University of Maryland sustainability council

Meeting Summary
April 8, 2021

Council Members Present (via Zoom):

Carlo Colella, Vice President for Administration (Chair)
Mary Hummel, Assistant Vice President, Student Affairs (in for Patty Perillo, Vice President, Student Affairs)
David Cronrath, Associate Provost
Maureen Kotlas, Executive Director, Department of Environmental Safety, Sustainability & Risk
Scott Lupin, Assoc Dir., Environmental Safety, Sustainability & Risk, & Dir., Office of Sustainability
Susan Corry, Manager, Engineering & Energy, Facilities Management
Bryan Quinn, Director of Technical Operation, Department of Electrical & Computer Engineering
Eric Wachsman, Prof., Materials Science and Engineering and Director, MD Energy Innovation Institute
Giovanni Baiocchi, Associate Professor, Geographical Sciences
Jana VanderGoot, Associate Professor, Architecture
Nina Jeffries, Undergraduate Student Representative
Nicole Barbour, Graduate Student Representative

Guests Present:

Bob Reuning, Assistant Vice President for Facilities, FM
Kristy Long, Executive Director, Operations & Maintenance, FM
Julie Kromkowski, Senior Communications Manager, Division of Administration
Katie Grimes, Communications Director, FM

Meeting start time: 10:00am

<u>Meeting Highlights</u>

NextGen

Carlo Colella gave a presentation (see appendix) on the NextGen Program, which is a major initiative to renew the university's district energy system. Discussion followed the presentation.

- Jana VanderGoot – Are international groups involved?
  - Carlo Colella – Yes, each group that was pre-selected for the procurement includes an international partner or international project experience.
- Eric Wachsman – Have you considered a distributed energy approach that is less dependent on a central energy plant?
  - Carlo Colella – The technical team considered distributed solutions and respondents to the request for proposals are asked to submit Alternative Technical Proposals, which could include innovative distributed solutions.
- Nina Jeffries – Are the cost of carbon offsets included in NextGen cost analysis?
  - Carlo Colella – Yes, each option analyzed included offsets to achieve carbon neutrality.

- Nina Jeffries – Can students be involved in the committee that will review proposals and select a winner?
    - Carlo Colella – We are considering that request and want more students to be involved, so we are looking to communicate with students in larger settings including the SGA. More to come on that.

Fee Proposal

Nina Jeffries and Mark Stewart from the Office of Sustainability provided an update on a proposal to increase the Student Sustainability Fee. The Sustainability Fund Review Committee, which also serves as the Fee Review Committee for the Student Sustainability Fee, recommended (see appendix) increasing the undergraduate fee from $6 to $15 for full-time students and from $3 to $8 for part-time students. The committee also recommended that the graduate students participate in the fee program. The SGA, GSG, and RHA will discuss this fee proposal during their general body meetings in April. Nina and Mark will report back to the Sustainability Council in May with the results of those discussions. Several Council members noted that is remarkable that students are in favor of increasing this fee when students so often advocate for decreasing student fees. This speaks to strong support for sustainability among students and a well-managed Sustainability Fund program.

Methane Emissions

Giovanni Baiocchi gave a presentation (see appendix) on methane emissions from natural gas production and transportation, which are not currently included in UMD's greenhouse gas inventory. UMD only accounts for emissions from the combustion of natural gas and does not account for associated up-stream scope 3 emissions from gas. The Office of Sustainability will learn what Second Nature, the organization that runs the Carbon Commitment, is doing to incorporate more scope 3 accounting methodology in its guidance for colleges and universities.

Open Forum

- Susan Corry shared that UMD's energy consumption decreased around 15% from 2019 to 2020 due largely to COVID-19 influences. Natural gas consumption was relatively flat, steam consumption was down by around 10%, and electricity consumption was down by around 20%.

Adjourn 11:50 pm

The NextGen Energy Program

The NextGen Energy Program (NextGen) is a plan to

Replace, Renew & Modernize

the University of Maryland, College Park's aging energy system.

55,000+

Students, Faculty & Staff

250+

Campus Buildings

The University of Maryland is a small city unto itself.

NextGen will ensure that our College Park campus has **reliable, efficient and affordable energy services** for decades to come.

NextGen is a

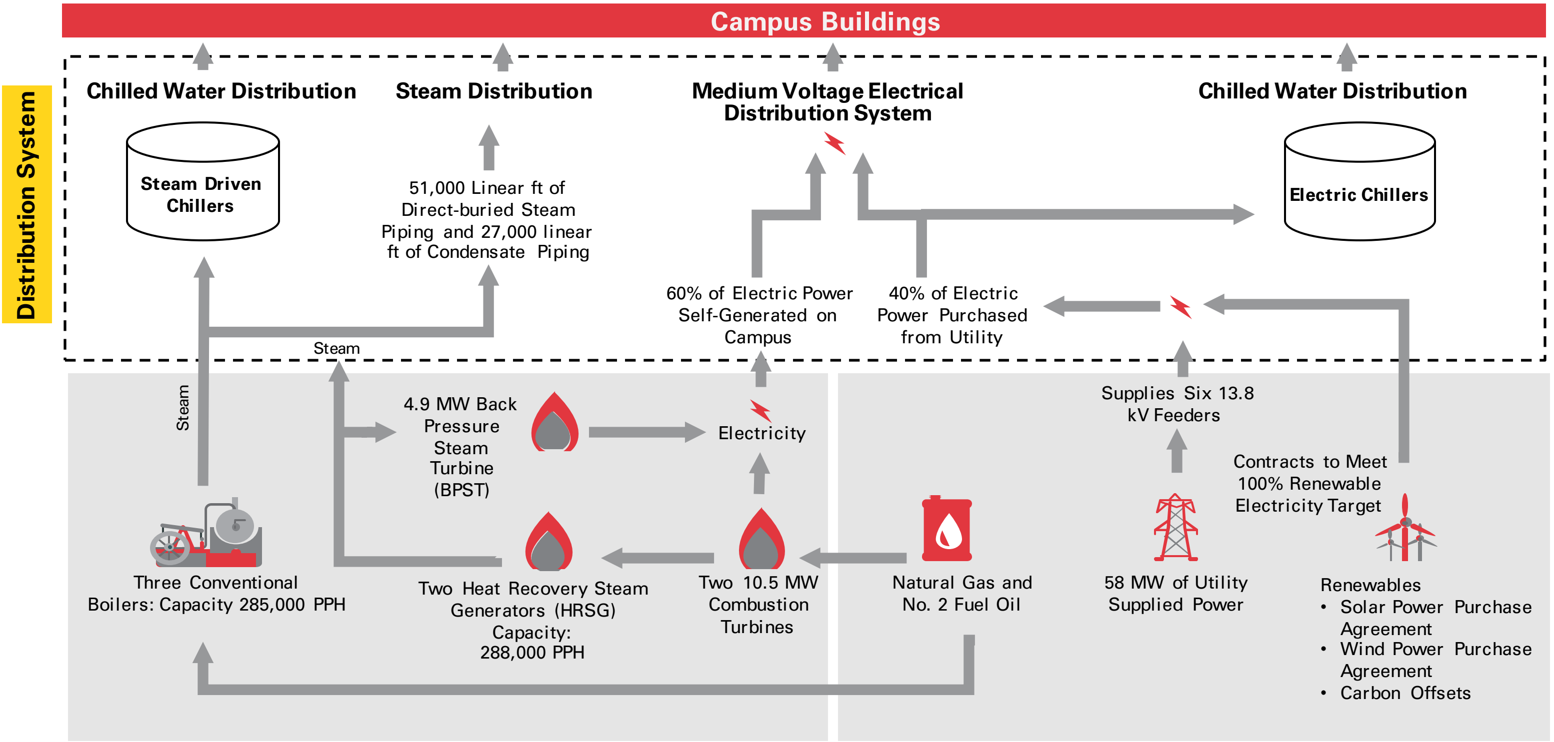
Carbon Neutral Energy Solution

that will advance the university's Climate Action Plan.

The NextGen Energy Program will serve as a platform to meet our critical UMD-wide sustainability goals for energy production and usage.

- **Improved operational efficiency and water recycling and decreased energy loss**
- **Flexibility to incorporate low- and zero-emission fuel options in the future**
- **Integration of energy storage or other microgrid compatible technologies**
- **Energy conservation measures through enhanced controls and monitoring systems**

UMD Energy System Overview



Central Energy Plant

Purchased Commodities

Production Capacity

- Electricity: 26 MW
- Steam: 573,000 PPH
- Chilled Water: 32,000 T

Peak Load (Five-year average)

- Electricity:~47 MW
- Steam: ~260,000 PPH
- Chilled Water(estimated): ~18,000 T

Energy System History (1997-2019)

June 1997
RFP issued for capital improvement and O&M

Feb. 1999
College Park Energy LLC (CPE) selected for program award

Apr. 1999
Approval secured from Board of Regents and Board of Public Works

Sept. 1999
O&M responsibilities assumed by CPE

Aug. 2019
1999 program contract expired

Sept. 2019
Interim Energy Program established

1999 UMD Energy Program	• UMD leased its existing steam and electric systems to the Maryland Economic Development Corporation ("MEDCO") to achieve the objective of financing capital improvements with tax-exempt, off-balance sheet debt • MEDCO entered into management and construction agreements with CPE and UMD entered into energy services agreement with MEDCO

2019 Interim Energy Program	• MEDCO tax-exempt bonds retired in July 2019 • 1999 program contract expired on August 31, 2019 • UMD, MEDCO and CPE negotiated agreements to preserve the status quo during NextGen's development and procurement phases • These agreements can be terminated for convenience on six months' written notice and payment of documented termination expenses up to $1 million • The interim program will operate until 2022, at which point NextGen will be implemented

Successes of the 1999 Program

The 1999 UMD Energy Program demonstrated the power of using a private-public partnership for higher education campus energy programs

Reliably delivered long term steam, electricity and chilled water to campus

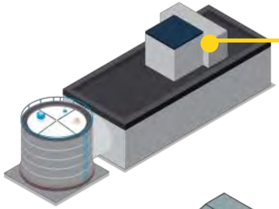
Performance requirements provided effective incentives and accountability measures

Trigeneration technology achieved environmental benefits and operational efficiencies

Onsite electric generation reduced costs and created financial benefits

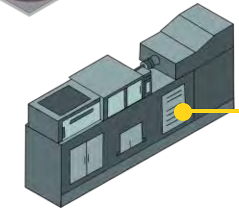
Our Aging Energy System

While UMD’s energy system can satisfy current load requirements, signs of an aging system are beginning to surface, informing our need for increased reliability



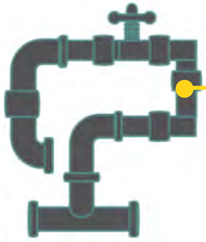
Central Energy Plant

Combustion turbines have reliability issues and frequently need replacement. With standard wait times to source spare parts lasting as long as 24 weeks, the plant’s reliability has significantly deteriorated.



Chilled Water System

Due to age and the type of refrigerant used, it is recommended the chillers be replaced in the near future.



Steam Distribution

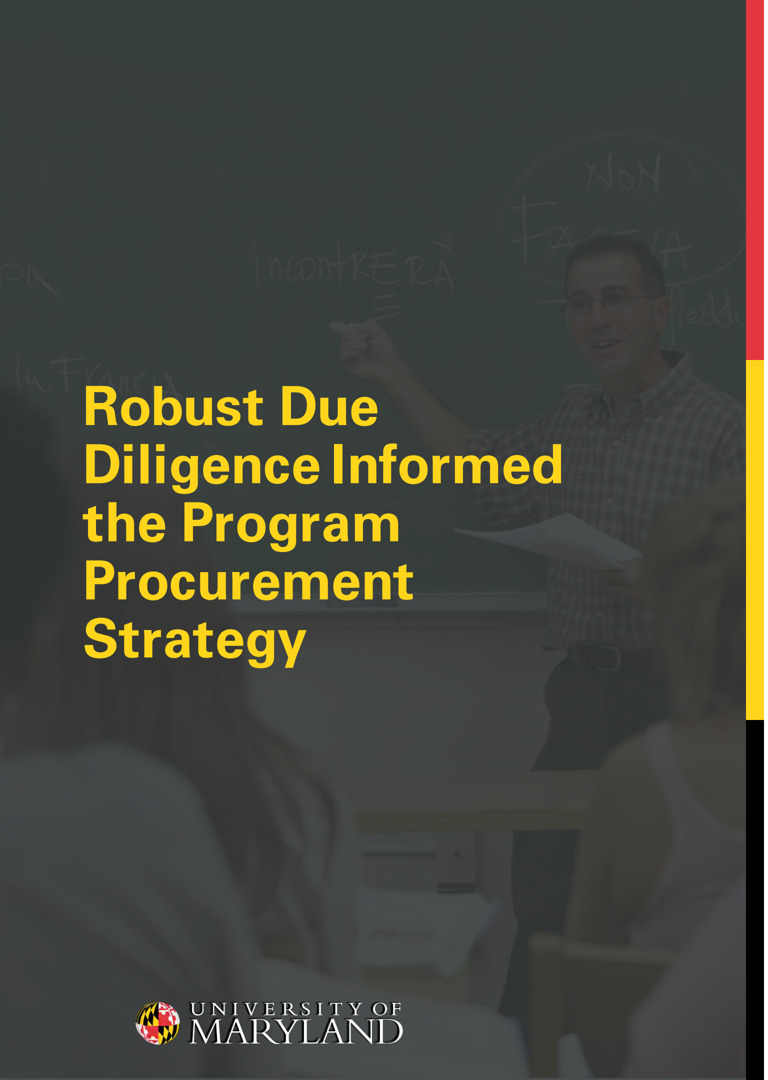
90% of manholes require repairs or upgrades, and 60% of the distribution piping is over 40 years old.

Securing A Reliable Future

While the 1999 UMD Energy Program pioneered university energy solutions, we identified 3 ways NextGen can advance the P3 model

1. Enhance access to and upgrade real time monitoring of metrics and data to optimize system performance
2. Use commercially-proven technology but constantly monitor industry for sustainable alternatives
3. Build a shared culture of continuing system improvements and innovation with selected partner

UNIVERSITY OF MARYLAND



Robust Due Diligence Informed the Program Procurement Strategy

Baseline Assessment: Conducted a baseline study to establish UMD's historical cost of services and energy consumption

Market Sounding: Met with 10 interested parties (operators and investors) to collect feedback on alternative technology and project delivery options as well as various procurement approaches

Service Delivery Options: Evaluated the pros and cons and financial implications of a range of service delivery options that would meet the campus' utilities needs. Options included (i) maintenance only, (ii) traditional gas fired boilers, (iii) cogen upgrade, (iv) geothermal (electrification) and (v) biomass.

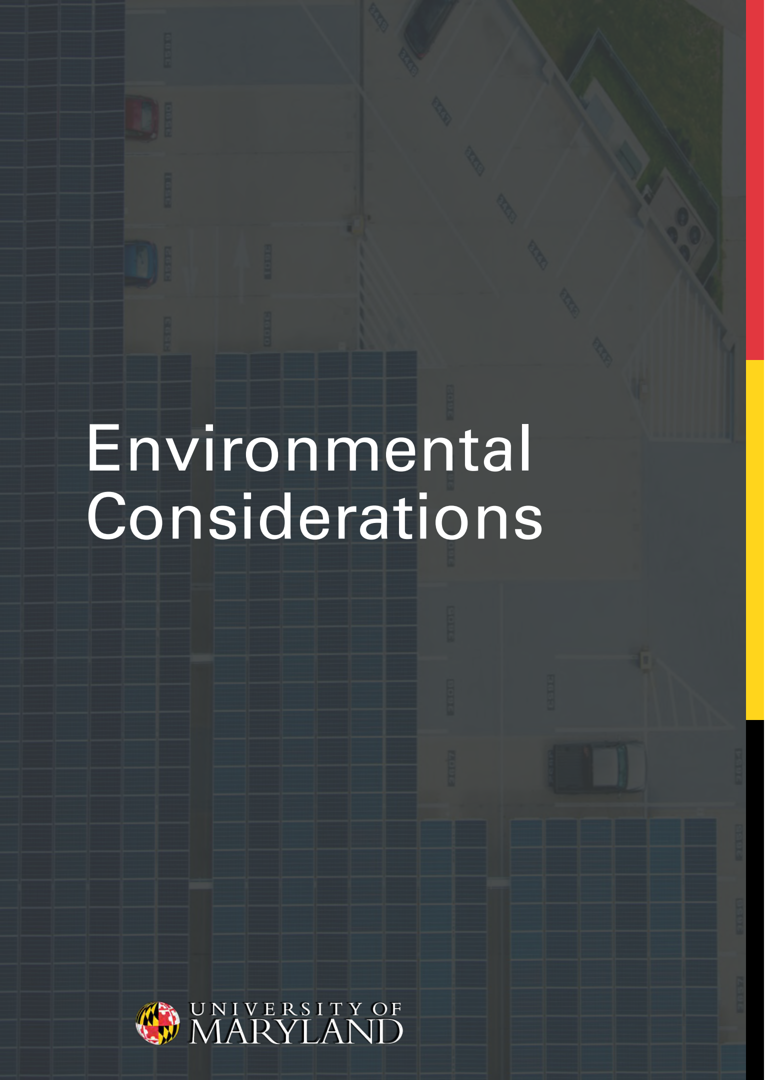
D/E

Commercial Delivery Options: Evaluated benefits and risks associated with alternative commercial structures. Options included (i) 501(c)(3) not-for-profit and (ii) concession.

UNIVERSITY OF MARYLAND

Finding the Right Energy System Option to Achieve Our Strategic Goals

UMD is evaluating a range of options to provide the university with efficient energy. **Our three key considerations** when selecting an energy system are its ability to **support the university's environmental goals**, **limit campus disruption** and **serve as a prudent use of financial resources**.



Environmental Considerations

- ✓ Supports carbon reduction efforts and aligns with goals set out in UMD’s Climate Action Plan
- ✓ Offers low-to-moderate complexity for environmental permitting
- ✓ Allows flexibility to incorporate efficiency programs, which will decrease the amount of energy required to power, cool and heat campus

UNIVERSITY OF MARYLAND

Campus Considerations

- ✓ Provides flexibility to meet campus expansion needs
- ✓ Limits campus disruption by minimizing construction and operating impact
- ✓ Offers more feasible implementation process in comparison to other potential options
- ✓ Improves campus resiliency by being able to adapt to changing conditions and recover rapidly from service disruptions

UNIVERSITY OF MARYLAND

Financial Considerations

- ✓ Minimizes overall lifecycle cost
- ✓ Energy system options compared based on estimated cost to build each project using today's dollar value

Evaluation of Potential Energy System Options

Considerations	**Status Quo** No substantial capital investment in equipment	**Boilers** Replace current system with traditional gas fired boilers	**Cogeneration** Replace current system with new cogeneration system to provide heat, power and cooling	**Geothermal (Electrification)** Implement geothermal district energy loop to heat and cool campus	**Biomass** Burning a feedstock such as woodchips, supplemented by a natural gas fired boiler
Supports Carbon Reduction Efforts	▲ Yellow	▲ Green	▲ Green	▲ Green	▲ Green
Moderate Complexity for Environmental Permitting	▲ Yellow	▲ Yellow	▲ Yellow	▲ Yellow	▼ Red
Provides Flexibility for Assumed Near-term Energy Efficiency Programs	▲ Yellow	▲ Green	▲ Green	▲ Yellow	▲ Yellow
Provides Flexibility for Extensive Campus Vertical Buildout	▲ Green	▲ Green	▲ Green	▲ Yellow	▲ Yellow
Limited Campus Disruption	▲ Yellow	▲ Yellow	▲ Yellow	▼ Red	▼ Red
Feasibility	▲ Yellow	▲ Green	▲ Yellow	▼ Red	▼ Red
Improves Campus Resiliency	▼ Red	▲ Yellow	▲ Green	▼ Red	▲ Yellow
Upfront Capital Investment	▲ Green	▲ Green	▲ Yellow	▼ Red	▼ Red
Ongoing Lifecycle Costs	▼ Red	▼ Red	▲ Green	▼ Red	▼ Red

UNIVERSITY OF MARYLAND

▲ Green = Strong alignment with goals

▲ Yellow = Medium alignment with goals

▼ Red = Low alignment with goals

Estimated Cost Comparison of Potential Energy System Options

UMD is committed to being a responsible steward of our financial resources, facilities and infrastructure and took into careful consideration the long term financial implications each energy option presented.

Relative Financial Impact	Status Quo	Boilers	Cogeneration	Geothermal (Electrification)	Biomass
Capital Recovery – Cost to finance the purchase	$	$	$	$$	$
Operations, General and Administrative Costs – UMD staffing costs, current P3 contract obligations, maintenance, other	$	$	$	$	$
Purchased Electricity – Cost of campus electricity bought from the grid, given what is produced on campus or not	$$	$$$	$	$$$	$$
Natural Gas – Cost of utility to provide natural gas to the plant	$	$	$	$	$
Water – Cost of water used in the heating system	$	$	$	$	$
Biomass Feedstock – Cost of biomass woodchips based on size of system and anticipated demand	--	--	--	--	$
Environmental Offsets – Cost of offsetting anticipated carbon emissions from burning fossil fuels from stationary combustion	$	$	$	$	$
Total Cost (Net Present Value)	$$	$$	$$	$$$	$$

UNIVERSITY OF MARYLAND

A New Vision for Our Energy System

Designed to be **adaptable**, the NextGen Energy Program will allow the University of Maryland to incorporate the **high-efficiency technologies of today**, while providing **flexibility to make regular upgrades** and utilize the technologies of tomorrow.

Three Ways NextGen Will Improve Our Energy System

1

Update the distribution system to make heating and cooling campus buildings more efficient

2

Implement measures to increase efficiency and resiliency based on available technology, cost and emissions considerations

3

Make modifications to incorporate new, renewable energy sources and technologies

The final scope and approach of the NextGen Energy Program will be determined based on an evaluation of proposals from bidders that best align with the university's goals.

UNIVERSITY OF MARYLAND

Getting To NextGen: A Roadmap

Apr. 2018 – Apr. 2019
Service Delivery Options Analysis

Discussions with stakeholders (e.g., FM, E&E, SUS, CP, USM / MEDCO, AG, members of UMD student body, etc.)

Sustainability Council Briefing

UMD Executive Steering Committee briefing

May – Oct. 2019
Commercial Model Options Analysis

Market sounding meetings with industry participants

Continued discussions with university stakeholders and student leaders

UMD Executive Steering Committee briefing

Oct. – Dec. 2019
USM P3 Authorization

UMD Executive Steering Committee briefing

Admin Council briefing

USM Board of Regents Staff Briefing

Presentation to Board of Regents

Jan. – Apr. 2020
Public Works Authorization

Legislative briefings to the Budget Committee Chairs

Pre-solicitation report submitted to the State

Briefings for Comptroller, the State Treasurer and other Maryland officials

Presentation to Board of Public Works staff

Formal Board of Public Works presentation

Approval from the State of Maryland Board of Public Works

Apr. – Sept. 2020
RFQ

Presentation to UMD Facilities Management and the Sustainability Office

Draft RFQ sent to UMD's Assistant General Counsel and Maryland's Assistant Attorney General for comments

Pre-submission conference with interested Proposers

UMD / USM Technical & SOQ Financial Evaluation Committee

UMD Executive Steering Committee briefing

Shortlist qualified proposers

Getting To NextGen: A Roadmap

2021
RFP

Competitive procurement process with shortlisted proposers

Winter 2022
Proposer Selection

Selection of preferred partner

Negotiating period

Spring 2022
Approval from Board of Public Works

Submit proposed transaction terms to Board of Regents and secure approval

Submit proposed transaction terms to Board of Public Works and secure approval

Summer 2022
Financial Close

Financial and commercial transaction close with new partner

Transition of operations to new partner

Fall 2022 and Beyond
NextGen Implementation

Commencement of phase I capital improvements. UMD's new partner will:

- Continue operations and maintenance of existing energy systems
- Make capital improvements to support reliability and resiliency
- Identify opportunities for permanent energy reductions, carbon emissions reductions and increased efficiency
- Begin construction and implement improvements based on proposed plan

Qualifications Evaluation

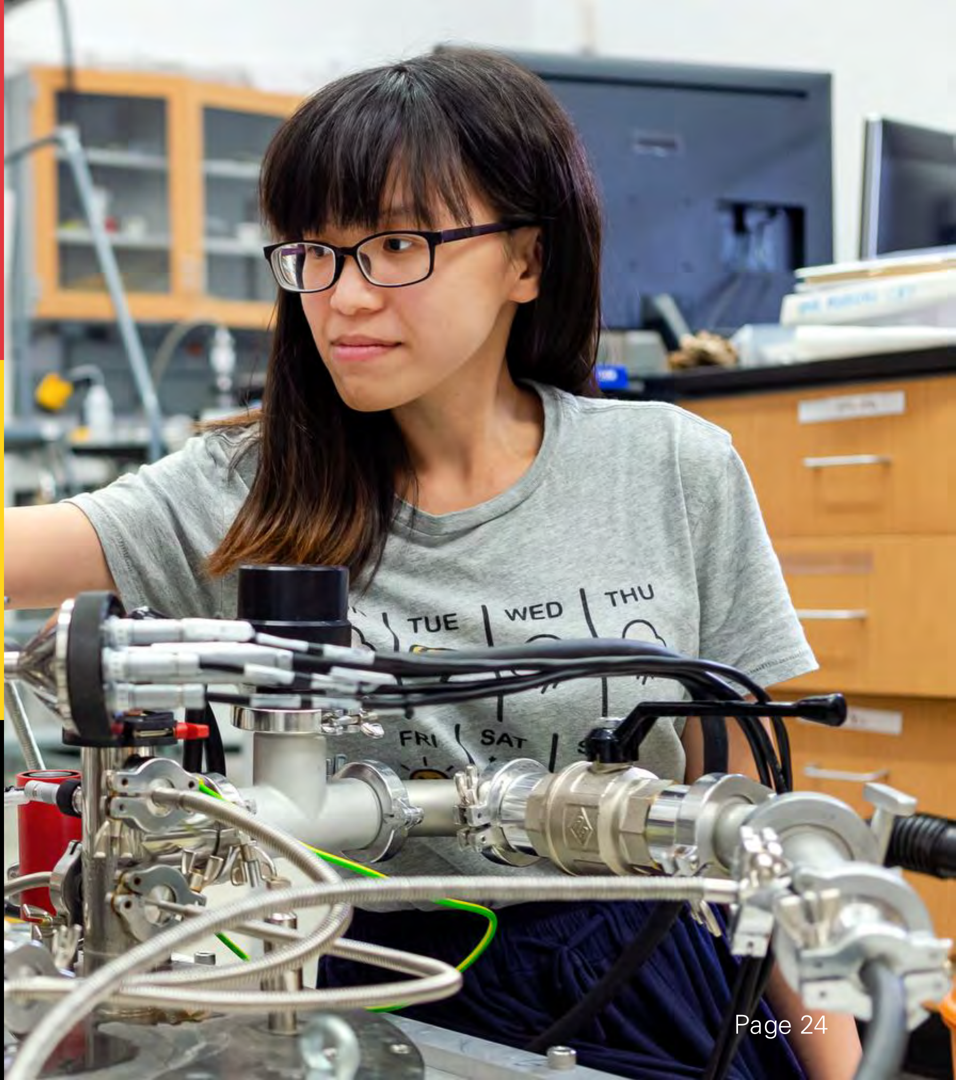
The Evaluation Committee identified five teams that were considered best capable of undertaking the scope of the NextGen program and met the P3 statute s responsibility determination requirements.

Consortium	Lead Member
Blackstone-AEI-Turner-NAES (Kepler Energy LLC, Blackstone Energy Partners III L.P, Blackstone Energy Partners VIII L.P, Affiliated Engineers, Inc., Whiting-Turner Contracting CO. Inc., NAES Corporation)	Blackstone via Kepler Energy, a subsidiary of Blackstone, has been appointed by the consortium as the lead member. Blackstone is a leading energy investor with $3.5 billion of equity investment in greenfield energy projects globally.
Maryland and Energy Impact Partners (Plenary Americas US Holdings Inc., Kiewit Development Company, Kiewit Power Constructors Co, Honeywell International, Inc.)	Plenary Americas, the proposed lead member and co-equity partner for NextGen, is a long-term investor in P3 public infrastructure in North America having a portfolio of 50 projects over $16 billion.
Terrapin Energy Collaborative Partners (Macquarie, MasTec Power Corp., Ameresco, Inc.)	Macquarie Financial Holdings Pty Limited, proposed lead member and sole equity provider for NextGen, is the world's largest infrastructure investor with $118 billion of assets under management.
Terrapin Energy Partners (ENGIE Development LLC, Meridiam, Engie Services U.S. Inc., Engie Generation NA LLC)	Engie Development LLC, the lead member for NextGen, is a wholly owned indirect subsidiary of Engie Holdings and is a member of ENGIE Global Group. ENGIE Global is world's largest independent power producer.
Vicinity Energy Inc. (Vicinity Energy Inc., Antin Infrastructure Partners, Bond Building Construction, Inc.)	Vicinity Energy is North America's largest provider of district energy solutions. It currently owns and operates a portfolio of 19 energy systems across 12 U.S. cities.

NextGen will continue our **legacy of achievement** as a preeminent center for **research and education**.

NextGen has the potential to foster new initiatives on campus.

- Groundbreaking research in collaboration with faculty and students
- Upgrades to campus facilities
- Student scholarships and internships
- New and innovative academic programs



UNIVERSITY OF MARYLAND

The entire university community has an essential role to play in achieving our environmental goals.

We can all do our part through everyday activities.

Learn more at
sustainingprogress.umd.edu

Conserve Energy

Turn off lights, choose LED light bulbs and energy efficient devices, use hibernate/sleep settings

Save Water

Wash clothes in cold water, shorten showers, turn off tap when brushing, report leaks

Reduce Waste

Use reusable bags & bottles, recycle & compost, donate items for reuse, avoid disposable plastics

UNIVERSITY OF MARYLAND

As the NextGen Energy Program progresses, **we are committed** to working alongside **the State**, the **university community** and other **stakeholders**.

UNIVERSITY OF MARYLAND

For more information or to contact us, visit

NextGen.umd.edu

UNIVERSITY OF MARYLAND

Working together we will replace, renew and modernize the campus energy system to:

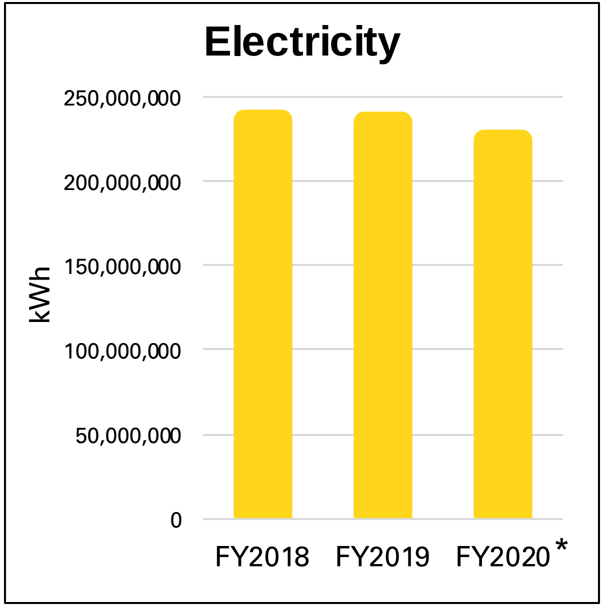
Energize Our Campus. Secure Our Future. Strengthen Our Resiliency.

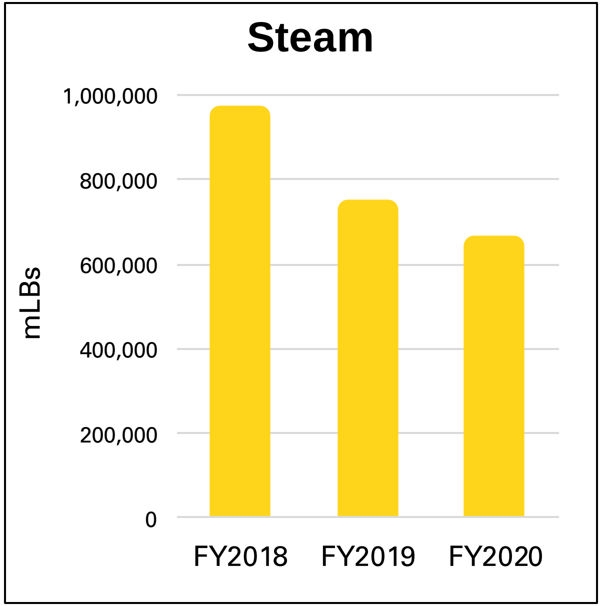
Appendix

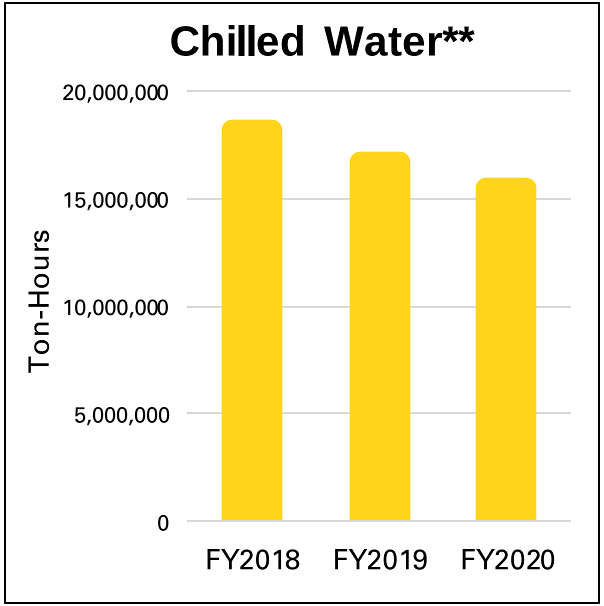
UNIVERSITY OF MARYLAND

Campus Energy Consumption

Campus energy services consumption over the past several years has remained relatively stable





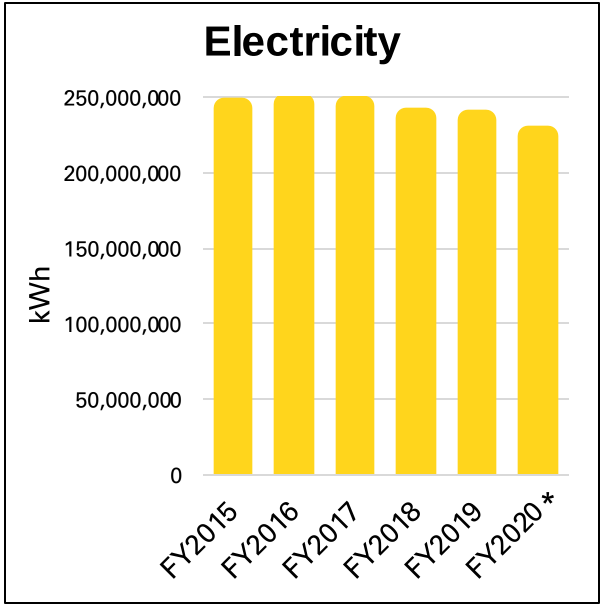


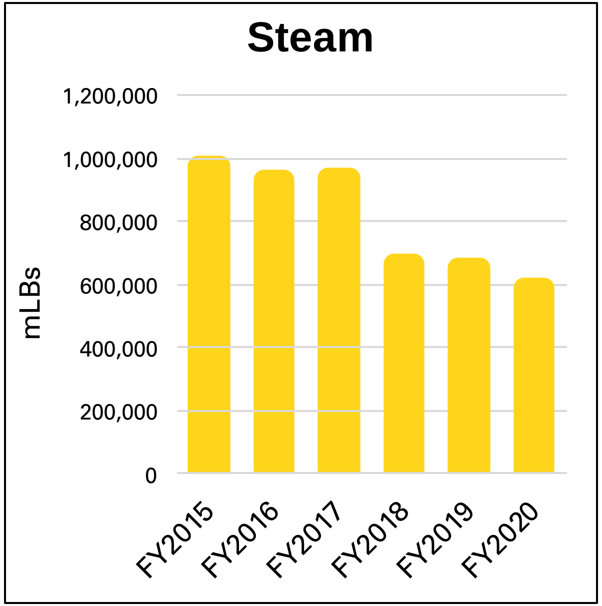
**Electricity consumption decreased in 2020 due to fewer students and faculty on campus utilizing buildings and resources as a result of COVID-19*
***Only reflects consumption from DTP-4*

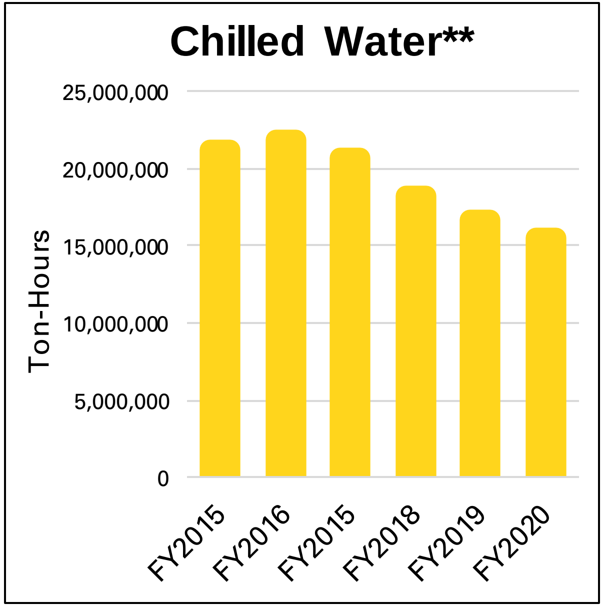
UNIVERSITY OF MARYLAND

Campus Energy Consumption

Campus energy services consumption over the past several years has remained relatively stable







*Electricity consumption decreased in 2020 due to fewer students and faculty on campus utilizing buildings and resources as a result of COVID-19

**Only reflects consumption from DTP-4

Friday, March 12th 2021

Sustainability Fund Review Committee:
Recommendation to Increase the Student Sustainability Fee

The student-majority Sustainability Fund Review Committee recommends increasing the undergraduate Student Sustainability Fee and encourages the graduate students to participate in this valuable program. The committee reports to the University Sustainability Council and is responsible for reviewing Sustainability Fund grant proposals and proposing adjustments to the Student Sustainability Fee.

In 2007, 91 percent of students who voted in that year's SGA election voted in favor of creating a Student Sustainability Fee to support the university's advancement of sustainability. The Student Sustainability Fee rate was set at $6 per full-time undergraduate student per semester and has remained at that level since then. It is the smallest of all student fees. Fee revenue is the funding source for the University Sustainability Fund, which supports student, staff, and faculty proposals that (1) improve the environmental performance of campus, (2) create opportunities for students to engage with sustainability, and/or (3) are research proposals that create meaningful involvement for students and have substantial implications for improving campus operations. Since 2010, the Fund has provided $3.2 million to 225 projects, many of which were proposed by or directly benefit students.

The Sustainability Fund has been a catalyst for sustainability projects that allow the University of Maryland to call itself a leader in environmental stewardship and responsibility. The sphagnum moss water treatment system at the Eppley Recreation Center, Terp Farm, Food Recovery Network, restoration of Campus Creek, and installation of water bottle filling stations campus-wide are just a handful of projects supported by the Fund, which the university continually references to demonstrate its commitment to sustainability. The Fund has also provided nearly $700,000 to projects that involve undergraduate and graduate students in sustainability research.

Student interest in sustainability education, research, and operations has increased dramatically since 2010 but the fee has remained at $6. Between 2014 and 2020, nearly four times more funding was requested each year than could be provided through the Sustainability Fund. Increasing the fee would allow more projects to be supported. There is additional interest in providing base funding for paid positions for undergraduate students, graduate students, and recent graduates to help run sustainability programs on campus. Several campus departments have proposed creating new opportunities for students if funding was available:

- Entry-level position focused on Zero-Waste activities
- Student positions at Terp Farm and the Farmer's Market
- Entry-level position running the Campus Pantry
- Paid internships and Graduate Assistantships supporting sustainability activities in Resident Life (ResLife), Office of Sustainability, and other campus units
- Entry-level position as a Campus Food Garden Coordinator

Friday, March 12th 2021

- Paid internships in the Environmental Finance Center and the Partnership in Action Learning in Sustainability (PALS) programs

This committee recommends increasing the fee because students created the fee, students control how fee revenue is spent, current students are supportive of increasing the fee, and campus departments have suggested new programming that would greatly increase opportunities for student involvement in sustainability initiatives. Suggestions for expanded programing include:

- Scholarship fund to support students who have unpaid sustainability internships on and off-campus
- Installing additional electric vehicle charging stations in student parking lots
- Launching a BikeUMD Student Ambassador program
- Establishing a permanent location for collecting and redistributing donated goods for students in need
- Base funding to support the Green Terp and Green Chapter programs

Several other higher education institutions have a student sustainability fee rate that is higher than or comparable to the fee rate proposed herein:

Institution	**Per Semester Fee**
Prescott College	$50/student/semester
Southern Oregon University	$30/student/semester
College of William and Mary	$20/student/semester
Hendrix College	$20/student/semester
Oberlin College	$20/student/semester
University of Colorado, Boulder	$17/student/semester
Northern Arizona University	$15/student/semester

The student members of the committee unanimously recommend increasing the fee to $15 for full-time and $8 for part-time undergraduate students. If approved, this fee rate would increase revenue from approximately $330,000 to $820,000 per year. Current requests for annual funding exceed $2 million. The Committee additionally encourages the graduate students to pay the Student Sustainability Fee, which is the only mandatory student fee paid by undergraduate and not graduate students.

Nina Jeffries

Nina Jeffries
Committee Chair

Marie Panday

Frances Marie Panday
Committee Vice Chair

Nina Jeffries - ENSP and ARAB '22 | Frances Marie Panday - ENSP '22
Calvin Penaflor - ENCE '21 | Kurt Willson - ENST '21 | Morgan Thompson - GVPT '22

Case for including Scope 3 methane emissions from natural gas

Giovanni Baiocchi

Department of Geographical Sciences, UMD

April 2021, College Park

The Climate Change Impact of Methane

- CO_2 is a long-lived greenhouse gas, which implies that much of our past and today's emissions could remain in the climate system for thousands of years.
- Methane, conversely, has a relatively short life of about 12.4 years, according to the IPCC's latest assessment
- however its ability to retain heat in the earth's surface is an order of magnitude higher than that of CO_2
- At the end of its life, methane becomes turns into CO_2 adding to the long term impacts.

Methane and the greenhouse-gas footprint of natural gas from shale formations

- Although natural gas is promoted as a bridge fuel over the coming few decades, in part because of its presumed benefit for global warming compared to other fossil fuels, very little is known about the GHG footprint of unconventional gas.
- The Council of Scientific Society Presidents warned that some potential energy bridges such as shale gas have received insufficient analysis and may aggravate rather than mitigate global warming.
- And in late 2010, the U.S. EPA issued a report concluding that fugitive emissions of methane from unconventional gas may be far greater than for conventional gas (EPA 2010).
- The footprint for shale gas is greater than that for conventional gas or oil when viewed on any time horizon, but particularly so over 20 years. Compared to coal, the footprint of shale gas is at least 20% greater and perhaps more than twice as great on the 20-year horizon and is comparable when compared over 100 years.

(Climatic Change, 2010)

Problem: GHG not being recorded in official inventories

- These emission estimates are mostly derived using bottom-up methods , which combine country-specific activity data with associated emission factors (IPCC, 2006)
- Air monitors : Miller et al. [2013] used NOAA Global Greenhouse Gas Reference Network in situ observations for 2007â2008 from ground stations and aircraft.
- Satellites : Turner et al. [2015] used Greenhouse Gases Observing Satellite (GOSAT) data for June 2009 to December 2011.
- Observations of atmospheric methane reviewed by Brandt et al. (2014) have implied that the US national inventory reported by the Environmental Protection Agency (EPA) may be greatly underestimated.

Large increase in U.S. methane emissions over the past decade inferred from satellite data and surface observations

- "A large increase in U.S. methane emissions over the past decade inferred from satellite data and surface observations: satellite retrievals and surface observations of atmospheric methane to suggest that **U.S. methane emissions have increased** by more than 30% over the 2002–2014 period. The trend is largest in the central part of the country, but we cannot readily attribute it to any specific source type."
- "estimating the contributions from different source types and regions is difficult due to spatial overlap in the sources and because sources mostly involve biological processes and fossil fuel losses that are **hard to quantify**"
- "The Greenhouse Gas Inventory of the U.S. Environmental Protection Agency [US EPA, 2014] provides the most detailed bottom-up estimate of U.S. anthropogenic methane emissions, following IPCC guidelines for reporting [Eggleston et al., 2006]. Figure 1 shows yearly emissions from 2002 to 2012. Values vary between 27.0 and 28.9 Tg a^{-1} over the period with **no significant trend**."

Methane Emissions

Three distinct processes contribute to GHG emissions in the production, distribution and consumption of natural gas from fracking wells. These processes are:

- Construction/Development of the unconventional fracking well
- Distribution of the natural gas
- Combustion of the natural gas

Natural Gas Supply Chain

Production, Gathering and Boosting (49 $MMtCO_2e\ yr^{-1}$ [32%])

1) Drilling and Well Completion
2) Producing Wells
3) Gathering Lines
4) Gathering and Boosting Stations

Processing (22 $MMtCO_2e\ yr^{-1}$ [14%]):

5) Gas Processing Plant

Transmission and Storage (52 $MMtCO_2e\ yr^{-1}$ [34%])

6) Transmission Compressor Stations
7) Transmission Pipeline
8) Underground Storage

Distribution (31 $MMtCO_2e\ yr^{-1}$ [20%])

9) Distribution Mains
10) Regulators and Meters for:
    a. City Gate
    b. Large Volume Customers
    c. Residential Customers
    d. Commercial Customers

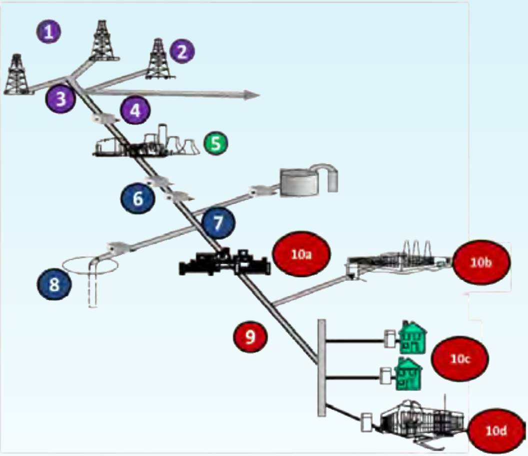


Figure 2. Methane emissions in 2011 from the natural gas supply chain ($MMtCO_2e/yr$) and contributions to total emissions (%)[34]

Controlling Methane Emissions in the Natural Gas Sector

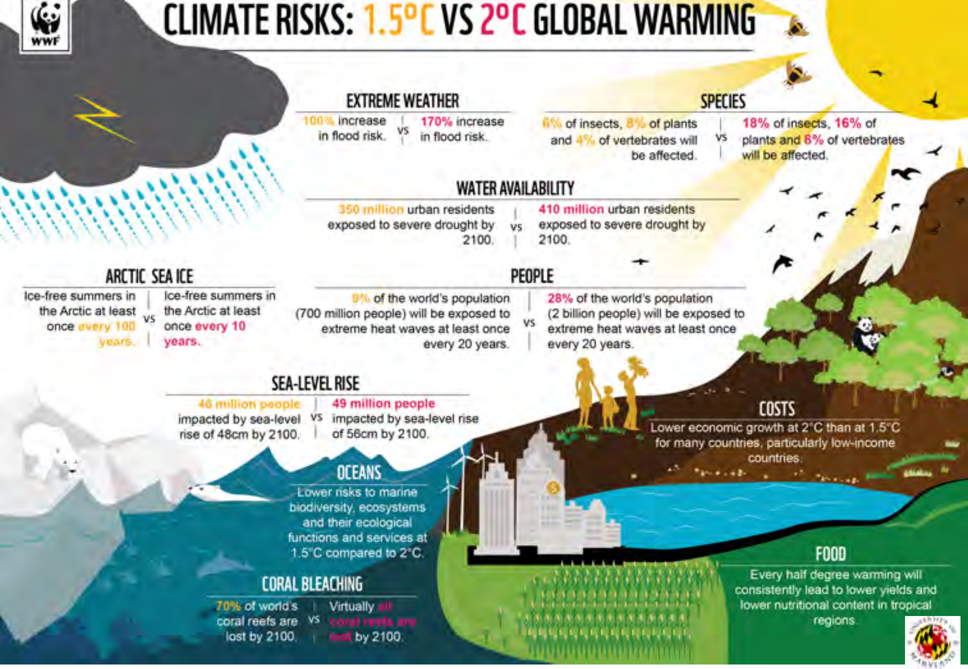
Methane emissions: choosing the right climate metric and time horizon

- Adopting 20-year GWP values to estimate GHG impacts, as opposed to the standard 100-years, would give much greater weight to short lived gases such as methane as opposed to CO_2 as well as to methane releasing sectors such energy and agriculture.
- SLCP are responsible for 40-45% of anthropogenic radiative forcing (WG1AR5 Chapter 8)
- This represents a great opportunity to achieve a more immediate impact, which cannot be obtained through CO_2 mitigation alone
- “Reducing SLCPs is critical for slowing the rate of climate change over the next several decades and for protecting the people and regions most vulnerable to near-term climate impacts.” (Primer on Short-Lived Climate Pollutants, IGSD, 2013)
- A two-value accounting approach, showing the impacts over short and long time horizons, is recommended by a growing number of studies to foster sustainable development and near-term climate goals progress.

Methane emissions: choosing the right climate metric and time horizon

Shindell et al. in "A climate policy pathway for near- and long-term benefits" (Science, 2017) highlight the case for urgency in curbing short-lived climate pollutants (SLCPs) such as methane:

- reduce the damage from climate change, particularly those that depend on the speed of climate change such as biodiversity loss
- can slow down positive feedbacks, such as snow-and-ice albedo
- mitigate the risk of potential nonlinear changes such as the release of methane from seas and soils in permafrost. Shakhova et al. (2008) conclude that "release of up to 50 Gt of predicted amount of hydrate storage [is] highly possible for abrupt release at any time"
- increase the probability of staying below 2 degrees for the next decades
- reduces long-term cumulative climate change damages
- reduces the cost of mitigation
- can stimulate further emission targets progress with early successes



WWF
CLIMATE RISKS: 1.5°C VS 2°C GLOBAL WARMING
EXTREME WEATHER
100% increase in flood risk. VS 170% increase in flood risk.
SPECIES
6% of insects, 8% of plants and 4% of vertebrates will be affected. VS 18% of insects, 16% of plants and 8% of vertebrates will be affected.
WATER AVAILABILITY
350 million urban residents exposed to severe drought by 2100. VS 410 million urban residents exposed to severe drought by 2100.
ARCTIC SEA ICE
Ice-free summers in the Arctic at least once every 100 years. VS Ice-free summers in the Arctic at least once every 10 years.
PEOPLE
9% of the world's population (700 million people) will be exposed to extreme heat waves at least once every 20 years. VS 28% of the world's population (2 billion people) will be exposed to extreme heat waves at least once every 20 years.
SEA-LEVEL RISE
46 million people impacted by sea-level rise of 48cm by 2100. VS 49 million people impacted by sea-level rise of 56cm by 2100.
COSTS
Lower economic growth at 2°C than at 1.5°C for many countries, particularly low-income countries.
OCEANS
Lower risks to marine biodiversity, ecosystems and their ecological functions and services at 1.5°C compared to 2°C.
CORAL BLEACHING
70% of world's coral reefs are lost by 2100. VS Virtually all coral reefs are lost by 2100.
FOOD
Every half degree warming will consistently lead to lower yields and lower nutritional content in tropical regions.

Too uncertain ("parties should take precautionary measures to anticipate, prevent, or minimize the causes of climate change and mitigate its adverse effects." (Article 3 of the United Nations Framework Convention on Climate Change (UNFCCC))

Methane emissions: choosing the right climate metric and time horizon

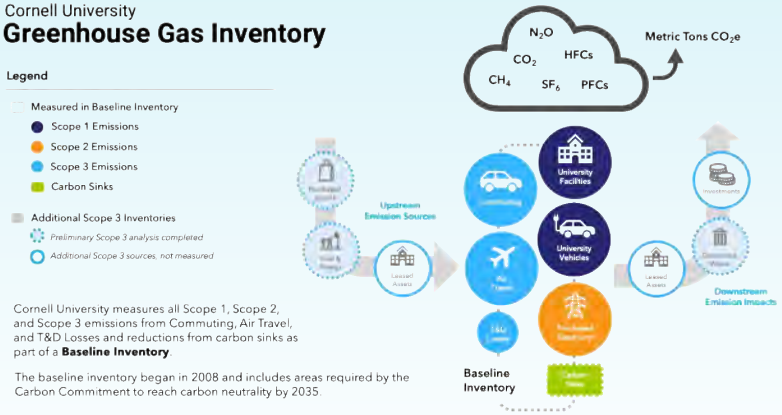
- Maryland General Assembly's 2021 Legislative Proposal
- SB 414/HB 583: Climate Solutions Now Act of 2021
- **State must account for methane emissions using the 20-year global warming potential**

Maryland Commission on Climate Change

Maryland Commission on Climate Change regarding the life-cycle emissions of fracked natural gas consumed in Maryland. The Maryland Commission on Climate Change through the Mitigation Working Group worded the recommendation to MDE as follows:

- "Regarding the State's GHG Emissions Inventory, due in 2018, the MWG recommends that MDE continue to work with the STWG, the University of Maryland, and the Departments of Natural Resources and Agriculture to ensure that the Inventory is both locally relevant and complete.
- This includes consideration of life-cycle emissions generated by out-of-state extraction, processing, and transportation of fossil fuel energy consumed in-state; and applying advanced methods to generate a more accurate accounting of emissions sinks such as agricultural soil and forestry management."

Scope 3 Emissions: Cornell's baseline greenhouse gas inventory



VT GHG Inventory and Assessment Report: Feb 12, 2021

The GHG emissions scope for this VT assessment includes:

- Scope 1 (emissions from campus direct fuel use),
- Scope 2 (emissions related to purchased electricity), and
- Some Scope 3 emissions related to campus behavior:
  - Commuter miles
  - Transit bus fuel
  - Waste/recycling/compost
  - Water/wastewater
  - Aviation fuel
  - Commercial business travel miles
  - Utility transmission and distribution (T&D) losses
  - Upstream natural gas (methane) direct leakage

Other commonly reported Scope 3 emissions include emissions associated with campus food and sequestration of carbon by trees and land. Upstream Scope 3 emissions for dining hall food will not be in scope for this assessment due to the scale of the data and analysis required for accurate results. Sequestration of carbon in Virgina Tech forestry and agricultural lands was also not included in this assessment due to lack of data and analysis time. Both of these categories will be included in future assessments.

VT GHG Inventory and Assessment Report: Feb 12, 2021

METHANE LEAKAGE

Methane, commonly known as natural gas, is a potent greenhouse gas with a GWP of 28. While natural gas is often discussed in news reports as a bridge fuel with lower GHG emissions compared to coal, this is only considering the combustion of the fuels. If one includes the leakage of natural gas across its lifecycle, from mining to processing to distribution, the overall carbon footprint of this fuel is higher. Reports in the literature suggest that natural gas leakage in the range of 3% cause the life-cycle GHG emissions of natural gas to be comparable to those for coal.[10] Including this GHG emission source in the updated VT Climate Action Plan was a major request by the VT Climate Justice group whose activities on campus raised awareness of climate change issues and led to an updated Climate Action Plan. This emission source is not reported by most organizations in their GHG Assessments, but it is similar to the electricity upstream transmission and distribution (T&D) losses which are typically reported.

Upstream Methane Leakage Estimate	Quantity
Natural Gas Leak Rate (from literature)	2%
VT Direct Natural Gas (m^3)	31,973,852
VT Indirect Natural Gas (from utility electricity)(m^3)	12,320,324
Natural Gas Leakage (m^3)	885,884
Natural Gas Mass Density (kg/m^3)	0.70
Total Methane Mass Leakage (kg)	620,118

Table 11. Virginia Tech Natural Gas Leakage Estimate

VT GHG Inventory and Assessment Report: Feb 12, 2021

The report notices:

- "Upstream natural gas leakage is an emissions source that is rarely considered in campus GHG reports".
- "However, like campus food which is reported occasionally, these emissions sources are very important to some stakeholders on campus as learned in the spring 2020 climate action surveys."
- Since these emissions can account for 5–10% of a campus carbon footprint and can be controlled by operational or student choices, they have been recommended by the 2020 CAC Committee to be tracked and analyzed as part of annual GHG inventory.

VT GHG Inventory and Assessment Report: Feb 12, 2021

- The GHG emission data from methane leakage due to upstream operations associated specifically with natural gas delivered to Tech is not available, but good scientific estimates of the average system leakage rates are available in the scientific literature.
- “An analysis in 2018 estimated the overall methane leakage rate from the oil and natural gas supply chain at 2.3% (95% CI 2.0 - 2.7%).” (This values are from Alvarez et al., “Assessment of methane emissions from the U.S. oil and gas supply chain”, 2018. The value is 60% higher than EPA estimates as existing bottom-up inverntory methods do not take into account abnormal operating conditions when most leakages happen)
- Another recent synthesis article of methane emission data focused on the natural gas supply chain, production through distribution, and found that 1.7% (95% CI 1.3% to 2.2%) of the methane in natural gas is emitted between extraction and delivery.

VT GHG Inventory and Assessment Report: Feb 12, 2021

- Based on the average value of these two scientific studies, we **used 2% leakage applied to all natural gas consumed** by Virginia Tech in the Central Power Plant, Buildings, and Leased Spaces.
- The primary natural gas used by the utility to generate electricity was also included by considering the natural gas percentage of 21% from the APCO 2019 fuel mix and an assumed utility power plant efficiency of 35%.
- This leakage value was multiplied by the total natural gas consumption volume, converted to mass based on the gas density at 20°C and 1 atm 14 , and entered into SIMAP under the Category of Refrigerants and Chemicals.
- These emissions were manually adjusted to Scope 3 emissions per GHG protocols.

Summary

- Mitigating methane emissions is vital to save critical ecosystems and avoid damage to vulnerable areas
- Methane leakage emissions are uncertain however they are significant and most likely underestimated
- 2018 estimate the overall methane leakage rate from the oil and natural gas supply chain to be around 2.3% (95% CI 2.0 - 2.7%). (Alvarez et al., “Assessment of methane emissions from the U.S. oil and gas supply chain”, 2018. The value is 60% higher than EPA estimates as existing bottom-up inverntory methods do not take into account abnormal operating conditions when most leakages happen)
- Accounting for Methane scope 3 emission has increasing support
- It is recommended by the state of Maryland
- It is adopted by an more and more universities and institutions
- Adopting this standard offers an opportunity to continue showing leadership in adopting immediate action in addressing climate change

Recommendations

- Hold a Stackeholder Survey
- Establish task force to
  - Consider including Scope 3 methane emission in GHG inverntory
  - Consider using Maryland values of leakage
  - Consider using 20-year global warming potential
  - Write a report

Thank you!