MCNEIL, CLIMATE and FORESTRY

- *Why is Burlington's Net Zero Energy Roadmap focused on fossil fuels and not carbon dioxide emissions?*

  The Net Zero Energy Roadmap adopted by the Burlington City Council in 2019 is focused on fossil fuel reduction because that's where the bulk of human-caused (anthropogenic) greenhouse gas emissions comes from. According to the United Nations, "fossil fuels – coal, oil and gas – are by far the largest contributor to global climate change, accounting for over 75 per cent of global greenhouse gas emissions and nearly 90 per cent of all carbon dioxide emissions."[1] "The Intergovernmental Panel on Climate Change (IPCC) has noted that between 2009 and 2018, 81-91% of anthropogenic greenhouse gas emissions were from the combustion of fossil fuels and cement production[2].

- *I heard biomass is worse than coal and natural gas. Is this accurate?*

  No. There is a difference in the accounting for "biogenic" carbon that comes from the above-ground carbon cycle, wherein trees sequester and store carbon while they grow and release it when they are cut or die naturally, and "geologic" carbon in fossil fuels that has not been in circulation in the atmosphere for millions of years and is extracted from underground, burned, and placed into the atmosphere with no commensurate sequestration.[3] As a multi-author research paper, co-led by employees of the Alliance for Sustainable Energy, which manages the Department of Energy's National Renewable Energy Laboratory and Oakridge National Laboratory, stated, comparing fossil fuel and biomass stack emissions is not an accurate accounting method:

  > "comparing GHG emissions from biomass and fossil fuels at the point of combustion ignores the fundamental difference between fossil fuels and biomass fuels. Burning fossil fuels releases carbon that has been locked up in the ground for millions of years. Fossil fuel emissions transfer carbon from the lithosphere to the biosphere–atmosphere system, causing temperature increases that are irreversible on timescales relevant for humans (Archer et al., **2009**; Solomon et al., **2009**; Ter-Mikaelian, Colombo, & Chen, **2015**). In contrast, bioenergy operates within the biosphere–atmosphere system, and burning biomass emits carbon that is part of the continuous exchange of carbon between the biosphere and the atmosphere (Smith et al., **2016**). Therefore, the effect on the atmospheric CO_2 concentration of switching from fossil fuels to biomass cannot be determined by comparing CO_2 emissions at the point of combustion (Nabuurs, Arets, et al., **2017**; Schlamadinger et al., **1997**)."[4]

  Greenhouse gas emissions are evaluated on a lifecycle basis. The IPCC, the EPA, and the State of Vermont do not simply look at emissions from the stack when it comes to biomass, instead the IPCC calls for evaluating the impact biomass energy has on the land use "flux."[5] The lifecycle of biomass harvested sustainably incudes regrowth of trees that help sequester and storage carbon.

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[1] https://www.un.org/en/climatechange/science/causes-effects-climate-change#:~:text=Fossil%20fuels%20%E2%80%93%20coal%2C%20oil%20and,they%20trap%20the%20sun's%20heat.

[2] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FOD_SPM.pdf (page 8)

[3] See, e.g., EPA - https://www.epa.gov/sites/default/files/2016-08/documents/biogenic-co2-accounting-framework-report-sept-2011.pdf -" fossil and biogenic carbon interact with the overall carbon cycle on very different time scales, and this difference has implications for understanding estimates of biogenic CO2 emissions from stationary sources. CO2 emissions from the consumption of fossil fuels will inevitably increase the amount of carbon in the atmosphere on policy-relevant time scales, but such an outcome is not inevitable with the consumption of biologically based feedstocks. The amount of biologically based feedstocks consumed at stationary sources during a year may be partially or completely balanced by the amount of feedstock that grows during the year. On that basis, as discussed in Section 2, EPA concludes that in order to develop an accounting framework to adjust total onsite biogenic emissions at a stationary source, it is essential to assess the carbon stored by growth of biologically based feedstocks."

[4] https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12844

[5] Per IPCC guidelines Vermont's ANR does not include biogenic CO2 in Vermont's emission inventories. "An important distinction when considering accounting practices for biogenic CO2 is that carbon dioxide emissions from the combustion of fossil fuels are coming from a geologic source, which is on a significantly longer time scale than carbon in the much faster carbon cycle which moves

The IPCC methods call for counting the emissions from a tree when the tree is cut, not at the stack when the tree is used for energy production (otherwise you'd be counting the emissions from the tree twice, and it can only count once). The IPCC also calls for balancing the emissions from cutting a tree with the regrowth of trees in the harvested lands. As the Obama Administration White House Council on Environmental Quality stated in its guidance to federal agencies for accounting for emissions: "This Guidance establishes guidelines for Federal agencies in calculating and reporting GHG emissions fluxes from different sectors and sources associated with agency operations, and seeks to avoid double counting….To that end, in IPCC inventories, carbon sequestration and CO2 emissions within biological systems, including the growth and harvest of terrestrial biomass, are assigned to Land Use, Land Use Change and Forestry (LULUCF) sector. Therefore, when biomass is burned for energy, the related biogenic CO2 emissions are accounted for in the LULUCF sector where the carbon was stored and initially emitted via harvest, not the Energy sector. (IPCC, 2006)."[6]

The Department of Energy's National Renewable Energy Laboratory published in 2021 a harmonization of 3,000 published lifecycle emissions studies in which it determined median ranges of greenhouse gas emissions for various technologies. That report finds that biopower/biomass has 52 grams of CO2 equivalent per kilowatt-hour compared to 486 grams of CO2 equivalent per kilowatt-hour for natural gas and 1,001 grams of CO2 equivalent per kilowatt-hour for coal, demonstrating that on a lifecycle basis biomass has a significantly lower median greenhouse gas emissions rate per unit of energy than gas or coal.[7]

- *But isn't cutting down trees a negative from a greenhouse gas emissions perspective?*

  As Vermont's Department of Forests, Parks and Recreation puts it: "The backbone of Vermont's heritage and economic viability is its working landscape. This 'working landscape' is comprised of agriculture, food systems, forestry, and forest product-based businesses. About 20% of Vermont's land is used for agriculture while another 78% is forested."[8] Even accounting for all forest product harvesting, "Vermont and Northern New York's forests have been adding forest inventory (and stored carbon) consistently for decades."[9]

  Managed forestry can support the maintenance of working lands as working lands, which is another significant topic of concern for many. In Vermont's most recent emissions inventory, one of the largest impacts on the ability to store and sequester carbon was the conversion of forests to developed lands.[10] As the Society of American Foresters notes: "use of low-value timber, salvage wood, and residues from thinning and other forest-sector activities can contribute to restoration goals, deter outbreaks of pests, reduce fuel availability for

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between pools on the order of months to centuries, which means that combusting fossil fuels adds more carbon that was in long term storage and effectively out of circulation into the atmosphere and into the more immediate carbon cycle. Carbon dioxide emitted from the combustion or decomposition of biogenic materials which are a part of the faster carbon cycle are assumed to be sequestered by the regrowth of the biogenic material that produced them, and are captured in the flux from the land use change as described above." "Carbon dioxide from electricity generated through biomass combustion is not included because the CO2 is of biogenic origin, but CH4 and N2O emissions are included in totals. States in the region differ on this accounting practice, however, it is consistent with IPCC inventory guidelines for the treatment of biogenic CO2."
https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/_Methodology_Vermont_Greenhouse_Gas_Emissions_Inventory_1990-2020_Final.pdf

[6] https://www.sustainability.gov/pdfs/federal_ghg%20accounting_reporting-guidance.pdf

[7] https://www.nrel.gov/docs/fy21osti/80580.pdf

[8] https://fpr.vermont.gov/forest/working-landscapeworking-lands-initiative

[9] https://www.burlingtonelectric.com/wp-content/uploads/VEIC-Final-Memo-to-BED-LCA-of-GHG-emissions-4.29.22-.pdf

[10] See page 25 – land converted to settlements - https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/_Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2020_Final.pdf

wildfires, and enhance forest conditions and the provision of ecosystem services."[11] Research[12] indicates the existence of a market for biomass energy can support maintenance of forest lands:

> "Expectation of increasing biomass demand could stimulate establishment of new forests to secure future wood production, which would provide additional carbon storage, and motivate management changes in existing forests to enhance growth (e.g. improved site preparation, faster growing tree species, fertilization), which could improve the climate outcomes from forests managed for biomass and other products (Favero et al., **2020**; Galik & Abt, **2012**; Kauppi et al., **2020**; Laganière et al., **2017**). For example, in Sweden, which was widely deforested in the 1800s, forest expansion together with intensive forest management has doubled the standing volume of forests over the last 100 years, at the same time as annual harvest has increased (Figure **2**). This outcome was supported by forest policy that ensures harvest does not exceed growth, and forests are regenerated after harvest (Eriksson et al., **2018**). A similar trend of increased forest carbon stock with simultaneous increase in harvest has occurred in Denmark (Nord-Larsen et al., **2020**), Finland (Luke, **2017**)…."[13]

As the IPCC stated in 2007, "In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit"; and the IPCC in 2019 stated that – "Sustainable forest management aimed at providing timber, fibre, biomass, non-timber resources and other ecosystem functions and services, can lower GHG emissions and can contribute to adaptation (high confidence)."[14]

McNeil's wood supply is primarily (88.4%) from in-woods chips/residues such as the tops and limbs left over from harvests occurring for higher-value wood products, with an additional 9.7% from sawmill residue and 1.6% from waste-wood yard wood.[15] Even the Manomet report, which is often cited by biomass opponents, makes clear that using the tops and limbs left over from higher-value harvests has a carbon benefit relative to fossil fuels: "Finally, it is interesting to consider the "harvest" and use of just tops and limbs. While this may not be directly applicable to forest management in Massachusetts (due to poor markets for pulpwood and limited opportunities for log merchandizing), it may be representative of situations involving non-forest biomass sources, such as tree trimming/landscaping or land clearing. The results in this case (also shown in Exhibit 6-12) indicate rapid recovery, with nearly 70% of the carbon losses "recovered" in one decade. Thus, all bioenergy technologies—even biomass electric power compared to natural gas electric—look favorable when biomass "wastewood" is compared to fossil fuel alternatives" (emphasis added).

- *But the professors at the TEUC forum suggested biomass was worse than fossil fuels. How do their assumptions differ?*

  Dr. Moomaw and Dr. Rooney-Varga and others who assert burning fossil fuels creates lower greenhouse gas emissions than biomass are only looking at emissions at the stack, and omitting the carbon sequestration benefits from the regrowth of trees and the maintenance of working lands as working lands. Their approach is flawed for the following reasons:

  - **Inconsistent with accepted carbon accounting protocols –** As outlined above, the IPCC, EPA, and State of Vermont do not simply look at biomass emissions at the stack, they consider the changes in land use flux. Dr. Moomaw and Dr. Rooney-Varga, however, do the opposite. At the TEUC forum they contrasted McNeil's emissions at the stack to fossil fuels, but assigned no carbon sequestration value from the regrowth of trees in

[11] https://www.eforester.org/Main/Issues_and_Advocacy/Statements/Utilization_of_Woody_Biomass_for_Energy.aspx
[12] https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12844
[13] https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12844
[14] See https://archive.ipcc.ch/publications_and_data/ar4/wg3/en/ch9s9-es.html and https://www.ipcc.ch/srccl/chapter/summary-for-policymakers/
[15] https://www.burlingtonelectric.com/wp-content/uploads/McNeil-Economic-Impact-26-June-2023.pdf (pages 5-6).

the areas where McNeil sustainably harvests.[16] Looking at emissions only at the stack does not account for the economic value McNeil provides to keep working forests as working forests, and gives the fossil fuel industry a pass on its upstream emissions.[17] This at the stack approach also assumes we can burn fossil fuels and continue to benefit from carbon sequestration from working lands, when burning fossil fuels provides no economic values to those lands in the way McNeil does. Dr. Moomaw and Dr. Rooney-Varga appear to acknowledge their view of counting emissions at the stack is not the recognized standard by scientific and governmental entities, by explicitly calling for adoption of their approach instead in slide 35 of their presentation.[18]

- **Counterfactuals and hypotheticals that are not consistent with science or actual markets for Vermont forest products -** Dr. Moomaw and Dr. Rooney-Varga suggest various hypotheticals and counterfactuals to diminish the greenhouse gas emissions reduction value of local wood. For example, in their presentation they compare use of wood energy to "no harvest" scenarios on slides 22-24 that indicate more carbon dioxide would be stored if no harvest activity was occurring. Of course this would be true, at least for a period of time (trees do eventually die naturally, pests, and fires and other disturbances can impact forest growth), assuming the private managed forests lands were not utilized for economic activity. But that is inconsistent with current economic and forestry practices[19] in Vermont which call for active forest management, including selective harvests. Forest lands in Vermont are under significant economic pressures, and harvest provide important value to forest landowners, helping to keep forest working lands as forests. These current realities, unlike Dr. Moomaw and Dr. Rooney-Varga's hypothetical scenarios, are also consistent with research[20] suggesting that having economic markets for forests products helps keep forests as working lands instead of facing development pressures, which are already documented[21] to be reducing carbon sequestration in Vermont's latest emissions inventory.

  A hypothetical "no harvest" alternative is also inconsistent with science used by the U.S. Forest Service[22], following IPCC protocols: "According to the best available science, harvesting and the use of harvested wood

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[16] https://www.burlingtonvt.gov/sites/default/files/Agendas/SupportingDocuments/Rooney%20Varga%20Moomaw%206-13-23%20McNeil%20Symposium%20Presentation%20v3%20%28002%29.pdf and https://www.cctv.org/watch-tv/programs/burlington-transportation-energy-and-utilities-committee-mcneil-symposium (1 hour mark) and https://www.cctv.org/watch-tv/programs/burlington-transportation-energy-and-utilities-committee-mcneil-symposium (2 hour 31 minute mark)

[17] Upstream fossil fuel emissions can significantly add to lifecycle totals, see, e.g. https://www.wri.org/data/upstream-emissions-percentage-overall-lifecycle-emissions

[18] https://www.burlingtonvt.gov/sites/default/files/Agendas/SupportingDocuments/Rooney%20Varga%20Moomaw%206-13-23%20McNeil%20Symposium%20Presentation%20v3%20%28002%29.pdf

[19] See, e.g. "The economic viability of Vermont's working lands is challenged by changing land use, development pressure, and macroeconomic trends in the forest product economy. Maintaining focus and investment in Vermont's working lands will grow forest businesses, improve our economy, and keep forests as forests."
https://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Vermont_Forests/Library/2017_VT_ForestActionPlan.pdf (page 6) and "Vermont's forest-based businesses are an important part of the state's rural economy. The forest-based industry (forest products, maple syrup products, and Christmas trees) contributes $861 million in sales to the state economy annually and provides direct employment for about 6,600 people (full-time equivalents)….Economic models used to account for this multiplier effect in other segments of the economy estimate that the forest products industry actually contributes 10,555 jobs and $1.4 billion in economic output (The Economic Importance of Vermont's Forest Based Economy 2013, North East State Foresters Association).
Helping to maintain the working forested landscape and a vibrant forest-based economy is the primary goal of the Department of Forests, Parks and Recreation's Forest Economy Program. Vermont's forest-based economy supports employment and provides forest landowners with solid financial returns through planned timber harvesting while promoting value-added manufacturing and tourism. https://fpr.vermont.gov/forest/working-landscape#:~:text=Vermont's%20forest%2Dbased%20businesses%20are,(full%2Dtime%20equivalents).

[20] https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12844 (see section on Sweden's experience later in this Q&A document)

[21] See page 25 – land converted to settlements - https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/_Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2020_Final.pdf

[22] https://www.fs.usda.gov/sites/default/files/Forest-Carbon-FAQs.pdf

products can play an important role in reducing carbon emissions along with good management for healthy forests….When considering the whole system—both forest carbon and use of forest products—carbon emissions can be much lower than if the forest was unmanaged."

Dr. Moomaw and Dr. Rooney-Varga appear to acknowledge that the carbon payback times for wood residues, McNeil's primary source of wood fuel, are quicker (see slide 25)[23]. Per the Manomet study (which has been positively cited[24] by Professor Moomaw), "The harvest and use of tops and limbs for biomass can have an important influence on carbon recovery times and profiles: tops and limbs decay quickly if left in the forest and so their use comes with little carbon "cost" which tends to shorten carbon recovery times."[25] The Manomet study concluded that "all bioenergy technologies—even biomass electric power compared to natural gas electric—look favorable when biomass "wastewood" is compared to fossil fuel alternatives."[26] At the TEUC forum, however, Dr. Moomaw and Dr. Rooney-Varga suggested another hypothetical. They said instead of using wood residues for energy (which is the actual long-term practice at McNeil and in Vermont), foresters should sell wood residues to a "counterfactual" hypothetical market for wood cellulose or strand board products. As foresters[27] at the TEUC forum noted, additional markets for wood residues in Vermont would be welcome, but they do not in fact exist today and would require years and substantial investment to develop. Such "counterfactual" alternatives are not currently viable and should not be presented as such.

- **Inaccurate facts on McNeil –** It does not appear from the TEUC presentation that Dr. Moomaw and Dr. Rooney-Varga actually analyzed or modeled the difference in greenhouse gas emissions between McNeil-based district energy and fossil fuels on a lifecycle basis. Third-party analysis from First Environment did do that and found an over 95 percent reduction in greenhouse gas emissions from McNeil-based district energy compared to natural gas.[28]

  Further, in a 2022 presentation to the Biomass Task Group of the Vermont Climate Council, Dr. Moomaw and Dr. Rooney-Varga's slide on McNeil (see slide 15)[29] had a number of inaccuracies – including:

  - stating that McNeil is a 55MW plant (it is 50MW nameplate),

  - stating that McNeil uses 500,000 tons of wood a year (it actually has never used that amount of wood on an annual basis over the last ten years, and in 2022 McNeil used just over 350,000 tons[30]),

  - stating McNeil is 20% efficient (it is approximately 25% efficient), and

  - stating that it burns a mix of waste wood and whole trees (McNeil's 2022 fuel supply was only 0.3% roundwood[31], and the vast majority of its wood chips came from wood residues and waste wood, sawmill residue, and the waste wood yard).

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[23] https://www.burlingtonvt.gov/sites/default/files/Agendas/SupportingDocuments/Rooney%20Varga%20Moomaw%206-13-23%20McNeil%20Symposium%20Presentation%20v3%20%28002%29.pdf

[24] https://sites.tufts.edu/gdae/files/2019/10/Moomaw_Comments_RegulationsFromDOER_APS_RPS_May2019.pdf

[25] Manomet Study page 109 – 110 https://www.manomet.org/wp-content/uploads/2018/03/Manomet_Biomass_Report_Full_June2010.pdf

[26] Manomet Study page 109 – 110 https://www.manomet.org/wp-content/uploads/2018/03/Manomet_Biomass_Report_Full_June2010.pdf

[27] https://www.cctv.org/watch-tv/programs/burlington-transportation-energy-and-utilities-committee-mcneil-symposium (see discussion around the 1 hour 50 minute mark).

[28] https://www.burlingtonelectric.com/wp-content/uploads/CI-Model-Letter-Report-draft-ver-3.pdf (natural gas has carbon intensity score of 79, McNeil-based district energy at 3.6, using GREET model).

[29] https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/2022%20VT%20Biomass%20Task%20Group%20v3.pdf

[30] https://www.burlingtonelectric.com/wp-content/uploads/McNeil-Economic-Impact-26-June-2023.pdf (page 6).

[31] https://www.burlingtonelectric.com/wp-content/uploads/McNeil-Economic-Impact-26-June-2023.pdf

At the TEUC forum, Dr. Rooney-Varga acknowledged that their model did not account for McNeil's actual fuel mix, which is primarily wood residues.[32] Dr. Rooney-Varga also made clear that their slides analyzing "no harvest" scenarios compared to harvest scenarios were not based on actual McNeil harvesting practices.[33] Lastly, Dr. Rooney-Varga stated that they had limited information to support any analysis of district energy, and focused instead on the idea Burlington should shut down McNeil all-together.[34]

In other forums, Dr. Moomaw and Dr. Rooney-Varga have acknowledged that tree regrowth can offset emissions from biomass energy, but critiqued the payback period relative to wind and solar.[35] The important point to remember here is that McNeil is not competing with wind and solar on the New England grid, so wind and solar are not the relevant comparison. Currently, McNeil competes with fossil fuels such as natural gas (which is the marginal fuel 92-98% of the time McNeil is running), and sometimes coal and oil.[36]

BED takes the question of biomass's lifecycle greenhouse gas emissions seriously and stands by the evidence- and policy-based analyses that have been done on this important question, all of which adhere to recognized biomass carbon accounting principles. Three separate third-party studies by reputable energy expert organizations—First Environment[37], VEIC[38], and Innovative Natural Resource Solutions (INRS)[39] —have all found using those principles that McNeil offers emission reduction benefits relative to natural gas and fossil fuels. INRS produced third-party analysis for BED of the private timberlands from which McNeil procures wood from and found that between 2007 and 2020 those lands added over 24 million tons of net CO2 storage in live trees (pointing to a positive result in the land use flux category referenced earlier). INRS compared that on an annualized basis to emissions from the stack at McNeil and associated emissions from transportation of wood chips and found the annualized carbon additions outweighed emissions by nearly 5x.[40]

- *But if we have to reduce emissions by 2030 can biomass still play a role?*

Yes. Two key considerations are important here. First, McNeil's fuel is sourced[41] from primarily (88.4%) in-woods chips (biomass residues such as tops and limbs) with an additional 9.7% from sawmill residue and 1.6% from waste-wood yard wood.[42] These sources offer some of the fastest carbon payback[43] for woody biomass.

Second, as the researchers from the multi-author paper led by the Alliance for Sustainable Energy staff noted, applying specific carbon "payback" timeframes to bioenergy does not reflect how the IPCC scenarios are modeled and is inconsistent in terms of application to mitigation measures:

> "Some authors (e.g. Booth, **2018**; Brack, **2017**; Norton et al., **2019**) propose that forest bioenergy should only receive support under renewable energy policies if it delivers net reduction in atmospheric CO_2 within about a decade, due to the urgent need to reduce GHG emissions. However, besides the subjectivity of payback time analysis raised above, applying a 10-year payback time as a criterion for

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[32] https://www.cctv.org/watch-tv/programs/burlington-transportation-energy-and-utilities-committee-mcneil-symposium (1 hour 5 minute mark).
[33] https://www.cctv.org/watch-tv/programs/burlington-transportation-energy-and-utilities-committee-mcneil-symposium (1 hour 1 minute mark).
[34] https://www.cctv.org/watch-tv/programs/burlington-transportation-energy-and-utilities-committee-mcneil-symposium (1 hour 6 minute mark and 1 hour 10 minute mark).
[35] https://commonwealthmagazine.org/opinion/baker-is-wrong-to-subsidize-wood-burning/
[36] https://www.burlingtonelectric.com/wp-content/uploads/VEIC-Final-Memo-to-BED-LCA-of-GHG-emissions-4.29.22-.pdf
[37] https://www.burlingtonelectric.com/wp-content/uploads/CI-Model-Letter-Report-draft-ver-3.pdf
[38] https://www.burlingtonelectric.com/wp-content/uploads/VEIC-Final-Memo-to-BED-LCA-of-GHG-emissions-4.29.22-.pdf
[3939] https://www.burlingtonelectric.com/wp-content/uploads/McNeil-Carbon-6.2023.pdf
[40] See pages 7-8 https://www.burlingtonelectric.com/wp-content/uploads/McNeil-Carbon-6.2023.pdf
[41] https://www.burlingtonelectric.com/wp-content/uploads/McNeil-Economic-Impact-26-June-2023.pdf (pages 5-6).
[42] https://www.burlingtonelectric.com/wp-content/uploads/McNeil-Economic-Impact-26-June-2023.pdf (pages 5-6).
[43] Manomet Study page 109 – 110 https://www.manomet.org/wp-content/uploads/2018/03/Manomet_Biomass_Report_Full_June2010.pdf

identifying suitable mitigation options is inconsistent with the long-term temperature goal of the Paris Agreement, which requires that a balance between emission and removals is reached in the second half of this century (Tanaka et al., **2019**). Furthermore, it reflects a view on the relationship between net emissions, global warming and climate stabilization that contrasts with the scenarios presented in the SR1.5: The report shows many alternative trajectories towards stabilization temperatures of 1.5 and 2°C warming that reach net zero at different times and require different amounts of CDR (IPCC, **2018**). The IPCC report did not determine that individual mitigation measures must meet specific payback times, but rather that a portfolio of mitigation measures is required that together limits the total cumulative global anthropogenic emissions of CO_2. Furthermore, applying a payback time criterion when evaluating forest bioenergy, and determining the contribution of bioenergy to meeting the Paris Agreement temperature goal, is complicated by the fact that bioenergy systems operate within the biogenic carbon cycle (see Section **3**), which implies a fundamentally different influence on atmospheric CO_2 concentrations over time compared to fossil fuel emissions (Cherubini et al., **2014**)."[44]

It is important to note too that fossil fuels like coal take millions of years to form[45], while biomass carbon accounting speaks of carbon payback periods in years and/or decades depending on the fuel sources utilized.

- *I have seen photos that show whole trees in the wood yard at McNeil, is McNeil really harvesting whole trees as its main wood source and not just tops and limbs?*

  No. There are sometimes logs in the wood yard at McNeil, but this "roundwood" represents a very small percentage of McNeil's annual supply (0.3% in 2022). We procure a small amount of roundwood that is not generally saleable for other forest product markets each year to support fuel security in the event of inability to get enough wood chips. [46] As the INRS report notes, the vast majority of McNeil's wood comes wood residues (in-woods chips/tops and limbs), mill residues, and the popular waste wood yard.

- *Isn't McNeil inefficient though?*

  The key question here is, inefficient compared to what? McNeil is a solid fuel electric plant that currently operates at approximately 25% efficiency. This level of efficiency is typical for a biomass electric plant and is in line with comparable facilities.[47] In addition, McNeil generates energy locally, instead of relying on power imported over long-distance transmission lines that can have losses.[48] Wood chips have moisture that impact the plant's efficiency values. With District Energy at McNeil, we can moderately improve efficiency by capturing some of its waste heat for use in energy production.

  Coal and nuclear plants can operate at typically 32-33% efficiency, with natural gas at approximately 44%.[49] However, as noted above, coal and natural gas have higher lifecycle greenhouse gas emissions per unit of energy than biomass, even considering their relative efficiencies.[50] Renewables have varying efficiency levels too, with solar at 18-25%, wind at 35-47%, and hydropower at 90%, but they still provide climate benefits.[51]

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[44] https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12844
[45] https://www.eia.gov/energyexplained/coal/
[46] https://www.burlingtonelectric.com/wp-content/uploads/McNeil-Economic-Impact-26-June-2023.pdf Page 5
[47] See, e.g. https://ucanr.edu/sites/WoodyBiomass/Woody_Biomass_Library/Energy/
[48] "The CELT forecast includes losses of about 8% of the total gross load, which is comprised of 2.5% for transmission and large transformer losses, and 5.5% for distribution losses." https://www.iso-ne.com/static-assets/documents/2022/02/transmission_planning_technical_guide_rev7_2.pdf
[49] https://yaleclimateconnections.org/2022/10/energy-loss-is-single-biggest-component-of-todays-electricity-system/
[50] https://www.nrel.gov/docs/fy21osti/80580.pdf
[51] https://yaleclimateconnections.org/2022/10/energy-loss-is-single-biggest-component-of-todays-electricity-system/

- *But what about traditional air emissions and health, don't I see smoke from the plant when it is operating?*

  What you see is not smoke; the visible emissions when McNeil is operating is water vapor.[52] BED and the McNeil Joint Owners take the plant's environmental compliance requirements seriously and have made efforts to reduce air emissions. In 2008, McNeil invested $12 million in a regenerative selective catalytic reduction system that significantly lowers emissions from the plant. In 2022, McNeil's NOx emissions were less than one-quarter of permitted levels. In addition, McNeil has air quality control devices that limit particulate stack emissions to one-tenth the level allowed by Vermont regulation.[53] The Climate and Health Program Manager for the Vermont Department of Health issued a memo addressing McNeil and Ryegate (Vermont's other biomass plant) air emissions and health impacts to the Biomass Task Group of the Vermont Climate Council in 2022 stating "– Based on the available data sources I have reviewed, the health impacts caused by air pollution from the two biomass power plants are essentially negligible…This is mainly a result of the two generating facilities operating with relatively efficient combustion technology and with extensive filtration, pollution controls, and regulations that in combination greatly limit emissions."[54]

[52] https://www.burlingtonelectric.com/mcneil
[53] https://www.burlingtonelectric.com/mcneil
[54] https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Follow_Up_Response_Health_Impacts_Jared_Ulmer.pdf