**Tracking Campus Emissions from Biomass Gasification**

**Introduction**

The following report was created by Gabe Desmond, ’20.5 as part of a summer 2020 sustainability fellowship with the [University of New Hampshire's Sustainability Institute](https://www.unh.edu/sustainability/) (UNHSI). The project was supervised by Jack Byrne, Middlebury’s Dean of Environmental Affairs. Additional guidance was given by Mike Moser, Director of Facility Services, Marc Lapin, Associate Laboratory Professor in Environmental Studies, and Adam Sherman, Manager of the Biomass Energy Resource Center (BERC). Support from UNHSI staff Jenn Andrews, and Megan Carney helped facilitate the project and larger summer experience.

Middlebury’s [biomass plant](http://www.middlebury.edu/sustainability/operations-and-action/biomass-gasification) first went online in February of 2009, as part of the college’s goal to be carbon neutral by 2016, a goal which has since been met. Because biomass is currently accounted for as a carbon neutral source of energy according to [GHG Protocol guidelines](https://ghgprotocol.org/sites/default/files/Stationary_Combustion_Guidance_final_1.pdf), the transition from combusting no. 6 fuel oil to gasifying woodchips, was a large part of how Middlebury met those carbon neutrality goals. The effect of that transition can be seen directly in Middlebury’s current greenhouse gas inventory, which saw a 34% reduction in emissions between fiscal year 2009 and fiscal year 2010 (Figure 1). This reduction is in large part due to not having to account for emissions related to biomass.

Figure 1: Middlebury's currently reported annual emissions. Data from Middlebury's GHG Inventory.

The carbon neutrality of biomass, however, is [highly disputed](https://www.scientificamerican.com/article/congress-says-biomass-is-carbon-neutral-but-scientists-disagree/). The aim of this report is to summarize the research done over the summer to better calculate the impacts of biomass on Middlebury’s carbon footprint. Ultimately, due to limited access to data and established methodology, an absolute value of the greenhouse gas emissions from Middlebury’s biomass plant was not derived. Upper and lower limits, however, were defined, along with a deeper analysis into the sustainability of Middlebury’s biomass system. Additionally, the upstream (scope 3) emissions from the harvesting, production, and transportation of woodchips was calculated. Annually, 30-40,000 metric tons of carbon dioxide (MTCDE) exit the smokestack of Middlebury’s biomass plant, while 50-70,000 MTCDE are sequestered on the lands where the woodchips are harvested. Please see accounting methodology for more information.

Additionally, according to the USDA’s [Forests of Vermont](https://www.fs.fed.us/nrs/pubs/ru/ru_fs119.pdf) report, a net 4,390,000 MTCDE are sequestered annually on timberlands in the state of Vermont. 3,050,000 of those MTCDE are sequestered directly by above ground biomass, while the rest stems from below ground biomass, dead wood, and soil carbon. Because there is net sequestration in the larger Vermont bioenergy system, many people consider biomass sustainable, although this would be entirely different if there was higher demand for wood products in the state and there was not net sequestration, as is seen in many parts of the world.

**Existing Methodology**

Currently there is no widely accepted methodology for bioenergy accounting. That being said, the Greenhouse Gas Protocol, World Resources Institute (WRI), and World Business Council for Sustainable Development (WBCSD) are collaborating on [such guidance](https://ghgprotocol.org/sites/default/files/GHG%20Protocol%20Carbon%20Removals%20%20Land%20Sector%20Project%20Overview%20FINAL.pdf) which is to be finished by the end of 2021. As such, it is highly recommended that biomass accounting at Middlebury is revisited once they publish their guidelines.

A screenshot of a cell phone

Description automatically generated Other methodologies are such as the [DRAX](https://www.drax.com/wp-content/uploads/2020/05/Biomass_Carbon_Calculator_User_Guide_V1.0.pdf) model, [BioGrace II](https://www.biograce.net/biograce2/), and Canada’s [National Forest Inventory Calculator](https://nfi.nfis.org/en/biomass) exist. These models, however, focus on system or nation-wide calculations about biomass. Additionally, due to model complexity, it is likely not sustainable to have Middlebury regularly train interns in running such models to update the college’s greenhouse gas inventory. Other guidelines, such as those designed by BERC (Figure 2) provide simpler guidelines, but rely on several assumptions that may or may not accurately reflect the realities of Middlebury’s biomass system. This methodology, for example, assumes that if a stand’s carbon stores are regenerated within a human lifetime, combustion is carbo neutral. While this may be true in a lifecycle analysis, it is not necessarily true in terms of annual accounting. Additionally, the model assumes that 90% of wood is sustainably harvested, a value they admit is a ‘conservative estimate.’ The reality is, we have very limited knowledge of how much of the wood we consume is sustainably harvested. According to a [senior thesis](https://drive.google.com/drive/u/0/folders/1T9leP_JCt5tnC4kNazlMIP9Tz_iPOj2h) by Ellen Kerchner ’15, all of three of the harvest sites she visited met Vermont Family Forest guidelines for sustainable harvesting. As such, it was decided that it made the most sense to develop new methodology for this project that allows for calculations related to not only biomass emissions, but also related sequestration and upstream emissions from harvesting, chipping, and transporting the fuel stock.

Figure 2: Middlebury Accounting Framework designed by BERC.

**Methodology**

Ultimately, the developed methodology is broken into three categories: direct (scope 1) emissions from combustion, indirect (scope 3) emissions from upstream harvesting, production, and transportation of woodchips, and sequestration of carbon.

Direct emissions are primarily a function of how many tons of woodchips are gasified each year. This data is collected each year by Jenn Pottinger, Facility Services’ Customer Service Coordinator. A [2003 study](https://www.researchgate.net/publication/242094365_A_reassessment_of_carbon_content_in_wood_variation_within_and_between_41_North_American_species) of the carbon content in Northeastern hardwoods allowed for calculating how much carbon dioxide is released from gasifying those woodchips. Lastly, EPA [conversion factors](https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf) were used to calculate the methane and nitrous oxide emissions from biomass gasification and their relative global warming potentials to derive a final MTCDE value for combustion.

Indirect (scope 3) emissions were broken down into four categories: tree harvesting, transportation from harvest site to chipping site, operating the chipping machinery, and transportation from chipping site to Middlebury. This is in line with the Greenhouse Gas Protocols’ [scope 3 calculation guidance](https://ghgprotocol.org/scope-3-technical-calculation-guidance). Unfortunately, during summer 2020, Middlebury’s biomass plant was not operating due to campus closures related to COVID-19. This made it difficult to be in contact with Lathrop Forest Products, the company that harvests and processes all of our woodchips. Mike Moser, Director of Facility Services, however, was able to get in contact with Chris Acker, who runs Acker Excavating, the delivery company Middlebury contracts with to get woodchips. Mike relayed the following information.

“From Chris Acker (who’s very in touch with Lathrop logging process).  For a single 30 ton load of chips of Midd:  log cutter operates about ½ hour and consumes 5 gallons of diesel.  Skidder operates for about 1 hour and consumes 5 gallons of diesel.  Assume about 10 gallons to load a log truck in wood and drive truck to Lathrop mill in Bristol, and unload truck at mill.  Assume about 5 gallons to chip 30 tons of logs at mill.  Assume another 5 misc gallons to load chip truck at mill and other parts of operation.  So…. 30 gallons of diesel / 30 tons of chips from harvest to loaded truck at mill ready for delivery to College”

Jenn Pottinger also has a log of how many deliveries are made each year. This allows for calculations to produce how many gallons of diesel are combusted annually upstream to get woodchips to the biomass plant. For consistency purposes, the emissions factor for diesel from the current Middlebury greenhouse gas inventory on diesel emissions was used to calculate MTCDE emitted from diesel.

Lastly, sequestration needed to be calculated. Every year the Vermont Agency of Natural Resources publishes [annual harvest reports](https://fpr.vermont.gov/harvest-reports). Given that the total wood consumption of Middlebury annually is known, the percent of annual harvests from Middlebury can be calculated. Additionally, the USDA publishes [net sequestration numbers](https://www.fs.fed.us/nrs/pubs/ru/ru_fs119.pdf) for Vermont. From here, a proportionate amount of sequestration for Middlebury can be calculated. Of course, not all sequestrations are the result of the wood products industry, so this number provides one end of the extreme boundaries. The calculator has a tool to change this percentage to see different sequestration numbers based on different assumption about what percent of sequestration can be seen as ‘upstream.’ Additionally, it should be noted that while these numbers represent the broad range of the impacts of Middlebury’s biomass plant, it would be inappropriate to actually claim ownership of those sequestrations, as that growth is occurring on land owned by others.

**Results and Discussion**

|  |  |
| --- | --- |
| Biomass combustion emissions | 34,438 MTCDE |
| Upstream emissions | 210 MTCDE |
| Total proportionate sequestration | -59,049 MTCDE |
| Maximum emissions (assumes no claimable sequestration) | 34,648 MTCDE |
| Minimum emissions (assumes all sequestration is claimable) | 24,402 MTCDE |
| Amount of sequestration needed to be claimed to meet carbon neutrality | 58.6% |

All in all, the impacts of biomass on Middlebury’s carbon footprint is heavily based on how much of the sequestration occurring on harvested timberlands is occurring as a result of the wood product industry. This ultimate end up being a value judgement, and additional research is needed to determine more concrete numbers. For example, would sequestration be happening on timberlands without a wood products industry? Or would landowners be forced to develop that land in order to afford owning it. If this were the case, would additional funding models arise to keep the land forested? Questions such as this make it incredibly difficult to calculate what portion of sequestration can truly be claimed as part of the biomass system. The created model, however, suggests that approximately 58.6% of those sequestrations would have to be directly related for the notion of ‘carbon neutrality’ to be a correct assumption for Middlebury to make (Table 1).

Table 1: FY 2019 Biomass emissions numbers

While this analysis might not help Middlebury home in on a highly precise final factor for annual biomass emissions, it does help set the range of values in which that number could exist. As seen in figure 3, there is a quite a significant range depending on this assumption. As such, the story that is told about biomass is highly dependent on what assumptions are being made about what ought and ought not to be included within the boundaries of greenhouse gas accounting. In a model that accounts assume carbon neutrality (as Middlebury currently does), there is relatively little flux on a year to year basis. Meanwhile, because the amount of carbon released per unit of heat is relatively high for wood, the extreme ‘maximum’ sees Middlebury’s greenhouse gas inventory more than quadrupling from what is currently reported. If sequestrations are accounted for, however, Middlebury’s footprint would actually be net negative, even before carbon offsets are brought into the picture. As such, it can easily be seen how reasonable scientists and politicians can come to wildly different conclusions about how sustainable biomass is, and whether or not it should be considered carbon neutral.

Figure 3: Middlebury's annual GHG inventory from 2007-2019 with three different assumptions about what to include in biomass accounting

**Concluding Thoughts and Next Steps**

A close up of a map

Description automatically generated While it is out of the purview of this report to make conclusions as to how sustainable biomass is or if it ought to be considered carbon neutral, I do think it is important to differentiate between emissions from biofuels and fossil fuels. While deforestation was the leading cause of CO2 emissions through the first half of the twentieth century, in modern times, global emissions are driven almost entirely by the combustion of coal, oil, and natural gas (Figure 4). While this does not necessarily mean that biomass is objectively sustainable, it might be a reasonable alternative, especially in a state with net forest growth. Especially given the difficulties around building electrification on an old campus, Middlebury is still decades away from being able to heat its campus solely from solar and wind power.

Figure : Global carbon emissions by source. Image courtesy of the Clean Energy Development Fund

Obviously, the scope of this research is fairly narrow and there is still significant work to be done in bioenergy accounting. With sufficient funding, a more in-depth study could visit a wide range of harvest sites and compare them with baseline models to understand how harvesting directly impacts forest stands. Addition interviews with timber land owners might yield additional guidance as to how critical the wood products industry is to maintaining forests in Vermont.

Beyond biomass, Middlebury is also in the process of co-developing a [anaerobic digester](https://www.renewableenergymagazine.com/biogas/middlebury-college-and-project-partners-celebrate-groundbreaking-20190821) to offset natural gas consumption with biomethane produced by cow manure and local food waste. As Middlebury continues to expand its bioenergy portfolio, it is important that the institution continues to explore questions of carbon footprints and how accurate notions of carbon neutrality are. Following the release of the GHG Protocol’s guidelines on bioenergy emissions in 2021, it is highly recommended that Middlebury reevaluate how it accounts for emissions in its greenhouse gas inventory.

**Acknowledgements**

A special thanks to Jack Byrne, Mike Moser, Adam Sherman, Jenn Andrews, Megan Carney, and the Higher Education BioEnergy working group for feedback as this report and biomass accounting tool were developed. Please feel free to contact me at [gabedesmond@gmail.com](mailto:gabedesmond@gmail.com) with any questions concerning this work for future reference.