The next Norwich Energy Committee meeting is Monday, 6/1/2020, at 7:00 pm
via Zoom: https://us02web.zoom.us/j/87215373132
via phone: 888 475 4499 US Toll-free
Meeting ID: 872 1537 3132

The meeting agenda includes:
- report on GHG inventory for Town with Eva Rosenbloom [PDFs attached]
- review of appointments, terms, chair/vice-chair
- updates...
  *Eat Low & Local campaign
  *UV e-bike lending library
  *Intermunicipal Regional Energy Coordinator
  *grant applications
- future work - 20% in 2020 promotion? 2020 Solarize? Climate Interactive? https://www.climateinteractive.org/
- other business, announcements

Greenhouse Gas Inventory and Emissions Reduction Plan

Town of Norwich, VT: Tracy Memorial Hall

Eva Rosenbloom
Prepared as part of a graduate research project for Harvard University: May 2020

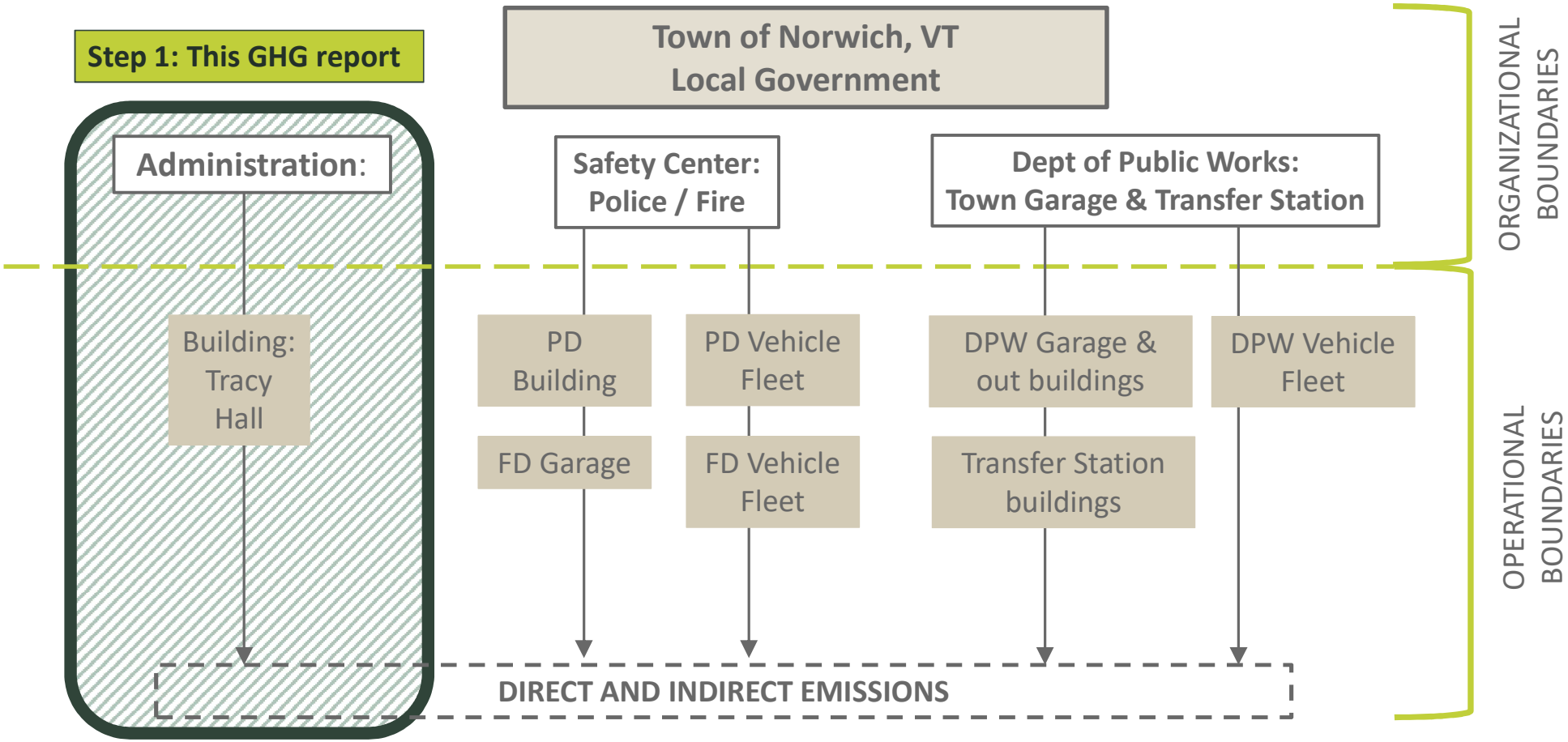
Determine Consolidation Approach

Norwich Organizational Structure

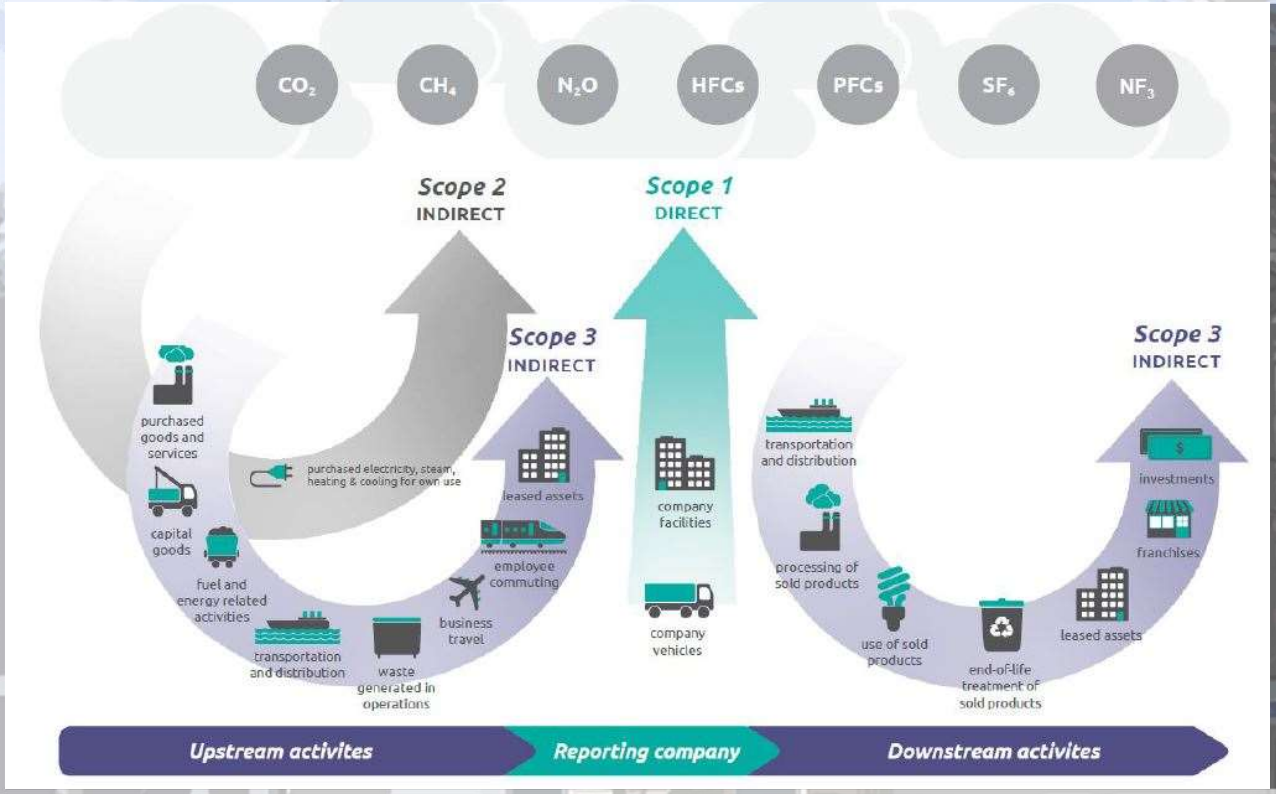
Wholly owned and joint operations / Buildings	Economic Interest	Control of operating Policies	Emissions Accounting for and reported by Norwich	
			Equity Share Approach	Control Approach
Tracy Hall: Administration	100%	Norwich	100%	100% for Financial 100% for Operational
Safety Center: Police & Fire	100%	Norwich	100%	100% for Financial 100% for Operational
Department of Public Works	100%	Norwich	100%	100% for Financial 100% for Operational
Norwich Public Library	71%	NPL	71%	0% for Financial 0% for Operational
Advanced Transit	20%	Advanced Transit	20%	0% for Financial 0% for Operational
Norwich Cemetary Association	X%	NCA	X %	0% for Financial 0% for Operational
Norwich Historical Society	X%	NHS	X%	0% for Financial 0% for Operational
Norwich Fire District	0%	Fire District	0%	0% for Financial 0% for Operational
Marion Cross Pubic School	0%	SAU70 school district	0%	0% for Financial 0% for Operational

Consolidation Approach = Operational Control

Establish Organizational and Operational Boundaries



Understanding Emissions Scope 1, 2 & 3



Define Emission Sources & Base Year

Emission Source			Scope
Tracy Hall: Administration			
	Relevant Categories		
Direct	Stationary Combustion	#2 Oil heating	1
	Mobile Combustions	-	
	Fugitive Sources	Refrigerants in heat pumps, refrigerator & window AC units	1
Indirect	Purchased Electricity	Electricity Admin Hall	2
Indirect	Purchased goods & services	Office supplies, contractor services, other	3
	Capital goods	Equipment, improvements and furniture	3
	Upstream Transportation	Shipping and delivery of above goods & services	3
	Waste generation	Solid & sewer waste generated by bulding functions	3
	Business Travel		3
	Employee Commuting	55,000 monthly mileage from employees & contractors	3
	Equity Investments (> $8000)	Norwich Public Library	3
		Advanced Transit	3
		Norwich Cemetery Association	3
		Norwich Historical Society	3
		Visting Nurse Association & Hospice	3

FY 2018

(July 2017-June 2018)

GHG Calculations Summary

Emissions Source		MT CO2e Emissions		
		FY 2018	FY2019	FY2020 est.
Scope 1	Stationary Combustion	**50.27**	48.45	46.46
	Mobile Combustion	0	0	0
	Fugitive Sources	2.24	2.24	2.24
Scope 2	Purchased Electricity:			
	Location Based	18.32	19.49	19.16
	Market Based	2.5	3.46	3.38
TOTALS	**SCOPE 1 & 2**	**55.01**	**54.15**	**52.07**
Scope 3	Office Supplies	3.21	2.84	2.89
	Employee Commuting	19.55	19.55	19.55
TOTALS	**SCOPE 1 & 2 & 3**	**77.77**	**76.54**	**74.51**

Scope 1

Burning Fossil Fuels

GHG Calculations Summary

Emissions Source		MT CO2e Emissions		
		FY 2018	FY2019	FY2020 est.
Scope 1	Stationary Combustion	50.27	48.45	46.46
	Mobile Combustion	0	0	0
	Fugitive Sources	2.24	2.24	2.24
Scope 2	Purchased Electricity:			
	Location Based	**18.32**	19.49	19.16
	Market Based	**2.5**	3.46	3.38
TOTALS	**SCOPE 1 & 2**	**55.01**	**54.15**	**52.07**
Scope 3	Office Supplies	3.21	2.84	2.89
	Employee Commuting	19.55	19.55	19.55
TOTALS	**SCOPE 1 & 2 & 3**	**77.77**	**76.54**	**74.51**

Scope 2

PPA with off-site solar

GHG Calculations Summary

Emissions Source		MT CO2e Emissions		
		FY 2018	FY2019	FY2020 est.
Scope 1	Stationary Combustion	50.27	48.45	46.46
	Mobile Combustion	0	0	0
	Fugitive Sources	2.24	2.24	2.24
Scope 2	Purchased Electricity:			
	Location Based	18.32	19.49	19.16
	Market Based	2.5	3.46	3.38
TOTALS	**SCOPE 1 & 2**	**55.01**	**54.15**	**52.07**
Scope 3	Office Supplies	3.21	2.84	2.89
	Employee Commuting	**19.55**	19.55	19.55
TOTALS	**SCOPE 1 & 2 & 3**	**77.77**	**76.54**	**74.51**

Scope 3

Est. GHG impact from employee commuting

Town Reduction Goals & Targets

March 2019 Voter-approved Article # 36:

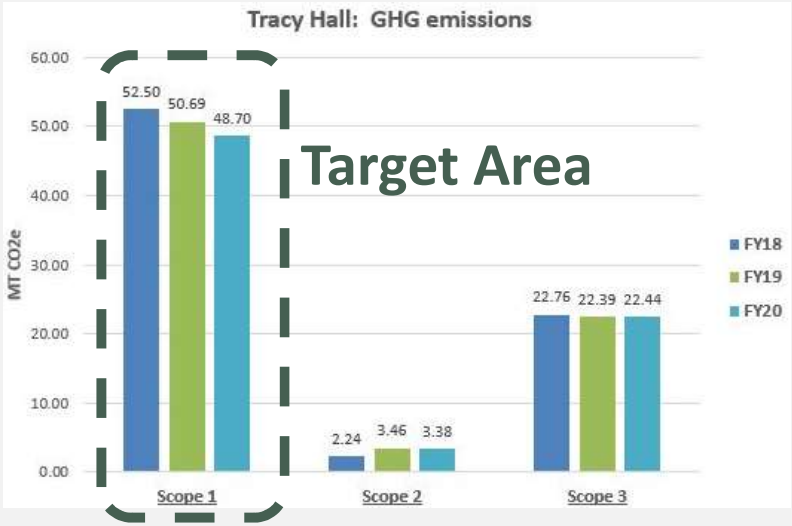
"…take **immediate and sustained efforts** to gradually and continually reduce the Town's direct use of fossil fuels, beginning at a rate of no less than **5% per year**…until they are eliminated entirely…"

Using **GHG terminology** and larger timeframes gives Norwich **more flexibility** in achieving goals

Set an *Absolute* target from a *Fixed* base year to align with voter mandate =

25% of FY2018 levels by 2025
50% of FY2018 levels by 2030
100% of FY2018 levels by 2040

Reduction Strategies: Scope 1 Tracy Hall



Target Scope 1: **Increase building efficiency / lower heating needs**

Install attic insulation

GHG Savings: 5 MT CO2e

Target Scope 1: **Eliminate fossil fuel dependency**

Replace oil boiler with ground sourced heat pump

GHG Savings: 49 MT CO2e

Reduction Strategies: Other Scopes

Target Scope 3: **Decrease employee commuting mileage**

Policies to reduce one employee commute / week

Cost: minimal to none

GHG Savings: 2.4 MT CO2e

Target all Scopes: **Creating an environment of behavioral change**

Align Town reduction mission with employee efforts

Cost: minimal to none

GHG Savings: 0-5 MT CO2e

Target all Scopes: **Purchase Carbon Offsets**

Cost: $11.00 / MT

GHG Savings: 0-10 MT CO2e

Target Scope 1 & 3: Eliminate fossil fuel dependency at Tracy Hall AND surrounding properties

Install District Geo Thermal

Cost: > $5,000,000 but grants may be available

GHG Savings: > 65 MT CO2e

Reduction Strategies: Other Scopes

Target Scope 3: **Decrease employee commuting mileage**

Policies to reduce one employee commute / week

Cost: minimal to none

GHG Savings: 2.4 MT CO_2e

Target all Scopes: **Creating an environment of behavioral change**

Align Town reduction mission with employee efforts

Cost: minimal to none

GHG Savings: 0-5 MT CO_2e

Target all Scopes: **Purchase Carbon Offsets**

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Cost: > $5,000,000 but grants may be available

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Reduction Strategies: Other Scopes

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Policies to reduce one employee commute / week

Cost: minimal to none

GHG Savings: 2.4 MT CO_2e

Target all Scopes: **Creating an environment of behavioral change**

Align Town reduction mission with employee efforts

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Target Scope 1 & 3: Eliminate fossil fuel dependency at Tracy Hall AND surrounding properties

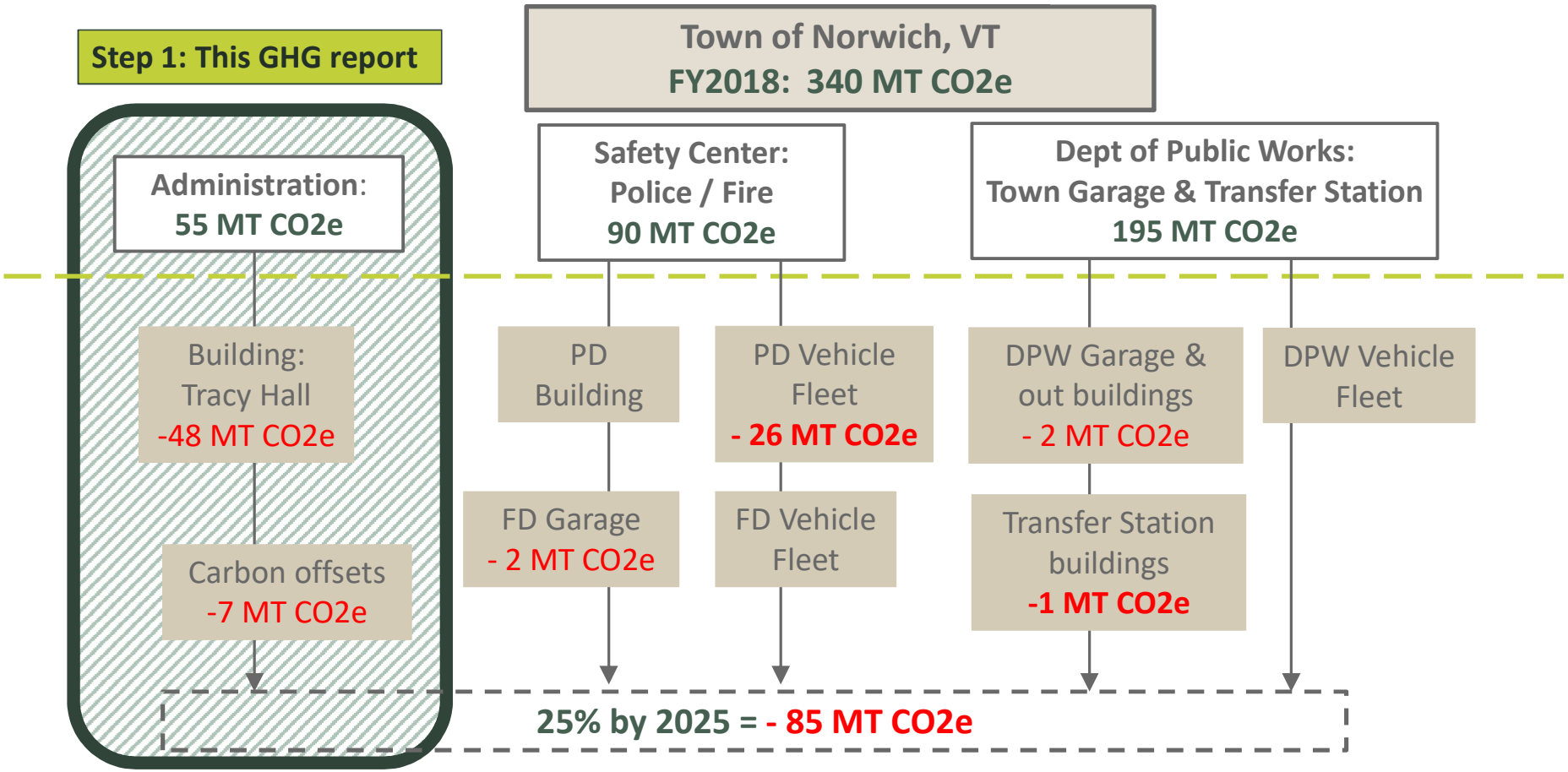
Install District Geo Thermal

Cost: > $5,000,000 but grants may be available

GHG Savings: > 65 MT CO_2e

Town GHG Goals

Target 1: 25% by 2025



Town GHG Goals Review

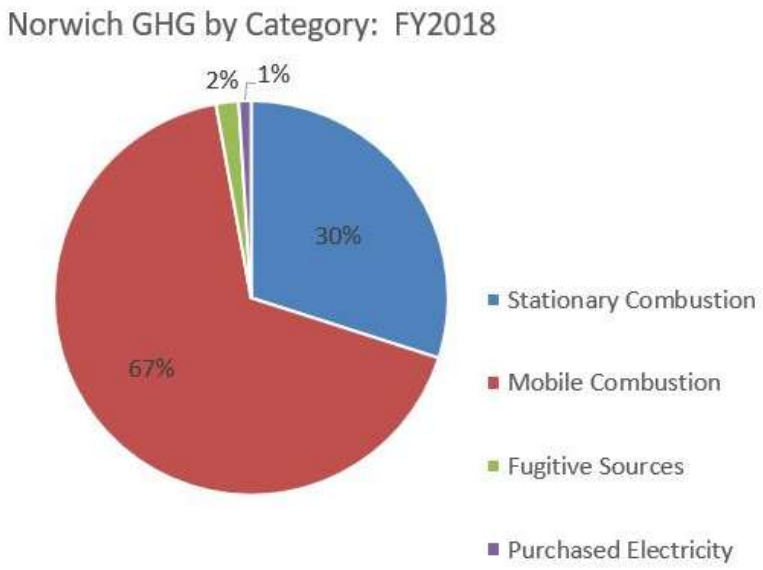
Target 1: 25% by 2025

Town of Norwich, VT
FY2018: 340 MT CO2e

Administration:
55 MT CO2e

Safety Center:
Police / Fire
90 MT CO2e

Dept of Public Works:
Town Garage & Transfer Station
195 MT CO2e



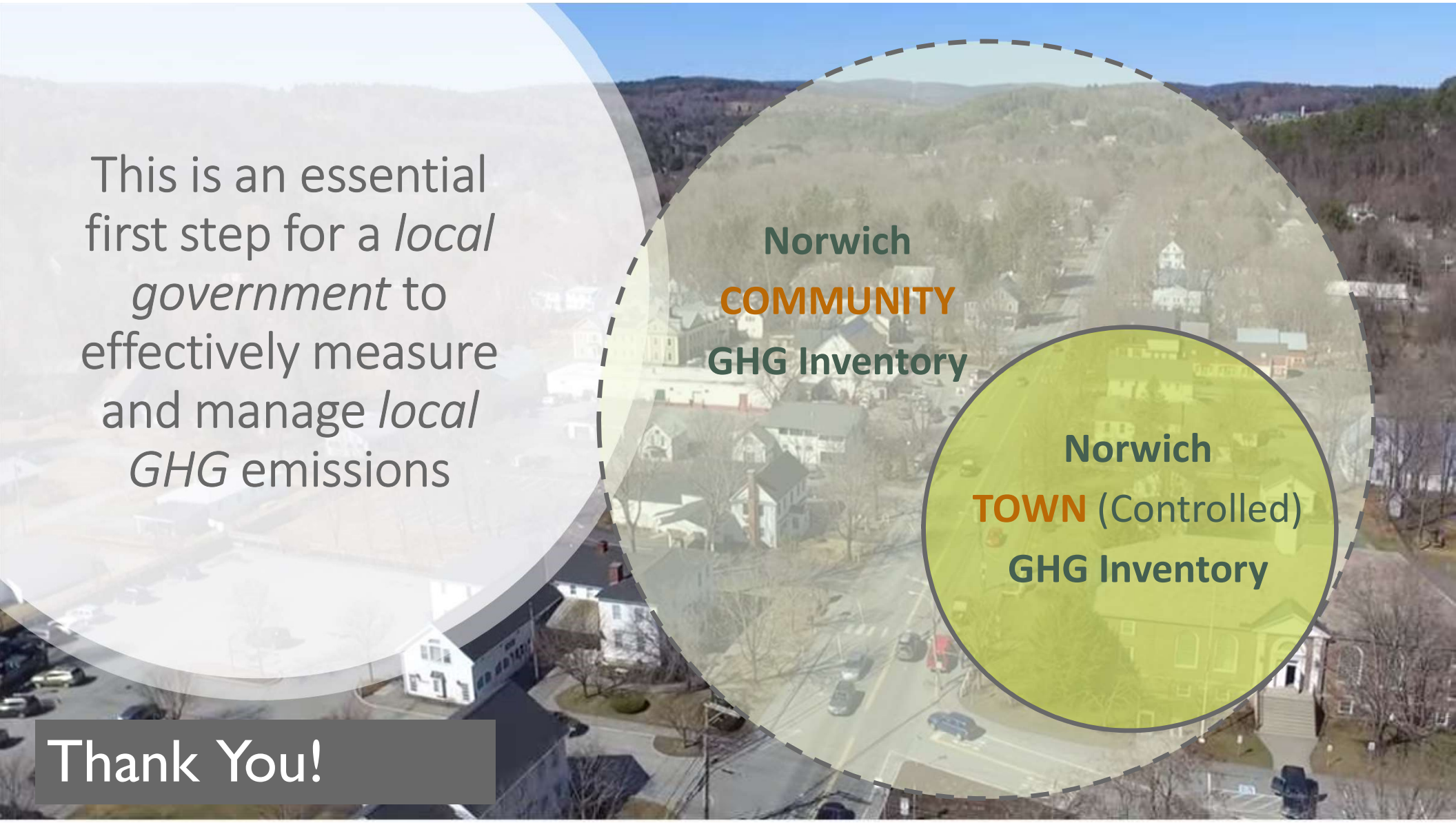
25% by 2025 = - 85 MT CO2e

50% by 2030 = - 170 MT CO2e

100% by 2040 = - 340 MT CO2e

Next Steps

- Finish total Scope 1 & 2 Inventory
- Determine Scope 3 sources and accounting
- Align GHG impacts with financial accounting
- Submit total inventory report and reduction plans
- Expand boundaries from operational control to geographic boundaries


This is an essential first step for a *local government* to effectively measure and manage *local GHG* emissions
Norwich
COMMUNITY
GHG Inventory
Norwich
TOWN (Controlled)
GHG Inventory
Thank You!

Greenhouse Gas Inventory and Emissions Reduction Plan*

Town of Norwich, VT: Tracy Memorial Hall

Eva Rosenbloom

May 2020

*Note: this report was compiled as part of a graduate research project for Harvard University

Table of Contents

List of Tables

List of Figures

1. Organization Description

The Town of Norwich, VT is small central Vermont town, home to approximately three thousand five hundred residents, located on the banks of the Connecticut River, and with close proximity to major highways (Norwich, 2014). The town of Norwich was first chartered in 1761 and the currently local government manages the Town Administration, planning, recreation, public safety and public works departments (Norwich, 2014). Norwich fully owns and operates all buildings and the vehicle fleet associated with these services. This greenhouse gas (GHG) inventory report will focus specifically on the emissions from the building and services concerning the administrative, recreation, and planning departments of Town government contained in Tracy Memorial Hall.

Centrally located on Main Street in the Village of Norwich, Tracy Hall contains most of the Town administrative offices, some meeting room spaces, and a gymnasium. Built in 1939, Tracy Hall was a part of the Public Works Administration (PWA) program, is a three story brick building and approximately 12,925 SF (The Living New Deal, 2014). The current heating system uses #2 oil fuel and there are some auxiliary mini-split heat pumps for supplemental heating and air-conditioning in the offices (NEC, 2020). There are no official Town-owned vehicles associated with the functions of Tracy Hall, nor are any products made or sold.

In March of 2019, the residents of Norwich voted in a majority to "reduce the Town's direct use of fossil fuels, beginning at a rate of no less than 5% per year…until they are eliminated entirely…" (Norwich, 2019). As Tracy Hall is one component of the Town system, this report will serve as a vital first step in a multi-phased process of accurately measuring and managing the GHG emissions as a result of all Town municipal activities and functions.

2. Organizational and Operational Boundaries

The Town of Norwich fully owns, controls and implements all operating policies with one hundred percent equity share and financial interest of all the facilities and assets associated with the functions of the Administration, the Safety Center, and the Department of Public Works. There are some auxiliary services partially funded by the Town, but these are fully controlled and operated by other entities. Following guidelines set by The Climate Registry's General Reporting Protocol version 3.0 (GRP), it is recommended that an inventory follows any framework specific to the organization (TCR, May 2019). After a preliminary evaluation of the equity and controlled actions of the Town as shown in Table 1 below, the consolidation method selected for a Town GHG inventory is the *Operational Control*

approach. According to the US Public Sector Protocol, this approach is most common with municipalities because government organizations like Norwich usually focus on providing services rather than products (WRI & LMI, 2010). Under this approach, the municipal buildings, assets and functions under the Town's operational control would be calculated in any Town GHG inventory reports and would be reflected in the inventory management plan (IMP) (TCR, May 2019).

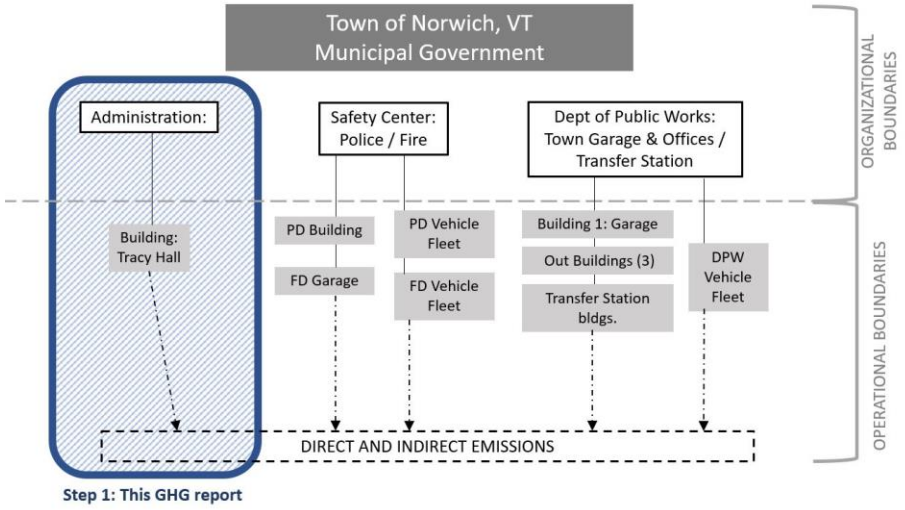
Table 1: Norwich organizational structure

Wholly owned and joint operations / Buildings	Economic Interest	Control of operating Policies	Emissions Accounting for and reported by Norwich	
			Equity Share Approach	Control Approach
Tracy Hall: Administration	100%	Norwich	100%	100% for Financial 100% for Operational
Safety Center: Police & Fire	100%	Norwich	100%	100% for Financial 100% for Operational
Department of Public Works	100%	Norwich	100%	100% for Financial 100% for Operational
Norwich Public Library	71%	NPL	71%	0% for Financial 0% for Operational
Advanced Transit	20%	Advanced Transit	20%	0% for Financial 0% for Operational
Norwich Cemetary Association	X%	NCA	X %	0% for Financial 0% for Operational
Norwich Historical Society	X%	NHS	X%	0% for Financial 0% for Operational
Norwich Fire District	0%	Fire District	0%	0% for Financial 0% for Operational
Marion Cross Pubic School	0%	SAU70 school district	0%	0% for Financial 0% for Operational

Likewise, the *organizational* boundary for a full GHG inventory for the Town encompasses the activities and assets under operational control, while an *operational* boundary would include indirect and direct emissions associated with those departments. Within this organizational boundary is the subject of this report; the Administration department and Tracy Memorial Hall as illustrated in Figure 1. This report is a subset of the Town system, follows the same reporting methodology, and includes all direct and indirect emissions found within the sub boundary of Tracy Hall.

The base year selected for Town GHG reporting is the Fiscal Year 2018 (FY2018) (July 1, 2017-June 30, 2018). According to the GRP, if reporting is done on an annual basis, following either calendar or fiscal year is acceptable (TCR, May 2019). Town accounting and procurement follows the fiscal year reporting methods and it is logical for the GHG accounting to align with the same approaches. It was determined that FY2018 would serve as a base year as it is the earliest and most data-comprehensive time period representative of current conditions. Data is complete for FY2018, FY2019, and up to March 31, 2020 for FY2020. The three months of missing data for FY2020 was estimated based on the monthly averages of the previous two years in order to make projections for FY2020.

Figure 1: Norwich organizational and operational boundaries



3. Emissions Sources

Tracy Hall is primarily an office building used for administrative purposes of Town functions including offices and meeting spaces. There is also a small gymnasium and stage located within it. Direct Scope 1 emissions are from the stationary combustion of heating fuel and fugitive refrigerant sources, while indirect Scope 2 emissions are from purchased electricity.

Applicable and probable indirect Scope 3 emissions categories for this building that are associated with the functions of Tracy Hall but beyond operational control include purchased goods and services, capital goods, upstream transportation, waste generation, business travel, employee commuting, and equity investments (WRI & WBCSD, 2013). Typical office supply purchases and equipment are utilized in its daily functions, as is the delivery transportation necessary for these items. Departments within Tracy Hall manage some financial funding to entities that are beyond Town operational control but provide a service to its residents. According to the Scope 3 Guidance document, these efforts are considered to be equity investments and the emissions from these entities should be included in Tracy Hall's Scope 3 inventory based on the percentage of investment (WRI & WBCSD, 2013). As a benchmark of possible sources, any annual funding of over $8,000 to an entity was a possible source of Scope 3 emissions. For example, the Norwich Public Library and Advanced Transit receive funding from Norwich to provide a service used by residents, but the Town does not own the building nor does it have control or influence of the operations, therefore any emissions from these entities would be calculated as Scope 3 emissions. Refer to Table 2 for an itemization outline of probable emission sources in the relevant categories for Tracy Hall.

Table 2: Emissions sources: Tracy Hall

Emission Source			Scope
Tracy Hall: Administration			
	Relevant Categories		
Direct	Stationary Combustion	#2 Oil heating	1
	Mobile Combustions	-	
	Fugitive Sources	Refrigerants in heat pumps, refrigerator & window AC units	1
Indirect	Purchased Electricity	Electricity Admin Hall	2
Indirect	Purchased goods & services	Office supplies, contractor services, other	3
	Capital goods	Equipment, improvements and furniture	3
	Upstream Transportation	Shipping and delivery of above goods & services	3
	Waste generation	Solid & sewer waste generated by bulding functions	3
	Business Travel		3
	Employee Commuting	55,000 monthly mileage from employees & contractors	3
	Equity Investments (> $8000)	Norwich Public Library	3
		Advanced Transit	3
		Norwich Cemetery Association	3
		Norwich Historical Society	3
		Visting Nurse Association & Hospice	3

4. Emissions Calculations

This report aligns with the policies of the GHG Protocol Corporate Standard and the GRP and includes reporting of the seven gasses defined in the Kyoto Protocol (TCR, May 2019) (WRI & WBCSD, 2004). From the emissions sources, the greenhouse gasses most relevant to this inventory for Tracy Hall are carbon dioxide (CO2), methane (CH4), nitrous oxide (NO2), and hydrofluorocarbons(HFCs). Emissions and global warming potential (GWP) factors used were sourced from The Climate Registry's (TCR) Default Emission Report of May 2019 (TCR, 2019) unless other more accurate or localized information was discovered and is noted as such. All calculations were manually performed using the formulas in the TCR and cross referenced and verified with the Center for Corporate Climate Leadership Simplified GHG Emissions Calculator (TCR, May 2019) (EPA, 2018).

4a. Scope 1 Emissions

Stationary combustion emissions are result of a burning fossil fuels in the heating system (WRI & WBCSD, 2004). The complete mechanical system of Tracy Hall consists of a boiler and a few mini-split air source heat pumps (ASHP) that provide supplemental heating and some air conditioning in the office spaces. The boiler uses #2 fuel oil and the ASHPs operate on purchased electricity, so only the combustion from the heating oil will be calculated in Scope 1. In FY2018, 4915.10 total gallons of # 2 oil were allocated to Tracy Hall for heating, 4737.5 gallons were used in FY2019, and it is estimated that 4543 gallons will be used in FY2020. For analytical purposes, when compared to the heating degree

days (HDD), the heating efficiency ratios are .66, .63, and .64 respectively. HDD were generated from the closest available weather station at the Lebanon Municipal Airport, eight miles away (BizEE, n.d.).

Mobile combustion There is no mobile combustion relevant to the actions and functions of Tracy Hall and is not calculated in this inventory.

Fugitive emissions are present as result of the refrigerants used in the ASHPs. A visual site inspection also uncovered two additional window air conditioners and a residential refrigerator. The gymnasium is not cooled and does not have any associated refrigerants. Since maintenance records were not available, the screening method was used to calculate the fugitive emissions from the ASHPs, the window units and the refrigerator. The five ASHPs are the same make and model and according to the label, have a capacity of 78oz of R-22 refrigerant each. This is an older type of refrigerant and according to the Environmental Protection Agency (EPA) the use of R-22 is being phased out due to high ozone depletion effects and recommends to replace with a less harmful refrigerant blend, R-410A (EPA, 2010). The emission and GWP factors for R-410A were used to calculate the fugitive emissions for these ASHPs. The window air conditioners both had smaller capacities of 9.88 oz each and used R-410A. The domestic style refrigerator was listed to have a capacity of 4.5 oz. and used R-134A.

Summary of Scope 1 emissions for Tracy Hall are represented below in Table 3 and complete calculations found in Appendix A.

Table 3: Scope 1 emissions summary

Emission Source			Scope	Totals MT C02e					
				FY18		FY19		FY20	
					HDD ratio		*HDD ratio*		*HDD ratio*
Direct	Stationary Combustion	#2 Oil heating	1	50.27		48.45		46.46	
	Mobile Combustions	-							
	Fugitive Sources	Refrigerants in heat pumps, refrigerator & window AC units	1	2.24		2.24		2.24	
		TOTAL	**1**	**52.50**	*0.66*	**50.69**	*0.63*	**48.70**	*0.64*

4b. Scope 2 Emissions

Purchased electricity is the primary source of Scope 2 emissions (TCR, May 2019). In 2013, the Town entered a net metering and power purchase agreement (PPA) with a local off-site solar farm facility, Solaflect Energy, for the electricity of the Town managed assets . According to guidance from the GRP, because of this agreement, the Scope 2 emissions will be calculated and reported in both the location-based and the market-based methods (TCR, May 2019). Since Tracy Hall is located in New England, location-based calculations were generated with emissions factors for the NEWE eGrid subregion using TCR's default factors found in Table 3.1 (TCR, 2019). The market-based calculations followed the

methods outlined as Market-B for the PPA agreement and Market-C for Utility-specific emissions factors for any remaining grid supplied power (TCR, May 2019).

According to the agreement and information from Solaflect, the renewable energy credits (RECs) are held with the facility, have not been sold, and have been retired (Callahan, 2020). This agreement has provided Norwich the opportunity to reduce its carbon equivalent emissions from electricity use across its facilities, including Tracy Hall. Emissions from the electricity provided by this solar facility are calculated as 0 CO2eq. The remainder of the power is from the grid of Green Mountain Power(GMP) and will be calculated using utility-specific emission factors according to Market C guidelines (TCR, May 2019). According to GMP, over ninety percent of the local grid electricity is provided by renewable sources (GMP, 2018). A representative from GMP reported that they use an emissions factor of 209lbs/MWh in calculating CO2 emissions and ten percent of the NEWE eGrid factors to calculate CH4 and NO2 emissions (Turk, 2020).

Tracy Hall KWhr usage data from GMP indicates the total consumption of Tracy Hall and the total supply provided by the PPA solar facility on a monthly basis. In FY2018, the solar facility provided sixty-three percent of Tracy Hall's total KWh consumption. These separate amounts were multiplied by the corresponding emissions and global warming potential factors in order to generate a cumulative total market-based emissions amount as shown in full calculations in Appendix B.

Summary of Scope 2 emissions for Tracy Hall are as follows in Table 4. It is clear from these calculations that the market-based method affords Tracy Hall with a greatly reduced total annual CO2eq emissions and will be used to calculate the final total.

Table 4: Scope 2 emissions summary

Emission Source			Scope	Totals MT C02e		
				FY18	FY19	FY20
Indirect	Purchased Electricity	Electricity Admin Hall	2			
		Location based		**18.32**	**19.49**	**19.16**
		Market Based		**2.50**	**3.46**	**3.38**

4c. Scope 3 Emissions

Due to certain extenuating circumstances during this inventory project, access to quantities and specific data for some possible Scope 3 emissions was limited and not available at this time. Basic and preliminary data was obtained for two categories of the Scope 3 emissions for Tracy Hall; employee commuting and purchased office supplies.

The scope of mobile combustion associated with employee commuting is worthy of measuring and managing for Tracy Hall as burning fossil fuels have high emissions factors and global warming potential (TCR, May 2019). Norwich is a small town in a relatively rural area with low-density population. Even though it is conveniently located off main roads and some public transportation exists, the primary mode of transportation for the surrounding area is the car. According to walkscore.com, the address for Tracy Hall is listed as "car-dependent with some bike infrastructure" with walk and bike scores of 47 and 58, respectively (Walk Score, n.d.). This rating, while higher than other small Vermont towns, is indicative of the dependency on vehicles and potential emissions that will be generated by the employees in Tracy Hall as a result of commuting to work.

In order to estimate the Scope 3 emissions from employee commuting, many assumptions and estimates were made due to the lack of exact data and inability to obtain this data. Tracy Hall has eight full time employees and two contractors (Norwich, VT, 2020). The general location of each employee residence was provided and an average travel distance per employee per day was calculated, which resulted in an estimated total weekly travel distance of 1,224 miles/week for all employees and contractors. This amount was multiplied by forty-five weeks to account for discrepancies, vacations and holidays to obtain a total annual mileage for Tracy Hall of 55,080 miles. The employee count is assumed to stay the same for FY2018, FY2019, and FY2020, so the same annual amount was used to calculate the emissions for each year.

To calculate these emissions, it was assumed that all vehicle miles would have utilized gasoline and a conservative average fuel economy of 24.9MPG was factored to account for a mix of vehicle types, highway-city driving, and fuel efficiency. The CO2 emissions factor recommended by the GRP is per gallon, so this fuel efficiency rate was used to convert the estimated mileage to estimated gallons of fuel used (TCR, 2019). With more specific information on individual employee attendance, commuting habits, vehicle type and driving styles, this calculation can be more accurate, but this estimation can offer a general sense of the impact that employee commuting has on the indirect carbon footprint of actions at Tracy Hall. The annual Scope 3 emissions from employee commuting for Tracy Hall are estimated in Table 5 below.

Indirect emissions from the purchase of goods necessary to fulfil the functions of an organization can be a source of unexpected emissions for a facility. Upstream purchased goods can generate emissions in multiple areas along the supply chain such as in material extraction, fabrication, and distribution to the facility destination (WRI & WBCSD, 2013). These emissions would be calculated as Scope 1 and 2 for the

respective suppliers and is suggested to be included in Scope 3 for the purchaser in order to grasp the full carbon footprint of an organization's operation (WRI & WBCSD, 2004). Measuring these impacts affords opportunities for potential risk evaluation, possible reduction strategies, and efficiencies available (WRI & WBCSD, 2013).

The annual Town Report of Norwich, VT for FY2019 was recently issued to residents which provides an overview of some expenditure information on Town purchases and expenses. According to the Town Report, the office supplies purchased for functions in Tracy Hall equaled $6045 in FY18, $5370 in FY19 and $5395 in FY2020 (Norwich, VT, 2020). The GHG emissions of typical office supplies purchased can be calculated using the value spent on these supplies with online calculators such as the standard model from eiolca.net (Eiolca, 2020). These monetary values were entered into the standard model calculator for office supplies which resulted in a total MT CO2e of 3.21, 2.84, and 2.89 accordingly for this activity.

Preliminary summary of Scope 3 emissions for Tracy Hall are summarized in the Table 5 below and in calculations in Appendix C. From these preliminary calculations, one could extrapolate that the Scope 3 emissions for Tracy Hall have the potential to exceed the amount of Scope 1 and 2 and are worthy of measurement.

Table 5: Scope 3 emissions summary

Emission Source			Scope	Totals MT C02e		
				FY18	FY19	FY20
Indirect	Purchased goods & services	Office supplies: Calculated based on $ spent	3	3.21	2.84	2.89
		Contractor services, other	3			
	Capital goods	Equipment, improvements and furniture	3			
	Upstream Transportation	Shipping and delivery of above goods & services	3			
	Waste generation	Solid & sewer waste generated by bulding functions	3			
	Business Travel	Minor in amounts	3			
	Employee Commuting	55,000 monthly mileage from employees & contractors	3	19.55	19.55	19.55
	Equity Investments (> $8000)	Norwich Public Library	3			
		Advanced Transit	3			
		Norwich Cemetery Association	3			
		Norwich Historical Society	3			
		Visting Nurse Association & Hospice	3			

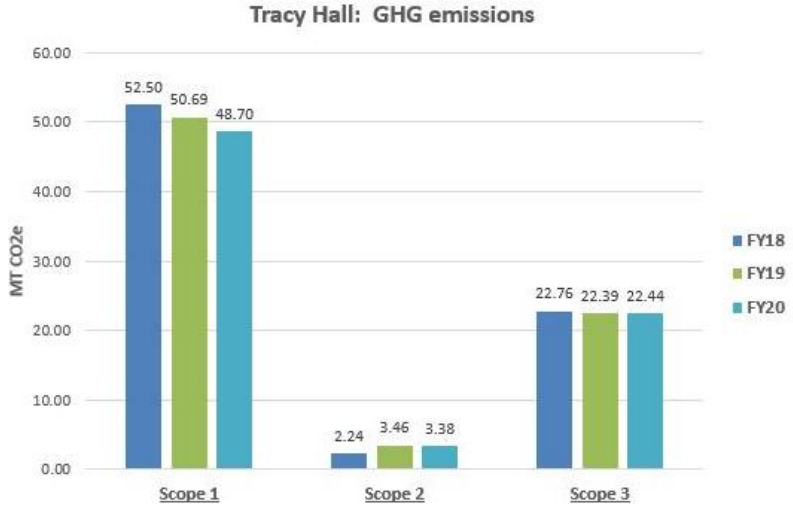
4d. Total Emissions Summary

The following Table 6 and Figure 2 documents the total Scope 1, 2, and 3 emissions calculated for FY2018, FY2019, and estimated for FY2020. Emissions are relatively consistent over the three years with a minor decreasing trend in Scope 1, but this is believed to be mostly due to the difference in heating degree days and not from a known reduction behavior.

Table 6: Total emissions summary

Emission Source			Scope	Totals MT C02e		
				FY18	FY19	FY20
Tracy Hall: Administration						
	Relevant Categories	**Totals**		**77.772**	**76.540**	**74.513**
Direct	Stationary Combustion	#2 Oil heating	1	50.27	48.45	46.46
	Mobile Combustions	-				
	Fugitive Sources	Refrigerants in heat pumps, refrigerator & window AC units	1	2.24	2.24	2.24
Indirect	Purchased Electricity	Electricity Admin Hall	2			
		Market Based		2.50	3.46	3.38
Indirect	Purchased goods & services	Office supplies: Calculated based on $ spent	3	3.21	2.84	2.89
		Contractor services, other	3			
	Capital goods	Equipment, improvements and furniture	3			
	Upstream Transportation	Shipping and delivery of above goods & services	3			
	Waste generation	Solid & sewer waste generated by bulding functions	3			
	Business Travel	Minor in amounts	3			
	Employee Commuting	55,000 monthly mileage from employees & contractors	3	19.55	19.55	19.55
	Equity Investments (> $8000)	Norwich Public Library	3			
		Advanced Transit	3			
		Norwich Cemetery Association	3			
		Norwich Historical Society	3			

Figure 2: Emissions summary for FY2018-FY2020



5. Major Emissions Sources and Reduction Strategies

From the chart in Figure 2 above, the emissions from Scope 1 are significant and stand out as a target for reductions. If further calculated, it is foreseeable that the Scope 3 emissions of Tracy Hall from all relevant categories would exceed Scopes 1 and 2 sources and would become the largest emissions source. With only two categories measured, Scope 3 is already almost half of Scope 1. The solar PPA and market-based calculations of Scope 2 have already afforded Norwich a responsible GHG management strategy from purchased electricity and may offer a little room for reduction compared to efforts in Scopes 1 and 3.

Scope 1 emissions from the #2 oil fossil fueled heating system and are ninety percent of Scope 1 and 2 emissions for Tracy Hall. Improving building heating efficiencies has the potential to lower oil use in turn reducing GHGs. It was reported from Town representatives that the boiler was last installed in 1994 and is nearing its expected lifetime and will need to be replaced soon. This timing provides the Town with an opportunity to examine and review global impacts with the decision on how to provide heating to this building. In addition, examining the complete Town GHG profile, Tracy Hall is the largest building in the operational boundary of the Town and a non-fossil fueled system can offer an aggressive reduction to meet overall Town GHG emissions goals.

Scope 3 emissions for Tracy Hall and the Administration department has the potential to be quite high when considering all the possible categories of Scope 3 sources. The preliminary calculation of employee commuting is already more that the location-based electricity amount which could be an indication that the total Scope 3 for Tracy Hall could be two to four times the amount of Scope 1 and 2. It is recognized by the EPA that local governments can impact and influence surrounding residents, behavior, and businesses by providing a role model of best GHG emissions practices (Denny & Pederson, 2015). These efforts and the financial influence that the Town (in this case Tracy Hall) has on their funded services, such as in the Public library or Transit facility, could inspire reductions in the Scope 1 and 2 emissions of those individual organizations, which would in turn lower Tracy Hall's Scope 3 emissions

5a. GHG Reduction Analyses

Fossil fuels are a main contributing factor in this GHG inventory. A prioritized reduction strategy would be to first target efforts to lower direct combustion Scope 1 emissions by reducing or eliminating the direct use fossil fuels. Tracy Hall could become a role model to influence actions in the other buildings owned and controlled by the Town. A more comprehensive measurement of Scope 3 emissions will lead to an evaluation of efficiencies and other possible reduction strategies. The following are some preliminary suggestions to reduce Tracy Hall's GHG impacts. Table 7 at the end of this section displays feasibility and efforts per recommendation.

Target Scope 1: Increase building efficiency, lower heating needs. Tracy Hall is an older building with many sources of air leaks and potentially substandard insulation. An energy audit report in 2012 indicated air sealing and insulation as an effective measure to reduce heating costs (Two Rivers, 2012). It is estimated that effective air sealing and attic insulation can provide approximately ten percent or more of a savings in heating energy/fuel used (Energy Star, 2020). Complying with the US Climate Zone

map, this facility is in zone 6A and according to the R-values that align with the International Energy Code of 2018, ceiling insulation should be at least R-49 (IECC, 2018). From previous existing energy audits, it was estimated that the attic insulation in Tracy Hall is below that insulating level at approximately R-30 (Two Rivers, 2012). An online calculator for the cost to remove, dispose of the old and install new blown-in cellulose attic insulation with air sealing for an estimated 8,000 SF of attic space costs about $25,000 (Homewyse, 2020) and would result in approximately 5 MT CO2 reduction annually based on ten percent energy savings estimate above. This investment is included in the cost analysis Table 7 below.

Target Scope 1: Eliminate fossil fuel dependency. A significant reduction strategy for Tracy Hall would to eliminate the fossil fuels entirely and switch from the #2 oil boiler system to non-fossil fuel heating system. Since the boiler is close to needing a replacement and Tracy Hall will need to make a new investment in its capital goods, this is an appropriate time to look at less carbon intensive systems. A non-fossil fuel dependent system available with high efficiency is ground-sourced heat pumps (GSHP), commonly referred to as geo-thermal. GSHPs use the constant temperature of the earth to supply energy for heating or to absorb it for cooling (Energy Star, 2020), and utilize an electric run pump to circulate fluid. In the case with Norwich, their market-based scope 2 calculations can offset any increases in electricity needed to accommodate the new system. GSHPs have a high initial cost due to the excavation and digging required to install the closed loop piping system (Energy Star, 2020) but replacing the oil burner with a non-fossil fuel system would reduce the carbon footprint of Tracy Hall by 49 MT CO2e, even with a possible slight increase in electricity use. This would also lower vulnerability and risk associated with fossil fuel dependence and associated emissions for Tracy Hall and Norwich.

Norwich recently contracted with a local energy advisor company, called EEI Inc, to provide preliminary pricing of these systems. EEI Inc compiled a report that the base cost to install a new oil burner system is $240,000. Assuming Tracy Hall will have to install a new heating system soon regardless, the alternative heat pump system cost is the delta increase from the base oil burner system. To maintain the efficiency of any system, it is recommended that the attic insulation be installed in addition to replacing the heating system no matter the source and is included in the costs of the new systems.

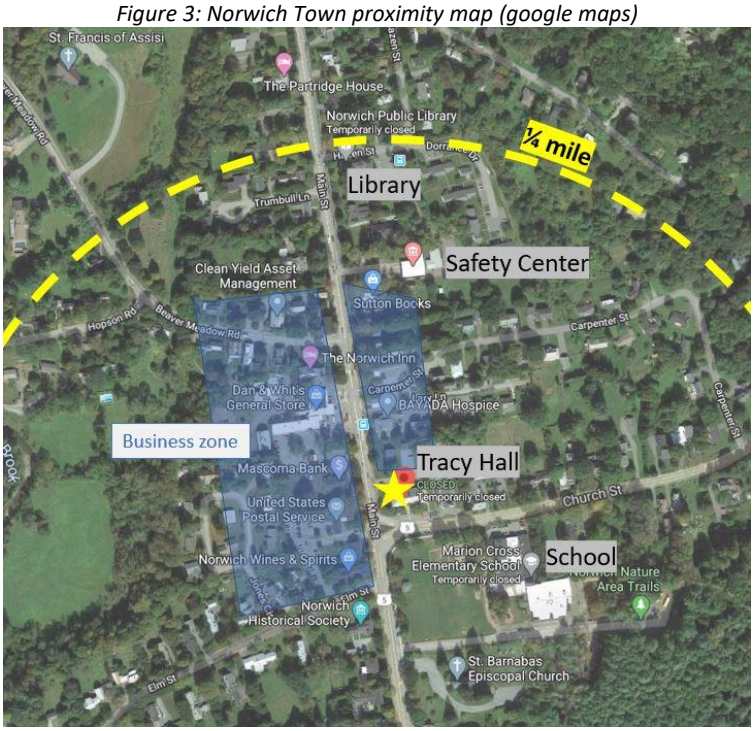
Target Scope 1 AND 3: Eliminate fossil fuel dependency at Tracy Hall AND surrounding properties. Fossil fuels used for heating are a large source of emissions in in similar climate zones towns like Norwich. With the timing as such where Tracy Hall will need an infrastructure heating investment in the short term future in addition to meeting the voter-directed fossil fuel reduction goals for the Town and

future calculations of community-wide GHG emissions, the Town of Norwich has an opportunity to expand their thinking and go beyond their organizational boundary. The Town could investigate the feasibility of investing in a renewable resource for local infrastructure and provide district geothermal heating and cooling to not only Tracy Hall, but the surrounding Town, residential and commercial properties. Within a quarter mile radius are the Safety Center, Norwich Public Library, the public elementary school, commercial businesses and some residences as in Figure 3. Distribution could follow Main Street which is easily accessible from properties. The school, private homes, and businesses are independent of Town financial, equity or operational control but those associated emissions would be calculated in a community wide GHG inventory. The Safety Center is within Town operational control and library is part of the Town's equity investments. With a geothermal heating system instead of current fossil fuels, Tracy Hall and the Safety Center would experience a reduction in Scope 1 and 3 because of the library's Scope 1 reduction.

A similarly sized small town in West Union, IA installed a system like this in 2013 successfully and could serve as a model for Norwich (Uhlenhuth, 2014). West Union took advantage of the timing from the need to replace other aging infrastructure and expanded that project to include geothermal heating to properties within a six-block radius in addition to improving storm water management (Geerts, 2018).

This endeavor would have a much higher initial investment than replacing just Tracy Hall's heating system, but this project has the potential to create a revenue stream for the Town and to increase the impact by dramatically lowering Tracy Hall's Scope 1 and Scope 3 emissions. Becoming a "utility provider" by distributing geo thermal heating and cooling would revise the Town's Scope emissions sources, but this would source theoretically be low because the emissions from district geothermal heating/cooling is significantly lower than fossil fuels (EIA, 2020).

Figure 3: Norwich Town proximity map (google maps)



The project in West Union cost about two million dollars at the time, with most of the funding coming from federal energy grants (Uhlenhuth, 2014). Based on this, a preliminary estimate of five million dollars for this project would be a first estimate minus any potential grant funding and potential revenue that Norwich could receive. There would still be the annual savings in fuel costs, but the concept of project pay-back would need to be evaluated with the potential of indirect and non-monetary values. The challenge with this endeavor would be gaining approval to proceed. Details would have to be approved by the Select Board of Norwich and then put out for voter approval to begin a project of this size and financial magnitude which may be a barrier for progress in the short term. For an immediate reduction estimate, Tracy Hall's GHG inventory would be reduced by 48-49MT CO2e plus any Scope 3 emissions from their equity investment in the library. The cumulative reductions estimated in West Union are significant at over 320 MTCO2e (EPA, 2017) and Norwich could expect similar results.

Target Scope 3: Decrease employee commuting mileage. The emissions from mobile combustion due to employee commuting are a large contributor to Tracy Hall's Scope 3 emissions. Until hybrid and electric cars are more commonplace, the administration from Tracy Hall and the Town could implement some programs and incentives that could reduce employee commuting mileage. With only eight to ten employees, there might not be a dramatic impact, but efforts would be able to be scaled up to include

the other departments of Town government and perhaps align with and inspire action in other neighboring businesses.

Efforts to reduce mobile combustion by Norwich already include two free electric vehicle charging stations, bike repair stations, and availability of a free public transportation entity, Advance Transit, that is shared with the neighboring towns (Advance Transit, 2020). The routes and times are limited and could be expanded to extend to more remote routes during logical business hours times. A resident and employee survey could be conducted to determine neglected routes to add to the current service area to increase ridership. From the residence location information provided during this inventory, some towns of employees are in the direction of others. Tracy Hall could create a commuting "buddy system" and pair logical carpoolers together to limit single occupancy vehicle occurrences during work hours. This program could be offered with an incentive such as flexible hours to accommodate each buddy's schedule or a bonus gas gift card to pay for the gas in a multiple occupancy vehicle. Some employees could operate remotely for a percentage of the work week, especially those commuting longer distances. This could be perceived as a highly valued benefit for some employees and could reduce emissions from total mileage.

To demonstrate the impact of these commuting reduction efforts, if one employee could eliminate one round trip commute each week, the annual mileage would be reduced by approximately ten percent resulting in a potential GHG emission reduction of 2.4 MT CO2eq annually.

Target all Scopes: Creating an environment of behavioral change. An organization's GHG emissions inventory can greatly depend on the facility daily use behavior from its inhabitants. It goes without saying that user-oriented actions in the work place such as limiting lighting levels, turning off power while not in use, more thought on recycling, being overly conscious about unnecessary waste, lowering water use, etc. depend on aligning the employee with the mission of the workplace and benefit from consistency across all stakeholders (Young, et al., 2015). Employee extrinsic rewards appropriate in scale and in the form of inclusion and ownership, financial gifts or bonuses, social and professional recognition and positive feedback can be highly effective in increasing participation in achieving an organization's environmental, corporate and social sustainable goals (Young, et al., 2015). Behavioral-change prompts such as signage and posters demonstrating the effect of the action would start to create an awareness in the office and at home. It would be difficult to pinpoint an exact GHG reduction from behavior changes but an aligned effort by all would lower emissions across all categories and could potentially have a positive trickle-down influence on neighboring and corresponding entities.

Target all Scopes: Carbon offsets. Norwich is fortunate, like most of Vermont and neighboring New Hampshire, to be mostly forested with many wetland areas. This already provides many existing natural carbon sinks and there is not much opportunity to expand this capability within the geographic boundary. Since Norwich is currently taking advantage of RECs from their PPA with the Solaflect facility, they could continue to reduce the carbon footprint of Tracy Hall and other departments with the purchasing of carbon offsets. Companies like Terrapass, Gold Standard, or Carbon Fund, for example, offer opportunities for businesses to balance their own global impact and support environmentally progressive programs, starting at $11.00 per MT CO2e (Terrapass, 2020). For $44.00 a year, Tracy Hall could offset 4 MT CO2e, the same amount from their office supply purchases. With some re-budgeting and an employee-use change of converting a previously paper-dependent tasks to all digital could immediately pay for those offsets with savings in the supplies budget.

Table 7: Simple pay back calculations / Feasibility assessment: Scope 1, 2, 3 reductions

Action	Scope Reduction	Initial Cost	Annual Cost Savings	Reduction in MTCO2e	Simple Pay back in years	Feasibility	Effort Level	Assumptions
Install Attic Insulation	1	$ 25,000.00	$ 914.37	5	27.34	Possible	Low	*Annual cost & GHG savings in heating oil is 10% of current costs
Install Geo Thermal Heating	1	$ 684,000.00	$ 10,167.18	48-49	67.28	Possible	Med-high	*Initial cost is the delta increase over the base cost of $240k for new oiler boiler. Cost & GHG savings reflects the elimination of oil but
District Geo Thermal	1, 3	$ 5,000,000.00	$ -	50-65 +	?	Major Investment	High ++	
Commuting strategies	3	$ -	$ -	>2		Free	Low	
Behavoir Changes	1, 2, 3	$ -	$ -	>5		Free	Low	
Carbon Offsets	1, 2, 3	$ 44.00	$ -	4		Low cost	Low	*Based on $11.00/ MTCO2e

A prioritized GHG reduction strategy would be to limit the heating fuel with improved insulation and perceive the need to replace the boiler as an opportune time to eliminate fossil fuel use completely with a heat pump system. It is also recommended that Tracy Hall immediately introduce user behavioral campaigns on commuting practices as this is little or no cost.

6. GHG Reduction Goals

In 2008, the Vermont state government issued legislation to control air pollution and established goals to reduce statewide GHG emissions by 50% from 1990 base by 2028 (Vermont General Assembly, 2008). The Vermont governor issued the Vermont Climate Action Commission Report in July 2018 which outlines a vision for communities to engage in smart growth strategies which will contribute to the state commitment of reducing GHG emissions by obtaining ninety percent of energy needs from renewable sources by 2050 (VCAC, 2018). Norwich is joining these efforts as demonstrated by the March 2019

voter initiative to reduce fossil fuel use (Norwich, 2019). Based on the voter bill language, fossil fuel use would be eliminated in approximately twenty years.

Tracy Hall is a part of the bigger system of Norwich and is representative of a larger operational boundary. A reduction strategy for the Town should be set with the intent that each asset (Tracy Hall for example) contributes to the reduction effort. Fossil fuels in Norwich are a significant contributor to any GHG inventory and are mainly rooted in heating and mobile combustion sources (beyond boundary of Tracy Hall). Completely eliminating fossil fuels from a vehicle fleet would require more innovation and technology that may or may not be viable within a twenty-year timeframe, especially for large scaled, heavy duty vehicles used in the Fire Department and the DPW. Reduction goals with this existing terminology from the voter initiative may be too limiting to achieve progress, therefore, it is recommended for Norwich to revise this language of intent to refer to total GHG emissions instead of direct fossil fuel use. With this revised terminology and by spreading out the reduction goals in larger time frames, there will be more flexibility in achieving set milestones and provide some opportunities for reduction without complete dependence on innovation.

Using GHG emissions terminology instead of fossil fuel quantities, based on the information provided, the voter-approved initiative, and aligning with State directives, it is suggested Norwich propose the following reduction goals from the FY2018 baseline year:

25% by 2025 ***50% by 2030*** ***100% by 2040***

From a preliminary review of scope 1 and scope 2 emissions of Town municipal operations, it is estimated that in FY2018, there were approximated 340 MTCo2e emitted, refer to Appendix D. As an order of magnitude, five percent a year would equal 17 MT, while a twenty five percent reduction would equate to 85 MT. From this inventory of Tracy Hall and after a preliminary GHG review of the rest of the town-controlled assets, the main source of emissions is from the fossil fuels used for heat combustion and the vehicle fleet associated with the Safety Center and Public Works. Because of the power purchase agreement with a local solar farm, the emissions from electricity use on the properties are well managed and at low levels.

In FY2018, Tracy Hall was the highest emitter amongst the town buildings at sixteen percent of the total Scope 1 and 2 emissions for Norwich (Appendix D). With current HVAC technology available, as outlined in the above section, there is an immediate opportunity to reduce Tracy Hall emissions dramatically. The reductions from a new electric based heating system could contribute to the 2025 goal by almost

sixty percent. Combined with additional heating efficiencies in other Town buildings, converting the Police vehicle fleet to hybrid models, and purchasing some carbon offsets, it would be ambitious but possible for Norwich to achieve that first reduction goal in FY2025.

Since these reduction goals are for Scope 1 and 2 emissions, it would be interesting and inspiring for Norwich to fully account for their Scope 3 emissions and commit to a reduction strategy for this Scope.

7. Conclusion

This GHG inventory for Tracy Hall is the first step in accurately measuring and managing Norwich's GHG emissions, from both a local government and community perspective. This report focuses on creating a clear inventory management plan that generates a framework for measuring the emissions under Town operational control, which will benefit Norwich by providing a foundation of measurability with transparency and viable metrics without vague terminology and confusion. These efforts would assist in planning as GHG accounting in Norwich follows other community precedents in expanding reporting from beyond municipal controlled activities to include the entire community-based emissions (Denny & Pederson, 2015). Like other local communities, it is a logical progression to expand the GHG inventory boundary of Norwich from municipal-controlled functions to a geographic boundary that includes emissions for the actions of the whole community in order to thoroughly understand, measure and manage the global impact of the town (Denny & Pederson, 2015). There are many resources and case study references for community scale inventories available to municipalities. The World Resources Institute publishes an Accounting and Reporting Standard for Cities (WRI, C40, & ICLEI, 2014)and ICLEI USA- Local Governments for Sustainability is a member based organization that supports local sustainable development (ICLEI , 2020).

Promoting the commitment to the reduction goal would prompt discussion and the creation of a realistic plan of reductions, while hopefully building community support. A public involvement in the "math" might also help to communicate the sense of emergency of this global climate situation and inspire Norwich to model of model and community development.

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Appendix A

Scope 1 Calculations

Heating Combustion

					Refences	
Global Warming Potentials	CO2	1			Table 5.1	TCR (2019), Default Emissions Factors
	CH4	28				
	N2O	265				
Relevant Emissions Factors	Source	Gas	Value	Units		
	# 2 heating oil	CO2	10.21	kg CO2/gallon	Table 1.1	TCR (2019), Default Emissions Factors
	# 2 heating oil	CH4	0.7	g/ MMBtu	Table 1.8	TCR (2019), Default Emissions Factors
	# 2 heating oil	N2O	0.4	g/ MMBtu	Table 1.8	TCR (2019), Default Emissions Factors
Facility: Tracy Hall	SF	12925				
Conversion Factors	1	gallon	137,381	Btu	https://www.eia.gov/energyexplained/units-and-calculators/	
	1,000,000	Btu	1	MMBtu		
	1000	kg	1	metric ton	google conversion	
	1,000,000	g	1	metric ton	google conversion	
	1000	Btu	1	Kbtu		

faciltity	Fiscal Year	Annual consumption	unit	MMBtu	kBtu	EUI	Notes
Tracy Hall	2018	4,915.10	gallons	675.24	675241.35	52.24	
Tracy Hall	2019	4,737.50	gallons	650.84	650842.49	50.36	
Tracy Hall	est 2020	4,542.74	gallons	624.09	624086.56	48.29	7yr average

faciltity	Fiscal year	kg CO2	MT CO2	g CH4	g CO2e (CH4)	MT CO2 (CH4)	g N2O	g CO2e (N2O)	MT CO2e (N2O)	Combustion Total MT CO2e
Tracy Hall	2018	50,183.17	50.18	472.67	13234.73	0.0132	270.10	71575.58	0.07158	**50.27**
Tracy Hall	2019	48,369.88	48.37	455.59	12756.51	0.0128	260.34	68989.30	0.06899	**48.45**
Tracy Hall	est 2020	46,381.40	46.38	436.86	12232.10	0.0122	249.63	66153.17	0.06615	**46.46**

Fugitive Emissions

					Refences	
Global Warming Potentials	R-22 (R-410A)	1924			Table 5.2	TCR (2019), Default Emissions Factors
	R-410A	1924			Table 5.2	TCR (2019), Default Emissions Factors
	R-134A	1300			Table 5.1	TCR (2019), Default Emissions Factors
Relevant Emissions Factors	Unit Type		Operating Emmission Factor (w)			
	Res & Com A/C units		10%		Table 4.1	TCR (2019), Default Emissions Factors
	Domestic Refrigeration		0.50%		Table 4.1	TCR (2019), Default Emissions Factors

Screening Method

Unit	R	Capacity (kg)	time	Emissions kg	CO2eq emissions kg	MT CO2e
ASHP-1	R-410A	2.2113	1	0.221	425.447	0.425
ASHP-2	R-410A	2.2113	1	0.221	425.447	0.425
ASHP-3	R-410A	2.2113	1	0.221	425.447	0.425
ASHP-4	R-410A	2.2113	1	0.221	425.447	0.425
ASHP-5	R-410A	2.2113	1	0.221	425.447	0.425
WAC-1	R-410A	0.2801	1	0.028	53.890	0.054
WAC-1	R-410A	0.2801	1	0.028	53.890	0.054
R-1	R-134A	0.1276	1	0.001	0.829	0.001

faciltity	Fiscal year	Total MT CO2e
Tracy Hall	2018	**2.24**
Tracy Hall	2019	**2.24**
Tracy Hall	est 2020	**2.24**

Appendix B

Scope 2 Calculations

					Refences	
Global Warming Potentials	CO2	1			Table 5.1	TCR (2019), Default Emissions Factors
	CH4	28				
	N2O	265				
Relevant Emissions Factors:	**Source**	**Gas**	**Value**	**Units**		
Norwich	NEWE eGRID subregior	CO2	558.20	lbs CO2/MWh	Table 3.1	TCR (2019), Default Emissions Factors
https://www.epa.gov/energy/power-profiler#/NEWE	NEWE eGRID subregior	CH4	90.00	lbs CH4/GWh	Table 3.1	TCR (2019), Default Emissions Factors
	NEWE eGRID subregior	N2O	12.00	lbs N2O/ GWh	Table 3.1	TCR (2019), Default Emissions Factors
Relevant Emissions Factors:	**Source**	**Gas**	**Value**	**Units**		
Norwich	Solaflect Solar	CO2	0.00	lbs CO2/MWh		
	Solaflect Solar	CH4	0.00	lbs CH4/GWh		
	Solaflect Solar	N2O	0.00	lbs N2O/ GWh		
Relevant Emissions Factors:	**Source**	**Gas**	**Value**	**Units**		
Norwich	Green Mountain Power	CO2	209.00	lbs CO2/MWh	Graham Turk @ GMP	
	Green Mountain Power	CH4	9.00	lbs CH4/GWh	10% of NEWE	
	Green Mountain Power	N2O	1.20	lbs N2O/ GWh	10% of NEWE	
Conversion Factors	1	MWh	1000	kWh	google conversion	
	1	GWh	1000	MWh	google conversion	
	2204.62	lbs	1	metric ton	google conversion	
	1,000,000	g	1	metric ton	google conversion	

LOCATION BASED

faciltity	FY	Annual consumption	unit	MWh	GWh	Notes
Tracy	2018	71,640.00	kWh	71.64	0.0716	
Tracy	2019	76,200.00	kWh	76.20	0.0762	
Est	est 2020	74,900.00	kWh	74.90	0.0749	

faciltity	FY	lbs CO2	MT CO2	lbs CH4	lbs CO2e (CH4)	MT CO2 (CH4)	lbs N2O	CO2e (N2O)	CO2e (N2O)	Total MT CO2e	
Tracy Hall	**2018**	39,989.45	18.14	6.45	180.53	0.08	0.86	227.82	0.10334	**18.32**	**Location-based Method**
Tracy Hall	**2019**	42,534.84	19.29	6.86	192.02	0.09	0.91	242.32	0.10991	**19.49**	
	est 2020	41,809.18	18.96	6.74	188.75	0.09	0.90	238.18	0.10804	**19.16**	

MARKET BASED

faciltity	FY	Annual consumption	unit	MWh	GWh	Notes
Tracy: Solar Grid	2018	45,291.00	kWh	45.29	0.0453	Solar
Tracy Local Grid	2018	26,349.00	kWh	26.35	0.0263	Grid
Tracy: Solar Grid	2019	39,809.00	kWh	39.81	0.0398	Solar
Tracy Local Grid	2019	36,391.00	kWh	36.39	0.0364	Grid
Tracy: Solar Grid	est 2020	39,374.50	kWh	39.37	0.0394	Solar
Tracy Local Grid	est 2020	35,525.50	kWh	35.53	0.0355	Grid

faciltity	FY	lbs CO2	MT CO2	lbs CH4	lbs CO2e (CH4)	MT CO2 (CH4)	lbs N2O	CO2e (N2O)	CO2e (N2O)	Total MT CO2e	
Tracy: Solar Grid	2018	0.00	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	**Market-based Method**
Tracy Local Grid	2018	5,506.94	2.49791	0.23714	6.63995	0.00301	0.03162	8.37898	0.00380	2.50	
Total	**2018**									**2.50**	
Tracy: Solar Grid	2019	0.00	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	
Tracy Local Grid	2019	7,605.72	3.44990	0.32752	9.17053	0.00416	0.04367	11.57234	0.00525	3.46	
Total	**2019**									**3.46**	
Tracy: Solar Grid	est 2020	0.00	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	
Tracy Local Grid	est 2020	7,424.83	3.36785	0.31973	8.95243	0.00406	0.04263	11.29711	0.00512	3.38	
Total	**est 2020**									**3.38**	

Appendix C

Scope 3 emissions calculations

Employee Commuter Mileage

						Refences				
Global Warming Potentials		CO2	1			Table 5.1	TCR (2019), Default Emissions Factors			
		CH4	28							
		N2O	265							
Relevant Emissions Factors		**Source**	**Gas**	**Value**	**Units**					
		Gasoline	CO2	8.78	kg CO2/gal	Table 2.1	TCR (2019), Default Emissions Factors			
		Gasoline	CH4	0.0078	g/ mi	Table 2.4	TCR (2019), Default Emissions Factors			
		Gasoline	N2O	0.0082	g/ mi	Table 2.4	TCR (2019), Default Emissions Factors			
Conversion Factors		1	gallon	24.90	mile	Average fuel economy				
		1000	kg	1	metric ton	google conversion				
		1,000,000	g	1	metric ton	google conversion				
faciltity	**Fiscal Year**	**Annual consumption**	**unit**	**miles**						
Tracy Hall: Commuter	2018	2,212.05	gallons	55080.00						
Tracy Hall: Commuter	2019	2,212.05		55080.00						
faciltity	**Fiscal year**	**kg CO2**	**MT CO2**	**g CH4**	**g CO2e (CH4)**	**MT CO2 (CH4)**	**g N2O**	**g CO2e (N2O)**	**MT CO2e (N2O)**	**Total MT CO2e**
Tracy Hall: Commuter	2018	19,421.78	19.42	429.62	12029.47	0.0120	451.66	119688.84	0.11969	**19.55**
Tracy Hall: Commuter	2019	19,421.78	19.42	429.62	12029.47	0.0120	451.66	119688.84	0.11969	**19.55**

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HOME >> USE THE TOOL >> BROWSE **US 2002 (428 SECTORS) PRODUCER** MODEL >> DISPLAYING...

Sector #339940: Office supplies (except paper) manufacturing
Economic Activity: $.006 Million Dollars
Displaying: Greenhouse Gases
Number of Sectors: Top 10

Change Inputs (Click here to view greenhouse gases, air pollutants, etc...)

Documentation:
The environmental, energy, and other data used and their sources.

Frequently asked questions about IO-LCA (or EEIO) models.

This EIO-LCA data model was contributed by Green Design Institute.

	Sector	Total t CO2e	CO2 Fossil t CO2e	CO2 Process t CO2e	CH4 t CO2e	N2O t CO2e	HFC/PFCs t CO2e
	Total for all sectors	*3.21*	*2.64*	*0.194*	*0.226*	*0.088*	*0.064*
221100	Power generation and supply	1.08	1.07	0.000	0.003	0.007	0.007
325190	Other basic organic chemical manufacturing	0.225	0.202	0.000	0.000	0.023	0.000
484000	Truck transportation	0.203	0.203	0.000	0.000	0.000	0.000
211000	Oil and gas extraction	0.192	0.054	0.035	0.103	0.000	0.000
324110	Petroleum refineries	0.117	0.117	0.000	0.000	0.000	0.000
331110	Iron and steel mills	0.115	0.043	0.071	0.000	0.000	0.000
339940	Office supplies (except paper) manufacturing	0.101	0.101	0.000	0.000	0.000	0.000
212390	Other nonmetallic mineral mining	0.077	0.077	0.000	0.000	0.000	0.000
325211	Plastics material and resin manufacturing	0.074	0.074	0.000	0.000	0.000	0.000
325130	Synthetic dye and pigment manufacturing	0.071	0.040	0.031	0.000	0.000	0.000

Download View Graph

Appendix D

Preliminary Town GHG Inventory Scope 1 and 2 emissions

GHG Inventory Summary: Norwich						
				Totals MT C02e		
Facility	Emission		Scope	FY18	FY19	estFY20
	Norwich Operational Control	Town Totals	1,2	339.88	347.86	331.38
	Tracy Hall: Administration	Totals	1,2	55.01	54.15	52.07
Direct	Stationary Combustion	Oil heating & generator fuel	1	50.268	48.452	46.460
	Mobile Combustions	-				
	Fugitive Sources	refrigerants in heat pumps, refrdigerators & window AC units	1	2.236	2.236	2.236
Indirect	Purchased Electricity	Electricity Admin Hall	2	2.505	3.459	3.377
	Safety Center -	Totals	1,2	90.24	83.41	84.61
Direct	Stationary Combustion	#2 Oil heating combustion - FD Garage & generator fuel	1	15.933	17.032	14.265
	Mobile Combustions	FD vehicles (estimated 10% of total Diesel use)	1	17.491	18.724	18.107
		PD vehicles (4)	1	53.488	44.326	48.907
	Fugitive Sources	refrigerants PD ASHP	1	3.327	3.327	3.327
Indirect	Purchased Electricity	Electricity FD /PD	2	0.000	0.000	0.000
	Dept of Public Works	Totals	1,2	194.63	210.31	194.70
Direct	Stationary Combustion	Propane heat - Garage + out bldgs & generator	1	31.290	36.717	25.472
		propane heat- transfer station & generator	1	3.742	1.853	2.830
		field maintenance - fertilizers: estimated	1	0.500	0.500	0.5
	Mobile Combustions	DPW vehicles (90% of diesel use)	1	157.415	168.512	162.963
	Fugitive Sources	refrigerants: fridge / window unit?: estimated	1	0.750	0.750	0.75
Indirect	Purchased Electricity	Electricity DPW - Garage	2	0.745	1.975	2.093
		Electricity Transfer Stat	2	0.187	0.000	0.092