Yale University's Carbon Charge:
Preliminary Results from Learning by Doing

October 10, 2016

"Global climate change and its consequences are critical challenges of our time, and Yale has important and necessary roles to play in addressing them." –Yale President Peter Salovey

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KEY CONCLUSIONS

- **Internal carbon pricing has potential for university campuses.** A carbon charge has considerable potential to increase understanding, motivation, and action for reducing energy use, costs, and greenhouse gas emissions at Yale. As momentum builds in the public and private sectors[1], higher education can contribute to the global effort of designing effective carbon pricing mechanisms.

- **Carbon pricing scheme design matters, but many variations can work.** While there are specific elements that may enhance the effectiveness of Yale's carbon pricing scheme, it is likely that any scheme would offer a positive outcome on emissions reductions. Yale is drawing on the lessons from its pilot and moving forward with a mechanism that fits the unique needs of its campus. Peer institutions can build on Yale's efforts by designing and testing mechanisms that align with their own policy objectives.

- **An effective carbon pricing scheme conveys clear information and incentives.** Yale's carbon charge is most effective when appropriate decision-makers receive actionable information and incentives align with organizational priorities and financial structures. In addition to refining its carbon pricing scheme, Yale is making its price signal more salient by developing reporting and accounting systems that facilitate the flow of data and dollars on a monthly basis.

- **Resulting emissions reductions can be cost-effective.** Yale's carbon charge can deliver emissions reductions by encouraging behavioral and operational changes that result in energy savings without significant capital investment. Preliminary results suggest that these reductions can come at marginal abatement costs less than -$100 per ton of carbon dioxide equivalent.

- **Carbon pricing benefits from experimentation and collaboration.** As the university expands its carbon charge from twenty to sixty buildings during the 2016-2017 academic year, Yale looks forward to opportunities for teaching, learning, and sharing that encourage peer institutions, businesses, and governments to experiment with carbon pricing.

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[1] Thirteen percent of global emissions are subject to carbon prices (World Bank and ECOFYS 2016) and over 400 companies disclose internal carbon prices through the Carbon Disclosure Project (CDP 2015).

1. Executive Summary

On the heels of a landmark climate accord in Paris in December 2015, momentum is building in the public and private sectors around a market-based solution to climate change: carbon pricing. Emissions trading schemes or carbon taxes covered 13% of global emissions in 2016 and 435 companies reported an internal carbon price in 2015—nearly three times the number from one year earlier. Higher education can contribute to this global effort of designing effective carbon pricing mechanisms.

In April 2015, the Yale Presidential Carbon Charge Task Force recommended that the university pilot an internal carbon charge as part of campus operations during the 2015-2016 academic year. The pilot sought to determine the administrative feasibility, effectiveness, and potential impact of a carbon charge applied to utility costs allocated to Yale's administrative units. This initiative afforded an opportunity for Yale to experiment with the design and implementation of an internal carbon charge at a university.

A steering committee composed of two project managers and administrators from the Offices of the President, Provost, Budget, Facilities, and Sustainability directed the pilot. Twenty buildings (i.e., "pilot units") representative of Yale's campus were assigned to one of four treatment groups. Three treatments received a new energy report and an incentive related to carbon pricing (i.e., "scheme"). One received the energy report only. Each scheme was a variation of the mechanisms proposed by the task force. They are characterized by information, target, redistribution, and investment (see Section 3b for more details).

1. **Information:** Five pilot units received a monthly building energy report with a \$40 per tCO_2e price signal, without financial consequences.
2. **Target:** Another five pilot units were subject to a reduction target of 1% below baseline; they paid or received \$40 per tCO_2e for emissions above or below this target value, respectively.
3. **Redistribution:** A third group of five pilot units were compared to the group's overall percent change in emissions from baseline, incurring charges or receiving rebates based on performance above or below this value; this scheme is revenue-neutral.
4. **Investment:** The final group of five pilot units received a subsidy of 20% their baseline carbon charge for spending on self-guided energy actions; this modification simulated the second year of this scheme, in which a portion of carbon charge revenues would have been returned to buildings as rebates earmarked for internal education, conservation, and efficiency initiatives.

258 other campus buildings served as the control group. Unlike the treatment groups, the control group was not subject to a scheme and did not receive additional information or engagement.

Between December 2015 and May 2016, nominated representatives from each of the twenty pilot units received six monthly utility reports. These reports included energy use and cost information, and a \$40 per metric ton of carbon dioxide equivalent (tCO_2e) charge applied to utilities used by the building. Yale's \$40 per tCO_2e carbon price is based on the Federal Government's estimate of the Social Cost of Carbon (SCC)[2]. Emissions covered by Yale's carbon price are the university's stationary Scope 1 and Scope 2

[2] See the Yale Presidential Carbon Charge Task Force's April 2015 report for the rationale behind this carbon price.

greenhouse gas (GHG) emissions. While units saw a carbon charge on their monthly energy report, they did not incur monthly chargers. Financials were settled at the end of the pilot instead. Pilot units were not permitted to purchase offsets to reduce their emissions at a carbon price lower than Yale's, as per the recommendation of the Presidential Carbon Charge Task Force.

Yale's pilot provided qualitative data from semi-structured interviews, an exit survey, and other observations. This qualitative research is useful in evaluating Yale's various carbon pricing schemes, in particular their effects on participants' levels of understanding, motivation, and action, collectively defined as effectiveness. The steering committee also tracked and analyzed metered energy use. While these quantitative data indicate a carbon charge's potential to reduce emissions at Yale, the pilot sample size is small and the pilot term is short. A second pilot that is larger and longer can enhance the significance of these quantitative results.

The steering committee's key findings are as follows.

Key Finding #1

It is administratively feasible to apply a carbon charge to Yale's administrative units.

Yale's extensive metering equipment and ability to both calculate campus-wide emissions factors and generate monthly energy reports are the main factors behind this finding. Previously, Yale did not provide building decision-makers with specific informational reports summarizing their monthly energy use, carbon emissions, and the costs associated with each of these quantities. Now, this monthly report can help establish the carbon charge as a regular price signal by integrating it into financial and operational decision-making. Rolling out this report to the rest of campus and further incorporating the carbon charge into Yale's existing budgeting and accounting processes are future goals of the project.

Key Finding #2

The combination of clear information and a carbon pricing scheme increases understanding, motivation, and action for reducing energy use at Yale.

More than half of the pilot units reported "higher" or "much higher" levels of understanding after the six-month pilot term. Three of four pilot units indicated these higher levels of motivation and action. This increased motivation led most pilot units to engage the Offices of Facilities and Sustainability on a variety of energy conservation and efficiency initiatives. The schemes with "carrot-and-stick" style incentives—Scheme 2 (target) and Scheme 3 (redistribution)—appear to be more motivating than those without similar win-loss structures, according to participants, with average reductions of 10.0% and 10.8%, respectively, during the pilot term.

Key Finding #3

While there were no significant differences in emissions reductions among Yale's carbon pricing schemes, there are clear differences in their administrative feasibility and effectiveness.

The following represent design elements that enhance the effectiveness of Yale's carbon pricing scheme:

- *A price signal is more effective when aligned with a pilot unit's distinct budget structure.* Yale's self-supported and centrally-supported units have different budget structures. As units responsible for their own budgeting and fundraising, self-supports are energy ratepayers. They are subject to both the profits and losses associated with their energy use changes, the costs of which are substantially larger than their carbon charge. Centrally-supported units are not responsible for their own fundraising or utilities expenses. These different budget structures suggest the need for treating self-supported and centrally-supported units separately with regard to carbon pricing. Designing carbon pricing schemes with incentives unique to these distinct budget types is likely to make for a more salient price signal across Yale.

- *Various factors influence the effectiveness of a price signal, including additional energy information and rebate mechanics.* The accounting and marketing of Yale's carbon charge influences the strength of its price signal. Information can make this price signal more or less salient to participants. Which data were included on the pilot units' monthly energy reports may have influenced the schemes' effectiveness. Pilot units received a running total of their "gross" carbon charge minus the rebate that they would receive based on their scheme's rules. Displaying only this "net" amount, instead of a monthly "gross charge" and a "gross rebate" at the end of the pilot, may have weakened the price signal by presenting smaller figures. While this "net" amount is the charge or rebate buildings incur or receive, respectively, at the end of the term and participants may consider this incentive too small to drive transformational change, it motivated participants during the pilot. Over time Yale may have to increase its carbon price to make these net values more motivating.

Key Finding #4

A revenue-neutral redistributive carbon pricing scheme must be perceived as fair and avoid perverse incentives.

Revenue-neutrality may be an important part of Yale's carbon pricing scheme, in particular for the self-supports. The redistribution of carbon charge revenues, however, presents a number of challenges, in addition to the potentially small incentives described in Key Finding #3.

- *Perceived fairness is an important part of competition.* Yale's carbon pricing scheme is more effective when participants consider the rules fair. A scheme that disadvantages certain buildings, departments, or schools prevents these affected populations from engaging fully. For example, in interviews the pilot units called Scheme 3 (redistribution) unfair, as it used the group's percent change in emissions to calculate financial rewards or penalties, and buildings vary in size and have more or less expensive reduction opportunities. However, it is important to note that an emphasis on fairness can compromise the price signal and the scheme's effectiveness.

- *Perverse incentives, predictability, and undesirable redistributive effects reduce impact.* How best to return some or all carbon charge revenues is a complex question and depends on organizational priorities. However, avoiding perverse incentives is one finding that applies widely. For example, Scheme 3 (redistribution) rewards buildings with increasing emissions so long as their emissions grow more slowly than average. While this perverse incentive could reduce impact by encouraging relative, not absolute emissions reduction, there was no evidence of collusion to minimize reduction during the pilot. Similarly, predictable schemes and those with undesirable redistributive effects reduce impact. For instance, a scheme that regularly redistributes carbon charge revenues from poorer to wealthier self-supports may be demotivating and ineffective at incentivizing emissions reduction.

Key Finding #5

A carbon charge has potential to reduce emissions cost-effectively at Yale.

Collectively, the pilot units reduced emissions more than the control group; they reduced emissions by 4.9 and 1.4 percent below the baseline, respectively, or 478 and 847 tCO_2e, despite cumulative emissions for these buildings being above baseline before the pilot. Each scheme had a lower average reduction than the control group by 2.4 to 6.5 percentage points. Schemes 2 (target) and 3 (redistribution) had the greatest average reductions, 10.0 and 10.8 percent, respectively. Scheme 4 (information) observed a 7.4% average reduction, suggesting that information and engagement alone may encourage abatement.

There were several capital improvement projects during the pilot, namely lighting retrofits. Most actions reported by the pilot units were behavioral programs and operational changes, suggesting that the carbon charge can deliver cost-effective energy savings and GHG reduction. Using energy-cost savings for the twenty pilot units, the pilot saw savings of $135 per tCO_2e. While it can be challenging to maintain energy, carbon, and cost savings associated with behavioral and operational changes, these values demonstrate the potential for Yale's carbon charge to serve as a complementary strategy to energy efficiency in meeting the university's sustainability goals cost-effectively.

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Looking Ahead

Yale plans to conduct another experiment in the 2016-2017 academic year incorporating these findings. This second pilot will test two carbon pricing schemes—one for self-supported and another for centrally-supported units. The self-support scheme will continue testing revenue-neutrality, as these units already have a financial incentive to reduce their energy use. This mechanism will be the same as the third scheme in Yale's 2015-2016 pilot. A new approach that involves sharing a portion of the carbon costs or savings will apply to the central-supported units as a first step toward fully decentralizing the utilities budget. Sixty buildings will be part of this second pilot. Further experimentation will help Yale continue to study scheme design and work toward wider implementation. As the carbon charge scales, administrative units learn of its existence, and members of the Yale community examine ways and means to reduce their energy use, the university must be modest and patient in its expectations about the impact of the carbon charge on emissions reduction.

The steering committee concludes that an internal carbon charge is an important part of Yale's campus climate action and financial stewardship. It has potential to reduce energy costs and emissions by improving energy literacy, encouraging behavior change, and driving demand for energy services. More broadly, the carbon charge enhances the university's operational and academic missions by supporting education and research on the campus and beyond. Yale looks forward to continued experimentation with carbon pricing, and hopes that peer institutions, businesses, and governments will join the discussion surrounding this innovative solution to global climate change.

2. INTRODUCTION

Anthropogenic climate change is an externality with significant implications for human society and the environment. Calculated action to reduce carbon emissions from all sectors and draw down existing atmospheric concentrations of carbon dioxide and other greenhouse gas (GHG) emissions is key to mitigating the speed and scale of climate impacts. Building energy use is one lever for reducing emissions and represents a popular research area. Today, buildings account for 38% and 6.5% of U.S. and global GHG emissions, respectively (U.S. D.O.E. 2016).

Most building energy research focuses on efficiency, which can deliver measurable and cost-effective emissions reduction. Savings can also be achieved through behavior change. Incentive programs are one strategy for encouraging this behavior change, in addition to investment in energy efficiency. Despite the energy-intensive operations of most university campuses, few research studies focus on carbon abatement strategies in the education sector. Yale University took a step to close this gap by launching a six-month pilot experiment on internal carbon pricing in December 2015.[3]

Carbon pricing has emerged as popular tool to promote carbon abatement in both the public and private sectors. A recent World Bank report shows emissions trading schemes (ETS) or carbon taxes covered 13% of global emissions in 2016 (World Bank and ECOFYS 2016). Ninety National Determined Contributions (NDC) included language on carbon pricing or other market-based mechanisms, suggesting broader government action in the future. Furthermore, research from the Carbon Disclosure Project (CDP) indicates growing adoption of voluntary carbon pricing in the private sector, with 435 companies reporting an internal carbon price—nearly three times the number from one year earlier (CDP 2015).

The quantity of emissions under a carbon price is expected to grow across sectors. The World Bank recently called on governments to double the percentage of global emissions covered by explicit carbon prices to 25% by 2020—an achievable goal considering the launch of China's ETS in 2017—and again to 50% within a decade.[4] In the private sector, CDP's survey results suggest similar trends in the private sector, projecting that the number of companies with an internal carbon price will eclipse 1,000 by 2017.

There are two common forms of carbon pricing in the public sector: an ETS (i.e., "cap-and-trade") and a carbon tax. An ETS sets a limit on emissions for a market and individual firms, and allows these entities to buy and sell allowances for emitting more or less carbon than they were permitted. Generally, auctions organized by the government determine prices based on supply and demand. Cap-and-trade represents a quantity-based approach to carbon abatement.

A carbon tax is an explicit price applied to the carbon content of fossil fuels. As with cap-and-trade, the intent of this fee is to account for the true cost of GHG emissions, including externalities such as air pollution, flood risk, and biodiversity loss, to name a few examples. In most countries, society does not

[3] http://news.yale.edu/2015/12/07/yale-introduces-innovative-carbon-charge-program-20-living-laboratories-around-campus
[4] http://www.worldbank.org/en/news/press-release/2016/04/21/leaders-set-landmark-global-goals-for-pricing-carbon-pollution

directly pay for these environmental and social damages when they consume carbon-based energy, goods, and services. Instead, they pay for these costs downstream. Pricing externalized costs levels the playing field for low-carbon alternatives by making carbon-intensive fuels more expensive. A carbon tax is a price-based approach to achieving an economically efficient level of pollution.

Corporate carbon pricing differs from government-level carbon pricing in that it is internal and voluntary. There are a wide range of prices and approaches. Generally, private-sector carbon pricing comes in three forms: implicit pricing, shadow pricing, and internal taxes or fees (WRI 2015).

- **Implicit pricing** is when companies base their carbon price on the cost of their internal GHG reductions. For example, Yale has a GHG reduction target of 43% below a 2005 baseline by 2020. The amount of money the university spends to achieve these reductions could be used to calculate an implicit carbon price. That implicit price is analogous to marginal abatement cost—the amount of money spent to reduce one tCO_2e.

- **Shadow pricing** is a form of explicit pricing often used in carbon-intensive industries like oil and gas. These internal values are usually applied to investment calculations. For example, an oil and gas firm might apply a range of shadow prices to a prospective oil reservoir to assess profitability under different policy scenarios. Similarly, an investor-owned utility in California might use a shadow price when designing and constructing a new co-generation power plant to understand the potential impact of California's cap-and-trade program on fuel procurement.

- **Internal taxes or fees** are forms of explicit pricing where companies charge a price for the emissions associated with the energy used in their operations. These prices usually fall in the $5-25 per tCO_2e range. Companies use the revenues collected from this carbon fee in a variety of ways. For example, Disney and Microsoft[5] use their revenues to pay for renewable energy credits (RECs), carbon offsets, and on-site energy efficiency projects. French Bank Société Générale allows its business units to apply for these funds to finance carbon reduction projects. One of Yale's carbon pricing schemes is revenue-neutral.

Like many companies, Yale is home to many energy challenges—from landlord-tenant split incentives to accommodating diverse needs and levels of understanding. Higher education and university campuses offer unique settings for experimenting with all forms of carbon pricing. Yet to the best of the steering committee's knowledge, no university has instituted an internal carbon tax. Yale's Presidential Carbon Charge Task Force recommended in April 2015 that the university pilot a carbon charge as part of campus operations during the 2015-2016 academic year. In December 2015, Yale launched this pilot experiment, becoming the first university to design and implement an internal carbon price.

As the first academic member of the Carbon Pricing Leadership Coalition (CPLC)—a private-public partnership among the World Bank, International Monetary Fund (IMF), governments, non-profits, and private sector companies to strengthen carbon pricing policies—Yale is pleased with the academic and

[5] Learn more at http://aka.ms/uplit and http://aka.ms/carbon.

operational progress it has made on carbon pricing so far.[6] Recognition from U.N. Secretary General Ban Ki Moon is evidence that Yale is addressing climate change in an innovative way.[7]

The university looks forward to further experimentation with its own carbon charge and opportunities for collaboration with companies and governments engaged in similar carbon pricing initiatives. Yale hopes that its role in this discussion—both on campus and through the Carbon Pricing Leadership Coalition—will encourage peer institutions to contribute to the global effort of developing effective carbon pricing.

The remainder of the paper is structured as follows: Section 3 provides background on Yale's carbon charge and explains the pilot design; 4 presents the pilot's quantitative and qualitative findings; 5 shares the steering committee's recommendations for a second pilot; and 6 shares lessons for peer institutions, policymakers, and business leaders.

[6] http://news.yale.edu/2016/03/15/yale-becomes-first-university-join-global-carbon-pricing-leadership-coalition
[7] http://news.yale.edu/2016/04/19/yale-s-innovative-market-based-approach-climate-change-gains-global-recognition

3. Background & Pilot Design

3a. History & Motivations

Yale's students, faculty, and staff collectively drove campus change, working with the administration to propose carbon pricing as a potential addition to the university's sustainability efforts.

In August 2014, Yale President Peter Salovey announced the formation of the Presidential Carbon Charge Task Force. Its goal was to investigate the feasibility and effectiveness of instituting an internal carbon price as part of Yale's sustainability efforts. A three-year, $21 million capital investment in campus energy conservation and GHG reduction; the installation of a 1.4-megawatt solar photovoltaic array on West Campus; and third-party verification and disclosure of the university's GHG inventory through The Climate Registry accompanied the establishment of this task force.

The idea for the task force started at an Earth Day event convened by the Offices of the President and Sustainability in 2014. Students, faculty, and staff were sharing thoughts on how Yale might use its campus as a test-bed for environmental policy when Professor William Nordhaus proposed that the university experiment with carbon pricing. Many economists, climate scientists, policymakers, and business leaders regard this financial tool as an important part of efforts to mitigate climate change.

Following this event, undergraduate and graduate students from Professor Daniel Esty's class wrote a letter to Yale's administration recommending that the campus serve as a living lab for experimenting with carbon pricing. At the same time, the Office of Sustainability had been researching internal carbon pricing in the private sector. This campus-wide interest and thought-leadership culminated in the creation of Yale's Presidential Carbon Charge Task Force.

The Presidential Carbon Charge Task Force conducted a preliminary study on internal carbon pricing for Yale and concluded that the university should pilot the concept in the 2015-2016 academic year.

The task force met bi-weekly for six months, consulting with internal and external experts, to conduct a preliminary assessment on internal carbon pricing for Yale. In an April 2015 report to the President and Provost, the task force recommended a pilot testing one of two proposed carbon pricing schemes in a select number of buildings during the 2015-2016 academic year.

According to the task force's research, an internal carbon charge offers a number of benefits:

1. **A carbon charge encourages individuals and administrative units to reduce emissions.** Sending a price signal set at the SCC and engaging building users in an incentive scheme provides decision-makers additional motivation for reducing emissions. Higher motivation increases interaction between campus buildings and the Offices of Facilities and Sustainability, creating a culture of energy awareness and action. This price signal also helps building occupants understand the true cost of their energy use.

2. **A carbon charge drives individual and departmental behavior change.** Behavior change comes in many forms within an institution. One form is individual behavior, such as shutting off lights or powering down computers. Another is departmental policy. For example, a department that chooses to decrease building operating hours or shorten the occupied modes of its heating, ventilating, and air-conditioning (HVAC) schedule saves energy and money. A third form is the willingness of individuals and departments to accommodate energy efficiency work or other capital upgrades. Engaged occupants and administrators create more efficient pathways between project identification and implementation by collaborating with the Office of Facilities.

3. **A carbon charge prepares Yale for a higher carbon-price future.** Understanding the organizational, operational, and technical elements of administering an internal carbon charge is a useful exercise in preparing for a higher carbon-price future. As a large purchaser of electricity and carbon-based fuels in the Northeast, Yale is subject to the Regional Greenhouse Gas Initiative (RGGI)—a cap-and-trade system among Northeast and Mid-Atlantic states. While the RGGI clearing price is low relative to the SCC and Yale's own power plants are currently small enough to be exempt from the program, future regulations could subject Yale to a higher carbon price.[8] Designing and implementing a voluntary carbon price allows time to prepare for this scenario by building support systems and educating the campus community in advance.

4. **A carbon charge enhances Yale's sustainability strategy.** Yale has a far-reaching Sustainability Strategic Plan that covers energy and GHG emissions.[9] One goal is to reduce campus emissions 43% below a 2005 baseline by 2020. A carbon charge that drives behavior change and promotes both energy conservation and efficiency supports progress toward this commitment. Yale's carbon price could also serve as a shadow price for capital investment decisions. Including this $40 per tCO_2e charge in financial evaluations has the potential to green-light more low-carbon projects by layering carbon cost-savings on top of energy cost-savings. The carbon charge's potential to encourage behavior change and low-carbon investment makes it another tool to help Yale achieve its GHG reduction goal.

5. **A carbon charge integrates academics with operations.** The carbon charge can provide faculty and students with opportunities to engage with internal policymaking. For example, students might conduct behavioral research with the pilot units, and faculty might collaborate with public- and private-sector leaders on educational programming. Connecting Yale's research to campus operations strengthens its academic and operational missions.

In sum, a carbon charge can support a range of objectives at Yale—from preparing the university for a higher carbon-price future to supporting student and faculty research. Additionally, it affords Yale a unique opportunity to experiment with sound governmental policy.

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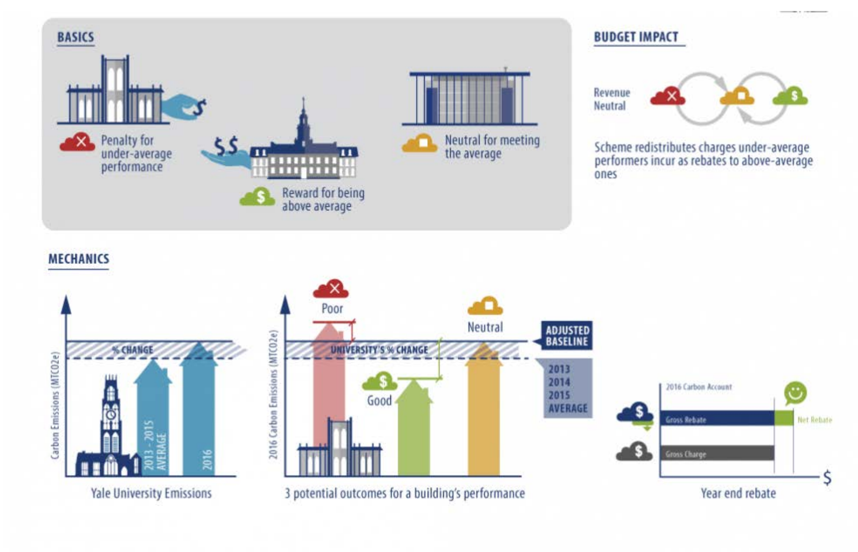
[8] The clearing price of the July 1, 2016 auction was $4.53 per tCO_2e. (https://www.rggi.org/market/co2_auctions/results) The RGGI price was not subtracted from Yale's $40 per tCO_2e charge for the pilot.
[9] http://sustainability.yale.edu/planning-progress

3b. Scheme Selection

The Presidential Carbon Charge Task Force proposed two possible carbon pricing schemes[10]. The steering committee refers to the first of these two as Scheme 3 (redistribution), which resembles a Swedish NO_x abatement program referred to in Sterner and Isaksson (2006) as a Refunded Emissions Payments (REP) scheme. Yale's REP scheme takes the form of a \$40 per tCO_2e applied monthly to carbon emissions associated with building energy use. At the end of the fiscal year, Yale returns all revenues to the collective of buildings based on their individual percent changes in emissions relative to the university's overall percent change (i.e., "average") (Figure 1). [11]

Figure 1. Diagram demonstrating the mechanics of Scheme 3 (redistribution), in which a building's baseline is adjusted by the group's overall percent change in emissions. The difference between that building's actual and adjusted baseline emissions determines whether they incur a charge or receive a rebate. The sum of charges and rebates is zero, making this scheme revenue-neutral by design.



Buildings with percent changes below this average receive a full refund and additional payment that together are more than they were charged, resulting in a net rebate. Those with percent changes above this average receive a refund amounting to less than they were charged initially, resulting in a net charge. The sum of these charges and rebates is zero. Therefore, the scheme is revenue-neutral for the university. However, it is not revenue-neutral for the individual buildings and administrative units.[12]

To illustrate how Scheme 3 (redistribution) works, consider three buildings, A, B, and C, with baseline emissions 100, 200, and 200 tCO_2e, respectively (Table 1). Say A, B, and C's actual emissions are 90, 200, and 160 tCO_2e. At \$40 per tCO_2e, these actual emissions mean that A, B, and C pay \$3,600, \$8,000, and \$6,400, respectively. Since the group's overall emissions reduced by 50 tCO_2e from 500 to

[10] http://carbon.yale.edu/sites/default/files/files/Carbon-charge-report-041015.pdf
[11] Yale's fiscal year runs from July to June.
[12] An administrative unit is the entity responsible for a building's budget. For example, Kroon Hall rolls up to the School of Forestry and Environmental Studies. Administrative units may have multiple buildings. Likewise, buildings may house multiple administrative units.

450 tCO_2e, or 10% below baseline, rebates equal baseline emissions multiplied by the adjustment factor, 0.9 (i.e., 450/500). Using this formula, A, B, and C receive $3,600, $7,200, and $7,200, respectively. Subtracting their charges from their rebates, A, B, and C receive net rebates of $0, -$800, and $800, respectively, and shows that the scheme is revenue-neutral.

Table 1. Example demonstrating the mechanics of Scheme 3 (redistribution). Baseline Emissions and Actual Emissions are in tCO_2e. The carbon price is $40 per tCO_2e.

Building	Baseline Emissions	Actual Emissions	Gross Charge	Gross Rebate	Net Rebate
A	100	90	$3,600	$3,600	$0
B	200	200	$8,000	$7,200	-$800
C	200	160	$6,400	$7,200	$800
Total	**500**	**450**	**$18,000**	**$18,000**	**$0**

This "redistribution" scheme benefits from its revenue-neutral approach. It would be interesting for Yale to test revenue-neutrality at a small scale, as it may be an important design feature of a national carbon pricing scheme. However, Scheme 3 (redistribution) lacks simplicity and predictability. The steering committee felt that participants might find their charge or rebate calculation confusing, as it depends on their performance relative to others. In addition, participants' inability to predict the number by which they are judged may make it difficult to conduct cost-benefit analysis, potentially diminishing energy action or resulting in suboptimal investment decisions.

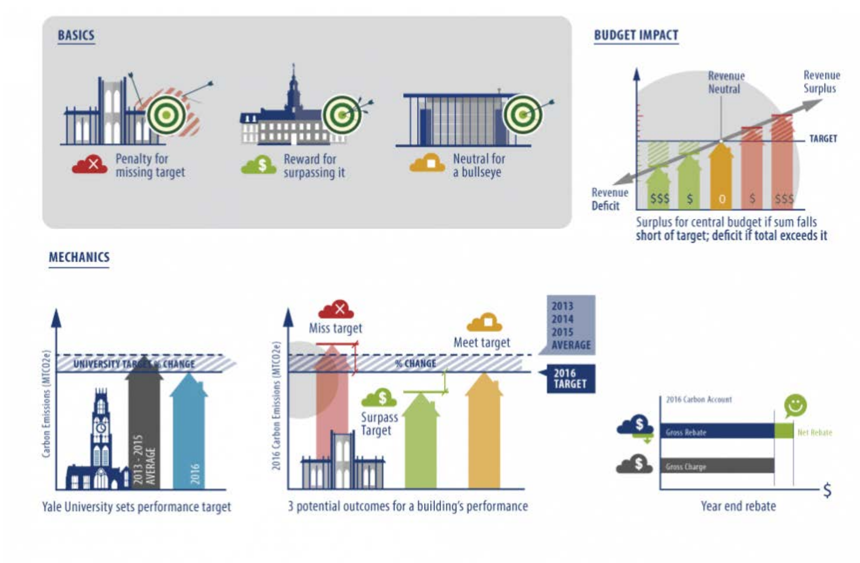
While simplicity and predictability are absent from the first scheme, they are part of Scheme 2 (target). This second model applies a monthly $40 per tCO_2e charge to carbon emissions associated with building energy use. At the end of the fiscal year, Yale returns most of these revenues to each unit based on its individual performance relative to a target. The definition of this target is a specific percentage reduction below baseline emissions. This value can be universally applied to all buildings or customized for each building. -1% was the target for the pilot.

To illustrate how Scheme 2 (target) works, consider the same three buildings, A, B, and C (Table 2). Instead of comparing these buildings to the group's overall emissions, Scheme 2 (target) compares them to a reduction target, 1% in this case. With an adjustment factor of 0.99, A, B, and C receive net rebates of $0, -$800, and $800, respectively, and shows that the scheme results in a central deficit.

Table 2. Example demonstrating the mechanics of Scheme 3 (redistribution). Baseline Emissions and Actual Emissions are in tCO_2e. The carbon price is $40 per tCO_2e.

Building	Baseline Emissions	Actual Emissions	Gross Charge	Gross Rebate	Net Rebate
A	100	90	$3,600	$3,960	$360
B	200	200	$8,000	$7,920	-$80
C	200	160	$6,400	$7,920	$1,520
Total	**500**	**450**	**$18,000**	**$18,000**	**$1,800**

Figure 2. Diagram demonstrating the mechanics of Scheme 2 (target), in which a building is compared to a 1% reduction target. The difference between that building's actual and target emissions determines whether they incur a charge or receive a rebate. The sum of charges and rebates is not zero by design, potentially subjecting the university to a surplus or deficit.



Buildings with emissions below this target receive a full refund and additional payment that together are more than they were charged, resulting in a net rebate. Those with emissions above this target receive a refund that is less than they were charged, resulting in a net charge. The sum of these charges and rebates is not revenue-neutral for the university by design. Generally, this scheme results in a deficit or surplus for the university. It is only revenue-neutral for the university if the buildings collectively meet the target. These possible outcomes also apply to the individual buildings and administrative units (Figure 2).

The steering committee did not view a deficit as a negative attribute for the centrally-supported units, as it translated to a small financial reward for the units and significant energy cost-savings for the university.[13] However, both a deficit and a surplus are unfavorable outcomes for the self-supports. On one hand, a deficit results in the university providing a subsidy to the self-supports for reducing their emissions below the target amount. On the other hand, a surplus has the appearance of a central tax on the self-supports for increasing their emissions relative to the target. These outcomes are challenging administratively because self-supports generally do not receive significant revenue from or pay taxes to the university.

Given the pros and cons of Schemes 2 (target) and 3 (redistribution) (Table 3), the steering committee designed a third carbon pricing scheme and an informational option. Scheme 4 (investment) explored the potential use of carbon charge revenues as a funding source for internal energy reduction projects, similar to many internal carbon fee models. However, the difference between most revenue-generating carbon

[13] Utility costs for centrally-supported units are paid by the university. If a centrally-supported building reduces its energy use, under the "target" scheme the corresponding administrative unit receives a small rebate, while the university receives the associated energy cost-savings. To a first approximation, the energy cost-savings are about ten times the rebate.

pricing schemes and this one is that it aims to decentralize the investment. In Scheme 4 (investment), a monthly \$40 per tCO_2e applies to carbon emissions from building energy use. At the end of the fiscal year, the building receives a full refund, with a percentage earmarked for internal carbon reduction initiatives. This portion is referred to as the "energy efficiency earmark." 20% was the earmark for the pilot. Yale returns the remainder without restriction. This unrestricted amount was 80% for the pilot. The steering committee chose these allocations to provide a reasonable price signal (i.e., \$8 per tCO_2e) and an amount of money pilot units could realistically capitalize during the six-month pilot.

Table 3. Pros and cons for the revenue-neutral and target-based schemes outlined in the Presidential Carbon Charge Task Force's report.

	Pros	Cons
Scheme 3 (Redistribution)	• *Value in Cost Certainty:* Revenue-neutrality provides cost certainty • *Not a Tax to Raise Revenue:* Revenue-neutrality avoids appearance of tax on self-supports • *Unpredictable as an Upside:* Lack of predictability may be motivating • *Reducing Isn't Chasing Tails:* While reducing may lower the average, a unit still reaps most of the benefit of their reduction • *Policy Implications:* Revenue-neutrality may be a cornerstone of effective carbon pricing policy	• *Cost Certainty for One, not All:* The scheme may be revenue neutral for the university, but it is not for the units • *Theoretically Motivating, Practically Paralyzing:* A moving average may make performance prediction difficult and real-time cost-benefit analysis difficult • *Uneven Playing Field:* Comparison to an average may unfairly penalize early-adopters while benefitting late-adopters • *The Price Isn't Right:* REP schemes result in net carbon prices that are lower than the original carbon price post-return • *Rewards for Growth:* If university emissions grow, units increasing at slower-than-average rates earn rewards despite growth • *Baselines Are Burdensome:* Percent change calculations require baselines, which are controversial and subject to gaming
Scheme 2 (Target)	• *Predictability as an Upside for Units:* Targets may be more actionable than an average by offering predictable cost-benefit accounting • *Reduction or Payment:* A target acts like a cap, ensuring reduction or pollution payment • *Individual Focus:* Targets focus competition internally, which may be more motivating and fairer than Scheme 1 • *Customization as an Option:* Ability to customize targets offers flexibility	• *Cost Certainty Isn't Assured:* Targets with linear payment functions subject the university to a potential deficit or surplus • *Targets and Baselines are Burdensome:* Targets, which also require baselines, are controversial and gameable, especially if they are custom and not universal • *Again, the Price Isn't Right:* Refunded Emissions Payment schemes—whether based on averages or targets—result in marginal carbon prices that are lower than the original carbon price after the return

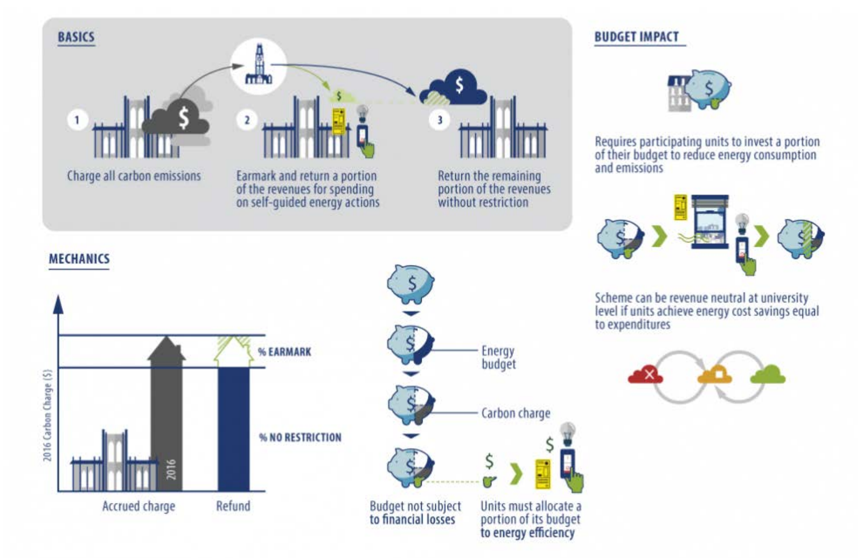
To illustrate how this investment-based scheme works, consider a building that emits 500 tCO_2e and incurs a carbon charge of \$20,000 (Table 4). This building would receive \$20,000 as a rebate at the end of the year. While it receives \$16,000 (80%) that has no spending restriction, it would have to spend \$4,000 (20%) on energy conservation and efficiency measures.

Table 4. Example demonstrating the mechanics of Scheme 4 (investment). Actual Emissions are in tCO_2e. The carbon price is \$40 per tCO_2e. Earmarked Rebate and Unrestricted Rebate are 20% and 80% of Gross Rebate, respectively.

Actual Emissions	Gross Charge	Gross Rebate	Earmarked Rebate	Unrestricted Rebate
500	$20,000	$20,000	$4,000	$16,000

These mechanics differed for the pilot. Instead, pilot units received a subsidy equal to 20% of their baseline carbon charge. This subsidy simulated the scheme's second year by providing pilot units with funds they accrue over time (Figure 3). Otherwise, the pilot units would have incurred a charge during the pilot and received a refund at the end, preventing the steering committee from studying their use of these funds. A spending account was created for each of the five buildings to monitor the use of their earmarked energy investment funds.

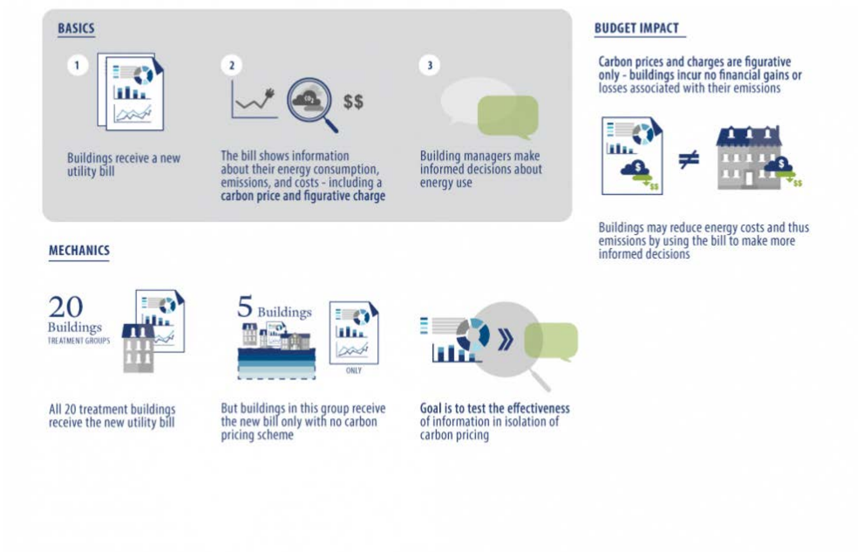
Figure 3. Diagram demonstrating the mechanics of Scheme 4 (investment), in which a building incurs a carbon charge and receive a full refund, with a portion earmarked for internal, self-guided energy actions. For the pilot, the earmark was equal to 20% and units received this amount as a subsidy to simulate the second year in which units would have access to this part of their refund.



While there are potential upsides to decentralizing energy investment, there are also potential downsides, namely that decentralized investment may not be as cost-effective as centralized capital investment in GHG reduction. Are Yale's rate-paying self-supports able to invest well without direct support from the Office of Facilities? Are centrally-supported buildings able to identify, scope, and execute similar projects? Whether Yale's administrative units are able to make decentralized capital investments that reduce energy use and are cost-effective is an interesting question. The answer can inform Yale's carbon pricing scheme design, specifically with regard to the use of revenues.

Scheme 1 (information) is the product of a task force recommendation on the need to communicate energy, carbon, and cost information to financial and operational decision-makers. Prior to the pilot, Yale did not provide building decision-makers with specific informational reports summarizing their monthly energy use, carbon emissions, and the costs associated with each of these quantities (Figure 4). Would such an informational report have an effect similar to an incentive scheme, despite having no financial implications? Testing this hypothesis involves developing a building-level energy report, including the SCC and information relevant to the three other carbon pricing schemes.

Figure 4. Diagram demonstrating the mechanics of Scheme 4 (investment), in which a building receives a new building energy report. The three carbon pricing schemes also received this report.



While introducing information as a fourth option adds another test condition, it allows for a comparison of information in isolation with information plus an incentive scheme. The steering committee decided to design an experiment to understand better the differences among these four schemes (Table 5).

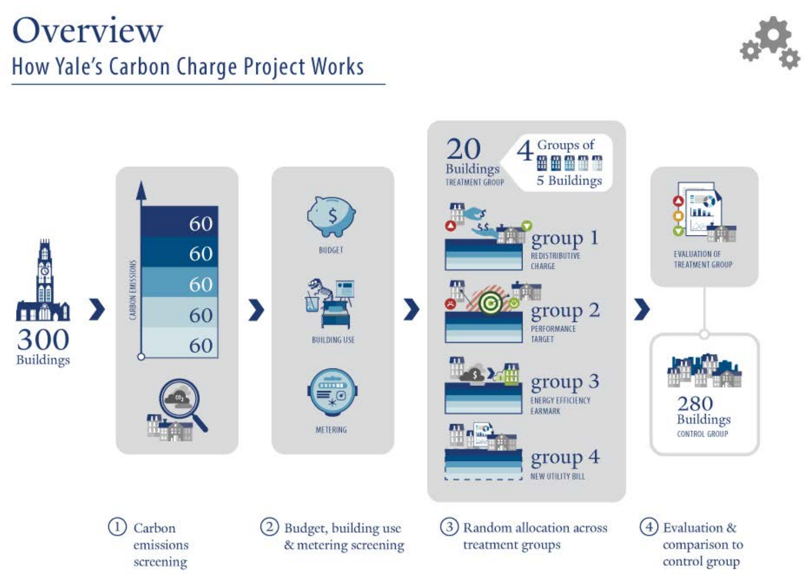
Table 5. Treatment group design for the pilot experiment. The third treatment also has a "target," in the sense that its target is a *moving* average, instead of a *fixed* target like -1% in the second treatment.

Scheme	Information	Target	Redistribution	Investment
Control				
1	✓			
2	✓	✓		
3	✓		✓	
4	✓			✓

3c. Building Selection & Scheme Assignment

The task force suggested that a small number of buildings participate in the pilot. To test two additional carbon pricing schemes, the steering committee selected twenty buildings from a group of about 300, allocating five each to the four schemes (Figure 5). These twenty pilot units were chosen based on their carbon footprint, building and budget types, and data quality. Remaining buildings served as the control.

Figure 5. Pilot design for the 2015-2016 academic year. Panel 1 illustrates dividing the 300 buildings into quintiles of carbon emissions. Panel 2 shows categorization by budget and building types, in addition to a data quality analysis. Panel 3 demonstrates allocation to the four schemes. Panel 4 highlights the control group of about 280 buildings.



Campus-wide emissions factors were developed to calculate buildings' carbon emissions (Table 6). These factors help level the playing field among buildings with different energy sources. For example, a campus-wide electric conversion factor removes differences between buildings served by Yale power plants and local utilities. This adjustment is important because end-users have no control over their energy source. However, this modification compromises Yale's ability to identify the emission reductions with the lowest marginal abatement cost through the carbon charge.

These emissions factors were applied to three years of monthly energy use data to calculate baseline carbon emissions for all 300 buildings. The average of the previous three fiscal years, FY 2013-2015, served as the baseline. These baselines were used to establish quintiles, each with an equal number of buildings. [14] The largest and smallest emitters were in the top and bottom quintiles, respectively. Buildings in transition or receiving capital investment were removed.

Table 6. Pilot emissions factors in tCO_2e per MMBTU. The electric conversion factor is a weighted average of generated and purchased electricity. Purchased electricity uses e-GRID 2012 data.

Electric	Steam	Chilled Water	Natural Gas
0.0964	0.0767	0.0368	0.0531

Buildings were categorized by building type (e.g., classroom, lab, office, dorm, etc.) and budget type (i.e., self-support vs. centrally-supported), then assigned to the four carbon pricing schemes until each scheme had one building from each quintile and a profile of building and budget types reflective of the campus.

Finally, the steering committee conducted a three-year analysis of quarterly metering data to ensure high data quality. While the original intention was to have treatment groups equal in size, several buildings in the original selection were replaced due to data quality and participation issues, altering the treatment group sizes considerably (Tables 7 and 8). For example, Schemes 1 and 3 are smaller than the other two because most buildings fall in the lower halves of their respective quintiles.

Table 7. Treatment group sizes. Baseline in tCO_2e and percent of the university's 2014 GHG inventory. Yale's GHG inventory totaled 293,225 tCO_2e for the 2014 calendar year.

Scheme	Baseline	% of 2014 GHG Inventory
1	1,459	0.50
2	2,418	0.82
3	1,606	0.55
4	4,380	1.49
All Schemes	9,862	3.36
Control	84,436	29.08
Total	**95,145**	**32.45**

[14] Stratifying the twenty pilot units across these five quintiles diminishes the statistical significance of paired comparison testing, specifically with regard to each carbon pricing scheme's impact on emissions reduction. However, it allows for an assessment of the four carbon pricing schemes' administrative feasibility and effectiveness across Yale's diverse set of buildings and budget types.

Table 8. Pilot units by scheme. Affiliation is department, school, office, etc. GSF is gross square-footage. Baseline is in tCO_2e.

Scheme	Building	Affiliation	GSF	Baseline
1	Berkeley College	Yale College	146,338	914
	Baker Hall	School of Law	137,443	331
	Gilder Boathouse	Department of Athletics	23,616	154
	Woodbridge Hall	Office of the President	11,346	43
	Allwin Hall	Ethics, Politics, Economics	7,433	17
			326,176	1,459
2	Lab of Epidemiology	School of Public Health	116,529	1,443
	Pierson College	Yale College	173,012	806
	32-36 Edgewood Ave	School of Art	64,118	109
	30 Hillhouse Ave	Department of Economics	15,988	41
	204 Prospect St	Department of Sociology	7,545	19
			377,192	2,418
3	Yale Physicians Building	School of Medicine	98,040	934
	Peabody Museum	Peabody Museum	88,468	451
	Betts House	Office of International Affairs	21,889	109
	Kroon Hall	School of Forestry	52,635	92
	Weir Hall	Yale College	19,718	19
			280,750	1,606
4	Sterling Divinity Quadrangle	Divinity School	160,365	1,865
	Edward P Evans Hall	School of Management	342,545	1,306
	Yale Health Center	Yale Health	147,006	1,099
	Stoeckel Hall	Department of Music	22,775	92
	301 Crown St	La Casa Cultural	7,938	18
			680,629	4,380
Total			**1,664,747**	**9,862**

3d. Communications & Onboarding

Moving from design to implementation required an important communications and onboarding phase. Communications and onboarding exercises took three forms:

1. An invitation from the Provost to the head of each administrative unit;

2. Time for engagement between the pilot units and steering committee; and

3. Orientations for each of the treatment groups.

Invitation

The steering committee sent invitations on behalf of the Provost to the pilot units (Appendix, Exhibits 1-2). There were two letters—one for Scheme 1, which is purely information; another for Schemes 2, 3, and 4, which have financial implications. These letters provided an overview of carbon pricing at Yale and outline the basic experimental design, specific rules of the unit's scheme, and available resources, including the creation of a new building energy report. Most importantly, it noted that the steering committee identified their building as a candidate for the pilot and requested their participation.

This letter also requested the appointment of a representative to administer the pilot. These individuals were nominated and responsible for coordinating their building's effort. They were required to participate in an orientation, two interviews, an exit survey, and a focus group. Lead Administrators and Operations Managers were recommended as potential candidates due to their extensive knowledge of administrative unit's finances and operations. Most units nominated a staff member fitting this profile (Table 9). Identifying the composition of decision-makers and the degree to which they were incentivized by the carbon charge was a goal of the pilot.

Engagement

The steering committee responded to questions and concerns from unit heads and staff. Two weeks were scheduled for this engagement period. Questions for the target and redistribution schemes primarily focused on the building selection criteria and potential financial impact to the target unit's budget. The investment scheme participants expressed confusion about the subsidy, and wanted to know the amount and spending rules before participating. Confirming that there would be no financial impact was the only question from the informational scheme participants. All participants expressed enthusiasm for the new building energy report.

Orientation

Hour-long orientations for each of the four treatment groups were held November 17-24. Briefing packets outlined basic information, responsibilities, and resources. These materials were customized to explain the differences among schemes. Participants were informed of the timeline of their formal responsibilities and provided their buildings' baseline emissions. These baselines were calculated using data specific to the pilot months, December through May. They were not pro-rated.

Table 9. Pilot unit designee job titles by treatment group.

Scheme	Building	Affiliation	Designee Job Title
1	Berkeley College	Yale College	Operations Manager
	Baker Hall	School of Law	Associate Dean
	Gilder Boathouse	Department of Athletics	Facility Manager
	Woodbridge Hall	Office of the President	Director of Business Operations
	Allwin Hall	Ethics, Politics, Economics	Operations Manager
2	Lab of Epidemiology	School of Public Health	Operations and HR Manager
	Pierson College	Yale College	Operations Manager
	32-36 Edgewood Ave	School of Art	Operations Manager
	30 Hillhouse Ave	Department of Economics	Operations Manager
	204 Prospect St	Department of Sociology	Operations Manager
3	Yale Physicians Building	School of Medicine	Chief of Staff
	Peabody Museum	Peabody Museum	Director of Operations
	Betts House	Office of International Affairs	Director of Operations
	Kroon Hall	School of Forestry	Director of Business Operations
	Weir Hall	Yale College	Operations Manager
4	Sterling Divinity Quadrangle	Divinity School	Director of Finance and Admin.
	Edward P Evans Hall	School of Management	Managing Director of Operations
	Yale Health Center	Yale Health	Manager of Building Services
	Stoeckel Hall	Department of Music	Operations Manager
	301 Crown St	La Casa Cultural	Operations Manager

3e. Data Collection & Analysis

Data collection and analysis is critical to generate insights about the administrative feasibility, effectiveness, and impact of Yale's carbon charge. Gathering qualitative data to inform the design of Yale's carbon pricing scheme was the focus of the 2015-2016 pilot. While quantitative data indicate potential impact, statistical significance was not a priority of this pilot, as scheme design was the focus.

Administratively feasibility, effectiveness, and impact were the three evaluation criteria for each of the four schemes. Administrative feasibility was defined as the technical and political feasibility of a scheme. Both were determined through assessments during the design and implementation process. Technical feasibility covers data quality and emissions factor, report-making, and budget compatibility. Unit head receptiveness and organizational readiness constitute political feasibility. Each of these factors was rated on a feasibility scale of low (1) to medium (2) to high (3).

Effectiveness is defined as the ability to increase participant understanding, motivation and action for reducing energy use and emissions. Two semi-structured interviews, an exit survey, and a focus group with each treatment group were used to assess levels of understanding, motivation, and action. These qualitative data were collected using standard ethnographic techniques. Each of these factors was scored on a numerical scale of much lower (1) to much higher (5), and weighted to create composite effectiveness scores out of 100.

Impact is defined as emissions reduction and evaluated using percentage change in emissions from a baseline. Percentage change calculations were performed for the individual buildings, each treatment group, the four treatment groups collectively, and the control group. These quantitative data are FY 2016 monthly metered energy use converted to tCO_2e. The baseline is the average of the six months corresponding to the pilot (i.e., December to May) for the previous three years (i.e., FY 2013, FY 2014 FY 2015). Participants received monthly building energy reports with custom information on energy, carbon, and cost (Appendix, Exhibit 3).

Financial transactions were settled at the end of the pilot, modifying the mechanics of the schemes of the second and third schemes in two ways:

1. The monthly statements showed the "net" charge or rebate, not a "gross" charge followed by a gross rebate at the end of the pilot.

2. The third scheme used the average of the group—not the university—as the metric of comparison.

The pilot's qualitative data are critical to advancing the design of Yale's carbon pricing scheme, while the quantitative data point to the potential of Yale's carbon charge to deliver cost-effective emissions reductions.

4. PILOT FINDINGS

4a. Administrative Feasibility

Key Finding #1

It is administratively feasible to apply a carbon charge to utility costs allocated to Yale's administrative units.

Administrative feasibility is "high" across three of the four schemes. The Office of Facilities' extensive building-level metering, ability to calculate campus-wide emissions factors, and existing data systems contributed to these "high" ratings (Table 10). Each component is critical to accounting and the development of a building energy report. The Budget Office's ability to expense carbon charges and issue rebates at the end of the pilot is also behind these ratings.

Table 10. Administrative feasibility rating, ranging from low (1) to medium (2) to high (3).

Category	**Criterion**	**Scheme 1** *Information*	**Scheme 2** *Target*	**Scheme 3** *Redistribution*	**Scheme 4** *Investment*
Technical	Data quality	3	3	3	3
	Emissions factors	3	3	3	3
	Report-making	3	3	2	3
	Budget compatibility	3	3	3	3
	New buildings	3	3	2	3
		15	15	13	15
Political	Receptiveness	3	3	1	2
	Readiness	3	2	2	1
		6	5	3	3
Total		21	19	16	18
Average		**3.0**	**2.9**	**2.3**	**2.6**

4b. Effectiveness: Understanding, Motivation, & Action

<u>Key Finding #2</u>

The combination of clear information and a carbon pricing scheme increases understanding, motivation, and action for reducing energy use at Yale, on a decentralized level in particular.

Over half of pilot units reported higher or much higher levels of understanding after the six-month pilot term. Three of four pilot units indicated equally high levels of motivation and action (Tables 11-14).

Table 11. Understanding data. Percent of pilot units indicating higher post-pilot levels of understanding.

	Scheme 1 *Information*	**Scheme 2** *Target*	**Scheme 3** *Redistribution*	**Scheme 4** *Investment*	**Total**
Same	2	1	3	3	9
Higher	2	1	1	2	6
Much Higher	1	3	1	0	5
% Higher or Much Higher	**60%**	**80%**	**40%**	**40%**	**55%**

Table 12. Motivation data. Percent of pilot units indicating higher post-pilot levels of motivation.

	Scheme 1 *Information*	**Scheme 2** *Target*	**Scheme 3** *Redistribution*	**Scheme 4** *Investment*	**Total**
Same	3	0	1	1	5
Higher	1	2	2	4	9
Much Higher	1	3	2	0	6
% Higher or Much Higher	**40%**	**100%**	**80%**	**80%**	**75%**

Table 13. Action data. Percent of pilot units indicating higher post-pilot levels of action.

	Scheme 1 *Information*	**Scheme 2** *Target*	**Scheme 3** *Redistribution*	**Scheme 4** *Investment*	**Total**
Same	3	0	1	1	5
Higher	1	3	2	4	10
Much Higher	1	2	2	0	5
% Higher or Much Higher	**40%**	**100%**	**80%**	**80%**	**75%**

Table 14. Composite effectiveness ratings. Scores out of 75 compiled using 25 points each for understanding, motivation, and action.

Criterion	Scheme 1 *Information*	Scheme 2 *Target*	Scheme 3 *Redistribution*	Scheme 4 *Investment*
Understanding	18	23	21	19
Motivation	18	23	21	19
Action	19	23	21	18
Effectiveness	**55**	**69**	**63**	**56**

Higher motivation translates to higher demand for energy services. Pilot units engaged the Offices of Facilities and Sustainability on a variety of energy conservation and efficiency projects. Examples include:

- *Pierson College and Jonathan Edwards College, two of Yale's twelve residential halls, implemented behavioral and education solutions.* To address unnecessary electric and thermal use during the winter and spring breaks, Pierson College's Operations Manager (Scheme 2, target) worked with their Head of College, Facilities Superintendent and several students to develop a checklist with a menu of energy-saving actions. Students who closed windows and adjusted radiators before leaving campus were eligible for a prize. The college observed a near-50% participation rate. In Jonathan Edwards College (Scheme 3, redistribution), they used a polling app to take the pulse of student energy awareness. One question dealt with the operation of radiators in student rooms. It turned out that only half of the respondents knew how to use theirs, presenting an opportunity for education and outreach.

- *The School of Art and Betts House implemented operational solutions.* To reduce nighttime energy use and costs, the School of Art (Scheme 2, target) moved past a design convention—the architect's desire to have the building serve as a "beacon of light" for the neighborhood—by working with the Dean's Office and Office of Facilities to reprogram the lighting. Betts House (Scheme 3, redistribution) worked with the Office of Facilities and students from the Office of Sustainability to adjust heating and cooling set points, as well as HVAC schedules. Now Betts House is exploring physical solutions, including lighting retrofits and occupancy sensors.

- *The School of Forestry & Environmental Studies formed a dedicated team.* Students and staff of Kroon Hall, the LEED Platinum-certified home of the country's oldest forestry school, embraced the carbon charge as a platform for directing attention to their ongoing work managing the most energy-efficient building on campus. Since the building's completion in 2009, its energy consumption has deviated above and below energy model predictions. This committed team, which regularly monitors Kroon Hall's energy use, grew during the pilot and helped the School of Forestry & Environmental Studies achieve a 17% reduction during the pilot term, December through May, despite being 5% above baseline for July through May.

Higher motivation also translates to more informed decision-making that does not result in energy savings. For example, the School of Art (Scheme 2, target) weighed the costs and benefits of increasing studio hours during winter break. One of the factors the Dean, Lead Administrator, and Operations Manager considered was the additional cost they might incur as a result of the carbon charge. Ultimately, they decided to extend winter studio hours, justifying the higher carbon cost in exchange for student productivity. Increasing the carbon price could reverse this decision, of course.

<u>Key Finding #3</u>

While there were no significant differences in emissions reductions across schemes, there are clear differences in administrative feasibility and effectiveness.

Clear information is one element that enhances the effectiveness of a carbon pricing scheme. All units found the building energy report (see Appendix, Exhibit 3) a useful tool for understanding their energy use, carbon emissions, and associated costs. While this report is a key driver behind understanding, it is not as motivating, nor as strong an action driver, as the carbon pricing schemes. Only 40% of Scheme 1 (information) participants reported "higher" or much "higher" levels of motivation and action. Participants' feedback shows that information in isolation is not as effective as an incentive scheme:

> *"[Without a financial incentive], it becomes a philosophical question, rather than an economic one."*

> *"The report is helpful, but it alone does not incentive us to reduce our energy use."*

A clear incentive scheme is another element that enhances the effectiveness of a carbon pricing scheme. The energy efficiency earmark in Scheme 4 (investment) does not provide a clear incentive scheme and is less effective than the incentive in Schemes 2 and 3. The data show that Scheme 4 has less potential to encourage "much higher" motivation and action than Schemes 2 (target) and 3 (redistribution). This difference is due to the lack of carrots and sticks in Scheme 4. While there is an incentive in Scheme 4—to reduce the amount of money a building is required to spend on energy action—this incentive is less transparent and less motivating than those in Schemes 2 and 3. Participants in Schemes 2 and 3 expressed interest in the ideas of winning and besting targets or peers, despite their fear of losing:

> *"We want to win so we can spend our rebate."*

> *"The rebates are motivating. If we beat the target, we earn money."*

A third element that enhances the effectiveness of a carbon pricing scheme is the incentive's fairness. Scheme 3 (redistribution) constitutes an unfair incentive for two reasons. One, it involves a tension between self-supports and centrally-supported units. Self-support units do not want to pay centrally-supported units if they perform poorly and vice-versa. Moreover, centrally-supported units consider competing with self-supports unfair because self-supports have their own capacity and capital for carbon reduction projects. Conversely, self-supports consider competing with centrally-supported units unfair because centrally-supported units can access the university's operational resources without footing the bill. A participant in a centrally-supported building highlighted this difference:

> *"Self-funded departments have been thinking about this for a long time. Our departments don't think about it because we don't have ownership over our budget."*

The second reason participants consider the incentive in Scheme 3 (redistribution) unfair is because it bases financial evaluations on performance relative to an average. Buildings have different marginal abatement costs—meaning it is more or less expensive to reduce emissions—for many reasons, including building age, primary use, and investment history. The unique energy profile of each building makes for these unfair comparisons, according to participants:

> *"The variety of buildings and financial structures [at Yale] make [this scheme] inherently unfair."*

> *"[This scheme and a moving average] offer less control over our destiny [than a fixed target]."*

While Scheme 2 (target) does not resolve the first issue, it fixes the second one by focusing the competition internally. Participants prefer internal performance benchmarks, as opposed to benchmarks based on factors outside their control, such as other buildings' performance. While participants considered Scheme 3 (redistribution) unfair for these reasons, they established a "peer-learning network" to collaborate and support each other's efforts, suggesting that stakeholders may engage effectively with a scheme even if they consider it unfair. Moreover, these participants noted that Scheme 3 may be fairer than alternative schemes not tested during the pilot, despite the fact that they considered it the least fair option of the four schemes.

In sum, the second and third key findings suggests that carbon pricing scheme design matters, but many variations can work. How to channel this additional understanding and motivation into action that results in cost-effective emissions reduction is important.

Key Finding #4

A revenue-neutral redistributive carbon pricing scheme must be perceived as fair and avoid perverse incentives.

Although revenue-neutrality may be an important part of Yale's carbon pricing scheme, in particular for the self-supports, the redistribution of carbon charge revenues presents a number of challenges. How best to return carbon charge revenues in a revenue-neutral fashion is a complex question.

First, fairness is an important part of the political feasibility of a revenue-neutral carbon pricing scheme at Yale. While ensuring equity is difficult, a scheme that does not unduly disadvantage certain buildings, departments, or schools enhances participation. For example, the pilot units considered Scheme 3 (redistribution) unfair because it used average percent change in emissions to calculate financial rewards or penalties, despite buildings having more or less control over their reduction options, not to mention different reduction potentials. However, this scheme may be fairer than alternative models.

That said, the pilot identified acceptable forms of competition. A majority of participants expressed a strong interest in a “leaderboard” displayed on the monthly building energy report. This leaderboard featured the top three reducers for the report month in rank order. Many participants found this feature a friendly and thus motivating form of competition:

> *“How do you determine who is on the leaderboard? We want to make the leaderboard.”*

These participants noted that the “lack of financial implications” and “sense of community” made this leaderboard an example of friendly competition. While other findings underscore the motivational value of a financial incentive-based carbon pricing scheme, this finding suggest that acceptable and motivating forms of peer competition exist.

Second, perverse incentives, predictability that promotes gaming, and undesirable redistributive effects reduce impact. Perverse incentives reduce a scheme’s impact by encouraging the wrong behavior and psychology. For example, Scheme 3 (redistribution) rewards buildings with increasing emissions if theirs grew more slowly than average. This perverse incentive could reduce impact by encouraging relative, not absolute emissions reduction. Similarly, predictable schemes and those with undesirable redistributive effects reduce impact. A scheme that regularly redistributes carbon charge revenues from poorer to wealthier self-supports may be demotivating and ineffective at incentivizing emissions reduction.

Third, various factors influence the effectiveness of a price signal, including rebate mechanics and additional energy information. The accounting and marketing of Yale’s carbon charge influences the strength of its price signal. Information can make this price signal more or less salient to participants. In the case of the pilot, the data shown on the monthly energy reports may have reduced the scheme’s effectiveness (Table 13). Pilot units received a running total of their “gross” carbon charge minus the rebate that they would receive based on their scheme’s rules.

Table 15. Yale’s “target” scheme had pilot units reduce emissions 1% below baseline. Say a building has baseline emissions of 1,000 tCO_2e. Reducing by 1% would amount to 990 tCO_2e. Multiplied by the $40 per tCO_2e carbon price, this results in a gross rebate of $39,600. But this building actually emitted 940 tCO_2e, resulting in a gross charge of $37,600 and a net amount of $2,000.

Baseline Emissions	Actual Emissions	Gross Charge	Gross Rebate	Net Amount
1,000 tCO_2e	940 tCO_2e	$37,600	$39,600	$2,000

Displaying this “net amount” only instead of a monthly “gross charge” and a “gross rebate” at the end of the pilot may have reduced the price signal and its effectiveness by presenting smaller figures. It also allowed participants to calculate another carbon price—the absolute value of the net amount that they paid or received divided by their actual emissions. In the example above, this carbon price would be

\$2,000 divided by 940 tCO_2e, or just over \$2 per tCO_2e. While proper communication is essential to establishing the carbon charge as a strong price signal, this finding also suggests that the magnitude of a revenue-neutral or nearly revenue-neutral carbon charge's marginal incentive is small. In fact, any scheme with a charge mechanism to collect a tax base and a refunding mechanism to return this revenue, fully or partially, that is not independent of performance reduces the incentive because the net charge or rebate is small relative to the gross equivalents.

For example, consider a building in Scheme 3 (redistribution), Betts House. While Betts House pays \$40 per tCO_2e on 73.24 emissions, totaling \$2,929.69, it receives a rebate of \$4,363.33, resulting in a net rebate of \$1,433.64. Dividing the net rebate of \$1,433.64 by the aggregate emissions of 73.24 produces a marginal carbon price of \$19.57 per tCO_2e. This value is nearly half the SCC. There is a similar result in the second scheme (target). The Lab of Epidemiology and Public Health incurs a net carbon price of \$1.62 per tCO_2e, nearly one-fortieth the SCC. Historical simulations support these values, with median and average marginal prices between \$8-12 and \$3-5 per tCO_2e for Schemes 2 and 3, respectively.

Participants noted paying less attention to gross prices, charges, and rebates, and more attention to the net equivalents. This combination of information and psychology reduces the incentive by a factor of ten in many cases. One participant in Scheme 3 highlighted that the net charge or rebate amounts were too small to warrant significant attention:

> *"[The net charge or rebate] would have to be at least \$50,000 to get our attention."*

This statement is hyperbolic, of course, as the baseline SCC for the largest participant in Scheme 3 (redistribution) is \$36,560. Additionally, there is considerable variance in units' budgets and individual participants' perceptions of a motivating dollar amount. While this finding may be a product of information and marketing, as the pilot units were provided with these net values instead of monthly charges and year-end rebates, it seems likely that participants would learn of the small magnitudes of the net charges and rebates after one year. If so, Yale may have to increase the carbon price if it moves forward with Scheme 3 or decouple the return mechanism from performance by reducing costs elsewhere (e.g., fixed-rate facilities charges allocated on a per square-footage basis).

While there are specific elements that may enhance the effectiveness of Yale's carbon pricing scheme, whether it is revenue-neutral or otherwise, it is likely that any scheme would offer a positive outcome for emissions reductions. Each of the four carbon pricing schemes tested in Yale's experiment were effective at increasing understanding, motivation, and action for reducing energy use. Impact will come as the carbon charge continues to scale, administrative units become aware of its existence, and members of the Yale community examine ways and means to reduce their energy use.

4c. Impact: Emissions Reduction

<u>Key Finding #5</u>

A carbon charge has potential to reduce emissions cost-effectively at Yale.

Collectively, the pilot units reduced emissions more than the control group; they reduced emissions by 4.9 and 1.4 percent below the baseline, respectively, or 478 and 847 tCO_2e, despite cumulative emissions for these buildings being above baseline before the pilot. Each scheme had a lower average reduction than the control group by 2.4 to 6.5 percentage points. Schemes 2 (target) and 3 (redistribution) had the greatest average reductions, 10.0 and 10.8 percent, respectively. Scheme 4 (information) observed a 7.4% average reduction, suggesting that information and engagement alone may encourage abatement.

There were several capital improvement projects during the pilot, namely lighting retrofits. Most actions reported by the pilot units were behavioral programs and operational changes, suggesting that the carbon charge can deliver cost-effective energy savings and GHG reduction. Using energy-cost savings for the twenty pilot units, the pilot saw savings of $135 per tCO_2e. While it can be challenging to maintain energy, carbon, and cost savings associated with behavioral and operational changes, these values demonstrate the potential for Yale's carbon charge to serve as a complementary strategy to energy efficiency in meeting the university's sustainability goals cost-effectively.

Table 16. Pilot results. Baseline, Actual, and Net values are in tCO_2e. % Change is the percent change from Baseline. Average is the average of the scheme's five buildings' individual percent changes.

Scheme	Baseline	Actual	Net	% Change	Average	Min	Max	n
1	1,459	1,194	-265	-18.2%	-7.4%	-25.0%	21.0%	5
2	2,418	2,352	-66	-2.7%	-10.0%	-18.7%	3.2%	5
3	1,606	1,601	-4	-0.3%	-10.8%	-33.0%	3.9%	5
4	4,380	4,237	-143	-3.3%	-6.7%	-14.1%	1.4%	5
All	9,862	9,384	-478	-4.9%	-8.7%	-33.0%	21.0%	20
Control	95,145	93,820	-847	-1.4%	-4.3%	-74.8%	147.4%	258

These preliminary quantitative findings suggest that all four schemes may reduce more and increase less than the control group, on average. The four schemes collectively outperform the control group. Yale looks forward to updating this document with a more rigorous statistical analysis of the pilot results after consulting with student and faculty experts.

Chart 1. Pilot results showing percent change from baseline for 262 of 278 buildings with percentage reductions between ± 50%. 5 represents the control group. Individual buildings' percent changes are in light blue. The average of these percent changes for each scheme is in gray. The group's total percent change is in dark blue.

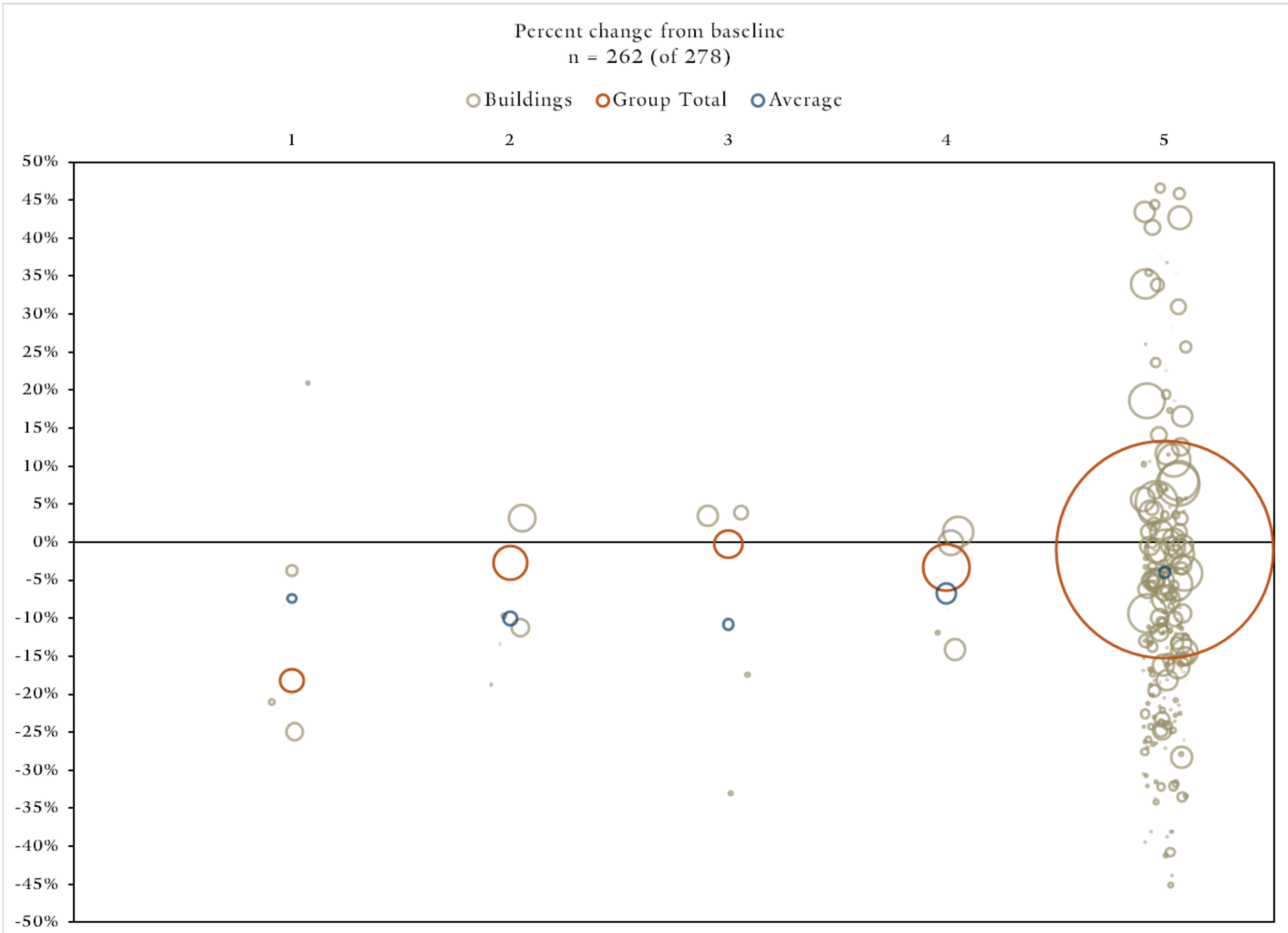


Table 17. Pilot results showing percent change from baseline by scheme and building for the pilot months, pilot term, and fiscal year to date.

Scheme	Building	FYTD	Pilot	May	April	March	February	January	December
1	Berkeley College	-19%	-25%	-2%	-13%	-37%	-29%	-28%	-25%
	Baker Hall	0%	-4%	11%	27%	-1%	-12%	-9%	-20%
	Gilder Boathouse	-16%	-20%	33%	-6%	-28%	-23%	-16%	-41%
	Woodbridge Hall	15%	21%	-11%	14%	57%	41%	35%	-16%
	Allwin Hall	-3%	-8%	9%	8%	-10%	-13%	-14%	-12%
		-13%	**-18%**	**4%**	**-2%**	**-25%**	**-22%**	**-21%**	**-25%**
2	Lab of Epidemiology & Public Health	5%	3%	16%	13%	1%	-1%	-1%	-5%
	Pierson College	-10%	-11%	7%	0%	-27%	-16%	-13%	-5%
	32-36 Edgewood Ave	7%	-10%	-17%	-12%	2%	-13%	-16%	-1%
	30 Hillhouse Ave	-16%	-19%	-42%	-15%	-14%	-12%	-18%	-22%
	204 Prospect St	-11%	-13%	-6%	0%	-11%	-26%	-9%	-19%
		0%	**-3%**	**11%**	**7%**	**-9%**	**-8%**	**-6%**	**-5%**
3	Yale Physicians Building	14%	3%	16%	7%	-1%	-10%	-12%	25%
	Peabody Museum	7%	4%	19%	35%	4%	-4%	-8%	-17%
	Betts House	-23%	-33%	-40%	-46%	-42%	-29%	-20%	-23%
	Kroon Hall	5%	-17%	1%	10%	-37%	-19%	-4%	-32%
	Weir Hall	-9%	-11%	-8%	-2%	-10%	-23%	-18%	-5%
		9%	**0%**	**12%**	**11%**	**-5%**	**-10%**	**-11%**	**6%**
4	Sterling Divinity Quadrangle	1%	1%	4%	2%	1%	1%	4%	-3%
	Edward P Evans Hall	-12%	0%	16%	18%	-13%	-2%	-3%	-8%
	Yale Health Center	-16%	-14%	-6%	-10%	-17%	-14%	-15%	-20%
	Stoeckel Hall	-16%	-12%	2%	10%	13%	-10%	-25%	-39%
	301 Crown St	-2%	-9%	20%	1%	3%	-9%	-19%	-27%
		1%	**-3%**	**5%**	**4%**	**-7%**	**-4%**	**-4%**	**-9%**

Chart 2. FY 2016 baseline (light blue) and actual (dark blue) emissions for the control group. Red lines indicate the pilot term. Months run from July to June, in alignment with Yale's fiscal year.

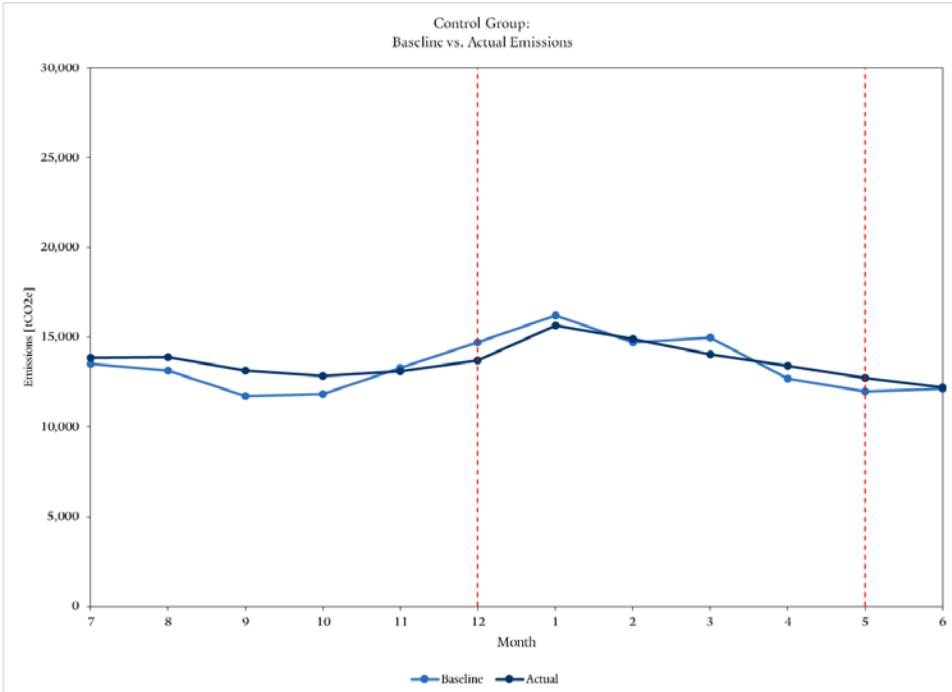
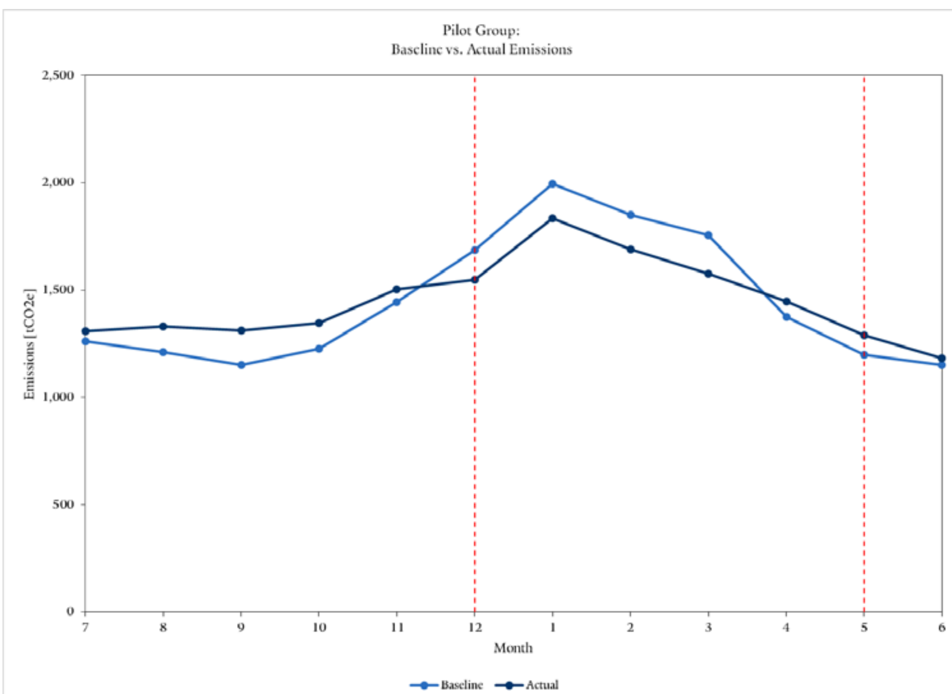


Chart 3. FY 2016 baseline (light blue) and actual (dark blue) emissions for all twenty pilot units. Months run from July to June, in alignment with Yale's fiscal year. Red lines indicate the pilot term.



Graphical data are also helpful to understand the impact of the four schemes. Chart 2 plots FY 2016 baseline and actual carbon emissions for the control group. Actual emissions are trending above and below baseline emissions in July and November, respectively, and are noticeably higher from August to October. The relationship between actual and baseline emissions is stable during the six-month pilot term, December through May.

Chart 3 plots FY 2016 baseline and actual carbon emissions for all four schemes (i.e., "pilot group"). Actual emissions are noticeably higher than baseline emissions between July and November. This trend reverses for the first two-thirds of the pilot, December to March. Actual emissions are noticeably lower than baseline emissions during this timeframe. While the actuals are higher than baseline for the last two months of the pilot, April and May, this dramatic shift between December and March is indicative of participant response to the four schemes, collectively. There are similar trends in the charts for the four schemes, individually (see Appendix, Chart 4).

5. Recommendations

5a. Scheme Design

The pilot findings indicate that carbon pricing scheme design matters, but many variations can work. That said, there are specific design elements that may enhance the effectiveness of Yale's carbon pricing scheme, and others that Yale may diminish its effectiveness. Table 16 outlines these design elements.

Table 18. Design elements to include and avoid when redesigning Yale's carbon pricing scheme.

To Include	To Avoid
• SCC as part of monthly utility charges • Separate incentives for different budget types • Revenue-neutrality and shared cost-savings for the self-support and centrally-supported units, respectively • Monthly charges and year-end rebates	• Unfair competition • Perverse incentives • Predictability that permits gaming • Monthly net charges and rebates • Unclear information and marketing

The pilot findings also suggest that an effective carbon pricing scheme conveys clear information and incentives. Yale's price signal is effective when decision-makers receive actionable information and their incentives align with organizational priorities and financial structures. These findings inform the redesign of Yale's carbon pricing scheme and a larger experiment in the 2016-2017 academic year.

Key Recommendation #1

Provide Yale's self-supported and centrally-supported units with distinct carbon pricing schemes.

Yale's self-supported and centrally-supported units have different budget structures. As units responsible for their own budgeting and fundraising, self-supports are energy ratepayers. They are subject to both profits and losses associated with changing energy use, the costs of which are substantially larger than their internal carbon charge. Centrally-supported units are not responsible for their own budgeting or fundraising, let alone their utilities expenses. These different budget structures suggest the need for treating self-supported and centrally-supported units separately with regard to carbon pricing. Designing carbon pricing schemes with incentives unique to these distinct budget types is likely to make for a more salient price signal across Yale.

The steering committee recommends continuing to test revenue-neutrality with the self-supports, as these budget units already have a financial incentive to reduce energy use—and thus carbon emissions. Historical simulations are Chart 5 of the Appendix. As for the centrally-supported units, the steering committee recommends a scheme in which these units share in the costs or savings associated with higher or lower energy use. This scheme would work by providing centrally-supported buildings with a carbon charge budget based on historical emissions—specifically, two fiscal years prior—and holding these buildings financially responsible for any positive or negative variance. If a building has emissions higher than its allocation, it would pay the difference by finding money in its budget. However, if it has emissions that are below budget, it would keep the savings.

As an example, consider a building with 500 tCO_2e of emissions in FY 2015. Its carbon charge budget for FY 2017 is $20,000, using the $40 per tCO_2e price. If its emissions are 550 tCO_2e in FY 2017, the building pays $22,000, and has to cover the additional $2,000 of carbon charge expense. This building would have a $2,000 positive balance if its emissions were to decrease to 450 tCO_2e. See Chart 6 in the Appendix for historical simulations. Whether the magnitudes of these potential gains and losses are large enough to be an incentive will be interesting to study.

Previously, the university paid all costs or collected all savings. While Yale still pays or collects the majority of these costs or savings, respectively, using this scheme, centrally-supported units share a fraction of the financial burden. This scheme may be motivating because it partially resolves the split-incentive problem in the centrally-supported units. Additionally, it is similar to Scheme 2 (target), which has the highest understanding, motivation, and action scores of the four schemes. Ultimately, carbon budgets can help Yale work toward a fully decentralized energy budget.

Key Recommendation #2

Avoid unfair competition, perverse incentives, and predictability that permits gaming in Yale's scheme.

Yale's carbon pricing scheme is more effective when participants consider the rules fair. A scheme that disadvantages certain buildings, departments, or schools prevents these affected populations from engaging fully. How best to return some or all carbon charge revenues is a complex question. While there may be no simple answer, avoiding unfair competition, perverse incentives, and predictable schemes that permit gaming are three ways to enhance the effectiveness of the self- and central-support schemes.

Key Recommendation #3

Highlight gross charges and rebates so as not to reduce the magnitude of Yale's price signal.

The accounting and marketing of Yale's carbon charge influences the strength of its price signal. Information can make this price signal more or less salient to participants. Showing gross amounts, especially the gross charge, may strengthen the price signal by presenting larger figures. Moreover, these higher values better communicate the true cost of emissions and help prepare financial and operational decision-makers for a higher carbon-price future.

While this finding may be a product of information and marketing, as the pilot units were provided with these net values instead of monthly charges and year-end rebates, it seems likely that participants would learn of the small magnitudes of the net charges and rebates after one year. If so, Yale may have to increase the carbon price if it moves forward with Scheme 3 or decouple the return mechanism from performance by reducing costs elsewhere.

Key Recommendation #4:

Expand the number of buildings participating in the next phase of Yale's carbon charge experiment.

The steering committee plans to conduct a larger, longer experiment in the 2016-2017 academic year, incorporating the pilot findings. It recommends expanding to sixty buildings, representing about one-third of the university's GHG inventory for Scope 1 and 2 emissions. These buildings should include the pilot units, the remaining residential colleges, and all self-support buildings, with the Medical School as an exception. Scaling to this size puts Yale on track to achieve full implementation by FY 2018.

5b. Energy, Sustainability, & Academic Resources

Student and faculty expertise is critical to the design and implementation Yale's carbon charge.

Hands-on learning and applied research from students and faculty strengthen the carbon charge. Working with professional engineers and sustainability practitioners from the Office of Facilities allows students to apply what they learn in the classroom on Yale's campus. For example, student research on energy conservation initiatives in pilot units generates insights that can be applied to the rest of campus. Similarly, faculty expertise is instrumental in researching, analyzing, and sharing the results of Yale's efforts. Expanding energy, sustainability, and academic resources in parallel with the carbon charge is key to successful implementation and action.

The Offices of Facilities and Sustainability's efforts enhance the carbon charge's impact.

The carbon charge increases understanding and motivation for reducing energy use. How to channel this additional understanding and motivation into action that results in cost-effective emissions reduction is key to the carbon charge's success. Pilot units consider access to technical expertise a key determinant of energy reduction. Yale's staff help cultivate pilot units' ideas and turn them into impactful energy conservation and efficiency projects. As the project scales and gains traction, it may be possible to earmark a portion of carbon charge revenues for reinvestment in energy efficiency through Energy Management.

5c. Outstanding Questions from the Presidential Carbon Charge Task Force

Question #1: How should Yale adjust its carbon price and campus-wide emissions factors?

<u>Carbon Price</u>

$40 per tCO_2e was used for the FY 2016 pilot for the sake of simplicity. According to the Federal Government's Interagency Working Group on the SCC, the mean price is $38 per tCO_2e in 2015, using a 3% discount rate.[15] This value is about 5% less than the $40 per tCO_2e price Yale used during the pilot. It is important for Yale to establish a discount rate moving forward. The university also has to decide whether and how to adjust for inflation and to avoid double-counting the RGGI price.

<u>Emissions Factors</u>

Yale calculated campus-wide emissions factors for the pilot using weighted averages. While campus-wide, utility-specific emissions factors are not part of GHG emissions accounting, they are critical to ensuring equity across carbon charge buildings, as end-users have no control over their energy source. Additionally, it is important to apply these factors to both the actual and baseline years to eliminate short- or long-term benefits driven by exogenous factors (e.g., a cleaner grid). The steering committee advises recalculating campus-wide emissions factors every three years, in alignment with the EPA's eGRID methodology. It is important to note that this decision means that Yale's GHG inventory for the carbon charge will differ from its actual GHG inventory disclosed through The Climate Registry.

Question #2: Should Yale use the carbon charge as a shadow price for capital investments?

The task force also recommended adopting the SCC as a shadow price for capital investments. They identified new constructions and equipment as key investments to influence with a carbon price. This application was not studied during the pilot and should be investigated as Yale expands the scope of the carbon charge. As a builder and operator of large, energy-intensive facilities, this proxy carbon price would help the university consider the potential impact of a higher carbon-price future on new buildings' energy costs. Additionally, as a buyer of energy-intensive equipment, a shadow price would reduce first-cost bias and guide decision-making toward energy-efficient alternatives.

Question #3: Should the carbon charge apply to scope 1 emissions from transportation or Scope 3 emissions?

Yale's carbon charge applied to stationary Scope 1 and 2 emissions during the pilot. However, the task force recommended exploring emissions related to transportation. The majority of university vehicles are owned and operated centrally. Several self-supports have their own vehicles. Owned and operated vehicles should be incorporated in the future, as Yale can track and influence these Scope 1 emissions. Whether and how the carbon charge should apply to any Scope 3 is an important question for further study. It is

[15] https://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

suggested that air travel be included once the carbon charge project reaches full implementation and becomes more politically acceptable, as these represent emissions that faculty and staff can control.

Question #4: What information should be on Yale's new energy report? How should it be refined?

All four treatment groups received new building energy reports during the FY 2016 pilot. Prior to the pilot, buildings were able to run a report showing energy use and cost; however, this information lacked context, specifically with regards to carbon emissions. The new building energy report included energy, carbon, and cost data, as well as performance analytics. Moreover, a nominated representative received it. In many cases, this designee shared the report with other members of the administrative unit. Comments from the pilot participants indicate that this informational report was helpful in monitoring energy use and carbon performance. While the pilot drew on focus groups and participant feedback to refine the report design, further qualitative research and the addition of A/B testing could help identify what metrics and analytics are most helpful to participants and most impactful at reducing emissions.

6. Lessons for Peer Institutions & External Partners

Yale is a large research institution that resembles a company or municipality. With over 25,000 students, faculty, and staff and 14 million square-feet of facilities, the university spent about $65 million on energy in FY 2015.[16] While energy represents a small portion of Yale's overall budget and it is important that the carbon charge fit into the broader agenda of the university, the carbon charge is an important part of Yale's sustainability efforts and academic mission. As the first institution of higher education with an internal carbon price and the first academic member of the Carbon Pricing Leadership Coalition, Yale hopes that this report can inform action in the public and private sectors. Below is advice that peer institutions, governments, and businesses may find useful in their carbon pricing efforts.

Set clear objectives for your carbon price using feedback from stakeholders across your organization.

Defining goals and establishing design constraints early is key to long-term success. Understanding how a carbon price fits into your broader environmental strategy and dovetails with non-environmental goals is an important part of the design process. Deep stakeholder engagement can help determine how best to align your carbon price with organizational priorities.

Keep it simple and allow the design and implementation process to inform development.

Deciding to put a price on carbon involves many considerations. For example, do you want to influence investment decisions or raise revenue with your carbon price? If you decide to raise revenue, how will you use these revenues? What is an appropriate carbon price be? Remember to keep it simple. Setting clear objectives is key to getting started. But objectives are subject to change, especially as you learn and grow. Allowing design and implementation to inform development allows you to adapt and evolve. Carbon pricing improves with experimentation.

Avoid the "right price trap" and recognize that there may be no universal solution.

While Yale decided to use the SCC (i.e., $40 per tCO_2e), this price level is a reflection of the university's priorities and interests, as well as the mechanics of its carbon pricing scheme. Move past what the World Resources Institute refers to as the "right price trap" to determine an appropriate price level by focusing on the objectives and mechanics of your carbon pricing scheme. Moreover, recognize that there is no universal solution to internal carbon pricing, as Microsoft points out. There are likely many carbon pricing variations that would offer positive outcomes for your organization.

Share best practices openly and widely.

As companies innovate on carbon pricing, it will be important to share lessons. Yale benefited greatly from the input of many individuals, corporations, and other organizations working in this space. An open dialogue is essential to scaling and strengthening carbon pricing, internally and externally.

[16] Yale's operating expenses totaled $3.2 billion in FY 2015.

7. References

Carbon Disclosure Project (2015). Putting a Price on Risk: Carbon Pricing in the Corporate World. https://www.cdp.net/cdpresults/carbon-pricing-in-the-corporate-world.pdf

DiCaprio, TJ (2013). The Microsoft Carbon Fee: Theory & Practice. Microsoft Corporation, Seattle, WA. http://download.microsoft.com/documents/en-us/csr/.../microsoft_carbon_fee_guide.pdf

DiCaprio, TJ (2015). Making an Impact with Microsoft's Carbon Fee. Microsoft Corporation, Seattle, WA. http://download.microsoft.com/download/.../Microsoft%20Carbon%20Fee%20Impact.pdf

Metzger et al. (2015). Executive Guide to Carbon Pricing Leadership. World Resources Institute, Washington, DC. http://www.wri.org/publication/executive-guide-carbon-pricing-leadership

Société Générale (2016). Corporate and Social Responsibility Report. Société Générale, Paris, France. https://www.societegenerale.com/sites/default/files/documents/Document%20RSE/Rapport_RSE_2015_VA/index.html#page=80

Sterner, T., & Isaksson, L. H. (2006). Refunded emission payments theory, distribution of costs, and Swedish experience of NO x abatement. Ecological Economics, 57(1), 93-106.

U.S. Department of Energy (2016). Carbon Dioxide Emissions for U.S. Buildings, by Year. http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=1.4.1

World Bank Group, ECOFYS (2016). Carbon Pricing Watch 2016. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/24288

Yale Presidential Carbon Charge Task Force (2015). Report to the President and Provost of Yale University: Findings and Recommendations on a Carbon-Charge Program at Yale. Yale University, New Haven, CT. http://carbon.yale.edu/sites/default/files/files/Carbon-charge-report-041015.pdf

8. ACKNOWLEDGEMENTS

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9. APPENDIX

Exhibit 1. Invitation to units heads in Schemes 1, 2, and 3—the schemes with financial implications—regarding participation in the inaugural six-month pilot.

Letter Requesting Participation in Pilot for Carbon Charge Project

[Click here to enter a date]

Dear [Choose a title] [Choose the name of a recipient]:

I write to request your participation in a pilot project to determine whether or how Yale might implement a carbon charge. This email has quite a bit of information, and I apologize in advance for its length but the project team and I wanted you to have all the background about the project.

In August 2014, President Salovey announced six new sustainability initiatives, one of which charged a university task force, chaired by Sterling Professor of Economics William Nordhaus, with investigating whether it would be feasible and effective for Yale to introduce carbon pricing as a fundamental component of its sustainability strategy. We are committed to piloting the concept in select units and continuing to test elements of the plan in the spirit of experimentation and institutional design.

Following the report of the Presidential Carbon Charge Task Force, several staff members have been working on the design and implementation of the pilot with oversight from a steering group and support from the President and Provost's offices. As Yale prepares to introduce the pilot during the 2015-2016 academic year, President Salovey has asked the project staff to identify a select group of buildings in which to experiment with carbon pricing. They have identified one of your buildings, [Choose a building], as a strong candidate for the pilot. On behalf of the carbon charge project, I would like to extend an invitation to [Choose a unit] to participate.

President Salovey will be volunteering his own building, Woodbridge Hall, as one of the twenty buildings in the pilot. We hope that you will consider joining President Salovey as a part of the pilot, which will run for six months, from October/November 1, 2015 to March/April 31, 2016, and will require your unit to:

1. Dedicate a small amount of staff time (about one hour per month) to meet with and review materials about your building's performance with the project staff; and
2. Potentially be subject to a financial charge or rebate at the end of the pilot term for the greenhouse gas emissions for which your building is responsible during the pilot period.

For the pilot, it is important to note that the stakes are low, with little to no financial risk, and that the University will ensure that no participant has to bear significant costs. The benefits of supporting this unique energy and environmental policy experiment are many, including:

A. A chance to be one of twenty units featured in a campus-wide announcement from President Salovey about the pilot;
B. The opportunity to participate in a first-of-a-kind study with implications for energy policy, climate change mitigation, and environmental economics;
C. Potential gains in energy efficiency and reduced energy costs through behavioral change; and
D. An opportunity to learn more about energy consumption and weigh in on programming, such as the ongoing development of a new, more informative utility bill.

If you choose to accept this opportunity, we ask that you please delegate an individual to manage the pilot on behalf of your building. We recommend assigning your Lead Administrator or Operations Manager. Her/his involvement will consist primarily of (a) 30- to 60-minute, bi-monthly meetings with the project staff, in which s/he will review a utility bill, receive advice and support, and provide feedback

Letter Requesting Participation in Pilot for Carbon Charge Project

on the pilot, as well as (b) making decisions about energy use and, if s/he chooses, guiding actions to reduce energy consumption in your building.

With the project on schedule to be announced by President Salovey later this month, we would like to finalize the list of participating units as soon as possible. I am hopeful, then, that you or your designee will kindly confirm your participation in the pilot by responding in the affirmative to Jennifer Milikowsky (jennifer.milikowsky@yale.edu; 203-641-8659) and Ryan Laemel (ryan.laemel@yale.edu; 203-623-0514), copied, at your earliest convenience.

Once the project staff receives your confirmation, they will reach out to your office and/or your designee to find a time to discuss further the project, as well as why your unit was selected, with the other participating units.

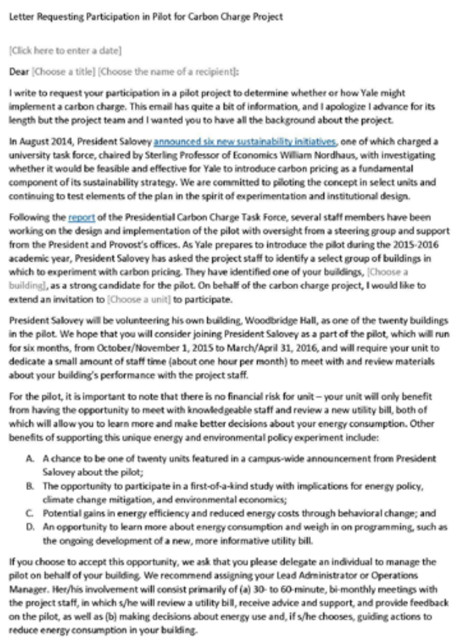
If you have any questions or concerns, or if would like to learn more about the pilot before accepting, please contact the project staff by emailing carbon@yale.edu or calling 2-3120. For more details about the project, please visit http://carbon.yale.edu.

Many thanks in advance for your effort to support and help us experiment with this important University project.

Sincerely,

[Choose a sender]

Exhibit 2. Invitation to units heads in Scheme 4 – the scheme without financial implications – regarding participation in the inaugural six-month pilot.



Letter Requesting Participation in Pilot for Carbon Charge Project

[Click here to enter a date]

Dear [Choose a title] [Choose the name of a recipient]:

I write to request your participation in a pilot project to determine whether or how Yale might implement a carbon charge. This email has quite a bit of information, and I apologize I advance for its length but the project team and I wanted you to have all the background about the project.

In August 2014, President Salovey announced six new sustainability initiatives, one of which charged a university task force, chaired by Sterling Professor of Economics William Nordhaus, with investigating whether it would be feasible and effective for Yale to introduce carbon pricing as a fundamental component of its sustainability strategy. We are committed to piloting the concept in select units and continuing to test elements of the plan in the spirit of experimentation and institutional design.

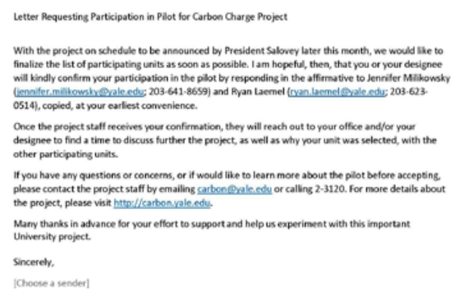
Following the report of the Presidential Carbon Charge Task Force, several staff members have been working on the design and implementation of the pilot with oversight from a steering group and support from the President and Provost's offices. As Yale prepares to introduce the pilot during the 2015-2016 academic year, President Salovey has asked the project staff to identify a select group of buildings in which to experiment with carbon pricing. They have identified one of your buildings, [Choose a building], as a strong candidate for the pilot. On behalf of the carbon charge project, I would like to extend an invitation to [Choose a unit] to participate.

President Salovey will be volunteering his own building, Woodbridge Hall, as one of the twenty buildings in the pilot. We hope that you will consider joining President Salovey as a part of the pilot, which will run for six months, from October/November 1, 2015 to March/April 31, 2016, and will require your unit to dedicate a small amount of staff time (about one hour per month) to meet with and review materials about your building's performance with the project staff.

For the pilot, it is important to note that there is no financial risk for unit – your unit will only benefit from having the opportunity to meet with knowledgeable staff and review a new utility bill, both of which will allow you to learn more and make better decisions about your energy consumption. Other benefits of supporting this unique energy and environmental policy experiment include:

A. A chance to be one of twenty units featured in a campus-wide announcement from President Salovey about the pilot;
B. The opportunity to participate in a first-of-a-kind study with implications for energy policy, climate change mitigation, and environmental economics;
C. Potential gains in energy efficiency and reduced energy costs through behavioral change; and
D. An opportunity to learn more about energy consumption and weigh in on programming, such as the ongoing development of a new, more informative utility bill.

If you choose to accept this opportunity, we ask that you please delegate an individual to manage the pilot on behalf of your building. We recommend assigning your Lead Administrator or Operations Manager. Her/his involvement will consist primarily of (a) 30- to 60-minute, bi-monthly meetings with the project staff, in which s/he will review a utility bill, receive advice and support, and provide feedback on the pilot, as well as (b) making decisions about energy use and, if s/he chooses, guiding actions to reduce energy consumption in your building.



Letter Requesting Participation in Pilot for Carbon Charge Project

With the project on schedule to be announced by President Salovey later this month, we would like to finalize the list of participating units as soon as possible. I am hopeful, then, that you or your designee will kindly confirm your participation in the pilot by responding in the affirmative to Jennifer Milikowsky (jennifer.milikowsky@yale.edu; 203-641-8659) and Ryan Laemel (ryan.laemel@yale.edu; 203-623-0514), copied, at your earliest convenience.

Once the project staff receives your confirmation, they will reach out to your office and/or your designee to find a time to discuss further the project, as well as why your unit was selected, with the other participating units.

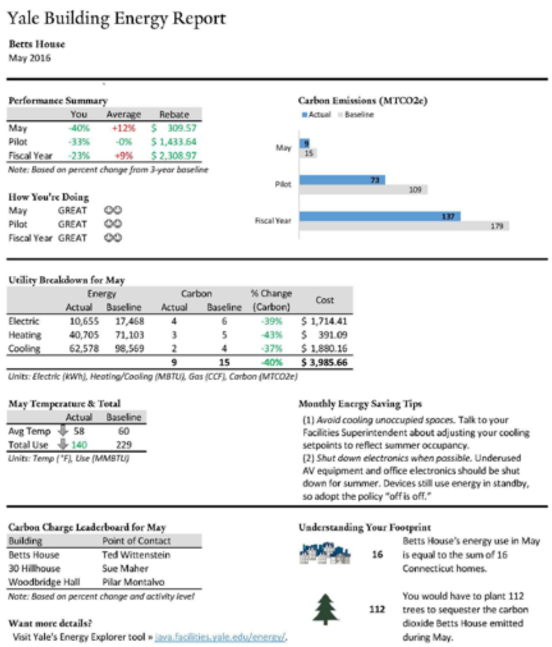
If you have any questions or concerns, or if would like to learn more about the pilot before accepting, please contact the project staff by emailing carbon@yale.edu or calling 2-3120. For more details about the project, please visit http://carbon.yale.edu.

Many thanks in advance for your effort to support and help us experiment with this important University project.

Sincerely,

[Choose a sender]

Exhibit 3. Examples of the building energy reports sent to the pilot units. Left is May 2016 data for Betts House (Scheme 3). Right is February 2016 data for Pierson College (Scheme 2). Note that the two reports are reflective of the month, building, and scheme.



Yale Building Energy Report

Betts House
May 2016

Performance Summary

	You	Average	Rebate
May	-40%	+12%	$ 309.57
Pilot	-33%	-0%	$ 1,433.64
Fiscal Year	-23%	+9%	$ 2,308.97

Note: Based on percent change from 3-year baseline

Carbon Emissions (MTCO2e)

Actual Baseline

May 9 15
Pilot 73 109
Fiscal Year 137 179

How You're Doing

May GREAT
Pilot GREAT
Fiscal Year GREAT

Utility Breakdown for May

	Energy		Carbon		% Change	Cost
	Actual	Baseline	Actual	Baseline	(Carbon)	
Electric	10,655	17,468	4	6	-39%	$ 1,714.41
Heating	40,705	71,103	3	5	-43%	$ 391.09
Cooling	62,578	98,569	2	4	-37%	$ 1,880.16
			9	15	-40%	$ 3,985.66

Units: Electric (kWh), Heating/Cooling (MBTU), Gas (CCF), Carbon (MTCO2e)

May Temperature & Total

	Actual	Baseline
Avg Temp	58	60
Total Use	140	229

Units: Temp (°F), Use (MMBTU)

Monthly Energy Saving Tips

(1) *Avoid cooling unoccupied spaces.* Talk to your Facilities Superintendent about adjusting your cooling setpoints to reflect summer occupancy.
(2) *Shut down electronics when possible.* Underused AV equipment and office electronics should be shut down for summer. Devices still use energy in standby, so adopt the policy "off is off."

Carbon Charge Leaderboard for May

Building	Point of Contact
Betts House	Ted Wittenstein
30 Hillhouse	Sue Maher
Woodbridge Hall	Pilar Montalvo

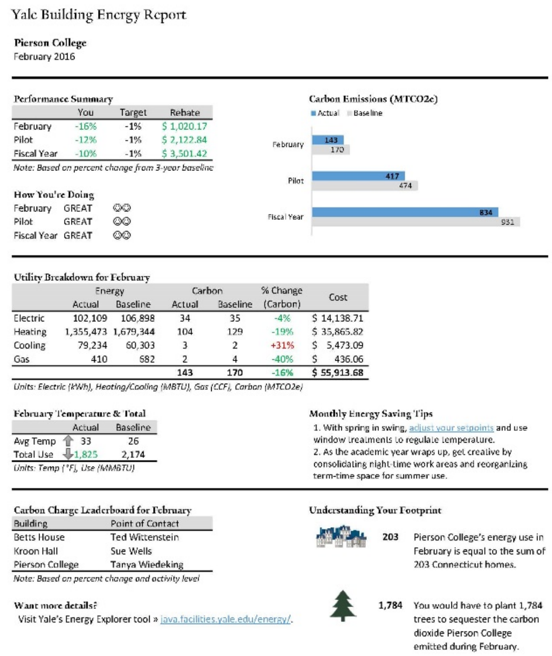
Note: Based on percent change and activity level

Want more details?
Visit Yale's Energy Explorer tool » java.facilities.yale.edu/energy/.

Understanding Your Footprint

16 Betts House's energy use in May is equal to the sum of 16 Connecticut homes.

112 You would have to plant 112 trees to sequester the carbon dioxide Betts House emitted during May.



Yale Building Energy Report

Pierson College
February 2016

Performance Summary

	You	Target	Rebate
February	-16%	-1%	$ 1,020.17
Pilot	-12%	-1%	$ 2,122.84
Fiscal Year	-10%	-1%	$ 3,501.42

Note: Based on percent change from 3-year baseline

Carbon Emissions (MTCO2e)

Actual Baseline

February 143 170
Pilot 417 474
Fiscal Year 834 931

How You're Doing

February GREAT
Pilot GREAT
Fiscal Year GREAT

Utility Breakdown for February

	Energy		Carbon		% Change	Cost
	Actual	Baseline	Actual	Baseline	(Carbon)	
Electric	102,109	106,898	34	35	-4%	$ 14,138.71
Heating	1,355,473	1,679,344	104	129	-19%	$ 35,865.82
Cooling	79,234	60,303	3	2	+31%	$ 5,473.09
Gas	410	682	2	4	-40%	$ 436.06
			143	170	-16%	$ 55,913.68

Units: Electric (kWh), Heating/Cooling (MBTU), Gas (CCF), Carbon (MTCO2e)

February Temperature & Total

	Actual	Baseline
Avg Temp	33	26
Total Use	1,825	2,174

Units: Temp (°F), Use (MMBTU)

Monthly Energy Saving Tips

1. With spring in swing, adjust your setpoints and use window treatments to regulate temperature.
2. As the academic year wraps up, get creative by consolidating night-time work areas and reorganizing term-time space for summer use.

Carbon Charge Leaderboard for February

Building	Point of Contact
Betts House	Ted Wittenstein
Kroon Hall	Sue Wells
Pierson College	Tanya Wiedeking

Note: Based on percent change and activity level

Want more details?
Visit Yale's Energy Explorer tool » java.facilities.yale.edu/energy/.

Understanding Your Footprint

203 Pierson College's energy use in February is equal to the sum of 203 Connecticut homes.

1,784 You would have to plant 1,784 trees to sequester the carbon dioxide Pierson College emitted during February.

Chart 4. FY 2016 baseline (light blue) and actual (dark blue) emissions for the four schemes. Top: Schemes 1 (L) and 2 (R). Bottom: Schemes 3 (L) and 4 (R). Red lines indicate the pilot term.

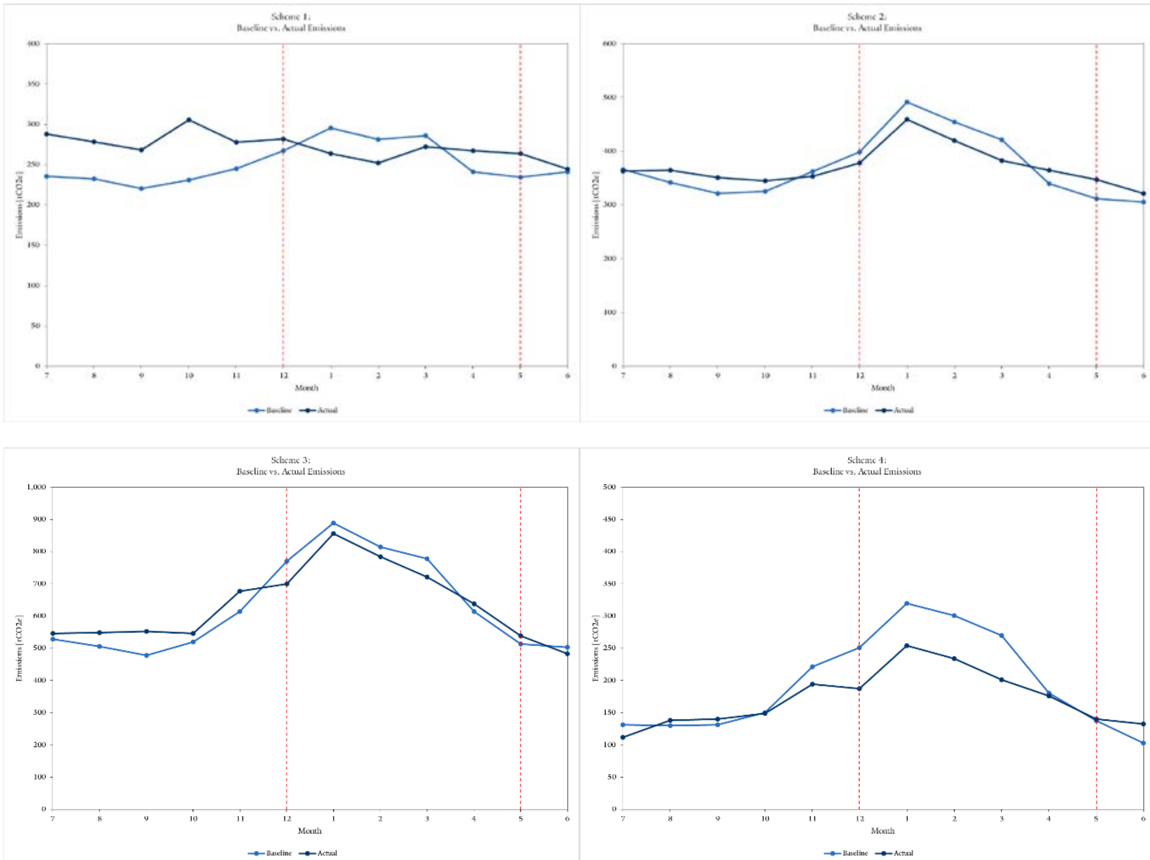


Chart 5. Historical simulation results for the self-support carbon pricing scheme showing net charges for FY 2010-2016. These data are categorized by 10 Column, a high-level classification of university budgets. Positive and negative values represent net charges and rebates, respectively.

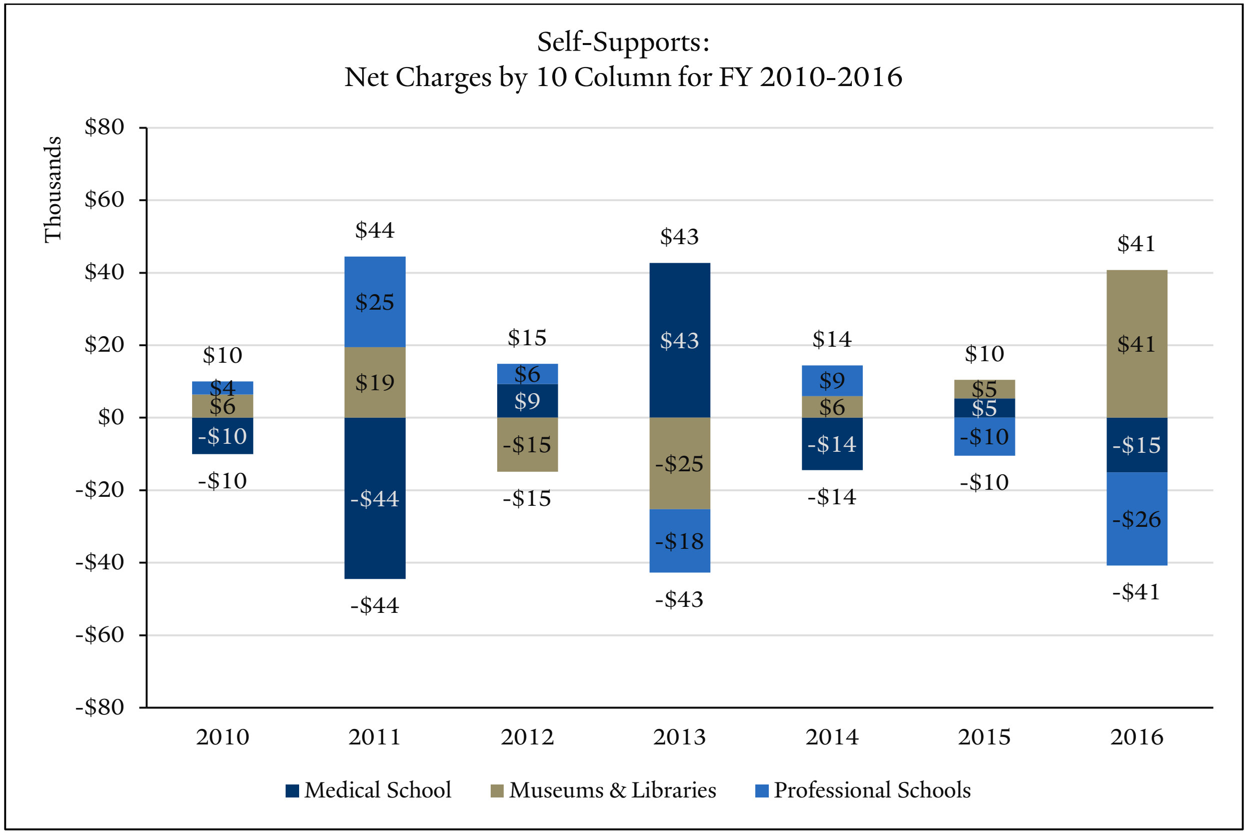


Chart 6. Historical simulation results for the centrally-supported units' carbon pricing scheme showing net charges for FY 2010-2016. These data are categorized by 10 Column, a high-level classification of university budgets. Positive and negative values represent net charges and rebates, respectively.

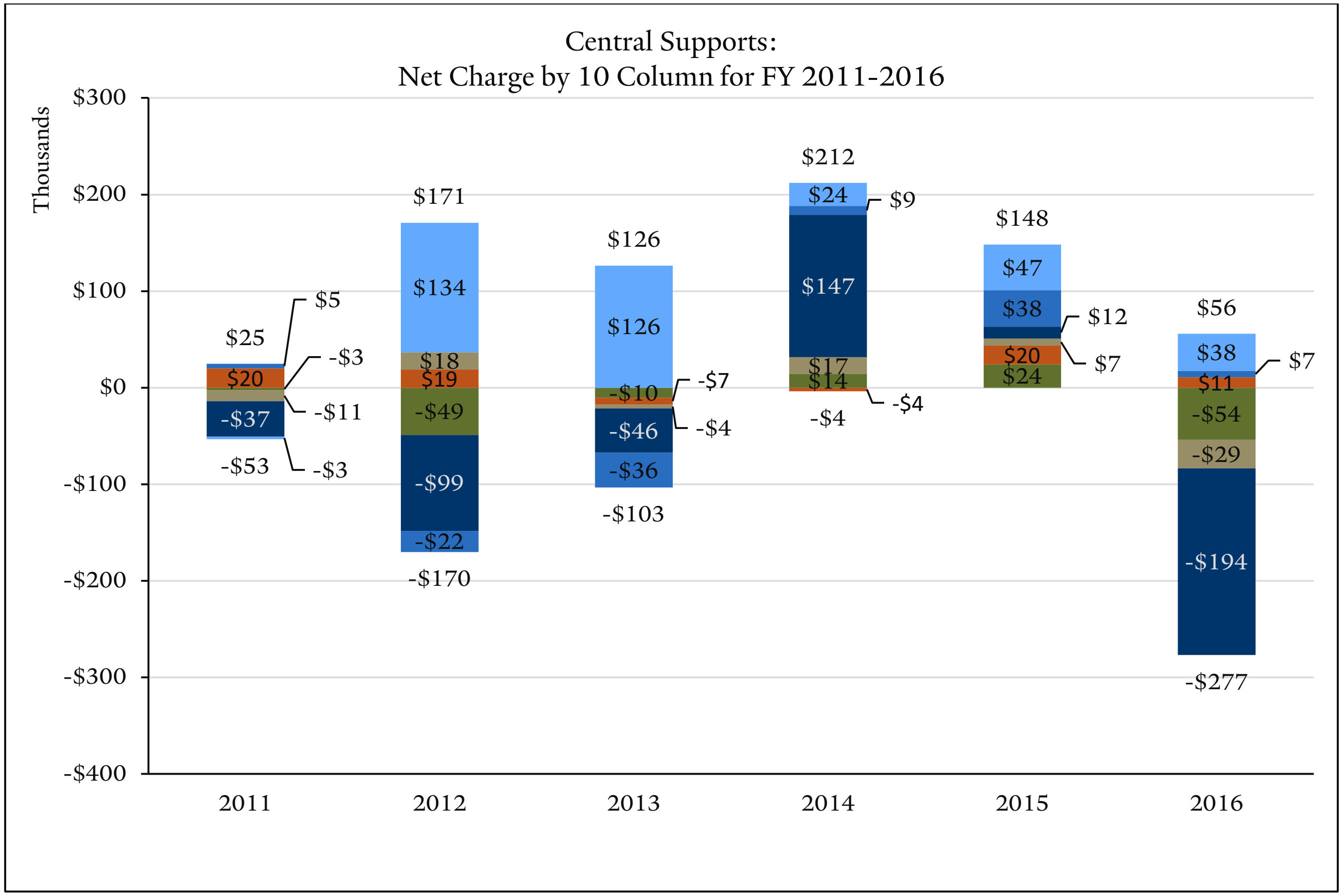


Table 19. Prospective buildings for FY 2017 pilot. Baselines in tCO_2e. Baseline definition is FY 2016, December through June.

	Building Name	Baseline
1	The Anlyan Center	5,748
2	Sterling Hall Med B	3,468
3	Amistad Street Building	2,783
4	Sterling Hall Med I	2,777
5	Becton E&As Center	2,503
6	Payne Whitney Gym	2,491
7	Boyer Ctr Molec Med	2,255
8	Yale U. Art Gallery	2,147
9	Sterling Div. Quad.	1,891
10	Sterling Mem Library	1,625
11	Lab Of Epidem, Pubhl	1,488
12	Chemistry Res Bldg	1,426
13	Edward P Evans Hall	1,305
14	Silliman College	1,239
15	Environmtl Science Ctr	1,074
16	Sterling Hall Med C	1,044
17	Sterling Law Bldgs.	1,030
18	Yale Physicians Bldg	966
19	Yale Health Center	944
20	Rudolph Hall	822
21	Dunham Lab	808
22	Sterling Hall Med L	786
23	Morse College	773
24	Davenport College	753
25	Branford College	743
26	Ezra Stiles College	730
27	Saybrook College	729
28	Pierson College	715
29	Calhoun College,John	712
30	Berkeley College	686
31	Timothy Dwight Coll.	622
32	Linsly-Chittenden	567
33	Sloane Physics Lab	562
34	Jonathan Edwards Col	532
35	Wc Collection St Ctr	530
36	Peabody Museum	469
37	Trumbull College	422
38	Greeley Mem. Lab	254

39	Leigh Hall	251
40	Sheffd-Sterl-Strathc	236
41	Rosenkranz Hall	207
42	Wc Adv Biosciences Ctr	198
43	Curtis Hall (Div)	145
44	Gilder Boathouse	122
45	Edgewood Ave, 32-36	98
46	Sage-Bowers Hall	92
47	Stoeckel Hall	81
48	Kroon Hall	76
49	Betts House	73
50	Hillhouse Ave,43	53
51	Woodbridge Hall	52
52	Marsh Hall	35
53	Hillhouse Ave,37	33
54	Hillhouse Ave,30	33
55	Prospect St,301	32
56	Weir Hall	17
57	Edwards St, 380	17
58	Prospect St,204	16
59	Allwin Hall	15
60	Prospect St,459	9
		52,314