DARTMOUTH
Office of Sustainability

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To: George M. Woodwell ’50, ’96 (H), President Emeritus, Founder, Woods Hole Research Center
William Schlesinger ’72, James B. Duke Professor of Biogeochemistry and Dean (Emeritus)
Nicholas School of the Environment, Duke University
John D. Sterman ’77, Jay W. Forrester Professor of Management, MIT, and Director,
Sustainability Initiative, MIT Sloan School of Management

From: Josh Keniston, VP of Institutional Projects
Rosi Kerr, Director of Sustainability

CC: Philip J. Hanlon '77, President, Rick Mills, Executive Vice President

Sub: Dartmouth Green Energy Project

Thank you for sharing your insights about the proposed Dartmouth Green Energy project. We have spent significant time analyzing how best to meet our campus energy needs while improving global sustainability and rising to the challenges of climate change. If you haven’t already, we would suggest taking some time to read the “Our Green Future” report from the Sustainability Task Force that President Hanlon convened (https://www.dartmouth.edu/~president/announcements/2017-0422.html). It has served as a guide for our work over the last several years.

Your letter highlights many complex issues that we have been wrestling with in recent years. Our view is that there is no single, or simple, solution to these challenges. Nor is there a perfect solution. Aligned with this perspective, the Green Energy Project has multiple components that go beyond a new thermal generation facility:

1. Convert heating distribution piping from steam to hot water.
2. Retrofit buildings to use efficient hot water systems.
3. Build a new generation facility using biomass as primary fuel and liquid biodiesel as secondary.
4. Develop a plan for adoption of non-combustion energy sources.

Nearly two thirds of the $200M capital investment for this project will go towards the conversions from steam to hot water (1 and 2 above). Our conservative estimate is that switching to a hot water system will provide a 20% gain in distribution efficiency, while also replacing aging steam infrastructure that is reaching the end of its useful life and would require significant investment to keep operational. Low temperature hot water systems are also much more flexible than pressurized steam allowing us to use other technologies such as heat pumps or solar thermal, enabling our transition to a future without combustion in the years to come. We view the switch to a hot water system as a long-term investment that provides the flexibility to adopt new technologies as they mature and become available.

Energy Efficiency

It is critical that we reduce energy demand from both heating and electricity as much as possible. This is among the most powerful tools we have to avoid emitting carbon. Energy efficiency has been a key focus area for the College for many years before we began discussing an updated system. Since 2005 we have had a dedicated efficiency program and have invested tens of millions of dollars in building retrofits including upgrades to HVAC systems, windows, insulation, and lighting as well as installing meters and energy monitoring tools throughout campus. Our square footage has grown by 19% over this period, but our efficiency efforts have reduced our absolute energy consumption by 24%. We have made systemic changes such as implementing energy guidelines for all capital projects and renovations to continually improve energy performance. Recent buildings such as the Class of 1978 Life Sciences Center perform impressively, much like the MIT Sloan School of Management building. We continue to pursue efficiency measures and this remains an important tool in addressing our energy future.

Electricity

We are adding renewable energy capacity. We have added rooftop arrays totaling 2% of Dartmouth’s total energy use over the last 18 months. We are also exploring options for a large-scale ground mounted solar installation that could generate 5 to 10 MW of solar, representing nearly 20% of the College’s electricity needs. We are also investigating options to purchase energy from utility scale renewable projects. We continue to seek financially responsible opportunities to transition more electrical load to renewable energy sources.

Thermal Energy

Our next move after energy efficiency is to tackle our thermal energy system. In assessing how we could improve our energy systems, we looked at nearly every available technology. As part of our analysis, we examined non-combustion technologies (e.g., heat pumps, geothermal, solar, wind). Unfortunately, for our geographic location, scale, and reliability requirements the available technologies would still require significant use of a combustion based fuel to fully meet load requirements. We would need a combustion system to back up heat pumps on the coldest days, for example, necessitating a redundant system. In addition, these strategies are cost prohibitive at nearly five times the capital cost and three times the operating cost of business as usual.

Once this became clear, the question was, what can we combust to generate heat? We could switch to natural gas. However, due to the expensive infrastructure required to transition to natural gas, we were concerned that a switch to natural gas would be a long term one to justify the investment. We could switch to entirely rely on liquid biofuels, but these markets are poorly developed for our volumes and there are few suppliers. We could continue to burn #6 oil for the next 20 years, but this is carbon intensive and the supply of number 6 is dwindling, creating volatility in the market due to global forces, and our current infrastructure requires new investments. Or, we could switch to another carbon-based fuel such as #2 fuel oil. These have problematic carbon emissions, unaccounted for supply chain emissions (probably commensurate with those of fracked gas due to the increased percentage of fracked oil in the supply chain), high risk and variable cost profiles and problematic human and environmental impacts along the supply chain.

Every option has significant liabilities and benefits. In addition to studies like the ones you cited we have also examined others, such as the 2010 Manomet[1] report, to understand the impacts of our proposed approach and how to mitigate negative impacts. Our choice to move to biomass was based on several key factors:

Burning biomass for the purpose of producing heat in a highly efficient system using a hot water distribution system is 89% efficient. So, while there is much less energy in wood, we are recovering more of that energy.

Burning biomass for electricity is, as you point out, incredibly inefficient in terms of carbon, dollars and energy. The study that you have referenced compares biomass to coal for electricity generation. This is dramatically more carbon intensive than using biomass for heat production. In addition, the source of the biofuel matters greatly and studies looking at biofuels often use carbon values for wood that reflect high carbon intensity from harvest, such as wood from clear cuts (as in the study you referenced) or from land conversion. It cannot and should not be assumed that biomass is carbon neutral. However, it's relative carbon impacts can be greatly reduced through careful fuel sourcing, emissions reduction techniques, and land use policies.

The Manomet study reaches as similar conclusion as the Sterman et al. studies in terms of using biomass for generating electricity. It also makes clear that when deploying biomass to produce heat, the equation is quite different. When deployed in a similar situation to what we intend to do at Dartmouth (going from #6 fuel oil to biomass for Thermal/CHP), our carbon debt is about 5 years. Given the life of our plant is intended to be 30 years, this makes it a better alternative than staying on Number 6 oil, though it is not perfect. Sustainable forestry is a critical part of the equation as well, key in reducing the carbon debt. Not all biomass plants are created equal and we firmly believe that in our use case switching to biomass provides a net positive impact on our environmental footprint.

We agree that wood biomass and liquid biofuels are imperfect fuels. Our reasons for choosing biomass are these:

1) We can commit to sourcing it sustainably. We are in the process of developing a fuel sourcing standard that centers carbon as well as accountability. Low grade wood greatly in excess of our demand is currently being sustainably harvested within 50 miles of Hanover.
2) It allows us to localize our supply chain and avoid the many negative effects of our current, unseen, supply chain. We can ensure, for example, that we select partners that prioritize workers safety. We can minimize supply chain emissions (currently unaccounted for in the case of #6) and impacts.

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[1] 2010, Manomet Center for Conservation Sciences, 'Biomass Sustainability and Carbon Policy Study', https://www.manomet.org/wp-content/uploads/2018/03/Manomet_Biomass_Report_Full_June2010.pdf

3) It has the potential to positively impact the Upper Valley. We hope that having our fuel budget stay in the Upper Valley can generate co-benefits.
4) It transitions our combustion from ancient carbon to modern carbon. While it is all the same to the atmosphere in terms of warming, it does seem qualitatively different to accelerate the addition of modern carbon into the atmosphere (while committing to re-sequestering a commensurate amount) than it does to introduce ancient carbon into the carbon cycle. All of our other options involve releasing ancient carbon into the atmosphere.
5) The technologies we plan to employ capture nearly all the minute particulate emissions from wood, greatly reducing the impact of emissions.
6) It buys us time while we begin the transition to a lower carbon, non-combustion system.

All that said, we do believe that non-combustion energy sources are the future and have been planning for the heating plant on a 30-year timetable with the assumption that it will be retired at the end of that period.

Sincerely,

Rosi Kerr
Director of Sustainability

Josh Keniston
Vice President for Institutional Projects