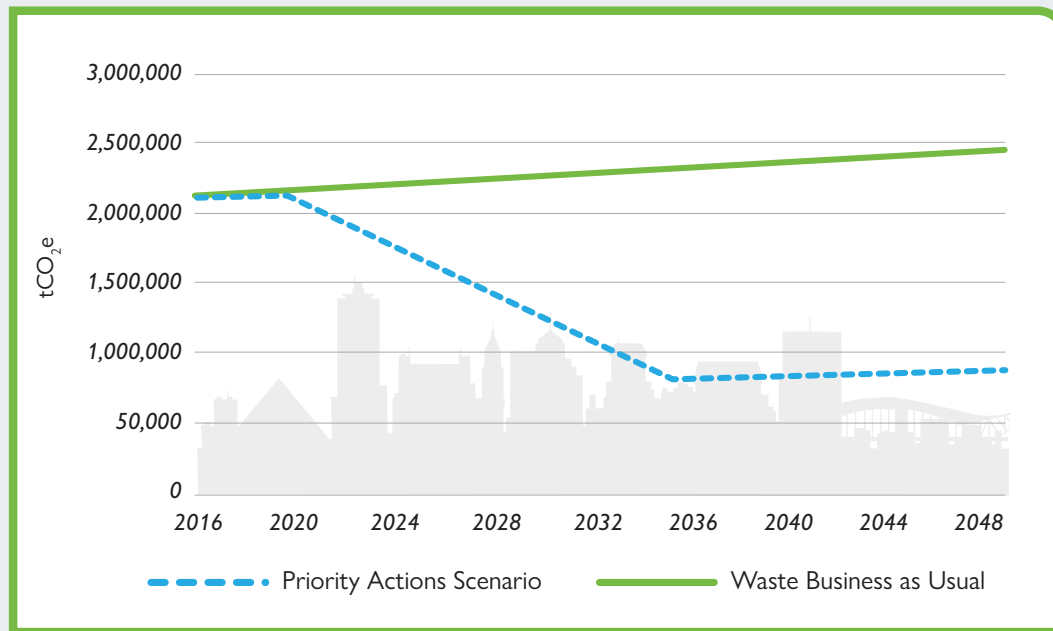
2 PROMOTE A CULTURAL SHIFT IN OUR COMMUNITY'S APPROACH TO WASTE

- ▶ Improve Tire Management and Collection Practices
- ▶ Expand Education and Outreach Efforts to Encourage Behavior Change

3 IMPROVE PRACTICES AND TECHNOLOGY AT WASTEWATER TREATMENT FACILITIES AND LANDFILLS

- ▶ Enhance Methane Recovery and Landfill Gas Destruction

Greenhouse Gas Emissions Reductions in the Waste Sector



The two figures to the left provide more detail on the projected carbon emissions reduction impact of the waste-related recommendations in this plan. The graph shows the potential cumulative emissions reductions for these actions over the next 30 years compared to the business-as-usual scenario, while the table below lists the emissions reductions for each individual action.

Based on the current analysis, methane recovery/landfill gas destruction, organic waste diversion, and waste reduction have the highest potential to reduce greenhouse gas emissions. Several actions in the waste sector were not quantified either due to the fact that their GHG benefits fall outside the County planning boundary or due to feasibility issues in determining GHG emissions reductions. While the analysis on this page focuses on emissions reduction, it is important to note that these actions have multiple beneficial impacts and can help our community meet other goals related to equity, resilience, and quality of life.

For more information on the data sources, calculations, and assumptions used for this analysis, please refer to Appendix 2.

(tCO ₂ e)	2016	2020	2035	2050
Waste Business as Usual Emissions	2,119,828	2,158,243	2,308,604	2,469,441
W.1 Organic Waste Diversion		0	-34,549	-36,578
W.2 Waste Reduction		-3,807	-44,868	-48,074
W.3 Inorganic Waste Diversion		non BASIC	non BASIC	non BASIC
W.4 Tire Management		NQ	NQ	NQ
W.5 Education and Outreach		NQ	NQ	NQ
W.6 Methane Recovery and Landfill Gas Destruction		-42,403	-1,450,009	-1,552,167
Priority Actions Scenario Emissions		2,112,033	779,177	832,622

NQ = Not quantified; supporting action with less clearly identifiable GHG emissions impacts
 Non-BASIC = Not required as part of Covenant of Mayors reporting; GHG emissions and benefits occur outside of boundary

1 REDUCE WASTE AND MOVE TOWARD A ZERO-WASTE FUTURE

This Action Area focuses on three main priority actions including diverting greater amounts of organic and inorganic waste sent to landfills as well as reducing the overall amount of waste generated in Shelby County. Incentivizing practices to use waste products in the local economy and generate revenue from these waste streams is central to these efforts.

Currently in Shelby County, 81.7% of waste is landfilled, while only 11.2% is diverted, including a small amount of food and yard waste. Recycling, including paper, plastics, metal and glass, accounts for only 7.1% of the tonnage produced out of Shelby County. An overarching strategy for this

sector involves the development of a long-range regional (county-wide) solid waste master plan that should include a waste characterization study, improved data on current landfill and diversion rates, a long-range vision for a zero-waste future, clear goals and objectives, and actions/recommendations for achieving these goals. Current strategies to increase the amount diverted and recycled can include the support and creation of new circular economies and generating revenue streams from those products. Incentivizing both larger commercial operations and homeowners to reduce the amount of waste generated through creating marketable alternatives is a regional effort, seeking creative uses for products that would otherwise be landfilled.



Photo: Memphis-Shelby County Office of Sustainability

1 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
W.1 Divert Greater Amounts of Organic Waste from Landfills	By 2035, cut the portion of yard and wood waste in municipal solid waste destined for landfills in half relative to 2016.	<ul style="list-style-type: none"> ▶ Implement a municipal curbside composting program for yard waste that includes fee changes to incentivize composting. ▶ Expand municipal composting facility capacity or consider contracting with a private composting facility for this service. ▶ Rework yard waste procedures to generate higher quality organic compost products. ▶ Incentivize the markets for compostable materials, especially in industry and commercial settings, in order to support a circular economy and reduce waste. ▶ Advocate for updated state-level landfill regulations that discourage and/or phase out disposal of organic waste in landfills.
W.2 Reduce the Overall Amount of Waste Generated	<p>Achieve:</p> <ul style="list-style-type: none"> - A 20% reduction in the share of paper and cardboard in the municipal solid waste stream from commercial, institutional, and industrial sectors sent to landfills by 2030. - A 10% reduction in the share of food waste in the municipal solid waste stream sent to landfills from commercial, institutional, and industrial sectors by 2030. 	<ul style="list-style-type: none"> ▶ Explore the development of programs and incentives to encourage increased paper/cardboard recycling and food waste composting for commercial, institutional, and industrial sectors, including specific use- or industry-themed competitions or challenges. ▶ Collaborate and coordinate with private waste hauling companies to meet waste reduction goals. ▶ Consider new regulations that require private waste hauling companies to offer recycling and/or food waste composting services. ▶ Advocate for updated state-level landfill regulations that discourage and/or phase out disposal of food waste in landfills.

1 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
W.2 Reduce the Overall Amount of Waste Generated <i>(cont.)</i>	<p>Achieve:</p> <ul style="list-style-type: none"> - A 20% reduction in the share of paper and cardboard in the municipal solid waste stream from commercial, institutional, and industrial sectors sent to landfills by 2030. - A 10% reduction in the share of food waste in the municipal solid waste stream sent to landfills from commercial, institutional, and industrial sectors by 2030. 	<ul style="list-style-type: none"> ▶ Explore the future implementation of a municipal curbside composting program for food waste that would increase food waste composting from the residential sector.
W.3 Divert Greater Amounts of Inorganic Materials from Landfills	<p>Increase the diversion rate of inorganic materials, namely construction and demolition waste as well as plastics, from disposal in municipal solid waste landfills.</p>	<ul style="list-style-type: none"> ▶ Reduce construction and demolition waste by revising the building code to require the reduction, reuse, and recycling of materials. ▶ Improve and develop public awareness and behavior change campaigns in the short-term to minimize single-use plastics. ▶ Advocate at the state level for legislation that focuses on recycling and reuse of single-use plastics (e.g. bottle redemption programs) or reduction of single-use plastics (e.g. local ability to impose plastic bag fees or bans). ▶ Advocate at the state level for incentives that support the development of renewable/recyclable product markets.

Priority Action W.1 Divert Greater Amounts of Organic Waste from Landfills

OBJECTIVE: BY 2035, CUT THE PORTION OF YARD AND WOOD WASTE IN MUNICIPAL SOLID WASTE DESTINED FOR LANDFILLS IN HALF RELATIVE TO 2016.

Background

Organic waste is a major component of the municipal solid waste (MSW) stream. Most MSW is landfilled, but the organic component (which includes food scraps, yard trimmings, paper, and spent grain from brewing facilities) could be easily diverted to composting operations. Organic waste diversion is known to significantly reduce greenhouse gas (GHG) emissions and reduce leachate production in landfills. Particularly, yard and wood waste could be diverted from landfills for biological treatment or composting. In 2016, 4.4% of MSW consisted of yard and wood waste that was placed in landfills. This action seeks to reduce the amount of yard and wood waste currently landfilled in favor of composting. In the policy scenario, increased diversion of yard and wood waste substantially reduces the amount of MSW landfilled and associated landfill gas emissions, while modestly increasing the amount of fugitive emissions from composting. The net effect is an overall reduction of GHG emissions in Shelby County.

Approach

Due to the scope of this plan, this action does not quantify the effects of collecting and composting yard and wood waste generated outside of Shelby County, although stakeholders recognize the potential benefits of a large-scale composting industry in Memphis that could service the adjacent 16-million-acre agricultural region. Yard trimmings and discarded wood are potential feedstock to the composting market. Processing an incremental volume of compost feedstock requires capital investments and incurs operational and maintenance costs, while also potentially generating revenue from compost sales and composting service fees. Instrumentation of this action may include changes to local and state policy or fiscal incentives to reduce organic waste volume that is landfilled. Research and development around composting for local feedstocks and encouraging producers of large amounts of organic waste to consider circular economy solutions will be crucial to successful implementation. Greater innovation for the use of organic waste products will help support the local economy and job creation. Awareness campaigns around environmental stewardship and the benefits of composting will also support this effort.

IMPLEMENTATION STEPS

Implement a municipal curbside composting program for yard waste that includes fee changes to incentivize composting.

Expand municipal composting facility capacity or consider contracting with a private composting facility for this service.

Revise yard waste procedures to generate higher quality organic compost products.

Incentivize the markets for compostable materials, especially in industry and commercial settings, in order to support a circular economy and reduce waste.

Advocate for updated state-level landfill regulations that discourage and/or phase out disposal of organic waste in landfills.

*Photo: Memphis-Shelby County
Office of Sustainability*

ACTION W.1 IMPACT SUMMARY

Objective	By 2035, cut the portion of yard and wood waste in municipal solid waste destined for landfills in half relative to 2016.
Implementation Partners	<p>City of Memphis Division of Solid Waste Management; Suburban municipalities; Shelby County Regional Solid Waste Board; Memphis-Shelby County Office of Sustainability & Resilience</p> <p>Agricenter International (research and development partner), waste diversion/reduction and composting outlets such as Project Green Fork and Compost Fairy, businesses with compostable waste streams such as International Paper, FedEx, Autozone, other community/nonprofit groups such as Clean Memphis</p>
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

Benefits (High Potential Impact): Equity Health Resilience Economic Development Environmental

Major Challenges: Financial Education/Behavior Change Operational Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

The City's Division of Solid Waste Management collects yard waste as part of its residential curbside pickup service. Much of this yard waste is composted by the City and provided back to residents in the form of mulch. Despite these efforts, the expansion of yard waste composting is held back by a number of factors. Disposal of yard waste in plastic bags makes it difficult and time-consuming to separate compostable materials from the non-compostable plastic. Yard waste is also often combined with other non-compostable waste making it impossible to separate and divert to composting operations. In addition, the City's composting facility does not currently have room or capacity to handle a significant increase in compostable yard waste.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Streamlined waste procedures and greater buy in from large organic waste producers (such as schools) will bring an improved waste culture to all residents, improving social dialogue and awareness.

Health: More efficient waste practices help improve air quality and create agricultural opportunities that decrease dependence on chemical fertilizers, improving food production practices, and reducing contamination of stormwater runoff.

Economic Development/Job Creation: Additional workforce creation related to the circular economy of organic waste products and compost as well as outreach specialists will be needed to successfully implement this action.

There are also a handful of companies and local nonprofits that are working to reduce and reuse organic waste, particularly food waste. Memphis Tilth shares information and resources on composting to community gardens and the broader community; Project Green Fork and Clean Memphis work with restaurants to reduce food and material waste; and Compost Fairy is a new local company that provides food composting services to residential and commercial customers. Working partnerships between public and private entities will support waste reduction programs and foster a better waste-reduction culture. Additional movement towards reaching organic waste reduction goals includes both augmenting existing programming and generating interest in new initiatives.

Environmental: Reductions in organic waste production result in reduced landfill gas emissions and potentially improved air and water quality in the region.

Resilience: This action will prioritize organic waste reduction which reduces the amount of land needed for landfill operations and supports the local economy in generating revenue streams for greater economic diversification and stability.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Identifying additional funding sources to expand the reach of existing programs, and determining viable circular economy strategies for the diverted organic waste stream may present challenges.

Operational: There is some concern that curbside collection of compostable materials lacks the quality profile for commercialization because it is often commingled with non-compostable elements (e.g., plastics, given household leaf litter protocol includes utilizing plastic trash bags for pickup by City

waste personnel). Changing practices to limit non-compostable materials in yard waste is one strategy to overcome this challenge.

Educational/Behavioral: Education and awareness combined with enhanced collection methods and materials could improve the quality of the compostable materials stream.

Policy Change: Updates to state-level regulations regarding organic waste sent to landfills could aid in implementation of this action.



Priority Action W.2 Reduce the Overall Amount of Waste Generated

OBJECTIVE: BY 2030, ACHIEVE A 20% REDUCTION IN THE SHARE OF PAPER AND CARDBOARD IN THE MUNICIPAL SOLID WASTE STREAM FROM COMMERCIAL, INSTITUTIONAL, AND INDUSTRIAL (CII) SECTORS SENT TO LANDFILLS. BY 2030, ACHIEVE A 10% REDUCTION IN THE SHARE OF FOOD WASTE IN THE MUNICIPAL SOLID WASTE STREAM SENT TO LANDFILLS FROM CII SECTORS.

Background

Shelby County annually emplaces 1.7 million tons of municipal solid waste (MSW) in landfills, 63% of which comes from commercial (27%), institutional (7%) and industrial generators (29%). It is estimated that in 2016, 28.3% of MSW generated in Shelby County was a combination of paper and cardboard that was ultimately sent to landfills. Similarly, 7.4% of county generated MSW consisted of food waste that was disposed in a landfill. This action aims to reduce the amount of paper, cardboard, and food disposed of in landfills, originating from the commercial, institutional and industrial sectors.

Approach

Waste from the commercial, institutional, and industrial sectors is primarily handled by private waste hauling companies; any approach to reducing waste from these sectors will need to involve collaboration and outreach to these companies.

Multiple instruments may be deployed for implementation of a commercial, industrial, and institutional waste reduction program, including adjusting taxes and fee structures, such as pay-as-you-throw. However, development of these types of programs would need to consider the propensity for illegal dumping or preventing sound waste decision-making. Procurement policies for public agencies that minimize waste should also be considered in

program implementation to reduce the overall amount of waste generated in Shelby County. Subsidies, incentives, or regulations targeting the commercial side (e.g., setting waste reduction goals for the hospitality sector or school system and/or implementing sector-specific challenges or competitions) will help promote tangible goals for industry partners. Infrastructure changes will need to accommodate greater volumes of food scraps, paper, and cardboard.

Education and information instruments, such as public disclosure of waste generation, will also support this effort. Public awareness around municipal solid waste contribution on the industrial side along with tapping into corporate social responsibility and sustainability goals can also help augment buy-in from industry. Future efforts should consider how to increase food waste diversion from the residential sector through the provision of a comprehensive municipal curbside composting program.

State-level legislation is also a possible avenue for supporting the reduction of organic waste into MSW streams. In 2014, Maryland enacted House Bill 878 2014 which supported best practices in the transportation and construction sectors to utilize compost-based materials. This includes compost-based berms and sediment traps. Similar systems would be possible in the Memphis area and provide evidence that cross-industry cooperation can help solve waste-related issues.

IMPLEMENTATION STEPS

Explore the development of programs and incentives to encourage increased paper/cardboard recycling and food waste composting for commercial, institutional, and industrial sectors, including specific use- or industry-themed competitions or challenges.

Collaborate and coordinate with private waste hauling companies to meet waste reduction goals.

Consider new regulations that require private waste hauling companies to offer recycling and food waste composting services.

Advocate for updated state-level landfill regulations that discourage and/or phase out disposal of food waste in landfills.

Explore future implementation of a municipal curbside composting program for food waste that would increase food waste composting from the residential sector.

ACTION W.2 IMPACT SUMMARY

Objective	By 2030, achieve a 20% reduction in the share of paper and cardboard in the municipal solid waste stream from commercial, institutional, and industrial (CII) sectors sent to landfills. By 2030, achieve a 10% reduction in the share of food waste in the municipal solid waste stream sent to landfills from CII sectors.
Implementation Partners	<p>City of Memphis and Shelby County; Suburban municipalities</p> <p>Large commercial/institutional/industrial entities in the county such as the public-school system, corrections facilities, private businesses, medical facilities, universities/colleges, and local government</p>
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High

Benefits (High Potential Impact): Equity Health Resilience Economic Development Environmental

Major Challenges: Financial Operational Education/Behavior Change Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

There are existing programs in place that support reducing the overall waste amount generated in Shelby County. Voluntary programs such as Project Green Fork and corporate environmental stewardship both generate awareness of the waste issue and offer implementable options for commercial waste minimization. The State of Tennessee sponsors a circular economy marketplace, which serves as a resource to communities developing

alternatives to traditional landfill emplacement. Government programs such as the City of Memphis' desk-side recycling program through the Office of Sustainability & Resilience also support the reduction of commercial waste generated from office spaces.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Reducing waste from these sectors can help decrease the need for new and/or enlarged landfills which often disproportionately impact low-income communities. In addition, the reuse and/or recycling of paper/cardboard and food waste has the potential to increase jobs and new industries. Workforce development programs related to these sectors should focus on low-income communities to provide more wealth-building opportunities and advance equity.

Health: Reusing and recycling paper/cardboard and food waste reduces landfill waste, resulting in improved air and water quality and public health outcomes.

Economic Development/Job Creation: Encouraging circular economy opportunities for paper/cardboard and food waste will add jobs to the region, as well as stimulate local business partnerships to creatively use these materials.

Environmental: This action has potential to improve water quality through less physical litter and improved waterways.

Resilience: This action supports resilience efforts in its comprehensive approach to reduce consumption, improve resident capacity to make sound decisions, and thereby reduce burdens on public services. Furthermore, incentivizing waste reduction and diversion supports new and innovative business models.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: The capacity to expand public services is limited but additional funding can support modifications and improvements to current waste management services. Incentives for business to reduce waste and generate revenue streams for waste products would further support these efforts.

Operational: Curbside waste pickup and comingling of materials, including contamination of unacceptable materials, complicates creating clean recyclable /reuse streams focused on one material.

Educational/Behavioral: Behavior change marketing along with programming shifts are slow and difficult to track for successful outcomes. Metrics and measures in this capacity will improve Shelby County's ability to track success and link actions to outcomes.

Policy Change: Updates to existing state policy or development of new regulations regarding organic food waste sent to landfills could aid in implementation of this action.



Priority Action W.3 Divert Greater Amounts of Inorganic Materials from Landfills

OBJECTIVE: INCREASE THE DIVERSION RATE OF INORGANIC MATERIALS, NAMELY CONSTRUCTION AND DEMOLITION WASTE AS WELL AS PLASTICS, FROM DISPOSAL IN MUNICIPAL SOLID WASTE LANDFILLS

Background

In 2016, about 899,000 tons of solid waste were disposed in landfills permitted to take construction and demolition (C&D) wastes, shredded tires and waste with similar characteristics. C&D materials include aggregates such as concrete, asphalt, asphalt shingles, gypsum wallboard, wood and metals, which can be recovered to offset the demand for virgin materials. While C&D materials generate little to no direct GHG emissions, recovered C&D materials tend to have lower life cycle emissions compared to their virgin material equivalent.

Despite plastic recycling efforts, municipal solid waste (MSW) disposed in landfills still contains up to 15% of plastics by weight. Plastic waste poses problems related to their long lifespan and the negative effects of plastics pollution on humans and the broader ecosystem. The amount of plastics in the MSW stream can be further reduced through circular economy efforts, such as connecting a carpet manufacturer with a viable plastic material reuse operation.

While there have been many efforts to increase plastic recycling in communities, one of the feasibility issues with this policy is how to design and implement an effective education and awareness campaign that creates buy-in from community members. It is possible that behavior change could occur through educating community members on the negative implications of sending plastic waste to landfills. Emphasizing the reduction of plastic use rather than simply recycling the material should be a priority of outreach in this sector.

Approach

Circular economy ideas again lace into the implementation of programs and policies to divert and reduce the amount of inorganic waste going to landfills. C&D diversion could be achieved by modifying the building code for construction/demolition, such that the permit would specify reduce, reuse, and recycle (RRR) requirements. Additional implementation instruments include tax incentives tied to re-use of existing buildings and materials, especially considering the number of historic districts and buildings located in the region. Grants and subsidies to support the circular economy will further support these initiatives. Together, these implementation strategies can create additional jobs and improve retention in the area.

Plastic diversion can be achieved through education and awareness campaigns and information instruments for plastic (such as clear labeling). Better enforcement and compliance with existing recycling regulations along with critical reviews and evaluation of recycling service pricing will also improve the region's capacity to improve plastics recycling. Overall, this strategy focuses on reducing the contribution of plastics to MSW with behavior change campaigns in the short-term to minimize single-use plastics and continue working with industry to further circular economy efforts in the long-term. Working with businesses to limit single-use plastic items, such as providing straws only upon request or using materials other than plastic for commonly used items such as to-go containers or bags, will further reduce plastic consumption and waste.

IMPLEMENTATION STEPS

Reduce commercial and demolition waste by revising the building code so permitting would require the reduction, reuse, and recycling of materials.

Improve and develop public awareness and behavior change campaigns in the short-term to minimize single-use plastics.

Advocate at the state level for legislation that focuses on recycling and reuse of single-use plastics (e.g. bottle redemption programs) or reduction of single-use plastics (e.g. local ability to impose plastic bag fees or bans).

Advocate at the state level for incentives that support the development of renewable/recyclable product markets.



Photo: Josh Whitehead

ACTION W.3 IMPACT SUMMARY

Objective	Increase the diversion rate of inorganic materials, namely construction and demolition wastes and plastics, from disposal in municipal solid waste landfills.
Implementation Partners	<p>City of Memphis and Shelby County (Memphis-Shelby County Division of Planning and Development, City of Memphis Division of Solid Waste Management); Suburban municipalities</p> <p>TN Department of Environment and Conservation, Project Green Fork, Clean Memphis, Memphis City Beautiful, Keep Tennessee Beautiful, Tennessee Materials Marketplace, building & development industry, recycling businesses, waste haulers</p>
GHG Reduction Impact (tCO ₂ e)	Not quantified
Estimated Net Cost (2018 \$; Cumulative)	Not quantified
Cost Effectiveness (\$/tCO ₂ e)	Not quantified
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High
Net Cost: Low → High
Benefits (High Potential Impact): Equity, Health, Resilience, Economic Development, Environmental
Major Challenges: Financial, Operational, Policy Change, Education/Behavior Change

EXISTING PROGRAMS AND POLICIES

Currently, there is no government ordinance in Memphis that requires builders to disclose how they will dispose of their construction and demolition waste. In Nashville, Ordinance 17.16.110 stipulates that any building permit applicants (builders/developers) must submit a plan for gathering, separating, processing, and transporting construction and demolition waste at all project sites. This kind of ordinance could result in pushback from standardized builders in the community who are likely to oppose the additional time and costs required to properly plan material disposal and then recycle C&D waste. An expedited permit or review process can promote greater buy in from builders and developers.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Reducing construction & demolition and plastic waste can help decrease the need for new and/or enlarged landfills which often disproportionately impact low-income communities.

Health: Reusing existing building materials and avoiding demolition reduces the chances of hazards such as lead-based paint or asbestos becoming airborne.

Economic Development/Job Creation: Additional workforce creation related to the circular economy of recyclable and C&D material will add jobs to the region, as well as stimulate local business partnerships to creatively use or dispose of materials.

Developers and builders in the Memphis area have shown leadership on the preservation and adaptive reuse of buildings. Crosstown Concourse - the adaptive reuse of a Sears distribution facility - and other significant projects in and around downtown Memphis that adapt older buildings to new uses contribute to a reduction in construction and demolition waste from new development.

Environmental: Beyond the reduction in GHG emissions, this action has potential to improve water quality through less physical litter and improved waterways. Microplastics and contaminated waterways also contribute to bioaccumulation and harm wildlife at both micro and macro-scales; fewer plastics result in improved ecosystem health overall.

Resilience: This action supports resilience efforts in its comprehensive approach to reduce consumption, improve resident capacity to make sound decisions, and thereby reduce burdens on public services. Furthermore, incentivizing waste reduction and diversion supports new and innovative business models.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: The capacity to expand public services is limited, but additional funding can support modifications and improvements to current waste management services. Incentives for business to reduce waste and generate revenue streams for waste products would further support these efforts.

Operational: Curbside waste pickup and comingling of materials, including contamination of unacceptable materials, complicates creating clean recyclable streams focused on one material. C&D debris is an ongoing issue given economic growth and renovations underway in historic and older neighborhoods. Scaling up markets for reuse of C&D waste and connecting waste producers to potential reuse opportunities may present challenges to implementation.

Educational/Behavioral: Behavior change marketing along with programming shifts are slow and difficult to track for successful outcomes. Metrics and measures in this capacity will improve Shelby County's ability to track success and link actions to outcomes.

Policy Change: Updates to the building and/or zoning code may be necessary to require construction and demolition waste plans, as well as to implement regulations requiring construction/demolition waste recycling for large projects.

2 PROMOTE A CULTURAL SHIFT IN OUR APPROACH TO WASTE

In order to improve waste practices in the Memphis region, this action area seeks to promote cultural changes and better decision making in regards to waste production and disposal choices. Tire management and collection practices were identified as a priority action through stakeholder technical advisory group meetings, and as such was developed more fully with that stakeholder input. Although the direct greenhouse gas reduction potential of tire disposal practices is difficult to quantify, this action has other clear co-benefits in terms of neighborhood improvements and reduced need to clean up improper disposal sites. Additionally, given the scope of Memphis' current greenhouse gas inventory, which includes only direct emissions rather than lifecycle emissions, the reduction potential of this action is low. If Memphis were to undertake a lifecycle emissions inventory, this action would likely have a significant effect.

Education and outreach efforts are also a key component to shift waste culture in Memphis. Behavior change campaigns will seek to target individual and business-level activities that are feasible and meaningful to reduce waste generation and thoughtfully dispose of materials. Making sure existing programs are well utilized, as well as expanding those efforts in Shelby County, will also be key to implementation. Partnerships with nonprofits and community development groups will support this initiative and create collaborative opportunities to leverage experience and reach a broad audience. While this action is difficult to quantify for direct GHG emissions reductions, it plays an important role supporting the success of other actions that reduce waste generation and increase the capacity for individuals, businesses, and industry partners to make more effective waste management decisions.



Photo: Michael Meister, TN Department of Environment and Conservation

2 ACTION AREA SUMMARY

PRIORITY ACTION	OBJECTIVE	IMPLEMENTATION STEPS
W.4 Improve Tire Management and Collection Practices	Increase the use of recycled tire materials in building projects and reduce improper tire disposal through targeted programs.	<ul style="list-style-type: none"> ▶ Reuse tires to offset carbon emissions from the production of other materials, for example using tires as a roofing material rather than asphalt, which is emissions intensive to produce. ▶ Reduce improper tire disposal through reworking current pickup practices and incentivizing recycling programs. ▶ Consider implementation of more stringent and traceable tracking requirements for tire handling and disposal companies.
W.5 Expand Education and Outreach Efforts to Encourage Behavior Change	Launch outreach and education campaigns to help residents become informed about waste management in their community, including programs they can take part in and information regarding how to properly dispose of waste.	<ul style="list-style-type: none"> ▶ Ongoing campaigns with the City of Memphis and other local governments will be supported by the Office of Sustainability and Resilience and assessed for opportunities to reach additional residents in meaningful ways. ▶ Conduct informal needs assessments with area stakeholders to determine marketing or social behavior change campaigns most needed in the region in 2020. ▶ Integrate needs assessment findings into campaigns and build upon existing communication already in place from parties involved in waste management. ▶ Create specific and targeted goals and outputs to assess impact. ▶ Monitor changes in waste disposal and management over the course of the outreach and education campaigns, gauge effectiveness and impact of outreach campaigns, and reassess programs.



Priority Action W.4 Improve Tire Management and Collection Practices

OBJECTIVE: INCREASE THE USE OF RECYCLED TIRE MATERIALS IN BUILDING PROJECTS AND REDUCE IMPROPER TIRE DISPOSAL THROUGH TARGETED PROGRAMS

Background

Under the Tennessee Solid Waste Management Act of 1991, whole tires are banned from landfill disposal and each county in the state must provide a temporary waste tire collection site for its citizens and tire dealers. Despite legal provisions for tire disposal and recycling, there is not yet an effective way to recycle waste tires in the City of Memphis and Shelby County, which results in many tires being disposed of in illegal dumping sites. Recycled tires can be turned into a variety of tire-derived products such as roofing, flooring, coatings and sealants, and accessibility solutions in building construction and pavers, tiles, paths, sidewalks, bike trails, landscaping, and playgrounds in the outdoor built environment.

This action focuses on two main goals: (1) Reuse tires to offset carbon emissions from the production of other materials, for example using tires as a roofing material rather than asphalt, which is emissions intensive to produce, and (2) Reduce improper tire disposal through recycling programs.

Approach

Improved waste tire management can be implemented through a variety of instruments, such as subsidizing the creation of septic chips from tires rather than other aggregate media, using tire chips for playgrounds, or reusing the tires for other means. It is estimated that about 80% of spent tires nationwide are already recycled or repurposed .

While proper recycling of tires does have some emissions reduction potential, given the avoided emissions from producing the materials that recycled tires can replace and a reduction in tires being burned which releases harmful emissions, this emissions reduction potential is negligible. However, given the co-benefits of reducing illegal dumping and removing the barriers to tire recycling this action emerged from the technical working group as a priority for the Memphis region.

In terms of the emissions reduction potential of this action, one potential feasibility issue is that there are no recycling or chipping facilities in Memphis, and shipping tires is not a carbon neutral activity. It is possible that tires could be shipped via barge or train. Working with partners to develop local chipping and reuse facilities will assist in addressing this issue, and mutually beneficial programs can emerge from such efforts.

IMPLEMENTATION STEPS

Reuse tires to offset carbon emissions from the production of other materials, for example using tires as a roofing material rather than asphalt, which is emissions intensive to produce.

Reduce improper tire disposal through reworking current pickup practices and incentivizing recycling programs.

Consider implementation of more stringent and traceable tracking requirements for tire handling and disposal companies.



Photo: Memphis City Beautiful

ACTION W.4 IMPACT SUMMARY

Objective	Increase the use of recycled tire materials in building projects and reduce improper tire disposal through targeted programs.
Implementation Partners	City of Memphis and Shelby County; Suburban municipalities Private businesses, Memphis City Beautiful and other nonprofits involved in cleanup efforts, neighborhood organizations
GHG Reduction Impact (tCO ₂ e)	Not quantified
Estimated Net Cost (2018 \$; Cumulative)	Not quantified
Cost Effectiveness (\$/tCO ₂ e)	Not quantified
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High
\$ \$ \$

Benefits (High Potential Impact):

Equity Health Resilience
Economic Development Environmental

Major Challenges:

Financial Education/Behavior Change
Operational Policy Change

EXISTING PROGRAMS AND POLICIES

The City of Memphis allows homes serviced for garbage collection to place up to four tires at curbside for collection.

Rubberized trail materials are occasionally used with Memphis' extensive trail systems and continued improvements. Tires to Trails is a local 5k race that benefits Memphis by raising awareness and participation in collecting used tires to be recycled for rubberized trails. Memphis City Beautiful engages individuals in cleaning up dumping in the community and beautifying Memphis. City of Memphis Solid Waste Division actively patrols over 200 illegal dumping sites and removes waste tires. Specific events such as MLK Day of Service projects address sites in need of tire-related clean ups. The Tennessee

Department of Environment and Conservation Waste Tire Program provides grants to counties to assist in collecting and finding beneficial end uses for their waste tires. They also form partnerships with local governments to clean up illegally dumped tires.

Expansion of existing programs such as these as well as developing new partnerships and events to promote tire re-use and proper disposal will help support this effort.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Neighborhoods will benefit from less blight and pollution, as well as improved physical conditions.

Health: Indirect benefits to health include the social and neighborhood improvements to support pride and ownership of an improved community space.

Economic Development/Job Creation: This action helps support reduced costs associated with tire cleanup by the City of Memphis Solid Waste Division. Furthermore, creative and innovative uses of tire materials for trails, roofing shingles, or other re-use options provide new job creation and circular market opportunities.

Environmental: With fewer and better managed tire stockpiles there is decreased fire risk and less storage capacity needed.

Resilience: Decreasing the number of tires that are landfilled and incentivizing re-use alternatives will improve resilience generally in repurposing materials otherwise disposed of and helping prevent improper dumping in vacant areas.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: The transportation of used tires is a financial barrier to efficient reuse projects, and shipping to facilities in order to chip or recycle tires is not a carbon-neutral activity.

Operational: Given the lack of chipping or recycling facilities in Memphis, tire repurposing is challenging and not a carbon-neutral activity due to shipping/transportation emissions.

Educational/Behavioral: The current tire disposal procedures result in many improper disposal sites, largely in abandoned lots, which provides additional challenges to shift the culture and incentives to better used tire management.

Policy Change: The potential implementation of tighter regulations and more traceable tracking procedures for tire handling and disposal companies may be challenging.



Priority Action W.5 Expand Education and Outreach Efforts to Encourage Behavior Change

OBJECTIVE: LAUNCH OUTREACH AND EDUCATION CAMPAIGNS TO INFORM AND SUPPORT RESIDENTS ABOUT WASTE MANAGEMENT IN THEIR COMMUNITY, INCLUDING PROGRAMS THEY CAN TAKE PART IN AND INFORMATION REGARDING HOW TO PROPERLY DISPOSE OF WASTE.

Background

Waste outreach and education plans should aim to influence the behavior of a target audience. This will make them more likely to minimize their waste and recycle, take advantage of the programs available in Shelby County, and understand the importance of diverting waste from landfills, reducing litter, and the connection between solid waste and climate change. A successful outreach campaign should lead to behavioral change regarding how residents and businesses in the greater Memphis area increase waste reduction and diversion. Education and outreach can also lead to greater support of public policy changes that can improve waste management and reduce GHG emissions.

Expanding this effort through commissioning a county waste study would further support and enhance the waste management actions proposed. This type of analysis would provide a better understanding of Shelby County's solid waste characterization at a minimum. Importantly, it could also identify opportunities for lower rates of waste generation, greater recovery of recyclable materials, and scaling up composting operations to serve more customers in Shelby County and neighboring areas.

Approach

Successful waste education programs elsewhere suggest that the minimum necessary resource to educate the public is a website with information on recycling options and contact information. Directly informing the public through newspapers and other media outlets of recycling information is also essential. Beyond those basic methods, there are opportunities for providing

more extensive education and outreach. For example, Michigan's recycling program dedicated approximately \$2 to \$2.50 per household to use on more extensive outreach and education, including school programming, education events, and waste processing facility tours. A key finding from this report highlights the importance of consistent and accessible education programming and messaging to support recycling efforts.

This action aims to launch an outreach and education campaign to inform and support residents of Memphis about waste management in their community, including programs they can take part in and information regarding how to properly dispose of waste. This outreach/education work should:

- Highlight both the reduction of waste generated and proper disposal of different materials.
- Build on existing programming and outreach already in place and design solutions appropriate for neighborhoods of various socioeconomic backgrounds, keeping in mind the burdens on low-income residents.
- Monitor changes in waste disposal and management over the course of the outreach and education campaign.
- Create specific and targeted goals and outputs to assess impact.
- Gauge effectiveness and impact, revising efforts as needed.

IMPLEMENTATION STEPS

Ongoing campaigns with the City of Memphis and other local governments will be supported by the Office of Sustainability and Resilience and assessed for opportunities to reach additional residents in meaningful ways.

Conduct informal needs assessments with area stakeholders to determine marketing or social behavior change campaigns most needed in the region in 2020.

Integrate needs assessment findings into campaigns and build upon existing communication already in place from parties involved in waste management.

Create specific and targeted goals and outputs to assess impact.

Monitor changes in waste disposal and management over the course of the outreach and education campaigns, gauge effectiveness and impact of outreach campaigns, and reassess programs.

Photo: Memphis City Beautiful

ACTION W.5 IMPACT SUMMARY

Objective	Launch outreach and education campaigns to inform and support residents about waste management in their community, including programs they can take part in and information regarding how to properly dispose of waste.
Implementation Partners	Tennessee Department of Environment & Conservation, Memphis-Shelby County Office of Sustainability & Resilience, Clean Memphis, Memphis City Beautiful, Shelby County Schools, Greater Memphis Chamber, City of Memphis Solid Waste Division, Shelby County Public Works, suburban municipalities; corporate and private sectors, nonprofits
GHG Reduction Impact (tCO ₂ e)	Not quantified
Estimated Net Cost (2018 \$; Cumulative)	Not quantified
Cost Effectiveness (\$/tCO ₂ e)	Not quantified
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High

Net Cost: Low → High
 \$ \$ \$

Benefits (High Potential Impact):
 Equity Health Resilience
 Economic Development Environmental

Major Challenges:
 Financial Education/Behavior Change
 Operational Policy Change

EXISTING PROGRAMS AND POLICIES

Several agencies in Memphis provide waste reduction/neighborhood beautification education and organize community cleanups, including Clean Memphis (private nonprofit) and Memphis City Beautiful (City of Memphis office in the Public Works Division).

Clean Memphis puts on a month-long event called 30 Days Straight Clean Memphis, which strives to de-litter Memphis for 30 days in a row, bringing together businesses, neighborhoods, nonprofits, and community centers to help implement 22+ large-scale cleanup projects.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Negative impacts from solid waste (landfill location, litter, pollution, etc.) are most often borne by low-income communities. Improving education and awareness on waste issues and waste reduction can lead to empowerment and better physical conditions for these communities. In addition, the promotion of circular economies for materials and waste products has the potential to increase jobs and new industries. Workforce development programs related to waste reduction and circular economies should focus on low-income communities to provide more wealth-building opportunities and advance equity.

Health: Reducing blight and improving residential waste practices helps promote healthier urban conditions for all residents.

The City of Memphis Solid Waste Management Division provides basic information and scheduling/procedures for waste pickup on their website and encourages appropriate separation of solid waste, recycling, and yard trimmings.

There are many sustainability-focused community events in the greater Memphis area, from Earth Day celebrations to educational conferences to neighborhood fairs. These events can bring visibility to recycling and improved solid waste disposal practices.

Economic Development/Job Creation: Improved participation in other actions associated with waste reduction campaigns helps support the local economy and improves efficiency in the waste management system.

Environmental: Reducing litter and promoting responsible waste practices improves waterways, water quality, and habitat quality in the region.

Resilience: This action can improve social cohesion and encourage cultural shifts towards more responsible waste practices. The operational efficiency also helps improve city programs and the allocation of public funds for other impactful practices.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Prohibitive costs to recycling for businesses and other commercial entities provide financial challenges to these initiatives.

Operational: Having a limited number of recycling vendor options is an ongoing challenge to implementation of this action.

Educational/Behavioral: There are currently limited centralized awareness campaigns in the region, giving opportunity to develop meaningful educational outreach practices and build on existing small-scale programs.

Policy Change: Implementation of this action is not expected to involve major policy changes.

3 IMPROVE PRACTICES AND TECHNOLOGY AT WASTEWATER TREATMENT FACILITIES AND LANDFILLS

In addition to actions that focus on waste reduction and changing community approaches to waste, it is important to consider actions that reduce emissions from existing landfills and wastewater treatment plants (WWTP). Given that both landfills and wastewater treatment plant activities release biogas, these practices provide potential for emissions reduction. Methane is a particularly potent greenhouse gas in that it traps heat to a greater degree than carbon dioxide. Even small reductions in the amount of methane released will therefore

have substantial impacts on our collective GHG emissions. Furthermore, creating more efficient systems for both landfill and waste water treatment biogas recovery reduces wasteful flaring and promotes the circular economy philosophies present in many of our priority actions. The goals and strategies in this section address how to improve methane recovery from wastewater treatment facilities and gas control practices at landfills in the Memphis area.



Photo: TVA

3 ACTION AREA SUMMARY

PRIORITY ACTION

W.6 Enhance Methane Recovery and Landfill Gas Destruction

OBJECTIVE

Extend the use of biogas controls to Class III and Class IV landfills. Improve the biogas capture rate at Class I landfills from 75% to 85% by 2020, and promote greater methane recovery over biogas flaring.

IMPLEMENTATION STEPS

- ▶ Starting in 2020, Division of Planning and Development (DPD) staff aim to inquire with Class I landfill operator(s) how their biogas capture rate compares with the national average rate of 75%. Provided that incremental capture rates are feasible, DPD staff will coordinate the conversations to launch an implementation and monitoring plan to achieve a landfill biogas capture rate of 85% by 2020.
- ▶ Starting in 2020, City of Memphis Public Works and DPD staff will initiate the conversations surrounding installation of controls at Class III and IV landfills with targeted completion by 2035. The prospect of bringing to market recovered biomethane could be a significant incentive for landfills with a large biomethane generation potential.
- ▶ Implement and support new legislation that lowers the threshold for mandatory installation of biogas controls, which can be used as a complementary implementation mechanism.
- ▶ Wastewater treatment plant (WWTP) operators can plan to install methane recovery systems in all facilities within Shelby County by the end of 2035 with support from DPD and City government personnel. Starting in 2020, staff can evaluate whether methane recovery or biogas flaring is feasible at uncontrolled WWTPs. Provided that installation of controls is feasible, launch an implementation and monitoring plan to achieve this goal.



Priority Action W.6 Enhance Methane Recovery and Landfill Gas Destruction

OBJECTIVE: EXTEND THE USE OF BIOGAS CONTROLS TO CLASS III AND CLASS IV LANDFILLS. IMPROVE THE BIOGAS CAPTURE RATE AT CLASS I LANDFILLS FROM 75% TO 85% BY 2020, AND PROMOTE GREATER METHANE RECOVERY OVER BIOGAS FLARING.

Background

The main byproduct of both solid waste management in landfills and biological treatment in wastewater treatment plants (WWTP) is biogas. Working to improve biogas management in these facilities is important because methane, which is a major contributor to greenhouse gas emissions, is one of the main components of biogas. This action calls for three strategies to reduce fugitive biogas emissions, and thus methane emissions, from landfills and wastewater treatment plants: 1) install biogas controls (i.e. biogas capture and flaring) at eligible Class III/IV landfills; 2) improve biogas capture rates at controlled Class I landfills; and 3) install methane recovery systems in all WWTPs within Shelby County.

There are three types of disposal facilities operating in Shelby County, namely, Class I, Class III, and Class IV. According to the Tennessee Department of Environment and Conservation, Class I disposal facilities receive non-hazardous municipal solid wastes such as household wastes, approved special wastes, and commercial wastes. Class III disposal facilities receive farming wastes, landscaping and land clearing wastes, demolition/construction waste, and shredded automotive tires. Class IV disposal facilities receive construction/demolition wastes, shredded tires, and waste with other similar characteristics.

Approach

This action combines three strategies that reduce fugitive methane emissions from landfills and wastewater treatment plants. First, improve biogas capture rates at controlled Class I landfills. Second, evaluate feasibility and cost-effectiveness of biogas controls at Class III and IV landfills. If warranted, continue with investigating installation requirements and procedures. Third,

install methane recovery systems in all WWTPs within Shelby County. Currently, biogas in Class I landfills is captured and either flared or recovered as renewable energy. Biogas management in Class I landfills could be enhanced by increasing the volume of biogas captured and sold in the biomethane market. Biogas is not currently captured in Class III or IV disposal sites. Installing a capture and flaring system at Class III and Class IV disposal sites could further reduce GHG emissions.

In terms of treatment volume, most wastewater (about 89%) is processed at either the Maynard C. Stiles or T.E. Maxson plants in Memphis. In 2007, the latest methane recovery systems were installed at the Maynard C. Stiles treatment plant. Lagoons at the T.E. Maxson plant were covered beginning around 1995 and associated biogas flared. A biogas treatment system was installed at T.E. Maxson in early 2019, although refinements and adjustments are ongoing to ensure the system meets specifications for biogas treatment. Installing methane recovery or flaring systems at other smaller wastewater treatment plants in the county could further reduce GHG emissions.

Instrumentation of this action may include changing regulations and standards to limit biogas emissions. Providing subsidies and incentives would also help facilities develop improved infrastructure to capture biogases. Voluntary measures as well as creative financing and investment also help support this process.

IMPLEMENTATION STEPS

Starting in 2020, Division of Planning and Development (DPD) staff aim to inquire with Class I landfill operator(s) how their biogas capture rate compares with the national average rate of 75%. Provided that incremental capture rates are feasible, DPD staff will coordinate the conversations to launch an implementation and monitoring plan to achieve a landfill biogas capture rate of 85% by 2020.





Starting in 2020, City of Memphis Public Works and DPD staff will initiate the conversations surrounding installation of controls at Class III and IV landfills with targeted completion by 2035. The prospect of bringing to market recovered biomethane could be a significant incentive for landfills with a large biomethane generation potential.

Implement and support new legislation that lowers the threshold for mandatory installation of biogas controls, which can be used as a complementary implementation mechanism.

Wastewater treatment plant (WWTP) operators can plan to install methane recovery systems in all facilities within Shelby County by the end of 2035 with support from DPD and City government personnel. Starting in 2020, staff can evaluate whether methane recovery or biogas flaring is feasible at uncontrolled WWTPs. Provided that installation of controls is feasible, launch an implementation and monitoring plan to achieve this goal.

Photo: Google 2019, Map Data: Google 2019

ACTION W.6 IMPACT SUMMARY

Objective	Extend the use of biogas controls to Class III and Class IV landfills. Improve the biogas capture rate at Class I landfills from 75% to 85% by 2020, and promote greater methane recovery over biogas flaring.
Implementation Partners	Landfill operators, wastewater treatment plant operators, City of Memphis Division of Public Works, Memphis-Shelby County Division of Planning and Development, Tennessee Department of Environment and Conservation
GHG Reduction Impact (tCO ₂ e)	
Estimated Net Cost* (2018 \$; Cumulative)	\$
Cost Effectiveness (\$/tCO ₂ e)	
Benefits	
Challenges	

Level of GHG Emissions Reduction Impact and Cost Effectiveness: Low → High 

Net Cost: Low → High 

Benefits (High Potential Impact): Equity Health Resilience Economic Development Environmental

Major Challenges: Financial Operational Education/Behavior Change Policy Change

* Cost analysis is cumulative (2019-2050) and includes costs for implementation, as well as savings resulting from reduced energy or fuel consumption, maintenance, and/or increased revenue.

EXISTING PROGRAMS AND POLICIES

Class I landfills currently operate with biogas controls and methane recovery systems. Additionally, biogas controls have been in place since 2007 at the Maynard C. Stiles WWTP. Biogas destruction (flaring) has been in place at

T.E. Maxson WWTP since 1995, and an upgraded biogas recovery system was recently installed in 2019, although adjustments to this new system are ongoing to ensure it meets all specifications for biogas treatment.

BENEFITS

The potential benefits from implementing this priority action include:

Equity: Indirect impacts to improve equity include improving opportunities for local workforce development and providing access to job and new skills/training opportunities for existing and new employees.

Health: Improved air quality helps decrease the incidence of respiratory illnesses and promotes healthier communities.

Economic Development/Jobs: Creating new markets for biogas helps support the circular economy and the use of innovative infrastructure at landfills supports development and retention of skilled labor and new job opportunities.

Environmental: Co-benefits of this action include cleaner air, and with improved infrastructure at landfills runoff or leachate potential also decreases.

Resilience: More efficient landfill operations helps streamline practices and promotes better use of byproducts otherwise discarded or flared. Safer protocols and infrastructure also help support resilience efforts.

CHALLENGES

Challenges for successfully implementing this action include:

Financial: Adding infrastructure to capture biogas can be cost prohibitive given the low return on investment with the absence of a more well established biogas market.

Operational: Demolition landfills (Class IV) have low biogas generation potential and may not warrant installation of a biogas capture and flaring system. Class III landfills that also accept Class IV waste are likely to have lower biogas generation potential than strictly Class III disposal sites.

Educational/Behavioral: Given the limited public involvement in this action, challenges exist to a greater degree in shifting the approach to waste treatment/management practices at the leadership and operational level.

Policy Change: Implementing these enhanced landfill controls will likely require regulatory changes at the local or state level which may present challenges.



PLAN IMPLEMENTATION

Advance Existing Efforts

While implementation of this plan will be challenging, existing local efforts in the energy, transportation, land use, and waste fields provide a solid foundation for the work needed to achieve these ambitious climate action goals.

Memphis 3.0 is the new roadmap for smarter growth and development that invests in existing neighborhoods in our region's largest city and economic engine. The new Transit Vision shows how we can enhance our bus service and improve access to employment opportunities and other goods and services. The recent expansion of MLGW's low-income weatherization program, current efforts to improve delivery of existing energy efficiency and weatherization programs for low-income Memphians, and grassroots efforts to address energy costs for communities with limited resources all demonstrate momentum for addressing the Memphis area's energy burden challenge.

New leadership at MLGW and growing local interest in clean, renewable energy present opportunities for transforming our power supply. High profile green buildings such as the LEED Platinum Crosstown Concourse and the recent adoption of updated building and energy codes demonstrate progress on making our building stock more energy efficient and sustainable. Efforts are underway to obtain funding for a regional solid waste characterization study as the first step in completing a long-range regional solid waste master plan. Many private businesses, neighborhoods, organizations, and individual residents across the Memphis area are taking steps both big and small to reduce their carbon

footprint and save money.

As the Memphis area looks to achieve even more ambitious emission reduction targets in the future, continued participation in international and national climate action initiatives (e.g., the Global Covenant of Mayors for Climate and Energy) and collaboration with other networks (e.g., Urban Sustainability Directors Network) is critical.

Leaders and Key Partners

While City and County government will play a strong role in implementing this plan - particularly in terms of cutting emissions from local government operations and prioritizing investments that reduce emissions - significant progress on addressing climate change will take the efforts of our entire community. Local government can help set the framework for climate action through policies, programs, and investments, but real change will be possible with commitment and buy-in from a broad range of actors in the Memphis area - from business and industry to individual residents.

To achieve our emission reduction goals, it will be important to work with the private development community to implement actions related to green building codes, more sustainable land use patterns, and electric vehicle infrastructure, as well as with local businesses and industry on energy efficiency and conservation, renewable energy generation, EV adoption, and transportation demand management efforts. Successful implementation will also depend on collaboration and communication with the general public, particularly groups most vulnerable to climate

change impacts. The way in which these actions are implemented must strive to increase equity and reduce potential negative impacts to vulnerable groups

The Office of Sustainability and Resilience will be a key convener, advocate, and progress monitor for the plan and work with other governmental departments on implementation. Agencies such as MLGW and MATA will also serve as key partners and co-leads for several priority actions. Collaboration and coordination with other external agencies such as TVA and the Tennessee Department of Environment and Conservation (TDEC) is essential.

Funding and Financing Tools

Identifying and securing funding is a potential challenge for many actions in this plan, particularly several actions that have the highest impact on GHG reductions. City and County government should first look at existing Capital Improvement Program (CIP) processes to see how these large capital investments can better align with climate action and GHG reduction goals. In addition, City and County government should work toward incorporating life-cycle cost assessments into the evaluation of CIP projects and the development of purchasing policies. This type of analysis will provide a more comprehensive picture of the impact of our public investments.

The scale of the issue and our corresponding climate action goals will also require the pursuit of new, innovative financing tools. For example, Pay for Success (PFS) – or Social Impact Bonds – offer one potential

mechanism for implementing actions that have both social and GHG reduction impacts. Locally, the Healthy Homes Partnership and the Green & Healthy Homes Initiative team have completed a feasibility assessment for using PFS to pay for home improvement measures that can lead to healthcare savings, primarily in terms of reduced hospital visits for asthma treatment. These healthy home improvements have the potential to improve energy efficiency, leading to GHG reductions. In addition, Environmental Impact Bonds represent another private sector tool that can be leveraged to finance municipal projects that advance climate mitigation and adaptation.

Local government, nonprofits, and the business community should also strengthen partnerships and programs that focus on achieving climate action and social equity goals. This public-private collaboration can take many forms. For example, local government should support and celebrate existing climate action efforts in the private sector, whether it's a business electrifying their vehicle fleet and setting goals for energy efficiency/conservation in their operations, or an advocacy group implementing energy efficiency/conservation education programs in low-income communities. These public-private partnerships and programs should also take advantage of growing interest from philanthropic groups/foundations in providing grant funding for projects that focus on climate action, health, and equity outcomes.

Tracking Progress and Plan Updates

Tracking progress and regularly updating the plan to incorporate policy or practice changes, technological advancements, or other

new information is also key to implementation. The Office of Sustainability and Resilience will complete annual progress reports on plan implementation along with updated greenhouse gas inventories at least every other year. Since this is a long-range document, staff will need to lead a more comprehensive update of the plan every 5 years. The overarching progress indicators or benchmarks for this plan are a reduction in greenhouse gas emissions and the more detailed objectives laid out for each priority action in the energy, waste, and transportation sectors. The Office of Sustainability and Resilience should also work with public and private partners to improve data quality and streamline data collection efforts. Staff should also explore a revamped sustainability

program website and the development of a regularly-updated public-facing dashboard on key climate action indicators such as: building energy consumption by sector; energy burden for residents; daily per capita vehicle miles traveled (VMT); renewable energy generation and purchased renewable energy; mode share of commutes (driving alone, carpooling, transit, walking, biking, telecommuting, etc.); number of registered electric vehicles; amount of landfilled waste and recycling rates; transit frequency and diverse uses within ½ mile of Memphis 3.0 anchor areas; tree canopy cover; share of electric vehicles and alternative fuel vehicles in local government fleets; and energy consumption in local government facilities.

MEMPHIS AREA
CLIMATE ACTION
PLAN

APPENDIX 1: COMMUNITYWIDE GREENHOUSE GAS EMISSIONS INVENTORY AND FORECAST METHODOLOGY

EMISSIONS RESULTS

The 2016 Shelby County communitywide inventory was developed to inform the deliberations of the CAP process and meet the requirements of the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventory, or GPC (World Resources Institute, 2014). The purpose of this section is to present the results of the GHG assessment and describe the methods and processes used to develop the base year and forecast scenarios.

Table A.1 summarizes emissions by key subsectors. The 2016 base year inventory served as the basis for the forecast scenario. Emissions were projected to three forecast years: 2020 (short-term), 2035 (mid-term), and 2050 (long-term).

Table A.1. Base Year and Forecast GHG Emissions

	2016	2020	2035	2050
Energy	7,900,671	6,282,301	6,200,552	6,674,442
Stationary Energy, Commercial and Institutional Buildings	3,692,414	2,863,435	2,789,344	3,013,517
Stationary Energy, Manufacturing and Construction	838,632	717,032	744,865	775,581
Stationary Energy, Residential Buildings	3,369,625	2,701,834	2,666,343	2,885,344
Transportation	7,171,416	6,236,170	5,357,523	6,566,940
Transportation, Aviation	352,392	351,547	348,396	345,274
Transportation, On-road	6,686,472	5,751,782	4,879,134	6,094,239
Transportation, Railway	88,591	89,718	89,873	90,100
Transportation, Waterborne navigation	43,961	43,123	40,120	37,327
Waste	2,119,828	2,158,243	2,308,604	2,469,441
Waste, Biological Treatment of Waste	101,766	103,610	110,829	118,550
Waste, Solid Waste Disposal	1,933,456	1,968,494	2,105,635	2,252,331
Waste, Wastewater Treatment and Discharge	84,606	86,139	92,140	98,560
Grand Total	17,191,915	14,676,714	13,866,679	15,710,823

Base Year Methodology

This section identifies key data sources, methods and assumptions informing the assessment of GHG emission for the three sectors comprising the GPC BASIC inventory, namely, stationary energy, transportation, and waste. Each sector was assessed using best-available energy and activity data in combination with best-in-class methodology. Sector GHG emissions were integrated into a single inventory using the Climate Action for Urban Sustainability (CURB) tool. The inventory adopted the global warming potential values from the Fourth Assessment Report.

Stationary Energy

Electricity and Natural Gas

Electricity and natural gas are provided to all customers in Shelby County by a single provider—Memphis Light, Gas and Water (MLGW). Data on 2016 sales of both electricity and natural gas were provided in MLGW's 2016 Annual Report (MLGW, 2016). Electricity sales for 2016, in terms of kilowatt-hours (kWh), were broken down by the following customer types: residential, commercial – general service, industrial, outdoor lighting and traffic signals, street lighting, and interdepartmental. Similarly, natural gas sales for 2016, in terms of thousand cubic feet (MCF) were broken down by the following customer types: residential, commercial – general service, industrial, interdepartmental, and spot gas.

Emission factors for natural gas were fuel-based while utility-specific emission factors were used for electricity. The natural gas CO₂ emission factor represents the standard carbon content by unit of energy of natural gas. Emission factors for electricity are dependent upon the resource mix used to generate the electricity (i.e., the percentage of generation provided by each type of fossil fuel, nuclear, and renewables). Tennessee Valley Authority (TVA) meets the electricity generation demands of all MLGW residential,

commercial, and industrial customers in Shelby County.

While the same generation resource mix is used for all its customers, MLGW has 35 industrial customers for whom time-based rates are used and for which TVA has precise consumption information to match to the generation mix at those times. When calculating the overall MLGW carbon allocation values, those industrial customers are excluded because they get values assigned from their time-based consumption data. MLGW provided the 2016 CO₂ emission rate for the non-industrial customers as well as the rates (without identifying information) of the 35 industrial customers (Williamson, 2018). The rates for these industrial customers were averaged to estimate the CO₂ rate for industrial electricity consumption. The methane (CH₄) and nitrous oxide (N₂O) emission factors from electricity generation for all customers are from the Environmental Protection Agency's (EPA) 2016 Emissions and Generation Resource Integrated Database (eGRID), representing the average systemwide resource mix used for electricity generation within the TVA region which includes all of Shelby County (EPA, 2018a).

The natural gas and electricity consumption totals for 2016 by sector were entered into CURB, along with the corresponding electricity emission factors by sector. From these inputs, the CURB tool calculated natural gas and electricity consumption emissions.

Biogas

Landfill gas releases methane, which in Shelby County is captured and used for both heating and electricity. For that reason, energy recovered from landfills is reflected in the Shelby County inventory as a stationary energy source.

Transportation

On-road

Emissions from the on-road sector were calculated using the geographic or territorial methodology. This methodology attempts to capture all on-road activity occurring within the geographic boundary, in this case, within Shelby County. Activity data on daily vehicle miles traveled (VMT) within Shelby County in 2016 were obtained from the Tennessee Department of Transportation (TDOT, 2018). Emissions for on-road vehicles were estimated using EPA's MOVES model (EPA, 2018b). Inputs to the MOVES model were generated using the VMT data, other Shelby County-specific data where available, and model defaults for Shelby County otherwise. Emissions were generated by MOVES and entered directly into CURB.

Rail

Data on the ton-miles of freight carried by rail in 2016 with either an origin or a destination of Memphis were extracted from the Federal Highway Administration's (FHWA) Freight Analysis Framework (FHWA, 2018). The ton-miles data from the Freight Analysis Framework represent the total distance of the rail trip, not just the portion that accrued in Shelby County. Therefore, emissions for this sector were calculated using the induced activity methodology defined by the GPC. With this methodology, the base year activity for rail transportation was calculated as 50% of the ton-miles of freight from trips either originating or ending in Memphis. The resulting activity in ton-miles was multiplied by product transport emission factors for rail in units of kilograms per ton-miles from EPA (EPA, 2015).

Aviation

The number of aircraft operations (arrivals and departures) comes from the Federal Aviation Administration's (FAA) Air Traffic Activity System (ATADS). The ATADS system had operations information on the two largest

airports in Shelby County – Memphis International Airport and Millington Regional Jetport (FAA, 2018). Operations at these airports were multiplied by an industry-specific CO₂ emission factor to reflect emissions from the landing/take-off cycles occurring within the County's geographical boundary (Intergovernmental Panel on Climate Change, 2000).

Waterborne Vessels

There was limited data available on the level of fuel consumption or marine vessel activity in Shelby County. Therefore, marine cargo tonnage from the US Army Corps of Engineers (USACE) Commerce Statistics Center (USACE, 2018) was used to estimate the local level of waterborne vessel activity relative to the national level. Marine cargo tonnage for the Port of Memphis was divided by the national marine cargo tonnage from the US Army Corps of Engineers Commerce Statistics Center. This ratio (0.13% of national activity) was then multiplied by total GHG emissions from Commercial Marine Vessels in the US EPA GHG Emissions and Sinks Inventory for 2016 (EPA, 2018c).

Waste

Solid Waste

The primary source for solid waste information was the Shelby County Solid Waste Needs Assessment, released January 2018 (Memphis Area Association of Governments, 2018). This provided information on solid waste tonnage, the proportion of commercial versus residential waste, and the flow of waste to landfills within and outside Shelby County. The amount of solid waste emplaced in landfills and the composition of landfilled waste were the main inputs to model landfill emissions using the methane commitment model embedded in the CIRIS tool (C40 Cities Climate Leadership Group, 2018). County specific solid waste composition data were not available, so the 2008 Waste Source Characterization Study, which provided information on the breakdown of waste generated in Tennessee (Tennessee State University

and Tennessee Department of Environment and Conservation, 2008), was utilized in this assessment.

Total landfill gas emissions were adjusted down to reflect current energy recovery and landfill gas flaring practices, namely, all landfills have controls with a capture rate of 75%, of which 55% is flared, and 45% is recovered as a bio fuel. Republic Services' Environmental Manager Heath Lockley provided information on biogas capture and flaring at landfills.

Finally, the output of the CIRIS solid waste module was entered into the CURB tool in units of tons of GHG emissions.

Wastewater

The wastewater estimate was based on data provided by the City of Memphis, the City of Bartlett, and the Town of Collierville. Key information for the assessment include an account of wastewater treatment options in Shelby County, the share of residents with wastewater access, and population in each jurisdiction. The information from these three areas was weighted based on population to reflect Shelby County as a whole.

Methane Emissions: each treatment system/option, emissions are calculated in the CIRIS tool (C40 Cities Climate Leadership Group, 2018) based on the county's population, a US default rate of biological oxygen demand (BOD) per capita, the proportion of residents with each type of wastewater collection, and distribution of total BOD by treatment system. The 2016 base year reflects a treatment system distribution as follows based on the volume of wastewater treated:

- Aerobic digester sludge, with biogas recovery (47.0%)
- Anaerobic deep lagoon, with biogas flaring (42.3%)

- Aerobic digester sludge, without biogas recovery (5.5%)
- Anaerobic deep lagoon, without biogas flaring (4.4%)
- Anaerobic, shallow lagoon (0.3%)
- Septic (0.5%)

Nitrous Oxide Emissions: emissions occur in aerobic treatment plants and during the discharge of nitrogen in the effluent to aquatic environments. Emissions from aerobic treatment plants are directly proportional to the size of population serviced by the centralized treatment system (99%). Methane and nitrous oxide emission as calculated in CIRIS were entered into CURB to reflect Shelby County's wastewater emissions.

FORECAST SCENARIO METHODOLOGY

The 2016 base year inventory served as the basis for the forecast scenario. Emissions were projected to three forecast years: 2020 (short-term), 2035 (mid-term), and 2050 (long-term). Table A.2 summarizes growth rates by inventory line item. A narrative description of the forecast methodology follows.

Table A.2 GHG Forecast Growth Rates

Sector/Subsector/Concept	2016-2020	2020-2035	2035-2050
Energy			
Residential Commercial			
Natural Gas	0.4%	0.4%	0.5%
Electricity	-7.8%	-0.3%	0.5%
Biogas	0.0%	0.0%	0.0%
Manufacturing and Construction			
Natural Gas	2.1%	1.0%	0.5%
Electricity	-4.0%	0.2%	0.3%
Transportation			
On-road			
LNG	-0.9%	0.5%	2.1%
CNG	-1.6%	0.2%	1.0%
Distance travelled passenger	-3.0%	-2.4%	0.6%
Distance travelled freight	-4.4%	0.0%	2.0%
Railways			
Diesel Oil	0.3%	0.0%	0.0%
Waterborne Navigation			
Diesel Oil	-0.5%	-0.5%	-0.5%
Aviation			
Jet Fuel	-0.1%	-0.1%	-0.1%
Waste			
Landfill			
Municipal Solid Waste	0.5%	0.5%	0.5%
Biological Treatment			
All Organic Waste	0.5%	0.5%	0.5%
Wastewater Treatment and Discharge			
All Wastewater	0.5%	0.5%	0.5%

Stationary Energy

Residential and Commercial Energy

Growth in population was used as the growth driver for the residential and commercial energy sectors. Shelby County population was projected by year through 2070 by the Boyd Center for Business and Economic Research at the University of Tennessee and available at the Tennessee State Data Center (University of Tennessee, 2017). Using these county population projects, growth factors were developed for the three periods of the Shelby County GHG forecast: 2016-2020, 2020-2035, and 2035-2050.

The growth rates for each of these periods were entered into the CURB model to project emissions from natural gas consumption in the residential and commercial sectors. No change in the CO₂e (carbon dioxide equivalent) emission rate over time is expected from natural gas consumption.

While electricity consumption is expected to grow in parallel with the population growth, emission rates from electricity used by the residential and commercial sectors are expected to change reflecting the alteration in the resource mix used to generate the electricity over time. Electricity for Shelby County is provided through MLGW and generated by TVA. TVA projects that their resource mix will include more generation from nuclear sources and renewable sources and will be less dependent on fossil fuels such as coal and natural gas. TVA provides information on their projected source of generation for 2018 and 2027 (TVA, 2018). Combining the projected resource mix data with the actual resource mix data for 2016, the annual change in the systemwide combined CO₂e emission rate was calculated for each projection period, assuming that the resource mix for years beyond 2027 is the same as that projected for 2027. The annual growth rate changes and CO₂e emission rate changes were combined and entered into the CURB tool to be used in projecting emissions from electricity consumption in the

residential and commercial sectors.

Manufacturing and Construction Energy

Manufacturing trends in natural gas and electricity consumption are not as likely to follow trends in population growth as the residential and commercial sectors. Therefore, regional trends in natural gas and electricity consumption were used to model growth in the manufacturing and construction sector. Projection data for industrial energy consumption were obtained from the US Energy Information Administration's (EIA) 2018 Annual Energy Outlook website (EIA, 2018a). Natural gas and electricity consumption for the industrial sectors for the years 2016, 2020, 2035, and 2050 were extracted from the table detailing "Energy Consumption by Sector and Source" for the East South Central region, which includes Tennessee. Separate growth factors for each project period and for natural gas consumption and electricity consumption were developed for the manufacturing and construction energy sector from these data.

As with the residential and commercial sectors, no changes were expected in the CO₂e emission rate over the projection period from the consumption of natural gas by the industrial sector. Thus, the regional growth rates for industrial natural gas consumption were entered into the CURB tool for this sector.

For electricity consumption by the manufacturing and construction sector, the electricity consumption growth rates were adjusted to account for the change in the electricity generation resource mix. This annual rate of change on the CO₂e emission factor was calculated in the same way and using the same TVA-based projection year electricity resource mix as for the residential and commercial sectors (TVA, 2018). The only difference in these calculations was the difference in the base 2016 electricity resource mix for the residential and commercial sectors versus the industrial sector. The resulting

annual rates of change in CO₂e emission rates for electricity consumption by the industrial sector were combined with the corresponding regional growth factors in industrial electricity consumption, and the combined factors were entered into the CURB tool.

Transportation

On-road Transportation

The growth in activity in on-road transportation was estimated from VMT forecasts for Shelby County provided in Table 4 of the Shelby County Air Quality Conformity Demonstration (Memphis Metropolitan Planning Organization, 2016). This data source provides contains annual VMT by vehicle source type for 2017, 2020, 2030, and 2040. Separate activity growth factors were developed for each growth period for onroad passenger vehicles and on-road freight trucks. MOVES model runs were executed for each projection year using the available Shelby County inputs (EPA, 2018b).

Changes in the emission factors over each time period were calculated from the model output, reflecting changes in fuel efficiency improvements resulting from fleet turnover. The VMT growth rates were combined with the corresponding fuel efficiency improvements to estimate the combined annual growth and control factors entered into CURB for each projection period and for passenger and freight vehicles.

Rail

For the rail transportation projections, activity growth was estimated from US projections of freight railroad ton-miles by rail from the 2018 Annual Energy Outlook (EIA, 2018b). Annual changes in fuel efficiency by freight railroads were based on freight railroad projected fuel efficiency data from the same source. The annual growth rates and efficiency change rates were combined into a single annual emission projection factor for each of the three

projection periods and entered into the CURB tool.

Aviation/Marine Vessels

Growth in population was used as the surrogate for growth in the aviation and marine vessel sectors. Shelby County population was projected by year through 2070 by the Boyd Center for Business and Economic Research at the University of Tennessee and available at the Tennessee State Data Center (University of Tennessee, 2017). Efficiency improvement for airplanes and marine vessels was estimated based on the forecast improvement in fuel efficiency in the Annual Energy Outlook. Marine vessels were estimated to have a fuel efficiency improvement of 0.93% per year (EIA, 2018b). The aviation sector estimated an annual fuel efficiency improvement of 0.51% per year (EIA, 2018c). The annual growth rates and efficiency change rates were combined into a single annual emission projection factor for each of the three projection periods and entered into the CURB tool.

Waste

Solid Waste

Growth in population was used as the surrogate for growth in the solid waste sector. Shelby County population was projected by year through 2070 by the Boyd Center for Business and Economic Research at the University of Tennessee and available at the Tennessee State Data Center (University of Tennessee, 2017). There were no data available on expected efficiency improvements in the Shelby County solid waste sector, so no efficiency improvements were assumed in the forecast.

Wastewater

Growth in population was used as the surrogate for growth in the wastewater sector. Shelby County population was projected by year through 2070 by the

Boyd Center for Business and Economic Research at the University of Tennessee and available at the Tennessee State Data Center (University of Tennessee, 2017). There were no data available on expected efficiency improvements for Shelby County wastewater, so no efficiency improvements were assumed in the forecast.

APPENDIX 2: ENERGY SECTOR PRIORITY ACTION IMPACT ANALYSIS

COST ANALYSIS APPROACH – ALL PRIORITY ACTIONS

In general, when developing the costs of these actions, differences between the business-as-usual baseline and the selected action were identified and costed where possible, as either additional costs or cost savings. For the energy sector, the primary cost or savings is the cost associated with an increase or decrease in fuel consumption from either electricity and natural gas. In addition, as identified in Action E.6, the decreases in carbon intensity of electric generation and the corresponding increase in cost associated with decarbonization are applied across all actions with an electricity component. Capital costs, such as the additional capital costs needed to create green buildings or for more efficient appliances or lighting, are included where appropriate. Agency outlays for subsidies or program costs are also included.

PRIORITY ACTION E.1 GREEN BUILDING STANDARDS AND INNOVATIVE GREEN BUILDING DESIGN

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results:

This program looks at the energy consumption of new green buildings compared with conventional buildings. This program also includes major renovations of residential, commercial, and institutional buildings. Energy savings are then applied to an estimate of the number of new residential and commercial buildings in Shelby County in order to estimate the fuel (electricity and natural gas) and GHG savings. GHG savings of this policy are significantly reduced due to overlap with Action E.6 (grid decarbonization). This policy serves to reduce electricity demand, but as the carbon intensity of the grid declines (as a result of E.6) the GHG savings of reducing electricity consumption also declines. The major costs of this policy are the additional construction or renovation costs of green buildings.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO _{2,e}	tCO _{2,e}	tCO _{2,e}	2018 Dollars	\$/tCO _{2,e}
178,795	69,775	3,797,441	\$216,433,008	\$57

2. Data Sources

- Data on energy savings of green buildings vs conventional in the Southern Region: Fowler, K., Rauch, E., Henderson, J., & Kora, A. (2011). *Reassessing green building performance: A post occupancy evaluation of 22 GSA buildings*. Retrieved from https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-19369.pdf
- Data on average building square footage and average energy consumption for residential buildings: US Energy Information Administration. (2015). Residential energy consumption survey (RECS). Retrieved from <https://www.eia.gov/consumption/residential/data/2015/>
- Data on average building square footage, and average energy consumption for commercial buildings: US Energy Information Administration. (2012). Commercial buildings energy consumption survey (CBECS). Retrieved from <https://www.eia.gov/consumption/commercial/data/2012/index.php?view=microdata>
- Data on number of new residential building construction in the city of Memphis: Tennessee State Data Centers. (2018). Economic indicators, Tennessee MSA building permits. Retrieved from <http://tndata.utk.edu/sdcindicators.htm>
- Electricity and natural gas price forecast: US Energy Information Administration. (2018). Annual energy outlook 2018, Reference Case, Table 8 and Table 13. Retrieved from <https://www.eia.gov/outlooks/archive/aeo18/>
- Additional cost per square foot of green buildings (costs later updated to 2018 dollars): Kats, Greg. (2003). *The costs and financial benefits of green buildings: A report to California's Sustainable Building Task Force*. Retrieved

from https://noharm-uscanada.org/sites/default/files/documents-files/34/Building_Green_Costs_Benefits.pdf

- Major Renovations in Shelby County: 2016-2018 Building Permit Information for Shelby County provided by Memphis-Shelby County Office of Construction Code Enforcement in personal communication, February 5, 2019.

3. Quantification Methods

This quantification examines the energy consumption of the new commercial and residential buildings expected to be built in Shelby County, as well as major renovations. The number of residential buildings built in Shelby County in 2016 was 4,357 (Tennessee State Data Center). The number of commercial buildings was not available, so this was estimated based on the ratio of new commercial buildings to new residential buildings in the South Region, according to the DOE's Residential and Commercial Energy Consumption Surveys. This gave an estimate of 220 new commercial buildings per year. A renovation was considered "major" if it had a project cost greater than \$50k for a residential building and greater than \$200k for a commercial or industrial building. The number of major renovations per year was estimated based on the average number of residential or commercial applications for major renovation permits in Shelby County, 2016-18. The average square footage from the Residential and Commercial Energy Surveys was then used to estimate total new square footage per year from construction of residential and commercial buildings in Shelby County.

This square footage was then multiplied by the average energy consumption per square foot of conventional buildings to get the BAU energy consumption from all new residential and commercial buildings. For the green buildings scenario, this same square footage was multiplied by the average energy consumption of green buildings, which is on average 46% lower than conventional buildings. These two different estimates (BAU vs green building

scenario) were then multiplied by the appropriate electricity and natural gas emissions factors to estimate the GHG reductions from the policy.

The primary driver of costs for this policy is the additional construction cost of green buildings. This includes additional insulation, more expensive windows, and other efficiency-focused building materials. On average, green buildings are estimated to cost an additional \$8.32 per square foot, and this is multiplied by all new square footage built each year (Kats, 2003 - see reference above). There are also cost savings that come from reduced energy and electricity costs. The price of electricity and natural gas comes from DOE's Annual Energy Outlook. Due to the long life of buildings, these cost savings do eventually pay back, but it is only in year 2035 and onward that the policy has negative net costs for the year.

4. Key Assumptions

This analysis assumes that 100% compliance with green building standards can be achieved in Memphis. Buildings are often granted exceptions to building codes at both the local and state level, and therefore this may be an overestimate of the true costs and GHG savings of green building standards. However, it is difficult to determine to what extent exceptions will be made, and the goal as written is for 100% compliance by 2025. Given the difficulty in setting and enforcing a green building standard, this is likely a high-end estimate of the potential for GHG savings of this policy.

This analysis has overlap with E.6 (grid decarbonization) and as a result the GHG savings are reduced for this option to account for the electricity emissions factor being less carbon-intensive. If this option were put into place without E.6 also being implemented, then the GHG savings achieved would be significantly greater in the later years.

PRIORITY ACTION E.2 LOW-INCOME HOUSING ENERGY EFFICIENCY

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

This program achieves significant GHG reductions by improving energy efficiency in low-income households. These savings come in the form of both reduced electricity and natural gas needs for low-income households. This will achieve significant energy savings and have improved citywide equity. GHG savings of this policy are significantly reduced due to overlap with E.6 (grid decarbonization). This policy serves to reduce electricity demand, but as the carbon intensity of the grid declines (as a result of E.6) the GHG savings of reducing electricity consumption also declines. The policy does come at a significant cost to either the government or electricity users, if the program is implemented as an expansion of the Share the Pennies program.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
27,209	16,110	618,379	\$78,035,768	\$126

2. Data Sources:

- Information on Existing Memphis Low-Income Programs:
 - TVA. (2018). *TVA invests in Memphis home weatherization program*. Retrieved from <https://www.tva.gov/Newsroom/Press-Releases/TVA-Invests-in-Memphis-Home-Weatherization-Program>
 - City of Memphis. (2018). *Weatherization assistance program*. Retrieved from <http://www.memphis-wap.org/>

- Tennessee Housing Development Agency. (2018). *Investments and impacts 2017*. Retrieved from <https://s3.amazonaws.com/thda.org/Documents/Research-Planning/Impacts-Investments-2017.pdf>
- Shelby County Department of Housing. (2018). *Consolidated plan, program year 2018 action plan July 1, 2018 through June 30, 2019: For housing and community development*. Retrieved from <https://shelbycountytg.gov/DocumentCenter/View/32435/Shelby-County-PY18-Annual-Plan>
- Statistical Data on Low-Income Households and Energy Consumption: Statistical Atlas. (2018). *Household income in Memphis, Tennessee*. Retrieved from <https://statisticalatlas.com/place/Tennessee/Memphis/Household-Income>
- US Energy Information Administration. (2015). *Residential energy consumption survey (RECS)*. Retrieved from <https://www.eia.gov/consumption/residential/data/2015/#squarefootage>
- United States Census Bureau. (2018). *QuickFacts Shelby County Tennessee*. Retrieved from <https://www.census.gov/quickfacts/shelbycountytennessee>
- Energy Price Forecast: US Energy Information Administration. (2018). *Annual energy outlook 2018, Reference Case, Table 8 and Table 13*. Retrieved from <https://www.eia.gov/outlooks/archive/aeo18/>

3. Quantification Methods:

GHG Reduction Potential

This analysis begins by establishing a baseline of low-income households enrolled in efficiency and weatherization programs. These include:

- MLGW's Share the Pennies program
- The Weatherization Assistance Program (federal program administered

locally by the City of Memphis Division of Housing and Community Development)

- The Tennessee Housing Development Agency Weatherization Assistance Program in Shelby County
- The Shelby County Department of Housing Rehabilitation Program

There are other low-income assistance programs for home renovations and efficiency improvements in place in Memphis, but these are believed to be the largest and most widely used programs. These programs are estimated to serve 433 households per year. Therefore, the goal is to increase this number to 2,163 households in ten years and stay steady at that level through the end of the policy period.

Low-income residential energy consumption is assumed to be a combination of electricity consumption and natural gas combustion. Based on information from the US EIA Residential Energy Consumption Survey 2015, as well as statistical information, we estimate that low-income households (defined as household income under 40k/year for this analysis), account for 51% of the Shelby County households, but only 42% of residential energy consumption. This share of residential energy consumption was then applied to total residential natural gas and electricity consumption to estimate energy consumption per low-income household.

The 30% reduction in energy consumption (which is the goal of the policy) was then applied to the low-income per household energy consumption, split between electricity and natural gas consumption. This reduction in energy consumption is where the GHG savings and cost savings of this policy come from.

Cost Evaluation

Energy cost savings are estimated by multiplying the electricity and natural gas saved by a forecast of energy prices from the Annual Energy Outlook reference case. The costs of this policy come from increasing the assistance to low-income households. The average cost from the Tennessee Housing Development Agency Weatherization Assistance Program and the Home Weatherization program was \$6,844 and this was used to estimate per household costs.

This analysis assumes that benefits from weatherization and efficiency improvements will last 10 years. Some improvements (such as efficient windows or insulation) last longer than ten years, while for other investments (like efficient appliances) savings will either decline with time or end in a 10-year period. The 10-year assumption is meant to serve as an average.

4. Key Assumptions

This analysis assumes that this low-income assistance program can achieve reductions without overlap with E.5. This analysis has overlap with E.6 (grid decarbonization) and as a result the GHG savings are reduced for this option to account for the electricity emissions factor being less carbon intensive. If this option were put into place without E6 also being implemented, then the GHG savings achieved would be significantly greater in the later years.

PRIORITY ACTION E.3 ENERGY OUTREACH AND EDUCATION PROGRAMS

Estimated Net GHG Reductions and Net Costs or Savings

Outreach and education are supporting activities without differentiated GHG reductions impacts from other priority actions in energy sector. It is likely that emissions reductions and costs of this policy overlap with E.1 Green Building, E.2 Low-Income Housing Energy-Efficiency, and E.5 Subsidies and Financing for Retrofitting.

PRIORITY ACTION E.4. LED STREETLIGHT RETROFIT

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

The proposed conversion of high-pressure (HPS) streetlights and leased outdoor lighting (LOLs) to LED has the effect of reducing energy consumption. If implemented, this action can reduce GHG emissions by about 11 thousand tons by 2035. GHG savings of this policy are significantly reduced due to overlap with E.6 (grid decarbonization). This policy serves to reduce electricity demand, but as the carbon intensity of the grid declines (as a result of E.6) the GHG savings of reducing electricity consumption also declines. Investments are needed to initially replace the HPS bulbs with LED bulbs, but over the long term, LED bulbs have much longer lifespans, require less maintenance, use less energy, and provide brighter lighting.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO _{2,e}	tCO _{2,e}	tCO _{2,e}	2018 Dollars	\$/tCO _{2,e}
10,822	0	191,984	-\$2,614,337	-\$14

2. Data Sources

- The MLGW Annual Report provided data on the kWh consumption of existing HPS streetlights and LOLs in the City of Memphis and Shelby County. MLGW. (2017). *MLGW Hands on Memphis: 2017 Annual Report*. Retrieved from <http://www.mlgw.com/images/content/files/pdf/MLGWAnnualReport2017-web.pdf>
- MLGW Facts and Figures was used to determine the number of streetlights and LOLs that currently exist in the City of Memphis and Shelby County. MLGW. (2017). *Facts & figures for year ending December 31, 2016*. Retrieved from <http://www.mlgw.com/images/content/files/pdf/Facts%20%26%20Figures%202017.pdf>
- Silsby, Shane L. (2013). *HPS to LED conversion: A city of Phoenix experience*. Retrieved from https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/silsby_msslc-phoenix2013.pdf. This report on Phoenix, Arizona's experience converting its HPS streetlights to LED was used to determine kWh conversions between HPS and LED bulbs and to estimate the costs of replacing HPS streetlights.

3. Quantification Method

GHG Reduction Potential

In the business-as-usual scenario, the total electricity consumption of streetlights and LOLs in the City of Memphis and Shelby County is 164 million kWh annually. About 46% of the electricity consumption is attributable to streetlights and 54% is attributable to LOLs, as LOLs are larger and require more electricity (on average).

This action is designed to retrofit 100% of HPS streetlights and LOLs in the City of Memphis and Shelby County with LED bulbs by 2030, starting in year 2025. In order to analyze the GHG emissions reduction potential of retrofitting existing lights with LED, the quantification assessed the change in kWh usage through 2050 as streetlights and LOLs were replaced between 2025 and 2030. Using an HPS to LED conversion analysis that was completed in Phoenix, Arizona, the longer lifespan of LEDs and lower energy usage were accounted for.

Cost Evaluation

The major costs of this policy are the costs of buying new LED fixtures and installing these fixtures. There is also an associated maintenance cost, but since LEDs have a longer lifespan they have a lower maintenance cost than their HPS counterparts.

The major cost savings of this policy are the energy savings associated with more efficient LED bulbs and the avoided cost of maintenance. This analysis found that there is a cost savings of \$13 associated with every ton of CO₂ equivalent abated under this policy.

4. Key Assumptions

This analysis assumes that all lighting in the business-as-usual scenario is high pressure sodium luminaries and that these lights will be replaced 1:1 with LED bulbs. Additionally, it assumes the average HPS bulb in Memphis is equivalent to the average HPS bulb in the Phoenix analysis and LOLs are approximately equivalent to standard streetlights in energy consumption and retrofitting requirements. In the absence of a streetlight inventory, the analysis calculated a system average HPS rating of 250 watts to be replaced for a 139 watts LED equivalent.

This analysis has overlap with E.6 (grid decarbonization) and as a result the GHG savings are reduced for this option to account for the electricity emissions factor being less carbon intensive. If this option were put into place without E.6 also being implemented, then the GHG savings achieved would be significantly greater in the later years.

PRIORITY ACTION E.5 FINANCING OPTIONS FOR RESIDENTIAL ENERGY EFFICIENCY RETROFITS

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

The proposed subsidy/financing for this action has the effect of increasing the number of homeowners that are purchasing ENERGY STAR rated HVAC systems and appliances instead of standard appliances/equipment. GHG savings of this policy are significantly reduced due to overlap with Action E.6. This policy serves to reduce electricity demand, but as the carbon intensity of the grid declines (as a result of E.6) the GHG savings of reducing electricity consumption also declines. Investments are needed to pay for the subsidy program, but the cost savings associated with the energy savings generated from residences using more energy efficient HVAC systems and appliances offset the capital needed to fund subsidies.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/CO ₂ e
33,925	0	892,189	-\$245,336,527	-\$275

2. Data Sources:

- Residential Energy End Uses in the East South Central Region: US Energy Information Administration. (2015). Residential energy consumption survey (RECS). Retrieved from <https://www.eia.gov/consumption/residential/data/2015/>
- Relative energy savings for ENERGY STAR appliances: Energy Star. (2018). Retrieved from <https://www.energystar.gov/>
- Baltimore Gas and Electric (BGE) Rebate Amounts: Baltimore Gas and Electric has a comprehensive appliance rebate program in place. Due to Baltimore's status as a Sister City, their rebate amounts were used to approximate how much a rebate program would cost. Baltimore Gas and Electric. (2018). Appliance rebates. Retrieved from <https://bgesmartenergy.com/residential/appliance-rebates>
- Consumer Reports Appliance Lifespans: Consumer Reports data was used to approximate the lifespan of the appliances included in the analysis. This was accomplished through taking the life expectancy for each appliance and averaging them. Consumer Reports. (2009). *By the numbers: How long will your appliances last? It depends.* Retrieved from <https://www.consumerreports.org/cro/news/2009/03/by-the-numbers-how-long-will-your-appliances-last-it-depends/index.htm>

3. Quantification Methods

GHG Reduction Potential

In the business-as-usual scenario, the total residential electricity consumption of the greater Memphis area is approximately 5.3 million kWh annually. Based on the 2016 Shelby County Inventory and Forecast, about 23% of this consumption is attributable to space heating, 20% is attributable to water heating, 19% is attributable to air conditioning, 6% is attributable to refrigerators, and 5% is attributable to clothes dryers. While other appliances account for the remaining residential electricity consumption figure, these

five categories accounted for the largest portions of energy consumption.

This action is designed to increase the number of homes using energy efficient HVAC equipment and appliances by 15% from the BAU scenario by 2025 using a subsidy program to incentivize homeowners. It is possible that the program could also target the oldest equipment through a buy back, as the incentives would be similar. Residential users replace equipment and appliances over time as they wear out, and therefore the comparison for this analysis is between a new standard efficiency appliance/unit and a new Energy Star high efficiency unit. For this analysis, the ENERGY STAR program was used to define “energy efficient HVAC equipment and appliances” since it is the most widely used energy efficiency rating program in the United States. The energy savings for these systems and appliances were taken from ENERGY STAR assessments of average energy savings as compared to standard appliances/equipment and the subsidies were approximated using the rebate amounts that Baltimore Gas and Energy offers their customers. The amount of residential energy consumption that each of the appliances (refrigerators, heaters, HVAC units, water heaters, and clothes dryers) accounts for was taken from the Energy Information Administration's 2015 Residential Energy Consumption Survey data, showing the major end uses of residential energy consumption by region.

The GHG reduction potential was calculated by approximating residential electricity consumption in the BAU scenario through 2050 and comparing it to residential electricity consumption if 15% of homeowners in the City of Memphis and Shelby County bought energy efficient HVAC equipment and appliances because of a county or city run rebate program or a utility rebate program.

This analysis has overlap with E.6 Grid Decarbonization and as a result the GHG saving are reduced for this option to account for the electricity

emissions factor being less carbon intensive. If this option were put into place without Action E.6 also being implemented, then GHG savings achieved would be somewhat greater (approximately 20% greater for most years).

Cost Evaluation

The major costs of this policy are the costs of providing homeowners with subsidies and/or rebates. The cost data for potential subsidy amounts comes from Baltimore Gas and Energy’s rebate program. The major benefits of this policy are the residential energy savings associated with more energy-efficient appliances/equipment. By multiplying energy savings by the average cost of electricity per kWh, the analysis can arrive at the monetary energy savings associated with this policy. The analysis suggests that the cost effectiveness of this program is a cost savings of \$275 for every ton of CO₂ equivalent abated, due to the energy savings attributable to ENERGY STAR appliances/equipment.

4. Key Assumptions

Subsidies can spur residential customers to purchase energy-efficient appliances/equipment at a rate of 5% above the business as usual (BAU) scenario. By purchasing ENERGY STAR appliances/equipment, customers can achieve a reduction of between 15% (refrigerators) and 35% (HVAC and heat pumps) in electricity consumption.

Utility rebates set to the same amount as those in Baltimore, Maryland can spur residential customers to purchase energy efficient appliances/equipment at a rate of 10% above the business-as-usual (BAU) scenario and maintain a level of 10% through 2050.

This analysis has overlap with E.6 (grid decarbonization) and as a result

the GHG savings are reduced for this option to account for the electricity emissions factor being less carbon intensive. If this option were put into place without E.6 also being implemented, then the GHG savings achieved would be significantly greater in the later years.

PRIORITY ACTION E.6 DECARBONIZE THE ELECTRIC GRID

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

This policy looks at the impact of purchasing green (carbon-free) electricity through a procurement order for Renewable Energy Certificates (RECs.) This would increase the percentage of carbon-free electricity in Shelby County to 80% by 2035, and 100% by 2050.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
2,205,241	4,811,919	75,992,009	\$370,389,930	\$5

2. Data Sources:

- The Shelby County Inventory and Forecast developed for this project was used to get the necessary electricity emissions factors over time.
- The additional costs of purchasing voluntary RECs: O’Shaughnessy, E., Heeter, J., & Sauer, J. (2018). *Status and trends in the US voluntary green power market: 2017 Data*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-72204. Retrieved from <https://www.nrel.gov/docs/fy19osti/72204.pdf>.
- Blau, M. (October 21, 2016). First new US nuclear reactor in 20 years goes live. Retrieved from <https://www.cnn.com/2016/10/20/us/tennessee->

nuclear-power-plant/index.html.

3. **Quantification Methods:**

GHG Reduction Potential

This analysis estimates the impact of purchasing additional renewable energy certificates (REC) to increase Shelby County's non-carbon mix up to 80% by 2035, and up to 100% by 2050. TVA has a goal of 56% non-carbon electricity by 2020, and this analysis is built on top of that, increasing that percentage to 80% between 2021 and 2035. The GHG impacts are estimated based on the difference in emissions from electricity in all sectors (residential, commercial and industrial) for the 2020-2050 period.

Cost Evaluation

The cost evaluation for this action assumes that the City/County would pursue more economical TVA/MLGW options for large-scale needs such as Southeastern RECs or Renewable Investment Agreements (RIA), or buy RECs from outside sources, based on whether the City/County has preferences on the geographic location of the renewable generation.

The average cost of RECs varies widely, from \$0.70 for short-term RECs sourced outside the region to \$1.50 for short-term wind RECs through Southeastern RECs and up to \$5.00 for long-term Renewable Investment Agreement RECs from new utility-scale solar projects that would be built locally/regionally. This cost evaluation assumes that the City/County would at first pursue the short-term outside RECs and Southeastern RECs while moving to Renewable Investment Agreements for utility-scale renewable generation built in the region. Estimations based on available data indicate the additional cost per household to implement this action could range from less than \$1 to \$10 or more annually.

Given that this evaluation is based on the assumption that TVA will continue to supply electricity to Memphis/Shelby County, the results of MLGW's in-progress power supply study/integrated resource plan could alter the path forward - and potential cost - for increasing clean, renewable energy in the Memphis/Shelby County electricity supply. This evaluation may need to be revisited depending on the results and recommendations of this study.

4. **Key Assumptions**

The TWG group was supportive of decarbonization through a combination of increased renewable energy and increased nuclear power. However, the goal of increasing the percentage of carbon-free electricity in Memphis by 2035 is too soon to have a nuclear plant come online. For example, 13 companies sought permits from the Nuclear Regulatory Commission to build nuclear plants in the late 2000s, and none of those plants are currently online. The fastest example available of a new plant coming online is the Alvin W. Vogtle Electric Generating Plant in East Georgia, which began the permitting process in 2006, and where the first unit is expected to go online in 2021. The TVA Watts Bar Nuclear Plant in Southeast Tennessee was able to go online more quickly (nine years) because some elements of siting and construction were partially completed in the 1980s (Blau, 2016 - see reference above). It is unlikely such a quick turnaround could be achieved on a new plant by 2035.

This policy is looking at the GHG impacts of purchasing additional carbon free electricity through a procurement order. This is assumed to be sold through a green power purchasing program.

This policy is in addition to TVA's 2020 policy goal of 56% carbon free electricity by 2020. Thus the policy is implemented beginning in 2021.

It is possible that this program could be implemented solely for municipal electricity purchases. This would reduce both the costs and the GHG impacts of the policy, but would allow the city of Memphis and Shelby County to show leadership in decarbonization.

PRIORITY ACTION E.7 EXPAND THE URBAN TREE CANOPY

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

This analysis looks at the GHG savings from expanding urban forestry in Shelby County. The GHG savings from Urban Forestry come from two sources: carbon sequestration in trees and reduced electricity consumption due to the temperature impacts of trees reducing the urban heat island effect. GHG savings of this policy are significantly reduced due to overlap with E.6. This policy serves to reduce electricity demand, but as the carbon intensity of the grid declines (as a result of E.6) the GHG savings of reducing electricity consumption also declines.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
135,781	246,759	4,174,555	\$35,127,597	\$8

2. Data Sources

- Percentage of Memphis with urban tree cover: The University of Memphis, Wolf River Conservancy. (2014). *Memphis regional urban tree canopy assessment*. Retrieved from https://issuu.com/univofmemphis/docs/1314-eng-627_cpjis_tree_canopy_repo
- The percentage of urban tree cover in Tennessee Cities as well as the

carbon sequestration, air quality and GHG benefits of urban forestry in TN: Nowak, D. and Greenfield, E. (2018). US urban forest statistics, values and projections. *Journal of Forestry*, 116(2): 164-177. <https://doi.org/10.1093/jofore/fvx004>

- Average number of trees and cost per managed urban forestry acre. McPherson, G., Simpson, J.R., Peper, P.J., Maco, S.E., & Xiao, Q. (2005). Municipal forest benefits and costs in five US cities. *Journal of Forestry*, 103(8): 411-416. Retrieved from https://www.fs.fed.us/psw/publications/mcpherson/psw_2005_mcpherson003.pdf

3. Quantification Method

GHG Reduction Potential

This analysis looks at the impact of doubling the amount of tree cover and forested acres in Shelby County. Based on information from the Memphis Regional Urban Tree Canopy Assessment, approximately 36.8% of Shelby County land area is at least partly or fully covered in trees (74,212 acres). This analysis increases that figure to 60% by 2050. The carbon sequestration and electricity savings in the BAU and policy scenarios were estimated by scaling down the TN total statewide impacts according to the share of TN's total urban forestry acreage that exists in Shelby County (11%).

Cost Evaluation

The costs of this program are based on the costs of additional planning, pruning, disposal, infrastructure, and inspection costs of expanded urban forestry. This policy also has significant cost savings from reduced electricity costs. This policy also estimates cost savings of the air quality benefits of urban forestry, primarily in the form of reduced PM emissions which reduce health costs and hospitalizations. These costs savings come from the estimated

benefits seen in five US cities, scaled to the size of the program in Shelby County.

4. Key Assumptions

This analysis assumes that energy savings from reduced heating and cooling will come as electricity savings. Some of these savings may be in stationary combustion, but it is likely to be relatively small and there would be GHG savings either way.

Trees take years or decades to grow before providing significant shading and cooling benefits. It is possible that the GHG emissions savings in the first few years are overestimating the impact of recently planted trees.

PRIORITY ACTION E.8 ALIGN CLIMATE MITIGATION AND ADAPTATION

Estimated Net GHG Reductions and Net Costs or Savings

This option does not have quantifiable GHG reductions associated with it.

APPENDIX 3: TRANSPORTATION SECTOR PRIORITY ACTION IMPACT ANALYSIS

COST ANALYSIS APPROACH – ALL PRIORITY ACTIONS

In general, when developing the costs of these actions, differences between the BAU baseline and the selected Action were identified and costed where possible, as either an additional costs or cost savings. For reductions in VMT, the costs associated with the fuel saved is accounted for. Similarly, when VMT increases, the associated increase in fuel costs is estimated. When new vehicles are added or replace other vehicles, these vehicle costs are assessed, as in T.5. In cases where city or county agencies are expected to be responsible for the implementation of an action (as in T.1 and T.3), the funding streams estimated to be needed are identified. Action T.4 identifies a cost to employers and T.5 identifies and estimates EV infrastructure costs, which, based on the T.5 policy, would be expected to be paid primarily by developers, but would also likely include some government and private sector investment.

PRIORITY ACTION T.1. LAND USE PATTERNS THAT SUPPORT ACTIVE TRANSPORTATION AND TRANSIT

Estimated Net GHG Reductions and Net Costs or Savings

It is expected that the measures included in this action would further support actions T.1, T.3, T.4, and T.5 and that the benefits of these measures would overlap with the benefits estimated under those actions. Therefore, a separate quantification of the GHG reductions and costs was not undertaken for these measures. However, the implementation of these measures should assist in achieving the goals of the other actions. In particular, changes in density and zoning practices have the potential to significantly reduce GHG emissions in the long term if undertaken in a judicious manner.

PRIORITY ACTION T.2. COMPLETE STREETS THAT PRIORITIZE WALKING, BICYCLING AND TRANSIT

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results:

The proposed Complete Streets program should lead to a reduction of personal vehicle trips, replacing them with pedestrian and bike trips. This in turn leads to reduced GHG emissions from the combustion of gasoline and diesel fuel. It is estimated that this action can reduce GHG emissions in 2035 by 102 thousand metric tons, increasing to a reduction of over 256 thousand metric tons by 2050. Capital infrastructure investments and operational maintenance will be needed to generate these reductions. Based on the assumptions of this analysis, it is estimated that these reductions could occur at a cost of \$12 per metric ton CO₂e reduced over the 2016 to 2050 time period.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
102,273	256,490	3,566,189	\$42,947,890	\$12

2. Data Sources:

- Average vehicle trip length and average commute trip length: US Department of Transportation, Federal Highway Administration. (2017). 2017 National Household Travel Survey, 2017 Survey Data [Data file]. Retrieved from <https://nhts.ornl.gov/downloads>
- Percentage of trips by mileage: US Department of Transportation, Federal Highway Administration. (2017). National Household Travel Survey, Popular Vehicle Trips Statistics, Number of Vehicle Trips by Trip

Distance. Retrieved from <https://nhts.ornl.gov/vehicle-trips>.

- Estimate of the cost of pedestrian road and sidewalk improvements: City of Memphis. (2015). *Memphis pedestrian and school safety action plan*. Retrieved from https://bikepedmemphis.files.wordpress.com/2015/06/mpss_action_plan_final_optimized.pdf.
- Estimate of the cost of bikeway and pedestrian infrastructure improvements: Oyler, Nicholas (Bikeway and Pedestrian Program Manager, City of Memphis). Email communication to Vivian Ekstrom, Memphis-Shelby County Office of Sustainability, December 6, 2018.
- Average cost per gallon of gasoline: US Energy Information Administration (2018). Monthly Energy Review, Table 9.4 Retail Motor Gasoline and On-Highway Diesel Fuel Prices. Retrieved from https://www.eia.gov/totalenergy/data/monthly/pdf/sec9_6.pdf.

3. Quantification Methods:

GHG Reduction Potential

GHG emissions reductions accrue from a reduction in passenger vehicle mileage. The baseline used for estimating the potential reduction was the total passenger vehicle miles traveled (VMT) from the Shelby County GHG Inventory and Forecast. Total passenger VMT was converted to an estimated number of passenger vehicle trips per day based on an average passenger trip length for the Memphis area of 7.85 miles. For this action, the number of trips were assumed to be reduced by 10% by 2030, starting in 2020, and increasing linearly to 40% by 2050. In calculating the VMT of these trips, 3 miles was assumed as the average trip length for the trips from 1 to 5 miles, comprising 55% of vehicle trips, and 0.5 miles for the trips under 1 mile, comprising 21% of vehicle trips. Thus, the average mileage per trip reduced was assumed to be 2.3 miles. The resulting VMT reduction was multiplied by the passenger vehicle GHG emission factor, as calculated in the Shelby County GHG Inventory and Forecast.

Cost Evaluation

The costs assessed for this measure included a vehicle fuel savings cost component and a cost representing improvements to the bike and pedestrian infrastructure. An average fuel cost of \$2.07 per gallon was used in the analysis, representing the average cost per gallon of conventional gasoline in 2016. This value was multiplied by the mileage reduced to estimate the fuel cost savings. The increased infrastructure costs were estimated at \$19 million per year for sidewalks and \$3 million per year for bike infrastructure. Note that these infrastructure items do not currently have a budget in the City of Memphis, so a dedicated funding source would need to be developed.

4. Key Assumptions

This analysis assumes that the necessary infrastructure funding streams could be identified and included in the Memphis budget.

PRIORITY ACTION T.3 ENHANCE PUBLIC TRANSIT

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

The potential reductions and costs of Enhancing Public Transit were analyzed. This action should lead to a reduction of personal vehicle trips, replacing them with bus trips. Because buses (excluding the electric buses) produce more GHGs per mile than passenger cars, a sufficient number of passenger vehicle trips must be eliminated to compensate for the increased bus GHG emission rate. The phasing in of electric buses helps in lowering the overall GHG emission rate per bus mile traveled. It is estimated that this action can reduce GHG emissions in 2035 by 7.6 thousand metric tons, increasing to a reduction of nearly 20 thousand metric tons by 2050. A \$30 million annual

funding stream is assumed to be needed to accomplish these reductions, leading to a cost effectiveness over the 2016-2050 period of \$1,533 per metric ton CO₂e removed. The table below summarizes these reductions and costs.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
7,636	19,847	283,589	\$434,262,717	\$1,531

2. Data Sources

- MATA bus revenue miles, passenger miles, unlinked trips, and bus revenue hours of service: Federal Transit Administration. (2016). *Memphis area transit authority 2016 annual agency profile*. National Transit Database. Retrieved from https://www.transit.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2016/40003.pdf
- Data for estimating average vehicle occupancy in Memphis: Memphis Metropolitan Planning Organization. *2040 regional transportation plan; Appendix B: Memphis MPO model update—model estimation and validation report*. Retrieved from <http://www.memphismpo.org/plans/livability-2040-rtp>.
- Average cost per gallon of gasoline and diesel: US Energy Information Administration (2018). *Monthly Energy Review, Table 9.4 Retail Motor Gasoline and On-Highway Diesel Fuel Prices*. Retrieved from https://www.eia.gov/totalenergy/data/monthly/pdf/sec9_6.pdf
- Bus electricity consumption (used average operating efficiency (kWh/mile) of XR Series Catalyst Vehicle with Duopower Drivetrain): Proterra. (2019). *Catalyst vehicle range*, Retrieved from <https://www.proterra.com/performance/range/>

3. Quantification Methods

GHG Reduction Potential

GHG emission reductions accrue from converting passenger vehicle trips to bus trips. The 2016 baseline bus VMT was obtained from the National Transit Database (NTD) specific to MATA (i.e., annual MATA bus revenue miles). The bus VMT was assumed to grow at the level of bus VMT growth in the 2018 Shelby County Inventory and Forecast. The 2016 bus passenger miles was also obtained from the NTD for MATA. Bus and passenger vehicle emission rates from the Shelby County Inventory and Forecast were used to calculate bus and passenger vehicle GHG emissions. Transit Vision envisions an increase of 165,000 bus revenue hours through the implementation of this program.

It was assumed that bus VMT would increase by the same percentage as the increase in revenue hours, or 37%. The 3.0 Transit Vision assumes that the revised bus routes and schedules would be fully implemented by 2022. In this analysis, the increased bus service was assumed to start in 2020, with a 5% increase in bus VMT, with the full 37% VMT increase achieved by 2022 and thereafter. Additionally, 10 electric buses were assumed to be added to the vehicle fleet in 2020, replacing existing diesel buses. By 2050, the entire bus fleet was assumed to be electric, with the phase-in occurring linearly from 2020. The VMT that would be expected from these electric buses was assumed to replace an equivalent amount of VMT from diesel buses.

The increase in bus passenger miles was assumed to be double the percentage increase in bus revenue miles. This increase in bus passenger miles due to the implementation of 3.0 Transit Vision was then converted to a reduction in passenger vehicle VMT by dividing the increase in bus passenger miles by an estimate of the average vehicle occupancy for Shelby County of 1.79 persons

per vehicle.

The GHG emissions savings from this scenario included the GHG emission reductions achieved by the reduced passenger vehicle VMT, added to the GHG emissions from the increased bus VMT. The portion of the bus VMT provided by electric buses was calculated by multiplying that portion of the VMT by the associated electricity GHG emissions needed to charge the electric buses (Proterra). The GHG emissions associated with the electric buses reflect the decarbonization of electricity as analyzed under Action E.6.

Cost Evaluation

The costs included in this analysis are the fuel savings from the reduction in passenger VMT and the cost of the 3.0 Transit Vision program. An average gasoline cost of \$2.07 per gallon was used in the analysis for passenger vehicles and \$2.30 per gallon for diesel for the buses, representing the average cost per gallon of conventional gasoline and diesel in 2016, respectively (EIA). This value was multiplied by the mileage reduced to estimate the fuel cost savings for personal vehicles. The fuel cost for buses was calculated as the total cost of bus diesel fuel and electricity minus the diesel fuel cost for the BAU scenario. This program was expected to require a \$30 million per year funding stream to accomplish the objectives of this program. It was assumed that the capital cost of acquiring the electric buses would also be included as part of that funding stream.

4. Key Assumptions

The increase in bus VMT and bus ridership was based on the expected increase in bus revenue hours. Actual changes in ridership could vary significantly.

PRIORITY ACTION T.4 REDUCE COMMUTE TRIPS THROUGH TRANSPORTATION DEMAND MANAGEMENT

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

This proposed action considers ways to reduce vehicle miles traveled from programs aimed at reducing the number of single occupant vehicle trips to work. It requires incentives to change worker's travel behavior. With stronger incentives, additional GHG benefits could be achieved. This analysis starts at a level of 10% of drive-alone work trips eliminated in 2022, increasing to 40% by 2050. The action is expected to reduce GHG emissions by 307 thousand metric tons in 2035, increasing to a reduction of 564 thousand metric tons in 2050. This measure is very cost effective, with an estimated cost effectiveness savings of \$9/metric ton CO₂e removed, indicating that the fuel savings costs from trips avoided more than makes up for the cost of incentives. The table below summarizes the benefits and costs of this measure.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
307,635	564,246	9,756,323	-\$83,836,344	-\$9

2. Data Sources

- Average vehicle trip length and average commute trip length: US Department of Transportation, Federal Highway Administration. (2017). 2017 National Household Travel Survey, 2017 Survey Data [Data file]. Retrieved from <https://nhts.ornl.gov/downloads>
- Average cost per gallon of gasoline: US Energy Information Administration (2018). Monthly Energy Review, Table 9.4 Retail Motor

Gasoline and On-Highway Diesel Fuel Prices. Retrieved from https://www.eia.gov/totalenergy/data/monthly/pdf/sec9_6.pdf

- Employer subsidy to employees to reduce single occupancy vehicle commuting VMT: National Center for Transit Research. (2017). Best workplaces for commuters, summary of requirements. Retrieved from <https://www.bestworkplaces.org/join/standard-of-excellence/>

3. Quantification Methods

GHG Reduction Potential

Emissions reductions accrue from a reduction to passenger vehicle mileage. The baseline used for estimating the potential reduction was the total passenger VMT from the Shelby County 2016 GHG Inventory and Forecast. Total passenger VMT was converted to an estimated number of passenger vehicle trips per day based on an average passenger trip length for the Memphis area of 7.85 miles (NHTS). From that baseline, the number of work commute trips per day was estimated, assuming 80% of weekday trips are work commute trips. The number of work trips per day was reduced by 10% starting in 2022, with the percentage increasing linearly to 40% in 2050. This number of work trips per day was multiplied by the average 1-way commute trip distance of 12.4 miles (NHTS). The VMT reduction was multiplied by the passenger vehicle GHG emission factor, as calculated in the Shelby County 2016 GHG Inventory and Forecast.

Cost Evaluation

The costs assessed for this measure included a vehicle fuel savings cost component and a cost to employers to incentivize employees to change behavior. An average fuel cost of \$2.07 per gallon was used in the analysis, representing the average cost per gallon of conventional gasoline in 2016 (EIA). This value was multiplied by the mileage reduced to estimate the

fuel cost savings. The costs to employers for reimbursing or incentivizing employees for ride sharing, flex work schedules, telecommuting, cashing out of parking, and other potential programs was estimated at \$30 per affected employee per month, based on Best Workplaces for Commuters.

4. Key Assumptions

This policy assumes that a percentage of work commute trips can be eliminated. For many types of jobs, teleworking or flexible scheduling will not work. Also, in order for ride sharing, vanpooling, or carpooling to work, employees need to be living and working in locations that are amenable to such matching.

This evaluation focuses on workplace trip reductions. VMT from work commuting was calculated based on an assumed percentage of daily trips that are work commute trips. Better, more specific data for the Memphis area is desirable to estimate either VMT or trips per day from commuting. Additionally, employers may need incentives to provide benefits to workers who are reducing single occupant vehicle travel to and from work. Some single-occupancy trips reduced would be converted to transit trips. This is accounted for separately under action T.3, but there would be some overlap between these actions.

PRIORITY ACTION T.5 ELECTRIC VEHICLE ADOPTION AND CHARGING INFRASTRUCTURE

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

The potential reductions and costs of EVs and EV infrastructure were analyzed. This action leads to reductions in GHG emissions by replacing gasoline and diesel passenger and freight vehicles with electric vehicles. While plug-in electric vehicles have no tailpipe emissions, there are GHG emissions associated with the process of generating the electricity needed to power these vehicles. However, electric vehicles are more efficient than conventional vehicles, leading to lower levels of GHG emissions even after the increase in emissions from the generation of additional electricity is accounted for. These emissions from electricity generation are assumed to be minimized by the implementation of Action E.6 which involves the decarbonization of the electricity supply. It is estimated that this action can reduce GHG emissions in 2035 by 913 thousand metric tons, increasing to a reduction of 3 million metric tons by 2050. Costs associated with EV infrastructure and the increased costs of electric vehicles over conventional vehicles are mitigated to some extent by fuel savings and lower maintenance costs of electric vehicles leading to a cost effectiveness over the 2016-2050 period of \$46 per metric ton CO₂e removed. The table below summarizes these reductions and costs.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
921,048	3,027,741	34,857,980	\$1,608,706,106	\$46

2. Data Sources

- Average cost per gallon of gasoline and diesel: US Energy Information Administration (2018). Monthly Energy Review, Table 9.4 Retail Motor Gasoline and On-Highway Diesel Fuel Prices. Retrieved from https://www.eia.gov/totalenergy/data/monthly/pdf/sec9_6.pdf
- EV truck cost, electricity consumption rate, and maintenance cost:
 - Tesla (2019). Tesla semi. Retrieved from <https://www.tesla.com/semi>
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- EV infrastructure needs and costs and passenger EV maintenance costs: US Department of Energy. (2019). Electric vehicle infrastructure projection tool (EVI-Pro) lite. Alternative Fuels Data Center. Retrieved from <https://afdc.energy.gov/evi-pro-lite>
- Average vehicle annual mileage accumulation: US Department of Transportation, Federal Highway Administration. (2017). Highway statistics 2017, table VM-1, data for 2016. Retrieved from <https://www.fhwa.dot.gov/policyinformation/statistics/2017/>
- Base electricity cost, electric amount (1000\$) divided by electric kWh (1000) from page H-1: MLGW. (2017). *MLGW Hands on Memphis: 2017 Annual Report*. Retrieved from <http://www.mlgw.com/images/content/files/pdf/MLGWAnnualReport2017-web.pdf>

3. Quantification Methods

GHG Reduction Potential

GHG emission reductions accrue from converting travel in gasoline passenger vehicles and diesel freight trucks to electric vehicles and trucks. This action has a target of converting passenger vehicle VMT from conventional gasoline vehicles to electric vehicles by: 5% in 2025, increasing to 30% in 2035, and

to 50% by 2050. Similarly, the target for converting diesel freight truck VMT to electric freight vehicles is: 3% by 2025, 20% by 2035, and 50% by 2050. The VMT expected to be converted to electric vehicle or truck VMT was calculated for each year from 2020 to 2050.

Based on information from the US Department of Energy's Alternative Fuels Data Center, a current passenger EV could drive 100 miles while consuming 25 to 40 kWh. A conservative estimate of 40 kWh per 100 miles was used in this analysis. Electricity consumption from these electric vehicles was estimated by multiplying the electric vehicle VMT in a given year by the electricity consumption rate of 40kWh/100 miles. Based on data on new electric freight vehicles from Tesla, an electric semi truck would consume about 2 kWh of electricity per mile. This electricity consumption rate was multiplied by the expected VMT from electric freight trucks. The electricity consumed by these electric vehicles and trucks was multiplied by the GHG emission factor for electricity as estimated in Action E.6 to estimate the GHG emissions from the electricity needed to power these vehicles. The baseline GHG emissions that would have been emitted from gasoline vehicles or diesel trucks in each year were subtracted from the electricity GHG emissions in the same year to estimate the overall GHG emissions reduction from this action.

Cost Evaluation

Four cost components were included in the evaluation of this action: the change in fuel vs. electricity costs; the difference in the cost between a new conventional vehicle and a plug-in electric vehicle; the difference in annual maintenance costs between a conventional vehicle and an electric vehicle; and the cost of the public EV charging infrastructure.

For the baseline scenario, an average gasoline cost of \$2.07 per gallon was

used in the analysis for passenger vehicles and \$2.30 per gallon for diesel for the buses, representing the average cost per gallon of conventional gasoline and diesel in 2016, respectively (EIA). The cost of electricity included a base cost of \$0.09 per kWh based on data in MLGW's Annual Report plus an incremental cost of future decarbonization as calculated in Action E.6. Gallons of conventional fuel consumed in the base scenario were calculated based on the amount of VMT converted to electric vehicle VMT divided by average fuel consumption of passenger vehicles and freight vehicles based on data in the 2018 Annual Energy Outlook. The resulting gallons were multiplied by the gasoline or diesel cost per gallon to estimate the baseline fuel cost. The annual gasoline or diesel costs were subtracted from the corresponding costs of the electricity needed to power the electric vehicles to estimate the change in fuel costs.

The number of electric vehicles and trucks needed was estimated by dividing the annual electric vehicle VMT by the average vehicle annual mileage as obtained from the Federal Highway Administration's Highway Statistics 2017. The average annual mileage of a passenger vehicle was reported as 11,370, and the annual mileage accumulation for a freight truck was 25,037 miles per year. The per-vehicle cost differential between a midsize gasoline car and a midsize 200 mile range EV was obtained by year from the 2019 Annual Energy Outlook. The cost differential for freight trucks was estimated based on Tesla's base estimate of \$150,000 for an 80,000 gross vehicle weight electric semi truck and an estimate of a 2019 model year Freightliner semi-truck of \$128,000. These per vehicle cost differentials were multiplied by the number of electric vehicles or trucks estimated in each year to obtain an estimate of the difference in cost between a conventional and electric vehicle or truck.

Per-mile vehicle maintenance cost differentials were multiplied by the VMT associated with the electric vehicles and trucks. An electric passenger

vehicle is expected to save \$0.0128 per mile over a comparable gasoline vehicle, based on data from DOE's Alternative Fuel Data Center (AFDC) EV Infrastructure Projection Tool (EVI-Pro) Lite. Based on the Tesla data, the electric semi truck would save \$0.25 per mile over a comparable diesel semi truck. These per-mile maintenance savings were multiplied by the annual VMT from electric vehicles or trucks.

Finally, the cost of the public EV infrastructure needed to support these electric vehicles and trucks was estimated. The number and types of charging stations needed in each year to support the EV population were estimated using the AFDC EVI-Pro tool. Costs for the EV charging equipment and installation were also obtained from AFDC. The unit costs of these charging stations were multiplied by the number of additional charging stations projected to needed in each year to meet the EV charging demand.

4. Key Assumptions

The EV truck costs are very uncertain and based on a single data point. In reality, a range of truck sizes and applications would be needed, which could lead to significant differences in EV costs.

APPENDIX 4: WASTE SECTOR PRIORITY ACTION IMPACT ANALYSIS

COST ANALYSIS APPROACH – ALL PRIORITY ACTIONS

In general, when developing the costs of these actions, differences between the BAU baseline and the selected Action were identified and costed where possible, as either an additional costs or cost savings. The capital and operating and maintenance (O&M) costs of installing and maintaining technology for treating waste is included. Under W.2, savings are achieved from the sale of compost and the revenue collected from the tipping fee and are accounted for in this analysis. The cost of recycling is considered for Action E.3.

PRIMARY DATA SOURCES – ALL PRIORITY ACTIONS

The impacts assessment for the waste sector is primarily informed by the recent Shelby County solid waste needs assessment (Shelby 2018) and the 2008 waste characterization study for the State of Tennessee (TSU 2008). These data sources were combined to develop a Shelby County waste characterization that is consistent with the state-level waste characterization profile and the county’s reported tonnage of municipal solid waste that is landfilled, diverted, and recycled (see Table A.3).

Table A.3 Shelby County Waste Characterization Profile

	TN	Shelby County			
		Landfilled	Diverted	Recycled	Total
Municipal Solid Waste (MSW)					
Tonnage	No Data	1,736,210	237,329	151,330	2,124,868
Tonnage distribution	No Data	81.7%	11.2%	7.1%	100.0%
Waste Characterization					
Paper/Cardboard	32.1%	28.3%		3.81%	32.1%
Textiles	2.7%	2.7%			2.7%
Food Waste	15.3%	7.4%	7.9%		15.3%
Yard Waste	6.4%	3.1%	3.3%		6.4%
Wood	1.3%	1.3%			1.3%
Rubber and Leather	2.7%	2.7%			2.7%
Plastics	17.1%	15.1%		2.03%	17.1%
Metal	5.7%	5.0%		0.68%	5.7%
Glass	5.1%	4.5%		0.60%	5.1%
Other	11.7%	11.7%			11.7%

PRIORITY ACTION W.1 DIVERT ORGANIC WASTE FROM LANDFILLS

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

The proposed organic waste management action has the effect of diverting the amount of decomposable organic compounds (i.e., yard and wood waste) that yield biogas when landfilled. If implemented, this action could reduce GHG emissions in 2035 by 35 thousand metric tons annually and has the potential of strengthening a local or regional circular economy for yard trimmings, clippings and possibly agricultural waste (e.g., corn stover). Modest investments are needed to process the incremental volume of diverted materials. While some revenue will be generated from the sale of compost, this revenue stream is not projected to offset the capital, operation, and maintenance costs needed to support this action as designed without an additional funding or revenue mechanism.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
34,549	36,578	789,203	\$8,775,676	\$11

2. Data Sources

- Tonnage of MSW emplaced in landfills and MSW diversion for composting: Memphis Area Association of Governments. (2018). *Shelby County solid waste needs assessment*. Retrieved from http://maagov.org/wp-content/uploads/2019/03/Shelby_NA_1_18-Revised-3.7.19.pdf; (pp. 7, 9)
- MSW composition for the state of Tennessee: Tennessee State University

and Tennessee Department of Environment and Conservation. (2008). *2008 Tennessee waste characterization study*. Retrieved from https://www.epa.gov/sites/production/files/2015-09/documents/2008_tn_wste_charac_stdy.pdf

- Cost of composting expansion: District of Columbia Department of Public Works. (2017). *District of Columbia compost feasibility study*. Prepared by RRS. Retrieved from https://dpw.dc.gov/sites/default/files/dc/sites/dpw/page_content/attachments/DC%20Compost%20Feasibility%20Study_vf_0417.pdf

3. Quantification Methods

GHG Reduction Potential

The emission reduction potential was assessed as the difference in landfilling and composting emissions levels between the BAU and the policy implementation scenarios.

The emission reduction potential reflects the emission rate difference between two treatment technologies, namely landfilling and composting. The emission metric for landfilling is 1.1 tCO₂e per ton of MSW emplaced while the metric for composting is relatively lower on the order of 0.5 tCO₂e per ton of compostable material. In the policy scenario, increased diversion of yard and wood waste substantially reduces the amount of MSW landfilled and associated landfill gas emissions, while modestly increasing the amount of fugitive emissions from composting. The net effect is an overall reduction of GHG emissions in the Shelby County boundary.

Cost Evaluation

Yard trimmings and discarded wood are potential feedstock to the composting market. Processing an incremental volume of compost feedstock requires

capital investments and incurs operational and maintenance costs, while also generating revenue from compost sales and composting service fees. The cost drivers associated with the launch of a new composting operation (aerated static pile treatment) are summarized below. Cost information comes from a composting feasibility study commissioned by the District of Columbia's Department of Public Works.

- Capital cost incurred over 5 years, \$17,040,188
- Operation and maintenance cost, \$55/ton
- Compost revenue, \$16/ton
- Service fee revenue, \$49/ton

4. Key Assumptions

The policy scenario analysis assumes that there is no local capacity to process incremental yard and wood materials, paper/cardboard, or food waste. Should processing capacity be available, it could reduce the cost of the program.

It is unclear from the Shelby County Solid Waste Needs Assessment whether all the reported diverted MSW is comprised of wood and yard trimmings. Furthermore, the analysis is based on the MSW composition characterization assessed for the state of Tennessee as a whole. The commissioning of a county waste study is recommended to increase the confidence of the general findings from the current analysis.

PRIORITY ACTION W.2 REDUCE WASTE GENERATION

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

The proposed waste reduction program has the effect of significantly diverting the amount of decomposable organic compounds (i.e., paper, cardboard, food waste) that yield biogas when landfilled. If implemented, this action can reduce GHG emissions in 2035 by 45 thousand metric tons annually and has the potential for strengthening a local or regional circular economy for otherwise discarded paper, cardboard, and food. Significant investments are needed to process the incremental volume of diverted materials. While some revenue will be generated from the sale of recycled commodities, this revenue stream is not projected to offset the capital, operation, and maintenance costs required to support a waste reduction program without an additional funding mechanism.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
44,868	48,074	1,172,844	\$234,357,677	\$200

2. Data Sources

- Tonnage of MSW emplaced in landfills and distribution of MSW by generator (e.g., residential, non-residential): Memphis Area Association of Governments. (2018). *Shelby County solid waste needs assessment*. Retrieved from http://maagov.org/wp-content/uploads/2019/03/Shelby_NA_1_18-Revised-3.7.19.pdf; (pp. 7, 9)
- MSW composition for the state of Tennessee: Tennessee State University and Tennessee Department of Environment and Conservation. (2008).

2008 Tennessee waste characterization study. Retrieved from https://www.epa.gov/sites/production/files/2015-09/documents/2008_tn_wste_charac_stdy.pdf

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3. Quantification Methods

GHG Reduction Potential

Emission reductions are proportional to the mass of paper/cardboard and food waste diverted from landfills. The avoided emission rate for paper/cardboard and food waste were derived from the base year 2016 inventory with values of 0.385 and 0.101 tCO₂e/ton diverted respectively. Additionally, the emission reduction assessment was adjusted down to account for biological treatment emissions associated with food waste composting in the policy scenario.

Cost Evaluation

Paper and food diversion from commercial, institutional, and industrial generators increases the feedstock for a recycling and composting market. This incremental feedstock will incur additional costs (e.g., collection, processing, and transportation) and generate a revenue stream from the sale of recycled commodities. It is not projected that the program's revenue will offset incremental costs. Net costs, normalized by tonnage, come from a cost analysis study commissioned by the California Department of Resources Recycling and Recovery (see reference above).

- \$129.42/ton for paper recycling
- \$160.34/ton for cardboard recycling
- \$164.95/ton for food composting

4. Key Assumptions

This policy scenario analysis assumes that there is no local capacity to process incremental paper/cardboard or food waste. Should processing capacity be available, it could reduce the cost of the program.

The policy scenario analysis does not contemplate the effects of voluntary waste minimization efforts in the commercial, institutional, and industrial sectors.

The source information for Shelby County's waste composition does not differentiate between paper and cardboard. For that reason, the cost analysis uses the average cost of paper and cardboard applied to the mass of paper and cardboard diverted. Should the program focus on paper recycling, costs could decrease given the smaller cost per ton rate of paper recycling compared to cardboard recycling.

Furthermore, the analysis is based on the MSW composition characterization assessed for the state of Tennessee. The commissioning of a county-specific waste study is recommended to increase the confidence of the general findings of the current analysis.

PRIORITY ACTION W.3 DIVERT INORGANIC WASTE FROM LANDFILLS

Estimated Net GHG Reductions and Net Costs or Savings

The GHG reduction benefits of plastic and C&D waste diversion reside primarily in lowering the demand for virgin materials that require fossil fuel-based energy to produce and transport over long distances. While quantifiable, these GHG benefits are located outside of the planning boundary of Shelby county, and therefore, not assessed as part of the Memphis area CAP in accordance with the carbon accounting guidelines of the GPC Protocol.

PRIORITY ACTION W.4 IMPROVE TIRE MANAGEMENT AND COLLECTION

Estimated Net GHG Reductions and Net Costs or Savings

The GHG reduction benefits of waste tire management reside primarily in lowering the demand for virgin materials that require fossil fuel-based energy to produced and transport over long distances. While quantifiable, these GHG benefits are located outside of the planning boundary of Shelby County, and therefore, not assessed as part of the Memphis area CAP in accordance with the carbon accounting guideless of the GPC Protocol.

PRIORITY ACTION W.5 WASTE EDUCATION AND OUTREACH EFFORTS - BEHAVIOR CHANGE

Estimated Net GHG Reductions and Net Costs or Savings

Outreach and education are supporting activities without differentiated GHG reductions impacts from other priority actions in waste sector. The effects of outreach and education are likely reflected in W.2 Organic Waste

Management, W.3 Waste Reduction Program, and W.4 Inorganic Waste Diversion.

PRIORITY ACTION W.6 METHANE RECOVERY AND LANDFILL GAS DESTRUCTION

Estimated Net GHG Reductions and Net Costs or Savings

1. Impact Results

This action combines three strategies that reduce fugitive methane emissions from landfills and wastewater treatment plants. First, improving biogas capture rates at controlled Class I landfills. Second, evaluate feasibility and installing biogas controls at Class III and IV landfills if warranted. Third, installing methane recovery systems in all WWTPs within Shelby County. The combined emission reduction potential has the effect of reducing GHG emissions in 2035 by 1.4 million metric tons annually as shown on the summary table below.

GHG Reductions			Cost, NPV	Cost Effectiveness
2035	2050	Cumulative	Cumulative	
tCO ₂ e	tCO ₂ e	tCO ₂ e	2018 Dollars	\$/tCO ₂ e
1,450,009	1,552,167	33,620,942	\$9,966,242	\$0.30

By 2035, most reductions (92%) will result from installing biogas controls at Class III and Class IV landfills in the county. The reduction potential was assessed as the sum of fugitive emissions modeled in CIRIS for all uncontrolled landfills in the base year 2016 and adjusted for growth to reflect the emission level of 2035 (i.e., 88,620 tCO₂e), then multiplied by a control efficiency of 85%. The installation of biogas controls at smaller uncontrolled WWTPs in the county is projected to account for 5.5% of the action's reduction

potential. Enhanced capture rates at Class I landfills will yield greater volume of methane recovery and contribute to 3.0% of this action's reduction potential. Elements included in the cost analysis consist of the upfront capital and operation and maintenance costs of installing a biogas capture and flaring system at eligible Class III and Class IV landfills, as well as the installation of methane recovery systems in uncontrolled WWTPs.

2. Data Sources

- Tonnage of MSW emplaced in landfills by landfill category and site: Memphis Area Association of Governments. (2018). *Shelby County solid waste needs assessment*. Retrieved from http://maagov.org/wp-content/uploads/2019/03/Shelby_NA_1_18-Revised-3.7.19.pdf
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Division of Solid Waste Management). Email Communication to Vivian Ekstrom, Memphis-Shelby County Office of Sustainability, December 11, 2018.

3. Quantification Methods

GHG Reduction Potential

In the business-as-usual (BAU) scenario, Shelby County emplaces 1.7 million tons of municipal solid waste (MSW) in landfills annually. About half (48%) is emplaced in Class I landfills with biogas controls, where the current capture rate stands at 75%. Captured biogas is either recovered for biomethane or flared (45% and 55% respectively).

This action is designed to extend the use of controls to Class III and Class IV landfills located in the county. Additionally, the action seeks to improve the biogas capture rate from 75% to 85% and promote greater methane recovery over biogas flaring (i.e., 55% and 45% respectively).

As for wastewater management, this action is designed to extend biogas controls to uncontrolled WWTPs by 2030. The GHG reduction potential analysis accounts for the fact that as of 2016, 89% of wastewater is treated in plants with existing biogas controls (i.e., Maynard C. Stiles plant and T.E. Maxson plant). Note that this action does not seek to control emissions from septic systems which treat less than 0.5% of the county's wastewater. The share of wastewater treated by each WWTP in the county is summarized in the table below based on permitted treatment volume reported to the TN Department of Environment and Conservation.

Table A.4 Shelby County Wastewater Treatment Plants Share of Wastewater Treated

Plant	City	Treatment Volume	Controls (year installed)
Bartlett Lagoon	Bartlett	1.03%	NA
Bartlett WWTP #2	Bartlett	0.24%	NA
Collierville Northwest STP	Collierville	4.47%	NA
Collierville STP	Collierville	1.65%	NA
E.E. Jeter School	Millington	<0.01%	NA
Meeman Shelby State Park	Millington	0.02%	NA
Maynard C. Stiles	Memphis	47.04%	2016
T.E. Maxson	Memphis	42.33%	Flaring 1995 Recovery 2018
Millington STP #2	Millington	2.73%	NA
Septic System	Bartlett	0.38%	NA
Septic System	Collierville	0.10%	NA

Cost Evaluation

Costs associated with biogas capture and flaring at Class III and IV landfills reflect the capital cost of drilling and installing a pipe gathering system, as well

as annual operation and maintenance costs of the system. Cost components are proportional to surface area of the landfill (i.e., one well per acre), except for the system cost of drilling and pipe crew mobilization. This analysis considered the installation of four systems over 150 acres. Itemized costs are presented below based on information from EPA's LFG Energy Project Development Handbook.

Table A.5 Itemized Costs for Biogas Capture and Flaring Systems

Cost Component	Cost	Cost Unit
Drilling and pipe crew mobilization	\$20,000	per system
Installed cost of vertical gas extraction wells	\$4,675	per well
Installed cost of wellheads and pipe gathering system	\$17,000	per well
Engineering, permitting, and surveying	\$700	per well
Annual O&M for collection (excluding energy)	\$2,600	per well
Annual O&M for flare (excluding electricity)	\$5,100	per flare

The cost of the methane recovery improvements at the T.E. Maxson WWTP served as a proxy for installing methane recovery systems at uncontrolled plants. The cost was scaled for each plant (excluding septic systems) proportionally to its treatment volume.

4. Key Assumptions

In the absence of landfill specific waste composition information, an average statewide composition was applied across all landfill classes, although it is likely that Class I landfills have a higher biogas generation potential than Class III and Class IV disposal sites. The cost of installing controls at Class III and Class IV landfill is approximate, and it is based on an aggregate landfill size of 360 acres.

Methane recovery systems for WWTP are expensive. For that reason, extending this type of control technology to small septic systems was deemed to be an ineffective use of resources.

APPENDIX 5: REFERENCES

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