REDUCTION OF

GREENHOUSE GAS EMISSIONS REPORT

DECEMBER 2023

WWW.MENV.COM

Maryland
ENVIRONMENTAL
SERVICE

Message from the Executive Director

The Maryland Environmental Service (MES) is pleased to share this annual report, highlighting our activities aimed at reducing greenhouse gas emissions within Maryland. This report is a mandated submission as per Section 3-103.4(f) of the Natural Resources Article in the Annotated Code of Maryland.

MES' mission is to deliver operational and technical services to protect and enhance the environment for the benefit of Maryland's citizens. MES is a not-for-profit business unit of the State of Maryland, operating on a fee-for-service basis, with no regulatory oversight outside of our own governance. MES serves public and private clients and partners, meeting or exceeding the environmental regulations required in our operations, while executing projects that support mitigation of greenhouse gas emissions, improving the lives of every Marylander.

Last year, the Maryland General Assembly enacted the most ambitious climate change mitigation goals in the country. The Climate Solutions Now Act (CSNA) of 2022 sets an aggressive climate change policy by mandating a 60% reduction in greenhouse gas (GHG) emissions by 2031, relative to 2006 levels, and achieving net-zero emissions in 2045. Climate change impacts Maryland citizens in many ways, from experiencing frequent droughts to threats to our infrastructure. While a great deal of work has already been accomplished towards meeting these goals, much more remains to be done to meet the directives set forth in the CSNA.

We are proud of the contributions made in every area of our operations at MES -- Environmental Dredging and Restoration, Water and Wastewater, Environmental Operations, and Technical and Environmental Services. We look forward to continued progress in the reduction of greenhouse gases, as we improve Maryland's environment together.

Sincerely,

Charles C. Glass, Ph.D., P.E.
Executive Director

MES' Carbon Offsets – At a Glance

Project	Carbon Emissions Avoided mt CO2 eq.	Equivalent Number of Cars Removed from Roadways per Year
MPA Dray Truck Program	387	86
MES Headquarters Solar Array	380	85
MES Headquarters Telecommuting	321	72
Biosolids Land Application	7,749	1,724
Prince George's County Materials Recycling Facility	87,085	19,379
Montgomery County Materials Recycling Facility	115,065	25,605
Midshore Regional Recycling Program	7,955	1,770
Harford County Integrated Solid Waste Management	3,993	889
Prince George's County Organics Food Waste Composting Facility	6,638	1,477
Montgomery County Yard Trim Composting Facility	1,695	377
Assateague State Park/Deep Creek Lake State Park Solar Panels	142	32
Totals =	231,410	51,496

Table of Contents

Introduction to the Maryland Environmental Service

MES was established by the General Assembly in 1970 to assist with the preservation, improvement, and management of the quality of air, land, water, and natural resources, and to promote the health and welfare of the citizens of the State. Today, we employ over 800 teammates and operate more than 1,000 environmental projects across Maryland and the Mid-Atlantic Region. As a not-for-profit business unit of the State of Maryland, MES provides multi-disciplinary environmental compliance services to enhance and protect the environment through innovative solutions to the region's most complex challenges.

We are a leader in solving Maryland's environmental problems. MES plans, constructs, and operates projects within our four main operating groups:

- Environmental Dredging and Restoration
- Environmental Operations
- Water and Wastewater Services
- Technical and Environmental Services

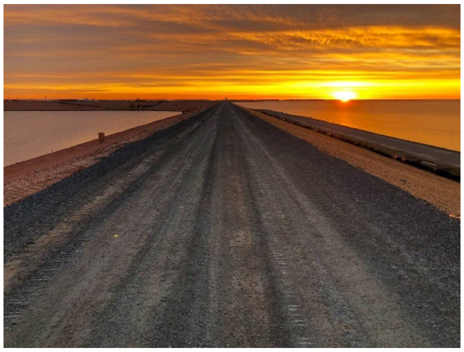
Detailed descriptions of each operating group are given below.

MES HQ

Environmental Dredging and Restoration Program

The Environmental Dredging and Restoration Group (EDR) provides operational and technical services on behalf of our clients in the areas of dredged material management, outreach and engagement related to dredged material management, habitat restoration, remediation, environmental management system implementation, and permitting and mitigation services. The EDR Group supports our clients with the planning, engineering, construction, environmental and regulatory management, and operations of our partners' facilities. MES operates three dredged material containment facilities (DMCFs) and the Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island (Poplar Island) on behalf of the Maryland Port Administration (MPA).

Poplar Island is a restoration effort located in the Chesapeake Bay in Talbot County that beneficially uses dredged material collected from the approach channels to the Baltimore Harbor to restore lost remote island habitat. The three DMCFs include the Masonville DMCF located near the Middle Branch of the Patapsco River in Baltimore, the Cox Creek DMCF in Anne Arundel County, and Hart-Miller Island DMCF, which stopped accepting dredged material inflow in 2009. MES is supporting MPA with the ongoing wildlife habitat restoration effort at Hart Miller, including the opening of the 300-acre south cell to public use in partnership with Maryland Department of Natural Resources (DNR). In December 2022, MPA purchased the former Tronox Hawkins Point facility adjacent to the Cox Creek DMCF. MES and our subcontractors are providing support to MPA for remediation planning and site operations at the Sediment Technology and Reuse (STAR) Facility. In coordination with remediation activities, the site will be developed to become the future hub of processing dredged material from the Cox Creek DMCF for innovative and beneficial reuse.



Cox Creek DMCF

MES further provides environmental management system support services to MPA at their marine terminals including environmental monitoring and reporting, hazardous waste management, groundwater treatment plant operation and maintenance, hazardous waste landfill post closure care, stormwater best management practices (BMP) maintenance, inspection, and repair services, and assists with their strategic plan to reduce emissions at the terminals.

MES also manages dredging projects for other clients including the Deep Creek Lake Arrowhead Cove Dredging Project on behalf of Garrett County. Past and current work has included planning, along with permitting and design with construction started in September 2023. The project will involve mechanical removal of approximately 11,000 cubic yards of sediment from Arrowhead Cove in Deep Creek Lake. The dredging will be complete in the first quarter of FY24, with site restoration to occur in spring/summer 2024.

As part of an initiative to reduce nitrogen, phosphorus, and sediment releases resulting from those nutrients that were previously trapped upstream of the Conowingo Dam, EDR completed the dredging of 1,000 cubic yards of sediment from the Susquehanna River in support of the Conowingo Sediment Characterization and Innovative Reuse and Beneficial Use Pilot Project. The dredged material was processed for use in a future innovative reuse project.

Environmental Operations

The Environmental Operations (EO) Group primarily serves counties, large municipalities, and rural communities, offering solutions for solid waste challenges and recycling services. Other services provided by the EO Group include engineering and operation of energy facilities on behalf of the Department of Public Safety and Correctional Services (DPSCS), used oil and antifreeze collection in partnership with the Maryland Department of the Environment (MDE), and mobile chlorofluorocarbon operations.

Solid Waste and Recycling Services

The Group operates award-winning landfills and dual- and single-stream recycling centers, which serve millions of Marylanders. Additionally, the EO Group manages composting facilities that transform yard, leaf, and food waste into the highly sought-after products, Leafgro® and Leafgro Gold®.

The EO Group provides Harford County with landfill operations, engineering services, composting, recycling, litter control, and managing the County's homeowner drop-off facilities.

The Eastern Shore counties of Caroline, Queen Anne's, and Talbot, and later Kent, (Midshore counties), established a regional agreement with MES to meet the solid waste disposal needs of their citizens for an 80-year period. MES currently oversees, engineers, operates, and monitors several solid waste facilities in the Midshore region on behalf of the partnering counties, including active and closed RCRA Subtitle D landfills, a solid waste transfer station, and multiple pre-RCRA Subtitle D landfills. MES also administers and operates a resident recycling program on behalf of the Midshore counties.

Midshore II Regional Landfill

MES operates a dual stream materials recycling facility (MRF) facility for the Montgomery County Department of Environmental Protection in Derwood, Maryland to recycle both mixed paper and comingled materials such as glass, metal cans, and plastic containers that are picked up from homeowners' residences. MES also operates a similar project at the Prince George's County's MRF. This recycling facility accepts single stream recyclables collected from Prince George's County residents. Recycling offers significant advantages relative to carbon offsetting, by avoiding the use of virgin materials and using recycled inputs instead to primarily save energy.

The EO group also operates very successful leaf and yard waste composting programs. Two compost products made by MES at the Montgomery and Prince George's Counties compost facilities, *Leafgro®* and *Leafgro GOLD®*, are marketed successfully by MES staff. Our *Leafgro GOLD®* Compost is produced using food waste as a feedstock at the nationally renowned Prince George's County Organics Composting Facility located in Upper Marlboro, Maryland. Food waste that is diverted from landfill disposal to compost facilities promotes the avoidance of methane emissions from the landfills. These emissions are a substantial contributor to climate change and, accordingly, these operations represent a significant opportunity to offset carbon emissions in the form of methane associated with the decomposition of food waste in landfills. The Maryland Commission on Climate Change notes that "*Methane is the second strongest driver of radiative forcing causing climate change."* [1]

Energy Plant Operations

The EO Group with the Department of Public Safety and Correctional Services operates a cogeneration facility supplying steam and electricity to the Eastern Correctional Institution (ECI), and steam for heating, laundry, and cooking at three other Maryland Correctional Facilities.

Essential Services

EO collaborates with various government agencies in Maryland to provide other essential services. The Group collaborates with MDE to support used oil and antifreeze collection and operate a mobile chlorofluorocarbon recovery unit. Additionally, EO partners with the Maryland Department of Aging to manage a Durable Medical Equipment program. This program receives discarded durable medical equipment, so it can be refurbished, recycled, and commissioned for reuse.

Water and Wastewater Services

MES' Water and Wastewater (W/WW) Group operates and maintains numerous municipal, County, and State-owned wastewater treatment plants (WWTPs) and drinking water treatment plants (WTPs). Privately owned facilities are also operated by this Group under contract. The Water / Wastewater Program operated 229 facilities across Maryland and the Mid-Atlantic region in fiscal year (FY) 2023. Staff provide operations for numerous small water and wastewater facilities throughout the State. Services for these smaller facilities are accomplished using an efficient "circuit-rider" model, where staff make the rounds from one facility to another to service these plants. MES personnel also respond to emergencies as needed.

The Water / Wastewater Group's Engineering Services Division within this Group also plans and implements capital improvement programs for many of these facilities. Engineers manage capital upgrades to achieve compliance with Maryland's Enhanced Nutrient Removal standards.

Solids generated from the WWTPs are managed by our Biosolids Management Section staff. Engineering, planning, permitting, regulatory compliance, and operational support is furnished by the biosolids staff. MES recycled 53% of the 3,009 dry tons of solids generated from the WWTPs in FY23 onto agricultural land.

Technical and Environmental Services

The Technical and Environmental Services (TES) Group provides multi-disciplinary environmental planning, monitoring, environmental systems maintenance, geospatial, and engineering and renewable energy services to our partners. This includes tasks such as:

- Planning
- Permitting
- Inspection Services
- Monitoring
- Regulatory Reporting
- Geographic Information Systems (GIS)
- Stormwater Management

- Renewable Energy Services


Deicing

One of our major projects involves providing environmental compliance and environmental systems maintenance support to the Maryland Aviation Administration (MAA) at the Baltimore Washington International Thurgood Marshall Airport (BWI). This includes collecting waste deicing fluid at BWI so that it does not runoff into nearby streams. MES staff collected 1.37 million gallons of spent de-icing fluid at BWI in the 2022-2023 deicing season. Some of the recovered deicing fluid is recycled rather than disposed, thereby reducing costs to MAA.

The TES Group continued to provide environmental compliance support services to the State Highway Administration (SHA). MES assisted with emergency drainage remediation projects that posed a potential impact to public safety and the environment. MES also began executing additional stormwater construction work for SHA.

TES staff assists the Maryland Energy Administration (MEA) with implementation and assessment of energy programs and policies. In support of the State's commitment to establishing clean energy, MES completed an evaluation of landfills, rubble fills, and brownfields. The study identified 56 suitable locations with the potential to site solar panels. Also, as part of our solar energy services, we continued working with DNR to install solar panels on the rooftops of structures at five State parks.

State of Maryland Greenhouse Gas and Climate Change Mitigation Policies

Global Climate Change

The Intergovernmental Panel on Climate Change (IPCC) notes that the Earth's global annual average surface temperature has increased by about 1 ^{o}C since the year 1850 (see Figure 1). This is unequivocally due to human activity. The IPCC declared that "Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades."[2]

The consequences of this temperature rise have resulted in numerous deleterious effects. Anthropogenic driven climate change has resulted in weather extremes. For example, globally averaged precipitation has increased since 1950. And mean sea level rise has increased by 0.2 meters since 1901. Heat extremes, and the resulting droughts, have become more frequent since the 1950s. And major tropical cyclone (category 3-5) activity has increased over the last 40 years. These extreme weather events have major implications relative to the resiliency of our infrastructure.

Reductions in GHG emissions to a "net zero" scenario, which is defined when the amount of GHGs produced equals the amount of GHGs removed from the atmosphere, and reductions in specific GHGs (e.g., CH_4) are required to mitigate climate change. This mitigation would also result in improved air quality overall. And net negative CO_2 emissions, where emissions removal exceeds anthropogenic based emissions generated, will be required to limit climate change to less than a 1.5°C temperature rise. This paradigm forms the basis for many of the regulatory efforts in the U.S. and worldwide at limiting climate change.

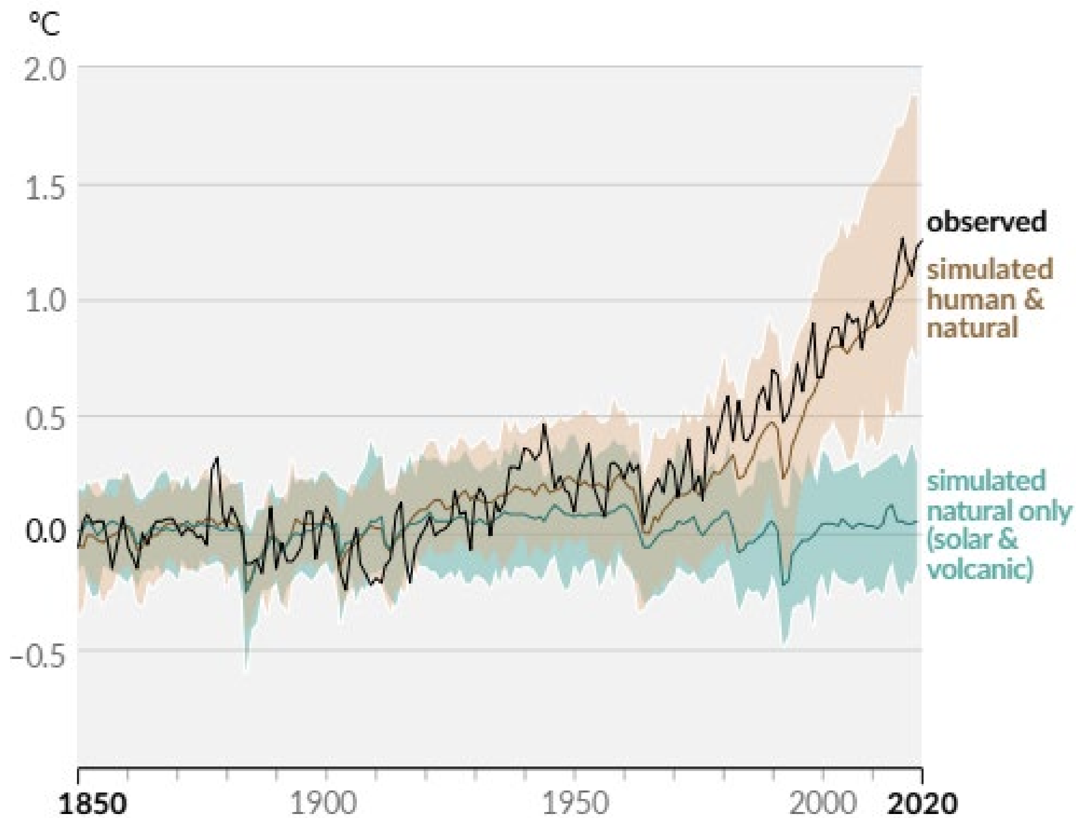


Figure 1 – Changes in Average Global Surface Temperature, Since 1850
Black Line= Annually Averaged Observed Global Temperatures,
Green Line = Modeled Global Temperatures due to Natural Drivers Only
(from IPCC, Summary for Policymakers, Reference 2)

<u>Maryland's GHG Inventory</u>

Previous iterations of the Greenhouse Gas Reduction Act (GGRA) required MDE to inventory the State's GHG emissions every three years. Results of the last inventory in 2020, presented by sector, are presented below in Table 1 and Figure 2.

Sector	2020 (20-yr) MMTCO2eq *	% of total
Electricity Use (Consumption)	18.33	21.5
RCI Fuel Use	13.64	16.0
Transportation – On Road	24.27	28.5
Transportation - Nonroad	5.51	6.5
Fossil Fuel Industry	4.59	5.4
Industrial Processes and Product Use	7.27	8.5
Agriculture	3.07	3.6
Waste Management	8.38	9.8
Total =	85.06	100
* - Assumes a 20-yr Global Warming Potential (GWP)		

Table 1 – Maryland 2020 GHG Inventory [3]

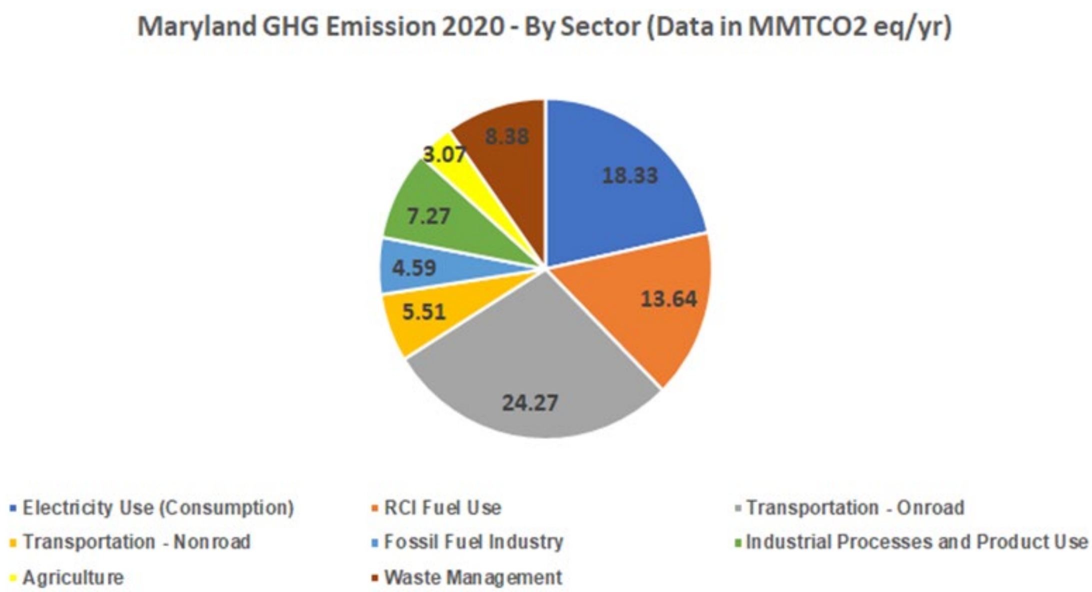


Figure 2 – Maryland 2020 GHG Inventory, Proportion by Sector [3]

The transportation sector accounted for the most GHG emissions in 2020, with 28.5% of the estimated emissions originating from on-road passenger vehicles and trucks. This is followed by GHG emissions from electrical consumption (both generated in-State and imported electricity from out of State sources), which accounted for an estimated 21.5% of the total emissions. Residential, Commercial, and Industrial (RCI) fuel use accounts for 16% of the GHG emissions in Maryland. These are emissions for direct fuel combustion of fossil fuels used for tasks such as space heating, hot water heaters, cooking, and industrial fuel use.

One sector of significance to MES is the waste management sector. These emissions originate from landfills, waste combustion and WWTPs. This accounted for approximately ten% of the State's GHG emissions inventory in 2020. MES is focusing on these emissions, especially CH_4 from landfills and N2O emissions from WWTPs.

Maryland has made progress towards meeting its GHG mitigation goals. Previous legislation, the Greenhouse Gas Reduction Act of 2009, mandated statewide GHG emissions reductions of 25% by the year 2020 (from a 2006 baseline). According to MDE, the State surpassed that goal and reduced GHG emissions by 30%[3].

Climate Solutions Now Act of 2022

It is crucial that aggressive programs be implemented to limit global warming to less than 1.5 °C, and that net-zero emissions be achieved by 2050[2]. In response to this situation, Maryland's legislature enacted the strictest GHG reduction law in the U.S. The Climate Solutions Now Act (CSNA) was passed by the legislature in 2022. It sets more ambitious GHG mitigation efforts than the previous versions of the GGRA. The CSNA requires the State to achieve at least a 60% reduction in CO2 emissions by 2031 and reach net-zero emissions by the year 2045. Specifically, the main provisions of the CSNA:

- Create a building energy performance standard for buildings (excluding school buildings) that are greater than 25,000 sq. ft. It requires State-owned buildings to achieve net-zero by 2035, and 2040 for privately owned buildings. By 2030, all state facilities would have or use at least 75% of their electricity from clean energy sources.
- Transition State government vehicles and transit buses to electric vehicles (EVs). The State government must electrify its fleet of passenger cars by 2031 and light duty trucks by 2036. The law requires the State Department of General Services (DGS) to develop charging infrastructure for this goal. It requires local governments to purchase electric school buses, under certain conditions.
- Provides incentives for community solar projects in the form of exemptions from personal property taxes if greater than 50% of the energy is provided to low- and moderate-income households.
- Incorporates CH_4 releases in emissions reduction plans.
- Institutes a long-term planning process for improving the electric grid to accommodate increased renewable energy generation.

Many of these provisions will affect MES' operations and facilities. Particularly, addressing CH_4 emissions from landfills that MES owns or operates, and the provision to purchase EVs for the Agency's fleet. Since MES either owns covered buildings (i.e., MES Headquarters Building) or occupies State buildings as part of our operations, the building energy performance standards, and the requirement that at least 75% of purchased electricity come from clean energy sources will be major projects that the agency must execute.

Current Projects, Carbon Emissions Mitigation

Overview of MES Efforts - GHG Emissions Reductions

Carbon emissions reductions are being achieved as a result of routine operations at MES. For example, our Headquarters solar array has been in place for 15 years. Ongoing programs, such as the Dray Truck Replacement Program that MES implements on behalf of MPA, not only offset CO_2 emissions, but result in cleaner air quality. The EO Group operates the two largest MRFs in Maryland and achieves carbon emission reductions by virtue of the energy saved by recycling materials instead of disposing of these wastes into landfills.

Plans for EV purchases and biochar production promise to offset carbon emissions even further. There are also solar energy projects planned, including some at State Parks.

Environmental Dredging and Restoration Projects

MPA Dray Truck Replacement Program

The Environmental Protection Agency (EPA) awards grants to replace older diesel trucks and port-based equipment in support of its Diesel Emissions Reduction Act (DERA) Program. The goal of this program is to retrofit or replace older diesel engines/vehicles to reduce emissions, and accelerate replacement of this equipment to newer, cleaner technologies. The MPA has a robust environmental program, which includes reducing emissions from vehicles and cargo handling equipment at port facilities. MES receives the EPA grant funding and administers the program on behalf of MPA. Companies that own the vehicles take part in the program by matching EPA funds which can be up to $30,000 or 50% of the purchase price of the new vehicle.

In 2023, a total of 14 vehicles participated in the Dray Truck Replacement Program (13 on-road, Class 8 heavy duty trucks and one non-road piece of equipment). The EPA's Diesel Emission Quantifier (DEQ) Tool[4] was used to quantify emissions reductions resulting from these replacements. The output from this tool is shown in Table 2 below. Inputs used for the DEQ tool were obtained from actual usage data for the vehicles that were being replaced. Diesel emissions reductions were achieved as a result of improved emissions control technologies and enhanced fuel efficiency. Emissions reductions for the criteria air pollutants (NOx and $PM_{2.5}$) as well as for hydrocarbons (HC) were realized. GHGs were reduced by 32.2%, or by 387 mt CO_2 eq.

Parameter	NOx	$PM_{2.5}$	HC	CO	CO_2
	metric tons per year or % reduction				
Baseline for Project (Before Upgrades)	8.22	0.45	0.73	2.54	1,201.78
Amount Reduced After Upgrades	5.89	0.43	0.63	0.89	387.38
Percent Reduction After Upgrades	71.60%	94.00%	86.60%	34.90%	32.20%

Table 2 – EPA DEQ Tool Output for MPA 2023 Dray Truck Replacement Program

MES Electric Pick-Up Trucks at MPA Facilities

MES is assisting MPA with implementation of the fleet electrification requirements of the Climate Solutions Now Act. In FY23 funding was approved to purchase two Ford F-150 Lightning® all electric ½ ton pickup trucks. The trucks were scheduled for delivery in late fall 2023 and will replace a 2012 diesel engine F-350 1-ton pickup truck and a 2015 gas engine ¾ ton pick-up truck. In addition, EDR continues to take steps to reduce the emissions associated with and maintenance of the diesel emissions systems in the trucks and equipment currently employed at the MPA facilities that MES operates on behalf of MPA. In FY23 MES replaced four pieces of diesel equipment operating at the DMCF's with equipment that meets newer more stringent diesel emissions standards, EPA Tier 4 final requirements.

Seagirt Loop Channel Feasibility Study

The Baltimore Harbor Anchorages and Channels (BHAC) Modification of the Seagirt Loop Channel Feasibility Study (BHAC Study)[5] was initiated in 2020 and finalized in June 2023. The approved recommended plan includes widening and deepening the West Seagirt Branch Channel to 50' to allow for safe passage of the ultra large Post-Panamax vessels. The project will move to the pre-construction engineering and design phase in early 2024.

As part of the study and on behalf of MPA, MES evaluated impacts related to the proposed project and managed a GHG accounting analysis. Findings showed that an increased reliance on Post-Panamax vessels will result in a reduction in GHG emissions per ton of cargo due to reduced idling time, less need for tug assist when leaving the terminal, and more efficient vessels; however, the projections of an annual increase in the number vessels calling to the Port will result in an overall increase in GHG emissions.

It should be noted that when considering long-term cumulative impacts related to Port activity, the recommended plan is part of a large-scale modernization effort at the Port. Fleet forecast projections show an increase in cargo moving through the Port with increased efficiency related to the Seagirt Marine Terminal Improvements and the Howard Street Tunnel Improvement Project which show reduced GHG emissions per ton of cargo related to modernization of landside equipment and increased reliance on cargo transport by double-stacked rail rather than trucks.

The BHAC Study can be found on the U.S. Army Corps of Engineers (USACE) Baltimore District website.

The Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island

As climate change increases global temperatures of air and water, polar ice melts and thermal expansion raises sea levels. Combined with land subsidence in the mid-Atlantic, rising sea level and wave action causes erosion, resulting in the loss of valuable island habitats throughout the Chesapeake Bay. In the last 150 years, it is estimated that 10,500 acres have been lost in the middle eastern portion of the Chesapeake Bay alone. Islands and the surrounding habitat are preferentially selected by many migratory birds, as well as other fish and wildlife species, for nesting/production areas. Poplar Island is an environmental restoration project located in the Chesapeake Bay in Talbot County. The beneficial use project relies on dredged material from the approach channels to the Baltimore Harbor (necessary to keep the Port of Baltimore's commerce flowing) to restore what was once a nearly completely lost remote island habitat within the Chesapeake Bay.

In 2001, Maryland enacted the Dredged Material Management Act of 2001, Maryland Annotated Code, Environment Article §§ 5-1101 through 5-1108. This prioritizes beneficial and innovative reuse of dredge material as the preferred placement options in Maryland.

The USACE and MPA began the project to achieve three goals:

- Restore remote island habitat within the mid-Chesapeake Bay
- Optimize the placement capacity for sediment dredged from shipping channels
- Cause no harm to the environment around the restoration site

The Poplar Island project is a cost share between the federal sponsor, the USACE who funds 75%, and the non-federal sponsor, MPA, who funds the remaining 25%. MES, on behalf of MPA, manages the daily operations and technical and environmental services on site as well as provides valuable onsite construction services to build portions of the island.

Coastal Wetland Equilibrium Model

In 2022, MES on behalf of MPA contracted with the University of South Carolina (USC, Dr. Jim Morris) to develop a Coastal Wetland Equilibrium Model (CWEM) specific for Poplar Island's restored wetlands. The model inputs included the vegetation data provided by the University of Maryland Center for Environmental Science along with local sea level rise (SLR) projections. This data was used to evaluate the resiliency of the restored marshes at Poplar Island against different rates of SLR, evaluate multiple low marsh/high marsh ratio scenarios, and evaluate current carbon sequestration rates of the marshes.

Conclusions drawn from the model include:

1. At the current elevation, the low-marsh platform at Poplar Island will drown in about 40 years at the current rate of SLR. The high-marsh platform will survive a century at current rates but will transition to *S. alterniflora*-dominated low marsh by the end of the century.
2. Poplar Island low marsh is currently gaining elevation at an average rate of 0.54 cm/yr, which is nearly equal to the local rate of SLR (0.57 cm/yr), but this high rate of vertical accretion is not sustainable.
3. Marshes grow biomass for at least a decade after first establishing. The buildout of belowground biomass adds volume and results in higher vertical accretion rates. When the marsh matures, the accretion rate slows.
4. Thin layer placement (TLP) applications can increase carbon sequestration, because TLP can reset the developmental sequence to an early stage of development.
5. TLP is a strategy that can increase a marsh's resilience and carbon sequestration. There is an optimum TLP sequence; it depends on the trajectory of mean sea level, characteristics of the marsh, and dredging costs.

Dr. Morris made the following recommendations for Poplar Island based on the outcomes of the model:

1. Balance the low-marsh to high-marsh ratio, closer to 50:50.
2. Create a low marsh platform of uniform elevation of 30 cm NAVD (North American Vertical Datum), close to the current optimum elevation for *S. alterniflora*.
3. Contour the high marsh landscape at the transition between low marsh and high marsh with a gradual slope from 40 cm to 120 cm NAVD. This allows for a more gradual future transition from high marsh to low marsh as sea level rises.

Environmental Operations Projects

<u>Midshore I Landfill - Stirling Gas Engine</u>

In FY23, MES installed, piloted, and later fully commissioned a 5.6 kW Qnergy PowerGen at the closed Midshore I Landfill.[6] This unit uses Stirling engine technology to externally combust landfill gas (LFG) that is of variable composition and is characterized by a relatively low heating value. The Stirling engine that was installed at the landfill is shown in photo below. A Stirling engine is an energy conversion device that uses thermal energy to generate mechanical work. For a landfill, the fuel source providing the thermal energy is from the LFG. When heated, a working gas such as helium expands in a compression chamber and moves a reciprocating displaced piston, which causes a power piston to move and interact with a linear alternator to produce electricity. As the gas cools and contracts, the process resets before repeating again. The use of LFG as a fuel reduces carbon emissions (in the form of methane), relative to the use of fossil fuels.

Electricity produced by the PowerGen is returned to the local grid, offsetting a portion of the site's electricity consumption. In early FY24, MES applied to the Maryland Public Service Commission (PSC) to certify the use of LFG to produce electricity via the Qnergy PowerGen as a Renewable Energy Facility under the Renewable Portfolio Standard (RPS).

Qnergy PowerGen Stirling Engine

Materials Recovery Facilities

Prince George's County MRF – Carbon Emissions Modeling

A summary of recycled commodities managed at the Prince George's County MRF is presented in Table 3 below. These recycled tonnages were input into the EPA's Waste Reduction Model (WARM) Tool.[7] This model calculates GHG emissions, and other impacts, by comparing a baseline management practice specific to the jurisdiction (in this case, landfilling with LFG collection for energy recovery) to an alternative option (i.e., recycling). The difference between the two is the carbon emissions avoided. WARM uses published emissions factors for each type of material that is recycled. There is a positive, net benefit from recycling in terms of GHG emissions levels. This is mostly achieved by generating less methane emissions at solid waste landfills and using recycled materials for manufacturing new products instead of using virgin raw materials. Positive energy impacts are realized when not having to use virgin raw materials for production.

The impact on GHG emissions resulting from recycling in Prince George's County is significant. It was estimated that a total of 87,085 mt CO2 eq. was avoided because of the operation of this facility in FY23. These carbon emissions avoided are equivalent to removing 19,379 gasoline powered cars from the roadways every year.

Montgomery County MRF – Carbon Emissions Modeling

Montgomery County MRF recycling data for FY23 is shown in Table 4. The facility recycled a total of 51,721 tons in FY23. The EPA's WARM model was run to determine the GHGs avoided due to recycling at this facility. The baseline case here was to assume that the solid waste accepted at the MRF would normally have been combusted at the Covanta Resource Recovery Facility (Waste-to-Energy) located in Dickerson, Maryland. The WARM model estimates emissions from the combustion of MSW (municipal solid waste) at Waste-to-Energy (WTE) facilities.

This analysis assumes that the metals from the Covanta incinerator from aluminum cans, ingot, and steel cans were recovered and recycled from the ash. Hence, there were no carbon emissions avoided in the baseline case relative to the MRF because these metals were recycled in the ash (see Table 4). Also, the Covanta facility recovered energy from mixed recyclables, whereas these were not recycled at the MRF.

Commodity	**Tons Recycled in FY 23**	**Carbon Emissions Avoided (mt CO_2 eq)**
Mixed Paper	11,191	37,539
Corrugated Containers	12,791	38,853
HDPE Plastic	852	663
PET Plastic	2,101	2,219
Polypropylene Plastic	371	302
Mixed Plastics	244	231
Aluminum Cans	477	4,363
Steel Cans	1000	1,852
Mixed Metals	241	1,063
Totals =	**29,268**	**87,085**

Table 3 – EPA WARM Carbon Emissions Modeling Results Prince George's County MRF

Factoring in the aforementioned assumptions, the WARM modeling shows that 115,065 mt CO_2 eq was realized as a result of the operation of the Montgomery County MRF. These avoided carbon emissions are equivalent to removing 25,605 passenger vehicles from public roadways each year.

Commodity	Tons Recycled in FY 23	Carbon Emissions Avoided (mt CO_2 eq)
Mixed Paper	15,702	66,098
Corrugated Containers	21,518	41,823
HDPE Plastic	967	2,024
PET Plastic	1,709	3,936
Mixed Plastics	498	1,106
Aluminum Cans	546	0
Aluminum Ingot	31	0
Steel Cans	1,011	0
Glass	9,737	2,944
Mixed Recyclables*	0	-2,866
Totals =	**51,721**	**115,065**

Table 4 – EPA WARM Carbon Emissions Modeling Results Montgomery County MRF (Assumes that the baseline case of WTE combustion results in carbon avoided emissions of mixed recyclable materials)

Harford County Integrated Solid Waste Management

MES has been providing solid waste services for Harford County since 2015. The EO Group provides several solid waste management services for County residents, including:

- Operation of the County's Landfill in Street, Maryland
- Homeowner drop-off center at the Landfill (Harford Waste Disposal Center)
- Engineering and Procurement Services
- Yard Waste Composting
- Single Stream Recycling Services
- Litter control and Adopt-a-Road Programs
- Recycling public education and outreach

Curbside recycling and material brought to the homeowner's drop-off site at the Harford Waste Disposal Center is transported to a transfer station and ultimately to a commercial recycling facility in Baltimore County. The County's recycling program managed 9,072 tons of material in FY 23 (See Table 5 below).

Recycled and composted material tonnage data was input into the EPA's WARM model to determine the carbon emissions mitigation for program. A total of 3,993 mtCO_2 eq emissions were avoided as a result of Harford County's recycling programs. This was equivalent to conserving 449,302 gallons of gasoline or removing 889 passenger vehicles from public roadways.

Commodity	Tons Recycled in FY 23	Tons Composted in FY 23	Carbon Emissions Avoided (mt CO_2 eq)
Food Waste (non-meat)	NA	3	2
Yard Trimmings	NA	6,640	-751
Mixed Plastics	6	NA	6
Electronic Peripherals	83	NA	32
Mixed Metals	17	NA	76
Structural Steel	1,363	NA	2,656
Tires	349	NA	0
Mixed Recyclables	612	NA	1,972
Totals =	**2,429**	**6,643**	**3,993**

Table 5 – Carbon Emissions Avoided Due to Recycling Programs Harford County Solid Waste

Midshore Regional Recycling Program

The Midshore Regional Recycling Program (MRRP) is a cooperative partnership between Caroline, Kent, Queen Anne's, and Talbot Counties that was established in 1993. The MRRP is a residential recycling drop-off program that allows residents of the four Midshore service counties to drop off their separated paper, cardboard, metal cans, and glass at one of thirty-five separate locations throughout the region. These source-separated recyclables are collected, transported, marketed, and sold by MES on behalf of the Midshore counties

In FY23, MES collected 2,802 tons of recycled materials for the program as noted in Table 6 below. This resulted in an estimated 7,955 mtCO_2 eq avoided.

Commodity	Tons Recycled in FY23	Carbon Emissions Avoided (mt CO_2 eq)
Mixed Metals	154	680
Mixed Paper	708	2,782
Cardboard	1,166	4,264
Glass	774	229
Totals =	**2,802**	**7,955**

Table 6 – FY23 Carbon Emissions Avoided Midshore Regional Recycling Program

Organics Composting

There are many benefits to composting organic residuals and wastes. Composting manure, for example, results in an avoidance of methane emissions that would normally occur if the manure was stored in a farm lagoon. Other wastes, such as food wastes, generate methane (a potent GHG) when disposed of into a landfill. With respect to carbon offsets, composting accomplishes two objectives: [8]

- The process avoids GHG emissions, primarily in the form of N_2O and CH_4 when the compost feedstocks ae managed by traditional means (e.g., landfilling food wastes).
- When the compost is used as a soil conditioner or fertilizer substitute carbon is sequestered in the soil.

MES operates two large-scale composting facilities that generate high-quality, marketable material. Their operational impact on GHG emissions is described below.

Prince George's County Organics Composting Facility

In 2019, the EPA estimated that a total of 66 million tons of food waste was generated per year by the food retail, food service, and residential sectors. Approximately 60% of this waste was disposed of in landfills.[9] This figure does not include the additional 40 million tons of food waste generated by the food and beverage manufacturing sector.

When food waste is disposed in a landfill it degrades, thereby generating methane emissions. Composting food waste is an alternative to landfill disposal. EPA estimates that 3.3 million tons of food waste was composted in 2019. In addition to mitigating GHG emissions, composted food waste can be applied as a soil conditioner, thus acting as a carbon sink. Food waste derived compost also adds nutrients to the soil, which offsets the purchase of commercial fertilizers and the resultant energy used.

MES continued to operate its very successful food waste composting facility for Prince George's County in Upper Marlboro, Maryland. Yard waste trim is also composted at the Prince George's County Organics Composting Facility. Food waste composting uses an innovative Gore™ cover system. This cover is waterproof and breathable yet minimizes odor emissions from the compost piles. It allows the use of positive aeration to create an optimized composting environment to degrade the food waste, and it optimizes energy since the compost piles are covered and retain heat better than an uncovered windrow. The food waste compost that is produced at the site is marketed as a branded product, Leafgro GOLD®. In FY23, MES sold 22,060 tons of Leafgro GOLD® and 8,221 tons of Leafgro®.

Prince George’s County Food Waste Composting

The EPA’s WARM model was used to determine the carbon emissions avoided because of producing Leafgro GOLD®. Landfill disposal of the food waste was the chosen baseline scenario case modeled in WARM. A total of 16,897 tons of food waste was accepted at the facility in FY23. The model showed that 6,638 mt CO_2 eq was offset because of composting food waste.

Montgomery County Yard Trim Composting Facility

The Montgomery County Yard Trim Composting Facility is located near Dickerson, Maryland and has been in operation since 1983. Leaves, grass, and yard trim collected in Montgomery County are accepted at this site where it is composted using windrow composting. In FY23 a total of 31,642 tons of material was accepted at the facility. Finished compost produced at the site is sold in both bulk and bagged form by MES staff as the trademarked Leafgro® product. MES staff sold a total of 14,760 tons of compost in bulk, and 650,000 bags (16,882 tons). The bagged Leafgro® compost is a popular organic product sold at garden centers and retail operations in the Mod-Atlantic region.

Carbon emissions were again modeled using the EPA’s WARM model. Waste-to-energy (WTE) combustion was set as the baseline case in the model since the alternative practice would have been to transport the yard trimmings to Covanta’s Montgomery County incinerator. Emissions from that baseline were compared with the composting operation’s emission. It should be noted that WARM does not take into account CO_2 emissions when combusting biomass such as yard trimmings because it is considered a biogenic source of emissions.[10]

A summary of the WARM modeling results is given in Table 7 below. The emission reduction from WTE combustion was greater than the carbon offset from composting. It should be stated that the carbon footprint modeling of the composting facility showed some emissions offsets (1,695 mt CO_2 eq), but according to WARM it was not greater than the reductions when using WTE.

Management Practice	Carbon Emissions Reduction, mt CO_2 eq
Waste to Energy (WTE) Combustion	5,066
Composting	1,695
Net Reduction in Emissions	- 3,371

Table 7 – Comparison of Waste to Energy Carbon Emissions Modeling Results for the Montgomery County Yard Trim Composting Facility FY23

Bagged Leafgro®

TES Projects

Solar Projects

According to the U.S. Energy Information Administration (EIA), the increase in renewable energy generating systems is expected to be the predominant source of electricity generation shares in 2024. Renewable sources of energy are expected to supply 25% of U.S. electricity generating capacity in 2023 with a forecasted addition of 29.1 gigawatts (GW) of solar generating capacity and six gigawatts (GW) of wind generating capacity. Also, U.S. battery storage has grown rapidly since 2021, with a planned storage capacity of 9.4 GW. Solar energy is the largest source of new generating capacity and accounts for approximately 54% of all additions in 2023.[11] (see Figure 3 below). Solar energy projects combined with battery storage represent a novel way of producing electricity without generating direct emissions (and hence are considered a low carbon intensive process).

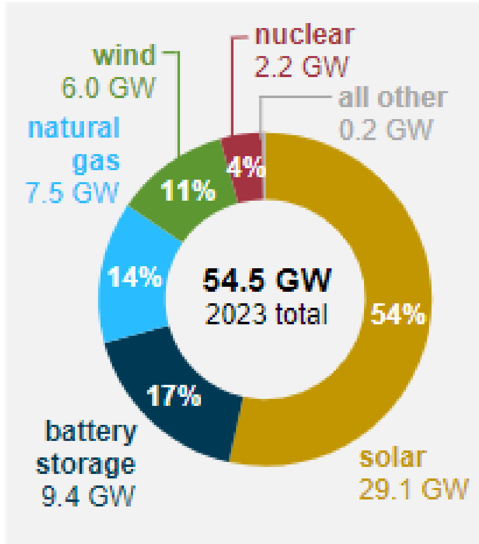


Figure 3 – Planned Utility-Scale Electric-Generating Capacity Addition in 2023
(from reference 15)

Work started in 2022 on solar panel installations at several DNR State Parks and continued in 2023. As of October 2023, contracts execution for installing solar panels at two sites, Assateague State Park and Deep Creek Lake State Park was in progress. These solar panels will be installed in FY24. A summary of all the planned solar projects at DNR's State Parks is given below in Table 8.

Using the EPA's online GHG Equivalencies Calculator, the 200,094 kwh per year to be generated at the Assateague State Park and Deep Creek Lake State Park installations is equivalent to offsetting 142 $mtCO_2$ eq. each year or removing the equivalent emissions from 32 passenger cars.

Solar Panels

Park Name	Building Name	Solar Capacity (kw)	Generation Target (kwh/yr)	Solar Generation as % of Building's Annual Electricity Use
Assateague State Park	Carpentry Shop	46.1	66,061	105
	Dormitory	12.1	16,272	105
	Day Use Building 1	13.5	18,168	22
	Day Use Building 3	24.5	32,948	105
Fair Hill NRMA	Para-Mutual Building	10.3	13,449	105
	Horse Barn #2	15.0	19,637	100
	Walls Hall	51.8	72,671	105
Merkle Wildlife Sanctuary	Visitors Center	23.3	29,903	44
	MCC House	11.0	14,148	62
Sandy Point State Park	Park Office	20.8	27,487	105
	South Beach Concession	28.1	37,128	52
	South Beach Bathhouse	11.7	15,418	105
	South Beach Comfort Station #2	12.3	16,262	105
Deep Creek State Park	Cold Storage Building	17.7	22,056	105
	Discovery Center	38.0	44,589	101
	Total Planned Electricity Generation=		**446,197**	

Table 8 – Planned Solar Panel Installations at DNR State Parks

MES is also working with MEA on other solar siting projects for various jurisdictions in the State.

New solar projects started in 2023 include:

- **Blum Military Reservation**- Solar site assessment at the military reservation building
- **Town of Middletown**- Solar site assessment at the town's water reservoir
- **Town of Berwyn Heights**- Solar site assessment at town hall and senior center
- **St. Mary's County**- Solar site assessment and geological analysis for Willows Recreation Center and the parking lot at Leonardtown Library and Garvey Senior Center

- **City of Laurel**- Solar site assessment for 11 various city-owned and operated sites
- **City of Baltimore**- Solar site assessment for 14 parking lots/garages throughout the city

Water and Wastewater Services Projects

Biosolids Program GHG Impacts

MES operates 67 municipal wastewater treatment plants (WWTPs) encompassing a wide range of capacities and treatment technologies. Sludge, or treated biosolids, generated from these sites are managed using a diverse array of management practices. MES' biosolids management regime includes transporting untreated sludges from most of the smaller capacity WWTPs to one of three larger, regional facilities. Once those sludges are received at our regional facilities they are dewatered and treated further using a process termed lime stabilization. This process treats the sludges and reduces the pathogens in the final product to meet MDE and EPA standards to make it suitable for land application onto farmland. The final lime stabilized product is then transported, and land applied by a contractor to farms in Virginia. The agricultural community endorses the reuse of treated biosolids and values the product for its nutrient content and soil-conditioning properties. Approximately 53% (expressed on a dry solids basis) of the biosolids generated by all of MES' facilities are recycled beneficially in this manner to farmland. This mirrors biosolids practices nationwide.[12]

Dorsey Run WWTP

The biosolids management carbon footprint for MES' facilities was calculated using the Biosolids Assessment Emissions Model (BEAM, version 2.0).[13] This model was originally developed by the Canadian Council of Ministers of the Environment in 2009, and further refined to its current version by the Northeast Biosolids and Residuals Association (NEBRA) in 2022. BEAM is the standard method of choice for biosolids management practitioners for determining the carbon footprint of each practice. Assumptions used in the BEAM model are given in Table 9.

One of the advantages of land application is sequestering carbon in the soil and offsetting the GHG emissions when substituting biosolids for commercial fertilizers.[14]/[15] Biosolids land application is also endorsed by the EPA, most State environmental agencies, and universities.

To determine the GHG mitigation impact from land applying biosolids, MES calculated the carbon footprint using BEAM for two scenarios - the current practice of land applying biosolids from our three regional facilities at the Dorsey Run, Freedom District, and Maryland Correctional Institution WWTPs. Along with a second hypothetical scenario where the biosolids from these three facilities would be landfilled instead of land applying the material. The difference in carbon footprints for these two scenarios documents the GHG emissions avoided by land applying instead of landfilling. These results are presented in Tables 9 and 10. Comparing the carbon footprint for the landfilling option versus beneficial reuse (current practice) shows that 7,749 mt CO_2 eq was avoided by reusing biosolids for agricultural land application. This has the same impact as removing 1,724 gasoline powered passenger cars from the public roadways for one year.

Avoiding carbon emissions in the form of fugitive landfill gas (LFG) accounts for the majority of the emissions that occur in a landfill. Also sequestering the biosolids carbon during land application and avoiding the use of chemical fertilizers at the farm where the material is applied results in a net negative carbon balance relative to soil management.

Item	**Assumptions**
Biosolids Tonnages and Analytical Data	FY23 data from MES in-house databases
Land Application Site Locations	Assumes Culpeper, Va.
Landfills - for Cambridge and ECI	Landfills used for Cambridge, ECI assume no landfill gas utilization for energy
Landfill - for La Plata	Assumes disposal to King George County, Va. Landfill; uses landfill gas utilization for energy
Landfill Option for Dorsey, Freedom, and MCI WWTPs	Assumes disposal to King George County, Va. Landfill; uses landfill gas utilization for energy
Polymer Usage	Assume 38 lb/day (from MES data for select WWTPs)
Lime stabilization dosage	Assumes 0.25 T lime/dry ton sludge treated (typical value)
Electricity for lime stabilization	Assumes negligible electrical use
U.S. Department of Energy eGrid region	SERC Virginia/Carolina - weighted GHG emissions = 284 g/kwh generated (published data)
Global Warming Potential (GWP)	GWP = 20; as per Maryland Commission on Climate Change
Average Truckload Weight	20 wet tons = 18 mt
Pathogen Treatment	Class B (for both land app and landfilling)
Bulk density of lime stabilized biosolids	50 lb/cu. ft = 881 kg/m3

Class 8 Heavy Duty Truck Fuel Efficiency	6.6 miles/gallon diesel fuel
BEAM default values	where indicated in model

Table 9 – Assumptions Used – BEAM Model

	Annual Amount Generated - FY23		Current Practice	
Facility Name	**Wet Tons/yr**	**Dry Tons/year**	**Management Method**	**C Footprint (mt CO2 eq/year)**
Cambridge WWTP	3,497.62	594.60	Landfilling	5,259
Deep Creek Lake WWTP	221.42	49.82	Landfilling	169
Eastern Correctional Institution (ECI) WWTP	538.56	102.67	Landfilling	23
La Plata WWTP	1,666.08	291.56	Landfilling	2,289
Dorsey Run AWWTP	1,013.13	238.09	Class B Land Application	106
Freedom District WWTP	3,127.28	922.55	Class B Land Application	244
Maryland Correctional Institution (MCI) WWTP	1,971.02	429.68	Class B Land Application	183
WWTPs - Transportation Practice Only	14,322.63	273.19	Transportation to Other WWTPs	32
Totals =	**26,357.74**	**2,902.16**		**8,305**

Table 10 – Carbon Footprint for MES WWTPs Current Practice – Land Application

	Annual Amount Generated - FY 23		Hypothetical Landfilling Practice	
Facility Name	**Wet Tons/yr**	**Dry Tons/yr**	**Management Method**	**C Footprint (mt CO2 eq/yr)**
Cambridge WWTP	3,497.62	594.60	Landfilling	5,259
Deep Creek Lake WWTP	221.42	49.82	Landfilling	169
Eastern Correctional Institution (ECI) WWTP	538.56	102.67	Landfilling	23
La Plata WWTP	1,666.08	291.56	Landfilling	2,289
Dorsey Run AWWTP	1,013.13	238.09	Landfilling	1,512
Freedom District WWTP	3,127.28	922.55	Landfilling	4,253
Maryland Correctional Institution (MCI) WWTP	1,971.02	429.68	Landfilling	2,517
WWTPs - Transportation Practice Only	14,322.63	273.19	Transportation to Other WWTPs	32
Totals =	**26,357.74**	**2,902.16**		**16,054**

Table 11 – Carbon Footprint for MES WWTPs Hypothetical Practice – Landfilling Instead of Land Application

Initiatives at MES Headquarters


Solar Panels at MES HQ

Solar Array at MES Headquarters

MES HQ is served by two solar photovoltaic arrays. The first solar arrays were installed in 2008 at the rear of the HQ building. This installation consisted of both ground mounted, and roof mounted thin film solar panels. The second solar array, a set of 300-kilowatt (kw) canopy type solar panels, was installed in portions of the MES Headquarters parking lot in 2016. There are 1,488 panels (300 kw) in the ground mounted/roof mounted solar installation, and 930 solar modules for the canopy project. For the first solar array, MES executed a fifteen-year Power Purchase Agreement (PPA) with Constellation Energy Group Inc. in 2008, which was subsequently transferred to Luminace Inc. The current agreement expires at the end of December 2023 and is being renewed.

Monthly performance data for our solar arrays for FY23 is presented in Figure 4. A total of 536,840 kwh was produced (as measured at the panels meters) in FY23. Using the EPA's on-line Greenhouse Gas Equivalencies Calculator[16], one can estimate the carbon emissions avoided for various mitigation strategies, in this case, from generating clean, solar energy. This amount of solar energy is equivalent to the avoidance of 380 mtCO_2 eq per year, or similar to removing 85 passenger cars from public roadways for one year.

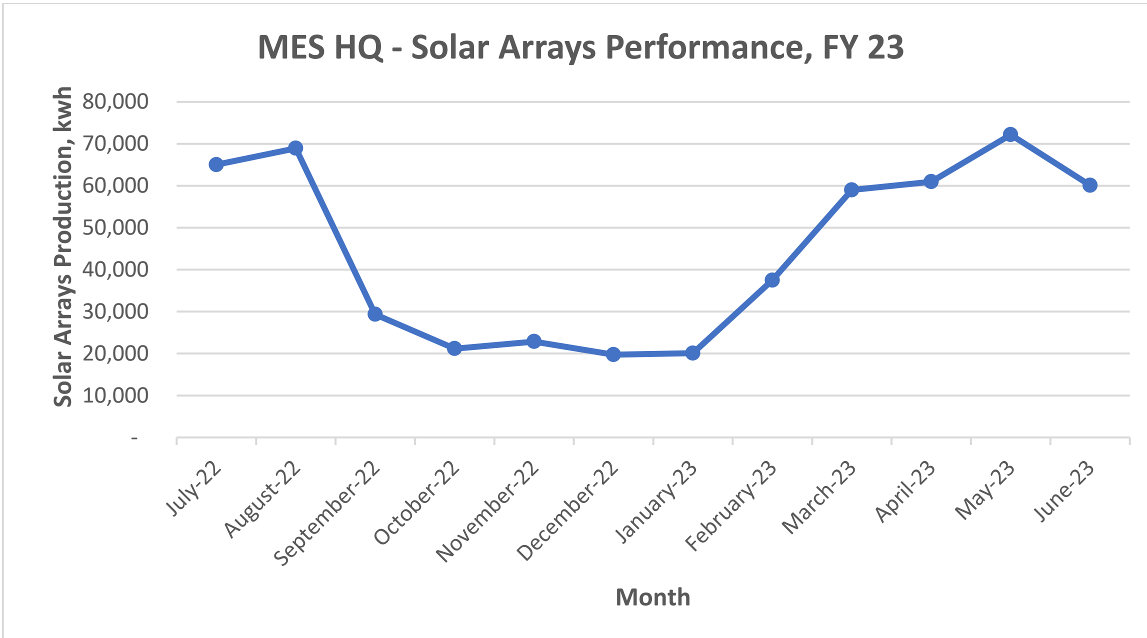


Figure 4 – Monthly Performance, FY23 Solar Installation at MES Headquarters

<u>Telecommuting Impact on GHG Emissions</u>

MES has continued the hybrid remote work at home policy for Agency Headquarters staff since 2020 in response to the lifestyle changes that resulted during the COVID-19 pandemic. This allows for an ecofriendly “greener” savings in terms of fuel use due to avoided commute driving. With the intention of documenting the number of commute miles avoided by MES staff while performing remote work duties, a survey was conducted in October 2023 to ask MES Headquarters staff about their work commute data (number of days worked from home, average round trip commute distance, etc.). The result was a documentation of the total commute miles, and hence GHG emissions, avoided per year due to telecommuting.

A total of 142 staff members responded to the survey. This represents most of the staff working at MES Headquarters. There were several assumptions made to calculate the number of miles avoided driven due to telecommuting. It was assumed that a five-day workweek was in place, and that passenger vehicles such as cars and light trucks were driven. The survey also assumed that the work year was 50 weeks in length, to account for leave time. It also does not include those MES staff who work in field assignments, since they are usually required to report to a worksite each day.

Using these assumptions, the survey calculated the total number of miles of vehicle use avoided by implementing the teleworking policy was 827,580 miles per year.

Using an average EPA fuel efficiency of 22.9 miles per gallon (mpg) this results in a gasoline reduction of 36,139 gallons of fuel consumption per year. Using a value of 0.009 mt CO_2 eq. avoided per gallon of fuel used, a total of 321 mt CO_2 eq. emissions per year were avoided because of the teleworking policy. This is equivalent to removing 72 passenger cars per year from the roadways.

Quantifying MES' Carbon Footprint

MES sets organization-wide goals every fiscal year as part of our Building Excellence and Success Together (BEST) program. These goals focus on achieving improvements in our environmental projects as well as gaining efficiency in administrative processes. The BEST program is designed to elevate the Agency's performance. One of the BEST goals chosen in FY23 was to quantify our calendar year (CY) 2022 baseline carbon emissions. By calculating our carbon footprint, MES can identify areas where we can target our future efforts towards reductions in greenhouse gas emissions. Each operating group as well as our headquarters operations were surveyed to accomplish this effort.

Results of this effort for each operating group are presented in Figures 5 through 8 below. The total agency wide carbon emissions were estimated to be approximately 274,551 mt CO_2 eq. in CY22. Each group selected which of their individual projects to quantify emissions. The approach to estimating the baseline emissions was to use simplified calculator tools where available. For example, the EPA's Simplified GHG Emissions Calculator was used in some instances to estimate values for different types of activities, such as for stationary combustion, mobile sources, and electricity consumption.[17] The W/WW program used the EPA's Local Greenhouse Gas Inventory Tool to estimate direct emissions from 62 of MES' wastewater treatment plants (WWTPs).[18] These calculator tools use published emissions factors to estimate carbon emissions per unit of activity.

There are data gaps that were encountered during this process. These data gaps lead to a calculated carbon footprint which resulted in an order of magnitude estimate. Because of these data gaps, the resulting carbon footprint estimate should be considered "biased low." Known shortcomings include:

- Input values, obtained at the project-level and used to derive estimated emissions, were unvetted internally and externally.
- Some scope two emissions representing purchased electricity were not able to be estimated accurately due to a lack of input data. For example, actual electricity use at most of the water and wastewater plants is unknown because utility bills are paid by others, and thus the data are not readily available to MES. For electricity usage, a literature value was used for average kwh consumed per million gallons treated. This value was cited from a study of energy efficiency at water and wastewater facilities.[19]
- Scope three emissions were not included. These are defined as indirect emissions resulting from products and services purchased by MES. For example, embodied carbon emissions due to purchased chemical usage at

MES' WTPs and WWTPs is not accounted for in the carbon footprint result. Scope two and three emissions can be significant for our WTPs since chemical usage and electrical consumption essentially account for most of the carbon footprint at a water plant.

- We did not include the emissions for some emission-generating infrastructure owned by our client-partners. One example is the greenhouse gas emissions generated from the landfill at the Harford County Waste Disposal Center.
- This calculated carbon footprint was not third-party validated.
- The calculator tool used for the W/WW footprint determination is now outdated and resulted in imprecise direct emission estimates. A more comprehensive tool has since been found that will be used in subsequent efforts to calculate the W/WW footprint.

Upon inspection of the agency-wide estimated emissions (Figure 9) the majority of the greenhouse gas emissions (87%) were due to stationary combustion/emission sources such as the two Midshore Landfills, the Eastern Correctional Institution (ECI) Co – Generation facility, and the Steam Plants operated on behalf of the DPSCS.

MES is in the process of refining this greenhouse gas footprint calculation as this task has again been selected as a BEST Goal for FY24.

Cambridge WWTP

Environmental Operations

Stationary Combustion	Mobile Sources	Gases / Refrigerants	Electricity
239,800	4,653	123	2,958

Total GHG Emissions = 247,534 MTCO2e

Stationary Combustion

Landfill[1] Emissions
- MS-I: 33,145 MTCO2e
- MS-II: 105,345 MTCO2e

ECI Cogen
- 78,274 MTCO2e

Steam Plants
- 22,793 MTCO2e

	Mobile Sources	Gases / Refrigerants	Electricity
Landfills	1,985	23	166
Steam & Cogen	14	0	2,576 [2]
Recycling	2,204	100	217 [2]
Mobile Ops	451	0	0

[1]Direct emissions from landfill gas. Other stationary combustion emissions present, but in relatively insignificant quantities.
[2]Imported electricity for steam plants was not obtained and, therefore, GHG emissions from electricity importation is underestimated.

Figure 5 -CY22 Baseline Carbon Emissions – Environmental Operations Group (carbon emissions are expressed as mt CO_2 eq)

Water/Wastewater

Wastewater Treatment Plants (WWTPs)[1]	Mobile Sources	Gases / Refrigerants	Electricity
422	433	0	25,872

Total GHG Emissions = 26,727 MTCO2e

Wastewater Treatment Plants (WWTPs):
- 62 WWTPs

Mobile Sources:
- 96 Vehicles

Electricity:
- 69,535 MG wastewater treated[2]
- 1,792 MG drinking water produced[3]

[1]Direct emissions from DWTP not quantified.
[2]National average energy use for wastewater treatment is 1,200 kWh/MG.
[3]National average energy use for production and treatment of public drinking water is 2,000 kWh/MG.

Figure 6 -CY22 Baseline Carbon Emissions – Water and Wastewater Group (carbon emissions are expressed as mt CO_2 eq)

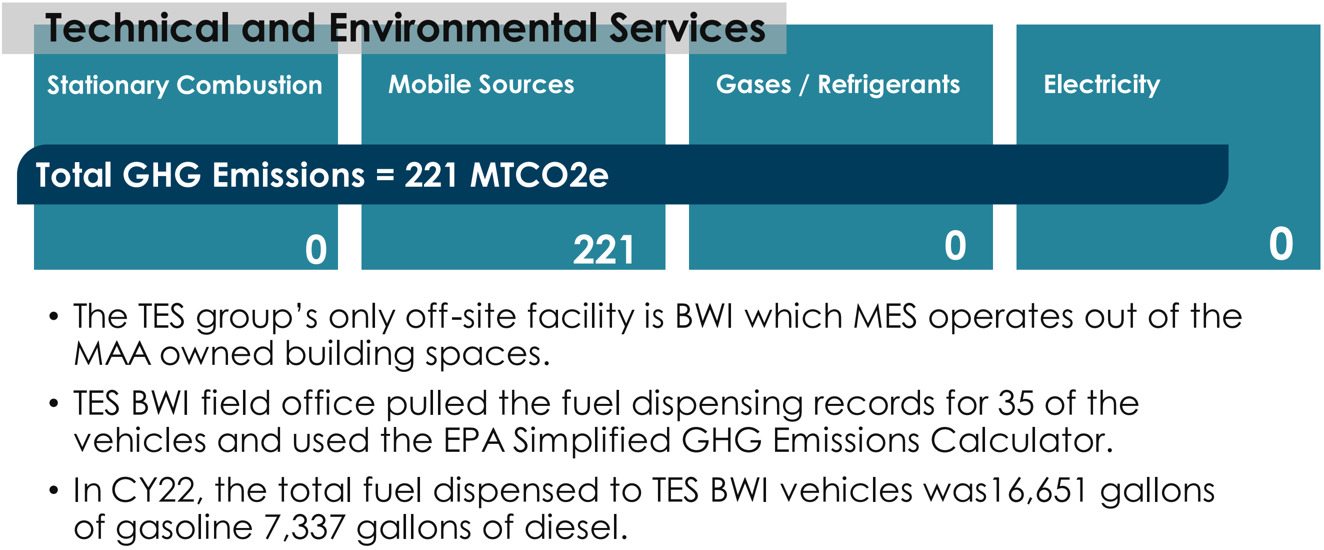


Figure 7 -CY22 Baseline Carbon Emissions – Technical and Environmental Services Group (carbon emissions are expressed as mt CO_2 eq)

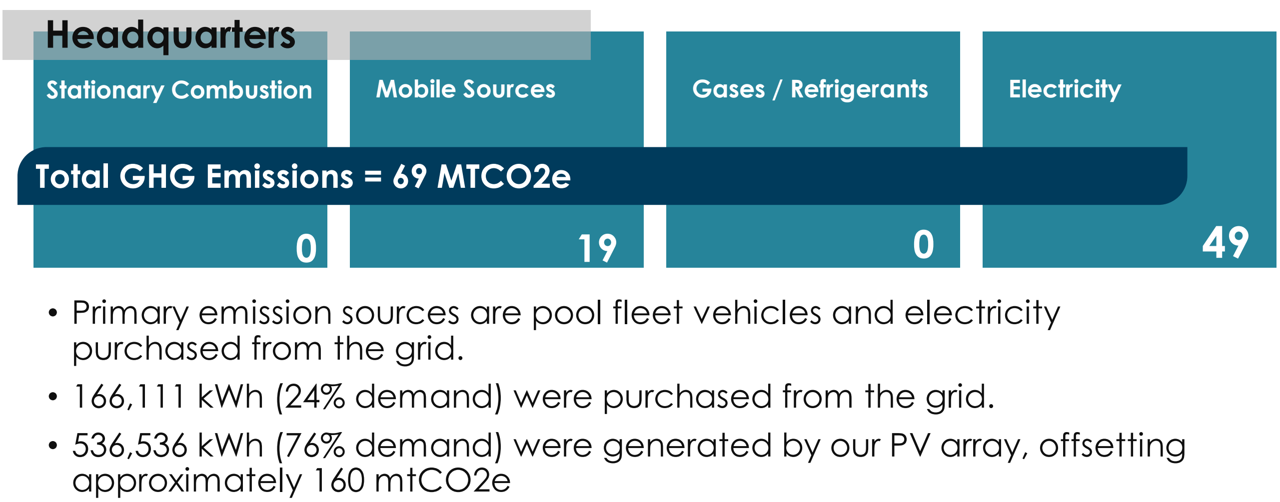


Figure 8 -CY22 Baseline Carbon Emissions – MES Headquarters Operation (carbon emissions are expressed as mt CO_2 eq)

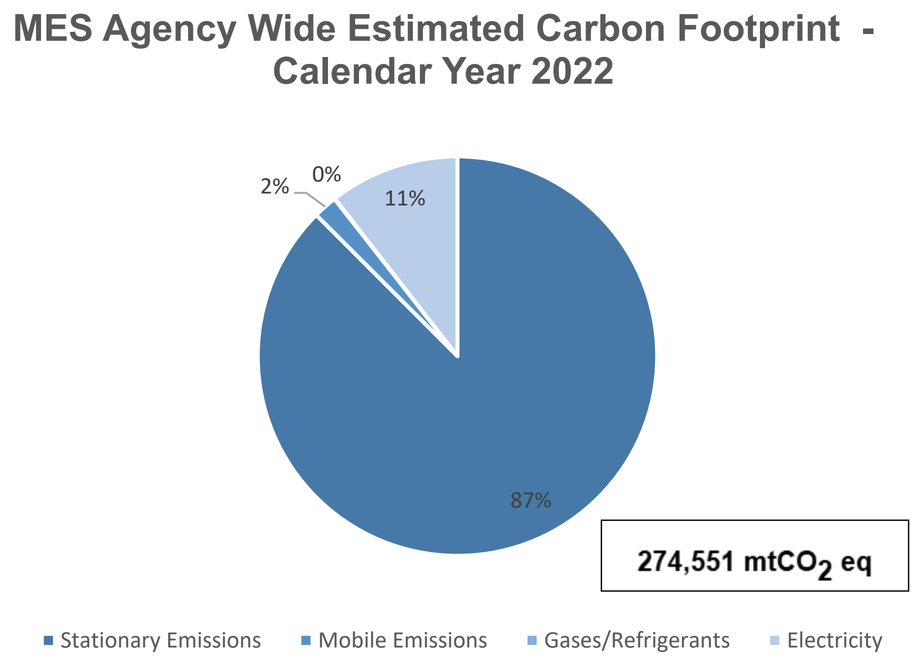


Figure 9 -CY22 Baseline Carbon Emissions – Agency Wide Summary (carbon emissions are expressed as mt CO_2 eq).

Future Carbon Emissions Mitigation Projects

Fleet Projects and EV Program

According to Maryland's 2020 GHG Inventory, the sector with the most carbon emissions is on-road passenger cars and trucks. To reduce these emissions, the CSNA requires State agencies to convert their fleet to electric vehicles (EVs). Even when accounting for the upstream electricity generation emissions from the utility power grid, on average EVs will emit 150 g CO_2 less per mile driven.[20] MES is actively working towards achieving the goal set in the CSNA. Our Fleet Department has several initiatives underway to purchase EVs and install the necessary charging infrastructure to meet the mandate specified in the CSNA.

MES currently has only one EV in its fleet (a Chevy Bolt). Two more vehicles have been procured since then, a Ford Lightning EV pickup truck, and a MACH E passenger car. Delivery of these vehicles has been scheduled for December 2023. These two vehicles will be added to our pool vehicle inventory for general use. It is anticipated that each vehicle will be used for 12,000 miles of travel per year.

Using U.S. Department of Energy (DOE) emissions estimates for each current EV, carbon emissions estimates and a comparison to a typical gasoline powered internal combustion be calculated [21] (see Table 12 below). Assuming the upstream power generation mix in MES' zip code, a 66.3 % decrease in carbon emissions will result from the use of these three EVs. The total emissions for EVs would be 4.84 mt CO2eq/yr. It is obvious that once the entire fleet is converted to EVs, a significant decrease in carbon emissions will result.

		EV Emissions		Gasoline Vehicle Emissions		
Vehicle	**Miles/Year**	**Estimated Emissions g CO_2/mi**	**Total Emissions mt CO_2eq/yr**	**Average Estimated Emissions g CO_2/mi**	**Total Emissions mt CO_2eq/yr**	**Emissions Avoided mt CO_2eq/yr**
Chevy Bolt	12,000	96	1.15	400	4.80	3.65
Ford Lightning F-150	12,000	169	2.03	400	4.80	2.77
MACH - E	12,000	138	1.66	400	4.80	3.14
		Totals =	**4.84**		**14.40**	**9.56**

Table 12 – MES EV Emissions Estimates

Midshore II - LFG Beneficial Reuse Request for Information (RFI)

MES issued a Request for Information (RFI) for the beneficial use of landfill gas at Midshore I's sister landfill, Midshore II, in FY23. Submissions to the RFI indicated that there is moderate external interest in using Midshore II's landfill gas for renewable natural gas (RNG) production, electricity generation to export to the grid, and electricity generation to power cryptocurrency mining. MES expects to issue a Request for Proposals (RFP) to third-party developers for the beneficially reuse of Midshore II landfill gas in the near future.

Eastern Correctional Institution Co-Generation Facility – Conversion to Natural Gas

Each of the four MES operating groups support unique environmental projects with a common goal of finding solutions to environmental issues while protecting the environment – with a commitment to the use of advancing technologies. In FY23, this included activities that support the production, generation, or distribution of both renewable and traditional energy sources.

The EO Group operates boiler plants at the Maryland Correctional Institution (MCI) at Hagerstown (Washington County), the Central Maryland Correctional Facility (CMCF) in Eldersburg (Carroll County), and the Jessup Correctional Institution (JCI) in Jessup (Anne Arundel County). Steam produced by those boilers provides heat for cooking, laundry operations, and heat for the prison complex.

In addition to the boiler plant operations, MES operates a biomass-fueled combined heat and power system (cogeneration plant) at the Eastern Correctional Institution (ECI) in Westover (Somerset County). Since 1988, this four-megawatt (MW) capacity plant has utilized debarked wood chips as its primary fuel source for two high-pressure boilers. In FY23, the facility consumed 47,521 tons of wood to produce 11,181 MWh of energy and an equivalent quantity of Renewable Energy Credits (RECs). The RECs are registered and sold on PJM's Generation Attribute Tracking Systems (GATS) trading platform. In total, the plant generated 55% of the electricity and 100% of the thermal needs for ECI in FY23 and fulfilled their primary responsibility of maintaining electrical power to the prison without interruption.

In August 2019, MES entered a 10-year Gas Service Agreement with Chesapeake Utilities to utilize natural gas as a bridge fuel at ECI. Subsequently, Chesapeake Utilities Corporation completed the Del-Mar Energy Pathway Project that added a natural gas transmission pipeline on the lower Delmarva Peninsula. A seven-mile leg of this new transmission pipeline extended service from Salisbury, Maryland to Westover, Maryland and was supported by the MES-operated ECI cogeneration plant - one of the two large anchor customers who supported this portion of the project through long-term gas transportation contracts. Shortly following the construction of the 7-mile transmission leg, MES contracted and oversaw the construction of a new 2,810-foot underground service pipeline to deliver natural gas from the Chesapeake Utilities distribution line to the ECI cogeneration plant.

After the construction of the service pipeline, MES, in July 2023, kicked off the Cogeneration Facility Boiler Conversion Project. This project entails converting the two (2) 38 MMBtu wood-fired boilers to natural gas. Concurrent with the boiler conversion work, MES began flowing natural gas on the new service pipeline to a temporary boiler installed at the facility to provide continuity of thermal energy to the prison. It is anticipated that the conversion of the boilers to the cleaner burning natural gas will result in approximately 55,000 tons of wood chips per year being replaced by 725,000 dekatherms of natural gas. It is estimated that the conversion will reduce the Cogeneration Facility's greenhouse gas emissions by roughly 19,000 $mtCO_2$ eq per year.

Pyrolysis and Biochar Production

Pyrolysis is a process by which carbonaceous organic material undergoes thermal degradation in the absence of oxygen into smaller volatile molecules. Solid wastes or other organic biomass (woody wastes, municipal sludges, etc.) are usually the feedstocks used in the pyrolysis process. Pyrolysis is usually conducted in the temperature range of 500 to 900 oC. Depending on the temperature, the products of pyrolysis are (1) a liquid, or bio-oil, (2) a charcoal like solid called biochar, and (3) a low BTU value synthesis gas, or syngas, which is composed of combustible gases such as CO (carbon monoxide), H2, (hydrogen) and light hydrocarbons. An example of a commercially available biochar product is shown in Figure 12.

The solid biochar product has many beneficial uses. Biochar is a charcoal like, stable carbon rich material. This char can be used as a soil conditioner and sequester carbon. The pyrolysis process sequesters the carbon in the char product, and because it does not readily degrade it remains in the soil for hundreds of years, thereby "locking" the carbon to the soil. One carbon sequestration evaluation for using biochar as a soil conditioner estimates that the process can sequester 0.58 mt CO2 eq per dry ton of biosolids. [22]

Biochar product used n Horticulture
(photo courtesy of Wakefield Biochar)

Another advantage to using pyrolysis is that the elevated process temperatures and conditions destroys persistent organic pollutants. Perfluoroalkyl and polyfluoroalkyl substances, or PFAS, are a family of industrially produced chemicals that are found in many consumer products, such as teflon, cosmetics, and food packaging. They are sometimes called "forever chemicals" because they persist in the environment and do not breakdown naturally. PFAS compounds are emerging pollutants of concern because of their adverse human health effects, such as certain cancers, liver damage, decreased fertility, and increased risk of asthma and thyroid disease. Much attention has been given recently to PFAS in contaminated wastes, such as sludges, landfill leachates, and solid wastes.

MES has been developing a capital improvement program to be employed at one of our wastewater treatment facilities, the Dorsey Run Advanced WWTP located in Anne Arundel County. This funding request is to design and construct a pyrolysis facility at Dorsey to treat the WWTP's sludge to meet the EPA's Class A standards (thereby destroying all the pathogens in the sludge) and producing biochar for beneficial reuse. Some providers of this technology have also developed innovative uses for the biochar, such as producing carbon black, paint tint, plastics, and consumer grade charcoal.

Water / Wastewater Services Projects

MES is planning for two clean energy projects at one State facility, the Dorsey Run Advanced Wastewater Treatment Plant (AWWTP). As part of a Preliminary Engineering Report (PER) effort currently being prepared for this facility, MES has directed the consultant to plan for installing solar panels on the facility roofs, and to include EV charging infrastructure at the site.

Current plans include installing Level 2 EV chargers for nine vehicles. These chargers will primarily service light-duty pickup trucks. These are the types of vehicles that are used by staff stationed at Dorsey when they are doing their daily rounds. Assuming a typical EV pick-up truck is used (i.e., Ford Lightning F-150), and an average mileage used at 12,000 miles per year per vehicle, the carbon offsets achieved from the use of nine EVs is estimated to be approximately 25 mt CO_2 eq/yr.

Details for the solar panels are currently unknown. We anticipate that these projects will be completed in FY25.

Report Summary and Conclusions

Carbon offsets were achieved in FY23 across all of MES' operating programs as a result of our ongoing operations. Our Environmental Operations Group's materials recycling facilities (MRFs) in Prince George's and Montgomery counties offset 87,085 mt CO_2 eq. and 115,065 mt CO_2 eq. of carbon emissions, respectively. Diverting food waste from the landfill the Prince George's County Organics Composting Facility achieved 6,638 mt CO2 eq of carbon offsets. An innovative application of a Stirling engine is reducing methane emissions from the closed Midshore I Landfill in Talbot County, Maryland.

Our Water and Wastewater Program beneficially reused approximately 53% (on a dry basis) of the approximately 3,000 dry tons of biosolids generated at our facilities in FY23. Modeling showed that 7,749 mt CO2 eq. of emissions was avoided by land applying the biosolids. Future MES projects are planning for the installation of solar panels at our facilities and deploying EVs for staff use.

MES' Fleet Department has procured two more EVs for use in our pool vehicle inventory. A procurement has also been advertised to install two more Level Two chargers at our Headquarters. Also, bids have been received to supply new, additional BGE power to our HQ building, which will give us the capacity to install 12 new EV charging ports.

Solar energy projects are currently either on-line or in the planning stages. The existing solar arrays at our Headquarters generated a total of 536,840 kwh in FY23, equivalent to offsetting 380 mt CO2 eq. per year. Our Technical and Environmental Services group has contracts pending for the installation of solar panels at multiple buildings at two State Parks that will generate a targeted 200,094 kwh/year, equivalent to offsetting 142 mt CO2 eq. per year.

On behalf of the Maryland Port Administration (MPA), MES' Environmental Dredging and Restoration Program continued managing the Dray Truck Replacement Program. This initiative, which uses EPA grant funding, works with companies at the Port of Baltimore to replace older, more polluting diesel trucks and equipment with newer equipment that generates less emissions. We estimate that greenhouse gases will be reduced by 387 mt CO_2 eq per year because of these replacements.

In accordance with our organization-wide goals, we attempted to quantify our CY22 baseline carbon footprint. In doing so, we will know where to direct our future efforts towards reducing greenhouse gas emissions. This exercise will continue in FY24, where we will refine our calculations to determine our carbon footprint for CY23 operations.

REFERENCES

[1] *2022 Annual Report*, Maryland Commission on Climate Change, November 2022

[2] *IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,* Masson-Delmotte, V., et. al, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32

[3] *Reducing Greenhouse Gas Emissions in Maryland: A Progress Report,* Maryland Department of the Environment, September 2022

[4] *EPA Diesel Emissions Quantifier (DEQ) Tool,* https://cfpub.epa.gov/quantifier/index.cfm?action=main.home , U.S. Environmental Protection Agency

[5] *Baltimore Harbor Anchorages and Channels Modification of Seagirt Loop Channel,* U. S. Army Corps of Engineers, June 2023*, https://www.nab.usace.army.mil/Missions/Civil-Works/Seagirt-Loop-Channel/*

[6] *Reclaiming Energy from Methane at* Maryland *Landfill,* Waste Today, September 20, 2022

[7] *EPA WARM Tool, v.15.1,* U.S. EPA, https://www.epa.gov/warm/versions-waste-reduction-model-warm#15

[8] *Composting and Greenhouse Gas Emissions: A Producer's Perspective,* Brown, S. and Subler, S., BioCycle, March 2007, Vol 48, No. 3

[9] *Food: Material- Specific Data*, U.S. EPA, https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/food-material-specific-data#:~:text=EPA%20estimates%20that%20in%202019,beverage%20manufacturing%20and%20processing%20sectors.

[10] *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM), Management Practices Chapters,* U.S. EPA, November 2020

[11] *More than half of new U.S. electric generating capacity in 2023 will be solar,* U.S. Department of Energy, Energy Information Administration, https://www.eia.gov/todayinenergy/detail.php?id=55419

[12] National Biosolids Data Project, https://www.biosolidsdata.org/, National Biosolids Data Project Collaboration

[13] North East Biosolids and Residuals Association (NEBRA), Northern Tilth LLC, and Northwest Biosolids, 2022. Estimating greenhouse gas emissions from biosolids management. BEAM*2022 spreadsheet model and supporting information, https://www.BiosolidsGHGs.org

[14] *Soil carbon response to long-term biosolids application,* Villa Y.B and Ryals, Journal of Environmental Quality, September/October 2021

[15] *Building Carbon Credits with Biosolids Recycling,* Brown, S., BioCycle September 2004, Vol. 45, No. 9, p. 25

[16] *EPA's Greenhouse Gas Equivalencies Calculator* , https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator , U.S. Environmental Protection Agency

[17] *Simplified GHG Emissions Calculator*, https://www.epa.gov/climateleadership/simplified-ghg-emissions-calculator , U.S. Environmental Protection Agency, EPA Center for Corporate Climate Leadership

[18] *EPA Local Greenhouse Gas Inventory Tool*, https://www.epa.gov/statelocalenergy/local-greenhouse-gas-inventory-tool , U.S. Environmental Protection Agency

[19] *Driving Energy Efficiency in the U.S. Water & Wastewater Industry by Focusing on Operating and Maintenance Cost Reductions,* Hamilton, G, et.al., 2009 ACEEE Summer Study on Energy Efficiency in Industry.

[20] *Are Electric Vehicles Definitely Better for The Climate Than Gas-Powered Cars?, https://climate.mit.edu/ask-mit/are-electric-vehicles-definitely-better-climate-gas-powered-cars#:~:text=The%20researchers%20found%20that%2C%20on,vehicle%20created%20just%20200%20grams. ,* MIT Climate Portal

[21] *Beyond Tailpipe Emissions Calculator,* https://www.fueleconomy.gov/feg/Find.do?action=bt2, U.S. Department of Energy

[22] *Bioforcetech: Sustainable Biosolids Management System,* Presentation to North East Biosolids and Residuals Management Association, July 2023

Maryland
ENVIRONMENTAL
SERVICE

259 Najoles Road
Millersville, MD 21108
410-729-8200