Changing the Game

A Playbook for University Athletics Departments
to Reduce Greenhouse Gas Emissions

Harvard Law School
Climate Solutions Living Lab
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While the input of these individuals informed our work, any opinions expressed in the manual are those of the students and not of Harvard University or Harvard Law School. If you would like to learn more about Harvard Law School's Climate Solutions Living Lab, please contact Professor Wendy Jacobs at wjacobs@law.harvard.edu.

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Introduction

The climate crisis is the defining issue of our era, affecting everyone and everything, university athletics departments included. For example, heatwaves may soon make it too hot for outdoor tournaments to take place during the day in some places. Snow-based winter sports may disappear. Student athletes with asthma may struggle to perform as air pollution affects their respiratory health.

To mitigate this crisis, we need to innovate. The call to action from student athletes is clear: athletes are campus leaders, and the teams they play for are visible contributors to climate action. Students and maintenance staff have mobilized to run zero-waste events at stadiums that seat tens of thousands of spectators, facilities staff have rethought landscaping practices to reduce pesticide use, and student athletes have disrupted major games in support of climate action.

University athletics departments are particularly well-positioned to make a difference. They have access to the vast resources, cutting-edge research, and pioneering technology that characterize higher education. Importantly, athletics departments are often the most public-facing component of a school. When they make a change for the better, the world watches.

The COVID-19 pandemic demonstrates how connected we are as a global community. Athletics departments are particularly affected by the consequences of the pandemic and the accompanying uncertainty. The pandemic, coupled with climate change, presents unprecedented challenges; at the same time, it presents an opportunity to engage in forward-thinking, innovative projects that include sustainable policy changes, health-promoting proposals, cost-saving investments, and climate-friendly capital planning.

In this playbook, we detail how athletics departments can reduce or offset some of their greenhouse gas emissions. We also identify ways to pay for this. Many athletics departments are particularly interested in offsetting their emissions from travel. They can achieve these reductions through “heavy-hitter” projects that target major emissions sources in athletics departments and “quick wins” that improve business-as-usual operations.

We also provide recommendations about how to spur community engagement and fund green initiatives, both of which are crucial to reducing emissions. Finally, we offer a number of tools that athletics departments can use to evaluate and reduce emissions. These include instructions for creating a greenhouse gas (GHG) emissions inventory and conducting a health impact assessment, as well as model green contract provisions and sustainable procurement guidelines. We hope you will find this both useful and inspiring as your athletics department reduces its emissions. Together, we can change the game.

Playbook Overview

This playbook provides actionable projects university athletics departments can implement to reduce their GHG emissions and offset emissions from athletics travel.

Context

→ Page 9

This playbook begins by describing how athletics departments are affected by climate change and why reducing their GHG emissions will save money and provide other benefits.

Climate change poses a challenge to the future of athletics and the global community.

Athletics departments can reduce GHG emissions by undertaking a variety of practical actions that target major sources of GHG emissions, including building operations and air travel.

Benefits include cost savings, positive publicity, healthier students, and a more stable global environment.

Actions

→ Page 16

It then identifies actions that athletics departments can take to reduce their emissions. These actions include heavy hitters, larger-scale projects with the potential for substantial emissions reductions, and quick wins, smaller projects that are easy to implement. Technical, legal, and financial implementation guidance accompany each action.

Heavy Hitters

1. Improve travel policies

2. Heat pools with solar water heaters

3. Reuse waste heat at ice rinks

4. Improve refrigerant management and disposal

5. Use of anaerobic digester for organic and compostable wastes

Quick Wins

1. Replace conventional lighting with LEDs

2. Improve laundry efficiency and apparel procurement

3. Generate power through on-site solar

4. Re-wild mowed lawns

5. Improve temperature control at ice rinks

Who should use this document? This playbook is designed for use by university athletics departments across the United States. It prioritizes steps that many universities could take to reduce GHG emissions, based on our discussions with university stakeholders and our examination of mid-sized universities in the southern and northeastern US.

Getting It Done → Page 50

Following this are strategies to build support through a discussion of stakeholder engagement and funding strategies.

Engagement. Create competitions to build support for sustainability among athletes and staff.

Funding Strategies. Develop funding strategies to support actions, such as:

- Air travel fees
- Student facilities fees
- Green games
- Athletics sustainability funds
- Green revolving funds

Appendices → Page 57

This playbook concludes with appendices for implementing actions and building support.

Financial Summaries: Calculations and assumptions used to estimate the costs and savings of each project

Legal & Implementation Resources: Model contract provisions and procurement guidelines

Emissions Inventory: Methods for benchmarking athletics department emissions

Project Screening: Analysis of project difficulty

Impacts: Method for analyzing health impacts

Table of Contents

"I think it's important to remember that sports and sustainability aren't locked in a zero-sum game; there are ways to maintain the same rigorous level of practice and competition in a more sustainable way. A lot of athletics comes from a place of strong tradition, which can make change harder. But, it's important for athletes, like myself, to remember that just like everything else, athletics needs to adapt to help confront the mounting climate crisis. We need to think more critically about where we're competing, how we're getting there, how we're using our facilities, and ultimately, how we can improve."

Varsity rower

Context

Why should athletics departments reduce GHG emissions?

By making their programs more sustainable, athletics departments can help protect their students' health, improve their local environment, and contribute to a greener, cleaner world for everyone. A critical component lies in reducing greenhouse gas emissions.

Greenhouse gases are gases that trap heat in the environment.[1] They include carbon dioxide, methane, nitrous oxide, and fluorinated gases such as hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

The benefits of reducing greenhouse gas emissions are multiple, including decreasing global warming, reducing the frequency of extreme weather events, preventing extreme temperatures, preventing sea level rise, and more.[2] These global benefits will be felt differently across the country—and the world—and highlight what we all stand to gain by actively reducing the amount of GHGs emitted into our atmosphere.

Projects that reduce GHG emissions have health and environmental co-benefits. By reducing the amount of fossil fuel-based energy consumed by an athletics department, the projects we propose will reduce air pollution. This in turn will improve health among student athletes, the university community, and local residents, as reducing air pollution reduces the burden of disease from stroke, heart disease, lung cancer, and respiratory diseases, including asthma.[3] The COVID-19 pandemic has underscored the impact of air pollution on health, as research indicates that populations with greater exposure to air pollution experience greater mortality rates due to the virus.[4] Other health benefits of these projects include improved mental and physical well-being and reduced stress for student athletes; environmental benefits include reductions in the waste heat and wastewater released into the local environment.

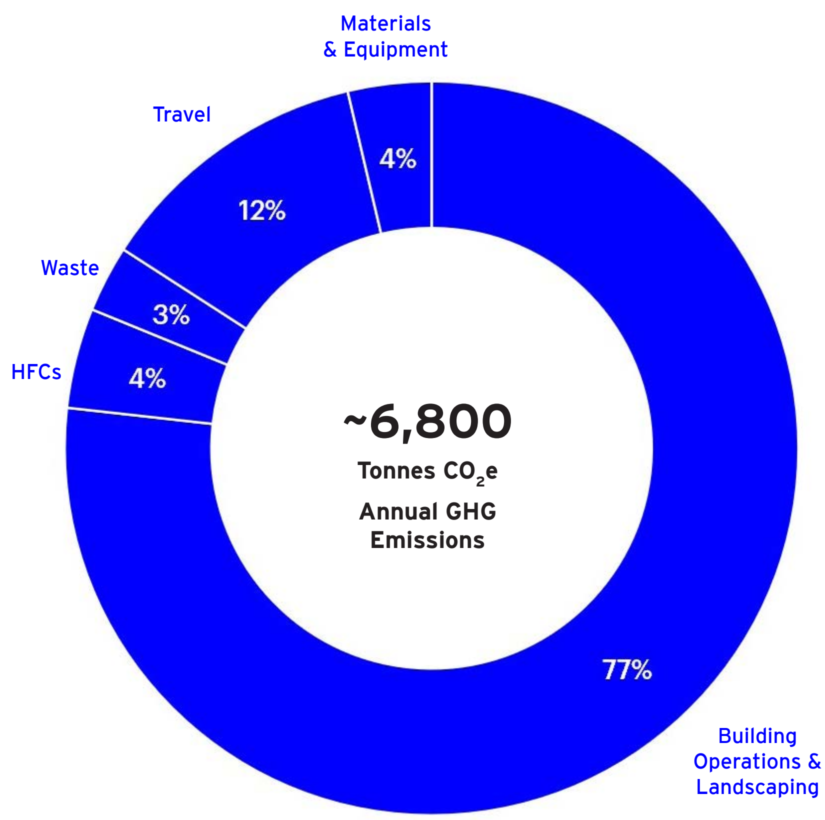
Furthermore, sustainability initiatives have been shown to give a positive reputational boost, which can help both athlete recruitment and fan loyalty.[5] Students care about the environment—they are more interested in playing for programs that embody their values. Many sustainability measures also make sound business sense by reducing costs, resulting in positive returns on investment. Beginnng on page 53, we identify a variety of funding strategies.

What drives emissions in athletics departments?

College athletics departments generate GHG emissions from a variety of activities, including building operations, air and ground travel, waste processing, equipment purchases and maintenance, and landscaping.

At most schools, routine building operations generate the majority of emissions; powering large gyms, illuminating playing fields, and heating pools consumes a lot of energy, which typically comes from emissions-intensive sources. Athletics buildings also contain cooling systems that can leak HFCs, GHGs with global warming potentials (GWPs) thousands of times that of CO_2. Team and recruiting travel, especially air travel, and waste management, particularly at schools with well-attended sports events, are the next highest emitters. The purchase and laundering of material goods such as uniforms and athletics equipment also produce emissions. Mowing and fertilizing athletics green spaces round out a department's emissions profile.

Example Annual GHG Emissions Inventory for a University Athletics Department



What is included in this manual's emissions inventory?

This emission inventory accounts for direct emissions from sources owned by the university (Scope 1 emissions), emissions from purchased heat and electricity (Scope 2 emissions), and some emissions from sources not directly owned or controlled by the university (Scope 3 emissions).[6] The emissions estimates in this manual represent those of an athletics department that serves a mid-sized university, with ~7,000 undergraduate students and 10–15,000 graduate students. Of course, exact emissions will vary by university. Athletics departments that want to reduce their emissions should begin by conducting an "emissions audit," an inventory that catalogues the sources and quantity of GHG emissions. Conducting an audit allows departments to identify the largest sources of emissions and thereby select the most effective reduction strategies.

→ **See Appendix D** for more information about conducting your own emissions audit.

→ **See Glossary** for more information about Scope 1, 2, and 3 emissions.

What does offsetting mean?
Carbon offsetting is the practice by which an organization that wants to reduce carbon emissions funds an initiative that lowers GHG emissions. In doing so, the funding organization claims those avoided emissions as its own. By offsetting its own emissions in this way, an organization can become "carbon neutral" while still continuing unavoidable carbon-emitting functions, like travel. However, it is important to remember that while carbon offsetting is an important tool to reduce emissions, it should only be used after an athletics department has directly reduced its emissions as much as possible.

What actions can athletics departments take to reduce their own GHG emissions?

Athletics departments can meaningfully reduce GHG emissions by implementing **heavy hitter** projects that tackle large emissions sources, such as swimming pools, ice rinks, and HFCs. Departments can pair these projects, which might require more initial capital expenditure and advanced planning, with a set of easy-to-implement **quick wins** that will help to build support for further emissions reductions.

1. Net Present Value (NPV) represents cost savings to the university over the lifetime of the project. Savings will vary depending on the price of electricity, the fuel used to generate electricity, and other factors specific to each university. The majority of projects in this playbook should generate a positive NPV. For some universities, the cost savings for some projects may be negative, meaning the upfront costs are not recouped over the lifetime of the project.

2. NPV per tonne of CO_2e reduced represents the cost savings to the university per the total CO_2e (equivalent) emissions avoided over the lifetime of the project. For ease of comparison, all GHG pollutants are compared to carbon dioxide. The emission of one ton of HFCs can be thousands of times more potent than carbon dioxide so its carbon dioxide equivalence number will be significantly higher than would be the case for one ton of emissions of either methane or carbon dioxide.

→ **See Assumptions & Definitions, page 17** for more information on calculations.
→ **See Financial Summaries in Appendix A** for information and assumptions used to estimate NPV and cumulative emission reductions.

3. Project Screening: Each project was screened to determine how easily a university could implement the project. The practicality of each project was assessed on the basis of four criteria:

- **Upfront cost**: Projects that have a high upfront cost will require additional buy-in from the university administration.
- **Legal considerations**: Projects that can use existing contracts are more straightforward than those that require new contracts.
- **Scale and term of disruption**: Some projects will require disruption of usual operations.
- **Accessibility of technology**: Projects require various interactions with technology; the more complex the technology, the more training of athletics department staff is required.

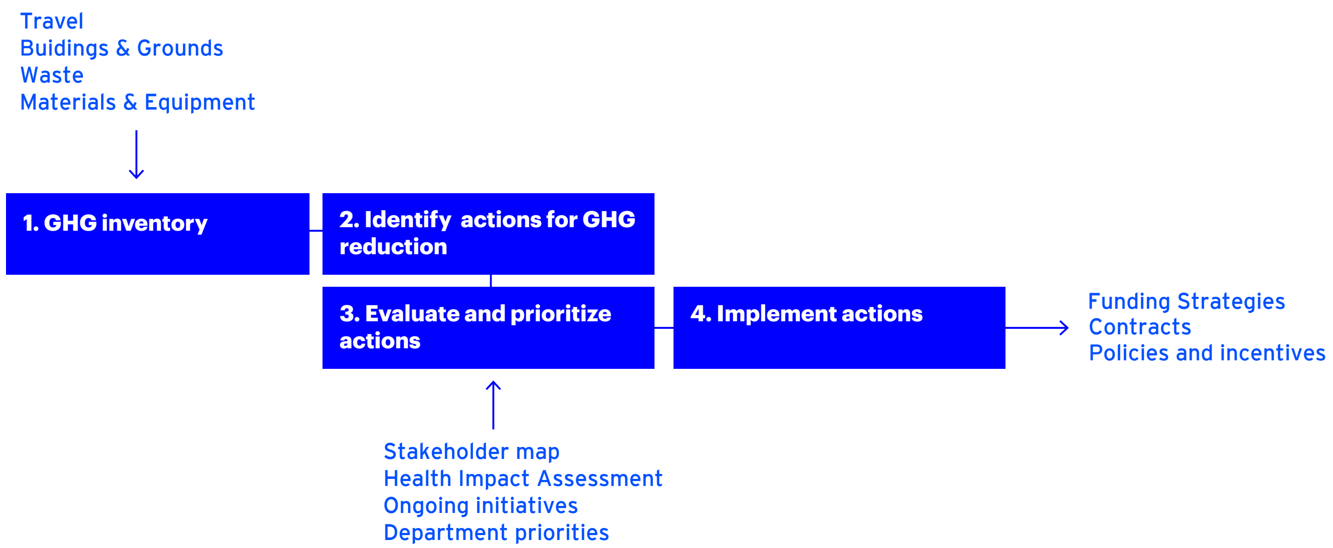
Each project is rated straightforward ■, intermediate ■, or stretch ■.

→ **See Appendix E** for the project screening analysis.

Heavy Hitters and Quick Wins Overview

Heavy Hitters	**Cumulative Emissions Reduction** Tonnes CO_2e	**Project Lifetime** Years	**NPV** $ (see definition on page 12)	**NPV per Tonne Reduced** $/Tonnes CO_2e	**Project Screening** Straightforward (green), Intermediate (yellow), Stretch (red)
1. Improve travel policies	3,000	10	$170,000	$56	Straightforward
2. Heat pools with solar water heaters	4,000	20	$65,000	$16	Intermediate
3. Reuse waste heat at ice rinks	5,400	24	$370,000	$70	Intermediate
4. Improve refrigerant management and disposal	10,000	20	($195,000)	($20)	Straightforward/Intermediate
5. Process waste in an anaerobic digester	8,600	20	$500,000	$66	Stretch
Quick Wins					
1. Replace conventional lighting with LEDs	185	5	$12,000	$65	Straightforward
2. Improve laundry efficiency and apparel procurement	81	12	$4,500	$55	Straightforward
3. Generate power through on-site solar	3,100	20	$40,000	$13	Intermediate
4. Re-wild mowed lawns	35	10	$40,000	$800	Straightforward
5. Improve temperature control at ice rinks	675	20	$45,000	$66	Straightforward

How can athletics departments get started?



1. Conduct an emissions inventory. Begin by developing an inventory of GHG emissions. This inventory will serve as a benchmark against which future emissions reductions can be evaluated. This inventory can be organized according to the major categories of (1) building operations, (2) travel, (3) waste, (4) materials and equipment, and (5) landscaping, which align with how staff are often organized in an athletics department.

→ **See Appendix D** for information on how to conduct an emissions inventory.

2. Identify actions. Build on the list of heavy hitters and quick wins in this report with additional emissions-reducing actions specific to your university. Lead guided conversations with staff, athletes, and other university departments to brainstorm additional actions.

3. Evaluate and prioritize actions. Set criteria for evaluating actions by looking at a range of existing and new data sources. These could include reviewing existing capital plans to identify how new actions could plug in to larger initiatives, mapping stakeholder relationships, conducting health impact assessments and codifying departmental priorities for GHG emissions. With these criteria in place, select actions to implement.

4. Implement actions. Using the financial summaries, model contract documents, and other implementation guidelines presented in the appendices to this playbook, start implementing projects. Quick wins may be easy to deploy without significant resources, while some heavy hitters will require more extensive studies and evaluation.

→ **See Appendices A, B, and C.**

"Sustainability is an essential topic for athletics teams to consider. Sports teams' frequent travel (especially by air) for competition increases emissions, as does our consumption of meat products. Also, many winter teams are at risk of losing their sports due to climate change, giving us all a vested interest in avoiding that outcome. Finally, many student athletes are well-known figures on campus, giving them the ability to affect change in their community and influence people around them to improve sustainability together."

Student Athlete

Actions

Heavy Hitters

1. Improve travel policies
2. Heat pools with solar water heaters
3. Reuse waste heat at ice rinks
4. Improve refrigerant management & disposal
5. Use of anaerobic digester for organic and compostable wastes

Assumptions & Definitions

The estimates of emissions reductions and net present value (NPV) that this manual provides for each project are not specific to a particular university; rather, they are meant to provide a framework and starting point for a university to do its own calculations based on site-specific circumstances such as the cost of electricity, type of fuel used to generate that electricity, climate, hourly labor costs, and the like.

All calculations are in 2020 US Dollars.

Cost of electricity: We used the US average electricity price of 12.79¢ per kWh.[7] Electricity prices vary greatly by state, so we recommend updating the estimates used to calculate NPV and cost according to local electricity prices.

Discount rate: The discount rate is the rate of return that a university expects to generate from a project over its lifetime. Alternatively, it is the cost of borrowing to finance these projects if the funds are not provided by the university. Depending on how your university sources its funding and the expected risk-return profile of a project, the appropriate discount rate is set by the CFO.[8] Because most universities are not-for-profit, the discount rate typically reflects the rate of return of the university's endowment. For our financial calculations, we used an 8% discount rate.

Emissions from electricity generation: Power grids emit different amounts of CO_2e based on what type of energy they use to create electricity (i.e., natural gas, coal, wind, solar, and nuclear). We used the US average of 0.99 pounds of CO_2e emissions per kWh, which is the equivalent of 0.000449 tonnes CO_2e/kWh.[9] Ask your local electricity supplier for its emissions rate.

HFC Global Warming Potential (GWP): GWP is the 20-, 50-, or 100-year warming potential of a substance relative to CO_2. The GWP of HFCs varies from 1,000 to 9,000, depending on the type of HFC.[10] This manual uses a GWP of 2,213, the mean of HFC 100-year GWPs from the IPCC Fifth Assessment Report.[11] You should calculate your HFC emissions based on the specific GWPs of HFCs in your inventory.

Project Lifetime: Project lifetime was calculated by determining how long a project would last. The lifetime of each project was used to calculate NPV.

Social Cost of Carbon (SCC): SCC represents the expected economic cost from changes in agricultural productivity, human health, property damages from increased flood risk, and the reduced value of ecosystem services caused by carbon emissions and climate change. The long-term harm from a tonne of CO_2 emitted today is calculated in dollars. SCC represents the total estimated monetary benefit of avoiding emitting that tonne. SCC estimates vary widely due to uncertainty about factors such as the climate's sensitivity to carbon; figures range from $1[12] to over $400.[13] This report uses the estimate of $42 per tonne CO_2, the estimated 2020 price calculated by the US EPA in 2016.[14]

Wage costs: Some projects include additional work. All cost estimates that included staff and contractor wages assumed a $10 per-hour wage. Costs including wages should be updated to reflect the average wage for hourly workers at your university.

For each project, we estimate the following:

Capital Cost: Capital cost refers to the estimated upfront cost of the project. Sometimes, the capital cost may be high, but will be paid back to the athletics department over the course of the project lifetime. Capital cost reflects how much money the department must have upfront in order to implement the project.

NPV per tonne of CO_2e: The NPV-per-tonne represents how much a university will pay or save per tonne of emissions saved. This was calculated for each project by considering the entire cost or savings over the project lifetime, represented by NPV, and the total amount of emissions avoided over the project lifetime. For many but not all universities, the NPV for the projects in this playbook will be positive, meaning the project represents a savings to the university. A positive NPV-per-tonne of CO_2e indicates a savings per tonne of CO_2e, while a negative NPV-per-tonne of CO_2e indicates a cost to reducing emissions.

Emissions reduction: The emissions reduction refers to the annual GHG emissions reduction in tonnes of CO_2e that can be attributed to the project multiplied by the life of the project. This number includes not only the direct reductions on the campus but also indirect reductions such as the demand for fossil fuel-generated electricity.

Net Present Value (NPV): To measure the financial benefit of each project, we calculated the Net Present Value. The NPV is the difference between the present value of cash inflows and cash outflows over the lifetime of a project.[15] It takes into account (i) the capital investment paid to set up and install the project, (ii) expected yearly future operating expenses, and (iii) expected yearly savings (from energy reduction, reduced consumption of materials on campus, or sales of beneficial by-products from a project). Future expenses are discounted using a discount rate of 8%.

NPV accounting for SCC: Several countries and states have introduced a cost of carbon through a tax or cap-and-trade scheme. We calculate NPV including the social cost of carbon, which was assumed to be $42, to reflect this. Our projects reduce the amount of CO_2 emitted. Therefore, NPV accounting for SCC is always more positive than the original NPV, representing a more beneficial financial result for the university that takes into account the public health and social benefits of the project.

Heavy Hitters

1 / Improve travel policies

3,000 Tonnes CO_2e
Emission reductions over 10 years

Immediate implementation; savings calculated over 10 years
Project lifetime

$Zero
Capital cost

$25,000
Annual travel savings after improved policies

$83
Annual savings/tonne of CO_2e emissions avoided

Project Screening Score

See Appendix A for Financial Summaries

Image Credit: Sean MacEntee, Creative Commons

University athletics departments send teams, coaches, and staff all over the country (and world) for competitions and training events, as well as to bring recruited athletes to visit campus. Air travel often makes up the largest percentage of these travel emissions; flights are typically more emissions-intensive than bus, car, and van travel. While travel is largely essential for athletics department operations, carefully crafted policies and strategic contracting can reduce emissions from travel. The other projects discussed in this manual can help offset the remaining emissions.

Implementation

1. Encourage bus travel over air travel. Implement rules regarding how far from campus a destination must be in order to justify taking a flight instead of traveling by bus or van. For example, trips under 300 miles should occur by bus, although longer trips should also occur by bus if time allows.

2. Reduce travel by charter flight. Phase out charter flights wherever possible; commercial flights produce fewer emissions per traveler. When a university charters a flight, it is responsible for that flight's emissions, regardless of whether the flight is full.

3. Implement an air travel fee. Encourage teams to choose ground travel by adding a surcharge to each airplane ticket a team purchases. Use the money collected to fund the sustainability initiatives discussed in this manual. → **See Getting It Done, page 53** for more details.

4. Contract for fuel-efficient travel options. When contracting with bus companies, require them to increase their fuel efficiency or switch to lower-carbon alternatives to diesel buses. Although hybrid-electric and fully electric buses are not yet common and can be expensive, try partnering with other departments or schools to exert pressure on bus companies to purchase more of these fuel-efficient vehicles.

Co-Benefits

- Travel across time zones and the resulting jet lag have been proven to negatively affect mood, cognitive function, and physical well-being, as well as individual and team performance. Reducing the number of players taken on cross-time zone flights would decrease the physical and emotional burden on team members.[16]

- Travel is one of the risk factors for sleeping disorders and sleep deprivation among student athletes, due to disruption to schedules and sleeping patterns, additional time demands, and uncomfortable sleeping positions.[17] Reducing the frequency of long trips for the team and reducing the number of players traveling could positively impact their sleep and stress levels, as well as physical performance.

Risks

- Traveling on commercial flights rather than charter planes may increase exposure to communicable disease. Switching to commercial flights may lead to increased travel time, leading to heightened stress for athletes and potentially more absences from class. Reduced air travel in favor of travel by bus or van will reduce exposure to communicable disease during travel.[18] It is important to evaluate the costs and benefits of each trip in terms of student health.

1 / Improve travel policies

Financial, Legal, and Regulatory Considerations

- The cost savings of switching from air to ground travel will depend on the costs and distance of individual trips. However, you can expect at least some cost savings, as bus and van travel is typically cheaper than air travel.
- Commercial flights are cheaper than charter flights.
- To address travel emissions that cannot be eliminated, consider following through on the other projects detailed in this report to offset the remaining emissions from travel.
- Use the air travel fee to incentivize coaches and teams to travel via bus or van instead of flying to competitions and training trips and raise funds for other GHG emissions reduction projects.

  → **See Appendix C** for model contract provisions between an athletics department and its external travel coordinator.

Moving Forward

- Assess your athletics department's travel profile. Do teams mostly travel regionally using buses? Does your athletics department travel mostly via air or ground? Does travel vary significantly by team? Understanding which modes of travel are dominant and which teams travel most frequently must guide your decision-making. → **See Appendix D** for details on how to calculate emissions associated with different types of travel.
- Changing travel policies requires significant buy-in from coaches and department leadership. If you are a department leader, invest in this project and seek support from the administrative staff who coordinate travel.

Image Credit: Author's photo

Image Credit: Author's photo

Heavy Hitters

2 / Heat pools with solar water heaters

4,000 Tonnes CO_2e
Project lifetime emission reduction

20 Years
Project lifetime

$500,000
Capital cost

$57,000
Annual energy savings

$65,000
NPV of capital costs and energy savings over 20 years

$16
NPV/tonne emission reductions over project lifetime

Project Screening Score

See Appendix A for Financial Summaries

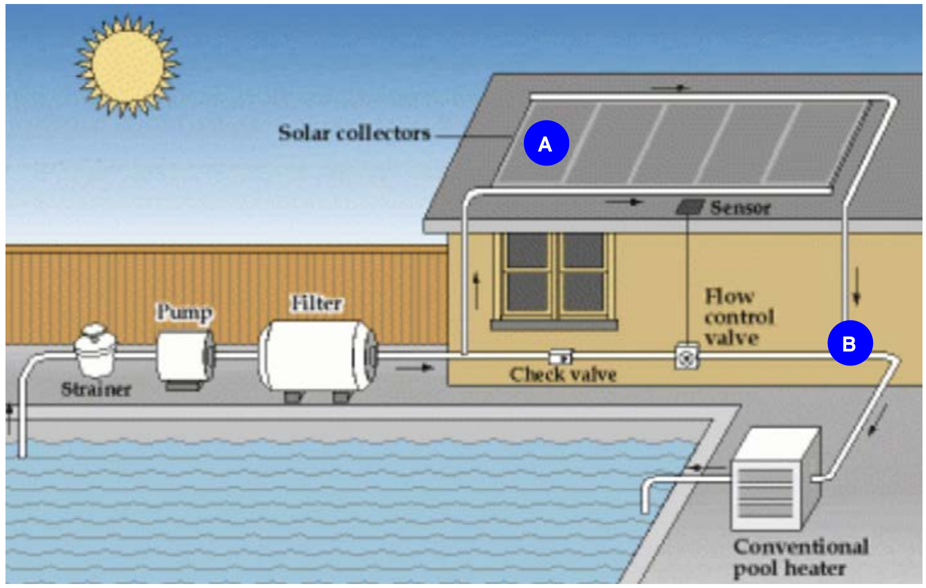


Image Credit: US Department of Energy

Solar water heating system

Heating a pool requires a tremendous amount of energy; it is a continuous process that requires near-constant heating to keep the pool between 78°F and 82°F.[19] Most swimming pools use natural gas or electric heat pumps to heat the pool, both of which generate GHG emissions. As an alternative, solar water heaters can be used. These heaters reduce or eliminate the need for electricity or gas to run the pool heater, thus saving energy and money after installation of the solar water heating system.

Implementation

A. Solar energy hits absorber plates on solar hot water panels; this captures the solar energy and converts it to heat.[20]

B. This heat is then transferred to pipes that contain water, and the water is run through the pipes until it reaches its destination. This destination could be a storage tank to maintain the hot water, or the swimming pool itself.

C. In a sunny, southern state, the area of solar panels needed to heat a pool is equivalent to the surface area of the pool.[21] For example, an Olympic-sized swimming pool is about 13,000 square feet, and it thus requires 13,000 square feet of solar panels to heat it. In northern states and areas that receive less sunlight, more solar panels will be needed.

D. Place panels in a southern-facing direction to maximize the amount of sunlight they can absorb.[22] Depending on building orientation and load capacity, the pool rooftop can be an ideal location for placing panels because it is necessarily at least the same size as the pool. However, given the weight of solar panels, not all pool roofs will have sufficient structural capacity to bear this load.

E. If the pool roof is not feasible for solar water panels, consider installing the panels on the roof of an adjacent building or in an open field area or parking lot. Even if pool heat cannot be fully powered by solar, a smaller-scale solar project can be helpful in reducing energy use while still maintaining the existing electric or natural gas swimming pool heating pumps.

Co-Benefits

- The visibility of rooftop solar will increase the visibility of the sustainability initiatives your athletics department is accomplishing.
- Using solar energy to heat a pool will reduce the amount of energy needed for the pool, thus reducing the amount of air pollution released by the power plant supplying this energy. Reducing local air pollution will improve the respiratory health of the student body and local community, particularly among vulnerable populations.[23]

Heavy Hitters

2 / Heat pools with solar water heaters

Financial, Legal, and Regulatory Considerations

- This project may recoup its cost within a 10- to 20- year time period → **See Financial Summary in Appendix A**; therefore, funding can likely be generated from a green revolving fund or any similar long-term, low-interest financing mechanism. → **See Getting It Done, page 56** for more information on green revolving funds.
- Many states and localities offer incentives to implement solar power technology. Check whether your state can help fund this project. The DSIRE database is a useful tool for researching which incentives may apply in your area.[24]
- Some solar installers allow for power purchase agreements, where the customer pays per kWh of energy produced rather than paying outright for the solar panels. Consider this potential option as it shifts costs from upfront capital expenditures to operational expenditures, which may be easier to source from a budgeting perspective.
- Cost savings will depend on the price your university pays for energy (electricity or natural gas). Similarly, GHG emissions reductions will vary based on the type of energy that feeds your local grid. If your energy grid relies primarily on coal or diesel power (more emissions-intensive), versus natural gas (less emissions-intensive), this project will have a greater emissions impact.

Moving Forward

- Conduct a review of athletics buildings to decide where the solar array could be most efficient. Ideally, the swimming pool rooftop or rooftop of a nearby building will be amenable to a solar panel installation, which would reduce the piping required to transport the heated water from the solar array to the swimming pool. In the northern hemisphere, south- facing roofs that are not shaded are the best for solar arrays.
- Solar installations weigh down rooftops considerably. This issue and associated costs need to be taken into account and should be raised in a Request for Proposal (RFP) that goes out to developers.
- Installing rooftop solar requires a time frame when the swimming pool can go unused. We recommend capital projects of this nature to take place over the summer, when students and athletes tend to be off campus and the facilities are being used less.
- Does your university have an ice rink? Consider using waste heat recovery from the ice rink to heat the pool instead of solar water heating.

Image Credit: Vandy Spirit, Creative Commons

Image Credit: R Boed - Creative Commons

3 / Reuse waste heat at ice rinks

5,400 Tonnes CO_2e
Project lifetime emission reduction

24 Years
Project lifetime

$300,000
Capital cost

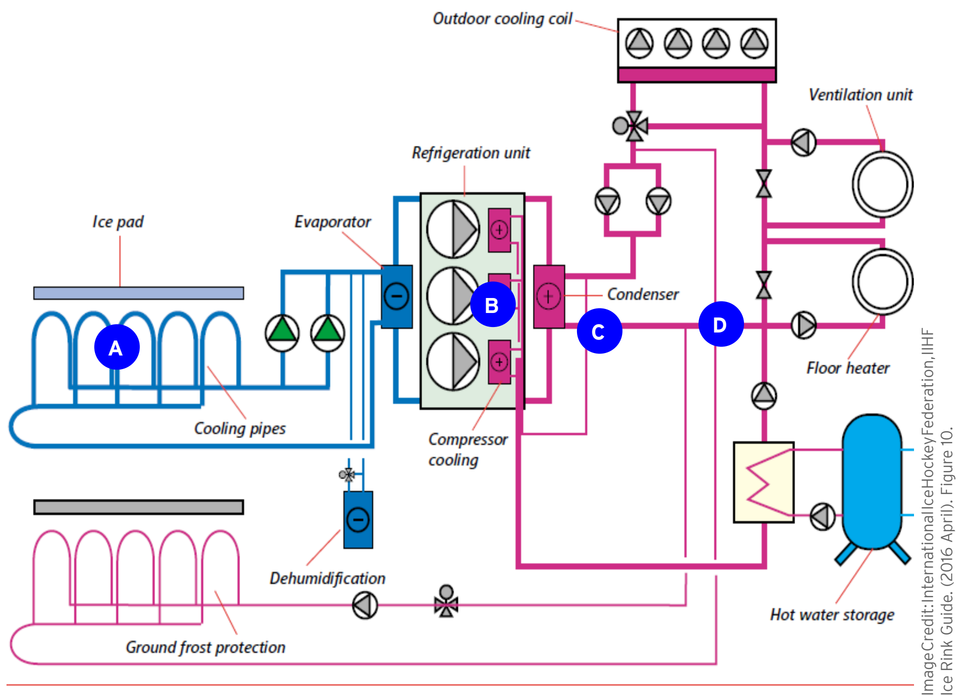
$64,000
Annual energy savings

$370,000
NPV of capital cost and energy savings over 24 years

$70
NPV/tonne emission reduction over project lifetime

Project Screening Score

See Appendix A for Financial Summaries



Graphic of ice rink refrigeration system with heat recovery

The ice rink is often an athletics department's most energy-intensive building. Ice rinks require simultaneous cooling and heating to get the ice ready to play while also keeping the arena warm enough for spectators. Although ice rinks have several energy systems (refrigeration, heating, ventilation, dehumidification, and lighting), the refrigeration system, which keeps the ice frozen by removing heat from the ice, typically uses the most energy (accounting for ~40% of an ice rink's total energy use).[25] As it cools the ice, the refrigeration system emits waste heat. Instead of letting this heat leave the building unused, athletics departments can capture heat from condensers to heat and ventilate other systems within the building.

Implementation

A. Ice rinks have different refrigeration systems depending on whether they cool the ice pad directly, indirectly, or as a combination. In a direct system, a refrigerant (such as R-22 or ammonia) circulates through tubes below the ice pad and directly cools the ice. In an indirect or hybrid system, a primary refrigerant (such as ammonia) cools a secondary refrigerant (such as glycol), which then circulates through cooling pipes below the ice pad before returning to the evaporator.[26]

B. Depending on exterior and interior temperature, compressors in the refrigeration unit adjust the amount of cooling production needed to cool the ice pad. When temperatures are lower (e.g., in the winter or overnight), the compressors produce less cooling, whereas hot exterior temperatures require compressors in the refrigeration unit to produce more cooling.

C. As the refrigeration unit works to maintain the ice, it rejects waste heat through a condenser. The refrigeration system produces two grades of heat: high-grade heat (140°F, approximately 15% of waste heat) and low-grade heat (80°F, 85% of waste heat).

D. Install a heat recovery system to capture this waste heat and redistribute it depending on whether it is high-grade heat or low-grade heat. High-grade heat is useful for heating water for locker rooms or restrooms. Low-grade heat can be stored in heat pumps and used for pre-warming fresh air entering public spaces, preheating dehumidifier reactivation wheels, or heating radiant floors (if present in the building).[27] In addition to using waste heat for local systems within the building, such as heating office spaces or melting ice shavings from the zamboni, a university could also direct waste heat to a neighboring pool.

Co-Benefits

- Improved energy efficiency will decrease the amount of energy produced in order to operate the refrigerant system, thus decreasing the amount of air pollution associated with the operation of the refrigerant system. According to the World Health Organization (WHO), reducing air pollution levels can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma.[28]

- Recovering the waste heat will lead to reduced waste heat release into the environment. On urban campuses in particular, waste heat can contribute to the "urban heat island" effect, which can exacerbate the impact of heat waves and negatively affect human health and comfort.[29] Waste heat from energy production can also negatively affect local aquatic ecosystems surrounding the university.[30]

3 / Reuse waste heat at ice rinks

Financial, Legal, and Regulatory Considerations

- Some ice rink refrigeration units use HFCs (such as R-22) as their primary or secondary refrigerants and could therefore be impacted by existing or emerging HFC regulations that limit the use of these potent GHGs. For example, CA, VT, WA, CT, DE, MD, and NY have each taken steps to limit the use of HFCs with high GWPs.[31] Other states, including MA, ME, and RI have proposed restrictions on the use of HFCs. If a new regulation will require retrofitting your ice rink, consider implementing this project concurrently to save time and costs.

- This project may recoup its cost within a 10- to 20-year time period. → **See Financial Summaries in Appendix A.** Therefore, funding can likely be generated from a green revolving fund or any similar long-term, low-interest financing mechanism. → **See Getting It Done, page 56** for more information on green revolving funds.

Moving Forward

- Consider whether this project is right for your school. If systems are older and no heat recovery efforts are in place, adding a heat recovery system may make sense.

- Conduct further analysis and cost estimation. Request a system evaluation and quote for heat recovery (including pipes, valves, and additional heat pumps) from a refrigeration consultant with expertise in ice rinks.

- Coordinate with your facilities schedule. Universities can undertake this type of update during the ice rink off-season, which is typically at least 1-2 months in the summer.

- Monitor baseline energy use before implementing the project so that improvement can be documented.

- Identify other opportunities to reduce energy at the ice rink. If your refrigeration systems use HFCs, consider replacing the refrigeration system with one that uses ammonia. There may also be opportunities to lower energy use through temperature controls; look into reducing the temperature set point in the stand or increasing ice temperature. → **See Quick Wins, page 48** for more details.

Heavy Hitters

4 / Improve refrigerant management and disposal

Strategy 1: Implement Preventative Maintenance

10,000 Tonnes CO_2e
Project lifetime emission reduction

20 Years
Project lifetime

$Zero
Capital cost

$22,000
Additional annual maintenance costs

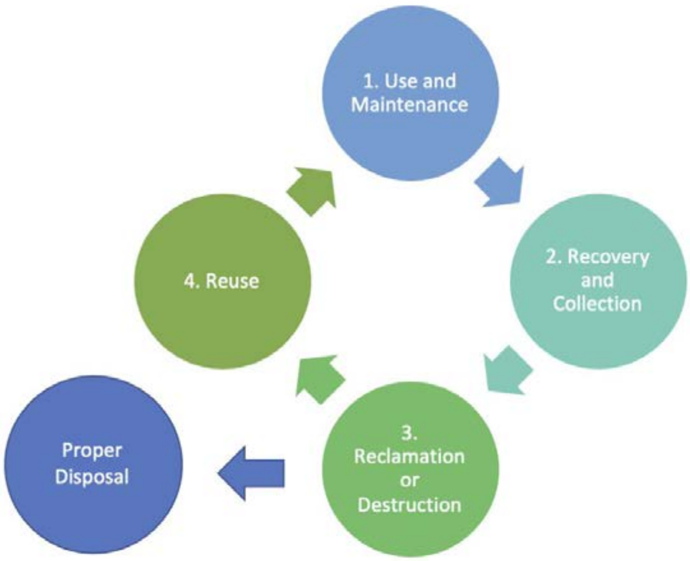
$2,500
Annual savings from reduced refrigerant purchases

($195,000)
NPV of additional maintenance costs and savings from reduced refrigerant purchases

($20)
NPV/tonne of emission reductions over project lifetime

Project Screening Score

See Appendix A for Financial Summaries



HFC management, recovery, reuse, and disposal process

Athletics departments typically use fluorinated chemicals (chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and hydrofluorocarbons (HFCs)) as chillers, or the working fluid in air conditioning systems, refrigerators and fire-extinguishing foams.[32] These chemicals, while effective refrigerants, have global warming potentials 1,000 to 9,000 times that of CO_2.[33] When these refrigerants escape into the atmosphere—either through small mechanical leaks or accidental catastrophic leaks—they drive global warming.

Athletics departments can reduce the impacts of these potent chemicals by (1) minimizing emissions leakage through preventative maintenance, (2) properly disposing of and using reclaimed HFCs, (3) replacing currently used HFCs with HFCs that have lower GWPs, or (4) replacing equipment. In order to achieve these strategies, departments should first create an inventory of all HFC systems under their purview, including those that use less than 50 pounds of HFCs, and ensure that at least one employee is responsible for managing these emissions.

Implementation

Strategy 1: Minimize emissions leakage through preventative maintenance.

Create an inventory of equipment that uses HFCs. While EPA guidance suggests keeping inventories for equipment containing more than 50 pounds of HFCs, we recommend expanding the inventory to include all HFCs in the athletics department.

HFC leaks cause high-GWP emissions and can occur for a number of reasons, including a burst pipe. Leaks become more likely as equipment ages.[34] Enhance leak detection through either a technological or manual solution. A manual solution might involve contracting with a service provider to check refrigeration equipment for leaks on a monthly basis. A technological solution includes installing leak detection hardware on refrigeration equipment.[35] This hardware detects when a room is not as cool as expected and alerts the system that something might be wrong with the refrigerant.

Strategy 2: Properly dispose of refrigerants and procure reclaimed ones.

Refrigerants release up to 90% of their emissions at the end of their life and therefore should be carefully removed from refrigeration systems and stored. At that point, they can be reused or transformed into chemicals with lower warming potentials. The EPA's Responsible Appliance Disposal program offers universities options for recycling or reusing refrigerants.[36] Costs vary depending on the structure of the local programs run by municipalities, local businesses, and utilities.

Use reclaimed HFCs when you need to replace leaked HFCs or when you want to substitute HFCs that have a lower global warming potential. When issuing RFPs for cooling systems, specify that you would like to use reclaimed HFCs. Reclaimed HFCs can be counted as an offset under the American Carbon Registry Methodology.[37] Make sure to also incorporate responsible HFC purchasing policies into your procurement guidelines. → **See Appendix B** for more information.

4 / Improve refrigerant management and disposal

Implementation

Strategy 3: Replace existing refrigerants with lower-GWP alternatives.

Phasing out HFCs requires replacing HFCs with alternatives that have lower global warming potentials and properly disposing of those replaced. Unfortunately, even with regular servicing and active maintenance, leaks will not be completely eliminated.[38] Different refrigeration systems require different mixes of HFCs, each with different GWPs. The most appropriate alternatives depend on the type of refrigerant mixture currently being used. For example, R-404a (GWP of 3,922) can be replaced by R-442A (GWP of 1,888) or a CO_2 system (GWP of 1).[39] Some of these replacements are "drop-in," which means that no system upgrades are required. Others require updated or new equipment. Alternative HFCs often save electricity, and therefore have a positive NPV. For details on positive NPV projects that replace high-GWP HFCs with lower-GWP alternatives, please review the manual *Reducing the Impact of Harvard's Halocarbon Use*.[40]

Estimated Potential Annual GHG Emissions Reductions from Typical Drop-In and Other Halocarbon Replacements

Halocarbon (HFC)	Typical Purpose in Athletics Department	20-Year GWP[41]	Possible	20-Year GWP of Replacement[42]	Difference in GWP Per lb of HFC over 20 Years
HFC-404a	Cooling	3,922	HFC-442a (Drop-in)	1,888	2,034
HCFC-22	Ice rink cooling	1,810	R-717 (Ammonia)	0	1,810
HCFC-22	Refrigeration and air conditioning	1,810	R-134a (Drop-in)	1,430	380
HFC-134a	Refrigeration and air conditioning	1,430	R-744 (CO_2)	1	1,429
HFC-410a	Air conditioning	2,088	HFC-32	675	1,413

4 / Improve refrigerant management and disposal

Co-Benefits

- Studies have found that HFCs have a low potential for human toxicity and do not pose a direct health risk.[43]
- The benefits gained from properly maintaining HFCs will increase as average temperatures continue to rise in many parts of the country and more air conditioning is needed to keep the athletics buildings at appropriate temperatures for student athletes and staff.

Risks

- A common HFC replacement, ammonia, is poisonous in large concentrations and flammable under specific conditions.[44] While accidents are historically very uncommon, it is critical to follow all appropriate safety guidelines when installing and maintaining a refrigeration system using ammonia or another natural refrigerant.

Financial Considerations

- HFCs are not typically managed by a single person within an athletics department, and despite having a high warming potential, they can fall between the cracks. Therefore, in addition to creating a complete HFC inventory, we recommend tracking operational costs (for preventative maintenance and replacements) and capital expenditures for HFCs.
- Strategy 1: Leak management can be a negative NPV project. Note, however, that Section 608 of the Clean Air Act prohibits the knowing release of refrigerant through leaks; hence, leak management is required.[45] There is likely to be a positive NPV when including the social cost of carbon.
- Strategy 2: Replacing HFCs may be NPV-positive, as some lower-GWP HFCs are more energy efficient.
- Strategy 3: The destruction or reclamation of HFCs is recognized as an offset.[46] Therefore, emissions reductions can be used to offset part of the expenditure for this project.
- Upfront costs of replacing or reusing HFCs could be funded in part through the green athletics donor fund, or even a green revolving fund if projects are NPV-positive.

Legal and Regulatory Considerations

- The Kigali Amendment has been ratified by 65 countries, each committing to reduce production and consumption of HFCs by more than 80% over the next 30 years. Universities could commit to the Kigali Amendment framework, which includes properly disposing of HFCs.[47]

- Some refrigerant systems could be impacted by federal and/or state HFC regulations that limit the use of these potent GHGs. For example, CA, VT, WA, CT, DE, MD, NY, MA, RI, and ME have each taken steps to limit the use of HFCs with high GWPs.[48]

- EPA provides guidance on reuse and recycling schemes for refrigerants.[49]

Moving Forward

Conduct an inventory of HFCs in your athletics department:

- First, identify all the cooling systems that use HFC refrigerants in your athletics department, even those that require less than 50 pounds of refrigerant. Document the type and amount of HFC used.
- Identify who is responsible for proactive maintenance and how leaks are currently detected.
- Determine when HFC refrigerants were last replaced and how the decision to replace them was made.
- Identify the process your department currently uses to dispose of HFCs at the end of their lives.
- Determine the cost of maintaining and retiring/ replacing existing HFC systems.

With this HFC inventory, conduct the following next steps:

- Identify a project lead. This person will likely be a facilities staff member in the athletics department who can work with the school's sustainability team and compliance department to manage HFCs. Given the emerging HFC regulations at the state level, your environmental health and safety department may wish to be involved in your decision-making.
- Conduct further analysis and obtain a cost estimate. Hire a consultant to assess potential alternatives for each HFC. For example, you may be able to use ammonia rather than HFCs to cool your ice rink.
- Review options for properly retiring HFCs in your state and municipality, and based on this research, create a policy for disposing of HFCs in your department.

Heavy Hitters

5 / Use of anaerobic digester for organic and compostable wastes

8,600 Tonnes CO_2e
Project lifetime emission reduction

20 Years
Project lifetime

$845,000
Capital cost

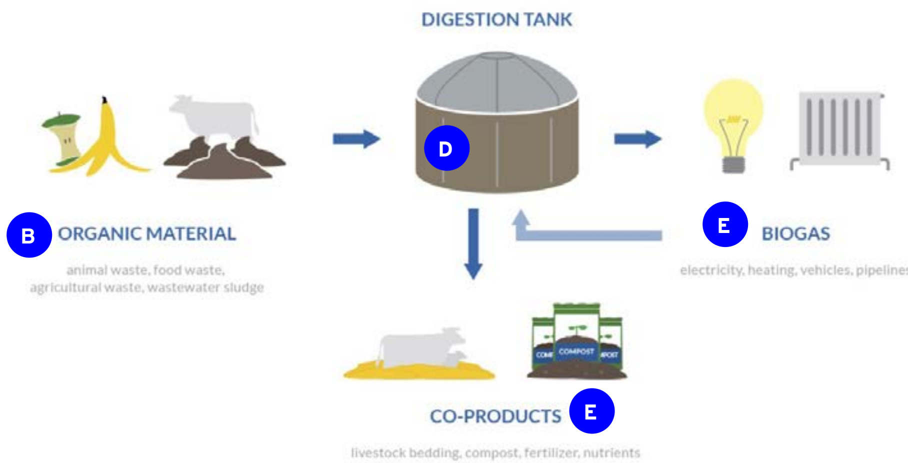
$140,000
Savings from energy generation and fertilizer sales, less annual digester operating costs

$500,000
NPV of capital and operating costs, fertilizer sales, and energy savings over 20 years

$60
NPV/tonne of CO_2e avoided over project lifetime

Project Screening Score

See Appendix A for Financial Summaries



Anaerobic digester process

Image Credit: J&J Carter

Food and other organic waste produce a large amount of GHG emissions. Anaerobic microdigesters provide a solution to this problem. Anaerobic digestion refers to the processing of organic waste in an oxygen-free environment. This form of waste disposal has dual benefits. First, it reduces the amount of organic waste that reaches landfills, thereby reducing the methane emissions associated with that type of waste disposal. Second, the byproducts of anaerobic digestion can be repurposed and sold. Captured methane can be used to generate heat or electricity, reducing energy costs. Additionally, the “digestate,” a nutrient-rich byproduct, can be sold as fertilizer.

By installing a small-scale anaerobic digester, also known as a micro-digester, athletics departments can both reduce the GHG emissions associated with the disposal of organic waste and offset fossil fuel use through the production of heat and electricity. However, the financial feasibility of an anaerobic digester largely depends on the quantity of waste that is diverted from landfills. Athletics departments typically do not alone produce enough waste to justify the cost of a digester.[50] We therefore recommend partnering with nearby large-scale organizations, such as other departments within your university, nearby schools, and large businesses.[51]

Implementation

A. A micro-digester is designed to process up to 1,000 tons of food waste per year and is about the size of a shipping container. The compact size of the digester means that it can be placed on athletics grounds. Carefully implement maintenance to ensure that the digester does not remain out of commission for prolonged periods and cause waste build-ups.

B. Waste comes in many different forms. In order to be processed in an anaerobic digester, waste must be sorted so that only organic matter is processed. Organic matter includes food waste, biodegradable packaging and materials, and landscaping waste.

C. Anaerobic digesters are cost-efficient when they operate at near maximum capacity (around 1,000 tons of organic waste). Most athletics departments currently produce around 50 tons of organic waste. Increase the use of biodegradable packaging used by concession vendors and organic waste on campus to increase the amount of available organic waste. To ensure the financial viability of anaerobic digesters, partner with local organizations and schools to aggregate organic waste.

D. The digestion process involves three steps: (1) the decomposition of organic materials, (2) the conversion of decomposed materials to organic acids, and (3) the conversion of organic acids to methane gas.[52]

E. There are two byproducts from anaerobic digestion: biogas and digestate. Biogas can be repurposed as heat or electricity for the athletics department's buildings and other university buildings, or purified and then resold to utilities to offset the upfront cost of the digester. Similarly, digestate can be used as a fertilizer on-site or can be resold.

Co-Benefits

- The anaerobic digester will reduce the amount of energy needed by the athletics department, thus reducing the amount of air pollution released by the power plant supplying this energy. Reducing local air pollution will help to improve the respiratory health of the student body and the local community, particularly in more vulnerable populations.[53]
- Using the digestate from the micro-digester will reduce the amount of synthetic fertilizer needed by the purchaser, thus reducing the amount of contamination by nitrogen runoff into nearby surface and groundwater.[54]

Risks

- If operations are not closely monitored, there is a risk of foul odor being released from the digester. Exposure to odor usually causes discomfort, but if excessive, may lead to coughing and respiratory irritation.[55] However, proper management will prevent the micro-digester from emitting odors.

5 / Use of anaerobic digester for organic and compostable wastes

Financial, Legal, and Regulatory Considerations

- Consider collaborating with other departments within your school, fellow schools, and local businesses to source organic waste and to share capital and maintenance costs of the digester. This will help ensure that the microdigester operates at full capacity.
- Look into selling the digestate as organic fertilizer to recoup digester operating costs. Note that different buyers require digestates with different properties.
- Athletics departments that invest in a microdigester should maximize their compostable waste. → **See Appendix C** for model contract provisions between an athletics department and its external landscaper and concessionaire.
- Renegotiate waste management contracts to exclude biodegradable and organic waste.
- An anaerobic microdigester is too small for waste facility management regulations to apply.
- → **See sample Financial Summary in Appendix A.**

Moving Forward

- To maximize organic waste, replace conventional packaging and products with biodegradable materials. → **See Appendix B** for model procurement guidelines.
- Include sustainability provisions and source-sorting requirements as standard language in contract provisions with landscapers and concessionaires. → **See Appendix C** for model contract provisions.
- Perform a waste audit to identify the extent of biodegradable waste produced by the athletics program. If there is insufficient waste to utilize the anaerobic digester to maximum capacity, partner with local organizations to divert their organic waste from landfills. Be mindful of the distance waste must travel from partner organizations; transportation may generate emissions.
- Identify an area that can host the digester with sufficient space and has access to roads and limited foot traffic.
- Establish partnerships with treatment facilities to sell the digestate byproduct. Identify whether biogas energy could be used to power athletics department buildings and other university buildings, or sold back to the local grid.

Actions

Quick Wins

1. Replace conventional lighting with LEDs
2. Improve laundry efficiency and apparel procurement
3. Generate power through on-site solar
4. Re-wild mowed lawns
5. Increase temperature control at ice rinks

Quick Wins

1 / Replace conventional lighting with LEDs

185 Tonnes CO_2e
Project lifetime emission reduction for converting to LED lighting at one mixed-use athletics facility

5 Years
Project lifetime

$30,000
Capital cost

$10,000
Annual energy savings

$12,000
NPV of capital cost and annual energy savings over 5 years

$65
NPV/tonne of emission reduction over project lifetime

Project Screening Score

See Appendix A for Financial Summaries

Image Credit: Osborn Aquatic Center

Before (right) and after (left) photograph of pool with LED lighting.

Lighting constitutes around 20% of total electricity usage at US schools.[56] Upgrading incandescent lighting to compact fluorescent lamp (CFL) lighting or light-emitting diode (LED) lighting can save 75%–80% of energy used for lighting.[57] Also, given that CFL lights can last up to 10,000 hours and LED lights can last up to 25,000 hours (10–25 times longer than traditional incandescent lighting), they cost less to operate over the lifetime of the bulb.[58]

Retrofitting with LED lights requires minimal expertise, so no additional expenses are incurred to install the cost of the fixture. A department's existing maintenance staff can conduct the replacement under minimal-to-no supervision. Because old light fixtures can be replaced one at a time, this project does not require a pause in building operations. Consider buying lights in large quantities to benefit from supplier discounts, then install them according to the needs of different buildings.

Financial, Legal, and Regulatory Considerations

- LED lights last much longer than standard incandescent bulbs, which reduces maintenance costs.
- LED conversion projects typically pay back within 3–5 years. Consider obtaining funding from a green revolving fund. → **See Getting it Done, page 56** for more information on green revolving funds. → **See sample financial plan in Appendix A.**

Co-Benefits

- LED lights have been found to improve productivity, increase employee and student motivation and commitment, and improve concentration and energy.[59]

Quick Wins

2 / Improve laundry efficiency and apparel procurement

81 Tonnes CO_2e
Project lifetime emission reduction

12 Years
Project lifetime

$10,000
Additional capital cost to purchase 10 Energy Star washing machines instead of inefficient machines

$2,000
Annual energy savings from running 10 Energy Star washing machines instead of inefficient machines

$4,500
NPV of capital costs and energy savings over 12 years

$55
NPV/tonne emission reductions over project lifetime

Project Screening Score

See Appendix A for Financial Summaries

Image Credit: Jeffrey Lin, Unsplash

Athletics teams use material goods in many forms, including what they wear (apparel) and what they train and compete with (basketballs, tennis rackets, helmets, etc.). The emissions it takes to produce and transport this equipment or apparel can be reduced by up to 20% through sustainable procurement decisions. Materials also need to be cleaned, and school laundry machines frequently run all day to clean uniforms. Using energy-efficient laundry machines can further reduce emissions by 40%.

Image Credit: Wade Austin Ellis, Unsplash

Strategy 1: Install Energy-Efficient Laundry Machines.

Apparel and clothes laundering results in notable GHG emissions. Replacing existing washing and drying machines with energy-efficient versions can save up to 40% of electricity used for laundry.[60] Products that earn the Energy Star certification are independently certified to save energy, save money, and protect the climate. This will involve installing new laundry machines, and could be done as part of scheduled replacements or proactively in order to reap the benefits of more efficient appliances. → **See Financial Summaries in Appendix A.**

Laundry-related behavioral changes within the athletics department could further reduce emissions. These include ensuring that only full loads are washed and dried, or washing on a cooler setting.

Strategy 2: Implement Sustainability Provisions with Suppliers to Reduce Manufacturing Emissions.

Material goods contain embedded emissions—the emissions generated by the production and delivery of goods—that are a source of Scope 3 emissions.[61] Athletics departments typically contract with one apparel supplier to keep apparel consistent across teams. Equipment and apparel suppliers produce sustainability reports that include the estimated emissions per product and their strategies to reduce emissions. Incorporating sustainability provisions in contracts with your materials or equipment supplier can reduce your emissions. For example, include a clause that requires a 20% reduction in per-product GHG emissions over 5 years.

Quick Wins

2 / Improve laundry efficiency and apparel procurement

Financial, Legal, and Regulatory Considerations

- Energy-efficient laundry machines have a positive NPV due to their lower operating costs as compared with non-energy-efficient machines. → **See Appendix A.**
- This project's NPV is calculated over a 12-year time period because that is the typical lifetime of a washing or drying machine.
- Implementing a sustainable purchasing initiative need not cost money. → **See Appendix B** for sustainable procurement guidelines.
- As changes to the Energy Star certification occur, your department may need to update energy savings projections.
- Make sure to discuss sustainability strategies with your apparel provider before making any purchases. → **See Appendix C** for model contract provisions between an athletics program and its apparel supplier.

Co-Benefits

- Emissions savings from changing non-energy-efficient laundry machines to Energy Star machines are largely due to more efficient water-heating systems. These systems reduce water use and conserve energy without changing the speed or quality of the cleaning or drying.[62]
- The reduction in water use and wastewater produced reduces contamination of the local water system, with potential health and environmental benefits.[63]
- Washing clothes in cold water (20°C, or 68°F), in combination with an ozone system and the right mix and application of chemicals, still disinfects clothes to the same level as thermal disinfection.[64] Cold water cycles are less damaging for workout clothes than hot water cycles.

Risks

- Consult with your laundry machine and detergents supplier to identify the cycles and chemicals mix needed at lower temperatures to achieve the level of disinfection you require.

Quick Wins

3 / Generate power through on-site solar

3,100 Tonnes CO_2e
Project lifetime emission reduction for on-site solar at one mixed-use athletics facility

20 Years
Project lifetime

$400,000
Capital cost

$45,000
Annual energy savings

$40,000
NPV of capital costs and energy savings over 20 years

$13
NPV/tonne emission reduction over project lifetime

Project Screening Score

See Appendix A for Financial Summaries

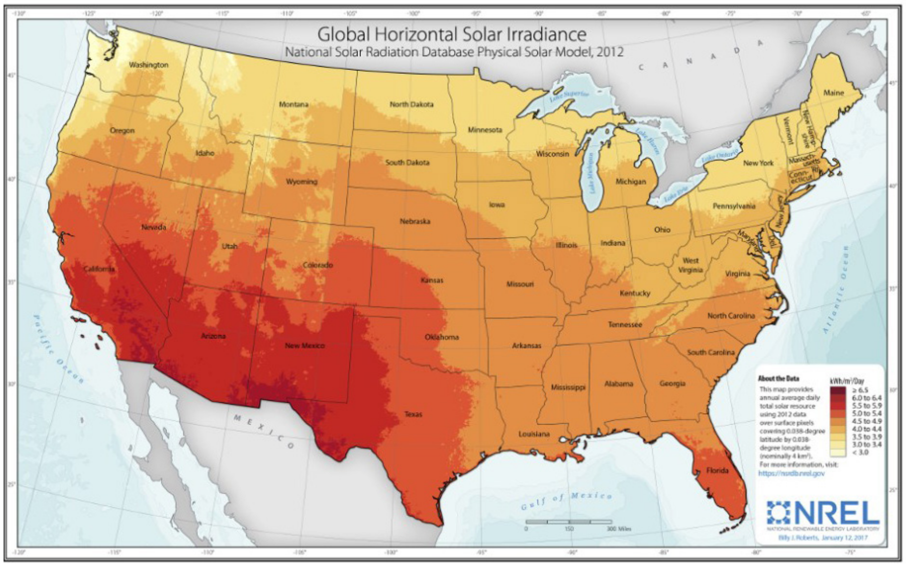


Image Credit: NREL

Global Horizontal Solar Irradiance in the U.S.

On-site solar reduces the amount of energy purchased from your local electric grid and replaces it with renewable energy. This reduces the emissions associated with electricity used in buildings. Start by identifying possible locations to host solar panels, ideally on large, flat rooftops that receive a lot of sun. The tops of parking garages and uncovered parking lots are also excellent candidates for hosting solar panels. Larger spaces, and larger solar arrays, will of course produce more power and reduce more emissions.[65] Identify the energy production of your solar array, which will differ based on size, efficiency of panels, panel placement, and geographic location of your school.[66] From there, calculate GHG emissions reductions by using your local utility's electricity-to-emissions factor.

Co-Benefits

- The visibility of solar installations on campus demonstrates a university's commitment to renewable energy and sustainability initiatives.
- Using solar energy to fulfill on-campus energy needs reduces the release of greenhouse gases, as well as other harmful pollutants, associated with athletics facilities. Reducing local air pollution improves the respiratory health of the student body and local community, particularly among vulnerable populations.[67]

Financial, Legal, and Regulatory Considerations

- Universities that produce their own solar energy have the ability to claim RECs (Renewable Energy Certificates) so that statements such as "20% of our University's locker rooms are powered by renewable energy," can be made.
- There are two options for installing on-site solar. A university can purchase the equipment and pay for its installation up front. Or, for larger-scale installations, the university may be able to enter into a lease agreement or a long-term Power Purchase Agreement (PPA), by which it buys power from a solar developer as it is produced over a 15–25 year period, eliminating the barrier of high upfront costs. → **See sample financial summary in Appendix A.**
- Many states offer incentives to implement solar power technology. Examples include the Massachusetts SMART Program,[68] NY-Sun,[69] and the California Solar Initiative.[70]

4 / Re-wild mowed lawns

35 Tonnes CO_2e
Project lifetime emission reduction

10 Years
Project lifetime

$20,000
Capital cost of re-wilding

$9,000
Annual savings from reduced gasoline and labor costs for mowing

$40,000
NPV of capital cost and annual savings over project lifetime

$1,100
NPV/tonne CO_2e emission reduction over project lifetime

Project Screening Score

See Appendix A for Financial Summaries

Image Credit: UT Environmental Landscape Design Lab

Students studying native plantings at University of Tennessee

Athletics departments maintain large swaths of grass as non-competition recreational spaces. Many departments use gasoline-powered landscaping equipment to mow and tend to these areas, which generates significant GHG emissions.[71] In addition, these spaces receive substantial doses of nitrogen-based fertilizer, which emits nitrous oxide, a potent GHG. Re-wilding these species with native plants will reduce the need for regular mowing and fertilizer application. Universities can begin re-wilding efforts by identifying mowed green spaces not necessary for varsity athletics practice or competition. Field sidelines, recreational common spaces, and even parking medians are all good candidates. Many grassy areas contain different species of plant wildlife, which will grow once left to themselves. Mowing can be reduced and fertilizers can be eliminated.[72] Landscaping teams can also plant low-maintenance wildflower species for visual interest.

Co-Benefits

- Increased biodiversity in green spaces (particularly perceived biodiversity[73]) is associated with improved cognitive performance,[74] improved well-being,[75] decreased stress,[76] and stronger connection to place.[77]
- Exposure to increased biodiversity has been shown to mitigate allergies.[78]
- The aesthetic value of native plants can contribute to the beauty of your campus.

Risks

- Re-wilding recreational areas may diminish opportunity for physical exercise.[79]
- Re-wilding may cause increased exposure to disease-bearing insects.[80]

Financial, Legal, and Regulatory Considerations

- Re-wilding is a basic and inexpensive project for an athletics department with limited capital that wants to participate in emissions reductions projects. → **See Financial Summary in Appendix A.** It is also a visible sign that the department is considering its carbon footprint.
- Re-wilding grassy areas reduces the need for intensive landscaping, thereby reducing a department's labor costs.
- Departments should ensure that there are no operative city ordinances prohibiting re-wilding spaces, such as those limiting grass height.

→ **See Appendix C** for model contract provisions between an athletics departments and its external landscaper.

Quick Wins

5 / Improve temperature control at ice rinks

675 Tonnes CO_2e
Project lifetime emission reduction

20 Years
Project lifetime

$50,000
Capital cost

$10,000
Annual energy cost reductions

$45,000
NPV of capital cost and energy cost reductions over 20 years

$66
NPV/tonne emission reduction over project lifetime

Project Screening Score

See Appendix A for Financial Summaries

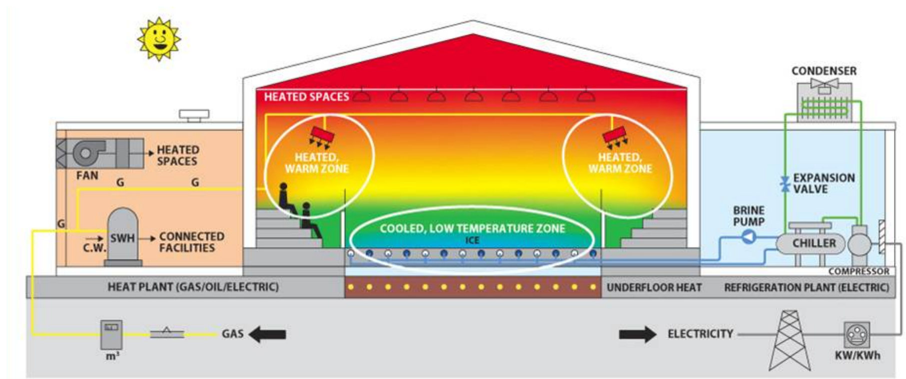
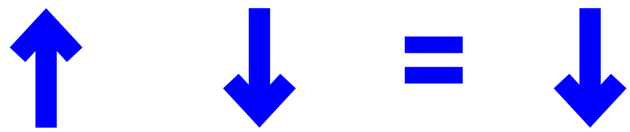


Image Credit: Retscree, 2005 in Karampour

Energy systems in ice rink



Ice rinks require a lot of energy to operate. A simple way of saving energy is to install a control system that allows the ice temperature to be increased. When the ice temperature set point is higher, the refrigeration system does not need to generate as much cooling, thereby reducing the amount of energy used by the refrigeration system.

Although increasing the ice temperature is not possible when the ice is in use, it can be done overnight without compromising skating quality. Raising and cooling ice temperature can even result in higher-quality ice.[81] To increase temperature at night, a school needs a compressor control system that can remotely control the compressors in the ice rink's refrigeration unit. This system, like most temperature and lighting automation control systems, is relatively inexpensive and straightforward to install.

Co-Benefits

- Improved energy efficiency will decrease the amount of air pollution related to the burning of fossil fuels. According to WHO, reducing air pollution levels reduces the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma.[82]

- Improved energy efficiency will also decrease the amount of thermal pollution from the power station associated with the ice rink. Thermal pollution can negatively affect local aquatic ecosystems, affecting the environment surrounding the university.[83]

Financial, Legal, and Regulatory Considerations

- Reduced refrigeration system usage will result in reduced energy usage, which will offset the initial capital investment within the first 10 years of the project's lifetime. → **See Financial Summary in Appendix A.**

- This project can be funded from a green revolving fund, or through the University's capital projects funding, since it pays back within the first 10 years and generates a positive NPV of between $5,000 and $45,000 over the 20-year lifetime of the project. → **See Getting It Done, page 56** for more information on green revolving funds.

Getting It Done

Student, Staff, & Spectator Engagement

Image Credit: Andrew Gearhart, Unsplash

Changing behavioral norms is crucial to lowering GHG emissions worldwide.[84] Student athletes are engaged and excited about playing a leading role in reducing emissions. Because of their visibility on campus, these athletes and their coaches can meaningfully engage in the effort to reduce GHG emissions and serve as a motivating example for others. The captain of a Division One swim team sums it up well, saying, "student athletes represent roughly 1/5 of all undergraduate students on our campus, yet when sustainable education is implemented on campus, it completely neglects athletics as an impact area. It's arguably the largest subset of people on campus, let's act on it!" This athlete's enthusiasm highlights how student athletes themselves can serve to mobilize their schools to act more sustainably. Student athletes are a powerful voice on campus, and they can provide a future-oriented perspective on how schools can improve.

There are many behavioral changes individual athletes and teams can make to help reduce GHG emissions, such as taking shorter showers, turning off lights in locker rooms and fields, reducing laundry, donating uniforms and equipment to new team members, and eating less red meat. Athletics departments can supplement heavy hitter and quick win projects with engagement efforts that encourage environmentally friendly behaviors. These can be led by athletics department staff, coaches, and/or by the student athletes themselves.

Creating Competitions to Reduce GHG Emissions

Athletics thrives on competition. An inexpensive yet impactful way of creating a culture of sustainability within an athletics department is to set up a competition between different teams to be the most sustainable. The competition could be run by an individual coach, an office for sustainability staff member, or the student athlete advisory committee that exists at many schools. The staff member in charge can set up a ranking system for a variety of sustainable behaviors, encouraging students and teams to be creative in how to change the culture of their teams. The winning team at the end of the academic year can choose how to spend their monetary award, with the requirement that any purchases be sustainably sourced.

Impact

- If a class of 200 graduating seniors gave away half their uniforms and equipment (15 products/athlete) to younger teammates, their team could avoid 21 tonnes CO_2 emissions by the new teammates not having to purchase new equipment.
- If an athlete knows they will not be playing or participating in a competition, choosing not to fly to attend the competition can lead to lowered emissions. If an athlete chooses not to take a round trip flight from Boston to Nashville, for example, a total of 1.74 tonnes CO_2 emissions would be avoided.
- If a team completely forgoes plastic water bottles for a season, assuming the average team uses approximately 30 plastic water bottles a week, they could lower emissions by 0.1 tonnes CO_2 per month,[85] or about 1 tonne CO_2 in an academic year.

Implementation

- Creating a competition among teams costs only as much as the monetary reward being granted to the team who wins and the additional stipend given to the staff member or coach who decides to run the competition. We recommend granting the competition manager a $5,000 stipend and giving a reward of $5,000 to the winning team.
- Alternatively, the sustainability office at a university could run this challenge.
- Student athletes often have advisory committees and organizations that might be interested in running events or “sustainability weeks” dedicated to raising awareness about sustainability and athletics.

Student, Staff, & Spectator Engagement

Co-Benefits

- Universities are in a unique position to develop future leaders and help students establish patterns of behaviors and thinking that will shape the rest of their lives. As such, sustainability projects on campuses can have a significant impact in encouraging sustainable lifestyles for their students and alumni.[86]

- Similar projects of student engagement, based on social change theory, have been implemented internationally to great success and highlight the impact and scalability of such approaches.[87]

- The publicity of teams engaging in sustainable behaviors can have an outsized effect if the in-person and TV spectator audience become educated about these behaviors and are inspired to incorporate them into their own lives.

Winning over Skeptics

- Not all athletics fans or participants will be equally convinced about the importance of reducing GHG emissions. If you predict resistance to "green" measures, we recommend emphasizing the cost-savings of the projects and presenting them as investments in institutional resiliency.

- Emphasizing the health benefits of the various sustainability efforts, such as improved physical performance and health of student athletes, can also help you gain a broad base of support regardless of climate-related beliefs. → **See Appendix F** for more information on project co-benefits.

Image Credit: Jonathan Chng, Unsplash

Funding Mechanisms

While many emissions-reducing practices save athletics departments money in the long run, some do not. Others require large up-front expenditures that take a long time to recoup. An athletic department's budget is therefore one of the most important factors in its lowering of emissions. As sustainability becomes a more pressing issue in the public conscience, new sources are emerging to fund initiatives that prioritize sustainability. By fundraising creatively, athletics departments can accomplish emissions reductions that once appeared beyond reach. The following are ideas for funding such projects.

Air Travel Fee

A sustainability fee added to flight bookings could fund offset projects for travel emissions. Many school athletics departments outsource the booking of their flights to a travel agency. Often, a fee of about $25 per flight is applied to each flight booked through an agency. Try adding an extra $5 fee to each flight booked, and charge it to the traveling team's account. This allows athletics departments to directly raise money from the flights whose emissions they hope to offset.

Depending on the number of flights booked, this initiative could raise anywhere from $5,000 to $50,000 annually. While this is not a huge amount of money, it could fund a number of the quick wins described above. This surcharge has the added benefit of encouraging teams to travel by ground.

Student Facilities Fees

Another option to fund green athletics initiatives is to add a sustainability charge to the gym and facilities fees that most students pay along with their tuition. This charge should be large enough to create a meaningful fund but should not be so large that students struggle to pay. As an add-on to gym fees administered by the athletics department, this charge can be directly utilized for the department's sustainability initiatives.

Many universities have university-wide green fees. For example, the University of Arizona added a $24 annual fee per student to create a green fund.[88] Other universities, including the University of Colorado Boulder,[89] Missouri State University,[90] and the University of Texas at Austin,[91] collect $2 to $5 per semester from each student to fund green initiatives on campus.

Charging sustainability fees via student fees would require buy-in from the broader university administration, current students, and alumni. At the University of Colorado Boulder, this was implemented through a student vote, while at the University of Texas at Austin, an entrepreneurial student coordinated with the Office for Sustainability to create the green fund. Money raised by these fees could go towards student-led or student-supported sustainability projects across the athletics department.

Green Game

Marketing a "Green Game" every season with a ticket surcharge could fund some of the sustainability initiatives outlined in this manual.

Athletics departments, especially at schools with large and well-known sports teams, have the funding advantage of regularly selling a product: athletics tickets. Hosting and marketing a "Green Game" with a small sustainability surcharge on ticket sales for one game per season could raise enough money to accomplish important emissions-reducing goals.

Demand for tickets to sporting events is inelastic,[92] meaning that adding a $3 surcharge to a $25 ticket is unlikely to deter spectators from purchasing tickets but would be an important supplement to sustainability budgeting. Proper advertising of this initiative may, in fact, engage fans and students passionate about climate change to attend games they otherwise may have skipped.[93] For example, a surcharge on just one football game with an attendance of 30,000 spectators could raise nearly $100,000.

Image Credit: Presentation College, Creative Commons

Athletics Sustainability Fund

An athletics donor fund focused on sustainability could support several sustainability initiatives outlined in this manual. Athletics departments provide opportunities for former athletes, parents, and other stakeholders to contribute to specific activities and projects. These donations support individual teams, capital projects, and targeted initiatives such as increasing gender equity in sports. This fund could support projects through grants without expectation of a return.

When creating this fund, effective messaging is crucial to its success. Potential donors like to know what they are giving to—try to be as specific as possible when describing how the fund money will be used. Try setting a different goal each semester or school year. For example, a department could advertise that the funds from the first year's proceeds will go towards installing solar panels on the roofs of a school's athletics facilities.

Sustainability offices can work closely with fundraising teams to develop a consistent message and outreach plan for the fund, as sustainability might not currently be a talking point of athletics fundraising teams. In order to raise the profile of this work, the sustainability fund could be advertised at events and through the school's alumni network, and might even attract donors not previously inclined to contribute money to the athletics program.

Green Revolving Fund

Funds raised from donations or fees could seed a replenishing fund that would provide schools with the upfront money necessary to pay for sustainability initiatives that recoup their costs.[94]

A green revolving fund would benefit projects that will reduce the greenhouse gas emissions of the university, require upfront capital, are NPV-positive, and have longer lifetimes than typical university projects. Each sustainability initiative funded would save the borrower money. Over several years, the borrower would pay back to the fund, plus interest. These types of funds are particularly effective at supporting small- to medium-budget items that recoup their costs within a time frame of around 7–12 years. For example, a green revolving fund could cover the cost of retrofitting athletics buildings with energy-efficient lighting, which often saves departments money in the medium-term.

If your school does not have such a fund, consider working with other university programs to advocate for one. Examples include Harvard University's Green Revolving Fund, the University of Vermont's Energy Revolving Fund, and Arizona State University's Sustainability Initiatives Revolving Fund.[95] A common funding source for seed capital is the university's annual operating budget.[96] Operating budgets are more flexible than other sources of capital, and savings generated by sustainability initiatives will likely accrue to operating budgets. Less common sources of funding include endowment principal, capital project budgets, donations, and government funding. See *Green Revolving Funds: A Guide to Implementation and Management* for a useful guide on establishing and sustaining a fund.[97]

Glossary

Anaerobic Digestion: A series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. This process is used to turn organic waste into biofuel, which then can be used to produce energy.

Carbon dioxide (CO_2): A gas produced by burning carbon and organic compounds. CO_2 is a primary contributor to global warming.

CO_2 equivalent (CO_2e): CO_2 equivalent is used to compare emissions from various greenhouse gases due to their global warming potential. Greenhouse gases like methane and HFCs are converted into their CO_2 equivalent so it is easier to compare across gases.

Embedded emissions: The emissions generated by the production and delivery of material goods. These emissions, which are typically counted as Scope 3, constitute a large percentage of an organization's emissions but are not typically quantified.

Greenhouse gases (GHGs): Gases that contribute to global warming by trapping heat in the atmosphere. Common GHGs include CO_2, methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes).

Global warming potential (GWP): A measure of how much heat a greenhouse gas traps in the atmosphere relative to carbon dioxide over a given time period (typically 100 years). CO_2 has a GWP of 1, while some potent compounds, like HFCs, have GWPs in the tens of thousands.

Hydrofluorocarbons (HFCs): HFCs are compounds frequently used in refrigeration and air conditioning systems. HFCs became popular as substitutes for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) because HFCs are less ozone-depleting. However, HFCs have very high global warming potentials, and as a result, countries and states have increasingly implemented phase-out regulations.

Life-cycle cost analysis (LCCA): A method for evaluating all relevant costs over the lifetime of a project, product, or other measure. LCCA is a preferred costing method because it takes into account the cost savings associated with, for example, purchasing a more energy-efficient product compared to purchasing a conventional product.

Scope 1 emissions: Direct GHG emissions owned or controlled sources (e.g., emissions from a university-owned power plant)

Scope 2 emissions: Indirect GHG emissions from purchased energy (e.g., emissions from purchased electricity)

Scope 3 emissions: All indirect GHG emissions not included in Scope 2 (e.g., emissions from production and transport of purchased equipment, waste disposal, and travel in non-university-owned vehicles)

Appendix A: Financial Summaries

Heavy Hitters

1 / Improve travel policies

Costs	
Capital and operating costs to change travel policies	$0
Annual travel *savings* after improved policies	$25,000
NPV of travel savings over 10 years	**$167,752**
Avoided emissions	
Annual emissions avoided (tonnes CO_2e)	300
Avoided emissions over 10 years (tonnes CO_2e)	**3,000**
Annual savings/tonne CO_2e emissions avoided	**$83**
NPV/tonne emissions avoided over 10 years	**$56**
Accounting for social cost of carbon (SCC)	
SCC ($/tonne CO_2e)	$42
Annual social cost savings from avoided emissions	$12,600
Annual travel cost savings + social cost savings	$37,600
Annual savings/tonne CO_2e emissions avoided, accounting for SCC	**$125**

Assumptions and sources

Discount rate	8%

Assumes improved travel policies (buses rather than flights, and commercial rather than charter flights) lead to less expensive travel for about 20 trips annually. Note that this number will vary depending on many factors, including the region that the university is in.

Assumes that taking buses rather than flights, and commercial rather than charter flights, for 20 trips annually will avoid emissions of about 300 tonnes CO_2e annually.

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix A

Heavy Hitters

2 / Heat pools with solar water heaters

Baseline	
Annual electricity usage (kWh)	1,500,000
Annual electricity costs	$(191,850)
Installation of solar water heater	
Capital and installation costs	$(500,000)
After solar water heater installation	
Reduction in electricity usage (%)	-30%
Annual electricity cost savings	$57,555
NPV of capital costs and electricity savings over 20 years	**$65,083**
Avoided emissions	
Annual electricity reduction (kWh)	450,000
Annual emissions avoided (tonnes CO_2e)	202
Avoided emissions over project lifetime (tonnes CO_2e)	**4,041**
NPV/tonne emissions avoided over project lifetime	**$16**
Accounting for social cost of carbon	
Social cost of carbon ($/tonne CO_2e)	$42
Annual social cost savings from avoided emissions	$8,486
Annual electricity savings + social cost savings	$66,041
NPV, accounting for social cost of carbon	**$148,401**

Assumptions and sources	
Electricity price ($/kWh)	$0.1279
Project lifetime (years)	20
Discount rate	8%
Electric utility emissions (tonnes CO_2e/kWh)	0.000449

Baseline pool energy usage, capital and installation costs of pool solar water heater, and reduction in pool energy use after solar water heater are estimates based on authors' conversations with university athletics facilities managers.

Project lifetime is estimated based on Internet searches regarding the expected lifetime of solar water heaters.

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix A

Heavy Hitters

3 / Reuse waste heat at ice rinks

Baseline	
Annual rink electricity usage (kWh)	2,500,000
Annual electricity costs of rink	$(319,750)
Installation of heat recovery system	
Capital and installation costs	$(300,000)
After installation of heat recovery system	
Reduction in electricity usage (%)	-20%
Annual electricity savings	$63,950
NPV of capital costs and electricity savings over 24 years	**$373,314**
Avoided emissions	
Annual electricity reduction (kWh)	500,000
Annual emissions avoided (tonnes CO_2e)	225
Avoided emissions over project lifetime (tonnes CO_2e)	**5,388**
NPV/tonne emissions avoided over project lifetime	**$69**
Accounting for social cost of carbon	
Social cost of carbon ($/tonne)	$42
Annual social cost savings from avoided emissions	$9,429
Annual electricity savings + social cost savings	$73,379
NPV, accounting for social cost of carbon	**$472,590**

Assumptions and sources	
Electricity price ($/kWh)	$0.1279
Project lifetime (years)	24
Discount rate	8%
Electric utility emissions (tonnes CO_2e/kWh)	0.000449

Baseline rink energy usage, capital and installation costs of heat recovery system, project lifetime, and reduction in rink energy use after heat recovery system installation are estimates based on authors' conversations with university ice rink operators.

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix A

Heavy Hitters

4 / Improve HFC management and disposal
Strategy 1: Implement Preventive Maintenance

Baseline		
	Refrigerant leak rate	15%
	Annual refrigerant leakage (pounds)	750
Implement preventive maintenance		
	Capital costs	N/A
After implementing preventive maintenance		
	Refrigerant leak rate	5%
	Annual refrigerant leakage (pounds)	250
	Additional annual maintenance costs	$(22,200)
	Savings from reduced refrigerant purchases	$2,500
NPV of capital costs, maintenance costs, and refrigerant savings over 20 yrs		**$(193,418)**
Avoided emissions		
	Annual reduction in refrigerant leakage (pounds)	500
	Annual reduction in refrigerant leakage (tonnes)	0.23
	Global warming potential of refrigerant (CO_2e/tonne)	2,213
	Annual emissions avoided (tonnes CO_2e)	502
	Avoided emissions over project lifetime (tonnes CO_2e)	**10,036**
	NPV/tonne emissions avoided over project lifetime	**$(19)**
Accounting for social cost of carbon		
	Social cost of carbon ($/tonne)	$42
	Annual social cost savings from avoided emissions	$21,076
	Annual maintenance costs/savings + social cost savings	$1,376
	NPV, accounting for social cost of carbon	**$13,512**

Assumptions and sources	
Project lifetime (years)	20
Discount rate	8%
Refrigerant cost ($/lb)	$5.00

Annual refrigerant leakage, leak rates, leak rate reductions, and refrigerant cost are estimates based on authors' conversations with facilities staff at universities. The global warming potential (GWP) of refrigerants is the mean GWP of HFCs, taken from the 5th IPCC Assessment. See "Assumptions & Definitions" in the manual for more information and sources regarding these GWP calculations and other assumptions in this table.

Appendix A

Heavy Hitters

5 / Use of anaerobic digester for organic and compostable wastes

Revenue and savings	
On-site energy generation by digester (kWh)	204,984
Savings from on-site energy generation by digester	$26,217
Revenue from fertilizer sales	$159,424
Costs	
Capital costs	$(845,000)
Annual operating costs	$(47,000)
NPV of capital and operating costs, fertilizer sales, and energy savings over 20 years	**$516,202**
Avoided emissions	
Avoided emissions from diverting organic waste from landfills (tonnes CO_2e)	686
Additional emissions from transportation (tonnes CO_2e)	(253)
Annual avoided emissions (tonnes CO_2e)	433
Avoided emissions over project lifetime (tonnes CO_2e)	**8,660**
NPV/tonne emissions avoided over project lifetime	**$59**
Accounting for social cost of carbon	
Social cost of carbon ($/tonne)	$42
Annual social cost savings from avoided emissions	$18,186
Annual maintenance costs/savings + social cost savings	$156,827
NPV, accounting for social cost of carbon	**$694,755**

Assumptions and sources	
Project lifetime (years)	20
Discount rate	8%
Generator capacity (kW)	26
Generator uptime (%)	90%
Generator yearly uptime (hr/year)	7884
Generator electricity generation (kWh/year)	204,984
Electricity price ($/kWh)	$0.1279

Assumes GHG emission reductions from sending less organic waste to landfills. Assumes that decreased emissions from the electric grid are offset by increased emissions from the digester's generator. Assumes increased emissions from transporting organic waste to the digester.

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix A

Quick Wins

1 / Replace conventional lighting with LEDs

Baseline for one mixed-use athletics facility	
Annual energy usage for conventional lighting (kWh)	275,000
Annual energy costs for conventional lighting	$(35,173)
Installation of LED lighting	
LED retrofit capital cost	$(30,000)
After LED lighting installation	
Energy reduction (%)	-30%
Annual energy cost savings	$10,552
NPV of capital costs and energy savings over 5 years	**$12,130**
Avoided emissions	
Annual energy reduction (kWh)	82,500
Annual emissions avoided (tonnes CO_2e)	37
Avoided emissions over project lifetime (tonnes CO_2e)	**185**
NPV/tonne emissions avoided over project lifetime	**$65**
Accounting for social cost of carbon	
Social cost of carbon ($/tonne)	$42
Annual social cost savings from avoided emissions	$1,556
Annual energy savings + social cost savings	$12,108
NPV, accounting for social cost of carbon	**$18,342**

Assumptions and sources	
Electricity price ($/kWh)	$0.1279
Project lifetime (years)	5
Discount rate	8%
Utility emissions (tonnes CO_2e/kWh)	0.000449

Baseline energy usage represents lighting usage in a mixed-use athletics facility with administrative offices, meeting rooms, a ticket office, training rooms, and locker rooms. Installation costs of LED lighting, project lifetime, and reduction in energy use based on authors' conversations with university energy and facilities staff.

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix A

Quick Wins

2 / Improve laundry efficiency and apparel procurement

Baseline for 10 non-Energy Star washing machines	
Annual energy usage (kWh)	37,500
Annual energy costs	$(4,796)
Capital costs	
Additional purchase price of 10 Energy Star washing machines compared to non-Energy Star models	$(10,000)
After installation	
Energy reduction (%)	-40%
Annual savings	$1,919
NPV of difference in purchase price and energy savings over 12 years	**$4,458**
Avoided emissions	
Energy reduction (kWh)	15,000
Annual emissions avoided (tonnes CO_2e)	7
Avoided emissions over project lifetime (tonnes CO_2e)	**81**
NPV/tonne emissions avoided over project lifetime	**$55**
Accounting for social cost of carbon	
Social cost of carbon ($/tonne)	$42
Annual social cost savings from avoided emissions	$283
Annual energy savings + social cost savings	$2,201
NPV, accounting for social cost of carbon	**$6,590**

Assumptions and sources	
Electricity price ($/kWh)	$0.1279
Project lifetime (years)	12
Discount rate	8%
Utility emissions (tonnes CO_2e/kWh)	0.000449

Energy usage, reductions in energy usage, and installation costs are based on additional costs and energy savings of choosing Energy Star when replacing ten washing machines, rather than choosing non-energy-efficient replacement machines.

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix A

Quick Wins

3 / Generate power through on-site solar

Baseline for one mixed-use athletics facility	
Annual energy usage (kWh)	2,000,000
Annual energy costs	$(255,800)
Capital costs	
Capital cost to install on-site solar	$(400,000)
After installation	
Energy reduction (%)	-18%
Annual savings	$44,765
NPV of capital costs and energy savings over 20 years	**$39,509**
Avoided emissions	
Energy reduction (kWh)	350,000
Annual emissions avoided (tonnes CO_2e)	157
Avoided emissions over project lifetime (tonnes CO_2e)	**3,143**
NPV/tonne emissions avoided over project lifetime	**$13**
Accounting for social cost of carbon	
Social cost of carbon ($/tonne)	$42
Annual social cost savings from avoided emissions	$6,600
Annual energy savings + social cost savings	$51,365
NPV, accounting for social cost of carbon	**$104,312**

Assumptions and sources

Electricity price ($/kWh)	$0.1279
Project lifetime (years)	20
Discount rate	8%
Utility emissions (tonnes CO_2e/kWh)	0.000449

Baseline energy use represents electricity usage of one mixed-use athletics facility with administrative offices, meetings rooms, a ticket office, training rooms, and locker rooms. Capital costs and energy reductions are authors' estimates based on discussions with energy experts.

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix A

Quick Wins

4 / Re-wild mowed lawns

Baseline	
Annual gasoline usage for mowing 10 acres weekly (gal)	520
Gasoline and labor costs for mowing 10 acres weekly	$(11,752)
Capital costs	
Rewilding costs for 10 acres	$(20,000)
After installation	
Annual gasoline usage for mowing 10 acres monthly (gal)	120
Gasoline and labor costs for mowing 10 acres monthly	$(2,712)
Gasoline and labor cost savings	$9,040
NPV of rewilding costs and gasoline and labor cost savings over 10 years	**$40,659**
Avoided emissions	
Reduction in gasoline usage (gallons)	400
Annual emissions avoided (tonnes CO_2e)	4
Avoided emissions over project lifetime (tonnes CO_2e)	**35**
NPV/tonne emissions avoided over project lifetime	**$1,146**
Accounting for social cost of carbon	
Social cost of carbon ($/tonne)	$42
Annual social cost savings from avoided emissions	$149
Annual gasoline and labor savings + social cost savings	$9,189
NPV, accounting for social cost of carbon	**$41,659**

Assumptions and sources	
Emissions from gasoline usage (tonnes CO2e/gallon)	0.0089
Project lifetime (years)	10
Discount rate	8%
Utility emissions (tonnes CO_2e/kWh)	0.000449
Gasoline usage and labor costs are authors' estimates based on discussions with university facilities and landscaping staff.	

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix A

Quick Wins

5 / Improve temperature control at ice rinks

Baseline	
Annual rink energy usage (kWh)	2,500,000
Annual energy costs of rink	$(319,750)
Capital costs	
Installation of temperature control system	$(50,000)
After installation of heat recovery system	
Energy reduction (%)	-3%
Annual savings	$9,593
NPV of capital costs and energy savings over 20 years	**$44,181**
Avoided emissions	
Annual energy reduction (kWh)	75,000
Annual emissions avoided (tonnes CO_2e)	34
Avoided emissions over project lifetime (tonnes CO_2e)	**674**
NPV/tonne emissions avoided over project lifetime	**$66**
Accounting for social cost of carbon	
Social cost of carbon ($/tonne)	$42
Annual social cost savings from avoided emissions	$1,414
Annual energy savings + social cost savings	$11,007
NPV, accounting for social cost of carbon	**$58,067**

Assumptions and sources	
Electricity price ($/kWh)	$0.1279
Project lifetime (years)	20
Discount rate	8%
Utility emissions (tonnes CO_2e/kWh)	0.000449

Baseline rink energy usage, capital and installation costs of temperature control system, project lifetime, and reduction in rink energy use after temperature control system installation are estimates based on authors' conversations with university ice rink operators.

See "Assumptions & Definitions" in the manual for additional assumptions.

Appendix B: Sustainable Procurement Guidelines

Green Procurement Policy

Designate a Sustainable Procurement Specialist
While everyone in the Athletics Department should receive notice of the Department's Green Procurement Policy, assign at least one employee to act as the point person on sustainable procurement. This point person can work with the university's sustainability office or with a sustainability consultant to create and monitor implementation of sustainable procurement policies.

Establish Price Preferences
For many purchases, cost will be a leading factor in product/service selection. In order to level the playing field for more expensive emissions-saving products and services, establish a specified percentage addition (5–15%) above the price of a conventional product/service which will allow the emissions-saving option to retain a preferred status. In addition, try to ensure that cost calculations and comparisons include the lifecycle cost of the product, including maintenance and replacement costs for each option.

Train Employees
Inform employees about your sustainable procurement policy and train them on how to select greener options.

Evaluate Options Before Making Purchases

Assess Need
Remind staff that the most sustainable purchase is the purchase not made. Before purchasing anything, staff should determine whether they can repurpose something else to serve their needs, purchase used equipment, or purchase an alternative product with lower associated GHG emissions.

Request Relevant Information
When soliciting supplier bids and/or Requests for Proposals (RFPs), require bidders to submit documentation on the GHG emissions associated with their products and services.

Appendix B

Evaluate Options Before Making Purchases

Look for Sustainable Certifications
Determining a product's carbon impact can be difficult — third-party organizations help by designating certain products as environmentally preferable. Prioritize products with any of the following types of third-party accreditations:

- Green Seal[1]
- Energy Star[2] (certifies energy-efficient products)
- EcoLogo[3] (certifies environmentally preferable products)
- Green-e[4]
- Forest Stewardship Council[5] (certifies wood and paper products from sustainably managed forests)
- USDA BioPreferred/Biobased[6] (certifies plant-based products)
- Biodegradable Products Institute (BPI)[7] (certifies compostable products and packaging)

Use Lifecycle Cost Accounting
Before choosing between a conventional product/service and one with a lower carbon footprint, calculate the lifecycle cost of each. Lifecycle analysis attempts to capture the total cost of a product/service, including initial costs, operating costs, longevity, and disposal costs. A conventional product may have a larger initial cost, but over time, the energy savings from a more efficient product may make back the initial investment.

Assess an Action's Carbon Impact
Before taking action, whether renovating a building, booking flights, or purchasing equipment, consider and calculate GHG emissions resulting from the action. While this step may add extra work to a project, it will lower emissions and prompt consideration of lower-GHG emitting options before money is spent.

Consider the Social Cost of Carbon
When taking an action or deciding between different products, include the social cost of carbon in cost calculations. The social cost of carbon is a measure of the economic harms from the emission of each tonne of carbon, expressed as a dollar amount. We recommend using the Obama administration's valuation - with each 1 metric tonne of CO_2 emitted equaling a cost of $42 at a 3% discount rate. Including this value (some universities apply a higher value) will more accurately reflect the economic value of any greenhouse gas emissions reductions.

Reporting
When the carbon impact, comparative cost, lifecycle or the social cost of carbon of a product or service is calculated, it should be reported and maintained in a centralized system in order to simplify future procurement decisions. Your sustainable procurement specialist should take charge of this database and periodically check to make sure that it is being updated and is accessible to the athletics department.

Appendix B

Use Best Practices

New Construction and Renovation
Construct and renovate buildings according to green building standards (for example, LEED). When constructing new buildings, use energy-efficient building envelope components such as reflective roof materials and efficient insulation and windows. These measures reduce a building's heating load in the winter and cooling load in the summer, saving energy and money. Use reclaimed stone, brick, and other materials when possible.

Lighting
Purchase energy-efficient lighting. Compact fluorescent lights (CFLs) and light-emitting diode (LED) lights use less energy than conventional lighting systems. For example, replacing 100 conventional light bulbs with compact fluorescent light bulbs (CFLs) can eliminate almost 31.5 metric tonnes of CO_2 emissions over a nine-year product lifetime.[8] LED lighting is even more cost-efficient. It also reduces maintenance costs because it lasts 35–50 times longer than incandescent lighting and 2–5 times longer than fluorescent lighting.[9]

Equipment and Materials
Fossil-fueled power plants are responsible for about 40% of the US's carbon emissions. When purchasing energy-powered equipment, choose products that qualify for an energy-efficient rating.[10] Replacing conventional equipment with energy-efficient equipment lowers a facility's energy use and energy bill. The Energy Star program, a joint initiative of the Environmental Protection Agency and Department of Energy, develops and regulates energy efficiency specifications. Energy Star products use 10–75% less energy than conventional products.[11]

When purchasing equipment and apparel, ask sellers to provide an estimate of the GHG emissions associated with the manufacture and delivery of each product. In your contract with the seller, include a provision that requires the seller to reduce these emissions figures by a certain amount each year.

Travel
For air travel, request that outside travel coordinators provide data about each trip's GHG emissions, airplane fuel efficiency, airline policies on offsetting, and price.

Nearly half of all emissions from flying occur during takeoff and landing.[12] Prioritize trips with non-stop flights over trips with layovers or plane changes.

When selecting ground travel, opt for hybrid-electric or fully electric buses. Because these buses may be more expensive to charter than traditional gasoline-powered buses, consider working with other departments at your school or even other schools in the area to negotiate a better rate with your bus rental companies.

Appendix B

Refrigerants

Where possible, replace high GWP refrigerants with lower GWP options. For some equipment, it is possible to do a swap. If a drop-in replacement (i.e., swap) is not possible, then at the equipment's end of life, replace the equipment with an alternative that utilizes a lower GWP refrigerant, which is often more energy efficient as well. In either event, try to use certified reclaimed refrigerants in: (1) domestic-scale refrigerators, (2) commercial refrigeration units, (3) cold storage warehouses, and (4) stationary air conditioning used to cool buildings. Reclaimed refrigerants should be certified by organizations such as the American Carbon Registry (ACR) or the Air-Conditioning, Heating, & Refrigeration Institute (AHRI). Reclaimed refrigerants can be used to service existing refrigeration and air conditioning equipment or can be purchased as part of newly manufactured refrigeration and air conditioning equipment. In RFPs, include a preference for reclaimed refrigerants.

Landscaping

When negotiating landscaping contracts with external vendors, require them to (a) use electric or hybrid gas/electric machinery and (b) minimize their use of synthetic fertilizers, pesticides, and fungicides.

For university-provided landscaping, ensure that synthetic fertilizers, pesticides, and fungicides are not being used. When purchasing new equipment, purchase electric or hybrid gas and electric machinery.

Waste

When possible, purchase plant-based products that are biodegradable and compostable. Ideally, these products should be certified by the Biodegradable Products Institute (BPI). In general, products made of 100% paper or wood that are uncoated, unlined, or clay-coated are considered commercially compostable without a certification. When biodegradable/compostable products are not available, purchase reusable products, recycled content products, or recyclable products. Avoid purchasing styrofoam, which is neither recyclable nor compostable.

When approving contracts with service providers, request that they provide an option incorporating and pricing out products and packaging with a lower carbon impact, including but not limited to reusable products, recycled content products, recyclable products, and biodegradable materials. When analyzing different options, evaluate whether the products and terms used by the provider align with the sustainability standards listed above.

When negotiating waste management contracts, request information about the option to send waste to a waste-to-energy facility. Negotiate waste management provisions that mandate the disposal of solid waste (i.e., non-recyclable and non-compostable waste) at waste-to-energy facilities whenever possible.

Appendix C: Contract Language to Implement Procurement Guidelines

Contracts for Apparel

Definitions:
"**Item of apparel**" means any piece of clothing, pair of shoes, or accessory meant to be worn by students, coaches, or athletics staff.

WHEREAS [UNIVERSITY] Athletics is committed to reducing the environmental impact of its apparel procurement,

RECOGNIZING THAT [APPAREL SUPPLIER] emits an average of [X] tonnes of CO_2e to manufacture and deliver apparel sold to [UNIVERSITY] Athletics,

[APPAREL SUPPLIER] shall reduce this average emissions figure by [20%][30%] over the next five years.

[APPAREL SUPPLIER] shall provide a yearly report to [UNIVERSITY] Athletics containing the measures [APPAREL SUPPLIER] has taken to achieve this target.

[APPAREL SUPPLIER] shall promptly notify [UNIVERSITY] Athletics in writing if [APPAREL SUPPLIER] is unable to comply with any of these provisions.

Appendix C

Contracts for Concessions

Definitions:
"**Anaerobic micro-digester**" means a small facility that uses microorganisms to break down biodegradable material in the absence of oxygen, thereby producing biogas.
"**Compostable**" means capable of being biologically decomposed. Compostable service ware includes paper products and service ware made from plant-based material. Compostable service ware is often listed as such in its sales description and/or packaging.
"**Recyclable Products**" means products capable of being used, cleaned, treated, and returned to the economy as raw material for future use. Recyclable products are made from materials including glass, plastic, and aluminum.
"**Zero Waste**" means sending no waste to landfills or incinerators. This is accomplished by reusing, composting, and recycling products and product waste.

WHEREAS [UNIVERSITY] Athletics is committed to reducing the environmental impact of its concessions operations,

[CONCESSIONAIRE] shall be responsible for the following services, each of which is meant to reduce the environmental impact of [CONCESSIONAIRE's] operations at [UNIVERSITY] by substantially reducing the non-organic, non-compostable waste generated by [CONCESSIONAIRE's]:

1. [CONCESSIONAIRE] shall not use, sell, or provide any plastic or polystyrene (styrofoam);
2. [CONCESSIONAIRE] shall separate out all fruit, vegetable, and meat preparation waste and other organic waste for composting;
3. [CONCESSIONAIRE] shall use either compostable or reusable service ware (e.g., cutting boards, plates, cups, cutlery).
4. [CONCESSIONAIRE] shall use recyclable containers, such as for beverages. [CONCESSIONAIRE] shall ensure that such service ware are clearly labeled to indicate whether it is reusable, compostable, or recyclable.
5. [CONCESSIONAIRE] shall scrape waste food from reusable service ware into a compost bin provided by [UNIVERSITY] before washing the service ware.
6. [CONCESSIONAIRE] shall separate, rinse, and collect its recyclable waste. [CONCESSIONAIRE] shall recycle such waste in compliance with UNIVERSITY's recycling program.
7. [CONCESSIONAIRE] shall deliver all compostable waste to [Location X] for processing in [UNIVERSITY]'s anaerobic micro-digester.
8. [CONCESSIONAIRE] shall conduct ongoing training of its staff regarding proper waste reduction, composting, and recycling procedures.
9. [CONCESSIONAIRE] shall record the amount, in pounds, of the waste it composts and recycles at [UNIVERSITY].

[CONCESSIONAIRE] shall promptly notify [UNIVERSITY] Athletics in writing if [CONCESSIONAIRE] is unable to comply with any of these provisions.

Appendix C

Contracts for Refrigerants Recycling

Definitions:
"**Collected refrigerated appliances**" means (1) domestic-scale refrigerators, (2) commercial refrigeration used in dining areas or kitchens, (3) cold storage warehouses, or (4) stationary air conditioning used to cool buildings.

WHEREAS [UNIVERSITY] Athletics is committed to reducing the environmental impact of its refrigerant procurement, use, and disposal,

[CONTRACTOR] represents that it is compliant with Section 608 of the 1990 Clean Air Act Amendments and the implementing regulations at 40 Code of Federal Regulations (CFR) Part 82 Subpart F and other applicable federal, state and local laws.

[CONTRACTOR] represents that it utilizes EPA-certified refrigerant recovery equipment and complies with all applicable laws governing the recovery, reclamation, and disposal of refrigerant.

[CONTRACTOR] agrees to implement best practices for the recycling, reclamation, and disposal of the collected refrigerated appliances.

[CONTRACTOR] agrees to recycle all recoverable durable materials including metal, plastic, and glass to the maximum extent possible.

Reporting
[CONTRACTOR] shall provide data as requested by [UNIVERSITY] Athletics to assist in the preparation of [UNIVERSITY's] RAD Annual Reporting Form due to EPA by January 31 each year. This information may include, but is not limited to:

- Leaks of any equipment including equipment containing fewer than 50lbs HFCs;
- Type and quantity of refrigerant recovered and reclaimed or destroyed;
- Type and quantity of foam blowing agent recovered and reclaimed or destroyed;
- Number, age, and description of appliances collected;
- Weight of metals, plastics, and glass recycled; and
- Quantity of hazardous waste products and used oil recovered or destroyed.

Appendix C

Contracts for Landscaping

WHEREAS [UNIVERSITY] Athletics is committed to reducing the environmental impact of its landscaping operations,

Definitions:
“**Anaerobic micro-digester**” means a facility that uses microorganisms to break down biodegradable material in the absence of oxygen to produce biogas.
“**Appropriate Green Spaces**” means land that [UNIVERSITY] Athletics has designated appropriate for Re-wilding. This land is not used for varsity athletics competition or practice.
“**Green Waste Material**” means any materials generated from the maintenance or alteration of [UNIVERSITY] Athletics landscapes that will decompose and/or putrefy including, but not limited to, yard clippings, grass, leaves, shrub/tree trimmings or prunings, brush, flowers, weeds, dead plants, small pieces of wood, and other types of organic waste produced from landscaping.
“**Re-wild**” means to return land to as close to its natural state, reducing the need for mowing and synthetic fertilization.

[LANDSCAPER]'s services shall, in all respects, comply with applicable laws. In addition, [LANDSCAPER] shall be responsible for the following services:

1. [LANDSCAPER] shall deliver all Green Waste Material to [Location X] for processing in [UNIVERSITY]’s anaerobic micro-digester.
2. [LANDSCAPER] shall Re-wild all Appropriate Green Spaces by planting them with low-maintenance, native species of grasses and wildflowers.
3. [LANDSCAPER] shall maintain all Appropriate Green Spaces in accordance with principles of natural landscaping.
4. [LANDSCAPER] shall minimize mowing events and use of fertilizers, pesticides, and fungicides.

Appendix C

Contracts for Travel

WHEREAS [UNIVERSITY] Athletics is committed to reducing the environmental impact of its travel,

[TRAVEL COORDINATOR] shall comply with the following requirements when making travel arrangements for [UNIVERSITY] Athletics' travel:

1. Air Travel:
    a. [TRAVEL COORDINATOR] shall not schedule air travel when the specified travel destination is less than 300 miles from specified travel origin unless specifically directed to do so by the Athletic Department's Director.
    b. When [TRAVEL COORDINATOR] does schedule air travel, [TRAVEL COORDINATOR] shall, when possible, schedule direct flights. Non-direct flight trips should be scheduled only when a direct flight is not available or when the cost of a direct flight is prohibitive.
    c. [TRAVEL COORDINATOR] shall provide [UNIVERSITY] information about GHG emissions, fuel efficiency of the airplane, airline's policies on offsetting, and price for scheduled air travel.
2. Ground Travel
    a. When scheduling bus travel, [TRAVEL COORDINATOR] shall endeavor to arrange for the travel to be on electric or hybrid buses.

[TRAVEL COORDINATOR] shall promptly notify [UNIVERSITY] Athletics in writing if [TRAVEL COORDINATOR] is unable to comply with any of these requirements.

Appendix C

REMEDIES (For inclusion in all Contracts)

[UNIVERSITY] Athletics shall notify [CONTRACTOR] in writing of [UNIVERSITY] Athletics' determination that [CONTRACTOR] is in breach of the contract and shall identify which requirement(s) [CONTRACTOR] has failed to meet.

[CONTRACTOR] shall be entitled to the opportunity to cure said breach by (1) remitting the payment for the fair value of the service not performed, which will be used by [UNIVERSITY] Athletics to fund its emissions-reducing initiatives, or (2) demonstrating to [UNIVERSITY] Athletics within 30 days of notice of breach that [CONTRACTOR] has brought itself into compliance.

Failure by [CONTRACTOR] to meet any of the requirements established above shall constitute a breach of this Agreement.

Appendix D: Developing a GHG Emissions Inventory

University athletics departments generate GHG emissions through a variety of activities. It is useful to conduct an "emissions audit," an inventory that catalogues sources and amounts of GHG emissions. Emissions audits allow programs to (1) quantify their emissions and understand the magnitude of their carbon footprints, (2) identify the largest sources of emissions so that they can use resources most effectively to reduce emissions, and, importantly, (3) establish a baseline against which to determine whether reduction measures are successfully lowering emissions.

While each athletics program will have its own unique emissions profile, the following broad categories are useful as a starting point: (1) building operations, (2) travel, (3) waste, (4) materials and equipment, and (5) landscaping.

Building Operations

Athletics departments manage a variety of buildings and facilities, including pools, tennis courts, ice rinks, and stadiums. Athletics departments also contend with significant seasonal variation in the use of their facilities and the lighting and conditioning (heating and cooling) demands of these facilities. Ice rinks need to be cooled; some sports teams can practice without air conditioning; others require it. Stadiums are often empty for significant portions of the year, followed by intense use at a handful of events.

In addition to ongoing energy use, athletics departments also construct new buildings and make major renovations to new and existing buildings. These large capital projects are highly energy intensive, but data on the embodied energy of these construction and renovation projects can be inconsistent and is rarely included in a university's GHG estimations. The following inventory focuses on "operational" energy use, but acknowledges that embodied energy is a major component of GHG emissions at a university and construction and renovation projects represent major opportunities to reduce GHG emissions.

An inventory of operational energy use should evaluate energy use and GHG emissions on a building basis and on a per square foot basis. This inventory should also account for HFCs, which can be potent sources of GHG emissions, and emissions caused by the athletics department's landscaping work.

Emissions Sources

- New Construction and Renovations: Emissions related to the extraction, production, processing and disposal of materials used for construction projects and renovations.
- Operational Energy: Emissions related to energy use for operations, including cooling, heating, ventilation, lighting and other energy uses.
- HFCs: Emissions related to maintenance and disposal of hydrofluorocarbons used in cooling and refrigeration equipment.
- Landscaping: Emissions related to maintaining grounds, including mowing lawns and using fertilizer or other chemicals for maintenance.

Appendix D

Building Operations

Calculating Emissions from Building Operations	
Description	Example Calculation
(1) Gather data on annual energy use by building. Depending on the composition of the university's energy sources, this could include both Scope 1 and Scope 2 emissions. For example, a university that has on-site energy generation at a cogeneration power plant[13] would have some Scope 1 emissions in addition to Scope 2 emissions from purchased electricity.	Building 1 (Offices, Team Locker Rooms, Trainers): 2,500,000 kWh Building 2 (Rec Center): 4,500,000 kWh
(2) Identify the GHG emissions per unit of energy (e.g., kg CO_2e/ MWh) given the source of the energy. This information will vary depending on the energy provider.	Assuming all energy provided by local utility, which provides GHG emissions in lb CO_2e / megawatt hour 990 lb CO_2e/MWh[14] x (1 tonne/2204.62 lb) **= 0.449 tonnes CO_2e/MWh** 0.449 tonnes CO_2e/MWh x (1 MWh/1000 kWh) **= 0.00449 tonnes CO_2e/kWh**
(3) Estimate the GHG emissions of each building's energy use.	Building 1 2,500,000 kWh x 0.000449 tonnes CO_2e/kWh **= 1,122.5 tonnes CO_2e** Building 2 4,500,000 kWh x 0.000449 tonnes CO_2e/kWh **= 2,020.5 tonnes CO_2e**
(4) Compare GHG emissions across buildings by evaluating emissions on a per square foot basis.	Building 1 - 200,000 sq. ft 1,122.5 tonnes CO_2e ÷ 200,000 sq. ft **= 0.0056 tonnes CO_2 e/sq. ft** Building 2 - 300,000 sq. ft 2,020.5 tonnes CO_2e ÷ 300,000 sq. ft **= 0.00673 tonnes CO_2 e/sq. ft**

Appendix D

Building Operations

(5) Determining the end uses of energy in an individual building can be difficult, especially when a single energy source (e.g., electricity) is used to run multiple systems (e.g., heating and lighting). The university's facilities teams can help estimate the share of emissions in a building that are attributable to different systems so that they can address the systems that emit the most GHGs. This will vary significantly depending on the building type, the age of its systems and the local climate, but some benchmarks can be provided by surveys such as the US EIA's Commercial Building Energy Consumption Survey (CBECS), which provides breakdowns on end use of energy based on building activity, size, age, region, and operating hours.[15]	For example, the US EIA CBECS inventory could be used to estimate the share of electricity dedicated to lighting use.[16] Begin by looking at a set of energy consumption intensities for different building characteristics that are similar to the study building. For example, Building 1 (recreation center) could be compared to: - 16.8% energy dedicated to lighting in Buildings with 200–500,000 sq. ft - 15.6%, Building with principal activity of education - 11.4%, Building with principal activity of public assembly - 14.1%, Building in a hot-humid environment These benchmarks suggest that ~15% would be a reasonable assumption for electricity use and GHG emissions attributable to lighting in Building 1.

Appendix D

Refrigerant Use

Calculating Emissions from Refrigerant Use	
Description	Example Calculation
(1) Begin by gathering data on HFCs used in equipment owned by the Athletics Department. A comprehensive inventory would include (1) a list of all air conditioning and refrigeration equipment, including those that have less than 50 pounds of refrigerant, (2) types of refrigerant, and (3) leak rates. Leak rates can also be estimated by EPA guidance. If leak rates or a full inventory is not available, work with Environmental Health and Safety and Facilities teams to get university-wide HFC estimates and average leak rates, which can be applied to the inventory to estimate the weight of fugitive emissions.	We assumed the athletics department owned 5,000 lbs of HFCs. 5,000 lb HFCs x 5–15% annual estimated leak rate **= 250–750 lb HFCs leaked**
(2) Convert pounds of HFCs into CO_2e. The EPA has guidance on emissions conversion factors for various types of HFC. For this calculation we have taken a mean across HFC conversion factors and used 2,213 tonnes CO_2/lb HFC, but we recommend that for accuracy you should you should use the actual GWP for the actual HFCs in your equipment.	250–750 lb HFCs x 1/2.205 kg/lb x 1/1,000 tonne/kg x 2,213 tonnes/tonne CO_2e **= 251–753 tonnes CO_2e**

Appendix D

Travel

Transportation accounts for almost 30% of the GHG emissions in the U.S.[17] University athletics travel falls into three major categories: team travel, recruiting travel, and spectator travel.

- Team travel includes travel by coaches, athletes, and trainers to practice, competitions, and special trips, such as training or international trips.
- Recruiting travel includes travel by coaches and recruiters to see potential athletes, as well as potential athletes coming to visit campus.
- Spectator travel includes travel by spectators to attend home athletics competitions.

For the purposes of this example analysis, the report focuses on team and recruiting travel. These two areas are under direct control of the athletics department and therefore present the most opportunity for changes.

Emissions Sources

For calculation purposes, major emissions sources can be evaluated by mode of transportation:

- Air travel: Emissions related to travel by air in commercial or chartered planes
- Bus travel: Emissions related to travel by bus, often used for team travel
- Car and van travel: Emissions related to cars and vans with up to 8 seats

Calculating Emissions from Air Travel	
Description	Example Calculation
(1) Gather data on athletics air travel. Many programs use external agencies to schedule flights. These agencies book and keep track of all commercial flights taken by program participants. Many possess a tool that calculates the GHG emissions associated with these flights. If charter flights are booked separately, or if the athletics program schedules flights itself, the program must keep track of these flights and calculate the resulting emissions itself.	If the travel agency provides an estimate of flight emissions for all air travel, no calculation should be needed on the part of athletics. If the travel agency does not provide an emissions estimate or if the program books flights itself, an online emissions calculator such as Atmosfair Emissions[18] can be used to calculate emissions. Air travel calculations are based on a variety of assumptions. We recommend confirming estimates given by a travel agency using an online emissions calculator and contacting your travel agency to understand the underlying assumptions of their estimates. For more information, see the Stockholm Environment Institute's extensive review of the different calculators and assumptions that go into these estimates.[19]

Appendix D

Travel

Calculating Emissions from Bus Travel	
Description	Example Calculation
(1) Compile a list of how many buses are being rented and where they are going, including an estimate of how far away the destination is, the type of fuel used by the buses, a miles-per-gallon estimate of the buses used (fuel efficiency), and the quantity of emissions released by using that fuel (emissions factor). Emissions factors are provided by the EPA.[20]	Trip: New Haven, CT to Boston, MA Length of trip: 138 miles Round trip: Yes Number of buses chartered: 2 Type of fuel used: diesel Fuel efficiency: 6 mpg Emissions factor: 10.21 kg CO_2e/gallon diesel
(2) Calculate total miles traveled.	138 miles x 2 (round trip) x 2 (buses chartered) **= 552 miles**
(3) Calculate amount of fuel used.	552 miles x 1 gallon diesel/6.0 miles[21] **= 92 gallons diesel**
(4) Calculate CO_2e emissions. Note that this is likely a low estimate, as it does not include any additional trips teams may make once at their destinations.	92 gallons diesel x 10.21 kg CO_2e/gallon x 1 tonne/1,000 kg **= 0.94 tonnes CO_2e**

Appendix D

Travel

Calculating Emissions from Car and Van Travel	
Description	Example Calculation
(1) Compile the same information as described in Method 2, except for car and van travel. Athletics departments rent or own cars and vans to transport athletes and coaches around campus or to practice and competition locations not on campus. Coaches also use cars when traveling for recruitment purposes, or when otherwise transporting athletes. Unlike chartered buses, which are used less frequently, it is often difficult to determine all the locations traveled to in a car or van. As a proxy, use receipts and/or invoices to estimate the number of miles traveled.	Gas fees paid for car: $10,000 Type of fuel used for car: gasoline Average price of gasoline in school's area: $3.00/gallon Emissions factor[22]: [(8780 g CO_2) + (0.38 g CH4 * 28 GWP) + (0.08 g N2O * 298 GWP) /gallon gasoline = 8,805 g CO2e/ gallon gasoline = 8.81 kg CO2e/gallon gasoline
(2) Calculate miles traveled.	$10,000 x 1 gallon gasoline/$3.00 **= 3,333.33 gallons gasoline**
(3) Calculate CO_2e emissions.	3,333.33 gallons gasoline x 8.81 kg CO_2e/gallon gasoline x 1 tonne/1,000 kg **= 29.37 tonnes CO_2e**

Appendix D

Waste

Several different types of waste are generated by athletics departments, each of which releases greenhouse gases when disposed of. However, different kinds of waste and different disposal mechanisms affect the amount of greenhouse gases released. When looking to minimize greenhouse gas emissions, sorting between compostable/ organic waste, recyclable waste, and solid waste can enable a more efficient disposal process. When disposing of solid waste, diverting waste from landfills will enable programs to minimize greenhouse gas emissions.

Emissions Sources

For calculation purposes, waste has been classified into the following three categories; organic/compostables, other solid wastes, and recyclables. These waste types are then disposed of in the following ways:

- Landfill: Emissions sources include methane from the decomposition of common-waste products which are deposited and buried
- Incineration: Emissions sources include those from combustion of non-recyclable waste which also creates fuel
- Compost: Emissions sources are from the slow decomposition of organic matter which holds nutrients in soil rather than releasing them into the atmosphere

Calculating Emissions from Landfilling Waste	
Municipal solid waste (MSW) includes all common waste products from the ordinary course of business. MSW landfills are currently the third-largest source of human-related methane emissions in the United States.[23] Methane emissions result from the decomposition of organic wastes.[24] Some landfills capture and use the methane; others do not. You need to identify which type of landfill you are using.[25]	
Description	Example Calculation
(1) Gather data on the amount of organic/compostable solid waste generated by your athletics department that is sent to a landfill that does not capture and use the methane emissions.	Total organic/compostable waste: 282 tonnes/ year Percent of waste sent to landfills[26]: 50% 282 tonnes waste/year x 50% sent to landfills **= 141 tonnes MSW/year**
(2) Calculate the total yearly emissions from that waste. The primary greenhouse gas emitted from landfills is CH_4, which has a larger GWP than CO_2.	Landfill emissions rate[27]: 0.0535 tonnes CH_4/tonne MSW 100-year GWP of CH_4[28]: 28 141 tonnes MSW/year x 0.0535 tonnes CH_4/1 tonne MSW x 28 **= 211 tonnes CO_2e/year**

Appendix D

Waste

Calculating Emissions from Incinerating Waste	
Incinerating solid waste offers a method through which energy can be recovered from waste. At an incineration facility, non-recyclable waste materials are converted into usable fuel through combustion. If materials cannot be reduced and recycled, incineration and energy recovery provides a more environmentally friendly method of disposing of solid waste than landfills.[29] Through combustion of the solid material, incineration facilities can both decrease the volume of waste destined for landfills and can recover energy through the process. In doing so, there is a dual benefit of incineration. First, it creates energy and reduces the need to purchase energy from fossil fuel sources. Additionally, it prevents methane generation from the decomposition of organic waste in landfills. For athletics programs that already dispose of a proportion of their waste through incineration facilities, it is important to identify the percentage of solid waste that is processed in this way. For programs that do not utilize incineration facilities, calculating the emissions saved by diverted waste intended for landfills can help offset waste production.	
Description	Example Calculation
(1) Quantify the total amount of trash destined for incineration facilities.[30]	Total waste: 282 tonnes/year Percent of waste sent to incineration facilities: 50% 282 tonnes waste/year x 50% sent to landfills **= 141 tonnes waste/year**
(2) Calculate yearly CO_2e emissions from waste incineration. Emissions per tonne of incinerated waste are as follows[31]: - CO_2: 0.95 tonnes CO_2e - CO: 0.000825 tonnes CO_2e - N_2O: 0.00341 tonnes CO_2e - NO_x: 0.0088 tonnes CO_2e	141 tonnes waste/year x (0.95 + 0.000825 + 0.00341 + 0.0088) CO_2e/tonne waste **= 136 tonnes CO_2e/year**

Appendix D

Waste

Calculating Emissions from Composting Waste	
Composting refers to the decomposition of organic matter. Various organic materials otherwise regarded as waste products are recycled in this process to produce soil conditioner (the compost). Compost is useful because it is rich in nutrients and can be used in gardens, landscaping, urban agriculture, and organic farming.[32] The process of composting involves collecting wet organic matter such as leaves, grass, and food scraps (green waste), collecting this waste in heaps, and waiting for a certain period of time (usually months) for the materials to break down. This process can be done on a small (domestic) or large (municipal) scale. For our project, we consider large scale composting facilities, which can either be stand-alone service providers or government-owned.	
Description	Example Calculation
(1) Quantify the amount of waste (green waste and biowaste) composted.	Green waste: 23 tonnes/year Biowaste: 5 tonnes/year
(2) Calculate CH_4 and NO_2 emissions from green waste. Emissions per tonne of composted waste are as follows[33]: - CH_4: 0.014 tonnes CO_2e - NO_2: 0.061 tonnes CO_2e	23 tonnes green waste/year x 0.014 tonnes CO_2e/tonne green waste = **0.31 tonnes CO_2e/year** 23 tonnes green waste/year x 0.061 tonnes CO_2e/tonne green waste = **1.38 tonnes CO_2e/year**
(3) Calculate CH_4 and NO_2 emissions per ton of biowaste. Emissions per tonne of biowaste are as follows[34]: - CH_4: 0.006 tonnes CO_2e - NO_2: 0.040 tonnes CO_2e	5 tonnes biowaste/year x 0.006 tonnes CO_2e/tonne biowaste = **0.03 tonnes CO_2e/year** 5 tonnes biowaste/year x 0.040 tonnes CO_2e/tonne biowaste = **0.20 tonnes CO_2e/year**
(4) Calculate the total yearly CO_2e emissions from both biowaste and green waste.	0.31 tonnes CO_2e/year + 1.38 tonnes CO_2e/year + 0.03 tonnes CO_2e/year + 0.20 tonnes CO_2e/year **= 1.9 tonnes CO_2e/year**

Appendix D

Materials & Equipment

Athletics teams use materials in many forms: what they wear (apparel), what they train and compete with (rowing boats, tennis rackets etc.), and when they are treated by medical professionals (plastic wrap and other materials). Apparel and equipment can be an important source of pride, with branded equipment and clothing binding a team together.

Emissions from material goods are a source of Scope 3 emissions. These goods contain embedded emissions: the emissions it took to produce the good and transport it. In addition, these goods need to be cleaned. Laundries often run all day to clean uniforms, towels and other soft goods.

Emissions Sources

- Team apparel and personal equipment: Emissions sources include manufacturing, raw materials, dyeing, assembly, and garment disposal. Due to the variable nature of materials used, locations of factories and more, athletics departments should use supplier-generated numbers for emissions per equipment and apparel.
- Laundry: Emissions sources from laundering are from chemicals, heating water, and electricity use. Laundering is estimated to produce between 40 and 80% of emissions from uniforms.[35] Laundry GHG emissions might be included in building electricity use because they are located in the same buildings as the athletics facilities, but we have included a calculation below to demonstrate that they comprise a significant portion of apparel emissions.
- Large athletics equipment: Emissions sources include the materials, transportation, assembly, and lifespan of large equipment such as rowing boats, elliptical machines, goal posts, free weights and others.
- Sports medicine materials: Emissions sources are from materials used in sports medicine, like plastic wrap to bind ice to players.

Appendix D

Materials & Equipment

Calculating Emissions from Team Apparel and Small Equipment	
Athletics departments typically contract with one apparel supplier to keep apparel consistent across teams. Apparel suppliers typically produce sustainability reports highlighting the different techniques to reduce the emissions associated with their materials, as well as the estimated emissions per product. In addition to a centralized order system, it is common for athletics teams to place additional orders for supporters, alumni and parents. These orders are unlikely to be accounted for in a centralized system.	
Description	Example Calculation
(1) Review your apparel supplier agreement. Ask the supplier for an estimate of GHG emissions per product. Using past order histories, determine how much apparel is ordered per athlete, coach, and staff member.	Emissions factor[36] : 7.33 kg CO_2e/product Number of athletes: 1,000 Average number of apparel products ordered per athlete: 40 Number of coaches: 50 Average number of apparel products ordered per coach: 20 Number of staff members: 20 Average number of apparel products ordered per staff member: 10
(2) Calculate total emissions due to the production of apparel.	Athletes 1,000 athletes x 40 products/athlete x 7.33 kg CO_2e/product x 1 tonne/1,000 kg **= 293.2 tonnes CO_2e** Coaches 50 coaches x 20 products/coach x 7.33 kg CO_2e/product x 1 tonne/1,000 kg **= 7.4 tonnes CO_2e** Staff 20 staff x 10 products / staff x 7.33 kg CO_2e / product x 1 tonne / 1,000 kg **= 1.46 tonnes CO_2e** **Total = 302 tonnes CO_2e**

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Materials & Equipment

(3) Calculate emissions from laundry operations. These emissions are likely to be embedded within the electricity calculations for the buildings where laundry is housed. However, we pull out the specific calculation here to demonstrate the substantial impact laundry has on GHG emissions from apparel.	10 Washing Machines x 15 kWh/Day[37] x 250 Days' Use Per Year x 1 lb CO_2/0.99 kWh[38] x 1 kg/2.205 lb x 1 tonne/1000 kg **= 16.84 tonnes CO_2** 10 Number of Drying Machines x 60 kWh/Day[39] x 250 Days' Use Per Year x 1 lb CO_2/0.99 kWh[40] x 1 kg/2.205 lb x 1 tonne/1000 kg **= 67.35 tonnes CO_2e** **Total Washing and Drying = 84.2 tonnes CO_2e**

Appendix D

Landscaping

Athletics departments manage large swaths of green areas for competition, practice, and recreation. Most departments use gasoline-powered equipment to mow their fields and otherwise maintain these spaces. In addition, many departments treat their fields with nitrogen-based fertilizer, releasing nitrous oxide (N_2O), a potent greenhouse gas, into the atmosphere.[41] Reducing mowing events and reducing fertilizer use will reduce emissions.

Emissions Sources

- Mowing: Emissions related to mowing green spaces
- Fertilizing: Emissions related to fertilizing green spaces

Calculating Emissions from Landscaping	
Description	Example Calculation
(1) Calculate the amount of gasoline used yearly for landscaping.	Area maintained: 10 acres Mowing frequency: 1 mow/week Gasoline used: 2.47 gallon/ha [42] 10 acres x 0.4047 ha/acre x 1 mow/week x 4 weeks/year x 2.47 gallons gasoline/ha **= 399.8 gallons gasoline/year**
(2) Calculate GHG emissions from burning gasoline.	Emissions factor: 8.81 kg CO_2e/gallon motor gasoline[43] 399.8 gallons gasoline/year x 8.81 kg CO_2e/gallon gasoline x 1 tonne/1000 kg **= 3.52 tonnes CO_2e/year**
(3) Calculate GHG emissions from fertilizer use and add to emissions from mowing.	Fertilizer emissions factor: 104.87 kg CO_2e/ha year 104.87 kg CO_2e/ha year x .4047 ha/1 acre x 10 acres x 1 tonne/1,000 kg **= 0.42 tonnes CO_2e/year** 4.60 tonnes CO_2e/year + 0.42 tonnes CO_2e/year = **= 5.02 tonnes CO_2e/year**

Appendix E: Screening of Projects

Practicality of each project was assessed on the basis of four criteria:

- **Upfront Cost:** Projects that have high upfront cost will require additional buy in from the university administration. 1 ≤ $30,000; $30,000 < 2 ≤ $100,000; $100,000 < 3
- **Legal considerations:** projects that can use existing contracts are more straightforward than those that require new contracts.

  1 = minimal contracting; 2 = moderate contracting; 3 = extensive contracting.
- **Scale and term of disruption:** Some projects will require short term disruption of usual operations. 1 = no disruption; 2 = disruption < 1 month; 3 = disruption > 1 month
- **Accessibility of technology:** Projects require various interactions with technology, the more complex the technology, the more training required. 1 = minimal interaction; 2 = some training required; 3 = more complex training required
- **Overall Feasibility:** 4 ≤ **Straightforward** ≤ 6 ; 7 ≤ **Intermediate** ≤ 9; 10 ≤ **Stretch** ≤ 12

Appendix E

Project	Upfront Cost	Legal Considerations	Scale and Term of Disruption	Accessibility of Technology	Overall Feasibility
Improve travel policies	1	1	3	1	6 = Straightforward
Heat pools with solar water heaters	3	2	2	2	9 = Intermediate
Reuse waste heat at ice rinks	3	2	2	1	8 = Intermediate
Improve refrigerant management and disposal	1 to 3	1 to 2	1	2	5 to 7 = Straightforward/ Intermediate
Process waste in an anaerobic digester	3	3	2	2	10 = Stretch
Replace conventional lighting with LEDs	1	1	1	1	4 = Straightforward
Improve laundry efficiency and apparel procurement	2	1	1	1	5 = Straightforward
Generate power though on-site solar	3	2	2	2	9 = Intermediate
Rewilding mowed lawns	2	1	1	1	5 = Straightforward
Improve temperature control at ice rinks	1	1	1	2	5 = Straightforward

Appendix F: Health Impacts and Recommendations

Introduction

An important step in evaluating whether to implement these emissions reduction projects within a university athletics department is to evaluate any potential unintended consequences, especially on vulnerable populations. A Health Impact Assessment (HIA) is a systematic approach to evaluating the health impacts (positive and negative) of projects or policies.[44]

How to Conduct a Health Impact Assessment

A health impact assessment follows six established steps to identify and assess potential effects, make recommendations, and evaluate the effectiveness of the process:[45]

SCREENING	Determines whether an HIA is appropriate for a given policy proposal. What is the added value of considering the health impacts of this proposal? Will the HIA have an impact on decision- making? Are the necessary resources (e.g., time, staff, expertise, data) available to conduct the HIA? Who are the stakeholders? Who are the most vulnerable populations who could be impacted?
SCOPING	Establishes a plan for conducting the HIA. What are the pathways through which this proposal is likely to affect health? Will the policy affect specific populations more than others? How and with what data sources might the pathways to health be studied, and can the data be obtained in a timely fashion? Which key stakeholders need to be
ASSESSMENT	Describes the baseline health and social conditions of the groups likely to be affected by the proposal and then assesses how the proposal may affect those baseline conditions.
RECOMMENDATIONS	Based on the assessment, identify practical recommendations to improve the health consequences of the proposed action, including measures to mitigate adverse
REPORTING	Engages decision-makers, community members and other stakeholders in discussing HIA findings and recommendations.
MONITORING AND EVALUATION	Evaluates HIA process according to practice standards and initial plan, impact on decision making, and actual versus HIA-predicted health effects.

Additional guidance and examples of HIAs can be found on the website for the Society of Practitioners of Health Impact Assessment.[46]

Appendix F

Assessing health impacts in this manual

While developing and evaluating the projects presented here, the team assessed the potential co-benefits and health impacts of each initiative. The following results should serve as guidance indicating potential consequences of these strategies, but should not be considered a full health impact assessment for each strategy.[47]

Strategy	Specific Health Impact	Direction	Affected populations	Geographic Extent	Magnitude	Likelihood	Significance
Reuse waste heat at ice rink	Improved respiratory health	+	Students, university community, local residents. Students with asthma in particular	Regional	Low	High (definite)	Medium
Reuse waste heat at ice rink	Reduced risk of health effects of heatwaves	+	Students, university community, local residents.	Regional	Low	Medium (probable)	Low
Install solar water heater for pool (using rooftop solar panels)	Improved respiratory health	+	Students, university community, local residents. Students with asthma in particular	Regional	Low	High (definite)	Medium
Limit air travel by using buses for travel within 400 miles away and limiting long trips	Improved mood, cognitive function, physical well-being, and individual and team performance from avoiding travel across time zones.	+	Student athletes	Local	Medium	High (definite)	Medium
Reduce the number of athletes that travel on major trips.	Reduced risk for sleeping disorders and sleep deprivation due to fewer disruptions to schedules and sleeping patterns, fewer time demands, and less time in uncomfortable sleeping positions.	+	Student athletes	Local	Medium	High (definite)	Medium
Reduce use of chartered flights	Increased exposure to communicable disease	-	Student athletes	Local	Low	Low (possible)	Low
Reduce use of chartered flights	Increased travel time leading to increased stress and absences from class	-	Student athletes	Local	High	High (definite)	High
Process waste in an anaerobic digester	Improved respiratory health	+	Students, university community, local residents. Students with asthma in particular	Regional	Low	Medium (probable)	Medium

Appendix F

Strategy	Specific Health Impact	Direction	Affected populations	Geographic Extent	Magnitude	Likelihood	Significance
Process waste in an anaerobic digester	By decreasing input to the landfill, could decrease leakage into local groundwater and lead to a decrease in waterborne diseases.[48]	+	Students, university community, local community	Regional	Low	Low (possible)	Low
Process waste in an anaerobic digester	Reduced use of nitrogen fertilizer leading to less surface and groundwater contamination by nitrogen runoff.[49]	+	Students, university community, local community	Regional	Medium	Medium (probable)	Medium
Process waste in an anaerobic digester	Discomfort from odors	-	Waste management staff and any students/staff proximal to the digester,	Local	Low	Medium (probable)	Medium
Replace HFCs and properly dispose of refrigerant with another HFC with a lower global warming potential. Improve HFC leak detection and servicing processes	Evidence of human health risk of HFCs or of removing HFCs has not been established.	=	Staff and students	Local	Low	Low (possible)	Low
Replace HFCs and properly dispose of refrigerant with another HFC with a lower global warming potential.	A common HFCs replacement, ammonia, is poisonous in large concentrations and flammable under specific conditions.[50]	-	System maintenance workers	Local	High	Low	Medium
Implement automated control systems at the ice rink to enable ice softening overnight	Improved respiratory health	+	Students, university community, local residents. Students with asthma in particular	Regional	Low	High (definite)	Medium
Convert conventional lights to LEDs across facilities	Increased employee or student motivation and commitment	+	Students and university	Local	Low	Medium (probable)	Low

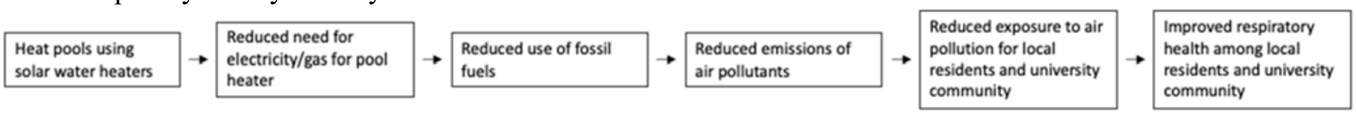
Appendix F

Strategy	Specific Health Impact	Direction	Affected populations	Geographic Extent	Magnitude	Likelihood	Significance
Convert conventional lights to LEDs across facilities	Improved concentration and energy	+	Students and university	Local	Low	Medium (probable)	Low
Convert conventional lights to LEDs across facilities	LED lights emit optical radiation that could in certain circumstances potentially damage the eyes and skin. Research indicates that this risk is very minimal.	-	Students, staff, and faculty a	Local	Low	Low (possible)	Low
Generate energy on-site (e.g., solar)	Improved respiratory health	+	Students, university community, local residents. Students with asthma in particular	Regional	Low	High (definite)	Medium
Install energy-efficient laundry machines	Improved respiratory health	+	Students, university community, local residents. Students with asthma in particular	Regional	Low	High (definite)	Medium
Re-wild mowed lawns	Improved restorative well-being associated with more biodiversity in green spaces (particularly the perceived biodiversity). Decreased stress, improved well-being, stronger connection to place	+	Students, staff, faculty	Local	Low	Medium (probable)	medium
Re-wild mowed lawns	Mitigated allergies and immune system regulation.	+	Students, staff, faculty	Local	Medium	Medium (probable)	Medium
Re-wild mowed lawns	Diminished opportunity for physical exercise due to rewilding of outdoor recreational areas.	-	Students, staff, faculty	Local	Medium	Medium (probable)	Medium
Re-wild mowed lawns	Increased exposure to disease-carrying insects	-	Students, staff, faculty	Local	Medium	Low	Medium

Appendix F

Sample causal chain for the relationship between projects to reduce GHG emissions and improved respiratory health

The causal chain below highlights the steps connecting reducing the use of fossil fuels and improved health. This can be used as a template for the causal chains for the other health impacts described above, and other potential health impacts you may identify.



Recommendations based on these assessments

When installing an anaerobic digester:

- Conduct proper training staff and maintenance of the micro-digester in order to prevent odors from being emitted.

When replacing HFCs with ammonia-based refrigerant systems

- Install the necessary ventilation systems and follow all safety regulations regarding set up of ammonia-based systems.[51]
- Conduct continuous, scheduled evaluations and preemptive maintenance to minimize risk of leakage or system failure.
-

When traveling on commercial flights:

- Remind all athletes and staff to engage in frequent handwashing and hygiene techniques to prevent infection with diseases including, though not limited to, COVID-19.

When switching from chartered to commercial flights:

- Evaluate the costs and benefits of each trip in terms of student health and academic performance.

When rewilding mowed lawns:

- Consider all uses and users of recreational areas prior to re-wilding to reduce impact on beneficial physical activity – or make sure ample outdoor recreational areas are available prior to reducing recreation areas.[52]
- When selecting areas for re-wilding, some consideration should be given to potential for level of human contact with areas, as re-wilded spaces can be a habitat for disease-bearing insects.

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