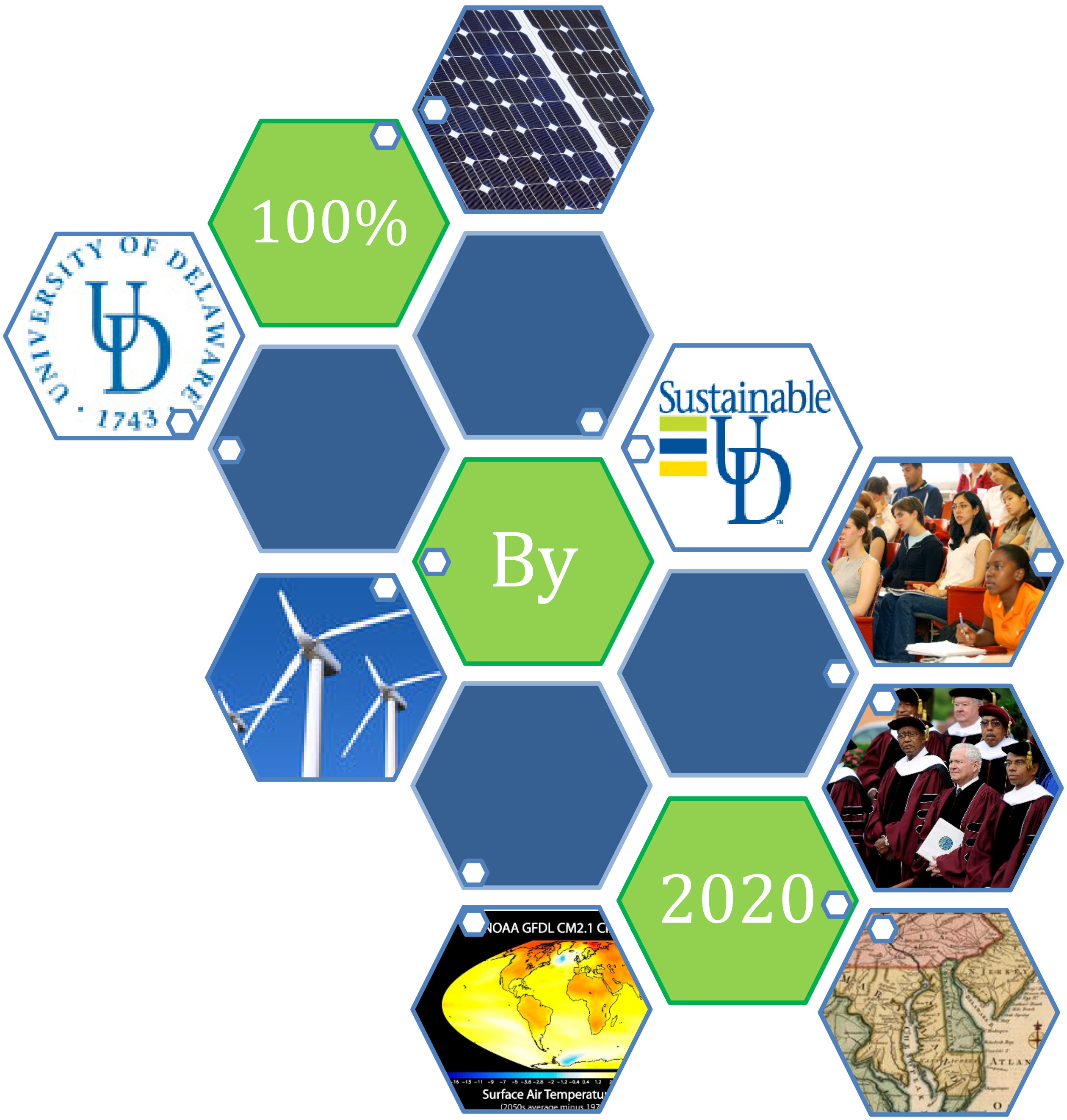
Renewables, Carbon Neutrality and the University of Delaware

Spring 2018



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The following report was prepared by the Sustainability, Energy and Engineering team of Facilities, Real Estate and Auxiliary Services, with substantial support from a dedicated undergraduate intern team. Research and information related herein was gathered from January through May of 2018.

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In coordination with the UD College of Engineering, UD Career Services Center, City of Newark, and Community Engagement Initiative.

Special thanks to Ryan Fuller from the Career Services Center for help in recruitment of the intern team.

Special thanks to 3Degrees for offering pro bono cost estimates for RECs to our intern team.

Executive Summary

In 2017 the University of Delaware Faculty Senate tasked the Sustainability, Energy & Engineering Department to, "determine whether it is economically practicable…[to] no later than January 1, 2020, power its campuses and installations with 100% renewable energy, with such powering to be accomplished through a mixture of…"

a) On-campus wind and solar self-generation, including owning associated renewable energy credits (RECs);
b) Power purchase agreements for wind or solar power and associated RECs
c) Purchase of wind and/or solar RECs.

By the time this report is delivered to the Faculty Senate, the University of Delaware will have about 1.5 years or less to reduce our collective greenhouse gas emissions by 19,891 MTCO2, or about 14%. For context, to date the University has reduced our emissions by 9,950 MTCO2 since our 2007-2008 baseline year, or 6.7%.

This report attempts to identify the best methods to meet the January 1st 2020 goal. In an ideal world, action to mitigate or combat climate change would complement the research and academic mission of our institution. This report attempts to outline best case scenario strategies, should the University decide to aggressively reduce its carbon footprint.

In order to meet the 2020 goal for all UD emissions, the most realistic short-term option is the procurement of RECs. This does not negate the financial, environmental and research benefits of renewable technologies on- or off-campus, but it does recognize our tight deadline. Pricing RECs is difficult, even for the professionals who aided us in the price analyses below.

A rough estimate of ANNUAL RECs procurement
to meet the 20% goal by 2020:
$30k - $70k per year

A rough estimate to meet 100% goal by 2020:
>$152k per year

The RECs market is complicated and volatile, making more
accurate estimates impossible without hiring a 3rd party

I. Introduction

In 2017 the University of Delaware Faculty Senate adopted a resolution encouraging the University to "examine the fiscal implications, including to the academic program, share its analysis with the Faculty Senate Budget Committee, and, in light of any comment by the Faculty Senate Budget Committee, determine whether it is economically practicable…[to] no later than January 1, 2020, power its campuses and installations with 100% renewable energy, with such powering to be accomplished through a mixture of:

d) Wind and solar on-campus self-generation and holding of associated renewable energy credits (RECs);
e) Power purchase agreements for the purchase of wind or solar power and associated RECs; and
f) Purchase of wind and/or solar RECs."[1]

Subsequent to this request, the Sustainability, Energy and Engineering Department of Facilities, Real Estate, and Auxiliary Services (FREAS) is pleased to present the following report on the status, options, costs and benefits to pursuing 100% Renewable Energy, or Renewable Energy Credits, for the University of Delaware.

This report was written by the Sustainability Program of the University of Delaware with a dedicated intern team, and also in coordination with the SEE Group, UD College of Engineering, UD Career Services Center, City of Newark, and Community Engagement Initiative. The sections detailing Renewable Energy Credits[2] were written by an undergraduate intern team:

Students	Class of	Major(s) / Minor
Margaret T. Cashman	2018	Economics / Business Administration
Ricky Bruce Lam	2018	Environmental & Resource Economics / Statistical Data Analytics
David Shulman	2018	Environmental & Resource Economics, Economics
Max Vetter	2018	Environmental Studies / Political Science

Special thanks to Ryan Fuller from the Career Services Center for help in recruitment of the intern team. Thanks also the Community Engagement Initiative for facilitating better coordination between the Sustainability Program and the City of Newark.

This report details UD's greenhouse gas emissions, their causes and sources, and UD's current Renewable Energy portfolio. It also describes what is known and unknown related to the potential for on-site and off-site renewable energy generation, as well as a detailed description of RECs as a tool for carbon offsetting. Throughout there is discussion concerning the January 1 2020 goal. A cost analysis for RECs is included, with discussion of potential benefits for the university, should it choose to invest in renewables directly or indirectly. Finally the intern team that prepared this report provided their own recommendations for the University of Delaware.

[1] Formatting & minor editing for clarity
[2] Sections V – XII, with minor edits by Michelle Bennett, Sustainability Manager.

II. University of Delaware's Greenhouse Gas Emissions

The Faculty Senate Resolution references dangers, impacts and actions related to climate change, so it's appropriate to first review the University's greenhouse gas emissions, its efforts to reduce or mitigate those emissions, and to understand the scale of the Resolution's proposed goal. The University has been tracking its greenhouse gas emissions since 2008, but with an intermission in tracking from 2009-2011 due to lack of staff resources and funding. Our current Greenhouse Gas Inventory tracks the Newark campus only, due to incomplete data at other locations. However, it's important to note that, to our best knowledge, the Lewes Turbine generates more energy than the Lewes campus consumes, thereby essentially rendering that campus carbon neutral.

In 2008, the University set a goal to reduce greenhouse gas emissions by 20% by 2020. According to the latest Greenhouse Gas Inventory from 2016-2017, the University is not on track to achieving its 20% reduction goal. **Since 2008, we have reduced our greenhouse gas emissions by about 6%.**

The total greenhouse gas emissions declined from 149,207 MT CO2 in 2007-2008 to 139,257 MTCO2 in 2016-2017, a reduction of only 9,950 MTCO2. In order to reach the 2020 goal, the University must reduce our total emissions by an additional 19,891 MTCO2.

The highest source of emissions for the University comes from Scope 2 emissions, which represent emissions from purchased electricity. Since 2008 there has been a 9% increase in electricity consumption, despite a 16% increase in full-time equivalent (FTE) student enrollment and a 21% increase in building square footage.

Although our consumption of electricity has increased since 2008, the quantity of greenhouse gases attributed to this source has decreased by 18%. This drop in emissions resulted from the improved environmental performance of our regional electric grid. Most of the power plants serving the Newark Campus have switched from coal to natural gas; renewable power generation has also grown. It's important to note that this reduction in greenhouse gas emissions has little or nothing to do with the actions or activities of the University of Delaware. This windfall accounts for about 2.5% of our total greenhouse gas reductions. The University's energy conservations and efficiency efforts are responsible for most of the rest of our emissions reductions.

GHG Inventories: Scopes of Emissions

Scope 1: emissions *on campus* related to everyday operations.

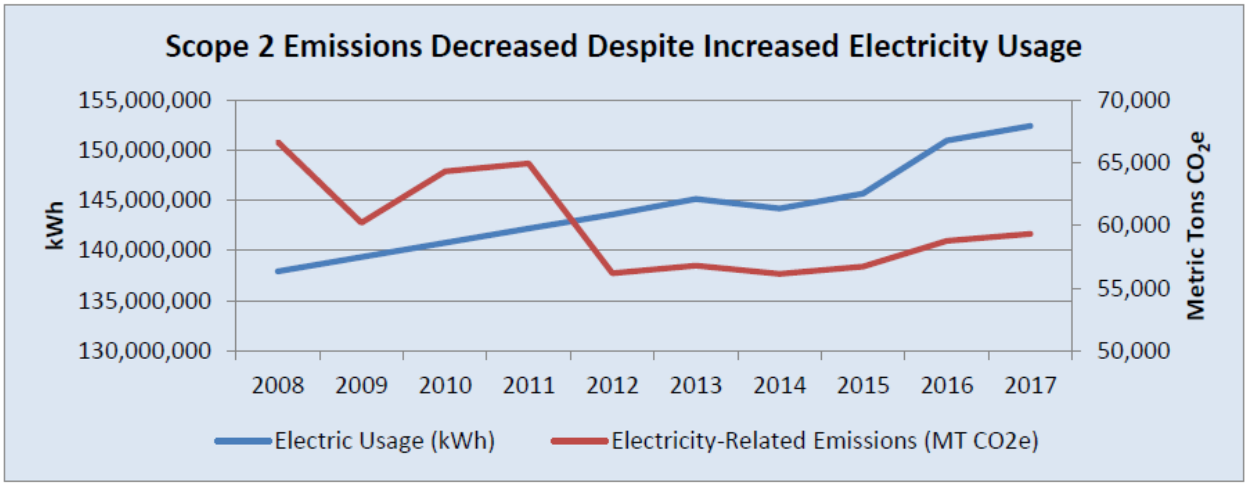
- For example, natural gas used to generate steam.

Scope 2: emissions *on behalf of* campus operations.

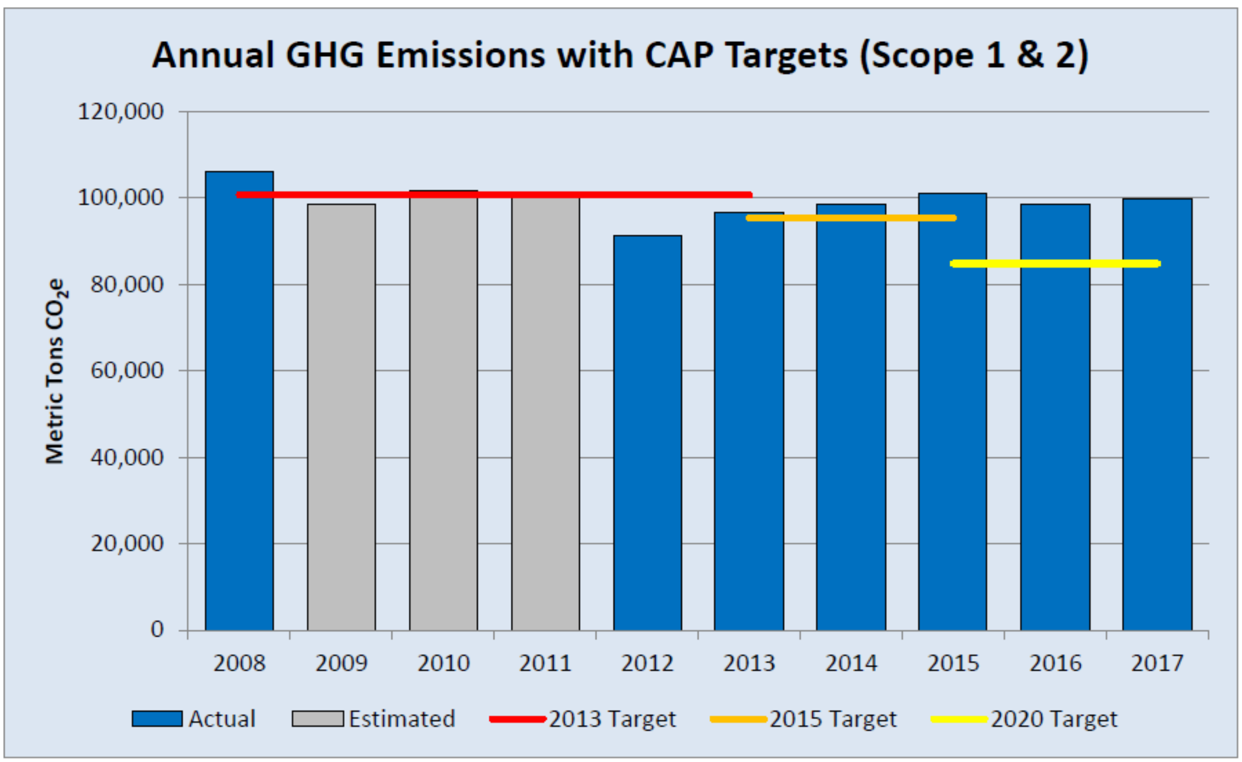
- For example, electricity generation

Scope 3: emissions *off campus* resulting from university operations.

- For example, landfill waste, commuting

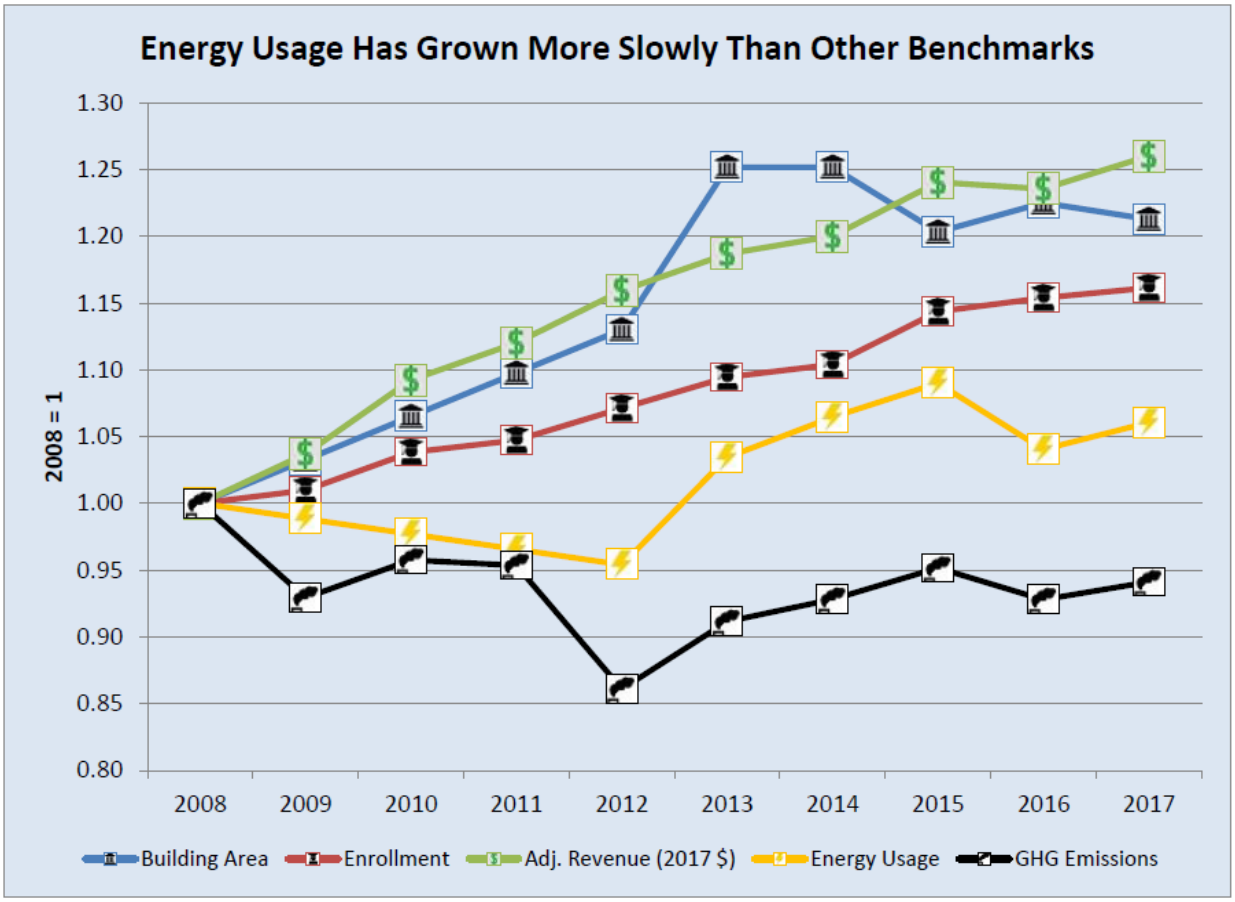


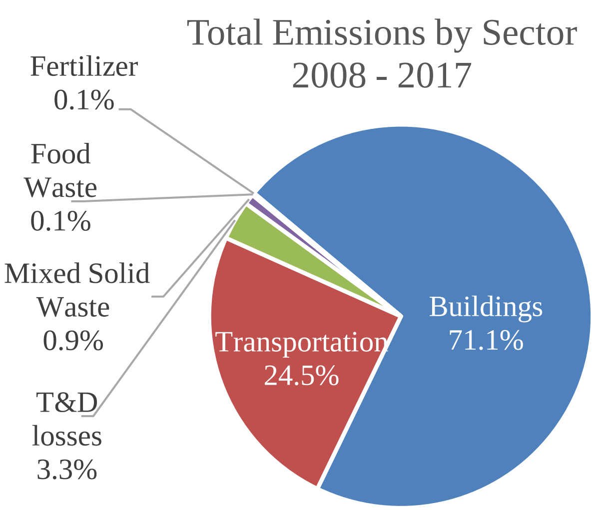
In FY2017, FREAS spent over $667,000 on energy efficiency projects, with a collective average payback of about 4 years, representing about $161,000 in energy savings per year. Energy efficiency projects are projects that occur only for their energy savings; they do not encompass other maintenance work with energy impacts (e.g., replacing a broken light with a more efficient new light). Examples of completed projects include LED lighting upgrades, low-flow shower heads, and installing zone sensors on lab fume hoods.

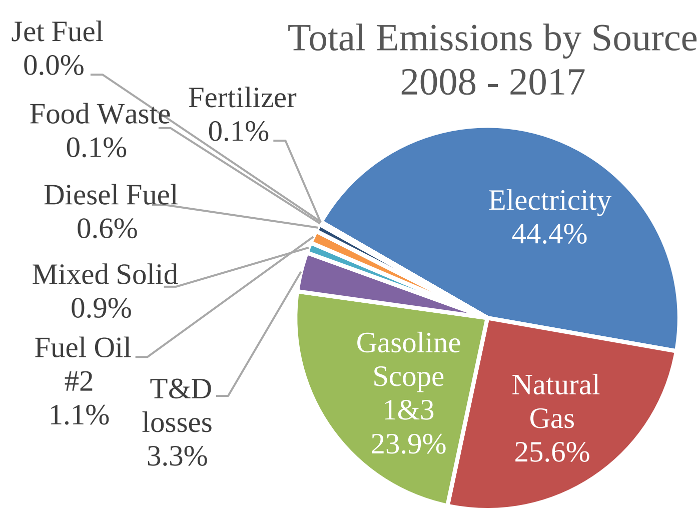


The University of Delaware's energy efficiency efforts are expressed through a decrease in our energy intensity. Since 2007-2008, the ton CO2e per FTE student decreased 19% in spite of the 16% increase in FTE enrollment.

GHG emissions attributed to electricity per square foot decreased by 22% in spite of a 21% growth in total square footage on campus.







III. On-Site Renewables & UD

The University of Delaware currently has three solar energy[3] installations on its Newark Campus, and a single wind turbine[4] at the Lewes Campus in southern Delaware:

Location	Capacity (Kilowatts)	Installed & Online	Est. Generation (04/17 – 03/18) Kilowatt hours	Est. Lifetime* Generation Kilowatt hours	Lifetime* tons CO2e offset
Early Learning Center, Solar	303.0 KW	2010	298,005 KWh	2,419,047 KWh	2,443.24
Clayton Hall, Solar	160.4 KW	2011	145,112 KWh	1,251,851 KWh	1,264.37
Field House, Solar	386.1 KW	2011	463,550 KWh	3,593,159 KWh	3,629.09
Lewes, Wind Turbine	2,000.0 KW	2010	5,606,400 KWh[5]	43,449,600 KWh[6]	30,597.00 [7]
TOTAL	2,849.50 KW	-	6,513,067.00 KWh*	50,713,657 KWh**	37,933.70*

* Lifetime figures are from date of installation to 03/30/2018
** Estimate only

In absolute terms, the University of Delaware aims to reduce its greenhouse gas emission to 119,365.60 tons of CO2e per year. As states above, in FY2017 we emitted 139,257.00 tons of CO2e, leaving the aforementioned 19,891 ton gap between our current performance and our 2020 goal[8]. As previously mentioned, these figures only include the Newark campus due to incomplete data from our other campuses and extensions.

Renewable energy generation alone, either on-campus or off-campus will not be sufficient to meet our 2020 greenhouse gas reduction target. The total CO2e figures in the table above represent lifetime offsets, meaning offsets achieved since the equipment was installed and

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[3] http://peer1.datareadings.com/client/moduleSystem/Kiosk/site/bin/kiosk.cfm?k=l_HTrt53
[4] http://www.ceoe.udel.edu/lewesturbine/index.shtml
[5] Wind turbine annual energy generated derived from the US EPA, which uses an "average nameplate capacity of a wind turbine in the U.S. (2.00 MW)" and estimates average U.S. wind capacity factor (0.32) and by the number of hours per year: 2000 KW average capacity x 0.32 x 8,760 hours/year https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references#wind. The actual figures from the wind turbine are not available online.
[6] The Lewes Turbine was brought online in June of 2010. Estimated KWh multiplied by 7.75 years, capturing half of 2010 and 3 months in 2018. This report was finalized in March of 2018.
[7] Wind turbine CO2e estimates were derived from the US EPA, which uses an "average nameplate capacity of a wind turbine in the U.S. (2.00 MW)" and estimates "3,948 metric tons CO2/year/wind turbine installed". Multiplied by 7.75 https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references#wind
[8] 19,891.40 / 2 = 9,945.70 tons reduced in both 2018 & 2019 to meet the proposed Jan 1, 2020 goal.

operational. Even an impressive solar array like the Fieldhouse is a drop in the bucket of our total emissions[9].

That does not mean investing in on-site renewable energy projects are not worthwhile, only that their benefits can meet medium- and long-term goals. For our looming deadline, we must look to short-term strategies.

IIIa. Electric Service Agreement

On-site energy generation at the University of Delaware has its own unique challenges. The University purchases its electricity from the City of Newark, as part of the University's intentional efforts to be a good neighbor to our surrounding community. The University comprises about half of the land within Newark City limits, but as a non-profit organization we do not pay taxes on that land. City revenue provides local services, including services that benefit our campus and our many students, faculty and staff who live in Newark. The University's Electric Service Agreement (ESA) with the City of Newark caps self-generation at 5MW per the 15year contract period[10], though there are regular intervals in which contract terms can be discussed or adjusted. Each new contract period releases an additional 5MW of self-generation. Please note that our current renewable technology produces well below the limit at 0.849MW.

"… University agrees to purchase from Utility in accordance with the provisions of this ESA **all of University's requirements for electric service** to the Load Electric Meters… at its facilities located within the service territory of Utility as it now exists or may hereafter be altered."

IIIb. Alternative Technology Options

Another consideration for the 5MW self-generation cap is which technologies would best benefit the university. While renewables are an attractive option for reducing emissions related to electricity, we can also continue to leverage energy efficiency and energy conservation programs to reduce our electricity consumption. About 25% of our greenhouse gas emissions are related to the consumption of natural gas to generate steam and chilled water.

Our district energy infrastructure heats and cools most of the buildings on campus; this method can be much more efficient than the stand-alone HVAC units that most people are familiar with in their homes and work places. If the University of Delaware invested in a Combined Heat & Power (CHP) system, it could improve the energy efficiency of our steam and chilled water districts by as much as 30%, with the added benefit of increased reliability and resiliency in our core infrastructure[11]. CHP was proposed in the original carbon action plan as a key project to reduce greenhouse gas emissions, but until recently there was no physical space to site the equipment.

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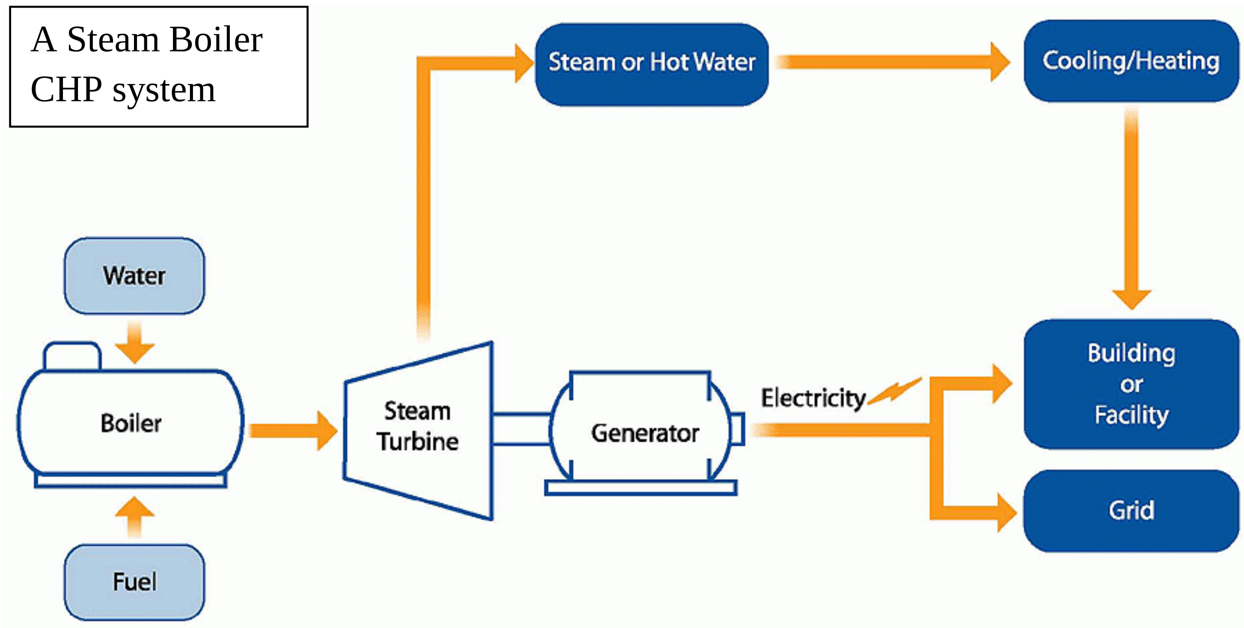
[9] 19,981 tons CO2e = 5 Lewes Turbines, estimated via https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[10] UD's current ESA was signed with the City of Newark in 2013, stabilizing electricity costs until 2028.

[11] https://www.epa.gov/chp/what-chp

Engineering studies must be completed before a proposal for the project can be created and funding secured. A CHP system could easily cost millions of dollars, but would significantly impact our greenhouse gas emissions. Our electric grid is slowly becoming greener as renewables come online, but there is currently no realistic alternative to natural gas in our region by the 2020 deadline.



A Steam Boiler CHP system

IIIc. On-Campus Renewable Technologies

Renewables, like real estate, thrive on the mantra, “Location, location, location.” Solar operates best with an unobstructed southerly view, and in our region wind turbines are most appropriate near the windy coast. It’s not currently clear how much renewable potential exists on campus. It is the understanding of the Sustainability Manager that some estimates have been made by faculty[12], but additional studies would be required to appropriately rule out historical structures, structures that cannot bear the weight of rooftop installations, and structures with an adequate amount of sunlight exposure. Then there are structures looking forward to future rooftop replacements, renovations, expansions or demolitions that could negatively impact a renewable technology installation.

Even with a concerted push to install more renewables on campus as soon as possible, planning and construction could easily take a year or more for each project. That does not invalidate renewables as a part of a larger Climate Action Plan but, as stated above, they cannot realistically contribute to the looming 2020 goal.

How much solar would we need to power the UD campus? UD’s Energy Manager Zach Platsis completed several calculations based on commercial solar panels available on the market today. We chose panels that are popular for balancing energy performance and price point[13]. Given our consumption (~152,387 MWh in FY2016-2017) and the amount of ideal sunlight

[12] The SEE team has not seen these studies, so their recommendations have not been assessed.
[13] 300W Mono Solar World 3.3ft x 5.5ft = 18ft2

available in Newark (~1500 sun hours[14]), we estimate that we would need to produce 130,245 KWh and 130MW to supply Newark Campus's electric needs. That shakes out to 433,333 panels (at 18ft^2 each), which in turn translates to 179 acres for the panels alone.

However, utility scale solar installations average 4 aces per MW due to row spacing, string length, fencing, vehicle access and other considerations. For 4 acres per MW, the University of Delaware would require 520 acres to self-generate its own solar electric power. This does not include emissions from other sources. The Newark campus is 490 acres.

IIId. Renewables Procurement History at UD

Historically the University has signed Purchase Power Agreements (PPAs) with solar installers for all of our solar installations. In these agreements the University agrees to pay a flat rate on a certain quantity of electricity produced by the solar panels. This rate is usually similar to the rate we pay on standard electricity, and the monies pay off the equipment and installation cost of the system over a 10-15 year period. The installer maintains ownership, maintenance costs and liability for the system. In exchange, the University puts $0 down on the installation costs and enjoys the environmental benefits of its operations. The installer generates profit through the sale of electricity and the generation of Renewable Energy Credits (RECs), depending on the terms of the contract.

PPAs can be structured in a variety of ways, usually the host organization does not provide any upfront payments for the project. PPAs can be signed for the equipment, installation, electricity, and/or for the RECs of a project. Projects can be on-site or off-site. Ownership of the equipment may or may not be turned over the host at the end of the contract period. PPAs are an increasingly popular tool for universities seeking to expand their renewable energy portfolios[15]. As such, PPAs are an attractive option for the University of Delaware for any potential renewable energy installations because we have experience with the legal and financial details of such agreements, we have successfully used them in the past, and minimal upfront investment would be required from the University.

IIIe. Towards a Renewable Energy Strategy

On-site renewables are a viable option for the University of Delaware, but currently would facilitate a medium- and long-term strategy for reducing our greenhouse gas emissions. Even with a cap of 5MW, the University can make significant strides towards carbon neutrality while serving as a good neighbor to our local community. However a renewables program needs to be carefully planned and managed to ensure the best possible use of University resources. Even a no-upfront-cost PPA requires non-trivial man hours in planning, legal, procurement and project management phases. It does not take into account any related infrastructure upgrades. For example, a new roof or structural upgrades could be necessary for a rooftop solar installation, and indeed any rooftop installation would necessitate an engineering review. **These costs are not necessarily included in a PPA agreement.**

Reducing annual energy costs, including the proposed costs to offset greenhouse gas emissions, is a short-term benefit. Energy costs are one of our highest operational costs. PPAs

[14] According to the NREL for Newark, DE
[15] See "Case Studies" below.

typically lock in energy prices around, or slightly below, current market rates to pay off an installation over 10-15 years. Stabilizing our energy costs with PPAs can reduce the risks of unforeseeable shocks from the energy market. Just because energy markets are stable today does not mean they will continue to be so in the next 10-15 years.

An aggressive program could cost hundreds of thousands of dollars over ten or more years, which means those resources would be competing with other University priorities. Establishing a revolving fund or some other financial tool for these internal costs would mitigate impacts to research and other programs. A revolving fund could support a stable, long term program, especially if it was supported by a one-time "start-up" injection of funding.

Reducing CO2 emissions is urgently needed, and the University's actions in this field are a litmus test for its wider attitude and policy towards the most pressing challenges of our day. In the ever-competitive market in higher education for student, faculty and staff talent, Universities distinguish themselves in a variety of ways, including climate change leadership. Renewable energy is a potent symbol of institutional dedication to climate change, even as research and other activities demonstrate academic excellence. Thus, if the University wishes to pursue carbon neutrality, it should develop a Sustainability Plan that includes a renewable energy strategy with projected and proposed resource requirements.

IV. Off-Site Renewables

Off-site renewable energy could hold a lot of promise for reducing greenhouse gas emissions, including in the short-term, but with significant caveats. Off-site renewables have the benefit of scale, being designed to maximize electric output, whereas on-site renewable projects will always be limited by site restrictions and competing fiscal, operational and aesthetic priorities. The main concern for off-site renewables comes from Section 2 of our Electric Service Agreement with the City of Newark[16]:

> "… University agrees to purchase from Utility in accordance with the provisions of this ESA **all of University's requirements for electric service** to the Load Electric Meters… at its facilities located within the service territory of Utility as it now exists or may hereafter be altered."

Though a legal review explicitly related to off-site renewable energy procurement has not been conducted, there is concern that *directly purchasing* electricity from an off-site renewable energy project could expose the University to legal risks. The University can work with the City of Newark to renegotiate the terms of our ESA in a way that continues to mutually benefit both parties, but that could be a time-consuming process. The ESA does not bar the University of Delaware from supporting projects that "green" our local electric grid, or procuring renewable energy credits (RECs) from local or national renewable energy projects.

[16] Electric Service Agreement between City of Newark & University of Delaware, section 2. Emphasis mine.

If renewable projects come online within our local area, the University benefits from the reduced greenhouse gas emissions and other environmental benefits related to electricity production, even if we don't directly procure the electricity or purchase affiliated RECs. Some universities are already directly investing in local and regional utility-scale renewable energy projects as a sound financial investment[17]. Depending on the nature of their partnership, Universities can claim a leadership role in combatting climate change and supporting local economic development. There is ample opportunity to work with local utilities and municipalities to support more renewables in our region.

For short-term greenhouse gas offsets, off-site projects that have already been built can be leveraged through RECs. New projects can similarly be leveraged for future greenhouse gas reductions through direct investment, indirect support, or RECs procurement. This is the strategy favored by Google and Apple, who both recently announced that they are matching 100% of their electricity consumption with purchased renewable energy.

The word "matching" is important here, because the electricity they procured, either directly or through RECs, does not necessarily directly power their operations in the exact time and location where the energy is consumed. However, this procurement strategy does secure one kilowatt hour of renewables for every kilowatt hour consumed by the company globally[18] through existing and new renewable energy installations. Many new renewable projects have been launched and completed to satisfy their combined demand for renewable energy.

IVa. Delaware & Renewables

Delaware is ranked 30th in the United States for solar installations, contributing about 1.21% of the state's electricity generation. Though solar in Delaware is estimated to double in capacity (from 113MW to 185MW) in the next five years, we would still see Delaware's national ranking slide to 38th when compared to the rest of the country. Solar is booming due in no small part to the 55% decrease in prices over the past five years[19].

There may be significant financial opportunities for the University to invest in renewable energy projects in Delaware, we are not aware of any internal analyses that have been conducted at this time.

Delaware has a relatively friendly policy regime for renewable energy installations, including a Renewable Portfolio Standard and favorable net metering laws. Recent zoning changes in New Castle

Kees van der Leun of Navigant Energy:

"A polluted river we could clean up, acid rain we could stop, in decades of global action we managed to pull the ozone layer away from collapse. But climate change is largely irreversible. Best advice: stop making it worse, reduce emissions to zero within decades."

Via Twitter, @Sustainable2050
11:39 PM, April 4th, 2018

[17] See "Case Studies" below
[18] https://www.siliconrepublic.com/companies/google-renewable-energy-purchase-goal
https://www.apple.com/newsroom/2018/04/apple-now-globally-powered-by-100-percent-renewable-energy/
[19] https://www.seia.org/state-solar-policy/delaware-solar, accessed 04/11/2018

County expanded the available land where solar installations could be placed, signaling friendly policies at the local level[20].

IVb. City of Newark & Renewables

Through the Community Engagement Initiative, the City of Newark has expressed interest in developing its own Sustainability Plan that coordinates, or at minimum complements, the University's Climate Action Plan. Since the University's Climate Action Plan will soon turn 10 years old, the Sustainability Manager is working directly with the city to develop these plans concurrently. Thanks to the efforts of the Conservation Advisory Committee, Newark secured a Sustainable Communities Planning Grant to develop a comprehensive plan based on the city's resources, priorities and capacities. Michelle Bennett is a member of the steering committee for that grant.

The intention of the Sustainability Manager at this time is to identify some of the University's priorities by engaging in the Master Planning process, by engaging University stakeholders and leadership, hosting events each semester to engage the wider community, and authoring reports with recommendations. This report is considered part of that process. Because sustainability encompasses more than greenhouse gas emissions and climate change, a Climate Action Plan will be one component of a larger proposed Sustainability Plan.

Partnering with the City of Newark could open up a number of opportunities. The City of Newark recognizes that renewable energy is a desirable part of our local energy mix, but also recognizes that renewables will inevitably impact a core revenue streams: electric distribution. As a result, the City hopes to develop a more sustainable revenue structure that will serve the community into the foreseeable future. The University of Delaware has much to benefit from aiding the City in this process, from both an applied research perspective and as a member of the Newark community.

IVc. UD & Off-Site Renewables

Even without the City of Newark, there are opportunities to support renewable energy. On STAR campus, for example, there is a sizeable plot of land[21] that is not currently served by roads, water, or sewer utilities. It is not projected to be developed for some time. It would make an excellent site for a solar installation and indeed several renewable energy businesses have approached the University to inquire about the plot. The Sustainability Manager meets with them as requested to support their efforts as appropriate.

Beyond STAR campus, the University could use renewable energy projects as an investment opportunity to generate medium- or long-term returns while simultaneously supporting research, "green" job skills training, and other community benefits. The University could promote itself as a leader in the twenty-first century economy, as a strong partner battling some of the greatest challenges of our time.

[20] https://www.delawareonline.com/story/news/2017/10/25/project-would-double-delawares-solar-energy-capacity/799003001/

[21] Approximately 20-25 acres, depending on end use. It's located on the southwest corner of the property, somewhat behind Bloom Energy.

These proposed efforts are not short term solutions to our 2020 goal. Even if we proposed and approved a large scale project tomorrow, it would not contribute enough environmental benefits by deadline to meet our goal. Similar to on-site renewable energy projects, off-site renewable energy can be a potent tool in reducing our greenhouse gas emissions in the medium- and long-term. The University should develop a Renewable Energy Strategy to pursue established goals. But in the brief time before our January 1st, 2020 deadline, we need to find existing solutions and action them as quickly as possible. Renewable Energy Credits provide a quick solution.

V. What are Renewable Energy Credits?

A Renewable Energy Certificate (REC) is a financial instrument used to track and represent the economic, environmental and social benefits of 1 megawatt hour (MWh) of generated renewable energy. It's important to understand that RECs represent both electric power and the various impacts of power generations; these two commodities can be sold together or separate from each other on the RECs market.

RECs are either "bundled" or "unbundled" to the physical energy generated from renewable sources. A bundled REC delivers both the electrons of electricity and the environmental benefits of the renewable generation to the purchaser. The buyer must be on the same electric grid as the renewable energy source, so bundled RECs are typically self-generated or sold at the local or regional level. An unbundled REC is created when renewable energy is generated and fed into the grid, where it mixes with energy from other sources, becoming "grey energy," leaving the certificate as proof of the renewable energy. If unbundled certificates are purchased, it is essentially declaring that UD is responsible for "x" amount of renewable energy somewhere in the world, and by extension the social, economic and environmental impacts of renewables compared to other forms of energy generation in that region.

For local renewable energy installations, it's also possible to claim the environmental benefits of the renewable energy without procuring the electricity or the RECs. As an electricity grid becomes "greener", everyone consuming the electricity can claim the environmental benefits. In fact, UD has already done this through no action of its own. Approximately 2.5% of our CO2 emissions reductions since 2008 are thanks to the electric grid switching from coal to natural gas. Supporting local renewable energy, even without direct investment, results in a net reduction of CO2 emissions for the University of Delaware.

A single REC is tracked using a certificate that contains unique attributes to prevent double counting. The RECs are used to account for the purchaser's environmental impacts, especially carbon emissions. These certificates can be generated or acquired through many channels, such as Self Generation, Power Purchasing Agreements (PPAs), Community Solar Generation, Utility Supplied Green Power, or direct procurement from a specific renewable energy project.

Va. REC Attributes

Sources of RECs, as of spring 2018

Solar	Geothermal	Biomass, biofuels
Wind	Small hydro-power facilities	Hydrogen powered fuel cells

REC unique identifying attributes:

- Certificate Data
- Certificate type
- Tracking system ID
- Renewable fuel type
- Renewable facility location
- Nameplate capacity of project
- Project name
- Project vintage (build date)
- Certificate (generation) vintage
- Certificate unique identification number
- Utility to which project is interconnected
- Eligibility for certification or RPS
- Emissions rate of the renewable resource

VI. Energy Markets in the United States

Most states in the country belong to an Electric Transmission System Operator (TSO). These entities are called Regional Transmission Organizations (RTOs) or Independent System Operator (ISO). The official definition of an RTO and ISO is: "An entity that is independent from all generation and power marketing interests and has exclusive responsibility for grid operations, short-term reliability, and transmission service within a region"[22]. RTOs and ISOs can span multiple states or operate in only one. Since electricity is considered interstate commerce, electric grids are regulated by the Federal Energy Regulatory Commission (FERC).

The main responsibilities of RTOs and ISOs is to monitor a region's wholesale electricity markets and provide reliable planning for the region's bulk electricity system. They help to coordinate the generation and transmission of electricity across wide geographic regions, matching generation to the load instantaneously to keep supply and demand for electricity in balance. They also facilitate competition among wholesale suppliers by overseeing the energy markets and provide transparency of transactions on the system. There are currently 7 different RTOs and ISOs that cover the United States and they account for about 60% of the electric power supply in the country.

Delaware is part of the PJM Interconnection RTO. PJM Interconnection is responsible for the electric grid in 13 states.

VIa. US Renewable Energy Markets (Voluntary V. Involuntary)

Mandatory markets are created by state policy and law, for example state renewable portfolio standards (RPS) requiring companies to procure specified amounts of renewables in their portfolio. Pricing in mandatory markets often exhibits some market distortion due to efforts to avoid noncompliance. Pricing tends to hover just below the non-compliance penalty cost. In Delaware, the noncompliance penalty is $25/MWh, "but failure to comply for consecutive years

[22] http://www.pjm.com/training.aspx

increases it to $50, and then $80 on the third year."[23] Additionally, there is a solar carve out where a certain amount of solar energy must be present, and the penalty for noncompliance with the carve out is $250/MWh

Voluntary markets, or "green power markets", are driven by consumer preference for certain types of renewable energy. Pricing in voluntary markets is based off supply and demand with little distortion, and tends to be cheaper than mandatory markets.

VIb. State of Delaware Regulations and the RECs market

The state of Delaware's Renewable Energy Portfolio Standard was established in 2005 and it requires twenty five percent of Delaware's energy consumption come from renewable energy resources by 2025-2026. At least 3.5% of the renewable energy must be sourced from photovoltaics (Del. Code Ann. 26 351 et seq)[24].

The Solar Renewable Energy Certificate (SREC) market in Delaware is operated by Delmarva Power. REC producers, including homeowners with rooftop solar installations, can choose to sell RECs through contracts with the equipment installer or Delmarva Power, or they can retain the RECs as a private asset.

It's not uncommon for REC producers to sign contracts locking in REC prices for the contract period. This returns the value of the RECs to the producer more quickly, or in regular intervals, and it cushions the producer from market fluctuations. It also provides REC consumers with some price stability.

VIc. State of Unbundled Voluntary Markets

It is estimated that about 69,500 customers purchased approximately 42.5 million MWh of green power through unbundled RECs in 2015. In 2016, the Voluntary market encompassed about 27% of the market, with the remainder labelled "Compliance" or "Other"[25].

NREL compiled data on states with the highest renewable energy demand (top measured in 1000x customers) and highest renewable energy output (bottom) in the Voluntary markets[26]. Texas registers the second highest output and the highest demand. This is logical given their abundance of locally produced energy, which keeps the prices down and the quantity demanded up. In comparison Illinois has the highest demand, yet only the third highest supply. Texas, California, and Illinois account for more than 1/3 of green power supply.

Unbundled RECs have shown the fastest growth of green power options and have become the largest in the voluntary market. Output has risen due to increasing size of purchases as well as increasing number of purchasers over the past year (+54%)[3]. REC purchases of 1 million MWH grew 22% from 2015-2016 while customer participation in unbundled RECs

[23] https://www.instituteforenergyresearch.org/wp-content/uploads/2011/01/Delaware-RPS.pdf
[24] Durkay, Jocelyn. State Renewable Portfolio Standards and Goals. National Conference of State Legislators, 1 Aug. 2017, http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx#de
[25] Heeter, Jenny. Status and Trends in the Voluntary Market. 2017 National Summit on RPS 7 Nov. 2017, https://www.cesa.org/assets/2017-Files/RPS-Summit/Jenny-Heeter.pdf
[26] Eric O'Shaughnessy, Chang Liu, and Jenny Heeter. "Status and Trends in the U.S. Voluntary Green Power Market (2015 Data)". National Renewable Energy Laboratory. Oct. 2016, https://www.nrel.gov/docs/fy17osti/67147.pdf

increased by more than half from 2015 to 2016. The market is expected to further grow as technology advances and supply grows, and even more companies commit to renewable energy.[27]

VId. Cost of Bundled vs. Unbundled RECs

In most markets, unbundled RECs are more affordable for a variety of reasons. They are interchangeable in a voluntary market, which drives price competition. Unbundled RECs have no geographic constraints and therefore can provide access to the least expensive renewable resources to a larger market. Other costs that impact price are also avoided. The supplier does not deliver the physical electricity to the REC purchaser, thereby avoiding the operations costs associated with electricity delivery and/or transmission and distribution loss. This splits those costs away from the REC, and the supplier is free to connect to the electricity grid in the most cost effective way they can. This is why an unbundled REC represents the environmental benefits of renewable energy, rather than the physical energy itself. It also explains why bundled RECs tend to be more expensive, even in a voluntary market.

As discussed earlier, involuntary markets operate under different rules and price pressures. The relative cost of bundled vs. unbundled RECs will be impacted by legislation or other market distortions and should be analyzed on a case-by-case basis.

VII. Procurement of RECs

Most RTOs and ISOs have their own online programs that assists with the certification, authentication, trading, and tracking of RECs in their regions. These online programs help to connect buyers and sellers. The PJM region uses the General Attribute Tracking System (GATS) to help track RECs in their energy market. In GATS, sellers can post RECs on bulletin boards with contact information; price information is optional. Buyers can use the boards to search for specific types of RECs and contact sellers. Third party sellers and aggregators can also list RECs on these boards.

All RECs sold through these programs retain their unique attributes, including serial numbers, to prevent double counting. Most programs allow unbundled RECs generated from other regions to be traded in their markets, including GATS.

States and energy markets that do not belong to a RTO or an ISO typically use their own online program based off the North American Renewables Registry (NAR) or the Generational Information System (GIS).

In claiming the seemingly intangible environmental benefits of RECs, it’s important to consider certifications by a trusted third parties. Green-E tracks and certifies that RECs are not double counted and come from projects built with-in the last 15 years, among other criteria. Not all RECs are certified, though arguably they still represent significant environmental benefits.

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[27] State of the Voluntary Green Power Market. 25 Jan. 2017, https://www.epa.gov/sites/production/files/2017-01/documents/webinar_20170125_kent.pdf

It's important to understand and establish internal standards for certification and/or quality controls before procuring RECs.[28]

The transparency and accounting attached to RECs is one reason they're sometimes considered more valuable than other forms of carbon offsetting. Purchasing carbon offsets is also popular, but without very high quality accreditation, it's sometimes unclear that your investment is having the intended impact. [29]

Green-E is provides an online search engine where anyone can browse intermediary companies that sell RECs[30]. The website allows you to filter companies based on their Renewable Content (e.g. 50% solar, 50% wind), which states they operate in, as well as other factors. You can visit company websites or find contact information via Green-E[31]. RECs can also be purchased directly from the GATS bulletin board, though there is less information about the sellers available there[32].

VIIa. Voluntary Market Procurement Options:

- Purchase RECs directly from a specific project or third party (broker, retailer)[33]
  - Typically with a fixed price over the contract period
  - Service fees may apply, but less administrative burden for the institution
  - Can be bundled or unbundled
  - Typically off-site
  - Can be local, regional or national
- Purchase directly from PJM via GATS
  - Difficult to fix prices, both risks and opportunities with market fluctuations
  - "Local" in the sense of the regional electric network
  - Can be bundled or unbundled
  - Off-site
  - High administrative burden, necessitates hiring someone with knowledge / skills to manage
- Utility Supplied Green Power Products
  - Contains the REC and Underlying Electrons Bundle
  - Typically with a fixed price over the contract period
  - Potential for wholesale pricing
  - Typically local or regional
- Self-Generation
  - Electric generation offsets energy costs
  - Ownership of affiliated RECs, which can be sold without forfeiting environmental benefits claims

[28] Guide to Purchasing Green Power. Mar. 2010, www.epa.gov/sites/production/files/2016-01/documents/purchasing_guide_for_web.pdf
[29] https://sustainability.berkeley.edu/sites/default/files/DRAFT_UCB_RECs_Offset_Recommendations_V2_0212.pdf
[30] https://www.green-e.org/
[31] Richardson, Luke. 2017 SREC Prices: How to Sell Your RECs in the U.S., EnergySage Solar News Feed, EnergySage, 28 Sept. 2017, https://news.energysage.com/srec-prices-explaining-u-s-srec-solar-market/
[32] https://gats.pjm-eis.com/gats2/PublicReports/BulletinBoard/PurchaseRequests
[33] Aggregator/Broker Listing, gats.pjm-eis.com/gats2/PublicReports/AggregatorBroker/Aggregator

- Upfront costs and maintenance costs
    - Limited by site constraints, budget priorities, etc.
- Power Purchase Agreement (PPA) for Renewables
    - Contract to buy RECs and/or Underlying Electrons Bundle from specific project.
    - Typically includes a fixed price over a long contract term (up to 20 years)
    - No upfront capital or maintenance costs
    - Protection from volatile energy prices.
    - Bundled or unbundled
    - On-site or off-site
    - Can be local, regional or national
- Virtual Net-metering / Community Solar
    - Allows utility customers to share electrical output and/or RECs from a single power project, typically in proportion to their ownership in said project
    - Upfront investment cost, but with potential for long-term benefits
    - Typically local
    - Bundled or unbundled

VIIb. Procurement

The rules of thumb for purchasing RECs are not significantly different from any other acquisition, but choosing the best supplier is important. The following should be taken into consideration during the procurement process:

- Supplier reputation compared to industry norms
    - Any past or present legal issues?
- Financial strength and performance in the market place
- Source location of RECs sold by the supplier: do they source regional or local?
- Product choice: do the RECs meet University standards?
- Environmental performance of the supplier: any past controversy?
- Prices for similar products
- Third Party verifications and certifications

VIII. Costs and Benefits of Action

The social cost of carbon emissions can be defined as the "measure of the economic harm from those impacts, expressed as the dollar value of the total damages from emitting one ton of carbon dioxide into the atmosphere"[34]. Recent attempts to estimate a social cost of carbon have resulted in a number of interesting academic debates, as well as more practical guidelines:

- A government study in 2015 used three economic impact models to estimate damages in dollars of carbon emissions. They concluded that an additional ton of carbon dioxide can cause up to $37 in economic damages.

[34] https://www.edf.org/true-cost-carbon-pollution

- A study published in the journal *Nature Climate Change* estimates that the social cost of carbon is actually higher. Frances Moore from Stanford's School of Earth Sciences says that "we estimate that the social cost of carbon is not $37 per ton, as previously estimated, but $220 per ton".[35]
- The World Bank's High Level Commission on Carbon Pricing[36] has recommended $44-$88 per ton of CO2 by 2020 and $55-$110 per ton by 2050[37] as an economic mechanism to meet the temperature goals proposed by the Paris Climate Agreement.[38]

The University of Delaware is a signatory of the Second Nature Climate Commitment[39], a signatory of the American Campuses Act on Climate Pledge[40], and most recently a signatory of the "We're Still In" letter[41]. All explicitly support the goals of the Paris Climate Agreement. It makes sense for the University of Delaware to support and enact a climate mitigation and adaptation strategy. Delaware is, on average, the lowest lying state in the USA[42]. We are particularly vulnerable to the extant and predicted impacts of sea level rise. Increasing instances and severity of extreme weather increases risks to our people, buildings, and research in the form of power outages, flooding, etc.[43] An ounce of prevention is worth a pound of cure; getting your flu shot is the smart decision *even if you don't contract the flu*, because the risks to yourself and others is mitigated.

Reducing greenhouse gas emissions can provide multiple benefits and opportunities, and a core goal of sustainability is to secure and maximize as many benefits as possible in any given program:

- Reducing the immediate costs and future risk of energy price variability.
    - Renewable energy procurement agreements can have longer contract periods than most distributors or utilities are willing to offer
        - If direct procurement is not possible, UD can still claim greenhouse gas reductions from renewable projects through either direct investment or RECs procurement
        - If direct procurement is possible, PPAs can often procure energy at a comparable or lower rate than we currently pay. Procurement strategy can require lower rates before consideration.
    - Energy price stability can be used to support other university strategic priorities by stabilizing future costs, freeing up monies for other initiatives.
    - See Case Study: University of Maryland, College Park

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[35] University of Stanford, "Estimated social cost of climate change not accurate, Stanford scientists say." Stanford News, 8 Apr. 2016, news.stanford.edu/2015/01/12/emissions-social-costs-011215/

[36] https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices/

[37] The prices above are converted to US tons for consistency in this report. The Commission recommends $40-$80/tonne by 2020 and $50-$100/tonne by 2050. 1 metric tonne = 1.10231 US tons.

[38] http://unfccc.int/paris_agreement/items/9485.php

[39] http://reporting.secondnature.org/institution/detail!797##797

[40] https://obamawhitehouse.archives.gov/the-press-office/2015/11/19/fact-sheet-ahead-conference-climate-change-more-200-colleges-and

[41] http://www.udel.edu/udaily/2017/june/open-letter-supporting-climate-action/

[42] https://www1.udel.edu/researchmagazine/issue/vol4_no1/slr_intro.html

[43] https://library.wmo.int/opac/doc_num.php?explnum_id=3414

- Research and innovation in technologies that will be in high demand in the near- and long-term future
    - Demand for energy is not projected to fall anytime soon. UD is already a research leader in this field, with notable experience in real-world implementation. Leveraging this expertise will demonstrate leadership and innovation.
    - Renewables technologies can have social opportunities to reach underserved communities across the globe where electric grids do not or cannot reach.
- Academic research funding opportunities including but not limited to engineering, chemistry, business, policy, and environmental sciences, etc.
- Creation of jobs, especially the opportunity to support local jobs, industries and economy
    - See Case Study: SUNY Buffalo
- Draw positive attention to the University. Case studies below illustrate campuses that have leveraged RECs as part of a larger carbon reduction / sustainability strategy and have received awards, national recognition and community recognition for their efforts.
    - See Case Study: Georgetown University
- Benefits the environment and conserves natural resources

Options for leveraging the impact of purchased RECs:

- Procure an appropriate quantity to meet 2020 carbon reduction goals
- Enter into long-term agreements to stabilize prices
- Buy from new or upcoming projects (off-site)
- Take an equity position in new projects (off-site)
- Own or host on-site projects
- Support renewable energy development (either directly or indirectly)
    - For example, support off-site projects through research collaborations, student engagement, community engagement, or political influence.

VIIIa. Benefits of Attracting & Retaining Talent

Many higher education institutions are increasingly pressured by donors, student applicants and (prospective) faculty or staff recruits to do more for climate change and sustainability. By 2025, more than half of the world population will be under 30, and these so called “Millennials" will make up 75% of the workforce.[44] Research from the U.S. Trust (2016)[45] and Deloitte[46], emphasis the environmental concerns of the Millennial generation and the impact they will have on the future. The surveys, which were designed to uncover significant topics of importance to this generation, show that 85% of Millennials believe that social and environmental impact is important to investment decisions and 87% believe that long-term success is more important than pursuing short-term profit maximization. The Princeton Review, and other college guides targeting prospective students, highlights schools that have made a commitment to sustainability. The Princeton Review published a survey in 2011 which showed

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[44] https://www.forbes.com/sites/danschawbel/2013/09/04/why-you-cant-ignore-millennials/

[45] http://www.ustrust.com/publish/content/application/pdf/GWMOL/USTp_ARXDJKR8_2017-05.pdf

[46] https://www2.deloitte.com/content/dam/Deloitte/global/Documents/About-Deloitte/gx-millenial-survey-2016-exec-summary.pdf

that 64% of high school seniors valued knowing about campus sustainability commitments as they select a college or university.[47] If Millennial trends identified by Deloitte and the U.S. Trust hold true, that 64% figure could be increasing.

Universities will see a greater demand from students and faculty to implement sustainability practices on campus not just in the coming years, but for decades to come. This will affect enrollment or employment by future prospective students, faculty and staff. The University of Delaware has already been impacted, with recorded cases of students and faculty leaving, or choosing not to join, the University due to its current sustainability track record, especially related to action on climate change.

There is also the consideration of applicant quality. Attracting educated, engaged and passionate students, faculty and staff is a competitive necessity in higher education, and high-quality applicants will be aware of, or attracted to, the most challenging issues. Climate change is the most challenging issue of our time[48]. It is not clear if UD collects information about sustainability attitudes when it assesses its student, faculty and staff recruitment strategies or activities. Perhaps we should.

Investment in renewable energy can be used as a recruitment tool and competitive advantage for the University of Delaware. Adopting a clean energy strategy can also appeal to current students, faculty and staff. While in some scenarios the University could incur an additional cost on top of standard electricity prices, the purchase of RECs and overall investment in renewable energy could provide the University with strategic qualitative paybacks and benefits in student, faculty and staff recruitment and retention.

IX. Case Studies: Comparator Institutions

IXa. The College of William and Mary

The College of William and Mary is a public university located in Williamsburg, Virginia and it has an undergraduate population of approximately 6,136 students. Their sustainability efforts spans across many disciplines. As a university they encourage their students to take environmentally friendly initiatives through research, committees, clubs, classes, etc. They have secured sustainability funding through various grants and committees to support their students in green initiatives. Examples of current funds and programs that they have at the moment are the Green to Gold Fund, Eco-ambassador Program, The Green Fee, Sustainability Research Grants and Community Engagement Grants. They also have a research center focused on research which integrates many different disciplines within a sustainable framework. The Commonwealth Center for Energy and the Environment pursues cutting edge research in various aspects of renewable energy and climate change.

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[47] https://cdn.princetonreview.com/uploadedFiles/sitemap/home_page/green_guide/princetonreview_greenguide_2011.pdf

[48] http://www.pewglobal.org/2015/07/14/climate-change-seen-as-top-global-threat/

IXb. The University of Maryland, College Park

The University of Maryland, located in College Park, Maryland, is a state school similar in stature to the University of Delaware except with an undergraduate population of approximately 28,000, located on 1.953 square miles. Their current sustainability plan stipulates 100% renewable energy powered electricity by 2020. Currently 86% of their electricity is purchased from renewable energy resources.

They utilize solar panels and a combined heat and power (CHP) plant to decrease their reliance on fossil fuels. CHP plants are typically more energy efficient than a traditional boiler system. The University of Delaware's Climate Action Plan proposed a CHP system but engineering studies identified significant cost barriers. Since the completion of the Harker ISE Labs and affiliative upgrades to our steam and chilled water networks, there are new opportunities to study the potential for CHP on UD's campus.

As part of UMD College Park's 2020 Sustainability Plan, they intend to upgrade their CHP plant to increase its efficiency and decrease affiliated natural gas consumption. They not only purchase energy in more efficient ways but they are also reducing their total energy consumption. They have increased efficiency standards for existing buildings and new construction.

Their program works to increase awareness of sustainability efforts throughout campus by incorporating sustainability language and coursework into many aspects of student life at UMD. They embed sustainability in their version of First Year Seminar and encourage or require sustainability principles in their RSOs. They funnel money into climate change research in order to become a pioneer in sustainability findings and actions. UMD reports that these actions are appealing to much of their current faculty and new hires due to the relevance and magnitude of issues related to climate change.

IXc. University of North Carolina, Chapel Hill

University of North Carolina is located in Chapel Hill and is a public research university with an undergraduate population of 18,715 students. One of their most remarkable initiatives concerning renewable energy is their Renewable Energy Special Projects Committee. This is a student committee made up of undergraduate and graduate students with partial faculty oversight. They have a budget funded by a "Student Renewable Energy Fee" of four dollars per student per semester. The fee was passed through a referendum on a student elections ballot. This fund allows for this committee to plan both large and small projects on their campus which decrease energy consumption and reduce greenhouse gas emissions.

A few example of projects that have been completed in the past decade include:

- Electric vehicle charging stations
- Solar panels on the student union
- LED lighting
- Solar thermal collectors

Their ultimate goal is to reduce the greenhouse gas emissions of the entire town of Chapel Hill by 60% by 2050. This is the first ever joint agreement between a university and their local town to reduce their environmental impact. This university's strategy is a key example of how to reduce carbon emissions without the use of renewable energy credits. According to Keegan Dean, a co-chair of the Renewable Energy Special Projects Committee,

"Our mandate is in energy efficiency and renewables. Given the constraints of our campus - limited southerly exposure, historic values on campus, and the cheap energy we receive- our organization does not develop many substantial solar arrays. You will find on our site that RESP has done about 93 kW solar on campus in the past few years and have a couple MW set to come online next spring (funded by the university). Our university benefits from cheap energy produced by our cogeneration facility (natural gas and coal) so we pay roughly .059/kWh. This makes many renewable projects financially impractical on campus due to the extended payback period. This facility produces about 30% of the energy we use and the rest we get from the grid (primarily coal and gas in our region) at a reduced university rate."

Despite not using RECS their main function is still: "Primarily to reduce GHGs on campus. Primarily this is done through energy efficiency projects like lighting retrofits and HVAC upgrades, but we also work to implement sustainable energy strategies with early stage building planning."

However their biggest recommendation to start purchasing RECs, according to Keegan, is "use our returns to set up revolving funds to ensure long term campus sustainability. For instance: we are about to solidify a revolving fun to gradually replace all of our inefficient lab ULT freezers. Reducing the impact of such large energy sinks as labs is the fastest path to campus sustainability in my eyes. They also have the added benefit of exponentially increasing returns."

IXd. Georgetown University

Georgetown University has an undergraduate enrollment of 4,793 and sits on 104 acres of land. Since 2013 Georgetown as purchased Green-e certified RECs for 100% of its electrical power use. They also received recognition in 2013 for completing their "Solar Street" project, which installed panels on six university-owned townhouses near the campus's main entrance. "Solar Street" garnered attention from the White House, with Gary Guzy, Deputy Director and General Counsel for the White House Council on Environmental Quality speaking at the completion ceremony. Students on the "Solar Street" project also won the "Best Overall Video" award from the White House's Youth Sustainability Challenge. For this and other energy-related efforts, Georgetown was awarded "2013 Green Power Partner of the Year" by the US Environmental Protection Agency.

In 2017 they signed a power purchase agreement (PPA) with Origis Energy USA for an offsite solar power system in La Plata, MD. This 32.5MW solar installation will provide approximately 50% of campus electricity. Origins Energy will build, own and operates the solar installation, and Georgetown University will receive both the GHG gas reduction credits from the installation and long-term energy price stability. As part of the PPA, Origins Energy will also support undergraduate scholarships for students with demonstrated financial needs.

In 2017 Georgetown University also signed a PPA with Community Renewable Energy to build on-site renewable energy. The system will be built across six buildings on campus, and will be the largest of its kind in Washington DC. Community Renewable Energy will own and maintain the panels, and will retain the environmental attributes and incentives. Georgetown will receive long-term energy price stability. A portion of the revenue generated will go towards a community investment fund to support clean energy projects in low income areas of D.C. The White House recognized Georgetown for its local efforts.

IXe. The State University of New York, Buffalo

The State University of New York at Buffalo has an undergraduate enrollment of 20,411 students and sits on a property of 1,350 acres. They generate a significant portion of their campus electricity through on-site and off-site renewables, as well as purchasing RECs for the remaining portion of their electric portfolio. New York State law stipulates greenhouse gas reductions and renewable energy adoption[49], which SUNY Buffalo has leveraged to gain grant money and other financial support from their state government. They have received recognition from Governor Cuomo for their efforts.

SUNY Buffalo utilizes both wind and solar energy, with on-site solar installations, a 4.5MW wind installation off site. The Localizing Buffalo's Renewable Energy Future initiative aims to install an additional 100MW of renewable energy by 2020. All of their offsite renewable energy projects are sited within Buffalo NY as part of a larger economic revitalization effort. Their sustainability department manages the purchase and selling of RECs without a designated energy manager. SUNY Buffalo was ranked on the EPA's Top Thirty Power Users list in October of 2017.

X. Pricing Trends

Prices depend on many factors, such as the vintage year the RECs were generated, location of the facility, current trends in supply and demand, whether the REC is used for RPS compliance, and the type of power generated. Pricing in these markets is fluid and fluctuates on a daily basis.

Pricing trends in the REC market over the past few years have created an optimistic outlook for the future of purchasing. The increased large customer commitments to Renewable Energy has resulted in lower unbundled REC prices, and according to the National Renewable Energy Laboratory (NREL), that trend is projected to continue:

"The interest of large customers in unbundled RECs is one key driver behind sustained growth in unbundled REC sales. Large customers, including Universities, are continuing to make commitments to renewable energy and GHG reductions. As these companies start investigating renewable energy purchasing options, they often begin with an unbundled REC purchase, as the purchase has low transaction costs, does not require a long-term commitment, and is straightforward compared to an off-site PPA or participation in a green tariff." [50]

The continuation of low REC prices likely explains the increase in much of the unbundled RECs market from 2015 to 2016. Purchasers with a set budget for purchasing renewable energy can purchase more RECs at lower prices.

Currently the most cost competitive source options for RECs are Wind and Solar, or a mixture of the two. It is predicted that by 2030, wind and solar will be the cheapest forms of

[49] https://energyplan.ny.gov/

[50] https://www.nrel.gov/docs/fy18osti/70174.pdf

electricity production in most of the world. According to a 2017 report from the World Economic Forum, solar and wind is now either the same price or cheaper than new fossil fuel capacity in more than 30 countries.[51]

The U.S. wind industry is a major source of investment and economic development.[52] Economists and analysts foresee that the U.S. offshore wind market will show significant growth in the coming decade. According to an article published by the Yale School of Forestry & Environmental Studies[53] several key factors are driving the takeoff of U.S. offshore wind. These include, among other factors; sophisticated turbine technologies and economies of scale that are driving down costs, advances in construction to allow wind farms to be built farther offshore, and states across the Northeast and the mid-Atlantic actively pushing development of offshore wind projects. It's important to note that wind farms further off shore allow turbines to access optimal winds while also reducing aesthetic concerns from communities on shore.

This growth has already been demonstrated, and due to Delaware's coastal location, there is a possibility of offshore wind energy significantly impacting the state's future economy. University of Delaware Senior Researcher Bonnie Ram has been studying offshore wind energy since 2001. She argues that advancements of wind turbines provides the state of Delaware with an opportunity to benefit economically. "It's a very competitive energy source and we see the cost coming down significantly for offshore wind."[54]

Economically, due to the University of Delaware's experience and voice in the wind energy industry, as well as projected growth nationally and locally in Delaware, an investment in wind energy would be a logical decision. The University of Delaware is renowned for the Wind Turbine installed in 2010 at the Hugh R. Sharp Campus in Lewes. It is a unique attribute to the University that has brought tremendous research opportunities and attention to the College of Earth, Ocean and Environment. As a result of this, the University connections and experience in advancing offshore wind through policy analysis, research, public testimony and industrial partnerships.

While purchasing RECs through local wind development would provide the greatest long-term economic benefits, it is not a short term solution for carbon reduction efforts. Consideration should be given to the long-term goals of the University of Delaware as a driver of sustainable economic development, "green" manufacturing jobs, and economic investment throughout the Delmarva Peninsula.

XI. Price Quotes

Due to the volatile nature of REC prices, numerous sources were contacted in attempt to attain current prices. A useful contact was a Senior Business Development Manager at the company 3Degrees. Having been named Top REC trader in the US by Environmental Finance magazine six times[55], and continually working with large companies and universities nationwide,

[51] http://www3.weforum.org/docs/WEF_Renewable_Infrastructure_Investment_Handbook.pdf
[52] https://www.awea.org/gencontentv2.aspx?ItemNumber=9852
[53] http://e360.yale.edu/features/after-an-uncertain-start-u-s-offshore-wind-is-powering-up
[54] http://www.wboc.com/story/37002790/delaware-considers-possibly-investing-in-offshore-wind-turbines
[55] https://www.environmental-finance.com/

3Degrees was a reputable and reliable resource. We reached out to obtain a price quote and to discover financial variances that exist between different sources.

We attempted to obtain quotes for 100% of our total greenhouse gas emissions, but 3Degrees advised us that this was very difficult to calculate because "RECs are sold on a per megawatt hour basis". 3Degrees was not willing to make such estimates on our behalf on a pro bono basis, and we are grateful for the time and effort they did contribute to this report.

To efficiently demonstrate pricing options, we created different volume tiers based on reduction options. The University's total electric usage for the 2016-2017 fiscal year was 152,387.116 MWh. We obtained price quotes for the scenarios of the University matching either 20%, 50%, or 100% of the total annual electricity with Renewable Energy Certificates. Wind sources were identified as the most cost effective, so they are represented below. The current Green-E wind REC quotes for the volume tiers (using 152,387 MWh as 100%) are demonstrated in the tables below:

XIa. REC's from mixed Wind Projects

% of Electricity Consumption	Representing ____ MWh	Cost of RECs (1 REC = 1 MWh)	ESTIMATED Cost per Year
100%	152,387	$0.68	$103,623.16
50%	76,194	$0.70	$53,335.45
20%	30,477	$0.76	$23,162.82

The above prices would all be from non-emitting US wind projects, but may come from a mix of wind projects rather than one. The specific project(s) would be listed with the REC attestation at the end of the Green-E reporting year (the April following the year covered by the RECs).

RECs would be purchased annually in addition to existing electricity costs, and the prices could fluctuate significantly year over year. The prices quoted above do NOT reflect administration, brokerage, or other costs associated with procuring and managing the RECs.

Electricity costs represented 42.6% of our campus-wide greenhouse gas emissions in 2017, and 44.4% of our total emissions from 2007-2017. In order to reduce 100% of our greenhouse gas emissions, we extrapolated the prices above to generate the following guestimates:

% of TOTAL Emissions	Representing ____ MT CO2e	Cost of RECs (1 REC = 1 MWh = 0.39 MT CO2e)[56]	ESTIMATED Cost per Year
100%	139,257.00[57]	$1.0948*	$152,458.56
50%	69,628.50[48]	$1.0948*	$76,229.28
20%	29,841.40[58]	$1.0948*	$32,670.36

*Very conservative, very estimated ballpark figure, **for illustration purposes only**.

XIb. RECs from a specific Wind Project

% of Electricity Consumption	Representing ____ MWh	Cost of RECs (1 REC = 1 MWh)	ESTIMATED Cost per Year
100%	152,387	$0.75	$114,290.25
50%	76,194	$0.77	$58,669.00
20%	30,477	$0.83	$25,296.24

The prices quoted above do NOT reflect administration, brokerage, or other costs associated with procuring and managing the RECs, and the RECs would be purchased annually in addition to existing electricity costs. There are advantages in procuring unbundled RECs from one specific project, but, as shown above, the price tends to be higher.

Advantages include:

- Ability to lock in long-term price stability in the procurement contract
- Local economic development associated with the specific project, which the purchaser is supporting and can claim
- Ease of engaging in research opportunities – impacts of the project are localized
- Ease of accounting and reporting the environmental benefits of the RECs
- Tangibility and authenticity in communications efforts
- Community engagement opportunities

For a price comparison from a variety of renewable sources, we collected current indicative prices for 152,387 MWh of Green-E certified RECs for reporting year 2018:

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[56] One megawatt hour of electricity in Delaware emits 0.39MT of CO2e. That means a factor of 0.61 must be added to the "cost" of a REC to equate to 1 MT of CO2e from other sources. Here I added that factor to $0.68 under the assumption that a much larger quantity of RECs purchased could drive down the cost. But we do not know how much lower the cost could get, so consider the figures above a **conservative ballpark estimate only.**

[57] Based on 2017 numbers, assuming no significant change in CO2 emissions in 2018

[58] 20% reduction goal from the 2007 baseline. In 2007-2008 we emitted 149,207 MT CO2e

XIc. Green-E Certified RECs from Any Renewable Project

% of Electricity Consumption	Representing ____ MWh	Cost of RECs (1 REC = 1 MWh)	ESTIMATED Cost
100%	152,387	$0.63	~$96,003.81

Buying RECs on the open market would mean annual costs would vary, sometimes significantly. RECs projects could include biomass, wind, solar, and/or hydro. During the course of this analysis, prices fluctuated daily for quantities at the 100% electric consumption volume. This variability makes it difficult to extrapolate pricing at 50% and 20% volume respectively because RECs are coming from a wide array of renewable projects and supply and demand impact prices for each project slightly differently. It's also important to note that the quantity of RECs procured impacts prices, though buying "in bulk" does not necessarily secure a lower price. In short, these comparisons are not and cannot be considered "apples to apples".

We similarly found it very difficult, if not impossible, to conduct a price comparison for RECs at the 100%, 50% and 20% greenhouse gas emissions scenarios. We chose not to estimate cost of RECs at 100% of greenhouse gas emissions because the analysis would be little more than "an estimate of an estimate of an estimate". Even though we tried to convert our total greenhouse gas emissions into "MWh" RECs, we found the daily price volatility to be overwhelming, just as 3Degrees had warned us. Instead, we present conservative and realistic prices to the Faculty Senate for consideration, even though these prices do not reflect the desired 100% greenhouse gas emissions as requested.

Procuring RECs from the open market in this manner presents both risks and opportunities. Buying in bulk does not necessarily present an advantage in this procurement strategy, and managing a RECs portfolio would be very complicated and time consuming. For example, very affordable RECs are often available on the marketplace, but they expire within months, weeks or days of their purchase. Maintaining a full portfolio of such products would require daily attention. Whereas a purchasing agreement for RECs directly from a specific project would greatly simplify portfolio management. The RECs supplier would sign an agreement guaranteeing anticipated quantity, and UD would be invoiced at set intervals based on electric consumption. Hiring a broker would be easier to manage still because they would handle the details and UD would pay for their services; service fees are not included in any of the cost analyses above.

XII. RECs Recommendations:

The following recommendations were agreed upon by the team of student interns who authors a very large portion of this report:

1. In order to meet the 20% reduction in GHG emissions by 2020 set by the University, the school should buy RECs to reach the goal.
    a. After 2020, more RECs can be bought for future greenhouse emission reductions.

    b. The University can continue to reduce GHG emissions by a 10% every 5 years till they reach 100%.
2. By purchasing green power, the university is helping the environment and meeting their own goals, such as financial benefits and public relations benefits.
    a. We encourage the university to sign a public commitment to the issue as other institutions have done or the creation of a fund office to lock in efforts to meet the university's goals.
3. The EPA recommends buying RECs that are certified and verified. This ensures that the green power was generated by a quality renewable resource, and what was bought was actually produced.[59]
4. Age Recommendation: The campus should purchase RECs that are considered "new" - began operation in 1997 or later.
5. Location Recommendation: REC purchases should be for products located in North America and more specifically in the U.S. in order to take advantage of using regional emissions rates for where the REC was generated. The most cost effective location is in the Midwest i.e. Texas, Kansas etc. However a possible long term goal should be purchasing RECs locally.
    a. Despite it not being the cheapest option at the moment there is projected growth and other economic benefits.
6. To amplify the impact of their purchases in the market the campus should consider purchasing future RECs for long-term impact and buy from new projects or recently completed renewable installations.
    a. This will help better guarantee the investment is delivering the expansion of new technologies and renewable energy deployment.
7. Simultaneously increasing other sustainability efforts which focus on students, faculty, and the university as a whole. Possible options for University of Delaware range from:
    a. Big financial endeavors like the construction of a CHP plant which would significantly increase the conservation of energy and the efficiency of our electricity use
    b. Intermediate practices such as replacing all light fixtures with LED bulbs and making sure all new construction follows Green Building guidelines are important
    c. Smaller projects which require zero financial strain such as increased sustainability focus across all disciplines, thereby creating a more aware student body and faculty who will make the effort to conserve water and energy at an individual level
8. Seek a fixed-price contract or a long-term contract. Renewable energy is often available at a fixed price without any fuel-cost adjustments.
9. Take advantage of all opportunities to promote the purchase of the renewable energy credits both internally throughout the university and externally.
    a. University can claim to be at the forefront of promoting renewable energy.
    b. This is something that can be highlighted to stakeholders to promote to recruits, alumni, faculty and staff.
10. We recommended a new goal of 50% of all electricity fueled by RECs by 2025:

[59] Guide to Purchasing Green Power. Mar. 2010, www.epa.gov/sites/production/files/2016-01/documents/purchasing_guide_for_web.pdf

% of TOTAL Emissions[60]	Representing ____ MT CO2e	Cost of RECs (1 REC = 1 MWh = 0.39 MT CO2e)	ESTIMATED Cost per Year
50%	69,628.50	$1.0948	$76,229.28

XIIa. SCENARIOS: Scale of Aligning with Competitors' Goals

1. Maryland (UMD) = 50% reduction of carbon emissions (from 2005 levels) by 2020 and 60% by 2025, then finally complete 100% reduction by 2050.[61]
   - Their plan was aggressive, for us to keep pace we would need to reduce 50% of our emissions (from our 2007 baseline) by 2022.

2. University of North Carolina (UNC) = Achieve "Climate Neutrality" or a 100% reduction in Greenhouse Gas by 2050 (from 2005 levels).[62]
   - If UD followed the same plan, we would need 100% reduction by 2052 (from our 2007 baseline).

3. University of Virginia (UVA) = 25% reduction of greenhouse gas emission by 2025 (from a 2011 baseline).[63]
   - If UD followed the same plan, we would need 25% reduction (from our 2007 baseline) by 2021.

XIII. Carbon Equivalent Formulas

1 gallon gas = 19.6 lbs emissions = 0.008887 Metric Tons[64]
(8,887 grams of CO2/gallon of gasoline = 8.887 × 10-3 metric tons CO2/gallon of gasoline)
UD used 3,770 gallons of gas 2017; 73,892 lbs emission from gasoline
33.77 kWh in 1 gallon of gas; UD used 3,770 gallons in 2017 = 127,312.9 kWh = 127.312 MWh = it would take 127 RECs to mitigate gasoline emissions
1 mcf natural gas = 121 lbs emissions = 0.055 Metric Tons
(0.0053 metric tons CO2-/therm x 10.37 therms/Mcf = 0.0550 metric tons CO2/Mcf)
UD used 58,063.434mcf in 2017 = 7,025,675.51 lbs emissions from natural gas

[60] See price analysis above for details.
[61] University of Maryland Climate Action Plan 2.0, https://sustainability.umd.edu/progress/climate-action-plan-20
[62] University, North Carolina. "The University of North Carolina at Chapel Hill Climate Action Plan Update." 2010-2011. https://sustainability.unc.edu/files/2015/11/Climate-Action-Plan-Update-2010.pdf
[63] University of Virginia Greenhouse Gas Action Plan. Sustainability UVA. April 2017. https://sustainability.virginia.edu/docs/University%20of%20Virginia%20Greenhouse%20Gas%20Action%20Plan_April%202017.pdf
[64] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

1 CuFt (mcf =1000CuFt) = 0.29kWh; UD used 58,063,434 CuFt; 16,838,395.9kWh = 16,838.396MWh = 16,839 RECs

1 kwh = 1.6 lbs emissions = 0.000744 Metric Tons

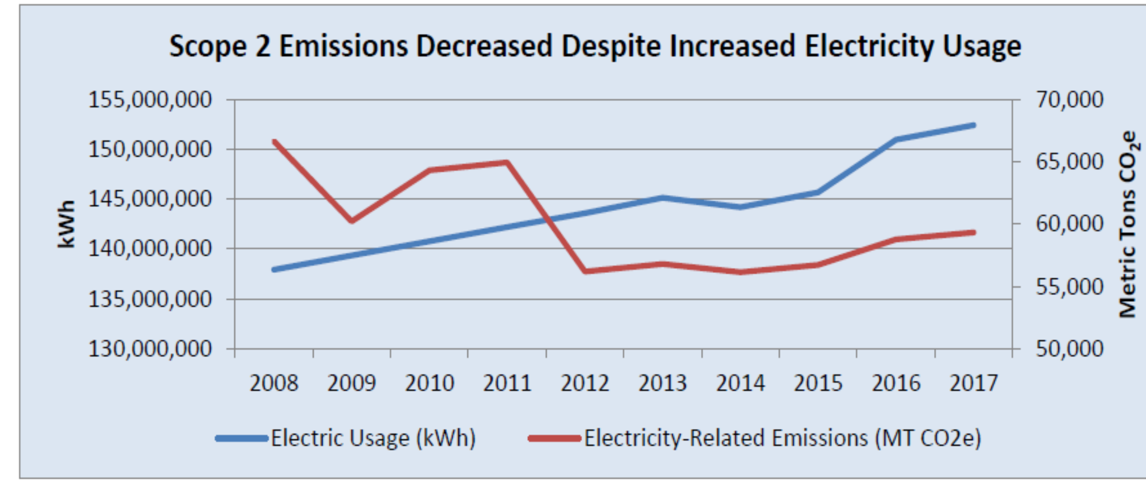
(1,640.7 lbs CO_2/MWh × (4.536 × 10-4 metric tons/lb) × 0.001 MWh/kWh = 7.44 × 10-4 metric tons CO_2/kWh

(*AVERT, U.S. national weighted average CO2 marginal emission rate, year 2016 data*)

The University of Delaware Today

Location	Capacity (Kilowatts)	Installed & Online	Est. Generation (04/17 – 03/18) Kilowatt hours	Est. Lifetime* Generation Kilowatt hours	Lifetime* tons CO2e offset
Early Learning Center, Solar	303.0 KW	2010	298,005 KWh	2,419,047 KWh	2,443.24
Clayton Hall, Solar	160.4 KW	2011	145,112 KWh	1,251,851 KWh	1,264.37
Field House, Solar	386.1 KW	2011	463,550 KWh	3,593,159 KWh	3,629.09
Lewes, Wind Turbine	2,000.0 KW	2010	5,606,400 KWh	43,449,600 KWh	30,597.00
TOTAL	**2,849.50 KW**	**-**	**6,513,067.00 KWh***	**50,713,657 KWh****	**37,933.70***

* Lifetime figures are from date of installation to 03/30/2018
** Estimate only



Since 2008 there has been:
- 9% increase in electricity consumption,
- 16% increase in student enrollment (FTE)
- 21% increase in building sq. ft.

2008

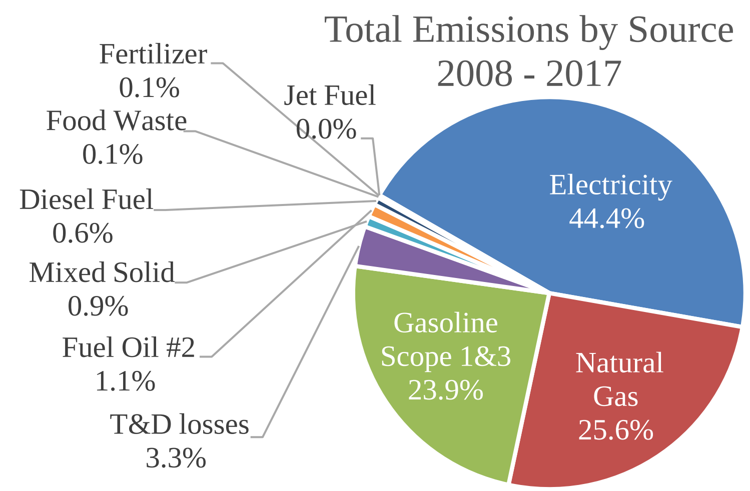
149,207 tons CO2e emitted

Climate Action Planning begun

FY 2016-2017

139,257 tons CO2e emitted

6.7% reduction

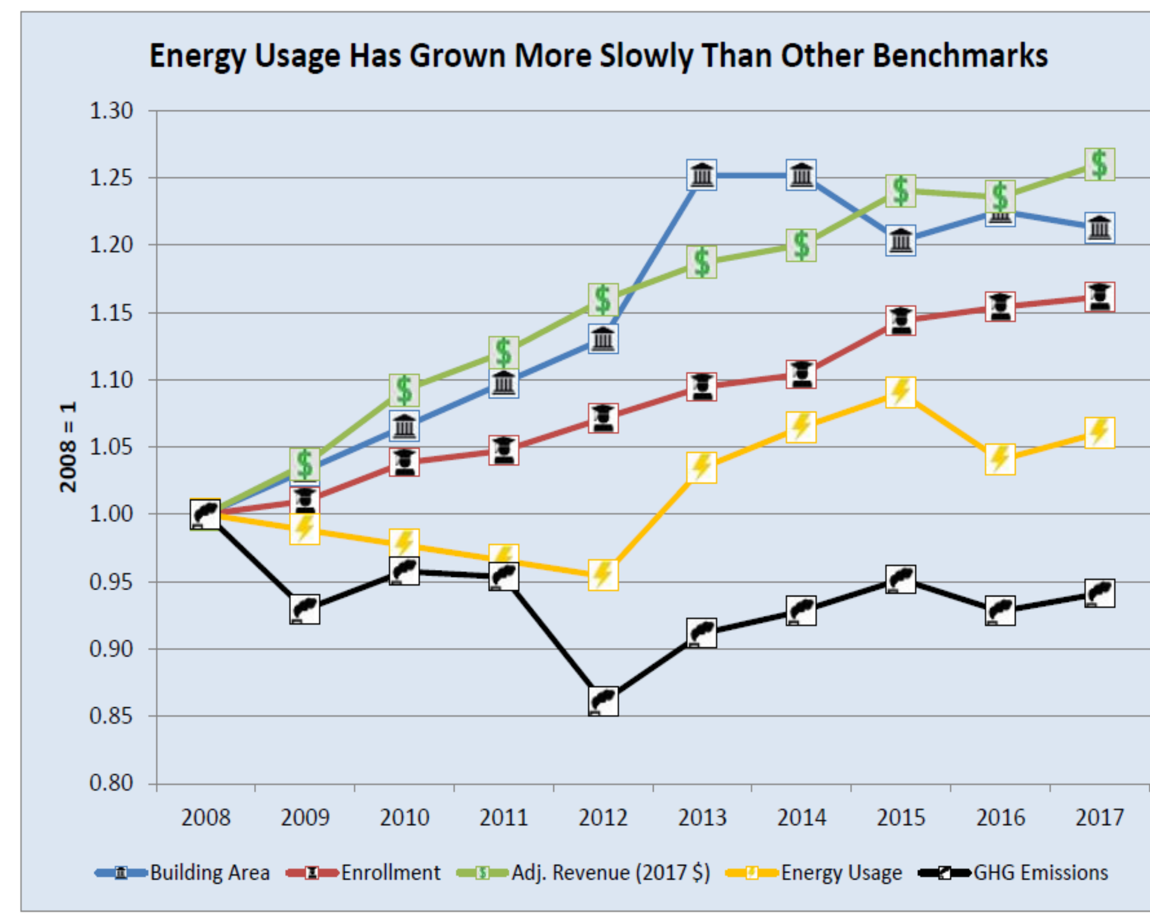


2020 Goal

Only emit 119,366 tons CO2e

Proposed Goal

Offset or reduce emissions to 0% by Jan 1, 2020



Purchasing RECs (ESTIMATES ONLY)

Option			Specific Wind Project Electric Only	Mixed Wind Electric Only	Mixed Wind All Emissions
Option 1: Meet 20% by 2020 goal			~$25k / Year	~$23K / Year	~$32k / Year
Option 2: Meet 50% by 2020 goal with strategy to reach 100% in future	Compete with competitor institutions		~$58k / Year	~$53k / Year	~$76k / Year
Option 3: Meet 100% goal by 2020	Demonstrate leadership in climate change beyond research excellence	Opportunities for investment in DE green economy	~$114k / Year	~$103k / Year	~$152k / Year

GOALS

To determine whether it is economically practicable… [to] no later than January 1, 2020, power its campuses and installations with 100% renewable energy…

… Via On- or Off-campus direct renewable energy or PPA agreements for renewables with associated RECs

… Or via Purchase of wind and/or solar RECs

The estimates above calculate "electric only" because RECs are purchased in MWh increments.

Pro bono brokers generated estimates based on MWh consumption, **NOT** the MWH-equivalence of our CO2 portfolio.

Those services are not available for free. The "All Emissions" calculations above are extrapolations only.