Maryland
Department of
the Environment

Appendix C

Greenhouse Gas Emission Projections Documentation (2014-2030)

2030 GGRA Plan

Maryland
Department of
the Environment

Larry Hogan
Governor

Boyd Rutherford
Lieutenant Governor

Ben Grumbles
Secretary

State of Maryland

Greenhouse Gas Emission Projections Documentation (2014 -2030)

November 8, 2018

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Maryland Department of the Environment
2030 Business-as-Usual (BAU) Greenhouse Gas Emissions Projection

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ACKNOWLEDGEMENTS

The Maryland Department of the Environment (MDE) appreciates the time and assistance provided by numerous contacts throughout Maryland, in neighboring States, and at federal agencies. Special appreciation is extended to the staff at several Maryland State Agencies for their input, in particular to:

- Office of Surface Mining Reclamation and Enforcement, with particular thanks to Cunningham, Thomas.
- PJM with particular thanks to staff member Ken Schuyler
- Maryland Forest Services, with particular thanks to Forester Robert Felft
- Maryland Department of Agriculture, particular thanks to Philip Davidson
- Controller of Maryland-Field Enforcement Division, particular thanks to Chuck Ulm

MDE would also like to express their appreciation to staff at MDE Air and Radiation Administration (ARA) compliance unit and Solid Waste-waste diversion division who provided valuable data during the development of this report.

Source Documentation:

- MDE-Air and Radiation Administration
    - MDE – ARA Compliance Program
    - MDE – ARA Permits Program
    - MDE – ARA Air Quality Planning Program
    - MDE – ARA Mobile Source Program
    - MDE – Solid Waste Program

- Maryland Department of Labor, License and Regulation
- Maryland Department of Transportation
- Maryland Department of Planning

Lead Agency and Quality Assurance:MDE ARA Air Quality Policy & Planning Division

MDE is the agency responsible for preparing and submitting the completed baseline GHG emissions inventory for Maryland. The MDE ARA Air Quality Planning Division compiled the GHG emissions inventory for the State of Maryland.

Acronyms and Key Terms

BOD	Biochemical Oxygen Demand
Btu	British Thermal Unit
C	Carbon*
$CaCO_3$	Calcium Carbonate
CCS	Center for Climate Strategies
CEC	Commission for Environmental Cooperation in North America
CFCs	Chlorofluorocarbons*
CH_4	Methane*
CO	Carbon Monoxide*
CO_2	Carbon Dioxide*
CO_2e	Carbon Dioxide Equivalent*
CRP	Federal Conservation Reserve Program
DOE	Department of Energy
DOT	Department of Transportation
EEZ	Exclusive Economic Zone
EIA	US DOE Energy Information Administration
EIIP	Emission Inventory Improvement Program
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FAPRI	Food and Agricultural Policy Research Institute
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FIA	Forest Inventory Analysis
Gg	Gigagrams
GHG	Greenhouse Gas*
GWh	Gigawatt-hour
GWP	Global Warming Potential*
H_2O	Water Vapor*
HBFCs	Hydrobromofluorocarbons*
HC	Hydrocarbon
HCFCs	Hydrochlorofluorocarbons*
HFCs	Hydrofluorocarbons*

HWP	Harvested Wood Products
IPCC	Intergovernmental Panel on Climate Change*
kg	Kilogram
km^2	Square Kilometers
kWh	Kilowatt-hour
lb	Pound
LF	Landfill
LFG	Landfill Gas
LFGTE	Landfill Gas Collection System and Landfill-Gas-to-Energy
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MAAC	Mid-Atlantic Area Council
MANE-VU	Mid-Atlantic/Northeast Visibility Union
MDDNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
Mg	Megagram
MMBtu	Million British Thermal Units
MMt	Million Metric Tons
MMtC	Million Metric Tons Carbon
$MMtCO_2e$	Million Metric tons Carbon Dioxide Equivalent
MSW	Municipal Solid Waste
Mt	Metric ton (equivalent to 1.102 short tons)
MWh	Megawatt-hour
N_2O	Nitrous Oxide*
NASS	National Agriculture Statistical Service
NEI	National Emissions Inventory
NEMS	National Energy Modeling System
NF	National Forest
NMVOCs	Nonmethane Volatile Organic Compound*
NO_2	Nitrogen Dioxide*
NO_x	Nitrogen Oxides*
O_3	Ozone*
ODS	Ozone-Depleting Substance*
OH	Hydroxyl Radical*

OPS	Office of Pipeline Safety
PFCs	Perfluorocarbons*
ppb	Parts per Billion
ppm	Parts per Million
ppt	Parts per Trillion
ppmv	Parts per Million by Volume
RCI	Residential, Commercial, and Industrial
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
SAR	Second Assessment Report*
SED	State Energy Data
SF_6	Sulfur Hexafluoride*
Sinks	Removals of carbon from the atmosphere, with the carbon stored in forests, soils, landfills, wood structures, or other biomass-related products.
SIT	State Greenhouse Gas Inventory Tool
SO_2	Sulfur Dioxide*
t	Metric Ton
T&D	Transmission and Distribution
TAR	Third Assessment Report*
TOG	Total Organic Gas
TWh	Terawatt-hour
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
VMT	Vehicle Mile Traveled
VOCs	Volatile Organic Compound*
WW	Wastewater
yr	Year

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1.0 EXECUTIVE SUMMARY

1.1 OVERVIEW

This document describes the procedures the Maryland Department of the Environment (MDE) used to project the greenhouse gas (GHG) emissions that would occur in Maryland in year 2030, under a Business as Usual (BAU) scenario, where no new measures or policies to reduce GHG emissions are implemented. The analysis is provided to assess the amount of GHG reductions necessary to achieve the Maryland Greenhouse Gas Emissions Reduction Act of 2016 (GGRA) goal of a 40% reduction in GHG emissions by 2030 from a 2006 baseline.

The 2030 BAU GHG emissions projection uses the Maryland 2014 Periodic GHG emissions Inventory as the reference Base Year. Surrogate growth factors were developed and applied to the 2014 Base Year to project the GHG emissions from 2014 to 2030. As fully described in the Base Year 2014 Inventory documentation[1], the emission sources are divided into the following eight source categories:

- Electricity Supply
- Residential, Commercial, and Industrial (RCI) Fuel Combustion
- Transportation Energy Use
- Industrial Processes
- Fossil Fuel Production Industry
- Agriculture
- Waste Management
- Forestry and Land Use

The emission projection estimates outlined in this document have been calculated on a state-wide basis and have not been spatially allocated to the county level unless otherwise stated. Descriptions of each emission source category are presented in the following sections.

1.2 Business-Business-as-Usual 2030 Emissions

Maryland's anthropogenic 2030 BAU GHG emissions and anthropogenic sinks (carbon storage) were estimated by projecting Maryland's GHG emissions from a 2014 Base Year using derived growth factors, specific to each of the different sectors. Sector specific growth factors were derived from several surrogate future growth forecast sources including:

- Maryland Department of Planning; "Population and Household Population Projections[2]"
- Maryland Department of Transportation; "On-Road Inventory Development Process[3]"
- Maryland Department of Labor, Licensing and Regulation; "Maryland Industrial Projection Workforce Information and Performance (2014-2024)[4]"
- PJM Load Forecast Report[5]
- EPA State Inventory Tool (SIT) Projection Tools[1]

[1] http://mde.maryland.gov/programs/Air/ClimateChange/Pages/GreenhouseGasInventory.aspx
[2] https://planning.maryland.gov/MSDC/Pages/s3_projection.aspx
[3] http://mde.maryland.gov/programs/Air/ClimateChange/MCCC/STWG/OnRoadInventoryMDOT.pdf
[4] http://www.dllr.state.md.us/lmi/iandoproj/industry.shtml
[5] http://pjm.com/~/media/library/reports-notices/load-forecast/2016-load-report.ashx

Table ES-1 correlates the 2014 GHG emission inventory source sector with the surrogate used for growth and the place where the surrogate growth data was obtained.

Table ES-1: GHG Source Categories – Growth Factor Surrogate and Source

Source Category	Surrogate Growth Factor	Source of Surrogate Data	URL
Electricity Supply	Electricity Consumption	PJM Load Forecast	http://pjm.com/~/media/library/reports-notices/load-forecast/2016-load-report.ashx
Residential Fuel Consumption	Housing Data	Maryland Department of Planning	https://planning.maryland.gov/MSDC/Pages/s3_projection.aspx
Commercial and Industrial Fuel Consumption	Employment Data	Maryland Department of Labor, Licensing & Regulation	http://www.dllr.state.md.us/lmi/iandoproj/industry.shtml
On-Road Transportation	Vehicle Miles Traveled	Maryland Department of Transportation	https://planning.maryland.gov/MSDC/Pages/s3_projection.aspx
Off-Road Transportation	Non-Road MOVES Model Projection Data	Non-Road MOVES Model	https://www.epa.gov/moves/moves2014a-latest-version-motor-vehicle-emission-simulator-moves
Fossil Fuel Industry	SIT Tool Projections	EPA SIT Projection Tool	https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool
Industrial	SIT Tool Projections	EPA SIT Projection Tool	https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool
Agriculture	SIT Tool Projections	EPA SIT Projection Tool	https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool
Waste Management	County Population	Maryland Department of Planning	https://planning.maryland.gov/MSDC/Pages/s3_projection.aspx

Emissions projections are assumed to indicate only what the future emissions would be if the assumptions that underpin the projections continue to occur. Projections are not forecasts or predictions about what will happen. In the preparation of these projections therefore, MDE assumptions are based on the forecasted growth in the gross domestic product, population, and economic growth, consistent with the MDE understanding of these assumptions as the expected drivers of future emissions.

[1] https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool

1.3 Projection Results

The projected 2030 GHG BAU emissions in Maryland were based on the Maryland statewide GHG emissions inventory for the base Year 2014 with respect to existing policy and regulations, without any consideration for any new policy or regulation implementation to reduce the GHG emissions from the base Year 2014. Year 2030 emissions were estimated to be approximately 106.04 million metric tons (MMT) of *gross*[1] CO_2e emissions (consumption basis).

Estimates of carbon sinks within Maryland's forests, including urban forests and land use changes, have been kept constant in this projection due to lack of reliable data and estimation methodology. The current estimates of 11.65 $MMTCO_2e$ was retained as the estimated amount of Forest biomass and agricultural soils carbon sinks that will be stored in 2030 in Maryland. This leads to *net projected* emissions of 94.40 $MMTTCO_2e$ in Maryland in 2030. Table ES-2 provides a summary of the projected 2030 GHG emissions for Maryland.

There are three principal sources of GHG emission in Maryland: electricity consumption; transportation; and residential, commercial, and industrial (RCI) fossil fuel use. Electricity consumption emissions are projected to account for 34% of gross GHG emissions in 2030. Transportation is projected to account for 40% of Maryland's gross GHG emissions in 2030, while RCI fuel use is projected to account for 16% of Maryland's 2030 gross GHG emissions. A graphical representation of the 2030 GHG emissions by source sector is presented in Figure ES-1.

[1] Excluding GHG emissions removed due to forestry and other land uses.

Figure ES-1: Gross Projected GHG Emissions by Sector, 2030, Maryland

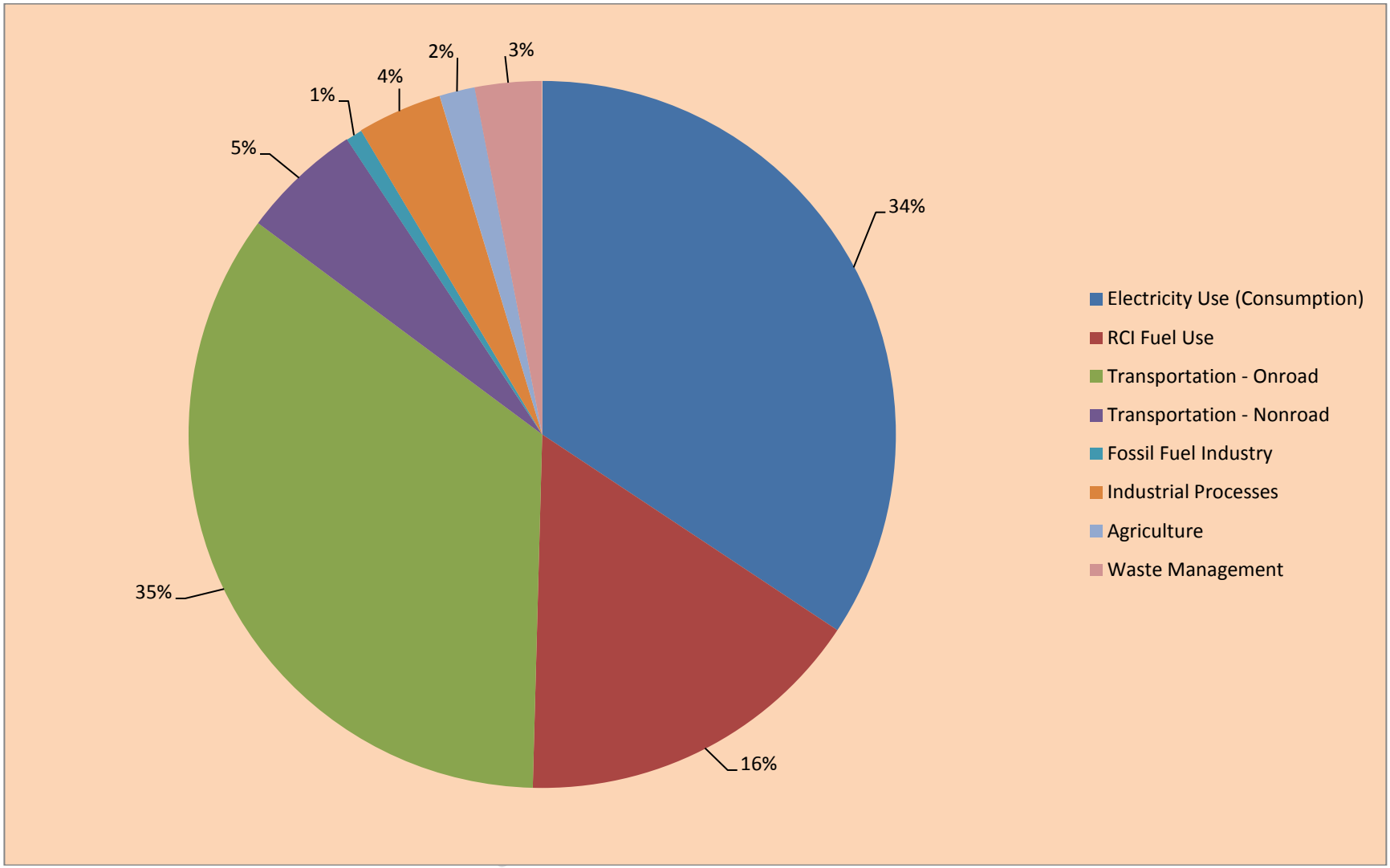
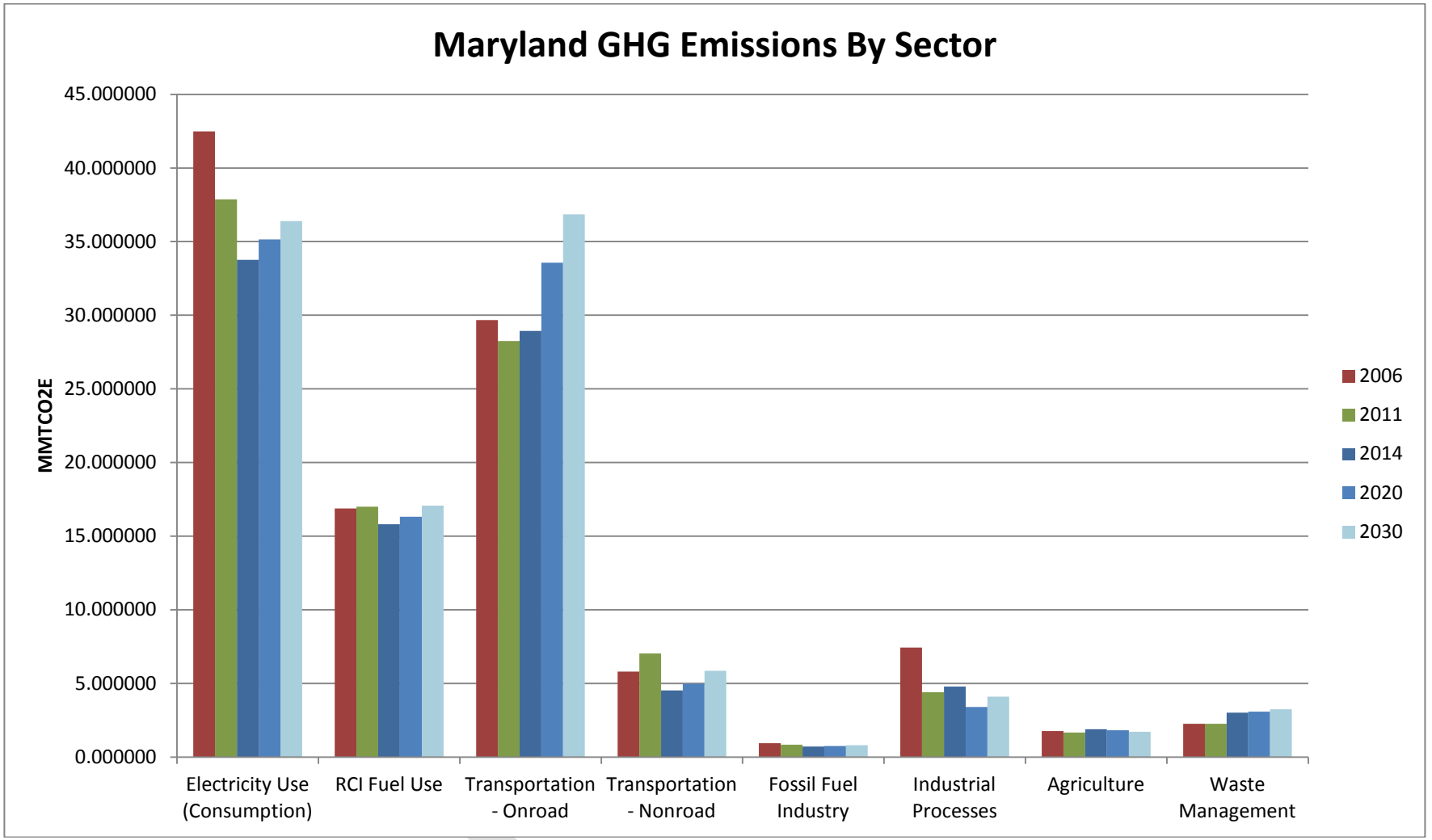


Figure ES-1 shows the how each sector contributes to the projected 2030 greenhouse gas emissions. Below, Figure ES-2 shows another representation of how each sector contributes to greenhouse gas emissions in mmtCO_2.

Figure ES-2: Maryland GHG Projected Emissions by Sector



Maryland's projected emission in 2030 (106.04 $MMTCO_2E$) will represent a slight decline in GHG emission from the 2006 Base Year.

1.5 EMISSIONS SUMMARY

Table ES-2: Maryland 2030 GHG Emissions Projection, by Sector

Source Category	Fuel Type	Year			
		2006 ($MMtCO_2e$)	2011 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
Energy Use (CO_2, CH_4, N_2O)		95.75995003	**90.966191**	**83.737002**	**96.97318**
Electricity Use (Consumption)[b]		42.**47567455**	**37.86012929**	**33.760155**	**36.402415**
	Electricity Production (in-state)	**32.16484764**	**24.546391**	**19.911764**	**21.4704556**
	Coal	28.27769105	21.931503	18.395077	19.8347717
	CO_2	28.13057387	21.84771288	18.270289	19.7001826
	CH_4	0.006356915	0.008782304	0.029584	0.03190727
	N_2O	0.140760271	0.075008138	0.095204	0.10268183
	Natural Gas	3.649880813	2.418826	1.116462	1.20414343
	CO_2	3.64841301	2.41333025	1.083775	1.16888964
	CH_4	0.000592766	0.000878591	0.002444	0.00263548
	N_2O	0.000875036	0.004617224	0.030243	0.03261831
	Oil	0.237275776	0.196062	0.400225	0.43154052
	CO_2	0.236572609	0.194627796	0.399099	0.43032561
	CH_4	0.00017791	0.000100932	0.000309	0.00033312
	N_2O	0.000525257	0.001333067	0.000818	0.0008818
	Wood	0	0.004705	0.000000	0
	CO_2	0	0.004668225	0.000000	0
	CH_4	0	1.16527E-05	0.000000	0
	N_2O	0	2.53259E-05	0.000000	0
	MSW/LFG				
	Net Imported Electricity	10.31082691	**13.30903291**	**13.848392**	**14.9319594**
Residential/Commercial/Industrial (RCI) Fuel Use		16.87079695	**17.000426**	**15.803958**	**17.06540**
	Coal	2.997788692	2.956523	1.507120	1.71561
	CO_2	2.976126985	2.935725929	1.496749	1.70360
	CH_4	0.007134829	0.006470354	0.003227	0.00374
	N_2O	0.014526878	0.014327213	0.007144	0.00827
	Natural Gas & LPG	9.21041471	**9.981745**	**10.710212**	11.46348
	CO_2	9.18802397	9.956569199	10.682922	11.43444
	CH_4	0.016000535	0.01780597	0.019803	0.02109
	N_2O	0.006390205	0.007370279	0.007487	0.00796
	Petroleum	4.576524718	**3.951282**	**3.472479**	**3.76789**
	CO_2	4.557477225	3.935724312	3.458150	3.75206
	CH_4	0.008508848	0.006658166	0.006760	0.00730
	N_2O	0.010538645	0.008899469	0.007569	0.00853
	Wood	0.086068834	**0.110875**	**0.113322**	**0.11842**
	CO_2	0	0	0.000000	0.00000
	CH_4	0.061142772	0.081869159	0.087520	0.090688
	N_2O	0.024926062	0.029005541	0.025801	0.02774

Source Category	Fuel Type	Year			
		2006 ($MMtCO_2e$)	2011 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
Transportation		35.47159388	**35.269544**	**33.452999**	**42.7032357**
	Onroad Gasoline	23.7595	22.526256	22.555441	28.7261932
	CO_2	23.195	22.51905514	22.472039	28.6199748
	CH_4	0.0462	0.006365838	0.006896	0.00878288
	N_2O	0.5183	0.000835306	0.076505	0.09743548
	Nonroad Gasoline	1.044117546	**2.736630**	**1.106684**	**1.36134321**
	CO_2	1.039550516	2.73189329	1.083478	1.32505867
	CH_4	0.000920455	0.000945048	0.023206	0.02305543
	N_2O	0.003646576	0.003791989	0.000000	0.00000000
	Onroad Diesel	5.9103	**5.720819**	**6.381042**	**8.1267778**
	CO_2	5.907	5.720528739	6.360214	8.10025167
	CH_4	0.0003	8.14833E-05	0.000096	0.00012165
	N_2O	0.003	0.000209191	0.020732	0.02640448
	Nonroad Diesel	1.503926174	**2.155778**	**1.994101**	**2.66266107**
	CO_2	1.488082933	2.133145965	1.993972	2.66252129
	CH_4	0.004221409	0.006155096	0.000130	0.00013978
	N_2O	0.011621832	0.016476938	0.000000	0.00000000
	Rail	0.238839589	**0.187039**	**0.187038**	**0.18703846**
	CO_2	0.236600579	0.185305079	0.185304	0.18530411
	CH_4	0.000391175	0.000303006	0.000303	0.00030301
	N_2O	0.001847835	0.001431341	0.001431	0.00143134
	Marine Vessels (Gas & Oil)	0.997636149	**0.353949**	**0.124965**	**0.1780107**
	CO_2	0.988598138	0.350663389	0.123832	0.17639727
	CH_4	0.00147329	0.000535566	0.000188	0.00026787
	N_2O	0.00756472	0.002749902	0.000945	0.00134556
	Lubricants, Natural Gas, and LPG	0.295955146	**0.455045**	**0.279941**	**0.37061003**
	CO_2	0.295955146	0.455044849	0.275343	0.36452274
	CH_4	0	0	0.00459805	0.00761276
	N_2O	0	0	0	0.00000000
	Jet Fuel and Aviation Gasoline	1.721319275	**1.134027**	**0.823787**	**1.09060121**
	CO_2	1.703343607	1.12251132	0.815404	1.07950256
	CH_4	0.001626024	0.000882398	0.000668	0.00088412
	N_2O	0.016349643	0.01063328	0.007716	0.01021453
Fossil Fuel Industry		0.941884638	**0.836092**	**0.719889**	**0.8021223**
	Natural Gas Industry	0.811536367	0.694295	0.584861	0.65558129
	CO_2	0.000128636	0.000327149	0.000353	0.00039475
	CH_4	0.811336294	0.693785907	0.584313	0.65496732
	N_2O	7.14367E-05	0.000181679	0.000196	0.00021922
	Oil Industry	0	0.000000	0.000000	0.00000000
	CO_2	0	0	0.000000	0.00000000
	CH_4	0	0	0.000000	0.00000000
	N_2O	0	0	0.000000	0.00000000
	Coal Mining	0.130348272	0.141797468	0.135028	0.14654101
	CO_2	0	0	0.000000	0.00000000

Source Category	Fuel Type	Year			
		2006 ($MMtCO_2e$)	2011 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
	CH_4	0.130348272	0.141797468	0.135028	0.14654101
	N_2O	0	0	0.000000	0.00000000
Industrial Processes		7.441042334	**4.398573**	**4.784851**	**4.10595168**
	Cement Manufacture	1.483241728	0.918256	1.580721	1.96165908
	CO_2	1.483241728	0.918255613	1.580721	1.96165908
	CH_4	0	0	0.000000	0.00000000
	N_2O	0	0	0.000000	0.00000000
	Limestone and Dolomite	0.113941192	0.08560464	0.143916	0.18688424
	CO_2	0.113941192	0.08560464	0.143916	0.18688424
	CH_4	0	0	0.000000	0.00000000
	N_2O	0	0	0.000000	0.00000000
	Soda Ash	0.04761102	0.040365129	0.039670	0.03172051
	CO_2	0.04761102	0.040365129	0.039670	0.03172051
	CH_4	0	0	0.000000	0.000000
	N_2O	0	0	0.000000	0.00000000
	Iron and Steel	3.597116387	0.90971244	0.000000	0.00000000
	CO_2	3.597116387	0.90971244	0.000000	0.00000000
	CH_4	0	0	0.000000	0.00000000
	N_2O	0	0	0.000000	0.00000000
	ODS Substitutes	1.971282442	2.276383733	2.972674	1.9013601
	CO_2	0	0	0.000000	0.0000000
	CH_4	0	0	0.000000	0.0000000
	HFC, PFC, SF_6	1.971282442	2.276383733	2.972674	1.9013601
	Electricity Transmission and Dist.	0.227222585	0.1673	0.047322	0.02379465
	CO_2	0	0	0.000000	0.00000000
	CH_4	0	0	0.000000	0.00000000
	HFC, PFC, SF_6	0.227222585	0.1673	0.047322	0.02379465
	Semiconductor Manufacturing	0	0	0.000000	0.00000000
	CO_2	0	0	0.000000	0.00000000
	CH_4	0	0	0.000000	0.00000000
	HFC, PFC, SF_6	0	0	0.000000	0.00000000
	Ammonia and Urea Production (Nonfertilizer Usage)	0.000626981	0.00095119	0.000548	0.00053311
	CO_2	0.000626981	0.00095119	0.000548	0.00053311
	CH_4	0	0	0.000000	0.00000000
	HFC, PFC, SF_6	0	0	0.000000	0.00000000
	Aluminum Production	0	0	0.000000	0.00000000
	CO_2	0	0	0.000000	0.00000000
	CH_4	0	0	0.000000	0.00000000
	HFC, PFC, SF_6	0	0	0.000000	0.00000000
Agriculture		1.771426158	**1.661948**	**1.892149**	**1.71831397**
	Enteric Fermentation	0.41906793	0.371870	0.337974	0.31980921
	CO_2	0	0	0.000000	0.00000000
	CH_4	0.41906793	0.371869619	0.337974	0.31980921
	N_2O	0	0	0.000000	0.00000000

Source Category	Fuel Type	Year			
		2006 ($MMtCO_2e$)	2011 ($MMtCO_2e$)	2014 ($MMtCO_2e$)	2030 ($MMtCO_2e$)
	Manure Management	0.32126318	0.324513	0.320611	0.33708254
	CO_2	0	0	0.000000	0.00000000
	CH_4	0.091393836	0.094279619	0.090378	0.09502113
	N_2O	0.229869344	0.230233016	0.230233	0.24206141
	Agricultural Soils	1.019673739	0.954137285	0.993803	0.79393854
	CO_2	0	0	0.000000	0.00000000
	CH_4	0	0	0.000000	0.00000000
	N_2O	1.019673739	0.954137285	0.993803	0.79393854
	Agricultural Burning	0.006273052	0.006280	0.234613	0.26147327
	CO_2	0	0	0.000000	0.00000000
	CH_4	0.003893109	0.003780396	0.143309	0.15971573
	N_2O	0.002379944	0.002499543	0.091304	0.10175754
	Urea Fertilizer Usage	0.005148257	0.005148257	0.005148	0.00601040
	CO_2	0.005148257	0.005148257	0.005148	0.00601040
	CH_4	0	0	0.000000	0.00000000
	N_2O	0	0	0.000000	0.00000000
Waste Management		2.257117951	**2.257118**	**3.0069**	**3.24201588**
	Waste Combustion	1.292301717	**1.429459**	**1.297629**	1.42275964
	CO_2	1.272171161	1.429417755	1.297587	1.42271392
	CH_4	0	8.86112E-06	0.000009	0.0000009
	N_2O	0.020130556	3.27724E-05	0.000033	0.000035933
	Landfills	0.388955279	**0.555365**	**1.1079**	**1.2147575**
	CO_2	0.151585044	0.467790091	0.313143	0.343339
	CH_4	0.237370235	0.087575305	0.79480	0.8714185
	N_2O	0	0	0.000000	0.0000000
	Wastewater Management	0.542860955	**0.558046**	**0.568317**	0.56831654
	CO_2	0	0	0.000000	0
	CH_4	0.377311419	0.392496531	0.402767	0.40276700
	N_2O	0.165549536	0.165549536	0.165550	0.16554954
	Residential Open Burning	0.033	**0.033000**	**0.033000**	**0.0361822**
	CO_2	0.033	0.033	0.033000	0.0361822
	CH_4	0	0	0.000000	0.0000000
	N_2O	0	0	0.000000	0.0000000
Gross Emissions (Consumption Basis, Excludes Sinks)		**107.2295365**	**99.283830**	**93.4209**	**106.03946**
Emissions Sinks		-11.79034917	-11.847884	-11.650369	-11.6504
	Forested Landscape	-10.44657783	-10.44657783	-10.4466	-10.4466
	Urban Forestry and Land Use	-1.331309142	-1.433719701	-1.2009	-1.2009
	Agricultural Soils (Cultivation Practices)	-0.051420445	-0.021306845	-0.0514	-0.0514
	Forest Fires	0.038958248	0.053720414	0.0485	0.0485
	CH_4	0.032452487	0.044749474	0.0404	0.0404
	N_2O	0.00650576	0.008970941	0.0081	0.0081
Net Emissions (Consumptions Basis) (Including forestry, land use, and ag sinks)		95.4391873	**87.435946**	**81.7705**	**94.38909**

2.0 Emission Projection Methodology

2.1 OVERVIEW

This section describes the data sources, key assumptions, and the methodology used to develop the 2030 BAU emission projection estimate for Maryland. The 2030 business-as-usual GHG emission inventory was estimated by projecting Maryland Base Year 2014 GHG Emissions, using Maryland specific growth factors for each of the different economic sectors. Growth factors are derived from several sources including; business economics employment projections, housing projections data and on-road mobile vehicle miles traveled projection data from MDOT. For the electricity consumption sector, the region's electrical load projection from PJM, the regional transmission organization, was used to develop the growth factors for the consumption of electrical energy. In all cases, the projection calculations reflect economic data or some other activity patterns to estimate future emissions. The 2030 projection uses the following general equations to estimate emissions by sector and by pollutant type:

2030 BAU Forecast (MMT) = **2014 Base Year Emissions (MMT)** x **Growth Factor (2015-2030)**

2.2 Electricity Supply by PJM

GHG emissions from the electrical sector are estimated on a consumption basis. As such, the electricity supply sector accounts for emissions occurring as a result of the combustion of fossil fuel at electricity generating facilities located both in and outside of the State. Carbon dioxide (CO_2) represented more than 99.5% of total sector emissions, with methane (CH_4) and nitrous oxide (N_2O) CO_2-equivalent emissions comprising the balance.

Maryland is a net importer of electricity, meaning that the State consumes more electricity than is produced in the State. For this projection, it was assumed that all power generated in Maryland was consumed in Maryland, and that remaining electricity demand was met by imported power.

The 2030 in-state and imported electricity generation emissions were derived from the statewide electricity demand forecasts by PJM Interconnection[1], a regional transmission organization (RTO), that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia). The projected PJM electrical consumption forecast was applied to the fuel-specific 2014 GHG emissions from the Electricity Consumption Sector.

The PJM load forecast model is an econometric model that produced estimates of non-coincident and coincident peak loads for each PJM zone, location deliverability area (LDA) and the RTO. It

[1] http://www.pjm.com/~/media/library/reports-notices/load-forecast/2016-load-report.ashx

uses local economic activity, weather, and day-type variables as explanatory variables/drivers. The model uses trends in equipment and appliance usage, anticipated economic growth and historical weather patterns to estimate growth in peak load and energy use. Recent improvements to the model include the addition of variables that reflect consumer behavioral trends to capture reductions in electricity use from more efficient lighting, air conditioning and heating, electronics and industrial processes.

The forecasted load demand in Maryland was used as a surrogate growth factor for both the in-state and imported electricity generation emissions in 2030. The 2030 Business-as-Usual emissions projection for the electric power sector is 36.40 $MMTCO_2E$.

Table 2.1: Maryland Base Year 2014 Electric Sector GHG Emissions, by Fuel Type

		Emissions	Emissions	Emissions	Emissions
	Consumption	CO_2	CH_4	N_2O	Total
Fuel Type	(Billion Btu)	($MMTCO_2E$)	($MMTCO_2E$)	($MMTCO_2E$)	($MMTCO_2E$)
Coal	186,207.44	18.2702886	0.02958395	0.095204565	18.39507712
Petroleum	3,901.03	0.399098633	0.000308856	0.000817578	0.400225068
Natural Gas	18,638.71	1.083775233	0.002443579	0.030242811	1.116461623
		19.7532	**0.0323**	**0.1263**	**19.9118**

Table 2.2: Maryland Electric Sector GHG Projection Emissions by Fuel Type

Fuel Type	2014 Emissions ($MMTCO_2E$)	2020 Emissions ($MMTCO_2E$)	2025 Emissions ($MMTCO_2E$)	2030 Emissions ($MMTCO_2E$)
Coal	18.2702886	19.02153	19.27427	19.69985
Petroleum	0.39909863	0.415509	0.42103	0.430326
Natural Gas	1.08377523	1.128338	1.14333	1.168575
TOTAL	**19.7531625**	**20.56538**	**20.83863**	**21.29875**

Table 2.3: Electricity Usage Sector (Consumption-Based) Growth Factor

PJM MID-ATLANTIC LOAD FORECAST[1]																
	2014	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
AE	10,531	10,399	10,407	10,441	10,441	10,387	10,328	10,315	10,309	10,340	10,303	10,282	10,260	10,267	10,224	10,175
			0.10%	0.30%	0.00%	-0.50%	-0.60%	-0.10%	-0.10%	0.30%	-0.40%	-0.20%	-0.20%	0.10%	-0.40%	-0.50%
BGE	32,863	34,075	34,236	34,461	34,568	34,640	34,644	34,789	34,934	35,200	35,259	35,402	35,552	35,826	35,908	36,003
			0.50%	0.70%	0.30%	0.20%	0.00%	0.40%	0.40%	0.80%	0.20%	0.40%	0.40%	0.80%	0.20%	0.30%
DPL	18,753	19,108	19,277	19,439	19,519	19,561	19,551	19,608	19,671	19,816	19,846	19,918	20,002	20,155	20,185	20,205
			0.90%	0.80%	0.40%	0.20%	-0.10%	0.30%	0.30%	0.70%	0.20%	0.40%	0.40%	0.80%	0.10%	0.10%
JCPL	23,172	22,880	23,151	23,437	23,531	23,383	23,260	23,288	23,337	23,471	23,453	23,491	23,558	23,700	23,736	23,733
			1.20%	1.20%	0.40%	-0.60%	-0.50%	0.10%	0.20%	0.60%	-0.10%	0.20%	0.30%	0.60%	0.20%	0.00%
METED	15,606	16,014	16,245	16,483	16,607	16,610	16,617	16,729	16,842	17,028	17,113	17,259	17,428	17,643	17,794	17,916
			1.40%	1.50%	0.80%	0.00%	0.00%	0.70%	0.70%	1.10%	0.50%	0.90%	1.00%	1.20%	0.90%	0.70%
PECO	40,910	41,882	42,434	42,989	43,274	43,236	43,211	43,435	43,692	44,121	44,290	44,585	44,946	45,444	45,765	46,049
			1.30%	1.30%	0.70%	-0.10%	-0.10%	0.50%	0.60%	1.00%	0.40%	0.70%	0.80%	1.10%	0.70%	0.60%
PENLC	18,057	18,062	18,049	18,082	18,065	18,129	18,079	18,086	18,071	18,118	18,089	18,116	18,135	18,184	18,157	18,142
			-0.10%	0.20%	-0.10%	0.40%	-0.30%	0.00%	-0.10%	0.30%	-0.20%	0.10%	0.10%	0.30%	-0.10%	-0.10%
PEPCO	31,100	32,057	32,242	32,501	32,644	32,759	32,751	32,879	33,016	33,282	33,357	33,520	33,690	33,955	34,053	34,172
			0.60%	0.80%	0.40%	0.40%	0.00%	0.40%	0.40%	0.80%	0.20%	0.50%	0.50%	0.80%	0.30%	0.30%
PL	40,639	41,380	41,835	42,339	42,563	42,583	42,526	42,710	42,905	43,282	43,400	43,680	43,996	44,439	44,705	44,911
			1.10%	1.20%	0.50%	0.00%	-0.10%	0.40%	0.50%	0.90%	0.30%	0.60%	0.70%	1.00%	0.60%	0.50%
PS	44,118	45,085	45,430	45,811	45,934	45,880	45,678	45,734	45,772	45,953	45,922	45,997	46,072	46,278	46,255	46,209
			0.80%	0.80%	0.30%	-0.10%	-0.40%	0.10%	0.10%	0.40%	-0.10%	0.20%	0.20%	0.40%	0.00%	-0.10%
RECO	1,512	1,535	1,537	1,542	1,541	1,546	1,539	1,538	1,537	1,541	1,539	1,536	1,534	1,536	1,529	1,525
			0.10%	0.30%	-0.10%	0.30%	-0.50%	-0.10%	-0.10%	0.30%	-0.10%	-0.20%	-0.10%	0.10%	-0.50%	-0.30%
UGI	1,055	1,036	1,046	1,056	1,058	1,048	1,042	1,042	1,042	1,045	1,041	1,044	1,045	1,052	1,054	1,055
			1.00%	1.00%	0.20%	-0.90%	-0.60%	0.00%	0.00%	0.30%	-0.40%	0.30%	0.10%	0.70%	0.20%	0.10%
PJM MID-ATLANTIC	278,318	283,513	285,889	288,581	289,745	289,762	289,226	290153	291,128	293,197	293,612	294,830	296,218	298,479	299,365	300,095
			0.80%	0.90%	0.40%	0.00%	-0.20%	0.30%	0.30%	0.70%	0.10%	0.40%	0.50%	0.80%	0.30%	0.20%
FE-EAST	56,835	56,956	57,445	58,002	58,203	58,122	57,956	58,103	58,250	58,617	58,655	58,866	59,121	59,527	59,687	59,791
			0.90%	1.00%	0.30%	-0.10%	-0.30%	0.30%	0.30%	0.60%	0.10%	0.40%	0.40%	0.70%	0.30%	0.20%
PLGRP	41,694	42,416	42,881	43,395	43,621	43,631	43,568	43,752	43,947	44,327	44,441	44,724	45,041	45,491	45,759	45,966
			1.10%	1.20%	0.50%	0.00%	-0.10%	0.40%	0.40%	0.90%	0.30%	0.60%	0.70%	1.00%	0.60%	0.50%
GROWTH FACTOR	**1**	**1.01867**	**1.02720**	**1.03688**	**1.04106**	**1.04112**	**1.03919**	**1.0425**	**1.04603**	**1.05346**	**1.05495**	**1.05933**	**1.06431**	**1.07244**	**1.07562**	**1.07825**

[1] http://pjm.com/~/media/library/reports-notices/load-forecast/2016-load-report.ashx, Table E-1

2.3 Residential, Commercial, and Industrial Sector

This section accounts for emissions associated with direct fossil fuel used in the residential, commercial and the industrial sector to provide space and process heating. Projected BAU growth in emissions in the residential sector is due primarily to the expected increase in housing and assumed increase use of natural gas for office building and small business sources of combustion, including small boilers, water heaters, and appliances in the commercial and industrial sectors.

2.3.1 Residential Sector

To project residential sector emissions, MDE used the Base Year 2014 emissions and estimated 2030 emissions based on the growth in projected households in Maryland. Housing projections were obtained from the Maryland Department of Planning (MDP).

Table 2.3.1: Maryland Base Year 2014 Residential Sector GHG Emissions, by Fuel Type

Fuel Type	Emissions CO_2 ($MMTCO_2E$)	Emissions CH_4 ($MMTCO_2E$)	Emissions N_2O ($MMTCO_2E$)	Emissions Total ($MMTCO_2E$)
Coal	0.0000000000	0.0000000000	0.0000000000	0.0000000000
Distillate Fuel	1.3776390768	0.0039229941	0.0034746519	1.3850367229
Kerosene	0.0247979623	0.0000713540	0.0000631992	0.0249325155
LPG	0.4833485256	0.0016478764	0.0014595477	0.4864559498
Natural Gas	5.0414319192	0.0094802387	0.0027989276	5.0537110855
Wood	**0.0000000000**	0.0687231309	0.0135264575	0.0822495884
			Total	**7.03**

Table 2.3.2: Residential Sector Growth – Housing Projection Estimates[1]

	Census	Census	Census	Census	Census	Projection		Projection		Projection		Projection					
	1970	1980	1990	2000	2010	2015		2020		2025		2030					
	1,174,933	1,460,865	1,748,991	1,980,859	2,156,411	2,242,088		2,325,516		2,416,861		2,503,843					
	Extrapolated Housing Data																
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
House-holds	2,224,952	2,242,088	2,258,773	2,275,459	2,292,145	2,308,830	2,325,516	2,343,785	2,362,054	2,380,323	2,398,592	2,416,861	2,434,258	2,451,654	2,469,050	2,486,447	2,503,843
	Growth Factors																
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Growth Factor	1	1.007701	1.007442	1.007387	1.007333	1.007279	1.007227	1.007856	1.007795	1.0077344	1.007675	1.007617	1.007198	1.007146	1.007096	1.007046	1.006996

Table 2.3.3: Maryland Residential Sector GHG Projection Emissions by Fuel Type

Fuel Type	2014 Emissions ($MMTCO_2E$)	2020 Emissions ($MMTCO_2E$)	2025 Emissions ($MMTCO_2E$)	2030 Emissions ($MMTCO_2E$)
Coal	0.0000000000	0.0000000000	0.0000000000	0.0000000000
Distillate Fuel	1.3850367229	1.3950462145	1.3955859673	1.3947271058
Kerosene	0.0249325155	0.0251126998	0.0251224160	0.0251069554
LPG	0.4864559498	0.4899715076	0.4901610809	0.4898594295
Natural Gas	5.0537110855	5.0902336395	5.0922030852	5.0890692782
Wood	0.0822495884	0.0828439961	0.0828760490	0.0828250460
TOTAL	7.0324	7.0832	7.0859	7.0816

[1] http://www.mdp.state.md.us/msdc/S3_Projection.shtml, Prepared by the Maryland Department of Planning, Projections and State Data Center, August 2017

2.3.2 Commercial and Industrial Sector

To project the commercial and industrial sector emissions, MDE used the Base Year 2014 emissions and projected 2030 emissions based on employment projections from Maryland Department of Labor, Licensing and Regulation (DLLR).

Table 2.3.2: Maryland Base Year 2014 Commercial Sector GHG Emissions, by Fuel Type

Fuel Type	Consumption (Billion Btu)	CO_2 Emissions ($MMTCO_2E$)	CH_4 Emissions ($MMTCO_2E$)	N_2O Emissions ($MMTCO_2E$)	GHG Emissions ($MMTCO_2E$)
Coal	198	0.01870759	4.16758E-05	0.00009228	0.0188
Distillate Fuel	9,215	0.68113232	0.001939607	0.00171794	0.6848
Kerosene	102	0.00746133	2.14693E-05	0.00001902	0.0075
LPG	2,638	0.16286542	0.000555256	0.00049180	0.1639
Motor Gasoline	171	0.01220452	3.59927E-05	0.00003188	0.0123
Residual Fuel	19	0.00142589	3.99919E-06	0.00000354	0.0014
Natural Gas	78,599	4.16733983	0.007836539	0.00231364	4.1775
Wood	2,333	0	0.013956395	0.00274697	0.0167
				Total	**5.0829**

Table 2.3.3: Maryland Base Year 2014 Industrial Sector GHG Emissions, by Fuel Type

Fuel Type	Total Consumption (Billion Btu)	Non-Energy Consumption (Billion Btu)	CO_2 Emissions ($MMTCO_2E$)	CH_4 Emissions ($MMTCO_2E$)	N_2O Emissions ($MMTCO_2E$)	GHG Emissions ($MMTCO_2E$)
Coking Coal	-	-	-	-	-	-
Other Coal	15,627	232	1.4780	0.0032	0.0072	1.4885
Asphalt and Road Oil	15,346	17,999	(0.1998)	(0.0002)	(0.0005)	(0.2005)
Aviation Gasoline Blending Components	-	-	-	-	-	-
Crude Oil	-	-	-	-	-	-
Distillate Fuel	6,743	106	0.4945	0.0004	0.0012	0.4962
Feedstocks, Naphtha less than 401 F	-		-	0.0000	0.0000	0.0000
Feedstocks, Other Oils greater than 401 F	-		-	0.0000	0.0000	0.0001
Kerosene	15	-	0.0011	0.0000	0.0000	0.0011
LPG	1,313	1,413	0.0272	(0.0000)	(0.0000)	0.0271
Lubricants	1,988	1,781	0.1334	0.0000	0.0000	0.1334
Motor Gasoline	4,253	-	0.3035	0.0003	0.0008	0.3046
Motor Gasoline Blending Components	-	-	-	-	-	-
Misc. Petro Products	270	-	0.0201	-	-	0.0201
Petroleum Coke	-	-	-	-	-	-
Pentanes Plus		-	-	0.0000	0.0000	0.0000
Residual Fuel	241	-	0.0181	0.0000	0.0000	0.0181
Still Gas	-	-	-	-	-	-
Special Naphthas	2,956	516	0.2138	0.0002	0.0005	0.2144
Unfinished Oils	-	-	-	-	-	-
Waxes	146	106	0.0061	-	-	0.0061
Natural Gas	15,474	599	0.8008	0.0003	0.0004	0.8015
Wood	8,205	NA	-	0.0049	0.0097	0.0146
					Total	**3.3253**

Table 2.3.4: 2030 Commercial and Industrial Sectors BAU Projection Growth Factor

MARYLAND 2010-2020 INDUSTRY PROJECTIONS		
http://www.dllr.state.md.us/lmi/iandoproj/industry.shtml		
	Employment	
NAICS DESCRIPTION	2014	2024
Total All Industries	198,493	215,638
Self-Employed and Unpaid Family Workers, All Jobs	196,649	213,799
Total Wage and Salary Employment	1,844	1,839

Table 2.3.4.2: 2030 Commercial and Industrial Sectors BAU Projection Growth Factor

Years	Forecasted Employment			Employment Growth Factors	
	Total All Industries	Self-Employed and Unpaid Family Workers, All Jobs	Total Wage and Salary Employment	Total All Industries	Self-Employed and Unpaid Family Workers, All Jobs
2014	198,493	196,649	1,844		
2015	200,208	198,364	1,844	1.008637584	1.008721122
2016	201,922	200,079	1,843	1.017275168	1.017442245
2017	203,637	201,794	1,843	1.025912753	1.026163367
2018	205,351	203,509	1,842	1.034550337	1.03488449
2019	207,066	205,224	1,842	1.043187921	1.043605612
2020	208,780	206,939	1,841	1.051825505	1.052326734
2021	210,495	208,654	1,841	1.060463089	1.061047857
2022	212,209	210,369	1,840	1.069100674	1.069768979
2023	213,924	212,084	1,840	1.077738258	1.078490102
2024	215,638	213,799	1,839	1.086375842	1.087211224
2025	217,353	215,514	1,839	1.095013426	1.095932346
2026	219,067	217,229	1,838	1.10365101	1.104653469
2027	220,782	218,944	1,838	1.112288595	1.113374591
2028	222,496	220,659	1,837	1.120926179	1.122095714
2029	224,211	222,374	1,837	1.129563763	1.130816836
2030	225,925	224,089	1,836	1.138201347	1.139537958

Table 2.3.5: Maryland Commercial Sector GHG Projection Emissions by Fuel Type

Fuel Type	2014 Emissions ($MMTCO_2E$)	2020 Emissions ($MMTCO_2E$)	2025 Emissions ($MMTCO_2E$)	2030 Emissions ($MMTCO_2E$)
Coal	0.0188415437	0.0198180162	0.0206317433	0.0214454704
Distillate Fuel	0.6847898595	0.7202794399	0.7498540903	0.7794287406
Kerosene	0.0075018188	0.0078906044	0.0082145923	0.0085385803
LPG	0.1639124787	0.1724073257	0.1794863649	0.1865654040
Motor Gasoline	0.0122723929	0.0129084159	0.0134384350	0.0139684542
Residual Fuel	0.0014334321	0.0015077205	0.0015696274	0.0016315344
Natural Gas	4.1774900101	4.3939905402	4.5744076487	4.7548247572
Wood	0.0167033678	0.0175690283	0.0182904120	0.0190117958
TOTAL	5.0829	5.3464	5.5659	5.7854

Table 2.3.6: Maryland Commercial Sector GHG Projection Emissions by Fuel Type

Fuel Type	2014 Emissions ($MMTCO_2E$)	2020 Emissions ($MMTCO_2E$)	2025 Emissions ($MMTCO_2E$)	2030 Emissions ($MMTCO_2E$)
Other Coal	1.4884574638	1.5655975238	1.6298809071	1.6941642905
Distillate Fuel	0.4961518276	0.5218651467	0.5432929126	0.5647206786
Feedstocks, Naphtha less than 401 F	0.0000027371	0.0000028790	0.0000029972	0.0000031154
Feedstocks, Other Oils greater than 401 F	0.0000627559	0.0000660082	0.0000687185	0.0000714288
Kerosene	0.0011009986	0.0011580584	0.0012056082	0.0012531581
LPG	0.0271406924	0.0285472725	0.0297194226	0.0308915727
Lubricants	0.1334373967	0.1403528572	0.1461157409	0.1518786247
Motor Gasoline	0.3046042879	0.3203905590	0.3335457849	0.3467010109
Misc. Petroleum Products	0.0201115810	0.0211538738	0.0220224512	0.0228910286
Pentanes Plus	0.0000099159	0.0000104298	0.0000108581	0.0000112863
Residual Fuel	0.0181464460	0.0190868948	0.0198706020	0.0206543093
Special Naphthas	0.2143824763	0.2254929564	0.2347516899	0.2440104233
Waxes	0.0061306399	0.0064483634	0.0067131330	0.0069779026
Natural Gas	0.8015052390	0.8430436529	0.8776589978	0.9122743428
Wood	0.0145692821	0.0153243425	0.0159535595	0.0165827765
TOTAL	3.5258	3.7085	3.8608	4.0131

2.4 Transportation Energy Use

Emissions estimated for this sector are the result of fossil-fuel consumed primarily for transportation purposes, both on-road mobile sources and non-road mobile sources of transportation. On-road mobile sources include the vehicles traditionally operated on public roadways, including:

- Cars
- Light-duty trucks
- Vans
- Buses
- Other diesel vehicles

Other modes of transportation, such as airplanes, trains and commercial marine vessels are included under the general category of non-road mobile sources. Non-road mobile sources also include the following motorized vehicles and equipment, which are normally not operated on public roadways:

- MOVES – Non-road Model Sources
  - Lawn and garden equipments
  - Agricultural or farm equipment
  - Logging equipment
  - Industrial equipment
  - Construction equipment
  - Airport service equipment
  - Recreational land vehicles or equipment
  - Recreational marine equipment

- Off-model Non-road Emission Sources
  - Locomotives
  - Aircraft
    - Commercial aviation
    - Air taxis
    - General aviation
    - Military aviation
  - Commercial Marine Vessels

- Lubricants, Natural Gas, and LPG

2.4.1 Transportation – On-Road Mobile Projections

Typically, traffic volumes and vehicle miles traveled (VMT) within the SHA traffic database are used to forecast future year emissions. Several alternatives are available to determine forecast growth rates, ranging from historical VMT trends to the use of Metropolitan Planning Organization-based travel models that include forecast demographics for distinct areas in each county.

For the 2030 BAU scenario, MDE used the Base Year 2014 and estimated 2030 emissions based on the growth in projected VMT derived from the Maryland Department of Transportation (MDOT) "VMT projection to 2030" [1]. The average statewide annualized growth rate in VMT is approximately 1.5%. This BAU estimate assumes no change in vehicle fleet mix over time.

As a result of the VMT and fleet mix assumptions, GHG emissions in 2030 from the transportation sector as a whole are expected to be 42.69 $MMTCO_2e$. The predicted emissions are dominated by emissions from on-road transportation (e.g., passenger cars and heavy-duty trucks).

Table 2.4.1: 2030 Transportation MD VMT 2030 Projections

MD VMT 2020 - 2030 Projections		
2014	2020	2030
56,400	65,442	71,830

Table 2.4.2: 2030 Transportation Growth Factors.

MD 2015- 2030 VMT Forecasts and Growth Factors									
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Forecast VMT	56,400	57,907	59,414	60,921	62,428	63,935	65,442	66,081	66,720
GF_2014Based	1.0000	1.0267	1.0534	1.0802	1.1069	1.1336	1.1603	1.1716	1.1830
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
Forecast VMT	67,358	67,997	68,636	69,275	69,914	70,552	71,191	71,830	
GF_2014Based	1.1943	1.2056	1.2170	1.2283	1.2396	1.2509	1.2623	1.2736	

[1] http://mde.maryland.gov/programs/Air/ClimateChange/MCCC/STWG/OnRoadInventoryMDOT.pdf

Table 2.4.3: 2014-2030 BAU On-Road Emissions

Year	VMT	Growth Factor 2014 Based	2014 On Road GHG Emissions ($MMTCO_2e$)		
			Gasoline	Diesel	Total
2014	56,400[1]	1.0000	22.5554	6.3810	28.9365
2015	57,907	1.0267	23.1581	6.5515	29.7097
2016	59,414	1.0534	23.7608	6.7220	30.4828
2017	60,921	1.0802	24.3635	6.8925	31.2560
2018	62,428	1.1069	24.9662	7.0630	32.0292
2019	63,935	1.1336	25.5688	7.2335	32.8024
2020	65,442[2]	1.1603	26.1715	7.4040	33.5756
2021	66,081	1.1716	26.4270	7.4763	33.9033
2022	66,720	1.1830	26.6824	7.5486	34.2310
2023	67,358	1.1943	26.9379	7.6209	34.5588
2024	67,997	1.2056	27.1934	7.6931	34.8865
2025	68,636	1.2170	27.4489	7.7654	35.2143
2026	69,275	1.2283	27.7043	7.8377	35.5420
2027	69,914	1.2396	27.9598	7.9100	35.8697
2028	70,552	1.2509	28.2153	7.9822	36.1975
2029	71,191	1.2623	28.4707	8.0545	36.5252
2030	71,830[3]	1.2736	28.7262	8.1268	36.8530

2.4.2 Transportation – Non-Road Mobile (MOVES Model) Projections

The non-road portion of the MOVES model (version 2014a) was used to project emissions from non-road model transportation subcategories. Non-road MOVES model runs for 2014 (base year), 2020, 2025 and 2030 were simulated and provided the basis for establishing growth factors for the source sector. For each annual simulation (2020, 2025 and 2030), the forecasted future emissions of CO_2 and CH_4 were summed separately for all non-road gasoline, non-road diesel and non-road other fuel use. Emissions for years not simulated were linearly extrapolated from corresponding model runs. Growth factors were then calculated per fuel type per pollutant by dividing the projection year CO_2 or CH_4 emissions by the 2014 base year emissions.

The 'Lubricants, NG, and LPG' source category was similarly grown from growth factors derived from the "other fuel" MOVES model future projections. These growth factors were then applied to the 2014 Emissions Inventory to project future emissions.

[1] 2014 MDOT Actual VMT
[2] 2020 MDOT VMT Projection – MOVES
[3] 2030 MDOT VMT Projection – MOVES

Table 2.4.4: 2014-2030 MOVES-Based Growth Factors

MOVES Based Growth Factors									
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Non-Road Diesel CO2	1	1.019845	1.039689	1.059534	1.079379	1.099224	1.119068	1.1418	1.164533
Non-Road Gasoline CO2	1	1.014589	1.029179	1.043768	1.058358	1.072947	1.087537	1.101176	1.114816
Other	1	1.020051	1.040102	1.060153	1.080204	1.100255	1.120306	1.14107	1.161833
Non-Road Diesel CH4	1	1.000553	1.001107	1.00166	1.002214	1.002767	1.003321	1.010227	1.017134
Non-Road Gasoline CH4	1	0.98609	0.97218	0.958271	0.944361	0.930451	0.916541	0.923151	0.92976
Other	1	1.005736	1.011472	1.017209	1.022945	1.028681	1.034417	1.042037	1.049657

Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
Non-Road Diesel CO2	1.187265	1.209997	1.232729	1.25324	1.273752	1.294263	1.314774	1.335286	
Non-Road Gasoline CO2	1.128455	1.142094	1.155734	1.169181	1.182628	1.196074	1.209521	1.222968	
Other	1.182597	1.20336	1.224123	1.243284	1.262445	1.281605	1.300766	1.319926	
Non-Road Diesel CH4	1.02404	1.030946	1.037853	1.045498	1.053143	1.060788	1.068433	1.076078	
Non-Road Gasoline CH4	0.93637	0.942979	0.949589	0.958375	0.967161	0.975947	0.984733	0.993519	
Other	1.057277	1.064896	1.072516	1.189143	1.30577	1.422397	1.539023	1.65565	

Table 2.4.5: 2014-2030 MOVES NON-ROAD Model Transportation Sector Projected CO_2 Emissions

Fuel Type Description	2014 CO2 (tpy)	2014 CO2 (MMTCO2e)	2015	2020	2030
Compressed Natural Gas (CNG)	16642.24619	0.015097579	0.015400302	0.016913915	0.019927695
Gasoline	1194330.698	1.0834777	1.099285097	1.178322082	1.325058672
Liquefied Petroleum Gas (LPG)	182467.4814	0.16553158	0.168850665	0.185446092	0.218489514
Marine Diesel Fuel	88359.70954	0.080158515	0.081749236	0.089702845	0.107034504
Nonroad Diesel Fuel	2109619.432	1.913812995	1.95179204	2.14168727	2.555486786
Fuel Type Categories					
Non-Road Gasoline	1194330.698	1.0834777	1.099285097	1.178322082	1.325058672
Non-Road Diesel	2197979.141	1.993971509	2.033541277	2.231390115	2.66252129
Other	199109.7276	0.180629159	0.184250967	0.202360008	0.238417209
Total	3591419.566	3.258078368	3.317077341	3.612072205	4.225997171

Table 2.4.6: 2014 MOVES NON-ROAD Model Transportation Sector CH_4 Emissions

Fuel Type Description	2014 CH4 (tpy)	2014 CH4 (MMTCO2e)	2015	2020	2030
Compressed Natural Gas (CNG)	213.2824954	0.004063216	0.004086523	0.004203061	0.006727264
Gasoline	1218.097711	0.023205814	0.022883025	0.021269083	0.023055428
Liquefied Petroleum Gas (LPG)	28.07393477	0.000534833	0.000537901	0.00055324	0.000885496
Marine Diesel Fuel	0.142074009	2.70663E-06	2.70813E-06	2.71562E-06	2.91255E-06
Nonroad Diesel Fuel	6.676364601	0.000127191	0.000127261	0.000127613	0.000136867
Fuel Type Categories					
Non-Road Gasoline	1218.097711	0.023205814	0.022883025	0.021269083	0.023055428
Non-Road Diesel	6.81843861	0.000129897	0.000129969	0.000130329	0.000139779
Other	241.3564302	0.004598049	0.004624424	0.004756301	0.00761276
Total	1466.27258	0.02793376	0.027637418	0.026155713	0.030807967

Table 2.4.7: 2025 MOVES NON-ROAD Model Transportation Sector GHG Emissions

Year	MOVES NON-Road Model Source Category	CH4 (Tons)	CO2 (Tons)	CH4 (MMTCO2e)	CO2 (MMTCO2e)	Total Emissions (MMTCO2e)
2025	Agricultural Equipment	8.56633834	256443.725	0.000163195	0.232641644	0.23280484
2025	Commercial Equipment	206.825817	378504.026	0.003940211	0.343372796	0.347313007
2025	Construction and Mining Equipment	63.1407737	1766919.42	0.001202886	1.602921031	1.604123917
2025	Diesel	4.63923997	107303.972	8.83813E-05	0.097344447	0.097432828
2025	Gasoline 2-Stroke	222.198117	199259.562	0.004233066	0.180765087	0.184998153
2025	Gasoline 4-Stroke	39.0585089	98288.1647	0.000744098	0.08916545	0.089909549
2025	Gasoline, 4-Stroke	0.07105521	109.26526	1.3535E-06	9.91237E-05	0.000100477
2025	Industrial Equipment	60.7859973	464168.851	0.001158027	0.421086555	0.422244581
2025	Lawn and Garden Equipment	637.053156	906451.898	0.012136414	0.822318659	0.834455072
2025	Logging Equipment	1.74406623	11391.057	0.000033226	0.010333785	0.010367011
2025	LPG	0.0002335	3.78963037	4.5E-09	3.43789E-06	3.44234E-06
2025	Recreational Equipment	111.00263	95276.212	0.002114696	0.086433055	0.088547751
2025	Underground Mining Equipment	0.41672976	3719.83549	7.9391E-06	0.003374575	0.003382514
2025	Airport Ground Support Equipment	0.7703163	27060.4615	1.46751E-05	0.024548818	0.024563493

Table 2.4.8: 2030 MOVES NON-ROAD Model Transportation Sector GHG Emissions

Year	MOVES NON-Road Model Source Category	CH4 (Tons)	CO2 (Tons)	CH4 (MMTCO2e)	CO2 (MMTCO2e)	Total Emissions (MMTCO2e)
2030	Agricultural Equipment	8.512088658	273992.3548	0.000162163	0.24856148	0.248723643
2030	Airport Ground Support Equipment	0.837051721	30148.09419	1.59466E-05	0.027349869	0.027365815
2030	Commercial Equipment	206.3335221	414867.0648	0.003930832	0.376360763	0.380291595
2030	Construction and Mining Equipment	64.05371461	1911619.134	0.001220279	1.734190293	1.735410571
2030	Diesel	5.214343948	115895.4071	9.93378E-05	0.105138459	0.105237797
2030	Gasoline 2-Stroke	226.7756548	204288.1604	0.004320272	0.18532695	0.189647223
2030	Gasoline 4-Stroke	33.15323752	100281.5473	0.000631598	0.090973815	0.091605413
2030	Gasoline, 4-Stroke	0.074173693	114.1786849	1.41307E-06	0.000103581	0.000104994
2030	Industrial Equipment	65.16189431	498739.1654	0.00124139	0.452448191	0.453689581
2030	Lawn and Garden Equipment	681.8456233	976812.3613	0.012989748	0.886148545	0.899138293
2030	Logging Equipment	1.856819174	10964.03651	3.5374E-05	0.009946398	0.009981773
2030	LPG	0.00018552	4.052434149	3.53431E-09	3.6763E-06	3.67984E-06
2030	Recreational Equipment	109.8149824	96781.46518	0.00209207	0.087798597	0.089890667
2030	Underground Mining Equipment	0.454360574	3981.373879	8.65596E-06	0.003611839	0.003620495

2.4.3 Transportation – Marine Vessel Projections

Marine vessel GHG emissions were projected using employment data. State-level employment data was collected from the Maryland Department of Labor, Licensing and Regulation[1]. Employment data from NAICS code 483 (reflecting water transportation) was chosen as the growth surrogate for marine vessels. GHG projected emission estimates for marine vessels are presented below.

Table 2.4.9: 2014 Transportation Marine Vessel Sector GHG Emissions

Fuel Type	Consumption (gallon)	Consumption (Billion Btu)		Emission Factor (Lbs C/Million Btu)		Combustion Efficiency (%)		Emissions (short tons carbon)	Emissions (MMTCE)	Emissions (MMTCO2e)
Distillate Fuel - Vessel Bunkering	3,042,000	422	x	44.43	x	100.0%	=	9,372	0.009	0.031
Residual Fuel-Vessel Bunkering	7,938,000	1,235	x	45.11	x	100.0%	=	27,855	0.025	0.093
TOTAL										**0.124**

Table 2.4.10: 2014-2030 Transportation Marine Vessel Sector GHG Projected Emissions

Marine Vessel Projections									
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Marine Vessels (Gas and Oil)	0.124965	0.12828	0.1316	0.134911	0.138226	0.141541	0.144857	0.148172	0.151488
Growth Factor	1	1.026531	1.079592	1.079592	1.106122	1.132653	1.159184	1.185714	1.212245
Year	2023	2024	2025	2026	2027	2028	2029	2030	
Marine Vessels (Gas and Oil)	0.154803	0.158119	0.161434	0.164749	0.168065	0.17138	0.174695	0.178011	
Growth Factor	1.238776	1.265306	1.291837	1.318367	1.344898	1.371429	1.397959	1.42449	

2.4.4 Transportation – Rail Projections

Rail GHG emissions were projected using employment data. State-level employment data was collected from the Maryland Department of Labor, Licensing and Regulation[2]. Employment data from NAICS code 482 (reflecting rail transportation) was chosen as the growth surrogate for railroads. Growth in this source sector is expected to remain constant.

Table 2.4.11: 2014 Transportation Rail Sector GHG Emissions

[1] http://www.dllr.state.md.us/lmi/iandoproj/industry.shtml

Distillate Fuel – Locomotive		CO2 Emissions							
Consumption (gallon)		Consumption (Billion Btu)		Emission Factor (lbs C/Million Btu)		Combustion Efficiency (%)		Emissions (short tons carbon)	Emissions (MMTCO2E)
18,081,260	x	2,508	x	44.43	x	100%	=	55,708	0.185
		N2O Emissions							
		Density (kg/gallon)		N2O EF (g/kg fuel)		N2O EM (Gigagrams)		N2O (MT)	N2O (MMTCO2E)
18,081,260	x	3.192	x	0.08	x	0.0046172306	=	4.617	0.001
		CH4 Emissions							
		Density (kg/gallon)		CH4 EF (g/kg fuel)		CH4 EM (Gigagrams)		CH4 (MT)	CH4 (MMTCO2E)
18,081,260	x	3.192	x	0.25	=	0.014428845	=	14.42885	0.000303
								Total	0.187

Table 2.4.12: 2014 Transportation Rail Sector GHG Emissions

Marine Vessel Projections (2015 - 2030)									
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Rail Sector	0.187038	0.187038	0.187038	0.187038	0.187038	0.187038	0.187038	0.187038	0.187038
Growth Factor	1	1	1	1	1	1	1	1	1
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
Rail Sector	0.187038	0.187038	0.187038	0.187038	0.187038	0.187038	0.187038	0.187038	
Growth Factor	1	1	1	1	1	1	1	1	

2.4.5 Transportation – Aircraft Projections

Aircraft GHG emissions were projected using operations data from the FAA Terminal Area Forecast for Baltimore-Washington Thurgood Marshall Airport[1]. Airport-specific take-off and landings operations data was collected from the Federal Aviation Administration. GHG projected emission estimates for aircraft transportation are presented below.

Table 2.4.13: 2014 Transportation Aircraft Sector GHG Emissions

[1] https://www.faa.gov/data_research/aviation/taf/media/taf_summary_fy_2016-2045.pdf

Fuel Type	Consumption (gallon)	Consumption (Billion Btu)	Emission Factor (lbs C/Million Btu)	Combustion Efficiency (%)	Emissions (tons carbon)	Emissions ($MMTCO_2E$)
Aviation Gasoline	2,058,000	175	41.53	100.0%	3,634	0.012
Jet Fuel, Kerosene	48,636,000	11,121	43.43	100.0%	241,503	0.803
TOTAL						**0.823787**

Table 2.4.14: Transportation Aircraft Sector GHG Projected Emissions

Aircraft Sector Projections (2015 - 2030)									
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Aircraft Sector	0.823787	0.817117	0.827123	0.863810	0.877150	0.890491	0.903832	0.922509	0.941186
Growth Factor	1	0.991903	1.004049	1.048583	1.064777	1.080972	1.097166	1.119838	1.14251
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Aircraft Sector	0.959862	0.978539	0.997216	1.015893	1.034570	1.053247	1.071924	1.090601	
Growth Factor	1.165182	1.187854	1.210526	1.233198	1.25587	1.278543	1.301215	1.323887	

2.4.6 Transportation – Lubricants, Natural Gas and LPG Projections

As stated above, the 'Lubricants, NG, and LPG' source category was grown from growth factors derived from the "other fuel" MOVES model future projections. These growth factors were then applied to the 2014 Emissions Inventory to project future emissions.

Table 2.4.15: 2014 Transportation Sector Lubricant GHG Emissions

Fuel Type	Consumption (Billion Btu)	Non-Energy Consumption (Billion Btu)	Storage Factor (%)	Net combustible Consumption (Billion Btu)	Emission Factor (lbs C/Million Btu)	Combustion Efficiency (%)	Emissions (short tons carbon)	Emissions ($MMTCO_2E$)
Lubricants	1,466	1,427	9%	1,295	43.97	100.00%	28,474	0.095
					CH_4	CO_2	CH_4	CO_2
					(short tons/yr)	(short tons/yr)	($MMTCO_2E$)	($MMTCO_2E$)
Compressed Natural Gas					213.28	16,642.25	0.0041	0.0151
Liquefied Petroleum Gas (LPG)					28.07	182,467.48	0.0005	0.1655
Total								0.2756

Table 2.4.16a: Transportation – Lubricants, NG and LPG Sector GHG Projected Emissions (CO_2)

Lubricants, NG and LPT Sector Projections (2015 - 2030) CO2 (MMTCO2e)									
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Lubricant, NG and LPT Sector	0.275343	0.280864	0.286385	0.291906	0.297427	0.302947	0.308468	0.314185	0.3199
Growth Factor	1	1.020051	1.040102	1.060153	1.080204	1.100255	1.120306	1.14107	1.16183
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
Lubricant, NG and LPT Sector	0.32562	0.331337	0.337054	0.342329	0.347605	0.352881	0.358157	0.363432	
Growth Factor	1.182597	1.20336	1.224123	1.243284	1.262445	1.281605	1.300766	1.319926	

Table 2.4.16b: Transportation – Lubricants, NG and LPG Sector GHG Projected Emissions (CH_4)

Lubricants, NG and LPT Sector Projections (2015 - 2030) CH4 (MMTCO2e)									
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Lubricant, NG and LPT Sector	0.004598	0.004624	0.004651	0.004677	0.004704	0.00473	0.004756	0.004791	0.00483
Growth Factor	1	1.005736	1.011472	1.017209	1.022945	1.028681	1.034417	1.042037	1.04966
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
Lubricant, NG and LPT Sector	0.004861	0.004896	0.004931	0.005468	0.006004	0.00654	0.007077	0.007613	
Growth Factor	1.057277	1.064896	1.072516	1.189143	1.30577	1.422397	1.539023	1.65565	

2.5 Fossil Fuel Production Industry

This section reports GHG emissions that are released during the production, processing, transmission, and distribution of fossil fuels, (primarily natural gas and coal) in Maryland. CH_4 emissions released via leakage and venting from oil and gas fields, processing facilities, and natural gas pipelines, and also fugitive CH_4 emissions resulting from coal mining are estimated in this section. Additionally, CO_2 emissions associated with the combustion of natural gas in compressor engines (referred to as pipeline fuel) are estimated.

GHG emissions in 2030 from the fossil fuel industry are expected to increase slightly to 0.8070 MMTCO2E from the base Year 2014, 0.72 MMTCO2E. This projected increase is assumed to be due to the continued increase in natural gas use, expansion of transmission and distribution facilities in Maryland.

To project the fossil fuel industry 2030 GHG emissions, MDE used the Base Year 2014 emissions and estimated 2030 emissions based on the growth in projected GHG emission of the natural gas industry and coal mining industry derived from the EPA State Inventory Tool (SIT) Forecast Module. The forecast module projects a state's future energy consumption based on regional energy consumption levels downscaled to the state level.

Table 2.5.1: Base Year 2014 GHG Emissions from Pipeline Natural Gas Combustion

	CO_2 (lbs/MMBtu)	N_2O (Mt/BBtu)	CH_4 (Mt/BBtu)	Total Emissions
Emission Factors	31.87	9.496E-05	0.00094955	
Total Natural Gas Consumption (Billion Btus)	6,644.0	6,644.0	6,644.0	
Combustion Efficiency (%)	100%	100%	100%	
Emissions ($MMTCO_2E$)	0.000352	0.0001956	0.000132	**0.000680**

Table 2.5.2: Base Year 2014 GHG Emissions from Natural Gas Production

Production Sector	Activity Data	Emission Factor (metric tons CH_4 per year per activity unit)	CH_4 Emissions (metric tons)	CH_4 Emissions ($MMTCO_2E$)
Total number of wells	7	4.10	28.72	0.00060
Total			**28.72**	**0.00060**

Table 2.5.3: Base Year 2014 GHG Emissions from Natural Gas Transmission

Transmission Sector	Activity Data	Emission Factor (metric tons CH_4 per year per activity unit)	CH_4 Emissions (metric tons)	CH_4 Emissions ($MMTCO_2E$)
Miles of transmission pipeline	978	0.6185	105	0.01270
Number of gas transmission compressor stations	6	983.7	5,773	0.12124
Number of gas storage compressor stations	1	964.1	1,415	0.02971
Total			**7,793**	**0.16365**

Table 2.5.4: Base Year 2014 GHG Emissions from Natural Gas Distribution

Distribution Sector	Activity Data	Emission Factor (metric tons CH_4 per year per activity unit)	CH_4 Emissions (metric tons)	CH_4 Emissions ($MMTCO_2E$)
Distribution pipeline				
Miles of cast iron distribution pipeline	1,278	5.80	7,417.16	0.156
Miles of unprotected steel distribution pipeline	35	2.12	74	0.002
Miles of protected steel distribution pipeline	2,817	0.06	169	0.004
Miles of plastic distribution pipeline	3,292	0.37	1,223	0.026
Services				
Total number of services	544,843	0.02	8,318	0.175
Number of unprotected steel services	77,194	0.03	2,528	0.053
Number of protected steel services	78,296	0.00	266	0.006
Total			**19,997**	**0.420**

Table 2.5.5: 2030 GHG Emissions Growth Factor from Natural Gas Distribution

EPA State Inventory Tool Projections (2015 - 2030)									
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Natural Gas	0.780144	0.785796	0.791791	0.797786	0.803781	0.809776	0.815771	0.82728	0.838789
Oil (petro)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Growth Factor	1	1.007246	1.01493	1.022615	1.030299	1.037984	1.045668	1.060421	1.075173
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Natural Gas	0.850298	0.861807	0.873316	0.873548	0.87378	0.874013	0.874245	0.874477	0.874477
Oil (petro)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Growth Factor	1.089925	1.104677	1.11943	1.119727	1.120025	1.120323	1.120621	1.120918	1.120918

Table 2.5.6: Base Year 2014 CH_4 Emissions from Coal Mining

Underground Mines					
Measured Ventilation Emissions (mcf)	**Degasification System Emissions (mcf)**	**Methane Recovered from Degasification Systems and Used for Energy (mcf)**	**Emissions (mcf CH_4)**	**Emissions ($MTCH_4$)**	**Emissions ($MTCO_2E$)**
0	0	0	0.00	-	-
Surface Mines					
Surface Coal Production ('000 short tons)	Basin-specific EF (ft^3/short ton)		Emissions ('000 ft^3 CH_4)	Emissions ($MTCH_4$)	Emissions ($MTCO_2E$)
1,200	119.0		142,800	5,091	106,901

Post Mining Activity – Underground Mines				
Coal Production ('000 short tons)	Basin & Mine-specific EF (ft^3/short ton)	Emissions ('000 ft^3 CH_4)	Emissions ($MTCH_4$)	Emissions ($MTCO_2E$)
700	45.0	31,486	605	12,695
Post Mining Activity – Surface Mines				
Coal Production ('000 short tons)	Basin- & Mine-specific EF (ft^3/short ton)	Emissions ('000 ft^3 CH_4)	Emissions ($MTCH_4$)	Emissions ($MTCO_2E$)
1,200	19.3	23,205	446	9,356
Post Mining Activity – SubTotal		Emissions ('000 ft^3 CH_4)	Emissions ($MTCH_4$)	Emissions ($MTCO_2E$)
		54,691	1,050	22,051

Total Coal Mining Emissions ($MTCO_2e$)	**128,953**
Total Coal Mining Emissions ($MMTCO_2e$)	**0.128953**

Table 2.5.7: 2030 Growth Factor from Coal Mining

	EPA State Inventory Tool Projections (2015 - 2030)								
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Coal Mining	0.174577	0.169348	0.169574	0.169799	0.170024	0.170249	0.170474	0.161682	0.159423
Growth Factor	1	0.970049	0.971338	0.972627	0.973916	0.975205	0.976494	0.926136	0.913192
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Coal Mining	0.157163	0.154903	0.175959	0.150384	0.148124	0.145864	0.143605	0.189462	0.189462
Growth Factor	0.900248	0.887304	1.007916	0.861417	0.848473	0.835529	0.822585	1.085262	1.085262

2.6 Industrial Processes

Emissions estimated in the industrial sector accounts for only process-related GHG emissions from the four main industrial processes that occurs in the State:

(1) CO_2 emissions from cement production, soda ash, dolomite and lime/limestone consumption;
(2) CO_2 emissions from iron and steel production;
(3) Sulfur hexafluoride (SF6) emissions from electric power transmission and distribution (T&D) system transformers use, and
(4) Hydrofluorocarbon (HFC) and perfluorocarbon (PFC) emissions resulting from the consumption of substitutes for ozone-depleting substances (ODS) used in cooling and refrigeration equipment.

The projection for the industrial processes emissions used the Base Year 2014 emissions and estimated 2030 emissions based on the growth in projected process emissions. This was done for each of the industries in Maryland using the EPA SIT Projection module industrial sector emissions projections.

The projection for ODS substitutes uses a source-specific EPA model which projects emissions of ODS substitutes nationwide. Maryland emissions in 2030 were determined by prorating national emissions based on population. SF6 emissions from the power sector now and in the future are expected to occur solely as the result of leaks. Leaks from transmission equipment are not expected to increase over time from current estimates.

The projected BAU 2030 emissions (4.11 $MMTCO_2E$) from the industrial sector is estimated to be slightly lower than the Base Year 2014 (4.79 $MMTCO_2E$) due to the exit of the iron and steel industry in Maryland.

The EPA SIT tool projects a state's future emissions based on a linear trend based on historical data.

Table 2.6.1: Base Year 2014 Cement Industry Process CO_2 Emissions

MD TOTAL CEMENT GHG EMISSIONS (Lehigh + Holcim)	CO_2 Emissions
MD Summary Cement Process CO_2 Emissions (short tons)	1,742,448
MD Summary Cement Process CO_2 Emissions (metric tons)	1,580,721
MD Summary Cement Process CO_2 Emissions ($MMTCO_2E$)	1.58

Table 2.6.2: Base Year 2014 Iron and Steel Industry Process CO_2 Emissions.

Source	Pollutant	CO_2 Emissions (metric tons)	CO_2 Emissions (short tons)	Data Source
Bleeders	CO_2	0.0	0.0	MDE ECR
	CH_4	0.00	0.00	
	N_2O	0.00	0.00	
L Blast Furnace	CO_2	0.0	0.0	MDE ECR
	CH_4	0.0	0.00	
	N_2O		-	
Sinter Plant	CO_2	0.0	0.0	MDE ECR
BOF	CO_2	0.0	0.0	MDE ECR
Total	CO_2	0.0	0.0	
	CH_4	0.0	0.0	
	N_2O	0.00	0.00	

Table 2.6.3: Base Year 2014 Soda Ash Consumption CO_2 Emissions.

	Consumption (Metric Tons)	Emission Factor (t CO_2/t production)	Emissions ($MTCO_2E$)	Emissions ($MMTCO_2E$)
Soda Ash	95,590	0.4150	39,670	**0.040**

Table 2.6.4: Base Year 2014 Limestone and Dolomite Use CO_2 Emissions.

	Consumption (Metric Tons)	Emission Factor (t CO_2/t production)	Emissions ($MTCO_2E$)	Emissions ($MMTCO_2E$)
Limestone	327,081	0.44	143,916	**0.144**

Table 2.6.5: Base Year 2014 Non-Fertilizer Urea Use CO_2 Emissions.

	Non-Fertilizer Consumption (Metric Tons)	Emission Factor (mt CO_2/mt activity)	Emissions ($MTCO_2E$)	Emissions ($MMTCO_2E$)
Urea	751	0.73	548	0.000547

Table 2.6.6: Base Year 2014 SF_6 Emissions from Electrical T&D[1] System.

Total US SF_6 Emissions from Electric Power T & D ($MMTCO_2E$)	2.0E+06	A
SF_6 GWP	23,900	B
US Total SF_6 Consumed (metric tons)	83.68	'C = A/B
Total US Electric Sales (MWh) (2014)	3,764,700,267	D
MD Total Electric Sales (MWh) (2014)	61,683,869	E
MD Apportioned SF_6 Consumption (metric tons)	1.3711	$F = C \times \frac{E}{D}$
Emission Factor	1.0	G
SF_6 Emissions (metric tons)	1.3711	H= G*F
SF_6 Emissions ($MTCO_2E$)	32,768.82	I=G*B
SF_6 Emissions ($MMTCO_2E$)	0.03277	$J=I/10^6$

Table 2.6.7: Base Year 2014 HFC & PFCs Emissions from ODS Substitutes

Total US GHG 2014 Emissions from ODS substitute (Metric tons CO_2 Eq.)	158,600,000
MD 2014 Population	5,976,407
US 2014 Population	318,857,056
Apportioned State Emissions ($MMTCO_2e$)	2.972

[1] T&D: Transmission and Distribution

Table 2.6.8: (2015- 2030) Industrial Emission Projections

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cement Manufacturing	722,252	864,412	866,538	868,664	870,791	872,917	875,043	877,170	879,296
Limestone & Dolomite	190,657	166,926	172,303	177,680	183,057	188,434	193,811	199,188	204,565
Soda Ash	40,154	40,222	39,681	39,140	38,599	38,058	37,518	36,977	36,436
Iron and Steel	0	0	0	0	0	0	0	0	0
ODS Substitutes	3,021,269	973,578	1,038,860	1,104,249	1,169,743	1,235,339	1,301,035	1,382,135	1,463,239
Electricity Power Transmission and Distribution Systems	91,740	54,252	53,362	52,472	51,582	50,692	49,801	49,509	49,216
Semiconductor Manufacturing	8,880	9,107	9,333	9,559	9,786	10,012	10,239	10,465	10,692
Ammonia and Urea Production (Nonfertilizer)	808	836	832	829	826	822	819	816	812
Aluminum Production	187,101	184,643	182,185	179,727	177,269	174,811	172,353	169,895	167,437

Table 2.6.9: (2015- 2030) Industrial Emission Projections

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cement Manufacturing	881,422	883,549	885,675	887,802	889,928	892,054	894,181	896,307	896,307
Limestone & Dolomite	209,942	215,319	220,696	226,073	231,450	236,827	242,203	247,580	247,580
Soda Ash	35,895	35,354	34,813	34,272	33,731	33,190	32,649	32,108	32,108
Iron and Steel	0	0	0	0	0	0	0	0	0
ODS Substitutes	1,544,349	1,625,465	1,706,585	1,751,808	1,797,004	1,842,175	1,887,321	1,932,442	1,932,442
Electricity Power Transmission and Distribution Systems	48,924	48,632	48,339	47,897	47,455	47,013	46,571	46,129	46,129
Semiconductor Manufacturing	10,918	11,144	11,371	11,597	11,824	12,050	12,276	12,503	12,503
Ammonia and Urea Production (Nonfertilizer)	809	806	802	799	795	792	789	785	785
Aluminum Production	164,980	162,522	160,064	157,606	155,148	152,690	150,232	147,774	147,774

Table 2.6.10: 2030 Industrial Growth Factors

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cement Manufacturing	1.00	1.20	1.20	1.20	1.21	1.21	1.21	1.21	1.22
Limestone & Dolomite	1.00	0.88	0.90	0.93	0.96	0.99	1.02	1.04	1.07
Soda Ash	1.00	1.00	0.99	0.97	0.96	0.95	0.93	0.92	0.91
Iron and Steel									
ODS Substitutes	1.00	0.32	0.34	0.37	0.39	0.41	0.43	0.46	0.48
Electricity Power Transmission and Distribution Systems	1.00	0.59	0.58	0.57	0.56	0.55	0.54	0.54	0.54
Semiconductor Manufacturing	1.00	1.03	1.05	1.08	1.10	1.13	1.15	1.18	1.20
Ammonia and Urea Production (Nonfertilizer)	1.00	1.03	1.03	1.03	1.02	1.02	1.01	1.01	1.01
Aluminum Production	1.00	0.99	0.97	0.96	0.95	0.93	0.92	0.91	0.89

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cement Manufacturing	1.22	1.22	1.23	1.23	1.23	1.24	1.24	1.24	1.24
Limestone & Dolomite	1.10	1.13	1.16	1.19	1.21	1.24	1.27	1.30	1.30
Soda Ash	0.89	0.88	0.87	0.85	0.84	0.83	0.81	0.80	0.80
Iron and Steel									
ODS Substitutes	0.51	0.54	0.56	0.58	0.59	0.61	0.62	0.64	0.64
Electricity Power Transmission and Distribution Systems	0.53	0.53	0.53	0.52	0.52	0.51	0.51	0.50	0.50
Semiconductor Manufacturing	1.23	1.25	1.28	1.31	1.33	1.36	1.38	1.41	1.41
Ammonia and Urea Production (Nonfertilizer)	1.00	1.00	0.99	0.99	0.98	0.98	0.98	0.97	0.97
Aluminum Production	0.88	0.87	0.86	0.84	0.83	0.82	0.80	0.79	0.79

2.7 Agriculture

The emissions estimated in this section refer to non-energy CH_4 and N_2O emissions from enteric fermentation, manure management, and agricultural soils. Emissions and sinks of carbon in agricultural soils are also estimated in this section. Energy emissions (combustion of fossil fuels in agricultural equipment) are not included in this section, but are already accounted for under the RCI and non-road transportation sub-sector.

2030 BAU emissions from the agriculture sector are projected to slightly decrease to 1.72 $MMTCO_2E$ from the Base Year emissions level (1.89 $MMTCO_2E$). The projection for the agriculture emissions used the Base Year 2014 emissions and estimated 2030 emissions using the agriculture sector of the EPA SIT Projection module.

Table 2.7.1: Base Year 2014 CH_4 Generation from Manure Management

	Number of Animals ('000 head)	Typical Animal Mass (TAM) (kg)	Volatile Solids (VS) [kg VS/1000 kg animal mass/day]	Total VS (kg/yr)	Max Pot. Emissions (m^3 CH_4/ kg VS)	Weighted MCF	CH_4 Emissions (m^3)
Dairy Cattle							
Dairy Cows	50.0	680	10.0	122,985,884	0.24	0.118	3,488,359
Dairy Replacement Heifers	25.0	476	8.4	36,587,282	0.17	0.012	77,547
Beef Cattle							
Feedlot Heifers	3.9	420	4.4	2668,401	0.33	0.013	11,556
Feedlot Steer	7.4	420	4.0	4,592,625	0.33	0.013	19,663
Bulls	4.0	750	5.2	6,613,800	0.17	0.011	12,368
Calves	33.0	118	6.4	9,110,597	0.17	0.011	17,037
Beef Cows	38.0	533	7.5	55,404,515	0.17	0.011	103,606
Beef Replacement Heifers	10	420	7.6	11,636,201	0.17	0.011	21,760
Steer Stockers	15.0	318	8.1	14,028,947	0.17	0.011	26234
Heifer Stockers	8.0	420	8.6	10,412,881	0.17	0.011	19,472
Swine							
Breeding Swine	3.0	198	2.6	563,706	0.48	0.301	81,336
Market Under 60 lbs	7.00	16	8.8	357,046	0.48	0.300	51,443
Market 60-119 lbs	4.0	41	5.4	320,090	0.48	0.300	46,119
Market 120-179 lbs	3.0	68	5.4	401,020	0.48	0.300	57,779
Market over 180 lbs	4.0	91	5.4	715,473	0.48	0.300	103,086
Poultry							
Layers							
Hens > 1 yr	2,364.0	2	10.8	16,773,998	0.39	0.051	335,113
Pullets	708.0	2	9.7	4,512,013	0.39	0.051	90,142
Chickens	10.0	2	10.8	70,956	0.39	0.051	1,418
Broilers	52,327.0	1	15	257,841,293	0.36	0.015	1,392,343
Turkeys	421.0	7	9.7	10,135,743	0.36	0.015	54,733
Other							
Sheep on Feed	0	25	9.2	-	0.36	0.012	-
Sheep Not on Feed	12.0	80	9.2	3,225,600	0.19	0.011	6,740
Goats	15.0	64	9.5	2,895,360	0.17	0.011	5,413
Horses	80.0	450	10	131,400,000	0.33	0.011	477,804
TOTAL							**6,501,072**

Table 2.7.2: Base Year 2014 N_2O Generation from Manure Management.

	Number of Animals ('000 head)	Typical Animal Mass (TAM) (kg)	Nitrogen Produced (kg/1000 kg Animal mass/day)	Total K-Nitrogen Excreted (kg)
Dairy				
Dairy Cows	50.0	680	0.440	5,460,400
Dairy Replacement Heifers	25.0	476	0.310	1,346,485
Beef Cattle				
Feedlot Heifers	3.9	420	0.300	179,913
Feedlot Steer	7.4	420	0.300	340,096
Swine				
Breeding Swine	3.0	198	0.235	50,950
Market Under 60 lbs	7.0	16	0.600	24,344
Market 60-119 lbs	4.0	41	0.420	24,896
Market 120-179 lbs	3.0	68	0.420	31,190
Market over 180 lbs	4.0	91	0.420	55,648
Poultry				
Layers				
Hens > 1 yr	2,364.0	2	0.830	1,289,113
Pullets	708.0	2	0.620	288,397
Chickens	10.0	2	0.830	8,725
Broilers	52,327.0	1	1.100	18,908,361
Turkeys	421.0	7	0.740	282,849
Other				
Sheep on Feed	0	25	0.420	-
Sheep Not on Feed	12.0	80	0.420	147,168
TOTAL				**30,118,367**

Table 2.7.3: Base Year 2014 CH_4 Emissions from Enteric fermentation

Animal	Number of Animals ('000 head)	Emission Factor (kg CH_4/head)	Emissions (kg CH_4/year)	Emissions (MMT-CH_4/Year)	Emissions ($MMTCO_2E$)
Dairy Cattle					
Dairy Cows	50.0	138.9	6,776,398	0.0039	0.142
Dairy Replacement Heifers	25.0	66.0	1,800,648	0.0010	0.038
Beef Cattle					
Beef Cows	38.0	94.4	3,252,618	0.0190	0.068
Beef Replacement Heifers	10.0	66.7	591,889	0.0030	0.012
Heifer Stockers	8.0	59.8	228,301	0.0010	0.005
Steer Stockers	15.0	57.9	860,117	0.0050	0.018
Feedlot Heifers	3.9	43.2	223,054	0.0010	0.005
Feedlot Steer	7.4	42.0	420,454	0.0020	0.009
Bulls	4.0	97.6	212,000	0.0010	0.004
Other					
Sheep	24.0	8.0	192,000	0.0010	0.004
Goats	13.0	5.0	65,000	0.0000	0.001
Swine	21.0	1.5	31,500	0.0000	0.001
Horses	80.0	18.0	1,440,000	0.0080	0.030
TOTAL				**0.092**	**0.338**

Table 2.7.4: Base Year 2014 CH_4 Emissions from Manure Management

	Emissions (m^3 CH_4)	Emissions (Metric Tons CH_4)	Emissions ($MMTCH_4$)	Emissions ($MMTCO_2E$)
Dairy Cattle				
Dairy Cows	3,488,359	2309	0.002	0.048
Dairy Replacement Heifers	77,547	51	0.000	0.001
Beef Cattle				
Feedlot Heifers	11,556	8	0.000	0.000
Feedlot Steer	19,663	13	0.000	0.000
Bulls	12,368	8	0.000	0.000
Calves	17,037	11	0.000	0.000
Beef Cows	103,606	69	0.000	0.001
Beef Replacement Heifers	21,760	14	0.000	0.000
Steer Stockers	26,234	17	0.000	0.000
Heifer Stockers	19,472	13	0.000	0.000
Swine				
Breeding Swine	81,336	54	0.000	0.001
Market Under 60 lbs	51,443	34	0.000	0.001
Market 60-119 lbs	46,119	31	0.000	0.001
Market 120-179 lbs	57,779	38	0.000	0.001
Market over 180 lbs	103,086	68	0.000	0.001
Poultry				
Layers				
Hens > 1 yr	335,113	222	0.000	0.005
Pullets	90,142	60	0.000	0.001
Chickens	1,418	1	0.000	0.000
Broilers	1,392,343	922	0.001	0.019
Turkeys	54,733	36	0.000	0.001
Other				
Sheep on Feed	-	-	0.000	0.000
Sheep Not on Feed	6,740	4	0.000	0.000
Goats	5,413	4	0.000	0.000
Horses	477,804	316	0.000	0.007
TOTAL	**6,501,072**	**4,304**	**0.004**	**0.090**

Table 2.7.5: Base Year 2014 CH_4 from Agricultural Residue Burning

Crop	Crop Production (metric tons)	Amt of Dry Matter Burned (metric tons)	Carbon Content (tons C/ tons dm)	Total C Released (metric tons C)	CH_4-C Emission ratio	CH_4 Emission (metric tons CH_4)	CH_4 GWP	CH_4 Emissions ($MMTCO_2E$)
Barley	1,642,480	1,718.06420	0.4485	20,184	0.007	134.56	21	0.0028258
Corn	48,552,667	26,599.6937	0.4478	485,764	0.007	3,238.43	21	0.0680070
Peanuts	-	-	0.4500	-	0.007	-	21	-
Rice	-	-	0.3806	-	0.007	-	21	-
Soybeans	17,206,332	21,856.0174	0.4500	347,317	0.007	2,315.45	21	0.0486244
Sugarcane	-	-	0.4235	-	0.007	-	21	-
Wheat	12,961,899	10,130.3992	0.4428	170,369	0.007	1,135.79	21	0.0238516
Total CH_4 from Agriculture Residue Burning ($MMTCO_2E$)								**0.143**

Table 2.7.6: Base Year 2014 N_2O from Agricultural Residue Burning

Crop	Crop Production (metric tons)	Amt of Dry Matter Burned (metric tons)	N Content (metric tons N/ metric tons dm)	Total N Released (metric tons N)	N_2O -N Emission Ratio	(N_2O - N) Emissions (metric tons N_2O)	N_2O Emissions (metric tons N_2O)	N_2O GWP	N_2O Emissions ($MMTCO_2E$)
Barley	1,642,480	1,718.0642	0.0077	346.53	0.007	0.09	3.812	310	0.0011817
Corn	48,552,667	26,599.693	0.0058	6,291.72	0.007	1.39	69.209	310	0.0214548
Peanuts	-	-	0.0106	-	0.007	-	0.0000	310	-
Rice	-	-	0.0072	-	0.007	-	0.0000	310	-
Soybeans	17,206,332	21,856.017	0.023	17,751.77	0.007	3.11	195.269	310	0.0605335
Sugarcane	-	-	0.004	-	0.007	-	0.0000	310	-
Wheat	12,961,899	10,130.399	0.0062	2,385.47	0.007	0.30	26.240	310	0.0081344
Total N_2O from Agriculture Residue Burning ($MMTCO_2E$)									**0.09130**

Table 2.7.7: Base Year 2014 N_2O Emissions from Manure Management

	Total N Emission from Manure Management (kg N_2O-N)	Total N Emission from Manure Management (kg N_2O)	Total N_2O Emission (MMT)	Total N_2O Emission from Manure Management ($MMTCO_2E$)
Dairy				
Dairy Cows	29,984	49,221	0.00416	0.01526
Dairy Replacement Heifers	14,786	23,235	0.00196	0.00720
Beef Cattle				
Feedlot Heifers	3,587	5,637	0.00048	0.00175
Feedlot Steer	6,807	10,696	0.00090	0.00332
Swine				
Breeding Swine	26	80	0.00001	0.00002
Market Under 60 lbs	24	74	0.00001	0.00002
Market 60-119 lbs	33	103	0.00001	0.000003
Market 120-179 lbs	31	98	0.00001	0.00003
Market over 180 lbs	42	131	0.00001	0.000004
Poultry				
Layers				
Hens > 1 yr	5,937	9,427	0.00080	0.00292
Pullets	356	565	0.00005	0.00018
Chickens	31	49	0.00000	0.000002
Broilers	383,556	602,731	0.05096	0.18685
Turkeys	25,860	40,638	0.00344	0.01260
Other	0.0	0		
Sheep on Feed	0.0	0	0.00000	0.0000
Sheep Not on Feed	0.0	0	0.00000	0.0000
TOTAL		**742,687**	**0.06279**	**0.23023**

Table 2.7.8: Base Year 2014 Direct N_2O Emissions from Fertilizer Application (Agriculture Soils).

	Synthetic Fertilizer	Organic Fertilizer
Total Fertilizer Use (kg N)	29,610,536	24,559,856
Total N in Fertilizers (Calendar Year)	24,559,856	31,404,891
Volatilization Rate	10%	20%
Nitrogen Content of Fertilizer	0	4.1%
Unvolatized N (kg)	22,103,871	1,030,080.4
Direct Emission factor (N_20 -N)	0.0100	0.0125
Direct Emission (kg N_20 - N)	221,038.7	12,876.00
Direct Emission (kg N_20)	347,346.54	20,233.7
Direct Emission (metric tons N_20)	347.35	20.23
Direct Emission (MMT N_20)	0.00034735	0.0000202
Direct Emission ($MMTCO_2E$)	0.107677425	0.00062725
Total Direct Emission ($MMTCO_2E$)	**0.11394879**	

Table 2.7.9: Base Year 2014 Indirect N_2O Emissions from Fertilizer Application - (Released to Atmosphere)

	Synthetic Fertilizer	Organic Fertilizer
Total Fertilizer Use (kg N)	29,610,536	24,559,856
Total N in Fertilizers (Calendar Year)	24,559,856	31,404,891
Volatilization Rate	10%	20%
Nitrogen Content of Fertilizer	0	4.1%
Volatized N (kg)	3,394,525.4	257,520.1
N_2O from Volatilization Emission Factor (N_20 -N)	0.01	0.01
Indirect Emission (kg N_20 -N)	33,945.254	2,575.2
Indirect Emission (kg N_20)	53,342.54	4,046.8
Indirect Emission (metric tons N_20)	53.3425	4.0467
Indirect Emission (MMT N_20)	0.000053342	0.000004047
Indirect Emission ($MMTCO_2E$)	0.016536188	0.0012544908
Total Indirect Emission ($MMTCO_2E$)	**0.01328614**	

Table 2.7.10: Base Year 2014 Indirect N_2O Emissions from Fertilizer Application - (Runoff /Leaching)

	Synthetic Fertilizer	Organic Fertilizer	Manure Excreted
Total Fertilizer Use (kg N)	29,610,536	24,559,856	
Total N in Fertilizers-kg (Calendar Year)	24,559,856	31,404,891	30,118,367
Volatilization Rate	10%	20%	20%
Nitrogen Content of Fertilizer	100%	4.1%	100%
Unvolatized N (kg)	22,103,870.4	1,030,080.43	9,878,824.38
Leached / Runoff Rate	30%	30%	30%
Leached / Runoff N (kg)	6,631,161.12	309,024.129	2,963,647.3
Indirect Emission factor (N_20 -N)	0.0075	0.0075	0.0075
Indirect Emission (kg N_20 -N)	49,733.71	2,317.68	1,094.17
Indirect Emission (kg N_20)	78,152.97	3,642.07	22,227.36
Leached /Runoff Emission (metric tons N_20)	78.15	3.642	22.23
Indirect Emission (MMT N_20)	0.00007815297	0.000003642	0.0000222735
Leached /Runoff Emission ($MMTCO_2E$)	0.02422742	0.001129041	0.000689048
Total Leached /Runoff Emission ($MMTCO_2E$)	**0.0032246941**		

Table 2.7.11: Base Year 2014 Direct N_2O Emissions from Agriculture Crop Residue

	Crop Residues	Legumes
	N Returned to Soils (kg)	**N-Fixed by Crops (kg)**
	36,786,057	54,229,732
Direct N_2O Emissions Factor	0.0100	0.0100
Direct N_2O Emission kg (N_2O -N)/ Yr	367,860.57	542,297.32
Direct N_2O Emission (kg N_2O)	578,066.61	852,181.50
Direct N_2O Emission (metric tons)	578.07	852.18
Direct N_2O Emission (MMT)	0.0005780667	0.0008521815
Direct Emissions ($MMTCO_2E$)	0.179200649	0.264176265
Total N_2O Emission from Residue ($MMTCO_2E$)	**0.4433769**	

Table 2.7.12: Base Year 2014 N_2O Emissions from Manure Application

	Livestock Emissions (metric tons N_2O)	**N_2O GWP**	**Livestock Emissions** ($MMT\ CO_2E$)
Indirect N_2O Emissions	117	310	**0.03618**
Direct N_2O Emissions -Manure Applied to Soil	717	310	0.22242
Direct N_2O Emissions -Pasture, Range and Paddock	294	310	0.09123
Sum Direct N_2O Emissions	**1,016**		**0.31366**
Total Animal N_2O Emisssions ($MMTCO_2E$)	**0.34984**		

Table 2.7.13: Base Year 2014 Indirect N_2O Emissions from Animal Waste Runoff - (Released to the Atmosphere)

	Number of Animals ('000 head)	**Total K-Nitrogen Excreted** (kg)	**Volatilization Rate**	**NH_3-NOx Emission Factor**	**Indirect Animal N_2O Emissions** (metric tons N)	**Indirect Animal N_2O Emissions** (metric tons N_2O)	**N_2O GWP**	**Indirect Animal N_2O Emissions** ($MMTCO_2E$)
Dairy Cattle								
Dairy Cows	50.0	5,460,400	20%	1%	10.9	17.13	310	0.0053
Dairy Replacement Heifers	25.0	1,346,485	20%	1%	2.7	4.242	310	0.0013
Beef Cattle								
Feedlot Heifers	3.9	179,913	20%	1%	0.40	0.63	310	0.0002
Feedlot Steer	7.4	340,096	20%	1%	0.70	1.10	310	0.0003
Bulls	4.0	339,450	20%	1%	0.70	1.10	310	0.0003
Calves	33.0	426,393	20%	1%	0.90	1.41	310	0.0004
Beef Cows	38.0	2,439,594	20%	1%	4.5	7.07	310	0.0022
Steer Stockers	15.0	539,726	20%	1%	1.10	1.73	310	0.0005
Total Beef Heifers	18.0	855,414	20%	1%	1.70	2.67	310	0.0008
Swine								
Breeding Swine	3.0	50,950	20%	1%	0.102	0.16	310	0.00005
Market Under 60 lbs	7.0	24,344	20%	1%	0.049	0.08	310	0.00002
Market 60-119 lbs	4.0	24,896	20%	1%	0.050	0.08	310	0.00002
Market 120-179 lbs	3.0	31,190	20%	1%	0.060	0.09	310	0.00003
Market over 180 lbs	4.0	55,648	20%	1%	0.111	0.17	310	0.00005
Poultry								
Layers								
Hens > 1 yr	2,364.0	1,289,113	20%	1%	2.578	4.05	310	0.0013
Pullets	708.0	288,397	20%	1%	0.577	0.91	310	0.0003
Chickens	16.0	8,725	20%	1%	0.017	0.03	310	0.00001
Broilers	52,327.0	18,908,361	20%	1%	37.817	59.43	310	0.01842
Turkeys	154.0	282,849	20%	1%	0.566	0.90		0.00028
Other								
Sheep on Feed	-	-						
Sheep Not on Feed	12.0	147,168	20%	1%	0.0294	0.05	310	0.00001
Goats	15.0	157,680	20%	1%	0.315	0.50	310	0.00001
Horses	80.0	3,942,000	20%	1%	7.884	12.40	310	0.0038
TOTAL		**37,138,792**			74	62.42		**0.0358912**

Table 2.7.14: Base Year 2014 Direct N_2O Emissions from Manure Applied to Soil

	Number of Animals ('000 head)	K-N Excreted by System (kg) Managed Systems	Volatili-zation Rate	Ground Nitrogen Emission Factor	Poultry Manure Not Mnage	Direct Animal N_2O Emissions (metric tons N) Manure Applied to Soils	Direct Animal N_2O Emissions (metric tons N_2O)	N_2O GWP	Direct Animal N_2O Emissions ($MMTCO_2E$)
Dairy Cattle									
Dairy Cows	50.0	2,676,859	20%	0.0125		51	80.142	310	0.0248
Dairy Replacement Heifers	25.0	660,089	20%	0.0125		13	20.43	310	0.0063
Beef Cattle									
Feedlot Heifers	3.9	179,913	20%	0.0125		2	3.143	310	0.0000
Feedlot Steer	7.4	340,096	20%	0.0125		3	4.71	310	0.0015
Bulls	4.0	NA	20%						-
Calves	33.0	NA	20%						-
Beef Cows	38.0	NA	20%						-
Steer Stockers	15.0	NA	20%						-
Total Beef Heifers	18.0	NA	20%						-
Swine									
Breeding Swine	3.0	40,179	20%	0.0125		0.0	0.0	310	0.0000
Market Under 60 lbs	7.0	19,198	20%	0.0125		0.0	0.00	310	0.0000
Market 60-119 lbs	4.0	19,633	20%	0.0125		0.0	0.00	310	0.0000
Market 120-179 lbs	3.0	24,597	20%	0.0125		0.0	0.00	310	0.0000
Market over 180 lbs	4.0	43,884	20%	0.0125		0.0	0.00	310	0.0000
Poultry									
Layers									
Hens > 1 yr	2,364.0	1,289,113	20%	0.0125	4.20%	12	18.857	310	0.0059
Pullets	708.0	288,397	20%	0.0125	4.20%	3	4.71	310	0.0000
Chickens	16.0	8,725	20%	0.0125	4.20%	0	0.00	310	0.0000
Broilers	52,327.0	18,908,361	20%	0.0125	4.20%	181	284.42	310	0.0882
Turkeys	154.0	282,849	20%			3	4.71		0.0015
Other									
Sheep on Feed	-	-							
Sheep Not on Feed	12.0	-	20%					310	-
Goats	15.0	NA	20%					310	-
Horses	80.0	NA	20%					310	-
TOTAL						**269**	**421.13**		**0.1281**

Table 2.7.15: Base Year 2014 Direct N_2O Emissions from Pasture, Range, and Paddock

	Number of Animals ('000 head)	**K-N Excreted by System (kg):**	**Direct Animal N_2O Emissions** (metric tons N)	**Direct Animal N_2O Emissions** (metric tons N_2O)	**N_2O GWP**	**Direct Animal N_2O Emissions** ($MMTCO_2E$)
		Unmanaged Systems - Pasture, Range, and Paddock		**Pasture, Range, and Paddock**		
Dairy Cattle						
Dairy Cows	50.0	360,170	7.20	11.31	310	0.0035
Dairy Replacement Heifers	25.0	88,815	1.78	2.80	310	0.0009
Beef Cattle						
Feedlot Heifers	3.9	NA				
Feedlot Steer	7.4	NA				
Bulls	4.0	339,450	6.79	10.67	310	0.0033
Calves	33.0	426,393	8.53	13.40	310	0.0042
Beef Cows	38.0	2,439,594	48.79	76.67	310	0.0238
Steer Stockers	10.0	539,726	10.79	16.96	310	0.0053
Total Beef Heifers	15.0	855,414	17.11	26.89	310	0.0083
Swine						
Breeding Swine	3.0	10,771	0.22	0.35	310	0.0001
Market Under 60 lbs	7.0	5,146	0.10	0.16	310	0.0005
Market 60-119 lbs	4.0	5,263	0.11	0.17	310	0.0001
Market 120-179 lbs	3.0	6,594	0.13	0.20	310	0.0001
Market over 180 lbs	4.0	11,764	0.24	0.38	310	0.0001
Poultry						
Layers						
Hens > 1 yr	2,364.0	NA				
Pullets	708.0	NA				
Chickens	10.0	NA				
Broilers	52,327.0	NA				
Turkeys	421.0	28,285	0.57	0.90		0.00028
Other						
Sheep on Feed	-	-				
Sheep Not on Feed	12.0	147,168	2.94	4.62	310	0.0014
Goats	13.0	157,680	3.15	4.95	310	0.0015
Horses	80.0	3,942,000	78.84	123.89	310	0.0384
TOTAL			**187.28**			**0.0912**

Table 2.7.16: (2015 – 2030) Emission Projection

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Enteric Fermentation	0.5109	0.5141	0.5142	0.5140	0.5148	0.5144	0.5142	0.5135	0.4965
Manure Management	0.3723	0.3734	0.3741	0.3749	0.3757	0.3766	0.3776	0.3786	0.3814
Agricultural Soils	0.9073	0.8708	0.8611	0.8514	0.8416	0.8319	0.8222	0.8124	0.8027
Agricultural Burning	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0017	0.0017
Urea Fertilizer Usage	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 2.7.17: (2015 – 2030) Emission Projection

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031
Enteric Fermentation	0.4949	0.4932	0.4916	0.4900	0.4883	0.4867	0.4850	0.4834	0.4834
Manure Management	0.3825	0.3837	0.3850	0.3863	0.3876	0.3889	0.3902	0.3915	0.3915
Agricultural Soils	0.7930	0.7832	0.7735	0.7638	0.7540	0.7443	0.7346	0.7248	0.7248
Agricultural Burning	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0018	0.0018
Urea Fertilizer Usage	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0018	0.00000

Table 2.7.18: (2015 – 2030) 2030 BAU Growth Factors

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Enteric Fermentation	1.0000	1.0063	1.0065	1.0061	1.0078	1.0069	1.0066	1.0051	0.9719
Manure Management	1.0000	1.0030	1.0049	1.0069	1.0092	1.0116	1.0143	1.0168	1.0244
Agricultural Soils	1.0000	0.9598	0.9491	0.9383	0.9276	0.9169	0.9062	0.8954	0.8847
Agricultural Burning	1.0000	1.0072	1.0143	1.0215	1.0286	1.0358	1.0429	1.0501	1.0572
Urea Fertilizer Usage	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 2.7.19: (2015 – 2030) 2030 BAU Growth Factors

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031
Enteric Fermentation	0.9687	0.9655	0.9623	0.9591	0.9559	0.9527	0.9495	0.9463	0.9463
Manure Management	1.0273	1.0305	1.0340	1.0375	1.0409	1.0444	1.0479	1.0514	1.0514
Agricultural Soils	0.8740	0.8633	0.8525	0.8418	0.8311	0.8203	0.8096	0.7989	0.7989
Agricultural Burning	1.0644	1.0716	1.0787	1.0859	1.0930	1.1002	1.1073	1.1145	1.1145
Urea Fertilizer Usage	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

2.8 Waste Management

GHG emissions from Maryland's waste management practices are estimated in this section. Emissions were estimated from the three (3) main classes of waste management in Maryland; (1) solid waste management, mainly in the form of CH_4 emissions from municipal and industrial solid waste landfills (including CH_4 that is flared or captured for energy production); (2) wastewater management, including CH_4 and N_2O from municipal and industrial wastewater (WW) treatment facilities; and (3) CH_4 and N_2O from municipal solid waste incinerations.

Landfill emissions were projected based on a 2020 estimate of waste deposition in California landfills. Waste deposition data was then used to determine future methane generation from landfills statewide. The landfill emissions projection applies the same estimation technique used to develop current inventory estimates, but uses the projected amounts of waste in landfills. Staff assumed that the composition of the waste and the number of landfills with landfill gas collection systems would remain the same.

Projected BAU emissions in 2020 for landfills are 7.7 MMTCO2E. This projection uses a recognized landfill gas emissions model developed by the Intergovernmental Panel on Climate Change (IPCC) and data from the California Integrated Waste Management Board (CIWMB). The project reflects assumptions regarding the continued decay of existing waste in landfills and estimates on the amount and character of new waste deposited in landfills through 2020.

Table 2.8.1: Base Year 2014 Waste Combustion Emissions

	2014	
MD Summary		
MSW Processed (tons)	1,443,604	
MSW HHV (mmbtu/short tons)	9.95	EPA factor
MSW Heat Input (mmbtu)	14,363,863	
CO_2 Emission Factor-(kg CO_2/mmbtu)	90.7	EPA factor
CO_2 Emission (kg CO_2)	1,302,802,356	
CO_2 Emission Estimate (short tons CO_2)	1,436,079	EPA factor
CO_2 Emission CEM Readings (short tons CO_2)	**1,430,321**	
CH_4 Emission Factor (kg/mmbtu)	0.032	
CH_4 Emissions (kg)	459,643.61	
CH_4 Emissions (short tons)	506.67	EPA factor
CH_4 Emissions (short tons)	**9.83**	**CEM/ECR**
N_2O Emission Factor (kg/mmbtu)	0.0042	
N_2O Emissions (kg)	60,328.22	
N_2O Emissions (short tons)	66.50	EPA factor
N_2O Emissions (short tons)	**36.12**	

Table 2.8.2: Base Year 2014 Landfill Emissions.

MSW CH_4 Generation (short ton CH_4)	126,314
MSW Generation ($MTCO_2E$)	2,406,400
Industrial Generation ($MTCO_2E$)	168,448
Potential CH_4 Emissions ($MTCO_2E$)	**2,574,848**
Flared CH_4 (short tons)	19,359
Flared CH_4 ($MTCO_2E$)	368,799
Landfill Gas-to-Energy (tons)	39,578
Landfill Gas-to-Energy ($MTCO_2E$)	754,001
CH_4 Avoided ($MTCO_2E$)	**1,122,800**
Oxidation at MSW Landfills (tons)	32,243.72
Oxidation at MSW Landfills ($MTCO_2E$)	614,271
Oxidation at Industrial Landfills ($MTCO_2E$)	42,999
Total CH_4 Emissions ($MTCO_2E$)	**794,778**
CO_2 Emission from (Flaring + LFGTE) ($MTCO_2E$)	254,654
CO_2 Emission from (Flaring + LFGTE) ($MMTCO_2E$)	0.2547
CO_2 Emission from Landfill ($MTCO_2E$)	313,143
CO_2 Emission from Landfill ($MMTCO_2E$)	0.3131
Total CH_4 Emissions ($MMTCO_2E$)	0.7948

Table 2.8.3: 2030 BAU Waste Management Growth Factors.

	Census	Census	Census	Census	Census				
	1970	1980	1990	2000	2010				
	1,174,933	1,460,865	1,748,991	1,980,859	2,156,411				
	Forecasted Census								
	2015	2020	2025	2030	2035	2040	2045		
	2,242,088	2,325,516	2,416,861	2,503,843	2,578,303	2,646,523	2,706,300		
	Extrapolated Census								
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Population	2,224,952	2,242,088	2,258,773	2,275,459	2,292,145	2,308,830	2,325,516	2,343,785	2,362,054
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Population	2,380,323	2,398,592	2,416,861	2,434,258	2,451,654	2,469,050	2,486,447	2,503,843	2,518,735
	Growth Factors								
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Growth Factor	1.0000	1.007701	1.007442	1.007387	1.007333	1.007279	1.007227	1.007856	1.007795
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Growth Factor	1.0077344	1.007675	1.007617	1.007198	1.007146	1.007096	1.007046	1.006996	1.006996

2.9 Forestry and Land Use

This section provides an assessment of the net GHG flux[1] (the balance between the emission and uptake of GHGs) resulting from land uses, land-use changes, and forests management activities in Maryland. The GHG emissions estimated in this section includes CO_2 emissions from urea fertilizer use, CH_4 and N_2O emissions from wildfires and prescribed forest burns and N_2O from synthetic fertilizers application to settlement soils. Carbon uptake (sequestration) pathways estimated in this section include; carbon stored in above ground biomass, below ground biomass, dead wood, and litters- (forest carbon flux), carbon stored in the form landfilled yard trimmings and food scraps, carbon stored in harvested wood product/wood product in landfills and carbon stored in urban trees.

Future emission projection for the forestry sector poses a unique challenge because it includes emissions from forest management activities and land-use changes, including wildfires, prescribed forest burning and urea fertilizer use, as well as removal (or sinks) of CO_2 from the atmosphere due to carbon sequestration into woody materials, and the 2030 BAU projection should account for both the positive emissions and negative removals into a single, net value. As a result of the uncertainty in estimating the several factors that can affect the 2030 BAU forest sector, MDE is assuming the 2030 BAU will remain same as Base Year 2014.

[1] The term "flux" is used here to encompass both emissions of greenhouse gases to the atmosphere, and removal of C from the atmosphere. Removal of C from the atmosphere is also referred to as "carbon sequestration".