Sustainability Policies and Programs

A Handbook for Academic Institutions

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This is a draft, very much a work in progress. Comments and suggestions welcome. kimbrough@wharton.upenn.edu

Contents

Preface

Permanent link to the most recent available version of this document: This document.

Or The Climate Decisions Lab folder.

(https://github.com/stevenokimbrough/sokpapers/blob/master/ClimateDecisionsLab/)

Then

Climate_Decisions_Lab_Handbook_Academic.pdf

Part I

Preliminaries

Chapter 1 Pool of Programs and Policies

Note: There are duplications and overlaps between sections 1.1 and 1.2. So be it.

1.1 Union List of Policies and Programs

These are **kinds** of programs and policies. Each has multiple specific variants. Combinations and consolidations among programs are options as well as implementing parts of individual programs and policies.

1. **Commit to 24/7 carbon-free energy**
   This is a much stronger commitment than net-zero energy. Under 24/7 carbon-free energy, **all** energy used is green or from carbon-free sources of generation (marginally carbon-free).
   https://blog.google/outreach-initiatives/sustainability/our-third-decade-
   https://blog.google/outreach-initiatives/sustainability/our-third-decade-climate-action-realizing-carbon-free-future
2. **Green banks: financing for rooftop solar, for building weatherization, for building electrification**
   A green bank is a program or office that facilitates green financing, e.g., for rooftop solar, building weatherization, building electrification. Green banks typically are not genuine banks. Instead they partner with banks and credit unions to facilitate and reduce the cost of financing green projects. Montgomery County, MD has a successful program.
   Householders then have the prospect near term of saving money on energy bills and, at least during daylight hours, being resilient to power outages.
   See chapter 4.
3. **Composting**
   See chapter 3.
4. **Electrification of lawn care and grounds care equipment**
   Example: Ban on two-cycle engines for powering lawn care equipment.
   In favor of battery-driven equipment.
5. **Participate in distributed demand response programs**
   Demand response participants are paid to curtail their electricity use during periods of peak demand. Historically, large industrial users have been the target of these programs. Residential participants typically work through an aggregator who holds the primary contract with the utility.
   In principle, academic institution could also be participants in such programs.
6. **Converting to using electric buses (and other utility vehicles).**

The economic case is now strong with health and (air and noise) pollution benefits extra. Synergy with own solar panels for cheaper, behind the meter, charging.

7. **Sustainable living information**

   Health and safety information programs serve as precedent. Can be done "in the small" by encouraging volunteer groups, students, and others to participate. Information can be aimed at faculty and staff and also be made available to the wider community.

   One form: **Public awareness programs for building electrification and energy efficiency**.

8. **Encourage building electrification.**

   Aimed at faculty and staff.

   Could be combined with green financing, (2.) and aimed as well at the larger community.

   The Energy Gang podcast of April 15, 2021, "Unlocking Home Electrification With Heat Pumps"

   Excellent discussion of operating characteristics and policy.

   https://podcasts.apple.com/us/podcast/unlocking-home-electrification-with
   id663379413?i=1000517299281

   https://podcasts.apple.com/us/podcast/unlocking-home-electrification-with-heat-pumps/id663379413?i=1000

9. **Food rescue programs**

   Feed the hungry with what would otherwise be wasted food from restaurants and grocery stores. Many examples exist of successful programs. Typically they are run by volunteers and NGOs. Students and other academic volunteers are a possibility as well.

   See chapter 13.

10. **EV charging stations**

    Construction of and commitment to an adequate presence on campus.

11. **Transition buildings to higher-grade efficiency standards**

12. **Incentive use of public transit**

13. **Expand bicycle and pedestrian thoroughfares**

    Often described as "low stress" bike routes and "last mile design." Study and assess the costs and benefits of adding and improving routes and connectors to and from the campus.

    See chapter 11.

14. **Advocate for amenities for public transit and bicycles**

    Study and assess the opportunities costs and benefits of making making public transit and bicycle commuting more attractive to use. Look at parking near transit hubs.

    See chapter 11.

15. **Support for use and composting of compostable food utensils and containers**

    Including water/liquid bottles. The issue here is that in many cases bottles and tableware advertised as compostable require industrial processing (to grind them up) and often cannot be handled by local outfits as they are presently configured.

See "Industrial grinding for composting" 16. on page 4.

See chapter 3.

16. **Industrial grinding for composting.**

    Invest in or obtain services for industrial grade compost grinding sufficient for composting so-called compostable bottles, table ware, etc.

    See "Support for use and composting of compostable food utensils and containers" 15. on page 3. See chapter 3.

17. Waste regulation, including ban on single-use plastics, bottle deposits, etc.
18. Soil management for carbon capture, etc.

    On campus and other institutional grounds.

19. **Low Embodied Carbon Concrete**

    See chapter 7.

20. Internal Carbon Pricing
21. **Behavioral Interventions**

    See chapter 9.

22. **Academic building electrification**

    See chapter 5.

23. **Work rules reform**

    Aimed at reduction of GHG emissions. One proposal being tried is for a 4-day (32 hour) work week (https://www.treehugger.com/spain-to-try-4-day-workweek-5120478). Other ideas include mixing on-site and distal work, extending practices from the Covid-19 pandemic.

24. Environmental and Sustainability Dashboard

    In part a form of behavioral intervention. In part an opportunity for citizen science. Valuable contributions can be had from students, as well as citizen hobbyists. Has educational and cultural value for the entire community. Moves towards the higher levels of environmental monitoring and management that will be needed with climate changes.

25. Promote a culture of walking and bicycling

    And being out and about as a pedestrian. Orient the built environment as much as is practicable towards pedestrians (bicycles, etc.). Create new walkways and upgrade existing walkways to make them more useful (e.g., connected with car parks, with public transit) and more pleasant (greenery, sound barriers.)

    Contributions: Reduced vehicle miles traveled (VMT) reduces GHG emissions. Walking promotes health and well-being. Greenery and sound barriers are pleasant and reduce stress. Greenery is beautiful.

26. Green walls, living walls

    Green walls, aka living walls, e.g., https://architizer.com/blog/product-guides/

product-guide/eantka-green-walls/.

Figure 1.1: Green wall on administrative building of the Musée du Quai Branly in Paris.

Green Engine Coffee in Haverford, PA:

http://www.greenenginecoffee.com/

https://www.yelp.com/biz/green-engine-coffee-haverford-2

Contributions: Encourages walking (which reduces VMT and promotes health), cleans the air, reduces stress. Greenery is beautiful.

See figure 1.1.

American vendor, Nedlaw Living Walls, http://nedlawlivingwalls.com/.

27. Sound barriers

    Contributions: Encourages walking (which reduces VMT and promotes health), reduces stress. See figure 1.2.

28. Green, planted areas for storm and flood buffering

    Convert areas prone to flooding to marshland and parkland that can quickly recover from flooding. Landscape for use for parks and recreation.

    Contributions: Mitigation of storm damage, expected to increase with climate change. Promotes health and well-being, beauty, and stress reduction.

    Note: Penn is doing this. Other opportunities?

29. Biochar

    An important form of carbon dioxide removal (CDR).

    Good discussion and references in https://cdrprimer.org.

    Integrate with grounds management.

Figure 1.2: Glass wall facing street in the garden of the Musée du Quai Branly in Paris.

30. Build and support solar PV

    Just do it. Valuable even as demonstration proejects.

    https://foreignpolicy.com/2021/04/13/solar-community-owned-projects-green

    https://foreignpolicy.com/2021/04/13/solar-community-owned-projects-green-transition/

31. Faculty and staff GHG reduction programs.

    Information and incentives for faculty and staff to reduce their carbon footprints, e.g., green financing for weatherization, for building electrification, etc.

1.2 UCSD 2020 Faculty Senate Report

The following items were gleaned from the 2020 UCSD Faculty Senate "Report of the Task Force on the Climate Crisis" [1],[1]. Thanks for Michael Weisberg for bringing this to our attention.

0. **Commit to recycling and composting goals.**

    In 2004, UCOP mandated that each UC campus divert 90% of its waste to recycling and compost by 2020. Some UCs are on track, such as UC Irvine, which has achieved 83% diversion. But UCSD falls short at only 38% https://sustainability.ucsd.edu/_files/UCSanDiegoZeroWastePlan.pdf.

    Source: [1, page 7].

1. **Cogeneration Plant: Undertake substantial fundraising to replace the cogeneration**

[1] https://senate.ucsd.edu/current-affairs/reports-recommendations/report-of-the-senate-task-force-on-the-climate-crises/. File: climate-crisis-task-force-report-revised-07-16-20-final.pdf.

plant with a mostly electric supply to campus (sourced from 100% renewables as soon as possible), while ensuring resiliency to shutdowns.

Instead of using predominantly natural gas(even if 'displaced' elsewhere by biogas), we could run our heating/cooling and local electricity needs from majority electricity input. This will cost a large amount of money. [For Stanford it was over 450 million https://law.stanford.edu/publications/managing-uncertainty-in-carbon-offsets-insi https://law.stanford.edu/publications/managing-uncertainty-in-carbon-offsets-insights-from-californias-standardized-approach/] Moreover, an important issue when considering powering UCSD with mostly electricity (instead of mostly natural gas) is to build in campus resiliency in the face of power shutdowns. Such shutdowns will become more likely with the fires exacerbated by climate change. The campus will need backup systems and to use the microgrid to maintain electricity to hospitals, data-servers and critical research infrastructure.

Source: [1, item 1]. Cost: large expense.

2. **Transportation: Make Facilities accountable to Scope 3 transportation goals now(not 2050).** Efforts should be made now to reduce emissions from ground transportation and campus-related aviation. Administrators at UCSD should be given specific goals for these emissions reductions, be provided with the appropriate resources, and be asked to report progress. The provision of the light rail trolley to UCSD in 2021 is a propitious movement for UCSD to better connect the campus with public transportation.

   Source: [1, item 2]. Cost: little or no expense, or even saves money.

3. **Replace the campus fleet by majority electric vehicles by 2025.**

   > It is part of UCSD's climate action plan to replace the fleet, and the Facilities Department has said: "over 60% of the fleet is already hybrid, all-electric, compressed natural gas, or renewable biodiesel" https://tinyurl.com/t38ztwn. Still, we note that while hybrid cars are an improvement they are only a partial step towards decarbonization, and, further, natural gas and biodiesel still entail substantial emissions. [1]

   Source: [1, item 3]. Cost: lesser expense.

4. **Measure campus-related aviation and develop a plan for substantial reductions.**

   > A plan should be developed for reducing campus aviation. This could include a) changing department cultures to encourage the use of virtual seminar and open-house 'visits', b) adjusting expectations for study-abroad programs, including building in an awareness of climate justice, c) signing up UCSD to the 'flyingless' movement https://noflyclimatesci.org/institutions, d) encouraging faculty to combine visits to multiple institutions in longer tours to avoid multiple flights, and also to take the lead to encourage more virtual

conferencing in their academic societies both to reduce the need for travel and as a means to enable more broadly-based participation.

The Coronavirus pandemic has already led to changes in behavior that will lower the barrier to adopting these recommendations. To change behavior we need to acquire data. Most or all business-related aviation (faculty, graduate students, postdocs, visiting undergraduates for open houses) is logged through MyTravel [at UCSD]. It should be possible for Information Technology staff to extract destinations and compute emissions per-passenger and at the department level. This could be communicated regularly to the wider institution for the purpose of creating concrete emissions goals.

Source: [1, item 4]. Cost: little or no expense, or even saves money.

5. **Make public transportation free at point of use for faculty, staff and students; incentivize carpooling and bus use; substantially extend campus micromobility.**

   a) UCSD should make Metropolitan Transport System (MTS) passes part of faculty/staff benefit packages. This will be cost-effective because UCSD can obtain MTS passes at about 10% of the cost (≈$60/year) that faculty/staff would have to pay if they purchased these passes directly from MTS (≈$600/year).

   b) UCSD should support a pay-per-use instead of a per month parking program. This system could be structured to reward people who choose to not drive on some days by carpooling, taking public transportation, or telecommuting, while also not penalizing faculty/staff who need to drive to work (for example to facilitate child pick up after school) or those (such as physicians) who have to park at UCSD on weekends as well as workdays. Execution of this pay-per-use parking plan in conjunction with free MTS bus passes would provide a fiscal incentive for people to carpool or take public transportation on days when it is possible for them to do so, without penalizing people for whom it is not feasible.

   c) The use of bikes and scooters on campus, and to campus from surrounding areas, should be facilitated through further development of dedicated lanes. This would help with "last mile" transportation to campus – for example, faculty/staff who enter campus at the new trolley stop in the south can then move via bike/scooter on dedicated lanes to the north.

   Source: [1, item 5]. Cost: lesser expense.

6. **Explore opportunities with the regional transit system to deliver rapid buses for service to and from the campus.**

   UCSD can use its knowledge of where faculty/staff, students and postdocs live to establish express routes from areas with high densities of UCSD commuters to the campus. When the Trolley is ready in 2021 express transport, could be put in, for example, from Ocean Beach to Old Town. This could take hundreds of cars off the road per day from that location alone, for those drivers and passengers who want to live more ecologically. Likewise, connections can be made from key areas in North Country with high densities of UCSD members, and also to other locations in San Diego.

Source: [1, item 6]. Cost: lesser expense.

7. **Support a telecommuting policy for knowledge workers.**
   Telecommuting has a huge decarbonization benefit due to a reduction in transportation. Allowing one day per week telecommuting could reduce traffic to campus by as much as one fifth. Dramatic behavioral changes under the Coronovirus pandemic clearly demonstrate that telecommuting has been highly effective for many knowledge workers.
   Source: [1, item 7]. Cost: little or no expense, or even saves money.
8. **Support location-efficient mortgages to encourage campus members to live close to the trolley/buses.** Location-efficient mortgages https://www.cnt.org/projects/rethinking-mortgages provide a larger loan when the cost of transportation is expected to be lower—for example for a public transportation-based commute. This could be modeled after the existing program at the University of Washington https://en.wikipedia.org/wiki/Location_Efficient_Mortgage.
   Source: [1, item 8]. Cost: lesser expense.
9. **Organic Waste: Build or source a large-scale composting facility that can recover organic waste.**

   Large amounts of organic waste are generated by our huge campus every day. Facilities is hoping that it will be able to send post-consumer food and other organic waste to EDCO's https://tinyurl.com/t38ztwn new facility in 2021. We should pay careful attention to this – if this is not an option soon, a dedicated campus facility should be built.

   Source: [1, item 9]. Cost: lesser expense.
10. **Prohibit single-use plastic from campus vendors and encourage emissions labeling on food.**
    a) Incentivize contracts with vendors who use sustainable products (such as single use plastic). Such policy should be applied to vendor contracts when they are up for renewal.
    b) Encourage carbon labeling of food items in our cafeterias https://www.sciencedirect.com/science/article/abs/pii/S0306919211001096. Recent research shows people desire it https://www.wired.co.uk/article/carbon-labelling-quorn. Methods for determining such labeling are getting easier.
    Source: [1, item 10]. Cost: lesser expense.
11. **Properly support the Green Labs program.**

UCSD's Green Labs https://sustain.ucsd.edu/involve/green-labs.html, which started in 2013, is a program that helps laboratories reduce their footprints without compromising research quality or safety. Since there are ≈900 research wet labs on campus and the Green Labs program has been able to certify ≈100 of them so far https://sustain.ucsd.edu/involve/green-labs.html#Green-Lab-Certification, it will take close to 30 years at the current rate to certify all labs on campus. Given the obvious cost benefits from reducing energy and water use in these labs, the funding, resources and goals for this program need to be scaled appropriately to promptly enable certification of all research labs, also with regular recertification.

Source: [1, item 11]. Cost: little or no expense, or even saves money.

12. **Where possible, record the emissions footprint of items acquired through campus procurement.**
    Guide purchasing decisions with information on carbon impact. If emissions data are available, purchasers can then instantiate the principles of emissions reduction when they choose among vendors.
    Source: [1, item 12]. Cost: little or no expense, or even saves money.
13. **Make vegetarian meals the default choice in campus dining rooms and start meatless Mondays.**
    Animal agriculture, especially for red meat consumption, is responsible for a large proportion of Greenhouse Gas emissions (13 to 18%) https://skepticalscience.com/animal-agriculture-meat-global-warming.htm. Some universities such as Goldsmiths London https://www.theguardian.com/environment/2019/aug/12/goldsmiths-bans-beef-from-university-cafes-to-tackle-climate-
    (https://www.theguardian.com/environment/2019/aug/12/goldsmiths-bans-beef-from-university-cafes-to-tackle-climate-crisis) and the University of Portugal https://www.newsweek.com/portugals-oldest-university-bans-beef-fight-climate-change-we-are-exp
    (https://www.newsweek.com/portugals-oldest-university-bans-beef-fight-climate-change-we-are-experiencing-climate-1461344) have gone so far as to ban red meat outright. One can start with meatless Mondays in campus dining halls. Campus policy can be developed to guide Housing and Dining Services as well as on-campus vendors.
    Source: [1, item 13]. Cost: little or no expense, or even saves money.
14. **Replace most gasoline-powered leaf blowers by electric.**
    Leaf blowers are used dozens, perhaps hundreds, of times per day at UCSD. Replacing gasoline with electric blowers will reduce both Greenhouse Gas Emissions and toxic pollution. There are issues of cost and functionality, but as difficult as it might be, UCSD should replace these polluting devices, which have been banned in many towns in the US, including Del Mar and Encinitas https://drive.google.com/file/d/

1GR1niTtOs6dTgomyNwGawmRqPS2aBuFc/view?usp=sharing. The state of California is considering banning them https://www.sfchronicle.com/business/article/California-s-latest-pollution-push-Banning-14951305.php#.

Source: [1, item 14]. Cost: lesser expense.

15. **Test carbon pricing schemes for aviation and cars.**
    Universities have pioneered tests of carbon pricing https://secondnature.org/climate-action-guidance/iv-case-studies/#resource9, and Yale University has a report on the social cost of carbon https://carbon.yale.edu/sites/default/files/files/Carbon-charge-report-041015.pdf. Regarding aviation, Point (4.), page 7 above, called for department-level measurement and culture change; here we go further and suggest experiments with pricing. We could, for example, emulate the UCLA levy https://secondnature.org/wp-content/uploads/UCLA-case-study.pdf on work-related flights, but increase it to a more substantial $25, and ear-mark the proceeds for new graduate student climate crisis projects or faculty teaching workshops. Regarding private car use, one possibility is to impose a carbon impact fee. This would need to have equity at its core, recognizing that campus members who come from further away may least be able to afford it and have worse options for public transportation. The monies raised could be matched by the university and funneled to public transportation options such as above.
    Source: [1, item 15]. Cost: little or no expense, or even saves money.
16. **16. Create transparency rules regarding corporate influence over energy and climate scholarship.**[2]

    > The UC has policy on conflicts of interest around human subjects research (focused especially on medical research funded by Pharma, and as required by Federal and State law). There is also a Regents Policy (2309) on Tobacco entitled "Policy Requiring Special Review/Approval Procedures Prior to University Submission of Research Proposals to Tobacco Industry Funders" https://regents.universityofcalifornia.edu/governance/policies/2309.html. A similar type of document as 2309, but for Fossil Fuel funding, is now being promoted through the UC systemwide Senate. Given that the consequences and urgency of the climate emergency dwarf those of pharma and tobacco, similarly enhanced scrutiny should be applied to research and other support provided by fossil fuel interests. UCSD should get behind this.
    >
    > Source: [1, item 16]. Cost: little or no expense, or even saves money.
17. **Shift campus banking away from large fossil-fuel funders such as Bank of America.**

[2]Thanks to Edward Hall and co-authors of the "Harvard University Response to the Climate Crisis" white paper for this suggestion: https://tinyurl.com/wcure4n.

In September 2019 the UC declared a climate emergency,[3] but its choice of commercial banks is not consistent with this. The three major Commercial Banks that UC uses are Bank of America, Wells Fargo, and Union. These banks have some of the worst records and policies in addressing the Climate Emergency of all major banks. Notably, alternative large commercial banks do exist with much smaller exposure to the Fossil Fuel Industry.[4] A proposal is currently being promoted through the UC systemwide Senate to request that the Chief Financial Officer of UC issues a Request for Proposals for commercial banking services that includes a criterion of adherence to Environment, Social and Governance principles. At UCSD, the office of Business and Financial Services confirmed that Bank of America is our main bank. UCSD should support this systemwide Request for Proposals. Further, UCSD should develop an ethical leasing policy at the Price Center (see example petition[5]), where there is, for example, a Chase branch. Chase is at number 1 in financing fossil fuel operations[6]. UCSD should promptly renegotiate Chase's contract.

Source: [1, item 17]. Cost: little or no expense, or even saves money.

18. **Expand campus green infrastructure as a means to decarbonize.**
Examples of green infrastructure include bioswales for stormwater management, green roofs, urban agriculture, food forests, foodwaste-to-soil and energy biodigesters and composting systems. Green Infrastructure can reduce carbon emissions in various ways, for instance, energy and operational efficiencies gained by integrated organic waste management, water harvesting, flood control, green buildings/green roofs/green walls, tree canopy shading/cooling, climate-friendly regenerative agriculture/aquaculture, sequestering carbon in trees and soil, providing green spaces and trails that encourage walking and human-powered transport.
Source: [1, item 18].

1.2.1 Teaching

UCSD has a moral and practical obligation to teach tens of thousands of students about the climate crisis. This will prepare students to think critically about what, for many, will be the biggest problem of their lives; to help them be part of collective action on genuine emissions reductions; and to provide them with relevant skills

[3] https://www.universityofcalifornia.edu/news/university-california-declares-climate-emergency

[4] See page 12 https://www.ran.org/wp-content/uploads/2020/03/Banking_on_Climate_Change__2020_vF.pdf

[5] https://ucsdgreennewdeal.net/wp-content/uploads/2020/02/Form-Letter-to-JPMorgan-Chase-Company.pdf

[6] https://www.ran.org/wp-content/uploads/2020/03/Banking_on_Climate_Change__2020_vF.pdf

for a workplace that is going to be increasingly affected by climate concerns: from healthcare, to engineering, to insurance.

In our view, teaching about the climate crisis is not the same as teaching about the physical basis of climate change. While teaching the former (the climate crisis) must encompass the latter (the physical basis of climate change) it must also cover: a) psycho-socio-political topics, for example the more than 40 year history of how the fossil fuel industry has systematically distorted the science, misled the public and influenced the political system; and, for example, a sober analysis of how emissions have radically escalated under the current political-economic systems of the US and other major countries; and b) the topic of climate justice – i.e. the recognition that the people who did the least to incur our planetary predicament (the poor, the vulnerable, those in the global South, and the young) are going to incur the worst consequences;[7] and how societal solutions to the climate crisis must be just.

While many departments at UCSD have faculty who are doing outstanding teaching on climate topics, and while UCSD is especially well-positioned to lead in interdisciplinary education on the climate crisis, teaching efforts should be quickly scaled up to reach thousands of students. Here we organize our summary and recommendations into three categories. Category 1 concerns interdisciplinary courses that run the full gamut of topics under the climate crisis; Category 2 concerns within-discipline teaching focused on climate change; Category 3 concerns the typical classes taught at UCSD, but in which faculty infuse climate change examples into the material.

Source: [1, pages 9–10].

19. **Increase the frequency of existing interdisciplinary courses on the climate crisis.** Departments and colleges should integrate these courses into existing elective and general requirements.
    Source: [1, item 19]. Cost: little or no expense, or even saves money.
20. **Encourage and reward the development of new interdisciplinary courses on the climate crisis.**

    > The development of new interdisciplinary courses should be encouraged. Interdisciplinarity is one of the hallmark characteristics of our university; one that has historically differentiated us from others. With its seminal contributions to climate science and its growing research activities across divisions, UCSD is well-placed to develop new interdisciplinary classes.
    >
    > Source: [1, item 20]. Cost: little or no expense, or even saves money.

21. **Reduce barriers to co-teaching climate crisis classes across disciplines.**

[7] http://www.columbia.edu/~jeh1/mailings/2018/20181206_Nutshell.pdf

This would encourage more faculty to teach these classes, which includes content that is outside of their specific discipline and ensure that faculty can also learn more in the process.

Source: [1, item 21]. Cost: little or no expense, or even saves money.

22. **Encourage faculty to develop new courses on climate change within their disciplinary perspective.**

    For example, SIO25 (Climate Change and Society) mostly focuses on the physical basis of climate change and is taught by faculty at SIO; MAE119 (Introduction to renewable energy: solar and wind) is taught within engineering; and PSYC185 (Psychology of the Climate Crisis) is taught in Psychology. An attempt at a full listing is here,[8] and includes classes in urban studies, economics, and anthropology, to name a few. Recent courses in this area (e.g. Climate Change Studies CCS102, CCS101, SIO190) were developed with funding from the Understanding and Protecting the Planet program.[9]

    Source: [1, item 22]. Cost: little or no expense, or even saves money.

23. **Offer training to help faculty infuse climate change content into existing courses.**

    Workshops could be facilitated through the Teaching and Learning commons, in a collaboration that would support faculty in these efforts and improve the visibility and the outcomes of this project. Adequate support (funding) should be provided to faculty to participate in these workshops and to create and implement new curricula. Course content that is produced as part of these workshops can be highlighted on the developing climate curriculum website at UCSD, and on other UC-wide websites such as through the UC-CSU NXTerra.[10]

    Source: [1, item 23]. Cost: lesser expanse.

24. **Within the proposed new holistic teaching evaluations [at UCSD], the senate CAP instructions and department chairs should acknowledge faculty efforts to teach the climate crisis.**

    Source: [1, item 24]. Cost: little or no expense, or even saves money.

25. **Acknowledge climate crisis teaching in regular department and college reviews and encourage climate crisis themes in stated learning outcomes.**

    Source: [1, item 25]. Cost: little or no expense, or even saves money.

26. **Incentivize graduate student participation in climate crisis teaching.**

    Interested and passionate graduate students should be able to engage with developing courses on topics related to the climate crisis and be given "extra credit" to incentivize

[8] https://climatecurriculum.ucsd.edu/demo-home/climate-change-coursework/

[9] https://scripps.ucsd.edu/research/upp

[10] https://www.nxterra.orfaleacenter.ucsb.edu/

participation, such as a certificate of accomplishment.

Source: [1, item 26]. Cost: little or no expense, or even saves money.

1.2.2 Research

27. **Direct a subset of new FTEs to climate crisis hiring in social sciences, arts and humanities and business.**

    These disciplines are mentioned given the observation (above) that a mere 0.12% of climate-related funding is in areas outside of physical science. These should be new FTEs not re-allocations of existing ones.

    Source: [1, item 27]. Cost: lesser expense.

28. **Steer research funds towards encouraging new-time investigators to begin climate crisis research projects.**

    This could include providing seed funding for projects to get pilot data; or for graduate student fellowships to allow student to branch out past their advisors. This should be new funding rather than a re-direction of existing funds.

    Source: [1, item 28]. Cost: lesser expense.

1.2.3 Health and Preparedness

29. **Measure the emissions of the existing Health Care Facilities.**

    While UCSD Hillcrest and La Jolla have met the "healthier food challenge"[11] the health system needs to now commit to equivalent programs for (a) leadership engagement and organization-wide decarbonization via leaner energy and decreased emissions, (b) waste abatement and increased recycling, (c) safer chemicals in its materials and (d) leveraging purchasing power of sustainable products. Health Sciences should begin by appointing an academic Climate Change Coordinator.

    Source: [1, item 29]. Cost: lesser expense.

30. **Design the New Hillcrest Hospital [of UCSD] to include Climate-Specialties such as Disaster Preparedness and Public Health Research.**

    A new hospital and health care complex is envisioned for Hillcrest campus that could be designed as a living laboratory for clinical care, education and research in public health. With extant research, teaching and clinical expertise in acute care (trauma, burn, emergency medicine, infectious, respiratory disease and psychiatry), Hillcrest hospital is in a unique position for expanding research and education in disaster preparedness and public health. New construction

[11] https://www.ucsf.edu/magazine/climate-crisis-health-crisis

could use the best possible low-emissions, zero-waste, and toxic-free methods, and incorporate public transportation to a maximum.

Source: [1, item 30]. Cost: lesser expense.

31. **Expand Telemedicine to reduce transportation emissions. The delivery of health care is expensive but its true cost does not even include the emissions impact of travel.**

    Telemedicine is an easy way to reduce emissions in healthcare provision. Telemedicine needs investment and its use by patients, staff and faculty needs to incentivized by exploiting travel UC Health remote care sites, promoting remote access to specialty care and developing compensation plans. Dramatic behavioral changes under the Coronavirus pandemic have accelerated telemedicine and shown to many that it can be effective.

    Source: [1, item 31]. Cost: little or no expense, or even saves money.

32. **Prioritize the climate crisis in all aspects of medical education.**
    The Deans of each school should make health climate awareness and decarbonization a priority to all teaching efforts that is at par with their school's systematic efforts to ensure equity and diversity of faculty and students.
    Source: [1, item 32]. Cost: little or no expense, or even saves money.

33. **Recognize climate crisis work in the assessments and career advancement of clinical faculty.**

    The Schools of Medicine, Pharmacy and Public Health should establish a Clinical Enrichment Program with specific funding and opportunities for faculty to both take CME courses that offer internship opportunities, campus projects and research opportunities related to the health consequences of climate and climate solutions.

    Source: [1, item 33]. Cost: little or no expense, or even saves money.

34. **Increase the number of mental health counselors in the Faculty and Staff Assistance Program and provide eco-anxiety training for them and for student mental health counsellors.**
    Source: [1, item 34]. Cost: lesser expense.

1.3 Links

- United States Climate Alliance http://www.usclimatealliance.org/
  http://www.usclimatealliance.org/state-climate-energy-policies
- [1] UCSD faculty senate report.

Part II

Programs and Policies

Chapter 2 School Bus Electrification

By: Jae Kwak

2.1 Faqs

1. What is the name of the policy or program type?

   School bus electrification

2. What is school bus electrification?

   The program intends to reduce carbon emissions by replacing diesel school buses with electric buses. Optimally, the excess capacity of the electric buses will be used for vehicle-to-grid (V2G) operations to provide electricity to the grid during peak times.

3. What are some examples in practice?

   In March 2020, Highland Electric Transportation made a deal with the city of Beverly, MA to receive an annual fixed fee to provide, fuel, and maintain electric buses for the school district.

   As a pilot program, Dominion Energy, a Virginia utility company, will sell 50 electric buses with bidirectional charging capabilities to a school for the price of typical diesel buses; in exchange, Dominion Energy will own and operate the charging equipment, using the electric bus batteries to help balance the grid.

   In 2018, Lion Electric Company, an electric school bus manufacturer; Nuvve, a V2G tech company; National Express, a British public transport company; and the White Plains School District of New York partnered to deploy five electric buses equipped with V2G technology.

   Since 2016, the Lion Electric Company has delivered 40 all-electric school buses to the Twin Rivers Unified School District in Sacramento, California. The program is part of the California Climate Investments, a state-wide initiative that uses cap-and-trade dollars for projects that improve the environment.

   In 2019, the California Energy Commission allocated \$94MM to its School Bus Replacement Program to replace old diesel buses with electric buses. The California Climate Investment Grant has also been funding electric buses at the local level, as in the case of the \$7.5MM grant to the Twin Rivers School District. In 2020 August, the state legislature passed a bill that would spend approximately \$1BB on green infrastructure for schools, which would also contribute to the efforts of replacing diesel school buses.

4. What does school bus electrification cost and who pays?

   Diesel school buses cost around \$100,000, and electric school buses cost around \$300,000 to \$400,000. In the case of California, there has been a number of local and state-level funding to cover the upfront costs of replacing diesel buses, but without funding they are too large for school districts to cover. In other cases, a utility company like Dominion Energy or a transportation company like Highland Electric Transportation will charge an annual fixed fee or a lump sum cost equivalent to the typical cost of purchasing or operating diesel buses. These companies plan to cover the difference through lower fuel and maintenance costs, and possibly through V2G operations by discharging power to the grid in peak times when electricity prices are high.

According to a US PIRG Fund Report, an electric school bus costs upfront on average \$120,000 more than their diesel equivalent, but can save about \$170,000 to \$240,000 in lifetime fuel and maintenance costs. Therefore it is highly likely that the upfront costs can be covered within a couple years.

5. What are the climate-related benefits of school bus electrification?

   According to Dominion Energy, replacing one diesel bus can drive down greenhouse gas emissions by 54,000 pounds per year, which translates to 3.75 pounds of CO2 per middle driven.

6. What are some additional benefits, co-benefits?

   Improved air quality inside and outside: By replacing diesel buses, this program can eliminate the diesel exhaust from traditional school buses. The diesel exhaust from diesel school buses are designated by the IARC to be carcinogenic and are linked to premature death, aggravated asthma, and decreased lung function; it can be even more harmful to children. The diesel exhaust affects the air in and around the bus and can potentially enter school buildings. These pollutants also contribute to acid rain and ozone pollution.

   Seat belt installation: Traditional diesel school buses often do not have seat belts equipped, but in the case of Dominion Energy's electric bus contract with the Virginia school districts, seat belts will be installed in the new electric buses. Although buses are generally considered to be very safe, seat belts provide additional protection in the case of serious crashes.

   Lower Maintenance and Fuel Costs: According to Thomas Built Buses, electric school buses can save nearly \$2000 per year in lower fuel costs and \$4400 per year in maintenance costs.

   Grid Balancing: If V2G operations are possible, the electric school bus batteries can be used as energy storage for the grid by charging them when prices are cheap and discharging power back to the grid at peak times. School buses are especially promising for V2G because of large capacity sizes, predictable operation schedules, and long idle times. Battery life reduction is a potential concern for V2G operations, but the Becker et al.(2019) case study shows that as long as proper thermal management is conducted, battery degradation can be minimized.

7. What are the dis-benefits?

Range: Electric school buses on average have a range of 100-135 miles. While typical bus routes are 30-40 miles in the morning and 30-40 miles in the afternoon, for some rural areas and for long-distance transportation, e.g. field trips, the range may not be enough. Route optimization and the expansion of local charging infrastructure may be able to mitigate this issue.

Charging Infrastructure: Installing, maintaining, and operating charging infrastructure for electric buses are costly tasks and school districts may not be equipped for the task. As a result, companies like Highland Electric Transportation and utilities like Dominion Energy are offering to install and operate the charging infrastructure for the school districts.

Training: Additional training of staff may be required because electric buses are operated and maintained differently from diesel buses.

8. How difficult is it to implement and maintain school bus electrification?

The two major barriers for replacing diesel school buses with electric buses are the higher upfront costs of electric buses and the costs involved in installing and operating charging infrastructure. In order to facilitate implementation, state government grants and funding like in the case of the Twin Rivers school district or contracts with companies like Highland Electric Transportation or Dominion Energy that would cover the difference in upfront costs are necessary. Attention has been slowly building up for this program, marked by increased media coverage. Emphasizing co-benefits like improved air quality for children would be helpful for gaining public support. V2G operations may face more challenges as not all utilities allow them, but it is expected that more and more utilities will be favorable to V2G in the future.

In terms of maintenance, electric buses have fewer parts that require maintenance compared to diesel buses, so they pose less challenges. Operating and maintaining charging infrastructure may be outside the expertise of existing staff employed by school districts, so the service of third parties may be necessary. Complexity will be further increased if V2G operations are employed, but V2G platforms like Nuvve or utility companies may be able to handle them more efficiently.

9. What are the leading vendors pertaining to P?

Bus Manufacturers:

- Proterra
- Yutong
- BYD Motors
- NFI Group
- Lion Electric Company
- Thomas Built Vehicles

V2G Technology: NUUVE

Utility: Dominion Energy

Transportation Company: Highland Electric Transportation, National Express

2.2 Useful Links

"Highland Electric Raises $235M, Lands Biggest Electric School Bus Contract in the US" (2021-02-25), Greentechmedia.com. (https://www.greentechmedia.com/articles/read/on-heels-of-253m-raise-highland-electric-lands-biggest-electric-school-bus-contract-in-the-u.s) https://www.greentechmedia.com/articles/read/on-heels-of-253m-raise-highl
s

"One small idea in Biden's infrastructure plan with big benefits: Electric school buses" (April 6, 2021) https://www.vox.com/future-perfect/2021/4/6/22364385/ one-small-idea-in-bidens-infrastructure-plan-with-big-benefits-electric-s
(https://www.vox.com/future-perfect/2021/4/6/22364385/one-small-idea-in-bidens-infrastructure-plan-with-big-benefits-electric-school-buses)

Chapter 3 Composting

By: Shan Shan (Christine) Liang

3.1 FAQs

1. What is composting?

   Composting is the process of turning organic, carbon-based materials into a nutrient-rich fertilizer for soil. It enhances the porosity, stability, water retention, and tillage of soil and improves its resistance to erosion and parasites. As an aerobic process, it decomposes trash from your yard, kitchen, home, or community in order to manage waste. This diverts the waste from going into a landfill and provides a variety of benefits.

2. What can be composted?

   The best compost includes a variety of materials in order to get a richer result with more micro-nutrients and diverse, beneficial microbial life. Generally, compost should have approximately 25–30 parts of carbon to 1 part of nitrogen. If there is too much carbon, decomposition slows down. If there's not enough carbon and too much nitrogen, the compost will give off an odor.

   Many random things from yards and kitchens can actually be composted because they are organic and carbon-based. Some materials like paper, cloth, wood, and string can also be composed but take more time because they need to be decomposed further. However, animal products and synthetic materials generally cannot be composted.

Yes	No
Leaves	Raspberry & blackberry brambles
Grass clippings	Long twigs or big branches
Brush trimmings	Pet droppings, especially dogs & cats
Manure (preferably organic) & Animal products—meat, bones, dairy, fish skins, fat	Coal ash
Any non-animal food scraps: fruits, vegetables, peelings, bread, cereal, coffee grounds and filters, tea leaves and tea bags	Colored paper
Old wine	Diseased plants
Pet bedding from herbivores ONLY—rabbits, hamsters, etc.	Inorganic materials
Dry cat or dog food	Synthetic chemicals
Dust from sweeping and vacuuming	
Dryer lint	
Old herbs and spices	

Table 3.1: Examples of compostable and non-compostable materials.

3. What is compost used for?
   - Agriculture: crops and sod farms
   - Landscapers: industrial and commercial properties, golf courses, athletic fields, landfill covers, and damaged soils
   - Plant Nurseries: seedling crops and reforestation projects
   - Public Agencies: highway median strips, parks, recreational areas, other public property
   - Residents: home landscaping and gardening
4. What are the benefits of composting?

   Without composting, most of this waste would go into a landfill. This is detrimental to our health and environment because of the toxic methane emissions released there. Instead, composing turns waste into a rich nutrient that improves soil health by preventing soil erosion and adding more nutrients. Since waste is diverted from landfills, cities and governments can also save money by reducing landfill capacity and avoiding landfill tipping costs. Moreover, composting improves plant growth and carbon sequestration and reduces soil contamination. This also creates opportunity to strengthen communities and boost local employment as people come together to protect their environment.
5. What are composting programs that can be implemented?

Curbside Collection	Drop-off Collection	Compost Bin Distribution
• Food waste is picked up by waste haulers every week and sent to a composting site • Different bins are provided to people to encourage waste separation	• Individuals store and drop off food waste at designated locations • Waste is transported to another location to be composted	• People receive their own compost bins at a subsidized cost • Composting happens at residents' own homes • Requires thorough education to teach residents about composting techniques

Table 3.2: Composting program types.

6. What composting services are on the market and who does them?
   - residential composting (food scraps and yard waste)
   - commercial composting (compostables from schools, businesses, restaurants and markets)

3.1.1 Vendors in the Philadelphia, PA region

(a). Kitchen Harvest, Inc.

Drexel Hill, PA 19026, Chris@MyKitchenHarvest.com, https://www.mykitchenharvest.com/

(b). Circle Compost https://www.circlecompost.com/.

Local community composter. Reported that claims of compostable bottles and tableware is mostly incorrect.

Feedstocks Accepted: Leaves,Grass,Brush,Tree Trimmings,Clean wood waste,Wood Chips,Garden Waste Yard Trimmings, Source Separated Food Scraps (Vegetative Only), Compostable paper, packaging and serviceware, Certified compostable bio-plastic packaging and serviceware Pre-consumer only (including food processing waste) Food Scraps Certified Compostable Bioplastic Bags, Clear Cups, Paper cups with bioplastic lining, Utensils, Plates and carryout containers Compostable Paper Kraft Bags,Soiled paper (e.g., napkins, towels, certified paper plates), Corrugated boxes (including pizza boxes), Wooden-only utensils, Crop/garden residuals.

Focuses on Center City, Philadelphia. There, $18/month for weekly pickup, $12 for bi-weekly.

(c). Philly Compost Inc. Philadelphia, Pennsylvania

Category: Community Composter, Organics Collection Service No website. Phone: (215) 880-0465.

Feedstocks Accepted: Leaves, Food Scraps, Bags, Clear cups, Paper cups with bioplastic lining, Utensils, plates and carryout containers.

(d). Organic Diversion LLC

http://www.organicdiversion.com/, Address: 46 South Maple Avenue, Marlton, NJ 08053. Phone: (609) 841-1326.

Commercial composter, focusing on supermarkets, restaurants, colleges.

Strictly food waste and a few other items.

Pricing depends on: location/distance, how it's collected, how much material is collected.

(e). County Conservation Co. LLC

https://www.countyconservation.com/, Address: 212 Blackwood-Bransboro Rd. Sewell, NJ 08080. Phone: T: 856.227.6900, F: 856.228.9600.

Category: Full Scale Composter. Feedstocks Accepted: Leaves, Grass, Brush, Clean wood waste.

(f). Laurel Valley Soils

https://laurelvalleysoils.com/, Address: 705 Penn Green Rd Landenberg, PA 19350-9204. Phone: 1-866-LV-SOILS (1-866-587-6457), Local 610-268-5555. Category: Full Scale Composter.

(g). Borough Of Phoenixville

https://www.phoenixville.org/212/Composting, Address: 351 Bridge Street Phoenixville, PA 19460. Phone: 610-933-8801. Category: Full Scale Composter.

(h). WeCare Denali Burlington County Co-Composting Facility
http://www.wecarecompost.com/ Address: not given. Phone: (888) 325-1522. Category: Full Scale Composter Feedstocks Accepted: Brush, Tree Trimmings, Wood Chips.

(i). Fairmount Park Organic Recycling Center Philadelphia, Pennsylvania
Category: Full Scale Composter. Feedstocks Accepted: Horse manure.

(j). Bennett Compost
https://www.bennettcompost.com/. Address: 5650 Rising Sun Ave, Philadelphia, PA 19120. Phone: (215) 520-2406.

7. What are some examples of successful, ongoing municipal composting programs?
Describe the programs and try to assess how successful they are, including on costs.

8. What are some examples of successful, ongoing composting programs at academic institutions?
Describe the programs and try to assess how successful they are, including on costs.

3.1.2 Expanding Scope through Grinding

Materials such as "compostable" bottles and tableware cannot be composted by ordinary composters. They require industrial grinding up first and there are no commercial vendors of this near Philadelphia.
An intriguing possibility is that an institution, such as Penn, might undertake to grind its own compost, thereby allowing various "compostable" plastics substitutes (food wrappers, plates, etc.) to be composted, either directly or by a third party. This needs to be looked into and its costs estimated.

3.2 Links

1. National locator for composters: www.findacomposter.com Useful site: http://www.findacomposter.com/.
2. "Municipal Composting Programs in Massachusetts: What Works, Where, Why and How," a nice report, undergrad thesis: [3]
3. U.S. Composting Council
4. "Austin, Texas, pitches customer cost savings as curbside composting reaches over 200K homes" from Wastedive.com,
https://www.wastedive.com/news/austin-residential-curbside-composting-exp 594499/. (https://www.wastedive.com/news/austin-residential-curbside-composting-expansion/594499/)
Interesting story and has several useful links as well.
5. U.S. Composting Council https://www.compostingcouncil.org/?. Trade and promotion organization for the composting industry.

6. Local full scale composting company, MyKitchenHarvest. https://www.mykitchenharvest.com/
7. Local community composter, Dave Bloovman, good guy: Circle Compost https://www.circlecompost.com/
8. Local composter: Bennett Compost https://www.bennettcompost.com/

Chapter 4 Green Financing

By Saahil Kamulkar

4.1 Green Bank Overview

4.1.1 What is a Green Bank?

- Institutions, not programs
- Provide financing not grants
- Prime objectives are modest profit, environmental impact
- The value proposition or mission is to reduce the cost of capital required for these projects, thus increasing the transition to renewables and sustainable living.

4.1.2 What problems do green banks solve?

- Provide customers with necessary information
- On-Bill financing allows customers with limited credit to take action
- Co-investment for areas with limited capital
- Standardized contract to streamline the underwriting process
- Securitization of smaller loans to then incentivize larger banks to participate (scale of larger banks prohibits them from taking such loans)

4.1.3 What are things to be cautious of?

- Crowding out
  The goal is not to compete with private equity, but rather serve projects that would not be able to get off the ground.

4.2 Green Banks: FAQs

We should say a little about costs, how this gets set up and the practicalities of keeping it going. Talk with someone from Montgomery Co. MD?

4.2.1 What is a Green Bank?

A green bank is an institution that is created to provide opportunities and funding for green initiatives. It is important to note that, contrary to the name, a green bank is not actually a bank; the institution is often a nonprofit that acts more as an investment vehicle. Rather than competing with existing financial institutions, a green bank provides financing with the goal of creating environmental impact, not maximizing profit. The green bank reduces the cost of capital for green projects, thus incentivizing the change towards a more sustainable future. Some green banks take on many smaller, conventionally unprofitable loans and securitize them for larger banks; this allows the green bank to pursue smaller projects and enables larger banks to partake in financing green projects. In addition to simple financing, green banks may implement creative or non-traditional methods of allocating capital to customers unable to dedicate sufficient money to green projects. For example, a green bank may choose to co-invest in a project that does not have sufficient funds or resort to On-Bill financing(allowing customers to include repayment as a part of their utility bill). However, the function of a green bank does not stop with financing; green banks provide ancillary services to customers, ranging from standardized contracts to project-specific consultation.

4.2.2 Where do Green Banks Invest?

Traditionally, a green bank primarily focuses on low-income areas. These areas are often too risky for traditional banks and are unable to secure enough funding to make the transition to more environmentally friendly projects. Many green banks declare their primary focus to be serving low- and moderate-income consumers, LMI. For the aforementioned reasons, these communities are often underserved; however, in order to create meaningful change, everyone must strive towards sustainability. Many community green banks have focused their attention on allocating capital to community solar projects, enabling low-income areas to switch to renewable power generation and saving money in the future. In terms of the actual projects that green banks commonly fund, there are seven primary categories:

1. Renewable power generation: solar, wind, geothermal, hydropower, ocean and hydrokinetic, and fuel cells
2. building efficiency, fuel-switching and electrification
3. clean transportation: electric vehicles, hydrogen vehicles, and associated charging or fueling infrastructure
4. industrial decarbonization
5. grid infrastructure including transmission, distribution, and storage;
6. sustainable agriculture: reforestation, afforestation, and regenerative agriculture climate-resilient infrastructure

4.2.3 How do Green Banks Invest?

As mentioned before, Green Banks play a key role in enabling small, underserved communities to transition towards sustainability. In order to do this, the Green Bank must provide low-cost capital to places where traditional banks and traditional investments do not service; it is important to note that these investors do not necessarily pass on these investments because of the risk involved, but rather because of the projects' size. The smaller transactions still have the same fixed and due diligence costs, making them less attractive compared to larger projects.

This is where Green Banks have a critical role. Green Banks work to take on and aggregate many small and medium-sized loans until the aggregate size is something that is sufficient for larger institutions. Then, the Green Banks works to securitize the loans or projects so that other, larger investors may invest. Green Banks utilize standardized contracts to create economies of scale that dilute the fixed cost relative to the total benefit. In essence, the Green Bank works to bundle the smaller projects into a singular larger project. Since institutional investors, like Penn, have a lower cost of capital and risk tolerance, a Green Bank would facilitate more investment into sustainability.

4.2.4 The Effects of the Green Bank Movement

Since 2011, green banks have caused over $5 billion in investments. This considerable funding was made possible by the partnership between publicly allocated money and investment from private organizations. Although the green banks themselves only invested $1.8 billion, they were able to actively attract further private investment of $3.8 billion. Over the past few years, cumulative investment caused by green banks has grown considerably. Moreover, many people consider green banks to be unsustainable long-term because green banks do not prioritize profits. However, this is not accurate. Over the last few years, many green banks have been able to grow operating income significantly. “Green banks in the United States collected $55.9 million in earned revenue to support their operations in 2019, a 22% increase over 2018’s $46.0 million in earned revenue and a 141% increase from 2017’s $23.2 million in earned revenue.”

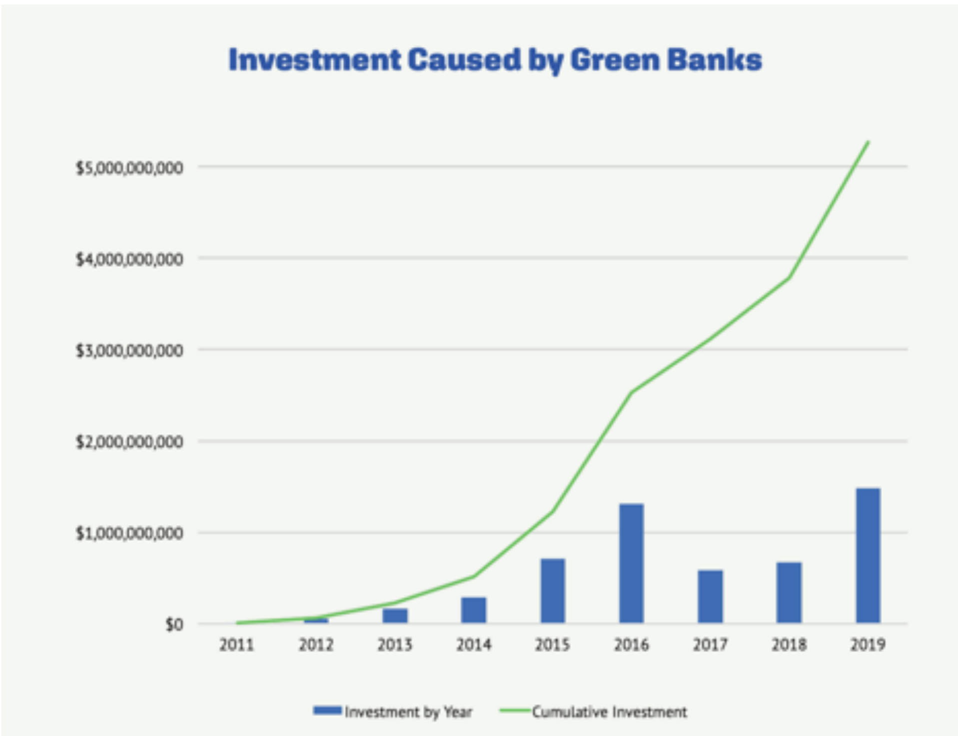

Figure 4.1: Green bank investment.

Do we have a source for this figure or its information?

4.2.5 Connecticut Green Bank Case Study

The Connecticut Green Bank had the goal of bringing solar energy and energy efficiency to LMI homeowners (these homeowners stand to benefit the most from this kind of project, because energy is a large cost relative to their annual income). The Connecticut Green Bank accomplished this using the following steps:

- Initiated a Request-for-Proposal Process: a general outline of the project that outlined the following features
- The project offered solar to single-family households.
- Incentivized LMI households through elevated performance based incentives (paying a certain amount ($/kWh) based on the energy production of the solar energy production)
- Offers Photovoltaic Systems that are leased to owners, so homeowners don't have to pay up-front. The lease has a 20-year term with fixed lease payments, allows the homeowner to purchase at the end of the term, and has a production guarantee (reimbursement if the system fails to provide enough energy).
- Bundled with a basic energy efficiency package from the local utility's Home Energy Solutions, with an EE installment option (ESA).
- Established Financing Logistics

  The project requires many people to participate: PosiGen(PV installer), tax equity investors, private-sector lenders, and CT Greenbank.
- Created a Special Purpose Entity which is owned by tax equity investors.

  This entity would own the project and thus benefit from the tax credit, benefits, and depreciation (these benefits replace the need for substantial cash flow from the project). PosiGen also invests in these SPEs utilizing senior third-party debt and subordinated CT Green Bank debt ("back leverage").
- Assisting with Deployment

  The Green Bank then helps by co-branded marketing This may include canvassing and troubleshooting market barriers In doing so, the Green Bank lowers the customer acquisition costs to PosiGen while raising awareness.
- Incentivizing Continued Operation

  The Green Bank continues to provide PBI's to the SPE, which incentivizes the LLC to continue to operate the solar panels efficiently (as they are paid per kWh)[PBIs end at a certain date, or kWh amount, if earlier]

  Homeowners benefit from lower cash payments, as tax equity investors are harvesting the benefit of the Tax Credits that would otherwise be largely unused by individual homeowners; LMI homeowners also benefit from the increased availability of credit, since the creditworthiness is not necessarily based on FICO(it may be based on other things like utility bill payment).

4.3 Implementing a Green Bank at Penn

sok, 3/30/21: This is a good start. Here are some suggestions.

1. Talk with the Penn Credit Union people and see if they just might possibly be interested. If so, let's set up a meeting to explore further.
2. Regarding:

   > The most effective way to implement a Green Bank at Penn would probably be to use a combination of the Bank and broker method. Rather than simply being an intermediary for green projects, Penn can start a green Bank that has some financial autonomy and power of its own.

   Don't start off with this. Instead make your recommendation after discussing alternatives, and painting the best picture you can of each. In particular, I suggest you consider these alternatives: (i) the broker model (teamed with? perhaps the credit union, perhaps some other institution. (ii) a fund-based model that does not require creating an actual bank that is chartered, regulated, etc. (iii) the hybrid model in which funds are raised and put in trust with a bank for lending and brokering activities accompany via Penn. I think this latter hybrid model is what you have in mind. This all needs to be spelled out very clearly.

The most effective way to implement a Green Bank at Penn would probably be to use a combination of the Bank and broker method. Rather than simply being an intermediary for green projects, Penn can start a green Bank that has some financial autonomy and power of its own. As opposed to simply raising awareness, these funds would be able to catalyze development by putting some teeth into the action (without independent funds of its own, this process might be more tedious, as it would require more stakeholders). In terms of marketing and legal operations, a hybrid method would certainly necessitate more personnel. However, along with this personnel, Penn would be better able to utilize the carbon credits cost-effectively and allocate the ancillary benefits(like tax credits) in the way it sees best. Nevertheless, the critical benefits to Penn will not be financial. Since the bank would be a non-profit, the green bank's primary aim would be to benefit the community– much like the purpose of most other green banks; this goal aligns well with Penn's philosophy and many of the outreach projects that Penn undertakes. The advantage of having a Green Bank is that it could be closely intertwined with some existing initiatives that Penn already funds; one such program is the Penn CURF Projects of Progress Prizes. A similar layout could help with funding projects that specifically address environmentally-conscious community improvements.

Expanding a little more on the ancillary benefits, including the Carbon benefits and the tax benefits. Both of these will be highly related to the project at hand; some projects may be more tax-advantaged than others, based on state tax laws. Similarly, the carbon offsets that Penn could use from the project will also depend on the logistics of the individual projects; certain projects will obviously be more impactful in terms of the environment. Going over the logistics of the Carbon Offsets, Penn has a few options. The first option is to undertake calculations of the offset independently. Under this method, Penn as an institution might be able to calculate and establish the carbon offsets of every project that it undertakes. One concern with this method might be the veracity of claims made by Penn, as there is a small conflict of interest: Penn stands to benefit from inflating the carbon offset number. An alternative method is to use a third-party verification service. Some of the services I found included American Carbon Registry, Verra, and Climate Action Reserve. These organizations are often the ones recognized by states like California, and thus are likely to be generally acceptable. Although using these reputable companies may be slightly more expensive, it is something that the Penn faculty would have to consider.

The following is incomplete. Good notes for further development.

Penn green bank lend to faculty and staff + landlords in Philadelphia

Maybe we can use payroll deductions

Externally funded greenbank

Projects for progress

4.4 Useful Links

For more information:

1. https://www.forest-trends.org/wp-content/uploads/2018/07/Factsheet_Producing-a-Voluntary-Carbon-Offset.pdf
2. https://coalitionforgreencapital.com/what-is-a-green-bank/
3. https://mcgreenbank.org/
4. https://michigansaves.org/about-us/
5. https://static1.squarespace.com/static/59bc05f0c534a543a9f96b0d/t/5edf9fbd8285f063f6c13bbe/159171373
   Saahil says read this. See page 7.
6. https://greenbanknetwork.org/reports-white-papers/
7. Mechanics of a transaction: https://greenbanknetwork.org/wp-content/uploads/2018/07/GB-TT-Connecticut-18-07-A_05-1.pdf
8. Agg. and sec.: https://greenbanknetwork.org/wp-content/uploads/2019/04/Green-Bank-Aggregation-and-Securitization-Coalition-for-Green-Ca
   pdf
9. https://cgs.umd.edu/sites/default/files/2020-12/CGS_Public-Private%20Partnership%20%26%20Clean%20Energy%20FInance_Green%20Bank_

Final%20Report_ENG.pdf

https://coalitionforgreencapital.com/what-is-a-green-bank/

(https://coalitionforgreencapital.com/what-is-a-green-bank/)

https://mcgreenbank.org/

https://michigansaves.org/about-us/

https://static1.squarespace.com/static/59bc05f0c534a543a9f96b0d/t/5edf9fbd8285f063f6c13bbe/1591713732941/2020+Annual+Industry+Report+Final.pdf

https://greenbanknetwork.org/reports-white-papers/

Mechanics of a transaction:

https://greenbanknetwork.org/wp-content/uploads/2018/07/GB-TT-Connecticut-05-1.pdf

Agg. and sec.:

https://greenbanknetwork.org/wp-content/uploads/2019/04/Green-Bank-Aggrega pdf

* * *

Montgomery County Maryland https://mcgreenbank.org/ Has a video

Green Bank Network https://greenbanknetwork.org/

Coalition for Green Capital https://coalitionforgreencapital.com/what-is-a-green-ban

New York Green Bank https://greenbank.ny.gov/

American Green Bank Consortium https://greenbankconsortium.org/

Chapter 5 Building Electrification

By: Anvit Rao

5.1 FAQs

1. What is the name of the policy program?

   Building Electrification

2. What is building electrification?

   Building electrification is the process of using electricity to power buildings and appliances as opposed to fossil fuels. This will comprise of both upgrading buildings themselves as well as using renewable sources such as solar, wind, and others to power them. This is an important task because buildings proportionally consume a significant amount of energy in the US and other countries as well.

3. What are some examples in practice?

   The most popular form of building electrification in practice is the replacements of gas furnaces and air conditions with heat pumps. Heat pumps rely on transferring air from outside a home to inside to heat and cool. Electricity is used to send heat where it is needed and remove it from where it is not. Other forms of electric heating in buildings is geothermal heating, which functions similarly to a heat pump except it uses heat from the earth. Additionally, there are also systems that rely on water to heat and cool buildings, sending it back and forth from a central location. The most significant for the future, however, will be heat pumps opposed to electric space heaters. There are many electric heating programs that have been implemented across the country. The most notable ones are:

   - Many states such as Maine and California mandated that all new construction must incorporate heat pumps. Maine specifically has a goal set for 100,000 new heat pumps by 2025. States like Vermont and New York are also implementing heat pump rebate programs.
   - In a case study done by the Sacramento Municipal Utility District, heat pumps were very economically advantageous for new residential buildings and for existing units that housed multiple families. Heat pumps were slightly more expensive for existing single family homes, as well as more expensive for small to medium sized office buildings.
   - There was a case study in Austin Texas that showed that adjusting building codes in addition to making electrification updates resulted in a 37% greater savings that having a system that only makes electrification updates.

- Stanford University fully converted its campus heating and cooling systems to a water-based system, and has cut emissions by 65 %

In addition to the area of heating, there is also potential to navigate away from the use of gas ovens and stove tops through the use of electric induction stoves. Currently, this write up focuses on heating and cooling, but there is more research to be done on electric appliances like inductions stove-tops

4. Important policy areas and considerations:
   - Incentivize use of electric heating and cooling
   - Manage increased demand on the grid

     There is potential for the involvement of smart grid technology, and there are multiple ways through which local governments can do this:
     - The incorporate of customer feedback on energy use. This is effective in both allowing customers to understand the impact they are having, as well as making a behavioral chance. BCG reports that utilities boosted their gross margin by more than 20% after incorporating more customer feedback methods.
     - Implementing a demand-response grid system. This would adjust utility service prices based on peaks in energy usage as well as allow for customers to sell electricity back to the grid for credit. Measures like these will incentivize off-peak electricity usage and have the positive impact of decreasing grid stress to accommodate for greater use of electricity in buildings
   - Improve technology to benefit building efficiency
5. What do heat pumps cost and who pays?

   On the residential side, heat pumps for a whole house can cost between $2,500 and $7,500 depending on the size of the home. These fees will generally come out of the pocket of the homeowner unless there is a government rebate. For larger buildings like universities or commercial buildings, the cost would follow a similar rate but depend on the size of the building

   More research to be done on the cost and varying pricing
6. What are the climate-related benefits of building electrification?

   By relying on electricity instead of natural gas or fossil fuels, building electrification reduces greenhouse gas emissions. Additionally, it caters better to renewable energy because that energy can now be used directly to heat and cool buildings. This is particularly impactful because homes and businesses burning natural gas, oil, or propane account for 560 million tons of CO2 each year, which is 10% of the total US emissions. Looking at universities specifically, on average, 53% of their energy usage comes from heating and cooling buildings. Making a dent in these highly energy-consuming processes has the potential for big climate impacts through reducing emissions as a result of less reliance on fossil fuels.

7. What are some additional benefits, co-benefits?

   One of the first benefits is in terms of cost. For new buildings being made, it is clearly more cost-efficient for them to rely on electric methods such as heat pumps. This is because, in the long run, electric heating methods can some roughly 30 to 40% on utility bills. On the other hand, the decision to renovate old buildings is a little bit more difficult, but once again, in the long run, switching to electric heating will lead to emissions savings. Additionally, electric systems such as heat pumps offer benefits in terms of health and safety. Studies have linked the presence of gas furnaces in homes to developing conditions such as asthma. Additionally, electric systems remove the risk of gas explosions and carbon monoxide leaks.

   More data on safety and health related risk still needs to be found

8. What are the dis-benefits?

   There are negative effects for natural gas and oil companies that rely on building heating and cooling systems to sell a lot of their product, as well as utilities that send these products to customers.

   This section still needs to be flushed out

9. How difficult is it to implement and maintain building electrification

   The biggest struggle with implementing large-scale heat pumps is the installation process, but states are already starting to develop groups that are trained for this installation. One note on the maintenance of this switch to electricity is the stress that it could potentially put on the electricity grid.

10. Additional notes on building electrification

    Something very interesting about building electrification is the possibility for it to work in tandem with other sustainability policies. First, because building electrification marks the transition away from natural gas, decoupling could be a potential solution to managing the effect on utilities. Second, because there will be more stress on the grid, smart grid and storage advancements could become even more important in managing the nation's electricity usage. Finally, green financing could play a significant role in funding building construction and retrofitting.

    There is more research still to be done on these policies and how they could work together with building electrification

5.2 Links

- "A Furious Industry Backlash Greets Moves by California Cities to Ban Natural Gas in New Construction"
  https://insideclimatenews.org/news/05032021/gas-industry-fights-bans-in-homes-businesses/
  https://insideclimatenews.org/news/05032021/gas-industry-fights-bans-in-h

- https://www.huffpost.com/entry/climate-green-building-codes_n_60381e23c5b60d98bec8dc7d
- “How Dangerous is Natural Gas?” (August 8, 2017) https://safer-america.com/dangerous-natural-gas/

Chapter 6 Electrification of Transit Buses and Utility Vehicles

By: Jae Kwak

6.1 FAQs

1. What is the name of the policy or program type?
   Transit Bus Electrification
2. What is transit bus electrification?
   Local policies that will replace diesel transit buses with electric battery-powered transit buses.
3. What are some examples in practice?
   Seneca, SC: In 2014, Seneca, SC became the first city in the world to launch an all-electric bus fleet. The policy is considered successful so far, as the new fleet has outperformed diesel equivalents in terms of fuel and maintenance costs and have beat expectations regarding range and charging times.
   Chicago, IL: The Chicago Transit Authority(CTA) launched 2 electric buses in 2014 as a test pilot, and found that they saved more than $24,000 each in fuel costs and $30,000 each in maintenance costs. Most importantly, the vehicles performed well without much difficulty in extreme cold weather. CTA is planning to fully electrify the bus fleet by 2040.
   King County, WA: Since 2016, the King County Metro Transit has been testing electric buses, and found them to perform well in a variety of weather conditions. However, there were some issues regarding battery life, range, and higher (than diesel) per-mile fuel costs due to high electricity demand charges. However, the King County Metro Transit considers the ROI to be reasonable if emissions reductions and other co-benefits are considered and is planning to expand the rollout.
   Albuquerque, NM: Albuquerque tested electric buses in 2018, but eventually cancelled the contract due to issues such as subpar battery life, inadequate range, and sensitivity to extreme heat. However, in August 2019, the city announced it would purchase five new 40-foot electric buses.
4. What does transit bus electrification cost and who pays?
   There are two main components of costs in providing public transportation service: operating costs and capital expenditures. On average, 25.4% of the total costs are funded by fares, 37.4% from Local governments, 20.5% from State governments, and 16.8% by the Federal Government. Operating costs are funded mostly with fares and local government funds, and capital expenditures are mostly funded by the local governments and the federal

government.

As of 2019, according to PIRG, on average diesel transit buses cost $500,000 while electric buses cost $750,000. Most of the difference in upfront costs will likely have to be borne by local governments through municipal bonds and local option transportation taxes. State grant programs and subsidies like in the case of California, if possible, will help cover the difference in upfront costs. The Federal Transit Administration's (FTA) Low or No Emissions Program, which funds state and local government agencies for low-emissions transit buses and related infrastructures, can also lower the cost burden for local government.

As long as electricity prices are stable, electric buses can produce substantial savings in terms of lower fuel and maintenance costs relative to diesel buses despite higher upfront costs. Proterra, one of the leading electric bus manufacturers, says its electric buses can save up to $50,000 a year relative to fossil fuel powered buses, indicating a 5 year payback period. However, as seen in the case from King County, WA, the cost savings of electric buses depend on electricity rate structures.

There is potential for even more cost savings if Vehicle-to-Grid (V2G) operations are implemented. Under V2G operations, the electric bus batteries are charged at times when electricity prices are cheap, while discharging power back to the grid at peak demand times. Partnerships with utilities are crucial for V2G to be viable.

5. What are the climate-related benefits of transit bus electrification?

   Electric buses emit substantially less carbon than diesel counterparts, even when the electric grid is carbon intensive. If an electric bus is charged with the national electricity mix, it produces less than half of carbon emissions per mile produced by diesel-hybrid or natural gas buses, which are considered to be "cleaner" than diesel buses. The reduction in carbon emissions will increase even more as the percentage of electricity generated by renewables and other clean energy sources increases.

   According to a 2019 PIRG report, replacing all of US diesel transit buses could eliminate more than 2 million tons of greenhouse gas emissions per year. On the local level, the Chicago Transit Authority can save approximately 55,000 tons of greenhouse gas per year if they electrify its entire fleet. Similarly, the Southeastern Pennsylvania Transportation Authority can reduce 2,000 tons of greenhouse gas emissions per year if they electrify all of its transit buses. These figures will further improve as US grids move towards more clean, renewable energy.

6. What are some additional benefits?

   Improved air quality: By replacing diesel buses, this program can reduce harmful emissions from diesel exhaust that pollute the air, thereby reducing health care costs. Pollutants that are expected to be reduced are ozone, lead, diesel particulate matter, carbon monoxide, sulfur oxides, and nitrogen oxides, which are all harmful for the human health and the environment. Exhaust from diesel buses are designated by the IARC to be carcinogenic and are linked to premature death, aggravated asthma, and decreased lung function. The exhausts are also linked to ozone pollution and acid rain. Air pollution tends to be more severe in low-income and minority communities, so municipalities like King County, WA are considering to first electrify buses in such communities to address social equity concerns.

Grid Balancing: If V2G operations are possible, the electric bus batteries can be used as energy storage for the grid by charging them when prices are cheap and discharging power back to the grid at peak times. Electric transit buses have potential for V2G because of large capacity sizes and predictable operation schedules. Battery life reduction is a potential concern for V2G operations, but the Becker et al.(2019) case study shows that as long as proper thermal management is conducted, battery degradation can be minimized.

Noise Reduction: Traditional diesel buses contribute to noise pollution, which can be harmful in some instances. A Toronto study found that 12% of transit bus noise exposure exceeded the EPA threshold for hearing damage risk. Electric buses can reduce the risk substantially because they are mostly quiet.

Lower Maintenance and Fuel Costs: As mentioned earlier, electric buses can save more in lifetime costs due to lower maintenance and fuel costs.

7. What are the dis-benefits?

Range: Range has often been cited as an issue for electric vehicles in general, especially during the early stages of development. Local municipalities need to test thoroughly before mass deployment to ensure that the original routes would not be disrupted, especially during extreme weather conditions. In King County Metro's electric bus pilot programs, there were some instances when the batteries were depleted faster than usual, especially in cold temperatures. The case was more severe for Albuquerque, as the average 177 mile range failed to meet the contractually-stipulated 275 mile per charge range, especially in hot temperatures. However, this doesn't mean that electric buses always fail to provide enough range. In the case of Seneca, the new electric buses were expected to provide a range of 30 miles, but the buses exceeded ranges of 40 miles. Similarly, the Chicago Transit Authority found its new electric buses to maintain its range through extreme cold temperatures. Overall, we recommend that local governments test the vehicles thoroughly in different conditions before committing to a contract.

Infrastructure: Building out the charging infrastructure will likely be a costly expenditure. The costs will be higher if on-route charging infrastructure is needed. However, as fleet sizes become larger, there is greater potential of economies of scale, which would bring down the infrastructure cost per vehicle. Furthermore, partnering with a local utility may bring opportunities to bring down the cost of installing charging infrastructure.

Operational Complexity: In the transition period where traditional buses and electric buses coexist, the complexity of managing the vehicles and organizing routes may sharply increase. Additional staff training will also be necessary. However, as we see more successful cases of adoption, it may be possible for more guidelines to be established that will help local transit authorities adjust to the changes.

Potential stress on the Electric Grid: If the transition to electric buses happens in a short period, it may potentially cause strain on the local electric grid. If electricity prices increase sharply due to strain, lifetime costs of electric buses may increase. One potential solution to mitigate this is to partner with utilities to coordinate charging and V2G operations.

8. How difficult is it to implement and maintain transit bus electrification?

   As mentioned above, the biggest obstacles for implementing would be the difference in upfront costs and the installment of charging infrastructure. For these financial obstacles, local governments should actively seek out federal and state grants or even pursue partnerships with local utilities.

   In terms of maintenance, the largest challenges would come from changes in operational complexity. However, we believe that these operational challenges would become easier to overcome as more and more transit authorities experiment with potential solutions.

9. What are the leading vendors pertaining to transit bus electrification?

6.2 Electric Bus Manufacturers

Yutong

BYD Motors

Proterra

AB Volvo

6.3 References and Links

2019 PIRG Report: https://uspirg.org/sites/pirg/files/reports/ElectricBusesInAm
US_Electric_bus_scrn.pdf

EPA on air pollution: https://www.epa.gov/dera/school-bus-idle-reduction#:~:text=Not%20only%20can%20diesel%20exhaust,acid%20rain%2C%20and%20climate%20change.

Public Transportation Funding: https://fas.org/sgp/crs/misc/R42706.pdf

Becker et al. (2019): https://www.nrel.gov/docs/fy20osti/74187.pdf

Yao et al. (2017): https://journalotohns.biomedcentral.com/articles/10.1186/s40463-017-0239-6

King County Metro Report (2017): https://kingcounty.gov/~/media/elected/executive/constantine/news/documents/Zero_Emission_Fleet.ashx

Holland et al. (2021): https://www.sciencedirect.com/science/article/pii/S0301421520306327

Xylia et al. (2018): https://www.sciencedirect.com/science/article/abs/pii/S0959652618330993

Blynn and Attanucci (2019): https://journals.sagepub.com/doi/abs/10.1177/0361198119842117

Greentech Media (2020): https://www.greentechmedia.com/articles/read/should-e-bus-fleets-be-paired-with-microgrids

https://www.greentechmedia.com/articles/read/on-heels-of-253m-raise-highla
s

Chapter 7 **Low Embodied Carbon Concrete**

sok: I think this might be a winner, both for Penn and for Lower Merion (i.e., for academic institutions and for local governments). Needs following up.

https://theconversation.com/bendable-concrete-and-other-co2-infused-cement

> Local governments are taking the first steps. "Low embodied carbon concrete" rules and projects to reduce the amount of cement in concrete have cropped up around the country, including in Marin County, California; Hastings-on-Hudson, New York; and a sidewalk pilot in Portland, Oregon.

It would be good to compute a cost of carbon offset for low carbon concrete. What does the additional cost of the concrete buy us in terms of reduced GHG emissions? This is a good source: https://www.concretecentre.com/Publications-Software/Concrete-Compass/Low-Carbon-Concrete.aspx. Depending on application and type of concrete, seems that saving 100 kg/m^3 is realistic.

https://www.carboncure.com/about/

Chapter 8 Internal Carbon Pricing

By Steven O. Kimbrough

State of the draft: This is a work in progress. The first section, on FAQs, is reasonably mature and can be circulated for comment.

Are there any studies of these programs?

8.1 FAQs

1. What is internal carbon pricing?

   Internal carbon pricing occurs when an organization—whether public, private or third sector—imposes on itself a price for greenhouse gas (GHG) emissions. The price is normally expressed in dollars per metric tonne of CO_2e (carbon dioxide equivalent) emissions. See `https://www.c2es.org/content/internal-carbon-pricing` for a standard description, aimed at the private sector but applicable generally.

2. Are there different ways of doing internal carbon pricing? If so, what are they?

   Yes, and they are not mutually exclusive and may be used in combination. See Figure 8.1 for a summary.

   For present purposes, we focus on pricing by *carbon fee* because it is likely the most important option for local governments and academic institutions. The *shadow price* method is mainly apt as a planning tool, to ascertain robustness of investments in a future in which external carbon pricing might be imposed.

3. How does a carbon fee work?

   (a). The institution identifies activities to be subject to the fees and quantifies CO_2e emissions for them.

   For example, an institution might designate a standard CO_2e emissions rate in tonnes per passenger mile traveled by airplane.

   (b). The institution sets the internal carbon price in dollars per tonne of CO_2e emitted.

   (c). When institutional funds are expended for a covered activity a carbon pricing fee is assessed for the activity. Typically, this would be internal carbon price times the standard rate for the activity times the amount of activity, e.g., carbon price $\times$ emissions per mile $\times$ miles traveled.

4. How much is the carbon fee?

   The level of carbon fee varies and is typically adjusted dynamically during an internal carbon pricing program. Figure 8.1 reports a range of \$5–\$20 per metric tonne of CO_2e. The Yale experiment set the price at \$40. Microsoft's current price is \$15.

5. What happens to the money collected by imposing the fee?

   The money is put into a special fund. Let us call it the Sustainability Fund. The institution then decides what to do with the money in the Fund. Common uses of the monies include:

   (a). Purchase carbon offsets.

   (b). Invest in greening the institution, that is in further reducing GHG emissions.

6. What are some examples in practice?

   There are many. In the private sector Microsoft and Disney, among others, have long had carbon fees.

   Among academic institutions, Yale University has experimented with a carbon fee. See https://carbon.yale.edu/project-overview, https://carbon.yale.edu/ and: (https://shopcases.som.yale.edu/products/putting-a-price-on-emissions-yale-universitys-internal-carbon-charge-experiment).

7. How is it working out?

   In the private sector it appears that a number of firms have carbon fees that have been in place for several years, perhaps most notably Microsoft:

   > In July 2020, we will start phasing in our current internal carbon tax to cover our scope 3 emissions. Currently this fee is $15/metric ton and covers all scope 1 and 2 emissions, plus scope 3 travel emissions. Unlike some other companies, our internal carbon tax isn't a "shadow fee" that is calculated but not charged. Our fee is paid by each division in our business based on its carbon emissions, and the funds are used to pay for sustainability improvements.
   >
   > https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/, 2020-01-16, accessed 2021-03-05.

   Examples of municipal and academic carbon pricing, especially carbon fees, are thin. Yale did an experiment that was considered successful. The following is from [2].

   > Yale University's carbon-charge pilot was launched as part of the university's broader sustainability initiative and ran from December 2015 to May 2016. The charges covered direct and indirect emissions from consuming energy sources such as electricity, gas, steam and chilled water. The price was set at $40 per tonne of CO2, which was close to the US government's estimated social cost.
   >
   > . . . By the end of the trial, buildings that had faced carbon charges had used less energy than those that had not (see 'Energy savings'). Reasons for this included increased awareness of energy use, competition between buildings and the higher price of energy.
   >
   > . . . At the end of the pilot, the university selected the revenue-neutral pricing structure to implement campus-wide, because of its financial stability. The

structure is not subject to potentially large outflows of funds if buildings exceed a target, saving energy because of an unusually mild winter, for example, or if energy needs rise unexpectedly owing to a cold snap or other reasons.

Yale implemented a carbon charging program in 2017, which continues today https://carbon.yale.edu/implementation.

Regarding municipal carbon pricing, the following is an interesting and well-researched proposal: "An Internal Carbon Price for the City of Ann Arbor" by Adam Freed, Lauren Jones, Yu-Ting (Eileen) Lo, Rosanna Ren.

https://deepblue.lib.umich.edu/bitstream/handle/2027.42/155014/354%20internal%20carbon%20price%20for%20city%20of%20ann%20arbor.pdf?sequence=1&isAllowed=y

8. Pros?
   (a). Promotes environmental awareness in stakeholders.
   (b). Encourages reduction in GHG emisssions, and efficiently so.
   (c). Prepares the institution for external carbon pricing.
9. Actual or Potential Barriers and Impediments?
   (a). Charging a fee for an expenditure that is funded by outside grants or donations. Is it permitted?
   (b). Administrative mechanics.
   (c). Setting the fee basis and maintaining it.
10. Bottom line?

    It's a contender. Careful follow up needed to ascertain feasibility and workability. Potentially an efficient way for an organization to reduce GHG emissions, by encouraging individual behavior.

8.2 Assessment of the Yale program and experience

8.3 Assessment of the Ann Arbor proposal

8.4 Model program for academic institutions

8.5 Model program for municipalities

8.6 Resources on Municipal Carbon Pricing

White paper on municipal carbon pricing: "IMPLEMENTING CARBON PRICING AT THE MUNICIPAL LEVEL".

https://climate-xchange.org/wp-content/uploads/2018/08/Implementing-a-Carbon-Price-at-

	CARBON FEE	SHADOW PRICE	IMPLICIT CARBON PRICE
Definition	A monetary value attached to each metric ton of emissions charged to business units for their emissions.	A theoretical internal cost of carbon applied in project planning processes to test the feasibility of capital expenditure and R&D investment decisions.	The value of past measures and initiatives implemented to reduce a company's greenhouse gas emissions and/or comply with climate policies and regulations.
Key Objectives	To create a dedicated revenue or investment stream that can fund projects to help meet a company's greenhouse gas reduction targets, and establish a common business "language" internally to address climate change.	To screen potential business risks of future carbon regulations, build a business case to shift investments to low-carbon options.	Identify marginal abatement costs of mitigating greenhouse gas emissions and complying with climate policies and regulations.
Calculation	Commonly calculated as the amount of funding or level of investment needed to meet the company's greenhouse gas reduction targets.	Commonly calculated as the current or expected future price of carbon regulations along with other market, technology, and policy factors (including indirect carbon pricing policies).	Can be calculated as the marginal abatement cost of reducing a company's greenhouse gas emissions and/or the cost of complying with regulations. Some companies calculate an implicit price as the costs associated with buying and generating renewable energy divided by the number of tons of emissions saved.
Observed Price Range[123]	\$5–\$20 per metric ton of CO_2e.	\$2–\$893 per metric ton of CO_2e.	No revealed prices or price ranges.[124]
Investment and Revenue Allocation	Revenues used to fund sustainability projects, realized as an actual monetary transaction between business unit(s) and the department collecting the fee.	A theoretical price that is not collected, but which guides future investments and research and development activities toward low-carbon alternatives.	There is no reinvestment or revenue allocation since the price is derived retroactively.
Key Benefits	Sends a direct price signal to business units to justify investments in low-carbon options and raise awareness among employees that carbon reductions are valuable. May help reduce greenhouse gas emissions and drive cultural change and accountability.	Can help prioritize investments in low-carbon options and prepare a company for future carbon pricing regulations. Easier to gain buy-in from C-suite executives. Often viewed a part of a risk management strategy, rather than a cost imposed across business units.	Helps understanding of a company's carbon footprint and the costs of abatement or compliance. It can serve as a benchmark before launching an explicit internal carbon pricing program.
Key Challenges	May pose upfront challenges for implementing, administering, and gaining internal buy-in because it is an actual financial cost imposed throughout the organization. Requires an administrative structure to collect revenues, evaluate revenue/investment allocation, and distribute funds to projects across business units.	As the theoretical price is not reflected in a company's or a business unit's budget, it may not shift investments to low-carbon options, may not provide a strong near-term signal or incentive to reduce emissions. It will also likely not motivate changes to employee behavior. Because it is part of a risk strategy, employees may not be engaged or aware of the price.	Retroactively calculated after measures have been implemented, therefore may not have same incentivizing effect as a carbon fee (and in some cases a shadow price) to mitigate greenhouse gas emissions and shift investments to low-carbon options.

Figure 8.1: From "The Business of Pricing Carbon: How Companies are Pricing Carbon to Mitigate Risks and Prepare for a Low-Carbon Future," Center for Climate and Energy Solutions, (http://www.c2es.org/document/the-business-of-pricing-carbon-how-companies-are-pricing-carbon-to-mitigate-risks-and-prepare-for-a-low-carbon-future/)

the-Municipal-Level-Climate-XChange-compressed.pdf

https://climate-xchange.org/wp-content/uploads/2018/08/Implementing-a-Carb
pdf

"Designing an European municipal Carbon pricing model: A collaborative project between Klimaatverbond Nederlandand Climate Alliance"

https://www.climatealliance.org/fileadmin/Inhalte/4_Activities/Projects/Carbon_pricing_working_group.pdf

8.7 Resources on Academic Carbon Pricing

The University of Illinois discussed it only, it seems: https://icap.sustainability.illinois.edu/project/internal-price-carbon

Swarthmore https://www.swarthmore.edu/sustainability/carbon-pricing-policy-br and Vassar appear to have instituted shadow pricing of carbon. (This is principally a planning tool. See Figure 8.1).

8.8 Useful Links

1. The Work Bank maintains a useful collection of links on carbon pricing: https://carbonpricingdashboard.worldbank.org/resources
   https://carbonpricingdashboard.worldbank.org/resources
2. "The Business of Pricing Carbon: How Companies are Pricing Carbon to Mitigate Risks and Prepare for a Low-Carbon Future," Center for Climate and Energy Solutions, (http://www.c2es.org/document/the-business-of-pricing-carbon-how-companies-are-pricing-carbon-to-mitigate-risks-and-prepare-for-a-low-carbon-future/)
3. "The State of Internal Carbon Pricing" McKinsey & Company, February 10, 2021 https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/the-state-of-internal-carbon-pricing
   https://www.mckinsey.com/business-functions/strategy-and-corporate-financ
   our-insights/the-state-of-internal-carbon-pricing

Chapter 9 Behavioral Interventions

1. Past programs and policies have thrived on using competition to motivate behavior. Take, for example, the company OPower. It showed a household's energy usage compared to others with the same house size and background. By creating a competitive environment, OPower successfully influenced peoples' actions.
2. Following the same line, something that OPower and other companies do that is very effective is making sure that
3. Toyota Prius Dashboard
   (a). Real-time and continuous feedback is important; people respond more to what they can directly see
   (b). Shows drivers real time how much energy their car is using and how much they are saving
4. Price base approaches have seen limited success and can be financially challenging
5. A more involved smartphone ap could be successful in making change
   (a). Visualizing behavior goals
   (b). Create a displace that is continually present on the lock screen, giving the effect of continuous feedback
6. Certain behaviors are easy to chnage by educating people when there are few disincentives to act
   (a). Recycling, turning off the lights
   (b). But it is not as successful when there are major disincentives to act like using public transportation of changing ones diet
7. It is important to make people feel that they have the ability to have a significant impact; if their self-efficacy is low, they are less likely to change their behavior in a positive way
   (a). Show people that they are having a significant positive impact
   (b). This relates to giving them reasonable outcome expectations
   (c). Help them estimate the impact of their actions
   (d). Compare actions in order to help consumers visualize the effect of their actions
8. There are a variety of views on being able to affect actions
   (a). People should be made aware of the negative impact of their actions
   (b). People should recognize their responsibility to act in a positive way
   (c). Behaviors should be related to one's personal values; if they believe their values are under threat and that they have the ability to protect their personal values
9. It is is important that set goals are both realistic and measurable
10. It is important to consider contextual factors; everyone will respond differently

  (a). Take note of what population you are trying to affect
  (b). People have difference mindsets when it comes to sustainable behavior: alarmed, concerned, cautious, disengaged, doubtful. Each of these groups represent different approaches and should be treated differently when it comes to trying to create change
11. Just information isn't enough to make change; emphasis needs to be placed on how and when information is delivered
  (a). People need to be aware of opportunities
  (b). People need to be provided with guidance and technical assistance
12. Everyone has the intent to act in a pro-environmental way, but they are not always able to do so
13. Changing the way people make decisions: choice architecture, is a way to adjust how they make decisions while still preserving their freedom to decide
14. Making the default the "green" setting
  (a). People are less likely to change from the default setting, so this will increase the likelihood that they will participate in green behavior
  (b). Make it an opt-out rather than an opt-in
15. Quotas can be very effective because they create an "either this or that" mindset
16. It is important to make people feel personally connected
  (a). Make people feel close and related to the issues they are trying to prevent Don't focus on the "future" or "over there", focus on "right here, and "right now"
17. It is important to reward people for their behavior, this keeps them engaged and motivated
18. Sustainable actions should be made the norm, so people do them without thinking and it becomes a habit
19. Small changes add up
20. Individual changes lead to large group changes
21. Frame your information in a way that makes it more likely for people to respond
22. Provide many opportunities for people to act sustainably
  (a). Give them more than one way to help make change
23. Create support networks; create a sense of community. This helps keep people more engaged in sustainable behavior
24. Foster mindfulness, get people thinking about sustainable behavior
  (a). This keeps them more engaged
25. Changing a physical environment can make it easier for people to act sustainabily

9.1

Chapter 10 Municipal Vehicle Electrification

By: Jae Kwak

10.1 FAQs

1. What is the name of the policy or program type?
   Municipal Service Vehicle Electrification. For this FAQ, the focus will primarily be on police patrol car electrification.
2. What is municipal service vehicle electrification?
   These are efforts in the local municipal level to replace fossil-fueled vehicles operated by municipal service departments with electric-powered vehicles. There are various types of vehicles operated by municipal governments, ranging from fire trucks and garbage trucks to police cars. The focus of this FAQ will be on electrifying police patrol cars, which has had more pilot experiments conducted on.
3. What are some examples in practice?
   In 2019, Bargersville, Indiana became the first police department in the nation to deploy a Tesla Model 3. (https://www.indystar.com/story/news/crime/2020/01/03/bargersville-chief-turns-heads-in-indianas-first-tesla-police-car/2606866001/, https://www.indystar.com/story/news/crime/2020/01/03/bargersville-chief-turns-heads-in-indianas-first-tesla-police-car/2606866001/) At a price tag of $39,500, the Model 3 cost about $14,500 more than its non-EV counterpart, the Dodge Charger, but over 6 years it is expected to save about $21,000 in fuel and maintenance costs. The department is planning on incrementally expanding its EV fleet.
   In 2019, the Fremont, CA police department deployed a 2014 Tesla S 85 as a patrol car. (https://www.governing.com/next/Fremont-Looks-to-Expand-All-Electric-Poli html, https://www.governing.com/next/Fremont-Looks-to-Expand-All-Electric-Police-Car-Fleet.html) After a highly publicized incident in which this vehicle ran out of battery in the middle of a high-speed pursuit, the department has made some improvements in how it operates the vehicle. Despite the incident, overall, the department evaluated the pilot to be successful in terms of emissions, costs, range, and service life. It acquired an additional 2020 Tesla Model Y at $57,000 and a 2021 Ford Utility Hybrid PPV for $48,000, with plans for further expansion.
   In 2019, the Westport, CT Police Department paid $52,900 to purchase a Tesla Model 3, compared to the $37,000 Ford Explorer which makes the majority of the fleet. (https://westfaironline.com/119360/westport-police-department-adds-tesla-model-3-t https://westfaironline.com/119360/westport-police-department-adds-tesla-model-3-to-its-

fleet/) The police chief believes that the fuel and maintenance savings over the life of the vehicle will compensate for the higher purchase price.

In 2015, the LAPD announced that it is leasing 288 electric vehicles, including 160 fully-electric vehicles, which were mostly BMW i3s. (https://electrek.co/2018/01/18/lapd-bmw-i3-fleet-barely-used/, https://electrek.co/2018/01/18/lapd-bmw-i3-fleet-barely-used/) However, it was later found that the all-electric vehicles were barely being used, with those with the most mileage having only a few thousand miles and most cars having only a few hundred miles on the odometer. It is speculated that they were rarely used because of range anxiety stemming from the fact that the vehicles can only go 80-100 miles on a charge. Eventually, the i-3 vehicles were sold by dealerships at cheap prices after the lease ended (https://www.businessinsider.com/lapd-selling-fleet-bmw-i3-cheap-ev-electric-vehicle-california-2020-9, https://www.businessinsider.com/lapd-selling-fleet-bmw-i3-cheap-ev-electric-vehicle-california-2020-9).

The LA fire department plans to introduce the first electric-powered fire truck in North America (https://www.govtech.com/transportation/Los-Angeles-Buys-in-to-the- html, https://www.govtech.com/transportation/Los-Angeles-Buys-in-to-the-Promise-of-the-Electric-Fire-Truck.html). By 2035, the LA Sanitation and Environment department plans to transition its garbage truck fleet to EVs.

4. What does municipal service vehicle cost and who pays?

   In the case of mid-size patrol cars, the Tesla Model 3 costs around $39,500, while the non-EV counterpart Dodge Charger costs around $25,000 (https://www.indystar.com/story/news/crime/2020/01/03/bargersville-chief-turns-heads-in-indiana 2606866001/, https://www.indystar.com/story/news/crime/2020/01/03/bargersville-chief-turns-heads-in-indianas-first-tesla-police-car/2606866001/). For police patrol SUVs, the Tesla Model Y costs $57,000 while the non-EV counterpart Ford Explorer costs $37,500 (https://electrek.co/2020/12/16/tesla-model-y-help-electrify-two-us-polic https://electrek.co/2020/12/16/tesla-model-y-help-electrify-two-us-police-departments/).

   In terms of fuels and maintenance costs, the Tesla Model 3 is expected to save $21,000 relative to its non-EV counterpart, while the Tesla Model Y is expected to save $30,000 relative to its non-EV counterpart.

   Vehicle purchases are financed by the municipal budget. State and federal grants and subsidies, if applicable, can help overcome the differences in upfront costs.

5. What are the climate-related benefits of municipal service vehicle electrification?

   Relative to petrol cars, average lifetime emissions from electric cars are up to 70% lower in places where most of the electricity is generated from clean sources, and is at worst 30% lower for areas where the grid is carbon intensive (https://www.bbc.com/news/science-environment-51977625, https://www.bbc.com/news/science-environment-

51977625).

6. What are some additional benefits?

   Decreased Air Pollution: Because of its zero direct emissions, all-electric vehicles can improve air quality in urban areas. The improved air quality will also lead to decreased health-related costs.

   Lower fuel and Maintenance Costs: As mentioned earlier, electric vehicles can reduce maintenance and fuel costs over its lifetime relative to non-EV counterparts.

   Virtually quiet: For police officers, the fact that a Tesla can go to zero to 60 mph in 3.2 seconds without making a sound may be beneficial to their operations.

7. What are the dis-benefits?

   Range: Range is the biggest concern for using EV as police patrol cars, as officers usually travel 70-90 miles in a 11-hour shift. Most EV models that police departments are considering using have ranges over 200 miles, so technically it wouldn't be an issue if the cars are always charged before shifts. However, as in the Fremont case where a Tesla had to drop out of a high-speed pursuit due to battery issues, the batteries aren't always fully charged before shifts. This is more of a compliance/logistics issue as police officers aren't used to charging the vehicles after shifts. There needs to be clear guidelines and routines in place to ensure that the batteries are sufficiently charged before shifts.

Chapter 11 Bicycle and Pedestrian Routes

By: ????

11.1 FAQs

1. What is the policy?

   Expand bicycle and pedestrian thoroughfares This is often described as "low stress" bike routes and "last mile design." Study and assess the costs and benefits of adding and improving routes and connectors.

   - Adding paths defined primarily as bicycling lanes physically protected from motorized traffic on busy streets to produce an experience similar to riding on an off-street trail
   - "Low stress" to incentivize more bike travel; distance from motor vehicles and busy roads
   - Emphasis on higher quality bike lanes and pathways; protected lanes with clear pathways
   - Can also look into increasing bike-share services

2. What are the benefits?

   These, among others:

   - Biking and walking do not create any additional pollution or greenhouse gas emissions: Increased bicycling and walking will help to slow the pace at which GHG emissions are increasing.
   - Low interference/demand for public resources and space.

3. Attributes?

   Costs:

   - Budget cost: MEDIUM-HIGH

     Can cost anywhere from 15k-400k a mile depending on the level of protection added to create a lane (ex. Posts, planters, buffers)
   - Social cost: LOW

     Does not create many negative externalities.

     Minimal use of public space and resources outside of construction; bike racks may be needed, but requires less than other transportation

     Does not burden public spaces immensely

     Main cost comes in adding the bike lanes (shutting down roads)
   - Time and attention: SIGNIFICANT

     Can be very time-intensive to see projects to completion; may require roads to be shut down temporarily.

Can be expedited in certain cases depending on how its prioritized with other local policies.

- Political capital: MEDIUM

  May be hard to gain traction with local/county governments.

  Need approval of certain number of bike lanes; also needs to fall within local budgeting.

Climate Benefits:

- Mitigation: MEDIUM

  Only would succeed in reducing if policy was more widely adopted (primarily in the US and Canada where bike travel rates are lower)

  "The IPCC's report classifies cycling and walking as 'non-motorised transport' and says that 'viability rests on linkages with public transport, cultural factors, climate and geography.' "

  Depends on ability to adopt multiple policies:

  - Offering more multimodal options for travel (bike some distance, public transportation the rest)
  - Funding bike lanes bike parking
  - Lowering speed limits in certain areas to make biking safer
  - Increase regulatory policies to protect cyclists Improving city layouts to connect neighborhoods with work spaces, schools, shopping centers, etc.

  Statistics:

  Bicycling could help cut carbon emissions from urban transportation 11% assuming 14% of world travel is done by bike by 2050; currently at 6%

  More than half of bicycling miles currently come from a select few countries (ex. Netherlands, China, Japan, Denmark)

- Adaptation: HIGH

  Easily adaptable in the current climate; may be even more suitable given peoples' increased desire for outdoor activity and local travel/commuting Less of a need for long-distance travel

- Transition: MEDIUM

  May encourage more widespread adoption of alternative forms of transportation

  May be again less adoptable in a post-COVID era

Co-Benefits:

- Environmental: HIGH

  Encourage greater plant life and less concrete in roadways; more lively spaces in communities

  Decrease need for cars and other public transportation infrastructure which may intervene with community spaces or add lots of noise

- Health: HIGH

  Physical health benefits

  Longer life expectancy (Netherlands as example)

- Other

  Economic: Support local bike businesses, ride-share economy is growing (job creation and local business stimulation)

  Social: More social and recreational than traditional transportation (could be used to promote bicycle usage)

Dis-Benefits:

- Aesthetics: LOW (cost on aesthetics)

  Adds to the aesthetics of local communities and neighborhoods through greenery (more expensive bike thoroughfares)

- Land use disruption: Significant

  Requires initial construction which may disturb local residents

  Requires shutting down potentially crowded roads

Chapter 12 Climate Corps

Nice article at https://e360.yale.edu/features/how-a-climate-corps-could-put-youth-to-work-ir (https://e360.yale.edu/features/how-a-climate-corps-could-put-youth-to-work-in-greening-america), “How a Climate Corps Could Put Youth to Work in Greening America." I don’t agree with everything, but this is a fine start. A related point is made in The Energy Gang podcast, on December 11, https://www.greentechmedia.com/articles/read/revisiting-pandemic-predictions- (https://www.greentechmedia.com/articles/read/revisiting-pandemic-predictions-for-energy). See (hear) the discussion on the “Youth Climate Corps" beginning just after 21 minutes from the end, about 45 minutes from the start. Jigar Shah makes a really interesting point that this sort of thing should not be just for youth. There are, he observes, lots of people who would like to “give back", participate in a non-commercial enterprise, “who don’t believe in the capitalist system," etc. We should leverage this impulse and all the NGOs out there who have been working in this space. The comments by all three participants in the podcast are terrific. This idea is redolent with promise.

Chapter 13 Food Rescue

The material here originated in sok's lecture notes for a class meeting of OIDD 525 in fall 2020. The notes should be accessible to the general reader, at least wrt to what a food rescue program is and why it can be successful. The paper by Mittal et al. can be downloaded from https://ieeexplore.ieee.org/document/9004732. One of my students asserted that there are very impressive food rescue programs operating in India. Also, The Robin Hood Army is an international organization that does this. https://robinhoodarmy.com/

13.1 Mittal et al., Food Rescue

13.1.1 QuickDoc

Stepping through a QuickDoc summary of the model in [4].

13.1.1.1 Title/Name

- *A small thing, but needed.*
- *Name the model and name the project.*
- *Can be the same name.*
- *Can be code name for development, e.g. H5.*

"AN AGENT-BASED MODEL OF SURPLUS FOOD RESCUE USING CROWD-SHIPPING" by Anuj Mittal et al., WSC 2019, [4].

The model is written in NetLogo and Dr. Mittal has graciously sent the implementation for use in teaching and research. The file is Mittal_NetLogo_WSC19.zip and is posted on Canvas.

13.1.1.2 Background and Motivation

The U.S. wastes a whole lot of food. This increases GHG emissions, municipal waste, which is expensive, and it deprives people in need. The problem is to find a way to make the situation better.

Problem statement from the paper:

> The Food and Agriculture Organization of the United Nations estimates that 1.3 billion tons (approximately one-third) of all food produced for human consumption worldwide is lost or wasted (Gustavsson et al. 2011). In developing countries, much of this waste occurs in the post-harvest and processing stages of the food

> supply chain, due to inadequate transportation and storage infrastructure. However, in industrialized countries, most food waste occurs at the consumption stage of the food supply chain, meaning that it is discarded even if it is still suitable for human consumption (Gustavsson et al. 2011). The U.S. Department of Agriculture estimates that 31% of the 430 billion pounds of available food supply at retail and consumer levels in the U.S. goes uneaten each year (Buzby et al. 2014).
>
> Because agriculture and food production are resource-intensive activities, producing surplus food is an unnecessary strain on the environment. Hall et al. (2009) estimate that more than 25% of total freshwater use in the U.S. is used to produce food that is finally wasted. The energy embedded in wasted food represents approximately 2% of total annual energy consumption in the U.S. (Cuéllar and Webber 2010). Furthermore, the production of food that is wasted at the retail/consumer level in the U.S. generates greenhouse gas emissions equivalent to the emissions of 33 million passenger vehicles annually (Heller and Keoleian 2015). The disposal of food waste also has severe environmental consequences. The U.S. Environmental Protection Agency (EPA) estimates that 15.1% of all municipal solid waste (MSW) in the U.S. is food, which translates to 246.8 pounds of food waste generated per capita annually (U.S. EPA 2018). Only 5.3% of this food waste is recovered, leaving 30.3 million tons to be sent to landfills. As a result, food waste is the largest component of all landfilled MSW in the U.S., comprising a total of 22%. MSW landfills account for nearly 18% percent of anthropogenic methane emissions in the U.S. (U.S. EPA 2017a). With a global warming potential that is 28 times greater than carbon dioxide (Myhre et al. 2013), methane from food waste is, therefore, a major contributor to climate change. [4]

13.1.1.3 Purpose

- *Purpose: Why are we doing this (building a model)? What do we hope to investigate with its help?*

To model and investigate how food that would otherwise go to waste might be "rescued" and gotten to those in need and benefit them. The study models a novel delivery system by which restaurant food waste that is still consumable is delivered to homeless shelters. The study explores use of "crowd-shipping":

> *Crowd-shipping* is defined as "an information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis, and is compensated accordingly" (Rai et al. 2017). Examples of commercial crowd-shipping schemes include Uber Eats and DoorDash, in which food vendors use an online platform to find an available driver from a pool of drivers

(i.e., the crowd-shippers) who is willing to pick up and deliver a customer's order (typically using his/her personal vehicle) for a predetermined price. The appeal of crowd-shipping lies in its ability to provide low-cost delivery service with greater flexibility and shorter lead times than conventional transportation service providers.

13.1.1.4 Basic Story

- *Recommended: A short paragraph, easily understood by your Aunt Martha or your boss.*
- *Clear and succinct on what the main action consists of.*
- *Focus on the main items, neglecting small details.*
- *In more recent versions of NetLogo the default Info tab begins with the categories What Is It? And How It Works?.*

  You might consider the basic story as aiming to answer these questions.

Restaurants sign up to participate in the surplus food-to-homeless shelters program. Three times a week food is pick up at the restaurant by a crowd-shipper agent (if available) and delivered to a homeless shelter. Operation of the system is monitored for reliability of pickup (are crowd-shipper agents ready and willing when called upon? how often does donated food not get picked up and delivered? What are the costs? etc.)

13.1.1.5 Basic Census

- *What do we have here?*
- *Main agents, or types of agents?*
- *Main (non-agent) entities?*
- *Main data (or parameter values) required?*
- *Main Measure(s) of Performance (MoPs)?*

  MoPs: Output of the model having diagnostic value; ultimately what we want to get in building the model.

- Agents: restaurants, crowd-shippers
- Non-agent entities: homeless shelters and crowd-shipper homes, both located spatially
- Data: driving time and distances from homes to restaurants, from restaurants to homeless shelters; cost of shipping
- MoPs:

> **The three key performance metrics of interest are the number of successful and failed deliveries over time and the number of restaurant donation requests.** A failure corresponds to a situation in which a restaurant is willing to donate food in a particular time-step, but none of the crowd shippers chooses to fulfill its request. A success corresponds to a donation that is picked up by a crowd shipper and delivered to the assigned shelter. The total number of

restaurant donation requests is, therefore, the sum of the number of successful and failed deliveries. Upon experiencing a failed delivery, a restaurant?s willingness to participate in the food rescue program in future time-steps decreases. Maintaining and increasing restaurant do- nations, therefore, requires consistent active participation by a sufficient number of crowd shippers.

13.1.1.6 Major Components

- *What are the principal procedures (command procedures and/or reporters in NetLogo) and briefly what are they for, what do they do? Emphasize: principal.*
- *What, if there are interesting (non-agent) entities, are their important aspects? What makes these important for the model?*
- Sub-Model 1: Restaurant Agent Decision-Making
- Sub-Model 2: Shelter Assignment
- Sub-Model 3: Crowd-Shipper Agent Decision-Making

13.1.1.7 Basic Procedures

- *For the principal procedures (command procedures and/or reporters in NetLogo) how to they work?*
  Emphasize: principal.
- *Main ways of answering:*
  - *Structured, terse natural language.*
  - *Flow chart.*
  - *Pseudocode.*
  - *Use case.*

There is a control procedure that drives the simulation in ticks of a day for a year. As indicated above, when the clock ticks, each restaurant decides if it has good to donate that day. Then the crowd-shipping agents are probed to see determine whether they will volunteer to make deliveries for the several restaurants. Each restaurant may or may not be assigned a volunteer, depending on availability. Volunteers show up at the restaurants at the arranged times and wait a random length of time. Once given food they deliver it to their assigned homeless shelter. Comment: The paper would be improved by presenting a detailed flow chart of this control procedure.

The individual decision making procedures are described in the paper in a series of 6 equations.

13.1.1.8 Approach to Validation

- *A HUGE topic, of course.*
  Here, just some high-level pointers.

- *Beyond these remarks, look for introductory material to the larger QuickDoc decks and, especially, to Rand and Wilensky, IABM Textbook, Chapter 7 [5].*
- *Commonly: verification versus validation.*
  Did we built the system right? versus Did we build the right system?
- *At the end of the day, there are no guarantees.*
  Only reasonable procedures that can be pursued assiduously. To a proper degree?
- *Foundationalism (demonstrating from first principles) is a non-starter.*
  Don't even think of going there. Software is like a written document (think: literate programming). Keep reviewing it and testing its behavior (assertions), and eventually it will be apparent you can stop.

The paper several times describes the study and model as "conceptual." This is an apt term, corresponding well to what we have called "insight". The aim of this exercise is to gain insight into a concept—crowd-shipping for food rescue—by building an approximate of one such system.

Validation (the term and its cognates do not appear in the paper) was principally undertaken by studying and emulating existing food rescue programs. The paper notes that 17 such programs are presently in operation in the U.S. Also, the model is calibrated to real-world data in several ways:

1. A several studies are cited to support the sub-model for determining whether a potential crowd-shipper will be willing to do particular jobs.
2. The model is placed in the context of Arlington, Texas, and focuses on several block groups in a census block, using census demographic data to ascertain properties of the potential crowd-shippers.
3. Being tied to a specific geography, the model uses estimated travel times using the Google Maps API.

13.1.1.9 Nagging Worries

- *Not that we should be Hamlet, but it's a good thing to write down potential problems.*
- *What has been assumed or implemented that really hasn't been checked out properly and may very well be quite mistaken, and significantly so?*

The paper explicitly asserts that this is a "conceptual" model and expresses the hope that it can transition to a decision support system (DSS) for managing a food rescue program. The concluding paragraph does well at summarizing and identifying some limitations in this regard.

> The model described in this paper serves as a starting point for the development of a system, in which the restaurant surplus food is diverted from landfill and provided to people in need. . . . To further capture the capabilities of this ABM, a larger sample of population needs to be modeled. Incorporating an estimated amount of food per donation into the model will help track the positive environmental impact

> of this volunteer-based crowd-shipping system for rescuing the surplus food from restaurants. This is a conceptual model incorporating motivation of participants that determines their utility based on factors that could be of primary importance to them and thus captures their decision-making process. The model could be used to further investigate specific motivations of these participants by collecting empirical survey data from them and thus strengthen the factors determining their utility for the specific application.

Although the authors do not make this suggestion, transition to a DSS for managing such a program could be furthered by running the model in parallel to an operating problem and using discrepancies to refine and tune the model.

File: Mittal-ABM-food-rescue-WSC-2019.tex

Chapter 14 ***Sustainable Living Information***

Liken to health and safety info.

Figure 14.1: Representative Dean's constituent services brochure.

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