ACHIEVING CAMPUS SUSTAINABILITY AT NORTHEASTERN UNIVERSITY THROUGH CARBON PRICING

ROOSEVELT NETWORK

REPORT BY **KARL MEAKIN**

JUNE 2019

ABOUT THE ROOSEVELT NETWORK

The **Roosevelt Network** trains, develops, and supports emerging progressive policymakers, researchers, and advocates across the US, focusing on communities historically denied political power Found on campuses and in cities across nearly 40 states nationwide, the network is built on the principle that changing who writes the rules can help fulfill the ideals of American democracy and build true public power. The network supports student-led, scalable policy campaigns that fight for the equitable provision, distribution, and accessibility of public goods at the campus, local, and state levels.

In addition to its student-led activities, the organization leverages the power of its alumni network—which includes public officials, lawyers, teachers, nonprofit executives, and researchers—to expand opportunities for the next generation of policy leaders. A program of the Roosevelt Institute, the network operates alongside leading economists and political scientists to bring the ideals of Franklin and Eleanor Roosevelt into the 21st century.

ABOUT THE AUTHOR

Karl Meakin is an undergraduate student at Northeastern University in Boston, Massachusetts, studying politics, philosophy, and economics with a double major in environmental science. He is passionate about creating just climate policies and working toward a safer future for all. In addition to his work with the Roosevelt Institute, Karl is currently completing an internship with the Centre for Urban Science and Engineering at the Indian Institute of Technology in Mumbai.

ACKNOWLEDGMENTS

The author would like to thank his advisor at the Roosevelt Institute, Fernanda Nogueira, for her support and input throughout the duration of the project. Without her guidance, this report would not have been possible. In addition, the author thanks Nathan Graf, the Climate Action Senior Fellow at Swarthmore College, for providing detailed information about Swarthmore's carbon pricing scheme and thorough input on a draft of this report. At Northeastern University, Professor Matthew Eckelman was instrumental in providing guidance in the early stages of the research process, and Jasmine Sun, Associate Dean for Administration and Finance at the College of Engineering, was extremely helpful in explaining the university budgeting system.

Executive Summary

In the coming decades, climate change will have huge impacts on humanity. Millions of people will be displaced by rising sea levels, more intense droughts, and extreme weather events. Reducing emissions now will prevent us from suffering the most devastating effects of climate change. Though government policies and private-sector action are essential to sufficiently reduce global emissions (the primary driver of climate change), all institutions and individuals have a role to play. Many institutions of higher education have pledged to curb their carbon emissions. For example, Boston University has pledged to reduce operations emissions to net zero by 2040, and New York University has pledged to become climate neutral by the same date (New York University n.d.; Boston University n.d.).

Northeastern University has also committed to reducing its carbon emissions, setting the less ambitious goal of 80 percent lower emissions by the year 2050. Furthermore, university President Joseph Aoun wants sustainability to factor into all of the university's "decisions and plans for new services, building designs, and product changes (Facilities Department 2016)." The facilities department has been measuring the school's emissions for more than a decade; the next logical step is for Northeastern to institute a carbon pricing mechanism. Specifically, by implementing a flat-fee, revenue-positive carbon price along with a proxy price on new construction and building renovations, Northeastern can reach and surpass its emissions-reduction goals and become a leader in global climate action.

A carbon pricing mechanism is a policy that attaches a dollar value to each unit of greenhouse gas (GHG) emissions. Carbon prices can take many forms, including fee-based and cap-and-trade systems. In addition, carbon pricing systems can be external—i.e., government-mandated pricing systems—or internal—i.e., those used by institutions, such as corporations or universities. Reasons for implementing internal carbon prices vary, as do the mechanisms chosen by institutions, but all pricing systems purport to reduce emissions by creating monetary incentives to reduce GHG-intensive consumption.

Recently, a number of universities and colleges, in the US and abroad, have pioneered various types of internal carbon pricing systems. This paper provides the rationale for Northeastern University to do the same. Section I provides background context on global climate change and the need to take immediate, decisive measures. Section II describes and defines the various types of external carbon pricing policies and policy design options, and it explores the variety of ways in which emissions can be valuated and carbon prices set. Section III introduces internal carbon pricing and provides examples from the private sector, describing various motivations for adopting an internal carbon price and how those motivations translate into policies. Section IV details the internal pricing schemes that have already been adopted in higher education. Section V provides an overview of the existing budgeting and energy systems at Northeastern, and section VI reviews which options would be suitable for the school. The concluding section supports the proposal that, given Northeastern's existing operating procedures and administrative structures, a flat fee and proxy-price system are ideal for achieving the university's emissions-reduction goals.

A Call to Act Now on Global Climate Change

Climate change poses an existential threat to humanity. Over the next few decades, sea-level rise will displace millions, extreme weather and heat will devastate urban and rural populations, and the disruption to the global economy will affect innumerable lives (IPCC 2014; USGCRP 2018). Human activities, particularly greenhouse gas (GHG) emissions, are responsible for global climate change (IPCC 2018). Human activities have already caused approximately 1.0°C of global average temperature increase above pre-industrial temperatures. If GHG emissions continue at the current rate, it is likely that temperature increases will reach 1.5°C above pre-industrial levels within the next three decades, resulting in more droughts, heat events, flooding, and other extreme weather events (IPCC 2018). Industries dependent on weather conditions (agriculture, tourism, etc.) will be severely affected (USGCRP 2018). Besides threats to ecosystems and massive effects on crop yields and fisheries, human health will be jeopardized. Already, an estimated 400,000 deaths per year are caused by climate change, and 4.5 million deaths per year are caused by the energy system (i.e., the drilling, mining, refining, and burning processes associated with the carbon economy) as a whole (Fundacion DARA Internacional 2012). Institutions and governments must take bold action now to decrease our carbon emissions and keep the global mean surface temperature increase to less than 1.5°C above pre-industrial levels (Pearce 2016).[1] To keep global warming below 1.5°C, the IPCC reports that global emissions need to be reduced to net zero by 2040 or 2050 (IPCC 2018).

Policymakers, engineers, frontline communities that are already feeling the impacts of climate change, and environmental-justice advocates are working to forestall the impacts of climate change through adaptation measures, such as sea walls, flood-prevention technologies, and heat-island-effect reduction efforts. However, it will be far less expensive

[1] Though 2.0°C is a commonly stated goal, research indicates that, by limiting global mean surface temperature change to 1.5°C, some of the worst effects of climate change, such as increased extreme weather events, may be avoided.

to mitigate the causes of climate change rather than take extremely costly measures to adapt to the inevitable effects (Krugman 2017). There is a short time frame in which to effectively address climate change. A carbon price slows climate change by making each unit of GHG emissions more expensive to emitters, incentivizing them to reduce costs and, consequently, emissions.

Serious emissions reductions must occur within the next decade to meet IPCC targets, so a serious public policy shift must occur (IPCC 2018). A number of carbon pricing schemes have been adopted by governments around the world as they update their policies to address the realities of a changing climate. Given that the federal government of the United States has not adopted a carbon price (although individual states and regions have), corporations and educational institutions need to take matters into their own hands, compelling policy advancements by changing their own practices to move toward carbon neutrality—a state of balancing carbon emissions with carbon removal or reducing carbon emissions to zero. One way to do this is to develop internal carbon pricing policies.

An internal carbon price is a mechanism through which an organization, rather than a government, attaches a monetary value to the emission of a unit of carbon dioxide and uses this to inform its decision-making. For example, an organization using a carbon price may choose to purchase electricity produced using renewable sources rather than fossil fuels, because the cost associated with the nonrenewable source, as dictated by the carbon price, may be greater than that of the renewable source. Organizations benefit from these mechanisms in several ways. An internal carbon pricing policy limits an institution's exposure to the financial risk posed by climate change. Future climate policies will likely cause significant increases in the cost of fossil fuels; by accounting for the full price of carbon in their budget planning now, institutions will be prepared for the inevitability of eventual fossil-fuel price increases. In addition, internal carbon pricing schemes can allow for more strategic decision-making by quantifying the institution's emissions footprint. They also provide a platform for institutions to show their commitment to innovation. These factors provide direct benefits to the adopting institution.

In 2007, Northeastern University President Joseph Aoun signed the President's Climate Commitment, in which he pledged to reduce Northeastern's emissions by 80 percent by 2050 (Second Nature 2015). This pledge was warranted: Parts of the Northeastern campus are at risk for climate change-caused flooding within the next few decades (Climate Ready Boston Map Explorer n.d.). However, the school has not yet adopted a policy on carbon pricing as a means to reach its emissions-reduction goal. By contrast, Boston Mayor Marty Walsh has committed to make the entire city of Boston, which is where Northeastern's campus is located, carbon-neutral by 2050 (Greenovate Boston 2017). As a university committed to "leadership in sustainability (Northeastern University 2018)," Northeastern needs to be doing more to combat climate change. One way to reduce emissions and prove true leadership in sustainability is for the school to implement a strong internal carbon price. An internal carbon pricing scheme will benefit Northeastern University, the surrounding communities, and the global community. A carbon price will provide a quantitative tool enabling Northeastern to take strong climate action.

Carbon Pricing: A Tool for Bold Action

Reducing emissions can seem expensive; the global economic system is largely built on fossil fuels, and reserves are sufficient to last well beyond the point at which we need to be operating without emissions (Shafiee and Topal 2009). However, the costs of failing to act are much higher than those of acting immediately. The sectors of the global economy that emit CO_2, such as the energy and transportation sectors—colloquially called the "carbon economy"—and the resulting climate change cost the world more than $1.2 trillion each year. These costs are projected to increase as climate change intensifies (Fundacion DARA Internacional 2012). Allowing climate change to continue unabated will have a much greater impact on the global economy than will pursuing measures to limit our carbon output (USGCRP 2018). According to one survey, 75 percent of prominent climate economists believe that carbon pricing is the most economically efficient way to reduce emissions (Howard and Sylvan 2015). In fact, all pathways in the IPCC reports (the Fifth Assessment Report and the 2018 Special Report) that meet the goal of 2.0°C of warming or less incorporate carbon prices (IPCC 2014).

A carbon price is an economic instrument that incorporates the externalities of carbon emissions into economic transactions to raise the price of fossil fuels, thereby disincentivizing their use and ultimately achieve an emissions-reduction goal. An externality is a consequence of a transaction borne by a party that did not consent to the transaction. Incorporating a carbon price shifts the burden of payment for the damages associated with climate change to those who are responsible for the emissions (World Bank Group 2018).

Broadly speaking, carbon prices can be levied in the form of a carbon cap or a direct price. A carbon cap is a hard limit set on emissions. A government can set the quantity of emissions allowable by firms for a given year and create a number of permits equal to that cap. Allocation of permits can be determined either through a cap-and-trade system (also known as an emissions trading system, or ETS) or centralized auction system (Boyce and Paul 2016). Cap-and-trade systems involve setting a maximum acceptable emissions level for a given period then allocating permits to firms, which can either emit to the level of their permits, buy additional permits and emit more, or sell their permits and emit less. Examples of cap-and-trade systems include the European Union ETS and California Cap-and-Trade (RGGI 2018; CA Air Resources Board 2018; EU 2018). An alternative to cap-and-trade is a system where the government auctions off permits to emit directly to the firms, thus eliminating the trading component of an ETS. This method makes the revenue from permit sales available to the public (Boyce and Paul 2016).

Rather than setting a fixed emissions cap and allowing the price of carbon to vary, the direct-price approach sets a fixed price—levied via a tax or fee—and allows the emissions level to vary. An explicit price is set on greenhouse gas (GHG) emissions and generally set as a price per metric ton of CO_2 equivalent (the standard unit for emissions measurement, represented as tCO_2e) emitted.

There are multiple schools of thought regarding where the price should be set. The price levied on carbon could be set to equal the social cost of carbon (SCC), a metric that indicates the net present cost of climate damages resulting from an additional unit of carbon dioxide emissions relative to a baseline scenario. This approach has the drawback of the imprecision of calculating such a figure; estimates for this cost vary from \$10/tCO_2e to \$1000/tCO_2e (Ricke et al. 2018). The large range of these estimates has several causes. Climate change is caused by local emissions but has global impacts. Furthermore, greenhouse gases remain in the atmosphere and contribute to climate damages for a long period of time. These factors make the calculation of damages for each ton of carbon dioxide emitted challenging (Auffhammer 2018). The US Environmental Protection Agency (EPA) estimated the social cost of carbon to be only between \$12/tCO_2e and \$62/tCO_2e (Ricke et al. 2018), but IPCC reports assess it to be considerably higher (Rogelij et al. 2018). To calculate these estimates, the EPA used several climate models to determine the likelihood of multiple scenarios of climate-related impacts. Climate-related impacts include those associated with loss of agricultural productivity, health costs, and property damage. Each impact scenario is associated with a certain level of emissions. The marginal cost of each additional unit of GHG emissions in a given scenario is the social cost of carbon for that pathway. Each emissions scenario yields a different social cost of carbon (US EPA, n.d.).

A second way of setting a price on carbon is by determining the amount of emissions that would be acceptable in order to avert the worst effects of climate change and then calculating a cost that would push the market to achieve this emissions level. This approach is favored by many who think the social cost of carbon is nearly impossible to accurately calculate and those who think that safety is a better criterion than efficiency (Boyce 2018). The price per tCO_2e would be much higher if this standard was adopted; even if the emissions limit was set to allow less than 2.5°C of global average surface temperature increase (a much less stringent goal than the commonly stated 1.5-2.0°C target), the hard emissions target would be \$229/tCO_2e in 2020, and rise to more than \$1000/tCO_2e in 2050. This price would achieve much greater emissions reductions than would an efficiency-driven SCC (Boyce 2018).

The revenue from direct pricing systems can be distributed in several ways. A revenue-neutral carbon price distributes all of the revenue back to consumers or businesses via a dividend or uses the revenue to finance tax cuts. If the government or administrative body retains some revenue and invests it, typically toward emissions abatement or other sustainability measures, then the carbon price is revenue-positive. Combinations of these systems are common: for example, proposed carbon pricing legislation in Massachusetts uses a mixed revenue-positive /revenue-neutral approach (Benson 2019).[2]

Internal Carbon Pricing Systems in the Private Sector

Governments are not the only entities with the ability, or the impetus, to devise carbon pricing systems—companies and academic institutions are increasingly implementing internal carbon prices. Private-sector motivations for creating carbon pricing mechanisms vary, as do the types of mechanisms that they select (Bartlett, Cushing, and Law 2017); an organization need not have emissions abatement as its only goal to benefit from an internal carbon pricing system. There are at least four reasons that an organization might consider a carbon pricing scheme. First, companies might be interested in preparing for either future governmental policies or the inevitable low-carbon economy. Implementing a carbon price is a concrete way of showing action on climate change, which could be used to defend against legal claims that the company is contributing to global warming. Furthermore, curtailing emissions reduces vulnerability to external carbon prices in the future. This is especially relevant for organizations that operate within jurisdictions already implementing or considering a carbon price, such as Massachusetts. Second, an organization might be interested in shifting the policy discussion in a certain direction. Given that many countries

[2] Often, the terms “fee” and “tax” are used interchangeably when discussing carbon pricing. The terms are not equivalent. A tax can be levied on the entire population and can be used for anything deemed in the public interest. Fees have a more narrow definition—they are charged to persons who consume a specific commodity or public good or participate in an activity that produces a negative externality. The funds must be used for a purpose directly related to the activity that the fee was charged for, unlike tax revenues, which can be added to a general fund. So, in most circumstances, “carbon tax” is a misnomer. Revenues are generally returned to the populace or used for emissions-abatement purposes, making the charge fall into the fee category. See: Spitzer, “Taxes vs. Fees.”

and states are considering carbon prices of various sorts, a particular actor may want to push for its preferred public policy mechanism (World Bank Group 2018). Third, an organization might want to make its internal decision-making more strategic with regard to emissions-reduction goals. Whether the goals are the product of a corporate social-responsibility target or externally mandated, carbon prices will enable the organization to meet these goals in a cost-efficient way by prioritizing the strategies that reduce emissions most at the lowest cost. Finally, an organization might want to showcase its innovation. Public perception of an organization is highly important, especially in the academic and nonprofit sectors. Internal carbon pricing can provide a public-relations boost. Ultimately, there are myriad and potentially concurrent reasons that could motivate the adoption of a carbon pricing policy. An organization's dominant motivations often determine which mechanism it will adopt.

The general structure of carbon prices on the governmental level offers insight into how companies and academic institutions can create similar mechanisms to address their own emissions. Like external pricing systems, internal carbon pricing systems can be based on direct fees or an ETS. Fees can be revenue-neutral (all revenue collected as a result of the carbon price is redistributed to the units paying in) or revenue-positive (revenue is redirected to emissions abatement schemes). Unlike external systems, internal carbon pricing systems can also take the form of a "shadow" or "proxy" price. A shadow price is a decision-making tool (Bartlett, Cushing, and Law 2017). Money does not move within the organization. Rather, when considering a new capital investment, the organization factors in an additional price on carbon relative to the amount of emissions that would be expected to be produced over the lifespan of the capital asset (Swarthmore College 2017b). This is helpful when considering, for example, heating options in a new building. If no shadow price is determined, it might be cheaper to install a gas heating system; with a shadow price, the adjusted cost of a ground-source heat pump might be cheaper because the lifecycle emissions of this type of heat are significantly lower than a gas heating system (Swarthmore College 2017b).

Some systems, such as fully revenue-neutral internal fee systems, are administratively complex, while others, such as shadow prices, are administratively simple. Organizations choose a system based on their institutional goals. For example, a company might choose a shadow price to reduce its emissions from new construction, or it might institute a fee system to incentivize behavioral change.

Or it may want to address a combination of goals. In 1998, BP Amoco (now BP plc), one of the largest oil-and-gas companies in the world, established the BP ETS—the most prominent example of an internal emissions trading system (Victor and House 2006). The corporation was motivated by multiple factors: an economic interest in becoming familiar with emissions trading systems in the event of their widespread adoption, a desire to push the public policy discussion away from carbon taxes and toward emissions trading systems, and the incentive to reduce emissions across diverse internal sectors as quickly and cheaply as possible. BP wanted to make institutional change in a manner that allowed operating units to figure out the best way to reduce their own emissions, rather than dictating that all units adopt the same emissions abatement practices (Victor and House 2006). Inspired by existing emissions trading systems and lobbying by the Environmental Defense Fund (EDF), BP chose an ETS to meet its stated goal of 10 percent emissions reduction below 1990 levels between 1998 and 2010.[3] A task force established to administer the trading scheme forecasted emissions for BP as a whole for 2000 and set the cap for the first trading period as that amount less 1 percent. Permits were allocated based on historical emissions to ensure relative administrative simplicity.

After the project's implementation, BP administrative units reduced emissions by much more than 1 percent in the first year. The company reached its 10 percent goal by 2001 and discontinued the ETS. The price for carbon within the ETS worked out to \$7.60/tCO_2e during 2000 and ranged between \$10 and nearly \$100/tCO_2e during 2001.[4] This price variability is a drawback of cap-and-trade systems. Fee-based systems are more predictable, thus simplifying long-term budget planning.

Analysis of the BP system indicated that awareness of emissions was as likely to have had a major influence on emissions reductions as the ETS itself. BP allowed noncompliance when the cost-saving emissions abatement strategies were exhausted, making it sharply different from an external system with a hard cap. BP's ETS gave operating units an incentive to quickly adopt win-win emissions reduction strategies (e.g., reducing flared gas in order to sell it) and avoid costly reduction strategies, while still meeting the organization's (admittedly fairly modest) goal (Victor and House 2006). The BP ETS experiment offers some other major lessons: administrative feasibility of a carbon pricing system is highly important; carbon pricing allows for cost-effective abatement strategies; and the combined presence of greater metering and some sort of pecuniary incentive, even if money does not actually change hands, can be an effective motivator for internal administrative units.

The BP ETS differs from most internal corporate carbon pricing systems, the vast majority of which are based on fee systems or a shadow price on investments (financial or capital), rather than on an ETS. Microsoft is an example of a firm with a well-established carbon fee

---

3 Department/unit heads within BP had determined that a 6–7 percent reduction would effectively cost BP no money, and outside consultations indicated to the CEO, John Browne, that this was likely a conservative estimate.

4 The price variability was caused by the fact that few trades occurred at the beginning of the year, resulting in low prices, and a realization that units needing to purchase permits to meet the target drove up prices toward the end of the trading period. Buy-in by unit administrators varied throughout the trading period, also affecting variability.

system. Microsoft tracks energy consumption from all of its administrative units (e.g., data centers, labs, and manufacturing centers), including air travel, and converts these figures into emissions data. The company first conducts in-depth monitoring of these company-wide emissions. Then, it creates a set of emissions abatement strategies, including internal initiatives such as improved efficiency and a movement toward low-carbon electricity sources and offset purchasing. The price on carbon is set by dividing the costs of these initiatives by company-wide greenhouse gas emissions (DiCaprio 2013). This price works out to approximately \$5–\$10/tCO_2e each year (Ahluwalia 2017). Finally, administrative units pay into a central fund an amount based on the product of their emissions and the centrally set price on carbon. Money from this central fund is invested in various emissions abatement strategies (DiCaprio 2013). A fee system provides a direct price signal for operating units; department heads can calculate the monetary benefit of reducing emissions by a certain amount.

The shadow pricing system, however, is one of the most common strategies used by companies to reduce their long run emissions and reduce vulnerability to price fluctuations for fossil fuels. There are multiple corporate examples of shadow pricing schemes, particularly in the energy industry, including ConocoPhillips, ExxonMobil, and Hess (Bartlett, Cushing, and Law 2017). Though prices vary widely—anywhere from \$5–\$150/tCO_2e—and variations in the thoroughness of life cycle emissions calculations exist, the essential mechanism remains more or less constant (Cassady and Taraska 2016). When making decisions regarding new capital investments, a certain price per tCO_2e estimated to be emitted over the life cycle of the investment is included in cost-benefit calculations. This price can propel the company toward low-carbon investments. However, shadow prices do not affect day-to-day operation of administrative units in the way that cap or fee systems do.

Just as companies have multiple reasons for implementing carbon pricing systems, they also have multiple methods for achieving their aims. They may embed carbon pricing into their practices using any of a number of mechanism types, including caps (both trading- and auction-based), fees (both revenue-positive and revenue-neutral), and shadow prices. Each of these strategies has different benefits and drawbacks for corporations; the same holds true for other entities in the private sector.

Internal Carbon Pricing Systems in Universities and Colleges

Like corporations, institutions of higher education have many reasons to choose to implement carbon pricing. As centers for innovation and research, universities may be interested in showing the broader public how they are contributing to the discussion on climate change mitigation. Modeling a carbon price at the university level provides a small-scale test case for future carbon pricing policies. Moreover, a carbon price has the same risk-reduction benefits for a university that it would for a corporation; governmental climate policies will affect academic institutions as well. Finally, many universities have climate action plans. An internal carbon price provides a cost-effective way to take action on those plans and to meet or exceed emissions goals that may have already been set.

Several schools, in the US and abroad, have introduced carbon pricing plans. The following case studies of three plans—at Yale University, Swarthmore College, and Arizona State University (ASU)—offer an overview of efforts toward and options for campus-level carbon pricing systems.

Yale University

During the summer of 2014, the president of Yale University formed the Presidential Carbon Charge Task Force to determine the feasibility and effectiveness of an internal carbon price system at the school (Nordhaus et al. 2015). The task force determined that such a carbon charge would be effective and in line with the goals of the university. Yale initiated a pilot program during the 2015–2016 academic year to test three different carbon pricing schemes in three sets of treatment groups; a control group received information regarding its emissions but instituted no carbon pricing system. The three carbon pricing mechanisms generally entailed an internal revenue-neutral direct charge, an approach with direct charges relative to a reduction target (which does not work out to be revenue-neutral), or a charge and full-refund system, with a portion of the refund earmarked for emissions abatement or other sustainability measures (Laemel and Milikowsky 2016).

Although the sample size for the pilot was small (n=20), all three carbon pricing schemes demonstrated emissions reductions (Gillingham, Carattini, and Esty 2017). Units (i.e., buildings) with a charge structure saw emissions reductions of approximately 10 percent over the course of the pilot. Units in the control group, which had no charge but access to greater information on reporting, noted emissions reductions of 7.4 percent (Laemel and

Milikowsky 2016). Key findings included the observation that details of the scheme matter—it must be designed with the specific characteristics of the institution in mind (Gillingham, Carattini, and Esty 2017). Simplicity is highly important for widespread adoption of internal carbon charges (Laemel and Milikowsky 2016). Also, participants must fully understand the scheme and perceive it to be fair (i.e., emissions are calculated relative to a baseline for the unit or building).

Based on these findings, Yale determined that a carbon charge could be an effective way to abate emissions at reasonable costs. The university decided to continue the program and adopted an internal fee and dividend system using the revenue-neutral approach, which works similarly to a larger-scale revenue-neutral policy: The cash flow for each administrative unit (defined as the entity responsible for a building's budget) in the Yale scheme is like the cash flow for an individual or household in a government-level policy. Emissions levels are calculated for a baseline period. Only Scope 1 and Scope 2 emissions are considered under the Yale carbon charge.[5] During the charge period, metered energy use is converted to tCO_2e and compared to the baseline period emissions for the unit. The emissions for the charge period are divided by baseline emissions to give an adjustment factor. Each unit is charged $40 per tCO_2e emitted during the charge period and is rebated by baseline emissions multiplied by the adjustment factor and the price (Laemel and Milikowsky 2016). This approach necessarily works out to be revenue-neutral, meaning that the university as a whole neither gains nor loses money as a result of the charge. In the case of an extreme event that requires larger-than-normal energy consumption, Yale can avoid the risk of potentially large payments—an advantage to the university's central accounting office (Gillingham, Carattini, and Esty 2017).

However, the approach has downsides. Potentially, a unit could have increased emissions but still receive money, provided that the emissions of the units increase slower than the average.[6] A second negative is that the effective price on carbon is lower than the original carbon price and much lower than most calculated social costs of carbon (Laemel and Milikowsky 2016; Ricke et al. 2018). Finally, the revenue-neutral scheme and the target scheme have the drawback, by design, of not providing a fund for emissions abatement. The refund scheme does this by earmarking 20 percent of the fully rebated charge for emissions abatement.

---

5 Scope 1 emissions are those arising directly from on-site sources, such as institution-owned natural gas heating. Emissions from vehicles owned by the organization are also classified as Scope 1. Emissions arising from the consumption of purchased electricity would be classified as Scope 2 emissions, as the combustion of fossil fuels occurs off-site. Scope 3 emissions are those caused by sources that are not owned or controlled by the institution: for example, air travel or waste disposal. See: Lawinsider.com: "Scope 1, 2, and 3 Emissions."

6 For example, if the University increases emissions by 3 percent for a year while an operating unit increases emissions by 1 percent, the operating unit will be rewarded by the price even though their emissions increased.

Yale's system design is complicated by the presence of two distinct types of administrative units. The college has both self-supported units (responsible for their own budgeting and fundraising and paying for their own utilities) and centrally supported units. A revenue-neutral internal charge is more effective for the self-supported units, as they have an existing financial incentive. Centrally supported units should have a carbon charge budget based on historical emissions and pay a fraction of the burden accordingly (Laemel and Milikowsky 2016).

Swarthmore College

The Swarthmore College Carbon Charge program, implemented during the 2016–2017 academic year, is distinct from the Yale system in two major ways. First, the flat-fee approach is designed to be revenue-positive. The mechanism is intended to raise revenue for a centralized Carbon Charge Fund, which is used for emissions abatement projects and education efforts. Funds collected from departments are not returned to those departments. Second, the charge does not directly levy fees for each department's emissions levels. Rather, the Carbon Charge Committee, which administers the Carbon Charge program, calculates a total amount based on college-wide emissions; the effective charge for the university works out to be about \$27/tCO_2e—lower than the Yale charge but within the range designated by the EPA (Swarthmore College 2018b, 2018a; Ricke et al. 2018). Each office or department pays a flat fee based on its operating budget such that the total fee collected equals the amount set by the committee and approved by college's governing body, the Board of Managers. The Carbon Charge Fund gathers another 10 percent of its total from additional funds donated by departments.

The Swarthmore system is notable for its simplicity. The flat-fee approach offers relatively easy accounting calculations for the institution. A second benefit of the Swarthmore program is the dedicated revenue stream for GHG abatement efforts. This revenue stream allowed Swarthmore to spend \$234,000 on energy savings projects, \$61,000 on emission reduction planning and assessment, and \$5,000 on education and engagement[7] in the first year of the program (Swarthmore College 2017a). Energy savings projects, like LED lighting retrofits, allow the college to both reduce its emissions and reduce its operating costs. The Carbon Charge program enables these projects by internally redistributing funds to focus on institution-wide reductions strategies. This approach is markedly different from the approach at Yale, which is largely decentralized and encourages building managers to undertake individual energy savings projects. Finally, the Swarthmore fee contributes to

[7] Including documentary screenings, panels, and workshops.

building momentum toward state- and national-level carbon pricing policies.

The downside to the Swarthmore mechanism is that, on the departmental level, the charge does not directly reward efficiency or emissions abatement. Regardless of emissions relative to their past levels, each department will pay the same amount in fees. This design choice was driven by lack of thorough metering and administrative feasibility. Yale had the ability to meter each unit individually, but this capability is not, at present, a possibility at Swarthmore.[8] Given that a major goal of the Carbon Charge program is to provide a fund for emissions reduction, prioritizing a revenue-positive approach was seen as more important than trying to charge each department exactly in accordance with its emissions (Graf 2018). The Swarthmore program drives home an important point: Universities can and should tailor a carbon pricing system to fit their exact needs.

Swarthmore does, however, directly address the social cost of carbon when making capital investments through its shadow price program. Swarthmore set its shadow price at $100/ tCO_2e (Swarthmore College 2017b). When considering a new building or other capital project, the college takes into account both financial and carbon life cycle costs over the building's operating life. This approach reduces campus emissions and provides a platform to promote carbon pricing both on and off the campus—two goals that the college set when developing its shadow price program.

Arizona State University

ASU took a different approach to carbon pricing from the other institutions discussed in this paper. Rather than focusing on Scope 1 or Scope 2 emissions, ASU put a price on a particular Scope 3 emissions source: air travel. All air travel sponsored by the university is subject to this price, starting in July 2018. After analyzing the projected price per offset tCO_2e in 2025 ($9.43), ASU determined the average price per offset tCO_2e for a round-trip flight to be $17.42. This was deemed too much of a strain, so the school set a flat fee of $8 per round-trip flight, which will gradually increase to $18 over four years. Notably, the flat fee prevents the discouragement of international travel. If the fee were indexed directly to flight distance, international flights would be much more expensive than domestic flights. The revenue from the fee is used for the ASU Carbon Project to develop carbon offsets that mitigate the university's emissions level (Dalrymple 2018).

ASU's approach has the clear benefit of directly addressing Scope 3 emissions. Even the fairly extensive Yale system does not account for Scope 3 emissions, although the Carbon

[8] The revenue from the carbon charge can be used to build capacity for future, more administratively complex, carbon pricing systems.

Charge Task Force at Yale indicated that this might be possible in the future once the carbon price becomes more politically acceptable (Laemel and Milikowsky 2016). The ASU solution is also simple: A flat fee does not require complex calculations for each flight booked. This reduces the amount of initial institutional effort necessary, increasing the feasibility of policy adoption (Dalrymple 2018). Other institutions, such as UCLA and the University of Maryland, also incorporated carbon prices on air travel (UCLA Sustainability, n.d.). The ASU approach, like Swarthmore's system, is revenue-positive. However, ASU uses the revenue to purchase market carbon offsets[9] and develop local offset projects (Dalrymple 2018).

The downside to the ASU approach is that a low charge is unlikely to affect behavior (i.e., it is not price-signaling). This is a feature, not a defect, of the ASU plan, the goal of which, like the Swarthmore system, is to set aside money for the reduction of carbon footprints. Instead of engaging in direct emissions reductions effort on campus, like Swarthmore, ASU chose instead to focus on offsets.[10]

Other Institutional Carbon Pricing Plans

There are several other examples of carbon pricing systems in universities. Smith College is piloting a proxy (shadow) carbon price of \$70/tCO_2e. When evaluating new capital projects, Smith can use the proxy price to determine the most cost-effective way to reduce lifecycle emissions of the project (Parker and Barron 2018). University College London (UCL) is also undertaking a pilot program by testing a financial mechanism for departments to reduce energy use. During the 2018–2019 academic year, approximately 12 departments will be subject to a charge on Scope 1 and Scope 2 emissions; Scope 3 emissions will be reported but will not be subject to the charge. The proposed cost is \$39/tCO_2e (£30/tCO_2e). UCL has not yet determined whether the price will be revenue-neutral or revenue-positive. Funding for low-carbon travel is one of the options being considered if a revenue-positive scheme is chosen (Marshall-Cook and Jebb 2018).

Notably, the University of British Columbia provides an example of a university subject to an external carbon price. The provincial government requires that the university pay \$60/tCO_2e emitted. This price is a combination of a \$35/tCO_2e charge on natural gas (determined by the British Columbia Carbon Tax) and a \$25/tCO_2e charge for offsets from operations emissions (determined by the Carbon Neutral Government Regulation). The

9 A voluntary carbon offset generally takes the form of paying another party to emit less to balance the first party's emissions levels.

10 A discussion of the value of offsets versus the value of direct emissions reductions is outside the scope of this paper.

university anticipates that the charges, which cover Scope 1, Scope 2, and Scope 3 emissions, will contribute to its ability to reach its goal to eliminate GHG emissions by 2050 (Madden and Bilodeau 2018). Universities can prepare for external prices, like those levied by the British Columbia Carbon Tax, by implementing an internal carbon price prior to passage of government regulations.

SUMMARY OF CARBON PRICE STRATEGIES AT INSTITUTES OF HIGHER EDUCATION

Type of Price	Description	Benefits[11]	Drawbacks	Examples
Proxy/Shadow	Decision-making tool. No money moved within institution. Applied when making capital budget decisions, including new construction or renovation projects.	Administratively simple. Informs strategic decision-making.	No price signaling to administrative units.	Swarthmore, Smith
Flat fee, revenue-positive	Flat fee charged across departments. Revenue flows to central fund, which is used for emissions abatement.	Provides earmarked revenue stream to strategically reduce university-wide emissions. Administratively simple.	No price signaling. Additional cost to revenue sources.	Swarthmore
Direct, revenue-neutral	Fee charged to departments relative to emissions. Revenue redistributed according to emissions change relative to baseline emissions.	Price signaling provides incentive for administrative units to take steps to reduce emissions. Minimal additional cost to revenue sources. Mimics/informs external price.	Administratively complex.	Yale
Direct, revenue-positive	Fee charged to departments relative to emissions. Revenue flows to central fund, which is used for emissions abatement.	Price signaling provides incentive for administrative units to take steps to reduce emissions. Mimics/informs external price.	Administratively complex. Additional cost to revenue sources.	No known example
Scope 3 travel charge	Fee charged when university members travel for study/work. Revenue flows to central fund, which is used for emissions abatement/ offsets.	Can fund offsets or emissions abatement strategies.	Minimal price signaling. No Scope 1/2 effects.	ASU, UCLA

TABLE 1

[11] All internal carbon pricing systems reduce risk of exposure to existing or proposed external carbon pricing policies. Furthermore, all carbon pricing systems either directly or indirectly lower the carbon footprint of an institution.

The Potential for Carbon Pricing at Northeastern University

Northeastern University is in an ideal position to consider its own carbon pricing system. The university already compiles annual data on its total GHG emissions. Between 2009 and 2016, total university emissions fell by 6.5 percent (Facilities Department 2014, 2017). Though this is a noticeable decrease, especially in light of several new buildings being constructed during that time period, it is less than the decreases seen under the Yale carbon charge pilot program, including the control group (Laemel and Milikowsky 2016).

To determine which carbon price approaches might work, and which may work best, it is important to understand how the financial and energy systems at Northeastern currently operate. Northeastern University uses a "hybrid budget model," which is a method of allocating revenues and costs across responsibility centers (RCs). Academic RCs include colleges, including the College of Science and the College of Social Sciences and Humanities, and other units that provide instruction, such as the Global Experience Office. Auxiliary RCs include units that do not provide instruction, such as Housing & Residential Life and Dining Services (Provost's Office 2017). RCs receive revenue from tuition and from internal and external grants, fees, and services. Tuition revenue flows fifty-fifty to the RC that provides instruction and the enrolling RC (or entirely to the RC, if these are the same).[12] Financial aid is averaged across the university and applied as a discount rate on tuition revenue. Incoming revenue from grants (excluding direct costs, which represent revenue that directly covers research expenses) may go to an RC, or it may flow into a central fund. Assets in the central fund are allocated based on institutional goals and strategic initiatives. Grants may also be split if the funding is for research across colleges, in which case revenue will be split in accordance with the grant application (Provost's Office 2018).

Costs to RCs fall into three main categories: allocated costs, Lifelong Learning Network (LLN) costs, and space costs. Allocated costs include general administration, academic infrastructure, research infrastructure, and library costs. These are charged as a flat percentage of RC direct expenses; the rate is 75 percent for academic RCs and 26 percent for non-academic RCs. Charges for the university's off-campus LLN offerings flow toward regional campuses, regulatory expenses, future investments, and marketing costs. Space costs include utilities, lease costs, depreciation, facilities, and other typical overhead

[12] For example, a student in the Mechanical Engineering program, whose enrolling RC would be the College of Engineering, will take a physics class, which is taught by the College of Science. The tuition for that class would be split evenly between the College of Science and the College of Engineering.

expenses. When determining space costs, a distinction is made between research space and non-research space (Provost's Office 2018). RCs are charged one final amount covering both assigned space—reserved for the RC's specific use and for which the RC is directly charged—and non-assigned space—communal or shared space, the cost of which is spread across all RCs. Non-assigned space is further split into two categories: classroom and administrative space. Administrative space is charged based on RC operating budget, while classroom space is charged relative to student enrollment numbers per RC. Northeastern's College of Engineering, for example, has three indirect charges (allocated cost, LLN, space) that sum to slightly more than total direct expenses (e.g., faculty salaries).

In addition to these three cost categories, RCs pay the University Contribution. This is a charge against revenues in all RCs that flows into a central fund to be used for strategic initiatives via the Current Fund Allocation. The Current Fund Allocation can also be funded by gifts and endowment earnings that are not restricted to a specific RC.

It is important to note that the university is considering a new budget model to be implemented in FY2020. Though the details of the new model are not yet known, a flat-fee and shadow price system can be modified to fit a range of budget models and should be implementable notwithstanding the pending changes.

Northeastern meters electricity and heating use at the building level, including both residential and academic buildings. With these energy-use proxies, the facilities department has been measuring Scope 1 and Scope 2 emissions on the university scale for more than a decade. This level of granularity is useful for identifying which *buildings* have high emissions, but it does not account for the emissions of specific *users* of those buildings because multiple departments and colleges often occupy a single building. Metering would need to become even more granular than the building level to levy the type of internal fee that Yale University employs. Metering shortcomings may limit the university's ability to implement this targeted a carbon pricing mechanism, but there are many other carbon pricing systems that could lead to strong emissions reductions.

Determining a Carbon Pricing Approach for Northeastern

Each carbon pricing system has different benefits and drawbacks. Different systems require different levels of administrative capacity. For example, the Yale system, an internal fee and dividend system, requires highly granular metering, an alignment between energy decision-makers and financial decision-makers, and relatively high investment in capacity-building (Yale has a full-time staff member dedicated to administering the carbon charge program) (Barron 2018). However, the Yale system is the closest replica of an external pricing system that is possible on the university level.

Other systems, like the Swarthmore flat-fee and investment scheme, are less administratively complex. Using a flat fee means that granularity in metering becomes less important. This scheme has the added benefit of setting aside money for university-wide emissions abatement projects, including capacity-building for more extensive carbon price systems. The drawback is that a flat-fee system doesn't directly incentivize departmental emissions reductions; it provides emissions reductions through centralized investment, not through a price signal. The Swarthmore-style proxy price system, which is the most commonly used type of carbon pricing scheme, requires less administrative work. This system lowers emissions in any capital project that it is applied to and has the benefit of being highly flexible.

Northeastern's current budget system means that there is already a system in place to levy a fee across all RCs, making a flat-fee internal carbon price ideal for the school, because the fee could simply be included in existing charges to RCs. Meanwhile, Northeastern's administrative capabilities encourage the flat-fee, revenue-positive approach along with a proxy price. This hybrid approach combines the benefits of multiple internal carbon pricing options. The flat fee, which could be implemented at the college level, will provide an internal revenue stream for emissions abatement, and the proxy price introduces a price-signaling mechanism that will reduce the lifetime carbon footprint of capital investments.

A fee in the Swarthmore model could be implemented at relatively low administrative cost. The fee could be charged at a flat rate and included in allocated cost payments (in the same way that, for example, Snell Library costs are charged to RCs). Or, it could be charged relative to space use and be rolled into the space costs charged to RCs. Both methods have the benefit of relative administrative ease; the budget model is already structured in a way that carbon pricing could simply be added as a surcharge, rather than a new category of payment.

A proxy carbon price will support the reduction of long-term university-wide emissions when Northeastern evaluates capital projects—new construction, building retrofits, or the renovation of a residential hall, for example. Most universities use a higher price than \$40/tCO_2e for proxy decision-making (Swarthmore College 2017b; Barron 2018), which Northeastern should be able to as well.

Following the method of multiplying campus-level carbon emissions by the $40/$tCO_2e$ value used by the EPA, Northeastern's goal should be to levy fees that would sum to $2.1M (Facilities Department 2017). The fund created by this revenue could be managed by the Senior Leadership Team (or a specifically designated committee) to ensure strategic decision-making across the entire university, rather than ad hoc decision-making by individual departments. One strategy that this team could support is capacity-building aimed at implementing a price-signaling carbon charge scheme in the long term.

PROPOSAL FOR NORTHEASTERN: A FLAT-FEE AND PROXY PRICING APPROACH

Given Northeastern's current budget structure and institutional goals, a carbon pricing strategy should be incorporated into university policy. Northeastern should implement both a flat-fee, revenue-positive system and a proxy price for future capital projects. These systems are both relatively simple and do not require major updates to the school's energy monitoring or budget systems. The proxy price will lower the lifetime carbon footprint of construction projects by informing the decision-making process in favor of lower emissions. It will help prioritize the most effective efficiency-improvement strategies. The flat-fee, revenue-positive system will provide a fund specifically earmarked for emissions abatement. Though not a direct price signal to RCs, the flat-fee system would enable the Senior Leadership Team to fund strategic emissions-abatement initiatives. Revenues from the pricing system could be allocated to the facilities department to lower emissions by increasing efficiency or invested in renewable energy generation and carbon offsets. It could also be used to build metering and administrative capacity in order to establish a price-signaling carbon charge in the future. Ultimately, a carbon price is an effective and appropriate tool for accomplishing President Aoun's goal of factoring sustainability "into all of our decisions and plans for new services, building designs, and product choices (Facilities Department 2016)."

References

Ahluwalia, Manjyot Bhan. 2017. "Companies Set Their Own Price on Carbon." *Center for Climate and Energy Solutions* (blog). September 12, 2017. https://www.c2es.org/2017/09/companies-set-their-own-price-on-carbon/.

Auffhammer, Maximilian. 2018. "Quantifying Economic Damages from Climate Change." *Journal of Economic Perspectives* 32 (4): 33–52. https://doi.org/10.1257/jep.32.4.33.

Barron, Alexander. 2018. "Internal Carbon Pricing Webinar." November 15.

Bartlett, Nicolette, Hannah Cushing, and Sarah Law. 2017. "Putting a Price on Carbon: Integrating Climate Risk into Business Planning." CDP. https://www.cdp.net/en/climate/carbon-pricing.

Benson, Jennifer E. 2019. *An Act to Promote Green Infrastructure and Reduce Carbon Emissions*. https://malegislature.gov/Bills/191/HD2370.

Boston University. n.d. "Climate." Boston University Sustainability Program (website). What We're Doing. Accessed March 29, 2019. https://www.bu.edu/sustainability/what-were-doing/climate-action/.

Boyce, James K. 2018. "Carbon Pricing: Effectiveness and Equity." *Ecological Economics* 150 (August): 52–61. https://doi.org/10.1016/j.ecolecon.2018.03.030.

Boyce, James K., and Mark Paul. 2016. "Making Them Pay." *Jacobin*, December 5, 2016. http://jacobinmag.com/2016/12/carbon-pricing-fossil-fuel-climate-environment.

CA Air Resources Board. 2018. "Cap-and-Trade Program." December 3, 2018. https://www.arb.ca.gov/cc/capandtrade/capandtrade.htm.

Cassady, Alison, and Gwynne Taraska. 2016. "A Tool for Fiscally Rational and Climate-Compatible Governance." Washington, DC: Center for American Progress. https://www.americanprogress.org/issues/green/reports/2016/04/18/135580/proxy-carbon-pricing/.

Climate Ready Boston. n.d. "Climate Ready Boston Map Explorer." Accessed February 11, 2019. http://boston.maps.arcgis.com/apps/View/index.html?appid=7a599ab2ebad43d68adabc9a9ebea0e6&extent=-71.1583,42.2897,-70.9309,42.4060.

Dalrymple, Mick. 2018. "Case Study: Price on Carbon for Air Travel." August 31, 2018. https://secondnature.org/wp-content/uploads/ASU-Case-Study-Price-on-Carbon-for-Air-Travel.pdf.

DiCaprio, Tamara. 2013. "The Microsoft Carbon Price: Theory & Practice." Microsoft Corporation.

European Union. 2018. "EU Emissions Trading System." https://ec.europa.eu/clima/policies/ets_en.

Facilities Department. 2014. "Northeastern University- Greenhouse Gas Inventory (2009)." Northeastern University.

———. 2016. "NU Sustainable Practices and Operations Guidelines." Northeastern University.

———. 2017. "Northeastern University- Greenhouse Gas Inventory (2016)." Northeastern University.

Fundacion DARA Internacional. 2012. "Climate Vulnerability Monitor: A Guide to the Cold Calculus of a Hot Planet." 2. Climate Vulnerability Monitor. Madrid: Climate Vulnerable Forum. https://daraint.org/climate-vulnerability-monitor/climate-vulnerability-monitor-2012/report/e.

Gillingham, Kenneth, Stefano Carattini, and Daniel Esty. 2017. “Lessons from First Campus Carbon-Pricing Scheme.” *Nature News* 551 (7678): 27. https://doi.org/10.1038/551027a.

Graf, Nathaniel. 2018. Swarthmore College Climate Action Senior Fellow. Interviewed by author, 2018.

Greenovate Boston. 2017. “Climate Action Plan.” Greenovate Boston. 2017. http://www.greenovateboston.org/climate_action_plan.

Howard, Peter, and Derek Sylvan. 2015. “Expert Consensus on the Economics of Climate Change.” New York: Institute for Policy Integrity, NYU School of Law. https://policyintegrity.org/publications/detail/expert-climate-consensus.

IPCC. 2014. “Summary for Policymakers.” Climate Change 2014: Mitigation of Climate Change. Cambridge and New York: Cambridge University Press. https://www.ipcc.ch/report/ar5/wg3/.

———. 2018. “Summary for Policymakers, Global Warming of 1.5 Degrees C.” Edited by P. Masson-Delmotte, H. Zhai, O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, et al. World Meteorological Organization. https://www.ipcc.ch/sr15/.

Krugman, Paul. 2017. “Salvation Gets Cheap.” *New York Times*, December 20, 2017, sec. Opinion. https://www.nytimes.com/2014/04/18/opinion/krugman-salvation-gets-cheap.html.

Laemel, Ryan, and Jennifer Milikowsky. 2016. “Yale University’s Carbon Charge: Preliminary Results from Learning by Doing.” Yale University. https://carbon.yale.edu/resources/white-papers.

Madden, John, and Leanne Bilodeau. 2018. “Case Study: Climate Action in the Context of an Externally Imposed Price on Carbon.” September 3, 2018. https://secondnature.org/wp-content/uploads/UBC-Case-Study-Climate-Action-in-the-Context-of-an-Externally-Imposed-Price-on-Carbon.pdf.

Marshall-Cook, Joanna, and Ciaran Jebb. 2018. “Case Study: UCL Carbon Accountability Scheme.” Internal Carbon Pricing in Higher Education Toolkit. Second Nature. https://secondnature.org/climate-action-guidance/iv-case-studies/.

New York University. n.d. “Sustain It.” NYU Office of Sustainability (website). Accessed March 29, 2019. http://www.nyu.edu/content/nyu/en/life/campus-resources/facilities-operations-maintenance/sustain-it.

Nordhaus, William, John Bollier, Robin Canavan, Virginia Chapman, Daniel Esty, Bradford Gentry, Peter Glazer, et al. 2015. “Report to the President and Provost of Yale University: Findings and Recommendations on a Carbon-Charge Program at Yale.” Yale Carbon Charge Project. New Haven, Connecticut: Yale University. https://carbon.yale.edu/resources/white-papers.

Northeastern University. 2018. “Commitment to Sustainability.” Northeastern University (website). https://www.northeastern.edu/sustainability/.

Northeastern University Office of the Provost. 2017. “Budgeting at Northeastern Update to Faculty Senate.” Slide presentation delivered Anthony Rini to the Northeastern University Office of the Faculty Senate. February 15, 2017. https://faculty.northeastern.edu/app/uploads/sites/2/2017/09/Budgeting-Update-2-15-17.pdf.

———. 2018. “Budgeting at Northeastern Update to Faculty Senate.” Slide presentation delivered by Breean Fortier to the Northeastern University Office of the Faculty Senate. April 4, 2018. https://faculty.northeastern.edu/app/uploads/sites/2/2018/04/4.10.18-Faculty-Senate-on-the-HBM-04_03_18.FINAL1_.pdf

Parker, Breanna Jane, and Alexander Barron. 2018. “Case Study: Proxy Carbon Price Strategy.” https://secondnature.org/wp-content/uploads/SMITH-Case-Study-Proxy-Carbon-Price-Strategy.pdf.

Pearce, Fred. 2016. "What Would a Global Warming Increase of 1.5 Degrees Be Like?" *Yale E360*, June 16, 2016. https://e360.yale.edu/features/what_would_a_global_warming_increase_15_degree_be_like.

Regional Greenhouse Gas Initiative. 2018. "The Regional Greenhouse Gas Initiative." Welcome. https://www.rggi.org/.

Ricke, Katharine, Laurent Drouet, Ken Caldeira, and Massimo Tavoni. 2018. "Country-Level Social Cost of Carbon." *Nature Climate Change* 8 (10): 895. https://doi.org/10.1038/s41558-018-0282-y.

Rogelij, J., D. Shindell, K. Jiang, S. Fifita, P. Forster, V. Ginzburg, C. Handa, H. Kheshgi, S. Kobayashi, E. Kriegler, L. Mundaca, R. Séférian, and M.V. Vilariño. 2018. "Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development." In *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. Edited by Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield. April 2019. https://www.ipcc.ch/sr15/chapter/2-0/.

Second Nature. 2015. "Northeastern University." Second Nature Reporting Platform. 2015. http://reporting.secondnature.org/institution/detail!1781##1781.

Shafiee, Shahriar, and Erkan Topal. 2009. "When Will Fossil Fuel Reserves Be Diminished?" *Energy Policy* 37 (1): 181–89. https://doi.org/10.1016/j.enpol.2008.08.016.

Swarthmore College. 2017a. "The Carbon Charge Fund." Swarthmore Sustainability (website). https://www.swarthmore.edu/sustainability/carbon-charge-fund.

———. 2017b. "The Shadow Price." Swarthmore Sustainability (website). https://www.swarthmore.edu/sustainability/shadow-price.

———. 2018a. "The Carbon Charge to Departments." Swarthmore Sustainability (website). https://www.swarthmore.edu/sustainability/carbon-charge-to-departments.

———. 2018b. "Carbon Charge Committee." Swarthmore Sustainability (website). https://www.swarthmore.edu/sustainability/carbon-charge-committee.

UCLA Sustainability. n.d. "Air Travel Mitigation Fund." UCLA Sustainability (website). https://www.sustain.ucla.edu/airtravelfund/.

US Environmental Protection Agency. n.d. "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866."

US Global Change Research Program. 2018. "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II." Washington, DC: US Global Change Research Program. doi:10.7930/NCA4.2018.

Victor, David G., and Joshua C. House. 2006. "BP's Emissions Trading System." *Energy Policy* 34 (15): 2100–2112. https://doi.org/10.1016/j.enpol.2005.02.014.

World Bank Group. 2018. "What Is Carbon Pricing?" The World Bank: Carbon Pricing Dashboard (website). 2018. https://carbonpricingdashboard.worldbank.org/what-carbon-pricing.

ROOSEVELT NETWORK