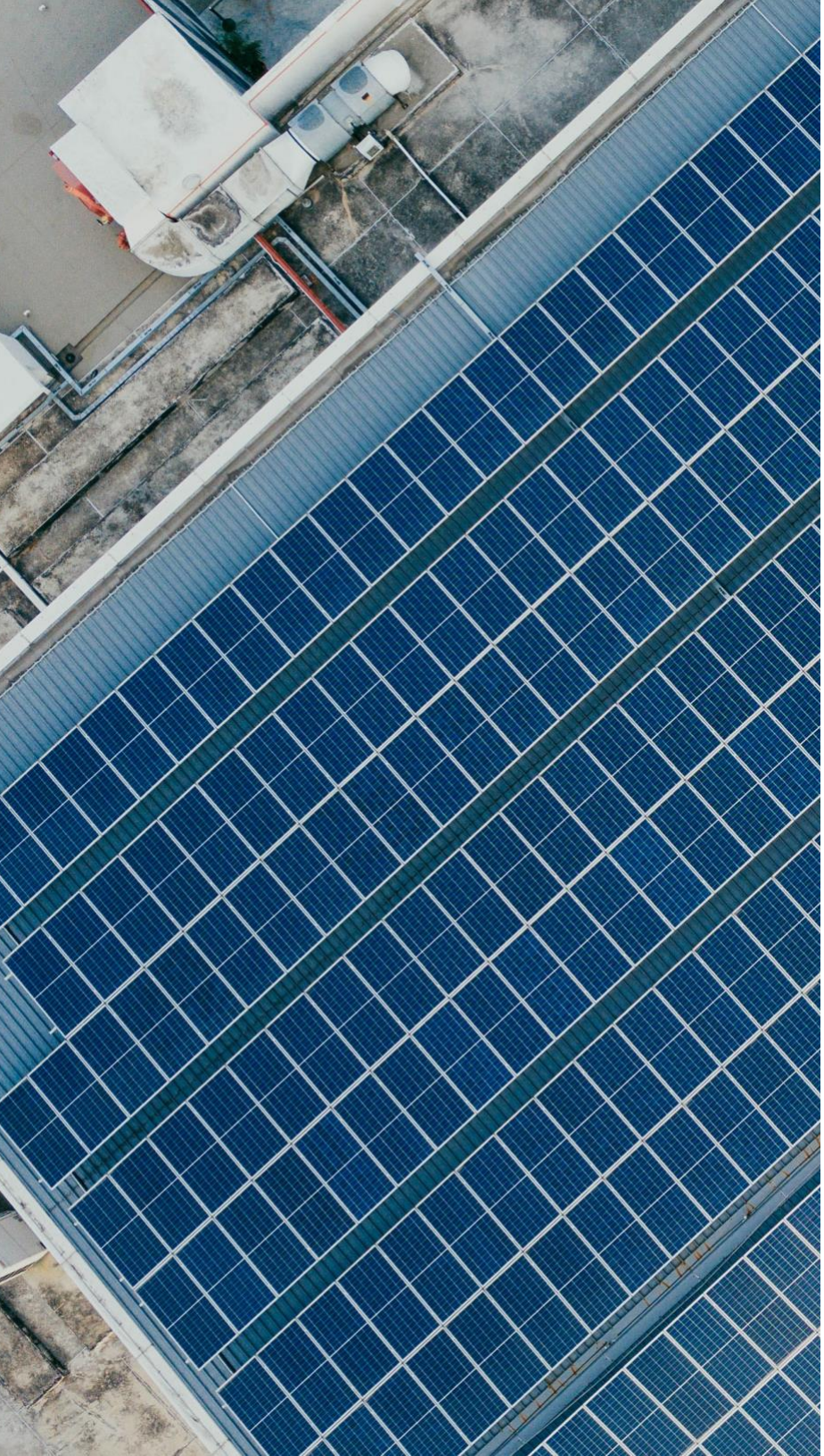

GREENHOUSE GAS INVENTORY REPORT (FY 14 – 20)

Oyster River Cooperative School District
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I. ABSTRACT

The Oyster River Cooperative School District is committed to advancing sustainability in its operations, culture, and curriculum. Since the creation of the district's environmental sustainability policy, considerable effort has been made in reducing its environmental footprint.

Since the hiring of its Sustainability Coordinator, the district has launched various initiatives aimed at reducing the district's environmental footprint and embedding sustainable thought into facilities department decision-making. Some of these initiatives include the establishment of composting infrastructure within school cafeterias, completion of energy audits and efficiency upgrades, and release of two ecological footprint reports. Five years removed from the district's last ecological footprint report, the Sustainability Coordinator invited a Sustainability Intern to analyze the district's greenhouse gas emissions.

A greenhouse gas inventory – measuring CO_2, CH_4, and N_2O emissions – was conducted across all buildings owned and leased by the district as well as all vehicles driven by district faculty and staff from fiscal year 2014 to fiscal year 2020. The inventory spanned scopes 1 (bus fleet, fertilizer, animals, stationary fuels, transport fuels), 2 (purchased electricity), and 3 (faculty commuting, food, paper purchasing, solid waste, wastewater, transmission and distribution losses). Due to the nature of data collection, various sources of emissions are unattainable while others are reported with low confidence. Most notably, fiscal years 2014 - 2018 were missing data on paper purchases, faculty commuting, and food. Additionally, fiscal years 2014 – 2020 were missing data on student commuting.

Following FY 2016, the district's greenhouse gas emissions decreased 12% for FY 2017 and another 4% for FY 2018. Although the district's greenhouse gas emissions increased 5% for FY 2019, this spike is still 11% lower than the district's FY 2016 spike. These reductions are largely attributable to emission reductions in stationary and transport fuels, purchased electricity, and direct transportation.

Transportation, electricity, utility, and solid waste are the greatest sources of greenhouse gas emissions for the district. While the district is expected to observe energy emission reductions due to its investment in building efficiency and resilience on continued regional grid "cleaning", it should invest additional resources in expanding composting infrastructure and developing carpooling initiatives. Moreover, the district should develop a better system for continuously collecting and entering data into SIMAP.

Key words: *greenhouse gases, scope emissions, waste, energy, transportation, climate leadership*

II. INTRODUCTION

i. Sustainability Policy

The Oyster River Cooperative School District (ORCSD) is a public school system with four campuses serving the three contiguous communities of Durham, Lee, and Madbury within the State of New Hampshire. The district serves 2,173 students and employs 438 individuals within its two elementary schools (grades K-4), one middle school (grades 5-8), and one high school (grades 9-12). In 2013, taxpayers from the three towns voted to fund a sustainability coordinator to assist in the implementation of the district's sustainability policy and procedures. Over the past eight years, the district has made considerable progress in reducing its environmental footprint. However, recognizing the urgency of community-driven climate action, the district has committed to including sustainability into its five-year strategic plan released in 2019.

The district highlights five principles within its sustainability policy. These include renewability, substitution, interdependence, adaptability, and institutional commitment. In conjunction with these principles, the district identifies five focus areas within this policy. These include food, energy, transportation, school curriculum, and community outreach. This report focuses largely on food, energy, transportation, and – additionally – waste. However, the district's previous Waste Management Report discusses school curriculum and community outreach.

At the forefront of the district's sustainability policy is its commitment to reduce its greenhouse gas emissions. The Oyster River Cooperative School District's environmental sustainability policy specifies that the district superintendent or designee should develop and revise as appropriate guidelines, procedures, or strategies to

> Reduce the district's ecological footprint through different methods, such as decreasing energy use, purchasing of products and services locally, encouraging biking and/or walking to school, and following conservation practices of natural resources.

ii. Major Milestones

Since the hiring of its Sustainability Coordinator, the district has launched various initiatives aimed at reducing the district's environmental footprint and embedding sustainable thought into facilities department decision-making. Since 2002, the district has instituted a "no-idling" bus campaign, conducted energy audits, created school gardens, introduced local food into school lunches, established composting infrastructure within school cafeterias, and standardized classroom disposal bins.

In 2017, the district installed a solar array on its service building reducing both its regional grid purchased electricity and greenhouse gas emissions. In 2019, the district completed an energy upgrade lease project within all buildings except for the middle school resulting in LED fixture installations and building envelope improvements. Most recently, in 2020, the district began construction on a new $49.8 M middle school equipped with high R-value insulation, triple pane windows, LED lights, photovoltaic panels, solar thermal panels, geothermal heating, and electric vehicle charging stations. Such technologies have the potential to reduce the middle school's ecological footprint by 85%.

Beyond these past achievements, the district has completed two ecological footprint reports that capture the economic and environmental costs of district transportation, solid waste, recycling, electricity, propane, natural gas, water, and sewage.

iii. Purpose of Report

This report is intended to be utilized both as an inventory and as a tool. As an inventory, this report captures the district's greenhouse gas emissions (FY 2014 - FY 2020) with a level of granularity previously uncaptured within its ecological footprint reports. This report:

- Emphasizes the environmental costs of energy, transportation, food, and waste among other activities;
- Includes data on food waste which is one of the largest emitters of methane (CH_4);
- Captures emissions data across the entire district, including the service building and transportation center;
- Normalizes for heating and cooling degree days;
- Distinguishes between major greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), and nitrogen (N) each of which differs in its atmospheric heating capacity; and
- Reports over a longer time span, allowing for the ability to observe data trends.

As a tool, this report offers recommendations for ways in which the district can further reduce its emissions, serves as a guiding document for future decision-making, and highlights the district's leadership in sustainability. Oyster River Cooperative School District remains the only school district within the State of New Hampshire to conduct a system-wide greenhouse gas inventory, thus emphasizing the district's historical leadership in sustainability.

ECOLOGICAL FOOTPRINT REPORT (2013)

Nicole D'Alessio
Environmental and Resource Economics, University of New Hampshire

For fiscal years 2011-12, D'Alessio completed an ecological footprint report analyzing the economic and environmental costs of transportation, solid waste, recycling, paper, electricity, propane, natural gas, and water.

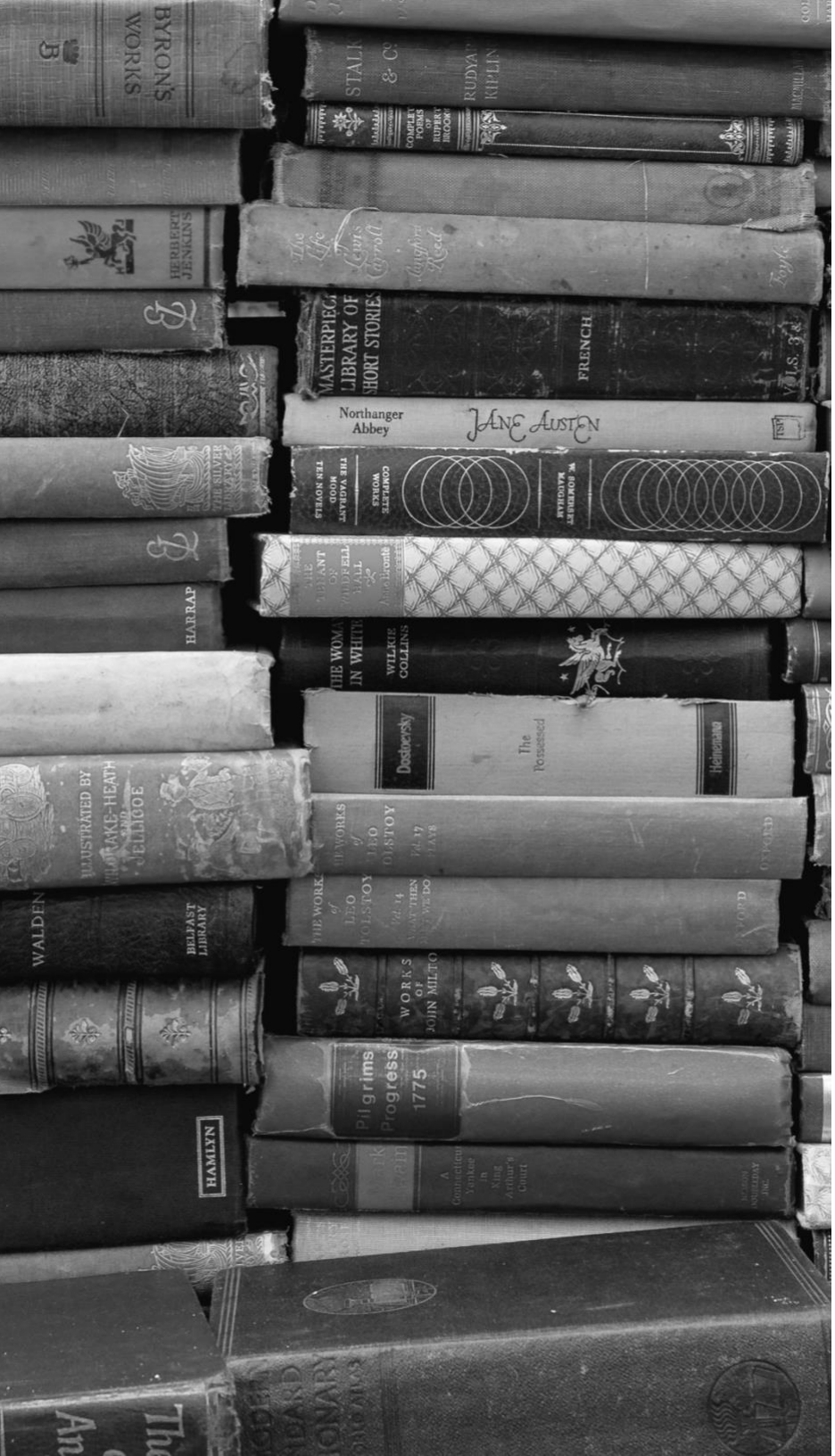
During this time, the **district reduced its carbon footprint by 5% which is equivalent to the amount of carbon sequestered by a 181 acres forest**. At the district level, electricity costs dropped 35%. At the building level, electricity costs dropped 50%, 49%, 38%, and 20% within Oyster River Middle School, Moharimet Elementary School, Mast Way Elementary School, and Oyster River High School respectively. Natural gas costs dropped 16% within the middle school and 14% within the high school. Propane costs dropped 17% within the elementary schools. Moreover, the installation of hydration stations within all schools had diverted over 86,200 plastic bottles.

ECOLOGICAL FOOTPRINT REPORT (2015)

Damian Woodard
Business Administration, University of New Hampshire

For fiscal years 2012-15, Woodard completed an ecological footprint report also analyzing the economic and environmental costs of transportation, solid waste, recycling, electricity, propane, natural gas, and water. Woodard's report closely paralleled D'Alessio's report.

At the district level, electricity usage dropped 10%. However, electricity cost did not steadily increase or decrease. At the building level, **electricity usage dropped 22%, 18%, 17%, 2% within Oyster River Middle School, Moharimet Elementary School, Mast Way Elementary, and Oyster River High School respectively**. Natural gas usage increased 21% within the high school and decreased 13% within the middle school. Similarly, natural gas cost increased 32% within the high school and decreased 9% within the middle school. Propane usage did not steadily increase or decrease. However, propane cost decreased 19% for Mast Way Elementary School and 38% for Moharimet Elementary School. Interestingly, the decrease in propane cost is not indicative of reduced usage but rather of a reduced market price of propane.



III. METHODOLOGY

iv. Inventory Objectives

A greenhouse gas inventory was conducted to better understand the sources and magnitude of the district's carbon, nitrogen, and methane emissions from FY 2014 through FY 2020. The overall goals of the inventory were to

Identify the major sources of GHG emissions. *Where do most of the district's emissions originate from (e.g. transportation, energy, food, water, solid waste)?*

Determine the degree in which GHG emissions have changed over time and by location. *Have the district's emissions increased or decreased over the past seven years? Are changes in scope emissions reflective of any district initiatives? Do some schools emit lower/higher emissions per capita and per square foot than other schools?*

Establish baseline conditions that allow for tracking over time. *Which fiscal year should be utilized as the district's emissions baseline for future inventories and potential climate goals?*

Develop a self-sustaining GHG emission tracking system. *What sources of emissions need to be tracked more closely? How can the district improve the confidence in which it reports its emissions? Who is responsible for populating SIMAP? How often should emission inventories be completed?*

Utilize the results to recommend future GHG emission reduction initiatives. *Which emission sources and/or locations represent the greatest opportunities for reductions?*

v. SIMAP

The Oyster River Cooperative School District partnered with the Sustainability Institute at the University of New Hampshire to access and utilize SIMAP (Sustainability Indicator Management and Analysis Platform). SIMAP, formerly the Campus Carbon Calculator developed by Clean Air-Cool Planet, is a web-based tool for calculating and projecting a campus's carbon and nitrogen footprints. SIMAP follows the same protocols outlined within the IPCC's (Intergovernmental Panel on Climate Change) workbooks for national-level inventories; however, it adapts the IPCC's data for use at the institutional-level (Leach, et al., 2018). Moreover, SIMAP uses the same methodologies codified by the Greenhouse Gas Protocol Initiative for accounting for greenhouse gas emissions (Leach, et al., 2018).

SIMAP calculates both carbon and nitrogen footprints in order to capture more holistically the breadth of environmental effects resulting from anthropogenic activity. Some of these impacts include biodiversity loss, water quality, air quality, and climate change. Carbon footprints include six greenhouse gases specified by the Kyoto Protocol (carbon dioxide CO_2, methane CH_4, nitrous oxide N_2O, hydrofluorocarbons HFC, perfluorocarbons PFC, and sulfur hexafluoride SF_6). Nitrogen footprints include reactive nitrogen forms (nitrate NO_3, ammonium NH_4^+, ammonia NH_3, nitrogen oxides NOx, and nitrous oxide N_2O).

SIMAP enables its users to define inventory boundaries, set custom emission factors, and apply data normalizations. Inventory boundaries include where, which, and when emissions are reported. Custom emission factors take into account geographical or institutional variations such as the heating value of fuels, utility emission factors, electrical grid regions, etc. Data normalizations include information such as budgets, square footage, and population counts into greenhouse gas emissions calculations. Data normalization helps a campus project its future emissions and compare its emissions to other campuses.

vi. Data Entry and Analysis

Beginning in March and finishing in August, Sabrina Lichtenwalner (ORCSD Accounts Payable) entered electricity, transportation, paper purchasing, solid waste, wastewater, food, fertilizer, and compost data from FY 2014 through FY 2020 into SIMAP. Sabrina specified the following criteria:

eGrid Region – NPCC New England
Emissions Factor – 2019
Global Warming Potential – AR5
Scope 2 Method – Market-Based
Organizational Boundary – Control Approach

Beginning in October, Sabrina assisted Kendall Gray (ORCSD Sustainability Fellow) in reviewing the data and connecting with Cassidy Yates (UNH Masters of Environmental Engineering Student, UNH Sustainability Institute Intern) and Allison Leach (Postdoctoral Researcher at UNH Department of Natural Resources and the Environment, Research Assistant at UNH Sustainability Institute) for a formal data review.

Beginning in November, Kendall and Maggie Morrison (ORCSD Sustainability Coordinator) established a three-person review committee to solicit feedback from various stakeholders and interest groups. This review committee included Jim Rozycki (ORCSD Facilities Director), Steven Wourgiotis (Mast Way Parent, Harvard University Masters of Sustainability Student), and Shelley Mitchell (Professor of Management and Sustainability at Hult International Business School).

SIMAP TERMINOLOGY (directly from SIMAP user guide)

ORGANIZATIONAL BOUNDARY – where you are measuring and reporting emissions

- **CONTROL APPROACH** – measures emissions for any operations over which you have practical control, whether at facilities that are owned or leased
- **EQUITY SHARE APPROACH** – measure emissions from facilities where you have some degree of ownership

OPERATIONAL BOUNDARY – which emissions are you measuring and reporting (figure 1).

- **SCOPE 1** – direct emissions from sources that are owned and/or controlled by your institution (fuel combustion, direct transportation, agriculture, fertilizer, refrigeration)
- **SCOPE 2** – indirect emissions from sources that are neither owned nor operated by your institution but whose products are directly linked to on-campus energy consumption (purchased electricity, purchased steam, purchased chilled water, renewable energy certificates)
- **SCOPE 3** – emissions that are neither owned nor operated by your institution but are either directly financed or otherwise linked to the campus via influence or encouragement (commuting, directly financed outsourced transportation, transportation and distribution losses from purchased energy, food, upstream emissions from directly financed purchases, solid waste, wastewater)
- **SINKS and OFFSETS** – ways your institution is trying to limit its footprint (compost, non-additional sequestration, offsets)

TEMPORAL BOUNDARY – what time frame you are measuring and reporting emissions

SCOPE 2 METHOD – how you are measuring and reporting purchased electricity emissions

- **LOCATION-BASED** – takes the total amount of power purchased from the grid and multiplies it by your regional eGrid factor
- **MARKET-BASED** – takes your renewable energy purchases/sales into account and uses a different set of emissions factors that account for market transactions

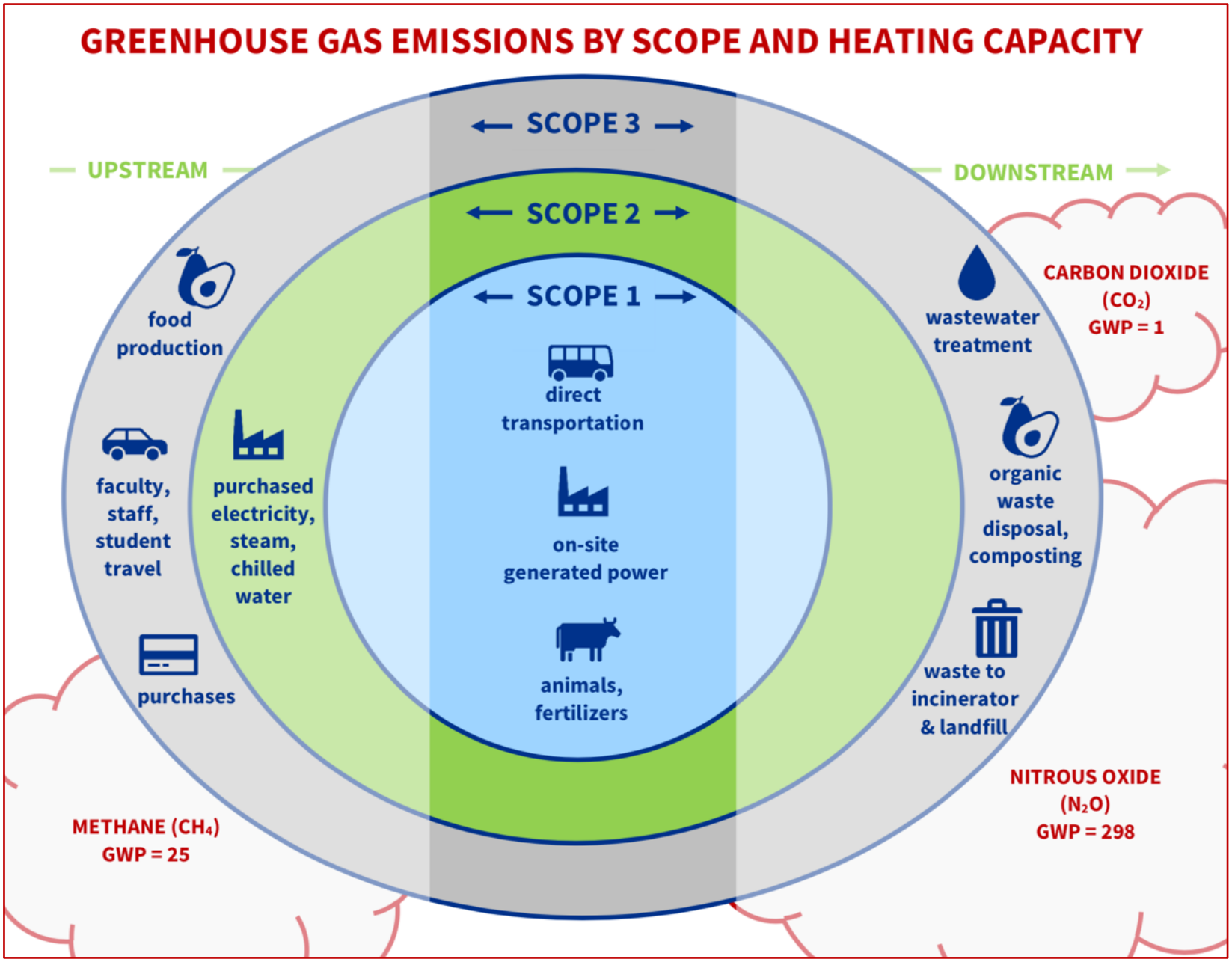


Figure 1. Sources of scopes 1, 2, and 3 emissions produced upstream, onsite, and downstream. Global warming potential (GWP) of the most common and potent greenhouse gases (carbon dioxide, methane, and nitrous oxide) (*adapted from SIMAP user guide*).

IV. RESULTS

vii. Greenhouse Gas Emissions By Fiscal Year

From FY 2014 to FY 2020, data on wastewater, solid waste, fertilizer and animals, purchased electricity, stationary and transport fuels, transmission and distribution losses, and direct transportation (bus fleet) were inventoried. Only from FY 2019 onward, were data on paper purchasing, faculty commuting, and food inventoried. No data on student commuting has been collected.

Since FY 2014, the district's greenhouse gas emissions have remained relatively consistent with a few notable increases and decreases in stationary and transport fuels, purchased electricity, and direct transportation (figure 2). FY 2016 reported the greatest GHG emissions at 2,695 MTCDE. GHG emissions steadily decreased to 2,365, 2,377, and 2,063 MTCDE for FYs 2017, 2018, and 2020 with a slight increase to 2,401 MTCDE for FY 2019. Nevertheless, total GHG emissions decreased 11% from FY 2014 to FY 2019.

GHG emissions from stationary and transport fuels, purchased electricity, and direct transportation largely follow this pattern previously noted. FY 2016 reported the greatest GHG emissions for stationary and transport fuels as well as purchased electricity at 992 MTCDE and 768 MTCDE respectively. GHG emissions from stationary and transport fuels decreased to 800, 785, and 806 MTCDE for FYs 2017, 2018, and 2020 with an increase to 909 MTCDE for FY 2019. Similarly, GHG emissions from purchased electricity steadily decreased to 632, 622, 578, and 504 MTCDE for FYs 2017, 2018, 2019, and 2020. FY 2015 reported that greatest GHG emissions for direct transportation at 622 MTCDE, GHG emissions steadily decreased to 561, 537, 480, and 420 MTCDE for FYs 2016, 2017, 2018, and 2020 with a moderate increase to 522 MTCDE for FY 2019.

DEGREE DAYS (from EIA)

TOTAL DEGREE DAYS – how cold or warm a location is, comparison of the mean outdoor temperature for a location to a standard temperature (65 F)

HEATING DEGREE DAYS – how cold a location is

COOLING DEGREE DAYS – how warm a location is

Δ (mean temperature °F of date #1 and standard temperature °F) + **Δ** (mean temperature °F of date #2 and standard temperature °F) = total degree days

Ex. | 35°F – 65°F | + | 40°F – 65°F |
= 30°F + 25°F
= 55 TDD

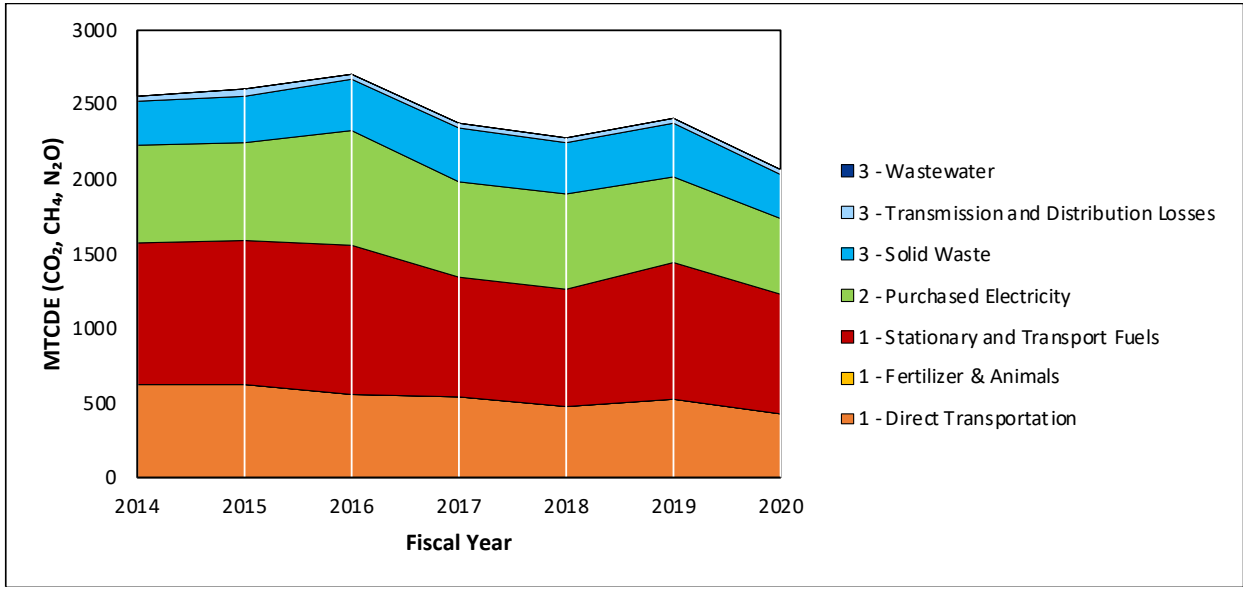


Figure 2. Metric tons of GHG emissions by scopes (1, 2, and 3) and source across fiscal years. Data gaps for FY 2014 – 2018 prohibit the inclusion of emissions data for faculty commuting, food, and paper purchasing.

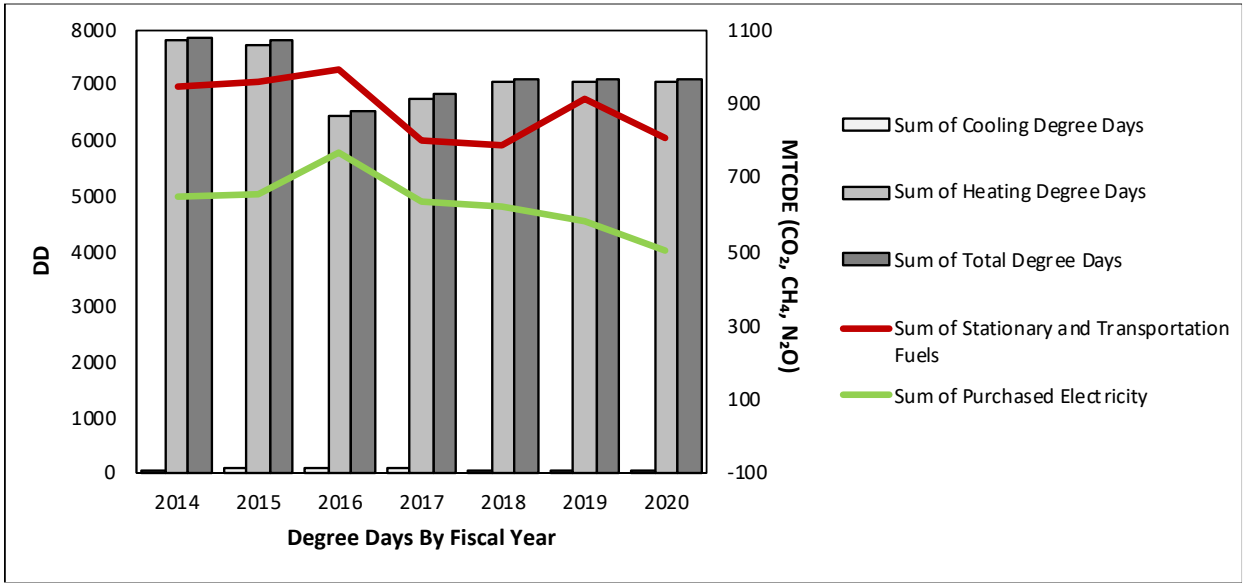


Figure 3. Metric tons of GHG emissions for stationary/transport fuels and purchased electricity transposed on heating, cooling, and total degree days for New England.

FYs 2014 and 2015 reported the greatest total degree days at 7,809 and 7,726 and FY 2016 reported the lowest total degree days at 6,515 (figure 3). Since FY 2016, total degree days has increased to 7,034 where it has remained constant for FYs 2018, 2019, and 2020.

Similarly, FYs 2014 and 2015 reported the greatest heating degree days at 7,809 and 7,726 and FY 2016 reported that lowest heating degree days at 6,432. Since FY 2016, heating degree days has increased to 7,034 where it has remained constant for FYs 2018, 2019, and 2020.

From FY 2014 to FY 2017, cooling degree days steadily increased from 57 to 112. Since FY 2016, cooling degree days has decreased to 66 where it has remained constant for FYs 2018, 2019, and 2020.

viii. Greenhouse Gas Emissions By Site and Source

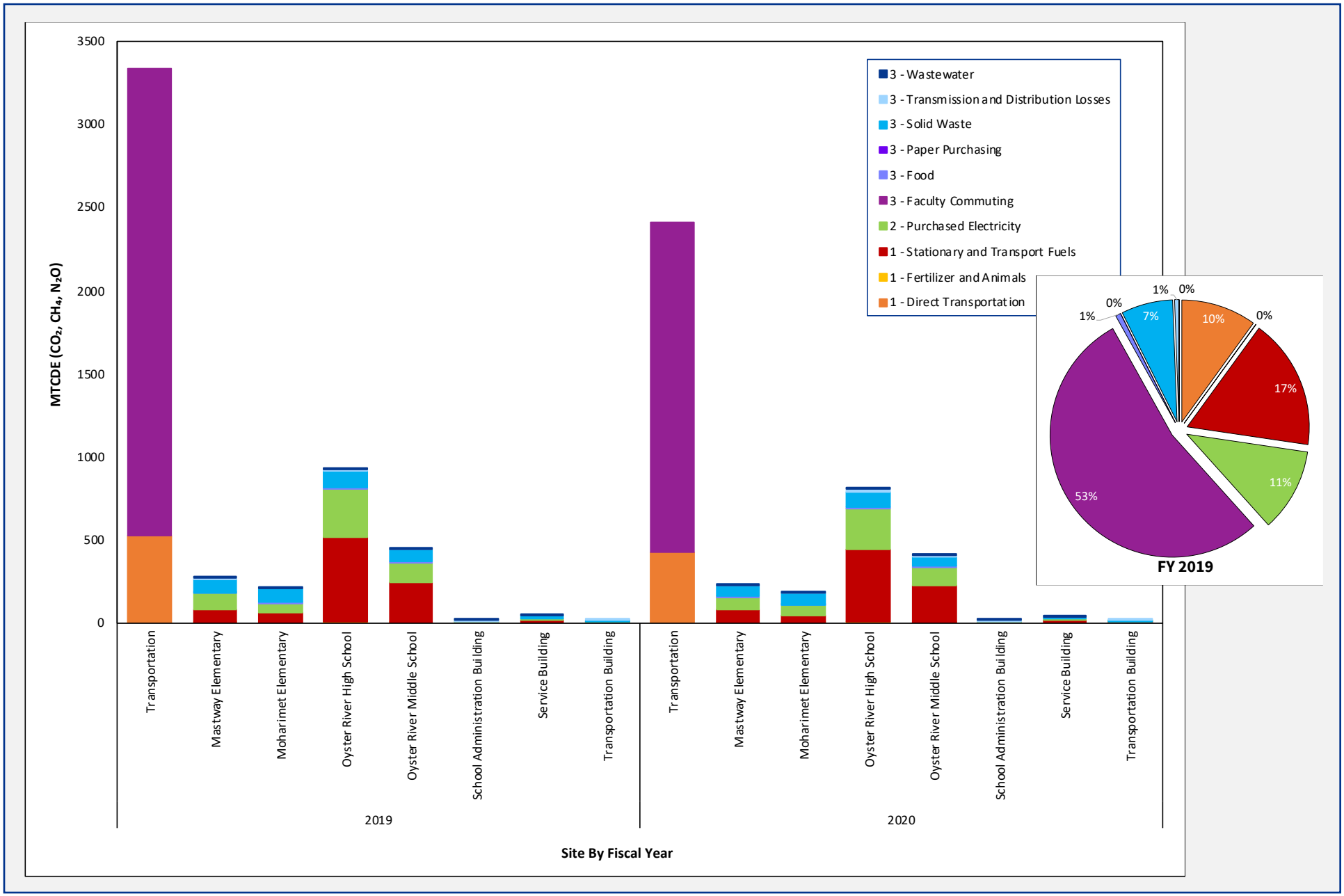


Figure 4. Metric tons of GHG emissions for FYs 2019 and 2020 across district site (left). Metric tons of GHG emissions for FY 2019 by source for entire district (right).

For FYs 2019 and 2020, the district emitted 5,248 and 4,084 MTCDE respectively. Transportation to/from school accounted for 64% (FY 2019) and 59% (FY 2020) of the district's GHG emissions with 53% (FY 2019) and 49% (FY 2020) of the district's GHG emissions resulting directly from faculty commuting. Academic buildings comprised 35% (FY 2019) and 39% (FY 2020) of the district's GHG emissions. Within academic buildings, stationary and transport fuels, purchased electricity, and solid waste accounted for 48%, 30%, and 17% of their FYs 2019 and 2020 GHG emissions.

For FY 2019, the district emitted 2.0 MTCDE per capita. Excluding transportation emissions, the Service Building, School Administration Building, and Oyster River High School emitted the most emissions per capita at 3.30, 1.18 and 0.92 MTCDE. Conversely, Moharimet Elementary School and Oyster River Middle School emitted the least emissions per capita at 0.57 and 0.58 MTCDE (figure 5). Again, excluding transportation emissions, the Transportation Building emitted the most emissions per 1,000 square feet at 19.06 MTCDE and the School Administration Building emitted the least emissions per 1,000 square feet at 3.03 MTCDE.

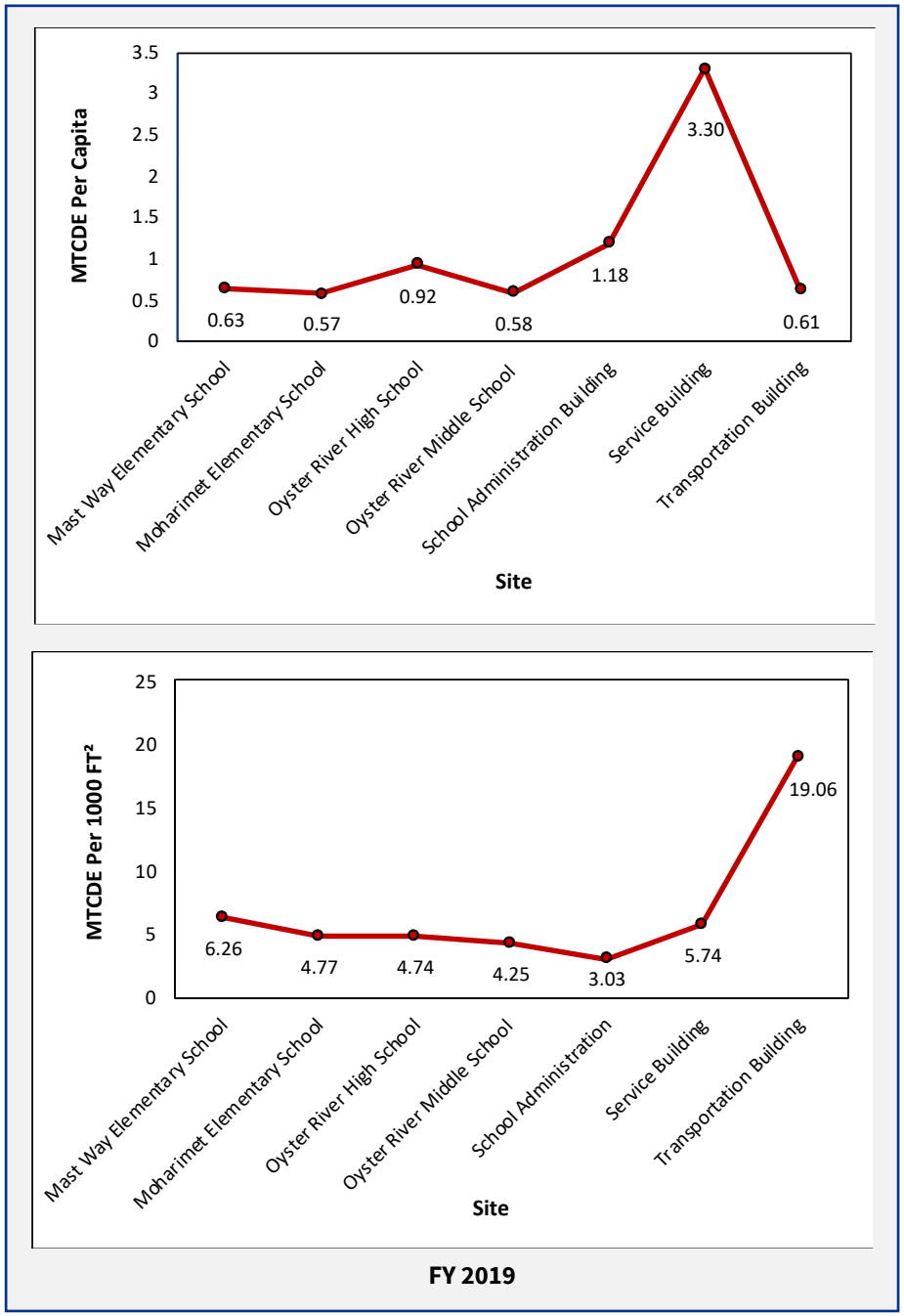


Figure 5. Metric tons of GHG emissions for FY 2019 per capita (top) and per 1,000 square feet (bottom) (*excluding transportation emissions*).

V. DISCUSSION

ix. Limitations

Common with data collection, earlier years (e.g. FYs 2014 through 2018) lacked data for various emission sources. Only from FY 2019 onward, was data on faculty and staff commuting, paper purchasing, and food readily accessible. Even so, no data on student commuting was accessible. Such data gaps prohibit an "apples to apples" comparison of FYs 2014 to 2018 to FYs 2019 to 2020, thus there is no comprehensive observable emissions trend from beginning to end of the inventory's temporal boundary. Nevertheless, FYs 2014 through 2020 were compared for the emission sources they did have in common (e.g. wastewater, solid waste, fertilizer and animals, purchased electricity, stationary and transport fuels, transmission and distribution losses, and direct transportation).

In addition to the lack of data access, the lack of data granularity weakened the confidence in which data on emission sources were reported. While stationary and transport fuel and purchased electricity were reported with high confidence, solid waste and commuting data were reported with low confidence.

Garbage bins are not weighed upon collection; therefore, only a rough estimate could be obtained for analysis (hence the relatively constant data values from FY 2014 through FY 2020).

Faculty and staff commute travel was approximated and averaged across the district. Additionally, all population dependent emissions sources (e.g. commuting) were based upon population statistics entered for FY 2020. Such statistics change yearly. Data on student commute travel was not accessible; therefore, the inventory under reports for travel emissions for FYs 2019 and 2020. Only through the calculation of each faculty, staff, and student's commute travel each year, would the district be able to report commuting emissions with high confidence.

Finally, food data only captures district purchased food. Data on faculty, staff, and student packed lunches are not obtained, thus lowering the confidence in which food data is reported.

Despite these limitations, valuable information can be obtained from the inventory which will certainly guide the district's future decisions. Moreover, each limitation highlights the ways in which the district can improve its reporting for future inventories.

x. Conclusions

From FY 2014 to FY 2020, the district observed some greenhouse gas reductions. Following FY 2016, the district's greenhouse gas emissions decreased 12% for FY 2017 and another 4% for FY 2018. Although the district's greenhouse gas emissions increased 5% for FY 2019, this spike is still 11% lower than the district's FY 2016 spike. If the district continued to produce the same amount of emissions for FY 2017, 2018, and 2019 as it had produced for FY 2016, the district would have emitted an additional 1,044 MTCDE. For perspective, a reduction in 1,044 MTCDE is equivalent to 102,527 gallons of diesel burned and the amount of carbon sequestered by a 1,363 acres forest each year.

These reductions are largely attributable to emission reductions in purchased electricity, stationary and transport fuels , and direct transportation.

Purchased Electricity

The district began recognizing purchased electricity emission reductions in FY 2017. Evidenced by the increase in total degree days from FY 2017 to 2020, the decline in purchased electricity emissions is not indicative of the climate. A rise in total degree days indicates that the weather is more variable, thus necessitating a greater amount of energy needed to heat and/or cool a space. The 8% increase in total degree days from FY 2016 to FY 2018 onward is not matched by a similar increase in purchased electricity emissions (and thus energy consumption). Given these data, the decrease in purchased electricity may be attributable to improved occupant behavior, increased building energy efficiency, and/or reduced carbon intensity of the regional grid energy mix .

Considerable resources were not invested into district building efficiency until FY 2019. During this year, the district completed an energy upgrade lease project within all buildings except for the middle school resulting in LED fixture installations and building envelope improvements. While FY 2020 under reported its emissions (due to COVID-19 school shutdowns), these improvements will yield important energy use reductions in future years.

The historical declines in purchased electricity emissions are likely not attributable to improved occupant behavior and increased building energy efficiency, they are more likely linked to New England's changing energy mix. During FY 2017, the district installed rooftop solar on its service building. The district's renewable energy installations will continue with its construction of a new middle school equipped with solar voltaic, solar thermal, and geothermal. Broadly speaking, New England is continually divesting from fossils fuels such as coal and oil (appendix). The percent contribution of coal to the region's total energy generation has declined each year. Dropping from 4.67% of the mix in 2014 to a negligible 0.09% in 2020 (ISO New England, 2020). The percent contribution of oil to the region's total energy generation has declined with two years of increase. Dropping from 0.75% of the mix in 2014 to 0.12% in 2020 (ISO New England). Conversely, New England is investing in renewables such as solar and wind. The percent contribution of solar to the region's total energy generation has increased 25% to 30% each year, comprising 0.3% of the mix in 2014 and 2.3% in 2020 (ISO New England). Similarly, the percent contribution of wind to the region's total energy generation has increased – less predictably – 1.5% to 25% each year, comprising 1.78% of the mix in 2014 and 3.7% in 2020 (ISO New England). This figures will continue to grow as rooftop solar becomes more commercially viable and as advocates continue pushing for off-shore wind developments.

A REDUCTION IN 1044 MTCDE IS EQUIVALENT TO
(from EPA)

THE CARBON DIOXIDE EMISSIONS FROM BY

1,150,036 pounds of coal burned

102,527 gallons of diesel consumed

120 homes' energy use for one year

CARBON SEQUESTERED BY

17,258 tree seedlings grown for 10 years

1,363 acres of U.S. forests in one year

Stationary Fuels

Similar to its purchased electricity emissions, the district began recognizing stationary and transport fuel emission reductions in FY 2017. However, these declines were not sustained for FY 2019 and FY 2020. Again, evidenced by the increase in heating degree days from FY 2016 to FY 2017 and subsequent decline in heating degree days from FY 2017 to FY 2018 onward, the initial drop and then following rise in stationary fuel emissions is not indicative of the climate. There is no clear reason for these declines and rises in emissions. Although the service building switched from natural gas to solar electricity during FY 2017, each other building is utilizing the same fuel sources. The middle school and high school have been heated with natural gas from FY 2014 through FY 2020. Similarly, the elementary schools and transportation building have been heated with LPG propane from FY 2014 through FY 2020.

The district could yield emission reductions by switching from LPG propane to natural gas or – better yet more challenging – switching from fossil fuels to solar voltaic or solar thermal. Natural gas has an emissions factor of 53.06 kg CO_2 per mmBTU while LPG propane has an emissions factor of 61.71 kg CO_2 per mmBTU. In other words, natural gas emits 14% less emissions than propane per mmBTU (U.S. Environmental Protection Agency, 2014). Interestingly, propane has a greater energy density than natural gas… meaning that more natural gas is needed to produce a BTU of energy than is necessary for propane. Propane has an energy density of 2,516 BTUs/ft^3 while natural gas has an energy density of 1,030 BTU /ft^3 (Meenan, 2021). In other words, propane runs 59% more efficiently than natural gas. However, even with the efficiency gains of propane, natural gas is more environmentally responsible than propane (Meenan, 2021). The major limitation of switching to natural gas is the lack of infrastructure and economic implications of establishing this infrastructure. Extensive coordination with the Towns of Lee, Madbury, and Durham as well as construction of pipelines would be necessary to convert building from propane to natural gas. Given these economic and logistical implications, it may be more feasible to switch from propane to solar voltaic and/or thermal. Such as switch would also more drastically reduce the district's greenhouse gas emissions.

Emissions By Building

The normalized data for each building's emissions show extensive variation. The middle school has the second lowest emissions per capita and lowest emissions per 1,000 FT^2 among the academic buildings. Conversely, the high school has the highest emissions per capita and the second lowest emissions per 1,000 FT^2 among the academic buildings. Moreover, the service building has the highest emissions per capita and third highest emissions per 1,000 FT^2 among the district buildings.

Perhaps, counter-intuitive, many "old" buildings consume less energy and produce less emissions than "new" buildings. The UNH Sustainability Institute's State of Sustainability in Higher Education 2017 Report states that buildings constructed <25 years ago consume ~33% more energy than buildings constructed >25 years ago and ~38% more than buildings constructed >25 years ago but recently renovated (Andrews et al., 2017).

These statistics are largely attributable to the greater sophistication of new buildings, including energy intensive components such as central heating and cooling. However, high performance building standards that emphasize energy and emission reductions can help combat this. While this study was conducted on college campuses, similar factors may be at play with the middle school.

The unique use of the high school and service building may account for the high school and service building's unique emissions profile. The high school's additional space such as its auditorium may account for its high emissions per capita but relatively low emissions per 1,000 FT^2 . Additionally, the high school's additional hours of operation for sporting events and community gatherings may account for its higher gross emissions. The service building's low efficiency construction and use as a sporting event concession stand may account for its high emissions per capita and per 1,000 FT^2. Additionally, emissions may be falsely assigned to the service building because it receives the majority of the district's invoices relevant to emissions.

Transportation

The district began recognizing transportation emission reductions in FY 2015 onward. Only during FY 2019 did transportation emissions rise. It is uncertain what factors contributed to decline in transportation emissions. The phasing out of old buses and phasing in of more fuel efficient buses may be one contributor; however, this has not been confirmed. Additional research must be conducted to determine what factors led to this steady decline and then period of rise in FY 2019.

Oyster River Middle School Design

xi. Future Implications

Transportation, electricity, utility, and solid waste are the greatest sources of greenhouse gas emissions for the district. In targeting its waste management and transportation systems, the district should actively engage its student population as part of the solution.

Electricity and Stationary Fuels

In coming years, the district is expected to observe energy consumption reductions due to its investment in building efficiency. Oyster River Middle School is projected to reduce its emissions the most upon completion of construction. It is projected that the new middle school will reduce its emissions upwards of 85%. The middle school's installation of electric vehicle charging stations has the potential to further reduce the district's transportation emissions.

Upon completion of the district's new middle school, the district can utilize SIMAP to determine how the old middle school compares to the new middle school as well as how the "envisioned" new middle school compares to the "actual" new middle school in terms of energy consumption and emission production.

The district should utilize SIMAP or EPA Portfolio Manager as tools to better understand its buildings energy score. In doing so, the facilities department will be able to better allocated resources to improve the efficiency of the district's most energy intensive buildings.

Solid Waste

The district's decision to send its waste to a waste-to-energy plant rather than a landfill or – worse – an incinerator had enabled the district to draw down its solid waste emissions. However, even waste-to-energy plants emit CO2 as a waste product. Therefore, increased composting infrastructure and education within all buildings and among all district faculty, staff, and students will reduce the amount of waste entering this plant.

To date, the high school's sustainability club is researching potential composting infrastructural systems including 1) the introduction of more centralized composting bins managed by facilities staff and 2) the introduction of classroom composting bins managed by faculty.

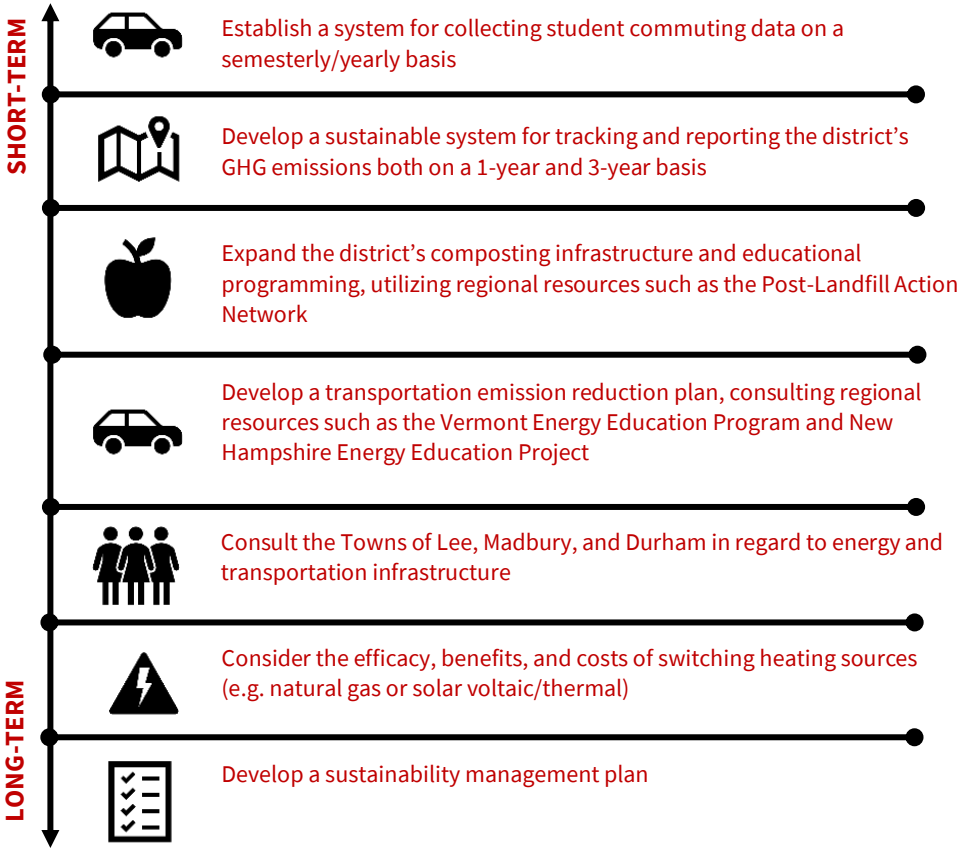
Transportation

Transportation is single-handedly the district's greatest source of emissions but also its greater potential for reductions. Before discussing potential transportation initiatives, the district must collect data on student commuting via a yearly or

semesterly administered survey and/or via student parking permit applications. The introduction of additional EV charging stations, the creation of bike corridors in partnership with the Towns of Lee, Madbury, and Durham, and the incentivization of carpooling are few avenues that the district may consider.

Reporting

The district should develop a better system for continuously collecting and entering data into SIMAP to ascertain that all emission sources are accounted for and accounted for more accurately. Research into more accurate commuting and solid waste reporting is advisable to improve future inventories robustness. The district should succinctly observe its emissions statistics each year and produce an inventory every three to five years. Moving forward, FY 2019 should be utilized as the district's greenhouse gas emissions baseline against which subsequent years will be compared (with the caveat of student commuting data included in future years).



VI. ACKNOWLEDGEMENTS

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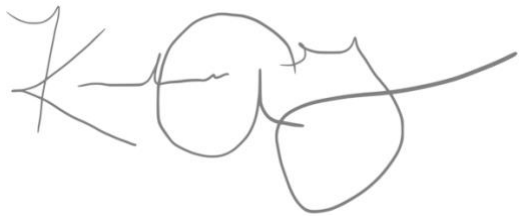
It is my hope that this report will help the Oyster River Cooperative School District become not only a more sustainable and resilient campus, but also a state leader upon which other K-12 school systems can look to for guidance and inspiration.



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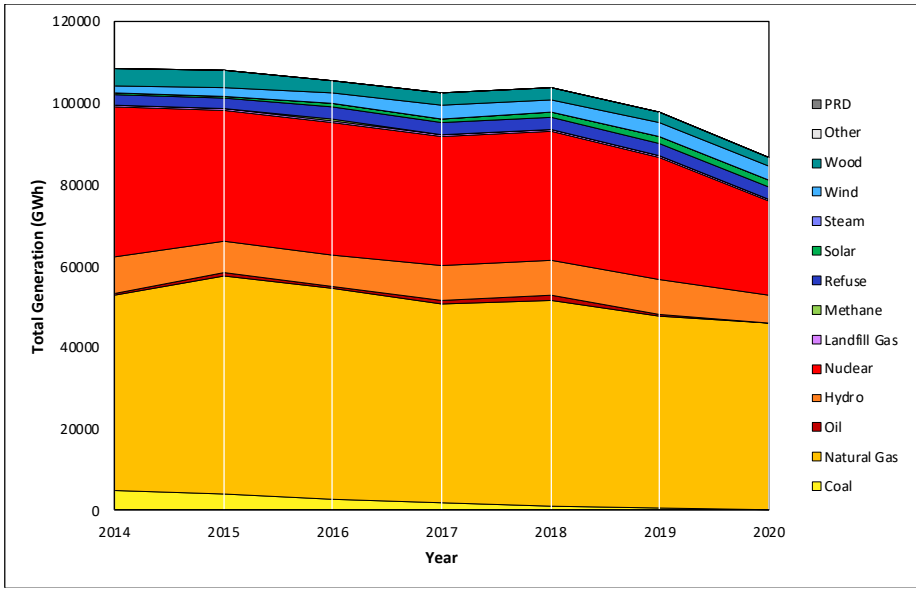
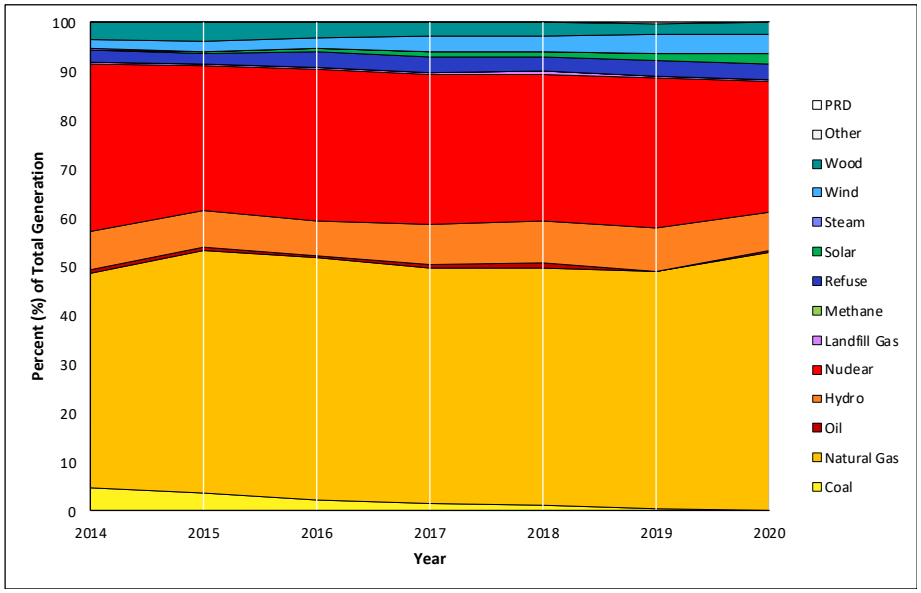
VIII. APPENDIX

xii. Acronyms

AR5 – annual report 5
CCD – cooling degree days
EIA – Energy Information Administration
EPA – Environmental Protection Agency
GHG – greenhouse gas
GWh – gigawatt hour
GWP – global warming potential
HDD – heating degree days
IPCC – Intergovernmental Panel on Climate Change
LPG – liquified petroleum gas
MMBTU – million British thermal units
MTCDE – metric tons carbon dioxide equivalent
NPCC – Northeast Power Coordinating Council
ORCSD – Oyster River Cooperative School System
PRP – price-responsive demand
SIMAP – Sustainability Tracking and Rating System
TDD – total degree days
UNHSI – University of New Hampshire Sustainability Institute

xiii. New England Regional Grid Energy Mix





(from ISO New England)