Pathways for Mitigation

Other Non-Energy Emissions – Summary Statement

The "Other Non-Energy Emissions" umbrella is made up of a variety of emissions sectors and categories, including emissions from the Industrial Processes, Solid Waste and Wastewater, Fossil Fuel and Agricultural sectors. There are a number of specific sources that contribute to greenhouse gas (GHG) emissions within this broader sector in Vermont which include the use of ozone depleting substances (ODS) substitutes, semiconductor manufacturing, solid waste and wastewater treatment, fugitive methane emissions from the transmission and distribution of natural gas, and numerous components related to agricultural emissions. Greenhouse gas emissions from the fossil fuel sector (fugitive methane emissions) will be addressed in the buildings sector section of this Chapter and agriculture sector emissions will be discussed and addressed in a separate Chapter of this report.

The majority of the greenhouse gases emitted by the sources within the Other Non-Energy Emissions sector are gases other than carbon dioxide (CO_2). These gases include methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3), and sulfur hexafluoride (SF_6), all of which are significantly more potent than CO_2 in terms of their ability to warm the planet. Sulfur hexafluoride, for example, is roughly 22,800 times more potent than CO_2 on a 100 year time scale[1]. While some of these gases stay in the atmosphere for a very long time, others such as CH_4 have short atmospheric lifetimes (approximately 12 years). Reducing emissions of high GWP short-lived climate pollutant (SLCP) gases is a priority for impactful GHG reductions in the near term.

This section will present pathways to address emissions from the wastewater sector, the use of high global warming potential refrigerants, and the production of semiconductors. While emissions from the solid waste sector continue, significant progress has been made to date, and the implementation of the Universal Recycling Law[2] should further reduce emissions from that

[1] Intergovernmental Panel on Climate Change (IPCC) – AR4 Global Warming Potential (GWP) values: https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

[2] Vermont Department of Environmental Conservation, Waste Management and Prevention Division: https://dec.vermont.gov/waste-management/solid/universal-recycling

sector. Future plans will evaluate whether additional solid waste actions are necessary to meeting 2030 and 2050 requirements. Additional pathways, strategies, and actions are available in the appendix and are also recommended for action. The actions presented below, however, represent priority actions necessary to meet the Global Warming Solutions Act greenhouse gas emissions reduction requirements.

Pathway 1: Reducing Emissions of Refrigerants in Vermont

High global warming potential (GWP) HFCs are often used in refrigeration end uses, such as commercial and industrial refrigerators and freezers, and when leakage or accidental releases of these gases occur from the refrigeration systems it can produce significant greenhouse gas emissions. Monitoring and preventing the leakage of HFCs from large refrigeration systems and transitioning those systems to low GWP refrigerants will be an important step to reduce GHG emissions from the Industrial Processes sector. This pathway includes strategies to minimize emissions of high GWP refrigerants in several ways with a focus on monitoring, reporting, and repair requirements for refrigeration systems over a certain size threshold, as well as leak detection systems and incentives for businesses to switch to lower GWP alternatives.

1. Adopting a Refrigerant Management Program (RMP) and Related Actions

Currently there is very little oversight related to the use of refrigerants in various systems around Vermont. Adopting a refrigerant management program, similar to that adopted by California[3], would require entities that use over a certain threshold of high GWP refrigerants to inspect and report on their systems periodically, and to fix any leaks. Additionally, permanent leak detection systems could be placed on larger refrigeration systems which would allow for more real-time monitoring and which has the potential to avoid catastrophic leaks, which have a much larger GHG emissions impact. These monitoring and leak detection components should also be coupled with incentives for businesses to transition away from high GWP refrigerants to lower

[3] California Air Resources Board (CARB) – Refrigerant Management Program: https://ww2.arb.ca.gov/our-work/programs/refrigerant-management-program/about

GWP alternatives. This switch would reduce the overall potential for leakage or release of refrigerants from these systems and speed the phase out of high GWP HFCs already underway in new or retrofit equipment through the Act 65 rulemaking[4] process.

High (and consensus medium) Priority Actions

Lead Implementer: Agency of Natural Resources, VEIC		
a.	**Action Details** Work with VEIC and other stakeholders to complete additional outreach and education to help determine the scope and thresholds for a refrigerant management program (RMP) for Vermont, as well as to evaluate the potential impacs of such a program. Additionally work with VEIC and other stakeholders to better understand the number of entities and potential associated costs and benefits would be necessary. While the evaluation and review of potential program details would provide greater certainty, the resulting RMP would likely require registration, periodic reporting, and repair obligations for businesses that meet the refrigerant threshold requirements.	**Impact** Reductions of emissions from high GWP refrigerants is an important component for mitigating emissions from the Industrial Processes sector. Ozone depleting substances (ODS) substitutes make up approximately 60% of emissions from the Industrial Processes sector[5] and high GWP refrigerants are an important component of that total.
		Equity Addressing sectoral emissions from the industrial process sector ensures that all Vermonters and Vermont businesses are contributing to the shared emissions reductions requirements. To implement reductions in refrigerant emissions equitably, it is critical that Vermont support BIPOC and New American-owned businesses and other small businesses that are required to participate. That support should come in the form of financial incentives, language access, and project counseling.
		Cost-Effectiveness The cost effectiveness for this action is somewhat variable due to the many different types and sizes of refrigeration systems. Costs associated with the RMP would be connected to the inspection and reporting requirements, as well as to any

[4] Vermont Department of Environmental Conservation (DEC): https://dec.vermont.gov/sites/dec/files/aqc/laws-regs/documents/Vermont_HFC_Rule_Adopted_CLEAN.pdf

[5] Vermont DEC – GHG Inventory: https://dec.vermont.gov/sites/dec/files/aqc/climate-change/documents/_Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2017_Final.pdf

		repairs required if leaks were found. In many cases these costs could be recouped over time because fixing leaks would lead to smaller amounts of refrigerants that would need to be purchased.
	Timeline to Implement One to two years	**Co-Benefits** - Potential cost savings for participating entities through purchasing less refrigerant. - Reducing short-lived climate pollutants has important near-term GHG benefit.
		Technical Feasibility Yes
b.	**Action Details** Require and provide cost share for the installation of permanent leak detection systems for facilities using over a certain threshold of high GWP refrigerants. Permanent leak detection systems would provide real-time monitoring of refrigeration systems to detect and allow for leaks to be repaired quickly. Specific funding needs will be informed by the development of the RMP to help inform which entities would benefit or qualify. Additional work with VEIC and other stakeholders to better understand the number of entities and potential associated costs and benefits would be necessary.	**Impact** The GHG reduction impact from a permanent leak detection system is potentially high but depends upon the type and amount of refrigerant being used within the system. Permanent leak detection systems can prevent catastrophic leaks from large systems by providing real time information (as opposed to less frequent inspections conducted as part of the RMP) and enabling the fixing of leaks before they become major issues.
		Equity Addressing sectoral emissions from the industrial process sector ensures that all Vermonters and Vermont businesses are contributing to the shared emissions reductions requirements. To implement reductions in refrigerant emissions equitably, it is critical that Vermont support BIPOC and New American-owned businesses and other small businesses that are required to participate. That support should come in the form of financial incentives, language access, and project counseling.

		Cost-Effectiveness The cost-effectiveness of permanent leak detection systems is variable because it depends upon both the costs of the equipment as well as the leaks prevented.
	Timeline to Implement One to two years	**Co-Benefits** - Potential cost savings for participating entities through purchasing less refrigerant. - Reducing short-lived climate pollutants has important near-term GHG benefit.
		Technical Feasibility Yes
c.	**Action Details** Provide incentives for businesses to transition from high GWP refrigerants to lower GWP alternatives. Outreach and funding could be targeted through information collected through the RMP to transition applicable businesses away from high GWP refrigerants. This would be a voluntary program that could help to speed the phase out of these high impact GHGs. The incentives would complement and supplement the Act 65 rulemaking which currently requires the phase out of high GWP HFCs in new equipment and retrofits by end use, and this program could potentially be expanded to include end uses beyond just refrigeration.	**Impact** The impact of the incentives would be variable and depend on the projects funded. Given the expected rise in emissions of HFCs in the coming years[6] and their high GWPs and often short atmospheric lifetimes reducing the use of these gases is an important step to take in mitigating GHG emissions in Vermont.
		Equity Addressing sectoral emissions from the industrial process sector ensures that all Vermonters and Vermont businesses are contributing to the shared emissions reductions requirements. To implement reductions in refrigerant emissions equitably, it is critical that Vermont support BIPOC and New American-owned businesses and other small businesses that are required to participate. That support should come in the form of financial incentives, language access, and project counseling.

[6] EPA Significant New Alternatives Program (SNAP): https://www.epa.gov/snap/reducing-hydrofluorocarbon-hfc-use-and-emissions-federal-sector-through-snap

		Cost-Effectiveness The cost-effectiveness of incentivizing the transition from high GWP refrigerants to lower GWP alternatives is variable because it depends on the equipment being replaced or retrofitted, as well as the gas being replaced and the new alternative refrigerant. In some cases, a transition to a new low GWP refrigerant can provide efficiency benefits that would provide cost savings over time.
	Timeline to Implement One to two years	**Co-Benefits** - Potentially new or updated equipment for qualifying businesses. - Potential for cost savings over time through increased system efficiency.
		Technical Feasibility Yes

Pathway 2: Reduce Process Emissions from Semiconductor Manufacturing in Vermont

Greenhouse gas emissions associated with semiconductor manufacturing in Vermont make up approximately 34% of the total for the Industrial Processes sector[7]. Global Foundries is the sole semiconductor manufacturer in Vermont and the GHG emissions associated with their industrial sector emissions include a number of fluorinated gases, including sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and nitrogen trifluoride (NF_3). Producing semiconductors requires the use of a number of high GWP gases in the etching and chemical vapor deposition (CVD) processes, as well as their use as heat transfer fluids[8] for various tools. Reducing emissions of these high GWP gases in these processes is important, but in many cases is technically challenging, and is an area where further exploration is needed.

[7] Vermont DEC – GHG Inventory: https://dec.vermont.gov/sites/dec/files/aqc/climate-change/documents/_Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2017_Final.pdf

[8] EPA – F-Gas Partnership Programs – Semiconductor Manufacturing: https://www.epa.gov/f-gas-partnership-programs/semiconductor-industry

1. Continue to Explore Efficiencies and Alternatives to High GWP Fluorinated Gases in the Semiconductor Manufacturing Process

Because of the precision and extremely technical nature of the semiconductor manufacturing process, the options for mitigation strategies in the sector are somewhat limited. Potential reduction strategies in the sector include process improvements, the use of technologies to destroy the gases when emitted, and the use of alternative chemicals, or chemical substitutuions, to perform the same functions. Chemical substitutions can provide potentially significant emissions reductions, but require extensive review and testing before implementation. Global Foundries has been pursuing several of these actions already and discussions have been ongoing between Global Foundries, the Public Service Department (PSD), and the Agency of Natural Resources (ANR) through a pending Public Utilities Commission (PUC) proceeding considering Global Foundries' petition to become a Self-Managed Utility (SMU). The PUC proceeding may or may not result in emission reductions for Global Foundries consistent with the GWSA requirements. As of the date of this plan, the PUC proceeding has not been concluded. In the absence of sufficient and/or binding emissions reductions consistent with the GWSA requirements, ANR will promulgate rules in a timely manner necessary to ensure the 2025, 2030, and 2050 emissions redutions requirements are met. In the event that the PUC proceeding has not concluded by December 1, 2022, ANR will commence rulemaking.

High (and consensus medium) Priority Actions

Lead Implementer: Agency of Natural Resources, Department of Public Service		
a.	**Action Details** Under either PUC or ANR jurisdiction (see above), Global Founds will implement technologies for the destruction of emissions of high GWP gases and potentially use chemical substitutions in the semiconductor manufacturing process. These technologies and/or chemical substitutions would be implemented in line with GWSA greenhouse gas emission reduction requirements.	**Impact** Reducing emissions from semiconductor manufacturing can have a very direct impact because there is only one facility in Vermont producing those emissions. By working with Global Foundries to implement emissions reduction strategies, specifically including the fugitive gas destruction devices proposed as a component of the PUC process, significant reductions from the 0.19 million metric tons of CO_2 equivalent ($MMTCO_2e$) attributed the the facility for 2017 can be achieved.
		Equity Addressing sectoral emissions from the industrial process sector ensures that all Vermonters and Vermont businesses are contributing to the shared emissions reductions requirements.

		Cost-Effectiveness Reducing emissions from the semiconductor manufacturing sector is relatively expensive. The installation of the 28 fugitive gas destruction devices proposed as a part of the PUC process is estimated to cost roughly $10 million dollars. Costs associated with chemical substitutions are unclear, but may also provide meaningful emissions reductions.
	Timeline to Implement Dependent upon PUC proceeding outcome. If current proposal goes forward, implementation of devices will occur over the next several years.	**Co-Benefits** - Reductions of toxic co-pollutants including hydrofluoric acid (HF).
		Technical Feasibility Yes

Pathway 3: Reduce Fugitive Emissions from Wastewater Treatment Facilities

Greenhouse gas emissions from wastewater treatment facilities (WWTFs) included in the GHG inventory consist mainly of methane (CH_4) from the decomposition of organic materials under anaerobic conditions (in the absence of oxygen). Methane is a GHG that is 25 times more potent than CO_2 on a per mass basis with an atmospheric lifetime [9], based on current GHG inventory guideline values, making it an important focus for near-term GHG emissions reductions. Emissions of methane from WWTFs are created in anaerobic conditions in a digester and are generally either combusted for a beneficial use, such as the generation of heat or electricity, or flared (burned off), both of which convert the CH_4 to CO_2. Based on design standards for WWTF's, all of the treatment facilities with anaerobic digester systems in Vermont are required to be equipped with flares. Ensuring these flares are operational and functioning as they should be is a straightforward action that will help to reduce methane emissions from the facilities. Ideally, over the longer-term, beneficial uses of the methane produced in these anaerobic

[9] Intergovernmental Panel on Climate Change (IPCC) – AR4 Global Warming Potential (GWP) values: https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

digesters can be incorporated, so that the produced methane can create energy for the facility or other uses. The strategy below represents a first step in that process.

1. Ensure Flares are Operational at Existing Anaerobic Digesters at Wastewater Treatment Facilities

There are currently 94 municipal wastewater facilities in Vermont and of those 94 facilities, 10 currently have anaerobic digester systems. The digester systems process treatment residuals from some of the larger municipalities in the state, which are often areas of high population densities and therefore produce significant volumes of wastewater as well as relatively large quantities of CH_4. Moreover, smaller municipalities often send treatment residuals to these larger WWTFs for further treatment in digesters. Additional review and outreach needs to be completed to determine the operational status of the flares at several of the 10 WWTFs with anaerobic digesters, but preliminary data suggests an opportunity for emissions reductions. Ensuring that the flares at several of these larger municipal facilities with digesters are operational could reduce emissions by an estimated 3,000 metric tons of CO_2e annually, and potentially more depending upon which additional facilities have non-functioning flares. One additional opportunity in this space is the potential for beneficial use of digester gas for digester facilities that do not currently have systems in place to take advantage of that existing fuel source. Installation of beneficial use systems may not be a cost-effective strategy for GHG mitigation, but does have co-benefits such as displacing fuel purchased for thermal needs and reliable and consistent electricity generation, as well as being able to recoup system installation costs over time.

High (and consensus medium) Priority Actions

Lead Implementer: Agency of Natural Resources

<table>
<tr><td rowspan="4">a.</td><td rowspan="3">Action Details Ensure that flare systems are functional for all 10 of the WWTFs in Vermont with anaerobic digester systems. Conduct additional outreach to determine the operational status of flares at each facility and any potential issues surrounding maintaining the flares going forward. For facilities with digesters that do not have beneficial use capabilities, require a subsidized engineering evaluation to determine the costs associated with the installation of such a system.</td><td>Impact The impact of ensuring that existing flares on WWTF digester facilities are operational is likely relatively small, however, because the flares are already required to be present at the facilities, this action should be fairly easy to implement. Existing data suggests that approximately 3,000 metric tons of CO_2e could be reduced annually with the potential for greater reductions based on results from the additional outreach performed.</td></tr>
<tr><td>Equity The operation of wastewater treatment facilities represents one of the most significant costs for Vermont municipalities, especially for low-income and economically depressed communities. Ensuring functioning flares across all community income spectrums is an important equity consideration. Further, functioning flares reduces odor and other public health concerns around facilities, addressing a significant environmental justice concern.</td></tr>
<tr><td>Cost-Effectiveness The cost effectiveness of ensuring flares at WWTFs with digesters are operational is high. There will likely be costs associated with returning flares to operational status where they are not currently running. Cost-effectiveness for installation of beneficial use systems is likely low for GHG emissions reductions but is worth investigating in order to take advantage of an existing fuel source for other reasons.</td></tr>
<tr><td>Timeline to Implement Two to three years</td><td>Co-Benefits
- Reduction of nuisance odors</td></tr>
<tr><td></td><td></td><td>Technical Feasibility Yes</td></tr>
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