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A Cleaner Energy Future; Energy and Sustainability in the United States and at Dartmouth

Executive Summary

The United States is heavily dependent on fossil fuels as a source of energy generation and consumption ("U.S. Energy", 2017). Dartmouth currently finds itself in a similar situation; since 1898, the College has predominantly relied on #6 fuel oil to meet its heat and electricity demands ("Power Plant", 2008). However, with increasing pressure to improve its energy portfolio, Dartmouth must establish a plan to improve its current energy system and sustainability. Through a two-step plan of conserving energy and transitioning away from #6 fuel oil, Dartmouth has the potential to improve its energy system efficiency, reduce its energy related costs, reduce its carbon emissions, and become leader in energy sustainability in the United States.

In 2016, total U.S. primary energy consumption was approximately 97.4 quadrillion Btu ("U.S. Energy", 2017). The U.S. is heavily dependent on fossil fuels, as 81% of total energy consumed in 2016 was produced from petroleum, natural gas, and coal ("U.S. Energy", 2017). However, the United States is striving to reduce its reliance on fossil fuels and carbon dioxide emissions as well as promote sustainable energy through renewable energy production. Increased wind and solar energy production contributed to a record high production and consumption of renewable energy in 2016 of approximately 10 quadrillion Btu ("U.S. Energy", 2017). In the efforts to reduce carbon dioxide emissions, the U.S. is also moving away from coal energy production, as coal production peaked in 2008 and continued to decline through 2016 ("U.S. Energy", 2017). Moreover, the development of more efficient and cost effective drilling and production technologies in crude oil and natural gas have resulted in a shift away from coal energy generation and resulted in record high natural gas energy production in 2015 ("U.S. Energy", 2017). The electric power sector consumes the most energy in the United States, as this sector uses approximately 39% of the total energy consumed ("U.S. Energy", 2017). Within the electric power

sector, 22% of the electricity is generated from nuclear and 15% is generated by renewable sources, resulting in 37% carbon free generation in the sector ("U.S. Energy", 2017). However, the other 62% of electricity consumed in the U.S. is generated by fossil fuels with coal as the primary fuel source ("U.S. Energy", 2017). The reliance of fossil fuels in the electric power sector heavily contributes to the total carbon dioxide emissions in the U.S., which points to the need for more sustainable practices in overall energy generation and consumption.

Like the U.S., Dartmouth College can greatly reduce its reliance on high emission energy production and increase its sustainable practices. Dartmouth has a long and successful history of energy management. In 1898, Dartmouth built a co-generation plant to meet its heat and electricity demands ("Power Plant", 2008). The central plant burns #6 fuel oil to produce steam and electricity, which is now distributed to over 100 buildings on campus ("Power Plant", 2008). However, the central plant steam turbine only produces approximately 65% of the electricity used on campus, so Dartmouth purchases 25% of its electricity from the regional grid (Kerr, 2017). While burning #6 fuel oil in Dartmouth's central plant was an agreeable and economical solution to meet Dartmouth's energy needs in the past, this system is now outdated and produces carbon emissions that do not meet Dartmouth's recent emission reduction and environmental stewardship goals (Kerr, 2017). Consequently, Dartmouth must build an energy plan that is sustainable and adaptable for years to come.

Dartmouth has a variety of innovative energy options that are environmentally and economically attractive. However, it is important to note that 75% of Dartmouth's carbon dioxide emissions are released from steam generation in the central plant compared to 17% from purchased electricity and 8% from cogeneration electricity (Einhorn, 2008). Therefore, Dartmouth must focus on strategies that address the demand and source of heating on campus to have the greatest impact

in reducing emissions and increasing environmental sustainability. Energy solutions that transition away from #6 fuel oil are beneficial for Dartmouth because the fuel oil is only 55-65% efficient and produces enormous carbon emissions every year (Kerr, 2017).

Dartmouth should devise a two-step approach to improve energy management and sustainability on campus. The first goal that Dartmouth should target is reducing energy demand through increased conservation. Strategies in which Dartmouth can reduce campus energy use include promoting behavioural changes in the student body and retrofitting old buildings to increase heating efficiency. For example, Dartmouth could install monitors in various buildings across campus that show real time energy consumption information from the buildings' energy meters. During a 2008 study at Dartmouth, campus electricity use decreased by 14-22% as an emotional response from energy consumption monitors installed in high-traffic locations (Cohen et al, 2017). Moreover, retrofitting old dorm buildings with glazed argon filled windows and doors, replacing old caulking, and installing spray foam are all effective ways in which Dartmouth can reduce the transfer of thermal energy and current heating and cooling demands (Allan et al, 2017). These strategies are relatively easy to implement and are proven to significantly reduce campus energy demand. They can also be executed in phases across campus and require relatively small investments in capital and labor.

The second goal Dartmouth should work towards is transitioning from #6 fuel oil to electric heating. This transition will significantly reduce carbon emissions released from Dartmouth's central plant without requiring large investments in infrastructure associated with transitioning to alternative fuel sources such as woodchips or hot water heating. Dartmouth should look towards replacing existing steam radiators with electric baseboard heaters in older buildings that do not have central air. Electric baseboard heaters are 99% efficient and produce the equivalent thermal

output as radiators without the need for steam (Davidson et al, 2017). For newer buildings that have central air, Dartmouth should install split heat pumps. These pumps can distribute hot or cool air through the existing air ducts and run entirely on electricity at 250% efficiency (Davidson et al, 2017). This technology is much more efficient than the steam heating Dartmouth currently uses and would allow Dartmouth to move away from its aging and costly steam distribution system. However, Dartmouth would also need to invest in an electricity storage system that could run the electric heaters in the event of a blackout or other cut of electricity supply (Davidson et al, 2017).

The primary environmental and economic benefits of electric heating are weighted heavily in the long term in Dartmouth's investments in renewable electricity generation. Although the local grid's fuel mix is cleaner than #6 fuel oil, Dartmouth can further transition to cleaner electricity generation through installing solar PV panels on campus and investing in a large-scale renewable generation project (Davidson et al, 2017). A large-scale renewable generation project such as the construction of a nearby wind farm would be an investment that could completely offset Dartmouth's carbon emissions and pose Dartmouth as an innovative leader in environmental sustainability while simultaneously producing economic benefits in the long run.

Dartmouth will inevitably need to replace its rapidly aging heating and electricity infrastructure and this two-step plan provides a sustainable solution that is also adaptable to the development of smarter energy technologies in the future. To act consistently with its reputation as a principal educator, innovator, and leader in the U.S., Dartmouth must act now to improve its energy portfolio to include more emission reduction strategies and reduce its reliance on dirty fuels. Dartmouth has the unique opportunity and crucial responsibility to set an example for the U.S. and guide the country in sustainable practices for a cleaner energy future.

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